

REALITY CHECK:

**Why the U.S.
Government Should
Nurture XR
Development**

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About The Digital Trade and Data Governance Hub



Since 2019, the Digital Trade and Data Governance Hub at The George Washington University has educated policymakers about digital trade, data governance and data driven change. The Hub is the only organization in the world that maps various types of data governance to show commonalities and differences. The Hub is now also part of the NIST-NSF Trustworthy AI Institute.

About The XR Association



Founded in 2018, the XR Association (XRA) is the voice of the immersive technology industry. Representing the businesses large and small that are shaping the immersive future, XRA provides insight to XR stakeholders on the issues that matter most. The XR Association is leading the way for the responsible development and adoption of XR.

**Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the George Washington University.*

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Executive Summary

In a world where geopolitical power is increasingly linked to technological advancement, the United States government should nurture XR development in a strategic and systemic way. If it fails to do so, other nations may step in to lead the world in the development, adoption, and governance of a technology that is poised to transform the way we live, work, communicate, and deliver essential human services.

Immersive technology – also called “XR” – includes virtual reality (VR), augmented reality (AR), and mixed reality (MR). This technology enables the integration of the physical world and various virtual elements and can be accessed through a variety of devices like head-mounted displays (HMDs), smartphones, tablets, and smart glasses. What is commonly referred to as “the metaverse” describes an emerging immersive, interconnected, and interoperable digital space that will leverage XR technology. While many in the United States still think of XR primarily in the context of gaming or entertainment, U.S. allies and competitors alike recognized years ago the power of this technology to impact critical sectors from manufacturing and infrastructure to healthcare and education, and they have developed a vision for its future. The United States is behind the curve.

XR technology matters because it is already driving economic growth, upskilling the workforce and creating new jobs, and it promises to become a multi-trillion-dollar industry by the end of the decade. It has also been designated a critical technology by both the National Science and Technology Council and the Department of Defense (DoD) because of its importance to national security and the economy. In 2022, Congress listed immersive technology in the CHIPS and Science Act (P.L. 117-167) as one of the 10 “key technology focus areas” designated for U.S. government investment. XR will help the United States address some of its most important strategic challenges such as industrial productivity, workforce development, education and opportunity, and environmental sustainability. What’s more, XR is widely expected to become the next major computing platform, succeeding the smartphone (as the smartphone succeeded the personal computer).

Yet, despite the government's acknowledgment of XR's importance and America's current standing as the world's largest market by revenue for immersive technologies and one of the world's largest producers of XR content and hardware, the United States has thus far not developed a strategy or institutional structure to nurture the XR sector. This failure puts the U.S. at a significant disadvantage and stands in contrast to other nations. If the United States does not correct course, it risks missing its opportunity to lead.

Case Studies: The Enabling Environment and Fostering a Systemic Approach

For a new technology to flourish, policymakers must create an enabling environment that rests on three core pillars: capacity and support for innovation; regulatory certainty; and trust. However, because technologies constantly evolve, policymakers must also adopt a systemic approach. The Organisation for Economic Co-operation and Development (OECD) notes that a systemic approach allows a government to encourage innovation, provide a predictable regulatory environment, protect users from harm, and build trust as technologies change over time. South Korea, the United Kingdom (UK), the European Union (EU), and China have made significant progress toward creating an effective XR enabling environment. Although none has maximized every aspect of a systemic approach to nurturing XR, each government has a vision for XR's role in society and the economy, and is actively working to achieve that vision on multiple fronts.

The Republic of Korea (South Korea)

South Korea is already a global leader in leveraging immersive technology to improve public services and the government is focused on creating the environment needed for the XR industry to grow. The Korean government implemented its Digital New Deal initiative to nurture the "hyper-connected and immersive emerging industries which will lead the digital future" and support Korean businesses to "go global" with innovative digital products and services. Korea has also established the Immersive Economy Policy Council to facilitate collaboration between the government and the private sector to nurture XR. It has published strategic roadmaps to proactively address regulatory challenges and opportunities associated with XR, and has implemented public service platforms using XR, like Metaverse Seoul.

The United Kingdom

The UK is emerging as a global leader in the realm of digital twins (digital representations of physical objects, people, or processes, contextualized in a digital version of their environment) and has prioritized immersive technology as an essential component of its vision for a 21st century Cyber-Physical Infrastructure. The UK has also developed strategies and policies to nurture XR content creation and is starting to put in place the building blocks for a strategy to govern the metaverse.

The European Union

The EU aims to be the world leader in the industrial use of XR and a dominant force behind the metaverse. The European Commission recently announced an investment of more than \$10 billion in funding for critical technologies, including virtual reality, as part of its Strategic Technologies for Europe Platform (STEP). And in July 2023, the EU released an official recommended strategy, “An EU initiative on Web 4.0 and virtual worlds: a head start in the next technological transition,” to set out proposed actions to ensure XR technologies develop in line with European values.

The People’s Republic of China (China)

China has integrated XR into its national industrial and technology strategies to position itself as a leading producer of immersive technology and to secure a commanding role in the XR sector. China has carefully engineered numerous strategies, such as the Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022–2026), and has demonstrated a willingness and ability to subsidize, nurture, and govern data-driven technologies at both the national and regional levels. Moreover, certain cities have already taken significant steps to streamline and consolidate supply chains, hoping to facilitate the emergence of Chinese companies that can dominate the future of XR production.

The United States

The United States is home to some of the world's largest producers of XR content and hardware, and the U.S. government has supported research in immersive technologies and invested in underlying infrastructure, like 5G. These lines of effort are further strengthened by the passage of the CHIPS and Science Act. However, the U.S. has not articulated a vision for XR. The U.S. is the world's epicenter for disruptive innovation, thanks to its exceptional research infrastructure and low barriers to entrepreneurs and start-ups. America should be the world leader in XR.

Opportunity For Both International Cooperation and U.S. Leadership

At the conclusion of their 2023 Annual Summit in Kyoto, Japan, the leaders of the world's largest economies, the G7, issued a Leaders' Communiqué that addressed the coming impact of XR technology and the metaverse, stating: **"We recognize the potential of immersive technologies, and virtual worlds such as metaverses, to provide innovative opportunities in all industrial and societal sectors, as well as to promote sustainability.** For this purpose, governance, public safety, and human rights challenges should be addressed at the global level. We task our relevant Ministers to consider collective approaches in this area, including in terms of interoperability, portability, and standards with the support of the OECD. We express our interest in possible joint cooperation in research and development on computing technologies. We also task our relevant Ministers to consider ways to further promote digital trade."

Thus, the United States has an invitation to partner with like-minded countries to shape the future of XR. In addition to the G7, there are a number of other multilateral fora where the U.S. is already helping bring together allies to shape the future technology landscape: the EU-U.S. Trade and Technology Council (TTC), the International Telecommunication Union (ITU), the Organisation for Economic Co-operation and Development (OECD), and the United Nations (UN) all provide opportunities for the U.S. to foster international cooperation on XR technologies. **America's technological prowess, economic influence, and commitment to democratic values, however, make the U.S. well-positioned not just to participate, but to lead initiatives to develop, deploy, and govern XR.**

As a pioneer in the creation of the technology, the U.S. possesses significant expertise and resources to guide international standards, regulations, and best practices in the field. In so doing, the U.S. can foster cross-border collaborations, facilitate knowledge exchange, and help ensure the responsible and ethical advancement of immersive technology worldwide. But first, the United States must develop its own strategic vision for XR.

Recommendations

The U.S. government should develop a strategy, a structure, and policies to nurture XR in the way that they have for other critical technologies. Specifically,

- 1. Congress should introduce legislation authorizing an advisory council to develop a strategy to nurture XR in the United States.**
- 2. Congress should empower U.S. government agencies to model how digital twins can be leveraged by the government to serve the public interest.**
- 3. Congress should pass a comprehensive federal data protection law.**
- 4. The White House should establish structures to coordinate, enhance, and fund federal XR research and development.**
- 5. The Department of State should host a global summit to foster debate and cooperation around complementary regulatory and governance frameworks and ensure that XR technology reflects democratic values.**

Introduction

U.S. policymakers have long believed that both America's soft power and its military might are built on a foundation of technological superiority.ⁱ In the most recent U.S. National Security Strategy, Biden Administration officials asserted that critical and emerging technologies "are poised to retool economies, transform militaries, and reshape the world."ⁱⁱ One of these transformative technologies is immersive technology (also called "XR").

XR – a suite of technologies that includes virtual reality (VR), augmented reality (AR), and mixed reality (MR) – will revolutionize the way we work, play, learn, engage with one another, and deliver essential human services. In fact, governments and business leaders around the world expect XR to underpin the next iteration of the internet and the future of computing.ⁱⁱⁱ In May 2023, the G7, a group composed of the leaders of the world's seven largest economies, issued a public statement outlining areas of consensus on global issues. In their official Leaders' Communiqué, the G7 stated, "We recognize the potential of immersive technologies, and virtual worlds such as metaverses, to provide innovative opportunities in all industrial and societal sectors, as well as to promote sustainability."^{iv} These leaders focused on immersive technologies because they understand XR is already supporting economic growth and that it is vital to the future of many sectors. Moreover, XR can help nations achieve imperative objectives such as responding to natural disasters, improving education and healthcare outcomes, and training the workforce of the future. For many countries, XR is essential to national security and economic progress. Indeed, the U.S. has designated XR a critical technology.^v

However, despite its importance to national security and economic progress, the U.S. has not:

- Developed a vision or strategy for XR and the XR ecosystem;
- Consistently invested in XR related research and development and infrastructure;
- Developed an effective enabling environment that is transparent and predictable and protects users from harm;
- Adopted a systemic approach to XR, one that can evolve as the technology changes over time, encourage continued innovation, build regulatory certainty, and sustain user trust.

In contrast, as of September 2023, the Republic of Korea, the United Kingdom, and the European Union and have all moved closer to these objectives. What's more, the People's Republic of China has included the development and deployment of XR in various government strategies at both the national and provincial levels.^{vi}

While many in the U.S. still think of XR as a niche technology used primarily for gaming and entertainment, officials in other nations recognized long ago that XR has the potential to revolutionize nearly every facet of our lives – and they are determined to get there first. If the United States does not correct course, it risks missing the opportunity to lead the world in the development, adoption, and governance of this powerful technology.

In this paper, we explain why XR is a transformative suite of technologies, and we discuss how it will impact national and international economies. We then examine five case studies to compare what various nations are doing to gain competitive advantage. Finally, we offer recommendations for how the United States can increase its competitiveness and serve as the world's leader.

Study Methodology

This study focuses on what governments are doing to encourage the competitiveness of their XR sectors. According to competitiveness scholar and Harvard Business School professor Michael Porter, competitiveness is a dynamic process which will change over time as consumer demand, technology, society, and the polity evolve.^{vii} Porter notes that a government's proper role in the competitiveness equation is one of "catalyst and challenger."^{viii} Similarly, the OECD stresses that policymakers must find ways to adapt governance as technologies change.^{ix} Therefore, governance is a key aspect of competitiveness.

Yet policymakers do not have an easy time governing emerging technologies because, as an analysis for the National Academy of Sciences (NAS) notes, they "involve a complex mix of applications, risks, benefits, uncertainties, stakeholders, and public concerns."^x Certainly, no single entity is capable of fully governing emerging technologies. Instead, policymakers must create "a governance ecosystem that cuts across sectors and disciplinary silos and solicits and addresses the concerns of many stakeholders."^{xi}

XR is a particularly complex system because it involves the concurrent, rapid evolution of supporting infrastructure: 5G; the cloud; components such as displays, sensors, batteries, and semiconductors; multiple stakeholders including funders, users, developers, and suppliers; and data inputs. Thus, in this paper, we view XR as part of a system of technologies intertwined with society.^{xii} Such a system requires a matching system of governance. According to the OECD, a systemic approach allows officials to encourage innovation, provide a predictable regulatory environment, protect users from harm, and build trust.^{xiii} Moreover, because XR technology and its components are rapidly changing, so too is competitive advantage.

A systemic approach to XR allows governments to address these complexities and encourage innovation while also providing a predictable regulatory environment that protects users from harm and builds trust cohesively, comprehensively, and consistently. Thus, we analyze XR governance as a key component of XR competitiveness, and we use a comparative approach to illuminate why the United States must develop a strategy for nurturing XR in order to remain competitive. We compare efforts in the Republic of Korea; the United Kingdom; the European Union; the People's Republic of China; and the

United States. We acknowledge that this group does not present a representative sample of regions, types of governance (democratic/authoritarian), economic systems, levels of development, or XR expertise. However, we chose these countries and the EU because they already have active XR sectors, and we seek to understand how policymakers are trying to advance XR development.

Specifically, we investigated:

- Has the government put forward a vision for nurturing XR?
- Has the government taken steps to support its immersive economy (funding R&D, and funding the underlying infrastructure for XR such as 5G)?
- Has the government adopted a regulatory approach that is transparent and predictable, supportive of innovation, and likely to build and sustain trust among XR stakeholders?
- Is the government's approach systemic?

In the pages that follow, we provide an overview of the state of the XR industry and detail the major investments, initiatives, and programs each government uses to support its XR sector. Next, we describe the regulatory environment for XR. We utilize the World Bank's definition specific to digital policies, which includes "policy, legal, market, and social considerations that interact at both domestic and global levels to create fertile conditions for [information and communication technology] ICT-led growth."^{xiv} We also discuss whether the government consults with its public.

Finally, we summarize our findings and provide recommendations as to how the United States can nurture XR in a transparent and effective manner. We believe these ideas are consistent with America's long history of promoting key technologies and can help American stakeholders sustain an innovative, trustworthy, and competitive XR sector.

CHAPTER I

What is XR & Why Does it Matter?

The Basics of XR Technology

The U.S. Government Accountability Office (GAO) defines “immersive technology” as a suite of technologies that enables the integration of the physical world and various virtual elements.^{xv} Immersive technology – also referred to as extended reality, or “XR” – includes augmented reality, mixed reality, and virtual reality, and can be accessed through a variety of devices like head-mounted displays, smartphones, tablets, and smart glasses.



Virtual Reality:

VR uses computers and HMDs to replace or occlude a user’s physical environment with a virtual one. A virtual environment can be any setting that can be represented in digitized form – anything from a semiconductor manufacturing plant, to a surgical theater, to a recreation of ancient Rome.

Augmented Reality:

AR uses computer graphics and visualization technology to layer digital content onto a user’s view of their physical space, thus providing an enriched, composite experience. For example, an AR-enabled windshield could display information about a driver’s speed or nearby traffic conditions without obscuring his view of the road.



