Smart City Digital Twin and Workshop Challenges: Towards Integration of Digital Twin and Smart City Thinking

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Turku, Thursday 2.11.2023

Many Interesting Issues and News in Smart Cities …

Published: 04 May 2023

A review study on digital twins with artificial intelligence and internet of things: concepts, opportunities, challenges, tools and future scope

Samar M. Zayed, Gamal M. Attiya, Ayman El-Sayed & Ezz El-Din Hemdan

Multimedia Tools and Applications (2023) | Cite this article

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CNN World Africa Americas Asia Australia China Europe India Middle East United Kingdom

Cities are being cloned in the virtual world. Here's what that means for the future

By Samantha Bresnahan, CNN
Published 6:59 AM EST, Tue January 31, 2023

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Hundreds of cities to deploy metaverse technology by 2030

Digital twins 25 Oct 2023 by SmartCitiesWorld news team

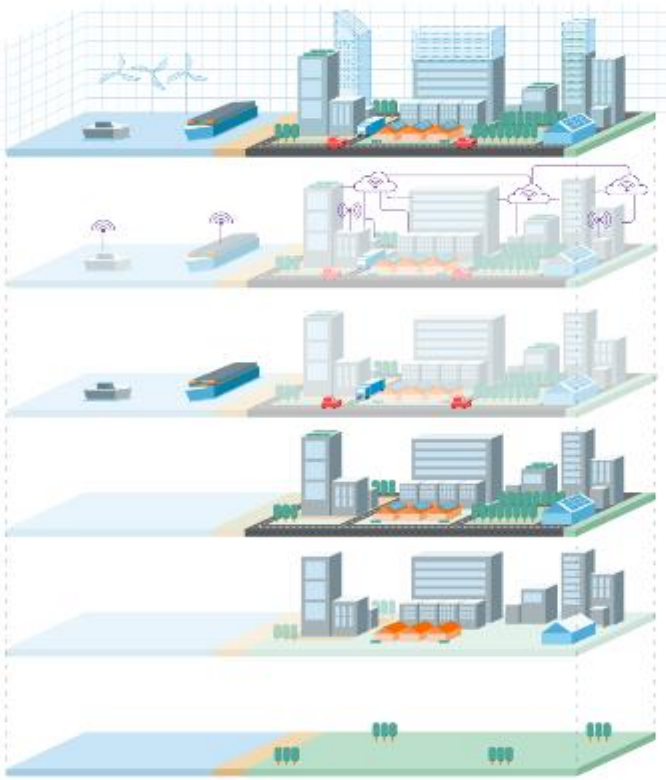
How a digital twin helped to modernise Brazil's sanitation system

Digital twins 27 Oct 2023

Aegea, which controls water and sewage utilities in 489 municipalities, worked with Bentley Systems to create the map as part of an intelligent infrastructure programme.

Cloned Twin Approach (By Samantha Bresnahan, CNN, Published 6:59 AM EST, Tue January 31, 2023)

Cities of all sizes around the world are creating virtual 3D models of themselves, known as digital twins to test and analyze urban planning scenarios. Data from sources such as satellites and sensors in the real city are layered together to form the model.



Source: G. White et al. (2021)
Graphic: Woojin Lee, CNN

CNN

The first, called "CTwin," focused on one of the city's major roadways to examine

Key Concepts, Characters & Communication processes of Digital Twin/s (A modiefied from Survey on Digital Twin: Definitions, Characteristics, Applications,and Design Implications by BARBARA RITA BARRICELLI, (Member, IEEE), ELENA CASIRAGHI, AND DANIELA FOGLI 2019)

- Key concepts: Digital Twin, Digital Thread, Product Avatar
- Key characters: Integrated system, Clone counterpark, Ties and links, Description, Constract & Information, Simulation, test & prediction, Virtual, mirror, replica
- Key application domains: Manufacturing, Buildings and architecture Transporation, mobility and aviation, Infrastuctures, Hospital management, Precision medicine

