#TechVision

Federal Technology Vision 2022

Government Enters the Metaverse

Four trends reshaping government for the metaverse continuum

Accenture Federal Services

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In May 2022, two contractor pilots, each flying a Berkut 540 aircraft, entered a section of sky over Ventura County, California, that took on an added dimension.

They had just entered a nascent military metaverse called the Combined Augmented Reality Battlespace Operation Network (CARBON).

Outfitted with customized augmented reality (AR) headsets, the pilots could see each other from their aircraft as they flew. But they could both see something else as well: a virtual Boeing KC-46 Pegasus Tanker, flying in formation with them. Each could see the same virtual tanker, but from their own perspectives based on their precise locations in the sky. While one pilot performed a refueling training mission with the virtual tanker, the other pilot observed in real-time.

This was a notable accomplishment: it was the first time that multiple live aircraft were connected into a common AR environment, outdoors, up in the sky.[1] "Never has it been possible for multiple pilots to communicate simultaneously in AR like this," said Brandon Harris, a test pilot for Red 6, the Florida-based company that performed the demonstration. He added: "One day, this training will produce the most elite warfighters in the world."[2]

Impressive as this was, it's nothing compared to what trailblazers in this space have in mind for the not-too-distant future.

Visionaries like Daniel Robinson, Red 6's founder and CEO, see this new half-real, half-augmented 3D environment eventually filling up with legions of very real warfighters from multiple services, all training and wargaming and mission planning together: "We are thrilled that our thesis has been validated and this achievement is a major step forward towards the creation of an outdoor Military Metaverse in which all warfighters, across all domains, can train together."[3]

Elsewhere in California, San Diego County is using the Accenture Virtual Experience Solution (AVEnueS) to train caseworkers how to work with families to determine their eligibility for various benefits. By creating an immersive virtual experience complete with frantic parents, distracted children, and ringing telephones, caseworkers can develop new interviewing skills, such as de-escalation techniques, needed to manage potentially stressful situations.

And the results? Over 90% of participants say the training improved their skills in engaging individuals and provided realistic expectations of their new roles, with all saying they would recommend it to coworkers as a valuable training approach.[4]

Welcome to the **"Metaverse Continuum"** – a spectrum of digitally enhanced worlds, realities, and business models that are rapidly taking shape and proliferating across enterprises. This continuum is bringing the next major wave of digital change to public and private sector enterprises alike, and government leaders need to start making big leaps forward in how they think about their agencies – today.

This Metaverse Continuum is where the real meets the unreal, the physical meets the virtual, and the authentic meets the synthetic. It is a world that holds enormous possibilities because it is where so many of today's emerging technologies are converging.

Extended reality, artificial intelligence, blockchain, quantum computing, advanced sensors, 5G, the Internet of Things, digital twins, advanced modeling and simulation, and other advancements — each of these individually can be considered breakthrough technologies; but when combined in various ways, they create incredible new spaces, rich in capability, that have the power to transform the world as we know it.

In a survey of 200 U.S. federal government executives,

99%

said continuous advances in technology are becoming more reliable than economic, political, or social trends in informing their organization's long-term strategy.

If some of this sounds a bit fanciful, think again. Government agencies are already dipping their toes into the future.

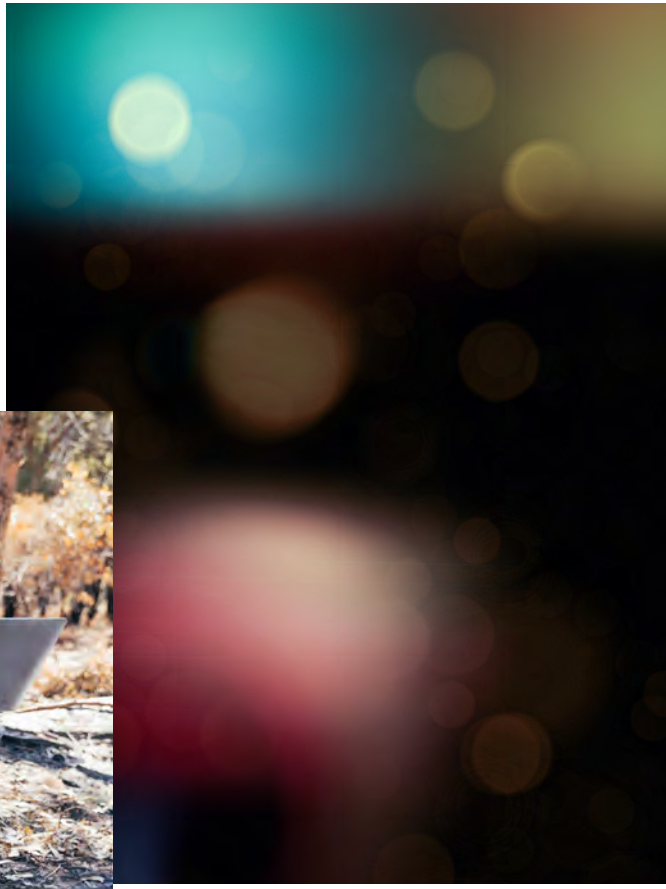
NASA's Jet Propulsion Laboratory is creating a shared virtual workspace where engineers can collaborate on designing future planetary and deep space remote sensing satellites, landers, and autonomous robots.[5] More ambitious still, NASA is creating a Martian metaverse — complete with realistic Martian gravity, day and nighttime light conditions, atmospheric conditions, space suits and rovers, and 400 square kilometers of terrain — for engineers and developers to create and experiment with as they plan future trips.[6]

Contractors for the Agriculture Department's Forest Service are using AI and digital twin technologies to simulate wildfires in a metaverse to better understand their dynamics and how they can slow or stop their spread.[7] U.S. Air Force leaders at Tyndall Air Force Base in Florida have created a digital twin of the entire base to help plan rebuilding projects following the 2018 destruction of Hurricane Michael.

Using a new virtual portal to access Tyndall's digital twin, planners can conduct "what if" scenarios and locate and design new flight line facilities that will support new squadrons of F-35 Lightning II strike fighters due to arrive in 2023.[8]

Other governments are exploring the possibilities of the Metaverse Continuum as well. The city of Seoul, South Korea, is creating "Metaverse Seoul" — which combines digital twins, virtual reality (VR), and collaboration — to improve city planning, city administration, and support for virtual tourism.[9] The city of Dubai in the United Arab Emirates has stood up a new government agency to regulate digital assets that will have a headquarters office in The Sandbox, one of the largest virtual worlds today.[10]

Some of these technologies are just getting established and have much room to advance and improve for widespread commercial and government use. But make no mistake — they are advancing and rapidly so, and enterprises today should not question whether they will be impacted by these trends, but rather how soon and how extensively.



Think about those pilots conducting AR-assisted training flights. With that same technology, they can engage in other AI-driven synthetic scenarios beside aerial refueling. They can fly in formation and even dogfight with virtual, AI-powered adversary fighter jets, all while actually flying and pulling real g's. "We can fly against whatever threat we want," said Red 6's Robinson. "And that threat could be controlled either by an individual remotely or by artificial intelligence."[11]

The Air Force has already recognized how transformative this kind of innovation might be. In February, it awarded Red 6 a contract to integrate its Airborne Tactical Augmented Reality System (ATARS) into the service's T-38 trainer aircraft. The company said it intends to eventually integrate the AR system into other Air Force aircraft as well, including the T-45, F-16 and F-15E.[12]

These anecdotes only scratch the surface of what is becoming possible as these trends continue advancing and converging.

We should expect the Metaverse Continuum to eventually play a key role in arenas such as healthcare, engineering, agriculture, citizen services, logistics and maintenance, industrial operations, research and development, environmental protection, industry oversight and regulation, modeling and simulation, urban planning, training and education, military readiness and preparation, and other traditional government mission categories.

It is important to point out that, while this may all seem futuristic now, this is already well on its way here. Seeing signals of profound change, the Accenture Federal Technology Vision found it apt to set its sights farther forward than ever before. The building blocks of the Metaverse Continuum are taking shape today but will coalesce over the next decade to create an entirely new enterprise landscape. The 2020s will see ambitious enterprises bringing shape to these new physical and digital realities, as well as worlds co-populated by people and AI, industries made possible by new computers, and more.

Why a Metaverse Continuum?

You've probably heard the word "metaverse" over the last year, evoking a science fiction future of a persistent and shared virtual reality space. The truth is, right now a lot of early metaverses are being built with many different initial focuses and ideas for how to get it right. Some are for enterprises, some for consumers. Each has different platforms, partners, and technologies at its core.

Eventually this spectrum of ideas will coalesce into a more broadly unified experience, but the range of mission areas that it will impact will only grow.

Just as the internet evolved beyond simple websites to underpin the majority of today's businesses, it would be wrong to think the experience of the metaverse will be constrained to digital space.

That is why we've introduced the "Metaverse Continuum." Accenture Federal Services looks at the metaverse as an evolving and expanding continuum on multiple dimensions:

- Comprising multiple technologies including extended reality, blockchain, artificial intelligence, digital twins, and smart objects – including cars and factories, and edge computing.
- Encompassing the "virt-real" – the range of experiences, from purely virtual to a blend of virtual and physical.
- Describing the spectrum of emerging consumer experiences and the mission and business applications and models across the federal agency enterprise that will be reimagined and transformed.

An era of opportunity — and caution

In many ways, the new worlds that governments and companies are starting to build have no history or legacy – no right way to do anything.

This means immense opportunity, but it also means that enterprises will be pushing boundaries far beyond the reach of today's policy and regulation. This will need to be a big and early area of focus for federal agencies with industry oversight and regulatory responsibilities.

And while the possibilities of these converging technologies are enormous, it is also important to point out that so too are the potential pitfalls. The Metaverse Continuum is certain to pose significant challenges — such as in the arenas of cybersecurity, privacy, digital identity, trust, and disinformation — to federal agencies that will require early planning and preparation.

Enterprises will find themselves on the front lines of establishing trust and safety and defining the human experience in these new places. Trust will be paramount to adoption of the new experiences leaders are beginning to build. Considerations (and concerns) already held today around privacy, bias, fairness, and human impact are becoming far more acute as the line between people's physical and digital lives further blurs. Enterprises that wish to lead in this space will shoulder the mantle of building a "Responsible Metaverse," and the actions and choices they make today will set the standards for all that follow.

It leaves government agencies at a critical moment to decide their path forward. These new frontiers of technology will redefine the entire context of every enterprise, shaping how they will operate and create value for decades to come. Those who shy away from the uncertainty ahead will soon find themselves operating in worlds others have defined – playing by someone else's rules. But bold government agencies will embrace the uncertainty and wield it as opportunity.

Inevitably, every agency executive will need to ask: What will my role be in this new continuum? Answering this – and acting on it – won't be easy; it's a journey riddled with uncertainty well outside the norms of what most companies are comfortable with. But the chance to shape the next decade of government, to build new worlds, and to explore the brand-new opportunities that these worlds create doesn't come often.

100%

of the U.S. federal executives in our survey agree that emerging technologies are enabling their organization to have a broader and more ambitious vision.

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Your future is starting today, are you ready for it?

Four building blocks of the Metaverse Continuum

Enterprises are starting to realize that, in their drive to survive during the pandemic, they have accelerated the future.

Though the challenges of the pandemic still weigh heavily on government agencies today, we are starting to adapt to our new reality, and leaders are taking a more deliberate approach to shaping what comes next.

In this year's Vision, we explore how today's technology innovations are becoming the building blocks of our collective future.

89%

of U.S. federal executives report that their organization has adapted to the disruption of the pandemic and has found a new normal.

The trends investigate the entire continuum, from the virtual to the physical, across humans and machines alike, identifying where perceptive enterprises can find rich opportunity to advance their missions by uprooting themselves from today and planting themselves firmly in the future.

First, in Trend 1: ***WebMe***, we explore how the internet is being reimagined. The last two years spurred enterprises to explore new modes of digital experience and pushed people to live virtually to an extent they never expected. Now the metaverse is emerging as a natural evolution that reconciles how the internet is designed today with what we will demand from it going forward. The advent of the metaverse, and underlying efforts to reimagine how data shapes our digital experiences, will challenge agencies to rethink their presence online and become a part of shaping the next platform revolution as they build new ways to connect to citizens, constituents, industry and academic partners, and their digital workforces.

But the value of new virtual worlds would be capped if not for parallel changes that anchor them in the physical one. The Trend 2: ***Programmable World*** tracks how technology is being threaded through our physical environments in increasingly sophisticated ways. It projects how the convergence of 5G, ambient computing, augmented reality, smart materials, and more are paving the way for agencies to reshape how they interact with the physical world. As technology becomes part of the fabric of our environment, it allows us to treat our environment more like technology – unlocking an unprecedented fidelity of control, automation, and personalization.

When it comes to populating new worlds, humans are the primary residents. But we are also tracking the emergence of Trend 3: ***The Unreal*** – a trend where our environments and businesses are increasingly filled with machines that are passably human. "Unreal" qualities are becoming intrinsic to the artificial intelligence, and even the data, that enterprises aspire to integrate into mission-critical functions.

At the same time, people are coming face-to-face with bad actors using this technology – from deepfakes to bots and more – igniting a growing concern that may turn into the biggest hurdle for enterprises looking to grow their use of AI. Like it or not, enterprises have been thrust into the forefront of a world questioning what's real, what isn't, and if the line between those two really matters.

Finally, we are on the precipice of resetting the boundaries of traditional industries as we begin Trend 4: ***Computing the Impossible.*** The outer limit of what is computationally possible is being disrupted as a new class of machines emerges. Quantum, biologically inspired, and high-performance computers are each allowing federal agencies to tackle grand challenges that once defined and shaped the very core of their sectors. As problems once considered impossible become ever more solvable, government leaders will be pushed to reimagine some of the most basic assumptions about their enterprise.

We stand at a unique precipice in time. Not because there are new technologies to master, but rather that mission performance in this next decade will require something more than just increasing technology and innovation skills. It will require a truly competitive vision – both for what these future worlds will look like and also what your agency will need to become to succeed in them.

Technology points us in the right direction, but the rest is up to you.

Our Four Technology Trends for 2022

WebMe

Putting the Me in Metaverse

The internet is being reimagined as metaverse and Web3 efforts transform the underpinning and operation of the virtual world.

Programmable World

Our Planet, Personalized

Control, customization, and automation are being enmeshed into the world around us, making the physical as programmable as the digital.

The Unreal

Making Synthetic, Authentic

As AI-generated data and synthetic content convincingly mimic what is "real," authenticity is the new north star.

Computing the Impossible

New Machines, New Possibilities

A new generation of computers are solving some of the world's most intractable problems, leading to one of the biggest technological disruptions of our time.

Lead Authors & Executive Sponsors

Kyle Michl
Managing Director –
Chief Innovation Officer
Accenture Federal Services

Chris Copeland
Managing Director –
Chief Technology Officer
Accenture Federal Services

Trend 01

WebMe

Putting the Me in Metaverse

THE BIG PICTURE

The internet is evolving rapidly to accommodate greater expectations in the wake of the pandemic.

In a recent Accenture survey of 24,000 consumers around the world, 70% report spending substantially more time online, 69% call it a lifeline for connecting with others, and 55% say more of their life and livelihood is moving towards digital spaces. Increasingly, our physical and virtual worlds are converging, as individuals distinguish between the two less and less.

Two distinct technology shifts — the rise of metaverses and the arrival of Web3 — are defining the latest evolution of the internet. Together, these disruptive technologies are conveying us to a realm where the virtual and the physical worlds overlap and where anyone can bend and shape their surroundings to their liking and conduct affairs with far greater agency than ever before.

Defining our terms

Thought leaders in this space often have varying definitions of terms like metaverse and Web3 because, admittedly, they are still-emerging concepts and can mean different things to different people. This fuzziness can make discussions tricky.

Metaverse

Accenture sees the ***metaverse*** as "an evolution of the internet that enables a user to move beyond browsing to inhabiting and participating in a persistent shared digital experience that spans the spectrum of immersion."

Web3

While ***Web3*** is an evolving term, in this report we use it to refer to the emerging initiatives that are leveraging technologies like blockchain and tokenization to build a more distributed data layer into the internet.

Metaverse and Web3 innovations are transforming the fundamental underpinnings and operation of the virtual world. Whereas the internet might be thought of as a disparate collection of dynamic websites and apps, metaverses envision persistent 3D environments, imbued with a sense of place and presence, where moving from an enterprise system to a social platform is as simple as walking from the office to the movie theater across the street. Web3 further shapes this evolution by introducing a data framework that generates veracity, trust, and consensus — things we've long had conventions for in the physical world but which have often eluded us in the virtual world.

Together they are driving a shift towards a more decentralized but also more human-centric internet, and federal agencies will need to prepare for these imminent changes.

Already,

64%

of U.S. federal government executives predict that metaverses will have a positive impact on their agency with 25% calling it breakthrough or transformational.

Of the one quarter anticipating the most significant impact,

94%

believe it will happen in the next four years.

The metaverse

For the uninitiated, the metaverse is an evolution for how we will experience the internet. It is a collection of rich, immersive, persistent virtual worlds where people can explore, play, socialize, train, collaborate, and create with others. Many first experienced immersive environments though online gaming like Fortnite, Roblox, and Minecraft, but broader use cases are fast emerging due to the rapid growth in creation tools, platforms, and technologies that enable new possibilities.

Rapid advancements in 3D digital content creation, digital twin, simulation, extended reality (XR), artificial intelligence (AI), graphics processors, and other technologies have spawned a growing global industry of metaverse creators, developers, builders, and investors. These companies include Nvidia, Microsoft, Apple, Roblox, Unity, Epic Games, Adobe, Qualcomm, Google, and many more. One of the most bullish steps taken into this brave, new world was by Mark Zuckerberg, who rebranded Facebook into Meta and is investing $10 billion in developing the metaverse.[13]

Most notably, this is fueling the emergence of dedicated metaverse platforms, virtual worlds that individuals can explore, interact with, and inhabit 24/7/365. These have historically been social platforms where users can take digital forms, engage with others, and chart their own adventure. In some cases, the use of virtual reality headsets and similar technologies create more immersive, even tactile, experiences in these fully dimensional digital worlds.

These metaverses are being quickly populated not only by gamers and creators, but also by bigtime brands and investors. We're seeing an increasing number of use cases to include collaboration and enterprise enablement. Recognizing that the next generation of consumers are already in the metaverse, Adobe has created a metaverse playbook and is partnering with leading brands like Coca-Cola and NASCAR to bring it to life.[14] Artists and entertainment companies are staging concerts in it. Disney is planning to build a theme park in the metaverse. Accenture plans to onboard 150,000 employees in the metaverse.[15]

Going a step further, car companies are using the metaverse to plan more efficient and safe factory operations and market their products. For example, there are more than 40 BMW models with over 2,100 potential configurations each (99% of the company's 2.5m vehicles are customized).

Using Nvidia's Omniverse platform, BMW created a digital twin of its factory to simulate and optimize assembly line production, enabling a 30% improvement in planning efficiency.[16]

Industry analyst Gartner projects that by 2026, 25 percent of people will spend at least an hour a day in the metaverse for work, shopping, education, social, or entertainment.[17] "Vendors are already building ways for users to replicate their lives in digital worlds," said Marty Resnick, research vice president at Gartner. "From attending virtual classrooms to buying digital land and constructing virtual homes, these activities are currently being conducted in separate environments. Eventually, they will take place in a single environment – the metaverse – with multiple destinations across technologies and experiences." That's the hope of most consumers, as 57% in our survey note that they expect organizations to "help unify my digital experiences."

While activity around a single platform metaverse is intensifying, we have yet to see a single, federated metaverse materialize, and we likely won't for several years. Experts like Forrester say this won't occur until there is interoperability across disparate platforms built upon a foundation of standard protocols for the presence, persistence, and transfer of identity and assets. As Richard Kerris, Nvidia's VP of Omniverse Platform Development, put it, "The metaverse requires connective tissue for it to be a reality."[18]

The building blocks of a future metaverse are being laid today in the form of 3D digital creation tools, real-time 3D gaming engines and single-vendor platforms, and federal agencies need to be aware of this future world in the making because they — like all organizations — will have a role to play, just as they did when the internet emerged as a global requirement more than two decades ago.

Web3

The other big trend driving WebMe is Web3, which provides an enhanced, distributed data layer to the internet. When the internet first hit the world stage in the 1990s (Web1), it was all about freedom, decentralization, and sharing ideas. This changed in the 2000s into today's highly centralized internet dominated by large companies like Google, Amazon, and Facebook (Web2).

Web3 intends to challenge this paradigm and "democratize the internet" — as advocates put it — by employing decentralized, multi-party technologies and design architectures like blockchain, digital assets, and smart contracts - what some call the internet of ownership. In our survey, nearly three-quarters (72%) of consumers say "...the next technology revolution needs to be led by people-centric experiences, giving me more control over my data."

By often building services and applications atop often permissionless blockchains outfitted with open protocols and open standards, Web3 will allow for more freedom, decentralization, and democracy for individual users, content creators, and projects. For example, one prominent feature of Web3 is decentralized autonomous organizations (DAOs), which are groups of people of any size that organize around a shared community or resource and democratically decide how to manage those resources and interact with the world.

Another core Web3 activity is DeFi, which also plays a key role in metaverses. DeFi refers to decentralized finance, which is about creating internet-native financial systems that use blockchains to replace traditional intermediaries and trust mechanisms. Instead of having traditional intermediaries — such as banks or stock exchanges — send and receive money, DeFi employs blockchain-based "smart contracts" and other distributed ledger technologies (DLTs) to ensure that transactions are fair and trustworthy.

Using DeFi tools and methods, people can do everything from buy or sell stock or real estate and borrow and lend cryptocurrency.

These financial assets are often based on nonfungible tokens (NFTs), which consist of digital data, stored on a blockchain, that attests to and verifies the asset's provenance. Because the ownership of an NFT is securely recorded on the blockchain and can be transferred by the owner, it can be sold and traded like any physical asset.[19] Roughly speaking, DeFi-related assets are valued in the tens of billions of dollars, and trading activity on decentralized exchanges — though largely unregulated — has grown by triple-digit percentages in the past year.[20]

Web3 also can deliver content creators greater ownership and control over what they create. Traditionally, online content gets aggregated on large platforms, such as YouTube, Spotify, and Medium, which get the lion's share of any monetary value that the content produces. Web3 advocates promise a more equitable reward for content creators.

For example, more artists are selling their art directly to consumers as NFTs, which enables the artist to collect a royalty on it for the lifetime of the art — so every time it's sold, the artist gets a cut. This ability to move away from big, centralized platforms can have a significant financial impact on artists and content creators.

> **Web3 is also a reaction to the internet's centralization and monetization of people's data, such as by social media platforms.**

As some envision it, future Web3 capabilities will empower individuals to decide how they want to collect, store, share, and, if they want, monetize their personal data.

"Your individual profile will identify what can and cannot be done with your data through blockchain-backed smart contracts, allowing advertisers or intermediaries to aggregate your data in exchange for payment through a clearinghouse," wrote Jeff Bell, CEO of LegalShield and IDShield.[21]

While most of the world still operates in Web2 today, Web3 has gained a solid foothold and is growing fast. In January 2022, the Oslo-based browser and web innovation company, Opera, launched the Crypto Browser Project, a dedicated Web3 browser for PC, Mac, and mobile phones that has an integrated cryptocurrency wallet and other Web3 functionality. The company claims to have "an engaged and growing base of hundreds of millions of monthly active users who seek a better internet experience."[22]

Metaverse + Web3

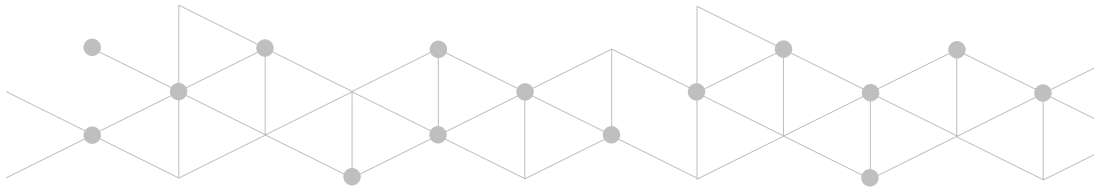
While powerful in their own right, many metaverse platforms are also adopting Web3 to enable more realistic, lifelike scenarios. For example, two of the leading platforms today, The Sandbox and Decentraland, are employing Web3 technologies so inhabitants can purchase virtual land and other assets and use them to create their own worlds and, importantly, even monetize their own content, games, and other applications. Both The Sandbox and Decentraland are developed on the Ethereum blockchain, so the land and other assets are represented and stored as NFTs, and metaverse transactions are conducted in the platform's native currency.