Mixed Reality:

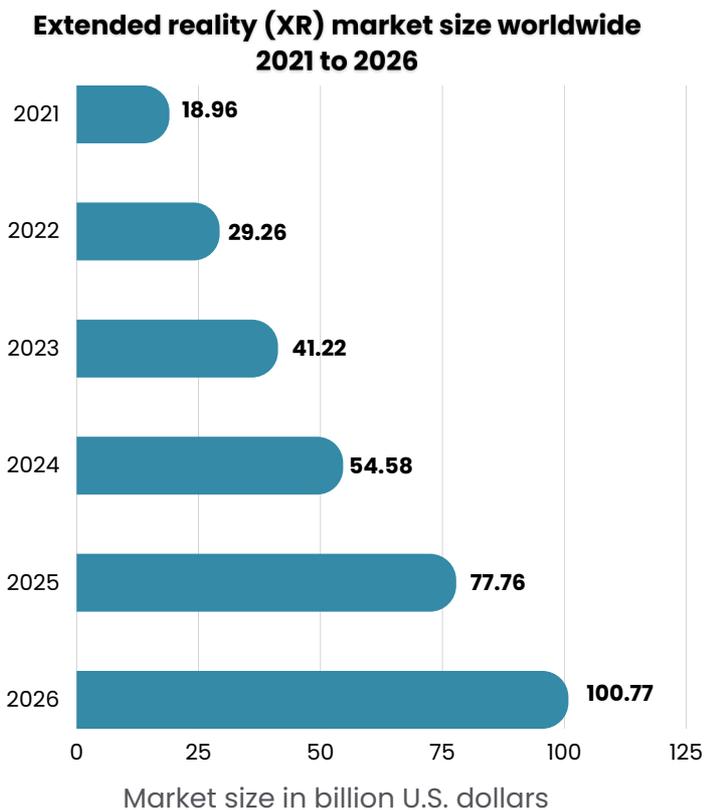
MR blends augmented and virtual reality, allowing users to experience simulated content within their physical environment and to manipulate and interact with virtual elements in real time. In MR, a surgeon can place a 3D image of a patient’s heart in her workspace, allowing her to turn, reposition, resize, and otherwise adjust the image to explore different parts of the anatomy.



To create the immersive experience, XR technology relies on inputs from various components (many of which are already in use in other popular devices like smartphones and fitness wearables) such as internal and external cameras, inertial measure units (IMUs) like gyroscopes and accelerometers, and microphones. Outward facing cameras visually capture the user’s environment to track movement within the physical space, improving the experience and helping the user to avoid bumping into physical objects. Inward facing sensors capture eye gaze, allowing the device to display content within the user’s view. And IMUs measure the device’s movement to support positional tracking, which also helps XR devices accurately display digital content relative to the physical world.^{xvi}

XR is Already Driving Economic Growth

XR and its component sectors, from cloud computing to AI and sensors, are already essential to the U.S. and global economy. In 2022, UK Research and Innovation, a body of the UK government that directs research and innovation funding, examined how organizations developing or applying immersive technology create economic, social, and cultural value in the UK. It found that some 2,106 immersive technology companies in the UK employed over 16,000 workers and achieved 83% growth in the last five years – despite the impact of



Source: Statista

the pandemic during much of that period.^{xvii} Although statistics on XR vary, Statista found that the global XR market is growing rapidly, reaching \$29.26 billion^{xviii} in 2022 and expected to rise to over \$100 billion by 2026.^{xix} PwC estimates XR will add as much as half a trillion dollars to the U.S. GDP, and \$1.5 trillion to the global economy, by 2030.^{xx} **McKinsey & Co. forecasts that the metaverse will grow into a \$5 trillion industry by 2030.**^{xxi} Regardless of which numbers prove to be most accurate, it is clear that immersive technology will contribute to economic growth worldwide.

XR Impacts Essential Sectors and Public Welfare

XR technology is already transforming various sectors of the economy including manufacturing, healthcare, education, public safety, infrastructure, and defense.

Design, Engineering, and Manufacturing

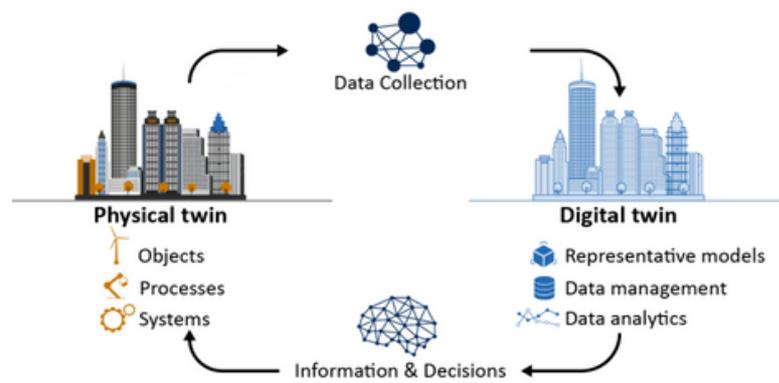
In the manufacturing sector, XR technology is making it easier to design and model products virtually without having to create costly prototypes. For example, Siemens and LG Energy Solution have used digital twins to optimize battery development and performance by testing for potential failure points before the battery is built. Boeing's use of digital twins has revolutionized the way the company designs aircrafts, allowing engineers to simulate how various parts will perform over the lifecycle of the airframe.^{xxii} Digital twins are also helping the United States to understand, prepare for, and mitigate the effects of climate change. After Hurricane Michael destroyed parts of Tyndall Air Force Base in Florida, for example, the Department of Defense used a digital twin to redesign the base from the ground up and create a new climate-resistant infrastructure.^{xxiii}

Manufacturers are also using augmented reality on the factory floor to provide guided instructions and real-time assistance for assembly and fabrication. For instance, engineers and mechanics at Lockheed Martin used AR glasses to overlay images onto their physical work environments to see renderings of cables, bolts, parts, part numbers, and instructions on how to assemble components for the Orion spacecraft – reducing errors and significantly accelerating production.^{xxiv}



Digital Twin

A digital twin is a form of immersive technology designed to digitally reproduce a physical space, object, system, or process. The physical object being studied—for example, a wind turbine—is outfitted with sensors which produce data about different aspects of the object’s performance such as energy output, and external factors like temperature and weather conditions.



Source: U.S. Government Accountability Office

This data is then relayed to a processing system and applied to the digital copy.

Governments and firms use these digital twins to model power generation; monitor large infrastructure

such as drilling platforms or bridges; improve manufacturing processes; and model how an earthquake might affect basic public services and the surrounding environment.^{xxv}

Healthcare

Immersive technology is enhancing medical training and healthcare, expanding access to cutting-edge therapies, and improving patient outcomes. According to the U.S. Food and Drug Administration (FDA), which has approved nearly forty XR devices for use over the past ten years, “Augmented Reality and Virtual Reality (AR/VR) have the potential to transform health care, delivering altogether new types of treatments and diagnostics, and changing how and where care is delivered. Central to their potential in diagnosis and treatment is their ability to deliver both standard and entirely new types of content in highly immersive and realistic ways, remotely, and tailored to a variety of clinical contexts. Physicians, patients, and caregivers can enlist AR/VR to help them prepare for, or perform, certain treatments or procedures.”^{xxvi}

In 2020, for instance, neurosurgeons conducted Johns Hopkins' first AR-guided spinal surgery by projecting images of the patient's internal anatomy based on CT scans.^{xxvii} Outside of the operating room, the Department of Veterans

A study from UCLA's David Geffen School of Medicine saw a 230% boost in overall performance in tibial intramedullary nailing, a procedure to repair a fractured tibia, among VR-trained surgeons relative to their traditionally trained counterparts.^{xxx}

Affairs uses VR technology to provide cognitive behavior therapy to soldiers with difficult to treat post-traumatic stress disorder and to reduce discomfort in amputees experiencing phantom limb pain.^{xxviii} XR also allows care providers to practice complex techniques in life-like, no-risk virtual environments. Case in point, students at the UC San Francisco School of Nursing are using VR to practice treating postpartum hemorrhaging, one of the leading causes of maternal morbidity.^{xxix}

Workforce Development

Across many sectors, XR is helping to prepare people for the future of work. According to the World Economic Forum's 2023 Future of Jobs report, 44% of workers' skills will be disrupted over the next five years.^{xxx} In a world where generations of technology are outpacing generations of workers, XR has become an essential tool for upskilling, retraining, and continuing education within the workforce. For instance, in the utilities industry, New Jersey Natural Gas is using VR to train workers on a range of modern public safety skills like fire suppression and natural gas leak emergency response. Fiber optics provider Millennium uses VR training programs to educate workers on procedures to efficiently identify and solve problems in the field.^{xxxi} Texas-based immersive learning firm, Interplay Learning, has partnered with the Associated Builders & Contractors Union to provide VR training in skilled trades such as HVAC, plumbing, solar, and electrical work and recently launched a Department of Labor-approved apprenticeship program. Meta is partnering with Interplay Learning to address the skills gap in vocational training by scaling Interplay's VR content through partnerships with high schools, community colleges, trade schools, small and medium sized businesses, and workforce development organizations.^{xxxii}

What's more, immersive technology allows workers to learn in-demand skills at their own pace from any location, and to receive instant feedback, helping create educational and workforce training opportunities in rural and underserved communities. Immersive technologies are also cost-effective, reducing the need for expensive training facilities.

According to a study from PwC & Talespin –

- **VR learners required less time to learn:** VR-trained employees completed training up to 4x faster than classroom learners, and 1.5x faster than e-learners.
- **VR learners demonstrated higher confidence in what they learned:** VR-trained employees were 275% more confident to act on what they learned after training – a 40% improvement over classroom learners, and a 35% improvement over e-learners.^{xxxiv}

Public Safety and Disaster Preparedness

Public safety professionals from law enforcement officers, to firefighters, to emergency medical personnel are using XR to better serve their communities and improve on-the-job safety. VR is helping police officers develop the skills needed to handle tense situations by allowing them to virtually practice de-escalation techniques and understand how body language and verbal commands influence outcomes.^{xxxv} Firefighters are using MR to see through smoke and identify people and objects in a burning building.^{xxxvi} XR technology can also assist with disaster coordination in real time.^{xxxvii} The University of Calgary, for example, is exploring the use of interactive 3D AR maps to examine flood patterns, assess damage, and determine evacuation routes.^{xxxviii} Meanwhile, Ohio State University has developed an immersive technology program to train first responders for mass casualty incidents like a bombing.^{xxxix}



Source: National Institute of Standards and Technology

National Security and Defense

The United States military was one of the earliest adopters of immersive technology and it continues to use XR for training and warfighting.^{xl} The Army's Synthetic Training Environment, which utilizes XR, helps to prepare soldiers for combat in different environments from dense cities to remote jungles. The Department of Defense has also explored ways to use VR to train medical personnel for work on the battlefield, as military medics often face situations that are difficult or dangerous to replicate in real life.^{xli} The Air Force is using XR to provide dynamic flight and sensor information to pilots, thereby improving their situational awareness. Meanwhile, the Army is developing the Integrated Visual Augmentation System (IVAS) - a day/night, mixed reality head-mounted device - to improve soldier mobility and lethality in^{xlii} combat.

XR Technology Will Help the United States Address Strategic Challenges

The CHIPS and Science Act of 2022 (Public Law No. 117-167) was enacted to strengthen American manufacturing, supply chains, and national security, and invest in research and development, science and technology, and the workforce of the future to position the United States as the leader of the industries of tomorrow.^{xliii} The bill articulates five societal, national, and geostrategic challenges faced by the United States and highlights the essential role technology will play in confronting them. **Specifically, CHIPS and Science names 10 key technology focus areas that must be prioritized to ensure America's status as the global leader - among them is immersive technology.** As the White House said in announcing the President's signing of the bill, "the CHIPS and Science Act makes the smart investments so that Americans can compete in and win the future."^{xliiv}



(e) INITIAL LIST OF KEY TECHNOLOGY FOCUS AREAS.—The initial list of key technology focus areas are the following:

(6) Advanced communications technology and immersive technology.

Societal, National, and Geostrategic Challenges identified in the CHIPS and Science Act:

1. United States national security.
2. United States manufacturing and industrial productivity.
3. United States workforce development and skills gaps.
4. Climate change and environmental sustainability.
5. Inequitable access to education, opportunity, or other services.

Key Technology Focus Areas listed in the CHIPS and Science Act:

- Artificial intelligence, machine learning, autonomy, and related advances.
- High performance computing, semiconductors, and advanced computer hardware and software.
- Quantum information science and technology.
- Robotics, automation, and advanced manufacturing.
- Natural and anthropogenic disaster prevention or mitigation.
- Advanced communications technology and **IMMERSIVE TECHNOLOGY.**
- Biotechnology, medical technology, genomics, and synthetic biology.
- Data storage, data management, distributed ledger technologies, and cybersecurity, including biometrics.
- Advanced energy and industrial efficiency technologies, such as batteries and advanced nuclear technologies, including but not limited to for the purposes of electric generation.
- Advanced materials science, including composites 2D materials, other next-generation materials, and related manufacturing technologies.

The United States has Designated XR a Critical Technology

The U.S. government designates some technologies as “critical” to both economic growth and U.S. national security. The U.S. first designated variants of XR as critical technologies in 1995.^{xlv} More recently, the National Science and Technology Council included augmented reality and virtual reality on the “Critical and Emerging Technologies List Update” of 2022.^{xlvi} This list identifies technologies that have the potential to further U.S. national security objectives including the protection of American citizens, the expansion of economic prosperity and opportunity, and the realization and defense of democratic values as outlined in President Joe Biden’s Interim National Security Strategic Guidance.^{xlvii} Also in 2022, policymakers included immersive technology on the Department of Defense critical technologies list^{xlviii} for its role in enhancing warfighter training, as well as its potential to help the military become more effective, resilient, cost-efficient, and sustainable.^{xlix} Augmented and virtual reality are named under the subheading “Effective Adoption Areas,” denoting technologies “where there is existing vibrant commercial sector activity.”¹

XR is Forecasted to be the Next Major Computing Platform

In 2016, Goldman Sachs proclaimed that immersive technology would become the next major computing platform.^{li} In 2021, former Vice Minister of the Chinese Ministry of Science and Technology, Wu Zhongze, said, “the metaverse will definitely become a wind vane of global technology development in the next decade, and will also become a new high ground of competition in the digital economy of all countries.”^{lii} Indeed, many technologists and policymakers see immersive technology as the next major computing platform and essential to the evolution of the internet.^{liii}

As Apple CEO Tim Cook said, “AR is a profound technology that will affect everything [...] The future is going to be about augmented reality, wearable computing, and immersive experiences.”^{liv} Apple backed-up this statement with the highly-anticipated release of its mixed reality HMD, the Apple Vision Pro, in June 2023. That announcement echoed Meta CEO Mark Zuckerberg’s



commitment to immersive technology. Zuckerberg also predicts XR will be “the next chapter of the internet” and will offer “completely new experiences that

don’t really fit how we think about computers or phones today.”^{lv} In September 2023, Meta released its third iteration of the market-leading Quest VR headset as well as the second generation of its AR glasses. Similarly, Jensen Huang, CEO of NVIDIA, believes virtual worlds are “where we will create the future” and transform how the world’s biggest industries operate.^{lvi}

What is the Metaverse?

XR serves as the foundational technology for what is often referred to as “the metaverse.” Although many different definitions have emerged, the metaverse is generally understood to be a persistent, online immersive space where users can engage with one another and manipulate the digital environment around them. It is yet to be seen how exactly this virtual world will evolve. But on the most bullish end of the spectrum, some envision “a massively scaled and interoperable network of real-time rendered 3D virtual worlds that can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments.”^{lvii}



CHAPTER II
**We are at a
Pivotal Moment**

U.S. firms lead the world in the development of XR and provide many of its key components. But without further U.S. government support, that lead may wane. Other nations – including South Korea, the United Kingdom, the European Union, and China – have developed strategies and policies to build a competitive advantage in XR,^{lviii} providing regulatory certainty for their domestic companies as they innovate.^{lix} The U.S. has not yet adopted such an approach.

