Citiverse Use Case Taxonomy Overview

Use Case Identification Track

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Citiverse Initiative

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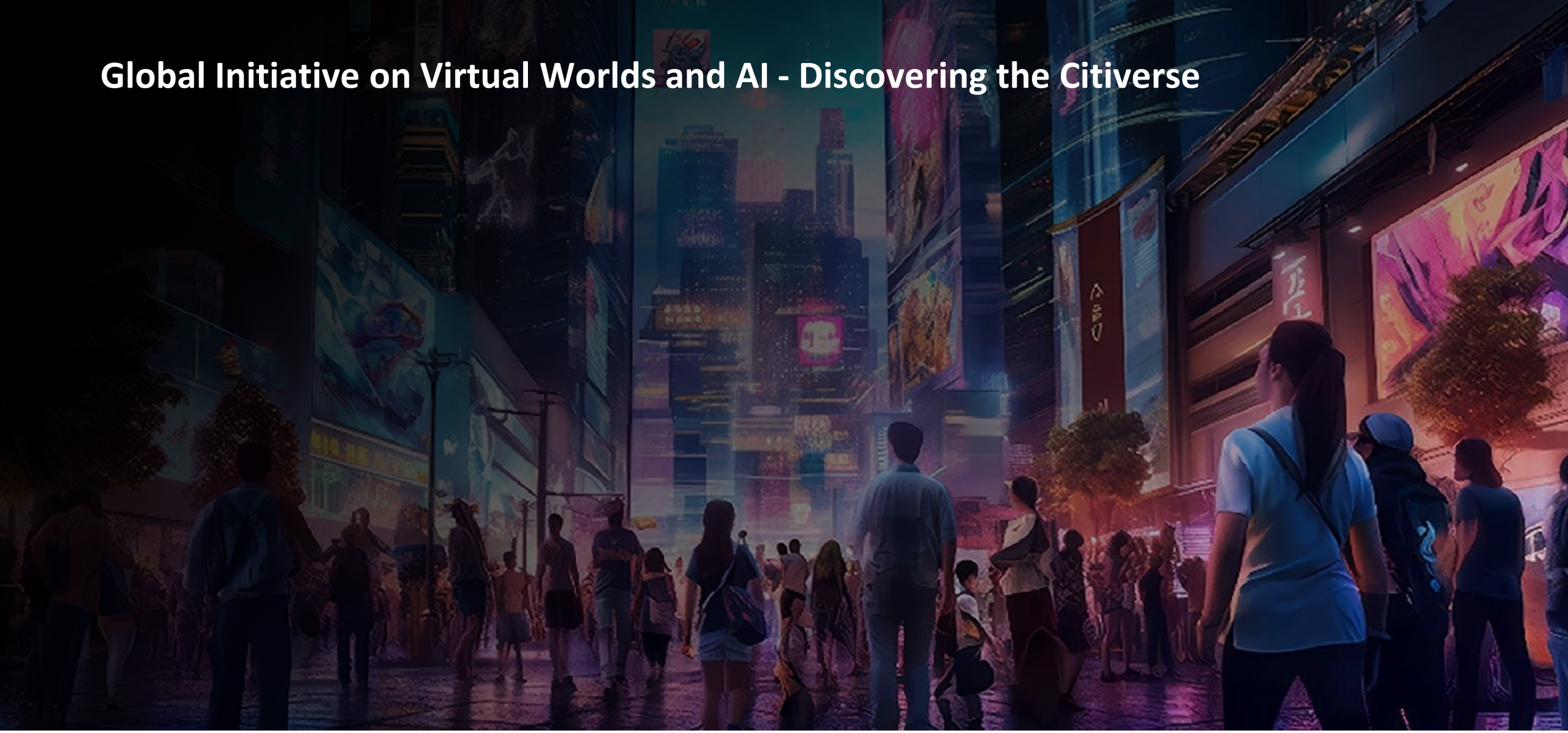
Disclaimers

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations, Executive Committee members or Steering Committee members of the Initiative. The findings presented in this report are based on a comprehensive review of existing literature and voluntary written contributions submitted by a diverse range of stakeholders.

Global Initiative on Virtual Worlds and AI - Discovering the Citiverse



Introduction

Global Initiative on Virtual Worlds and AI – Discovering the Citiverse

The concept of virtual worlds envisions a digital, immersive layer seamlessly integrated with the physical urban ecosystem. In this context the gap between the digital and physical worlds can be bridged with the help of emerging technologies such as augmented reality (AR), virtual reality (VR), artificial intelligence (AI), metaverse and digital twin. As virtual worlds continue to evolve, an innovative concept known as the Citiverse has emerged.

A citiverse can be composed of a series of interconnected distributed virtual worlds representing their physical counterparts and synchronized at a specified frequency and fidelity to address the necessities and aspirations of cities and their inhabitants.

Under the auspices of the **Global Initiative on Virtual Worlds and AI – *Discovering the Citiverse***, this vision is gaining momentum. The Global Initiative on Virtual Worlds and AI - *Discovering the Citiverse* (hereon called "the Initiative") was established and launched by ITU, UNICC and Digital Dubai on 14 June 2024 during the 1st UN Virtual Worlds Day. The initiative serves as a global platform that aims at fostering open, interoperable and innovative virtual worlds that can be used safely and with confidence by people, businesses and public services.

Global Initiative on Virtual Worlds and AI – Objectives

01 Serve as the avenue for developing normative frameworks addressing principles, enablers and governance for applying metaverse solutions in cities.

02 Provide training and hosts events to disseminate knowledge, raise awareness and share best practices and solutions among cities worldwide.

03 Deliver a sandbox environment to test, and experiment with metaverse scenarios in cities around the world.

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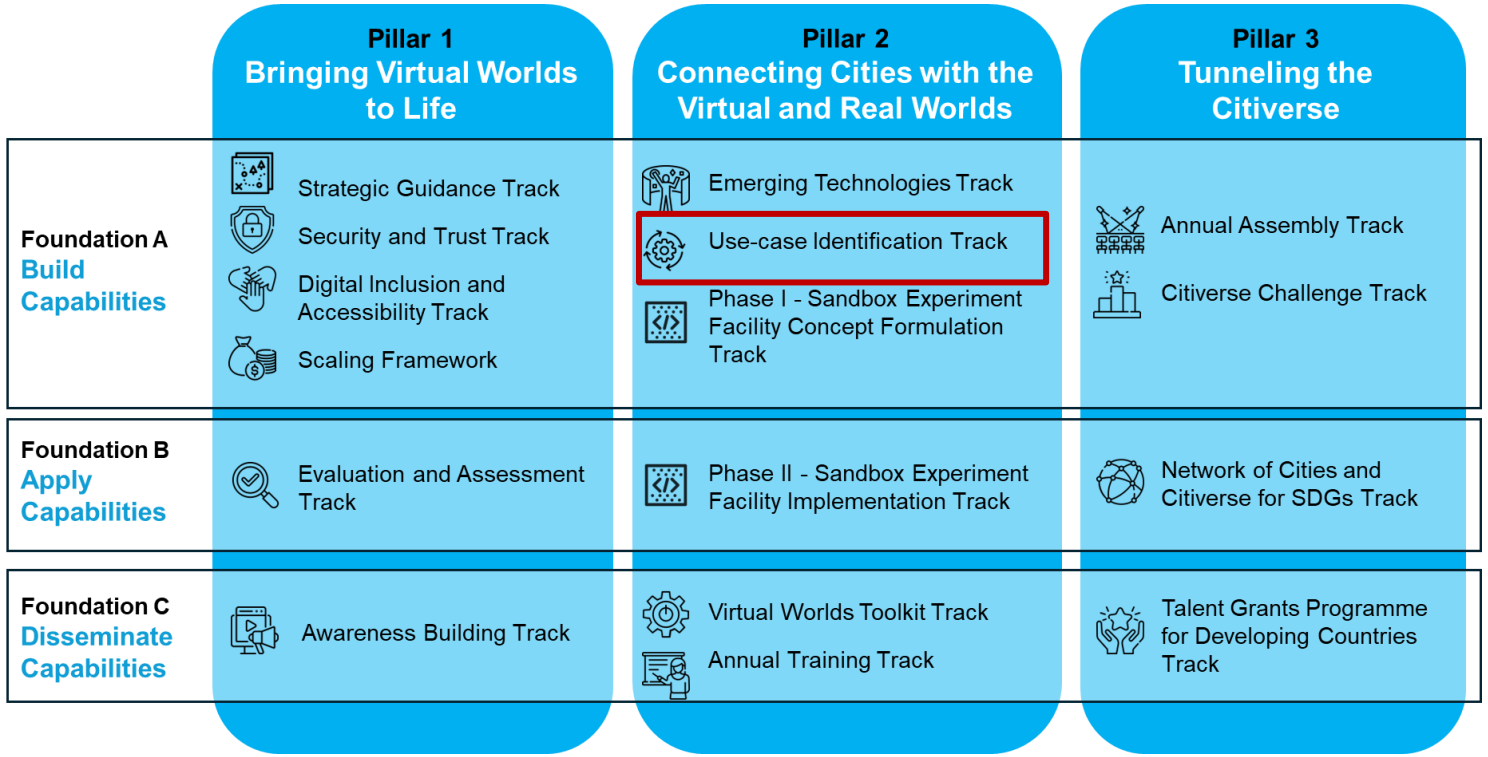
Global Initiative on Virtual Worlds and AI – Pillars and Tracks



- The first pillar, bringing virtual worlds to life, focuses on **strategic aspects** of the initiative such as developing guidance, building awareness and creating evaluation and awareness frameworks.
- The second pillar, connecting cities with the virtual and real worlds, focuses on the **operational aspects** of the citiverse such as the integration of emerging technologies, key use cases and best practices and providing the environment, tools and events for city experimentation.
- The third pillar, tunnelling the citiverse, creates a **community of practice** and mechanisms to engage with city leaders, academia and industry.

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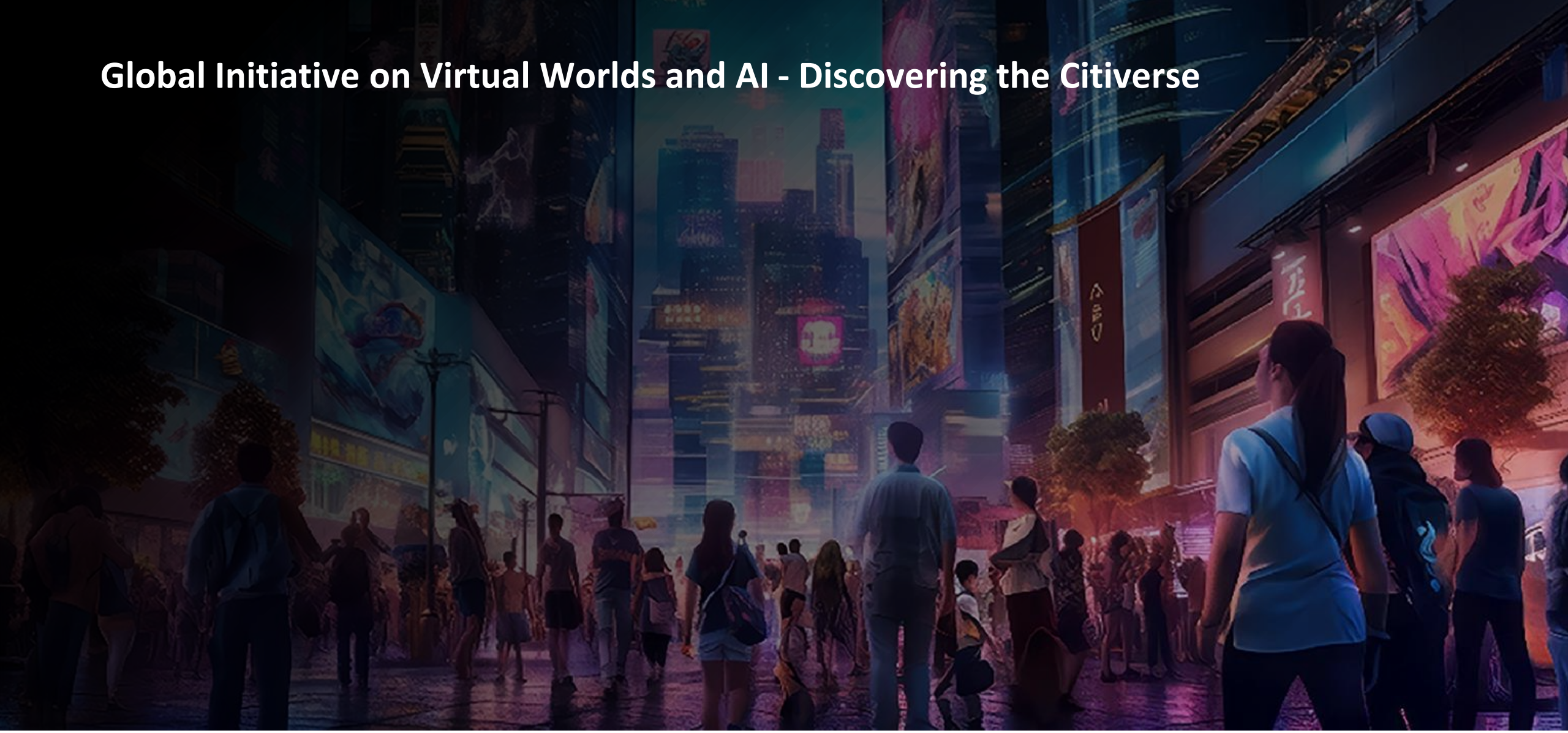
Use Case Identification Track

The use-case identification track focuses on the collection and curation of new use cases pertaining to virtual worlds, including the adoption of digital technologies, such as AI, VR, AR, digital twins and AI cities. The track beings together insights on the expected opportunities, risks, and maturity horizons associated with the use cases identified. The track has two core outputs:

1. Citiverse Use Case Taxonomy Overview – this PPT presentation that provides a library of Citiverse use cases
2. Citiverse Use Case Taxonomy Accompanying Document – a report which acts as a companion to the taxonomy and provides a more detailed overview of the use cases presented.



Methodology

Overall Approach

The development of the Citiverse Use Case Taxonomy followed a structured, multi-phase methodology designed to ensure that the use cases identified are diverse, representative, and practically relevant for cities exploring the potential of virtual world technologies.

Phase 1: The initial phase of the Use Case Taxonomy work track focused on collecting a broad range of use cases across 5 thematic areas.

Phase 2: To create a short list for each of the thematic areas of approximately 10 use cases, the use cases were assessed by the working group using four core criteria validated by the broader Global Initiative on Virtual Worlds and AI Community: alignment with SDGs, scalability, impact and feasibility. Each expert scored each of the 5 criteria from 1-10. Those with the highest scores were then integrated into a short list for each thematic group; consideration was also given to ensure a diverse range of case studies with coverage across key topics. It is these use cases that are presented within the Citiverse Use Case Taxonomy.

Phase 3: A use case profile was then created for each use cases including aspects such as a use case description, case study, horizon, risk, and technology mapping, key impacts, and alignment with SDGs. This methodology will highlight the process for risk, horizon and technology mapping. A summary of the use case is presented in this document, the full use case description is provided in: Citiverse Use Case Taxonomy Accompanying Document.

Thematic Areas

Thematic Area	High Level Description
Urban Planning, Placemaking, and Infrastructure	This thematic area is focused on leveraging virtual worlds to transform the way we create liveable places and transform the built environment around in cities and includes topics such as placemaking and liveable spaces and urban infrastructure engineering.
City Administration, Services, and Public Participation	This thematic area is focused on leveraging virtual worlds to transform city governance, enhance public services, and foster meaningful citizen engagment and includes topics such as public service delivery, sustainable city operations and citizen participation and co-creation.
Economic Development, Education and Tourism	This thematic area is focused on leveraging virtual worlds to provide immersive and personalised education, drive sustainable economic development in cities and promote sustainable tourism and includes topics such as the blue economy, circular economy and vocational training.
Transport and Mobility	This thematic area is focused on leveraging virtual worlds to transform the way people and goods move through cities and includes topics such as public transportation, active transportation and micromobility.
Public Safety, Health and Disaster Resilience	This thematic area is focused on leveraging virtual worlds to strengthen public safety, health and disaster resilience and includes topics such as first responder training, health crisis management and climatic resilience.

Criteria for Prioritising Use Cases

A long list of use cases was created for each thematic area. To prioritise these and create a short list of 10 use cases per thematic area, the use cases were assessed against 4 criteria validated by the broader Global Initiative on Virtual Worlds and AI Community. For each use cases, the experts assigned a score of between 1-10 against these 4 criteria. Those with the highest scores were then integrated into a short list for each thematic group; consideration was also given to ensure a diverse range of use cases with coverage across key topics.

