Smart City Digital Twins Project
Workshop Assessment Report: WROCŁAW

Cover Graphic Resource Tech Guidance

Co-funded by the European Union

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SUMMARY

The convergence of Smart Cities (SC) and Digital Twins (DTs) concepts emerges as a desirable alliance in the dynamic interplay of urbanisation and innovation enabled by Internet and Communication Technologies (ICTs), inspiring cities to an outstanding wisdom in the future. At city level operations DTs transforms standard public services into efficient real-time actions, and strategic precision uses cutting-edge ICTs. Amidst latest technological advances – Artificial Intelligence (AI), Machine Learning (ML), Data Analytics, Extended Reality (XR), Internet of Things (IoT), and sensor technologies, for example, the synergy between SC and DTs allows cities confidently navigate the complex landscape of urban transformation by using DTs as their visionary compass. Likewise, strategic use of DTs optimises public sector open data, promoting data-based economic growth, social well-being, and environmental sustainability.

While cities intensively pursue to explore the possible futures of SC with DTs and realizing the what-if scenarios could come to life, reveals a plausible future for their cities in which smart grids might flourish and traffic might move autonomously and seamlessly. While the ideal alliance of DTs and SC could open the door to a revitalised future urban landscape, this mission necessitates a systemic integration of ICTs, public awareness, talent & tech-skills, public-private-people partnership, and continuous strategic transitions in the city systems.
Thus, the project's main goals, which are in line with the Finland Digital Compass, Ecosystem Agreements and Smart Specialisation Strategy – 3S, were to advance sustainable public procurement, implement innovative strategies for regional development, and promote competency in DTs. Accordingly, the project emphasises the value of collaboration between the public, private, and people domains by highlighting the necessity of resolving the matching problem regarding SCDT development models.

With this motivation, the project designed as a one-year foresight research project spanning from February 1, 2023, to April 30, 2024, stands as a promising endeavour in the realm of urban innovation. In collaboration with esteemed partners, University of Turku, Turku University of Applied Sciences and Turku Science Park Ltd., this visionary project is co-funded by the European Regional Development Fund and fuelled by a total budget of EUR 241.399. This initiative completed wide-ranging up-to-date integrative literature review, mapping survey and engaged on-site workshops held within partner cities.

Mapping survey was publicly available via Webropol weblink and aimed to get insights of subject matter expert respondents on Smart City Digital Twins. In this regard, while the survey link has been provided to partner cities to distribute experts in their networks, it was also

accessible in the project website. Eventually, the survey reached 982 potential respondents, and 22 of which 45 started responding, submitted their responses .

Aligning with project objectives, the foresight workshops were held in;

- September 19th 2023 Gdańsk Science and Technology Park,
- September 21st 2023 Wrocław Technology Park,
- October 5th 2023 Vilnius Municipality Building,
- November 2nd EDUCity, Turku - Part 1 (Current Solutions)
- November 22nd 2023 EDUCity, Turku - Part 2 (Visions & Near Future Needs)

Participants registered to workshops via the project website. Total foresight workshop participant number was 99 and according to registration records, city-based participants numbers are 17, Gdańsk; 22, Wrocław; 41, Vilnius and 19, Turku respectively (See, Figure 1).

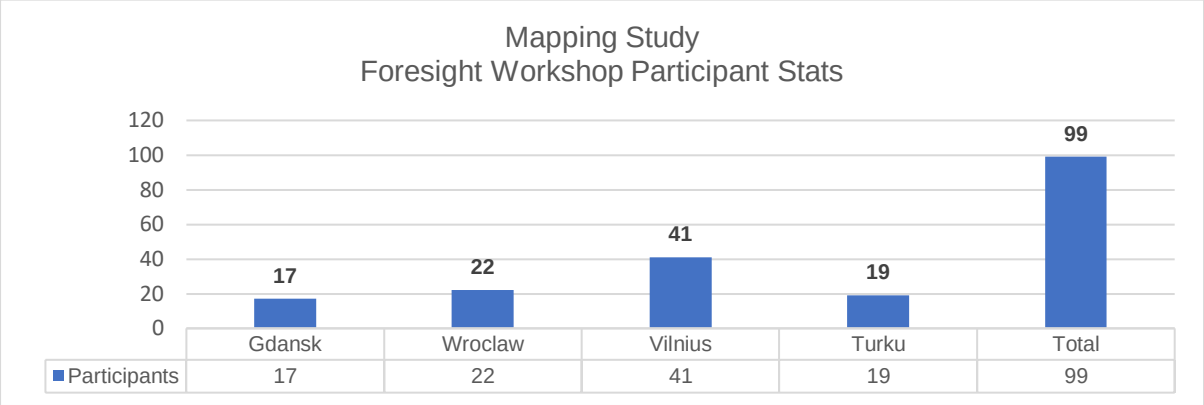


Figure 1 Foresight Workshop Participants in Number.