A Brief History of the Federal Government's Role in U.S. Technology Development

The United States has always been a nation of tinkerers, inventors, and researchers.^{lx} Many of the nation's founders including Benjamin Franklin, Thomas Jefferson, and George Washington were also inventors.^{lxi} Collectively and over time, tinkering, inventing, and research helped the United States become a global technological leader.^{lxii} Yet, throughout our history, Americans have debated the proper role of government in nurturing innovation.^{lxiii} In general, policymakers have been reluctant to pick winners and losers.^{lxiv} Still, U.S. government support can be an important contributor to the development of an enabling environment that supports invention and technology breakthroughs.

Over the course of the past two centuries, the U.S. government's involvement in technology development has ebbed and flowed. In the 19th century, the government funded key investments in infrastructure and President Lincoln signed the Pacific Railway Act – facilitating completion of the Transcontinental Railroad and setting the stage for decades of commercial and industrial expansion.^{lxv} In the mid-20th century, policymakers recognized that technology could help the Allies win World War II and encouraged researchers, companies, and soldiers to tinker. Over time, many of the technologies developed during World War II such as microwaves, computers, and antibiotics, became commercialized, moving from military to consumer use.^{lxvi} But the U.S. lacked a formal strategy and structure to encourage further research and development at that time.

Then, in 1950, the White House called for, and Congress approved, the creation of the National Science Foundation (NSF) "to promote the progress of science, to advance the national health, prosperity, and welfare, and to secure the national defense."^{lxvii} This approach to supporting science and technology worked well for some 50 years. As a result of a national vision and a coordinated approach, America put a man on the moon in 1969, and research and development commissioned by the DoD led to the creation of the internet in the 1970s. But by the 1990s, technologies like artificial intelligence, advanced manufacturing, biotechnologies, and human-machine interfaces, had become increasingly complicated, intertwined, and global – and America risked losing its competitive edge.



Source: National Aeronautics and Space Administration

In recognition of this new complexity, the U.S. Congress mandated that the government develop a list of critical technologies that experts viewed as essential^{lxviii} to both the nation's security and its economic prosperity. Policymakers were now obligated to build strategies and institutions to nurture innovation, research and development, and technology transfer.^{lxix} Soon thereafter, the U.S. began to invest in a wide range of basic and applied research and provided incentives for innovation. By 2020, however, this system began to show cracks as other countries invested even more money in research and development and skills training, and developed their own incentives to stimulate innovation in key sectors.^{lxx}

Where We Are Today

To bolster U.S. innovation, in 2022 Congress passed the landmark CHIPS and Science Act, which appropriated billions of dollars to jumpstart U.S. semiconductor capacity. The act also greatly increased authorizations for federal science and technology research and development programs, allocating \$174 billion through Fiscal Year 2027 to support the nation's science and technology base. In addition, the CHIPS and Science Act authorized \$10 billion over five years for the newly established Regional Technology and Innovation Hubs program at the Department of Commerce,^{lxxi} and authorized the creation of the Regional Innovation Engines program under the NSF. These programs were designed to support "technology development, job creation, and the expansion of U.S. innovation capacity."^{lxxii}



Source: U.S. Department of State

In January 2023, the U.S. Department of State announced that it was creating a new position, a Special Envoy for Critical Technologies, because "the competition to develop and deploy foundational technologies is intensifying."^{lxxiii} The authors of this report believe this intensification is occurring for several reasons. First, technological innovation has become

increasingly important to all nations. Recent global history has vividly demonstrated that early success in specific technology spheres such as e-commerce and social media results in substantial compounding and self-propagating advantages for the earliest creators of infrastructure, standards, and policy of such technologies. For example, American companies Facebook (now Meta), Amazon, Twitter (now X), Google, Uber, and Airbnb have become global economic engines, spawning supporting industries and further growth in their own right. Recognizing this, Chinese officials made technological innovation a top priority, beginning in 2015 with the "Made in China 2025" strategic plan. Then, in 2023, the Chinese Communist Party (CCP) reorganized the government to take greater control over emerging technologies.^{lxxiv}

Secondly, competition is intensifying because emerging technologies not only fuel economic growth but underpin military power.^{lxxv} And finally, a growing number of countries including the UK, Germany, France, Sweden, China, and South Korea not only put large amounts of money into research, but their governments also make substantial, enduring investments in STEM education from primary to doctoral levels. These countries are creating a formidable cadre of skilled workers and technologists.^{lxxvi}

Not surprisingly, scholars and analysts increasingly argue that America's approach to fostering the competitiveness of its technologies must change because of this intensifying competition.^{lxxvii}

Other Nations are Invested in XR

Other countries around the world are investing in XR and supporting innovation in the field. China has already carefully engineered numerous strategies to secure a commanding role in XR, such as the Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022-2026), and has demonstrated the willingness and ability to subsidize, nurture, and govern data-driven technologies.^{lxxviii} Similarly, South Korea has implemented its Digital New Deal initiative to nurture the "hyper-connected and immersive emerging industries which will lead the digital future" and support Korean businesses to "go global" with innovative digital products and services.^{lxxix} And in the EU, the European Commission (EC) recently announced an investment of more than \$10 billion in funding for critical technologies, including virtual reality, as part of its Strategic Technologies for Europe Platform (STEP).^{lxxx} The UK and France have also developed strategies and policies to nurture XR and put in place the building blocks of the metaverse.^{lxxxi}

Opportunity for Both International Cooperation and U.S. Leadership

As noted previously, the G7 issued a Leaders' Communiqué upon concluding their annual summit in Japan which recognized that technology development is outpacing technology governance. They pledged to “work with technology companies and other relevant stakeholders to drive the responsible innovation and implementation of technologies,” and “to discuss ways to advance technology for democracy and to cooperate on new and emerging technologies and their social implementation, and look forward to an inclusive, multi-stakeholder dialogue on digital issues[...].”^{lxxxii} With respect to immersive technology, the G7 recognized the potential impact of the metaverse, stating:

“We recognize the potential of immersive technologies, and virtual worlds, such as metaverses to provide innovative opportunities in all industrial and societal sectors, as well as to promote sustainability. For this purpose, governance, public safety, and human rights challenges should be addressed at the global level. We task our relevant Ministers to consider collective approaches in this area, including in terms of interoperability, portability, and standards with the support of the OECD. We express our interest in possible joint cooperation in research and development on computing technologies. We also task our relevant Ministers to consider ways to further promote digital trade.”^{lxxxiii}

Thus, the United States has an invitation to partner with like-minded countries to shape the future of XR. In addition to the G7, there are a number of other multilateral fora where the U.S. is already helping bring together allies to shape future technology landscape: the EU-U.S. Trade and Technology Council (TTC), the International Telecommunication Union (ITU), the OECD, and the United Nations (UN) all provide opportunities for the U.S. to foster international cooperation on XR technologies.

What's more, America's technological prowess, economic influence, and commitment to democratic values make the U.S. well positioned to lead initiatives to develop and deploy XR. As an early leader in the creation of the technology, the U.S. possesses significant expertise and resources to guide international standards, regulations, and best practices in the field. In so doing, the U.S. can foster cross-border collaborations, facilitate knowledge exchange, and help ensure the responsible and ethical advancement of immersive technology worldwide. But first the United States must develop its own strategic vision for XR.



CHAPTER III

The Enabling Environment and Fostering a Systemic Approach

For new technology to flourish, policymakers must create an enabling environment that nourishes innovation while protecting market participants and the public alike. Most countries also seek to create an enabling environment that builds trust and provides certainty to market actors.^{lxxxiv} This paper examines three core pillars of an enabling environment: capacity and support for innovation; regulatory certainty; and trust. These pillars are also key elements of a systemic approach. The OECD notes that a systemic approach comprehends that new technologies are often part of a complex ecosystem that evolves over time. Hence, a systemic approach not only encourages innovation, provides certainty, protects people from harm, and builds and sustains trust, but it also evolves as the technology evolves.^{lxxxv}

Capacity and Support for Innovation

Innovation capacity reflects the fundamental conditions, investments, and policy choices that create the environment for innovation in a particular place.^{lxxxvi} National innovation capacity depends in part on the technological sophistication and the size of the scientific and technical labor force in a given economy. It also reflects the array of investments and policy choices of the government and the private sector that affect the incentives for a country's research and development activities.^{lxxxvii} **While the United States has long ranked as the world's top nation for innovation capacity, others have stepped-up their efforts, particularly in the field of XR.**

For example, as far back as 2016, South Korea's Ministry of Science, ICT (Information and Communications Technology), and Future Planning recognized XR development as one of nine national strategic projects that would be "responsible for the future."^{lxxxviii} Through the years, South Korea has maintained its commitment to fostering XR by investing more than \$175 million to support the production of 3D objects under its Digital Twin Activation Strategy and establishing the Emerging Metaverse Industry Promotion Strategy.^{lxxxix} Similarly, in 2018, China's Ministry of Industry and Information Technology published the Guiding Opinions for Accelerating the Development of the Virtual Reality Industry, which outlined strategic initiatives and policy measures to stimulate growth and innovation and position the country as a global leader in XR.^{xc} The Chinese government also developed the Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022-2026), outlining what policymakers should do to nurture XR.^{xcii}

Regulatory Certainty

According to Deloitte, “a regulatory approach that can proactively identify, manage, and deploy regulations that specifically respond to unique challenges can create a new form of competitive advantage going forward.”^{xciii} Businesses rely on predictable, transparent, and streamlined regulatory frameworks to make key investment decisions,^{xciv} and countries that create a regulatory environment that is not overly burdensome provide a strong foundation for this type of future-planning. On the other side, regulatory uncertainty can create the perception of risk and reduce investment, which is detrimental to growing the economy and creating job opportunities.^{xcv}

Various nations are rethinking how to structure regulatory frameworks to nurture and govern immersive technologies.^{xcvi} For example, the UK’s Department of Science, Innovation, and Technology (DSIT) has committed to “lead on the regulation of AI and on the future of web technology, sometimes known as Web 3 or the Metaverse [...] to maximise the potential of Web3 and spur UK growth and innovation, alongside empowering individuals to influence how their data is used, and managing downside risks to privacy, security and harms.”^{xcvii} And the European Commission is actively working on a virtual worlds initiative and has developed a vision for the metaverse, based on respect for digital rights and EU laws and values.^{xcviii}

Trust

Trust is essential to data driven technologies. Thus, how XR firms use personal data is a key element of how firms build that trust. Businesses providing XR hardware, platforms, and services must build trust with their consumers in order for the immersive technology industry to grow and flourish. In fact, studies show that customers will take business elsewhere if they feel a company is not delivering on trust.^{xcix} Accountability, fairness, reliability, privacy, safety, and transparency are key components of establishing trust in digital technologies like XR.^c However, XR can be opaque, complex, and difficult for users to understand. Many VR systems rely on headsets that utilize specialized sensors to function effectively, as discussed earlier in this paper. These sensors collect various types of personal data and information about users' location, movements, gaze, posture, and sometimes autonomic responses like pupil dilation and heart rate.^{ci}

To convince XR users that XR is safe and predictable, XR creators and deployers, as well as governments, must find ways to engender trust in the governance of data.^{cii} The European Commission has taken steps in that direction, creating a citizens' panel made up of a diverse group of Europeans to advise the EC on how virtual worlds will impact the public and how they might be governed. These panels helped to educate users about immersive technology and demonstrated that the government was working to build the processes and frameworks necessary to engender trust in XR. More generally, all of the governments we studied for this paper, except for the United States, have adopted national laws governing the use of personal data, including biometric data, in order to provide a baseline set of expectations and protections, helping to foster consumer trust and confidence in data-driven technologies.^{ciii}

A world map is centered in the background, rendered in a light gray tone. Several regions are highlighted in a darker blue color: North America (including the United States and Canada), Western Europe, and East Asia (including China and Japan). The map is overlaid with a semi-transparent white rectangular box that serves as a background for the chapter title. The background of the entire page is a light gray with a pattern of white, curved, glowing lines that create a sense of motion and depth.

CHAPTER IV

Case Studies

The heart of this report is the suite of case studies that follow. Here, we present the basic facts about what key U.S. allies and competitors are doing to support the development and adoption of immersive technology. Some governments are pursuing a national approach, while others are thinking more globally. Regardless of these distinctions, **what each of the governments we examined share is that they are working with industry, academia, and often their public to nurture, invest in, and encourage XR in a systemic manner. In this regard, the U.S. is the exception.**

The Republic of Korea (South Korea)

Overview

South Korean officials consider XR to be a strategic technology that aligns with their ambitions for global competitiveness and technological sovereignty.^{civ} They also recognize the potential of immersive technology to stimulate economic growth and improve human welfare.^{cv} Accordingly, South Korean policymakers have implemented multiple initiatives and strategies, and stood up public-private partnerships to nurture the XR sector.^{cvi} What's more, the South Korean government has taken a comprehensive approach to nurturing XR, providing significant funding for both research and XR-related infrastructure (such as 5G), and crafting a regulatory environment designed to promote innovation and trust. South Korean policymakers are currently in the process of drafting metaverse-specific regulations to establish the country as a metaverse leader.^{cvii}



Government Policies and Actions to Build XR Capacity and Innovation

South Korea was among the first nations to adopt a strategy to advance XR. In 2016, the Ministry of Science, ICT, and Future Planning identified XR development as one of nine national strategic projects that would be “responsible for the future.”^{cxviii} ^{cxix} Later that year, the Ministry announced plans to develop technologies, platforms, experiences, and an industrial ecosystem that would allow the immersive economy to flourish.^{cx} The Ministry recognized the potential of XR to drive economic growth and enhance public welfare across a range of sectors including manufacturing, medical care, national defense, and education. Hence, it committed to investing \$210 million and to raising an additional \$96.5 million from the private sector by 2020.^{cx} These funds would be used to expand research and development in core XR technologies and to promote strategic flagship projects including the development of service platforms, immersive game experiences, a VR theme park, advanced display screens, and innovative educational applications.^{cxii}

By 2019, the South Korean government had concentrated its support for XR into three principal areas: 1) developing the core technologies; 2) supporting immersive cultural content creation; and 3) encouraging the development of products and services that integrate XR with other technologies.