Scoring Criteria	Key Question
Alignment with SDGs	To what extent does this use case contribute to one or more SDG targets?
Scalability	How relevant is this use case for multiple cities and how easily can it be replicated and scaled?
Impact	How impactful will the case study be for social, economic and environmental outcomes?
Feasibility	What are the long-term maintenance and resource requirements? What is the time to value?

Horizon Mapping

To illustrate the maturity and temporal applicability of use cases, each was assigned to one of three **horizons**.

The horizon stages and definitions have been drawn from IDC's methodology for horizon mapping and validated by the Use Case Identification Track working group of experts.

- **Horizon 1**: Solutions that are mature and currently being deployed in real-world settings.
- **Horizon 2**: Emerging use cases with demonstrated pilots or early-stage implementation.
- **Horizon 3**: Conceptual or experimental use cases that show significant long-term potential but are not yet operational. For these horizons, case studies have not been included as they are in the 'discovery' phase.

Use Case Risk Mapping

Each use case was also evaluated against four risk dimensions to help cities assess implementation challenges and mitigation needs. For each risk dimension the use case was classified as low, medium or high risk. In this taxonomy, the risk level will be provided, in the *Citiverse Use Case Taxonomy Accompanying Document,* an explanation of the risk classification will be elaborated.

Risk Dimensions	Description
Public Safety	Evaluates how a use case may impact the physical and digital safety of individuals and communities. It considers both unintentional harms and the misuse of technology that could threaten public well-being.
Stakeholder Acceptance	Reflects the expected level of endorsement or opposition from key stakeholders, including city officials, community members, and private partners, taking into account cultural values, political contexts, and potential equity concerns.
Data Privacy and Security	Assesses the sensitivity and volume of personal or sensitive data involved in a use case, as well as the robustness of governance, encryption, and compliance mechanisms in place to safeguard it from misuse, breaches, or unauthorized access.
Financial and Operational Risk:	Captures the potential economic and logistical challenges associated with implementing the use case, including high upfront costs, complex procurement or regulatory hurdles, ongoing maintenance requirements, and the need for cross-departmental coordination or new workforce capabilities.

Key Technologies

Key technologies were also selected for each use case. A pre-defined list was created from which to select relevant technologies (see table below). This list is not intended to be exhaustive; it was selected by the expert group based on the technologies most pertinent across the Citiverse use cases. This list may evolve based on the work of the Emerging Technology Track and can be integrated into future iterations of the Citiverse Use Case Taxonomy.

Technology	Definition	Reference
Metaverse	An integrative ecosystem of virtual worlds offering immersive experiences to users, that modify pre-existing and create new value from economic, environmental, social and cultural perspectives. NOTE – A metaverse can be virtual, augmented, representative of, or associated with the physical world.	FGMV-20
Digital Twin	A digital twin network is a digital representation of an object of interest.	ITU-T Y.4600
Augmented Reality (AR)	An environment containing both real and virtual sensory components. The augmented reality continuum runs from virtual content that is clearly overlaid on a real environment (assisted reality) to virtual content that is seamlessly integrated and interacts with a real environment (mixed reality).	ITU-T P.1320
Virtual Reality (VR)	An environment that is fully generated by digital means. To qualify as virtual reality, the virtual environment should differ from the local environment.	ITU-T P.1320

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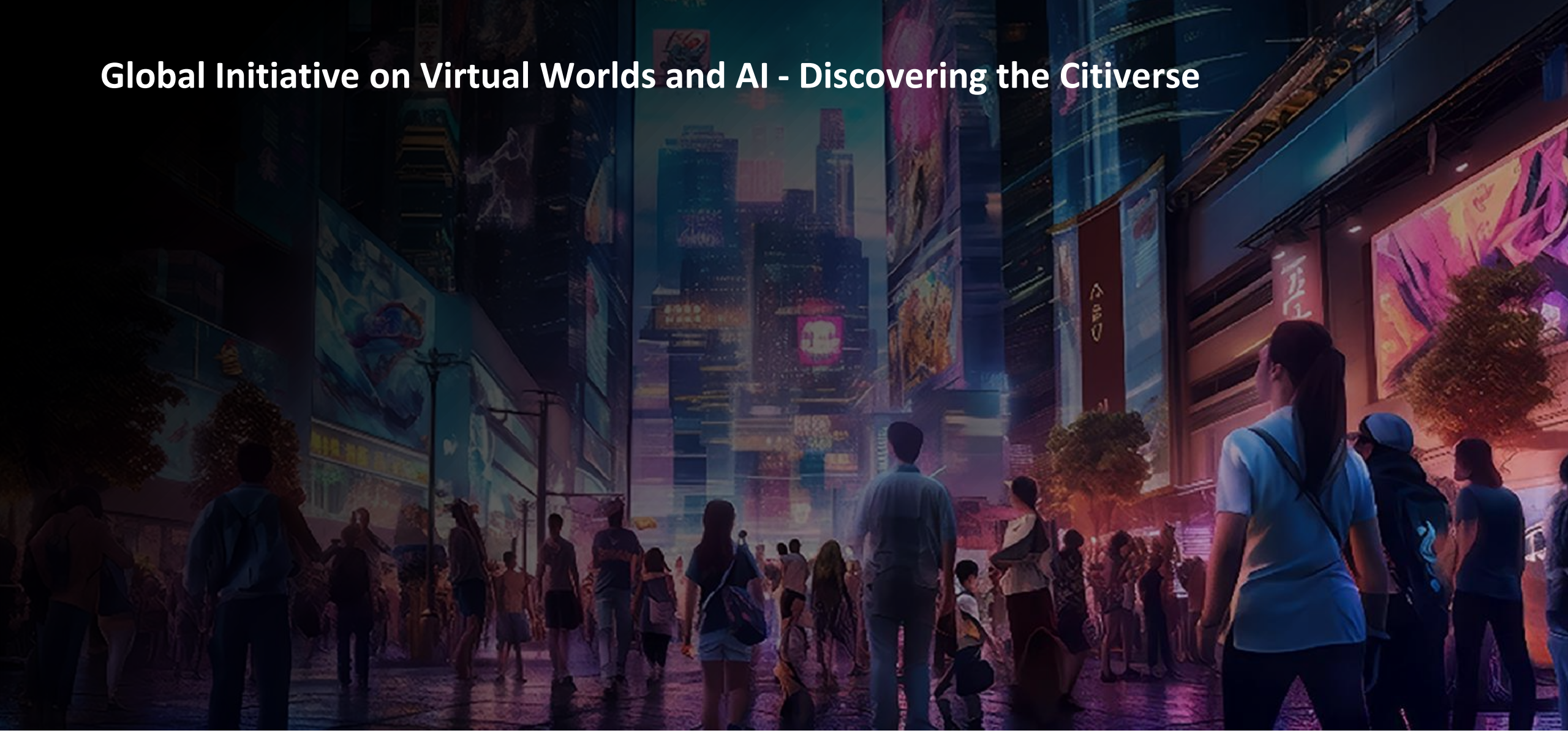
Key Technologies

Technology	Definition	Reference
Mixed Reality (MR)	An environment containing both real and virtual components that are seamlessly integrated and interact with each other in a natural way (one end of the augmented reality continuum).	ITU-T P.1320
Internet of Things (IoT)	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.	ITU-T Y.4000
Artificial Intelligence (AI)	Computerized system that uses cognition to understand information and solve problems.	ITU-T M.3080
Generative AI (GAI)	GAI refers to a broad field of research and development that focuses on creating intelligent systems that can generate new, original content, such as images, videos, music, text, and even entire conversations. These systems use machine learning algorithms to learn patterns and structures within the data they are trained on, and then use this knowledge to generate new content that resembles the original data, but is not necessarily identical to it.	FGMV-22



Use Case Identification Track Experts

Use Case Identification Track Experts

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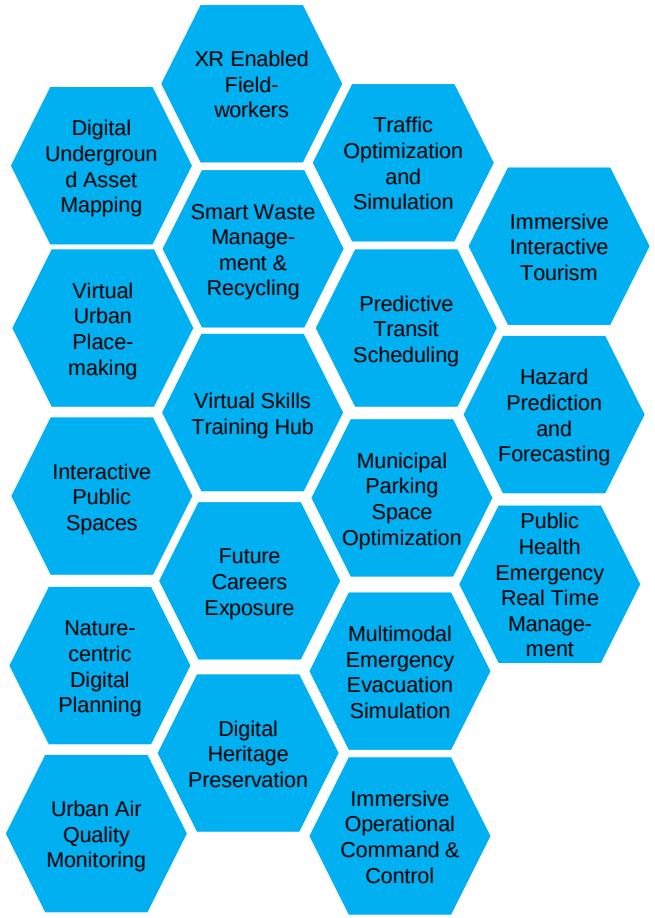
Andrew Schroeder – VP of Research and Analysis, Direct Relief
Kanika Kalra – WHO, Technical Officer
Queen Ndlovu – CEO and co-founder of QP DroneTech, South Africa Flying Labs.

Global Initiative on Virtual Worlds and AI - Discovering the Citiverse

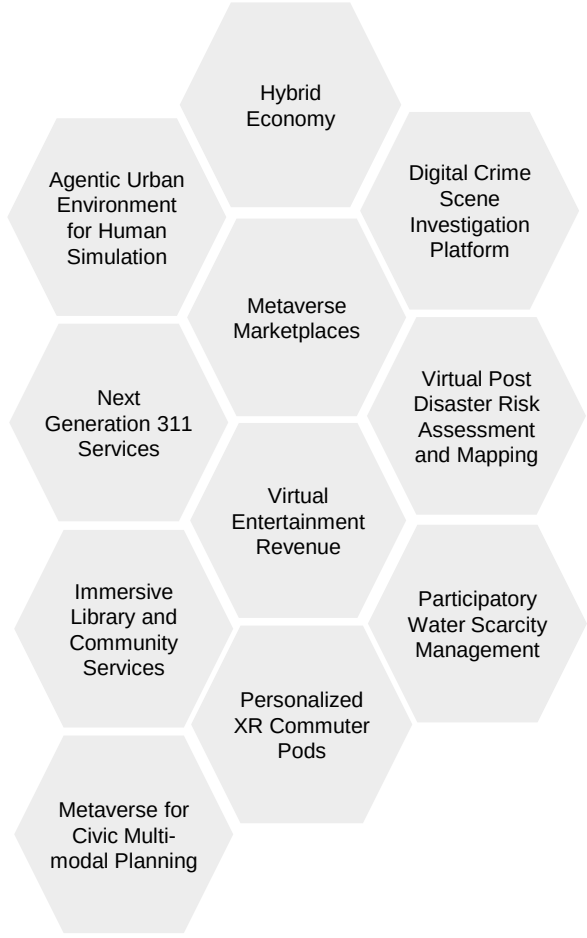
Use Case Overview and Horizon Mapping

Citiverse Use Case Overview and Horizon Mapping



Horizon 1: Current Deployment

Horizon 2: Piloting



Horizon 3: Discovery

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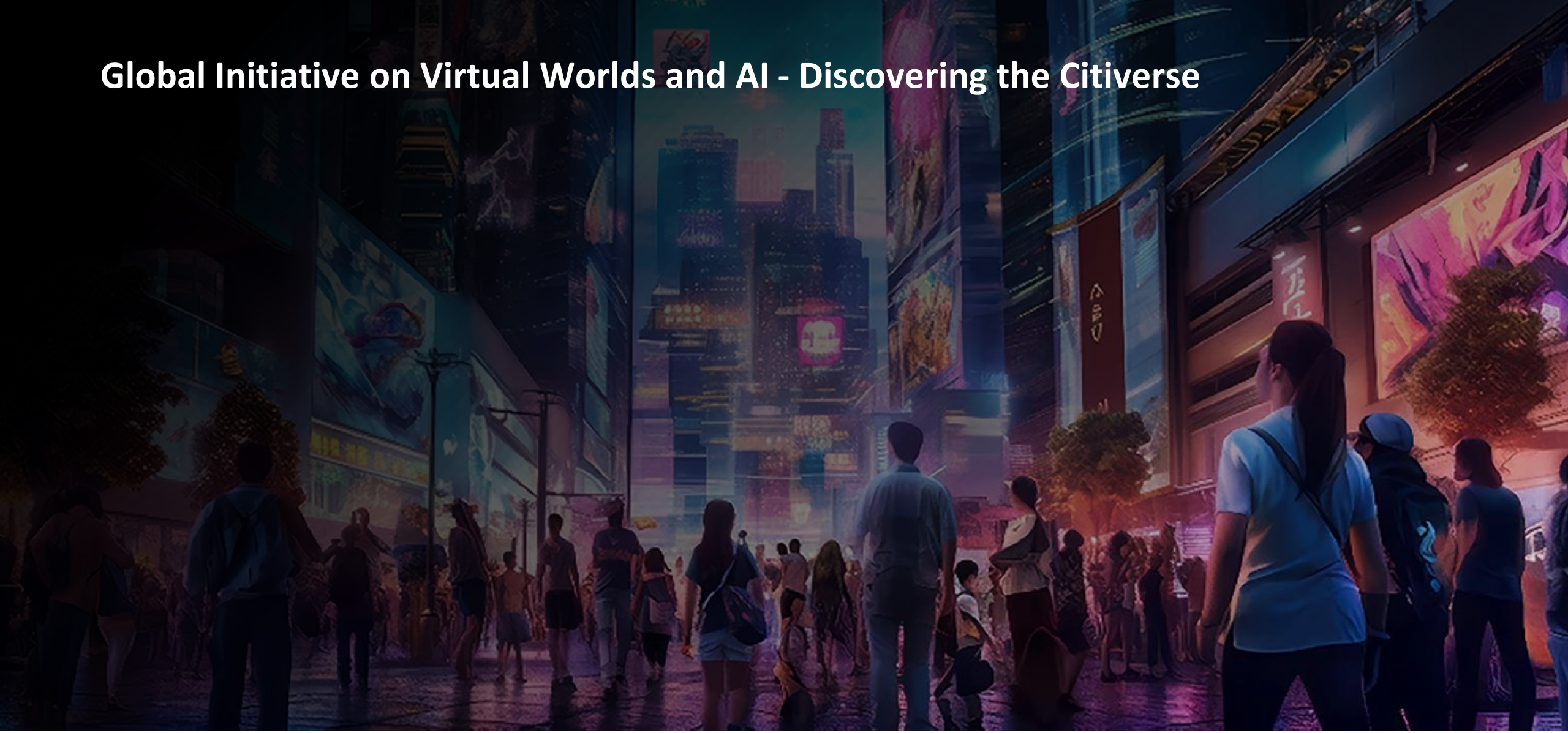


Thematic Area 1: Urban Planning, Placemaking and Infrastructure

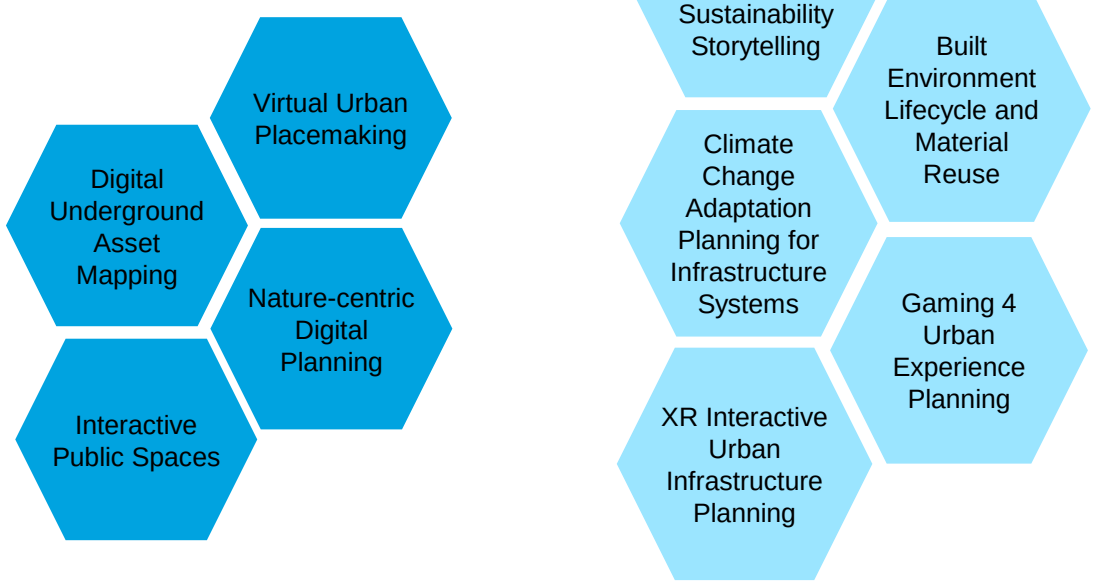
Thematic Area Overview

The discipline of urban planning is crucial when it comes to the governance and evolution of cities and urban systems. When energy, water, transport and the built environment evolve over time, urban and infrastructure planning have to anticipate the positive opportunities to maximise social benefit.