Project research team recorded 433 insights after completing workshops in four partner cities. According to the data, participants added 216 current solutions, 125 visions and 60 near future needs during workshop sessions (See, Figure 2).

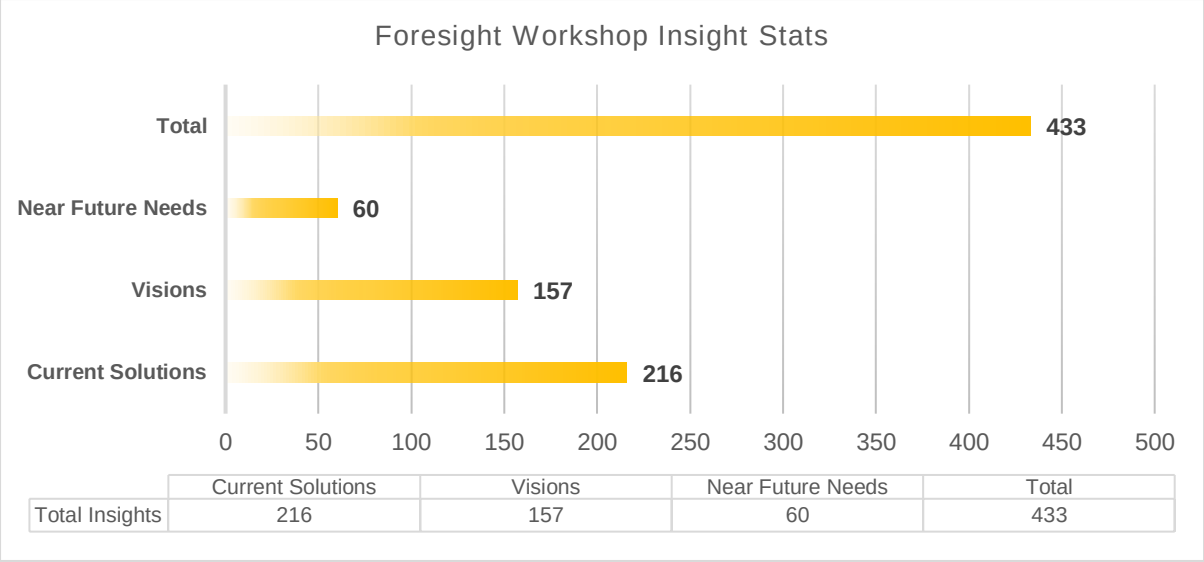


Figure 2 Total gathered insight numbers by workshop theme.

Notably, the project has initiated the creation of a marketplace for Smart City Digital Twin solutions, marking a pivotal step in its journey towards advancing the concepts of Smart Cities. In this sense, companies and start-ups running their business in partner cities had the opportunity to pitch their business solutions before each foresight workshops held in four cities. Then they were able to publish their SCDT solutions in the project marketplace.