Then, between 2019 and 2020, Korea introduced formal policy documents related to XR^{cxiii} which would:

- Establish specialized funds to support XR startups.^{cxiv} The most important of these are the 5G Realistic Content Fund announced by the 2019 5G+ Strategy Action Plan, and the Digital Content Fund.^{cxv} Established in 2015, the Digital Content Fund held \$485 million as of November 2022 and had received hundreds of millions more from subsequent policies.^{cxvi}
- Encourage the adoption of XR in the defense, education, manufacturing, and medical sectors.^{cxvii}
- Establish a Realistic Content Policy Council^{cxviii} – later renamed the Immersive Economy Policy Council – which brings together government ministry representatives and private sector experts to discuss and coordinate on the question of how to foster the immersive economy.^{cxix}
- Set a target investment amount of \$1 billion by 2023.^{cxx}

The Digital New Deal

In response to the COVID-19 pandemic, South Korean officials doubled down on efforts to advance digitization, introducing the Digital New Deal in 2020 as part of a larger coronavirus recovery and jobs package. They planned to invest some \$33.8 billion by 2025 to accelerate the digital transformation and establish a “non-face-to-face society.”^{cxxi} Policymakers emphasized integrating data, networks, and AI throughout the economy; accelerating the convergence of AI and 5G; establishing a digital education infrastructure; promoting remote work; and developing digital twins for smart logistics and management.^{cxxii} Through programs related to the Digital New Deal, South Korea intends to become one of the top five countries in the world for XR, with an anticipated domestic economic impact of \$23 billion by 2025.^{cxxiii cxxiv}

Notably, the Digital New Deal included XR-specific initiatives and funding, including the following:^{cxxv}

- Expanding XR utilization throughout the economy and society, and identifying key sectors including manufacturing, healthcare, construction, education, logistics, and defense for priority integration of XR technology.^{cxxvi}
- Utilizing variants of XR to solve complex problems. For example, the Immersive Economy Development Strategy proposed the development of XR-based solutions for disaster response and safety training.^{cxxvii}
- Developing and funding infrastructure, including not only advanced networks and data accumulation but also a supportive legal system.
- Establishing XR Device Centers and Hologram Centers to enhance competitiveness and promote regional industries.
- Providing support to Korean XR companies by creating XR Funds, fostering specialized XR companies and promoting the convergence of XR with other industries like manufacturing and artificial intelligence.^{cxxviii}

And as noted, the South Korean ICT Strategy Committee issued a Digital Twin Activation Strategy in September 2021. In this strategy, the Committee pledged to invest over \$175 million in 2022 to support the production of 3D objects and make them widely available through an open online platform. In addition, the strategy included plans to introduce digital twin-based simulations and warning systems to help the government prevent disasters like floods and industrial accidents.^{cxxix}

The Emerging Metaverse Industry Promotion Strategy

In 2022, the Ministry of Science, ICT, and Future Planning announced the Emerging Metaverse Industry Promotion Strategy. **This strategy aims to pioneer the creation of a metaverse platform economy, expand opportunities for individuals, and position South Korea as a global leader in the new “digital continent” of the metaverse.**^{cxxx}

The Metaverse Strategy includes:

- Supporting metaverse creators and content development.
- Enhancing the competitiveness of Korean metaverse companies by establishing a hub for supporting corporate growth as well as a demonstration lab.
- Creating a safe and reliable metaverse environment by publishing Metaverse Ethical Principles; overhauling the regulatory system to ensure principles of self-regulation, minimum regulation, and preemptive regulatory innovation; realizing community value and supporting citizen participation and digital inclusion; and continuing the discussion of necessary policy directions within the country and leading the discussion in international fora.^{cxxx}
- Establishing a Metaverse Policy Council to examine governmental progress towards the goals in the strategy and to collaborate with other ministries and with the private sector to publish action plans.^{cxxxii}
- Establishing a Metaverse Graduate School, which would provide training in essential subjects such as XR, big data, artificial intelligence, and business administration.^{cxxxiii} The Ministry also included plans to establish a Metaverse Academy, where students would be trained in both engineering and humanities. In December 2022, the Metaverse Academy welcomed 210 students in its inaugural class.^{cxxxiv}

Pioneering Governance Through Digital Platforms

South Korean policymakers are committed to using emerging technologies to serve their constituents and meet their needs both as consumers and citizens. They say they are building a governance system that is “people-centered, scientific, and transparent”^{cxxxv} and that they aim to address social issues while fostering collaboration among individuals, businesses, and the government through a digital platform that integrates data.^{cxxxvi} For example, the Seoul Metropolitan Government has launched Metaverse Seoul, a public metaverse



Source: Seoul Metropolitan Government

platform that enables citizens to access various administrative and civil services through avatars on their smartphones. This model is intended to serve as a blueprint for virtual municipal administration.^{cxxxvii} South Korean officials frequently discuss their commitment to safety, inclusion, and well-being as they advance digital transformation.^{cxxxviii}

National policymakers intend to cultivate additional metaverse platforms, recognizing the metaverse’s potential to bring about a transformative shift comparable to the evolution from PCs to smartphones.^{cxxxix} As explained above, the Emerging Metaverse Industry Promotion Strategy emphasizes support for the creation of a decentralized, creator economy-driven metaverse platform ecosystem, envisaging applications across diverse sectors including education, office work, manufacturing, media, culture and arts, and the provision of public services.^{cxli} To help make this ecosystem a reality, the Ministry of Science, ICT, and Future Planning in collaboration with industry, academia, and research partners, established the Metaverse Alliance in 2021. The core purpose of this alliance is to foster collaboration, explore emerging technologies and services, and facilitate the growth of the metaverse ecosystem. Since its inception, the Metaverse Alliance has grown to include over 950 large and small members.^{cxlii}

Another important project aligned with the concept of a digital government platform is the “data dam.” As part of the Digital New Deal, South Korean officials created a central repository to collect data generated through public and private networks, which is then standardized, processed, and shared.^{cxlii} The data will be used to improve AI-powered products and services in both the public and private sectors, and enhance overall innovation throughout the economy.^{cxliii} Policymakers later expanded the scope of the data dam to enable use for XR projects, specifically.^{cxliv}

Regulatory Certainty and Trust

South Korea aims to create a regulatory system that can evolve as technology changes, while also fostering innovation and trust. Government officials have already put in place key components of that system, taking steps to reduce or clarify the regulatory burden on companies that are designing and developing XR. Many of the capacity-building plans mentioned earlier, such as the Digital New Deal and the Immersive Economy Development Strategy, include provisions oriented towards reducing or easing regulation. For example, the Digital New Deal aims to streamline the authorization process for XR content creation,^{cxlv} and the Immersive Economy Development Strategy includes provisions encouraging regulation-free zones, regulatory sandboxes, and tax incentives.^{cxlvi}



Source: CryptoSlate

In 2020, the South Korean government published its Roadmap for Preemptive Regulatory Innovation in the VR/AR Field. This plan provided a comprehensive assessment of the regulatory landscape and the future direction of technological and business model development in the XR industry, and recommended that policymakers use the government's ongoing regulatory sandbox program to support XR commercialization.^{cxlvii} Then, in March 2023 the South Korean government announced the Preemptive Regulatory Innovation Plan for the Metaverse, which emphasizes principles of self-regulation and the relaxation of existing regulations guided by standards, clarification in areas like copyright, and ethical principles.^{cxlviii} The Ministry of Science, ICT, and Future Planning stated, "We will not make the mistake of regulating a new service with existing law."^{cxlix} Hence, policymakers are drafting a Metaverse Special Act which could provide a legal basis for promoting policies for "extended virtual worlds."^{cl}

South Korea was also the first OECD member to propose principles for the metaverse. In 2022, the Ministry of Science, ICT and Future Planning introduced the Metaverse Ethical Principles.^{cli} The principles call for metaverse system developers and users to follow the principles of authenticity, autonomy, reciprocity, privacy protection, fairness, inclusiveness, and responsibility for the future.^{clii} It should be noted, however, that these principles are not binding and do not hold the force of law.

With respect to data protection, in 2016 South Korea adopted a personal data protection law: the Personal Information Protection Act. The Act covers sensitive data, including information related to an individual's physical, physiological, and behavioral characteristics that are generated through technical means for the purpose of identifying a specific individual.^{cliii} In 2021, the government released Biometric Information Protection Guidelines to focus on rules related to biometric data, specifically.^{cliv} South Korea also has guidelines on anonymization and de-identification of personal data.^{clv}



Key Points

South Korea has:

- Recognized XR as a technology critical to its future since 2016.
- Established the Immersive Economy Policy Council, facilitating collaboration between the government and private sector to foster XR.
- Published strategic roadmaps to proactively address regulatory challenges and opportunities associated with XR and the metaverse.
- Implemented public service platforms utilizing XR and metaverse technology, such as Metaverse Seoul.
- Introduced a Metaverse Strategy, Metaverse Ethical Principles, and is in the process of drafting a Metaverse Law to provide a legal basis for government support of the sector.

XR Initiatives

- Immersive Economy Development Strategy
- XR Device Centers and Hologram Centers
- 5G Realistic Content Fund
- Digital Content Fund
- XR Funds
- Digital Twin Activation Strategy
- XR Data Dam
- Emerging Metaverse Industry Promotion Strategy
 - Metaverse Ethical Principles
 - Metaverse Policy Council
 - Metaverse Graduate School
 - Metaverse Academy
- Metaverse Seoul
- Metaverse Alliance
- Preemptive Regulatory Innovation Plan, both for XR and for the Metaverse
- Metaverse Special Act
- Metaverse Ethical Principles

The United Kingdom

Overview

The United Kingdom has the largest and fastest-growing immersive economy in Europe.^{clvi} Like South Korea, the British government has identified XR as an



important strategic technology and governmental bodies frequently collaborate with the private sector to drive innovation.^{clvii} In 2018, global consultancy firm PwC estimated that the UK VR entertainment and media sector was set to grow at an average annual rate of 34%, and to be worth \$1.5 billion in 2022.^{clviii} Since 2017, the government has invested in XR through sectoral and economy-wide initiatives,^{clix} and has provided support to XR companies through tax incentives, innovation grants, and funding competitions. The UK has further fostered XR hubs throughout the country as

part of its Creative Industries Clusters Programme.^{clx} London also plays a pivotal role in the UK's immersive technology landscape because it is one of the world's leading financial centers, and is consequently an attractive base for XR developers and entrepreneurs from around the globe.^{clxi} In addition, London is home to many large businesses with active VR and AR departments.

Government Policies and Actions to Build XR Capacity and Innovation

Innovate UK

The British government allocates funds for XR through Innovate UK, a government agency that collaborates with networks and accelerators to drive industrial development. In 2014, Innovate UK launched the Digital Catapult, an innovation center aimed at accelerating the adoption of digital technologies and facilitating connections among companies, financiers, and technical experts.^{clxii}

The Digital Catapult houses several programs devoted to the immersive economy, including dedicated facilities to provide businesses with access to the latest immersive technologies, a financing program for early-stage creative technology companies, and an acceleration program for immersive startups.^{clxiii} Meanwhile, Immerse UK, a non-profit organization that emerged out of Innovate UK in 2016, links industry professionals, the public sector, researchers, and other stakeholders and connects innovators to funders.^{clxiv}



Source: UK Digital Catapult

The UK Industrial Strategy

UK policymakers first began to encourage XR through industrial strategies in 2017 when the UK described several specific Grand Challenges crucial to the UK's economic success^{clxv clxvi} and allocated funding through collaborative business and government Challenge Funds.^{clxvii} For example, the Audience of the Future Challenge Fund invested \$48.6 million in the immersive economy to foster the development of creative content. These investments led directly to the establishment of a diverse range of supportive programs which have since proven critical to the success of Britain's domestic XR industry.^{clxviii}

The UK's industrial strategy also included a series of "sector deals" – tailored agreements negotiated between the government and specific industries to promote investment, collaboration, and growth. The 2018 Creative Industries Sector Deal, which included a variety of initiatives aimed at supporting the growth of the UK's creative industries,^{clxix} focused in part on "capturing new audiences with funding for cutting-edge, immersive content."^{clxx} The Creative Industries deal further launched the Creative Industries Clusters Programme, which invested \$148 million in the establishment of regional hubs for creative industries. XR and interactive storytelling were among the main areas of focus for this program.^{clxxi} These regional clusters have become integral components of the immersive economy in Britain, creating new opportunities for businesses.^{clxxii}

In combination with the Creative Industries Clusters Programme, the Audience of the Future Challenge Fund has supported 906 research and development projects and businesses and attracted \$305 million in co-investment from public and private funders.^{clxxiii} Similarly, the Construction Sector Deal invested \$89 million in the Core Innovation Hub, which supports the modernization of construction sector infrastructure through the development and use of advanced technologies, especially XR.^{clxxiv}

The UK Innovation Strategy

In 2021, the British government released several strategic documents that have helped grow the British XR sector. The Build Back Better: Our Plan for Growth strategy aims to create a more innovative, dynamic, and resilient economy by modernizing regulations, reducing bureaucratic obstacles, and fostering competition to drive innovation.^{clxxv} The UK Innovation Strategy aims to increase R&D spending, streamline regulations, and encourage employment of high-skilled immigrants, among other objectives.^{clxxvi} As part of the UK Innovation Strategy, the government announced an investment of nearly \$93 million in Prosperity Partnerships which involve business-led research projects receiving co-investment from industry and universities, including XR projects.^{clxxvii} What's more, policymakers specifically highlighted XR as a member of the AI, Digital & Advanced Computing Group, one of the "seven technology families of UK strength and opportunity."^{clxxviii}

Digital Twins

The third important strategy document from 2021, **Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy, articulates a vision for the UK to become a "science and tech superpower by 2030."** The strategy specifically calls for a "national capability in digital twinning."^{clxxix} The UK has focused on digital twins since 2017 when the National Infrastructure Commission issued a report emphasizing that data troves are an essential component of the UK's infrastructure. The report recommended that the government use digital twins to model the country's infrastructure to integrate and prioritize maintenance needs, optimize investments, clarify interdependencies, identify energy efficiencies, and eventually acquire predictive capabilities.^{clxxx}

In response to the Commission’s report, the Department for Business, Energy & Industrial Strategy worked with Cambridge University to establish the National Digital Twin Programme at the Centre for Digital Built Britain^{clxxxi} to coordinate and lead efforts to create a digital replica of the UK.^{clxxxii} Researchers began their work by developing a framework to establish a standard approach to information management across the industry, followed by overarching principles to align definitions and values. Finally, they established the Digital Twin Hub, a collaborative learning network for digital twin operators.^{clxxxiii}

UK policymakers have also involved the public in the process of developing digital twins. In its 2021 Innovation Strategy, the

government committed to public consultation on the “potential value of and options for a national capability [in] cyber-physical infrastructure,”^{clxxxiv}

which is defined as an ecosystem of advanced

interconnected systems, including digital twins and smart robotic systems, that span the digital and physical worlds.^{clxxxv}

British policymakers intend to use this system of cyber-physical infrastructure to solve complex problems, stimulate regional economic growth, and earn recognition as a science and innovation superpower.^{clxxxvi}



In March 2023, the Department of Science, Innovation & Technology presented its vision for an ecosystem comprised of networked cyber-physical systems that are accessible across the entire economy.^{clxxxvii} To make this vision a reality, the Department launched several funding competitions, including a competition awarding \$247,000 for the development of a cyber-physical infrastructure ecosystem capability; a \$25 million initiative to establish a digital twin research hub focusing on decarbonization and enhanced integration of transport systems; and a \$3.7 million fund to foster the growth of a digital twin research community.^{clxxxviii} In addition, the Alan Turing Institute, UK’s national institute for data science and artificial intelligence, is currently establishing a hub to “democratise access to digital twin technology by providing open and reproducible computational and social tools.”^{clxxxix} The Institute previously invested \$32 million in digital twin research and innovation.^{cxc}

In June 2023, the UK's Transport Technology and Decarbonisation Minister announced plans to implement digital twins for all modes of transportation by 2035. In the Transport Digital Twin Vision and Roadmap 2035, the Transport Research and Innovation Board (TRIB) outlined steps towards a cohesive digital twin for UK transport in four key areas: strategy and innovation; enabling environment; people, skills and culture; and technology and data.^{cxci} TRIB aims to establish a trusted ecosystem of connected digital twins to enable effective decision-making and deliver efficient, safe, and environmentally conscious mobility. TRIB awarded the Connected Places Catapult, a government sponsored innovation accelerator, a grant to develop a shared 2035 Vision and Roadmap.^{cxcii}

Regulatory Certainty and Trust

British policymakers appear to be building a systemic approach to governing data-driven technologies. Britain is in a unique position because it is no longer subject to EU regulations, and thus has an opportunity to rethink its regulatory scheme. The UK adheres to the General Data Protection Regulation (GDPR), which includes provisions regarding the use of consumer and biometric data. But it is currently undertaking a review of its data protection laws, and it is not certain how biometric data will be governed in the future.^{cxci}