The Urban Planning, Placemaking & Infrastructure thematic area focuses on leveraging virtual worlds to transform the way we create liveable places and transform the built environment around in cities. The thematic area will span the following topics, inter alia:

- **Urban planning and governance (top-down)**: including enhancing the processes and tools for the development and design of land use and built environment to drive better data-driven decisions and sustainable outcomes.
- **Placemaking and liveable spaces (bottom-up)**: strengthening public participation in urban planning and placemaking processes to improve livability.
- **Urban Infrastructure Engineering**: optimizing the design of urban infrastructure such as energy and water systems.
- **Regulatory frameworks and building codes**: including strengthening regulatory development and compliance to support greater building safety, resilience and sustainability.
- **Lifecycle management and maintenance**: optimizing the lifecycle management and maintenance of urban infrastructure such as energy and water systems. This involves circular economy innovations for the innovative re-use of materials.

Use Case Overview and Horizon Mapping



Horizon 1: Current Deployment

Horizon 2: Piloting

Horizon 3: Discovery

Digital Underground Asset Mapping

Horizon 1

Description

Virtual world technologies such as digital twins can be used to create an interactive digital map of underground pipes and cables spanning public and private sector energy, water and telecommunications assets. City stakeholders such as urban planners, public works department, and utility providers can use this platform to plan new infrastructure projects, issue permits more efficiently, identify safety issues, avoid utility strikes during street digging, and coordinate amongst different stakeholders to coordinate utility maintenance and upgrade projects. AI could be leveraged for predictive maintenance and to identify collaboration opportunities in order to limit disruption to residents, visitors and local businesses.

Example

The geospatial commission in the UK is building a digital twin of underground pipes and cables - the National Underground Asset Register (NUAR). NUAR is improving the efficiency and safety of buried infrastructure by providing a secure way to access data from over 600 public and private sector asset owners. The first phase covered London, Northeast England, with further roll out to all of England and Wales. It is estimated that this project will lead to economic growth of at least £400 million per year through increase efficiency, fewer accidental strikes and reduced disruption.

Impacts

- Quality infrastructure
- Enhanced Safety
- Cost savings
- Quality of life
- Operational efficiency
- Regulatory compliance

SDG Alignment

Target 9.1

Target 11.3

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Climate Change Adaptation Planning for Infrastructure Systems

Horizon 2

Description

Digital twins can be used to improve climate adaptation and resilience across a system of infrastructure systems. An ecosystem of connected digital twins enables those who own and operate infrastructure systems to use secure, resilient, information sharing across sector boundaries to mitigate the effect of impacts such as flooding on network performance and service delivery. Combining data and insights across sectoral and organisational boundaries enables improved coordination of operational and investment decisions, including inter- and intra-sector collaboration, to increase resilience against extreme weather events and improve response times.

Example

The Climate Resilience Demonstrator (CReDo) in the UK is a pioneering climate change adaptation digital twin project that provides a practical example of how connected data can improve climate adaptation and resilience across a system of systems. It looks specifically at the impact of flooding on energy, water and telecoms networks, bringing together three of the major infrastructure providers in the UK to demonstrate the capability of connected digital twins to improve resilience planning and incident response and recovery.

Impacts

- Improved infrastructure systems resilience
- Coordinated responses for vulnerable citizens
- Community resilience
- Collaborative planning in virtual environments
- Enhanced safety

SDG Alignment

Target 9.4 Target11.2

Target 13.1, 13.3

Key Technologies

- **Digital Twin**
- Metaverse
- AR
- **VR**
- MR
- **GAI**
- **AI**
- **IoT**

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 1

Hybrid Public Spaces

Description

This use case leverages metaverse technologies and XR to simulate and co-create interactive public spaces and social engagements within phygital environments. By blending digital storytelling, hybrid events, and participatory design, these platforms strengthen cultural identity, foster playful interactions, and encourage broader public participation across diverse communities. Virtual access also lowers traditional barriers to engagement while enabling resilient civic and cultural interaction during disruptions or crises. The use case also supports urban development goals by increasing the number of people accessing, experiencing, and shaping public spaces in creative, experiential ways.

Example

Event organizers created a virtual counterpart to their annual desert festival, the Burning Man Multiverse in 2019. Using formerly available platforms like AltspaceVR and custom-built virtual worlds, they enabled over 100,000 global participants to co-create digital art, explore virtual camps, and join shared rituals. This preserved the community's creative culture during physical restrictions, expanded access, and showcased how immersive platforms can foster cultural continuity, participatory urbanism, and global engagement.

Impacts

- Community Resilience
- Quality of Life
- Participatory Co-Creation
- New Economic and Tourism Opportunities
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 9.1

Target 11.6

Key Technologies

Digital Twin	**Metaverse**	**AR**	VR	MR	**GAI**	AI	**IoT**

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 2

Built Environment Lifecycle and Material Reuse

Description

Circular Twin utilizes Metaverse technologies to optimize lifecycle management and material reuse in real estate development. By creating immersive digital twins of buildings and urban assets, stakeholders can track material flows, simulate renovation scenarios, and plan for circular deconstruction. Architects, developers, and sustainability experts collaborate in virtual environments to assess environmental impact, maximize resource efficiency, and explore reuse potentials before implementation. The platform fosters transparency, supports circular economy principles, and extends the lifespan of built assets through data-driven decision-making.

Example

The province of Utrecht in the Netherlands is developing a digital twin platform to support circular and sustainable urban development. By integrating spatial and environmental data in a 3D environment, it enables planners to simulate material flows, reuse potential, and lifecycle impacts of housing projects.
Though not yet immersive, it sets the stage for Metaverse-based collaboration focused on resource efficiency and climate resilience.

Impacts

- Lower Carbon Emissions
- Reduced Construction and Demolition Waste
- Extended Building Lifespan
- Data-Driven Decision-Making
- Transparency and Material Traceability
- Collaborative Planning in Virtual Environments

SDG Alignment

Target 12.2
Target 12.5

Target 13.2

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

Horizon 2

Gaming 4 Urban Experience Planning

Description

A participatory urban simulation leverages immersive gaming environments as dynamic platforms for planners, designers, and civic stakeholders to co-create and test urban interventions within interactive virtual worlds. Utilizing a digital twin embedded in a gaming engine, this use case captures real-time behavioral data from thousands of users navigating simulated urban infrastructure. The resulting insights reveal emergent patterns in pedestrian flows, mobility choices, and spatial engagement, informing evidence-based planning decisions. This approach fosters a feedback-rich, experiential model of urban design that prioritizes user agency, real-world complexity, and iterative development through continuous digital experimentation.

Example

Mas Colonia pioneered using Fortnite as a beta testing platform to observe real user interactions with urban infrastructure in an immersive, gamified environment. Thousands of players navigated the virtual city, providing invaluable behavioral data on transportation preferences, public space usage, and pedestrian flows. These insights directly informed the final urban design to maximize functionality, sustainability, and resident satisfaction in the physical implementation.

Impacts

- Quality infrastructure
- Quality of Life
- Cost savings
- Walkability
- Participatory Co-Creation
- Citizen Engagement

SDG Alignment

Target 9.1

Target 11.3,11.7

Target 16.7

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	**High**
Financial/operational	Low	**Medium**	High

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Horizon 3

Agentic Urban Environment for Social Simulation

Description

An agentic urban simulation provides a sophisticated computational virtual platform for urban planners, architects, and policy-makers to explore complex social dynamics and spatial interactions within emerging virtual world infrastructures. By leveraging multi-agent AI systems, the simulation generates emergent behavioral patterns that dynamically respond to urban design interventions, allowing experts to test urban design scenarios through high-fidelity agent-based simulations or to predict community engagement and spatial utilization in proposed virtual environments. The use-case describes thereby a responsive, data-driven environment with individual preferences, behaviors, and adaptive responses of agents.

Example

Project Sid, simulates AI agents working together in a Minecraft server to create virtual civilizations complete with economies, governments, cultural practices, and even religious institutions. What makes this experiment unique is the agents' ability to operate independently for extended periods without human intervention. The programmers first introduce the PIANO (Parallel Information Aggregation via Neural Orchestration) architecture, which enables agents to interact with humans and other agents in real-time while maintaining coherence across multiple output streams.

Impacts

- Risk-Free Urban Design Experimentation
- Cost-Effective Strategic Planning
- Enhanced Community Engagement
- Gender equality in urban places

SDG Alignment

Target 10.2

Target 8.3

Key Technologies

Digital Twin	**Metaverse**	AR	**VR**	MR	**GAI**	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

Horizon 2

XR Interactive Urban Infrastructure Planning

Description

XR-enabled digital twins are transforming how cities approach urban planning, design, and community engagement. By combining geospatial data, 3D models, and immersive XR technologies, these digital environments provide an interactive platform to simulate, analyze, and visualize urban development scenarios in real time. Planners, architects, and stakeholders can explore proposed infrastructure, policy impacts, and environmental changes in a dynamic, human-centric way. This approach enhances decision-making by making complex spatial data intuitive and accessible. It also enables more inclusive planning by allowing citizens to experience future developments in a virtual context.

Example

Nottingham City Council developed an advanced 3D digital twin to support more efficient, transparent, and inclusive urban planning. Built on geospatial and planning data, and enhanced through XR visualization, the platform allows planners and citizens to explore future developments in immersive 3D. It integrates layers such as heritage zones, flood risk, and live transport data to support scenario analysis and stakeholder engagement. The digital twin has played a key role in unlocking over £4 billion in investment by streamlining planning workflows and enhancing communication across sectors.

Impacts

- Emission reduction
- Quality of Life
- Biodiversity
- Walkability
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 11.3 11.6. 11.7

Target 9.1

Target 13.2

Target 16.7

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 2

Climateverse for Sustainability Storytelling

Description

This use-case describes the establishment of a citizen-centric virtual environment for climate transition of urban spaces, e.g., on neighborhood or district level: Building a virtual climate image, real laboratory and playful incentive systems for the transfer of knowledge and participation. An application could be an interactive, virtual cityscape as classroom that teaches fundamental concepts of sustainable development. Topics such as climate change, resource management, and social justice are vividly experienced in an open and interoperable urban 3D environment. The use-case could be extended with participatory crowd-funding of climate-mitigation measures in urban spaces.

Example

The EELISA Metaverse & Sustainability Community has developed educational games on sustainability and climate change mitigation in urban areas through the power of game design and the metaverse – based on the roblox platform in 2023. The Climateverse Futures Lab as strategic foresight + climate storytelling studio helps (since 2024) organizations and teams to anticipate change, to engage meaningfully with climate and justice issues, and to radically imagining & co-creating better futures.

Impacts

- Behavioral citizen Transformation
- Immersive Climate Awareness
- Participatory Urban Planning
- Collaborative Climate Problem-Solving
- Inclusive Social Climate Justice Modelling

SDG Alignment

Target 4.7

Target 13.3

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 1

Nature-Centric Digital Planning

Description

A nature-centric digital planning model offers an advanced virtual environment for integrating ecological systems, seasonal dynamics, and biodiversity into urban design and simulation processes. This use case enables planners, ecologists, and designers to visualize and assess the role of green infrastructure, water cycles, and vegetation growth patterns within evolving cityscapes. By simulating temporal changes in natural elements and their interaction with human activity, the use case supports scenario testing for climate resilience, urban cooling, and habitat connectivity. The platform facilitates data-driven decision-making allowing for more adaptive, sustainable, and regenerative urban environments.

Example

Herbarium.ai Finland an urban vegetation information and 3D modeling provider with a repository of species and types of urban vegetation. First Use-Case in the cities of Talinn and Helsinki.

Tree-D Fusion: developed by MIT, Google, Purdue University, it is an AI-powered system that generates accurate 3D models of urban trees. Its first case study was the modelling of all trees in N-America.

Both incorporate growth models that simulate seasonal changes and growth cycles.

Impacts

- Emission reduction
- Quality of Life
- Biodiversity
- Walkability
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 11.3. Target 13.2 11.6, 11.7

Target 15.5; 15.9

Key Technologies

- Digital Twin
- Meta-verse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

Horizon 1

Virtual Urban Placemaking

Description

AR/VR-driven digital twin and metaverse urban placemaking is an emerging approach that uses immersive technologies to enhance how people experience, interact with, and shape urban spaces. by creating detailed virtual replicas of real-world environments, cities can offer new layers of engagement - ranging from virtual tourism and cultural programming to participatory planning and augmented public art. These technologies enable both physical and digital participation in placemaking, allowing communities, artists, and planners to co-create dynamic, inclusive urban experiences that transcend geographic and social boundaries, while also supporting innovation, sustainability, and cultural expression in the built environment.

Example

Virtual Helsinki is a creative placemaking initiative that uses AR/VR & metaverse technologies to transform Helsinki into an immersive digital experience. Developed by Helsinki Marketing and Zoan, the project features a photorealistic 3D twin of the city, enabling virtual tourism, cultural events, and interactive storytelling. Through social VR, residents and global users can explore landmarks, attend concerts, and engage with community-driven art installations. The hybrid urban experience fosters inclusivity, enhances civic engagement, and creates a shared cultural platform.

Impacts

- Citizen Engagement
- Quality of Life
- Data-driven decisions
- Social Inclusion
- Local Economic Development
- Sustainability and Efficiency

SDG Alignment

Target 11.3, Target 11.4

Target 8.9

Key Technologies

- **Digital Twin**
- **Metaverse**
- **AR**
- **VR**
- **MR**
- GAI
- AI
- IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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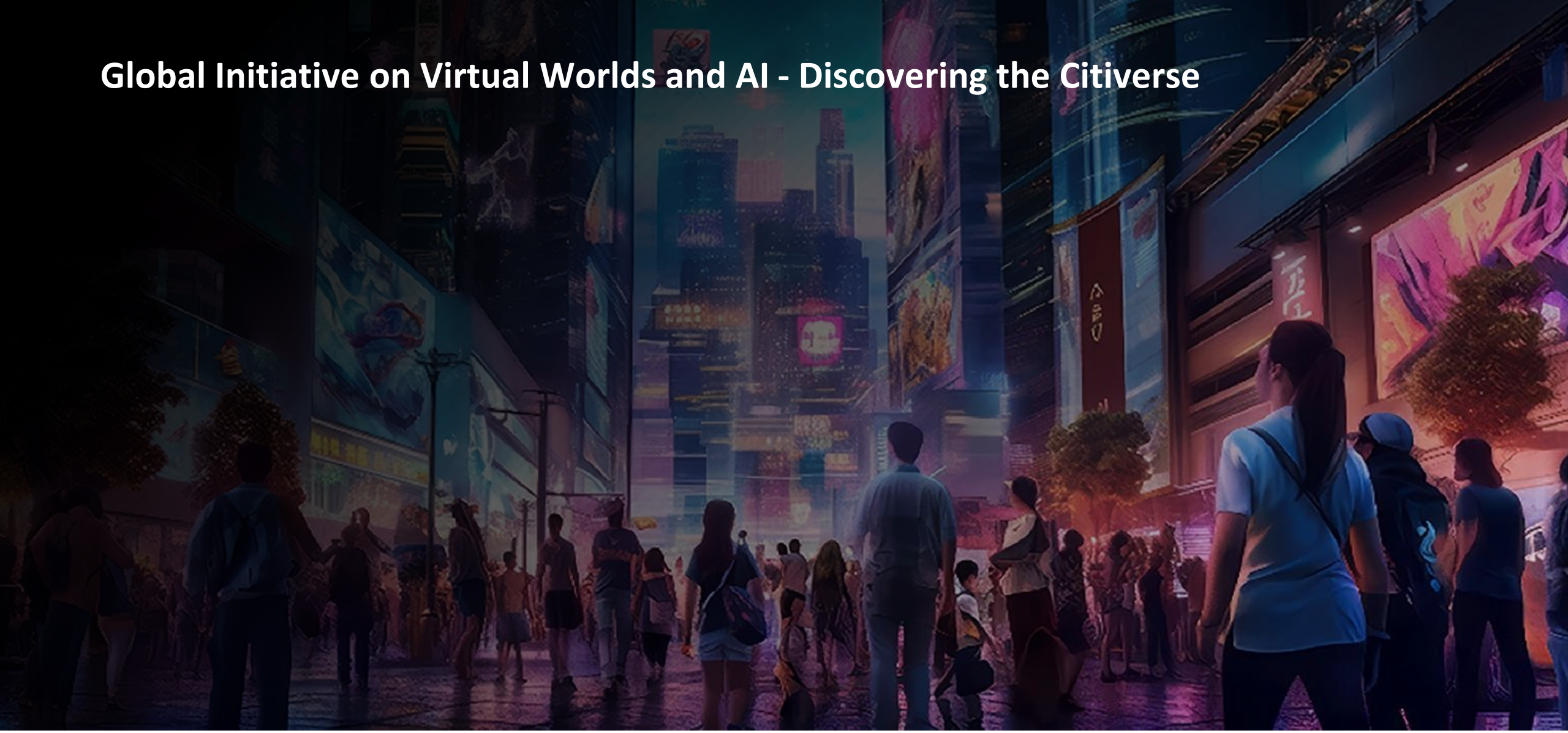