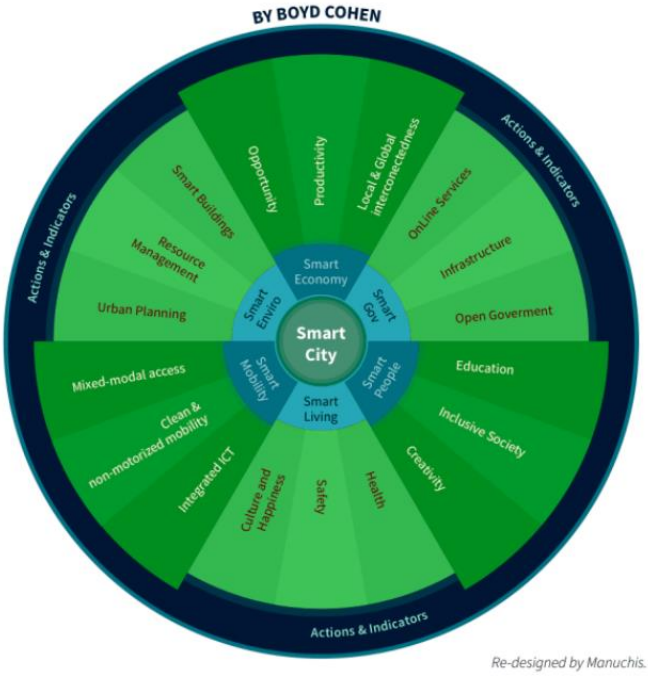
1. Introduction

Smart City Digital Twins are currently in an exciting phase of development. They offer vast potential for the advancement of Smart City initiatives, promising benefits to society, the economy, businesses, and the environment. The Smart City Digital Twins project is specifically dedicated to harnessing the power of public sector open data to foster sustainable economic growth within urban areas in Finland. This initiative explores the capacity of digital twins to facilitate the transition to environmentally friendly practices, support equitable working conditions, enhance citizen well-being, and promote the adoption of advanced technologies in larger subsequent projects.

The project actively contributes to the enhancement of research and innovation capabilities. The incorporation of advanced technologies into research and development, the project aspires through the following avenues such as strengthening expertise, foresight, and innovation activities by driving the development of digital twins, piloting their capabilities, and introducing potential commercial applications in line with the Public-Private collaboration model. This project serves as an implementation and development platform for the Research, Development, and Innovation (RDI) cooperation model, as it collaborates with the University of Turku, Turku University of Applied Sciences, and Turku Science Park. There are four cities: Turku, Vilnius, Wrocław, and Gdańsk that operate in three countries, Finland, Lithuania, and Poland.

2. Mapping Study

2.1. Workshop Method



The Smart City Wheel (SCW) is an analytical tool for smart city ranking and benchmarking developed originally by Boyd Cohen. While it is applied by various scholars for case studies, city officials may find it a useful tool for self-analysis since indicators are easy to assess. Essentially, SCW is a framework for understanding six key components of a smart city: Smart Economy, Smart Government, Smart People, Smart Living, Smart Mobility and Smart Mobility. The rankings are done with mostly publicly available

data (i.e., secondary data) with data collected directly from eligible cities (primary data). Since 2014, SCW assess smart cities with 62 indicators in which 16 of them are also directly mapped to the ISO standards for Sustainable Cities and Communities (ISO 37120:2018). (To achieve indicators, please check **Bibliography**)

Within the SCW, each 6 dimension contains 3 sub-components.
Therefore, there are 18 total sub-components in the model, and with 62 indicators. Each of the 6 components are then assigned a maximum of 15 points and the results are transformed in a way that the highest performing city in each category is assigned 15 points. Thus, if one city is to lead in each of the six components, the city would obtain a maximum score of 90 points.

Moreover, it is clear from our foresight workshop on smart city digital twins that ISO standards are essential for directing the creation and evaluation of sustainable, resilient, and smart cities. For example, aligning with Boyd Cohen's Smart City Wheel including some vital ISO 37120:2018 indicators, our analysis will broaden the examination of existing SCDT solutions via ISO 37120:2018, which focuses on indicators for city services and quality of life. We emphasise the significance of evaluating and enhancing current urban SC services as well as the general well-being of inhabitants. Looking ahead, ISO 37122:2019, which focuses on indicators for smart cities, is extremely relevant to our data analysis about needs for the near future because it highlights the vital role that cutting-edge technology plays in fostering innovation via DTs, improving data-driven decision-making, and streamlining city operations. Finally, the indicators for resilient cities covered by ISO 37123:2019 are directly in line with project goals of developing urban settings that are resilient to a range of unpredicted landscape issues. By incorporating these ISO standards into our analysis, the project aims to ensure that cities are using smart technologies to their fullest potential while moving towards a sustainable and resilient direction. They also provide a foundational framework for measuring the success of smart city initiatives in partner cities Gdańsk, Vilnius, Wrocław, and Turku.

2.2. Workshop Objectives

Foresight workshops in partner cities aimed to find out type of SCDT current solutions cities have now. Also, by gathering insights about their visions and near future needs the project aimed to map different cities' current systems, current system providers, and their future visions. By conducting workshop in cities, project aims to assess:

Current Solutions: The workshops will find out how cities work now. By sharing the current situation of different cities, we find out current systems, current suppliers, and their abilities, what kind of data repositories currently exist, and environmental impact assessments.

