TAMPERE.
FINLAND

ROAD TO CITIVERSE

TAMPERE

TEPPO RANTANEN

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ROAD TO CITIVERSE

– from smart city thinking to citiverse, case Tampere

Foreword

This book is about one of the most interesting trends happening in our world, where advanced technology is changing the way citizens are living their lives and getting their services in a modern society. As a case study I am using Tampere, my home town where I served 10 years as an innovation leader, smart city leader and citiverse leader.

My background is in the world of accounting and consulting. I started my professional journey in a family-owned accounting firm, then moved over to a national firm, which became part of Arthur Andersen. My journey continued from being a local CEO of the Finnish firm to Nordic leader in Risk Consulting based in Stockholm. After Andersens demise I took over the CEO role of Deloitte Finland, and then to Global role in London on our Technology, Media, Telecom industry leadership team. I also started to coordinate our activities on IOT development, which lead me to work also on Smart Cities.

People often wonder what is this Citiverse, that people talk about. I try to give a brief explanation in this book. While the definitions vary, the goal to me is clear. How the technology can help the everyday life of our citizens. Especially I think we need to focus on groups who have challenges on digital access, elderly people and young children, special groups. But overall question of user interface is key for our citizens.

Other key topics are the use of data, digital sovereignty, combining data from different sources, both public and private as well as the question about consent on personal data.
I am now involved in United Nations Virtual Worlds -work through ITU, serving as chair of one of the tracks of initiative called The Global Initiative on Virtual Worlds and AI – Discovering the Citiverse. My track is called Strategic Guidance. I am also a co-chair of the initiative of United for Smart and Sustainable Cities (U4SSC) called Digital Development Goals for Cities, where we are looking to lay foundation (like SDGs) on digital development of cities. In addition I am involved in EU established LDT CitiVERSE EDIC, where we are looking at Networked Digital Twins towards the CitiVERSE. One of the goals is to look how we can have applicable standards for interoperability and use of AI.

I want to thank City of Tampere and my great colleagues Outi Valkama, Anniina Autero, Maiju Viiki, Sebastian Valkama, Anni Joela and Tiia Joki for the great work, and also Business Tampere Kristian Valkama and Markku Niemi. Several other people from Tampere have been helping on the way. I also want to thank Bas Boorsma, Cristina Bueti, Karl-Filip Coenegrachts, Christina Yanzhang, Roland van der Hejden, Ernesto Faubel and Arturo Castello, and many others on my international travels.

Tampere, 23.5.2026
Teppo Rantanen

1. The Road to the Citiverse: Tampere’s Journey Through Digital Urban Evolution

Introduction — A City at the Edge of Digital Transformation

Cities rarely evolve in straight lines. Their histories bend, weave, and accelerate with technological shifts, political movements, and the ambitions of the people who steward their future. Tampere, a city known for its industrial heritage and cultural vibrancy, has become one of the most recognized European frontrunners in digital transformation. Its journey—from a Smart City to a Data Driven City, to a Metaverse City, and finally to a Citiverse City—forms a powerful narrative of vision, courage, and innovation.

This chapter tells the story of how Tampere built its future step by step. It illustrates how early digital infrastructure laid the groundwork for more complex data ecosystems; how these ecosystems enabled immersive and hybrid realities; and how these realities, in turn, became the basis for the Citiverse—a human centric digital twin of urban life designed for sustainability, participation, and wellbeing.

Foundations: The Birth of the Smart City

1.1. Early 2000s — The Digital Awakening

The beginning of Tampere's transformation traces back to early programmes like **eTampere** and **Open Tampere**, which signaled the city's ambition to leverage ICT for economic and social renewal. These initiatives positioned Tampere as a technological innovator long before "smart city" became a mainstream term. They laid the foundational competence in internet technologies, open innovation, and digitalization.

eTampere program was a large-scale urban innovation and information society development initiative 2001-2005. The goal was to position Tampere as an internationally competitive knowledge and technology hub by strengthening collaboration between universities, research institutes, companies and the public sector. The program focused especially on ICT, digital services and applied research, aiming to turn academic expertise into business growth, new jobs and societal benefits.

eTampere combined research funding business development, startup incubation, and public-sector digital service pilots into a single strategic framework. It was notable for its scale, long-term vision, and for treating the city as an active innovation partner, not just a regulator or funder.

The program played a key role in shaping Tampere's reputation as a technology- and innovation-driven city, and many of its principles later influenced smart city strategies and innovation ecosystem models in Finland and beyond.

The Open Tampere Program was a city-led internationalization and ecosystem development initiative designed to make Tampere a more open, attractive, and globally connected city for talent, companies, students, and investors.

The program focused on strengthening Tampere's international competitiveness by opening the city's innovation ecosystem to the world. Its key priorities included attracting international talent and startups, supporting the global growth of local companies, promoting foreign direct investment, and improving the city's ability to welcome and retain international professionals and students.

Open Tampere emphasized openness, collaboration, and co-creation across the public sector, higher education institutions, companies, and international networks. Rather than operating as a single project, it functioned as a platform of coordinated actions, combining talent services, startup support, investment promotion, and place branding under a shared strategic direction.

The program helped position Tampere as an international innovation hub—particularly in areas such as smart cities, manufacturing, health technology, and digital solutions—and laid the groundwork for Tampere's current international talent, startup, and investment services.

Tampere's early digital era was characterized by experimentation and optimism. Digital public services emerged, open data became accessible, and the city began actively inviting private sector partners to collaborate on new models of urban development.

1.2. Smart Tampere — The First Phase of Urban Intelligence

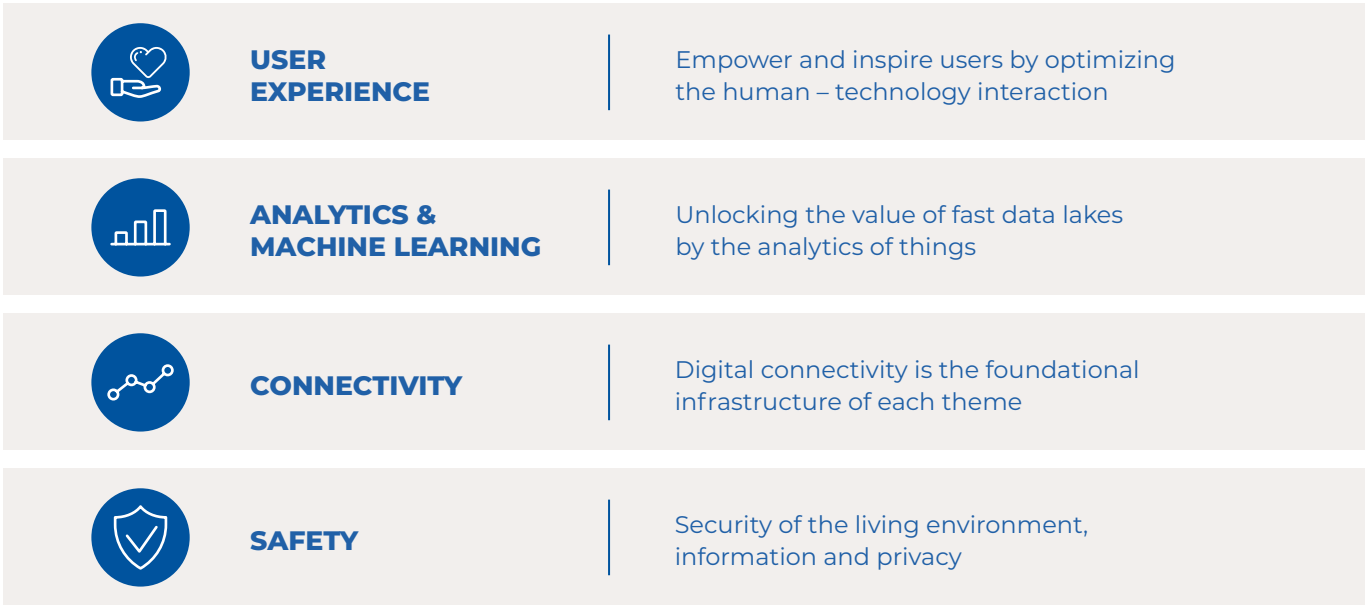
Smart Tampere program was initialized in June 2016. the program grew out of need to do systematic and holistic approach on smart city development and start building a structured approach on ecosystem management. the first version became finalized in autumn 2016, as the program was officially launched in January 2017 for 5 years. First point of analysis was how different ecosystems work and what makes them tick. Looking at best practices around the world helped Tampere to shape the basis of Smart Tampere program as a full-fledged ecosystem play, which brought different ecosystem stakeholders like never before.

The time this program was established the smart city boom was growing and becam eth ehot topic for forward-looking cities around the world. Barcelona was probably one of the first internationally known Smart Cities building an a close collaboration with companies like Cisco. Barcelona was one of the early models for Tampere as well and one of cities with early ties built. Barcelona also became home of one of the most famous smart city events, Smart City Expo World Forum (SCEWC). Tampere also started the first events (Smart City Week, later Imagine) who made Tampere famous for its thinking.

The headline of the program became in the spirit of ecosystem play "Grow.Smart.Together" and the vision was " Be an internationally recognized sustainable smart city attractive for business and citizens", mission "Drive a thriving and collaborative smart Tampere ecosystem to accelerate participant's growth and citizen's welfare" and objectives were " Achieve growth and value for all smart Tampere ecosystem participants, increase smart Tampere ecosystem participants international competitiveness, attract and grow talent, knowledge and skills in smart Tampere ecosystem, contribute to a sustainable Tampere community and increase the quality of life in Tampere.

Initial model of the ecosystem was describe through verticals and horizontals.

Key elements of Smart Tampere



Tampere ecosystem in Smart Tampere 2016-2017

Initially it started with six verticals and three horizontals, but evolved in the course of the program to include seventh vertical “education” and fourth horizontal “user experience”

The whole program was run within the city as a matrix, so a small dedicated team was multiplied by almost a hundred people from different parts of the city organization, thus making adopting new ideas and communication much easier than in a traditional way. In the spirit of ecosystem, each vertical and horizontal were lead by different ecosystem partners, from the companies, academia or public sector. One of the key principles in each of the group was that all competitors can join and they are obliged to work together to develop new things.

Tampere also was rethinking the role of the city and taking bold new stands how the role of the city can be described in this ecosystem world.

City Ecosystem Roles

DIFFERENT ROLES OF THE CITY

INNOVATOR & INVESTOR

Apply the principles of innovation in the internal organization and processes. Stimulate innovative solutions by acting as launching customer.

STRATEGIST & ADVOCATE

Sets out a clear direction for the City of Tampere: what is our vision and ambition with the Smart Tampere Ecosystem. Furthermore: be an active advocate of the city as innovative hub for new business.

SOLUTION ENABLER

Build ecosystems by gathering parties that normally do not work together to deliver creative new solutions. Support the ecosystems by channeling government funding.

DIRECTOR & REGULATOR

Create or change laws and regulations to allow new business models and disruptive entries, and simultaneously protect the interests of citizens and users of the city.

STEWARD

Create an environment in which new businesses and smart solutions can emerge and grow. For example by providing ‘open data’ and by facilitating start ups.

CONNECTOR & PROTECTOR

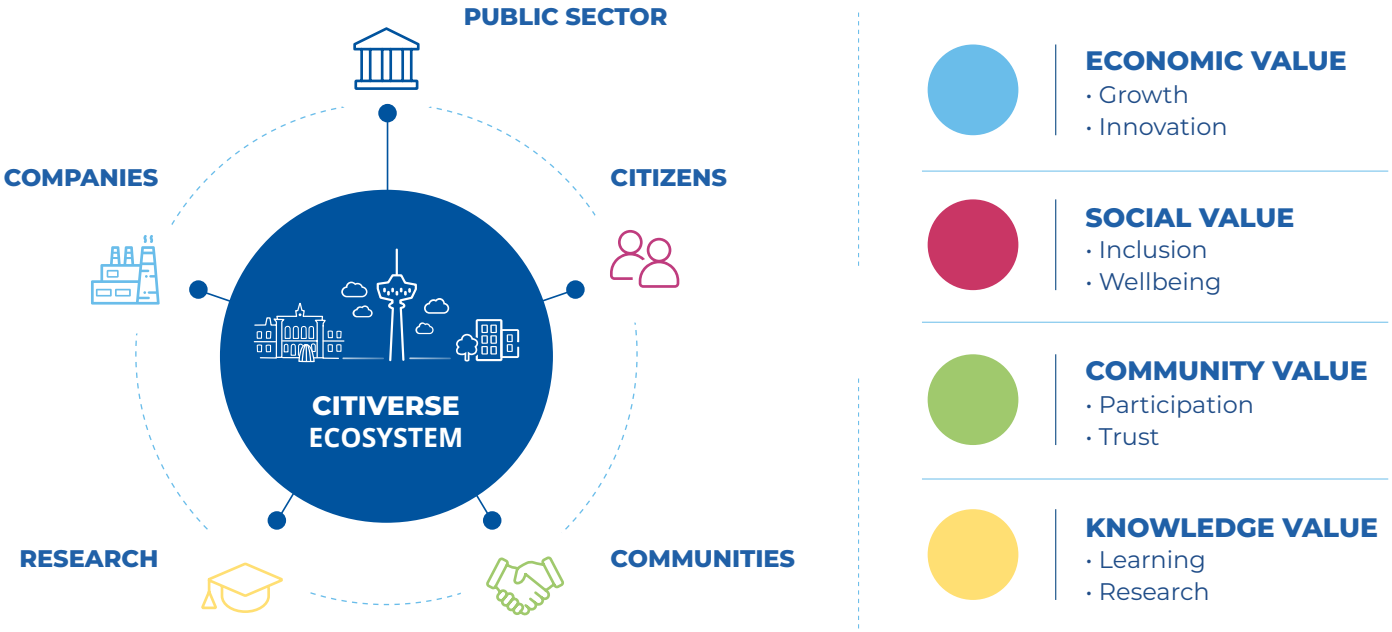
Secure modern transportation infrastructures, energy grids and digital networks. Set standards and take measures to make these vital infrastructures resilient and safe.

Tampere was one of the leading cities developing new kind of an ecosystem thinking, which paved the way for future steps towards Citiverse thinking.

Smart Tampere program was able to also benefit from the major investments Tampere was doing, and add as use cases areas like new city district of Hiedanranta, Deck and Areena and Light rail tram.

Tampere also started to develop new understanding of the value created by platform ecosystem programs like Smart Tampere.

Value creation in platform ecosystem



Elements of value creation in Smart Tampere

Value creation became important in the first phase of the program, since the investments made by the City were significant. Economic value is the one which usually drives most of the attention when decisions are made, and will be significant as we look at Citiverse initiatives as well. But more important values actually are social values and community values from a city and especially citizens point of view.

Some of the elements of the model were developing fast, especially in the are of mobility. The future of mobility got exciting future aspects in 2019 as the following diagram shows.

Strategic roadmap

FUTURE OUTLOOK OF MOBILITY: 2020–2050

	2020-2022	2025	2030	2050	2050+
KEY MILESTONES	BaaS pilots – Several MaaS operators in Tampere region	50% reduction in CO_2 from transport – Car free neighborhoods	Carbon positive transportation system		
Objectives towards reaching carbon neutralit in Tampere	Change in mode of transport: more users to public transportation Tampere BaaS pilots to city's employees and students (Possible) Traffic and congestion charges	Rail traffic connections Growth in population: +3000 per annum Electric and connected cars	Target: 50 % reduction in CO_2 Remote work and flexible forms of work Congestion peak times will level off	Carbon positive transportation system Drone taxis	The era of autonomous vehicles Passenger- and goods transport drones
Key trends in moblity	Mobility budgets & -credits (to residents and employees) Sponsored MaaS services (with event organizers & companies) MaaS mobillity hubs (services, logis-tics, mobility) Demand responsive transport	Mobility during weekends From car ownership to access economy Above ground parking spaces (cost savings)	Drone deliveries are business as usual Robot cars operate in restricted areas	Automatiization of PT Shared autonomous cars (less need for parking space)	Rise of the self employed
Physical and technical solutions	Mobility data operator busi-ness (supports implementa-tion of BaaS pilots) Need for parking spaces diverges New options for mobility (tram, city bikes, micro-mobility, MaaS on water)	BaaS widely adopted In B2B segment in Tampere region Changes in parking policies: · Electric and hybrid vehicles, · Charging stations Commission policy and incentives to support PT, walking and biking	The era of data economy: public trans-portation could be free to a resident if the mobility data is made available to the city Car free neigborhoods Tampere-Pirkkala airport ecosystem: (mobility services, drones)	Autonomous mobiliity rev-olutiones the use of space in the city: · parking space to a more productive use · Changes city planning and infra-structure · Radically de-creases costs of city mandated transporta-tion (disabled, elderl etc.)	

Overall, the Smart Tampere program was the City of Tampere's strategic innovation and economic development program aimed at strengthening the city's role as a leading smart city and innovation hub.

The program focused on using digitalisation, data, and emerging technologies to drive sustainable urban development, business growth, and high-quality public services. Its core objectives include accelerating R&D and innovation, supporting startup and scale-up ecosystems, enabling testbeds and real-life pilots, and turning research and technological expertise into internationally competitive business.

Smart Tampere brought together the city, universities, research institutes, companies, and startups in a coordinated ecosystem. The city acted as a platform, test environment, and first customer, enabling experimentation and co-creation in areas such as smart mobility, health and wellbeing, sustainable industry, data-driven services, and digital public services.

The program also emphasized internationalization and talent attraction, aligning innovation activities with global networks, EU funding instruments, and foreign investment.

Smart Tampere represents a mature phase in Tampere's long-term development strategy—building on earlier initiatives such as eTampere and Open Tampere—by integrating innovation, digital transformation, sustainability, and global competitiveness into a single, city-wide framework.

Under the program, the city systematically implemented IoT technologies, digital services, and smart mobility experiments. These efforts formed a unified ecosystem:

- Connected city services
- Data producing sensors
- Growing interoperability between systems
- Partnerships between academia, industry, and the public sector

One element of the smart Tampere program was a look at safety and security. As part of Tampere's Smart and data driven city development, the city launched the **SURE (Smart Urban Security and Event Resilience)** program to strengthen safety, preparedness, and operational resilience in public spaces and large events. Developed between 2019 and 2023 with EU funding, SURE introduced a platform based approach that enables authorities, city operators, and event security personnel to share real time situational awareness using city owned sensors and infrastructure. Rather than relying on heavy system integrations, SURE brings data from cameras, IoT devices, and urban systems into a common operational view, supporting both live operations and multi stakeholder simulations. A key innovation was the integration of smart lighting into the city's IoT platform, allowing lighting to be used dynamically for crowd guidance, emergency response, and everyday urban operations. Tested in major events in Tampere and later scaled beyond the city, SURE demonstrated how data, AI, and urban infrastructure can be combined to improve safety while remaining aligned with humancentric and ethical principles. Tampere worked together with corporate partners like Nokia, Insta and Securitas to bring this solution live.

Urban Safety

SYSTEMIC APPROACH

SIMULATION AND PREPAREDNESS EXERCISES

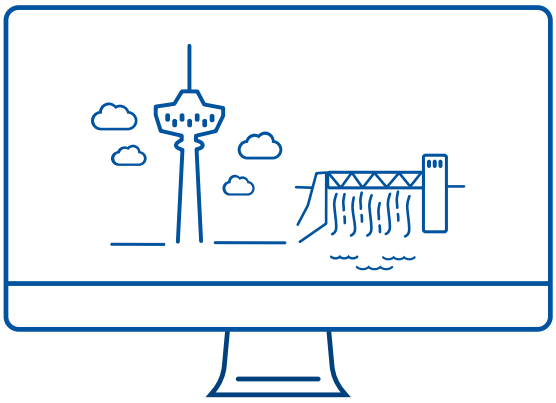
SERVICE DESIGN

SCALING UP

SENSORING

OPERATIONS

MONITORING & RESPONSE



- Situation room of first response
- Situation room of first dept.
- Situation room of police
- Situation room on location
- Situation room of traffic control

AI AND ANALYTICS

During Smart Tampere the most significant learning was how to build the ecosystem, which had more than 200 companies and schools and universities piloting more than 100 projects. Examples of these projects are exploration of use of **robots in schools** as a way to improve inclusion, participation, and learning experiences. Within the Smart Tampere program, educational robots were piloted not as technological novelties but as pedagogical tools integrated into everyday teaching. The **Elias humanoid robot** was used to support language learning by interacting directly with pupils in multiple languages, while the **AV 1 telepresence teaching robot (ALMA)** enabled children with long term illnesses to participate in classroom life remotely, maintaining social connection and continuity of learning. These experiments reflected Tampere's broader approach to digital education: technology was introduced only where it clearly served human needs, strengthened equality, and supported teachers' work. Long before the Citiverse concept emerged, these pilots demonstrated how robotics could enhance accessibility and wellbeing in education when guided by humancentric design principles.

As Tampere advanced toward a more data driven and human centric city, it also experimented with the use of artificial intelligence in employment services. One such pilot involved **Osaamisbotti**, an AI based conversational "robot" used to interview unemployed jobseekers. Instead of a traditional first interview with a human counselor, jobseekers engaged in a structured dialogue with the bot, which helped identify their skills, experience, and capabilities in a consistent and scalable way. The information gathered was then used by employment professionals to support personalized guidance, job matching, and employer outreach. The goal was not to replace human interaction, but to free professionals from repetitive intake work and allow them to focus on coaching, problem solving, and building pathways to employment. This early experiment illustrated how AI could augment public services in a respectful and pragmatic manner—using automation where it adds value, while keeping human judgement and responsibility at the core.

Test platforms

As part of the Smart City program, one of the key features and principles was to offer test platforms for companies to do piloting, stand-alone as well as in connection with other partners, as well as with the city. One of them where Tampere invested early in is **5G test platforms** to provide the connectivity backbone required for advanced digital urban services. Under the **Smart Tampere** program, the city built the **Towards 5G** test environment in close cooperation with **Nokia**, universities, research institutes, and private companies, positioning the city as a real world laboratory for next generation wireless technologies. The platform combined multiple 5G base stations, fiber connections, and edge computing to enable ultra low latency testing for applications such as smart mobility, automated transport, intelligent machines, and robotics. Key environments included the **Viinikka and Hervanta areas**, university campuses, research facilities, and later the **Nokia Arena**, which evolved into a world class 5G millimeter wave testbed for immersive media, XR, and event scale use cases. By offering open access to city infrastructure for experimentation—rather than deploying 5G only as a commercial network—Tampere enabled companies and researchers to develop, test, and validate solutions in authentic urban conditions. These 5G platforms strengthened Tampere's role as a living lab and laid the high performance connectivity foundation for data driven services, digital twins, and ultimately the city's emerging Citiverse vision.

Other platforms were also physical platforms. One of the most ambitious examples of Tampere's platform based urban development is **Hiedanranta**, a former industrial area being transformed into a **smart, sustainable city district and large scale pilot platform.** Located close to the city centre, Hiedanranta has been deliberately developed as an **open innovation environment,** where new solutions in **sustainable mobility, energy systems, circular economy, digital services, and climate positive urban living** can be tested in real conditions. The district functions as a living lab that brings together the city, companies, research institutions, and residents to co create and pilot new technologies, services, and governance models. Hiedanranta has been used to experiment with **smart energy and emissions management, circular resource flows, digital participation, and new mobility solutions,** supported by the extension of the **Tampere tramway** and other low carbon transport modes. Temporary uses, events, and experimental projects have been actively encouraged, making the area a continuously evolving testbed rather than a traditionally phased construction project. Through Hiedanranta, Tampere has been able to treat an entire city district as a platform—accelerating learning, reducing risk for innovation, and translating strategic sustainability and digital goals into tangible urban solutions that later informed broader citywide and Citiverse oriented development.

Beyond its role as a transport system, the **Tampere tramway** has been deliberately developed as a **living laboratory for sustainable urban mobility and digital innovation.** Under the Smart Tampere program, the city established the **Tampere Urban Rail Mobility Services (TURMS) Living Lab,** which uses the operational tram network as a real world environment for testing and validating new technologies, services, and business models. The living lab provides companies, researchers, and public actors access to an operating tram system, dedicated test vehicles, and rich mobility data, enabling experimentation in areas such as smart mobility services, automation, connectivity, and user centric design. A concrete example is the **Lyyli Living Lab**, launched in 2022, which utilizes a dedicated tram car and the wider tramway infrastructure to support real life testing of next generation urban mobility solutions in cooperation with the city, Tampere Tramway Ltd, industry partners, and universities. By opening a critical piece of urban infrastructure for co creation and experimentation, Tampere transformed its tramway into more than a transport investment: it became a platform that accelerates innovation, strengthens ecosystems, and supports the city's broader transition toward data driven, low carbon, and human centric urban development—an approach that later aligned naturally with Citiverse thinking.

Living Labs and Test Platforms

TURMS LIVING LAB PLATFORM

Use of these kinds of platforms strengthened Tampere ecosystem and working together with different types of companies – as well as large global corporations as wells as mid-size and small companies and start-ups.

One of the platforms opened in 2020, and the use has been ever increasing since then. The **Nokia Arena** has emerged as one of Tampere's most visible and high impact **test platforms for smart city solutions,** combining large scale public events with cutting edge digital infrastructure. Built as a multipurpose venue at the heart of the city, the arena has been deliberately used as a **real world laboratory** for experimenting with **5G millimeter wave connectivity, immersive XR experiences, AI driven services, and advanced situational awareness.** Through collaborations between the City of Tampere, Nokia, Elisa, technology partners, universities, and startups, the arena has hosted pilots ranging from **XR and 360 degree live event experiences to visual positioning, people flow analytics, and smart venue services.** Its high capacity 5G network has enabled ultra low latency testing during live concerts and sports events, allowing solutions to be validated under demanding, real world conditions rather than in controlled lab environments. By opening a flagship venue to experimentation, Tampere transformed Nokia Arena into more than an entertainment facility: it became a scalable platform where smart city technologies could be tested, demonstrated, and refined in front of real users—providing concrete references for future urban services and contributing directly to the city's broader Citiverse and digital twin ambitions.

The Smart Tampere period demonstrated a key realization: digital transformation was not only about tools, but about orchestration—organizing people, technology, and governance around a shared vision.

Three lessons stand out from Smart Tampere:

1. **Technology is not enough** – culture change is essential.

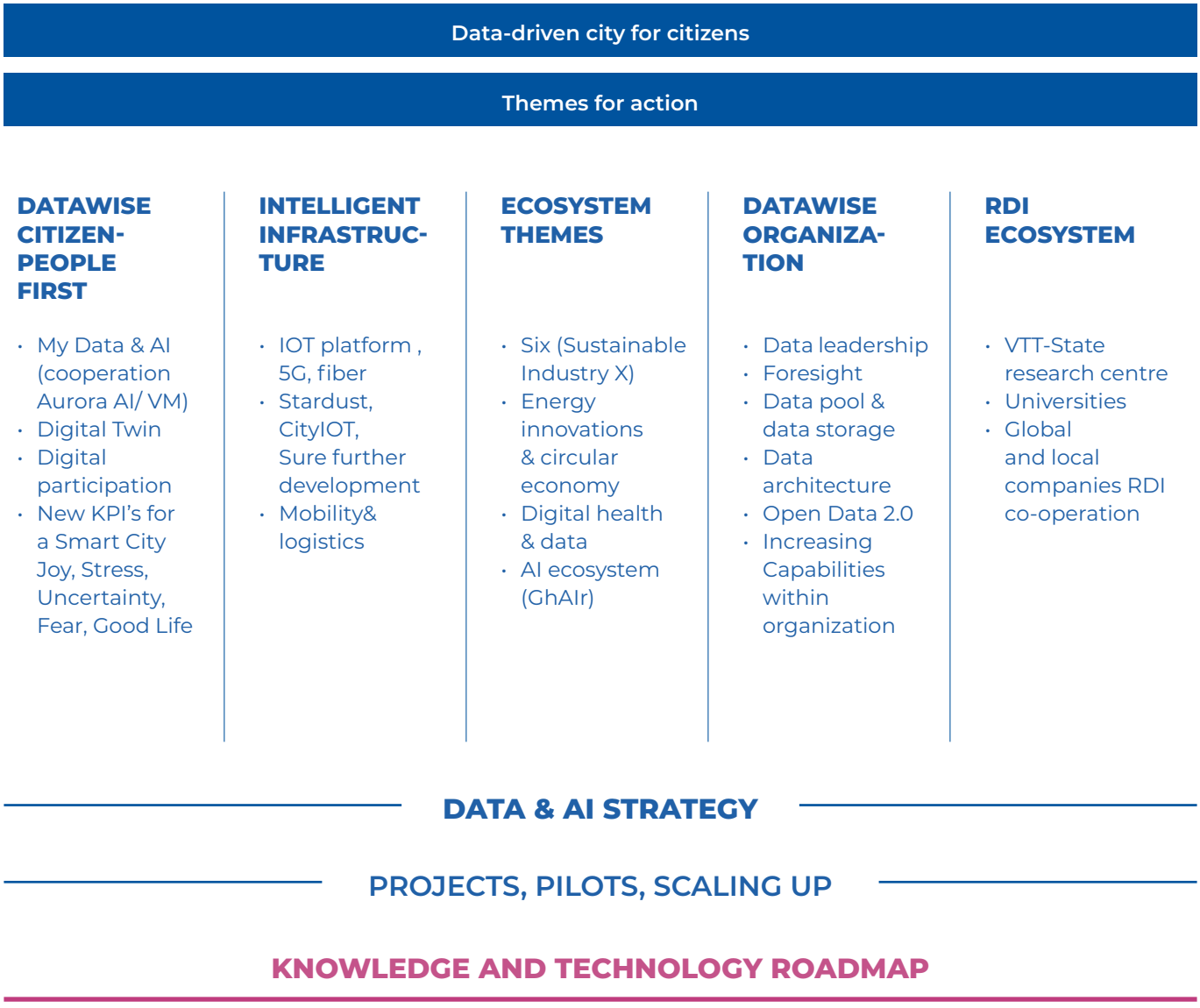
2. **Collaboration is the engine** – cross sector partnerships became Tampere's competitive advantage.