Thematic Area 2: City Administration, Services and Public Participation

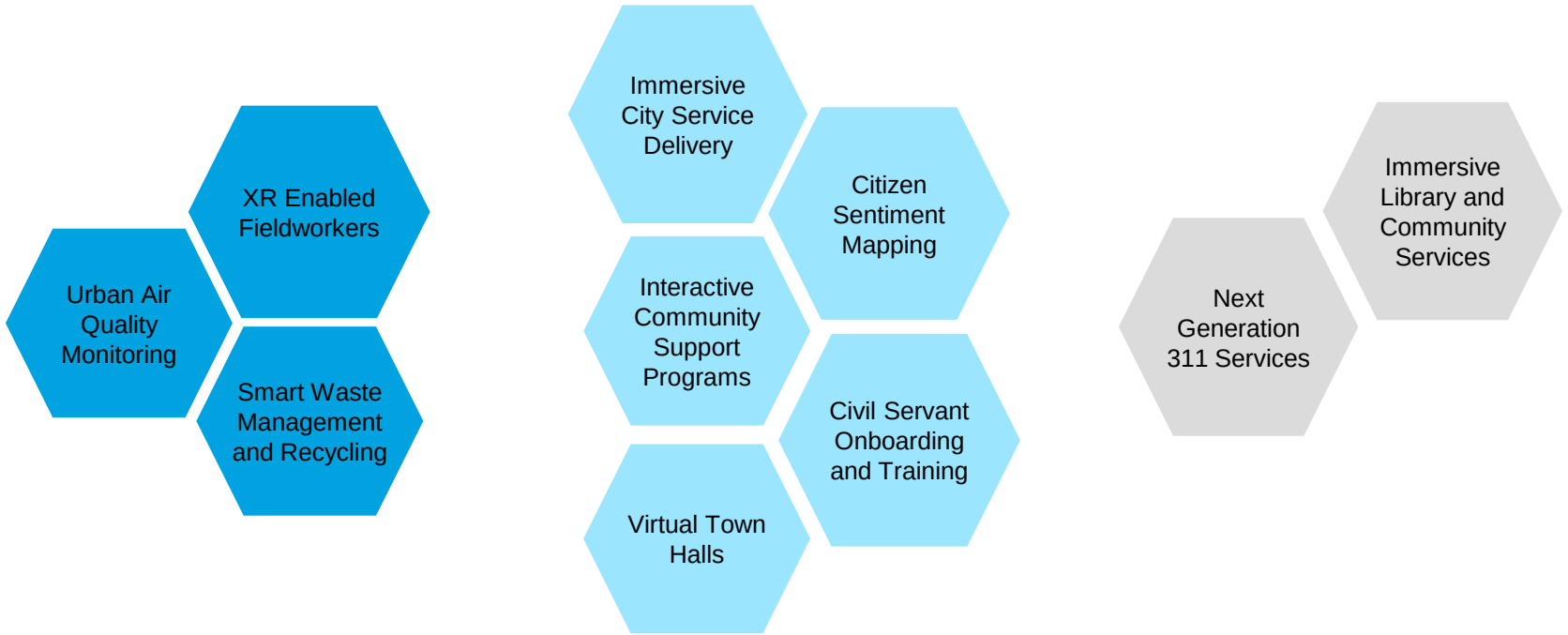
Thematic Area Overview

Cities are increasingly adopting digital technologies to transform governance, enhance public services, and foster citizen engagement. This is imperative as citizen expectations of public services are rising with citizens expecting seamless, accessible and personalised interaction akin to their engagements with the private sector.

The city administration, services and public participation thematic area focuses on leveraging digital technologies, such as AI, VR, AR, and digital twins, to transform city governance, enhance public services, and foster meaningful citizen engagement. Use cases will span:

- **Public Service Delivery**: Enhancing access and efficiency in services such as tax management, permit applications, licensing and social support.
- **Citizen Engagement, Participation and Co-creation**: Increasing forums for more inclusive, interactive and meaningful public participation and engagement.
- **Sustainable City operations**: Initiatives to monitor and support the city's transition to net zero and promote resource efficiency and circularity for the city and community. This includes a focus on improvements to urban air quality waste management services.
- **Transparency and Accountability**: Increasing transparency and citizen oversight into areas such as municipal budgets, service performance, and public project updates in order to build trust and confidence.

Use Case Overview and Horizon Mapping



Horizon 1: Current Deployment

Horizon 2: Piloting

Horizon 3: Discovery

Horizon 1

XR Enabled Fieldworkers

Description

XR technologies can enhance the capabilities of government fieldworkers such as building and environmental inspectors as well as law enforcement agents. By leveraging X, fieldworkers can view critical data overlays, access step-by-step instructions, and troubleshoot on-site issues with expert support. They can receive real-time, remote guidance from experts virtually present during inspections. AI can be integrated for real-time risk detection and compliance monitoring, improving safety and regulatory adherence. Additionally, VR simulations can be used to train fieldworkers in realistic, immersive environments, allowing them to practice high-risk tasks without the dangers of real-world scenarios.

Example

In Cedar Falls, Iowa, XR and VR is being used to train police cadets. This immersive experience allows the trainer to not only change scenarios in real time but also allows the trainer to insert themselves into the training and give instruction to the cadets. Through this training method cadets are encountering real life examples and obstacles they will face. They will also be able to use this in field when they encounter scenarios that require additional support. Further, the BRISE project in Vienna is piloting combining BIM, AI and AR into an end-end digital automated building approval process, including on-site inspection.

Impacts

- Workforce Productivity
- Quality of Life
- Enhanced Services
- Public Safety
- Knowledge Sharing
- Regulatory Compliance

SDG Alignment

Target 4.4

Target 16.6

Key Technologies

- **Digital Twin**
- Metaverse
- **AR**
- **VR**
- MR
- **GAI**
- AI
- **IoT**

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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Horizon 2

Citizen Sentiment Mapping

Description

Virtual world technologies, including AI and digital twins, can be used to capture and analyze citizen sentiment, allowing governments to make informed decisions based on public opinion. By using virtual replicas of city spaces and leveraging data from social media, surveys, and sensors, authorities can visualize citizen sentiment across different neighborhoods. AI algorithms can process this data to detect patterns, trends, and emerging concerns, which can then be displayed on dynamic models of the city. This interactive system enables policymakers to track public sentiment on a variety of issues and engage citizens in the decision-making process by visualizing how their feedback impacts policy.

Example

The city of Patras, Greece, is developing an Urban Resilience Digital Twin to enhance urban management by integrating citizen feedback into the decision-making process. This digital twin collects real-time data and citizen feedback data to map and analyze public sentiment across the city. This allows the city to track emerging trends and prioritize areas that need immediate attention. By incorporating public sentiment into urban planning, Patras aims to improve citizen engagement, trust in local government, and the overall resilience of the city.

Impacts

- Resource Allocation
- Quality of Life
- Effective Policy Making
- City Service Improvement
- Citizen Engagement

SDG Alignment

Target 16.7

Target 11.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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Horizon 2

Civil Servant Onboarding and Training

Description

By creating immersive training environments, new employees can interact with digital replicas of government buildings, familiarizing themselves with workplace dynamics, policies, and procedures in a safe, virtual setting. In a metaverse-like environment, new recruits can simulate real-world scenarios, such as handling public inquiries, managing emergencies, or collaborating with colleagues across departments. AI-powered virtual assistants can guide employees through their training, providing tailored learning paths and assessments. This would not only accelerate the onboarding process but also improve knowledge retention, employee engagement, and overall job preparedness, helping civil servants transition into their roles effectively.

Example

The City of San Diego has begun piloting immersive virtual training tools for onboarding public sector employees. Leveraging VR and AI, the city developed interactive modules simulating various scenarios – from emergency response to public engagement. These simulations allow new hires to familiarize themselves with municipal procedures and service standards in a risk-free environment. AI tutors guide trainees through personalized learning journeys, enhancing retention and building confidence before entering the field. The initiative has reportedly improved onboarding speed and training outcomes, while reducing logistical costs associated with traditional programs.

Impacts

- Enhanced Learning Experience
- Increased Employee Engagement
- Cost Efficiency
- Standardized Training
- Safe Environment for Mistake-Making

SDG Alignment

Target 4.4

Target 8.2, 8.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT
✓	✓		✓			✓	

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 2

Virtual Town Halls

Description

Virtual town halls, powered by the metaverse and XR technologies, offer an innovative way for citizens to engage with local government and community leaders. These virtual events create immersive, 3D environments where citizens can participate in open forums, ask questions, and provide feedback in real time, no matter their physical location. Using avatars and virtual spaces, participants can attend sessions with a level of presence and interaction that traditional video conferencing tools cannot match. Additionally, AI-powered moderators can assist in managing questions, prioritizing issues, and ensuring a smooth flow of conversation.

Example

Seoul's Metaverse Seoul Platform" project is the world's first public metaverse platform implemented by a city government, designed to enhance accessibility, citizen participation, and digital public service delivery. Through immersive virtual environments, citizens can attend town hall meetings, consult with officials, access various services – all without physical constraints. The platform exemplifies how emerging technologies like XR, AI, and the metaverse can foster inclusive, participatory urban governance and set a global benchmark for smart city innovation.

Impacts

- Increased Accessibility and Inclusion
- Quality of Life
- More Effective Communication
- Cost Reduction
- Environmental Benefits
- Citizen Engagement

SDG Alignment

Target 16.7

Target 11.3

Key Technologies

Digital Twin	**Metaverse**	AR	**VR**	MR	**GAI**	**AI**	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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Horizon 3

Next Generation 311 Services

Description

311 services create avenues for citizens to engage with the city administration and report issues with local services and infrastructure. Virtual world technologies can create next generation 311 services for citizens. Digital twins can create virtual replicas of urban environments that are updated with real-time data from sensors, service requests, and citizen inputs to visualize the status of ongoing infrastructure repairs or quality-of-life improvements, allowing residents to track requests. MR can enable residents to use their smartphones or AR glasses to scan their surroundings and access information about service requests, maintenance schedules, or the progress of repairs.

Example

The 311SA Mobile App allows you to interact with the City of San Antonio by submitting service requests for concerns that need attention. By doing so, you can earn rewards, strengthen communities and connect with your city to improve your neighborhood. Through the app, citizens are able to flag (geo-locate a service request), attach a photo, and provide supporting information for issues. The requests go straight to the appropriate City department for evaluation and investigation. This service and others could be augmented with digital twin and XR capabilities.

Impacts

- Community Improvement
- Quality of Life
- Placemaking
- Service Improvement
- Citizen Engagement

SDG Alignment

Target 16.6

Target 11.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 1

Urban Air Quality Monitoring

Description

Virtual world technologies such as digital twins can be used to create a real-time, interactive map of urban air quality, integrating data from IoT sensors across the city that measure GHG emissions. City stakeholders such as environmental agencies, public health departments, and urban planners can use this platform to monitor pollution hotspots, design targeted interventions, simulate the impact of policy changes, and engage with residents around air quality initiatives. AI could be leveraged to predict pollution trends, optimize mitigation strategies, and improve long-term public health outcomes for communities. GAI could be used to make the platform more interactive through querying the data in natural language.

Example

BINUS University, Jakarta is developing a Digital Twin to enhance air quality management. This initiative integrates real-time data from air quality sensors, meteorological data, traffic patterns, and urban infrastructure into a 3D model of the city. Utilizing MR, the twin allows city officials and stakeholders to visualize pollution patterns, identify hotspots, and simulate interventions for effective decision-making. The project aims to provide a comprehensive understanding of urban air pollution, facilitating collaborative strategies to improve public health and environmental conditions.

Impacts

- Emission reduction
- Quality of Life
- Environmental Conservation
- Sustainable Urbanism
- Health and wellbeing
- Research and Innovation

SDG Alignment

Target 13.2, 13.3

Target 11.6

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Smart Waste Management and Recycling

Horizon 1

Description

Virtual world technologies such as digital twins can be used to create an interactive digital platform for managing urban waste collection and recycling across residential and commercial areas. City stakeholders such as public works departments, sanitation agencies, and environmental planners can use this platform to optimize waste collection routes, monitor recycling rates, track environmental impacts, and allocate resources more efficiently. AI could be leveraged to predict waste generation patterns, automate maintenance schedules, and identify opportunities to improve recycling participation to lower costs and support a transition to a more sustainable, circular economy.

Example

The city of Copenhagen, Denmark, is advancing its smart city strategy through a digital twin project in partnership with Cisco and Tele Danmark Communications. The initiative connects and manages data on infrastructure like lighting, parking and waste covering a 7-mile urban area. Real-time monitoring enables the city to optimize operations, reduce costs, and improve service delivery. By integrating multiple systems into a single, scalable model, Copenhagen aims to drive economic growth, environmental sustainability, and quality of life improvements for its residents.

Impacts

- Emission reduction
- Quality of Life
- Biodiversity
- Walkability
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 11.6

Target 12.5

Key Technologies

- **Digital Twin**
- Metaverse
- AR
- VR
- MR
- **GAI**
- **AI**
- **IoT**

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Horizon 3

Immersive Library and Community Services

Description

The metaverse and XR can redefine the way library services are delivered by creating virtual libraries and community spaces. Libraries can build immersive spaces where users can explore different genres, attend author talks, or join book clubs in a fully interactive environment. Using XR technologies, users could also interact with digital versions of books, engaging with multimedia content such as videos, audio, or interactive exhibits. AI can be integrated to provide personalized recommendations and facilitate virtual librarians who can guide users through the resources. Libraries could also host virtual/XR educational sessions, making it easier for individuals to access workshops, research, and even remote study groups.

Example

Coventry Library Services, in partnership with The Space, launched the Digital Spaces programme to explore the potential of public libraries as venues for digital cultural content. The initiative included VR sessions at Coventry Central Library and other local libraries, offering a catalogue of immersive films across various genres. By providing accessible VR experiences, the programme aimed to engage the community with new forms of storytelling and cultural expression. This could be extended to explore different aspects of the immersive library use case and integrate more permanent virtual environments.

Impacts

- Quality Education
- Accessible Education
- Vocational Education
- Community Engagement
- Quality of Life
- Life Long Learning

SDG Alignment

Target 4.3, 4.4, 4a,

Target 11.7

Key Technologies

- **Digital Twin**
- Metaverse
- **AR**
- **VR**
- MR
- **GAI**
- AI
- **IoT**

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	Medium	High

Horizon 2

Interactive Community Support Programs

Description

Virtual world technologies, like metaverse along with AI-powered chatbots, can revolutionize community support programs by offering immersive, interactive platforms for residents to access help, guidance, and resources. In a virtual environment, local services can be delivered to provide real-time assistance for a variety of community needs, including social services and community groups. Additionally, immersive VR environments could be used to host virtual support groups or workshops, where individuals can engage in real-time discussions, share experiences, and receive counselling or advice. This could foster a more connected, responsive, and inclusive community support system.

Example

In 2021, Westminster launched the Virtual Reality for Relaxation and Wellbeing (VR-RAW) programme. This initiative employs virtual reality to promote the well-being of communities affected by serious youth violence. The program offers immersive VR experiences aimed at relaxation and mental health support, providing participants with innovative tools to cope with stress and improve overall wellness. Similarly, in Seoul, South Korea, Metaverse Seoul was launched as a 3D virtual space and provides services including a virtual youth mentoring consultation room.

Impacts

- Emission reduction
- Quality of Life
- Biodiversity
- Walkability
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 3.5, 3.7, 3.8

Key Technologies

Digital Twin	**Metaverse**	**AR**	**VR**	**MR**	**GAI**	**AI**	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	Medium	**High**
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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Horizon 2

Immersive City Service Delivery

Description

By creating virtual spaces and experiences that digitally recreate the real-world constituents will be freer to interact with government and their community members using technologies such as the metaverse, AR/MR/VR and blockchain to apply for and receive holistic services and benefits. Public services such as permit applications, benefit applications and non-emergency services can be administered through these environments. For certain populations, this may enable ease of access to government services. This medium can also enable public participation in decision-making, including for proposed development plans.