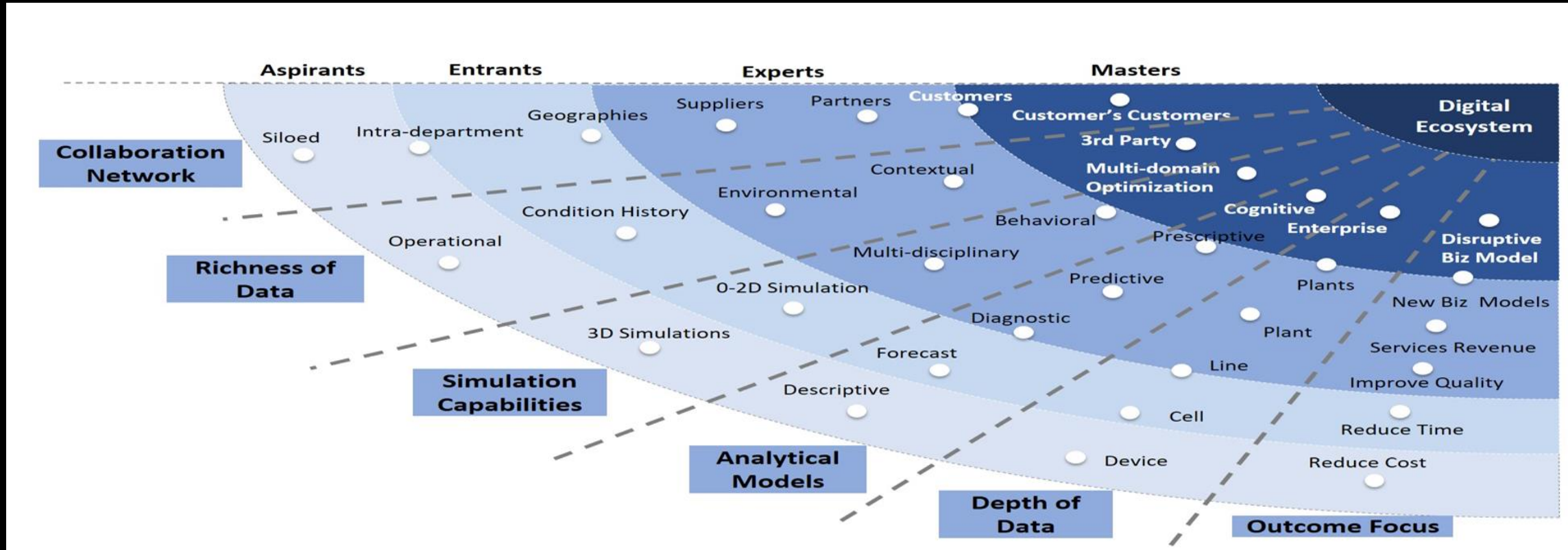
There are mainly three types of communication processes that need to be designed:

- 1) Between the physical and the virtual twin.
- 2) Between the DT and different DTs in the surrounding environment.
- 3) Between the DT and domain experts, which interact and operate on the DT, through usable and accessible interfaces

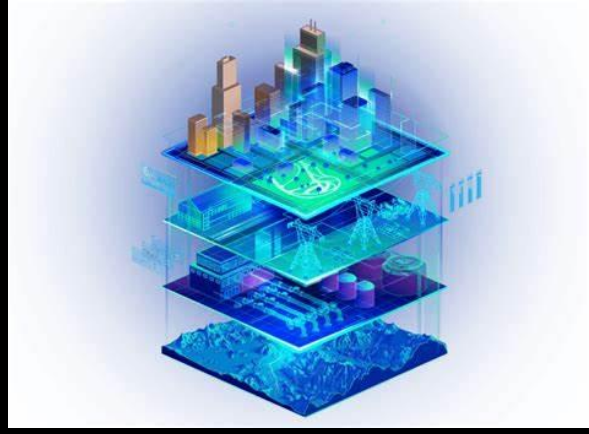
Theme 1: What is Digital Twin?