And with Web3, metaverses are not just places to hang out and play games.

> They are fast becoming thriving digital economies, powered by DeFi applications, which enable users to trade assets, get loans and store deposits, and enjoy play-to-earn (P2E) games where they can potentially earn cryptocurrency.

In fact, participating in many metaverse platforms requires not just a computer, smart phone, or extended reality (XR) headset, but also a crypto wallet. In a sign of how far things have progressed, many fashion brands are already releasing direct-to-avatar (D2A) digital collections in which digital apparel is being sold to and for consumers' avatars![23]

Clearly, the metaverse and Web3 are in nascent stages, but they are also emerging and developing fast. We have seen many similar technological developments — including the internet, smart phones, and, most recently, online video collaboration tools — redefine our everyday lives and work experiences. As with those, we should expect to see significant volatility and evolution associated with WebMe in the months and years ahead. But, given the enormous potential that WebMe offers in terms of creating powerfully compelling digital environments for us to collaborate, train, engage, and conduct business in, federal leaders should start thinking now about how this trend will intersect with their agencies' future trajectories.



THE ANALYSIS

Where do federal agencies fit in a WebMe world?

For many, this may all sound a bit fantastical and futuristic. But be forewarned: it is closer than you think. Some federal agencies are already exploring the possibilities.

One of the most ambitious efforts underway is the Army's Synthetic Training Environment (STE), which aims to revolutionize the Army's entire training paradigm by allowing units and soldiers to conduct realistic, multi-echelon, collective training anywhere in the world. Currently scheduled to be fully operational in 2023, the STE will combine live, virtual, constructive, and gaming training environments that simulate real-world terrain in its full complexity.

The Army is designing the STE to be AI- and machine learning-enabled; accessible "at the point of need"; and capable of joint, interagency, and multi-national interoperability. Ultimately, STE will give soldiers "unprecedented access to realistic virtual training, while open architecture enables interoperability across echelons, domains, forces and with partners," according to an Army description of the program.[24]

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement.

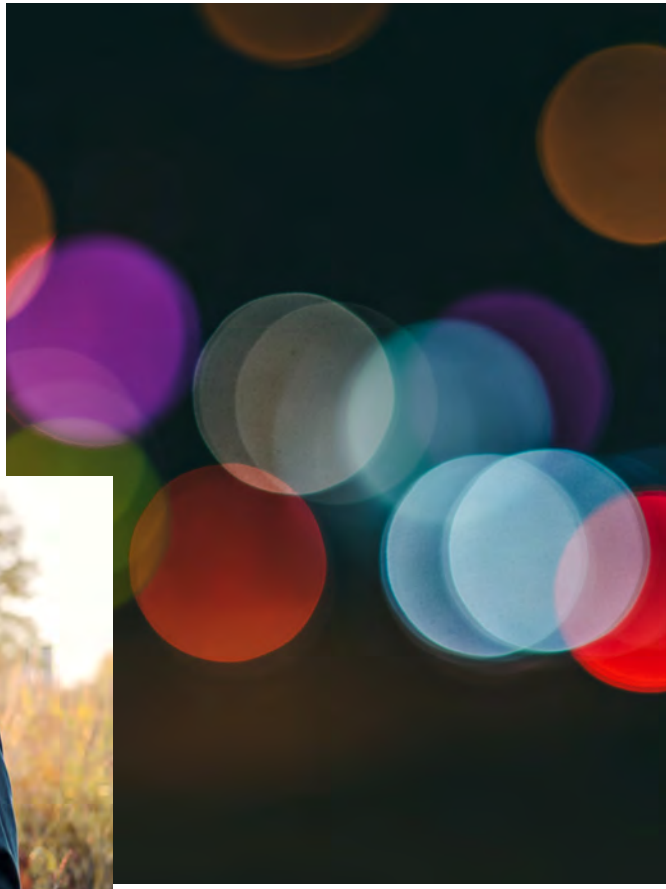
Other agencies are edging their way into the metaverse as well.

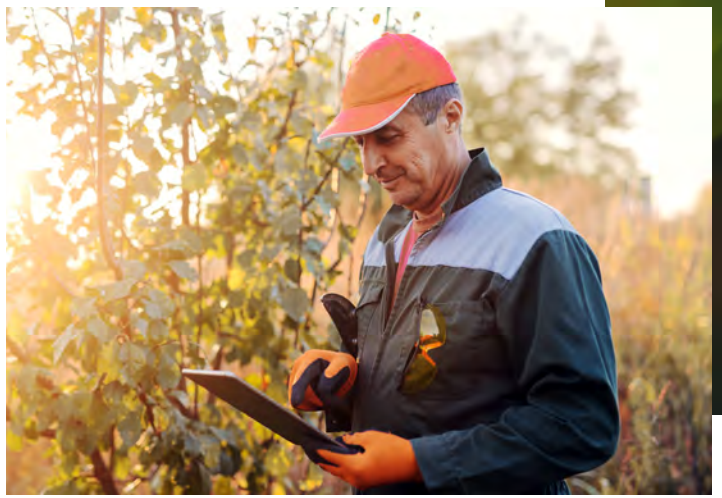
The Veterans Health Administration Innovation Ecosystem (VHA IE) Extended Reality Network was developed to explore new care models for Veterans suffering from post-traumatic stress disorder (PTSD), anxiety, depression, chronic pain, and other challenges. They can experience XR-based care to reduce stress, spending 30 minutes, for example, walking along a beach.

As one Veteran noted, "That was like going to see a good movie – you don't want it to end." For those suffering chronic pain, XR sessions have reduced the use of opioids – a 72% reduction in opioid usage for post-operative patients in one study.[25]

The Department of Agriculture's Forest Service is relying on AI and digital twin simulation technology operating in the metaverse to better understand wildfires and stop their spread. Specifically, Nvidia is helping to create the world's first AI-centric lab dedicated to predicting and responding to wildfires. "The lab will use Nvidia AI infrastructure and the Nvidia Omniverse advanced visualization and virtual world simulation platform to process a fire's magnitude and forecast its progress. By recreating the fire in a physically accurate digital twin, the system will be able to suggest actions to best suppress the blaze," according to an Nvidia blog.[26]

The U.S. Air Force is pondering the creation of a space-themed metaverse and has even trademarked a name for it: SpaceVerse. According to the Air Force's trademark application, SpaceVerse will be "a secure digital metaverse that converges terrestrial and space physical and digital realities and provides synthetic and simulated extended-reality (XR) training, testing, and operations environments."[27]





NASA: Welcome to our metaverse

Perhaps one of the most compelling cases of a federal agency employing WebMe capabilities to design and create its own virtual environment is occurring at NASA's Jet Propulsion Laboratory near Los Angeles, which is developing a future collaboration space for its engineering and design teams.

Like most federal agencies, JPL shifted to a mostly remote-work model in the early days of the COVID 19 pandemic. "As the Lab's workforce dispersed across the country, employees wondered what this new phase meant for JPL's culture, particularly the move from in-person collaboration and meetings to videoconferencing and the now-all-too-familiar impacts of 'Zoom fatigue,'" wrote JPL's Chris Mattmann, chief technology and innovation officer, and Whitney Haggins, an IT communication strategist, in an April 2022 article in IT Talk, a quarterly journal published by NASA's Office of the CIO.[28]

"JPL's key business of engineering future planetary and deep space remote sensing satellites, landers, and autonomous robots is predicated on dynamic communication and collaboration among teams. Enabling that via videoconference is extremely challenging."

In response, JPL's IT organization launched the "Welcome to Our MetaVerse" project. The project team began scanning workspaces and rooms at JPL and then digitally reconstructing and importing them into an application by Spatial.io, which creates 3D virtual worlds.

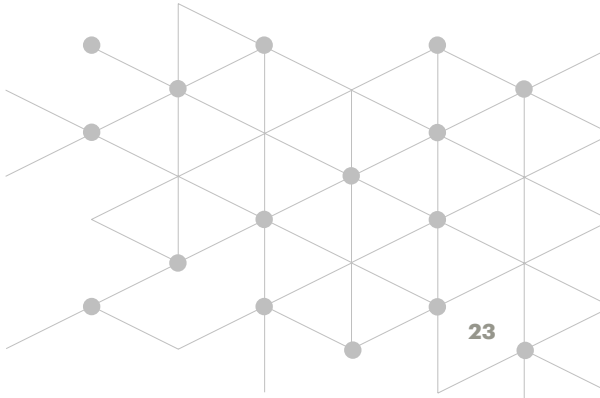
> JPL employees can then wear Oculus Quest 2 headsets to attend virtual meetings in those scanned locations.

The project then plans to bring JPL employees themselves into the metaverse by using Spatial.io's 3D face-scanning technology to create realistic avatars to represent them.

"JPL participants can congregate, meet, and take advantage of VR capabilities from the Quest 2, including spatial audio and gestures (e.g., high-five, thumbs up), as well as other features that add to the sense of realism and interactivity and the experience of 'being together' in as full a sense as possible," Mattmann and Haggins wrote. "With the MetaVerse, remote and hybrid teams can innovate, create, and perform engineering activities without having to physically procure and manipulate actual materials and assemblies."

JPL teams in this homegrown metaverse can even use the lab's custom collaboration tool for engineering activities, called ProtoSpace, to do things like import complex computer-aided design (CAD) drawings, including JPL mission hardware, which can then be visualized and realized in a clean room alongside partially finished builds of the same hardware. "Engineers can perform just-in-time and early phase assessments and adjustments, evolving engineering design activities for missions at an extremely low cost with a high payoff," they wrote.

One challenge the project team had to figure out was how to include more people into the metaverse than the allowable platform limit. They devised a solution that mimicked a videoconference integration using screen and audio sharing. "In testing, 25 people joined the MetaVerse in VR while an additional 30 joined via videoconference through the workaround solution.



Participants from either platform were able to interact with those in the other platform seamlessly. This not only provided a solution to the limit on the number of participants but also offered a lower barrier to entry for those who are VR-hesitant," Mattmann and Haggins wrote.

Being able to integrate these various technologies for different types of users carries potential cost-saving implications. Engineers, for example, could enter a clean room and, using augmented reality (AR) capabilities, look at a partially completed, physically built spacecraft assembly for a particular mission and then compare it to a fully realized virtual NISAR spacecraft using ProtoSpace. "Seeing the full, realized, and completed assembly in mixed reality enables assessment, adaptation, and full end-to-end engineering without having to finish and test the CAD [computer-aided design] model and fabricate it fully in production, thus saving costs, energy, and critical resources," Mattmann and Haggins wrote.

"Using the [Microsoft AR head-mounted display] HoloLens and with ProtoSpace loaded, JPL engineers can build the elements for complex interplanetary missions much earlier, faster, and more collaboratively than if they were performing these activities solely based on what was occurring in real life."

Extending today's digital operations into the metaverse continuum

Clearly, NASA's JPL is on the cutting edge of exploring the WebMe trend. But it is paving a path that other federal agencies will eventually follow by taking technologies and capabilities already in wide use today — such as digital twins, blockchain, office collaboration tools, virtual and augmented reality — and extending them into more fully realized, self-contained, highly functional virtual environments.

Potential federal use cases for this approach abound. Military organizations today, for example, already employ digital twins to quickly and efficiently design and test new weapon systems, improve weapons system maintenance, and run industrial operations more efficiently.[29] In the not-so-distant future, we should expect military organizations to deploy digital twins into richer, immersive virtual environments where dispersed engineers and designers can more easily collaborate on the same tools and integrate AI and machine learning capabilities.

There are also many commercial examples of this already. For example, Shanghai is one of the world's largest cities with 26 million inhabitants and it now boasts its own digital twin. Metaverse creater 51World modeled the city with over 100,000 elements – from garbage cans to e-bike charging stations – to enable interactive planning and simulate the effect of natural disasters like flooding on city operations.[30]

P&G LifeLab allows the consumer packaged goods giant to explore how different audience segments engage with its products[31] while Hyundai has opened a next generation showroom.[32] Microsoft is working with Boeing, Heinz, and Kawasaki to create an industrial metaverse for each company's operations, combining AR, IoT and digital engineering to digitize their manufacturing processes.[33]

In the same way, federal agencies could conceivably employ digital twins in the metaverse to optimize warehouse and logistics operations; mitigate vulnerabilities and improve resilience in industrial processes and operational technology (OT); conduct 'what if' scenarios on infrastructures and in environments that would otherwise be impractical; and deliver improved maintenance to weapons systems, equipment, and fleet vehicles in austere locations.

This same approach of extending current technologies into richer, more immersive environments for greater capability applies as well to today's popular office collaboration tools. Today's standard is to connect remote employees through video calls and conferences. But tech firms are already starting to bring more robust WebMe capabilities to market, enabling enterprises to actually place remote employees in the same virtual space and using the same tools, much like we see at NASA's JPL.

For example, Microsoft is already building a mixed reality metaverse for office collaboration within its popular Microsoft Teams app. In March 2022, Microsoft previewed Mesh, which enable people to connect holographically as 3D avatars as they conduct meetings, engage in design sessions, conduct training, help others remotely, and host virtual meetups.[34] Mesh integrates with Microsoft 365 so that connections, calendars, content, and workflows transition to these mixed-reality workspaces.

Numerous similar offerings — including Meta's Horizon Workrooms, MeetinVR.com, and Immersed — are rapidly emerging in the marketplace as well.

> The emerging capabilities of WebMe offer enormous benefits to a wide array of other federal missions and programs as well.

Citizen services, for example, can become personalized virtual experiences where citizens can be more easily assisted — or assist themselves — through visual aids. Instead of having to travel to a federal office building that may be many miles away, a citizen can discuss their case in a virtual setting where all relevant resources and information are within arm's reach.

WebMe also holds enormous promise for training and education, healthcare, and recruitment. Consider recruitment, for example. We already know that younger generations spend more time in the metaverse, mostly because of the youth-oriented gaming and online social culture that helped spark its incredible growth from the start.

It is this digitally native demographic that federal agencies need to connect with for military recruitment, federal hiring, and the many citizen services that federal agencies deliver. For these citizens, the promise and reality of the metaverse and Web3 are not futuristic in the least — they are the unfolding reality of today. And their heightened expectations of what digital experiences and interactions should look like are already raising the bar for how federal agencies must present themselves in our fast-evolving virtual world.

How some governments are diving into WebMe

Governments around the world are taking note of the exploding economic and cultural growth of the metaverse — and some are going all in.

The city of Seoul, South Korea, for example, is laying the foundation for a metaverse ecosystem called "Metaverse Seoul" for all areas of its municipal administration. The effort combines digital twins, VR, and collaboration to improve city services as well as planning, administration, and support for virtual tourism.[35] Longer term, the city aims to use its metaverse to support business development services, education, and city services for filing complaints, inquiring about real estate, and filing taxes.

For its part, the Caribbean nation of Barbados announced plans in November 2021 to open the world's first metaverse embassy in Decentraland. The country is clearly leaning into this new virtual world by championing digital advancements and adopting a digital currency. It plans to post embassies in other virtual platforms as well. Gabriel Abed, Barbados' ambassador to the United Arab Emirates (UAE) (another metaverse proponent on the global stage), said the new virtual embassy offers "a fully immersive way to showcase our culture and business opportunities."[36]

The glamorous Middle East city of Dubai in the UAE has created an entire government agency to regulate digital assets. Moreover, the agency — called the Virtual Assets Regulatory Authority (VARA) — plans to set up a metaverse headquarters in The Sandbox virtual world. "Our presence in the metaverse... marks the beginning of a new phase in the Dubai government's march for the future; one that will have a positive impact in the long run," Sheikh Hamdan bin Rashid Al Maktoum, Crown Prince of Dubai and Chairman of the Dubai Executive Council, said in a statement.

The VARA intends to serve as Dubai's "primary channel to engage [Virtual Asset Service Providers] across the globe to initiate applications, enable younger licensees [to] enter the metaverse, openly share knowledge and experiences with consumers and peer regulators to raise awareness, enable safe adoption, and drive global interoperability," according to a statement.[37]

Federal agencies need to start thinking now about how to establish a presence in the metaverse and how to effectively employ Web3 technologies to advance their missions and programs. Secondarily, agency leaders will need to think about how they will do this: which human, technical, data, and other resources will they need — and which outside partners are best positioned to assist them — to competently move forward in this arena?

38%

of consumers globally agree their digital life is increasingly becoming their "real life."

THINGS TO LOOK OUT FOR

Regulating WebMe for today and tomorrow

Federal leaders are bullish on this future.

Most (88%) say that the realization of Web3 over the next decade will fundamentally change how enterprises engage with users online, and nearly all (97%) agree that digital platforms must support interoperable user data to deliver unified experiences regardless of environment. However, challenges must be accounted for as well.

Many federal agencies need to think about these emerging capabilities not only from a use case perspective, but also from a regulatory and policy perspective.

To what extent do existing laws, policies, and regulations apply to the economic, financial, business, and social activities occurring in the metaverse? And what particular skill sets and capabilities are needed to provide adequate industry oversight and regulatory enforcement over those activities?

In fact, agencies across the federal government are already thinking through these challenging questions.

In March 2022, President Biden signed an Executive Order on Ensuring Responsible Development of Digital Assets, directing agencies across the government to develop consistent controls and policies to promote responsible behaviors in the digital economy.[38] The executive order notes that, in late 2021, non-state issued digital assets reached a combined market capitalization of $3 trillion, up from approximately $14 billion only five years earlier.

"The United States has an interest in responsible financial innovation, expanding access to safe and affordable financial services, and reducing the cost of domestic and cross-border funds transfers and payments, including through the continued modernization of public payment systems," the executive order reads.

"We must take strong steps to reduce the risks that digital assets could pose to consumers, investors, and business protections; financial stability and financial system integrity; combating and preventing crime and illicit finance; national security; the ability to exercise human rights; financial inclusion and equity; and climate change and pollution."

With this executive order, scores of federal agencies are having to ponder large questions about how traditional government concerns — such as consumer protection and fraud, antitrust behavior, market and currency manipulation, public and child safety, counterterrorism, national security, law enforcement jurisdictions, transparency, privacy and security, and financial integrity — extend into a borderless, virtual environment that is almost entirely unregulated today.

Hardly a government agency will be untouched by this effort, and all will need to think through policies and programs that promote innovation while also mitigating any risks to consumers, investors, and businesses, broader financial stability, and the environment.

57%

of consumers globally state "I expect companies to help me unify my digital experiences."

Other WebMe challenges for federal agencies

Because virtual interaction and transactions are key components of WebMe, particular emphasis will need to be placed on digital identities and the ability to verify, protect, and secure those identities and the security clearances associated with them. For a couple of random avatars crossing paths at a virtual concert, that may not be especially important. But for a federal agency holding a virtual meeting among employees or assisting a veteran with her medical benefits, it will be critical.

For that matter, how will agencies verify the integrity of a fungible or non-fungible token? For government interactions that require financial transactions, will they accept cryptocurrency payments and, if so, how will that be done?

Another challenge: creating satisfying citizen experiences for federal services will take an even more demanding turn.

Some agencies today still struggle with meeting people's elevated expectations that have been shaped by the leading brands in technology, entertainment, fashion, and other industries. As we all move headlong into 3D virtual environments, the bar for acceptable customer and citizen experience will get even higher.

There are also digital divides to think about. Many communities — particularly those that are underserved and underrepresented — still lack adequate access to the internet so they can leverage the government's digital services. Agencies will need to factor those communities into their strategies and planning as they strike out for the metaverse.

But those divides exist also across the government itself. Digital maturity and presence vary dramatically from one agency to the next. While this divide is certainly noticeable on the Web2 internet, the contrast will be even greater in the Web3 metaverse. Agencies will need to think about how to bridge those divides and create a more consistent and seamless experience for citizens.

ACTIONS TO TAKE

Taking your agency to tomorrow's internet

There are four steps that federal agencies can start taking today:

01 Understand the developing landscape around the metaverse and Web3

02 Lay the needed technical foundation

03 Acquire the talent, expertise, and tools needed to gain proficiency

04 Define standards and protocols that will deliver the greatest interoperability for your digital offerings and systems

First, federal agency leaders should start learning, understanding, and building new strategies today. This means exploring the potential that new digital products and services have to impact your mission as well as training your executives on the technologies that will soon be foundational to their missions and programs.

> You can start by gaining a firm understanding of the foundational building blocks of WebMe: blockchain, digital assets, digital twins, data management, the cloud, the metaverse, and Web3, among others.

See how other governments and analogous industries are preparing for and envisioning the next major evolution of our digital landscape.

As metaverse and Web3 technologies continue to mature, the governments and companies that are prepared and willing to be the first to experiment with these new platforms and data structures will be the ones who define what the next generation of digital services looks like.

Success also hinges on putting your technical foundation into place. At a minimum, cloud will be essential, as will rebuilding your applications with microservices architectures and APIs to be easily usable by and shareable with others. The metaverses that emerge (whether enterprise or consumer-driven) will be defined by the services and platforms they encompass. Put another way: enterprises must have the infrastructure in place to share applications widely and securely. These steps can, and should, be taken today – even if the end state of the metaverse remains uncertain.

Next, start identifying – and working toward – the Web3 and metaverse skills and capabilities you will need. For example, federal agencies looking to create metaverse experiences will require 3D artists and experts on the platforms on which they plan to build. And leveraging the opportunities and features of Web3 will demand that agencies stock up on staff and partners that possess expertise in distributed ledger technologies (DLTs) such as blockchain and the distinct business and operating models that they support.

This might sound like a lot of new skills to develop in a short amount of time, but in many cases, you don't have to start entirely from scratch. The increasing sophistication and democratization of immersive design tools, for instance, is making it easier than ever to start experimenting with these technologies. A plethora of tools — such as Epic Games' Unreal Engine and Nvidia's Omniverse — has already emerged in the marketplace to help people create 3D environments and experiences.

For many of these technologies, the best way to be an early innovator is by deploying them internally. This is what Accenture did by creating its own enterprise metaverse, the "Nth floor."[39] Accenture is deploying VR headsets to employees around the world and expects to provide immersive VR environments for onboarding, learning, and collaboration for 150,000 employees this year — all while demonstrating best practices for VR rollouts and projects to clients. Aside from gaining the necessary in-house skills and expertise, it is also a critical to form new partnerships and ensure you can participate in future partnerships and collaborations.

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement.

Lastly, strive early on for as much interoperability in your digital products and services as possible, such as through the use of microservices, API connectivity, open standards, and open architectures. This will help ensure that your offerings are able to leverage internal and external data and systems as needed. For example, in architecting and developing its STE, the Army aims to achieve joint, interagency, and multi-national interoperability. The STE will interact with multiple operational networks, virtual military equipment, and live training instrumentation. The STE will also be compatible with the Army's Common Operating Environment (COE), which is an approved set of computing technologies and standards that enable secure and interoperable applications to be rapidly developed and executed across a variety of computing environments.[40]

Agencies also can tap into existing consortiums like the Khronos Group, which comprises more than 150 organizations including Apple, Google, and Amazon and is working to set open industry standards for extended reality, 3D graphics, and more. If you plan to build Web3 applications, consider linking with the InterWork Alliance, which has created the Token Taxonomy Framework so that multiple parties can work together to define a "common language, behaviors, and properties" for digital tokens. The importance of consortiums and industry standards like these is twofold. They enable greater interoperability between entities, making it easier to deliver cross-platform experiences or to jointly collaborate on an experience, and they often make it possible to do so securely and without jeopardizing privacy. And, by agreeing to a common framework when a technology is in its infancy, agencies and businesses can set themselves up to provide more compatible services to future shared consumers, which will help them stand the test of time as the internet continues to evolve.

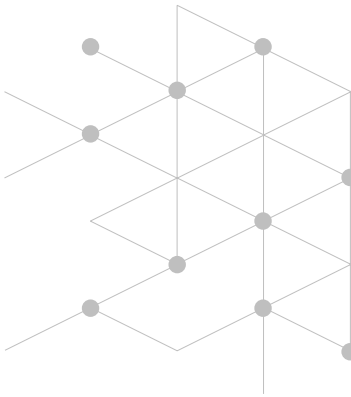
Conclusion

Today's efforts around metaverse and Web3 are creating the next version of the internet. They are two momentous technology shifts, simultaneously working to eliminate the friction that exists between today's many digital platforms and to reinvent how data moves and is used across digital experiences. And in the process, they are driving new lines of business, new ways of working, and new means of interaction between governments, businesses, and people. For most, this is the first and best chance they have ever had to define and architect a new kind of digital world.