Example

The city of Seoul, South Korea, has launched Metaverse Seoul, the world's first metaverse project developed by a municipal government. The platform offers citizens a 3D virtual space where they can access a variety of services, including youth counseling, tax support, and document issuance. It integrates citizen participation by providing a virtual space for shared activities and fostering the local industrial ecosystem through venture and startup opportunities. Metaverse Seoul streamlines city services with AI chatbots and document delivery to the "Seoul Wallet" app.

Impacts

- Service Accessibility
- Quality of Services
- Citizen Engagement
- Health and Wellbeing
- Economic Development

SDG Alignment

Target 16.6

Target 11.3

Key Technologies

Digital Twin	**Metaverse**	**AR**	**VR**	**MR**	**GAI**	**AI**	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	Medium	**High**

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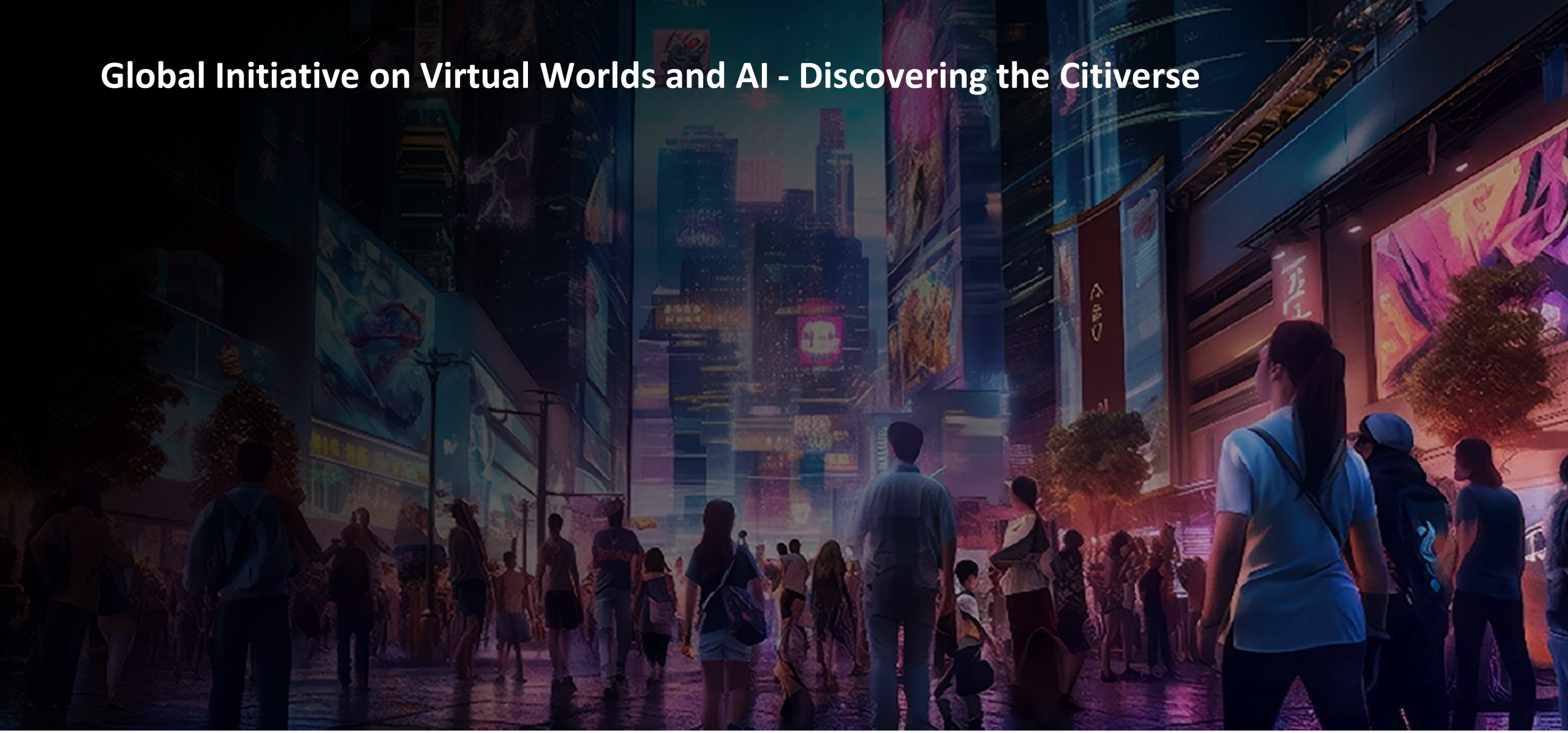


Thematic Area 3: Economic Development, Education, and Tourism

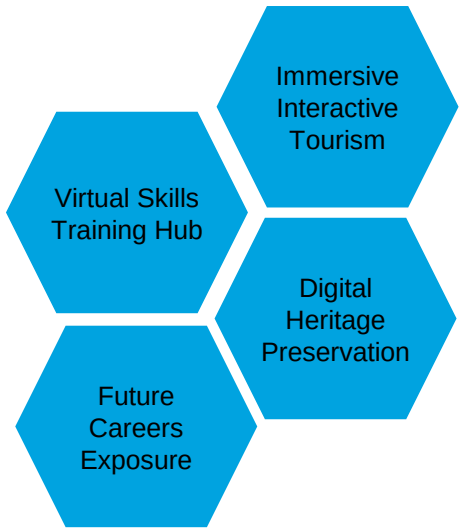
Thematic Area Overview

The convergence of technological innovation and shifting societal values is reshaping how cities support economic development, education, and tourism. Traditional models of economic measurement, educational delivery, and tourism-driven growth are being challenged by demands for greater resilience, inclusivity, and environmental stewardship.

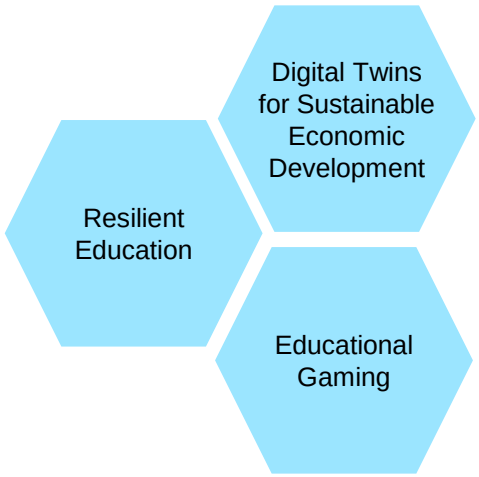
The Economic Development, Education & Tourism thematic area focuses on leveraging virtual worlds to transform how cities facilitate learning, professional growth, economic opportunity, and cultural experiences in a more sustainable and human-centric way. The thematic area will span the following topics, inter alia:

- **Resilient and immersive education**: using virtual worlds to ensure continuity of learning beyond physical boundaries and creating highly engaging, personalized learning environments that improve outcomes and foster global collaboration.
- **Economic system transformation**: enabling more sustainable economic development through support for the circular economy, blue economy initiatives, remote work hubs, and real-time economic forecasting that enhances decision-making and investment planning.
- **Sustainable and cultural tourism**: preserving indigenous heritage and cultural identity while reimagining tourism experiences that blend physical and virtual engagement, reduce environmental impacts, and generate greater benefits for local communities.

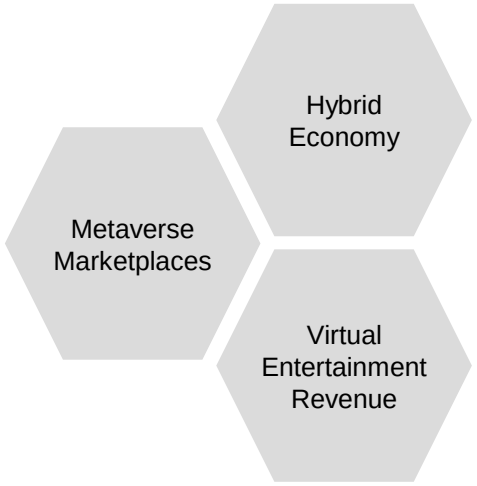
Use Case Overview and Horizon Mapping



Horizon 1: Current Deployment



Horizon 2: Piloting



Horizon 3: Discovery

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Horizon 2

Resilient Education | Conflict and Natural Disaster Areas

Description

The metaverse can offer continuing education through immersive and interactive environments for students in crisis affected regions, be it for conflict, humanitarian crisis or natural disasters, whereby, the basic human right to education is disrupted or restricted by external factors. Through creating alternative pathways to connect students and tutors at a global level, it can provide some sense of normality, resilience and hope, supporting both educational and psychological aspects, whilst reducing the disruptive impact on education that crises have, allowing students to complete their studies during emergency situations as well as during the rebuilding and recuperation phases.

Example

The UN Department of Political and Peacebuilding Affairs introduced a VR experience, Pathways Colombia. The initiative provided immersive insights into post-conflict reintegration, justice, and reconciliation efforts under the UN Verification Mission in Colombia. The VR experience was later extended to local communities, engaging former FARC combatants and over 200 children in reintegration zones. This case highlights the potential of virtual worlds in delivering impactful, context-specific educational experiences where conventional methods may fall short – supporting awareness, empathy, and social cohesion.

Impacts

- Quality Education
- Reduced Inequalities
- Peace, Justice and Strong Institutions
- Humanitarian Assistance
- Health and Wellbeing
- Citizen Engagement

SDG Alignment

Target 4.3, 4.5, 4.7

Target 10.2, 10.3

Target 16.1, 16.10

Key Technologies

Digital Twin	**Metaverse**	**AR**	**VR**	MR	**GAI**	**AI**	**IoT**

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	Medium	**High**
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 1

Virtual Skills Training Hubs

Description

Many cities are facing significant employment challenges such as skills shortages, with the gap between demand and labor capacity widening, particularly in sectors such as the green economy. Combining immersive technologies in key skills training helps to bridge the gap by building skilled workforce or re-skilling existing workforce in targeted skills more rapidly. By offering flexibility, portability, and realistic simulations, these immersive skills training hubs allow learners to experience and safely practice new skills while gaining industry-standard qualifications or licensing. They can accelerate vocational training, break down barriers to employment, communication or cultural sensitivity and address continuing upskilling necessities with tailored training modules and workplace safety and regulations.

Example

The TRACE Centre is a state-of-the-art facility designed to rapidly train, retrain and upskill workers focusing on renewable energy and green industrial sectors in alignment with Scotland´s Net Zero ambitions. By Combining immersive VR and AR with industry-standard offshore safety training, TRACE addresses urgent skills shortages at the city, regional and UK-wide level. By transforming under-utilized industrial land into a vibrant training hub & providing mobile XR training equipment for outreach projects, TRACE promotes inclusivity and accelerates Scotland's transition to Net Zero, positioning Grangemouth for excellence in industrial skills training innovation.

Impacts

- Poverty
- Quality Education
- Decent work and Economic Growth
- Reduced Inequalities
- Sustainable Cities and Communities
- Climate Action

SDG Alignment

Target 4.4

Target 8.9

Target 13.3

Key Technologies

Digital Twin | **Metaverse** | **AR** | **VR** | **MR** | **GAI** | **AI** | IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Horizon 1

Future Careers Exposure

Description

Immersive, hands-on future careers exposure delivered through XR, and other virtual world technologies can deliver inspirational education to students and open them to a wider range of career choices in specific emerging fields. By virtually experiencing careers that students wouldn´t otherwise be aware of or be exposed to, empowers them to access a diverse range of options and knowledge necessary to follow new fields and consider new pathways to career satisfaction and long-term stability. This technology can also open school´s curriculum to new areas of learning addressing teacher´s shortages in specific areas and better serve remote communities. The creation of early awareness and promotion of interest in developing areas can foster the preparation for the future of workforce reducing unemployment rates and focus on addressing future market gaps.

Example

An immersive education program in New South Wales is using XR and VR technologies to provide students with engaging hands-on learning about careers in offshore wind energy and sustainable marine development. The initiative aligns with the New South Wales curriculum and focuses particularly on the Hunter and Illawarra regions with an aim to reduce economic disparity. Additionally, it prepares students for over 3,000 in-construction and 300 permanent roles in the renewable energy sector. The program increases access to STEM careers for underserved communities, promoting inclusivity, sustainability, and long-term workforce development in Australia’s clean energy transition.

Impacts

- Skill Development
- Workforce Readiness
- Educational Access
- Economic Growth
- Sustainability Awareness
- Responsible Production

SDG Alignment

Target 4.3, 4.4

Target 8.9

Target 13.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 1

Digital Heritage Preservation

Description

Global cultural and natural heritage faces growing threats from conflict, disasters, increased tourism, climate change, and environmental damage, endangering our shared history. Traditional preservation methods alone are insufficient. Virtual world technologies, can support education, research, heritage management, and community sustainability, protecting cultural identity and providing benefits for global scholars, institutions, Indigenous communities and future generations. By providing open access to digital heritage data and detailed 3D and immersive models, cultural and scientific resources can be democratized as a unified world patrimony, ensuring future generations access to their cultural identity and heritage information fostering public engagement worldwide and ensuring that humanity´s history is safeguarded.

Example

Global Digital Heritage (GDH) is a not-for-profit organisation digitally documenting and preserving cultural and natural heritage using advanced 3D visualisation and geospatial technologies. Collaborating closely with governments, museums, scholars, and indigenous communities, GDH safeguards cultural identity and community heritage addressing global threats from conflicts, natural disasters, increased tourism, and rapid environmental change. Global Digital Heritage addresses this urgent need through innovative 3D digital documentation, virtualisation, and open-access models preserving and safeguarding a variety of physical sources in their original format.

Impacts

- Quality Education
- Cultural heritage preservation
- Improved accessibility
- Sustainable tourism
- Climate Change Adaptation
- Environmental protection

SDG Alignment

Target 11.4

Target 17.7

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	**Low**	Medium	High
Financial/operational	**Low**	Medium	High

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Horizon 3

Hybrid Economy

Description

The economic benefits brought by globalization are being counterbalanced with its environmental impact, inequalities and the pressure on local communities and cities to continue rapid growth rates and unsustainable resource use. Converging virtual worlds technologies and data analytics to create a twin economy, can empower city stakeholders and local communities to control their digital spaces and virtual market presence, creating new opportunities to diversify their economy, virtually showcasing local businesses, nature, sites, traditions and culture, develop ecommerce, share experiences/data, explore NFTs and engage in digital currency exchange options. This dual reality/virtual economy platforms can provide the opportunity to rebalance inequalities, promote inclusivity and lessen the impact on the environment.

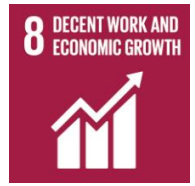
Example

The Social Interactive Twin Economy (SITE) network is a global collection of interoperable metaverse worlds offering immersive experiences in travel and commerce. Each virtual world represents a location, allowing local communities and cities worldwide to digitally showcase and monetize their assets, services and uniqueness. Leveraging innovative XR, AI, and blockchain technologies, SITEnetwork supports sustainability, fosters expansion, global collaboration, and enhances both local and international engagement. Evolving to sharing public data with users can also lead to creation of new experiences, trends and customization of services to fit a changing society.

Impacts

- Economic growth
- Employment opportunities
- Economic resilience and diversification
- SME growth
- Quality Education
- Environmental protection

SDG Alignment



Target 8.9

Target 11.4

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	**Low**	Medium	High

Key Technologies

Digital Twin | Metaverse | AR | VR | MR | GAI | AI | IoT

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Horizon 1

Immersive Interactive Tourism

Description

Virtual world technologies can be used to reduce the negative impact of tourism on the environment and on the economy such as seasonal unemployment, dependency and overcrowding. From making available city/region multilingual XR guide systems, to virtual tours around the city, to having immersive interactive multi-sensory sites, metaverse allows users to experience all events and places anytime from anywhere. Tourism stakeholders can provide personalized exploration of cultural and historical content, offer more inclusive city visit options, have visitors immerse in a storytelling experience with different perspectives, without affecting the value of the experience, easily tailoring and customizing experiences to visitor´s preferences.

Example

The National Museum of the Islamic Revolution and Holy Defense, located in Tehran, can be considered a prime example of the combination of different technologies to create life like experiences for tourist attractions. Through AR and VR, holographic projections, multi-sensory spaces, 360-degree theaters, AI powered guide systems, customizable tours, visitors can experience key moments of history first-hand, interact with artefacts without physical touch, bringing historical narratives to life and providing a deeply engaging and educational journey.