Challenges:

-DT meets customer needs broadly
-DTs connect 3rd parties and many motivated stakeholders
-DT includes multi-domain optimization
-DT development leads to cognitive enterprise 4.0/5.0 ecosystems
-DT includes disruptive business model thinking



The Term of Digital Twin (E Scholarly Encyclopedia 2023)



- *John Vickers of NASA* first coined the term “digital twin” in 2002 [11]. Around the same time, the research professor Dr Michael Grieves worked with Vickers to adapt the concept of digital twins as a way to improve product lifecycle management (PLM) in the manufacturing sector [12]. Initially, he called it the “Conceptual Ideal for PLM”. However, even during this early stage, he touched upon several key properties of digital twins [13]. In his paper, Grieves spoke about the difference between real and virtual spaces and highlighted the need for the exchange of data and information between the real and virtual entities to mirror each other.

Some Alternative Definitions of Digital Twin (Deren et al. 2021)

	Part of Understanding	Ideal Characteristics	Digital Twin Cities	Dimensions
1	a. Digital twins are 3D models b. Digital twins are copies of physical entities c. Digital twins are virtual prototypes	Multi-dimensional/multi-space-time/multiscale Dynamic/evolutive/interactive High fidelity/ Highly reliable/high-precision	Accurate Mapping	Model
2	a. Digital twins are data/big data b. Digital twins are PLM (Product Lifecycle Management) c. Digital twins are digital thread d. Digital twins are digital shadow	Total factor/all-service/ complete flow scheme/full life circle Virtual-real fusion/ multi-source fusion/heterogeneous integration Real-time update/real-time interact/real-time respond		Data
3	a. Digital twins are Physical union platform b. Digital twins are industrial Internet platforms	Bi-directional connection/interaction/driving Cross-agreement/interface/platform	Virtual-real Interaction	Connection
4	a. Digital twins are simulation b. Digital twins are virtual verification c. Digital twins are visualization	Model driven + Data driven Simulation verification/visualization/control/predict/optimize	Software Definition	Services/Functions
5	a. Digital twins are pure digital representation or virtual bodies b. Digital twins are irrelevant to entities	models vary from object to object/data vary by feature/services and functions vary according to needs	Intelligent Feedback	Physical

Basic Idea of Digital Twin (E Scholarly Encyclopedia 2023)