The UK is evaluating other aspects of its regulatory frameworks as well.^{cxci} To foster a pro-innovation approach to the governance of emerging technologies, the government has implemented several measures:

- The Regulators' Pioneer Fund: Since 2019, this fund has provided tens of millions of pounds to regulators and local authorities to support projects that promote a regulatory environment conducive to business innovation and investment.^{cxci}
- The Regulatory Horizons Council: The Council is responsible for identifying the implications of technological advancements and providing impartial expert guidance to the government on regulatory changes necessary to support their swift and safe adoption.^{cxci}

- The Digital Regulation Cooperation Forum: This joint effort involving the Competition and Markets Authority, Information Commissioner’s Office, Office of Communications, and Financial Conduct Authority, works to improve coordination in regulating the digital economy.^{cxcvii} The Forum has identified immersive technologies as a priority area for accelerating knowledge sharing and it hosted the 2022 Metaverse Symposium to facilitate idea exchange among stakeholders.^{cxcviii}
- The Regulatory Sandbox Program at the Information Commissioner’s Office: Since 2019, the Sandbox has supported organizations in developing innovative and safe products and services that utilize personal data. In 2023, the program identified immersive technologies as a key area of focus.^{cxcix}
- The Digital Markets Unit inside the Competition and Markets Authority (in process): This unit will promote competition and innovation in digital markets, while safeguarding consumers and businesses from unfair practices.^{cc}

In addition, in September 2023 the UK Parliament passed the Online Safety Bill, a new regulatory framework aimed at improving online safety standards and addressing harmful content.^{cci} This measure will require online platforms to prioritize safety by design and grant the government expanded powers to hold companies accountable for harms caused to their users. It will also cover platforms providing XR and metaverse services.^{ccii}

Finally, in April 2023 the UK government stated that it will develop a regulatory effort on “the future of web technology, sometimes known as Web 3 or the Metaverse.”^{cciii} The newly formed Department of Science, Innovation, and Technology is expected to explore the opportunities and challenges of the metaverse, including how to ensure its trustworthy, democratic, and accountable governance.^{cciv}

United Kingdom

Key Points

The United Kingdom has:

- Invested in research and development through a variety of strategies including challenges, missions, and funding partnerships.
- Implemented a National Digital Twin Programme based on a vision for XR and digital twins to become key components of national infrastructure.
- Created organizations like Immerse UK and Digital Catapult to provide support to XR companies and foster connections between innovators, funders, researchers, and policymakers.
- Developed a clear and predictable regulatory environment that reflects technological change and attempts to encourage innovation and build trust.
- Consistently sought public comment on plans and policies.

XR Initiatives

- Innovate UK and the Digital Catapult (XR-specific funding and resources)
- Immerse UK
- UK Industrial Strategy
 - Audience of the Future Challenge Fund (XR-specific funding and resources)
 - Creative Industries Clusters Programme (XR-specific funding and resources)
- UK Innovation Strategy's Prosperity Partnerships (XR-specific funding and resources)
- National Digital Twin Programme
- Cyber-physical Infrastructure
- Transport Digital Twin Vision and Roadmap 2035
- The Digital Regulation Cooperation Forum's 2022 Metaverse Symposium

The European Union

Overview

The European Union is both a major producer of XR and a major market for XR. As of 2023, the EU estimates its 27 nations account for one-third of the global XR market.^{ccv} The EU has allocated significant funding for XR research and development, targeting sectoral applications for health, education, and entertainment, as well as XR components like semiconductors and infrastructure like cloud capacity.^{ccvi} Moreover, the EU has recognized the potential societal benefits of XR technologies, including digital twins.^{ccvii} **In 2021, economic research and consulting firm Ecorys, in collaboration with the XR Association, conducted a study of XR’s potential in Europe. They found that XR is likely to create 1.2 to 2.4 million new jobs in Europe directly or indirectly by 2025.**^{ccviii} Another study produced for the European Commission estimated that as of 2021, the EU XR market was valued at around \$12.7 billion^{ccix} and could grow to \$150 billion by 2030.^{ccx}

The XR industry in the EU is distributed across various countries and regions, with prominent hubs often specializing in specific applications and technologies. Paris, Berlin, and Amsterdam are among the region’s top XR destinations.^{ccxi} Meanwhile, Stockholm, Prague, and Warsaw have gained recognition for their expertise in gaming, while Madrid is known for its contributions to industrial applications. And Brussels, Amsterdam and Dublin have emerged as hotspots for XR start-ups. The EU Digital Innovation Hubs network, developed to support technology testing, technical expertise, and knowledge exchange,^{ccxii} has played a key role in providing incubator and accelerator services, further fostering growth and innovation in the local XR communities.^{ccxiii}



At the member-state level, in Germany domestic companies have emerged as global leaders in smart manufacturing and the industrial metaverse. More than a decade ago, German policymakers launched the Industrie 4.0 initiative, which provided substantial funding to increase the digitalization of manufacturing and to support research and collaboration.^{ccxiv} The German government has since encouraged the integration of XR into various industrial sectors like construction and healthcare.^{ccxv} France has also emerged as a center of XR activity, with multiple hubs driving growth in both creative content production and industrial applications.^{ccxvi}

The French government has also provided funding for content creation and start-ups, with an emphasis on promoting French culture through immersive technologies.^{ccxvii} In April 2023, French President Emmanuel Macron declared his intent to create "digital sovereignty" for Europe through a European Metaverse and opened a formal consultation for setting up a framework for the future of "virtual immersive worlds." According to the press release announcing the consultation, the French government believes it is necessary to develop a national strategy for how to handle the technological and cultural developments leading up to immersive digital worlds. It also believes that an alternative to the vision offered by international companies (primarily American tech giants) should be found in order to build a French-style metaverse.^{ccxviii}

Government Policies and Actions to Build XR Capacity and Innovation

The EC is the main funder of basic and applied research in the EU (although member states also fund such research) and policymakers play a key role in deciding the areas of research to be prioritized. Since 1984, the EU has supported scientific and applied R&D through several programs, the most important of which are the multi-annual Framework Programmes. Virtual reality was first mentioned in the fourth iteration of the Framework Programme in 1994,^{ccxix} and, according to the European Commission in 2020, EU research funds have supported over 450 XR-related projects since the 1990s.^{ccxx}

Horizon 2020 Framework

Policymakers first provided funding for XR as a separate workstream in Horizon 2020, the research and innovation program that ran from 2014–2020. The Horizon 2020 Work Programme for 2018–2020 included two work streams on “interactive technologies” focused on enhancing pan-European coordination efforts, boosting competitiveness, advancing XR technology, and promoting innovation.^{ccxxi} Upon its completion, Horizon 2020 had allocated more than \$45 million to some 64 XR projects.^{ccxxii} These grants funded a variety of initiatives, including solutions for motor function rehabilitation, AR to facilitate English learning, and VR for neuropsychological syndrome diagnosis.^{ccxxiii} They also funded XR4ALL (now XR4Europe), an industry group designed to bring together members of the EU XR community.^{ccxxiv} In sum, the Horizon 2020 Programme has supported a wide range of XR companies throughout Europe.^{ccxxv}



Source: Horizon Europe

Horizon Europe Framework

The current framework programme, Horizon Europe, has a budget of over \$102 billion for 2021–2027, with \$16 billion allocated to fund Digital, Industry, and Space programs.^{ccxxvi} In the 2021–2022 Work Programme, policymakers allocated a total of \$112 million for seven XR workstreams aimed at improving usability and accessibility, and fostering innovation, competitiveness, and responsible governance of XR.^{ccxxvii} Some of these projects are aimed at building social acceptance of XR systems, improving accessibility for the visually impaired, and developing telepresence technologies.^{ccxxviii} Meanwhile, the 2023–2024 Work Programme includes three major funding streams, including \$28 million for the development of “next generation eXtended reality,” \$27 million for “eXtended Reality for Industry 5.0,” and \$2 million for “supporting the emergence of an open human centric metaverse.”^{ccxxix}

Additional XR Funding

The EU has funded XR infrastructure and research through other programs as well. For example, under the 2023 budget for the Digital Europe program policymakers are funding common data spaces, cloud-to-edge infrastructure, and AI testing and experimentation facilities, and they are implementing digital twins like Destination Earth and Virtual Human Twins for healthcare.^{CCXXX}

Destination Earth is designed to simulate the interaction between natural phenomena and human activities. In doing so, the EU hopes it will contribute to achieving the objectives of the twin transition: green and digital.^{CCXXXI}

European officials have also helped to create the VR/AR Industrial Coalition, which facilitates dialogue, identifies opportunities and challenges, and informs policy decisions to promote the integration of XR technologies across various industries.^{CCXXXII} They have further created and funded the European Media and Immersion Lab, a pan-European network of XR laboratories that accelerates the development of content, services, and applications for the media – including XR – through physical and virtual infrastructures.^{CCXXXIII}

An EU Initiative on Web 4.0 and Virtual Worlds

In September 2022, EC President Ursula von der Leyen’s State of the Union Letter of Intent outlined a new initiative focused on harnessing new digital opportunities and trends like the metaverse.^{CCXXXIV} This initiative sparked several work projects from the EC to clarify Europe’s rules and expectations for the

metaverse. **In July 2023, this work culminated in the Commission’s Communication on Virtual Worlds^{CCXXXV} and Web 4.0, “An EU initiative on Web 4.0 and virtual worlds: a head start in the next technological transition,” aimed at establishing the EU as a global leader.** The strategy document seeks to capitalize on virtual worlds’ potential in various sectors while addressing the associated opportunities and risks. While it



Source: European Commission

lacks specific investment targets, the strategy nonetheless represents a significant turning point in global recognition of the potential of XR technology.

The strategy focuses on four pillars:

- **People and Skills:** The Commission aims to raise awareness and improve digital proficiency for widespread user acceptance of virtual worlds. It plans to invest in ICT specialists and content creators and create a “Virtual Worlds Toolbox” for the general public, providing guidelines on managing virtual identities, assets, data, and combating disinformation.
- **Business Support:** The EU will collaborate with stakeholders to develop crucial technological components, facilitate connections between developers and industry users, and provide access to financing through various programs to support innovative business models and creators. It will also foster a supportive business environment by encouraging innovation through regulatory sandboxes, supporting innovative SMEs and startups, facilitating innovative cooperative models in industry, addressing intellectual property challenges, and promoting interoperability and open standards to prevent dominance by large entities.
- **Government Involvement:** The government’s role in advancing Web 4.0 involves improving public services and addressing societal challenges like health and climate change. Flagship projects will include the European CitiVerse, a metaverse platform for citizens and cities, and the European Virtual Human Twin for improved healthcare services. Both will be supported by access to common European data spaces.
- **Global Governance:** Finally, to ensure effective governance, the Commission will form expert groups to exchange best practices among Member States, while also supporting the creation of a technical multi-stakeholder governance process to ensure open, secure, and interoperable virtual worlds at the EU and global level.^{ccxxxvi}

In response to the EC’s strategy, two European parliamentary committees released draft reports on the policy implications of virtual worlds. In August 2023, the Committee on the Internal Market and Consumer Protection (IMCO) published a draft report titled, “Virtual worlds – opportunities, risks and policy implications for the single market” which called on European policymakers to create a universal definition of “virtual worlds” and emphasized the importance of open standards and interoperability for ensuring fair competition.^{ccxxxvii} Then in October 2023, the Committee on Legal Affairs (JURI) issued a draft report “on policy implications of the development of virtual worlds – civil, company,

commercial and intellectual property law issues” which highlighted regulatory challenges and uncertainty around the applicability of certain private international, civil, and intellectual property law to the metaverse.^{ccxxxviii} Although these documents are non-legislative, they underscore that immersive technology is a high priority area for European lawmakers.

Regulatory Certainty and Trust

Because the EU is comprised of 27 separate member states, EU Commissioners face unique challenges in balancing innovation and regulation.^{ccxxxix} They must navigate the various priorities, languages, cultures, digital expertise, and infrastructures of members while aiming to ensure digital rights for all citizens. While most governments want to protect user privacy and consumer rights, the EU has made it a top and consistent priority—some say to the detriment of innovation.^{ccxli} Despite ongoing efforts to build domestic capacity and ensure European sovereignty, however, the top ten XR companies in the European market are all based outside of Europe.^{ccxlii}

In an interview with Politico in 2022, Executive Vice President of the European Commission for a Europe Fit for the Digital Age (the “EU digital czar”), Margrethe Vestager, spoke about the difficulties of regulating competition in virtual worlds where national boundaries may not apply.^{ccxliii} Despite its unique considerations, however, the EU has emerged as the technology governance leader whose approach is often emulated (if not directly replicated) by other nations around the world.^{ccxliv} The EU regulates data, platforms, and technology through three key laws: the 2018 GDPR; the 2022 Digital Services Act (DSA); and the 2022 Digital Markets Act (DMA). The GDPR outlines the fundamental rights of users and the obligations of those processing data.^{ccxlv} The DSA regulates the behavior of online intermediaries and platforms,^{ccxlv} and the DMA governs “gatekeeper” online platforms, encouraging them to share certain types of data with competitors and governments.^{ccxlvii} In addition, the EU is considering a comprehensive AI Act, which would prohibit high-risk AI systems (like government social scoring) and regulate other high-risk applications.^{ccxlvii}

Although the GDPR has clarified the rights of users and the responsibilities of firms to protect personal data, the regulation has not provided regulatory certainty to foreign or domestic firms. These firms must comply with different national approaches to implementing the GDPR.^{ccxlviii} Smaller firms struggle with the costs of compliance, and some argue that the regulation has increased market concentration.^{ccxlix}

Public Consultations

EU policymakers recognize the importance of building and sustaining consumer trust in key emerging technologies, including XR. Moreover, they know that engaging the public to understand both the technology itself and the governance challenges it may present is a way to build that trust. Case in point: in 2023 the EC organized a series of Citizens' Panels on Virtual Worlds.^{ccli}

The EU citizens who participated in the panels then provided a series of recommendations for consideration by the Commission. **The EC also launched a public consultation on Virtual Worlds in April 2023, calling for input on the EC's efforts to "develop a vision for emerging virtual worlds (e.g. metaverses), based on respect for digital rights and EU laws and values.** The aim



Source: European Commission

is open, interoperable, and innovative virtual worlds that can be used safely and with confidence by the public and businesses.”^{ccli ccli}

Both of these efforts directly informed the EU strategy on Web 4.0 and Virtual Worlds.^{ccliii} Similarly, as discussed above, the French Directorate General for Enterprise launched an online public consultation on virtual immersive universes in April 2023.^{ccliv} French policymakers also released a report, Mission Metaverse, in 2022 that proposed ideas for a French and European strategy.^{cclv}

The European Union

Key Points

The European Union has:

- Engaged the public through Citizens' Panels, gathering input and recommendations for their strategy on Web 4.0 and virtual worlds.
- Made substantial investments in research and development, including common data infrastructures, as well as the advancement of digital twin projects that contribute to public good efforts like sustainable development and healthcare.
- Fostered cross-border collaboration and partnerships through initiatives like the European Media and Immersion Labs and the Virtual and Augmented Reality Industrial Coalition.
- Established a comprehensive regulatory and governance framework for data and digital technologies, prioritizing citizen protection.