Impacts

- Quality Education
- Quality of Life
- Tourism Development
- Local economic growth
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 4.7

Target 11.7

Target 16.10

Target 17.17

Key Technologies

Digital Twin | **Metaverse** | **AR** | **VR** | MR | **GAI** | **AI** | IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Horizon 2

Digital Twins for Sustainable Economic Development

Description

What if we can make Virtual Actions have Real-World Impact? It´s exactly what Digital Twins can bring to the economy. By replicating the real world, both land and sea structures, Metaverse can be used to simplify testing, execute simulations, play out risks and consequences proactively and analyze possible outcomes. City and business stakeholders can leverage these features in their decision making processes scaling it up or down as they see fit before implementation and use it as a transparency tool .As this technology can be accessible anywhere, anytime, on any device, it can serve as a gateway to the virtual world providing a simple and sustainable path to use reality based immersive experiences, allowing user engagement in an highly personalized manner, materialize transparency of policy making, provide for better informed choices and present the impact of actions in the real world.

Example

Madalia is the first Digital Twin with Land and Under Sea Structure of Madeira Islands and surrounding ocean. This fractal computing platform works as a gateway for metaverse technology including XR, AI, Digital Twins, Virtual Reality and Blockchain, optimizing experiences and delivering remote computing power on a functional based method thus giving any device the power to access XR, Blockchain and AI of the highest quality as well as other high-tech processes in a simple and seamless way accessible to all.

Impacts

- Sustainable economic growth
- Decent employment opportunities
- Reduced Inequalities
- Marine protection
- Climate change adaptation
- Citizen Engagement

SDG Alignment

Target 13.3

Target 14.1, 14.2, 14.7

Key Technologies

Digital Twin | Metaverse | AR | VR | Blockchain | GAI | AI | IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 2

Educational Gaming

Description

To be able to achieve a better balance between economic growth, environmental sustainability and social equity for new generations, we need to approach existing challenges in different and more effective ways by providing tools and reformulating education from a sustainability angle. Web3 and immersive gaming technologies can fuse purpose with digital play in an interactive educational experience to foster awareness and knowledge, enforcing rules to adequately address issues and provide options for better management of resources aiming at creating a balance between economic growth and preservation of resources from early age in a dynamic, interactive and more effective way of learning.

Example

The Scubaverse project uses cutting edge Web3 and immersive gaming technologies to create interactive platforms to deliver engaging educational experiences for users in the area of marine conservation. This use case can be particularly relevant for coastal cities. The combination of environmental advocacy and gamified education empowers Scubaverse players to explore virtual ocean environments, building awareness of marine ecosystems, climate action and the importance of biodiversity. The initiative aims to engage, educate and inspire a new generation of advocates while supporting global efforts to preserve aquatic life through accessible digital experiences.

Impacts

- Environmental Awareness
- Youth Engagement
- Marine Conservation
- Biodiversity
- Climate Action
- Gamified Education

SDG Alignment

Target 4.4

Target 13.3

Target 14.1, 14.2

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 3

Virtual Entertainment Revenue

Description

Large scale, immersive digital experiences for audience driven events powered by spatial computing, Generative AI, and XR technologies are transforming the way audiences attend and engage with live events. Covering different types of events from football matches to concerts, festivals or even motorsports races, virtual arenas and custom skybox lounges will bring live streamed experiences to fans as well as the opportunity to interact with fellow enthusiasts and the chance to enjoy one on one video chats with their idols anywhere in the world. Additionally, enthusiasts can immerse in event merchandising retail experiences and access Hall of Fame information about the event. These virtual live event experiences offer new levels of accessibility and inclusivity, fostering innovative ways of utilizing existing city infrastructures, growing marketing opportunities, building new revenue streams and focus on intellectual and nonmaterial property ownership protection and management.

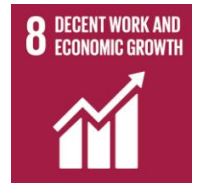
Example

FIM Speedway Grand Prix uses spatial computing, AI and XR technologies to bring the thrill of live motorsports events to audiences around the globe. Custom digital arenas and skybox lounges provide fans with a chance to interact with each other, view multiple event camera angles, and connect directly with race pilots via video chat or teleport straight to the Hall of Fame Museum and immerse in Merchandising retail experiences to buy at virtual stores. The experience removes any potential geographical and financial barriers to attendance, increases fan engagement and brings new revenue streams. focusing on enhanced data ownership, greater reach with one event and new revenue streams for event organizers, teams and brands by driving global fan engagement with an otherwise locally limited live event.

Impacts

- Accessibility
- Quality of Life
- Citizen Engagement
- Local Economic Development
- Sustainable Attendance
- Cultural Participation

SDG Alignment



Target 8.9

Target 17.7

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Metaverse Marketplaces

Horizon 3

Description

Metaverse marketplaces can play a significant role in advancing circular economy and entrepreneurship in cities and communities as well as supporting remote employment and expanding business reach. Interactive immersive environments for trade through virtual stores or offices, exhibition centers, learning booths or showrooms can be created with custom or ready-made content facilitating trade of products and services or setting up new businesses without the physical infrastructure nor the initial material and logistic costs. Sales processes can be simplified and trade facilitated, promoting utilization and reuse of virtual assets and services, incentive sustainable practices and second-hand sales, re-educate consumers and stimulate direct consumer engagement with brands whilst providing real time data updates worldwide and explore digital currency exchange.

Example

rooomSpaces is a virtual showroom platform empowering users to create interactive 3D environments such as showrooms, exhibition booths, learning or shopping spaces, . The “Made in Germany” case study, makes highly technical products such as marine engines digitally accessible. Viewers can use intuitive user guidance and navigation whilst engineers and marketing can update design features and annotations themselves in multiple languages. Furthermore, sales team can meet clients virtually without having to travel with products for demonstrations and technicians can engage in maintenance instructions and training directly. This platform is also data protection compliant.

Impacts

- Responsible Consumption and Production
- Decent Work and Economic Growth
- Gender Equality
- Partnerships for the Goals
- Reduced Inequalities

SDG Alignment

Target 8.9, 8.2

Target 12.2

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Key Technologies

Digital Twin | **Metaverse** | **AR** | **VR** | MR | GAI | **AI** | IoT

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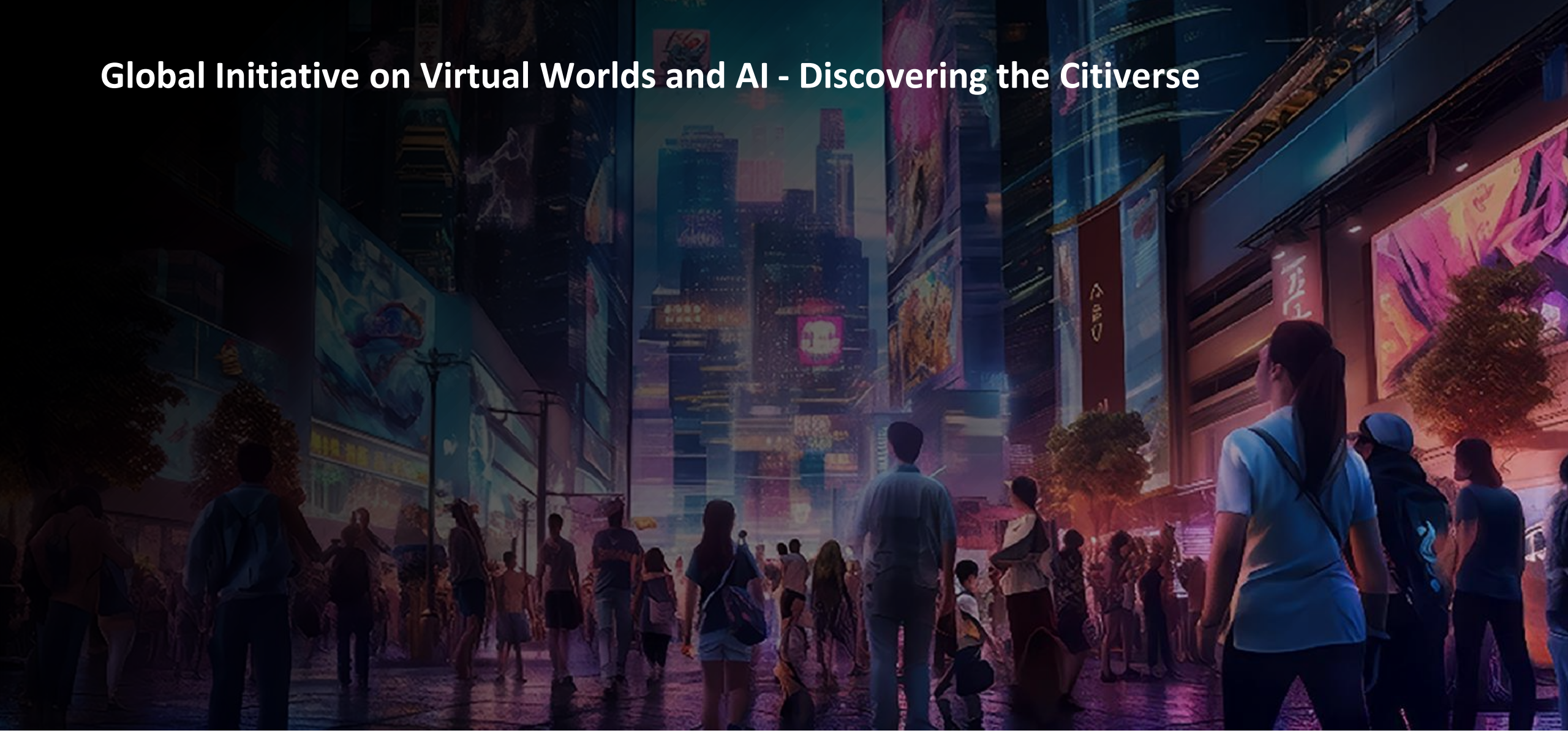


Thematic Area 4 : Transport and Mobility

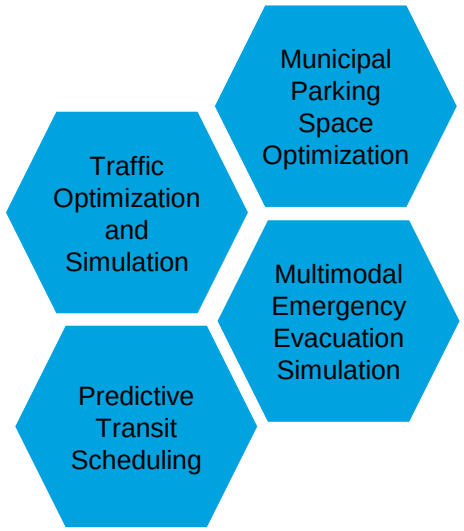
Thematic Area Overview

Cities are grappling with high levels of GHG emissions and air pollution linked to transport. Estimates suggest that urban areas are responsible for 70% of global C02 emissions, with transport and buildings being among the largest contributors (IPCC 2022). Many cities are also facing high levels of traffic congestion, ageing infrastructure, and growing populations.

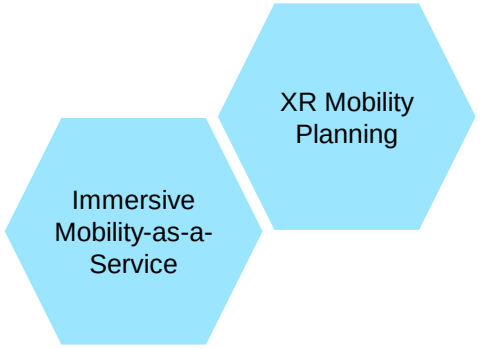
The transport and mobility thematic area focuses on leveraging virtual worlds to transform the way people and goods move through cities. Use cases will span, inter alia:

- **Public transportation:** Including enhancing the access, sustainability, efficiency, customer experience and modal share of public transport from railways to bus networks.
- **Active transport and micro-mobility:** Increasing opportunities and reclaiming urban spaces for safe and attractive walking, cycling and micro-mobility such as scooters.
- **Private vehicles:** Reducing traffic congestion and safety and enabling EV adoption through better urban infrastructure systems.
- **Urban logistics and freight:** Optimizing the movement of goods within cities through smarter and more intelligent systems from supply management to last-mile delivery.
- **Transportation hubs:** Transforming stations, city ports and airports into seamlessly integrated multimodal transport hubs.

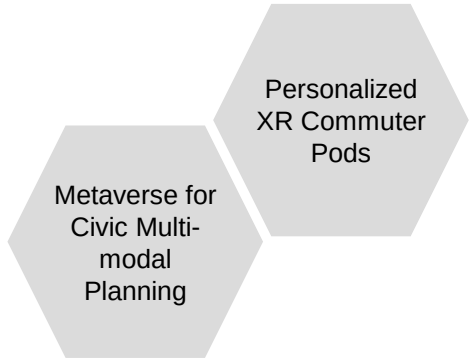
Use Case Overview and Horizon Mapping



Horizon 1: Current Deployment



Horizon 2: Piloting



Horizon 3: Discovery

Horizon 1

Traffic Optimization and Simulation

Description

Virtual world technologies such as digital twins can be used to create a real-time simulation of traffic flows across cities. City stakeholders such as transport planners, traffic management authorities, and public safety departments can use this platform to monitor mobility patterns, model different traffic scenarios, and adjust infrastructure operations to optimize flow and enhance safety. IoT devices such as sensors and connected traffic signals feed live data into the digital twin, enabling continuous updates to the virtual model. AI can be leveraged to predict congestion hotspots, dynamically adjust traffic signal timings, and recommend rerouting strategies to minimize delays, reduce emissions, and improve travel experience.

Example

Seoul's Smart Traffic Management System and digital twin integrates over 5,000 sensors with AI to control traffic lights and intersections. The primary goal of Seoul's digital twin initiative is to reduce congestion and improve public safety by predicting and managing traffic conditions more effectively. It aims to provide a real-time model of the city's transport network, which can help optimize traffic signal timings, reroute emergency vehicles, and support long-term infrastructure planning The initiative has cut average travel time by 25% in test areas and is expanding across the city.

Impacts

- Reduced Congestion
- Increased Safety
- Cost savings
- Improved Road Safety
- Operational efficiency
- Improved Emergency Response

SDG Alignment

Target 3.6

Target 9.1

Target 11.2, 11.3, 11.6

Key Technologies

- **Digital Twin**
- Metaverse
- AR
- VR
- MR
- **GAI**
- **AI**
- **IoT**

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Horizon 2

Immersive Mobility-as-a-Service

Description

Virtual world technologies such as AR can be integrated into MaaS platforms to create immersive wayfinding experiences and enhance multimodal journey planning for users navigating urban transport networks. Transport operators and city authorities can use these platforms to deliver real-time virtual overlays that guide travelers through stations and city streets while personalizing routes based on preferences and accessibility needs. IoT devices can provide live transport data to continually update the AR environment and improve accuracy. AI could be leveraged to predict service delays, optimize intermodal transitions, and offer adaptive journey recommendations and GenAI could support a multi-lingual personalized interface.

Example

London is enhancing its multimodal transportation system by integrating AR into MaaS platforms. Citymapper, a city navigation app tested an AR navigation prototype in London, allowing users to visualize their route using smartphones or AR glasses, improving user orientation and comfort. This initiative allowed users to navigate the city more effectively by layering digital information over the physical world. The goal was to make city navigation seamless, inclusive, and engaging, particularly for tourists and users with accessibility needs.

Impacts

- Reduced Congestion
- Reduced User Friction
- Cost savings
- Increased Transit Adoption
- Operational efficiency
- Improved Accessibility

SDG Alignment

Target 9.1

Target 11.2

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Horizon 1

Predictive Transit Scheduling

Description

Digital twins can be used to support AI-powered predictive transit scheduling by simulating and visualizing real-time passenger demand, traffic conditions, and operational scenarios across city-wide transport networks. City stakeholders such as fleet operators and transport planners can use these platforms to dynamically adjust transport schedules, optimize vehicle dispatching, and reduce service gaps based on live and forecasted data. IoT sensors across vehicles, stations, and road networks can feed real-time information into digital replicas of the transit system to enable continuous performance monitoring. AI could be leveraged to anticipate surges in demand, recommend fleet adjustments, and optimize resource allocation.

Example

Madrid has embraced the power of AI and digital twins to modernize its public transport system, focusing on bus scheduling. The Empresa Municipal de Transportes optimizes bus deployment based on passenger demand, traffic conditions, and environmental data. This approach minimizes delays, improves fleet efficiency, and enhances the rider experience, especially during peak hours or disruptions. AI helps to predict ridership surges and adjust frequencies, contributing to operational cost savings and sustainability goals.