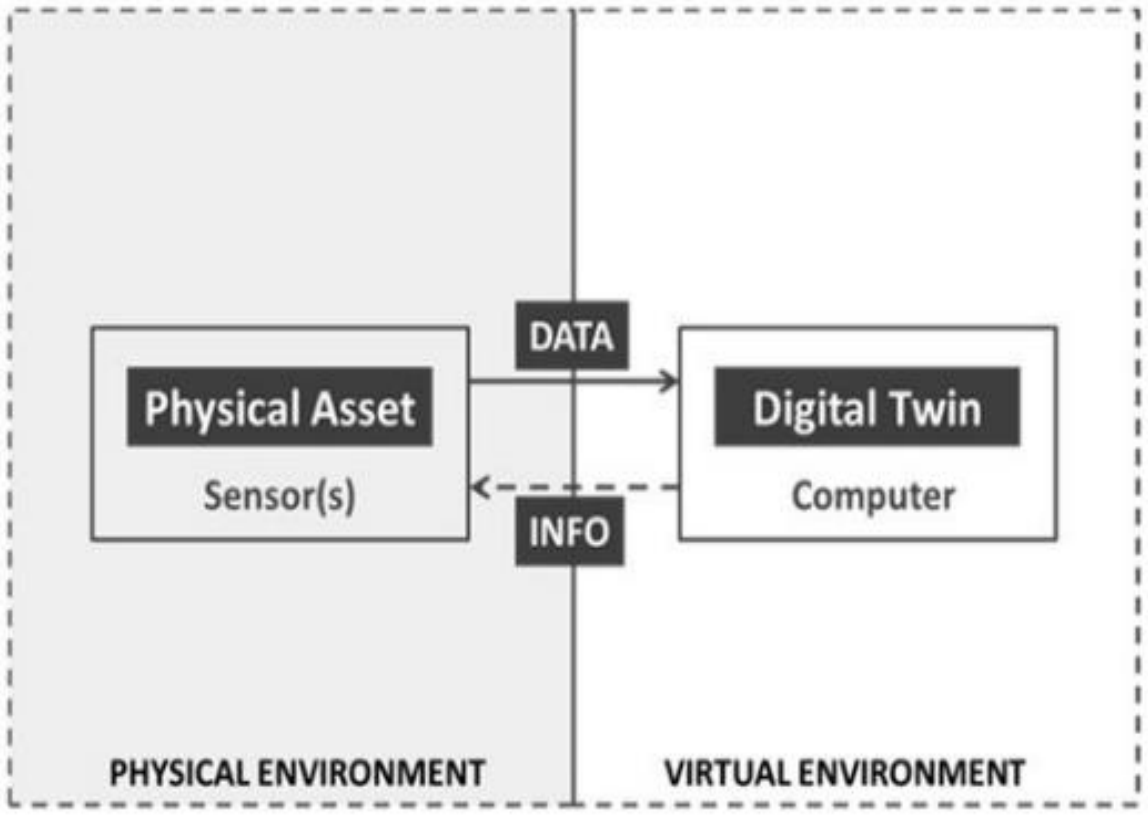


Figure 2. A conceptual representation of digital twin technology and its relation with a physical asset.

Digital Twin BIM Development in Building and Construction Industry (Deng et al. 2020)

Level 5: Ideal Digital Twin
Ideal Matrix Digital Twin

Level 4: BIM – simulation model linked to Articificial Intelligence (AI)
Digital Twin for Sensor-based and AI-based simulation

Level 3: BIM-mode linked closely to simulation model
Digital Twin for Sensor-based simulation

Level 2: BIM-model supporting simulation
Digital Twin for Gaming, ”Mirror” Game

Level 1: BIM –Basic level
BIM = Building Information Modeling
”Shadow Level (Shadow BIM)