XR Initiatives

- Framework Programmes (XR-specific funding and resources)
 - Horizon 2020 (XR-specific funding and resources)
 - Horizon Europe (XR-specific funding and resources)
- Destination Earth
- Virtual and Augmented Reality Industrial Coalition
- European Media and Immersion Lab
- EU initiative on Web 4.0 and Virtual Worlds
- Virtual Worlds Toolbox (forthcoming)
- European CitiVerse (forthcoming)
- European Virtual Human Twins (forthcoming)
- Citizens' Panels on Virtual Worlds

The People's Republic of China (China)

Overview

The People's Republic of China is a leading producer of XR as well as the second largest XR market by revenue after the United States.^{cclvi} The Chinese Communist Party (CCP) has made the nation's digital development a top priority in the belief that these sectors can enhance economic progress and national security.



Chinese officials have identified immersive technology as one of the “7 key industries of the Digital Economy,”^{cclvii} and they are actively working to shape the development of the metaverse.^{cclviii} China envisions a future where XR becomes tightly intertwined with various sectors including manufacturing, healthcare, and entertainment.^{cclix}

In support of this vision, the CCP has provided long term funding and support for XR-related initiatives and encouraged national and local level competition to advance the industry. Chinese officials have also encouraged the creation of VR Towns where companies can collaborate and more easily coordinate their supply chains. These initiatives have helped China nurture cutting-edge XR technologies. While it is difficult to assess the full scope of China's XR efforts due to the opacity of Chinese statistics and recent efforts by the Chinese government to tighten access to data,^{cclx} the German statistics platform, Statista, reports that the Chinese XR market generated a total revenue of approximately \$6.6 billion in 2023.^{cclxi} Similarly bullish, the International Data Corporation predicts China will capture 25% of the global XR market by 2026, with a compound annual growth rate of 42.2% over the next five years.^{cclxii}

China is simultaneously a competitor and a huge market opportunity for XR companies and investors.^{cclxiii} **Prominent Chinese companies such as ByteDance, Alibaba, Huawei, Baidu, and Xiaomi have made substantial investments in the development of XR devices and platforms,**^{cclxiv} and often partner with and invest in foreign firms. Tencent, for example, holds 40% and 49% shares, respectively, in U.S. companies Epic Games and Roblox.^{cclxv} Moreover, in 2021 ByteDance bought Pico, the world's second largest VR headset manufacturer.^{cclxvi} Meanwhile, foreign investors have been eager to invest in Chinese XR companies because of Chinese consumers' enthusiastic embrace of XR technologies (as evidenced by their broad adoption of XR-enhanced online shopping experiences and their patronage of VR arcades, where they can rent immersive hardware and play XR games).^{cclxvii}

Government Policies and Actions to Build XR Capacity and Innovation

Chinese Communist Party leaders, especially President Xi Jinping, recognized early on that data could transform the economy from one based on manufacturing, to one built on both manufacturing and high-value services.^{cclxviii} They subsequently issued a wide range of plans designed to drive economic growth, enhance governance, and transform society.^{cclxix}

For example, China has invested heavily in digital infrastructure. China has long been at the forefront of constructing 5G networks, and, as of 2022, more than 60% of global 5G connections occurred in China.^{cclxx} Leading telecommunications infrastructure provider Huawei holds approximately 29% of the global 5G market share and has constructed about 70% of Africa's 4G networks.^{cclxxi} Moreover, both the national and local governments in China have made the development of "new infrastructure" a key focus as they aim to further the country's digital ambitions.^{cclxxii} This concept, first introduced in 2018, encompasses the construction of critical enabling components like 5G networks, as well as IoT (Internet of Things) data centers, high-speed rail systems, and research and development institutes.^{cclxxiii} Dozens of provinces have announced new infrastructure investment plans worth billions of dollars for the next several years.^{cclxxiv}



Source: The Economist

Whole-of-Government XR Strategies

In 2015, the Chinese government launched the Made in China 2025 strategy, designed to upgrade Chinese industries, increase technological self-sufficiency, and move towards high-tech and high-value production.^{cclxxv} Soon thereafter, various branches of the Chinese government, including the Ministry of Industry and Information Technology, the National Development and Reform Commission, and the Ministry of Science and Technology, began issuing statements, guidance opinions, and detailed strategies to promote the development of XR. By highlighting the importance of XR, these officials signaled that the technology would be a priority.

In 2016, the 13th Five-Year Plan for Informatization, the Outline of the National Innovation-Driven Development Strategy, and the 13th Five-Year Plan for the Development of Strategic Emerging Industries highlighted the importance of XR and emphasized the need for further research into how XR could be used to grow new technologies and platforms.^{cclxxvi} For example, the government encouraged firms to utilize XR in smart wearable devices through policies like the Internet+ Artificial Intelligence Three-Year Action and Implementation Plan, the Special Action Notice for the Innovation and Development of the Intelligent Hardware Industry, and the Guiding Opinions on Expanding Information Consumption.^{cclxxvii} Additionally, the 2017 New Generation Artificial Intelligence Development Plan identified XR as one of the ecosystem elements that the government would “forcefully develop” to accelerate the transformation and application of key AI technologies.^{cclxxviii}

Also in 2016, the Ministry of Industry and Information Technology (MIIT) released its White Paper on the Development of Virtual Reality Industry 5.0, which recommended that policymakers invest in research and move quickly to develop a standardization system for XR. The Ministry also called for the creation of an “industry operation information platform” and a “virtual reality hardware product quality supervision information platform.”^{cclxxix} While the authors of this paper were not able to ascertain whether these recommendations were implemented, they demonstrate that many government agencies were working early on to encourage XR development.

In 2018, MIIT published the Guiding Opinions for Accelerating the Development of the Virtual Reality Industry, which outlined strategic initiatives and policy measures to stimulate growth and innovation and position the country as a global leader in XR.^{cclxxx} The Ministry aimed to develop a robust VR industry supply chain, drive breakthroughs in key technologies, and establish successful and replicable VR companies by 2020. It also identified specific technologies and applications that the government wanted to see developed further, including XR headsets.^{cclxxxi}

In 2022, MIIT, along with four other government agencies, published the Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022–2026) which outlined the ways in which policymakers would nurture XR.^{cclxxxii} Specifically, the Ministry said that China would establish 100 “backbone enterprises,” 10 regional concentration areas, and 10 public service platforms to support technical research and content development, showcase and incubate pioneering applications, and achieve an overall market value of over \$50 billion by the end of 2026.^{cclxxxiii} The Ministry also suggested that the Chinese XR sector should ship 25 million VR devices globally by 2026 (by comparison, by the end of 2022 not even 20 million VR headsets had ever been sold anywhere).^{cclxxxiv} Finally, the Ministry recommended that XR firms find ways to integrate VR into specific initiatives such as the VR/AR Mass Fitness project in the fields of sports and health.^{cclxxxv}

Most recently, in September 2023 five Chinese ministries led by the MIIT published the Three-Year Action Plan for Industrial Innovation and Development of the Yuanverse (2023–2025) for cultivating “three to five metaverse companies with global influence” by 2025.

According document, the plan was made to “seize the opportunity of the global acceleration of the metaverse industry,” which has the potential to “lead the next generation of internet development and accelerate the upgrade of the manufacturing industry to be more advanced, intelligent and greener.” Specifically, the strategy addresses the application of XR to improve efficiency within various industries including automotive, aerospace, steel, textiles, and home appliances. In the long run, according to the document, China wants to build a mature Chinese metaverse for industrial use that can help drive new growth in manufacturing.^{cclxxxvi}



Source: TooRichCity

Although the Chinese government has played a pivotal role in nurturing the XR industry through funding initiatives, competitions, and infrastructure development, state-backed industry groups have also been proactive. The China Mobile and Communications Association, the country's leading telecom industry organization, established the Metaverse Industry Committee in 2021,^{cclxxxvii} and the China Computer Industry Association formed the Metaverse Industry Professional Committee in 2022 to collaborate with policymakers, draft industry standards and roadmaps, and support metaverse startups.^{cclxxxviii}

Local Government Initiatives

As discussed, the Chinese government set ambitious goals and approved many initiatives at the national level to nurture XR. However, policymakers never clearly delineated how these objectives should be achieved or which agencies, firms, or groups would fund them. Observers of Chinese politics assert that such vagueness is not unusual for Chinese officials. China is governed under a system of "fragmented authoritarianism" by which the central government encourages the provinces to compete to attract capital, labor, and other resources. Provincial leaders who develop the best approaches to fostering innovation and regional development could be rewarded with visibility, incentives, and promotions if successful.^{cclxxxix}

Thus, provincial and local officials have played a significant role in XR. At least 26 local governments have issued policy documents outlining their strategies to promote and apply XR in various fields, promising funding for regional business clusters, public service platforms, and research and development centers.^{ccxc} More than 20 towns, provinces, and cities have also established innovation centers, experimental areas, incubation bases, or industrial parks to connect different parts of the XR supply chain.^{ccxci} In addition, some provinces have developed VR Towns, as mentioned above, that serve as industrial parks incorporating industry planning, education, innovation, field trips, experiences, and trading of VR products.^{ccxcii}

These towns aim to integrate XR technologies into daily life, particularly in fields like healthcare, education, manufacturing and design, and entertainment.^{ccxciii} By consolidating the XR supply chain, provinces hope to gain a competitive advantage, stimulating industry growth and replicating the success of the Chinese drone industry's consolidation strategy.^{ccxciv}



Source: Guian New Area

We do not have specific figures or reports on outcomes related to XR, and the Chinese system remains opaque.^{CCXCV} But over time, this combination of national, provincial, and local strategies, structures, and initiatives appears to have nurtured a broad range of companies to serve both domestic and foreign markets in XR. Table 1 below provides an overview of select initiatives undertaken by local governments to support XR companies, XR research, and the commercialization of XR products.

Table 1: Select Regional VR Initiatives in China^{CCXCVI}

Province	Policy Document	Industrial Cluster	Other Initiatives
Guangdong	Measures for Promoting the Innovation and Development of the Metaverse (Guangzhou city, 2022)	Shenzhen Metaverse Innovation Lab	
Hunan	Implementation Opinions on Promoting the Development of Metaverse Industry (2022)	Metaverse Ecological Leading Zone (in progress)	Zhangjiajie metaverse tourism R&D center
Beijing	Beijing City Sub-Centre Metaverse Innovation Development Action Plan (2022-2024)	Zhongguancun Virtual Reality Industrial Park	
Shanghai	Shanghai Action Plan for Fostering Metaverse (2022-2025)	Joint Research Institute of Metaverse and Virtual-Reality Interaction	Virtual City Hall platform
Jiangxi	About Accelerating VR/AR Several Policies for Industrial Development (Nanchang city, 2018)	Virtual Reality Industry Base	Nanchang City AI+VR Innovation Center
Guizhou	Gui'an New Area Virtual Reality Industry Development Overview (2016)	Gui'an New District VR Industry Base; Beidou Bay VR town	VR Star Theme Park

Regulatory Certainty and Trust

Over the past several years, China has adopted laws and regulations designed to engender trust in new data-based technologies, including XR. For example, China has established clear data protection requirements for the private sector. In 2021, China approved the Personal Information Protection Law, on which it further elaborated in the 2022 Personal Information Security Specification.^{ccxvii} These regulations require user consent for collecting and processing sensitive personal information, including biometrics. China's enforcement of many of its regulations, however, is uneven and often opaque. Moreover, the government is exempt from many of these rules.^{ccxcviii} As a result, it is difficult to describe the Chinese governance context as predictable or systemic.

China has also used regulation to protect its citizens and firms from perceived harms from specific technologies and from what it labels "disinformation." For example, the Regulations on the Administration of Deep Synthesis of Internet Information Services are designed to prevent the spread of false information and protect citizens' rights by requiring providers of deep synthesis (otherwise known as "deepfakes") to label content and regularly review their algorithms.^{ccxcix} China's cyberspace regulator also drafted the Provisions on the Administration of Internet Information Service Algorithm Recommendations, which requires providers of personalized internet algorithm recommendation technologies to protect user rights, refrain from monopolistic behavior, and establish various mechanisms to review algorithms and strengthen information security.^{ccc} In addition, in 2023 the central government published the Administrative Measures for Generative Artificial Intelligence Services which covers issues such as data protection, non-discrimination, bias, and algorithmic transparency for generative AI services offered to the public.^{ccc} It should be noted that the Chinese government exercises broad powers to compel companies to provide support and assistance for national security and criminal investigation purposes, including providing access to data.^{cccii} Thus, Chinese users may ultimately believe that their data is in fact not adequately protected.

Finally, this past year China took steps to tighten government control over information databases, restricting overseas access to various databases involving economic, financial, and corporate registration information, as well as patents, procurement documents, academic journals, and official statistical yearbooks. As a result of these new rules, foreign companies are concerned about their ability to transfer proprietary data.^{ccciii} No one yet knows how these regulations will be enforced, and so China's regulatory environment for XR, AI, and the data that underpin these technologies, remains uncertain.

The People's Republic of China

Key Points

China has:

- Adopted strategies that take a comprehensive approach to nurturing the data-driven economy, linking data governance to investments in “new” digital infrastructures including 5G networks, data centers, R&D institutes, and regional industrial clusters.
- Produced XR strategies that incentivize provincial governments to make significant investments and innovations in XR, including organizing supply chains and industrial efforts through VR Towns.
- Tried to engender user trust by regulating data, technologies, and business practices and creating rules governing personal data, deepfakes, recommendation algorithms, and generative AI.
- Taken steps designed to preserve social stability by cracking down on foreign firms' access to basic data, limiting audits, and limiting the influence of domestic technology companies.

XR Initiatives

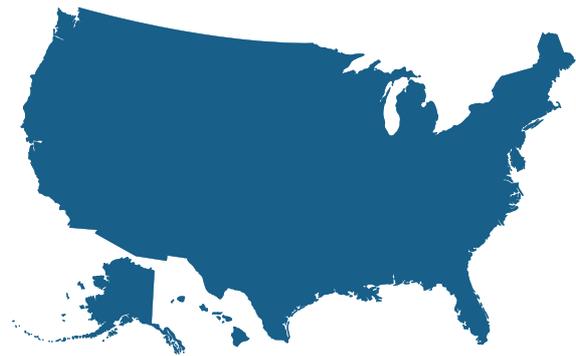
- Made in China 2025 (supporting infrastructure)
- 13th Five-Year Plan for Informatization (strategy highlighting/prioritizing XR)
- Outline of the National Innovation-Driven Development Strategy (strategy highlighting/prioritizing XR)
- 13th Five-Year Plan for the Development of Strategic Emerging Industries (strategy highlighting/prioritizing XR)
- Internet+ Artificial Intelligence Three-Year Action and Implementation Plan (strategy highlighting/prioritizing XR)
- Special Action Notice for the Innovation and Development of the Intelligent Hardware Industry (strategy highlighting/prioritizing XR)
- Guiding Opinions on Expanding Information Consumption (strategy highlighting/prioritizing XR)
- New Generation Artificial Intelligence Development Plan (strategy highlighting/prioritizing XR)
- White Paper on the Development of Virtual Reality Industry 5.0 (strategy highlighting/prioritizing XR)
- Guiding Opinions for Accelerating the Development of the Virtual Reality Industry (strategy highlighting/prioritizing XR)
- Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022-2026) (strategy highlighting/prioritizing XR)
- VR/AR Mass Fitness
- China Mobile and Communications Association's Metaverse Industry Committee
- China Computer Industry Association's Metaverse Industry Professional Committee
- VR Towns
- Three-Year Action Plan for Industrial Innovation and Development of the Yuanverse (2023-2025)

The United States of America

Overview

The United States is the world's largest market by revenue for immersive technologies and one of the world's largest producers of XR content and hardware.^{ccciv} California-based Meta leads the world in XR headset sales, capturing 80% of the overall market in 2022.^{cccv} In addition, **the United States is home to some of the largest companies developing XR hardware including Apple, Google, Magic Leap, Meta, Microsoft, and Snap, as well as the biggest engines for developing XR content – Unity Technologies and Unreal Engine.**

According to PwC's estimations, XR has the potential to contribute \$537 billion to the U.S. GDP and generate over two million jobs by 2030.^{cccvi} Analysis Group, backed by funding from Meta, has estimated that the metaverse could make a yearly contribution of \$560 billion to the U.S. GDP by 2031. More recently, Deloitte, also with funding from Meta, forecasted that the metaverse could have an annual U.S. GDP impact ranging from \$402 billion to \$760 billion by 2035.^{cccvii}



As discussed, the U.S. government has historically recognized the importance of the XR sector. Policymakers designated variants of XR as a critical technology as early as 1995, and, more recently, Congress included funding for immersive technology in the landmark CHIPS and Science Act of 2022.