The Needs of The Near Future: The analysis of near-future needs helps to understand what kind of fast-coming needs exist in different cities. This helps to target the development and possibly find common needs that can be met quickly: systems to be developed, challenges, interfaces, modularity and data, and assessments of environmental effects.

Visions: What kind of SCDT services can we expect in the future. Future opportunities and challenges are envisioned: different SCDT visions are described, what kind of research and education is needed to implement the visions, how standards, open-source codes, modularity, and data repositories can have an impact, and assessments of environmental effects.

2.3. Key Insights Gathered from Turku Workshop

2.3.1. Current Solutions

Economy

- **Smart Lighting:** Implementing smart lighting solutions.
- **Facilitate Local Businesses by Hosting Meetings:** Organizing meetings to support local businesses.
- **Online Websites Wrocław Project Actions:** Creating online platforms for Wrocław project actions.
- **Networking Events, Websites:** Hosting networking events and websites for business connections.
- **Revenue Management at Hotels:** Implementing revenue management systems at local hotels.
- **Startup Ecosystem :** Nurturing a startup ecosystem through the efforts of numerous ICT companies.
- **Citizen Card for Discounts (NASZ Wrocław Project):** Exploring the concept of a "citizen card" that provides discounts and benefits to registered citizens as a way to strengthen their commitment to the city.

Environment

- **Solar Benches:** Installing solar-powered benches.
- **Solar Bus Stops:** Equipping bus stops with solar energy solutions.
- **EVs (Electric Vehicles):** Promoting electric vehicle adoption.
- **Breathing Wrocław:** Initiatives to address air pollution.
- **Systems for Mitigating Weather/Air Pollution:** Implementing systems to combat weather and air pollution.
- **Waste Segregation:** Promoting waste segregation practices.
- **Limit Cars in Traffic:** Measures to control and reduce car traffic.
- **Smart City Lights:** Implementation of smart lighting systems in the city.
- **Growing Number of Bicycle Roads:** Expanding the network of bicycle lanes and roads in the city.
- **Greening Up the City (Parks, Squares):** Initiatives to create and maintain green spaces, including parks and squares within the city.

Mobility

- **Easy Up Traffic Congestion, Save Time for Transportation:** Solutions to alleviate traffic congestion and enhance transportation efficiency.
- **Reduce City Population and Save Environment:** Initiatives aimed at reducing urban population and environmental impact.
- **Save Energy Use and Use Solar Energy:** Efforts to conserve energy and promote solar power.
- **Last Mile Delivery Solutions:** Strategies to optimize last-mile delivery.
- **Autonomous Public Transportation:** Implementing autonomous public transportation solutions.
- **Trams Timing Adoption on Stops/API with Real-Time Bus/Tram Tracking:** Enhancing tram timing with real-time tracking.
- **E-ticketing with API or Credit Card:** Introducing electronic ticketing options.
- **Bike Rental Services with Bike's Location:** Offering bike rentals with location tracking.
- **Lack of Interconnectedness of Different Transportation Options and Services:** Addressing the need for better integration among various transportation options.
- **Ticket Share: Some Technologic Solutions Between Bus and Trams:** Implementing technological solutions for sharing tickets.
- **Bus/Tram Arrival Predictions, Location Tracking:** Enhancing the accuracy of arrival predictions and location tracking.
- **Digital Machine for Bus Tickets:** Implementing digital ticketing systems.
- **Computer Vision System (Cameras) for Traffic Monitoring:** Using computer vision for traffic monitoring.
- **Traffic Privilege System for Trams:** Giving trams traffic privileges.
- **Train Two-Way One-Day Ticket Discount:** Offering discounted two-way train tickets for a single day.
- **Car Sharing and Sharing Economy:** Promoting car-sharing and the sharing economy for more efficient transportation.
- **Smart Parking:** Implementing smart parking solutions to improve parking availability.
- **Separate Bus Lanes from General Traffic:** Enhancing public transportation with dedicated bus lanes.

- **Smart Traffic Lights and Countdown Systems:** Implementing smart traffic lights with countdown systems.
- **Traffic Route Optimization Platform (jakdojade.pl):** Utilizing platforms for optimizing traffic routes and ticket purchasing.
- **Intelligent Transportation Systems/Trains and Buses:** Employing intelligent transportation systems with timing and ticketing features.
- **Discussion on Scooters:** Examining the impact of scooters on transportation, including safety zones and related legal considerations.