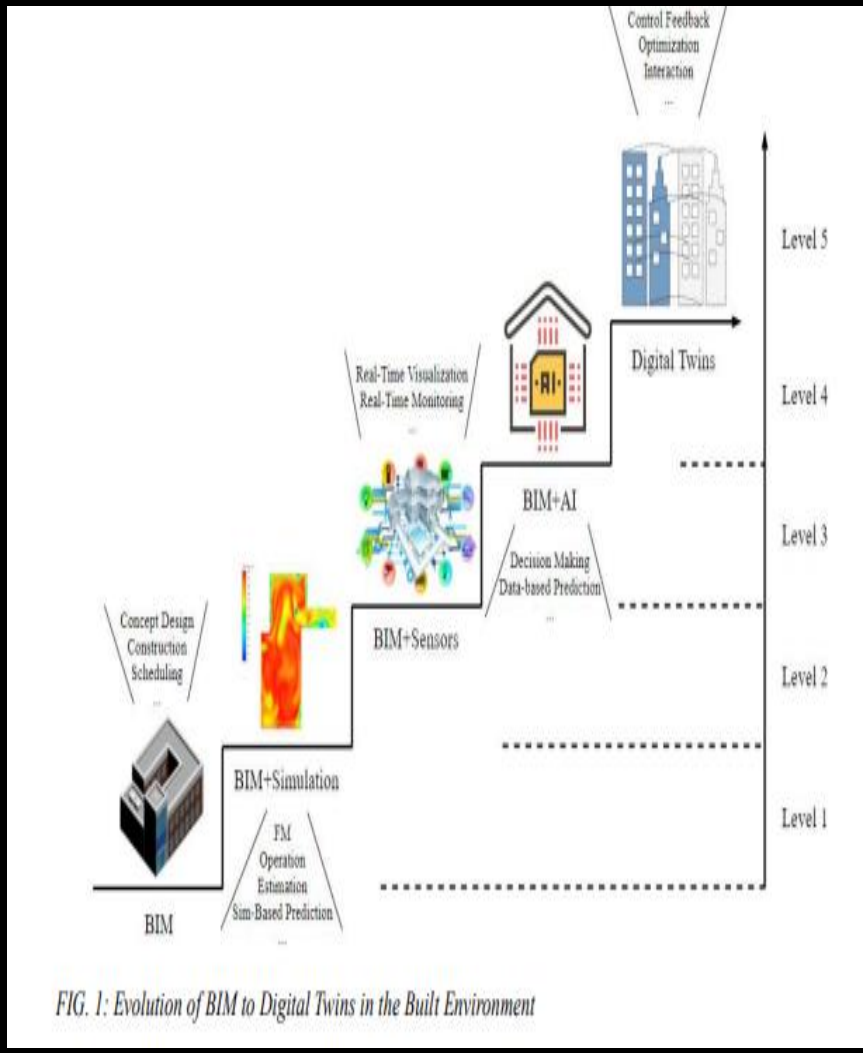


FIG. 1: Evolution of BIM to Digital Twins in the Built Environment

Industry 4.0 and Techno Futures in Cities and Business: Next Steps and Challenges (Allied ICT Finland, AIF 2022). Towards Metaverse Roadmap

AIF 2022 THEME forms a focused topic & agenda that aims to 0) initiate the theme via strategy work, 1) network top-knowledge, 2) create strategy, priority and narrative, 3) build high-impact, and 4) self sustaining.

- Each THEME has a AIF sponsor, operative lead(s), agreed work methods, and target setting based on agreed agenda
- THEMEs will report to AIF board periodically, AIF network will support each theme, based on needs
- THEMEs will be promoted to key external stakeholders based on THEME strategy and targets

Strategy/publication
Project/portfolio
Roundtable/ThinkTank
External influencing
Cause/Ecosystem
Infra/systemic action

Metaverse

Lead: Jari Kaivo-oja
Focus: Metaverse tech roadmap, 6G Scenarios, Moonshot Opportunities, Game Changing Open Windows, Global Follow Ups.

Status: 2

Human driven ICT

Lead: Dominik Siemon
Focus: Design and development of human-centred ICT, driven by human values and needs.

Status: 1-2

Industry X

Lead: Jari Kaivo-oja
Focus: IX dynamics analytics by big data, cross-border innovation management (EU S3 analytics), EDIH network analytics, global digital, waves analytics, game changing opportunities,
open window, global research follow ups.

Status: 2-3

Future Data Economy

Lead: Marika Iivari
Focus: Advancing "born digital" business opportunities based on new technologies holistically by combining business, societal, technology & environmental perspectives.

Status: 1-2

Strategy notes

AIF aims to identify emerging and key priority topics per annum though strategy dialogue between core partners, vast expert network and advisors.

Criteria for elevating topics to theme:

- Major opportunity
- Core of Finnish R&D
- Stakeholder interest
- Scientific & R&D upside
- Expectation of impact
- Availability of funding
- Partnership creation

Each selected themes will target to create a strategy, key people network, outbound narrative, KPIs and impact portfolio.

Current strategy topics are described,engaged, executed and advertized throughout AIF internal and external network.

Themes are supported by AIF board and steering group, wth reporting responsibility.

Emerging topics for next strat round:

- Addressing the changing worldview, NATO membership, security concerns, resilience and subsequent new research topics.
- Cross-co-creation between themes.

IoT next

Lead: Marjo Heikkilä
Focus: User-centric, trustworthy, low-cost, sustainable, scalable, and responsible IoT.

Status: 2

Future connectivity

Lead: Jaakko Sauvola
Focus: Bridging 5G to 6G, support national 6G Finland hub, and through Flagship - creating priority projects of applied research and verticals around Finnish 'G'-core.

Smart Campus

Lead: Risto Jurva
Focus: From campuses to business life and smart cities. Piloting of multi-discipline research innovations and scaling up to businesses and smart cities.

Status: 3

Microelectronics - Hardware

Lead: TBD (from industry or research)
Focus: Strategy creation with key Finnish actors to clarify focus, define targets, roles, identify collaboration and national standing.