3. **Early digital infrastructure creates compounding returns** – each investment paved the way for more advanced innovation later.

1.3. The Data Driven City for Citizens

The Strategic Shift Toward Data

As Tampere matured in its smart city journey, a strategic shift occurred: the city recognized that **data—not devices—was the real infrastructure of the future.** The city-wide program succeeding Smart Tampere was named as Data-driven city for citizens.



5 themes were identified in the beginning of the DDCC program

This led to the emergence of the **Data Driven City for Citizens** model, which emphasized strengthening capability maturity across key domains like connectivity, data & AI, XR/AR, digital twins, and citizen services.

Building the Technologies Behind the Data-Driven City

The next phase involved transforming static systems into intelligent networks:

- **IoT sensors** provided real time feedback loops
- **Digital twins** began mirroring the city's physical environment
- **AI models** enabled predictive analysis and insight-based decision making
- **Data platforms** facilitated interoperability and transparency

Through these tools, Tampere could respond more quickly to emerging trends, model potential interventions, and design services based on actual citizen needs.

A critical enabler of Tampere's journey toward a data driven and ultimately citiverse ready city has been the development of a **citywide IoT platform** that turns urban infrastructure into a shared digital foundation. Built as an open, API based system and developed on the **IoT TICKET platform by Wapice,** Tampere's IoT platform connects sensors, cameras, and control systems across the city into a single operational layer. It enables real time monitoring and management of street lighting, traffic flows, city maintenance, heating systems, and safety related infrastructure, while allowing new services to be built without heavy system to system integrations. One of the platform's most visible applications is **smart lighting,** where streetlights function not only as energy efficient infrastructure but also as a digital backbone for sensors, analytics, and crowd guidance in everyday situations, large events, and emergencies. The platform's openness has allowed companies, researchers, and startups to develop and pilot new services directly on city infrastructure, ranging from predictive maintenance to visitor flow forecasting and smart tourism services. By treating IoT not as a collection of devices but as a shared urban platform, Tampere laid the groundwork for insight based decision making, cross sector collaboration, and the scalable use of data and AI—foundations that later became central to the city's Citiverse vision.

Citizen Centric Data Governance

Data was not treated merely as a resource—but as a shared asset. Ethical practices, transparency, and consent-based models guided development, echoing the city's commitment to human centric design. The Data Driven City became a platform where residents could influence how their information contributed to better services.

Real-World Applications

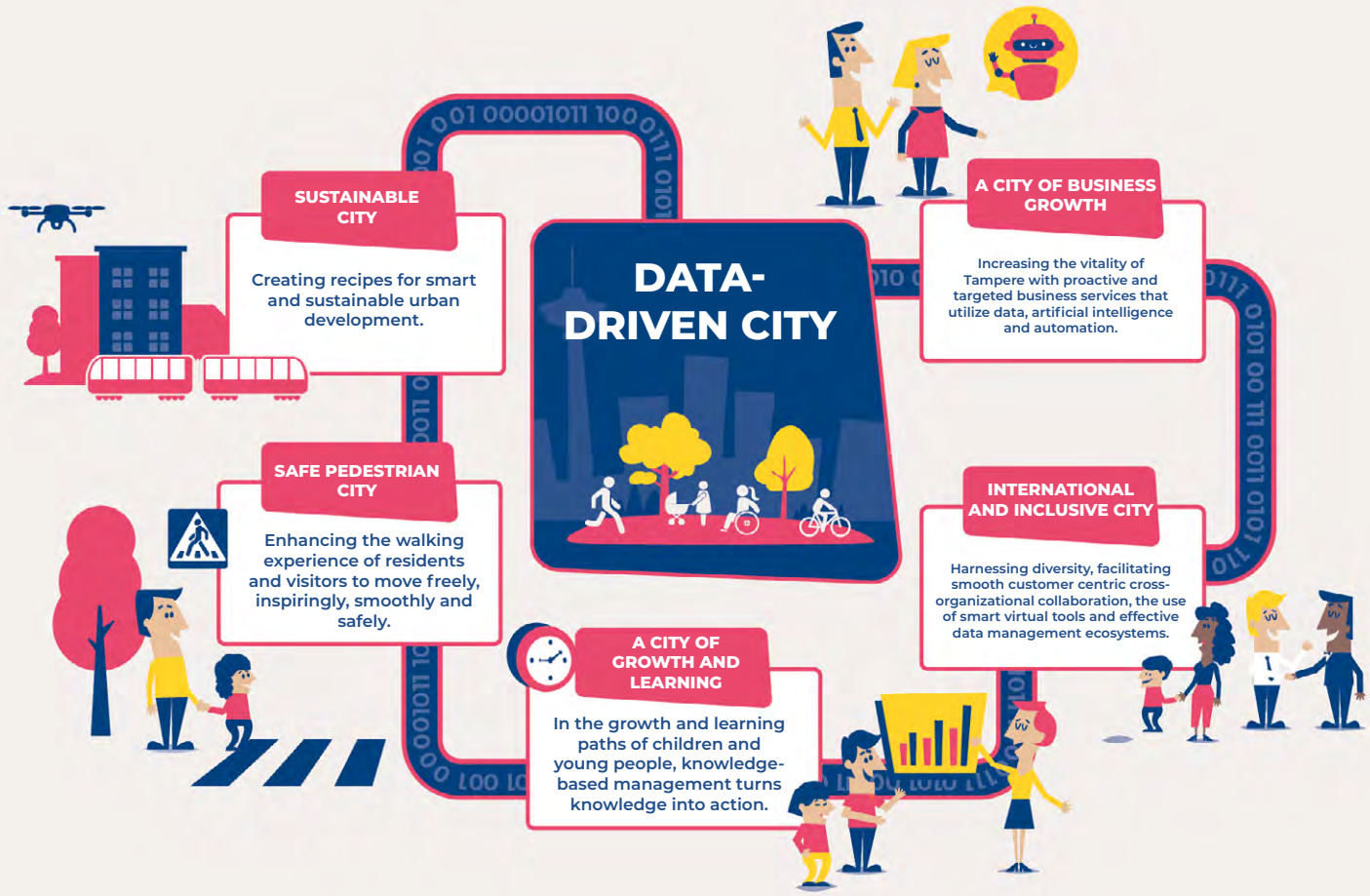
Concrete benefits included:

- Predictive traffic flow optimization
- New approaches to sustainability, energy use, and waste management
- Early XR/AR enhanced planning, enabling residents to visualize designs before construction
- Data-informed healthcare and wellbeing interventions

These applications proved that data could enhance not only governance efficiency but also the lived experience of every resident.

In the program five flagships were identified and put to practice, so at the same time as the program is developing, also bringing some of the low-hanging fruits and concrete elements of different elements of the city, and also bringing it closer to the citizens.

Our Flagships of Transformation



5 Flagships of Transformation by Data-driven City for Citizens -program

One of the early and most pragmatic pilots of Tampere's **Data Driven City for Citizens** program focused on **companies and business data,** recognizing that a city's vitality depends as much on the wellbeing of enterprises as on that of residents. In this pilot, Tampere began systematically combining and analyzing existing data on companies, their operating environment, and their interaction with city services to create a clearer, shared understanding of local business realities. The aim was twofold: to provide companies with better situational awareness to support decision making and growth, and to enable the city to **target its services, guidance, and development measures more precisely.** This work also laid the foundation for Tampere's emerging Tampere international talent **Data as a Service (DaaS)** approach, where data is treated as a shared asset that can be responsibly reused by businesses, public actors, and ecosystem partners. Rather than building isolated dashboards, the pilot demonstrated how trusted data, analytics, and collaboration could strengthen the business ecosystem, improve policy effectiveness, and support new data driven business models—marking an important step from smart city experimentation toward a truly citizen and company centric digital city.

The second flagship was focusing on bringing skilled workforce from abroad to the region and using data to analyze their needs and also targeted services. As part of the **Data Driven City for Citizens** program, Tampere launched an **international talent data pilot** to better understand, attract, and support skilled professionals from abroad as an integral part of the city's long term vitality. In this pilot, the city began systematically combining data related to international talent flows, skills, employment, education, and service use to form a more coherent picture of the needs and life situations of people moving to the region. The objective was not surveillance, but **improved user understanding:** enabling the city to design more targeted onboarding services, anticipate integration challenges, and support employers in accessing global talent. By using data and analytics to connect talent attraction, employment services, education pathways, and everyday city services, Tampere took a step toward treating international talent as full participants in the urban ecosystem rather than a separate policy silo. The pilot also contributed to Tampere's broader **Data as a Service** and ecosystem approach, demonstrating how trusted, ethically governed data can support both inclusive growth and international competitiveness—an essential capability for a city operating in a global, Citiverse ready context.

Tampere also explored a **"digital twin of the unemployed"** concept—an early step toward **human digital twins** in public services—designed to improve labour market matching and reduce the friction between skills and open jobs. In practice, the city developed a **skills inventory** approach that brings together anonymized jobseeker information, open job vacancy data, and education offering data, and can be complemented by **MyData** that individuals explicitly authorize. Built around predictive AI text analytics, the aim is to create a clearer, more timely picture of workforce capabilities and demand: helping jobseekers identify suitable opportunities, enabling employers to find qualified candidates, and giving the city a more proactive view of labour market needs. The work has progressed through piloting stages, including early testing with synthetic jobseeker data and later collaboration with national employment actors, with a continuing emphasis on privacy, security, and user centred design.

Data Driven City for Citizens

DIGITAL TWIN OF SKILL INVENTORY

INPUTS
(raw data sources)

Anonymous jobseeker data
from a government database

Education offering data
from education institutions

Open Jobs data
from the industry

Jobseekers' My-data
that they have authorizised

AI ANALYSIS

HEADAI
Language model based on unique predictive text analytics

The innovation process is build around predictive AI text analytics

OUTPUTS

Region level skills inventory
visualisation and analysis for the government/city

Jobs and training recommendations
for the job seeker

Direct candidates
for the industry

Knowledge for needed trainings and courses
for the education institutions

Third flagship focused on youth and schools, to use data to better understand the situation and needs for especially those who are in a vulnerable and challenging situation.

A city's capacity to grow is inseparable from its capacity to learn. In the **Data Driven City for Citizens** phase, Tampere made this relationship explicit by treating data not merely as an efficiency tool, but as a **strategic enabler of economic growth, skills development, and continuous learning.** Growth was no longer understood only in terms of GDP or investments, but as the city's ability to strengthen capabilities—of people, companies, institutions, and ecosystems—over time.

Earlier smart city initiatives had focused primarily on optimizing services and infrastructure. In the Data Driven City for Citizens program, Tampere took a further step: it began to design **learning systems,** where data continuously feeds back into decision making, service design, and ecosystem development.

The City of Growth and Learning perspective was equally visible in Tampere's focus on **youth and schools.** Data was used to better understand the situations of young people, especially those in vulnerable or challenging circumstances, with the goal of enabling earlier and more targeted support.

Rather than ranking or controlling schools, the emphasis was on **insight based intervention**—learning where structural challenges existed and how educational, social, and wellbeing services could work together more effectively. This approach reinforced the idea that long term urban growth is built on inclusive learning outcomes and equal opportunities from an early age.

Across all these domains, a unifying element was Tampere's continued commitment to **ecosystem based development.** Companies, universities, research institutions, and public actors were not merely service users, but co learners in shared platforms and pilots.

The city acted as an orchestrator of learning: enabling experimentation, lowering barriers to collaboration, and ensuring that insights generated in one domain could inform others. In this sense, the Data Driven City for Citizens program transformed Tampere into a **collective learning environment,** where growth emerged from accumulated knowledge rather than isolated successes.

Fourth flagship builded around a very successful EU-project SURE on AI-driven analysis of video and sensor feed in connection with big events, tested in the ice-hockey world championship games in 2022 Tampere, and continued to look at different AI and AR applications for the city center environment.

In a Data Driven City for Citizens, safety is not treated as a separate technical domain or a reactive function—it is a **foundational condition for everyday wellbeing, inclusion, and trust.** For Tampere, the concept of a **Safe Pedestrian City** emerged as one of the most tangible and citizen visible applications of data driven urban development.The focus was simple but ambitious: how can data, digital infrastructure, and intelligent systems make moving through the city safer—especially for pedestrians—without turning the city into a controlled or surveilled environment?

Traditionally, pedestrian safety has been addressed through physical measures: crossings, traffic lights, signage, and speed limits. While essential, these measures alone cannot respond dynamically to changing urban conditions such as weather, crowd density, events, or unexpected disruptions.

In the Data Driven City for Citizens program, Tampere expanded the definition of safety to include **experiential safety**—how safe people actually feel when moving through the city, at different times and in different situations. Data became the key enabler for understanding and improving this experience.

The Safe Pedestrian City approach was built on Tampere's citywide data infrastructure:

- **IoT sensors** producing real time information on traffic flows, pedestrian movements, and environmental conditions
- **Smart lighting** acting both as physical infrastructure and as a digital backbone
- **Data platforms** enabling interoperability across traffic, lighting, maintenance, and safety systems
- **Analytics and AI** supporting situational awareness and predictive insight

By combining these elements, the city could move from static safety measures toward **adaptive, context aware safety management.**

One of the most concrete manifestations of a Safe Pedestrian City was the use of **smart lighting.** Streetlights were no longer passive infrastructure but became active elements of the safety ecosystem.

Smart lighting enabled:

- Improved visibility in pedestrian heavy areas
- Dynamic adjustment based on time of day, weather, or crowd situations
- Integration with sensor data to support guidance and safety in both everyday conditions and special events

This approach enhanced safety while remaining discreet and human centric—supporting people without demanding their attention or altering their natural behavior.

Tampere's experience with large public events, particularly in the city centre and around major venues, highlighted the importance of pedestrian safety as a **systemic capability.** Data driven situational awareness made it possible to understand pedestrian flows, anticipate congestion points, and support safer movement without relying solely on physical barriers or manual control.

Crucially, the same systems used during major events also improved **everyday pedestrian safety**—for commuters, families, elderly residents, and visitors. This dual use principle ensured that investments served daily life, not only exceptional situations.

A defining feature of Tampere's Safe Pedestrian City approach was its strong emphasis on **ethical data use.** Safety solutions were designed to:

- Avoid unnecessary personal identification
- Rely on aggregated and anonymized data where possible
- Support transparency and public trust
- Complement, not replace, human judgment

Pedestrian safety was framed as a **public good,** not a justification for intrusive surveillance. This alignment with the broader principles of the Data Driven City for Citizens ensured that safety enhancements strengthened trust rather than undermined it.

Beyond immediate safety improvements, pedestrian related data became a **learning resource** for the city. By analyzing movement patterns and safety related indicators over time, Tampere could:

- Identify locations requiring redesign or improved accessibility
- Support safer routes for walking and active mobility
- Inform urban planning and street design decisions
- Strengthen the city's long term transition toward sustainable mobility

In this way, the Safe Pedestrian City contributed not only to safety outcomes but also to **urban learning and continuous improvement.**

As one of the five flagships of the Data Driven City for Citizens program, the Safe Pedestrian City demonstrated how data can be translated into **immediately visible benefits for citizens.** It showed that data driven development does not have to start with abstract dashboards or distant policy goals—it can begin with the simple act of walking safely through one's city.

This flagship also illustrated a broader lesson that carried forward into Citiverse thinking: *the most advanced digital cities are not those that showcase technology, but those that quietly make everyday life safer, easier, and more humane.*

One of the best examples of combining the data from different sources is a solution called "Tampere Pulse". As Tampere progressed in its Data Driven City for Citizens program, it became increasingly clear that the challenge was no longer the availability of data, but the city's ability to understand what that data meant in practice. Information was being produced continuously across mobility systems, events, public services, infrastructure, and the urban environment, yet these signals often remained fragmented. Tampere Pulse emerged as one of the most concrete responses to this challenge, representing a practical way to combine data from different sources into a shared situational understanding of the city.

The core idea behind Tampere Pulse was not to create another standalone system or analytical tool, but to improve the city's ability to sense and interpret what was happening in everyday urban life. In a Data Driven City for Citizens, value does not come from individual datasets viewed in isolation, but from their combination and contextual interpretation. Tampere Pulse embodied

this principle by focusing on how different data streams relate to one another and to real situations experienced by people moving through the city.

Rather than emphasizing automation or control, Tampere Pulse supported awareness. By bringing together signals from multiple urban domains, the city could develop a clearer picture of changing conditions without requiring citizens to actively interact with digital systems. This approach aligned with Tampere's broader human centric philosophy, where technology operates largely in the background and supports better decisions rather than drawing attention to itself.

The relevance of Tampere Pulse became particularly visible in areas where situational awareness is essential, such as pedestrian safety, the use of public space, and large events. By combining information from different systems, the city could better understand how crowd movements, environmental conditions, infrastructure use, and timing influenced one another. This made Tampere Pulse a natural complement to initiatives such as the Safe Pedestrian City, where safety depends not only on static infrastructure but on the ability to recognize and respond to changing circumstances. The same logic applied both to exceptional situations and to everyday urban life, ensuring that investments supported daily wellbeing as well as peak moments.

A defining characteristic of Tampere Pulse was that it did not attempt to replace human judgment. Instead, it functioned as a learning mechanism for the city organization. By observing how combined data reflected real world situations, city professionals could improve their understanding of patterns, interactions, and emerging issues over time. This supported more informed planning, better alignment between services and lived reality, and a gradual strengthening of the city's institutional learning capacity.

Within the Data Driven City for Citizens program, Tampere Pulse illustrated a broader lesson: the most significant value of data emerges at its intersections. While individual systems and platforms remain necessary, the real transformation occurs when their outputs are connected and interpreted together. Tampere Pulse demonstrated how a city can move beyond siloed analytics toward a more holistic understanding of urban dynamics, while remaining aligned with ethical principles and public trust.

Looking ahead, Tampere Pulse can also be seen as an early conceptual step toward Citiverse thinking. The Citiverse relies on interconnected representations of urban life, where meaning is created through relationships between systems, people, and environments. By focusing on combination, context, and situational understanding, Tampere Pulse anticipated this shift. It showed that the path toward more immersive and intelligent urban futures does not begin with virtual worlds, but with the city's ability to understand its own reality more clearly.

Tampere Pulse was never intended to be a visible service for citizens in its own right. Its strength lay in its subtlety. By quietly improving how the city understands itself, it enabled services, environments, and decisions to work better without demanding attention. In this sense, Tampere Pulse captured the essence of the Data Driven City for Citizens: technology in the background, insight at the forefront, and people at the center. The next iterations on Tampere pulse are also being prepared.

The fifth flagship geared towards digital twins and their use looking at both built and non-built environment. As Tampere's development progressed from a Smart City toward a Data Driven City for Citizens, digital twins gradually emerged as a unifying way to connect data, space, and decision making. Rather than being introduced as a single technology project, digital twins evolved organically from earlier investments in data platforms, IoT infrastructure, and urban modeling. In Tampere's context, digital twins were understood not as static 3D models, but as **living representations of the city,** capable of reflecting both the built environment and the dynamics of urban life.

In the Data Driven City for Citizens program, digital twins became a practical tool for improving understanding before action. As real time data from sensors, infrastructure, and city systems was increasingly available, the need arose to anchor this data spatially and contextually. Digital twins provided this anchor. By mirroring physical environments digitally, the city could observe how data related to streets, buildings, transport systems, public spaces, and services, and how changes in one part of the city affected others.

A key characteristic of Tampere's approach was that digital twins were not developed for visualization alone. While early use cases included 3D city models and planning visualizations, the more significant value came from linking these models with live and historical data. This enabled the city to move from descriptive representations toward **insight based analysis,** supporting better understanding of traffic flows, pedestrian safety, energy use, and the functioning of public space. Digital twins thus became part of the city's learning infrastructure, helping professionals explore "what is happening" and "what might happen" before decisions were implemented in the physical world.

Digital twins also played an important role in participatory urban development. By allowing residents and stakeholders to see and experience planned changes in a spatially accurate digital environment, Tampere could support more inclusive and informed dialogue. In this way, digital twins strengthened transparency and trust, making complex plans easier to understand and discuss. This aligned closely with the principles of the Data Driven City for Citizens, where improved user understanding and citizen experience were explicit goals.

As Tampere advanced, the scope of digital twins expanded beyond the built environment. The city began to explore how data related to people, movement, and services could be reflected in digital representations while respecting ethical boundaries. Early experiments, such as skills based models in employment services and aggregated views of pedestrian movement, hinted at the possibility of **human centric digital twins**—not as individual profiles, but as anonymized, consent based representations of patterns and needs. These explorations reinforced the idea that digital twins should support wellbeing and learning, not control or surveillance.

Digital twins also became closely connected to Tampere's safety and resilience work. In initiatives such as Safe Pedestrian City and the SURE program, digital representations of urban environments helped combine data from multiple sources into a coherent situational picture. By understanding how people move through spaces, how events affect flows, and how infrastructure responds under different conditions, the city could improve preparedness and everyday

safety. Here, digital twins functioned as a bridge between real time situational awareness and longer term urban learning.

Throughout this development, Tampere maintained a strong emphasis on openness, interoperability, and ethical governance. Digital twins were built on shared data platforms and open interfaces, enabling collaboration with companies, universities, and research institutions. This ecosystem approach ensured that digital twins were not isolated city assets, but part of a broader innovation and learning environment. It also reinforced the principle that the value of digital twins lies in their connections—to data, to people, and to decision making processes.

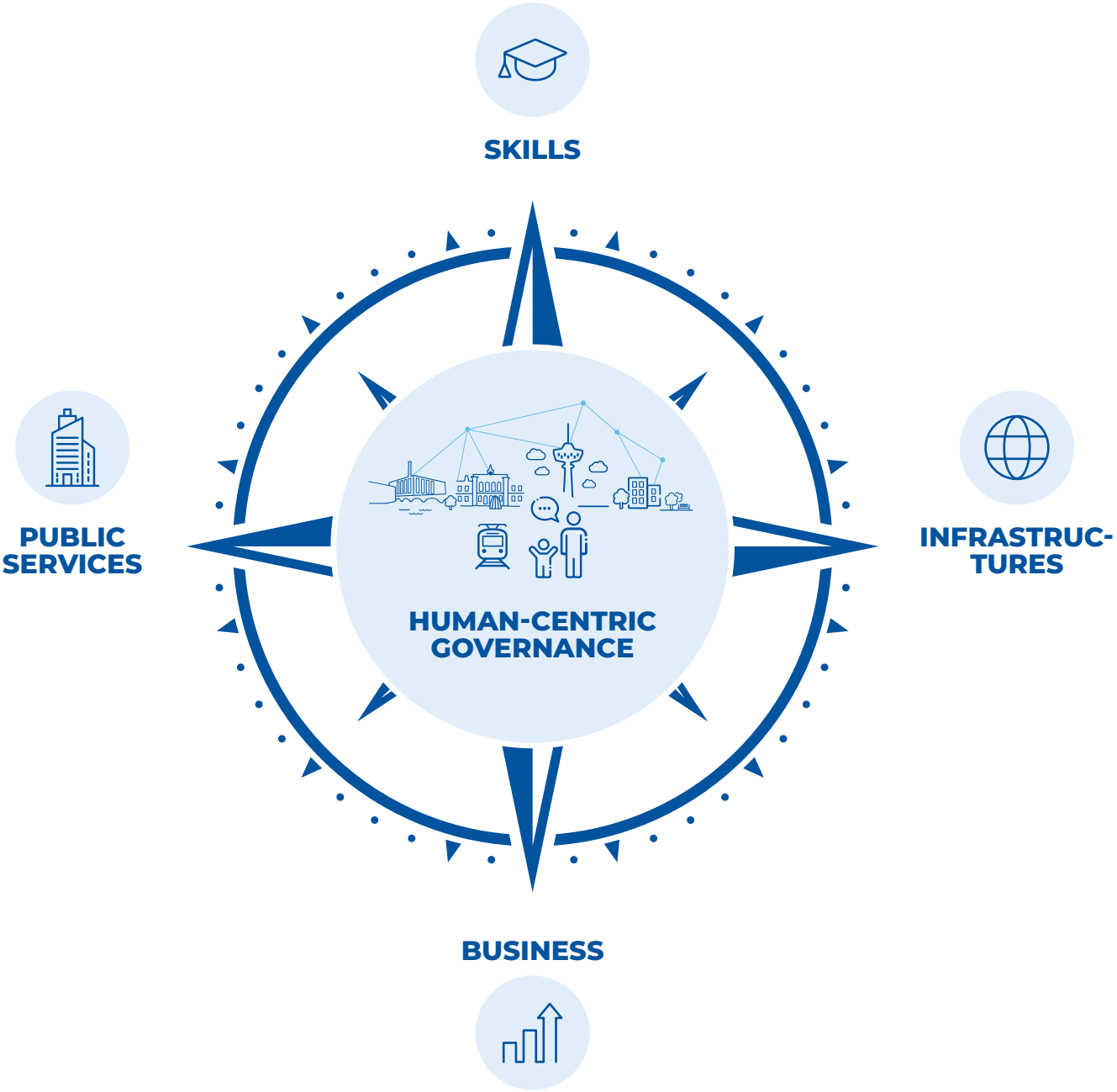
Looking toward the future, digital twins form a central building block in Tampere's transition toward the Citiverse. In this emerging paradigm, multiple digital twins—of infrastructure, services, environments, and systems—interconnect to create a more holistic representation of urban life. Tampere's experience shows that such a future is not achieved by leapfrogging directly into immersive virtual worlds, but by patiently building the capability to understand the city through data, space, and context.

In Tampere, digital twins ultimately became a means to an end rather than an end in themselves. Their purpose was to help the city learn, anticipate, and design better outcomes for citizens. By embedding digital twins into everyday planning, safety, and service development, Tampere demonstrated how this technology can quietly strengthen decision making while keeping people, trust, and lived experience at the center of urban transformation.

Tampere also took inspiration and was one of the first cities to look through the lense of EU´s digital compass. All the local goals were defined so that the Digital Compass elements were recognized and adjusted locally.

Data Driven City for Citizens

DIGITAL COMPASS: CITY OF TAMPERE



The **Data Driven City for Citizens** program in Tampere was indeed designed and implemented at a time when the European Union was defining a common direction for Europe's digital transformation through the **EU Digital Compass.** Rather than treating the Compass as an external policy framework to be reported against, Tampere used it as a **strategic lens** through which local goals, priorities, and actions were interpreted and translated into concrete urban development.

At its core, the EU Digital Compass defines Europe's digital future around four dimensions: skills, infrastructures, business, and public services. The Data Driven City for Citizens program addressed each of these dimensions not through isolated projects, but through an integrated, city wide approach in which data, learning, and human centric governance were central.

From a **skills and human capital** perspective, the program emphasized that digital transformation must begin with understanding people. Tampere used data to improve insight into citizen wellbeing, youth situations, skills development, and labour market dynamics. Initiatives such as skills based employment services, international talent data pilots, and youth focused data use reflected the Compass objective of strengthening digital and professional skills across society. Importantly, Tampere framed skills not only as technical capabilities, but as part of lifelong learning and inclusion, ensuring that digital development supports participation rather than deepening divides.

In terms of **digital infrastructure,** the Data Driven City for Citizens program built directly on Tampere's long term investments in connectivity, IoT platforms, data platforms, and digital twins. These infrastructures correspond closely to the Digital Compass ambition of secure, high performance, and interoperable digital foundations. Tampere's approach was distinctive in that infrastructure was never treated as an end in itself. Connectivity, sensors, and platforms were developed to enable insight based decision making, real time situational awareness, and learning across domains such as mobility, safety, energy, and urban planning. This ensured that infrastructure investments translated into real societal value.

The **business and innovation** dimension of the EU Digital Compass was addressed through Tampere's strong ecosystem model. The Data Driven City for Citizens program continued the city's role as a platform for companies, startups, universities, and research institutions to develop and test new data driven solutions. By treating data as a shared asset and advancing Data as a Service thinking, Tampere supported the creation of new business models, improved competitiveness, and innovation driven by real urban needs. In this way, the city aligned with the Compass goal of increasing the uptake of digital technologies by businesses, while grounding innovation in ethical and human centric principles.

With respect to **digital public services,** the Data Driven City for Citizens program closely reflected the Digital Compass vision of citizen centric, accessible, and trusted digital government. Tampere focused on improving user understanding and experience through data rather than simply digitizing existing processes. Services were designed to become more proactive, targeted, and adaptive, whether in employment services, safety, mobility, or urban planning. Ethical data use, transparency, consent based models, and avoidance of unnecessary personal identification

were treated as foundational requirements. In this way, Tampere addressed the Compass ambition for trustworthy digital public services while strengthening public trust.

Across all these dimensions, the most important alignment between the Data Driven City for Citizens program and the EU Digital Compass lay in the **governance model.** Tampere did not pursue digitalization as a technology agenda, but as a learning process. Data was used to help the city understand itself better, to adapt policies and services over time, and to balance innovation with rights, inclusion, and sustainability. This learning oriented approach mirrors the broader intent of the Digital Compass: to ensure that Europe's digital transition strengthens democracy, wellbeing, and resilience.

By translating the EU Digital Compass into locally meaningful goals and practices, Tampere demonstrated how European level digital policy can become actionable at city level. The Data Driven City for Citizens program showed that alignment with the Compass does not require rigid compliance structures, but rather the ability to interpret shared principles through local context, experimentation, and continuous learning. In this sense, Tampere's data driven development can be seen not only as compliance with the EU Digital Compass, but as a **living example of how its objectives can be realized in everyday urban life.**

1.4. Toward the Metaverse City

The Arrival of the Metaverse Moment

As immersive technologies began to mature in the early 2020s, Tampere recognized that the metaverse debate was rapidly shifting from speculative futures toward concrete applications in industry, cities, and public services. Rather than reacting to external hype, the city chose at the end of 2022 to start a proactive approach and developed the **Tampere Metaverse Vision 2040** as a strategic framework to explore how hybrid physical digital environments could support long term urban development. This work was done together with London-based Metaverse Institute.