Governance

- **Digital ID Card:** Implementation of digital ID cards.
- m**Obywatel (**https://obywatel.gov.pl**):** Utilizing the mObywatel platform for citizen services.
- e**Puap (E-Government Services):** Offering electronic government services (e-Puap) to streamline administrative processes.
- **Digital ID on iPhone:** Using digital IDs on smartphones (e.g. iPhone) for various purposes, such as insurance.
- **Queuing Systems:** Implementing electronic queuing systems at municipal and regional levels.
- **Streamlining Government Offices:** Addressing long and bureaucratic processes in government offices, particularly for migrants.
- **Center for Crisis Management:** Establishing a crisis management center for monitoring and managing city-wide crises and emergencies.

Living

- **Multi-Sport App/Program:** Promoting the use of a multi-sport app or program.
- **Monitoring Systems for Resident Safety:** Enhancing safety through monitoring systems.
- **Less Noise and Advertisement in Public Space:** Reducing noise and advertisements in public areas.
- **Digitalization of Government Services:** Transitioning government services to digital platforms.
- **Time Management for Daily Living Activities:** Focusing on time management for daily activities.
- **Tele-Medicine:** Making smart use of telemedicine for healthcare consultations.

- **Public Health Solutions:** Improving public health services, including appointment scheduling and prescription management.

People

- **Simplifying of the Apps for Older and Younger People Especially:** Enhancing the usability of apps for all age groups.
- **Younger Generations to Teach the Older About Technology:** Encouraging knowledge transfer between generations.
- **New University Courses Focusing on Transformation Towards Greener, More Balanced, and Resource-Efficient Future:** Offering courses that focus on sustainability and green technologies.
- **Public Campaigns: Bringing Awareness to Citizens:** Conducting public awareness campaigns.
- **Technology Park Corporations with Universities and Other Companies:** Collaborations between technology parks, universities, and companies.
- **Alert RCB - Country Information System for Warning:** Including a country-wide information system for warnings. (https://www.gov.pl/web/rcb)
- **ITCORNER Unites People:** Building a platform like an ITCORNER to connect people with similar interests.
- **Tele-Medicine:** Expanding telemedicine services, enabling remote consultations and analysis of health data through wearable devices.
- **Public Health Solutions:** Enhancing public health services for appointments, prescriptions, and vaccinations.

2.3.2. Visions

Economy

- **RFID Technology Substitution of Credit Card Payment:** Replacing traditional credit card payments with RFID technology.
- **Central System for Capital Cash Flow within Companies in Real-Time:** Establishing a centralized system for real-time capital cash flow management in companies.
- **Virtual Shopping (No Physical Shops):** Moving toward a model of virtual shopping with no physical stores, utilizing avatars in a digital twin.
- **Digital Currency and Hurdles to Overcome:** Discussing the adoption of digital currency while addressing potential concerns such as electric shocks and power outages.

Environment

- **Flood Simulation Since Terrain of Wrocław Mostly Covered by Rivers:** Implementing flood simulations to address the city's river-covered terrain.
- **Air Circulation Simulation for Fume in the City at Critical Levels:** Using simulations to manage air quality during critical levels of pollution.
- **Green Zones in City Limits:** Creating green areas within the city to enhance environmental sustainability.
- **Autonomous Trash and Salvage Management:** Implementing autonomous systems for waste and salvage management.
- **Green City Urban-Nature Approach:** Implementing an urban-nature approach, inspired by cities like Singapore, to make environmentally friendly development more affordable.
- **Zero Carbon Footprint:** Striving to achieve a zero-carbon footprint in the city.
- **Automated Environment Monitoring & Elevating:** Employing automated systems for monitoring and improving the environment.
- **Garbage Recycle System/Application:** Utilizing applications and systems for efficient garbage recycling and incentivizing recyclable waste collection.

Mobility

- **Autonomous City Traffic System:** Implementing an autonomous traffic management system for the city.
- **Digital Model of Car Traffic Where City Influences Traffic Lights:** Using a digital model of car traffic to optimize traffic lights.

- **Traffic and Public Transport Optimization:** Enhancing traffic and public transport efficiency.
- **Detection System to Know Where to Build Staff:** Implementing detection systems for strategic resource allocation, possibly in response to audio input.
- **Air Traffic:** Managing air traffic efficiently.
- **No Private Cars (Sharing Economy 100%):** Transitioning to a sharing economy with no private cars, potentially involving government support.
- **Autonomous Cars for Safer Traffic:** Implementing autonomous vehicles to enhance traffic safety and efficiency.
- **Managing Abandoned Vehicles:** Addressing issues with abandoned vehicles, especially if sharing companies go bankrupt.
- **City-Digital Twin:** Creating a digital twin of the city to enhance urban planning and management.
- **Integrated Mobility System (National & Regional):** Developing an integrated mobility system for national and regional transportation, with a unified platform for services and advice based on user behavior.