Impacts

- Reduced Congestion
- Ridership Analysis
- Reduced Emissions
- Increased Transit Adoption
- Operational efficiency
- Improved Accessibility

SDG Alignment

Target 9.4

Target 11.2, 11.3, 11.6

Key Technologies

- **Digital Twin**
- Metaverse
- **AR**
- VR
- MR
- GAI
- **AI**
- **IoT**

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

XR Mobility Planning

Horizon 2

Description

Urban planners can use immersive XR environments to simulate proposed changes in transit routes, station placement, and pedestrian impact before construction begins. Urban planners, transport authorities, and community engagement teams can use these platforms to visualize design impacts, assess accessibility improvements, and integrate public feedback into infrastructure projects. These tools allow residents to virtually walk through redesigned transport infrastructure and give feedback before construction begins. These tools also enable public participation and equity-focused design.

Example

The City of Boston and the Massachusetts Bay Transportation Authority are using immersive VR tools to improve public engagement and equity outcomes in the design of new transit infrastructure. By combining GIS, urban simulation, and VR headsets, stakeholders and residents can experience proposed changes to bus stops, subway stations, and pedestrian interfaces in three dimensions. This fosters a deeper understanding of the urban environment and helps ensure that infrastructure meets the needs of all users, particularly underrepresented communities.

Impacts

- Inclusive Urban Planning
- Stakeholder Engagement
- Improved Urban Design
- Increased Transit Adoption
- Active Mobility
- Improved Accessibility

SDG Alignment

Target 16.7

Target 11.2, 11.3

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

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Horizon 3

Metaverse for Civic Multi-modal Mobility Planning

Description

A metaverse environment can allow stakeholders – from city planners to residents – to interact with with different 3D models of mobility systems, going beyond simulating proposed changes to individual infrastructure assets, to enabling citizens to explore the impacts on multi-modal connections. This can be used to simulate routes for active travel such as cycling and micro-boility to test safety and experience. In a metaverse environment, citizens can also interact and vote on policy proposals. AI and GAI can be leveraged to generate different design options and support multi-lingual and personalised inrteraction interfaces for users to navigate the virtual environment.

Example

Kaunas Municipality is discussing a participatory planning pilot using Unreal-powered 3D models and VR environments to visualize tram alignments. Citizens can walk through proposed tram stations virtually, explore multimodal connections, and vote on key choices – a Baltic-first approach to deep civic engagement in transport infrastructure planning.

Impacts

- Transparent and Inclusive Planning
- Alignment with Community Needs
- Increased Trust in Public Infrastructure
- Increased Transit Adoption
- Active Mobility
- Improved Accessibility

SDG Alignment

Target 16.7

Target 11.2, 11.3, 11.6

Key Technologies

Digital Twin | Metaverse | AR | VR | MR | GenAI | AI | IoT

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	Medium	**High**

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Horizon 1

Multi-modal Emergency Evacuation Simulation

Description

Virtual world technologies such as digital twins can be used to create detailed, dynamic models of transport systems that simulate disaster scenarios, evacuation routes, and emergency service deployment in real time. City stakeholders such as emergency management agencies, urban planners, and public safety departments can use these platforms to identify vulnerabilities, optimize evacuation strategies, and plan resource allocation before and during critical events. This is particularly valuable for complex multi-modal, multi-provider transport systems. AI could be leveraged to predict the spread of hazards, optimize response routes, and recommend real-time adjustments to improve public safety outcomes and reduce response times during emergencies.

Example

Singapore has developed a city-wide digital twin that enables simulation of disaster scenarios and supports evacuation planning. The initiative is led by the Urban Redevelopment Authority and the Housing & Development Board in collaboration with GovTech and A*STAR. This real-time, hyper-realistic model allows city officials to visualize how urban environments and transport systems would respond to floods, fires, and terrorist attacks, enabling more coordinated, effective, and equitable responses. It is especially valuable in dense urban settings with multi-modal transport systems.

Impacts

- Disaster Resilience
- Faster Emergency Response
- Reduced Casualties
- Citizen Safety
- Optimized Evacuation
- Improved Mobility During Crises

SDG Alignment

Target 11.2, 11.3

Key Technologies

- **Digital Twin**
- **Metaverse**
- **AR**
- VR
- MR
- GenAI
- **AI**
- **IoT**

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	Medium	**High**

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Horizon 1

Municipal Parking Space Optimization

Description

Digital twins can be used to create detailed, dynamic models of municipal parking infrastructure that monitor real-time space availability, usage patterns, and future demand across cities. Transport planners can use these platforms to identify parking pressure points, inform policy decisions, and plan more efficient resource allocation. This is particularly valuable for dense urban environments where optimizing space utilization directly impacts traffic congestion and accessibility. AI can be leveraged to automate the detection of parking occupancy using aerial and street imagery, predict future demand fluctuations, and recommend dynamic management strategies to improve mobility outcomes for residents and visitors.

Example

In Leipzig, as part of the Connected Urban Twins project, AI-driven methods are used to analyze parking space availability and usage by combining aerial and street view imagery. By integrating geo-referenced data from mobile camera sources and aerial images, the system achieves a high accuracy rate of up to 94% in detecting parking structures. The results are visualized in dashboards for city planners, enabling data-driven decision-making to alleviate parking pressure, optimize urban mobility, and support future infrastructure planning.

Impacts

- Reduced congestion
- Improved quality of life
- Improved visitor/resident experience
- Operational efficiency
- Economic development

SDG Alignment

Target 11.2, 11.3

Key Technologies

- **Digital Twin**
- Metaverse
- AR
- VR
- MR
- GenAI
- **AI**
- **IoT**

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	**Low**	Medium	High
Financial/operational	**Low**	Medium	High

Horizon 3

Personalized XR Commuter Pods

Description

Virtual world technologies such as AR, VR and MR can be used to create personalized immersive environments inside shared autonomous pods, transforming the travel experience into a dynamic, user-centric space. Travelers can be provided with real-time navigation assistance, wellness programs, entertainment, or productivity tools customized to individual needs during their journey. IoT sensors embedded in the vehicle interior monitor environmental and user data to dynamically adapt the XR environment to optimize comfort, safety, and engagement. AI could be leveraged to analyze biometric feedback, predict traveler preferences, and generate personalized immersive content.

Example

Holoride has developed a VR entertainment system that synchronizes with real-time vehicle movement, aiming to transform passenger experiences in vehicles, particularly autonomous ones. Their platform, dubbed the 'Motorverse,' integrates games and apps with live ride information to provide immersive experiences. By aligning visual stimuli with the car's motion, the technology aims to reduce motion sickness and enhance in-car entertainment. Early demonstrations have begun in cities such a LA, New York and in Germany, however, city-level pilots have not yet occurred.

Impacts

- Resident experience
- Increased shared transit
- Vistor experience and tourism
- Workforce productivity

SDG Alignment

Target 8.2

Target 11.2

Key Technologies

Digital Twin | **Metaverse** | **AR** | **VR** | **MR** | **GenAI** | **AI** | **IoT**

Risk Level

Public safety	Low	Medium	**High**
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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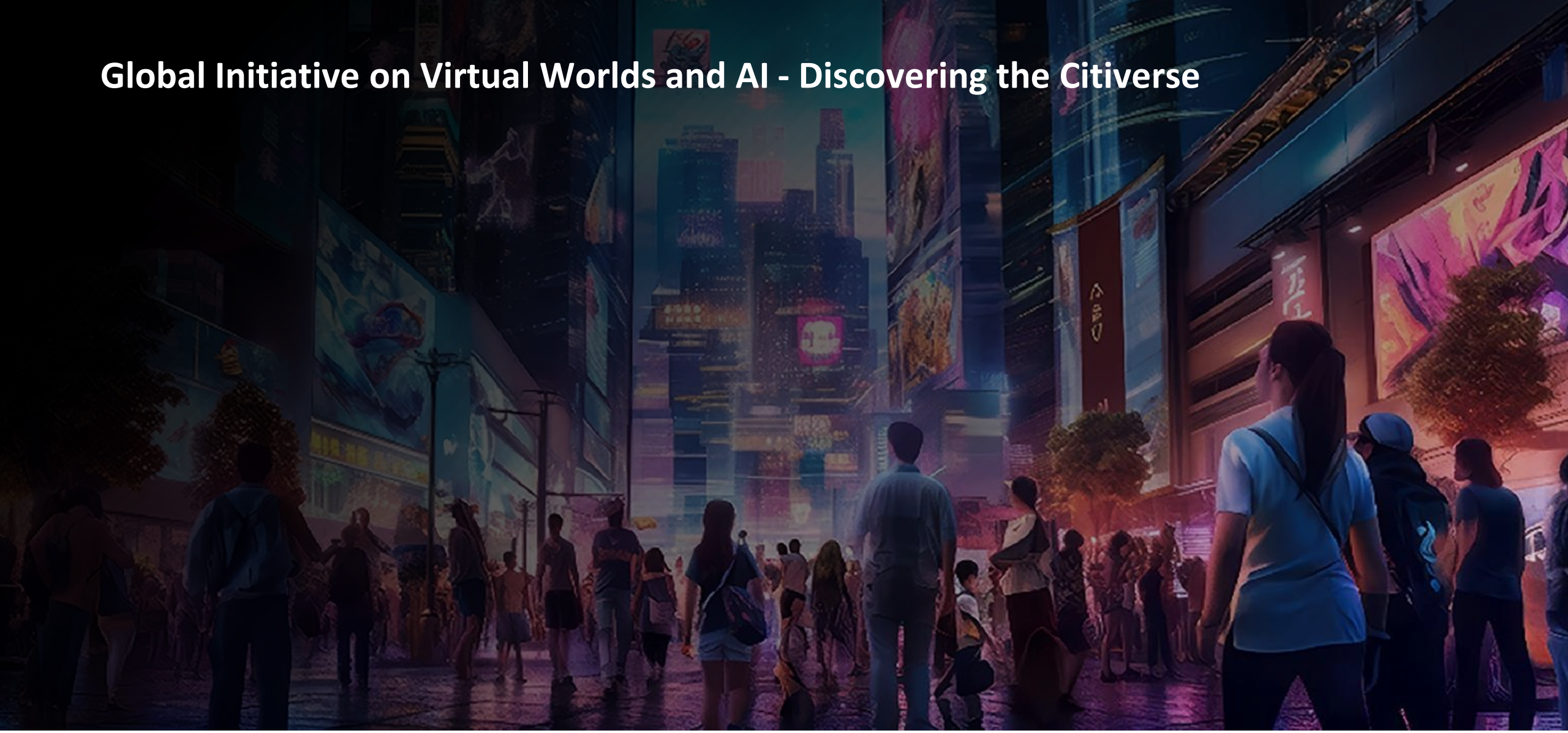


Thematic Area 5 : Public Safety, Health and Disaster Resilience

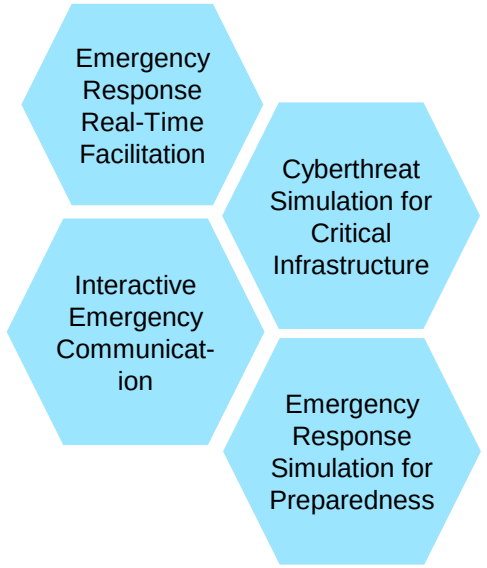
Thematic Area Overview

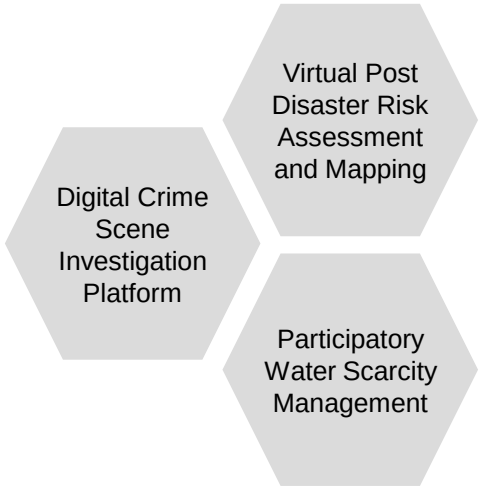
Cities face mounting challenges in protecting their communities from emergencies, health crises, and natural disasters. Recent studies indicate that urban areas, which house over half the world's population, are particularly vulnerable to cascading risks from climate change, public health threats, and safety incidents. Many cities struggle with aging emergency response systems, rising emergency call volumes, and increasingly complex threat landscapes.

The public safety, health, and disaster resilience thematic area focuses on harnessing virtual worlds to transform how cities protect and support their communities. Use cases will span:

- **Emergency Response:** Including enhancing the speed, coordination, and effectiveness of first responders across police, fire, and emergency medical services through integrated command systems and advanced training.
- **Public Health Management:** Strengthening healthcare system resilience, disease surveillance, and emergency medical response capabilities while improving access to health services for all community members.
- **Crime Prevention:** Developing more effective, equitable, and community-centered approaches to public safety through better training, resource allocation, and preventive strategies.
- **Disaster Preparedness:** Building community resilience through improved early warning systems, evacuation planning, and multi-agency coordination for natural and human-made disasters.
- **Critical Infrastructure Protection:** Safeguarding essential urban systems and services through enhanced monitoring, risk assessment, and emergency response protocols.

Use Case Overview and Horizon Mapping





Horizon 1: Current Deployment

Horizon 2: Piloting

Horizon 3: Discovery

Immersive Operational Command and Control

Horizon 1

Description

The Immersive Operational Command and Control (IOCC) capability transforms traditional emergency management through shared virtual environments that enable real-time collaborative decision-making. By integrating live geospatial data, IoT sensor feeds, and team communications into an intuitive 3D space, IOCC creates a "digital twin" of crisis scenarios where responders can visualize complex situations, simulate response options, and coordinate actions across distributed teams with speed, clarity and efficiency.

Example

Singapore's National Research Foundation developed a digital twin that integrates IoT sensors and environmental data into a comprehensive 3D city model. Emergency management authorities utilize this immersive command center to visualize flooding scenarios, plan evacuation routes, and optimize resource deployment. The system successfully reduced response times during the 2023 monsoon season and has since expanded to include disease surveillance and health resource management capabilities.

Impacts

- Enhanced situational awareness
- Accelerated decision velocity
- Cross agency coordination
- Resource deployments
- Reduced cognitive loading
- Effective, lower cost training

SDG Alignment

Target 11.5, 11.7

Target 16.1

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 2

Cyberthreat Simulation for Critical Infrastructure

Description

Cyberthreat simulation for critical infrastructure provides critical infrastructure operators with an immersive 3D command center to visualize and respond to cyber-physical threats across connected utility networks in real-time. The system transforms complex IoT sensor data and security metrics into intuitive holographic displays, enabling rapid threat detection and response coordination across vast infrastructure networks, impossible to monitor with traditional 2D tools.

Example

In Australia, Energy Queensland integrated its Advanced Distribution Management Solution (ADMS) and its Geographic Information System (GIS) to deliver a single source of truth across the enterprise. This Network Digital Twin of critical infrastructure provides a consistent and shared network model representing the as-built and as-operated status of the company's grid and allows for scenario planning and simulation to occur without unnecessarily jeopardizing critical services.

Impacts

- Massively scaled network visibility
- Enhanced threat visualization
- Rapid response coordination
- Simulation of cascading failures
- Predictive analysis
- Low risk training environment

SDG Alignment

Target 11.5

Target 16.1

Key Technologies

Digital Twin | Metaverse | AR | VR | MR | GAI | AI | IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

Horizon 3

Digital Crime Scene Investigation Platform

Description

Digital Crime Scene Investigation Platforms leverage metaverse technologies to revolutionize criminal investigations through immersive 3D environments. These platforms transform traditional crime scene analysis by creating persistent, interactive virtual replicas that enable collaborative investigation, training, and evidence preservation across jurisdictions while maintaining chain of custody. Key features include high-fidelity 3D crime scene reconstruction; multi-user collaborative investigation tools; integrated evidence tagging and documentation; cross-jurisdictional access controls; AI-powered pattern recognition and analysis, and; immersive training simulations.

Example

INTERPOL's early pilot programs are testing how metaverse technology can create digital twins of crime scenes. These virtual replicas preserve crime scenes in their original state, enabling analysis long after physical locations have been modified. This serves dual purposes: it maintains pristine documentation of the scene's initial condition and facilitates thorough examination of evidence, ultimately producing better-prepared field personnel. It also allows jury members to virtually tour crime scenes, providing crucial spatial context that may lead to more comprehensive deliberations.