The vision was initiated during the Data Driven City for Citizens program and developed through a series of expert workshops involving international metaverse specialists. From the outset, Tampere positioned the metaverse not as a parallel virtual world, but as an **extension of everyday urban life,** where digital and physical layers coexist and reinforce one another. The central question was not technological capability, but purpose: how immersive technologies could improve wellbeing, participation, resilience, and sustainability.

At the core of the vision was a strong commitment to **human centricity.** Tampere emphasized that immersive technologies must serve people rather than distract from real life or deepen digital divides. Ethical considerations, inclusion, accessibility, and trust were treated as foundational design principles rather than afterthoughts. The vision explicitly rejected technology first thinking in favor of outcome oriented development focused on citizens' lived experiences.

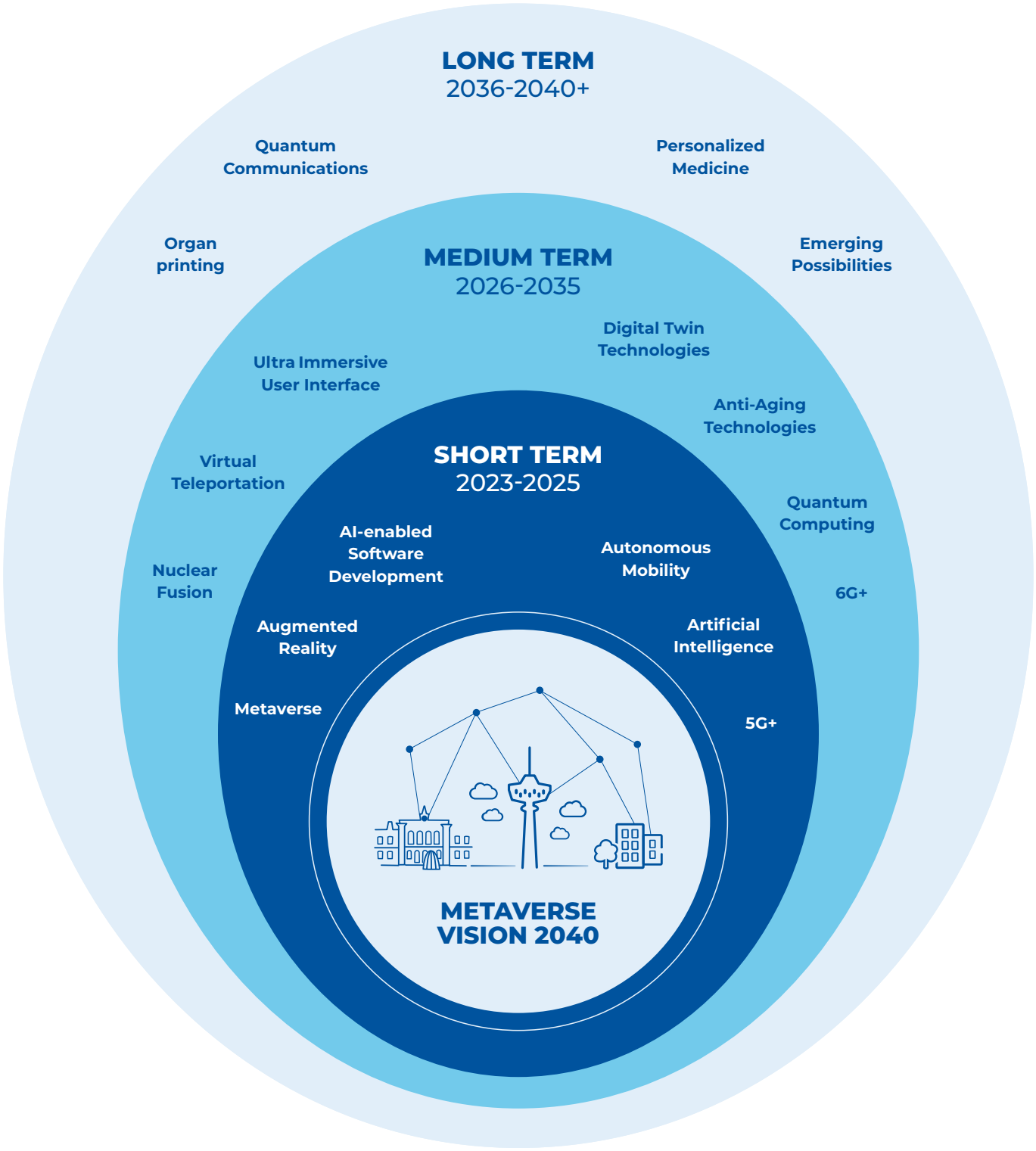
Conceptually, the Tampere Metaverse Vision introduced the idea of a **cognitive city,** where multiple digital layers interact intelligently. Digital twins provide spatial anchors for understanding the city, while AI supports orchestration, learning, and ethical governance. XR technologies enable new forms of engagement, participation, and cultural expression, and trusted data systems connect these layers into a coherent whole. In this framework, the metaverse is not a destination but a **capability** that allows cities to sense, simulate, and design better futures.

Cognitive city framework

The vision also outlined a long term technology trajectory, acknowledging that immersive user interfaces, advanced digital twins, AI enabled software development, and next generation connectivity would evolve over decades. Tampere treated this roadmap not as a prediction, but as a **directional guide** to ensure that investments made today would remain compatible with more advanced urban digital environments in the future.

Data Driven City for Citizens

TAMPERE METAVERSE VISION 2040



Crucially, Tampere grounded the vision in practice. Through EU funded projects and city level pilots, immersive technologies were tested in cultural institutions, public spaces, event environments, and participatory planning processes. These experiments demonstrated that metaverse related technologies could strengthen inclusion, creativity, and democratic participation when applied thoughtfully and ethically.

In the Tampere Metaverse Vision, the metaverse was never presented as an isolated goal. Instead, it was framed as a **transitional stage** toward the broader concept of the Citiverse—an interconnected, ethical, and human centric digital urban ecosystem shared across cities. The vision concluded that the true value of immersive technologies lies not in virtuality itself, but in their ability to help cities understand themselves better and design more humane, resilient, and sustainable ways of living.

In this sense, the Tampere Metaverse Vision 2040 served as both a strategic compass and a learning framework, bridging the Data Driven City for Citizens with the emerging Citiverse paradigm and ensuring that Tampere's digital future remains firmly rooted in human values.

The vision emphasized:

- **Human centricity** — Technology must serve wellbeing, equality, and inclusion
- **Ethical digital futures** — Governance frameworks must ensure safety and responsibility
- **Hybrid city experiences** — Digital and physical layers should coexist seamlessly

The key question became: *How can immersive technologies help build a more resilient, participatory, and sustainable city?*

Metaverse infrastructure in Tampere developed across several layers:

- **AI** as the orchestrator of services and ethics
- **Digital twins** as spatial anchors
- **XR** as a medium for engagement
- **Trusted data systems** as connective tissue between all layers
- **Connectivity**

Together, they created an environment where real-time digital overlays could enrich governance, culture, and community life. The conclusion in the vision was that it is not about technology, but finding the deeper goals of citizen's wellbeing and happiness. Key elements of the strategy were happiness, equality, governance, health and wellbeing and sustainability. So nothing about technology!

1.5 The Emergence of the Citiverse

At the same time Tampere was taking first steps towards Metaverse, EU was defining the digital future of the cities, and launched 15. June 2023 as part of the Digital Decade Program new

instrument European Digital Infrastructure Consortium (EDIC) on Local Digital Twins & Citiverse. At the same time EU launched call for proposal on Citiverse, where Tampere took the lead in a consortium where Rotterdam, Flanders, IMEC and Nokia were key partners. The program was named X-Cite, and it focused on digital twins.

EU also created a definition of CitiVerse as a new kind of digital space where European cities connect, collaborate, and co-create solutions for real-world challenges. It's where cities use shared digital tools and data to work smarter, plan better, and involve their citizens more directly in shaping urban life. At the heart of the CitiVerse are technologies like digital twins — real-time virtual models of cities that allow citizens, planners, and policymakers to simulate changes, test ideas, and make informed decisions together. Whether it's improving traffic flow, redesigning public spaces, or responding to climate risks, the CitiVerse helps cities act faster, more transparently, and more effectively.

This also helped Tampere to define the goals for the metaverse in the city, and call it Citiverse. For Tampere it represents an interconnected virtual physical urban ecosystem centered on human needs. It is more expansive than the metaverse:

- It integrates governance
- Embeds ethical frameworks
- Supports economic, cultural, and social life
- Connects multiple cities into shared digital environments

Tampere became one of the leading European cities shaping the Citiverse through participation in EU level development efforts, contribution to normative frameworks via the ITU Global Initiative on Virtual Worlds and AI and leadership in the x CITE and other CitiVerse European projects

What does the architecture of Citiverse look like in Tampere. The building blocks include:

- **Multi-layered digital twins**
- **XR/AR integrated public spaces**
- **AI powered ethical governance**
- **Participatory digital environments**
- **Secure and transparent data marketplaces**

In Tampere, digital twins have been developed and used not as a single technical solution, but as a **multi layered capability** that connects physical space, data, services, and human activity into a coherent understanding of the city. This approach has evolved gradually through the Smart City and Data Driven City for Citizens programs and now forms a central foundation for Tampere's transition toward the Citiverse.

At the most fundamental level, Tampere's digital twins are anchored in the **built environment.** High quality 3D city models and spatial datasets provide an accurate digital representation of streets, buildings, infrastructure, and public spaces. These models create a shared spatial reference that allows data from different systems to be understood in context. Rather than serving

only planning or visualization purposes, this physical layer enables the city to connect abstract data to concrete places, making urban phenomena easier to interpret and discuss.

On top of this physical layer, Tampere has added **infrastructure and system level digital twins.** Real time and historical data from mobility systems, street lighting, energy networks, environmental sensors, and maintenance systems are linked to spatial models. This allows the city to observe how infrastructure behaves over time and under different conditions. Traffic flows, pedestrian movements, energy consumption, and environmental factors can be examined not as isolated metrics, but as interacting elements within a living urban system. This layered approach has been particularly important for safety, resilience, and sustainable mobility, where understanding interactions matters more than optimizing individual components.

A further layer focuses on **urban dynamics and situational understanding.** By combining data from multiple domains, Tampere uses digital twins to interpret what is happening in the city at specific moments. Crowd movements during events, changing conditions in the city centre, or the interaction between weather, lighting, and pedestrian safety can be explored through a shared digital representation. In this sense, digital twins act as a bridge between real time situational awareness and longer term urban learning, supporting both everyday operations and strategic planning.

Beyond infrastructure and space, Tampere has also explored **human centric layers of digital twins.** These do not represent individual people, but anonymized, aggregated, and consent based patterns related to skills, mobility, service use, and wellbeing. Early examples include skills based models in employment services and aggregated representations of pedestrian movement. The purpose of these layers is not control or profiling, but improved understanding of needs, gaps, and opportunities. This reflects Tampere's broader ethical stance: digital twins should support inclusion, learning, and better outcomes, not surveillance.

A defining feature of Tampere's multi layered digital twins is their role in **participatory urban development.** By allowing plans, scenarios, and impacts to be explored in a spatially accurate digital environment, digital twins support dialogue between the city, residents, companies, and other stakeholders. Complex changes become easier to understand, discuss, and challenge. This strengthens transparency and trust, aligning digital twin development with the principles of the Data Driven City for Citizens.

The multi layered structure also supports **continuous learning.** Digital twins in Tampere are not static representations, but evolving tools that help the city ask better questions. By observing how different layers interact over time, city professionals can learn how policies, investments, and services affect real urban life. This learning oriented use of digital twins marks a shift from predictive control toward informed anticipation and adaptive governance.

Throughout their development, Tampere's digital twins have been built with a strong emphasis on **openness, interoperability, and ethical governance.** Shared data platforms and open interfaces enable collaboration with companies, universities, and research institutions, ensuring that digital twins are part of a broader ecosystem rather than isolated city assets.

Ethical principles guide how data is combined, visualized, and used, reinforcing public trust in digital development.

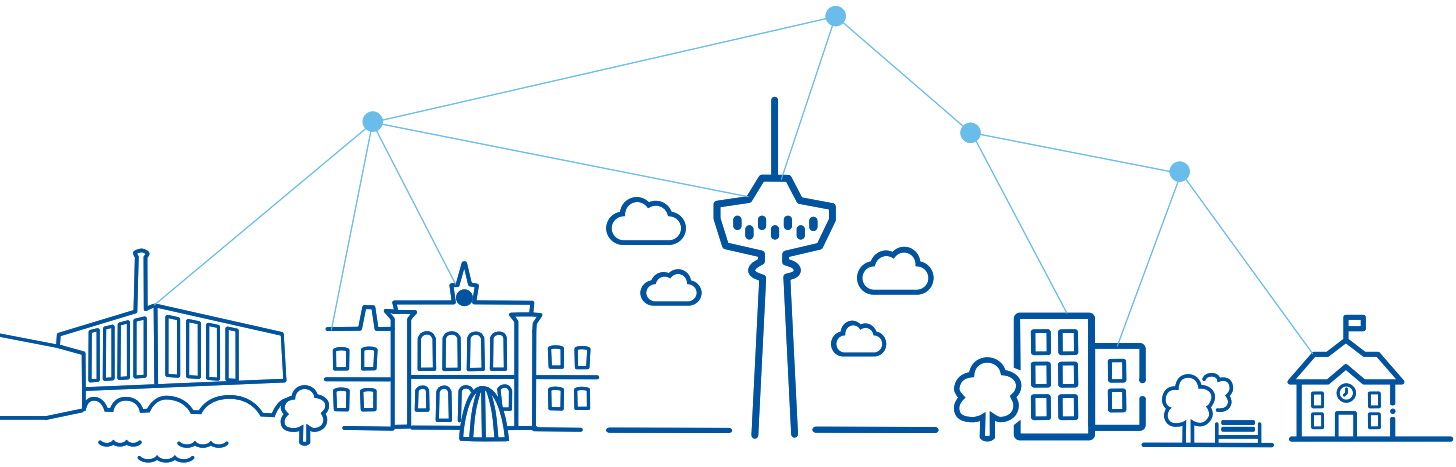
Today, multi layered digital twins form a central building block in Tampere's move toward the Citiverse. In this emerging paradigm, different digital twins—of infrastructure, services, environments, and human activity—are interconnected rather than separate. Tampere's experience demonstrates that such complexity cannot be achieved through a single leap into immersive virtual worlds, but through the patient layering of spatial, technical, and human understanding.

In Tampere, multi layered digital twins have ultimately become a means to support better decisions and better lives. By connecting physical reality, data, and human experience into a shared frame of understanding, they enable the city to learn, anticipate, and act with greater confidence—quietly strengthening governance while keeping people and trust at the center of urban transformation.

DIGITAL TWIN FOUNDATIONS

- **3D MODELS**
- **DIFFERENT TYPE OF DIGITAL TWINS**
- **DIFFERENT SOCIAL AND PHYSICAL ENVIRONMENTS**
- **EXTENDED REALITY**
- **IOT-PLATFORM**

SERVICES FOR THE DIGITAL ENVIRONMENT OF THE FUTURE



As Tampere advanced from a Data Driven City for Citizens toward a Metaverse City and ultimately the Citiverse, **XR and AR technologies were introduced deliberately into public spaces as extensions of everyday urban life,** not as isolated digital attractions. The goal was to integrate immersive technologies into the physical city in ways that enhance accessibility, participation, culture, and civic engagement, while keeping technology largely in the background. XR and AR were framed as **media for engagement,** connecting people more deeply to their surroundings rather than pulling them away from them.

In Tampere's approach, XR and AR are closely linked to **digital twins and trusted data systems,** forming one of the key infrastructure layers of the city's metaverse development. Digital twins provide the spatial and contextual foundation, while XR and AR make these digital layers visible and experiential in public spaces. This enables real time digital overlays to enrich how citizens experience streets, cultural venues, events, and planning processes, without separating digital interaction from physical presence.

Practical experiments with XR and AR in Tampere have focused on **culture, public space, and participation.** Immersive cultural experiences have been piloted in museums and exhibition environments, enabling new forms of storytelling and access to cultural heritage. In city centre environments, AR installations have been used to explore how digital content can interact with streets and public places, allowing people to experience information, art, or future scenarios in situ rather than through abstract representations. These pilots demonstrated that XR and AR can strengthen inclusion, creativity, and democratic participation when applied thoughtfully and ethically.

XR enabled public spaces have also played a role in **events and shared urban experiences.** Large venues and event environments have been used as testbeds for immersive technologies, exploring how digital layers can support collective experiences, wayfinding, and engagement during major gatherings. These experiments emphasized hybrid experiences, where physical presence remains central and digital elements enhance understanding and participation rather than compete for attention.

A defining characteristic of Tampere's XR and AR integration is its strong emphasis on **human centric and ethical design.** Immersive technologies are introduced only where they clearly serve wellbeing, accessibility, and participation. XR and AR are not treated as attention grabbing interfaces, but as subtle tools that support understanding, dialogue, and shared experience. This aligns with Tampere's broader AI and data ethics framework, which prioritizes trust, transparency, and the avoidance of unnecessary intrusion in public spaces.

XR and AR have also been used to support **participatory urban development.** By visualizing plans, changes, and alternative futures directly in their real spatial context, citizens and stakeholders can better understand and discuss complex urban transformations. This strengthens transparency and enables more meaningful dialogue between the city and its residents, reinforcing the idea that immersive technologies should empower people rather than overwhelm them.

Within the Tampere Metaverse Vision, XR and AR are not ends in themselves, but **transitional capabilities** on the path toward the Citiverse. They function as interfaces that connect people to

multi layered digital twins, data, and services in a tangible and experiential way. Through XR and AR integrated public spaces, Tampere has demonstrated how immersive technologies can be embedded into the city fabric to quietly improve understanding, participation, and quality of life.

One of the interesting features of Tampere's road to implement the Citiverse was understanding the role of data and AI better. In As artificial intelligence has become an increasingly important part of the City of Tampere's operations and public services, the city has recognized that technological capability alone is not sufficient to ensure socially sustainable outcomes. Tampere has therefore developed an **AI Ethical Guide,** grounded in a broader **AI governance model,** to ensure that artificial intelligence is used responsibly, transparently, and in a way that strengthens trust, wellbeing, and democratic values. The guide frames AI not as a standalone technology initiative, but as an integral element of good governance and public sector responsibility.

The starting point of Tampere's AI Ethical Guide is the understanding that regulation and standards, while essential, cannot on their own steer artificial intelligence toward outcomes that are socially desirable and human centric. AI development is guided internationally by both hard law and soft law, yet many ethical questions related to fairness, accountability, and societal impact require continuous ethical reflection rather than static compliance. Tampere therefore positions AI ethics as a form of governance and coordination aimed at minimizing risks, supporting the common good, and ensuring social and economic sustainability in the long term.

Human centredness and participation form the foundation of the ethical guide. Artificial intelligence is introduced only where it clearly supports people—citizens, city employees, and ecosystem partners—rather than replacing human judgment or distancing decision making from lived experience. Tampere emphasizes that people must remain at the center of AI supported services and governance, and that the impacts of AI on everyday life must be understandable and explainable. Participation and transparency are treated as essential preconditions for trust, particularly in the public sector context where legitimacy depends on openness and accountability.

The ethical guide also highlights that responsible AI use is not merely a technical issue, but an organizational one. Ethical artificial intelligence depends on leadership, organizational culture, and clearly defined processes and structures within the city. Tampere's AI governance model links ethical principles with foresight in management and decision making, ensuring that AI adoption remains aligned with the city's strategic goals and values over time. This approach embeds ethics into everyday practices rather than treating it as a separate review step.

Transparency, fairness, and trust are central pillars of Tampere's AI ethics. The city places strong emphasis on responsible data use, privacy protection, and data security as prerequisites for ethical AI. Where possible, AI solutions rely on aggregated, anonymized, and consent based data, and unnecessary personal identification is avoided. Oversight and accountability are seen as essential to ensure that AI systems remain understandable, contestable, and aligned with the public interest. In this way, ethical AI governance is directly linked to maintaining citizens' confidence in digital public services.

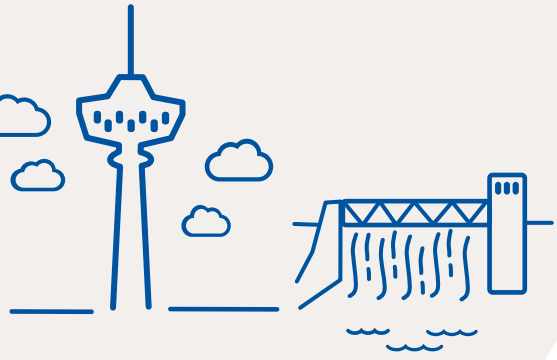
Citizen participation and skills development are also integral to the AI Ethical Guide. Tampere understands ethical AI governance as a learning process in which both the city organization and its residents develop their understanding of artificial intelligence, its opportunities, and its limitations. By strengthening competences within the city and engaging citizens and ecosystem partners, Tampere seeks to ensure that AI adoption remains inclusive and does not deepen existing digital divides. Ethical governance is therefore closely connected to education, skills, and participation rather than being limited to risk management alone.

In practice, the Tampere AI Ethical Guide supports the city's ambition to provide more proactive, automated, and data driven services while preserving public trust. Artificial intelligence is positioned as an enabler of better services, improved foresight, and more responsive governance, but always within a framework that prioritizes ethical reflection, transparency, and social responsibility. This balance between innovation and responsibility has become a defining characteristic of Tampere's data driven development.

Looking ahead, Tampere's AI Ethical Guide is not treated as a static document, but as a living framework that evolves alongside technological development, regulation, and societal expectations. It forms a foundational element of the city's transition toward the Citiverse, where AI plays a central role in orchestrating digital twins, immersive services, and data driven governance. By grounding artificial intelligence in clear ethical principles, Tampere aims to ensure that future digital urban environments remain trustworthy, inclusive, and firmly aligned with human values.

ETHICAL PRINCIPLES OF AI

01	HUMAN-CENTREDNESS AND PARTICIPATION
02	SUSTAINABILITY
03	TRANSPARENCY AND COMMUNICATION
04	EXPLAINABILITY AND JUSTICE
05	RESPONSIBILITY AND TRUST
06	PRIVACY AND DATA SECURITY
07	SAFETY AND CONTROL
08	CONTROL OF THE PEOPLE
09	PARTNERSHIPS



1.6. Developing CItiverse further

One of the key elements of developed citiverse are new way to collect, use and synthetize data Use of data needs to be well constituted in order to get the approval and usability of it. Tampere did a major development work in something called **Tampere Pulse,** published at Smart City Expo in 2023. This was the first major test to sensing the City- moving from fragmented data to urban understanding

As Tampere advanced from a Smart City toward a Data Driven City for Citizens, a new challenge emerged—one that was less visible than sensors or platforms, yet more fundamental. Data was everywhere. Urban systems continuously produced signals: mobility flows, environmental measurements, event data, infrastructure status, service usage, and safety related indicators. The city had succeeded in building digital infrastructure, but understanding the city as a living whole remained difficult.

The problem was no longer data scarcity. It was fragmentation.

Information existed in silos, interpreted through domain specific tools and dashboards. Each system offered a partial truth, yet the city itself operates through interactions: people moving through spaces, events affecting mobility, weather influencing safety, infrastructure shaping experience. Without a way to connect these signals meaningfully, insight remained limited and reactive.

Tampere Pulse emerged as a response to this moment—a shift from collecting data to sensing the city.

Tampere Pulse was never conceived as another standalone system or control platform. Its purpose was simpler, yet more ambitious: to improve the city's ability to understand what is happening in everyday urban life and provide this understanding to users in a simple easy-to-use format.

At its core, Tampere Pulse is a **situational awareness capability that combines data from multiple urban domains** into a shared, contextual view. Rather than focusing on prediction, optimization, or automation, Pulse emphasizes interpretation—helping city professionals recognize patterns, relationships, and changes as they unfold.

This distinction matters. In Tampere's approach, value does not come from replacing human judgment with algorithms, but from supporting better judgment through clearer understanding. Tampere Pulse therefore operates largely in the background. It does not demand attention from citizens, nor does it present itself as a visible digital service. Its impact is indirect, yet pervasive: decisions, services, and environments work better because the city understands itself better.

Tampere Pulse did not begin as a greenfield innovation. It grew organically from the city's long term investments made during the Smart Tampere and Data Driven City for Citizens programs.

Key foundations included:

- **A citywide IoT platform connecting sensors, lighting, and infrastructure**
- **Open, API based data platforms enabling interoperability**
- **Experience in combining data across mobility, safety, events, and urban services**

These capabilities meant that Pulse could be developed without heavy new integrations. Instead of building another system, Tampere focused on connecting what already existed, aligning data streams around real situations rather than organizational boundaries.

This approach reflected a broader principle that had guided Tampere's journey from the beginning: digital maturity is not achieved by adding layers of technology, but by orchestrating them coherently.

Tampere Pulse also served as a learning mechanism for the city. One of the most distinctive characteristics of Tampere Pulse is its role as a learning tool for the city organization.

Pulse was designed to help professionals observe how different urban signals interact over time. By combining data from multiple sources, the city could begin to see how crowd movements relate to events, weather, and infrastructure,how pedestrian safety conditions change dynamically rather than statically and how everyday patterns differ from assumptions embedded in planning models.

Importantly, Tampere Pulse does not seek to eliminate uncertainty. Instead, it makes uncertainty visible and interpretable, allowing learning to accumulate gradually. Over time, this strengthens institutional understanding, improves alignment between services and lived reality, and supports more informed anticipation rather than rigid control.

In this sense, Tampere Pulse represents a shift in governance logic: from optimizing predefined processes to learning continuously from the city itself.

The relevance of Tampere Pulse became particularly clear in areas where conditions change quickly and where understanding context matters more than precision.

Pedestrian safety, the use of public space, and large public events all share a common feature: they are shaped by interactions between people, environment, and infrastructure. Static rules and isolated systems are insufficient to manage such complexity.

By combining signals from mobility systems, smart lighting, environmental data, and event information these kind of systems enable a more nuanced understanding of these situations. The same logic applies both to exceptional moments—such as major events—and to everyday urban life. This dual use principle ensures that investments serve daily wellbeing, not only peak scenarios. Crucially, this situational awareness was developed in alignment with Tampere's ethical principles. The focus remained on aggregated and anonymized understanding rather than individual identification, reinforcing trust and humancentric governance. Pulse was not designed to monitor individuals, nor to automate decisions without accountability replaced—by data.

This approach aligns closely with Tampere's broader **AI and data governance framework, where transparency, proportionality, and public trust are treated as prerequisites** rather than constraints. By avoiding unnecessary visibility and interaction, Tampere Pulse demonstrates how advanced digital capabilities can operate quietly in the background, improving outcomes without reshaping everyday behavior.

In hindsight, Tampere Pulse can be seen as an early conceptual step toward Citiverse thinking. The Citiverse relies on interconnected representations of urban life, where meaning emerges at the intersections of systems, data, space, and human activity. Tampere Pulse anticipated this logic by showing that the most significant value of data lies not in individual datasets, but in their combination and contextual interpretation.Rather than beginning with immersive environments or virtual worlds, Tampere's path toward the Citiverse began with understanding reality more clearly. Pulse demonstrated that before cities can simulate futures, they must first learn to sense the present.

Later iterations of Tampere Pulse, presented publicly as part of Tampere's Citiverse development, build on this foundation. Yet the essence remains unchanged: technology in the background, insight at the forefront, and people at the center.

On the road to the Citiverse, Tampere Pulse represents a crucial milestone—not a destination, but a capability. A way of sensing the city that makes future digital layers meaningful, ethical, and deeply human.

Next development phases are planned to include situational awareness for the healthcare district especially for first responders and also including data from law enforcement offcials. Ideally they could start predicting crimes and even preventing crimes from happening. Just think about movie Minority Report, it is soon possible!