Governance

- **Coalition for Digitalization of Wrocław Joint Company Efforts:** Forming a coalition to collectively drive the digitalization of the city.
- **Ethics Board of AI and Data in the City, High-Level Authority for AI and Data Governance:** Establishing an ethics board to oversee AI and data governance at a city level.
- **No Physical Mail:** Discussing the elimination of physical mail in favor of electronic communication.
- **Integrated Public Health System:** Creating an integrated public health system that centralizes tests and medical history in one place.

Living

- **Last Mile Delivery Solutions:** Developing solutions for efficient last-mile delivery.
- **Planning City Infrastructure for City Growth (SCDT Simulations); Having Many Decentralized Social Zones:** Planning infrastructure for the city's growth using SCDT simulations and creating decentralized social zones.
- **Planning Public Utility Buildings and Services:** Strategically planning public utility buildings and services.

- **Prevention of Creating Suburbs with Only Apartment Buildings:** Preventing the creation of apartment-only suburbs.
- **AI Technology Helping Daily Habits:** Leveraging AI to assist in daily routines.
- **Generation of Healthy Lifestyle: Sport, Work, Learning, and Relationships:** Promoting a balanced and healthy lifestyle encompassing sports, work, learning, and relationships.
- **Simulate Living Buildings for Old/Young Citizen Relations:** Imagining living buildings where different generations coexist, fostering mutual support and resilience within the community.
- **No Internet Zones:** Addressing the impact of potential internet-free zones.
- **Monitory System for Safety:** Implementing a monitoring system to ensure safety across the city.
- **Unified Ecosystem (Apps and Platforms):** Developing a unified ecosystem for various applications and platforms.

People

- **Digital Transformation (DT) of Bodies and Organs, Customized Health Service and Monitoring Health of Organs:** Advancing digital transformation for personalized health monitoring.
- **People Become More Educated by Universities:** Increasing education and learning opportunities through universities.
- **Smart Relationships:** Facilitating relationships between generations.
- **Smart Facilitation for Communities Enabled within SCDTs:** Using smart city technologies to enhance community interactions within SCDTs.
- **Metaverse as F2F Replacement:** Exploring the potential of the metaverse to replace face-to-face interactions, considering the generation Z behavior.
- **Behavior Prediction Systems:** Implementing systems for predicting and optimizing public behavior in various contexts.
- **Paperless Bureaucracy and Full Automation:** Moving toward a 100% paperless bureaucracy with automated processes and no unnecessary vacancies.

2.3.3. Near Future Needs

Economy

- **A Business Model for Accessing DT (Digital Twins):** Developing a business model for enabling access to Digital Twins.
- **Limitation of AR and VR:** Recognizing the time constraints of using AR and VR technologies, limited to about 3-4 hours.
- **Mindset Change:** Encouraging a shift in people's mindset towards adopting new economic models, such as sharing economies and sustainable practices.
- **Standardized Platform and Data:** Promoting the use of standardized platforms and data sharing to avoid redundancy in innovation.

Environment

- **3D Model of the Savage Electric, Based on City Plans:** Creating a 3D model of electric infrastructure based on city planning.
- **Sensor Implementations and Model for Simulation Building:** Implementing sensors and simulation models for building management.
- **Segmented Model Building, Including Trash Bin Macro Creation:** Segmenting model building, with a focus on creating and multiplying trash bin models.
- **Education on Sharing Economy/Ecology Impact:** Raising awareness and educating the public about the environmental impact of sharing economy practices.

Mobility

- **3D Scan of the City Through Satellite/Google Maps, Drone Scanning, and AR Scanning:** Conducting a 3D scan of the city using satellite data, drones, and AR technology.
- **Government Funding Model for Basic City Mobility:** Developing a government funding model to support basic city mobility.
- **Cameras for Traffic Implementation:** Implementing cameras for traffic monitoring and management.
- **Infrastructure Must Be Built:** Emphasizing the need for developing necessary infrastructure to support future mobility solutions.