Impacts

- Immersive learning and retention
- Scalability and adaptability
- Resource efficiency
- Global collaboration
- Visualization capabilities
- Low risk training environment

SDG Alignment

Target 11.5, 11.7

16.1

Key Technologies

Digital Twin | Metaverse | AR | VR | MR | GAI | AI | IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	Low	Medium	**High**
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	Medium	**High**

Horizon 1

Natural Hazard Prediction and Forecasting

Description

In the context of climate change, cities are increasingly exposed to climatic hazards. To anticipate these phenomena as well as geomorphic hazards and better protect populations, digital twins are emerging as a key solution. These virtual replicas of cities make it possible to accurately model risk to develop prevention plans, simulate disasters in real time and explore combined risks and cascading effects. By integrating extensive meteorological, hydrological, and geomorphic and urban data, these decision-support tools provide decision-makers with a dynamic view of threats and enable them to adopt proactive strategies before a flood crisis.

Example

The Port de Bordeaux has created a digital twin of the Gironde Estuary. The digital twin helps stakeholders in their tactical decision making, e.g., with information on water levels, pollution and navigation as well as strategic decision making for modelling the impacts of climate change to the Estuary to support scenario planning and identify mitigation solutions, including to flood risk. In the future additional capabilities will be added including a flood alert system. The digital twin has been built as an open-source model.

Impacts

- Territorial Resilience
- Enhanced Safety
- Data-driven decision making
- Exploring cascade and combined effects
- Real-time uses
- Collaborative planning

SDG Alignment

Target 11.5

Target 13.1, 13.2, 13.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	Medium	**High**
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

Horizon 2

Emergency Response Simulation for Preparedness

Description

Simulation exercises involving multiple organizations and roles are already a crucial aspect of planning and preparedness for disaster events. In their form as “tabletop” exercises they have been limited by lack of data and the latency of interactions. As new AI and virtual world technologies are integrated into training exercises there are new opportunities emerging for digital twinning as part of humanitarian preparation. These platforms can be used to simulate disaster scenarios with real-time environmental changes, communication challenges, and infrastructure disruptions. Participants can practice coordinated response activities, test resource deployment strategies, and evaluate decision-making processes.

Example

Nasa Lifelines in October 2024 hosted the first ever global digital humanitarian data simulation exercise, focused on preparedness for the use of satellite imagery in complex emergencies. While this was convened in its present form using videoconferencing and chat platforms, future iterations can be expected to occur in immersive metaverse forms. Similalry, an EU project, Extended Reality for Disaster Management and Media Planning leveraged VR, integrated with sensor data to enhance situational awareness of those managing disasters, manmade crisis or public events.

Impacts

- Disaster Risk Reduction
- Strategic Planning
- Anticipatory Action
- Access to Education
- Health and wellbeing
- Stakeholder Engagement

SDG Alignment

Target 3.d

Target 16.7

Key Technologies

- Digital Twin
- Metaverse
- ~~AR~~
- VR
- ~~MR~~
- GenAI
- AI
- ~~IoT~~

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	Low	**Medium**	High
Data privacy and security	Low	**Medium**	High
Financial/operational	**Low**	Medium	High

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Horizon 2

Emergency Response Real-Time Facilitation

Description

Humanitarian coordination requires precise information about relevant risks and events to decision-makers of many kinds in rapidly changing environments, and immersive technologies such as digital twins as well as AI can significantly enhance the speed, clarity, and effectiveness of communication.New spatially and temporally specific communications tools are already shaping the landscape of rapid and flexible humanitarian coordination. Virtual world technologies can facilitate real-time communication, task management, and spatial awareness among staff, enabling efficient public service delivery and better operational oversight. XR features allow for enhanced visualization of locations and tasks, improving workflow coordination.

Example

Balcony Labs has implemented AR-enabled geo-messaging tools for humanitarian coordination which use networks of mobile devices to set up rapid ad hoc structures for evacuation, resource allocation, and other response actions. These have already been deployed in Afghanistan, Ukraine, Colombia, and Haiti.The integration of augmented reality enhanced the ability to use real-time spatial data in situational context through rich visualization. Moving forward, generative AI could deepen capacity for pattern analysis across large amounts of rapidly changing information.

Impacts

- Disaster Risk Reduction
- Health and Wellbeing
- Early Warning
- Climate Adaptation
- Inclusion
- Citizen Engagement

SDG Alignment

Target 11.5

Target 1.5

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GenAI	AI	IoT

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	Medium	**High**
Financial/operational	**Low**	Medium	High

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Horizon 3

Virtual Post-Disaster Assessment and Risk Mapping

Description

After disasters, a combination of aerial and satellite imagery plus geospatial AI can rapidly produce high-quality assessments of impacted areas. By integrating both tasking and interpretation or annotation of imagery with collaborative local community-based response frameworks, digital twins of affected areas can be rapidly produced and assessed for priority response interventions.

Example

The RescuEye prototype aerial imagery, computer vision, and AI chatbot platform is one example of a potential future fusion of AI, computer vision, sensors, and other networks for immersive post-disaster assessment. This type of technology requires strong community engagement, education, and collaboration to reach its potential.

Impacts

- Disaster Risk Reduction
- Climate Adaptation
- Inclusion
- Poverty Alleviation
- Health and wellbeing
- Citizen Engagement

SDG Alignment

Target 11.5

Target 13.1

Target 1.5

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GenAI	AI	IoT

Risk Level

Public safety	Low	**Medium**	High
Stakeholder acceptance	**Low**	**Medium**	High
Data privacy and security	Low	Medium	**High**
Financial/operational	Low	**Medium**	High

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Horizon 3

Participatory Water Scarcity Management

Description

Cities are increasingly exposed to water shortages. Digital twins and IoT can be used to create virtual replicas of city water systems including manmade and natural water bodies as well as water infrastructure and networks. Water demand and supply can be monitored and forecasted, and decision makers can conduct scenario planning. When necessary, mitigation measures can be introduced to promote participatory climate action. An open digital twin and XR can demonstrate to citizens why and when to limit usage through an interactive environment and provide an open environment to debate public policies.

Example

Port de Bordeaux has created a digital twin of the estuary including several water stakeholders such as the local water agency, public basin organizations, river agency, oceanographic service and French navy. The digital twin enables scenario planning for future climate scenarios and the sharing of daily forecasts in conjunction with the International Office for Water. Additional functionalities could be added for participatory water scarcity management.

Impacts

- Climate change adaptation
- Hydro-diplomacy
- Data-driven decision making
- Water management
- Citizen participation
- Collaborative planning in virtual environments

SDG Alignment

Target 9.1 Target 13.1

Target 11.3

Key Technologies

Digital Twin	Metaverse	AR	VR	MR	GAI	AI	IoT
■		■	■				■

Risk Level

Public safety	**Low**	Medium	High
Stakeholder acceptance	Low	Medium	**High**
Data privacy and security	**Low**	Medium	High
Financial/operational	Low	**Medium**	High

Horizon 2

Interactive Emergency Communication

Description

In an emergency, city governments can use XR to provide real-time guidance to citizens through mobile apps including visualizing disaster hotspots, identifying safe evacuation routes, locating shelters, avoiding crowded spaces during outbreaks, and providing medical guidance. The metaverse can host virtual town halls or press conferences or other virtual rooms where city officials provide updates, discuss strategies, and engage citizens in disaster-related decision-making. AI can be leveraged to classify users in communication groups and allocate them to the appropriate communication rooms/spaces and personalize the messaging they receive to best fit their requirements.

Example

In cities undergoing pandemics, people needed to receive guidance about vaccination, social distancing etc. Seoul dashboard for daily updates provides a timeline of events and necessary countermeasures. Seoul's media outlets were used by SMG to keep the public informed. Smart map of Seoul: the Corona Map, Corona 100, Self-diagnosis and Mask Apps in Seoul allow real-time tracking of the virus by creating maps of hotpots, with regular updates. The above can be enhances through the application of emerging technologies.

Impacts

- Transparency
- Enhanced Safety
- Cost savings
- Quality of life
- Operational efficiency
- Regulatory compliance

SDG Alignment

Target 9.c Target 3.3, 3d

Target 11.5

Key Technologies

- Digital Twin
- Metaverse
- AR
- VR
- MR
- GAI
- AI
- IoT

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	**Medium**	High

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Public Health Emergency Real-time Management

Horizon 1

Description

In an emergency, city governments can use digital twins and metaverse to visualize real-time outbreak across the urban environment and perform the appropriate decision making around mitigation and risk reduction measures. Real time data can be through sources such as city IoT networks (e.g., meteorological data and water quality data), hospitals and research centers, smart city platforms etc. Public health officials can utilize the virtual space to depict the outbreak in an interactive way to multiple stakeholders and apply changes directly to system delivery and services. AI algorithms can perform predictions and enable automatic alerting and guidance based on these decisions (i.e., hospital preparation and routes).

Example

The ITU-T Y.4233 Framework for smart public health emergency management in smart and sustainable cities can be used as a basis for this use case. The Seoul dashboard for updates and Korean patient management system (C40) helps to streamline hospital bed capacity and take action to minimize pressure on the hospitals. Capabilities include: IoT sensing, disaster safety monitoring, disaster simulation and safety management. Virtual world technologies can augment the capabilities available through such platforms.

Impacts

- Early response
- Enhanced Safety
- Cost savings
- Quality of life
- Operational efficiency
- Regulatory compliance

SDG Alignment

Target 9.c Target 3.3, 3d

Target 11.5

Key Technologies

- **Digital Twin**
- Metaverse
- AR
- VR
- MR
- GAI
- **AI**
- **IoT**

Risk Level

Public safety	Low	Medium	High
Stakeholder acceptance	**Low**	Medium	High
Data privacy and security	Low	**Medium**	High
Financial/operational	Low	Medium	**High**

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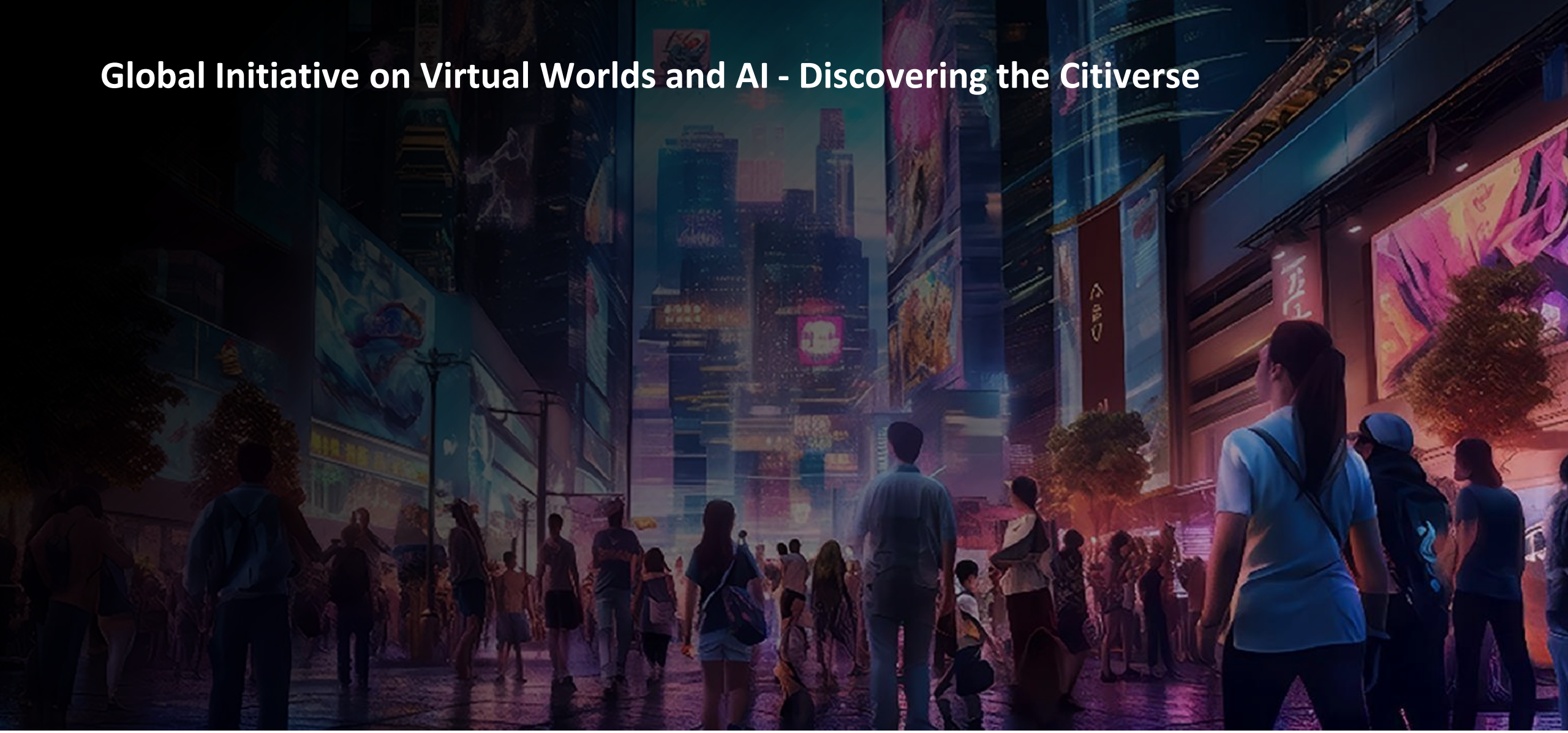

Conclusions

Key Takeaways

- **The Citiverse enables cities to create immersive, digital representations of urban environments-bridging the physical and virtual** through technologies like the metaverse digital twins, AR/VR, AI, and IoT. AI and GAI has a critical role to play within the Citiverse as an enabler and accelerator. AI is increasingly serving as a foundational technology that drives innovation, enhances user experiences, and supports the creation of interactive and immersive virtual environments. As Agentic AI capabilities emerge, their impact on virtual world technologies and use cases should also be explored.
- **Citiverse use cases span 5 core thematic areas**: Urban Planning & Infrastructure, City Administration & Public Participation, Economic Development & Tourism, Transport & Mobility, and Public Safety, Health & Disaster Resilience. Each area leverages virtual worlds to address unique challenges, from climate adaptation and circular economy to citizen engagement and emergency management.
- **The Citiverse use cases mapped in the Taxonomy can contribute to the achievement of a broad range of SDGs,** namely SDG1, SDG3, SDG4, SDG8, SDG9, SDG10, SDG11, SDG12, SDG13, SDG16, SDG17.
- **The Citiverse's success depends on open standards, interoperability, robust governance, and security**. Collaborative, multi-stakeholder approaches ensure the platform remains inclusive, resilient, and adaptable to evolving urban needs.
- **Cities must balance risk and opportunities when adopting Citiverse use cases.** A systematic risk taxonomy-covering public safety, stakeholder acceptance, data privacy/security, and financial/operational risk-enables cities to prioritize use cases that balance innovation with manageable risk. This approach supports informed decision-making, ensuring that high-impact, scalable solutions are prioritized for early adoption, while more experimental or higher-risk concepts are piloted or explored further before city-wide rollout.

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Key Takeways

Among other key strategic outcomes, Citiverse use cases can:

- **Foster Inclusive, accessible forums for civic engagement** such as virtual town halls, participatory planning, and sentiment mapping-empowering citizens to co-create policy and urban spaces regardless of physical barriers.
- **Enable Data-driven, resilient and sustainable city services and infrastructure** including optimizing infrastructure, transport systems, managing resources efficiently, and model scenarios for climate resilience, disaster preparedness, and operational efficiency.
- **Revolutionize education, vocational training, and onboarding** for both students and city employees. They provide safe, engaging, and personalized learning experiences, supporting life-long learning and workforce adaptability in rapidly changing economies.
- **Drive economic diversification and cultural preservation** The Citiverse opens new avenues for economic growth-through virtual marketplaces, immersive tourism, digital heritage preservation, and support for creative industries. These use cases promote local economic resilience, cultural continuity, and global accessibility.
- **Promote sustainability across all aspects of the city** from mapping and designing with nature, facilitating circular economy and recycling through waste management and the built environment, providing educational opportunities including gamifying sustainable behaviours and modeling climate change adaptation strategies.
- **Create hospitable worlds and creative experiences and places** by creating a new medium for artistic expression, cultural participation, new public spaces and forums, personalization of experiences and community connection and wellness.

Next Steps

- The use case taxonomy presented here is both a **snapshot** of current innovation and a **foundation** for future collaboration. As cities continue to scale and expand initiatives, and experiment with pilot projects and sandbox environments, this living resource will continue to evolve. Ultimately, the Citiverse is not a fixed destination – it is a journey of **collective innovation**, **iterative learning**, and **shared urban futures**. By identifying, analyzing, and amplifying promising use cases, this report contributes to shaping that journey.

- The use case identification track's work will feed into several other tracks in the Global Initiative for Virtual Worlds and AI, including the emerging technologies track, security and trust track, evaluation and assessment track and awareness building track.

- The Citiverse Taxonomy was launched at the second UN Virtual Worlds Day on 12 June 2025 providing participants from across local, municipal and national governments, private sector organizations, SMEs, multilateral organisations, NGOs and all other participants with an opportunity to explore the evolving landscape of Citiverse use cases and tangible examples of best practices from around the world.


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