Venue Assistant – VIP Tampere – the latest example of ongoing development work

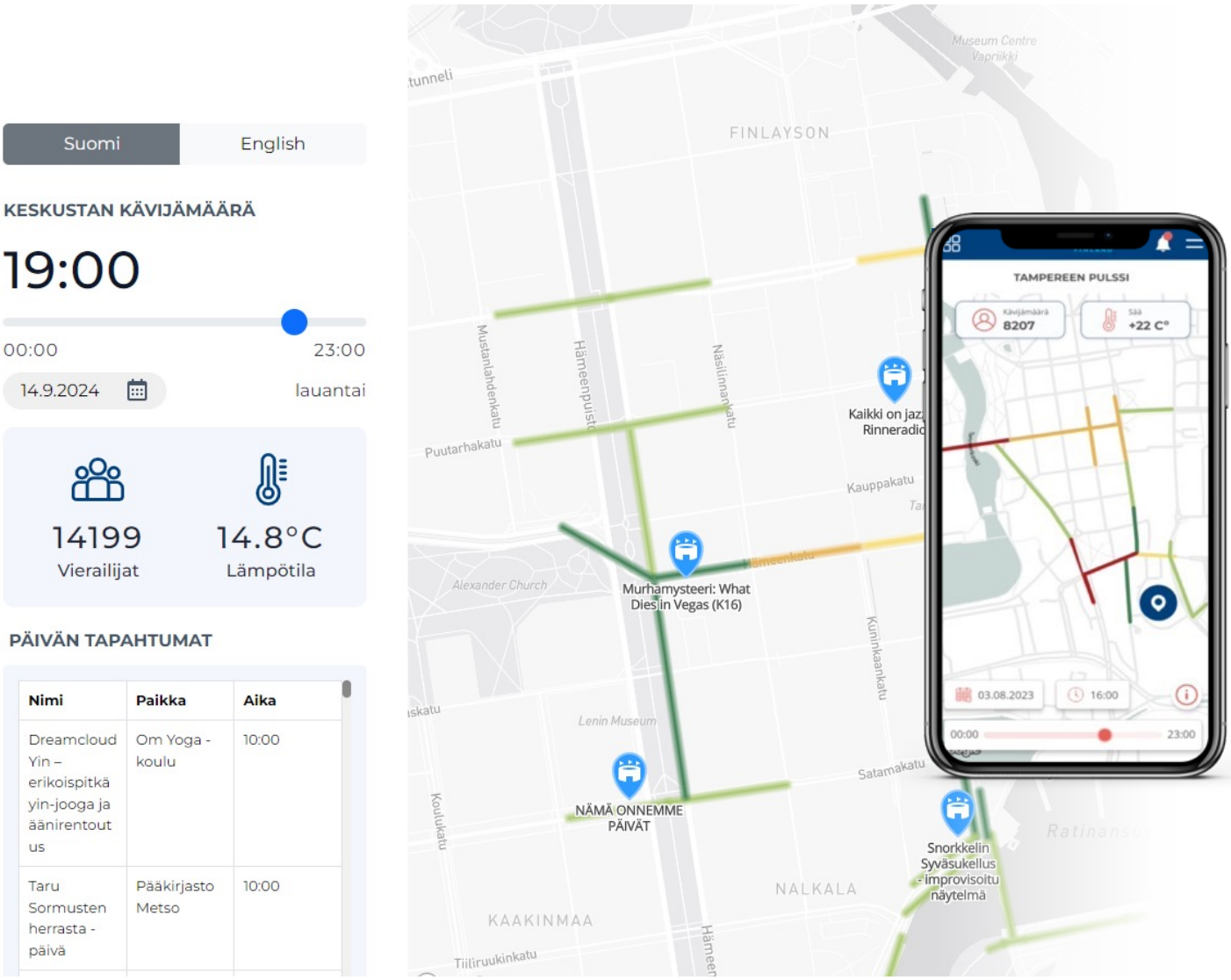
From City to Venue – A Different Starting Point

While much of Tampere's digital development has focused on understanding the city as a whole, a parallel and equally important line of innovation has emerged from venues and event environments. This work did not begin from citywide data integration, but from the practical realities of operating complex, high intensity places where thousands of people, multiple services, and time critical situations converge. This was also demonstrated earlier with SURE project and now with Venue Assistant- Tampere VIP project.

The Tampere Venue Assistant originated from development work initiated by VTT together with the Nokia Arena, responding to the unique demands of large venues rather than to the needs of the city at large. The question was not how to sense the entire city, but how to better understand, coordinate, and support what is happening inside a specific place, at a specific time, during a specific event.

Digital Services

TAMPERE PULSE



PREDICT
Visitor flows
Crowd insights

INFORM
Events
Weather
Real-time data

CONNECT
Residents
Businesses
Authorities

Nokia Arena as a Living Environment

The Nokia Arena provided an ideal environment for this exploration. As a modern, multi purpose venue hosting sports, concerts, and large public events, it represents one of the most complex operational settings in the city. Visitor flows, safety considerations, service logistics, and experience quality all intersect in ways that cannot be fully managed through static plans or isolated systems.

Rather than treating the arena solely as an event location, the development work approached it as a living environment—one where digital tools could be tested against real operational pressures. This made the arena not just a user of technology, but an active context for innovation, where ideas could be validated, refined, or discarded based on actual needs.

VTT played a central role in initiating and shaping this work. The starting point was applied research: how context aware digital assistance, use of data and immersive realities could support complex environments where conditions change rapidly and where multiple actors both hold the data and need a shared understanding of what is happening.

Crucially, this was not a technology first exercise. The development focused on situational understanding rather than automation, support for human decision making rather than replacement and practical usability in demanding, real world conditions.

By grounding the work in an operating venue, the development avoided abstract concepts and remained closely tied to everyday realities.

In this context, Venue Assistant does not refer to a generic chatbot or single application. It represents a broader assistant concept: a context aware digital capability designed initially for venues and event environments as well as guiding individuals through the city showcasing different services (restaurants, shops) as well as points of interest in the city. First version of this has been built as an app to create test-user friendly way of getting to know the concept and get feedback. The pilot was done during the major Eurovision qualification UMK 2026 in Tampere,

Its purpose is to help different actors—operators, organizers, service providers, and most importantly visitors—develop a clearer understanding of what is happening right now, how conditions are evolving and how different elements of the venue interact during an event.

Physical + Virtual Assistant

CITY VENUE ASSISTANT

Tampere.Finland app

Application for services in Tampere

IoT Ticket

Data & innovation platform to build and manage City IoT and AI applications

Tampere Pulse

Application to predict visitor flow for next month

Open Data Tampere

Venue Data Exchange and Market Portal

VENUE APPLICATION

3rd parties

Partners
of Venue Operator

Customers
of Venue Operator
- Event organizers
- Sports clubs

Local citizens

Partners
of Venue Operator
- Building service providers
- Event service providers
- Mobility service providers
- Venue food & beverage service providers

Venue end-users
Prosumers

Venue end-users
Prosumers

Customers
of Venue Operator

Local citizens

Neighborhood services
- Accommodation
- Food & beverage
- Pre- and after-event services (e.g. Spa, Health, Games, ...)
- Shops

City infrastructure
- Teleoperators
- City infra service providers
- Mobility operators

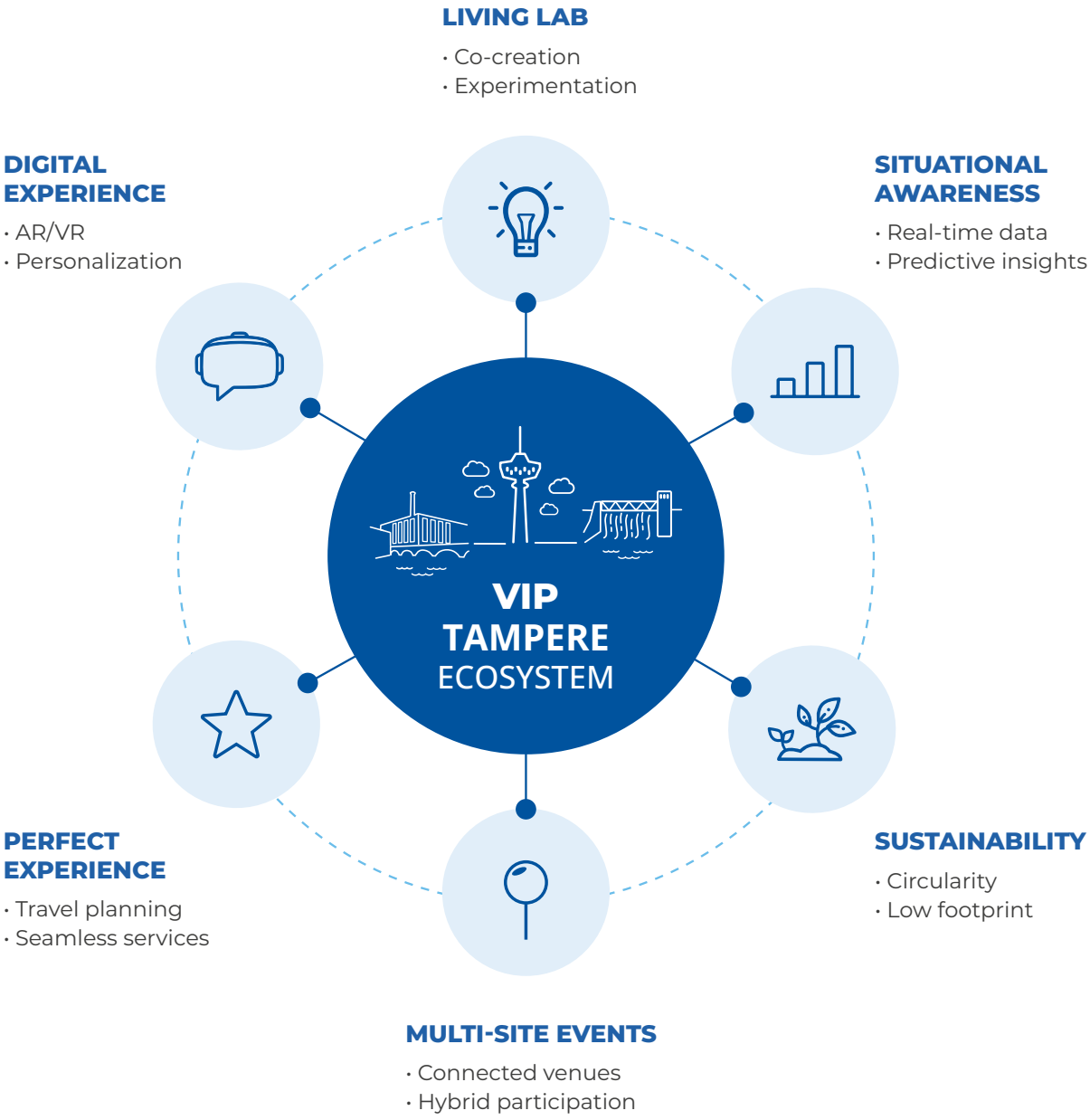
DISCOVER
- Places
- Events
- Services
- Offers

GUIDE
- Navigation
- Recommendations
- Real-time assistance
- Personalization

ENGAGE
- Live updates
- Support
- Feedback
- Participation

Living Labs and Test Platforms

VIP TAMPERE ECOSYSTEM



Early use cases identified for the VIP Tampere ecosystem

VIP Tampere — Continuation and Evolution

VIP Tampere represents the continuation and maturation of this venue based development path. While it is not defined it as a formal platform or citywide system, its placement in Tampere's narrative signals an ongoing effort to extend and apply venue specific assistant concepts beyond initial pilots.

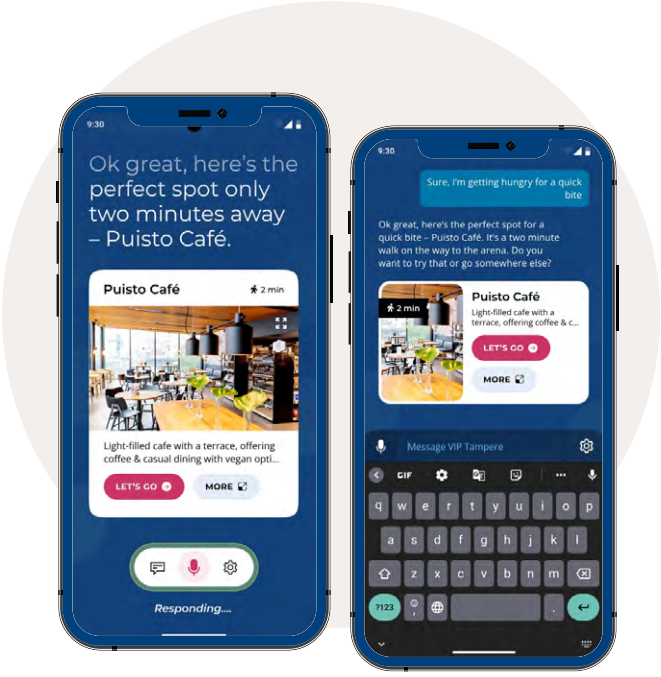
VIP Tampere illustrates how insights gained from the Nokia Arena context can inform broader applications, while still remaining **environment specific** rather than city generic. It shows how intelligent assistance can evolve incrementally—moving from one venue, one context, and one use case at a time.

Future paths of developing VIP Tampere have been painted out and one of them is to use the tool as part of our ongoing improvement aimed at international talent moving to Tampere. What if Tampere could through immersive experiences get new citizens engaged with the city in a new way, helping them to get to know the city and feel at home with the help of 3D models, digital twins, use of AI and data, but also engage with other citizens.

Physical + Virtual Assistant

TAMPERE VIP CONTENT

Your intelligent companion
for discovering the city,
getting guidance and
engaging with experiences –
both on site and from anywhere.



DISCOVER
Places
Events
Services

GUIDE
Navigation
Recommendations
Personalization

ENGAGE
Digital twins
Interactive content
Citizen participation

A Parallel Path Toward the Citiverse

Although Tampere Venue Assistant and VIP Tampere are not based on Tampere Pulse, they align with the same deeper principles that guide Tampere's journey toward the Citiverse.

Both development paths emphasize:

- **Real environments over abstract systems**
- **Incremental learning over grand designs**
- **Supportive intelligence rather than automated control**
- **Human experience and trust as guiding criteria**

In this sense, venue based assistants form a parallel layer of urban digital development. They demonstrate that the Citiverse does not emerge only from citywide platforms, but also from specific places where digital capabilities are tested, refined, and grounded in lived experience.

Conclusion — Why Venues Matter

Venues and events are moments when a city becomes highly concentrated: people, services, emotions, and infrastructure all converge in a limited space and time. Developing intelligent assistance in such contexts offers lessons that extend far beyond the venue itself.

Tampere Venue Assistant and VIP Tampere show how context aware digital intelligence can grow from practical needs, mature through real use, and contribute to a broader urban vision without losing its grounding in reality. They remind us that the road to the Citiverse is not built only at city scale, but also one place at a time.

1.7. Other programs funded by EU initiatives

One of the EU-funded initiatives connected to Tampere's Citiverse trajectory is WeGenerate, a Horizon Europe Innovation Action project focused on co-creating people-centric, sustainable neighbourhoods through urban regeneration. In the project, Tampere acts as a demonstration city with a particular focus on revitalising the city centre from residents' needs and strengthening community-centric redevelopment through new forms of participation. Tampere's demo activities emphasise the practical use of digital twins and XR in city planning and decision-making, including testing innovative solutions that support walkability and perceived safety and exploring metaverse-enabled approaches in an urban context. To make citizen experience measurable and comparable in a digital twin environment, Tampere has defined a set of criteria—accessibility, physical safety, walking attractiveness, reachability, proximity of services, and environmental quality—and is developing and evaluating walking concepts (e.g., cultural walks, school-area walks, families-with-children routes, nightlife routes, and station-area green public space) using digital-twin-based simulation, testing, and analysis together with citizens and stakeholders.

Another closely related initiative is DT aCoGo (Digital Twinning as a Common Good), a Digital Europe pilot under the European Data Space for Smart. The pilot connects Tampere with the

Dutch cities 's Hertogenbosch and Rotterdam to demonstrate how an urban data space can enable secure sharing of public and private (including non open) data "at the source", supporting interoperable digital twins and model to model integration across domains. For Tampere, the work is implemented jointly by the city's GIS unit and the Competitiveness and Innovations group, and focuses on using data spaces to feed city twinning capabilities such as predictive traffic management and sustainable mobility planning as well as data services related to weather, climate, and extreme events, with the aim of producing common operational pictures and improved multi stakeholder decision making while maintaining data governance, cybersecurity, and trust.

A third relevant EU initiative is AI4Citizens *(Supporting ethical and effective AI governance in European cities and regions)*, an Interreg Europe project, where Tampere leads the seven-partner consortium together with Helsinki, Amsterdam, Riga, Piemonte (Torino), Bacau County, and Bucharest–Ilfov Regional Development Agency. The project is built around interregional learning and exchange of good practices to help cities and regions adopt AI in the public sector in a way that is safe, ethical, transparent, and trusted. For Tampere, the key deliverable is the further development and embedding of a citywide AI governance model (covering legal, operational, skills and ethical dimensions), combined with work to strengthen AI literacy and enable open citizen dialogue so that different groups can participate in shaping AI-enabled services. In practice, AI4Citizens also supports Tampere's preparedness for the obligations and implementation questions arising from the EU AI Act, helping translate regulation into workable processes for city operations and public services.

In parallel to city-focused AI governance work, Tampere is also involved in embrAIsme (Improving conditions and policies for SMEs to embrace AI), an Interreg Europe project that aims to strengthen regional policies and support measures that help SMEs adopt artificial intelligence. The project addresses typical barriers for SMEs—such as limited awareness and data readiness, skills gaps, access to finance, lack of networks, and legal/ethical concerns—through interregional learning and the transfer of good practices into regional action plans. In the Tampere region, the project is implemented by Business Tampere and is used to further develop the regional AI strategy and the operations of the Tampere AI ecosystem, with an explicit focus on creating practical models that support AI uptake in SMEs. The Council of the Tampere Region (Pirkanmaan liitto) participates as an associated partner as the owner of the relevant policy instrument (digital compass), ensuring that lessons learned translate into policy and programme improvements.

Tampere is also involved in CitCom.ai, a Digital Europe initiative that builds a European Testing and Experimentation Facility (TEF) for AI and robotics in smart and sustainable cities and communities. The project establishes an EU-wide network of real-world test environments where AI startups and SMEs can validate solutions safely, improve maturity (incl. raising technology readiness), and receive support for compliance with emerging EU requirements (e.g., the AI Act and data-related regulation). CitCom.ai is organised around three super-nodes—POWER, MOVE, and CONNECT—and, in the Nordic node, Business Tampere contributes Tampere's city-scale testbeds and data assets, such as the Tampere IoT platform and connected environments (e.g., mobility/autonomous driving, energy systems, and event/venue contexts), enabling companies to test solutions with real infrastructure, datasets, and operational stakeholders.

The smart city development trajectory is further enriched by the digital twin of the Station Area developed within the Horizon WeGenerate project, which concretely demonstrates a cultural shift toward participatory urban planning. The digital twin functioned not merely as a visualization tool, but as a platform through which different user groups could genuinely and proactively influence the planning process. This work received international recognition when the overall solution was awarded at the Capital Mobile Awards together with the PULSE solution.

New forms of participation were also tested in real-life environments. For example, in Kirjastopuisto Park, the interactive use of urban lighting was piloted with children, young people, and vulnerable groups. These experiments highlighted how the physical and digital city can together create safer and more meaningful experiences. In addition, at the Hakametsä Sport Campus, test sessions were conducted with senior citizens to explore how future sports and wellbeing environments can better support accessibility, safety, and active ageing. These experiments highlighted how the physical and digital city can together create safer and more meaningful experiences for diverse user groups.

Digital twins were also applied in a targeted way to meet the needs of different user groups—families with children, cultural actors, nightlife users, and school students, particularly from a preparedness perspective. This approach not only enhanced participation but also proved to be an effective way to collect precise, context-specific data to support decision-making.

At the same time, initial steps have been taken in experimenting with AI-driven agency. In the Kyttälä area, AI agents have been piloted in collaboration with local businesses, and in the Station Area, an AI agent incorporating a multispecies perspective has been developed. In these experiments, the focus has been on the responsible use of data and on translating it into understandable and actionable insights to support urban development.

Within the DDCC the Livable Wellbeing City Index LWCI international alliance is being developed and tested through a growing network of global urban actors, including cities and regions such as Japan, Taiwan, South Korea, New York, Santa Monica, and Barcelona. These cities act as co-development environments, where the index is continuously tested, validated, and refined across diverse cultural and institutional contexts. In parallel, the work is connected to United Nations Multi-Country Regional (UN MCR) collaboration frameworks, which provide a broader global governance and policy alignment layer. Through this connection, DDCC insights and the Livable Wellbeing City Index can be linked to international sustainability, resilience, and urban development agendas, ensuring that locally generated data and methodologies contribute to global learning systems. This dual structure, city-led experimentation combined with UN-level coordination, enables a scalable approach where urban intelligence is not only locally relevant but also globally interoperable. It supports the translation of data-driven urban insights into policy-relevant knowledge that can inform sustainable and adaptive city development worldwide.

In addition to the international EU programmes listed above, Tampere has also prepared the AIRA project *(AI solutions for human sustainability and productivity in knowledge work)*, in which the city, together with Forum Virium Helsinki, Business Tampere, Oulu University of Applied Sciences and Kajaani University of Applied Sciences, committed to implement the Tampere subproject in

Tampere, aligning the work with the city's broader aim to adopt AI in ways that support well-being, trust, and productivity in public-sector knowledge work.

Tampere is also preparing THRIVE *(Transformative Horizons for Resilient Innovation in Virtualized Environments)*, a Horizon Europe proposal, where the project aims to move from research and prototyping to practical deployment by developing AI driven digital twin ecosystems for urban planning and digital building lifecycle (DBL) management, bringing selected solutions from TRL 5 to TRL 8. Tampere acts as the coordinator (lead partner) and uses the Asemakorttelit area as a key demonstration context to support the city's climate neutral transition, linking the work to the European Green Deal, the Cities Mission, Tampere's SUMP, and local climate targets. In addition to core digital twin and data integration work (e.g., land use, energy consumption, mobility patterns, socio economic indicators), THRIVE develops participatory, multi channel AI user interfaces for citizen engagement (incl. mobile, voice and AR tools), and pilots lifecycle-based decision tools such as carbon pricing, circular-economy analysis and life cycle cost assessment. Expected outputs include open-source toolkits, policy recommendations, and training materials to support replication across European cities. The partnership brings together city and research/innovation actors in Tampere and peer cities and organisations from Rotterdam, Łódź and the Barcelona metropolitan area with supporting research and SME partners.

Building on this foundation, the next evolution is represented by THRIVE 2.0, a collaborative initiative involving New York, Columbia University, and the city of Trento. The focus of THRIVE 2.0 is on urban adaptivity—how cities continuously adjust and evolve their operations, systems, and decision-making in response to changing conditions. At the core of this development is the concept of the adaptive city index, which seeks to make urban adaptability measurable and comparable across contexts. It reflects a shift from static planning toward dynamic, responsive urban systems that can learn and reconfigure themselves over time.

1.8. Resilience is becoming key element in Citiverse

Resilience, especially in current era, has become even more important part of Citiverse. From a city perspective, resilience is not a single capability but a portfolio of strengths that help the urban system absorb shocks, adapt, and continue to provide everyday wellbeing. It includes **infrastructure resilience** (energy, mobility, water, and the reliability of public spaces), **social resilience** (inclusion, trust, community networks, and support for vulnerable groups), **economic resilience** (diverse local economy, talent attraction, and the ability of businesses to recover), and **environmental and climate resilience** (heat, flooding, biodiversity, and the capacity to transition toward low carbon living). Increasingly, cities must also build **digital and cyber resilience**, because data platforms, AI, and connected infrastructure have become critical dependencies. Finally, none of these dimensions work without **governance resilience:** clear roles, cross sector collaboration, preparedness routines, and the ability to learn from weak signals. In a Citiverse context, resilience can be strengthened by combining situational awareness, digital twins, and ethical data governance to understand changing conditions early, test interventions safely, and coordinate action transparently across city actors.

Building on this evolving framework of urban intelligence and adaptive capacity, Tampere has decided to be part of the **Cross City Resilience Program,** which introduces a concrete implementation layer for shared innovation between cities. The program connects Valencia, Tampere, Rotterdam, and Lviv in a collaborative effort to build a safer and more resilient urban future through technology, collaboration, and knowledge exchange.

1.9. Citiverse being integral part of international collaboration

Tampere's smart city journey has been shaped not only by local experimentation, but also by sustained international collaboration where the city both learns from others and contributes its own practices to shared frameworks. From early ecosystem work in Smart Tampere, the city has actively positioned its testbeds—such as Hiedanranta, the tram living lab, the Nokia Arena and the citywide IoT platform—as open environments for partners from academia, startups, and global companies to pilot solutions that can be scaled beyond Finland. In recent years, Tampere's role has expanded into the emerging Citiverse agenda through EU- and UN-level cooperation: the city has contributed to global guidance work in the **ITU Global Initiative on Virtual Worlds and AI – Discovering the Citiverse,** advanced common digital development thinking in **U4SSC,** and engaged with the EU's **LDT CitiVERSE EDIC** agenda for interoperable, networked local digital twins. At the project level, Tampere has taken part in—and in several cases led—multi-country initiatives that connect digital twins, XR participation, data spaces and ethical AI governance, including **x CITE** (with Rotterdam and Flanders), **WeGenerate, DT aCoGo, AI4Citizens,** and the **CitCom.ai** testing and experimentation facility network. Complementing these structured programmes, Tampere has also built city-to-city collaboration around resilience and safety, linking practical operational learning with strategic Citiverse development. Together, these collaborations show how Tampere treats international networks as an extension of its local innovation ecosystem—turning shared standards, reusable components, and peer learning into concrete capability building for a human centric digital city.

Tampere has also been founding member of **OASC** (Open & Agile Smart Cities & Communities) is a global network of cities that works to make smart city solutions **interoperable** and **reusable** across cities. In practice, OASC helps cities and suppliers align around open standards and "Minimal Interoperability Mechanisms (MIMs)", so data and digital services (including local digital twins and Citiverse components) can be exchanged and scaled more easily between municipalities, rather than being locked into one vendor or one city. Tampere was also one of the founding members of **Nordic Smart City Network (NSCN)** is a collaboration initiative that brings together cities across the five Nordic countries to share experiences and develop practical approaches to **liveable, sustainable, and citizen centric smart city development.** In practice, it functions as a peer network where cities exchange best practices, data-driven methods, and reusable solutions (often emphasizing open data and citizen engagement) and where Nordic cities can jointly create visibility and market opportunities for innovations that can scale across the region.

In addition Tampere has built one-to-one collaboration between cities across the globe in smart cities and citiverse space, the latest collaboration happening between Rotterdam and Valencia. In

addition we have had close ties with cities like Austin, Los Angeles, Prague, Riga, Seoul, Dubai, Barcelona, Dublin, Tokyo, Guangzhou, Amsterdam when developing our innovations and solutions.

International awards and recognitions

Tampere's smart city and emerging Citiverse work has also received international recognition through external awards that validate both the technical maturity and the human centric orientation of its approach. These recognitions have been linked especially to Tampere's capability to combine data, AI, digital twins, and real-life test environments into solutions that produce measurable public value.

- **World Smart City Awards 2023 (Smart City Expo World Congress):** Recognised in the category Enabling Technologies, highlighting Tampere's work on AI and insight enabled urban services and the creation of social value through data.
- **Seoul Smart City Prize 2024:** Recognised for human centered smart city development, linked to Tampere's work in real-life environments such as the Nokia Arena context.
- **Capital Mobile Awards:** The Station Area digital twin work (developed within the WeGenerate context) received international recognition together with the Tampere Pulse solution, underlining Tampere's leadership in practical, participatory digital twin based city development.

TAMPERE
SMART CITY & CITYVERSE

World Smart City Awards 2023

Enabling Technologies

Seoul Smart City Prize

Human-Centered Smart City 2024

Capital Mobile Awards

Digital Twin & Tampere Pulse

1.10 Working with friends

Tampere has enjoyed a close cooperation especially with two cities, Valencia and Rotterdam. Tampere even prepared a short description together with the other cities on their roadmap. Lij-Saan Wong-Ng has prepared the following text from the two cities and the quote is here for readers to see see comparisons,

Valencia

Host of the LDT CitiVERSE EDIC

Since February 2024, Valencia has been the statutory seat of the LDT CitiVERSE EDIC, the European Digital Infrastructure Consortium for Networked Local Digital Twins, established by Commission Implementing Decision (EU) 2024/459. Fourteen Member States founded the consortium, with Spain acting as coordinator and Valencia chairing the Assembly. The EDIC is headquartered in the La Harinera building and connects local digital twins across Europe into a shared, interoperable infrastructure for geodata, AI and virtual worlds. Its first General Assembly was held in La Harinera in December 2024. For Valencia, hosting the EDIC is not only a matter of prestige: it anchors the city's commitment to European digital autonomy, open standards and public values in the development of the Citiverse.

Smart City Platform and bidirectional Digital Twin

Valencia has a long tradition in geographic information systems (GIS) that has evolved into a fully-fledged urban digital twin. What sets it apart is the bidirectional connection with the city's Smart City Platform: the twin is continuously fed with real-time data and, in turn, feeds back into municipal systems. The platform is open by design, enabling new applications and new businesses to be built on top of it, and evolves continuously with services such as AI assistants and immersive visualisations. Interoperability and inclusivity — narrowing the digital divide — are guiding principles. Valencia applies the Minimal Interoperability Mechanisms (MIMs) and is recognised as a reference city in this area. The platform is currently structured around four main domains: tourism (enhancing visitor experiences with immersive technologies), urban planning (simulating the impact of major projects), citizen participation (virtual models that allow residents to engage with alternative scenarios) and a virtual civil servant chatbot providing accessible public services.

Valencia Immersive City

In March 2026, the City of Valencia and the University of the Arts London (UAL) signed a Memorandum of Understanding that launched Valencia Immersive City, a strategic alliance to position Valencia as a European reference in the application of immersive technologies to urban transformation. Valencia is the first Spanish city to combine advanced urban simulation with immersive technologies to test and discuss major urban projects before they are built. The initiative is being rolled out through the Valencia Immersive City Lab, organised around three work streams: immersive experiences tied to the urban fabric, training and talent programmes in creative technologies, and the development of a local business ecosystem in XR and digital storytelling. A first joint workshop with the London College of Communication is scheduled for May 2026 at La Harinera and Las Naves, with a public installation in Plaza de la Reina as a follow-up deliverable. Academic collaboration with the Universitat Politècnica de València (UPV) is being facilitated in parallel.

Urban Sandbox and GovTech Challenges

Valencia turns the city itself into a testing ground for innovation. Urban Sandbox provides a regulatory and operational framework that allows start-ups, SMEs, universities and research centres to pilot new solutions on real urban assets — from streets and squares to public buildings and city events. In parallel, the GovTech Challenges programme translates concrete municipal needs into open calls for start-ups, creating a pipeline for public innovation procurement: by 2025, fourteen challenges were active and new rounds were presented at the Valencia Digital Summit. Together, Sandbox and GovTech turn city management into a living innovation platform: they lower the barriers to urban experimentation, de-risk the adoption of new technologies by public services, and feed the Smart City Platform and the Digital Twin with evidence from real-world pilots.

European projection: CitCom.AI and the Citiverse Alliance

Valencia's role in Europe goes beyond hosting the EDIC. The city leads the Southern Supernode of CitCom.AI, one of the European Testing and Experimentation Facilities for AI, bringing together eleven countries to validate AI solutions for cities. In November 2025, during the first Citiverse Assembly held in La Harinera, Valencia announced the launch of the Citiverse Alliance, an open coalition of cities and partners committed to advancing the Citiverse along shared ethical and technical principles. Valencia also hosts the largest office of the United Nations International Computing Centre (UNICC), reinforcing its standing as a Mediterranean hub for digital public infrastructure.