Decision Points

Is your agency ready for the next generation of the internet?

- A significant transformation is coming to our digital world, and even if the end state is not yet fully formed, many changes are already underway. Leaders should kick off a market and technology scan to understand what is evolving today and how it may impact or disrupt current digital efforts, then prioritize the opportunities and partners available.
- Use case development will be key as enterprises track the maturity of the underlying metaverse and Web3 technologies. Every federal agency will be impacted differently, with no clear best practices. Maintaining focus on desired outcomes will mean developing a concise set of use cases for how enterprises intend to drive value from these emerging worlds.
- There are technology investments you can already make today to improve your short-term and long-term ability to adapt to the impending changes. Cloud is the table stakes for every agency. More discrete industry impacts are happening across spaces like VR, AR, digital twins, distributed ledgers, and virtual marketplaces.



How are you developing the skills needed for the next digital world?

- Just as federal enterprises needed to hire interaction designers, software engineers, and more to execute their digital transformations, a new set of skills will be required for a future driven by metaverses and Web3. Start by identifying where you expect to have a presence and what skills gaps will prevent successfully executing those strategies.
- Developing the pipeline for new talent will be a longer-term effort that should nevertheless begin today. In the interim, companies should explore upskilling existing employees through vendor-based training and building familiarity and skills with the metaverse and Web3 platforms they intend to use.
- Low-code and no-code platforms are another avenue that may jumpstart an agency's ability to pursue metaverse and Web3 initiatives.

How are you going to start?

- Already, there are some standard metaverse use cases that agencies can leverage without high levels of risk. For instance, immersive technologies for training or productivity have been tested and experimented with for years.
- To guide their pilots, agencies should investigate the ways their enterprise platforms may be holding them, their stakeholders, or their users back. They should empower development teams to design and test new kinds of experiences that eliminate or circumvent these pain points.
- To keep up with – and influence – the development of metaverse and Web3 technologies, fast track participation in consortiums.

What security (and safety) will your agency need to operate and fully engage with citizens and other constituents and partners in the metaverse?

- Begin planning for the metaverse architecture with new identity and data governance and frameworks and Web3. As cryptocurrency services may form the building blocks for user identity and transparent transactions, evaluate how practiced your company is in these technologies.
- Strategize on what your agency wants to become in the metaverse. What is your role in creating a secure and trusted metaverse, and shaping the future of human and enterprise interaction? Could you become a leader in bringing your agency values of trust, security, privacy, and safety to the metaverse?
- Have product and services teams begin planning for the compound risk of new services and integrated experiences in a shared marketplace. Assess how this changes the risk exposure of those initiatives.

Authors

Alejandro Lira Volpi
Managing Director –
Financial Services Strategy Lead
Accenture Federal Services
in

Christina Bone
Senior Innovation Architect
Accenture Federal Services
in

EJ Dougherty III
Extended Reality Lead
Accenture Federal Services
in

Dave Dalling
Cybersecurity Chief
Technology Officer
Accenture Federal Services
in

Kyle Michl
Managing Director –
Chief Innovation Officer
Accenture Federal Services
in

Terrianne Lord
Managing Director –
Salesforce Delivery Practice Lead
Accenture Federal Services
in

Trend 02

Programmable World

Our Planet, Personalized

THE BIG PICTURE

How do we infuse greater intelligence and adaptability into our physical world and everyday lives?

That's a question that will increasingly define the balance of this decade, especially as organizations look to take on challenges like climate change, public safety, increased geopolitical tensions, and population health.

Beginning a decade ago, many cities around the world, trying to better address increasing flood risk, began installing "smart sewer" systems.

These sewer systems rely on advanced sensors, data models, and AI algorithms — all carefully architected together — to autonomously monitor and assess in real time the dynamic conditions of extreme weather events. When and where the AI tells them it's appropriate, these smart sewers activate gates to redirect threatening water flows away from populated areas and toward spare storage capacity in the sewer system network.

In similar ways, we're making everything from facilities, campuses, cars, and even entire city-wide systems smarter and more autonomous by embedding in them robust digital capabilities — in effect, seizing even greater control over them with unprecedented precision.

Today, we see a fascinating twist to that model emerging: we are programming our environments to interface and interact smartly, not just with the physical world around them, but with us as individuals — and we're doing it in a far more personalized and interconnected way.

In one telling example of this, McDonald's installed AI-enabled digital menu boards at drive-thru locations across the U.S. as part of a $6 billion refresh.[41] The menu offerings on these digital boards change from customer to customer to dynamically reflect local menu trends, time of day, weather, current restaurant traffic, and suggestions that would pair well with what the customer has already ordered.[42]

The investment appears to be paying off. Customers use the boards to customize orders and see items suggested to them based on what they have already ordered. For its part, McDonald's is seeing larger average orders, higher overall revenue, and shorter wait times.[43]

Expect more of this. While McDonald's is the leader of the pack in rolling out digital menu boards, every other national fast-food chain is following suit.[44] "We believe that [in the future] a bigger percentage of the menu will be controlled by algorithms and that third-party data such as weather and calendar (payday, weekends, feasts etc.) will be added. This will not only drive average check [order size] but also create an overall better guest experience in McDonald's restaurants," said Anders Apelgren, CEO at Visual Art, a Sweden-based digital signage provider that has partnered with McDonald's.[45]

98%

of U.S. federal leaders believe that leading organizations will push the boundaries of the virtual world to make it more real, increasing the need for persistent and seamless navigation between the digital and physical worlds.

Welcome to the programmable world

Going forward, attributes such as control, customization, and automation – things taken for granted in software – will be increasingly enmeshed into the environment around us. People will have unprecedented ability to command the world to meet their own individual needs, deciding what they see, interact with, and experience with greater ease and fidelity than ever before. And enterprises will build and deliver these experiences, as well as reinvent their own operations for a new kind of world.

> Simply put, the world is becoming a place that can be shaped as broadly, as personally, and as often as our experiences on the internet – fundamentally changing the way we live.

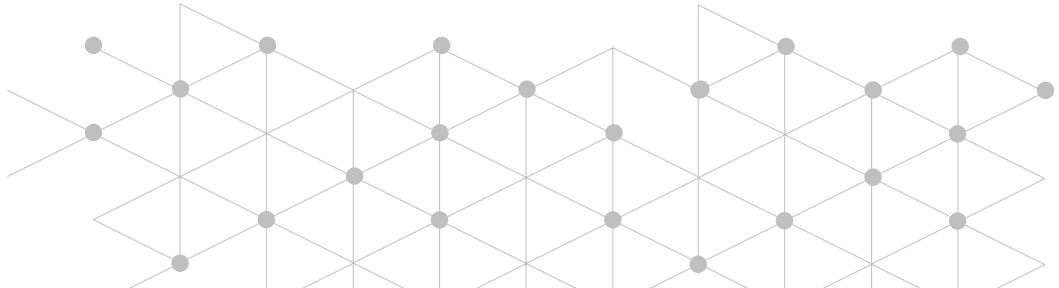
In these scenarios, digital capabilities are woven into the very fabric of the world, making the physical world as smart, configurable, and programmable as we expect the digital one to be. People have more information about their real-world surroundings, along with greater context, and they can frictionlessly interact with their environment in novel and more efficient ways.

We've been building toward the programmable world for years: Digital technologies have proliferated across the physical world for over a decade. We've put cameras everywhere and filled our homes with smart devices and microphones. Now, advances in natural language processing, computer vision, and edge computing are amplifying the capabilities of those devices, freeing digital interactions from being trapped and turning them into an ambient and persistent layer across our environment.

The global 5G rollout adds more fuel to the fire, setting the stage for the further proliferation of low-power, low-latency connected devices. And researchers across enterprise and academia alike are working on even more transformative technologies, like augmented reality glasses, new methods of manufacturing, new kinds of smart materials, and programmable matter.

As we enter a new era of digital change, our belief is that it is helpful to think of the metaverse as a continuum: a spectrum of digitally enhanced worlds, realities, and business models that will revolutionize nearly all aspects of life and business in the next decade by accelerating collaboration in virtual spaces, augmented physical places, and a blend of both. Moreover, it will create new lines of business and transform interactions between citizens and government agencies.

To deliver on the metaverse's full potential, we need to replicate the best aspects of the virtual world within our physical environments. This requires having persistent, virtual environments that interface and interact with our surroundings; that employ intelligent, adaptive systems, such as digital twins that can accurately model physical objects and their interactions; and that bend our surroundings to our individual needs.



Consider, for example, how frictionless shopping technology is revolutionizing the experience of going to the store. Customers simply scan an app on their phone or a credit card upon entry and proceed to take what they want off the shelves. Computer vision, sensor fusion, and deep learning AI algorithms, all bound together by IoT connectivity — many of the same technologies as those used in driverless cars — collaborate to understand exactly what each customer takes and then charges that customer's card or account and sends them an electronic receipt when they walk out the door.

The biggest vendor in the contactless shopping space is Amazon, whose Just Walk Out technology is being used by numerous store chains, including Amazon's own Amazon Go and Whole Foods.

But other vendors, like San Francisco-based Zippin and Israeli startup Trigo, are also contributing to this revolutionary trend taking hold throughout the retail industry. And this isn't stopping with retail stores. Similar integrated solutions are reducing points of friction and adding greater personalization, adaptivity, and efficiencies to container yards[46] and even Disney theme parks.[47]

So how will this emerging programmable world affect federal agencies?

THE ANALYSIS

The idea of overlaying integrated digital capabilities across our surroundings to make employees, their work environments, and even the materials they work with more effective and adaptive presents enormous opportunities for federal agencies.

Most (94%) federal leaders believe that programming the physical environment will be a strategic competency with 69% saying that augmented reality will disrupt government over the next three years.

Consider these potential use cases:

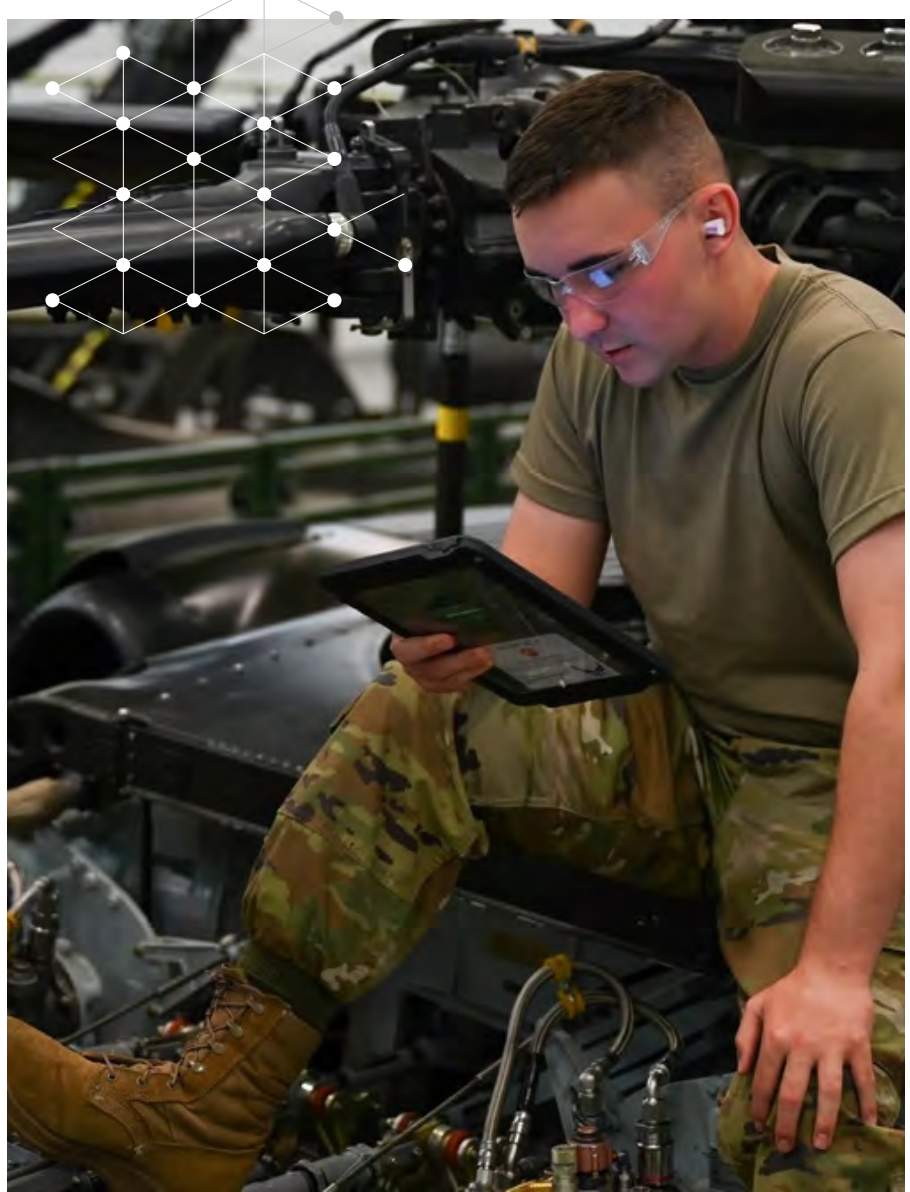
Smart workers

Agencies across the federal government run highly specialized environments and equipment in serving their missions and operations. Think, for example, about federal research labs, hospitals, shipyards, logistics and distribution centers, mail processing facilities, space centers, satellite ground stations, and air traffic control towers.

All of these operations and the equipment supporting them require extensive training and expertise for the federal and contractor staffs who run, maintain, and repair them. What if the information that those people need to do this was available to them when and where they needed it as they interact in those specialized work environments?

In fact, this is already happening. So-called connected worker platforms deliver frontline workers augmented work instructions on digital devices — such as tablets, mobile phones, or even smart glasses — as they move about their workspaces and perform workflows or maintenance activities to improve productivity, quality, and standardization.[48]

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement.



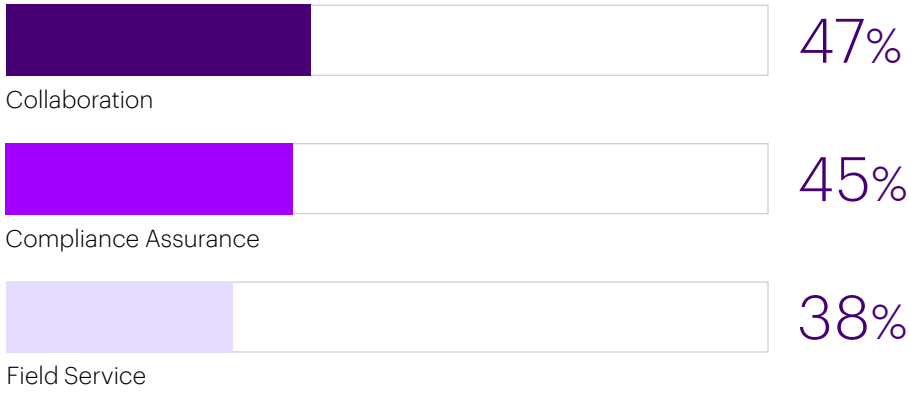
These platforms guide workers with visual aids, augmented reality (AR) or mixed reality, and contextual information. Some offer voice-activated, hands-free instructions through industrial headsets to maximize safety. Some have remote assist functionality that can connect offsite Journeymen- or Craftsman-level experts with on-site workers who have less expertise via AI Bots and AR. When combined with an AI capability, a connected worker platform can intelligently customize each work procedure based on the individual's proficiency and expertise level.

For example, Accenture partnered with a large federal agency to explore the use of Microsoft HoloLens AR glasses to support facilities around the world. This program enabled local staff to partner with U.S. based experts to collaboratively inspect and repair complex systems remotely.[49]

To capture needed data, many of these platforms integrate with an organization's manufacturing and supply chain software systems, such as ERP systems, manufacturing execution systems, supply chain suites, and advanced planning and scheduling (APS) software, and also with environmental health and safety (EHS) software for increased worker safety.

In December 2021, the U.S. Air Force contracted with Augmentir, which offers an AI-enabled connected worker platform, to "utilize artificial intelligence and augmented reality to enable Air Force maintainers to inspect, troubleshoot, and repair more efficiently," according to a company statement. Under the contract, the Air Force will use the platform to improve productivity and quality through AR-based digital work instructions that will help to increase the accuracy and consistency of routine maintenance and inspection procedures. The Air Force also expects the platform to improve knowledge sharing, quality assurance and compliance, and training and workforce development.[50]

U.S. federal executives identify the following as the most anticipated AR use cases over the next three years:



Smart environments

Many people are already aware of smart facilities, such as buildings programmed to autonomously turn off lights and adjust temperature controls after business hours. But today, we have entered an era where we can create life-like digital twins of facilities or equipment that we can then manipulate and interact with to explore options and run planning scenarios.

Air Force leaders at Tyndall Air Force Base, near Panama City, Fla., have created a digital twin of the entire base to help it plan better how to rebuild after the devastating destruction caused by Hurricane Michael in 2018. In March 2022, the base unveiled its new Hololab, which is the portal to access Tyndall's digital twin and conduct "what if" scenarios and explore how new designs might look.[51]

This will help base planners and engineers locate and design new flight line facilities that will support three new squadrons of F-35 Lightning II strike fighters, scheduled to begin arriving in late 2023.[52] With the digital twin, they can explore various design options so they can make support operations more efficient. They also can use the digital twin to better understand security vulnerabilities and conduct resilience planning.[53] For example, planners and engineers can use the digital twin to perform storm surge modeling and simulate the effects of another big storm on the base's critical infrastructure or conduct a range of active-shooter scenarios to optimize preparation and response planning.[54]

When digital twins are enhanced with real-time data streaming, the use cases expand further. Real-time digital twins, for example, can track every vehicle in a fleet to identify maintenance issues or schedule issues as they emerge. When monitoring sensor data streaming from individual nodes in a power grid, a digital twin can detect issues, such as an impending failure that could cause a fire or outage, in near real time. A real-time digital twin of a high-security facility could stream data at critical entry and exit points to detect unauthorized incursions and threats to employee safety.[55]

Jet engine manufacturer Rolls-Royce, for example, is collecting real-time engine data from its airline customers to model performance in the cloud using digital twins. The company's goal is to reduce unnecessary maintenance and ground time, but another key driver is to develop more sustainable flying and maintenance practices that could lower carbon emissions, according to the company's CIO Stuart Hughes.[56]

"The last few years, as part of our digital transformation, we've been building a digital twin of our engines," Hughes said in an article. "So, the way I want you to think about it is we've got a new generation of intelligent engine platform, which is built on cutting edge data analytics. In the past, we would have 30 sensors, and they would capture data like five times in the flight at key points. Whereas the latest generation of engines going into service now capture hundreds of data points every second.

So, we've kind of moved from floppy disk to half a gig of data per engine flight, so you can see the change is very, very real."[57] To process that high volume of data, the company created a new platform to import that streaming data and feed it into a Microsoft Azure data lake. The data is then analyzed using Databricks machine learning and AI tools.

This field is advancing rapidly. As digital twin technologies continue to mature, it is incentivizing mathematicians, researchers, academics, and engineers to develop ever more sophisticated algorithms and models that can mimic the complex dynamics and interactions of the real world, which is pushing these capabilities even further.

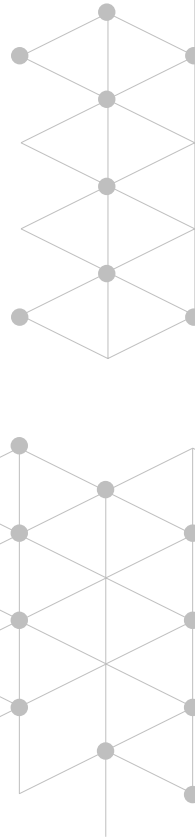
In a July 2021 article in the science journal ScienceDirect, for example, two civil engineering academics described new software they developed to build real-time digital twins of stormwater networks that will "pave the way for continuous monitoring and control of urban drainage systems."[58]

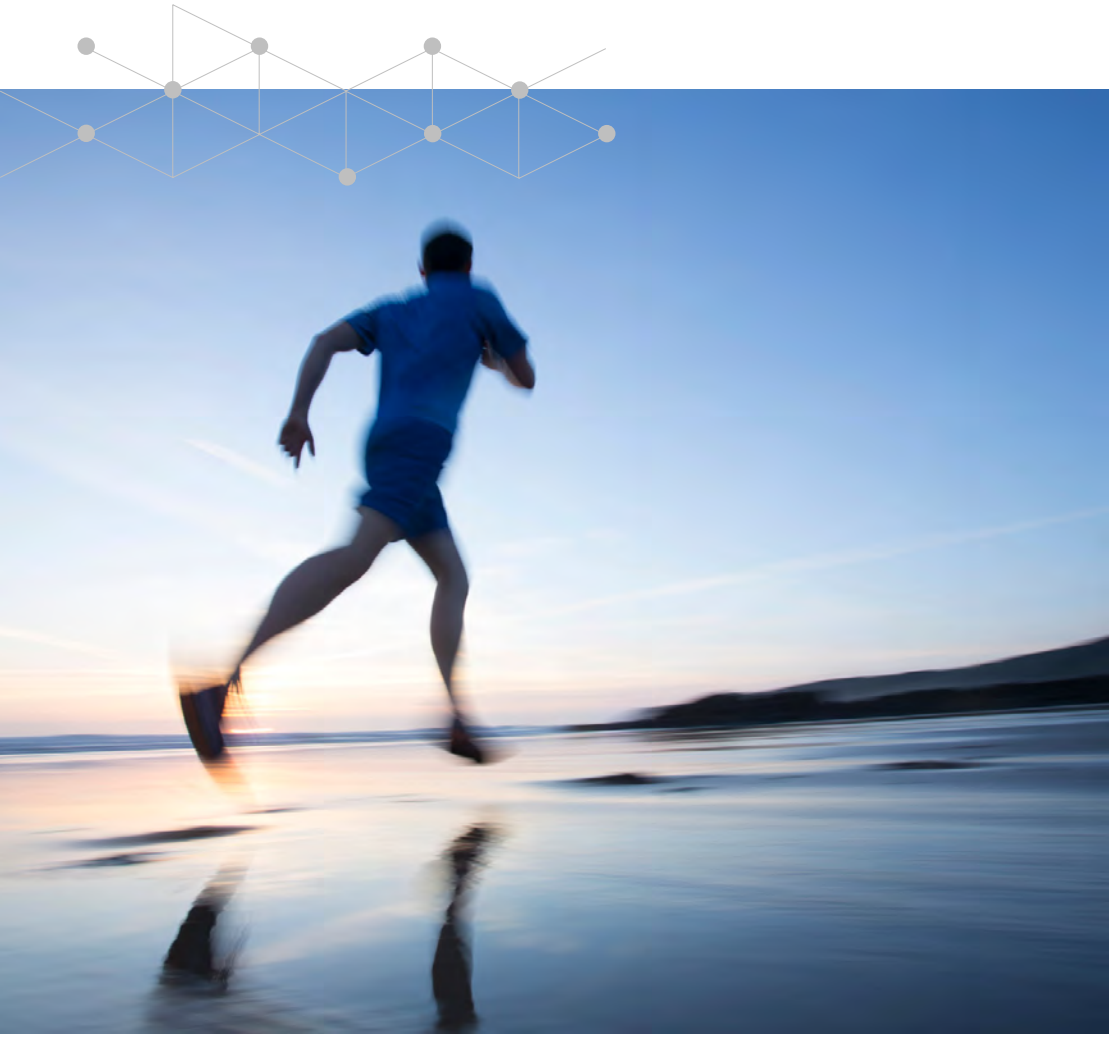
> Eventually, real-time digital twin capabilities can help urban water managers reduce flooding in populated areas, reduce combined sewer overflows that pollute nearby waterways, reduce operational costs, and improve urban water quality.[59]

By far, the federal government's most ambitious foray into the programmable world is the military's goal of overlaying connected modern digital capabilities atop the battlefields of the future for faster, more precise results. A Defense Department-wide effort known as Joint All-Domain Command and Control (JADC2) aims to radically improve cross-domain, joint military capability by employing innovative, connected technologies that will dramatically improve the military's ability to "sense, make sense, and act" on the battlefield.[60]

Ultimately, JADC2 planners aim to connect innumerable battlefield and space sensors with any weapon system in any domain across the joint force, all enabled and accelerated by open architectures, open standards, and artificial intelligence. Although still in the early vision and strategy stages, the JADC2 effort will ultimately emerge as an amalgam of interconnected systems developed across the different service branches.[61]

These capabilities also have enormous potential in advancing many other federal missions and operations, whether they concern moving people through airport security more efficiently, urban planning, improving healthcare and logistics, or delivering citizen services.