Status: 0

Space ICT

Lead: Heidi Kuusniemi
Focus: ICT solutions for space industry and sectors applying space-based data.

Status: 3

CyberSecurity

Lead: Martti Lehto
Focus: continuing to work with all OEMs on the HX project.
Strengthening the ecosystem.

Status: 2-3

Green ICT

Lead: Jari Porras
Focus: Realization of the LVM Climate and Environmental Strategy for the ICT sector.

Status: x

Smart Logistics

Lead: Sami Kantanen
Focus: Carbonneutral supply chain is main priority. Looking for possibility to Apply application.

Status: 0

Health, wellbeing and Sports

Lead: Laura Rajala
Focus: Boosting R&D to promote Health.

Status: 3

Automotive ICT

Lead: TBD
Focus: Sharpen Finnish strategy and create enablers-platforms-solutions roundtable & RDI portfolio for ICT automotive needs.

Status: 1

Software

Lead: Kari Systa
Focus: Update to the 2018 study started. Community meeting in the Fall.

Status: 2-3

External affairs (EU, US, Asia)

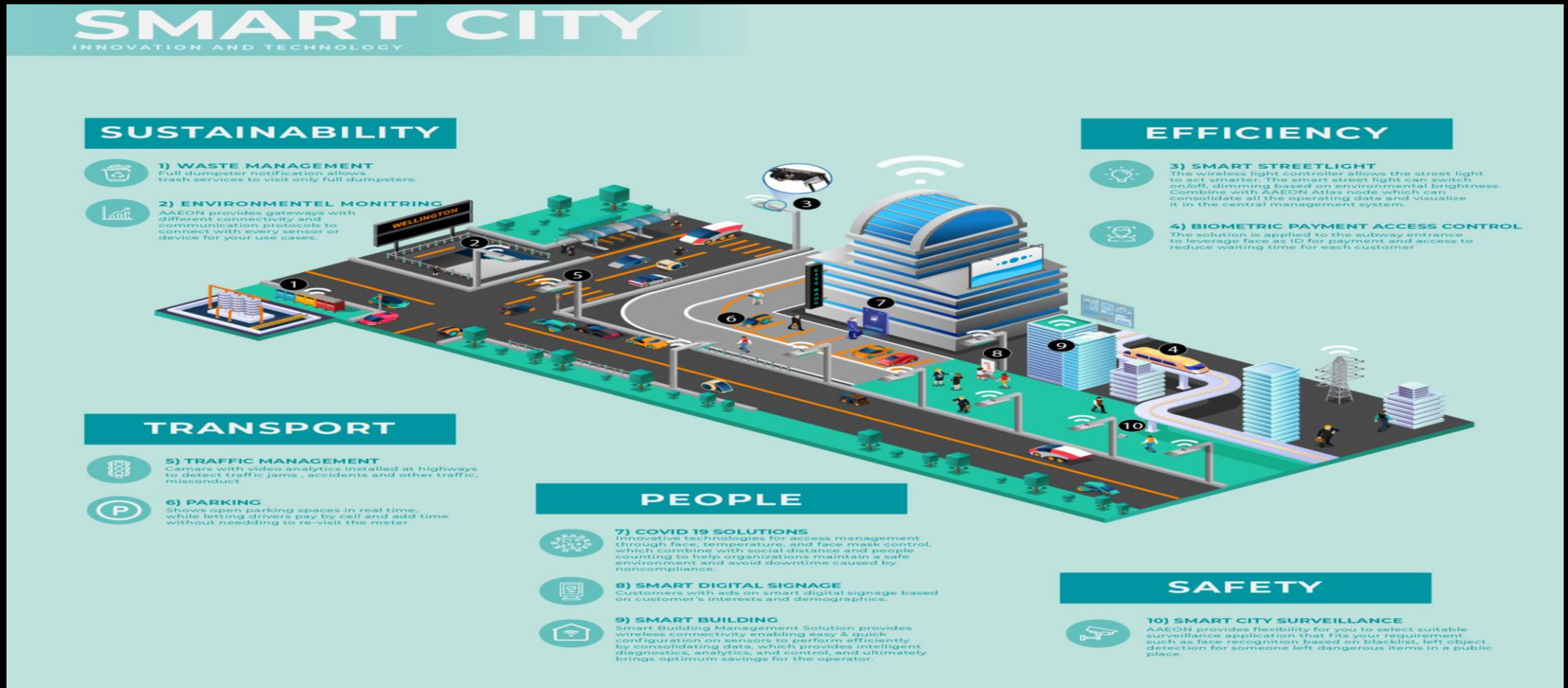
Lead: P. Sivonen, I. Peltonen, M. Klemettinen
Focus: Systematic collaboration - a forum addressing strategy, content and actions for key partners.