Resilience after the DANA

The DANA of October 2024 was a turning point for Valencia and for the region. Beyond its immediate human and economic toll, it made visible how data, simulation and immersive visualisation can help cities anticipate, communicate and respond to extreme events. The Smart City Platform, the Digital Twin and the immersive tools now being developed are part of a broader, post-DANA commitment: to build a city that is better prepared, more transparent with its residents, and more capable of making sharp and sound choices in the face of climate, social and technological change. This is the contribution Valencia brings to the Lighthouse Association and to the Citiverse: a city that has learned, the hard way, why the infrastructure behind the Citiverse matters.

Rotterdam Citiverse

Rotterdam is internationally among the leaders in creating the basic conditions of the Citiverse, even having the world's first Chief Citiverse Officer, and reached the finals of the 2026 European Capital Innovation Awards. The municipality of Rotterdam assumes a continuously mutually influencing social, physical, and digital reality. Rotterdam Citiverse is a citizen-oriented, social-physical-digital ecosystem based on trust, interoperability, and inclusivity.

Open Urban Platform

The Open Urban Platform (OUP) is the hub of the digital infrastructure that provides all residents of Rotterdam with a safe, responsible, and insightful digital environment. It is a platform by and for all residents, businesses, and organizations of Rotterdam. In one common place, you can find all current data of Rotterdam gathered together. In such a way that everyone can use it, add data, and share it. This makes the Open Urban Platform the basis for new applications, services, information provision, and participation. Think of a housing corporation that makes

3D information of buildings available to the fire department, enabling them to fight a fire more effectively. Or of residents who are already co-designing in 3D in a pilot project, for example, the redesign of a square in their neighborhood. It is a public-private partnership. The next step is that humans can also become part of the digital city (social component).

Rotterdam is exploring what the Citiverse exactly means and what the future city will look like as these worlds increasingly converge.

The goal is to, by the end of 2027, arrive at a vision for the digital transformation of the city of Rotterdam and the Rotterdam ecosystem.

To reach this desired vision, work is being done along three axes:

1) Four perspectives:
   a. Municipal services;
   b. Digital economy;
   c. Digital inclusion & equality;
   d. Adaptive and resilient digital infrastructure

1) Twelve building blocks, think of digital identity, youth and innovation, port economy. These are the issues that Rotterdam faces, translated into opportunities for Rotterdam.

1) A growing number of workshops. Currently, these are:

- Ecosystem of Applications: Appstore on top of the Open Urban Platform: applications that communicate with each other and reuse data.
- x-CITE: EU project with Tampere, Flanders, and Rotterdam: XR and AI for citizen participation and the school of the future.
- Digital Imagination: Research on AR/VR and 3D visualizations as a tool for understandable co-creation with residents and companies.
- Digital Humans & AI: Experiments at the intersection of AI and ethics, including the 'digital human' Digiderius (based on Desiderius Erasmus).
- Web3.0 / Citizen Data Vault: Citizens maximally in control of their own data through a reliable personal data vault for municipal services.

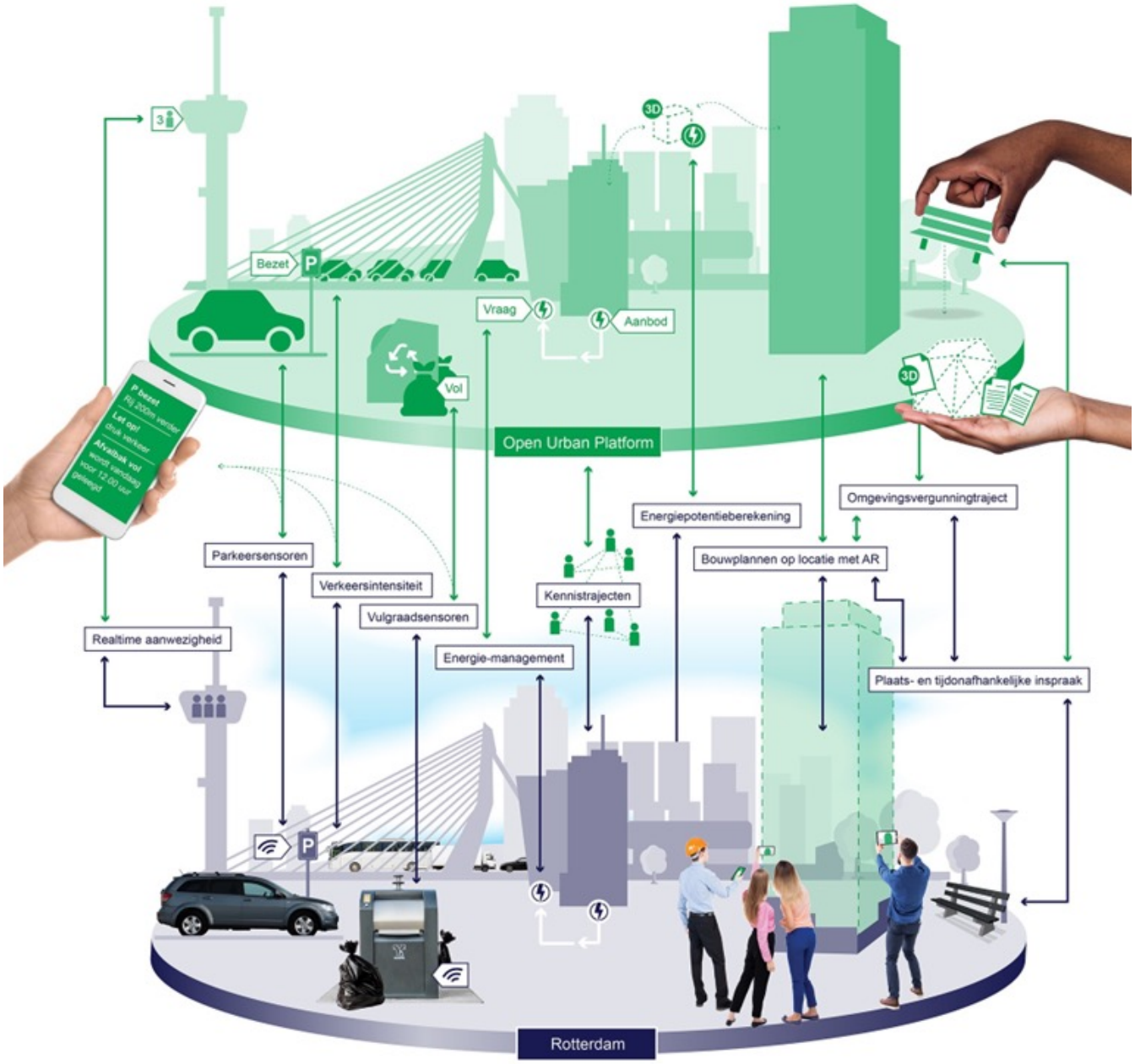
The goal is to share and acquire knowledge and to translate this knowledge as much as possible into relevant insights for the vision of Rotterdam Citiverse.

International Citiverse Examples

ROTTERDAM CITIVERSE

Rotterdam has started to view layers of Citiverse from digital twin perspective.

- Physical
- Digital
- Social



1.11 Tampere 2040 and Beyond — A Vision in Motion

The road to citiverse has been on its way in Tampere for more than a decade. Next ambitious steps are already planned. A key strategic anchor for this shift has been **Tampere Digital Vision 2035,** crystallized in the phrase **"City of Action – intelligently digital, digitally equal."** Rather than describing technology projects, the vision sets a long-term direction for how digitalisation should improve everyday life and strengthen the city's vitality while ensuring that benefits are shared across different groups. It provides a common compass for successive four year digital roadmaps and helps align development across service areas. The vision highlights three connected perspectives: residents and visitors should experience services that are human, proactive and increasingly seamless across physical and digital touchpoints; businesses and communities should be supported through data driven, anticipatory services and open collaboration platforms; and the city organisation should modernise its own work through digital intelligence, better cross boundary processes, and tools that support employees as a "digital co worker." In Tampere's journey, this vision has functioned as a bridge between smart city experimentation and a more mature, governance driven approach that ultimately enables Citiverse development.

Tampere translates this long term direction into action through a **digital roadmap:** an annually updated, four year plan that brings the vision down to concrete priorities, initiatives, and capability building across the whole city organisation. The roadmap functions as a bridge between the city strategy and mayor's programme on one side, and the practical service area plans and investments on the other—ensuring that digitalisation is not a collection of isolated IT projects but a coordinated renewal agenda. In practice, the roadmap clarifies what the city will develop (and in what order) in areas such as citizen centric and proactive digital services, data and AI utilisation, platform and interoperability development, skills and change management, and the governance requirements that enable trust—such as information security, privacy, and responsible data use. By updating the roadmap regularly, Tampere keeps its digital priorities aligned with changing needs, emerging technologies, and lessons learned from pilots—supporting a continuous journey from smart city experimentation toward mature, Citiverse ready city capabilities.

Across its four-year horizon, the roadmap typically groups work into a set of reinforcing initiatives: making city services more **citizen centric and proactive** (often around life events and smoother service journeys), strengthening **data and AI utilisation** for insight based decisions and better targeting of support, and building shared **digital platforms** with strong **interoperability** so that new solutions can be reused across service areas instead of remaining isolated pilots. It also treats **digital twins** as a citywide capability for planning, participation, simulation and operations, while investing in **skills development and change management** so that employees and partners can adopt new ways of working. Finally, the roadmap frames **trust** as a prerequisite for scale by continuously improving **information security,** privacy, and responsible data governance, and by keeping ecosystem collaboration and testbeds as a practical route from experimentation to adoption.

City of Doing –

INTELLIGENTLY DIGITAL, DIGITALLY EQUAL

Progress towards Vision 2035 with stakeholder-specific targets

PEOPLE LIVING AND MOVING AROUND IN TAMPERE

Tampere

- Interaction with the city is humane and intelligent
- The services are proactive and help with a wide range of life events
- In the living environment, the physical and the digital combine seamlessly.

TAMPERE COMPANIES AND COMMUNITIES

City of Tampere

- Is an attractive collaboration platform for business, research and the public sector
- Creates vitality with knowledge
- supports the success of companies and communities with data-driven and predictive services.

THE CITY OF TAMPERE'S OWN OPERATIONS

The City of Tampere

- Productivity develops with digital intelligence
- For employees, technology is a natural and value-adding co-worker
- The operations are digitally renewable and cross organisational boundaries.

The vision for this program was “Clear Citizen understanding leads into good Citizen experience and overall achievement of city goals” The following goals for the program were established:

- Citizen wellbeing and regional success will be advanced using data and AI broadly.
- Creating Data as a service-model (DaaS) for companies, organizations and citizens
- Continue ecosystem program to create new opportunities for our companies, universities and research institutions to develop new business models
- Succesful implementation of the above will lead to better understanding of use of data and AI and both improved citizen ux, and improved efficiency for the city through targeted services

The future city will continuously evolve through AI supported governance, immersive participation, and interconnected global citiverses. Collaboration with other world-leading cities ensures shared learning and innovation. Tampere’s trajectory suggests a future where urban life blends physical presence with digital depth, enabling richer, fairer, and more sustainable ways to live.

Conclusion — A Blueprint for the World

Tampere’s transformation demonstrates what is possible when a city systematically invests in digital infrastructure, ethical governance, and human centric innovation. Its journey from Smart City to Citiverse City is not simply a technological evolution—it is a model for how societies can shape digital futures that elevate the human condition.

2. How to develop citiverse globally

Kuva: Laura Vanzo / Visit Tampere

EU initiated the Citiverse terminology and has since been working on developing it as a part of Digital Agenda for Europe. United Nations started initiative on Virtual Worlds and ITU (International Telecommunications Union) has been promoting the topic through various programs. OASC (Open & Agile Smart Cities & Communities) has started its own Citiverse program to focus on the topic.

Three complementary streams are shaping the Citiverse into something cities can actually build. At the global level, **ITU** convenes the UN's work on AI and virtual worlds through its Global Initiative on "Discovering the Citiverse," producing shared language, guidance, and practical (such as sandboxes and capacity building) to keep development inclusive, trusted, and interoperable. In Europe, the **LDT CitiVERSE EDIC** provides the implementation vehicle to connect local digital twins across Member States into a common, reusable infrastructure aligned with European values on trust and sovereignty. Meanwhile, **OASC** translates interoperability into day to day

delivery through its Minimal Interoperability Mechanisms (MIMs), helping cities mechanisms procure and deploy components that can be reused across vendors and borders—turning the Citiverse from a concept into a federated, working ecosystem.

2.1. EU initiatives enabling the CitiVerse

In the EU context, "CitiVerse" is emerging through a set of mutually reinforcing policy and investment instruments rather than a single programme. The common goal is to help cities build **interoperable, trustworthy, and reusable** building blocks—especially **networked local digital twins**—so that successful solutions can scale across municipalities and Member States, avoid fragmentation, and remain aligned with European values on privacy, transparency, and digital sovereignty.

- **LDT CitiVERSE EDIC (Networked Local Digital Twins towards the CitiVERSE):** a Digital Decade multi country initiative that creates shared governance, standards and reusable components for connecting city digital twins across Europe.

- **Digital Europe / CitiVerse project portfolio:** EU co funded projects that develop and validate practical CitiVerse capabilities such as interoperable local digital twins, XR enabled participation, and citizen facing services (for example, x CITE referenced in this book).

- **European Data Space for Smart Communities (DS4SSCC):** work to enable trusted data sharing "at the source" between public and private actors so digital twins can be fed with high value data while keeping control, cybersecurity and compliance in place (including pilots such as DT aCoGo).

- **Destination Earth (DestinE):** EU digital twins of the Earth system that can strengthen city resilience by providing climate, weather and extreme event intelligence that local digital twins can reuse.

- **Living-in.EU:** a city and region movement that supports adoption by sharing common tools and interoperability guidance, helping cities translate EU frameworks into deployable local practice.

2.1.1 LDT CitiVERSE EDIC

The **LDT CitiVERSE EDIC (Networked Local Digital Twins towards the CitiVERSE)** is a **European Digital Infrastructure Consortium (EDIC)** created under the EU's Digital Decade Policy Programme 2030 to help Member States jointly build and operate the foundations of a shared European CitiVERSE. In practice, the EDIC focuses on making city-scale Local Digital Twins (LDTs) data-driven digital representations of urban assets and processes (such as mobility, energy, environment, and public-space operations) interoperable, reusable, and connectable across borders. Rather than funding isolated pilots, it aims to put in place the common governance, reference approaches, and shared building blocks that allow cities to share components, align data and interface practices, and scale solutions without fragmentation or vendor lock-in.

A central theme is enabling city twins to be enriched with trusted data and analytics (including AI) so that they can support both planning and operational use cases, while remaining aligned with European principles on **trust, transparency, security, and digital sovereignty.** The EDIC is headquartered in Valencia, Spain, and brings together a growing group of participating countries to coordinate delivery, co-investment, and long-term sustainability of this cross-border digital infrastructure. The EU "CitiVERSE" vision (as described in EU fact pages) is a shared digital space for cities, leveraging:

- Digital Twins
- Data
- AI
- AR/VR (XR) for participation and interaction

In that framing, **LDT CitiVERSE EDIC is the infrastructure-and-interoperability engine:** it's meant to make it feasible for many cities to participate using compatible digital twin building blocks rather than isolated city-specific stacks. It has a unique opportunity to bring together different EU-projects and initiatives. The promise it has made is to create economies of scope & scale that benefit cities as well as companies, by pooled resources for capacity building, maturity and procurement services, testing and experimentation facilities (validation & certification), common development of advanced open solutions, replicable AI-powered tools for responsible public services, a common repository of tools & services, coordination with industry, an interoperable marketplace (Open Urban Data Space) fostering a thriving public-private solution ecosystem involving cities, businesses, SMEs, and compliance with European values and interoperability standards. Tampere has been involved in discussions with EDIC and Finland joining EDIC since February 2025. Tampere is also part of the EDIC Sandbox Alliance.

EDIC Sandbox Alliance

The EDIC Sandbox Alliance is a practical delivery mechanism within the LDT CitiVERSE EDIC designed to close the gap between promising EU-funded solutions (often reaching prototype or pilot maturity) and their real operational use in cities. Its core idea is "validation from practice": instead of testing digital-twin tools only in controlled lab environments, the Alliance uses the real sandboxes of cities and regions to verify that products, services, and building blocks are interoperable, deployable, robust, and reusable under everyday conditions. In this way, the Sandbox Alliance supports the EDIC's mission to turn toolkits and specifications into **repeatable implementation patterns** that can be adopted across Member States.

Operationally, the Alliance starts with a **core group of frontrunner cities** that commit capacity, test environments, and implementation know-how, while remaining **open to other cities** as the model matures. The participating cities jointly define **testing and evaluation criteria** (for example around deployment effort, documentation quality, cybersecurity and data governance prerequisites, integration with existing city platforms, and portability across different technical stacks). A concrete early focus has been the coordinated testing of the **EU LDT Toolbox,** where the Sandbox Alliance provides a shared framework for city-by-city pilots while also exploring how tools can be offered through a **centrally deployed EDIC sandbox environment** (in addition to possible on-premise city deployments). The same approach can be extended to other

relevant building blocks, such as components from the **Data Space for Smart Communities** blueprint, Green Deal-related data-space assets, and CitiVerse/virtual-worlds pilots, with the aim of accelerating learning and reducing duplication between cities.

2.2. OASC Citiverse activities

OASC (Open & Agile Smart Cities & Communities) has increasingly positioned the Citiverse as a practical continuation of its long-term mission: making city solutions interoperable and reusable across borders. In the OASC framing, a Citiverse is not a single platform or vendor-led virtual world, but an ecosystem of connected city digital twins, data spaces, and services that can exchange information and components in a trusted way. OASC's contribution is therefore less about building "the" Citiverse and more about ensuring that the building blocks different cities create can work together.

In practice, OASC's Citiverse-related work shows up through a set of interoperability mechanisms, community agreements, and implementation support that help cities avoid one-off integrations:

- Minimal Interoperability Mechanisms (MIMs): OASC maintains and evolves the MIMs as a practical "minimum set" for interoperability. These mechanisms (covering areas such as context information management, shared data models, APIs, and security/trust fundamentals) provide a common baseline so that data and services can be exchanged between city platforms and across suppliers without bespoke integration work for every new use case.

- Common Data Foundation (CDF): OASC promotes a shared approach for organizing and exchanging city data (including near real-time IoT and operational data) so that digital services and digital-twin applications can be built on top of a consistent, reusable data layer.

- Alignment with local digital twins and CitiVERSE work: As more cities build Local Digital Twins, OASC focuses on how twins can connect to open data spaces, reuse common interfaces, and exchange models and outputs. This makes digital twins more portable between cities and reduces fragmentation between "twin stacks".

- Data spaces and trusted data sharing: OASC links its interoperability work to the broader European data-space direction by encouraging patterns for sharing data "at the source" under agreed governance, rather than copying data into closed platforms. This is increasingly important for Citiverse use cases that require combining public and private datasets under clear rights and cybersecurity constraints.

- Replication and procurement support: A recurring OASC theme is that interoperability must be *procured* and *implemented*, not only discussed. OASC supports cities by promoting common requirements language, reference architectures, and peer learning so that solutions proven in one city can be replicated in another with lower cost, lower risk, and less vendor lock-in.

- Community building and working groups: OASC convenes cities, regions, standards bodies, and suppliers around practical working groups where interoperability mechanisms are tested against real deployments. This "learning by doing" approach is essential for Citiverse development, because cross-city interoperability challenges tend to surface only when cities try to connect operational systems, not when they remain at the conceptual level.

- Practical examples and "implementation patterns": Beyond generic guidance, OASC continuously collects and shares concrete patterns cities can reuse—such as how to publish real time city data through standard interfaces, how to structure a city data catalogue, and how to connect a local digital twin to operational data feeds without creating fragile point to point integrations.

Examples of OASC activities that cities typically recognise as directly Citiverse-enabling include:

- Driving adoption of common API patterns (e.g., NGSI-LD / context management): supporting cities in moving from proprietary IoT feeds to shared, standards-based interfaces so that applications (including digital-twin components) can be ported between cities with minimal rework.

- Showcasing and validating reference stacks: encouraging use of open, modular building blocks (often aligned with widely used open-source ecosystems) so that cities can assemble a "good enough" baseline platform and then add domain solutions on top.

- Cross-city challenges and peer learning: using community events, working groups, and city-led challenges to test interoperability in realistic scenarios (mobility, environment, safety, energy), not only in paper architectures.

- Procurement templates and requirements language: translating MIMs into requirements that cities can put into tenders (for example, requirements around open APIs, data portability, and identity/trust), helping procurement become a lever for interoperability

- Trust and identity building blocks: promoting practical approaches for identity and access management and secure data sharing across organisational boundaries—an essential prerequisite for networked digital twins and data spaces.

- Replicable use cases and "solution reuse": curating examples of city deployments that other municipalities can replicate (including guidance on what data, governance, and interfaces are needed), so that Citiverse capabilities can scale beyond one-off pilots.

Tampere-specific OASC activities

For Tampere, OASC has been an important international "interoperability peer network" alongside EU programmes. Tampere's engagement has focused on bringing practical city experience into the interoperability conversation, and on using OASC's shared mechanisms (especially the MIMs) as a reference point when building city platforms, digital-twin foundations, and ecosystem procurement practices that aim to avoid vendor lock-in and maximize reusability.

- Founding-member role and Nordic alignment: Tampere has been part of OASC from early stages and used it as a channel to connect Nordic smart-city practices with broader European interoperability work.

- Interoperability as an ecosystem principle (not an IT feature): In the Smart Tampere and Data Driven City for Citizens programmes, Tampere institutionalized an "open-by-default" mindset (open APIs, reusable components, shared data layers) that aligns with OASC's MIM logic.

- Platform foundations that can feed digital twins: Work on the citywide IoT platform, data platforms, and situational-awareness capabilities (e.g., Tampere Pulse) has been shaped to be modular and shareable—exactly the kind of prerequisite OASC highlights for portable digital-twin and Citiverse components.

- Procurement and replication learning: Tampere has used international networks to refine how interoperability requirements are expressed in practice (requirements language, openness, data portability), so that city solutions can be replicated across contexts rather than rebuilt from scratch.

- Connecting OASC to UN and EU Citiverse work: Tampere's Citiverse development has combined OASC-style interoperability thinking with EU LDT/CitiVERSE and UN/ITU normative work—helping keep the narrative grounded in deployable building blocks rather than "metaverse hype".

Seen through the Citiverse lens, OASC's role is to make sure that cities can move from isolated pilots to networked capability: digital twins, data services, and citizen-facing applications that can be connected and reused across borders. For cities, this reduces duplication and accelerates time-to-value; for companies and innovators, it expands the market for solutions that comply with open interoperability requirements; and for citizens, it increases the likelihood that digital services remain trustworthy, portable, and aligned with public values as the Citiverse evolves.

2.3. ITU & United Nations activities on Citiverse

While the EU has framed CitiVerse mainly through digital-twin infrastructure and interoperability for cities, the **United Nations system**—with **ITU** as a key convenor and standards body—has been building a complementary track focused on **global norms, safety and trust, inclusion, capacity building, and practical implementation support** for AI enabled virtual worlds that serve public goals. The UN/ITU work is particularly relevant for cities because it links virtual worlds to the **Sustainable Development Goals (SDGs)** and emphasizes that the Citiverse must remain open, interoperable, and human centric.

- **UN Virtual Worlds Day:** a recurring UN convening (hosted at ITU in Geneva) that brings together UN agencies, governments, cities, industry, and academia to discuss how virtual worlds (including the metaverse and spatial computing) can advance SDGs—especially around sustainable cities, public services, resilience, education, and inclusion.

- **ITU-T Focus Group on Metaverse (FG MV):** an ITU pre-standardization effort (concluded in mid 2024) that mapped metaverse/virtual-world requirements and produced a large set of technical reports and specifications across topics such as definitions, architecture, virtual–real integration (incl. digital twins), interoperability, networking, and security/PII protection. Its work has helped shape the technical vocabulary and problem framing for later Citiverse efforts.

- **Global Initiative on AI and Virtual Worlds – Discovering the Citiverse:** launched by ITU with UNICC and Digital Dubai as a global multi-stakeholder platform to translate virtual-world concepts into city-relevant guidance, tools, and collaboration. It is organized around three pillars: (1) *Bringing the Citiverse to Life* (strategic guidance, inclusion, scaling, evaluation), (2) *Connecting Cities with the Virtual and Real Worlds* (use cases, emerging tech, security & trust, sandbox/experiment facility, "citiverse on the ground"), and (3) *Tunneling the Citiverse* (community-building through assemblies, alliances, toolkits, training and talent programmes).

- **UN Citiverse Challenge:** a global innovation challenge inviting students, startups and innovators to develop prototypes that use AI, digital twins, and virtual worlds to solve public problems (for example access to services, sustainability/resilience, and tourism/digital culture), explicitly linking Citiverse ideas to SDG outcomes and inclusive innovation.

- **U4SSC (United for Smart Sustainable Cities):** a UN initiative coordinated by ITU, UNECE and UN Habitat that provides city-focused guidance and KPI frameworks for smart sustainable cities. U4SSC work streams on digital transformation, data/API requirements, digital wellbeing and digital public infrastructure provide adjacent "governance and measurement" foundations that help cities implement Citiverse capabilities responsibly.

- **ITU-T standardization continuation (e.g., Study Group 20 and coordination activities):** beyond special initiatives, ITU's technical study groups on IoT, digital twins and smart cities continue to be the place where many of the underlying technical standards and interoperability discussions mature over time.

Tampere's role in ITU initiatives

Tampere is not only a "case city" in the Citiverse discussion but also an active contributor to the ITU-led work. The city has used the ITU platform to bring a practical, city-operations perspective into global guidance—grounded in themes Tampere has worked on locally (digital twins, data governance, ethical AI, inclusion, and real-world testbeds). This engagement is visible both in leadership roles and in concrete deliverables and events.

- **Leadership in the Global Initiative:** Tampere has been represented in the executive leadership of *the Global Initiative on Virtual Worlds and AI – Discovering the Citiverse,* including roles such as **Vice Chairman** (Deputy Mayor **Jouni Markkanen**, followed by **Jaakko Mustakallio**) and **Vice Chair of the Steering Committee** (Executive Director **Teppo Rantanen**).

- **Chairing/leading the Strategic Guidance Track:** Tampere has had a central role in the initiative's **Strategic Guidance Track,** coordinating expert inputs and helping shape the guidance deliverables that translate Citiverse principles into actionable direction for cities and governments.

- **Deliverables and expert mobilisation:** Tampere has contributed to the preparation and review of track deliverables (e.g., strategic guidance documents and supporting materials) and mobilised an expert group spanning city practitioners, academia and industry to ensure that the outputs reflect real deployment constraints and opportunities.

- **Citiverse Assemblies and visibility:** Tampere has been invited to speak at ITU's **Citiverse Assembly** events (e.g., the 1st Assembly in Valencia and the 2nd Assembly in Geneva), sharing city-level experience on moving "from vision to delivery".

- **Co-organising the UN Citiverse Challenge:** Tampere has been listed as an **organising partner** of the UN Citiverse Challenge, supporting global innovation around themes such as accessibility of public services, sustainability/resilience, and tourism/digital culture.

- **Recognised supporter city:** Through active participation in tracks, events, and use-case development, Tampere has been recognised as a **supporter** in the Initiative's partner ecosystem.

- Tampere is also involved in the latest ongoing initiative under U4SSC to develop **Digital Development Goals for Cities.**

For Tampere, this ITU engagement serves two purposes. First, it helps ensure that global Citiverse guidance stays anchored in implementable city realities (interoperability, trust, procurement, governance, and inclusion). Second, it gives Tampere early visibility into emerging global expectations—so local Citiverse development can be aligned with international norms and standards rather than diverging into a one-off "local metaverse".

Taken together, UN and ITU initiatives are making the Citiverse more actionable by producing **shared definitions, technical requirement baselines, trust and safety considerations,** and **capacity-building mechanisms** (toolkits, training, challenges, and sandboxes) that cities can reuse. For city leaders, the practical value is that these efforts help connect local experimentation (digital twins, XR participation, data spaces, and AI-enabled services) to a broader global "rules and learning" layer—reducing fragmentation and increasing the chances that Citiverse solutions remain interoperable, ethical, and scalable.

As part of ITU work, Tampere has been actively involved in planning a playbook helping cities globally to address the way to Citiverse. This work has been done in cooperation with Petri Takala from Capgemini and Sanni Pöntinen from Tampere University, and a product of that work is the next chapter in this book. It got also inspired by our friends Rotterdam, Valencia, Dubai and Singapore.

3. Ecosystem Development Playbook for Citiverse


Kuva: Laura Vanzo / Business Tampere

Navigating Governance Diversity in Citiverse Development

Citiverse solutions do not require a specific form of governance to function. They are inherently adaptable and can be implemented within a wide range of political and administrative systems—from decentralized democracies to more centralized or directive models. However, what Citiverse ecosystems do require is a certain degree of **systemic stability, predictability, and trust** to operate effectively across cultural contexts.

Finding this balance is essential. It enables Citiverse initiatives to deliver on their strategic goals: inclusive participation, intelligent services, and sustainable urban transformation. Regardless of the governance model, successful Citiverse implementations must meet a set of **ecosystem-level conditions,** such as:

- Shared understanding of roles and responsibilities
- Mechanisms for coordination and collaboration
- Transparent data governance and ethical oversight
- Citizen engagement and responsiveness to local values

Different governance and market dynamics may shape the form and tools of implementation, but they must all respond to these foundational ecosystem principles. The playbook is designed to support this diversity—offering frameworks that are flexible, context-sensitive, and grounded in the realities of complex urban systems.

Ultimately, Citiverse is not about imposing a model. It is about enabling cities and communities to co-create digital futures that reflect their unique identities, values, and aspirations—while remaining interoperable, inclusive, and resilient.