Smart materials

Even the materials we use to manufacture things or wear on our bodies can be programmed to respond to particular interactions. Today, we have entire classes of smart materials that are designed to modify some of their properties when exposed to certain external stimuli, such as mechanical stress or temperature. And federal leaders are taking notice, with 89% saying smart materials have the potential to create new opportunities and drive the next generation of capabilities, properties, and form factors.

Piezoelectric materials, for instance, can convert mechanical energy into electrical energy and vice versa. These can change their shape in response to an electrical impulse or produce an electrical charge in response to an applied mechanical stress. Shape memory materials can change their shape and return to their original shape when exposed to a heat source or other stimuli.[62]

There are many more.

Researchers at MIT, for example, developed a moisture-responsive exercise outfit that has ventilating flaps that open and close in response to an athlete's body heat and sweat. The ventilating flaps, each about the size of a thumbnail, are lined with live microbial cells that shrink and expand in response to changes in humidity. When a person wearing the suit begins exercising and works up a sweat, the bacterial cells, acting as tiny sensors and nanoactuators, sense the increased temperature and moisture and shrink. This curls up the latex flaps they are layered on, opening them, and allowing outside air to evaporate the sweat, cooling off that part of the exposed skin.[63]

Even bandages can be high-tech. So-called smart bandages do different things depending on the types of sensors integrated within the bandage material. A thin layer of flexible electronics is embedded in the bandage that detects and interprets various physiological responses, such as thermal changes, oxygen/moisture content, or pressure variations at the wound site.[64]

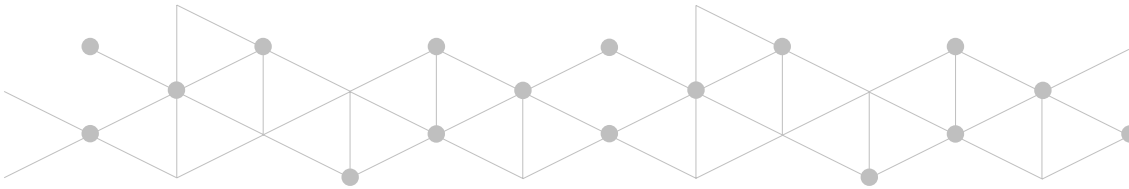
A Department of Veterans Affairs research team at the Advanced Platform Technology Center in Cleveland developed a bandage that applies electrical stimulation to treat chronic wounds, also known as pressure injuries, that would otherwise struggle to heal on their own. Pressure injuries are often painful for patients, slow to heal, and expensive to manage: the Agency for Healthcare Research and Quality estimates the cost to treat them in the U.S. ranges from $9.1 billion to $11.6 billion per year.[65] Veterans especially are at high risk of chronic wounds, and because many veterans live long distances from a VA medical center, treatment often requires extended hospitalizations.

The problem with chronic wounds is that the healing process often stalls. The wounds can become colonized with bacteria that form a biofilm, which delays healing. Preliminary data suggest that electrical stimulation can disrupt the biofilm, minimize infection, and promote the growth of new blood vessels, according to Dr. Kath Bogie, who led the research and development project. "The general thinking is that electrical stimulation provides the energy to promote healing in a chronic wound," Bogie said.[66]

> This led her team to create a layered bandage that was embedded with a mechanism to deliver electrical stimulation, temperature sensors, and a smart chip.

The top half of the smart bandage contains the electronics and battery — a separable bottom layer is the absorbent bandage, which can be used for up to seven days before being discarded and replaced, repeatedly if necessary for as long as the patient requires.

The smart bandage also records temperature readings and impedance across the wound, which inform the clinician how well the wound is healing and whether the wound is infected or potentially ischemic (suffering restricted blood flow). If the patient is remote, the chip in the bandage can even connect to the patient's phone so it can send information to the clinician for analysis and responsive treatment (that capability, however, has not yet been approved for use by VA, according to Bogie).



Bringing the programmable world to life

Merging the physical world with the digital world in ways that responsively address our needs and challenges requires that federal enterprises develop a deep understanding of three layers that comprise the programmable world: the Connected, the Experiential, and the Material.

Many are already investing in and deploying the first layer of programmable world technology, creating a connected foundation. The fifth generation (5G) of wireless technology, which lies at the heart of this connectivity, will completely transform telecommunications networks and the global digital landscape along with it due to its high speed, improved efficiency, better mobility support, high connection density, and capability to connect to many devices. The continued expansion of 5G networks will enable richer, more robust experiences and promote a greater integration of IoT-based devices for a mass machine communication approach so that these devices can communicate and handle data without human dependencies.

Another important contributor to this connectivity layer will be the adoption of open architectures and open standards to more easily interconnect disparate systems and components. We know that when networks, systems, data, sensors, and IoT devices converge, the sum value of those assets can deliver transformational capabilities — just as Defense Department leaders anticipate with their ongoing JADC2 endeavors. It will be open standards and open architectures that enable that convergence and the transformation that comes with it.

The next layer of the programmable world is experiential. This is about creating natural computer interfaces linking the physical and digital worlds. In the absence of keyboards and microphones, a focus on human-centered design can help create these connections by exploring how users' approach and learn how to interact with new experiences, such as through the trial-and-error process of using gestures to direct complex systems. These seemingly simple interfaces must overcome numerous obstacles, such as our natural fear of looking ridiculous as well as the need to communicate back with users in an intuitive way.

Once again, the retail and hospitality sector are pioneering new applications here. For example, 7-Elevens in Japan are testing the use of holographic cash registers to guide customers through transactions. And PepsiCo is piloting the use of gesture-based ordering in its KFC restaurants.[67] Were there issues? Yes, but they were quickly resolved using iterative development to fine-tune interactions, underscoring the role that service design can play in creating these next-generation interfaces.

> The materials we use to flesh out the programmable world are also increasingly important. New generations of manufacturing and materials will bring programmability into the truly physical aspects of our environments.

Advances in digital manufacturing techniques are changing how and where physical goods can be made, making on-demand and hyper customized products a reality.

For instance, 3D printers can now print a much wider variety of objects, and the number of viable filament materials is growing too. This makes 3D printing – which is far better suited for highly customized and local production – increasingly attractive for today's enterprises. Similarly, advances in digital textiles production are making textile customization easier and on-demand production increasingly possible.

A number of federal agencies are already using additive manufacturing for a wide variety of uses. For example, the Army employs it to build parts for ground vehicles that are "select readiness drivers, are obsolete, have no technical data packages, have no source of supply and are of immediate need." The VA uses it to develop and create custom-built orthotics, prosthetics, and dental solutions.[68]

The security imperative

Finally, across every layer of this emerging programmable world, there must be robust security embedded throughout. After all, with this degree of connectivity — including the increased connectivity of IT and OT (operational technology) networks — comes far greater degrees of vulnerability and exposure. And the stakes increase significantly when physical environments — such as power and energy networks, factory operations, transportation systems, and military bases — become extensions of our virtual worlds.

> Yes, the programmable world holds tremendous promise for us, but it also vastly expands the attack surface available to cyber threats, putting critical networks and infrastructures further at risk.

It must also be noted that this is a today challenge, as 65% of U.S. federal executives report that they have significantly or exponentially increased their deployment of IoT and edge devices over the past three years. In short, there must be a security-first mindset throughout as we move down this path of a more programmable world.

Security has been a factor in 5G since its inception — nevertheless, the exponential increase we will see in new devices and connections in the coming years will add far greater complexity and scale to the security challenges of today. Federal agencies and industry will need to develop comprehensive security strategies that account for resilience, communication security, identity management and security, privacy, and data integrity and protection.

Rigorous security features and protocols, using system design principles applied with a risk-based mindset, will need to extend from the networks to the IoT devices — and even the supply chains of those devices — to the data itself.

Everything from the IoT devices to the cloud service providers must be rigorously vetted. And much thought must be given to the integration of these many components from a security perspective.

Holistic, smartly architected security frameworks, such as zero trust, will be critical in protecting these hyper-connected environments. Traditional approaches focused on establishing a strong perimeter to keep out bad actors no longer work. Passwords and firewalls are no longer sufficient. In a programmable world, perimeters become less and less obvious or obsolete all together. With zero trust, every connection is considered a potential threat until it's verified not to be. Even for a project as ambitious as DoD's JADC2, zero trust is a critical ingredient.[69]

But security is not simply a matter of putting the right technical solutions in place — there are also educational and cultural issues that federal agencies must address. New risk-aware practices, protocols, incentives, and mindsets must be brought into play.

U.S. federal executives identify the following factors (exclusive of lower cost) for increasing the value of AR and VR technologies:

39%

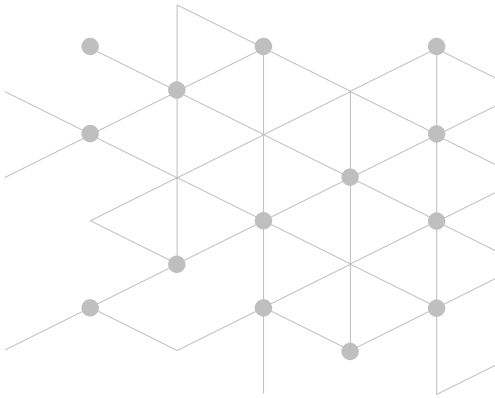
Improved knowledge of the technology

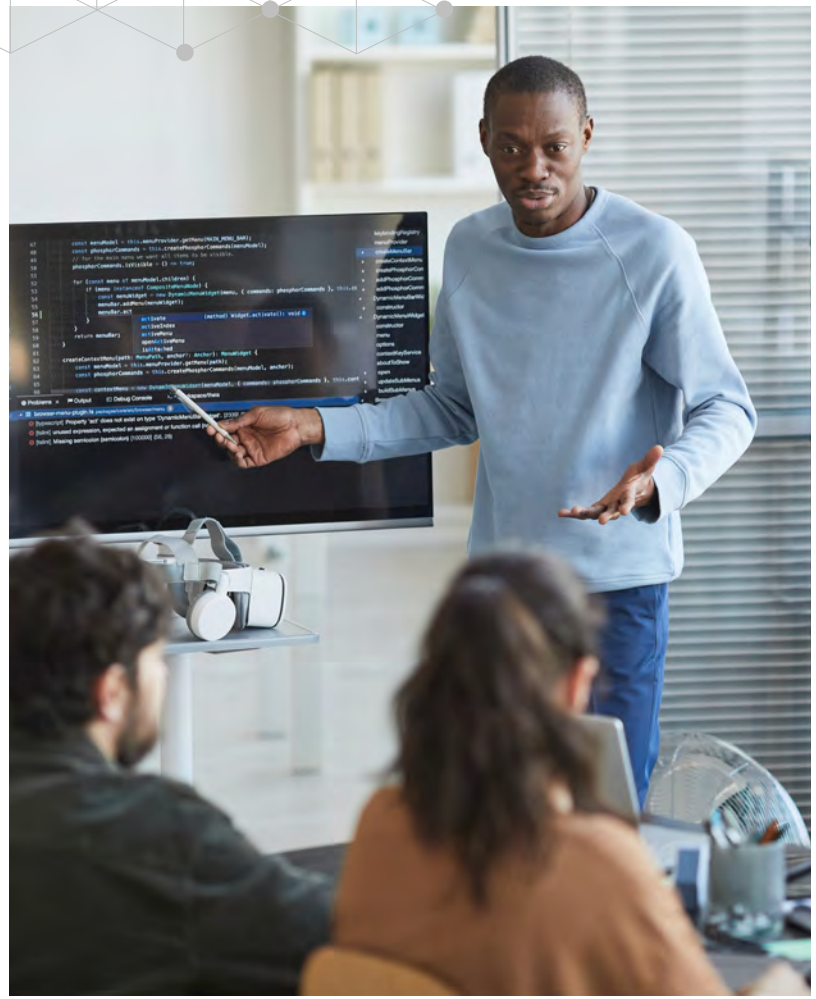
38%

Improved ease-of-use/accessible design

38%

Enhanced data security





THINGS TO LOOK OUT FOR

As we smarten, connect, and personalize the environments around us, challenges await

Building a smart device is far easier than building a smart system.

The complexity of managing interoperability among many systems and devices multiplies with every added component, and there is potential for disconnects at every level of the system architecture.

Designers and architects must be mindful of countless questions: Are all the sensors and algorithms operating on the same data standards? For example, are measurements uniformly expressed in metric or United States Customary System terms?

Can data from proprietary sensors be exported and processed downstream as needed? Are there interoperability hurdles posed by vendor firmware? The potential obstacles to interoperability seem endless.

Interoperability problems do not just degrade an employee's or citizen's experience. They have the potential to impair safety and security as well. This is why system architects need to make interoperability a top consideration as they orchestrate programmable environments that work as a cohesive whole and are easy to use.

In addition, federal agencies can participate in public-private alliances and consortia that are helping to shape the development of industry best practices, architectural frameworks, and new technology standards. From an interoperability perspective, this could mean participating in ecosystem-wide efforts to set standards for how devices connect and communicate. For example, the Digital Twin Consortium® — a collaborative partnership of experts from industry, academia, and government — has developed a Digital Twin System Interoperability Framework that characterizes the many facets of system interoperability that relate to building digital twins.[70] The Open Geospatial Consortium is another group pursing similar standards.[71]

Another big concern for federal agencies as they begin to roll out smart and connected environments and citizen services is the need to address the problem of unequal access. Digital infrastructures, affordability, and digital proficiency varies widely across the country.

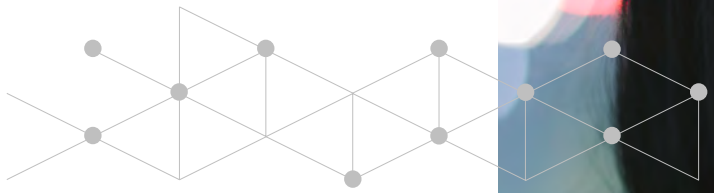
This inequality will likely grow as 5G-enabled networks, phones, and other devices roll out to consumers.

Government digital services, as wonderful as they may be, are only as effective as citizens' ability to leverage them. Consequently, federal decision makers will need to think through how to address these accessibility challenges as they design and deploy these solutions and services. One potential solution is for federal agencies to reach out to some of the many organizations that exist that are working on this problem. These include the National Digital Inclusion Alliance, Partners Bridging the Digital Divide, the Schools, Health and Libraries Broadband Coalition, and U.S. Digital Response.

Finally, because of the complexity and fast-evolving specialized skill sets needed to build these smart, connected systems, there is another big challenge: talent and expertise. After all, not everybody can build a digital twin of a jet engine or military base.

> **Federal agencies will need to rely far more on outside organizations to obtain the necessary talent and skills.**

Entirely new industries — digital twins and connected worker platforms, for example — are emerging that federal agencies will need to become educated about and partner with.



ACTIONS TO TAKE

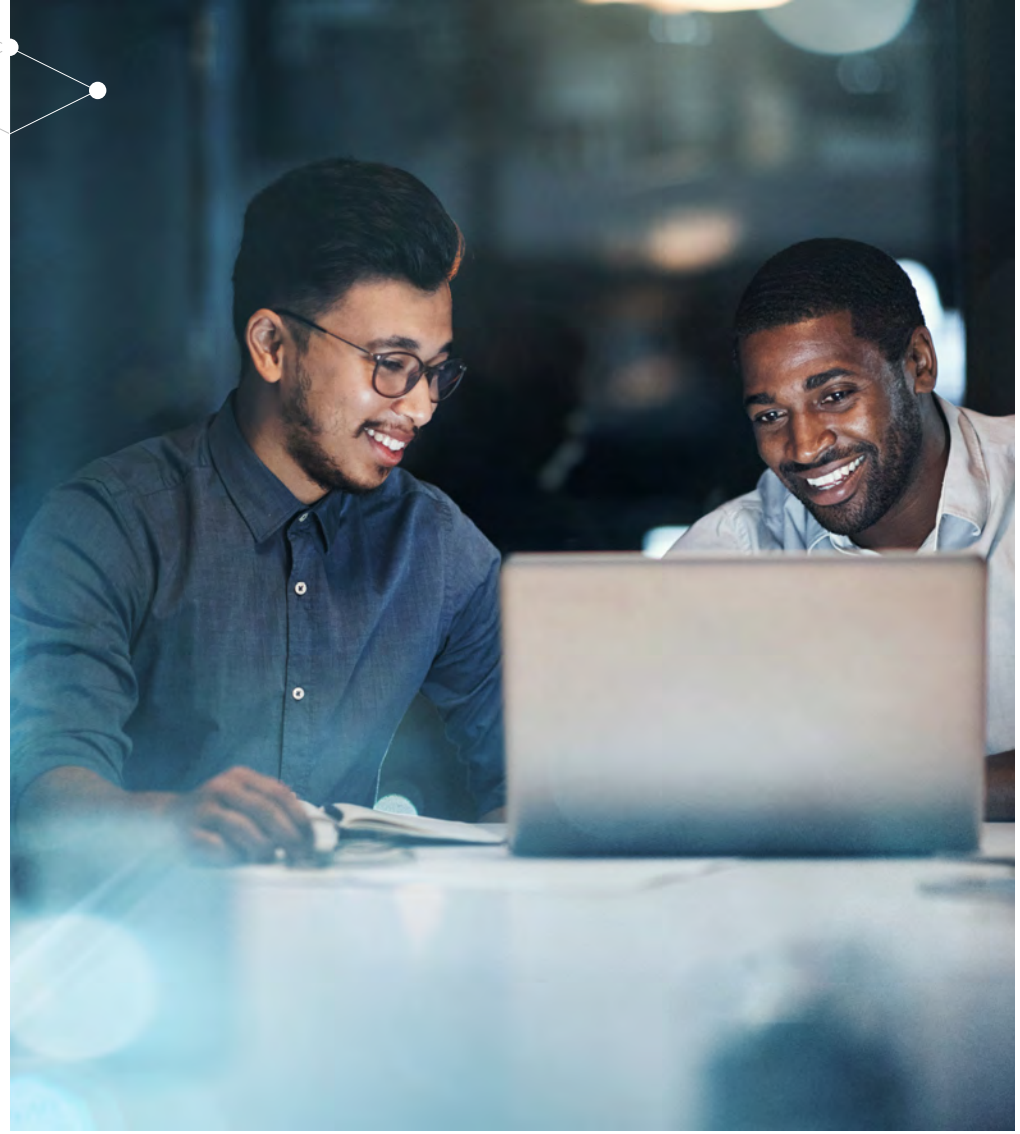
Full stack programmability

Beyond the fundamentals of interoperability, privacy, and security, becoming a leader in the programmable world will require wide-ranging exploration, experimentation, and development across the Connected, Experiential, and Material layers we discussed.

Organizations need to start working toward "full stack" programmability today.

To start, federal agencies should find ways to level up their foundational, connected layer. Notably, 5G is poised to be game-changing in terms of its speed and low latency, but rollouts are still very much in the works. A 2020 Qualcomm study found that the wide range of 5G use cases are not expected to be fully realized until 2035.[72]

This provides agencies with opportunities to experiment and pilot new use cases that leverage 5G capabilities so they can hit the ground running when it's more broadly available. Moreover, 5G comes with security and privacy enhancements – from improved edge computing to network slicing, where data from one "slice" can be isolated from the rest of the network. It's just a matter of time before 5G comes into full effect, so anyone wanting to be among the first to create these solutions needs to start now.



For the experiential layer, enterprises can start to bridge their digital and physical worlds by building digital twins that allow them to model and experiment with complex system interactions. However, they can't overlook the role of the individual in these exchanges. Disciplines like service design can help them focus on the orchestration of services, processes, and data needed to meet user needs. At the same time, developing competencies in human factors engineering is needed to build the more natural computing interfaces that will define success.

Finally, it's important that agencies continuously explore and educate themselves on emerging technologies on the material layer.[75]

> Partnerships with startups and universities are a good way to stay at the forefront of real-world technology innovation.

Look at what universities like MIT are working on. In late 2020, a team of researchers at MIT's Center for Bits and Atoms published their work around four new material subunits called voxels.[73]

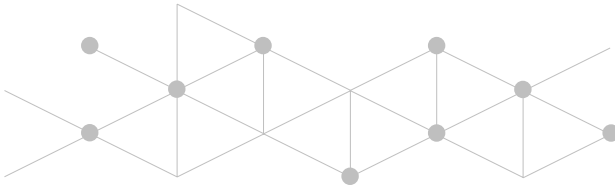
The voxels are mechanical metamaterials, each with a different shape, which can be combined to form larger objects with special mechanical properties, like bulging inwards rather than outwards when compressed or responding to compression by twisting. Though they haven't yet been widely tested, the researchers believe voxels could be programmed into certain combinations to create objects that change and respond to the environment around them – like airplane wings that shapeshift in response to different air conditions – and they believe tiny robots could be used to assemble, disassemble, and reassemble the voxels into a nearly limitless variety of objects. Or look at the xenobot developed by researchers from Tufts University, Harvard University, and the University of Vermont.

The xenobot is a "programmable" organism created by assembling stem cells like building blocks, and in a paper published in December 2021, the researchers said they witnessed the organic robot self-replicating by sweeping up loose stem cells in its petri dish, which then formed into copies of the original bot – something that has never been seen before. Among other things, the researchers believe the xenobots could be programmed for purposes like finding cancer cells or trapping microplastics in the ocean and believe its self-replicating capability could have implications for regenerative medicine.[74]

Voxels and xenobots may not be commercially ready for a while, but the fact that they already exist is what's important.

The building blocks for each technology layer of the programmable world are proliferating and maturing, and enterprise decision makers need to keep an eye on this future.

Enterprises may choose to excel at one layer or another, but the full technology stack will be needed to truly realize the revolutionary capabilities of the programmable world. Ultimately, agencies should be asking themselves how they can build programmable environments that become more valuable over time – rather than obsolete.



Conclusion

The arrival of the programmable world will be the most disruptive turning point for people, agencies, and businesses in decades. We're about to live in environments that can physically transform on command, that can be customized and controlled to an unprecedented degree, and that can change faster and more often than we have ever seen before. With these environments, a new arena for government innovation will be born. Will you be ready?

Decision Points

Is your agency poised to innovate in the programmable world?

- Enterprises will need to develop strategies that take advantage of every layer of the programmable world, but right now they may only have exposure to a fraction of the developments underway. Leaders should develop a tech scouting program that can help track and anticipate changes across the technology landscape.
- Agencies need to be prepared to adapt over time as new programmable world technologies mature. Investing in digital twins and IoT technologies today will position enterprises with the experiential and data foundations they need to rapidly innovate and respond to new developments over time.
- Be mindful that the technologies of the programmable world will open the door to new business models and strategies that are yet to be defined. As this space continues to mature, leaders will need to revise the way they consider return on investment and what key performance indicators look like. Creating successful pockets of innovation throughout the enterprise will mean creating the space for safe experimentation and the ability to fail fast and iterate, while exploring new avenues for the future.

How could your agency fundamentally change in the programmable world?

- Programmable technologies will allow for greater control, customization, and automation in nearly any physical world environment. This will change everything, from how your agency operates (such as with fleet management, logistics, or facilities management, for instance) to how your agency interacts with citizens (through digital citizen experiences, contact center engagements, and in-person interactions). Prioritize the areas where programmability will have the most impact for your agency, like operational efficiency or increased customer satisfaction.
- To be seamlessly programmable, myriad technologies from different companies will need to work together. Partnerships, consortiums, and industry standards can all be leveraged here to generate ecosystem-wide value. Look out for any of these that may already exist in your mission space. When looking to strengthen your own relationships, search for new ways you could support the capabilities of your downstream partners.

Is your agency prepared for the challenges of the programmable world?

- Security, privacy, reliability, and safety are the predictable challenges of the programmable world that you can start addressing today. These risks are particularly significant here because they will not be relegated to just the digital world but will have serious consequences in the physical world as well. Make experiences secure by design and data privacy a core part of your own innovation efforts. Choose industry partners based on their security practices and track records. Increased connectivity leads to increased speed and impact of cyberattacks. Practice scenarios to find areas of improvement and ensure successful responses.
- Avoid walled gardens in favor of interoperability to not only meet citizen and employee expectations, but to ensure utility and longevity of the solutions. Make these components key performance metrics in your technology development and implementations.
- Ask yourself how well you know your customers. What would be a welcome connected experience, and what would be just creepy? Where in the service or experience should you share and where should you ask to understand the individual's security, privacy, and safety needs? Create a diverse customer advisory board that can help you imagine the rich connected experiences that are welcome and share what touchpoints they want in that experience.