Governance

- **City Collaboration with Consulting Companies for Solution Tools:** Collaborating with consulting companies to address specific problems and develop solution tools.
- **Source Form of Access (Public/Private/People) to Digital Twins:** Determining access mechanisms, whether public, private, or public-private, for Digital Twins.
- **Meetings Between Companies and City Officials to Establish Current Solutions:** Facilitating discussions between companies and city officials to identify existing solutions within Wrocław for data and AI.
- **Education, Law, Societal/Public:** Focusing on educating citizens, evolving laws, and addressing societal and public concerns in governance transformations.
- **Develop AI Laws (Ethics) and Social Media Regulations:** Discussing the need for legal frameworks governing AI ethics and regulations for social media platforms.
- **Question of Trust:** Raising the issue of trust in government officials' handling of personal data and data ownership. Emphasizing the need for EU requirements and transparency.
- **Money and Motivation Needed:** Acknowledging the financial and motivational aspects required for implementing transformative initiatives.
- **New Standards, Legislation, Infrastructure:** Advocating for the development of new standards, legislation, and infrastructure with a collaborative approach involving various stakeholders.
- **Incentives for Building Digital Twins:** Highlighting the importance of providing incentives to companies involved in building digital twin projects due to their significant scale.

Living

- **Rising Awareness:** Raising awareness of relevant issues and opportunities.
- **AI Assistant:** Implementing AI assistants to aid daily living.
- **Funding Neuro-Technology (Human Sensory System Bypass):** Supporting the development of neuro-technology that bypasses human sensory systems, potentially eliminating the need for AR glasses.

- **Unified App/Platform for City Offer Features:** Advocating for a unified app or platform that centralizes various smart solutions instead of being dispersed across multiple applications.

People

- **Access to Education: Recorded Courses and AI Mentors:** Providing access to education through recorded courses and AI mentors.
- **University-Corporate Collaboration for Disruptive Technologies:** Encouraging collaboration between universities and companies for the development of disruptive technologies and innovative problem-solving.
- **Companies Facilitating Sessions and Workshops for Creativity and Relationships:** Companies facilitating sessions and workshops to foster creativity and build relationships among employees.

3. Conclusion and Discussions

The Wrocław workshop inputs highlight a range of solutions, visions, and near-future needs across various dimensions, such as Economy, Environment, Mobility, Governance, Living, and People. These insights on SCDT reflect the necessity of innovative approaches to address challenges and opportunities in Wrocław's development. Considering the workshop results, the integration of ICT in city services for sustainability, and community well-being is evident how SCDT project objectives are aligning with cities' needs against future uncertainties.

Moreover, the workshops that were conducted in Wrocław have yielded significant insights into a range of areas related to urban development, namely in relation to the economy, environment, mobility, governance, living standards, and people. The purpose of these workshops was to gain an understanding of the current solutions, near-future needs, and visionary aspects of SCDT for various cities. Smart lighting, online platforms, green initiatives, support for small enterprises, autonomous vehicles, digitalization of government services, and health technology were just a few of the many issues they explored. Participants discussed the potential and problems brought about by technological advancements, as well as the significance of financial incentives, the necessity for standardisation, and ethical issues. These observations will be crucial in determining how these cities develop in the future and how smart technologies are more widely adopted to enhance the resilience of smart cities in the future.

To further enrich these insights, firstly more insights for each dimension and each theme; Current Solutions, Visions and Near Future Needs, are needed. Additionally, it is vital to get more feedback and explore more in-depth for the following topics:

1. **Cross-Dimensional Synergies:** Are there opportunities for these dimensions to intersect and create integrated solutions? For instance, how can governance support environmental initiatives or mobility solutions enhance economic growth?
2. **Community Engagement:** How can residents and local communities actively participate in these initiatives and co-create solutions?

3. **Technological Integration:** What specific technologies (e.g., AI, IoT, blockchain) are expected to underpin these solutions, and how might they be seamlessly integrated?
4. **Sustainability Metrics:** What indicators or metrics are being considered to measure the sustainability and long-term impact of these solutions?
5. **Collaboration and Funding:** What collaboration mechanisms exist between public and private sectors, and what are the funding strategies in place or needed to realize these ideas?
6. **Legal and Ethical Considerations:** What legal and ethical issues have been identified, and how are they being addressed in the development of these projects?

By gaining more insights into these aspects, a holistic understanding of the current solutions, visions, and near-future needs in Wrocław could be achieved.

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