Urban governance is undergoing a profound transformation. Emerging technologies—artificial intelligence, extended reality (XR), digital twins, and immersive platforms—are converging to create new possibilities for planning, service delivery, and citizen engagement. This integrated environment, increasingly referred to as the **Citiverse**, represents more than a technological upgrade. It is a systemic shift toward **human-centered digital ecosystems** that embed local values while remaining globally interoperable.

The Citiverse is defined by the International Telecommunication Union (ITU) as *"a metaverse for cities that prioritizes a human-centered approach and promotes sustainable development."* Its ambition is to enable inclusive participation, ethical data use, and resilient urban services. Unlike fragmented smart city initiatives, the Citiverse offers a holistic framework where physical infrastructure, social systems, and virtual environments interact seamlessly.

Why does this matter? Cities face mounting challenges—climate adaptation, demographic shifts, resource constraints, and rising citizen expectations. Traditional models often prioritize technology over people, resulting in siloed solutions. The Citiverse addresses this gap by combining **open standards, interoperability mechanisms (MIMs),** and **participatory design** to create adaptive, future-ready urban ecosystems.

This playbook serves as a **practical guide,** not a prescriptive blueprint. It is designed for mayors, CIOs, innovation leaders, and ecosystem partners who seek clarity on:

- What foundational capabilities are required before investing in immersive technologies?
- How can governance models evolve to balance agility with accountability?
- Which pathways accelerate readiness without compromising trust and inclusion?

The chapters ahead provide structured guidance—from strategic vision to implementation toolkits—while recognizing that every city's journey is unique. For cities requiring diagnostic tools, consult the **Future Cities Blueprint** and the **UN/ITU Citiverse Readiness Checklist,** which detail tiered maturity models and evidence-based scoring systems. These resources complement the playbook by offering granular indicators across governance, infrastructure, and innovation domains.

Ultimately, the Citiverse is not about imposing uniform solutions. It is about enabling cities to co-create digital futures that reflect their identity, values, and aspirations—while remaining interoperable, inclusive, and resilient.

3.1. Strategic Vision and Goals

The Citiverse sets a **strategic, shared vision** for **inclusive, intelligent urban ecosystems.** It treats the city as a living socio-technical system in which **human-centred design, interoperability, and ethical governance** are the primary success factors. A persistent digital layer —built from **digital twins, AI, XR, IoT, cloud/edge, open APIs, and trustworthy identity/provenance**—synchronises with the physical city to enable **real-time awareness, predictive simulation, and participatory decision-making.** The goal is not "more technology," but **better outcomes for people:** equitable access to services, resilient infrastructure, and transparent, accountable institutions.

Inclusivity by design. In the Citiverse, inclusion is not an afterthought. Accessibility services (multilingual content, alternative input/output modalities, explainable interfaces) are embedded into public-facing channels; citizen data agency is respected through clear notices, granular consent, and straightforward routes to view, correct, or contest records; and **human-in-the-loop oversight** remains in place for determinations affecting rights or benefits. This makes participation tangible—virtual town halls, spatial budgeting, and 3D "what-if" exploration—while upholding trust.

Intelligence in service of public value. Intelligence is operational, not decorative:

- In **climate and infrastructure resilience,** city-scale twins integrate hydrology, microclimate, asset condition, and dependency graphs so planners can evaluate adaptation pathways and coordinate investments across utilities.

- In **transport and mobility,** DT+AI+IoT fuse traffic, transit, micromobility, and weather into demand-aware orchestration, improving signal timings, schedules, and evacuation guidance while making trade-offs legible to residents through XR visualisation.

- In **energy and sustainability,** grid-level twins model weather/vegetation impacts and failure propagation, enabling proactive maintenance and neighbourhood-scale optimisation around storage and flexible loads.

- In **public safety and health,** multi-agency operational twins consolidate situational awareness; XR training accelerates skill acquisition; and edge analytics/drones compress detection-to-response time.

Alignment with global goals. This strategic vision directly advances the **UN SDGs**, especially:

- **SDG 11:** inclusive, safe, resilient cities through participatory planning, transparent governance, and resilience KPIs;
- **SDG 9:** innovation ecosystems and interoperable infrastructures that avoid vendor lock-in;
- **SDG 13:** climate action via predictive scenario modelling and data-driven adaptation. It also supports the UN-wide **Digital Development Goals (DDGs)** by operationalising **open, safe, inclusive, and human-centred** digital infrastructures, and by encouraging cities to adopt **privacy-by-design,** ethical AI, and **interoperability across legal, organisational, semantic, and technical layers.**

From vision to practice. The Citiverse is implemented through phased capability building: (1) **Assets & Connectivity** (map and instrument assets; resilient fibre/5G/Wi-Fi/LPWAN; geospatial and asset standards); (2) **Data Aggregation & Processing Hubs** (hybrid cloud–edge lakehouse; data quality and governance; BIM/CIM/GIS/IoT integration; open APIs and minimum interoperability mechanisms); and (3) **Operations** (immersive dashboards, XR training, citizen participation channels with accessibility services; algorithm registry; continuous KPI audits for resilience, equity, and productivity). This lifecycle ties strategic aims to measurable impacts, ensuring that investments remain **outcome-anchored.**

Practical illustration (kept brief). Tampere's Digital Vision 2035 ("City of Doing—Intelligently Digital, Digitally Equal") exemplifies how a municipality can translate this shared vision into everyday services: anchoring proactive, humane, and **data-driven** delivery in life events (graduation, starting school, changing jobs), using a standards-based **city digital twin** to support planning and engagement, and positioning technology as a **value-adding colleague** for staff rather than an end in itself.

In sum, **Strategic Visions and Goals** for the Citiverse define a pathway where **inclusion and intelligence** are inseparable: global commitments (SDGs, DDGs) are realised through local co-creation; ethics and trust are embedded in each capability; and the city's digital foundations remain **open, sovereign, and interoperable,** ensuring **no one is left behind.**

3.2. Ecosystem Architecture and Complexity

The Citiverse must be understood as a **complex, adaptive system,** not a monolithic technology stack. It is a living ecosystem where **technical layers, institutional arrangements, and cultural practices** interact dynamically. At its core, the Citiverse differs from traditional smart city or digital twin models in two ways:

1. It treats **experience delivery**—control rooms, XR field applications, citizen-facing web viewers—as a primary architectural concern, rather than an afterthought.

2. It designs **compute, networks, and data lifecycles around interaction latencies and scene complexity,** ensuring responsiveness for immersive engagement rather than focusing solely on back-office integration.

This complexity means the Citiverse cannot be "installed"; it must be **cultivated**. Its architecture spans seven logical layers—from physical assets and IoT sensing to interoperability frameworks, digital twins, XR interfaces, and social governance. Each layer introduces dependencies and feedback loops, making the system inherently adaptive. Changes in one domain—such as new privacy regulations or XR standards—ripple across the ecosystem, requiring continuous alignment.

Emergent vs. top-down development. Two contrasting but complementary approaches shape Citiverse evolution:

- **Top-down orchestration** provides structure through global standards (ISO, ITU, OASC), governance boards, and policy frameworks. It ensures interoperability, ethical safeguards, and alignment with SDGs and DDGs.

- **Emergent pathways** arise from local pilots, community-driven innovation, and experimental sandboxes. These approaches inject creativity, contextual relevance, and rapid iteration. A resilient ecosystem blends both: top-down for coherence and trust; bottom-up for agility and innovation.

Social architecture and stakeholder orchestration. Technology alone does not guarantee success. The Citiverse is a **multi-actor governance challenge,** requiring coordination among municipalities, national agencies, private firms, academia, and civil society. This orchestration involves negotiating **control points, incentives, and cultural norms.** As workshop insights note, authoritarian systems often centralize control, while democratic contexts distribute it—but neither model inherently produces better ecosystems without clear accountability and shared governance principles.

Effective social architecture demands:

- **Shared governance models** that define roles and decision rights across actors.

- **Transparent data practices** and algorithm registries to build trust.

- **Mechanisms for distributed decision-making,** enabling local innovation within global interoperability frameworks.

Ultimately, the Citiverse thrives when governance is **adaptive, inclusive, and standards-aligned,** balancing flexibility with structure. It is not merely a technical blueprint but a **living ecosystem,** where social contracts and technical protocols co-evolve to deliver trusted, human-centred digital futures.

3.3. Maturity Framework and Playbook Pathways

The Citiverse is a **lifecycle, not a leap.** Cities progress through **five maturity levels,** each requiring distinct capabilities:

1. **Level 1 — Concept**

- Define strategic vision aligned with SDGs and DDGs.
- Identify 2–3 anchor use cases (e.g., flood resilience, multimodal mobility).
- Secure leadership commitment and initial funding.

2. **Level 2 — Pilot**

- Launch small-scale proof-of-concept in one domain.
- Engage stakeholders early; test interoperability and data governance principles.
- Document lessons for scaling.

3. **Level 3 — Development**

- Expand pilots across domains; integrate BIM/CIM/GIS/IoT into unified data layers.
- Adopt **open APIs and Minimum Interoperability Mechanisms (MIMs).**
- Draft governance frameworks for privacy, ethics, and accountability.

4. **Level 4 — Operational**

- Deploy hybrid cloud–edge data hubs and immersive dashboards.
- Enable citizen-facing channels with accessibility services.
- Institute algorithm registries and human-in-the-loop oversight for high-stakes decisions.

5. **Level 5 — Scaled Ecosystem**

- Federate digital twins across sectors; enable cross-border interoperability.
- Institutionalize continuous KPI audits (resilience, inclusivity, productivity).
- Embed adaptive governance and ethical AI as standard practice.

Playbook pathways:

- **Concept > Pilot:** Start with outcome-anchored use cases; secure partnerships and funding.

- **Pilot > Operational:** Build technical backbone (connectivity, data hubs); formalize governance; embed accessibility and privacy-by-design.

- **Operational > Scale:** Expand XR interfaces, federate twins, and institutionalize ethical AI and interoperability standards.

Typical challenges and solutions:

- **Challenge:** Fragmented data and vendor lock-in > **Solution:** Adopt open standards (ISO, ITU, OASC).
- **Challenge:** Governance gaps > **Solution:** Create multi-actor governance boards and algorithm registries.
- **Challenge:** Cultural resistance > **Solution:** Communicate benefits, run XR-based engagement, and provide capacity-building.

This maturity framework offers **clarity and confidence:** cities can benchmark progress, anticipate risks, and follow structured pathways from **vision to scaled impact,** ensuring that innovation remains **inclusive, ethical, and outcome-driven.**

3.4. Citiverse Maturity Model

When helping cities to analyze and identify the best road for them to get started and how to move forward I have been thinking about a model to assess this. It should be able to look at this from three different angles, physical, digital and social. I have come up with the first version of this. which will need a lot of development work, **5-Level Maturity Model (Physical–Digital–Social)**

How to assess (quick method)

- Score each dimension (Physical, Digital, Social) separately at Level 1–5 based on observable capabilities—not aspirations.
- Require evidence for the chosen level (e.g., asset registry/O&M workflow, data catalog & APIs, governance charter & participation results).
- Use “lowest level that is consistently true” across the scope (area/service/asset class) to avoid over-scoring.
- Record gaps as the difference to the next level per dimension; convert gaps into a 90–180 day improvement backlog.

If you need one overall rating, take the minimum of the three dimensions (or set gates, e.g., Social ≥3 to claim Operational).

	PHYSICAL	DIGITAL	SOCIAL
01 Concept	Priority area/asset class selected; baseline condition captured; scope boundaries defined.	Vision + anchor use cases; initial data inventory; target architecture sketched; ownership/funding identified.	Problem framing and stakeholder map; co-creation setup; initial commitments and legitimacy considerations.
02 Pilot	Limited sensing/surveys in pilot; field validation routines; operators engaged in trial workflows.	PoCs and first data pipelines/dashboards; basic data quality checks; early APIs; baseline security controls.	Testing with users/operators; feedback loops and comms; early training; consent/privacy practices initiated.
03 Development	Expansion to more domains; standard asset IDs; integration with O&M (inspections, work orders).	Unified data layers; open APIs/MIMs adopted; governance in place; reusable components; analytics informing decisions.	Cross-department/partner co-development; clear roles (product owner, data steward, operator); procurement/partnership model stabilizes.
04 Operational	Twin-supported operations and incident response; performance targets; resilience/continuity embedded.	Production hybrid cloud/edge; monitoring/SRE; IAM and security maturity; role-based/immersive views; lifecycle management.	Value realized in services; citizen/business channels in routine use; change management embedded; KPIs tied to accountability.
05 Scaled ecosystem	Replicable onboarding kit; cross-domain optimization (mobility–energy–land use); systemic outcomes measured.	Federated twins; cross-border interoperability; automated KPI/compliance audits; data space/marketplace connections where relevant.	Durable ecosystem governance; equity impacts tracked; long-term skills pipeline; shared innovation portfolio and trust at scale.

3.5. Governance Models and Evolution

The Citiverse introduces governance challenges that extend beyond technology. It is a **multi-actor, socio-technical ecosystem,** requiring models that ensure continuity, trust, and adaptability. **Governance independence from political systems** is critical: while political stability underpins long-term investment, governance cannot be hostage to electoral cycles. Instead, it should be codified through **standards, institutional agreements, and shared principles** that persist across administrations.

Comparative models:

- **Centralized governance** concentrates authority in a single entity (e.g., a national agency or city council). This model accelerates decision-making and simplifies compliance but creates vulnerability to control failures and raises concerns about surveillance and data misuse.

- **Distributed governance** delegates authority to multiple trusted organizations—municipalities, utilities, research institutions—reducing concentration risk and fostering resilience. However, it can suffer from coordination complexity and inconsistent practices.

- **Hybrid governance** blends central oversight with federated autonomy, enabling local innovation within a coherent standards-based framework. This model is increasingly favored for ecosystems that span multiple domains and jurisdictions.

Evolutionary trajectory: Governance often begins with **tight control** during concept and pilot phases to ensure clarity and risk management. As ecosystems mature, governance shifts toward **horizontal coordination,** where roles are distributed and collaboration becomes the norm. This evolution requires:

- **Transparent data practices** (clear notices, consent models, algorithm registries).
- **Interoperability frameworks** (legal, organizational, semantic, technical layers).
- **Adaptive governance board**s that include public, private, and civic actors.

Insights from global frameworks and local dialogues highlight that governance is not purely technical—it is cultural and institutional. Different contexts exhibit varying dynamics: authoritarian systems may enforce strong central control, while democratic environments rely on multi-actor negotiation. Neither guarantees success without **accountability, openness, and shared governance principles.**

Political stability remains a prerequisite for continuity, but governance resilience depends on embedding **privacy-by-design, ethical AI, and interoperability standards** into the ecosystem's DNA. In practice, this means creating governance structures that can **survive leadership changes,** maintain trust, and enable innovation without sacrificing rights or transparency.

In Tampere, one the key elements of a working governance structure is a holistic ecosystem approach across different stakeholders. Open, transparent and timely exchange of information,

co-creating solutions together and continuous improvement mindset amongst all stakeholders (public sector, private sector and research sector) and also with public (citizens, NGO's) creates a unique strong element for governance as well.

3.6. Public Service Logic in Ecosystem Context

The Citiverse reframes digital transformation through **public service logic,** which differs fundamentally from **business logic.** Business logic seeks efficiency and profit; public service logic seeks **equity, resilience, and legitimacy.** In an ecosystem context, this means prioritizing **collective outcomes**—climate adaptation, inclusive mobility, trusted governance—over narrow optimization metrics.

Differentiating logics:

- **Business logic:** transactional, competitive, profit-driven; success measured in ROI and market share.
- **Public service logic:** relational, collaborative, value-driven; success measured in societal impact, accessibility, and trust.

In the Citiverse, this distinction shapes **service architecture.** Rather than designing for monetization, systems are built for **participatory governance and citizen empowerment.** Interfaces must be **inclusive by design**—multilingual, accessible, and adaptable to diverse needs. Consent and transparency are not optional features but **core principles,** enabling citizens to understand and influence how their data and digital identities are used.

Principles of good public governance provide the ethical foundation:

- **Transparency:** Clear communication of data practices, algorithmic logic, and decision criteria.
- **Proportionality:** Interventions calibrated to respect rights and avoid overreach.
- **Accountability:** Human oversight for high-stakes decisions; algorithm registries and audit trails to prevent opacity.

These principles align with global frameworks (UN SDGs, DDGs) and echo insights from governance dialogues: strong structures exist in theory, but practice often falters due to fragmented responsibilities and cultural inertia. Embedding governance into the Citiverse requires **systematic interpretation and enforcement of these principles,** not rhetorical commitment.

Service architecture and citizen-centric design operationalize this logic. The Citiverse must integrate **experience-first design**—starting from civic outcomes and flowing backward to data and infrastructure. This includes XR-enabled participation (virtual town halls, spatial budgeting), privacy-preserving analytics, and adaptive interfaces for vulnerable groups. Ethical AI and human-in-the-loop oversight ensure that automation augments, rather than replaces, democratic accountability.

Ultimately, **public service logic in the Citiverse is a social contract expressed through technology.** It demands that digital ecosystems serve as enablers of **trust, inclusion, and shared prosperity,** not as instruments of control or commodification. By embedding these principles into architecture and governance, cities can ensure that innovation strengthens democratic values and delivers tangible public good.

3.7. Participation, Inclusion and Communication Strategies

Participation and inclusion are **cornerstones of the Citiverse vision,** transforming digital infrastructure into a civic platform. Unlike transactional engagement, Citiverse participation is **continuous, multi-layered, and rights-anchored.**

Participation models across governance systems differ widely:

- **Centralized systems** often adopt structured consultation, with limited scope for co-creation.
- **Distributed or federated ecosystems** enable participatory budgeting, open data platforms, and XR-based planning sessions.
- **Hybrid models** combine central oversight with local autonomy, balancing coherence with contextual flexibility.

Rights and responsibilities in citizen engagement must be codified. Citizens have the right to:

- Transparent data practices and algorithmic explainability.
- Accessible participation channels (digital and physical).
- Influence over decisions that affect their lives.Responsibilities include constructive participation, respect for shared norms, and stewardship of community data.

Cultural and systemic differences in inclusion shape design choices. Nordic governance traditions emphasize consensus and trust, requiring **co-design and transparency.** In contrast, contexts with lower institutional trust demand **visible accountability mechanisms,** grievance redress, and strong privacy guarantees. Global South cities often prioritize **affordability and mobile-first access,** while multilingual and culturally adaptive interfaces remain universal imperatives.

Local anchoring and identity are critical for legitimacy. Citiverse experiences should reflect local narratives—through language, visual culture, and context-specific use cases. Identity systems must respect sovereignty while enabling seamless participation across virtual and physical spaces.

Communication and trust strategies by region operationalize these principles:

- **Europe/Nordics:** Emphasize openness, algorithm registries, and participatory XR tools.
- **Global South:** Leverage community intermediaries, low-bandwidth solutions, and inclusive pricing models.
- **Authoritarian or hybrid systems:** Focus on clear governance rules, strong safeguards, and demonstrable benefits to citizens.

Practical mechanisms include **XR town halls, citizen apps with accessibility features,** and **offline engagement for digitally excluded groups.** Communication must be **two-way,** combining proactive information with responsive feedback loops. Trust is earned through **transparency, proportionality, and accountability,** embedded in both governance and technology.

3.8. Data Governance and Transparency

Data is the lifeblood of the Citiverse—but without governance and transparency, it becomes a liability. Effective governance must function at **two levels:**

1. **Organizational governance:** Each agency or department must implement clear policies for data collection, storage, and processing, aligned with legal and ethical standards. This includes appointing Data Protection Officers, conducting privacy impact assessments, and enforcing role-based access controls.

2. **Ecosystem-level governance:** Beyond organizational silos, the Citiverse requires **shared frameworks** for interoperability, consent management, and accountability. This means harmonizing data models, adopting open standards (ISO, ITU, OASC), and creating governance boards that span public, private, and civic actors.

Mechanisms for correcting personal data and ensuring fairness are critical for citizen trust. GDPR and similar frameworks mandate rights to access, rectification, and erasure. In practice, cities should provide:

- **Self-service portals** for data review and correction.
- **Algorithm registries** disclosing logic behind automated decisions.
- **Audit trails** for transparency and accountability.
- **Proportionality principles** to prevent excessive data retention or intrusive profiling.

GDPR as a framework—not a barrier. Far from hindering innovation, GDPR offers a blueprint for ethical digital ecosystems. Its principles—privacy by design, data minimization, and accountability—align with Citiverse goals. Compliance should be integrated into architecture, not treated as an afterthought.

Learning from eGovernment leaders:

- **Estonia:** X-Road enables secure, standardized data exchange across sectors, while digital ID empowers citizens to control access.
- **Denmark:** Strong emphasis on consent and transparency in public services, supported by clear governance structures.
- **Netherlands:** Open data initiatives and algorithmic transparency frameworks set benchmarks for fairness and trust.

These cases prove that **responsible data governance and innovation can coexist.** By embedding privacy, fairness, and interoperability into the Citiverse's DNA, cities can unlock the full potential of data while safeguarding rights and reinforcing public trust.

3.9. Funding, Business Models and Market Dynamics

The Citiverse is not just a technical project—it is an **economic and governance ecosystem.** Its sustainability depends on **funding models, business logic, and market structures** that align innovation with public interest.

Funding models:

- **Public funding** anchors projects in societal priorities, leveraging municipal budgets, national programs, and global initiatives (e.g., UN Digital Development Goals). While stable, it is vulnerable to political cycles and fiscal constraints.

- **Private funding** accelerates technology adoption but risks prioritizing commercial interests over inclusivity and transparency.

- **Blended models (PPPs)** offer agility and scale, provided governance frameworks prevent monopolistic control and ensure accountability.

Public service logic as a value creation model distinguishes Citiverse ecosystems from purely commercial platforms. Whereas business logic optimizes for profit and market share, public service logic measures success in **resilience, equity, and trust.** This requires embedding **good governance principles**—transparency, proportionality, accountability—into contracts, standards, and operational models.

Market dynamics:

- **Monopolistic ecosystems** often emerge when proprietary platforms dominate. They can deliver efficiency but risk vendor lock-in, reduced interoperability, and weakened public oversight.
- **Regulated markets** enforce compliance and fairness, supporting interoperability and ethical safeguards, but may slow innovation if overly rigid.
- **Open markets** encourage competition and creativity, provided interoperability standards and ethical norms are enforced.

Each structure has governance implications:

- Monopolies demand **strong oversight and algorithmic transparency.**
- Regulated markets require **adaptive compliance mechanisms** to avoid stifling innovation.
- Open markets need **shared standards (ISO, ITU, OASC), algorithm registries, and trust frameworks** to maintain fairness.

Global lessons:

- **Estonia** demonstrates how secure interoperability (X-Road) and digital identity enable efficient, trusted ecosystems.
- **Denmark** emphasizes citizen control and consent in service delivery, supported by clear governance.
- **The Netherlands** pioneers open data ecosystems and algorithmic transparency, balancing innovation with accountability.

These examples show that **responsible governance and market agility can coexist.** By combining **blended funding, open standards, and public service logic,** cities can scale Citiverse ecosystems without sacrificing inclusivity or trust.

3.10. Experimentation and Iterative Development

The Citiverse is a **complex, adaptive system,** and its success hinges on **iterative development rather than linear execution.** This chapter outlines how **experimentation, feedback, and scaling strategies** transform vision into sustainable practice.

Pilot projects and learning loops

Pilots are the foundation of Citiverse implementation. They provide controlled environments to test technical components (digital twins, XR interfaces, IoT integration), governance models, and citizen engagement strategies. Effective pilots share three characteristics:

- **Outcome orientation:** Each pilot is tied to measurable KPIs (e.g., reduced flood risk, improved mobility efficiency, increased citizen participation).
- **Cross-sector collaboration:** Public authorities, private partners, and civil society co-create solutions.
- **Knowledge capture:** Lessons learned are documented and shared across the ecosystem.

Adaptive planning and feedback mechanisms

Agility is critical. Iterative cycles—**plan > prototype > evaluate > adapt**—enable cities to respond to emerging challenges and stakeholder feedback. Mechanisms include:

- **Citizen feedback loops** via XR town halls and digital platforms.
- **Algorithm audits** to ensure fairness and transparency.
- **Performance dashboards** tracking resilience, inclusivity, and service quality.

Scaling and replicability across contexts

Scaling requires **modularity and interoperability.** By adopting open standards (ISO/IEC, ITU-T, OASC MIMs), cities can replicate successful pilots without vendor lock-in. Replicability also

depends on **contextual adaptation:** while core architectures remain consistent, cultural and regulatory nuances shape implementation. Global exemplars illustrate this principle:

- **Estonia** scaled secure data exchange through X-Road, enabling cross-sector interoperability.
- **Denmark** institutionalized citizen-centric portals, embedding privacy and accessibility into service design.
- **Netherlands** advanced algorithmic transparency frameworks, reinforcing trust during scale-up.

Why iterative development matters

Big-bang approaches fail in complex ecosystems. Iteration reduces risk, accelerates innovation, and builds trust through visible progress. It also aligns with **public service logic,** ensuring that technology serves societal outcomes rather than short-term efficiency.

3.11. Key Barriers and Transition Risks

The Citiverse represents a paradigm shift, and like all systemic transformations, it faces **multi-layered barriers:**

Structural barriers

- Fragmented governance and overlapping mandates create coordination gaps.
- Siloed data infrastructures hinder interoperability and real-time integration.
- Absence of shared frameworks for identity, consent, and algorithmic transparency.

Cultural barriers

- Resistance to change among public officials and frontline staff.
- Low digital literacy among citizens, limiting participation.
- Fear of automation displacing human roles, eroding trust in technology.

Legal barriers

- Privacy regulations (e.g., GDPR) often misinterpreted as obstacles rather than enablers.
- Lack of clarity on cross-border data exchange and liability in multi-actor ecosystems.
- Slow legislative adaptation to emerging technologies.

Technological barriers

- Legacy IT systems incompatible with modular, interoperable architectures.
- Vendor lock-in and proprietary platforms restricting flexibility.
- Insufficient connectivity and compute capacity for XR and real-time analytics.

Trust, transparency, and institutional inertia

Even where technical solutions exist, governance inertia and opaque decision-making undermine adoption. Citizens demand **clear rights, visible accountability, and grievance mechanisms**—without these, participation remains superficial.

Political and administrative fragmentation

Short electoral cycles and shifting priorities disrupt continuity. Multi-level governance (national, regional, municipal) often lacks coordination, creating duplication and inefficiency.

Lack of shared service logic and coordination mechanisms

Public agencies frequently optimize for their own mandates rather than collective outcomes. Without a unifying **public service logic,** ecosystems risk becoming patchworks of disconnected pilots.

Transition Risks

Scaling from concept to ecosystem maturity introduces new vulnerabilities:

- **Governance drift:** Early clarity erodes as actors multiply, leading to inconsistent rules.
- **Over-centralization:** Tight control persists beyond pilots, stifling innovation and local adaptation.
- **Under-regulation:** Rapid expansion without safeguards risks privacy breaches, algorithmic bias, and reputational damage.
- **Resource misalignment:** Funding and capacity fail to keep pace with scaling ambition

Mitigation strategies

- Embed **privacy-by-design and interoperability standards** from inception.
- Establish **algorithm registries and audit trails** for transparency.
- Create **adaptive governance boards** with multi-actor representation.
- Use **sandbox environments** for safe experimentation before scaling.

Global leaders offer lessons:

- **Estonia** demonstrates secure interoperability and citizen control through X-Road.
- **Denmark** institutionalizes consent and accessibility in service design.
- **Netherlands** pioneers algorithmic transparency frameworks to reinforce trust.

3.12. Ethics and Human Oversight

The Citiverse introduces profound ethical questions. Unlike private platforms, public ecosystems must reconcile **efficiency with legitimacy,** embedding moral reasoning into every layer of architecture and governance.

Moral reasoning and bounded rationality

Decision-making in complex systems is constrained by uncertainty and competing priorities. Algorithms excel at optimization but cannot weigh normative values. Public authorities must therefore apply **bounded rationality**—acknowledging limits while using ethical frameworks to guide choices. This means prioritizing **equity, transparency, and proportionality** over short-term gains.

Human oversight in automated systems

Automation accelerates service delivery but risks eroding accountability. High-stakes decisions—such as welfare eligibility, emergency response, or urban planning—require **human-in-the-loop** mechanisms. Practical measures include:

- **Algorithm registries** disclosing logic and decision criteria.
- **Explainability standards** for AI models.
- **Escalation protocols** for contested or ambiguous cases.

Oversight is not a barrier; it is a **trust enabler,** ensuring that citizens retain agency and recourse.

Ethical frameworks for public sector innovation

Global norms (OECD AI Principles, EU Ethics Guidelines for Trustworthy AI) and local governance codes converge on key principles:

- **Transparency:** Clear communication of data practices and algorithmic logic.
- **Accountability:** Defined roles and audit trails for decision-making.
- **Proportionality:** Avoid excessive data collection or intrusive profiling.
- **Inclusivity:** Design for accessibility and cultural diversity.

Learning from leaders

- **Estonia** integrates algorithmic transparency and citizen control into its digital governance stack.
- **Denmark** enforces human oversight for automated welfare decisions, balancing efficiency with fairness.
- **Netherlands** publishes algorithm registries, enabling public scrutiny and reinforcing trust.

Ethics in the Citiverse is not an afterthought—it is a **systemic design principle.** By embedding ethical safeguards into architecture, governance, and operations, cities can ensure that digital transformation strengthens democratic values and delivers **trusted, inclusive public services.**

3.13. International Case Studies

Citiverse concepts are not theoretical—they are being tested globally through **digital twin and immersive city initiatives.** These cases illustrate how **ecosystem architecture, governance, and citizen engagement** converge in practice.

Tampere (Finland)

Tampere's **Digital Vision 2035** positions the city as a collaborative platform, embedding life-event-driven services and a city-scale digital twin. Its approach emphasizes **public service logic,** interoperability, and citizen-centric design, aligning with SDGs and DDGs.