Authors

Bill Marion
Managing Director –
Defense Portfolio Growth & Strategy
Lead, Air & Space Force Lead
Accenture Federal Services

Jessica Bannasch
Technology, Solutioning & Delivery
Excellence Lead - Digital Platforms
Accenture Federal Services

Jessica Powell
Managing Director –
IRS Client Account Lead
Accenture Federal Services

Rick Driggers
Critical Infrastructure
Cybersecurity Lead
Accenture Federal Services

Scott Van Velsor
Managing Director –
Federal DevSecOps Practice Lead
Accenture Federal Services

Trend 03

The Unreal

Making Synthetic, Authentic

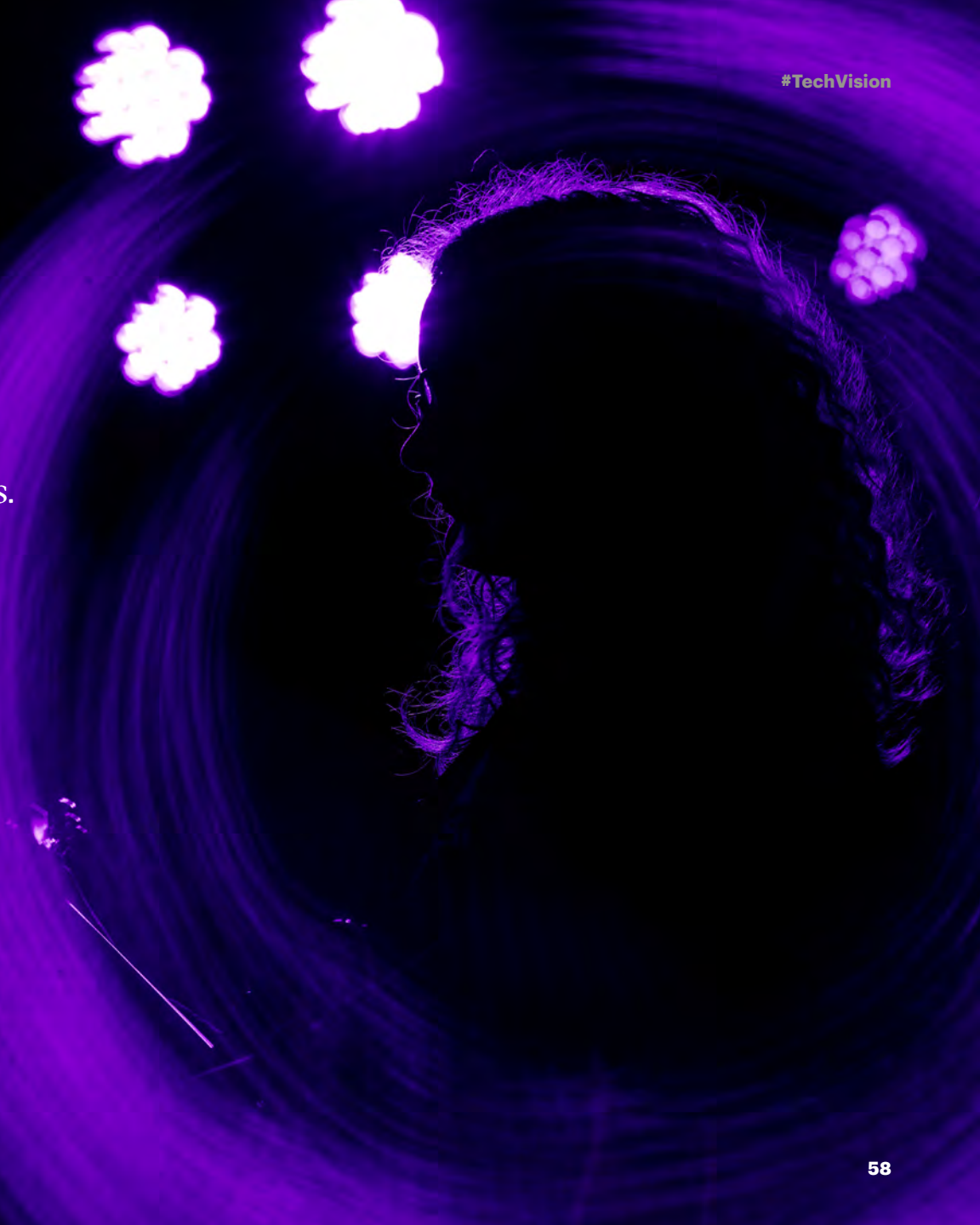
THE BIG PICTURE

In mid-March, a minute-long video appeared on many major social media sites in which Ukrainian President Volodymyr Zelenskyy, motionless and expressionless, announced his surrender to Russia's invading forces and asked Ukrainian troops to lay down their weapons.

The problem, though, was that Zelenskyy never surrendered nor made such a video. The video was a "deepfake" — a fabricated piece of media created by using artificial intelligence (AI).

This was one of the earliest examples of a weaponized deepfake, intentionally created and circulated on social media to sow confusion and mistrust during war.

While the precise objectives and origin of the fake video remain uncertain, it ultimately had little impact in this instance: the Ukrainian government was anticipating such a tactic and warned the world well before it surfaced. The technical quality of the deepfake was poor and many people could see it for what it was. Once the deepfake appeared, Zelenskyy himself quickly issued a real video saying that Ukraine planned to continue fighting on. Major social media sites quickly took the fake video down.



Just

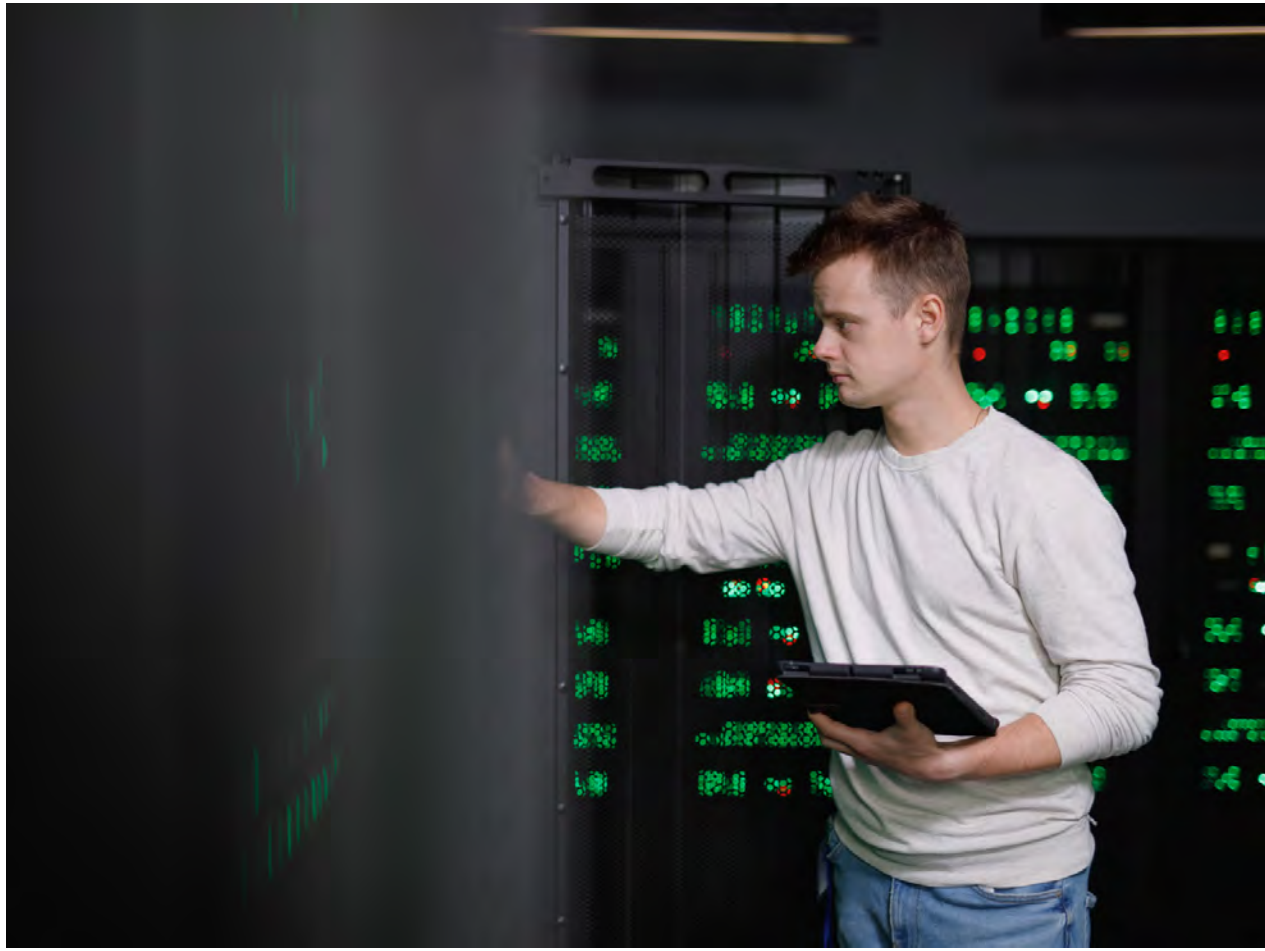
35%

of consumers are confident or very confident they can recognize or identify deepfake videos or synthetic content.

Nevertheless, the precedent was made and the many potentially malicious implications of deepfakes — especially as their quality improves over time — are becoming clearer to see. But while this example highlights the perils of synthetic data and generative AI, it is important that we not overlook the many opportunities they present us as well.

In fact, it is no exaggeration to say that the continued advancement of AI is highly dependent on the use of synthetic data. That is because AI relies upon extensive, well-defined data to function properly — something frequently in short supply.

Perhaps it is worth pausing here to reflect on just how important AI is becoming to us. Federal agencies use AI today to accelerate regulatory reform; combat fraud, waste, and abuse; identify information security threats; enhance the security and interoperability of information systems; streamline processes for grant applications; model weather patterns; facilitate predictive maintenance; and much more.[75]



85%

of U.S. federal government executives report that their organization is dependent on AI technologies to function effectively.

Or consider, for a moment, the many ways AI has been instrumental in helping us tackle COVID-19. Convolutional neural network (CNN)-based models have helped detect and classify in real time COVID-19 infections in patients employing chest X-ray images. Researchers even developed a fully automatic deep learning system to generate a diagnosis and prognosis of COVID-19 using computed tomography (CT) scans. AI-based methods have been used to track COVID-19 spread over time and place, to conduct disease surveillance by scanning public spaces for people with potential COVID-19 infection, and to enforce various social distancing measures or lockdowns. An AI-enabled mobile app, called Aarogya Setu and launched by the government of India, allows users to check their safety status based on whether they have crossed paths with Covid-19 positive patients.[76] Most importantly, AI helped researchers dramatically accelerate the genomic sequencing of SARS-CoV-2 and its variants and develop potential treatment approaches and even vaccines.[77]

A critical role for synthetic data in our COVID-19 response

But many of these developments could not have been possible without synthetic data. For example, many researchers needed information about how the SARS-CoV-2 virus and its evolving variants, such as delta and omicron, were affecting the human body and public health. Much of this data is collected in patients' electronic medical records. But researchers typically face delays or barriers obtaining national data from medical records because of concerns about preserving the privacy of those patients.

Synthetic data enables researchers to get around such obstacles. Data for a wide array of COVID research, for example, is artificially generated and informed — though not directly derived — by actual patient data. To generate synthetic data, researchers produce an entirely new set of simulated patients that, in aggregate, recreate the exact statistical characteristics of real patient data.

For example, synthetic data might be generated to mimic the aggregated blood pressure, body mass index, and kidney function of a set of real patient data. But the real patients' identities and privacy are protected because the simulated patients have no direct counterparts in the real data.

Understanding these constraints on the use of real patient data, the National Institutes of Health (NIH) in 2021 partnered with the California-based startup Syntegra to generate and validate a nonidentifiable replica of the NIH's extensive database of COVID-19 patient records, called the National COVID Cohort Collaborative (N3C) Data Enclave.[78] Today, N3C consists of more than 5 million COVID-positive individuals. The synthetic data set precisely duplicates the original data set's statistical properties but with no links to the original information so it can be shared and used by researchers around the world trying to develop insights, treatments, and vaccines.[79]

According to two research studies by Washington University School of Medicine in St. Louis, the synthetic data generated from real COVID-19 patients accurately replicated the results of the same analyses conducted on the real patient data. Moreover, not only did the synthetic data accurately reflect the patient characteristics on a broad scale, it also accurately recreated the pandemic's spread and impact over time and in geographic areas that were highly tested for COVID.[80]

"We've shown that we can build sophisticated predictions of what is going to happen in a population with a disease like COVID-19," said co-author and principal investigator Philip Payne, chief data scientist and director of the Institute for Informatics at Washington University. "It is critical that we protect patients' rights to privacy and confidentiality while also responding to the threat posed by COVID-19 in a timely manner. No single institution can address these needs alone.

Through the unique capabilities afforded by the use of synthetic data, we are accelerating our efforts to diagnose, treat and, perhaps most importantly, prevent this disease while also demonstrating how we can more effectively respond to future public health emergencies."

Synthetic data is used for a wide variety of use cases, not only when there are privacy concerns around real world data. It can also be used to address shortfalls or gaps in real world data. Take the example of trying to train a machine learning algorithm to calculate a response for a specific scenario that occurs rarely or perhaps not at all. Training a self-driving car to respond accordingly when debris from a truck falls on a highway at night might be difficult if there is little imagery available of such a scenario. Synthetic data allows for data to be created via software to fill such gaps in the available real-world data, boosting the model's overall robustness.

Synthetic data's many use cases

In addition to providing data for edge cases (rare events), synthetic data also can help improve model performance, remove bias in data, reduce the cost of data, and increase the speed of data collection.[81]

Like healthcare, the financial sector is another industry that is heavily reliant on AI and, in turn, has the potential to benefit from advances in utilizing synthetic data. Insurance companies, banks, credit card companies, and others use AI to lower lending risk in their portfolios, detect and counter fraud, and develop new products and offerings. But data projects like these typically require collaboration and data-sharing, both internally and externally. Privacy fears and compliance headaches can make their own data sets, generated from real-world customer activity, too risky to put to work.

Anonymizing real-world data is not always reliable in assuring individuals' privacy, and encrypting it undermines the data's utility. However, creating synthetic data sets avoids the risk of data leaks and privacy breaches while also overcoming scalability limitations.

> With synthetic data, organizations can rapidly produce high-volume, artificial test data, thereby shortening test cycles and reducing time to production.

Moreover, synthetic data can be generated in many structured and unstructured forms: text, tabular, and even media data such as video, images, and sounds.[82] Google's Waymo, for example, is using AI to generate simulated camera images from sensor data collected by its autonomous-driving vehicles. It is then using those simulated images to train its cars.[83]

In short, synthetic data has become a boon for researchers, data scientists, and organizations that depend upon AI. Perhaps that's why industry analyst Gartner predicts that, by 2024, 60 percent of the data used for AI development and analytics projects will be synthetically generated.[84] It also explains the rapid proliferation of startups — such as MOSTLY AI, Datagen, and Synthesis AI — that are filling out an entirely new industry focused on synthetic data catering to a wide assortment of industry sectors.[85]

AI as modern-day data factories

But how do we generate synthetic data rapidly, at great scale, and accurately? One way is to use AI itself to generate that data. We call this generative AI. Another important dimension of the unreal world, generative AI can consist of a wide array of data types, including text, visual data, and multimedia. Examples of this are when technologies draw and paint pictures or use information gathered on the internet to create articles. In essence, generative AI enables computers to learn patterns from a large amount of real-world data and generate new content that mimics those underlying patterns.

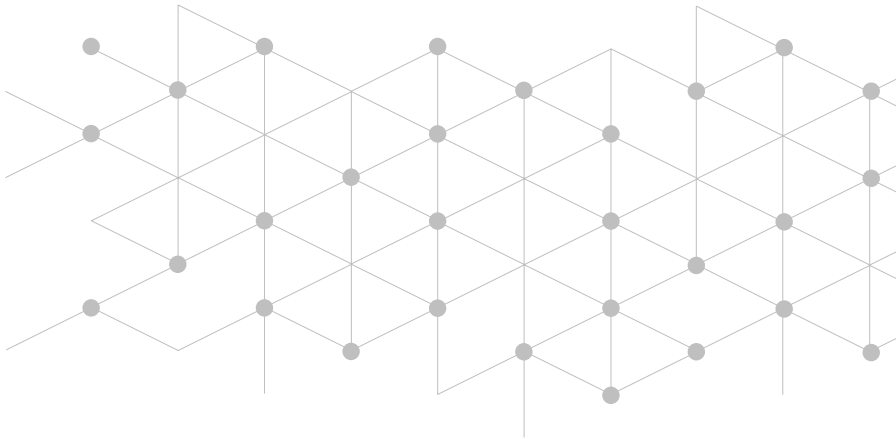
One common approach to generative AI is through the use of generative adversarial networks (GANS). GANS, fundamentally, are generative modeling architectures that, during training, pit two neural networks — a generator and a discriminator — against each other. The generator network generates new data or content based on the patterns it is learning from real-world source data.

As it does so, the discriminator network's task is to differentiate between the source real data and the generated data from the generator. This creates a feedback loop in which the generator constantly learns to produce more realistic data, while the discriminator gets better at differentiating fake data from the real data. GANS can generate a wide variety of content, including images, photographs of human faces, realistic photographs, face aging, and 3D objects.

This powerful architecture has made GANS the primary technology used to create deepfakes, which has justly earned the technology considerable scrutiny. But this same type of generative model can also be easily steered toward highly beneficial use cases. For example, they can be used to improve fairness and remove bias in credit and loan decisions by generating training data that removes biases from protected variables (e.g., gender, race, ...) while the discriminator tries to guess the values of the protected variables based on the generated data.

When it becomes impossible for the discriminator to guess these values, the generator has successfully learned to produce debiased data that can be used to train the credit and loan decision model.[86]

This is heady stuff. More and more enterprises are becoming architects of the unreal world. And as they push AI into more collaborative and creative roles, they are blurring the lines between what's real and what isn't. Advances in generative AI, and GANs in particular, are making the creation and use of synthetic data that is incredibly realistic – while being unreal – possible.



A metric for the unreal world: authenticity

As we enter a world with synthetic realness, where AI-generated data — in the form of synthetic data, images, and chatbots, as well as augmented and virtual realities — convincingly reflects the physical world, we are forced to face the questions of what's real, what's not, and perhaps more importantly, when do we care? When we see the news, we want to know if the video of the president is real – but when we watch the latest Doritos commercial, maybe it doesn't really matter. And sometimes, we may actually prefer the unreal, like when we speak to a synthetic nurse about a potential sexually transmitted disease or train an AI model with synthetic data adjusted to counter historical discrimination.

As synthetic realness progresses, conversations about AI that align good and bad with real and fake will shift to focus instead on authenticity.

Instead of asking "Is this real?," we'll begin to evaluate "Is this authentic?" based on four primary tenets:

> **Provenance** – what is the history?
>
> **Policy** – what are its restrictions?
>
> **People** – who is responsible?
>
> **Purpose** – what is it trying to do?

With these principles, synthetic realness can push AI to new heights. By solving for issues of data bias and data privacy, it can bring next-level improvements to AI models in terms of both fairness and innovation.

And synthetic content will enable customers and employees alike to have more seamless experiences with AI, not only saving valuable time and energy but also enabling novel interactions.

That said, using these technologies pushes enterprises — and especially government entities — into controversial terrain. It raises tough questions about how to leverage synthetic data and generative AI in a trustworthy way in the service of government missions – all within the context of bad actors using these same technologies to create deepfakes and disinformation that undermine trust. Like it or not, the unreal world is about to become a part of reality, and the path ahead will be fraught with risk. But authenticity can, and should, be the guide.

THE ANALYSIS

When discussing synthetic data, it is important to think of it as part and parcel to AI. Synthetic data can be used for a wide variety of use cases, both good and bad.

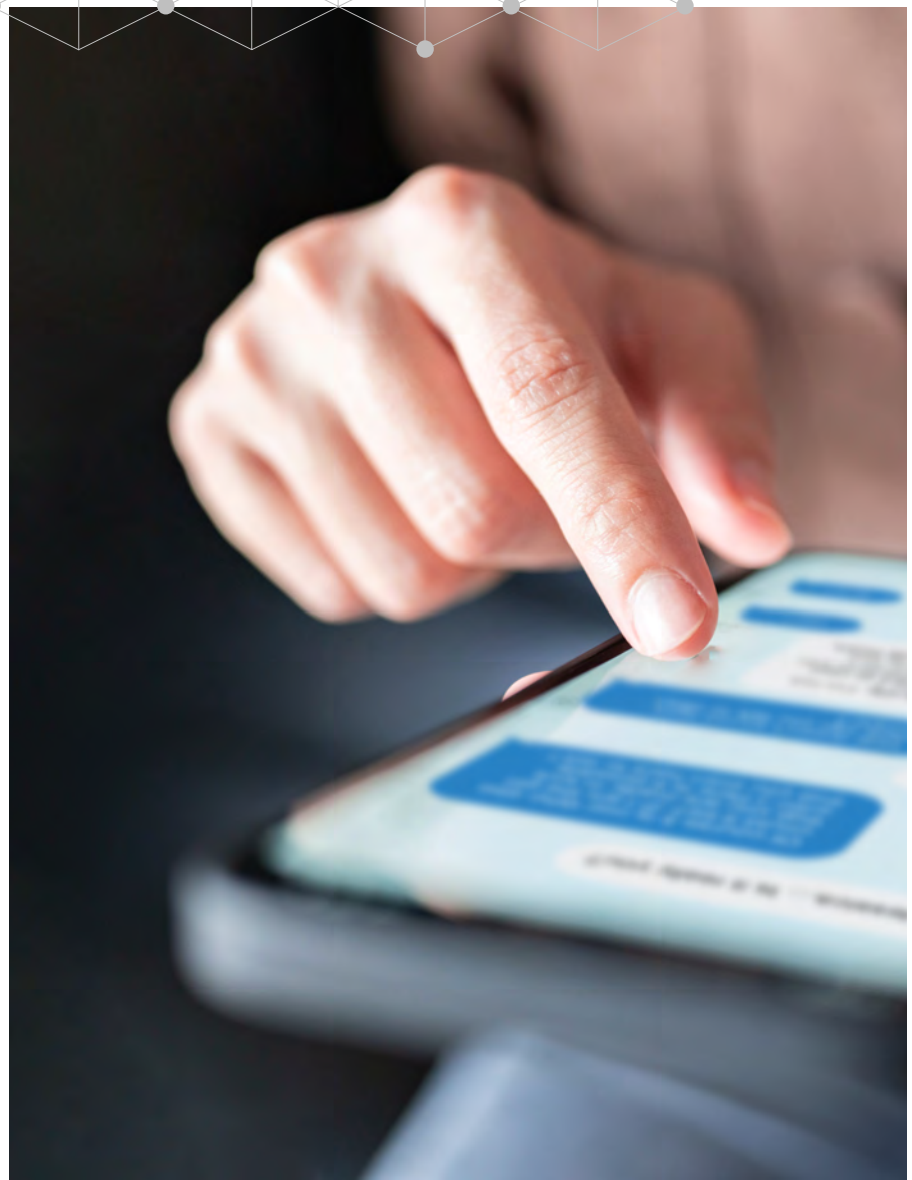
And as AI activity in the federal government continues to quickly ramp up, so too will the use of synthetic data. Here are some areas where we already see federal agencies actively producing and relying on synthetic data to advance their missions.

Customer care

Chatbots are one of the government's biggest use cases for AI, and bot technology is fast evolving. Chatbots must be trained to recognize specific intents in the language they read or hear, such as "I want to find out if my government health insurance will cover this procedure." This intent can be stated in any number of ways.

Synthetically generated text can enable help computers more quickly learn patterns in conversation and produce more effective chatbot responses to the customer inputs they are receiving. This helps speed up the bot development process and lower costs.

Emerging technologies today are pushing the state of the art even further, making bots even more realistic. AI company Hour One, for instance, creates digital characters, based on real people's likeness, that can be shown speaking any text in highly realistic videos (each human receives a micropayment when their character is used, and that use is restricted to safe content).



These characters can play virtual customer service representatives or language teachers, easily converting static text content into video – saving hours of actors' and production crews' time in the studio.