However, in contrast to the other countries discussed in this report, the United States has not developed a strategy or institutional structure to nurture the XR sector.^{cccviii}

Government Policies and Actions to Build XR Capacity and Innovation

Government Research

The United States' attention to immersive technologies has waxed and waned over the past decades. The Networking and Information Technology Research and Development (NITRD) program, which coordinates federal research and development of information and communication technology across government agencies,^{cccix} serves as a good barometer for analyzing the actions and priorities of the U.S. government vis-à-vis technology.^{cccx} Our review of NITRD funding shows that interest in XR has fluctuated. Beginning in 1995,^{cccxi} the U.S. government began exploring "Human Centered Systems," the synergistic combination of human skills and information technology.^{cccxi} In the years that followed, the U.S. government funded projects using data visualization, virtual reality, and human-machine interfaces.^{cccxiii} Meanwhile, the Department of Defense funded research on how it could use simulations and virtual modeling for military training.^{cccxiv}

In the period between 2000 and 2016, the U.S. government's overall spending on XR-related projects decreased. However, policymakers did continue to fund immersive technologies for defense training purposes.^{cccxv} Officials also funded new efforts to apply XR to education, environmental modeling, and disaster response.^{cccxvi} In 2017, policymakers reorganized funding to focus on projects that could achieve public good objectives. The government established the Computing-Enabled Human Interaction, Communication, and Augmentation (CHuman) program which funded projects that use digital twins to model how to improve crop yields and research climate resilience and flood prevention.^{cccxvii} Under CHuman, NITRD also funded an augmented reality system to upskill healthcare workers.^{cccxviii}

Individual Agency Support for XR

Specific U.S. government agencies have invested in XR projects and infrastructure and leveraged the technology for their own operations. The DoD has been the most active, funding the Synthetic Training Environment, a platform that combines live, virtual, constructive, and gaming environments to create a comprehensive training environment; the Augmented Reality Sandtable, an R&D testbed that utilizes mobile software applications; and mixed-reality headsets, used for battlespace visualization and improving the common operating picture.^{cccxix}

The Department of Homeland Security implemented an XR program called the Enhanced Dynamic GeoSocial Environment, which is a VR training platform designed to help first responders and educators plan for coordinated responses to critical incidents such as active shooters.^{cccxx} The Federal

Emergency Management Agency produced the Immersed VR tool, which is designed to educate local officials on flood preparedness and mitigation actions by immersing them in a flood crisis scenario.^{cccxxi}

And in 2016, the Department of Education launched the EdSim contest to fund educational XR experiences.^{cccxxii} Additionally, the Department of Veterans Affairs' VA Immersive program has deployed

over 1,200 VR headsets to more than 160 VA medical centers and clinics across the country to train staff and treat soldiers with post-traumatic stress disorder.^{cccxxiii}

In April 2023, the VA's Office of Healthcare Innovation and Learning (OHIL) established a three-year collaboration with California-based medical device company Penumbra to test, co-develop, and scale additional virtual reality solutions. These solutions will increase veteran access to rehabilitation care in Community Based Outpatient Clinics and at home.^{cccxxiv}



Source: U.S. Department of Veterans Affairs

Congressional Actions

Congress recently passed two laws that may enhance U.S. XR competitiveness. First, in the 2021 Infrastructure Investment and Jobs Act (P.L. 117-58), Congress allocated \$65 billion for fast broadband connectivity, which is essential infrastructure for uptake of XR.^{cccxxv} Then, in 2022 Congress passed the CHIPS and Science Act (P.L. 117-167), which greatly increased authorizations for federal science and technology research and development programs, allocating approximately \$174 billion through 2027 to support the nation's science and technology base.

These funds are intended to foster innovation and encourage commercial applications of emerging technologies. CHIPS and Science designates “immersive technology” as a “key technology focus area,” while also including many of the components that enable XR like semiconductors, artificial intelligence, and batteries.^{cccxxvi} As part of the National Science Foundation’s effort to implement its new mandate under CHIPS and Science, the agency solicited public comment on how it should prioritize investments and research in the “key technology focus areas” articulated in the act.^{cccxxvii}

Also authorized under the CHIPS and Science Act are the newly established Regional Technology and Innovation Hubs program at the Department of Commerce, and the Regional Innovation Engines program under the NSF.^{cccxxviii} Together, these initiatives are designed to support “technology development, job creation, and the expansion of U.S. innovation capacity.”^{cccxxix} By fostering collaboration and partnerships across sectors and fields, these programs could play a crucial role in advancing critical technologies, including XR and those that enable XR.

Regulatory Certainty and Trust

Unlike the other countries studied in this report, the United States has not established a comprehensive, predictable regulatory environment governing key aspects of XR technology like data protection and online safety. Moreover, policymakers have not developed a systemic approach to nurturing the technology. Notably, several prominent executives within the XR industry have called on the U.S. government to provide clearer rules for XR and the metaverse.^{cccxxx}

With respect to personal data protection, Congress has thus far taken a sectoral approach, enacting federal laws designed to provide protection for individuals’ personal information in certain industries such as healthcare and financial services, and data subcategories like data pertaining to children under the age of 13.^{cccxxxi} Several states, however, have passed laws governing the use of consumer data and biometric data more generally, thus creating an unwieldy patchwork of compliance obligations for companies in the U.S.^{cccxxxii} Moreover, Congress has not clearly delineated the rights of users to challenge unauthorized access or use of data.^{cccxxxiii}

The Federal Trade Commission (FTC) has the authority to protect user privacy and is the primary regulatory body with authority over data protection in the United States. But its enforcement powers are weak, especially in contrast to those overseas organizations formed specifically to enforce user privacy protections.^{cccxxxiv} In May 2023, the FTC issued a policy statement affirming its authority to regulate the use of biometric data, including data collected through XR sensors.^{cccxxxv} In the statement, the FTC noted that, when weighing enforcement action, it would take into consideration failure to anticipate potential harm to consumers; inadequate response to known or foreseeable risks; surreptitious or unexpected collection or use of data; and failure to assess the practices and capabilities of third parties.^{cccxxxvi} The FTC has also warned about deepfakes, recognizing that computer-generated simulations could increasingly blur the line between reality and fiction in what we see, hear, and read. The agency noted that it monitors such simulations to prevent potential risk of human-computer interactions taking “new and possibly dangerous turns.”^{cccxxxvii}

However, neither of these policy statements from the FTC hold legal force. Moreover, agency guidance can be rescinded or amended from administration to administration. Consequently, such policy statements do not provide clarity or regulatory certainty for businesses, including the XR industry, in the United States.

The United States

Key Points

The United States has:

- Invested in research and development around immersive technology and human-machine interfaces.
- Developed digital twins to solve complex problems at the local and national levels.
- Widely utilized XR for military training purposes and treatment of veterans.
- Lacks a comprehensive vision or coordinated internal structure to nurture XR.

XR Initiatives:

- NITRD funding through the Program Component Areas
 - Human Centered Systems; Human Computer Interface and Information Management; and Computing-Enabled Human Interaction, Communication, and Augmentation (CHuman)
- Department of Defense - Synthetic Training Environment; Augmented Reality Sandtable
- Department of Homeland Security - Enhanced Dynamic GeoSocial Environment
- Federal Emergency Management Agency - Immersed VR
- Department of Education - EdSim contest
- Department of Veterans Affairs - VA Immersive program
- CHIPS and Science Act
- Department of Commerce - Regional Technology and Innovation Hubs
- National Science Foundation - Regional Innovation Engines

CHAPTER V

Findings and Recommendations

XR is important to America’s future. It can help the United States government anticipate and address complex public problems; it is a critical technology that is essential to both economic and military security; and many observers expect it to be the next major computing platform. In this paper, we compared how the governments of South Korea, the United Kingdom, the European Union, China, and the United States are attempting to encourage competitiveness in XR.

In researching each of our case studies, we focused on four essential questions:

- Has the government put forward a vision for nurturing XR?
- Has the government taken steps to support its immersive economy (funding R&D, and funding the underlying infrastructure for XR such as 5G)?
- Has the government adopted a regulatory approach that is clear and predictable, supportive of innovation, designed to protect users from harm, and likely to build and sustain trust among XR stakeholders?
- Is the government’s approach systemic?

We found that the foreign governments we examined have adopted a variety of policies to both nurture XR and create an enabling environment that supports innovation, protects users from harm, and builds trust and predictability among XR stakeholders as the technology changes over time. In general, these countries have a vision for how to encourage XR. As many of these actions and policies are new, it is too early to assess if they will be effective. Nonetheless, the U.S. can learn from what other governments are doing.



Findings

Through our research, we found the following:

A Strategic Vision for XR

Research indicates that when policymakers devise a technology strategy, such plans often inspire government and private sector investment.^{CCXXVIII} South Korea, the EU, and China have developed, or are developing, national strategies for XR and virtual worlds. South Korea's vision aims to position the country as a global leader in the new "digital continent" through its Emerging Metaverse Industry Promotion Strategy. South Korea also views XR as essential to its comprehensive Digital New Deal strategy which is focused on accelerating digital transformation throughout the country.

The European Union has set out a strategic vision for XR through its initiative on Web 4.0 and virtual worlds. The strategy centers around four pillars: people and skills; business; government (e.g. public services); and governance and seeks to help establish the EU as a leader in the next technological transition.

China released a comprehensive vision for XR technology through its Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022-2026) which details actions policymakers would take to nurture immersive technology. Key XR components are also a part of Beijing's Made in China 2025 strategy.

The UK has articulated a vision for XR's use in a cyber-physical infrastructure, and it is discussing potential metaverse regulatory frameworks at a national level. However, it has not yet drafted a strategy or vision for how to use XR to fully realize economic and social benefit.

In contrast with these nations, the United States has not put forward a vision for XR, despite its importance to the economy and national security.

Support for Research and Development in XR

All our case study governments have invested in XR R&D. Starting in 2016, South Korea committed to investing \$210 million and raising an additional \$96.5 million from the private sector by 2020 to expand R&D in core XR technologies and promote strategic flagship projects.

The UK has included XR projects under its Innovation Strategy which aims to increase R&D spending, streamline regulations, and grow the emerging technology sector. Meanwhile, the EU has provided extensive support for scientific and applied R&D through its multi-annual Framework Programmes. Horizon 2022 and Horizon Europe, the EU's current Framework Programme running through 2027, have invested in workstreams aimed at using XR for education and medical diagnoses, improving the accessibility of XR, and supporting start-ups.

As early as 2016, China's Five-Year Plan for Informatization, the Outline of the National Innovation-Driven Development Strategy, and the 13th Five-Year Plan for the Development of Strategic Emerging Industries underscored the need for further research on how XR could be used to produce different technologies and platforms. China's Guiding Opinions for Accelerating the Development of the Virtual Reality Industry similarly laid out plans to stimulate innovation and position the country as a global leader in XR.

The U.S. has supported R&D in XR through various research programs on Human Centered Systems and Computing-Enabled Human Interaction, Communication, and Augmentation. Last year, the U.S. Congress passed the CHIPS and Science Act, which listed immersive technology as a "key technology focus area" prioritized for NIST and the NSF.

By comparison, however, the United States has done little to target research and development support to XR specifically.

Investment in Infrastructure that Supports XR

All the case studies we examined invest in underlying infrastructure needed to support XR, such as 5G networks and cloud data centers. South Korea has established a 5G+ Strategy Committee and 5G+ Implementation Plan, and the government's Digital New Deal also seeks to accelerate the convergence of AI and 5G. The UK's Wireless Infrastructure Strategy aims to deliver 5G to all populated areas in the UK by 2030.^{cccxxxix} The EU's 5G Action Plan has been coordinating investment and deployment of 5G since 2016, and the 2023 budget for Digital Europe provided funding for common data spaces, cloud-to-edge infrastructure, and AI testing. China has invested heavily in 5G as part of its development of new infrastructure to support the country's digital goals. The United States' National Strategy to Secure 5G^{cccxi} details how the government will lead deployment of 5G, and the Infrastructure Investment and Jobs Act (P.L. 117-58) included \$65 billion for the expansion of high-speed internet. Many of the key components of XR technology, such as semiconductors, are also included in industrial strategies such as the CHIPS and Science Act in the United States and the European Chips Act.

An Enabling Environment that Builds Confidence and Trust

Regulation

Research shows that for new technologies to succeed, policymakers must build trust and confidence in the technology itself and in the policies that govern it. Regulations must be clear and consistently enforced, while also allowing governance to evolve as technology and society change over time.

The UK and South Korea have adopted regulatory approaches to data, AI, and XR that are designed to be flexible. In addition, both governments have established new structures (such as the UK's Regulatory Horizons Council and South Korea's Metaverse Policy Council) to forecast the implications of emerging technologies (although it is worth noting that the UK is currently in the process of updating its regulatory frameworks post-Brexit, which has created some uncertainty overall). China's regulatory environment is also somewhat uncertain because the government has challenged large tech companies, limited foreign access to databases, and enforced laws unevenly. Finally, the EU has struggled to balance its precautionary approach with efforts to nurture innovation.

While the U.S. tends to excel at nurturing innovative technologies, it has been less effective at finding a balance between a precautionary approach and one that strengthens and facilitates innovation.

With respect to personal data protection, the UK, the EU, South Korea, and China have each enacted national personal data protection laws to safeguard consumer data and address concerns over misuse. While the U.S. Congress is considering several proposals for personal data protection on a national scale, it has not yet been successful.

Public Consultation

When it comes to building public trust, consultation is key. Research shows that people who are consulted are more likely to feel heard and to trust what governments are doing.^{cccxi} Both the UK and the EU have engaged in extensive public consultations on issues related to XR. The EU in particular has focused on educating and involving citizens in the development of its metaverse strategy, and thus, it may be well positioned to build trust in this emerging technology.^{cccxii} Under the auspices of the Initiative on Web 4.0 and Virtual Worlds, the EU hosted citizens' panels, which helped to educate the public about the metaverse and provide a forum for them to make recommendations to support the European Commission's initiative. The Commission also requested public feedback through a formal consultation. China has sought public comment on its regulation of data and AI, but not on issues of XR governance. Similarly, South Korea has not sought public comment on its metaverse strategies.

Although the U.S. has not directly engaged the public on issues of XR governance, various U.S. government agencies have sought public feedback on the opportunities and risks attending immersive technology, or associated component technologies, through public meetings and formal Requests for Information (RFIs).