Rotterdam (Netherlands)

Rotterdam leverages digital twins for **flood resilience and climate adaptation,** integrating IoT sensors, weather data, and geospatial analytics. Governance is multi-actor, involving municipal authorities, research institutions, and private partners—an example of **hybrid governance** in action.

Valencia (Spain)

Valencia's virtual city twin supports **urban management, tourism, and heritage preservation.** Citizen engagement is enabled through XR interfaces and open data portals, reinforcing transparency and participation.

Singapore

Singapore's **Virtual Singapore** is a national-scale 3D platform enabling **scenario planning for sustainability, mobility, and emergency response.** It demonstrates how **centralized governance with strong standards** can deliver interoperability and trust at scale.

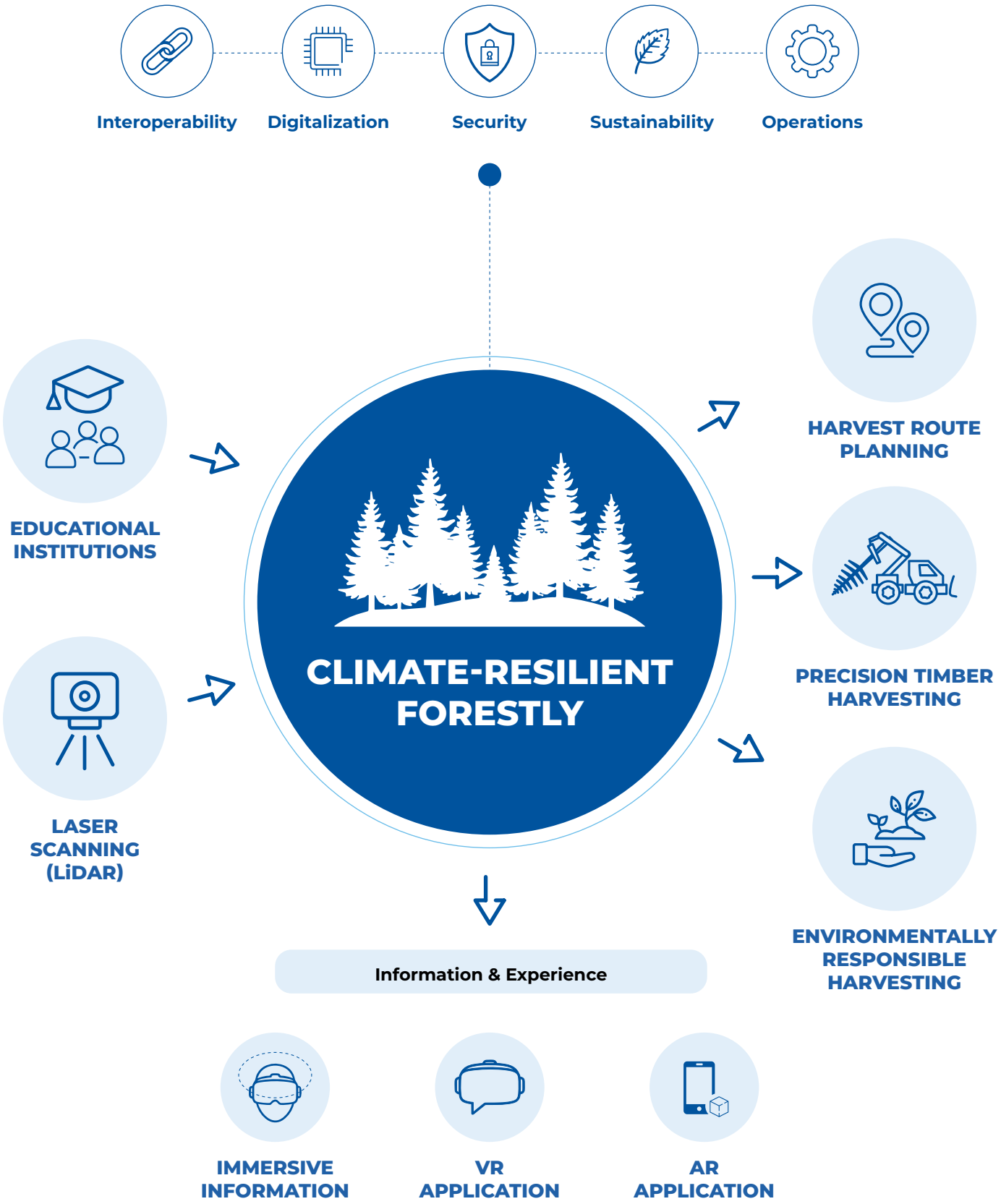
Dubai

Dubai's **Virtual AED2030** integrates XR citizen services with smart infrastructure planning, reflecting a **top-down governance model** adapted to local cultural norms. Its focus on immersive engagement and predictive analytics aligns with Citiverse principles.

Lessons Learned and Contextual Adaptation

- **Start small, scale smart:** Successful ecosystems begin with domain-specific pilots (e.g., mobility, resilience) and expand modularly.
- **Governance matters:** Open standards and algorithm registries prevent lock-in and build trust.
- **Local anchoring:** Cultural narratives, language, and regulatory frameworks shape adoption.
- **Participation and transparency:** XR town halls, citizen apps, and algorithm disclosure strengthen legitimacy.

These cases confirm that **Citiverse ecosystems thrive when technology, governance, and participation co-evolve,** balancing **global interoperability with local identity.**


Interoperability
Digitalization
Security
Sustainability
Operations
EDUCATIONAL INSTITUTIONS
LASER SCANNING (LiDAR)
CLIMATE-RESILIENT FORESTLY
HARVEST ROUTE PLANNING
PRECISION TIMBER HARVESTING
ENVIRONMENTALLY RESPONSIBLE HARVESTING
Information & Experience
IMMERSIVE INFORMATION
VR APPLICATION
AR APPLICATION

ACTORS

Educational institutions

Educational institutions integrate learning, community building, place-based engagement and digital inclusion.

TECHNOLOGY

Laser scanning

Utilizing existing machine trails and open areas in the terrain.

SERVICES

Harvest route planning

Tree selection and forest management at the micro-stand level.

Precision timber harvesting

Educational institutions integrate learning, community building, place-based engagement and digital inclusion.

Environmentally responsible harvesting

Climate-resilient thinning operations take into account erosion-sensitive slopes and soft soils, as well as biodiversity considerations in logging.

INFORMATION CONTENT

Immersive information

Immersive information refers to presenting and experiencing information in a way that allows the user to become absorbed in the content multisensorily and interactively.

APPLICATIONS

VR application

VR application provides experiential value in use cases where the goal is to create deep, immersive, and temporally extended experiences.

AR application

AR application provides experiential value in use cases where the goal is to create deep, immersive, and temporally extended experiences.

3.14. Practical tools to move forward

A. Implementation Checklists

A1. Governance Readiness

- Governance model decided (centralized / distributed / hybrid) and documented.
- Multi-actor governance board (public, private, academia, civil society) with clear mandates.
- **Algorithm registry** and **AI explainability** requirements defined; human-in-the-loop for high-stakes decisions.
- **Privacy-by-design** and **ethical principles** (transparency, proportionality, accountability) embedded.
- Performance/KPI set (resilience, inclusivity, service efficiency), with public reporting cadence.

A2. Technical Backbone

- Asset registry complete (location, attributes, condition).
- Connectivity plan: fiber for backbone; 5G/Wi-Fi/LPWAN per latency/coverage needs; redundancy/failover.
- Hybrid cloud–edge **data hub** (lakehouse, lineage, governance), open **APIs.**
- Interoperability standards adopted: **OASC MIMs, OGC** (SensorThings/3D Tiles), **ISO/IEC** (geospatial, asset, AI governance).
- Security posture: device identity, code signing, secure boot, segmentation, continuous monitoring.

A3. Citizen Engagement & Inclusion

- Participation channels (**XR town halls,** apps/web portals) with **accessibility & multilingual** support.
- Consent management, **self-service portals** for data access/correction, grievance redress.
- Two-way communication loops; publish decisions, rationale, and algorithmic policies.

B. Visual Toolkit (deliverables)

- **Maturity Matrix (Levels 1–5):** Concept > Pilot > Development > Operational > Scaled Ecosystem, each mapped to governance, technical, and engagement capabilities.
- **Playbook Pathways Diagram:** arrows and feedback loops—**Plan > Prototype > Evaluate > Adapt > Scale.**
- **Governance Evolution Flow:** Tight control (early) > Hybrid (structure + autonomy) > Horizontal coordination (multi-actor).
- **Risk Matrix:** Structural / Cultural / Legal / Technological barriers × Mitigations × **Transition risks** (governance drift, over-centralization, under-regulation, resource misalignment).

C. Contract & Policy Templates

C1. PPP / Procurement Clauses

- **Open standards & format portability** (no vendor lock-in).
- **Data sovereignty,** consent & audit trails; rights to **algorithmic transparency.**
- **Interoperability obligations** (APIs, schemas), security baselines, accessibility requirements.
- Service-level objectives (latency, freshness, availability), **KPI reporting,** penalties & remediation.

C2. Citizen Data Rights Policy

- Access, rectification, erasure (where lawful), portability; consent renewal cycles.
- **Explainability** for automated decisions; human escalation routes.
- Proportionate retention; de-identification; **public algorithm registry;** incident disclosure.

D. Case-Based Lessons (list format)

- **Tampere:** Life-event anchoring builds relevance; define outcomes first, then assemble tech.
- **Rotterdam:** Start in **resilience;** co-produce standards and models with utilities & researchers.
- **Valencia:** Use **XR** to make planning tangible; publish open datasets to sustain trust.
- **Singapore:** Identity + standards = scalability; central orchestration can work if accountability is visible.
- **Dubai:** Pair immersive front-ends with clear rules; align with local culture & expectations.

Each bullet can be expanded into a **one-page "pattern card"** (context > challenge > approach > outcomes > re-use).

E. Quick Reference Tables

- **Funding Models vs. Governance:** public / private / blended <> oversight, transparency, risk of lock-in.
- **Public Service Logic vs. Business Logic:** societal outcomes vs. ROI; equity/trust vs. monetization.
- **Participation Models vs. Regional Strategies:** centralized / distributed / hybrid <> communication & trust tactics.

F. Transition Risk Dashboard

- Governance drift, over-centralization, under-regulation, resource misalignment > **early warning indicators** and **mitigation playbooks.**

3.15. Appendices

A. Agreement Templates and Governance Models

Purpose: provide ready-to-adapt contractual language and operating models that preserve **interoperability, public value, and trust** across multi-actor ecosystems.

1. **Public–Private Partnership (PPP) / Procurement Model Clauses**

- **Open Standards & Portability:** require APIs, schemas and formats aligned to OASC MIMs / OGC / ISO to prevent lock-in.
- **Data Sovereignty & Privacy-by-Design:** stipulate citizen data rights (access, rectification, erasure where lawful, portability), proportional retention, and de-identification; mandate DPIAs for high-risk services.
- **Algorithmic Transparency & Human Oversight:** require algorithm registries, model documentation, and human-in-the-loop review for high-stakes determinations.
- **Accessibility & Inclusion:** embed multilingual UX, WCAG-conformant front-ends, and assistive modalities; include measurable SLOs (latency, freshness, availability) and audit rights.

2. **Governance Operating Models**

- **Centralized:** rapid decisions and clear accountability; use when national/legal mandates require uniformity.
- **Distributed / Federated:** resilient and innovation-friendly; define shared standards, inter-agency MoUs, and escalation routes.
- **Hybrid:** central policy + local autonomy; recommended for city-region ecosystems to balance coherence with context.
- **Evolution Path:** tight control (pilot) > hybrid (multi-actor) > horizontal coordination (ecosystem co-production).
- **Reference anchors used in this playbook:** structural governance and standards discussions derive from the **Global Digital Citiverse Framework (Track 7),** including its technical backbone and interoperability sections (Ch.1–6).

4 . Future of Citiverse


Kuva: Laura Vanzo / Platform6 / Visit Tampere

The global future of the Citiverse will not be a single “planet-scale platform”, but a **federation of interoperable city capabilities:** connected local digital twins, trusted data sharing, AI-enabled services, and immersive participation channels. In this direction, the Citiverse becomes a form of **public digital infrastructure for cities**—built to be open, safe, inclusive, and aligned with sustainable development goals.

4.1 What the global Citiverse is likely to become

- **From pilots to infrastructure:** digital twins, city data spaces, identity/trust services, and interoperability “minimums” (e.g., OASC MIMs) move from project mode to permanent city infrastructure.

- **Networked local digital twins (federation over centralization):** cities keep control over their models and data, but connect them for cross-city use cases (climate risks, mobility corridors, events, logistics, and shared resilience scenarios).

- **Data spaces become the connective tissue:** more high-value data is shared "at the source" under clear rights, governance, and cybersecurity, enabling multi-actor collaboration without mass copying of sensitive datasets.

- **AI moves from analytics to orchestration:** AI supports situational awareness, simulation, and service coordination (e.g., mobility optimization, energy balancing, emergency response). The key global shift is that AI is deployed with auditing and accountability as standard practice.

- **Immersive tools become an interface, not a destination:** AR/VR is used where it improves participation and understanding (virtual town halls, planning "what-if" exploration, training), while most value is created by the data/twin/AI layer behind the scenes.

- **Trust-by-design becomes non-negotiable:** citizens and institutions expect transparent data practices, clear consent where relevant, algorithm registries (for impactful AI), and accessible grievance/appeal routes.

- **Resilience becomes a primary driver:** climate adaptation, infrastructure dependencies, and crisis preparedness push cities to adopt operational digital twins and shared playbooks, not only planning twins.

- A marketplace of reusable components emerges: instead of bespoke city builds, the ecosystem shifts toward reusable building blocks (connectors, data models, simulation modules, XR participation tools) that can be validated and replicated across regions.

- **Public service logic stays the differentiator:** unlike consumer metaverses, the Citiverse remains anchored in public value—equity, legitimacy, wellbeing, sustainability—so success is measured in outcomes, not only usage.

- **Global alignment strengthens through "soft" and "hard" layers:** the EU pushes implementation infrastructure (EDIC/LDT toolbox, data spaces), while ITU/UN initiatives focus on global guidance, inclusion, safety and trust, capacity building, and shared terminology—together improving interoperability worldwide.

4.2 What success could look like (2030–2035)

By the early 2030s, "Citiverse-ready" cities will be able to **connect and collaborate quickly** across borders: exchange city-twin outputs through interoperable interfaces, run shared resilience simulations, and involve citizens in decisions through accessible digital channels. For citizens, this should feel less like living in a virtual world and **more like living in a city where services are more proactive, more transparent, and more inclusive.** For industry and inno-

vators, success means a larger market for solutions that comply with open standards and trust requirements—reducing reinvention and accelerating replication.

4.3 Risks to avoid

The biggest risks are: (1) **fragmentation** into incompatible city-twin stacks; (2) **vendor lock-in** that blocks reuse and learning across cities; (3) "smart surveillance" dynamics that damage trust and legitimacy; (4) **exclusion** if immersive or AI-enabled services are not designed for accessibility and low-friction access; and (5) **cybersecurity failures** that turn connected infrastructure into systemic risk. A global Citiverse will only scale if trust, interoperability, and public value are treated as design requirements—not as add-ons.

4.4. Vision of different futures with different groups of citizens

The following vignette is not a prediction, but a grounded imagination exercise: a single day in a Citiverse-ready city roughly 10–15 years from now, where networked digital twins, trusted data sharing, ambient AI, and spatial interfaces have become ordinary infrastructure. The purpose is to make the abstract tangible—by seeing how the same city feels different when experienced through the eyes of a child, a teenager, a working-age adult, and an older citizen.

A day in the Citiverse (2036–2041): five lives, one city

Morning begins before the streets look awake. The city's physical rhythms still exist—trams passing, lights changing, doors opening—but they are now shadowed by a quieter layer: a continuously updated civic digital twin. It is not a single 3D model, but a federation of models—transport, energy, weather, public space, events, health, education—stitched together by open interfaces and rules about what can be shared, when, and for what purpose. Most people do not "enter" the Citiverse the way earlier generations entered a website. They simply move through the city, and the city responds—sometimes with visible cues through glasses or public displays, sometimes with invisible orchestration that makes queues shorter, crossings safer, and services more proactive.

1) Aino, 8: the city as a learning playground

Aino's school morning starts at the kitchen table, but the first "lesson" is already outside. Her jacket sleeve has a soft haptic strip—cheap enough that every child has one, simple enough that it never needs a password. When she steps into the stairwell, it vibrates twice: a gentle, universal signal meaning "your planned route is safe." Her mother does not see the same message, because she does not need it. Aino's safety profile is different: the system uses the city's real-time picture—weather, lighting, traffic, crowd density, construction zones—to choose a route that avoids a slippery underpass and a temporarily busy crossing near a building site.

At the park the city has placed small, almost invisible beacons in the ground—not to track children, but to anchor public content accurately. Aino points her inexpensive glasses toward

an old birch tree and the bark becomes a storybook: a translucent overlay shows how the tree exchanges nutrients with fungi, where birds nest in spring, and how storms affect root stability. The content is local, in her language, and designed to be understood at eight years old. She does not need to log in; the city treats this as public digital infrastructure, like a library. When she tries to record a clip for her class project, the system asks one clear question—"Share only with your class?"—and shows an icon of who will have access. Her mother once taught her that in this city you do not share by accident. Consent is not buried in legal text; it is made into something a child can understand.

In the classroom, the "board" is still a wall, but it can become any place. Today it becomes a scaled model of the neighbourhood, because the class is planning a safer route to the library. The teacher does not ask children to memorize traffic rules in the abstract. Instead, they walk through scenarios in the school's twin: what happens if a bus is delayed and more pedestrians arrive at once; what happens when it rains; what happens when the tram stop is crowded because there is a sports event. Children propose changes—more lighting here, a different crossing there—and the teacher sends the group's suggestions to the city as a structured package: a small civic "proposal object" linked to the same data layers the planners use. Aino's class does not know the technical term for what they are doing. They just know that the city listens, and that their ideas are treated as real, not as a school exercise.

On the way to school, Aino passes a tram stop where the timetable is no longer a fixed list but a living promise. The display shows two lines: what is scheduled, and what the city currently believes will happen. A small icon—designed like a children's sticker—signals "high confidence." Another means "could change." Aino likes the honesty of that. She has learned that the city does not always know the future, only probabilities. When the wind picks up and a light snow starts falling, the stop quietly changes its own behaviour: warmer lighting, less glare, and a slightly brighter edge line painted in light on the platform to make the boundary obvious for small feet and tired eyes alike.

At school, a quiet kind of personalization happens that adults often miss. One child in Aino's class struggles with reading; another is learning the language; a third is sensitive to noise. The room adapts without labeling anyone. When the teacher starts the group exercise, Aino's glasses show simple pictograms, while another child sees the same content with line-by-line highlighting and slower pacing. The system works because the profiles are stored locally under the family's control and shared only as "needed capabilities," not as diagnoses. Even the teacher does not see the underlying reasons—only what helps each child participate. This is one of the Citiverse's smallest revolutions: it makes support ordinary, not exceptional.

After lunch, the class walks to the library. The route is the one they discussed earlier, and Aino feels proud when she recognizes the "problem corner" that the twin had shown—a spot where sightlines are short and bicycles come fast. Today, the city has temporarily reconfigured it: a projected zebra crossing appears for two hours because a nearby school group has registered a walking slot. Nothing permanent has changed yet; the city is testing a solution in the real world before pouring concrete. Aino's teacher later explains that the city can run "micro-trials" now—short-lived adjustments to lighting, signaling, and markings—then measure whether people feel safer and move more smoothly. For Aino it is simple: the city can practice, like children do.

On the corner of the kitchen table sits a small cardboard "city kit" Aino built in class: a paper street, a tiny bridge, a few trees cut from green felt. Her mother used to think learning about a city meant reading a textbook chapter. Now it often starts with play, and play is connected to the city's real patterns without exposing anyone's private data. When Aino places a tiny blue sticker on the paper road—"icy"—her school app pulls a public weather object and shows what "icy" means for walking speed and risk. It is not a scary warning, only a child-friendly simulation: little dots representing pedestrians slow down; a small icon suggests adding grit. Aino is learning, without being told, that the city is a system of cause and effect, and that her observations matter.

At school pickup time, Aino's mother receives a short message that reads more like a story than a report: "Aino explored tree biology in the park layer; she shared one clip with her class; she contributed two notes to the safe-walk project." The message is deliberately plain, because the city learned that parents do not want dashboards. They want reassurance and a way to talk with their child. Aino's mother taps one item and sees the same consent prompt Aino saw earlier, preserved as a "receipt": who can view the clip, for how long, and how to revoke access. It is a small detail, but it changes the tone of family life. Technology becomes something they discuss together, not something that quietly happens to them.

Park learning overlay

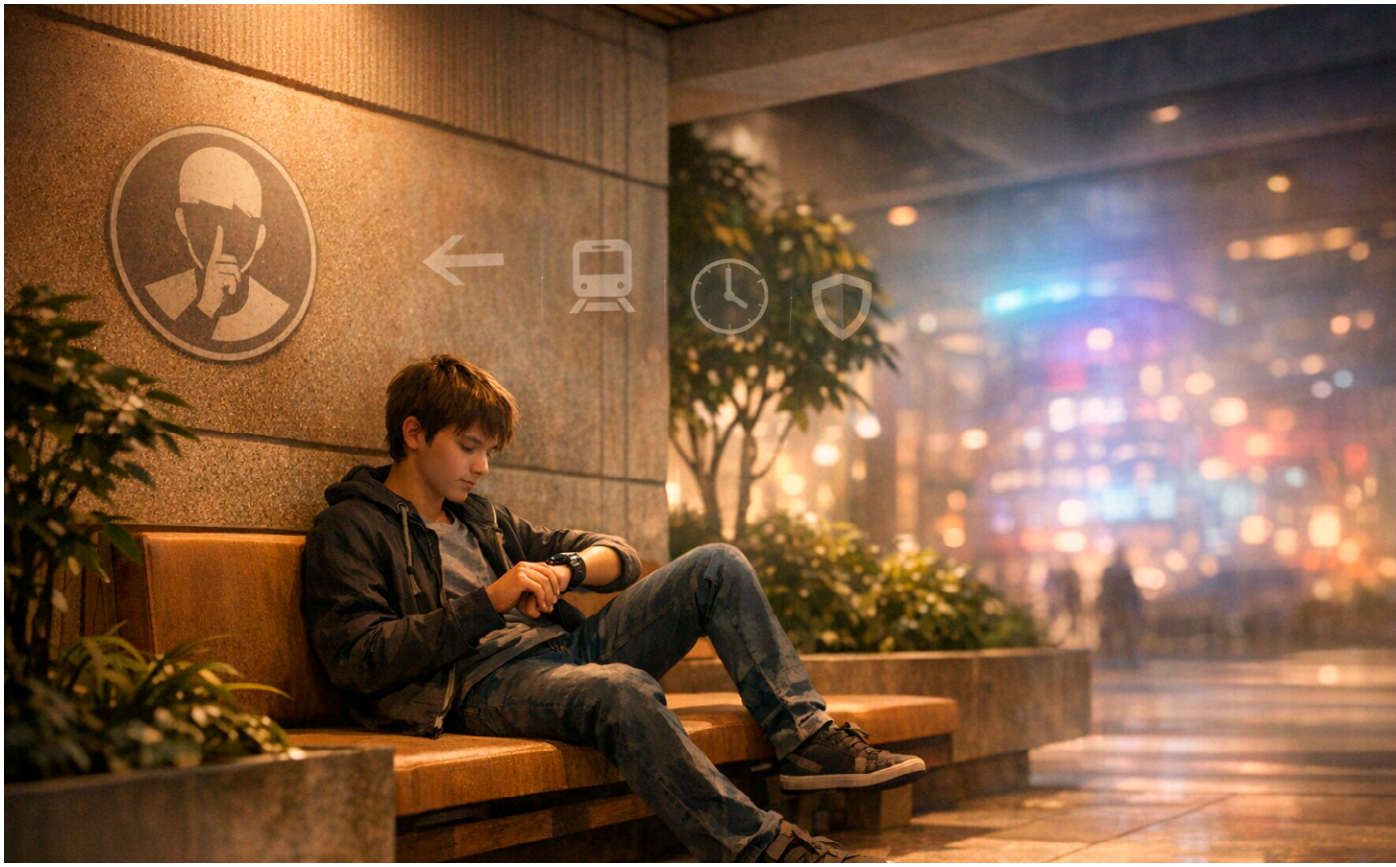
In the afternoon, Aino and her friend stop at a small plaza on the way home. The plaza looks normal—benches, a fountain, a few trees—but it has a “quiet layer” designed for children: when the space detects a school-age cluster arriving, the fountain shifts into a slower pattern and a playful, low-volume soundscape begins near one corner, making the area feel like a place to linger rather than rush through. The system does not identify the children; it only reads the rhythm of movement and the time window. Aino’s bracelet vibrates once again, not as surveillance but as a simple agreement between the city and the child: we are paying attention to the kind of attention children deserve.

At night, Aino’s world narrows to the radius of a bedtime routine. Yet even here the Citiverse is present—not as spectacle, but as a quieter kind of care. Her mother opens the class project clip Aino recorded at the tree, and the system offers one last reminder: the sharing window ends in two days unless renewed. Aino chooses to let it expire. She likes the idea that memories can be shared without becoming permanent. When the lights dim, Aino’s haptic sleeve gives a soft single pulse—“home mode.” It doesn’t mean she is being tracked. It means the household’s chosen settings are active: fewer notifications, no late prompts, and a gentle safety perimeter that only triggers if a door opens unexpectedly. Aino falls asleep thinking not about the city’s technology, but about the birch tree’s hidden roots, now part of her own inner map.

2) Mika, 16: identity, autonomy, and the right to disappear

Mika leaves home later, with the practiced speed of a teenager who knows where time leaks away. His relationship with the Citiverse is different from Aino's. He is not impressed by overlays and smart routes; those are background. What matters to him is control—what the city assumes about him, what it offers him, and what it refuses to know. When he turns on his "private mode," his glasses still show public information—transit times, museum hours, the location of a water fountain—but the city does not personalize. No suggestions based on his history, no nudges about his sleep schedule, no "helpful" mental health prompts. In earlier decades, privacy was something you had to fight for. In this city, it is a designed feature: the right to disappear from personalization without disappearing from the public realm.

At school, Mika meets his study group in a hybrid room where some students are physically present and a few appear as volumetric "presence tiles" because they are home with illness or caring responsibilities. The group is preparing for an exam, and their AI tutor is not a single personality but a set of small agents—one specializes in explaining concepts, another in checking logic step-by-step, another in suggesting practice tasks. The teacher can see which agents were used, how often, and for what purpose, because the city requires transparency for AI used in public education. Mika can also see it. On his wrist device, one tap opens a plain-language view: "This recommendation was based on your recent practice tasks and the official curriculum goals. No health data used. No location data used." It is not poetry, but it is trust made practical.



No-nudge zone

After class, Mika heads toward the arena district where a concert will fill the evening. The city is already preparing: not with police tape and megaphones, but with subtle choreography. Tram frequency increases, pedestrian crossings get longer green phases, and lighting shifts to make routes legible. In the Citiverse layer, the event is a moving system of flows. Mika sees a simple message—"Less crowded path to the west entrance"—and chooses to ignore it, taking the busy route because that is where his friends are. The point is not to force behaviour. The point is to give the option. This is one of the city's quiet rules: guidance without coercion.

Mika's friends tease him for reading the "why" behind recommendations, but he does it anyway. He has grown up in the era of algorithm registries and public debates about automated decisions, and he knows that convenience can slide into manipulation. Sometimes he opens the city's public ledger—an interface that shows what categories of systems exist (mobility orchestration, learning support, public-space safety) and what they are allowed to do. It is written in plain language first, legal language second. When a system crosses a boundary—like targeting minors with commercial nudges—the city can be challenged, and Mika has seen it happen. The point is not that the city never makes mistakes. The point is that there is a visible path from complaint to correction.

On the way to the concert district, Mika flips into a creative layer that is not city-run at all. A local youth collective has published an AR "skin" for the main square—digital graffiti that appears only if you opt in. The city permits it through a licensing model that treats certain virtual overlays like street art: allowed in defined zones, time-bounded, and removable if it becomes harmful. Mika's generation cares about the right to remix their environment. They do not want a sterile, corporate metaverse; they want spaces where culture can breathe. In the Citiverse city, that tension has been negotiated into a rule set: freedom with guardrails, expression with accountability.

As darkness settles, Mika experiences another kind of design choice: safety that does not feel like suspicion. Around the venue, the city's situational systems use aggregated crowd patterns and edge analytics to detect dangerous congestion, not to identify individuals. When a bottleneck starts forming near a stairwell, lighting shifts to guide people toward an alternative corridor, and a soft audio cue activates only in that micro-area. Mika notices it, adjusts his path, and keeps talking with his friends. Later, if something had gone wrong, the system would have produced a "decision trace"—what signals were detected, what interventions were triggered, and who had oversight. Mika likes knowing that even safety systems can be audited. It makes the city feel like a partner rather than a watcher.

Mika's autonomy is also social. He maintains a "circle" that changes by context: friends, family, school, public. In the Citiverse city, identity is not a single login. It is a set of credentials and relationship tokens he can present selectively—proof he is allowed into the evening event, proof he is a student for a discount, proof he has completed a first-aid course, without sharing his name when it is not needed. This selective disclosure has become normal, like showing a ticket without handing over your diary. It reduces the constant trade of privacy for access, and it gives Mika a language to say no without feeling paranoid.

He still feels the pressure of being seen, of course. Cameras exist. People record everything. The difference is that the city's public systems are required to behave differently from commercial ones. When a rumour spreads at school—an edited clip making someone look foolish—the school's mediation team uses a verification service that checks provenance markers on media. It cannot erase gossip, but it can establish what is authentic and what is manipulated, and it can do so without creating a permanent dossier. Mika watches this and learns a new form of literacy: in the Citiverse era, truth is supported by infrastructure, not by trust in a single platform.