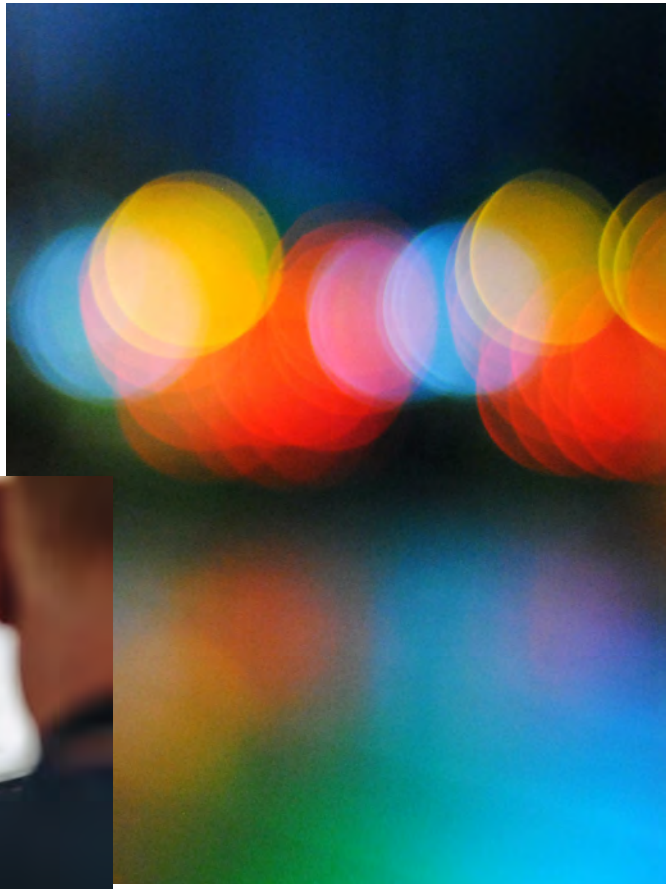
If it sounds like Hour One is creating deepfakes, that's because it is. These are clearly videos of real people saying or doing things they haven't said or done. But in this case, the videos are safe and legal, the actors have given permission for the use of their likeness, and the videos are clearly labeled as computer-generated (Hour One requires that each video disclose that the content is computer-generated and is embedded with an "Altered Visuals" watermark).

The AI-based video bots that Hour One creates seem far from malicious. But does that mean it's okay — is it ethical? This points to the potential challenges and pitfalls that can arise with the government's use of synthetic data.

The proliferation of purposely malicious deepfakes and disinformation has already caused damage, eroding the public's trust in the media they see and read. The public's trust in the technology sector is on a steep decline, reaching all-time lows in 17 out of 27 countries.[87] More to the point, Americans' trust in the government is also at record lows — since 2007, the percentage of citizens saying they can trust the government always or most of the time has not surpassed 30 percent.[88]

> So federal agencies will need to tread carefully and thoughtfully — employing the critical metrics of transparency and authenticity throughout — as they move down this path.

As conversational AI technologies continue advancing and redefining the state of the art in commercial customer experience, we should expect to see federal agencies similarly follow suit as they strive to improve their own citizen experiences around the government services they deliver. As with chatbots today, synthetic data will surely play a key role in developing those technologies in the future.



Open data

One of the earliest federal use cases for synthetic data can be found at the U.S. Census Bureau, which regularly collects vast stores of national data of immense value to many fields of research.

In 2001, the Census Bureau was authorized to integrate person-level micro-data from its longitudinal household survey, called the Survey of Income and Program Participation (SIPP), with IRS tax and earnings data and Social Security Administration retirement and disability benefits data.[89] The resulting data trove offers the most comprehensive information available on how the nation's economic well-being changes over time, and it's a goldmine for academics, researchers, economists, and policy makers.[90] With SIPP data, they can examine, for example, national income distributions, the impacts of government assistance programs, and the complex relationships between government tax policy and economic activity at the local levels.

The problem for Census, however, is that the highly detailed nature of the SIPP data makes it particularly sensitive because the micro-data could be used to identify specific individuals. To make the data safe for public use while also retaining its research value, the Census chose to create synthetic data from the SIPP data sets.[91] The result is the SIPP Synthetic Beta (SSB), a Census Bureau product that was first made public in 2007 and continues to be updated and released periodically.[92]

Federal healthcare

Similarly, the NIH's N3C Data Enclave is an open data initiative aimed primarily at advancing COVID-19 research. Since the database was opened to researchers in September 2020, it has grown to include billions of rows of data representing more than 5 million COVID-19 positive patients, making it the largest open U.S. database of data from patient electronic health records.

Because of its advanced informatics technologies and data linkages to demographic, mortality, and other information, the database helps researchers create clearer pictures of COVID-19 health outcomes among different communities and enables them to find patterns faster than traditional database methodologies allow. Moreover, the N3C Data Enclave has become useful for research well beyond COVID — researchers have used it to improve our understanding of health equity, diabetes, cancer, HIV, rural mortality rates, and chronic obstructive pulmonary disease as well.[93]

Under the open data initiative, scores of federal agencies and subagencies have already made data sets freely available to researchers on Data.gov, the main web portal for open government data.[94] But some data sets cannot be shared because they could reveal personal details of specific individuals. As we see in the Census and NIH examples, synthetic data is an avenue for agencies to bring even more federal data sets to the research community.

As mentioned, synthetic data is increasingly indispensable for medical researchers who must work around data privacy and compliance obstacles. But deep generative models, such as GANS, are also becoming critical tools for creating more robust data sets to train AI-driven diagnostic tools that can be safely applied across many demographic categories.

AI algorithms need to be trained on large, diverse datasets to be generalizable across a variety of populations and to ensure they are not biased in ways that affect their accuracy and reliability. Historical patient data, such as images or scans of certain maladies, often lack the needed diversity and representation to achieve this. For example, a 2020 analysis of data used to train image-based diagnostic AI systems found that approximately 70 percent of the studies that were included used data from three states, and that 34 states were not represented at all.[95]

Algorithms developed without considering geographic diversity, including variables such as disease prevalence and socioeconomic differences, may not perform as well as they should across a varied array of real-world settings.[96] To help address these shortfalls, some developers of AI-based diagnostic tools are looking to GANs. GANs are showing much promise in generating realistic images of skin lesions, pathology slides, colon mucosa, and chest X-rays in a range of imaging modalities, according to recent studies.[97]

For these reasons, federal medical researchers are sure to make greater use of generative images and data in their work. But synthetic data will also carry big implications for federal regulatory agencies in the healthcare arena.

In 2021, the U.S. Food and Drug Administration (FDA) unveiled a new "action plan" for how it will regulate AI-based software as a medical device (AI-SaMD).

The plan recognizes that FDA's traditional processes for regulating software and AI products must change to keep pace with today's innovations – namely, AI, machine learning algorithms and synthetic data embedded in many of today's devices continue to change over time long after they go to market and are in use. With its action plan for AI-SaMD, FDA voiced an intent to review AI/ML software products from pre-market development to their post-market performance. FDA officials also are reportedly considering the use of synthetic data as an approved method for ensuring that data sets used to train AI/ML models in medical devices are diverse and accurately reflect the patient population in which the technology will be used.[98]

Constituent services

The Department of Veterans Affairs intends to leverage synthetic data as part of a new initiative to reduce veteran suicides by 10 percent.

> By parsing synthetic data, department leaders hope they can better clarify veteran challenges and refine predictive risk factors so department programs can be more proactive in addressing the problem.

"It's very clear that we need to use reliable and timely data to identify and address issues impacting our veterans, while also ensuring privacy," said Dr. Carolyn Clancy, assistant under secretary for Health for Discovery, Education and Affiliate Networks at the Veterans Health Administration (VHA). "We believe synthetic data, modeled to precisely mirror real veteran data, while protecting veteran privacy is a great path forward."

THINGS TO LOOK OUT FOR

Can the unreal be trusted?

While synthetic data initiatives can and do help advance federal missions, there are clear risks and challenges to be aware of.

A core concern for any federal agency, of course, will always be trust.

"In the end, adoption of synthetic data becomes an issue of trust in the protected privacy and accurate representation of the original data," wrote the American Council for Technology-Industry Advisory Council (ACT-IAC), a non-profit public-private partnership that promotes the effective and innovative application of technology in government, in a January 2022 whitepaper for the Department of Veterans Affairs.[99]

"Trust can only be engendered through validation efforts, and this may be where the greatest need for policy guidance exists — how can we quantify that the generated synthetic data holds sufficient utility for analytic end uses?"

Just

42%

of consumers believe AI is being used to improve their lives and experiences and only

35%

fully trust how it's being implemented by specific organizations.

The FDA, for example, in its action plan for regulating AI/ML-based Software as a Medical Device, acknowledges the unique ethical dimensions of regulating this class of products, noting that "AI/ML-based devices have unique considerations that necessitate a proactive patient-centered approach to their development and utilization that takes into account issues including usability, equity, trust, and accountability." In doing so, the FDA said it would make transparency a central tenet in its regulatory approach. "Promoting transparency is a key aspect of a patient-centered approach, and we believe this is especially important for AI/ML-based medical devices, which may learn and change over time, and which may incorporate algorithms exhibiting a degree of opacity," the plan says.[100]

Toward this end, FDA officials met with an advisory committee of patients and caregivers in October 2020 to gain insight into what factors impact their trust in these technologies.[101]

FDA also held a public workshop in October 2021 to elicit additional input from the broader community on how device labeling could support transparency objectives for users.[102] In one published account of that 2021 workshop by Stacy Cline Amin, leader of Morrison Foerster's FDA Regulatory & Compliance practice and a former chief counsel at FDA, participants discussed the idea of labeling AI-based medical devices with something akin to today's food labels — but instead of listing nutritional information, these labels would describe the limitations of a particular device and offer guidance for how to properly interpret and use its data in administering care.[103]

Likewise, in building its SIPP Synthetic Beta product, the Census Bureau was mindful of the challenge of building trust among the public and the research community — again, adopting transparency as a key tactic. The agency published numerous articles explaining in detail its exact methodologies in developing the product as well as how researchers should use SSB data in their research.[104]

Authenticity builds trust

73%

of consumers expect businesses to clearly communicate their use of AI as it pertains to the consumers' interactions with them.

77%

of consumers believe (45% strongly agree) that organizations must be held accountable for their misuse of artificial intelligence.

98%

of U.S. federal government executives report that their organizations are committed to authenticating the origin of their data and genuine use of AI.

Another key to building trust in synthetic data is proactive outreach and dialog with stakeholders. Just as the FDA is engaging patient and caregiver stakeholders as it formulates policy on regulating AI/ML-based medical devices, so too is the NIH consulting with American Indian and Alaskan Native (AI/AN) communities to decide how and whether to make AI/AN COVID-related data available to researchers via the N3C Data Enclave. Currently, AI/AN data in N3C is obscured. Two NIH entities— the National Center for Advancing Translational Sciences (NCATS), which administers the N3C Data Enclave, and the Tribal Health Research Office — are consulting with Tribal stakeholders on whether and how to provide AI/AN data respectfully. "Learning from past examples, our Center wanted to seek prospective support from Tribal Nations in a manner that respects Tribal sovereignty. NCATS decided not to make this data accessible until after it had consulted with Tribal Nations," the Center said on its N3C FAQ website.[105]

Another hurdle is the scarcity of effective policy around the use of synthetic data. Like the FDA, other federal agencies are similarly struggling with how to delineate the appropriate place and role of synthetic data within their purviews. They will need to address questions about how it fits within existing regulatory frameworks; how it can be used to protect patient privacy, address bias in data, and improve medical decision-making; and what steps should be taken to alleviate the trust and accountability concerns that are sure to arise with its use.

This problem is growing urgent for some. While the VA sees much promise in using synthetic data to help reduce veteran suicides, it has yet to put in place the policy guardrails needed to guide the department as it moves forward. The VA even has a cloud-based platform in place to generate synthetic data. But the lack of policy for how and when to use synthetic data complicates the task of standardizing and using synthetic data across the enterprise.[106] In response, the VHA has collaborated with ACT-IAC to help develop policies. The collaboration has resulted in a white paper that proposes how to create and use synthetic data.[107]

The dark side of the unreal

As we see, even when the unreal is put to work in service of productive and well-meaning use cases, there are challenges aplenty. When the use cases turn malevolent, the challenges quickly get more complicated and difficult. This takes us back to the growing problem of discerning and countering malicious deepfakes. AI and ML technologies are reducing the time, cost, and skill sets needed to create deepfakes. And this will only accelerate as computing power and data volumes continue increasing.

It is an open question whether the technologies used to detect deepfakes will be able to keep pace — or whether it even matters. In some cases, the purpose of a deepfake may be to simply fool enough people to create a response. The bigger concern is that the rapid proliferation of deepfakes is undermining our trust in all videos and media, whether genuine or not. When we begin to question what's real or not as a matter of course, truth itself becomes elusive.

There is much to be done to tame this problem. One approach that some are advocating is using blockchain technologies to help ensure provenance and altering of media material.[108] The distributed ledger technology underlying blockchain makes it highly resistant to data modification. In a recent report, the Federal Trade Commission (FTC) notes "...given the limitations of using AI to detect harmful content, it is important to focus on key complementary measures, particularly the use of authentication tools to identify the source of particular content and whether it has been altered. These tools – which could involve blockchain, among other things – can be especially helpful in dealing with the provenance of audio and video materials."[109]

85%

of U.S. federal government executives report that their organizations are planning to mitigate the risk of deepfakes and/or misinformation by preparing proactively and implementing verification mechanisms.

83%

of U.S. federal government executives report that blockchain is going to be critical to their organization's ability to verify the origin of digital content.

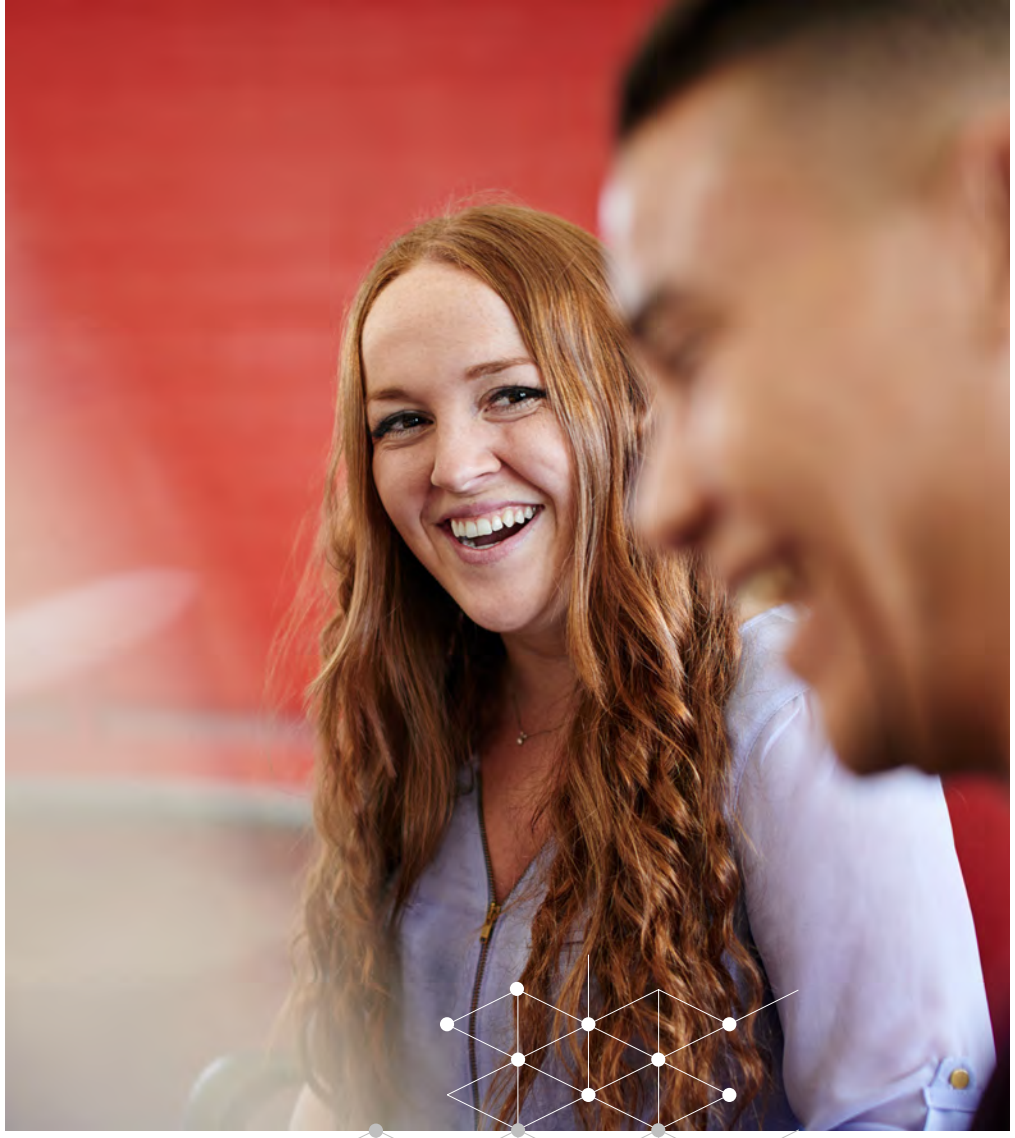
ACTIONS TO TAKE

Elevating authenticity

While synthetic realness has the ability to sow distrust and discord, it also has the power to improve human relationships.

Consider an experiment conducted at Yale University in which participants were put into small groups, each with a humanoid robot, and told to collaborate on a task.[110] The robots were programmed to make occasional mistakes. Some of the robots were designed to admit to those mistakes in a humorous and self-deprecating way – and it was their groups that performed better because the robots improved the participants' communication, allowing them to work together in a more fun and relaxed manner.

In another experiment, people were put into virtual social networks with a few incognito bots and assigned a collaborative task. Again, some of the bots were programmed to make mistakes, and the social networks that they were in grew more flexible in response and consequently outperformed those with bots that did not make errors. This research demonstrates that if designed and deployed in the right ways, AI with human-like qualities like wit and, significantly, imperfection can be used to improve people's performance and strengthen their relationships with each other.



Since we know that being real has no direct bearing on being good, being real should not be the guiding star for business or society. Rather, we propose authenticity as the new compass. Authenticity means being true to oneself and genuine in a way that others can attest to – and more concretely, using generative AI in an authentic way means taking heed of provenance, policy, people, and purpose. By observing these four tenets, businesses can gain confidence not only in their decisions to trust others but also in their use of generative AI such that others can trust them – thus enabling full participation and success in the unreal world.

One way to verify the provenance of digital content and identity – thereby demonstrating authenticity – is through the use of distributed ledger technology (DLT). As an example, Project Origin, led by Microsoft, the BBC, CBC, and The New York Times, is tackling the spread of disinformation using DLT to establish provenance from publishing to presentation.[111]

The Coalition for Content Provenance and Authenticity (C2PA) has built upon this foundation and similar work by the Adobe-led Content Authenticity Initiative (CAI) to propose new standards for authenticating visual media. According to Adobe's Andy Parsons, the goal of the standard is "...so that users can be assured that when media is uploaded with content authenticity, that it is maintained throughout the entire chain of sharing [and] publishing creation, back and forth."[112]

In fact, many analysts are predicting that a large portion of news and video content will be authenticated by blockchain in the coming years. No matter what technologies you use, establishing provenance will be critical as your agency increasingly deals with potential deepfakes and disinformation – and enabling others to establish provenance as they interact with your agency and content will be just as important too.

Next, take stock of your agency's policies with respect to generative AI.

In 2019 for instance, the U.S. state of California passed the BOT Disclosure Law, which states that one must disclose the use of a bot when they are used in communication to sell goods or services or influence a vote in an election.[113] And the EU has drafted legislation to regulate "trustworthy AI," with the purpose of protecting the rights of citizens.[114] The current proposal takes a risk-based approach, banning unacceptable uses of AI and having strict obligations for high-risk use cases. The Business Roundtable has brought together CEOs from some of the largest U.S. corporations to recommend guidance for government regulation of AI.[115] Much of this space is yet to be defined, so where there isn't guidance, agencies will need to define their own policies based on their particular set of missions and business operations, their stakeholders' perspectives, input from Congress, industry best practices, insights from subject matter experts, and their agency's values. And if you are proactive in sharing what works and what doesn't, your agency can be involved in shaping the future of the unreal world – rather than just reacting to it.

From a people perspective, your agency must be prepared organizationally to deal with the challenges that arise with the use of AI.

> Ask yourself, for example, who is responsible for having these tough conversations, and what committees are drafting internal policies?

What departments are using synthetic data or content within the agency, and who will be held accountable if privacy is compromised or customers feel duped? Finally, who will be the point person responsible if your company falls prey to a deepfake or disinformation attack? Having these governance structures in place is imperative to handle the inherent risks baked into the unreal world.

Last but not least, genuine purpose is essential to authenticity. In particular, agencies must define the purpose behind the use of synthetic content, its advantage over non-synthetic content, and the key metrics that can attest to it. For instance, if your agency uses a basic customer service bot simply to cut costs (as opposed to improving availability), there's a good chance it's not living up to its intended purpose of serving customers. However, if the purpose of using synthetic data in a model is to insert counterbias, thereby improving the output of the model, then it could be an authentic use of generative AI. As another example, Soul Machines creates synthetic people that can be used in cases where customers might fear judgment from others and actually prefer to speak to digital people.[116]

Yumi is one such "autonomously animated digital influencer" that answers customers' questions about their skin for P&G's skincare brand SK-II. Yumi's realness can enable more seamless and personal interaction – while simultaneously, its digital essence puts customers at greater ease. Here, the purpose of using a synthetic person is clear on multiple fronts, and as such, is convincingly authentic.

Conclusion

As AI progresses and models improve, enterprises are building the unreal world. But whether we use synthetic data in ways to improve the world or fall victim to malicious actors is yet to be determined. Most likely, we will land somewhere in the expansive in-between, and that's why elevating authenticity within your organization is so important. Authenticity is the compass and the framework that will guide your agency to use AI in a genuine way – across mission sectors, use cases, and time – by considering provenance, policy, people, and purpose. Ultimately, it will unlock new attitudes towards and experiences with AI, unleashing the benefits of the unreal world.

Decision Points

Is your enterprise prepared to take full advantage of unreal world technologies?

- Explore the use of synthetic data. Determine how its advantages could improve existing data strategies, and the algorithms and AI fueled by them, like improving data set quality, reducing privacy risk, and correcting for bias present in historic data sets.
- Identify where unreal content like chatbots or AI-generated images, video, or content could help improve your agency's customer experiences. Find the ways it can create new avenues of connection with your customers, improve the quality of their experiences, and drive new outcomes.
- Pilot the use of unreal technologies to augment the enterprise. Enable employees to leverage them as a partner, enhancing design, simulation, or decision-making capabilities.

How are you protecting your organization and your customers from malicious use of the unreal?

- Identify emerging malicious applications of unreal world technologies before they become a systemic risk. Focus on the veracity and provenance of the information coming into the organization, like potential scams or disinformation, and out of the organization, to ensure unintended falsehoods aren't perpetuated. Consider techniques like the use of distributed ledger technologies to establish provenance.
- Differentiate your use of unreal world technologies from those of threat actors and build trust with your customers by having a clear and communicated purpose. Give people the ability to attest to the genuineness of the agency and its outputs. For example, protect the enterprise from malicious impersonation by incorporating verifiable identity markers throughout your platforms and content.
- Have a plan for how your organization will respond to malicious use of deepfakes or disinformation campaigns against your agency. Explore the most damaging threat scenarios and build the playbook to respond to the events and train, train, train.

How will your enterprise shape the unreal world?

- Authenticity must become an enterprise-wide priority and a C-suite responsibility for generative AI. Know that regulations are formative in this new territory of the unreal world. Have each of your major enterprise functions identify the existing regulations they must adhere to and close the gaps with internal policies that align to agency values. These should be reported up to the accountable C-suite leaders who should maintain a regular agenda item concerning the impact of AI to their programs and business operations, and how to hold it to a higher standard.
- Raise the bar on standards and engage in the standards-making processes. Distrust or harm created by a malicious, careless, or negligent organization or actor in the unreal world could affect how people will embrace and trust the unreal at large. Look for ways to affect the authenticity of the unreal world and hold it to a higher standard.
- Empower your people to not just ask the tough questions but find the tough answers. Exploring the unreal will have implications across security, communications, public affairs, R&D, and beyond. It will be critical for the organization to have a consistent approach to decision making around big topics like security, privacy, safety, transparency, and ethical conduct. A useful starting point is to have specific people or groups be accountable to these answers and ensure that there are effective metrics to monitor the ongoing success and effects of any unreal innovations.