For example, in 2023, the National Science Foundation issued an RFI on its roadmap for the new Directorate for Technology, Innovation, and Partnerships (TIP).^{cccxliv} TIP was established in the CHIPS and Science Act of 2022 to “advance critical and emerging technologies, address pressing societal and economic challenges, and accelerate the translation of research results from lab to market and society.”^{cccxliv} The RFI specifically references immersive technology.



Source: National Science Foundation

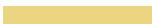
In 2021, the Office of Science and Technology Policy issued an RFI on Public and Private Sector Uses of Biometric Technologies.^{cccxliv} And in 2022,

the Food and Drug Administration Center for Devices and Radiological Health Patient Engagement Advisory Committee convened a series of meetings regarding Augmented Reality and Virtual Reality Medical Devices.^{cccxlvi}

A Systemic Approach

Overall, none of our case study governments have yet adopted a systemic approach to XR that can evolve as the technology changes over time, encourage continued innovation, build regulatory certainty, and sustain user trust. However, with the exception of the United States, all are moving in that direction and developing policies that reflect the complex and evolving XR ecosystem.

Table 2: Summary Table of XR-Specific and Supporting Initiatives

	Research and Innovation	Supporting Infrastructure	Vision for XR	Regulatory Approach to Build Trust
<p>SK</p> 	 <ul style="list-style-type: none"> • XR Device Centers and Hologram Centers • XR Funds • Metaverse Alliance 	 <ul style="list-style-type: none"> • Digital New Deal • Metaverse Graduate School • Metaverse Academy • 5G+ Strategy Committee • 5G+ Implementation Plan • Data Dam 	 <ul style="list-style-type: none"> • Immersive Economy Policy Council • Immersive Economy Development Strategy • Digital Twin Activation Strategy • Emerging Metaverse Industry Promotion Strategy • Metaverse Seoul 	 <ul style="list-style-type: none"> • Metaverse Ethical Principles • Metaverse Policy Council • Preemptive Regulatory Innovation Plan for the Metaverse • Metaverse Special Act* • Personal Information Protection Act • Biometric Information Protection Guidelines
<p>UK</p> 	 <ul style="list-style-type: none"> • Innovate UK • Digital Catapult • Audience of the Future Challenge Fund • Creative Industries Clusters Programme • UK Innovation Strategy-Prosperity Partnerships • National Digital Twin Programme • Digital Twin Hub 	 <ul style="list-style-type: none"> • UK Industrial Strategy • UK Wireless Infrastructure Strategy 	 <ul style="list-style-type: none"> • Cyber-Physical Infrastructure • Transport Digital Twin Vision and Roadmap 2035 • 2022 Metaverse Symposium 	 <ul style="list-style-type: none"> • Regulators' Pioneer Fund • Regulatory Horizons Council Digital Regulation Cooperation Forum • Regulatory Sandbox at ICO • Digital Markets Unit at CMA* • General Data Protection Regime • Online Safety Regime

Reality Check: Why the U.S. Government Should Nurture XR Development

	Research and Innovation	Supporting Infrastructure	Vision for XR	Regulatory Approach to Build Trust
EU 				
	<ul style="list-style-type: none"> • Framework Programmes (Horizon 2020 and Horizon Europe) • XR4Europe • Destination Earth • European Media and Immersion Lab • European Virtual Human Twin* 	<ul style="list-style-type: none"> • Digital Europe • 5G Action Plan • European Chips Act 	<ul style="list-style-type: none"> • EU initiative on Web 4.0 and virtual worlds • VR/AR Industrial Coalition • European CitiVerse* 	<ul style="list-style-type: none"> • Virtual Worlds Toolbox * • Virtual Worlds Citizens' Panels and Public Consultation • General Data Protection Regime • Digital Services Act • Digital Markets Act • AI Act*
CCP 				
	<ul style="list-style-type: none"> • Made in China 2025 • Guiding Opinions for Accelerating the Development of the Virtual Reality Industry • VR/AR Mass Fitness • VR Towns • Provincial XR Strategies (see Table 1) 	<ul style="list-style-type: none"> • Internet+ Artificial Intelligence Three-Year Action and Implementation Plan • Special Action Notice for the Innovation and Development of the Intelligent Hardware Industry • New Generation Artificial Intelligence Development Plan • Guiding Opinions on Expanding Information Consumption 	<ul style="list-style-type: none"> • 13th Five-Year Plan for Informatization • Outline of the National Innovation-Driven Development Strategy • 13th Five-Year Plan for the Development of Strategic Emerging Industries • White Paper on the Development of Virtual Reality Industry 5.0 • Action Plan for the Integration and Development of Virtual Reality and Industrial Applications (2022-2026) • Industrial Clusters for the Metaverse • Metaverse Industry Committee 	<ul style="list-style-type: none"> • Metaverse Industry Professional Committee • Personal Information Security Specification • Regulations on the Administration of Deep Synthesis of Internet Information Services • Provisions on the Administration of Internet Information Service Algorithm Recommendations • Administrative Measures for Generative Artificial Intelligence Services

	Research and Innovation	Supporting Infrastructure	Vision for XR	Regulatory Approach to Build Trust
US 	<ul style="list-style-type: none"> • Human Centered Systems – NITRD • Chuman – NITRD • Synthetic Training Environment and Augmented Reality Sandtable at DOD • Enhanced Dynamic GeoSocial Environment at DHS • Immersed VR at FEMA • EdSim at Ed • VA Immersive • Regional Technology and Innovation Hubs at Commerce • Regional Innovation Engines at NSF 	<ul style="list-style-type: none"> • National Strategy to Secure 5G • Infrastructure Investment and Jobs Act • CHIPS and Science Act 		
			N/A	N/A

*Not yet completed.

What Does This Mean for the United States?

Many of the actions and policies outlined in our case studies are new, and it is too early to assess if they will be effective. Nevertheless, the U.S. can learn from what other governments are doing to support innovation, protect users from harm, and build trust and predictability as the technology changes over time.

Over the past two Administrations, we have seen indications that Congress and the White House are collaborating to nurture technological advancement and innovation and to develop policies that build trust and provide predictability.^{cccxlvii}

However, U.S. policymakers have not developed a strategy, a structure, or policies to nurture XR in the way that they have for other critical technologies as Table 3 illustrates.

Table 3: U.S. Critical Technologies – Strategy and Structure^{cccxlvi}

Underlying Tech and Inputs	Does the U.S. have a national strategy?	Is a person or government agency responsible for encouraging development?
Future Generation Wireless 5-6G	In development	NTIA*, DOD
Artificial Intelligence	Yes	OSTP, NSF, DOD
Integrated Network System of Systems (sensors)	No	N/A
Microelectronics (circuits and components)	In development	OSTP
Advanced Computing and Software (supercomputing, cloud computing, data storage, computing architectures, and data processing)	Yes	OSTP
Human-Machine Interfaces (VR/AR)	No	OSTP

Table by Susan Aaronson, Source Critical Technologies List

*NTIA is the National Telecommunications and Information Administration and is responsible for advising the President on telecommunications and information policy issues.

We can look to the United States' approach to AI as a model of a collaborative, whole-of-government approach to enabling the development of an emerging technology. In 2018, Congress created the National Security Commission on AI to study the opportunities and risks associated with AI, keeping in mind the importance of developing the technology in accordance with American democratic values.^{cccxlx} In 2020, Congress passed the National Artificial



Intelligence Initiative Act with its six strategic pillars focused on development, adoption, and regulation.^{cccl cccli} In January

2023, the Congressionally-mandated National AI Research Resource (NAIRR) Task Force released an implementation plan for providing data as well as computational, testbed, and software resources to AI researchers affiliated with U.S organizations.^{ccclii} Also in 2023, NIST released the AI Risk Management Framework to help organizations and

individuals characterize and manage the potential risks of AI technologies.^{cccliii} Meanwhile, Congress is presently considering several bills to advance AI and build-in guardrails. In contrast, the U.S. is only in the initial stages of creating a predictable regulatory environment for XR that can both nurture innovation and build trust and support the technology as it evolves.

Recommendations

1. Congress should introduce legislation authorizing an advisory council to develop a strategy to nurture XR in the United States.

Congress should authorize an advisory council to be established by the Department of Commerce in consultation with other government agencies. Diverse stakeholders with interdisciplinary expertise from academic institutions, the private sector, nonprofit and civil society entities should be appointed to the council.

The advisory council should be tasked with developing a comprehensive national strategy on immersive technology aimed at guiding and promoting its development and deployment across the U.S. economy.

This strategy should include:

- An assessment of the specific measures — such as standards, regulations, investments, and improved trust and safety practices — that are needed to ensure that immersive technology is designed, developed, and deployed in a manner that protects people's rights and safety;
- An assessment of the national security benefits and risks associated with immersive technology and the ways in which benefits can be maximized and risks mitigated;
- An assessment of the role of immersive technology in the broader emerging technology ecosystem and how the U.S. can support the synergistic effects of such an ecosystem;
- Economic objectives around the development and use of immersive technology;
- A projection of the research and development investment needed to ensure the United States is the global leader in immersive technology development, production, and implementation;
- A plan for developing and retaining the talent and workforce needed to ensure America's position as the global immersive technology leader; and
- Recommendations for how the U.S. government can leverage immersive technology to service the public good.

2. Congress should empower U.S. government agencies to model how digital twins can be leveraged by the government to serve the public interest.

Governments around the world are increasingly using digital twins to solve complex problems, streamline government operations, and find efficiencies. The U.S. also funds digital twins for a wide range of uses including to predict floods, to model earth systems, and for defense purposes, but the U.S. can do more. Congress should authorize agencies including the Department of Transportation, the Department of Health and Human Services, and the Federal Emergency Management Agency to develop test beds for using digital twins to advance urban planning and sustainability goals, enhance healthcare delivery and education, and improve disaster response and mitigation, among other core societal challenges. Moreover, tasking U.S. agencies to model and develop digital twins would help the government establish best practices and common standards for deploying XR technology across the federal government.

3. Congress should pass a comprehensive federal data protection law.

In contrast with other countries examined in this report, the U.S. does not have an overarching law governing the use of data. Hence, Congress should pass legislation that clearly delineates the rights and responsibilities of both the individuals that provide data and the entities that collect, analyze, and control data. The law should be technology neutral. Businesses and individuals will benefit from the certainty of an overriding federal data protection law, as opposed to the current patchwork of municipal and state legislation.

4. The White House should establish structures to coordinate, enhance, and fund federal XR research and development.

Several agencies are involved in XR research and development efforts in the federal government, but they do not consistently coordinate and cooperate. Moreover, almost every key agency, from the Office of Science and Technology Policy (OSTP) in the White House to National Institute for Standards and Technology (NIST) in the Department of Commerce, has limited staff working specifically on XR. The same is true for Presidential and interagency advisory committees, including the National Science and Technology Council and the Networking and Information Technology Research and Development (NITRD) program which is responsible for coordinating and tracking R&D across federal agencies. The White House should designate an interagency working group within NITRD for CHuman, the project component area in which XR research is coordinated, to enable agencies to effectively align their research with the government's priorities, pool resources for foundational research, and facilitate the implementation of XR innovations. The White House should also appoint an individual in OSTP and on the National Science and Technology Council to be responsible for coordination of XR policy.

5. The Department of State should host a global summit to foster debate and cooperation around complementary regulatory and governance frameworks and ensure that XR technology reflects democratic values.

Because XR technology transcends national borders, and because there is currently no set of universal rules governing the technology, it is especially difficult to regulate. The Department of State, in consultation with other U.S. government agencies such as the Department of Commerce and Office of the U.S. Trade Representative, should host a conference with international leaders to foster consensus on principles, standards, and frameworks that could govern XR.

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End Notes

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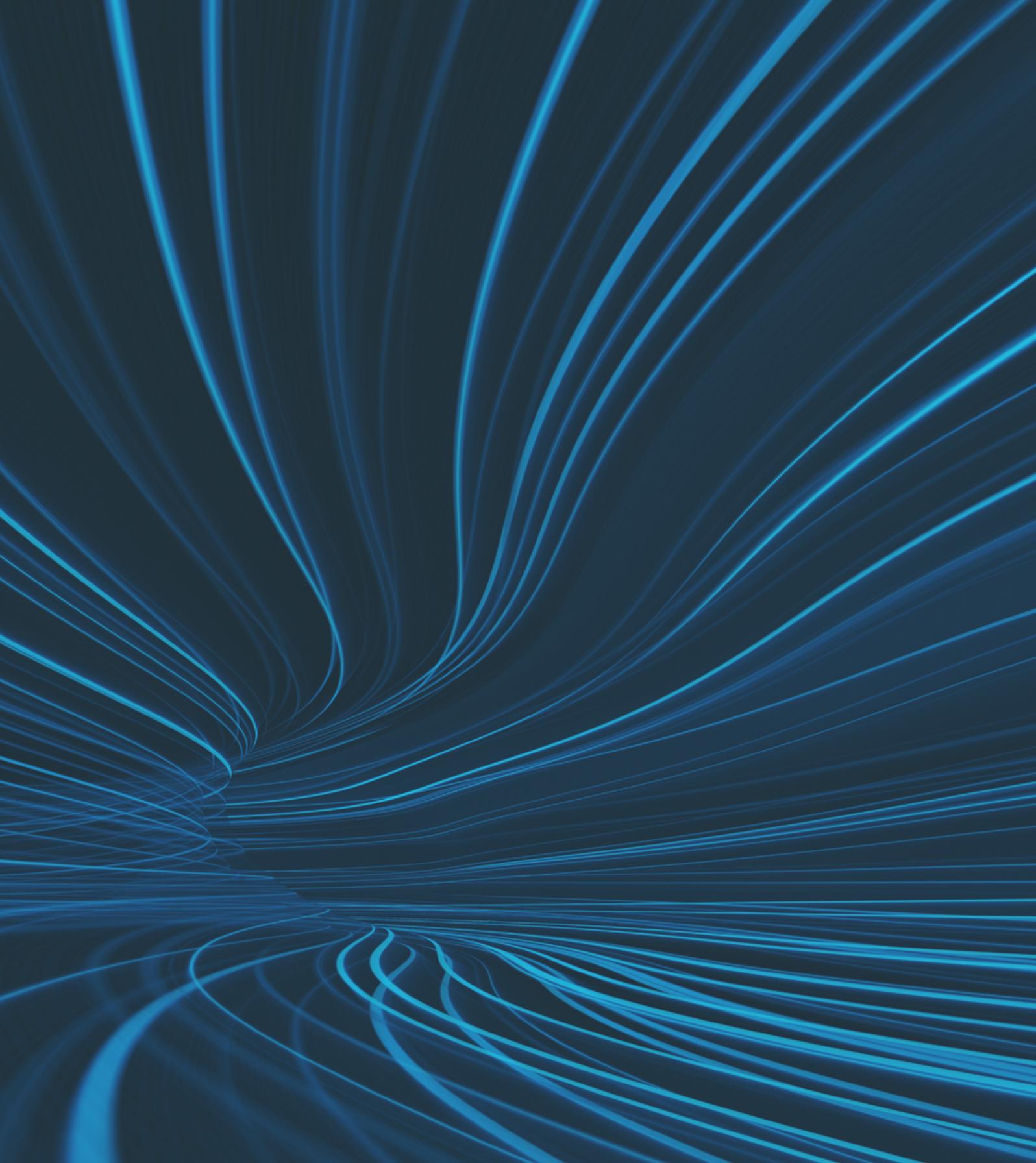
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