Before meeting his friends, Mika steps into a small "no-nudge zone" near the transit hub. It is a public policy made physical: in certain places—schools, clinics, youth centers, and designated quiet corners—commercial overlays are suppressed, and public overlays are limited to essentials. The city learned that attention is part of health. The air feels the same, the benches are the same, but Mika notices the absence: no shimmering ads, no algorithmic invitations to buy, no "you might like" trails following his gaze. He sits for three minutes, checks a message from his mother, and then leaves. The best technology in this moment is restraint.

At the venue entrance, the flow is almost effortless. Mika's ticket is a one-time credential stored in his wallet app; he presents it, the gate confirms validity, and nothing else is retained beyond an anonymous count. But one of Mika's friends complains: "Why is it slower for me?" The system explains, quietly, that his friend chose an extra safety option last month after losing his phone—stronger verification, more steps. In the Citiverse city, friction is often the visible cost of choice. Mika understands the logic, but he also understands the social embarrassment of being "the one who needs extra checks." The city tries to design dignity into these moments, yet it cannot fully erase the awkwardness of being human.

Inside the concert, Mika feels what the city cannot simulate: heat rising from the crowd, bass vibrating through ribs, voices folding into one another. Yet the Citiverse still matters at the edges. The venue's safety layer watches flows in aggregate, and when a corridor becomes too dense the lighting shifts subtly, making an alternate route feel obvious without feeling like an order. Mika notices that nothing flashes his name, nothing "scores" his behaviour. The only personalization is what he brings himself: his chosen accessibility settings, his private mode, his circles. When he records a short clip, his device asks whether faces should be blurred by default. He accepts. It's not because he has become moral overnight; it's because norms changed, and the tools made the decent choice easier than the careless one.

When the concert ends, the city becomes a moving organism. Doors open, thousands exhale into the streets, and the night fills with small decisions: which direction, which platform, which friend to follow. Mika switches his glasses back to "public only." He wants to be uninteresting to the system, and the system accepts that. The route guidance becomes generic—well-lit streets, open services, last departures—without linking to him as a person. The city has learned that young people need two things at night: safe options and the dignity of not being treated as a problem. Mika walks with his friends to the transit stop. A "late-night calm corridor" activates along the way—brighter lighting, fewer crossing conflicts, more visible staff presence—built from infrastructure, not surveillance. By the time he gets home, his digital traces have already begun to fade, by design.

Around midnight, the city quietly runs its most important routines—the ones nobody applauds. A thin band of freezing rain is predicted to pass through before dawn, and the civic twin turns the forecast into coordinated action: maintenance routes are re-planned, grit and de-icing schedules reshuffle, lighting along key walking corridors increases to reduce glare on wet pavement, and transit timetables adjust in small increments to keep late-night transfers from piling into crowded platforms. Somewhere in that choreography, Aino's street becomes a little safer for the morning walk she will take without thinking about it. Mika's journey home stays calm because crossings and signals have been tuned for the departing crowds. Sara's personal assistant receives a public "night works" object and quietly updates her tomorrow's commute—locally, without revealing anything about her. Jari's building slips into an energy-saving mode that still keeps the air clean for cleaning staff finishing their shift. Leena sleeps while her preferred route to the community centre is flagged as "treated first," not because the city knows her name, but because the city has learned which sidewalks matter most to people who walk slowly. In a Citiverse-ready world, midnight is where technology stops trying to impress and starts proving it can be trusted.

3) Sara, 28: work, services, and a personal digital twin that is actually hers

Sara's day begins with a choice that used to require paperwork: she is switching jobs and moving apartments in the same month. In earlier times, each change would have triggered separate bureaucratic journeys—new addresses, new contracts, new benefits, new daycare schedules, new transport passes. Now the city treats it as one life event. Her personal "life-event assistant" opens a timeline that she can drag like a ribbon: start date at the new job, move-in date, notice period, estimated income, commuting preferences, desired energy profile for the apartment. The assistant can propose a plan only because Sara allows it to temporarily connect her data sources: employment contract, housing options, transport patterns, and a budget boundary she sets herself. The city's system does not "own" her data; it negotiates access, and the negotiation is visible.

When Sara approves the plan, she receives something like a modern receipt: a short, human-readable record of what was accessed, for how long, and by which service. She can revoke permission later, and the system must prove it complied—because the rules of the city's data space are designed around auditability. In her inbox, the message is mundane: "Access granted for 30 days to employment contract metadata (not full text) for onboarding eligibility checks." Yet this mundane clarity is what makes the Citiverse feel safe. It is the opposite of the old digital world, where convenience often meant opacity.

Sara works in a small company that builds services on top of the city's open interfaces. Her team meets in a mixed setting: two colleagues at home, one traveling, three in a shared studio. They stand around an interactive model of a street segment—pulled from the public digital twin but enriched with their own design layer—and test a new wayfinding service for international visitors. Their prototype can "snap" onto public anchors (bus stops, cultural venues, hospitals) because the city maintains a shared spatial reference. For Sara, this is not science fiction; it is simply how work happens. The city is no longer only a market. It is an API-enabled environment where small companies can build value without asking permission from a single platform owner.

Mixed reality planning view

Sara's afternoon includes a civic task that used to be intimidating: commenting on a redevelopment plan near her new apartment. Instead of reading PDFs, she steps into a lightweight mixed-reality view of the street as it is and as it could be. She can toggle between scenarios—more trees, fewer parking bays, a redesigned crossing—and see estimated impacts: shade in summer, noise levels, walking times, accident-risk proxies. The numbers are not presented as certainties; they come with ranges and assumptions, and she can open the sources if she wants. She leaves a comment by drawing directly onto the scene: "Make this corner slower for bikes," and the system turns her mark into a structured suggestion linked to the exact coordinates and scenario version. Participation becomes something you can do in three minutes while waiting for coffee.

In the late afternoon, Sara gets a notification from her own personal twin—again, not a city-owned profile but a bundle of models and preferences she carries across services. It suggests she might want to adjust her commuting plan next week because construction will shift tram platforms. She notices the subtle but important detail: the suggestion did not come from continuous tracking. It came from two things she chose to share—her preferred commute corridor and her "reliability preference" (she would rather arrive early than risk lateness). The city's side simply published a construction-change object through open interfaces, and her own assistant matched it locally. This is what digital sovereignty feels like in everyday life: systems talk, but your personal context stays yours.

Back in the studio, Sara's team prepares for a pilot launch. In earlier years, a small company would have struggled to negotiate data access and integration with city systems. Now, much of that complexity is standardized: data-space contracts, security baselines, and interoperability tests are packaged as a repeatable onboarding process. Their service must pass a conformance check—does it respect consent signals, does it cache only what it is allowed to, does it provide an explanation view for users?—and once it passes, it can be deployed to multiple cities that share compatible building blocks. Sara is proud that her work is both local and exportable. The Citiverse is not only a citizen experience; it is also an ecosystem economy built on rules that let smaller actors compete.

Later, Sara meets a landlord in a building that offers three "energy personalities." One optimizes for the lowest bills, another for the lowest emissions, and a third for steadiness—never too hot, never too cold, even if that costs more. In the past, these would have been marketing claims. Now they are tied to verifiable performance histories published through the building's operational twin: past consumption, retrofit timelines, comfort complaints, maintenance responsiveness. Sara can inspect the summary without seeing any other resident's private details. The twin makes the offer legible. It turns the hidden life of a building—pipes, insulation, sensors, routines—into something a citizen can understand well enough to choose.

In the elevator, she opens her data wallet and checks permissions the way earlier generations checked bank statements. One vendor app still has access to her location history from a travel week months ago. She revokes it with a swipe. Another service requests access to her "mobility preference profile" to recommend a subscription bundle; Sara denies it and chooses a public option instead. The city's systems do not punish her for being cautious. They have learned to compete for trust, not for capture. When Sara closes the wallet, she feels the quiet relief of agency—an emotion that used to be rare in digital life.

Back at work, Sara's team ships faster than teams once could, largely because software has changed. Their development environment includes code-generating agents that propose modules, write tests, and even suggest security fixes. But speed comes with obligations. Before deployment, the service must produce a compliance bundle: what data it touches, what models it uses, how it handles bias, what logs it keeps, what users can contest. This documentation is partly automated, but Sara knows that automation can also automate nonsense. She reads the bundle like a pilot reads a checklist: not because she distrusts her tools, but because public trust depends on boring diligence. In the Citiverse economy, governance is not a barrier around innovation; it is part of the product.

In the evening, Sara joins a short virtual neighborhood meeting. She does it from her couch, but it does not feel like scrolling a feed. The meeting is spatial: a simple shared model of the block, with proposals pinned like notes on a map. People can speak, type, or just point. A translation layer helps those who prefer another language; an accessibility layer turns complex planning terms into simpler ones when requested. Not everyone participates, and Sara knows that democracy will always be imperfect. Yet she also knows that the barrier has dropped. Participation is no longer reserved for people with free evenings, strong confidence, and patience for bureaucratic language. It has become something you can do briefly, honestly, and without needing to be an expert.

After the neighborhood session, Sara closes the spatial model and feels the familiar fatigue of having cared. Participation is easier now, but it still costs attention. Her assistant suggests a summary of what changed and what did not—who supported which option, which constraints the city cited, what the next decision point will be. Sara saves it and sets a reminder for later; she refuses the temptation to keep optimizing her civic life in real time. Then she does something that would have felt radical a decade earlier: she opens her permission ledger and checks what the meeting used. The answer is comforting in its smallness: temporary audio transcript for accessibility, anonymized interaction counts, no personal profile linkage. The city's systems cannot demand trust. They can only behave in ways that deserve it.

Later that night, Sara walks past a street where new lighting has been tested for nighttime comfort. She sees two realities at once: the physical glow and the invisible governance behind it—who decided, who evaluated, what metrics were used, and whether people could contest the change. She does not open the details now. She simply notices that the option exists, like a door in the wall. At home she activates a personal rule: "no service nudges after 22:00 unless safety-critical." Her assistant complies without argument because it runs on her terms. The Citiverse has given Sara many tools, but the most valuable one is this: the ability to say, consistently, 'not now.'

4) Jari, 45: the city that negotiates with your time

Jari's morning is a set of constraints: a meeting across town, a child who needs to be dropped off at practice, an elderly parent whose medication needs renewing, and a project deadline that will not care about any of it. In the old city, these constraints would collide until the day fractured into stress. In the Citiverse-ready city, the collisions are not eliminated, but they are negotiated. Jari's mobility assistant does not merely choose a route; it explains trade-offs. " If you take the tram now, you arrive five minutes earlier but will walk longer in rain. If you take a shared pod, you arrive later but can complete two administrative tasks on the way." Jari chooses the pod, because time has become the rarest currency.

Inside the pod, the city's interface is not a screen that demands attention. It is voice, when he wants it, and silence when he does not. A reminder appears: "Prescription renewal eligible. Would you like to request it now?" In earlier years, such a message would have felt invasive. Now it is normal, because the city has learned a discipline of minimalism: it asks only when it can act, and it states clearly why it is asking. Jari confirms, and the request is routed to a clinician queue. He knows it will not be decided by an algorithm alone; the system can propose, but a professional confirms. This boundary—automation for the repetitive, responsibility for the consequential—has become one of the city's non-negotiables.

At work, Jari manages facilities for a public building. The Citiverse has changed his job, not by replacing him, but by making him responsible for a smarter system. The building has its own operational twin linked to the city's energy and maintenance layers. When a ventilation unit starts behaving oddly, the system does not merely send an alert; it shows a hypothesis ("filter degradation likely"), the evidence (sensor readings and maintenance history), and two options ("replace today" or "monitor for 48 hours"). Jari chooses to replace now because a children's theatre event is scheduled in the evening and air quality matters. The work order is generated

automatically, but the decision is his. For him, the Citiverse is not an immersive world—it is a way of seeing consequences before they become problems.

Jari's workday is also full of small predictions that prevent larger failures. The city's infrastructure twin does not only model buildings; it models dependencies. When the theatre event begins, the system quietly checks a chain: ventilation load, energy price spike, grid constraints, and the likelihood of a tram delay pushing a late crowd surge into the lobby at once. Nothing dramatic happens, but Jari sees the value in the background. When a minor anomaly appears in the heating loop, the system proposes a temporary adjustment that saves energy without affecting comfort. It is the kind of optimization that used to be reserved for engineers with time to study graphs. Now it is delivered as an option to the people who actually run the city, in the language of their daily decisions.

In the late afternoon, Jari's personal life re-enters through the same life-event logic that helped Sara, but in a quieter form. His parent's care plan is coordinated across providers, and today a small change is needed: a nurse visit should happen earlier because the evening will be busy around the arena district. Jari does not have to call three numbers. He approves a rescheduling request, and the system shows what it is doing: "Checking availability within the care team," "Confirming medication pickup window," "Ensuring transport compatibility." Each step is visible, and each can be stopped. Jari appreciates that the city's intelligence does not pretend to be human; it behaves like a careful administrator that finally learned manners.

Before heading home, Jari spends five minutes on a city maintenance forum—an internal-but-open channel where residents and staff can flag issues, see status, and understand prioritization. Someone has asked why a certain underpass still feels unsafe. The system shows a layered answer: lighting has been upgraded, but sightlines remain poor; reported incidents are low, but perceived safety scores are still weak; a redesign is scheduled, but budget is constrained. It is not a perfect reply, but it is transparent. Jari adds a note from his operational perspective and marks it as "field-confirmed." In this city, trust is built not by claiming everything is fine, but by showing the work of making things better.

Jari's colleague jokes that he has become "a manager of invisible things." He used to manage cleaning schedules, repairs, and contractors. Now he also manages data contracts, sensor health, and model drift. If a sensor starts reporting bad readings, the twin can become a storyteller that lies. So Jari has a new routine: once a week he reviews a short "reality check" report that compares model expectations with on-site inspections. It is not glamorous work, but it protects the city from a subtle danger—believing its own simulations more than its streets.

Digital twin alert

In the early days of the transition, many workers feared that “smart city” meant fewer jobs. What actually happened was more complicated. Some tasks disappeared; others multiplied. Jari remembers the negotiation with staff representatives: if the city wanted more automation, it had to commit to training and to defining accountability clearly. Today, the people who maintain physical infrastructure also have access to micro-courses in the field—short XR-guided tutorials that appear when you face a machine and ask for help. Jari likes that the city treated skills as infrastructure, too. It made the shift feel less like replacement and more like evolution.

On his way home, Jari encounters the kind of failure that reminds everyone why resilience matters. A small power fluctuation hits a cluster of streetlights, and one block becomes unexpectedly dim. Ten years earlier, this would have meant phone calls, a technician dispatched, a gap between problem and response. Now the streetlighting twin detects the anomaly, reroutes power from a nearby segment, and increases lighting in adjacent streets to keep routes readable. A maintenance crew is scheduled for the morning. The fix is not magic; it is contingency planning made executable. Jari notices that nothing dramatic happens—people continue walking, the city continues breathing—and he feels grateful for systems that fail softly.

Night arrives like an invoice. Jari’s calendar empties, but responsibility does not. He leaves the building after the event begins, walking through a lobby that feels easy—air clear, lines moving, staff not rushed. The operations twin sends a final note: the replacement worked, energy use

stayed within bounds, and the system recommends a follow-up inspection in two weeks. Jari approves it with a gesture and then pauses, as if to confirm to himself that he is allowed to stop thinking. The city's systems can run all night, but the city has learned that people cannot.

On the way home, his phone stays quiet—by agreement. His household rule blocks non-urgent prompts, and the city respects the boundary. Still, one message slips through because it should: a short alert that a pedestrian route near his home is temporarily less lit due to maintenance and that alternative lighting has been raised on the parallel street. It does not ask him to do anything. It simply tells him what the city is doing and what options exist. Jari thinks of his child walking alone next year, and the thought is equal parts pride and worry. A few years ago, he would have downloaded an app, checked a map, and hoped for the best. Now the city publishes a "safe route object" that any family assistant can interpret locally. The comfort is not in the technology itself, but in the predictability of the response.

At home, Jari briefly checks the city maintenance forum one last time. Someone has thanked the facilities team for the comfortable air during the performance. The comment is small, almost trivial, but it closes a loop: work becoming lived experience, then becoming feedback, then becoming motivation to keep doing the unglamorous tasks well. Jari turns off the last screen and lets the night be dark. In the Citiverse city, darkness is no longer a sign of neglect. It is sometimes a sign that the system has been designed to leave people alone.

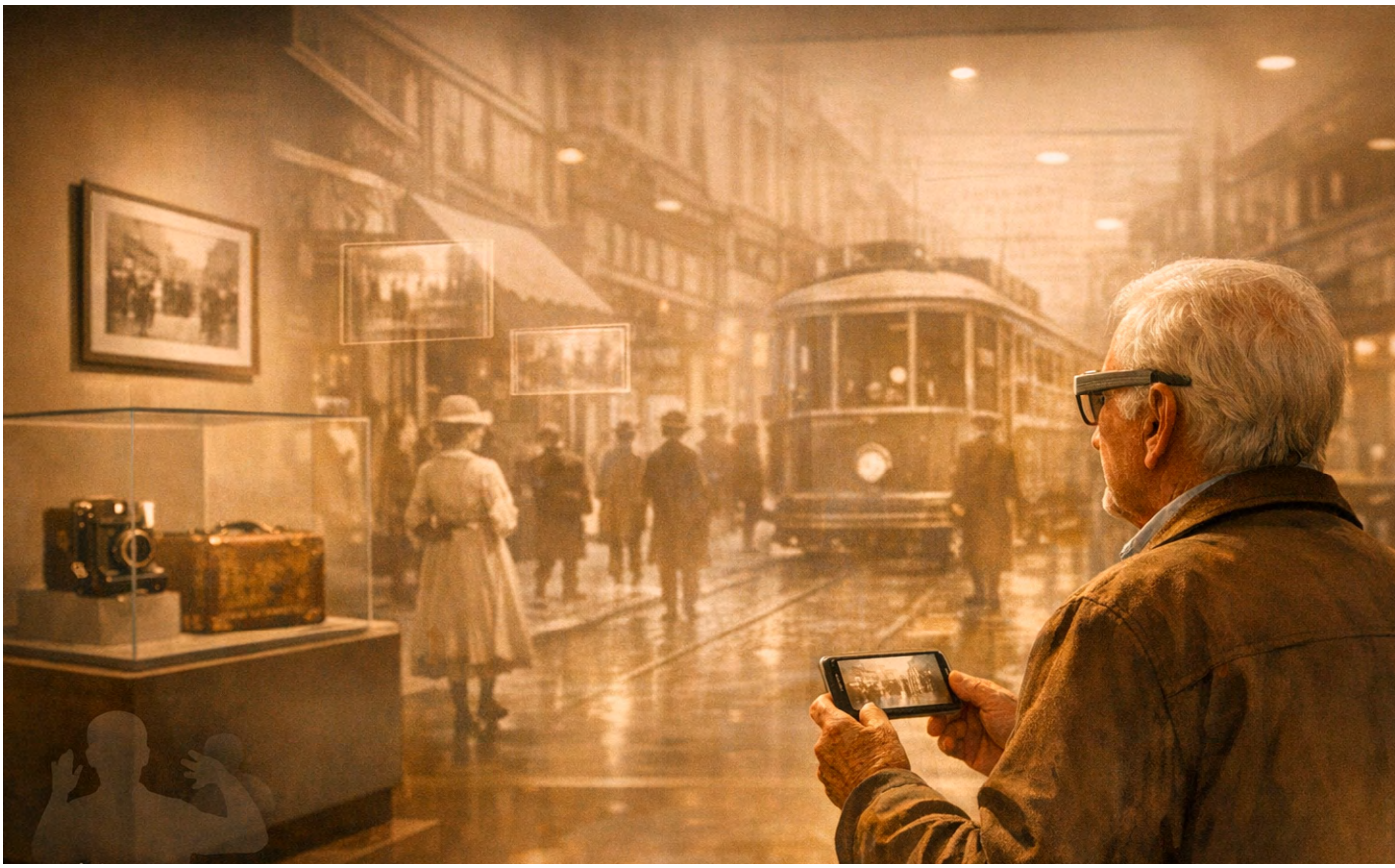
At home, Jari's family has a rule: no city notifications during dinner unless they are safety-critical. The assistants respect it because the rule is encoded locally, not negotiated with every app. When his child asks why their route suggestions look different on different devices, Jari explains in simple terms: "The city sees patterns; we choose what it knows about us." The child nods, more interested in dessert, but Jari senses something important: the next generation is growing up with governance as a household concept. That may be the most lasting infrastructure of all.

5) Leena, 74: independence, dignity, and human support at the edges

Leena wakes to quiet light that gradually brightens the room, synchronized with her preferred sleep rhythm. She does not talk about "smart home technology." She talks about feeling steady. The floor sensors—embedded long ago during a renovation—do not stream video anywhere. They notice patterns of movement and only raise a flag when something unusual happens. Leena chose this setup because she could understand it. Her daughter chose it because it does not feel like surveillance. In the Citiverse city, care begins with a promise: support without humiliation.

Leena's outing is a small expedition to a community centre where she meets friends. Her mobility assistant is not a futuristic robot; it is a simple service that knows which sidewalks are icy, which benches are available, and which entrances are step-free today because a ramp is temporarily under maintenance. The city's public displays adjust automatically: larger text, higher contrast, language she understands. Nothing announces that this is "senior mode." The city simply adapts, the way good design always should. When she arrives, she joins a culture session

that is half physical and half digital: a local museum hosts a guided walk, and participants can summon layered stories—old photos, spoken memories, translations—into the space around them. Leena has never cared for headsets. She likes that she can hold a lightweight viewer for a moment, then put it down and still be part of the conversation.



Museum memory layer

Later, she has a remote check-in with a nurse. The appointment feels ordinary, but its logistics are not. The nurse has access to a relevant slice of Leena's data—only what Leena has permitted for care—and the system highlights changes without pretending to diagnose. "Balance has been slightly less stable this week," the interface notes, with a link to the raw pattern and the confidence level. The nurse asks two questions, listens, and decides whether anything needs adjusting. In this world, AI is an attentive assistant, not a silent judge. The city learned this the hard way: people accept digital help when it is honest about uncertainty and when a human remains accountable at the edges.

After the call, Leena makes tea and looks out at the courtyard. She can still remember when digital services arrived as a demand: new passwords, new apps, new confusion. Now, the city's digital layer mostly arrives as an accommodation. When she forgets a bill, the system does not scold her; it offers a simple option: "Would you like a human to call?" The call center is smaller than it once was, but it is still there—because the city decided that the "last mile" of digitalization

is often human. Leena is not forced into an interface she dislikes. She is offered one, and the alternative remains dignified.

In the evening, Leena receives a message from her grandson: a short clip from the concert crowd, shared with “family only” permissions. She watches it once, smiles at the noise, and closes it. Then she opens something she actually enjoys: a “memory layer” of the city, curated by residents. Standing by her window, she can see an overlay of how the street looked fifty years ago—old shop signs, a winter market, the first tram route plans pinned in a municipal office. The Citiverse has not only added new futures; it has made the past easier to carry. For Leena, that continuity matters. It means that the city’s digital evolution did not erase her world; it added depth to it.

Later that night, a weather alert arrives: freezing rain is expected after midnight. Leena does not need to act, but she likes knowing what the city will do. The message is specific: “Sidewalk treatment scheduled at 03:00. Smart lighting will increase along main walking routes. If you plan to go out early, consider the sheltered route via the community centre.” It reads like a neighbour’s advice, not a command. Leena knows that behind this is an operational twin linking weather services, maintenance crews, and energy planning. She also knows that if something goes wrong, someone is accountable. That knowledge—quiet, firm, and human—lets her sleep.

Leena’s independence is protected by small redundancies. She carries a simple card in her wallet with a tactile notch cut into one corner. It is not “retro.” It is a deliberate backup credential that works if her phone is forgotten, broken, or stolen. At the clinic, the kiosk recognizes the card as a proof-of-eligibility token without displaying sensitive details on screen. Leena appreciates this design choice because it assumes that life includes mistakes. The Citiverse city is advanced, but it is not fragile; it has learned to keep a low-tech door open for everyone.

A few years ago, Leena agreed to join a voluntary wellbeing program—not one that diagnoses, but one that offers gentle invitations. The city calls it “community support,” and the rules are strict: participation is opt-in, the data stays minimal, and the default outcome is always “offer, never decide.” When Leena has not visited the community centre for a couple of weeks, she might receive a message: “There is a music afternoon on Thursday. Would you like a ride?” Sometimes she declines. Sometimes she accepts. The important thing is that the city treats loneliness as a civic problem without treating the citizen as a problem to be managed.

In the museum session, Leena notices how different people use different interfaces. One person wears glasses all the time; another uses audio descriptions; another prefers printed text; a young volunteer carries a tablet and helps those who want assistance without taking over. The museum’s guide can switch layers on and off for the group: historical photographs, subtitles, sign language avatar, simplified language. Leena likes that she can remain herself in the room. She can be curious without being made into a “user segment.” The best accessibility is the kind that does not require you to announce your needs to strangers.

Leena has also learned to be careful. Scams did not disappear in the future; they adapted. The city runs a public “trust service” that flags known fraud patterns, but it never forces decisions.

When Leena receives a suspicious message pretending to be from a utility, she forwards it to the trust service with one tap and gets a calm response: “Likely fraud. No action needed. If you prefer, a human advisor can call.” She chooses the call. A patient voice confirms it is a scam and reminds her of one simple rule. This is what safety looks like at seventy-four: not perfect protection, but reliable support that does not blame you for being human.

As evening arrives, their lives overlap without them noticing. Aino’s class project appears as a small item in a planner’s queue. Mika and his friends flow toward the concert, helped by lighting and transit timing that make movement feel calm. Sara’s team tests a wayfinding feature that will quietly help visitors find the same venue entrances. Jari’s decision to replace a filter improves air quality for the crowd. Leena, on her way home, walks along a well-lit route that feels safe without feeling controlled. The Citiverse, in this version of the future, is not a parallel universe. It is the connective tissue that makes ordinary life less fragile.

What makes this day plausible is not one breakthrough device, but an accumulation of design choices: interoperability that prevents one-off solutions, data governance that turns consent into a daily practice, inclusion that is engineered into interfaces rather than promised in strategies, and AI that augments judgement instead of replacing responsibility. The “Citiverse feeling” is therefore subtle. It is a city that explains itself, adapts to different life stages, and allows people to opt out of personalization without opting out of society. If the next decade goes well, the most advanced layer of the city will be the one that rarely asks to be admired—because it is busy making everyday life work.

Why fiction?

This fictional chapter is meant to function as a decision-making lens, not a forecast. By translating Citiverse building blocks—networked digital twins, trusted data sharing, ambient AI, spatial interfaces, and governance-by-design—into ordinary moments across different life stages, it makes the future concrete enough to discuss, challenge, and plan for. For leaders and policymakers, the value is practical: the vignette surfaces the real choices hidden inside the technology (what becomes public digital infrastructure, what remains optional, how consent is made understandable, where human oversight stays mandatory, and how inclusion is engineered rather than promised). Used this way, narrative becomes a planning tool—helping decision makers stress-test strategies, prioritize investments, align stakeholders around shared principles, and keep public value, trust, and everyday usability at the center as cities move from pilots toward Citiverse-scale capability. Most times we are too limited by our ability to imagine the future and work through the unknowns. We do not know how much this will become true, but I hope this helps when we are navigating through our journey for a better future.

5. Concluding remarks

Kuva: Laura Vanzo / Visit Tampere

The road to citiverse is only in the beginning. We are now seeing different international organizations waking up on this, as well many cities and regions around the world are starting to ask for advice how to move to this direction. If you look at the current initiatives of certain international organizations, Three complementary streams are shaping the Citiverse into something cities can actually build. At the global level, **ITU** convenes the UN's work on AI and virtual worlds through its Global Initiative on "Discovering the Citiverse," producing shared language, guidance, and practical mechanisms (such as sandboxes and capacity building) to keep development inclusive, trusted, and interoperable. In Europe, the **LDT CitiVERSE EDIC** provides the implementation vehicle to connect local digital twins across Member States into a common, reusable infrastructure aligned with European values on trust and sovereignty. Meanwhile, **OASC** translates interoperability into day to day delivery through its Minimal Interoperability Mechanisms (MIMs), helping cities procure and deploy components that can be reused across vendors and borders—turning the Citiverse from a concept into a federated, working ecosystem. All of them are just present trying find a good way of working together around the implementation of Citiverse.

At the same time the understanding of what it is is relatively low but the understanding of what it might mean to our citizens is even lower. We need to continue to educate city leaders, political and civil servants alike. And the time to move is right now. For example technologies supporting immersive use like see-through smart glasses with full functionality will be out on a price point acceptable to consumers in 2027-2028. 6G technologies will be in commercial use 2029-2030. Edge and chip technologies evolve in making this possible without heat and processing power become too problematic. And of course most importantly, agentic and physical AI development will continue with accelerative speed.

But the biggest challenge is in the minds of people – both people in the public sector and people. How will we be able to convince the citizens and also people responsible for making decisions and delivering services this is the way to go. I believe we must be able to show concrete benefits for everyone. And this has to be visible sooner than later.

How to make this happen? I hope this book has brought concrete ideas how to move Citiverse thinking forward. There is a lot of good material existing in the ITU material bank, but practical advise how to use it will be needed. Tampere story is a good story to tell, and practical elements can be found in the story. If you summarize why Tampere is a success story, you come down to a few essentials. First, you need inspirational leadership, to be able to showcase the sstory with good storytelling, in order yo get the political decisionmakers on board. Then you need such political stability that can be found in Tampere. You also need the boldness to make big decisions, to take risks, reach for the unknown. You need a great ecosystem where everybody speaks the same language and shares the same vision, be it the city, national government, science university, applied science university, vocational school or college, big global corporation, large or medium sized local company, small company, startup or scaleup, non-profit or group of citizens. And that happens in Tampere.

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