Authors

David Lindenbaum
Machine Learning Director
Accenture Federal Services
in

Marc Bosch Ruiz, Ph.D.
Managing Director –
Computer Vision Lead
Accenture Federal Services
in

Shauna Revay, Ph.D.
Machine Learning Center of Excellence
Lead, Strategic Solutions
Accenture Federal Services
in

Jennifer Sample, Ph.D.
Applied Intelligence Growth
& Strategy Lead
Accenture Federal Services
in

Nilanjan Sengupta
Managing Director – Applied
Intelligence Chief Technology Officer
Accenture Federal Services
in

Viveca Pavon-Harr, Ph.D.
Applied Intelligence
Discovery Lab Director
Accenture Federal Services
in

Trend 04

Computing the Impossible

New Machines, New Possibilities

THE BIG PICTURE

Many experts believe that the biggest advances in computing capability are still ahead of us.

For federal agencies — charged with tackling the world's gnarliest and most pervasive problems — these fast-emerging capabilities in computational power present both an incredible opportunity as well as a significant potential threat. This trend, Computing the Impossible, explores both the positive and cautionary dimensions of the growing computing power coming into our grasp.

Over the last five decades, the state of computing has progressed at a truly astonishing rate.

Consider that in 1971, chip-maker Intel launched the Intel® 4004 processor, the first general-purpose programmable processor on the market. At that time, the 4004 was a technical marvel: the size of a small fingernail, it held 2,300 transistors — tiny electrical switches representing the 1s and 0s that are the basic binary language of computers.

Each transistor on the 4004 was 10 micrometers wide — about one-tenth the thickness of a human hair.[117]

Impressive as that was, today, we see state-of-the-art microprocessors packing 60 billion — even 80 billion — transistors[118]; and the size of a single transistor is now approaching 2 nanometers (nm), less than the width of a single strand of human DNA.[119]

This trend towards ever-smaller transistors and ever-more-powerful computers has been remarkable to observe. Incredibly, it was also entirely predicted way back in 1965. That's when Gordon Moore, then the research director at Fairchild Semiconductor Corporation, observed in a magazine article that, due to the ever-shrinking size of transistors, twice as many transistors would be able to fit onto a computer chip roughly every 12 to 18 months. This observation became known as Moore's Law. (In 1975, Moore adjusted his estimate to a doubling of transistors every two years.[120])

Indeed, Moore's observation has charted pretty accurately the trajectory of technology since then, becoming a cornerstone on which much of our recent innovation and economic growth has been built. But today, many industry leaders, including Moore himself, agree that Moore's Law will soon — if it hasn't already — bump into the physical and engineering limits of what is possible.

The basic components driving technology today are approaching a fundamental limit of smallness: the atom (which ranges from about 0.1 to 0.5 nanometers). Getting smaller yet requires new, more innovative designs and different materials.

However, even as the blistering pace of advancement for classical or binary computing begins to cool, entirely new varieties of computers are now emerging that apply completely different approaches to the challenge of fueling tomorrow's technological advances.

68%

of U.S. federal executives say quantum computing will have a breakthrough or transformational positive impact on their organizations in the future, while 55% say the same for high performance computing (HPC), and 18% for bio-inspired computing.

Quantum computing

The advancement getting the most attention, because it promises to be so disruptive and transformative, is quantum computing. This fast-emerging technology harnesses the laws of quantum mechanics — the unique way that exceptionally small, subatomic particles can appear as two distinct objects at the same time — to solve problems too complex for classical computing.

With classical computing, the smallest unit of data is a bit, which has a single value of either 0 or 1. Conversely, quantum computers utilize basic units known as qubits (pronounced "cue-bits"). Its computing power derives from the potential for each qubit to be both 1 and 0 simultaneously, rather than being restricted to one or the other. This undefined quality of qubits enables quantum computers to run more complicated algorithms, tackle millions of computations simultaneously, and operate far faster than traditional computers.

That's because, as the number of qubits in a quantum computer grows, the computer becomes exponentially more powerful: two qubits hold four values, three qubits hold eight values, four qubits hold 16, and so on.

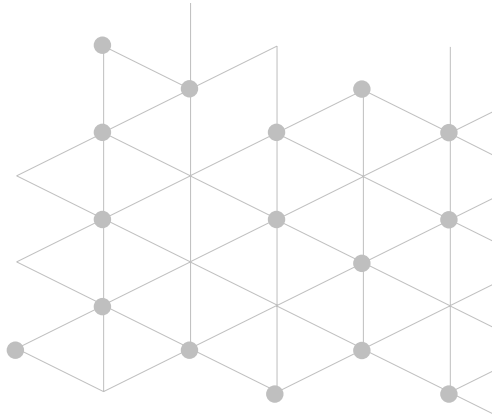
The breakthroughs in quantum computing are now occurring on a nearly continuous clip.[121] One significant milestone occurred in 2021 with the creation of an atom-scale quantum integrated circuit in which individual atoms are the qubits.[122]

Indeed, even though widespread commercial use of quantum computers is still thought to be at least several years away, one very specific and practical application of quantum computers is already weighing heavily on the minds of cybersecurity experts around the world: the decoding of current encryption standards. Today's cryptographic algorithms are generally impervious to classical computers, but not to quantum computers.

> As far back as 1994, mathematician Peter Shor demonstrated that a quantum computer would be able to quickly neutralize RSA encryption, one of the primary security standards in use today.[123]

Cyber experts even have a special name for that fateful day when quantum computers will be able to render current encryption standards useless: Q-day. That is when everything that runs on computer systems — our financial accounts, government secrets, power grids, transportation systems, and more — may suddenly become susceptible to quantum-powered cyberattacks.[124]

This is a major national security concern for the U.S. government since near-peer competitors such as China and Russia are investing billions of dollars to advance their own quantum capabilities in what has become a high-stakes arms race.[125]



Already, cyber experts note that criminals and nation states have adopted an 'intercept now, decrypt later' strategy in which they seize and store sensitive encrypted electronic traffic now with the intention to unscramble later after they develop sufficient quantum computing capabilities.[126]

The U.S. government is taking notice. In 2015, the National Security Agency announced its intention to transition to quantum-resistant protocols.[127] And in 2022, President Joe Biden signed a National Security Memorandum (NSM) — titled Promoting United States Leadership in Quantum Computing While Mitigating Risks to Vulnerable Cryptographic Systems, also known as NSM-10 — that directs federal agencies to migrate vulnerable cryptographic systems to quantum-resistant cryptography as part of a multi-year effort.[128]

While a necessary step, there is far more that needs to be done to move the country's digital operations to new quantum-safe security standards. Any proposed replacement will need to withstand months or even years of public scrutiny and challenges before it is entrusted to protect intellectual property, financial data, and state secrets.

High-performance computing

Quantum today is considered the pinnacle of next-generation problem solving, but there are others. High performance computers (HPC), or massively parallel processing supercomputers, are the most mature of the new categories of compute. HPCs help organizations leverage large volumes of data that may be too expensive, time-consuming, or impractical for traditional computers to handle. HPCs typically rely on different hardware and system designs — where multiple computing processors, each tackling different parts of a problem, are connected together to operate simultaneously — to solve more complex problems that involve large amounts of data. Common types of HPC system designs include parallel computing, cluster computing, and grid and distributed computing.

Scores of HPC service offerings by public and private technology and cloud service providers have already sprung up in response to exploding commercial demand and an ever-expanding menu of use cases.

In financial services, for example, HPCs are helping detect fraud, analyze risk, and conduct simulations. In retail, they are used to conduct consumer profiling, inventory analysis, logistics, and revenue predictions. In life sciences, HPCs are enlisted for genome processing, molecular modeling, and pharmaceutical design. In the energy sector, they process seismic data needed to search for oil and gas deposits and conduct weather simulations needed to calculate optimal wind turbine parameters. And HPCs take on a wide array of other projects to support automotive, film, media, gaming, and aerospace companies, among others.

Biocomputing

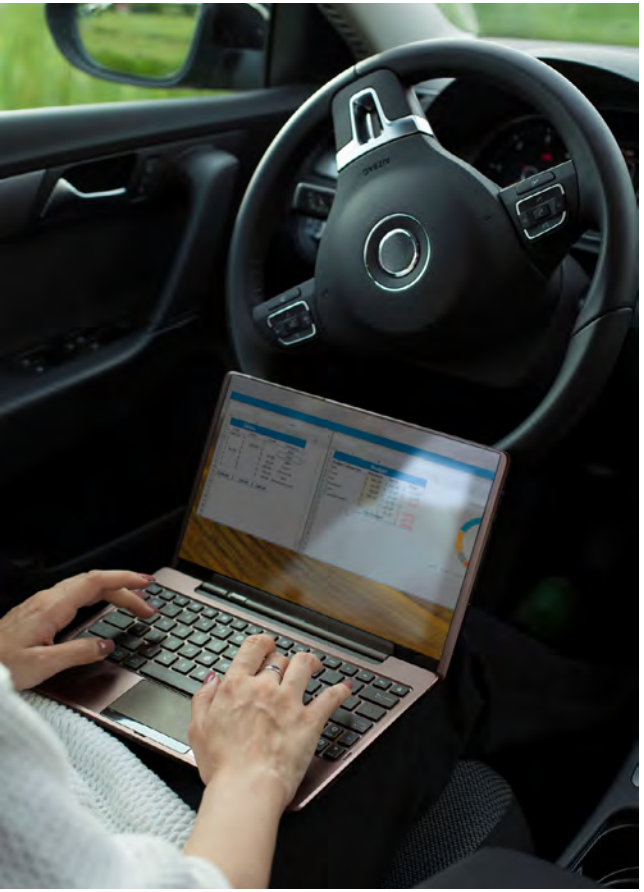
Another emerging category of next-generation computing relies directly on natural biological processes to store data, solve problems, or model complex systems in fundamentally different ways. At the forefront of biocomputing is data storage.[129]

> One estimate predicts DNA could store an exabyte of data in just one cubic centimeter of space, with the potential to persist over 700,000 years based on biological DNA found on earth.[130]

The reliability along with the economical use of space and energy could be transformative at a time when our penchant for creating data is rapidly outpacing our ability to effectively store it. Companies are generating more data than ever, and especially in highly regulated industries like financial services, are expected to keep and store that data for long periods of time. Indeed, DNA as a solution to this problem is more than science fiction. In 2019, Microsoft became the first company to demonstrate the ability to successfully store and retrieve data in fabricated DNA.[131]

But biological-based computing goes well beyond data-storage use cases. For example, in 2017, a team of researchers programmed human cells to obey 109 different sets of logical instructions, proving that cells can understand and execute directions correctly and consistently. With more development, this could lead to the programming of cells to fight diseases, like cancer, in more sophisticated and controlled ways.[132]

In this case, the researchers programmed cells that lacked a specific enzyme to produce a blue fluorescent protein that made them light up. Using similar approaches, cells could be programmed to light up when mixed with a patient's blood sample, indicating that the patient has a particular disease — a much cheaper alternative to current methods requiring expensive machinery and analysis of blood samples.



Bio-inspired computing

Somewhat related to biocomputing is biology-inspired computing systems. Also known as biomimicry, these computers draw inspiration from biological processes and have been used in areas ranging from chip architectures to learning algorithms, and successful pilots have shown this emergent field can deliver benefits like greater power efficiency, speed, and accuracy in more complex problems. For instance, one technology at the forefront of biomimicry is neuromorphic computing. Neuromorphic chips, like Intel's Loihi, have introduced a brand-new design to computer chips: They are modeled after the human brain.[133] The chips use artificial neurons to transmit information in a way that is more power-efficient than traditional CPUs. Also, this architecture is optimized for the execution of Spiking Neural Networks (SNNs), a different approach to neural networks than the Artificial Neural Networks (ANNs) that power today's AI systems.

The SNN leverages simulated neurons to transmit input and output data, while an artificial synaptic layer strengthens (or weakens) the connections between each neuron – allowing the system to learn very similarly to the way the human brain operates.

Stepping back to what these machines actually let us do, consider robotics. Currently, to design autonomous or semi-autonomous robotics, engineers must decide where to put the intelligence.

> The machines need to be able to execute a set of instructions, but also adapt, react, and learn about their environment.

One option is to place AI models out in the field (or "the edge," as many in the Defense Department refer to it), far from a supporting data center. This is, for example, how self-driving cars learn to drive: by driving out on the road to allow their machine learning models to ingest more data and develop better responses to what they "see". But in such cases, algorithms require extremely power-intensive GPUs. With the current limitations of batteries, power consumption becomes a significant design challenge, not just on the battery but on what can be done with the system. A library of 100 words for natural language processing, for instance, is going to be a lot less computationally intense and power hungry than a library of 2,000 words – which means power considerations will directly affect uses like human-to-machine interactions.

Another option is for AI processes to run in the cloud, but then engineers run into a different set of limitations around bandwidth and latency. No one wants a drone or a car that makes a decision half a second too late. This is where neuromorphic computing provides a clear advantage – it can run AI systems that allow for learning, more natural interaction, and more, in a power-efficient way. It opens the door to a world of robotics and edge computing that we can see from afar but have yet to attain.

And robotics and edge computing are just the beginning. As the field grows, it's becoming clear that the human brain is particularly good at solving certain problem sets (relatively) quickly. For instance, modeling multidimensional chemical processes or solving constraint satisfaction problems are areas where brain-inspired algorithms can provide a distinct computational advantage.

These advantages could be leveraged for use in waste or carbon recapture or for hyper-personalization, which many view as potential billion-dollar businesses on the horizon.

These new, non-classical varieties of computing capability will dramatically reduce the difficulty of solving some of the world's biggest challenges. Moreover, while these advancements may lead us to faster, more efficient computing power, they shouldn't be viewed as eventual replacements or substitutes for the classical computers we rely on today. Their use cases and capabilities will vary depending on how they are designed and architected.

THE ANALYSIS

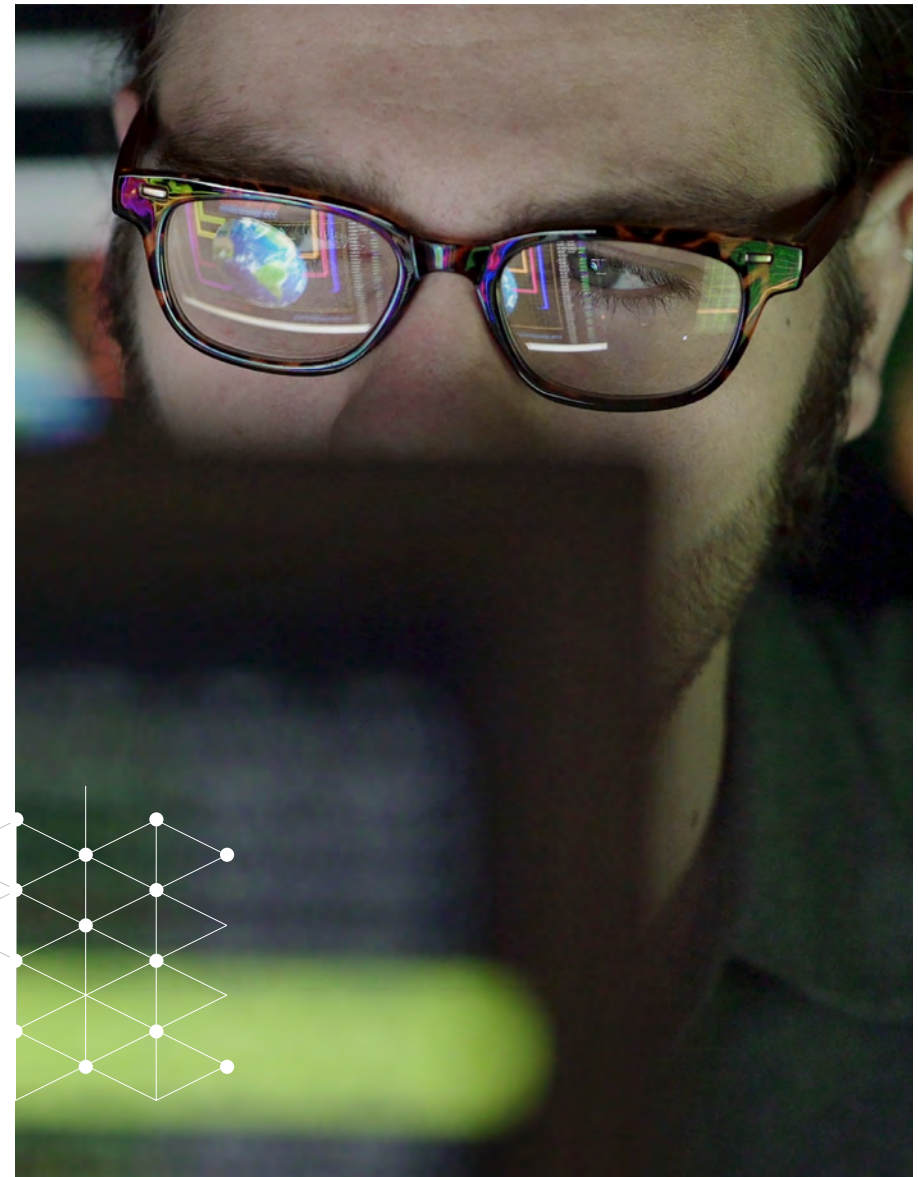
Given the breakthrough technologies above, change, perhaps dramatically so, is expected. So, what will this change mean for federal agencies and the missions and business operations they support?

The global race to quantum

Let's start with quantum, which is coming at us with incredible velocity due to the intense degree of priority, investment, and geopolitical consequence attached to it. When it comes to computing the impossible, the hottest space to be in is quantum, where there is a high-stakes R&D contest under way among tech giants, startups, and governments alike. Already, it appears that quantum pioneers have eclipsed a prized milestone: "quantum supremacy," which is when a quantum computer performs a calculation that no classical computer can perform in a reasonable amount of time.

97%

of U.S. federal executives agree that their organization is pivoting in response to the unprecedented computational power that is becoming available.



In October 2019, Google claimed it was the first to achieve quantum supremacy when its 53-qubit quantum computer, called Sycamore, performed a task known as random circuit sampling, which involved repeating a sampling process a million times. The computer completed the task in 200 seconds — by contrast, Google claimed it would take a state-of-the-art supercomputer 10,000 years to do the same task. But Google's claim of quantum supremacy was immediately disputed by another top rival in the quantum race, IBM, which published a paper arguing that the same calculation could be performed in 2.5 days on a classical supercomputer using an improved technique.[134]

In 2020, China's leading quantum research group made its own declaration of quantum supremacy. A team at the University of Science and Technology of China, in Hefei, used its system to accomplish a mathematical task in 200 seconds that it calculated would take the world's then-most-powerful supercomputer, Japan's Fugaku, more than 600 million years to accomplish.[135]

The Chinese system, called Jiuzhang, takes an entirely differently approach to quantum computing than Google's Sycamore: whereas Sycamore relies on super cold, superconducting metal for its quantum circuits, the Jiuzhang's design relies on manipulated light photons.[136]

> Ultimately, of course, the real objective is not quantum supremacy, but rather useful, practical quantum computers that can help address today's many complex challenges such as cancer and climate change.

Nevertheless, the well-publicized drama around the race to quantum supremacy illustrates the intensity and high stakes at play today — and it has set off an intense flurry of investment. In 2021, an estimated $3.2 billion was invested into quantum firms around the world, according to The Quantum Insider – an astounding increase from $900 million in 2020.[137]

And these investments are now further accelerating the worldwide contest to deliver on the promise of quantum. In November 2021, for example, IBM made headlines by creating a 127-qubit quantum computer, the world's largest — which is more than double the size of comparable machines made at that time by Google and the University of Science and Technology of China.[138] And in May 2022, the company announced plans to unveil a 433-qubit processor by the end of this year and a 1,121-qubit processor in 2023.[139]

But the biggest contest in quantum is playing out at the geopolitical level where the United States and China view quantum supremacy as a top national security imperative. Military planners see huge potential for quantum to dramatically transform computing; networks; communications and cryptography; position, timing and navigation (PNT); sensors; and other foundations of the modern warfare.[140]

The Defense Science Board (DSB), which advises Pentagon leaders on scientific and technology matters, has determined that quantum sensing is the most mature military application of quantum technologies and is currently "poised for mission use," according to a 2022 Congressional Research Service report that summarizes the DSB findings.[141] "For example, it could provide alternative positioning, navigation, and timing options that could in theory allow militaries to continue to operate at full performance in GPS-degraded or GPS-denied environments," the CRS report said. Importantly, quantum's computational power may also turbo-charge advanced AI applications, such as those needed for autonomous weapons and machine-based targeting, the CRS report added.

> Pentagon planners recognize they are up against a potential adversary — China — that has made enormous progress already in developing its own quantum capabilities.

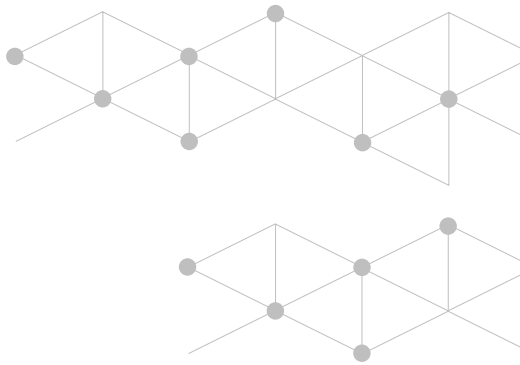
By one measure, China is considerably ahead of the U.S.: China holds more than 3,000 quantum-related technology patents, about twice as many as the U.S.[142] Moreover, in 2021, China announced it had built a 4,600 km quantum communication network, which can effectively relay quantum data between satellites and locations on earth.[143] All told, the Chinese government has invested as much as $25 billion into quantum technology from the mid-1980s through 2022, according to one estimate.[144]

Likewise, the U.S. government is also marshalling considerable resources to develop a wide array of quantum capabilities. Congress passed the National Quantum Initiative Act in 2018, which authorized $1.2 billion in investments over five years to help animate the White House's National Strategic Overview for Quantum Information Science of the same year.[145] That strategy aims to leverage quantum capabilities for national security and economic growth by developing a quantum-smart workforce, deepening the government's engagement with the quantum industry, providing needed critical infrastructure, and advancing international cooperation.[146]

The funds authorized by the law have been creating new federal research centers, institutes, and a new U.S. National Institute of Standards and Technology (NIST)-led Quantum Economic Development Consortium (QED-C) to harness myriad efforts across industry, academia, and government.

More recently, in NSM-10, President Biden declared it U.S. policy to "maintain United States leadership in QIS [quantum information science] through continued investment, partnerships, and a balanced approach to technology promotion and protection."[147] Today, we already see numerous federal agencies involved in quantum R&D efforts, including NASA, the Defense Department, the National Science Foundation, the Intelligence Advanced Research Projects Activity (IARPA), the Department of Energy National Laboratories, and NIST.

One key focus area for U.S. government agencies, Biden said, is mitigating the threat of future quantum computers being able to crack the public-key cryptography that keeps today's digital systems relatively secure.

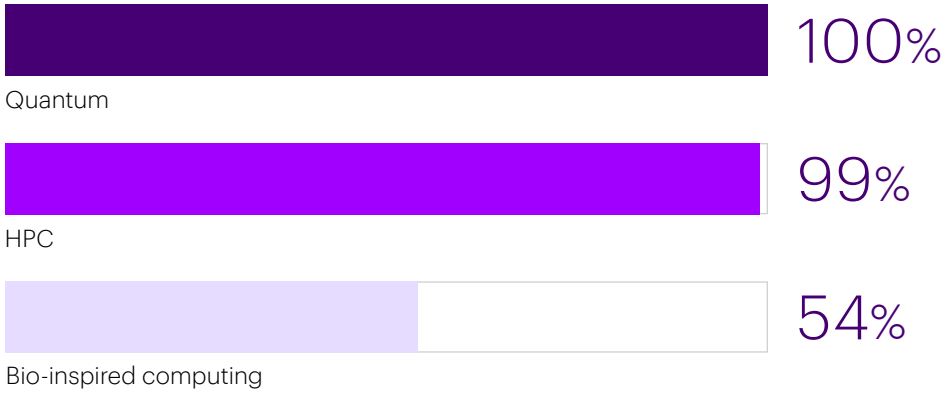


Toward that effort, NIST led an international competition and selected four 'Post-Quantum Cryptography' (PQC) algorithms that even quantum computers will not be able to solve that can serve as a standard for internet security in the future.[148] NIST expects to finalize that standard by 2024.

99%

of U.S. federal executives agree that next generation computing will become essential to their organization's ability to reach its sustainability goals.

U.S. federal executives recognize that next generation computing has the potential to address previously unsolvable problems:



Federal use cases for quantum

But as the government works with industry and academia to expand R&D and maintain U.S. leadership in this arena, are there quantum computing (QC) service offerings and use cases available either today or in the near-term future to advance federal missions and business operations?

While some debate exists about what qualifies as general-purpose QC and when it will become readily available, more targeted cloud-based offerings are commercially available today.

> **By focusing on more limited use cases, providers can industrialize the operating environment to achieve the stability needed to deliver reliable problem solving.**

These include offerings from both QC pure-plays like IBM, Rigetti, and D-Wave as well as cloud leaders AWS, Microsoft Azure and Google Cloud Platform.

"Real quantum computers exist and can be used to solve meaningful problems," notes IDC in the analyst firm's Worldwide Quantum Computing Forecast, 2021–2025 report.[149] "However, the underlying technology is still not ready for large-scale production and requires exceptionally stringent operating conditions to deliver stable outcomes and only the top IT vendors and service providers can afford to build and maintain them." IDC further points out that within the next decade, QC technology "will be closer to large-scale consumption and be suited for solving problems so complex that no amount of classical compute, even in the shape of accelerated supercomputers, could solve them."

In terms of use cases, quantum machines today are best suited for solving optimization problems that can incorporate large numbers of factors and criteria.

Not only can quantum computers handle large problem sets like that very quickly, they can present the entire landscape of possible solutions to decision makers so they can better understand the art of the possible, the alternative choices, and the potential tradeoffs that can occur.

> In this way, quantum has great potential in the future to reshape the way decisions are made as it relates to federal policies, programs, and operations.

Many of the QC use cases today across all industry sectors involve what is known as quantum annealing, which concern the solving of discreet combinatorial optimization problems. Optimization problems search for the best of many possible combinations. This might involve, for example, finding greater efficiencies in scheduling or supply chains.

Sampling problems involve building a probabilistic model of reality, typically for machine learning applications. Samples of data inform an algorithm about the model state for a given set of parameters, which can then be used to improve the model. Probabilistic models explicitly handle uncertainty by accounting for gaps in knowledge and errors in data sources.[150] While quantum annealers are among the preferred types of QC technologies employed today, so too are quantum algorithms, cloud-based quantum computing, and quantum simulators.[151]

Optimization challenges are particularly prevalent in the financial service and manufacturing industries, where much of today's early QC activity is occurring. In the financial sector, companies are employing QC for credit and asset scoring, derivative pricing, portfolio management, fraud detection, investment risk analysis, and portfolio management, among others.

Similar use cases would apply as well to federal agencies that are heavily financial — for example, the departments of Agriculture and Treasury, the Federal Reserve Board, the Federal Deposit Insurance Corp., and the Securities and Exchange Commission.

In manufacturing, current QC use cases include fabrication optimization and process planning, manufacturing supply chain, materials and chemistry discovery, structural design, fluid dynamics, aircraft design optimization, autonomous vehicle navigation, battery simulation, and robotics. Similar use cases would apply to fleet optimization, Defense Department agencies such as the Armed Services' material and systems commands, the Defense Logistics Agency, and the Missile Defense Agency, among others.

But many ripe use cases exist as well in the fields of healthcare and life sciences, energy, distribution and logistics, transportation, and IT services, most of which would have relevance for federal agencies.

HPCs assist many federal mission activities

Although much of the technology headlines today are focused on quantum, it is high-performance computing (HPC) that is getting a great deal of use across the federal government. Only a decade ago, HPC was prohibitively expensive for many organizations.

> The cloud has helped to lower costs and dramatically broaden HPC's appeal, just as the need for complex simulations, massive data analytics, and AI has gained considerable traction across many industry sectors.

Most large cloud vendors today include HPC-specific options among their offerings. But there are even hybrid cloud offerings, managed services, industry-focused solutions, and specialized colocation from companies such as Hewlett Packard Enterprise (HPE), IBM, and Penguin Computing. And as cloud-based HPC offerings have proliferated, so too have federal use cases and anecdotes.

The Energy Department's National Renewable Energy Laboratory is developing its Kestrel supercomputer to answer key questions needed to advance the adoption of cleaner energy sources. Core capabilities will include applied mathematics to support the most advanced problem-solving algorithms; computational science for complex modeling; energy-efficient operational features; and advanced computer science, visualization, and data management to empower programmers.[152]

Three federal departments joined forces to create the COVID-19 Insights Partnership, which enabled the departments of Health and Human Services and Veterans Affairs to leverage the Energy Department's Summit supercomputer, located at Oak Ridge National Laboratory, to accelerate COVID-19 research by running large scale, complex analyses on vast amounts of health data.[153]

The U.S. Geological Survey moved early to use HPCs to simulate the impact of climate perturbations and glacier mass balance change in regions such as the ecologically important Copper River watershed in Southcentral Alaska.[154] Developing accurate models of glacial behavior is important for evaluating hydrologic, cryospheric, ecologic, and climatic trends and for understanding when, and to what extent, streamflow may increase or decrease as glaciers respond to a changing climate.[155]

The Defense Department has five DoD Supercomputing Resource Centers (DSRCs), that are used to tackle challenges in the areas of fluid dynamics; chemistry and materials science; electromagnetics and acoustics; climate, weather, and ocean modeling and simulation; among other applications.[156]

One of the more high-profile examples of how federal agencies teamed up with academia and the private sector to leverage HPC to address a national crisis is the COVID-19 High Performance Computing Consortium. In the early days of the COVID-19 pandemic March 2020, the Office of Science and Technology Policy (OSTP), DoE, NSF, and IBM quickly teamed up to create a unique public-private partnership between government, industry, and academic leaders to provide COVID-19 researchers around the world no-cost access to advanced HPC and cloud computing systems and data resources along with technical expertise and support.

So far, the consortium has supported more than 115 projects covering a broad spectrum of technical areas ranging from understanding the SARS-CoV-2 virus and its human interaction to optimizing medical supply chains and resource allocations.[157]

The consortium demonstrated how the rapid availability of an advanced computing infrastructure can serve as a strategic national asset in times of crisis response, such during hurricanes, earthquakes, pandemics, and wildfires. Consequently, the White House in October 2021 publicly proposed the creation of a new National Strategic Computing Reserve, a new public-private partnership — modeled after the Civil Reserve Air Fleet and the United States Merchant Marine — that can quickly mobilize compute, software, data, and technical expertise in times of urgent need.[158]

Many other potential use cases abound.

For example, just as federal agencies have used HPCs to better understand the behaviors and qualities of the SARS-CoV-2 virus, so too could they use HPCs to better understand compounds that could create cleaner fuels or that are difficult to clean up in the environment.

Biocompute brings energy efficiency and speed to mission computing

Federal agencies are also taking active steps towards promoting bio-inspired computing. Not surprisingly, they are taking a leading role in defining key concepts and sponsoring advanced research through the work of a host of agencies, including NIST, NIH, DARPA, IARPA, NSF and the Energy Department. Going a step further, the U.S. Navy is prototyping an autonomous robot inspired by how large fish, like tuna, navigate the open seas.[159]

However, investments in neuromorphic computing are likely to have the most immediate impact. For example, the Army Research Laboratory, Department of Defense Supercomputing Resource Center (ARL DSRC) is exploring the use of neuromorphic computing to enable low-power AI systems more suitable for field deployment.[160]

Researchers at Sandia Labs recently published a paper showing how neuromorphic computing can surpass AI in complex problem solving. Using the random walks statistical method for neuromorphic simulations, they were able to model a number of complex scenarios, such as disease transmission, X-ray scanning, social network interactions, and financial trading, with the potential to solve these problems faster using more energy-efficient methods.[161] "These problems aren't really well-suited for GPUs [graphics processing units], which is what future exascale systems are likely going to rely on," notes Brad Aimone, the report's author. He adds, "Basically, we have shown that neuromorphic hardware can yield computational advantages relevant to many applications, not just artificial intelligence to which it's obviously kin."

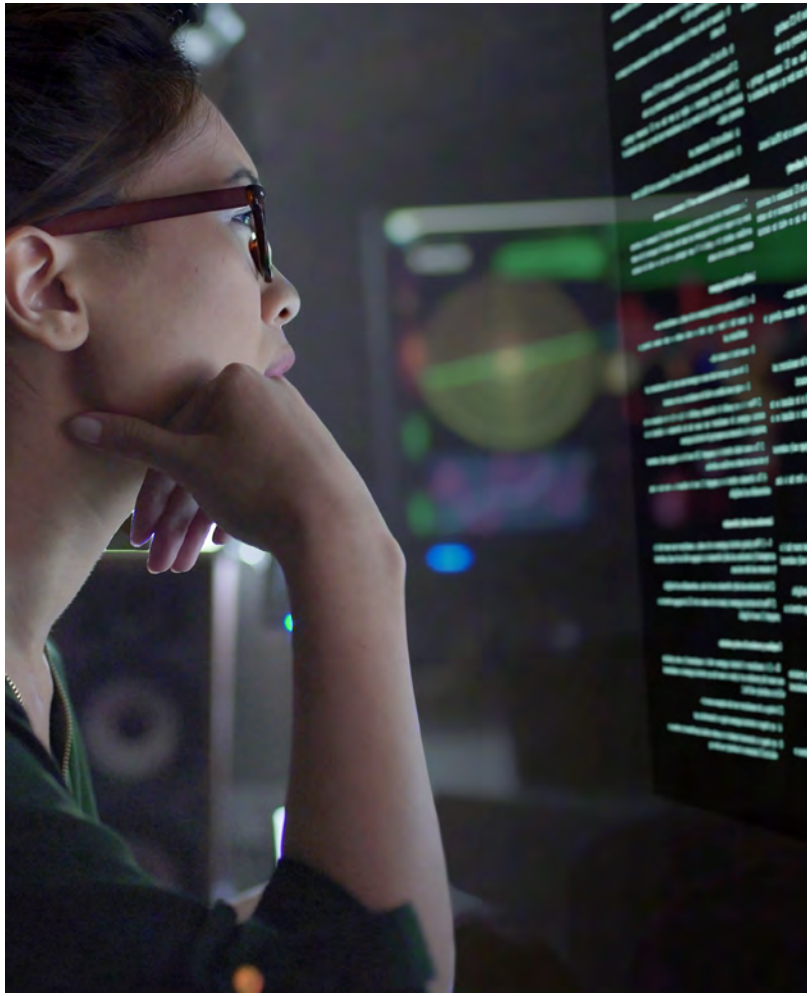
Each one of these compute areas – quantum, HPC, and bioinspired compute – contributes to a specific niche, but taken as a whole, a clear trend emerges: We are in the midst of an evolution towards machines that, down to the very physics of their operation, are unlike any in existence today. As they grow, they will expand the window of what's possible.

97%

of U.S. federal executives agree that their organization's long-term success will depend on the next generation computing they leverage to solve the seemingly unsolvable problems not addressable by classical computing.

68%

of U.S. federal executives believe that next generation computing has the potential to disrupt their organization's current business model.



THINGS TO LOOK OUT FOR

Preparing for ‘Q-Day’

The biggest near-term impact in this emerging era of computing the impossible is the challenge to today’s standards for computer security.

The president’s National Security Memorandum on Promoting United States Leadership in Quantum Computing While Mitigating Risks to Vulnerable Cryptographic Systems has already put agencies on alert that their digital systems that use existing public standards for public-key cryptography could be vulnerable to an attack by a CRQC. The memo directs federal agencies to begin thinking, planning, and preparing for the eventual transition to post-quantum cryptography.

In partnership with NIST, DHS has created a detailed Post-Quantum Cryptography Roadmap to provide relevant stakeholders with concrete and achievable steps they can take now to prepare.[162] For example, federal agencies should consider taking inventory of their current cryptographic systems, the data being protected, and prioritizing their systems for transition to ensure a smooth and efficient transition to the new post-quantum cryptography standard once it becomes available.

Also, as mentioned earlier, NIST and the National Security Agency are already developing technical standards for quantum-resistant cryptography for their respective jurisdictions with an eye toward publicly releasing new standards by 2024. But federal agencies will need to take steps now to be prepared for this migration — something the White House calls "cryptographic agility." That means that when those future cryptographic standards are finalized, agencies will need to be ready to act quickly and seamlessly to update their systems.[163] To accomplish this, agency policy and technical leaders will need consult with experts and think through how this transition can be optimized for their particular mission space. NSM-10, for example, calls upon agencies to identify and report all instances where quantum-vulnerable cryptography is used by National Security Systems.

This imminent transition to a new cryptography standard may also present an imperative for some agencies to ensure they have the right skills and procurement mechanisms in place to plan and implement their migrations to the new standards.

> These are dimensions of the challenge that agencies will need to think about more broadly as well: The impact of these machines will directly follow the emergence of skilled workers who can leverage them.

A Classiq survey of 500 U.S. executives revealed the belief that top factors delaying potential quantum deployments today are a trained worker shortage as well as software and hardware availability. In that same survey, half of respondents believed that lack of quantum experts is what was stopping quantum from being even more popular.[164]

In the longer term, federal agencies should view these emerging new computing technologies much like artificial intelligence in its early days. The problem-solving capabilities enabled by this new wave of computing may lead to the biggest technological disruptions of our time.

And as more development breakthroughs occur, and the promise of these next-generation computing technologies becomes clearer, there will be greater investment and attention placed on accelerating their development further. In other words, the pace of development — and adoption — will continue to accelerate going forward. That means that agency leaders should begin thinking now about what the implications of Computing the Impossible could mean for them.

ACTIONS TO TAKE

Forging tomorrow's agencies

The computers that will create and fuel the next generation of government and industry are already being built, and enterprises need to be part of this wave or risk being swept away by it.

Agencies will need to understand how these new forms of compute may be used to solve the unique problems facing their mission space – and they need to start today. The good news? We can forecast where things are starting to happen. Just like Shor's algorithm, the impact can be shown on paper before it can be seen in the real world. There's no excuse for getting caught by surprise.

The quickest action to take is to begin evaluating how these technologies will shape the operations of your enterprise. What insurmountable problems are simply considered the cost of doing business? How would it reshape the agency if you could start solving those problems? Which class of machines is likely to impact your enterprise earliest? Frankly, most enterprises don't even have the skill sets to fully answer these questions today – which is why federal agencies need to start acting now to identify their knowledge needs and begin filling them in before it's too late. And this should not be left as a thought experiment. Agency leaders should be asking themselves what hardware they can start building or using to solve their biggest and most impossible problems.

Federal agencies should also keep in mind that many of these next-generation computing capabilities are becoming more accessible through as-a-service offerings. These would be a great way to conduct initial experiments to get a feel for how these new capabilities work, the use cases they could be appropriate for, and the skill sets and competencies that your agency will need.

Forging the in-roads with potential partners is also a critical next step to take. Not only do most enterprises have skills and capabilities to gain from partnerships or participation in a consortium, many of these problems actually require this level of collaboration. Think back to the example of the COVID-19 Insights Partnership, which enabled the departments Health and Human Services and Veterans Affairs to find insights in their COVID-related patient data using the Oak Ridge National Laboratory's supercomputer.[165]

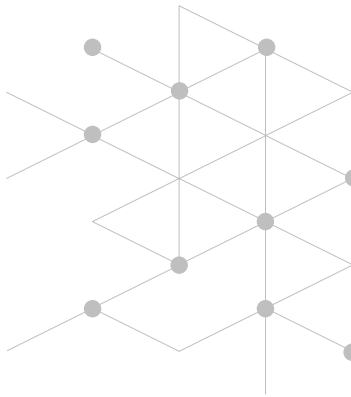
Consortiums are also converging, committed to the growth and development of these fields as a whole. The NIST-led QED-C, for example — composed of corporations, academic institutions, public health organizations, federally funded laboratories, and more — aims to find use cases, determine technology and workforce gaps, and work with stakeholders to fill gaps in the quantum computing ecosystem.[166] In addition, Western Digital, Microsoft, Twist Bioscience, and Illumina partnered to launch the DNA Data Storage Alliance to create standardization and definitions in the field of DNA data storage — with the ultimate hopes of developing cost and energy-efficient commercial archival systems.[167]

73%

of U.S. federal executives are planning to partner with others in the next three years, while another

50%

plan to invest in technology or startups to address previously unsolvable problems using next generation computing.



Conclusion

For decades, computers that could efficiently solve the world's grand challenges have been nothing more than theoretical concepts. But enterprises can't afford to think about them in the abstract any longer. They are rapidly improving, and their impact on our most fundamental problems and parameters may be the biggest opportunity in generations. The agencies that start anticipating a future with these machines will have the best shot at taking full advantage of that opportunity.

Decision Points

Are you ready for systemic change in your agency's mission space?

- Prepare to reevaluate your agency's biggest barriers and impossibilities. Imagine how your agency — and its mission responsibilities — would fundamentally change if these previously intractable problems could be efficiently solved with new computing models.
- Start making bets on the future of computing. Establish a group for scanning and benchmarking this specifically. They should meet quarterly or semi-annually to match the pace of change in your mission space. Determine which class of machines is likely to impact your enterprise the earliest, and in what way.

Decision Points

What foundations will you need to rethink as these grand challenges are solved?

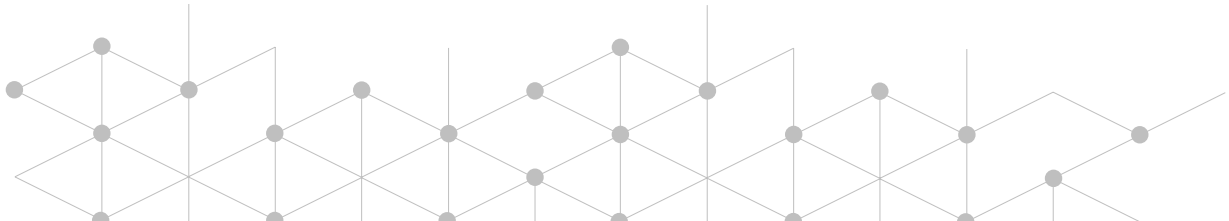
- Create a futurist team to game through how new technologies could threaten the status quo of your agency. Pick a diverse team – skills, cognitive, gender, race, age, ethnicity – and give them space and a mandate to explore and free think.
- Prepare for the move to quantum safe cryptography. Develop a plan that emphasizes cryptographic agility at your agency and follow the progress and selection of the post-quantum encryption methods at standards bodies such as NIST and NSA.
- Assess the technical debt your organization carries. What is the innovation interest you are passively incurring by holding onto technologies too long? Create a roadmap for investment to pay down the technical debt and move to more agile architectures and technologies.
- Identify the new risks and opportunities that these new compute architectures present. How will you test the integrity of the output and protect against poisoning the new capabilities that enable innovative new business models?

How will you leverage partnerships in your next-generation innovation strategy?

- The biggest challenges that federal agencies are concerned with are too big for anyone to tackle alone. Partnerships are no longer optional, and enterprises should already be starting to build relationships with next-generation computing providers, which are increasing in number and variety.
- Pay attention to the signals coming from your partners and other agencies that you interact with. Seek out opportunities for joint investments, like consortiums, with others facing similar challenges to increase your collective access to emerging compute.

Do you have the skills to lead the search for new computing solutions?

- Even in a rich partnership ecosystem, it is important to invest in the development of your own in-house capabilities. This will help you access more purpose-specific technology capabilities.
- There is a significant talent shortage already in technology, and it only gets more severe as technologies and the skills associated with them become more advanced. Create a people strategy that prioritizes identifying, acquiring, and developing these skills. Enterprises that don't start competing for this talent soon are setting themselves up to fall behind.



Authors

Chris Copeland
Managing Director –
Chief Technology Officer
Accenture Federal Services

Chris Hagner
Managing Director – National
Security Technology Innovation
& Engineering Lead
Accenture Federal Services

Garland Garris
Post-Quantum
Cryptography Lead
Accenture Federal Services

Justin Shirk
Managing Director –
National Security Cloud GTM Lead
Accenture Federal Services

Mary Lou Hall
Chief Data Scientist,
Defense Portfolio
Accenture Federal Services

Mimi Whitehouse
Emerging Technology
Senior Manager
Accenture Federal Services

Finishing the story

Each year's technology trends are part of a bigger story. Specifically, our annual Technology Vision encompasses a three-year set of trends, with this report including trends from 2020 and 2021. Tracking their evolution over time provides leaders with an opportunity to plan, adapt and transform for the future.

Accenture Federal Technology Vision 2020

Asking the question Tech-lash or Tech-clash, we examined the five trends defining post-digital government:

The I in Experience

Enabling individual control over the experience

Build greater trust and engagement through a more collaborative, human-centered experience. When agencies become partners in experience creation—and not just providers of it—they can transform their relationships with citizen customers.

AI and Me

Unlock AI's full potential through human-machine collaboration

Civilian and national security agencies can achieve better overall outcomes by changing the nature of their work and empowering human employees with better information and greater capabilities.

The Dilemma of Smart Things

Avoid the perils of the "beta burden"

As both a provider and consumer of digital products that are in constant flux, the federal government has an opportunity to mitigate risks and enhance its supplier and consumer relationships.

Robots in the Wild

Viewing robots through a mission lens

The value and versatility of robots serving federal missions is growing rapidly. To capitalize, agencies will need focus, imagination, and education.

Innovation DNA

Thriving in an era of continuous change and advancement

Agencies know they cannot solve our biggest national challenges with conventional tools and approaches. But to adopt innovation as core to what they do, they will need to assemble the right mix of capabilities and partnerships.

Accenture Federal Technology Vision 2021

In the full wake of the COVID-19 pandemic, we argued that leaders weren't waiting for the future to arrive, they are already building it by embracing five technology trends:

Stack Strategically

Rearchitecting government for what's next

A new era of government is dawning – one in which an agency's technology architecture will be a critical factor in whether they succeed or fail in their mission responsibilities. But building and wielding the best technology stack for mission success means thinking about technology differently, and making business and technology strategies indistinguishable.

Mirrored World

Digital twins report for duty

Leaders are building intelligent digital twins to create living models of shipyards, jet fighters, supply chains, product lifecycles, and more. Bringing together data and intelligence to represent the physical world in a digital space will unlock new opportunities to operate, collaborate, and innovate.

I, Technologist

Empowering innovators in the workforce

Powerful capabilities are now available to people across the agency enterprise, adding a grassroots layer to enterprises' innovation strategies. Now every employee can be an innovator, optimizing their work, fixing pain points, and keeping the business in lockstep with new and changing needs.

Anywhere, Everywhere

Integrating your virtual workplace

It's time to transform remote work from an accommodation to an advantage by rethinking what the organization looks like and what it can achieve with a virtualized workforce model. Leaders must develop "bring your own environment" strategies, addressing the security ramifications of remote work, necessary cultural shifts, and the evolving purpose of physical office space.

From Me to We

Take the mission further with multiparty systems

The demand for contact tracing, frictionless payments, and new ways of building trust brought into sharp focus what had been left undone with enterprises' existing ecosystems. Multiparty systems enable agencies to employ the power of partnerships and trusted data to address increasingly complex challenges.

Behind the Vision

The Accenture Technology Vision takes a systematic look across the enterprise landscape each year to identify evolving technology trends with highest possibilities to disrupt businesses, governments, and societies over the next three years. For 22 years, corporate and government leaders have relied upon this research to prepare their organizations for what's next.

The Accenture Technology Vision is produced by Accenture Labs and Accenture Research. It draws on internal research and analysis, insight from the Technology Vision External Advisory Board, and results of a global survey of 4,660 c-suite executives spanning 23 industries and 24,000 consumers worldwide. Instead of focusing just on the drivers of technological change, the Accenture Technology Vision is distinguished by its examination of the broader themes poised to have the most enduring and transformative impact on how enterprises operate.

The Accenture Federal Technology Vision 2022 applies these insights and findings to the unique challenges and demands facing the U.S. federal government. It features in-depth analysis from more than 50 Accenture Federal Services experts and results of a survey of 200 U.S. federal government executives.

Accenture Federal Technology Vision 2022 Editorial & Marketing Team

John Conley, Riley Panko, Steve Watkins and Katrina "Kat" Szakolczai

Accenture Technology Vision 2022 Editorial & Research Team

Michael Biltz, Ari Bernstein, Julian Dreiman, Maria Fabbroni, Naomi Nishihara, Lara Pesce Ares, and Krista Schnell

Accenture Research (for the Accenture Technology Vision 2022)

Renee Byrnes, Mariusz Bidelski, Gerry Farkova, Harrison Lynch, Sandra Najem, Haralds Robeznieks, Swati Sah, Abira Sathiyanathan, Gabe Schmittlein, and Mélina Viglino

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