Status: 2-3

Theme 2: What is Smart City?

Challenges:

-SC supports sustainability, efficiency, safety and smart living of people meets customer needs
-SC includes top standards of Digital Twins, resilience and sustainable development
-SC supports smart enterprise 4.0/5.0 development
-SC is having various domains of smartnesss

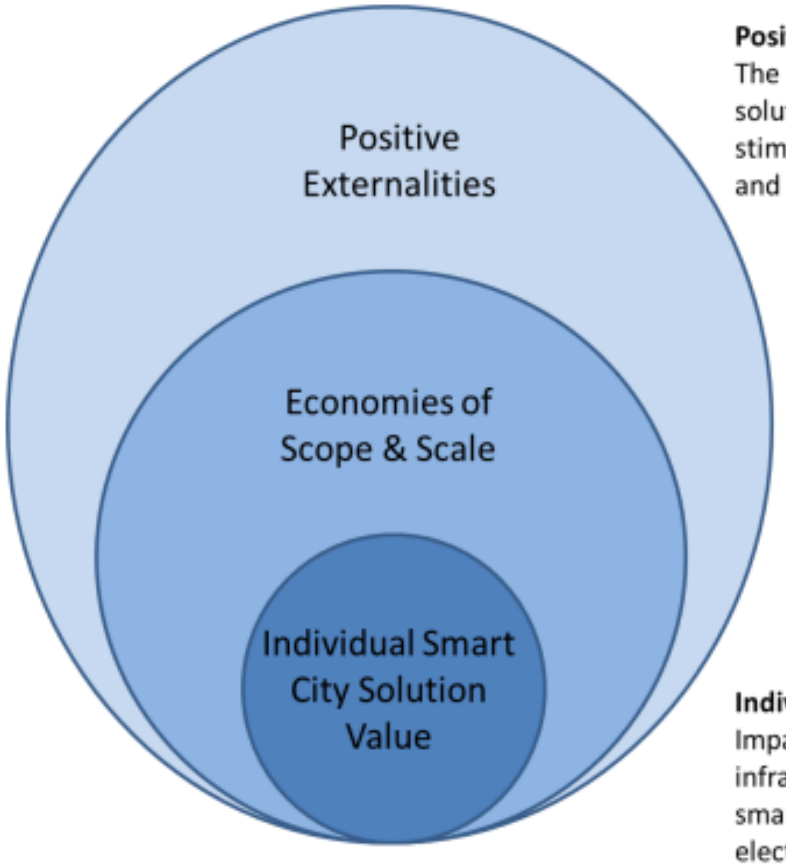


Smart City Wheel Classification (Boyd Cohen)

- Smart Economy Apps
- Smart Environment Apps
- Smart Government Apps
- Smart Living Apps
- Smart Mobility Apps
- Smart People –Apps

Why Smart Cities Need Our Attention? Benefits of Smart City Development (European Commission 2014)

Figure 24: The different levels of benefit of a Smart City solution[150]



Positive Externalities:
The incremental benefits of the solution such as economic stimulation, service innovation and citizen engagement

Economies of Scope & Scale:
The cost-savings and efficiency gains of smart city initiatives that are realised across the projects

Individual Smart City Solution Value:
Impacts of investments in infrastructure-related ICT, such as smart buildings, transport system, electricity grids etc.

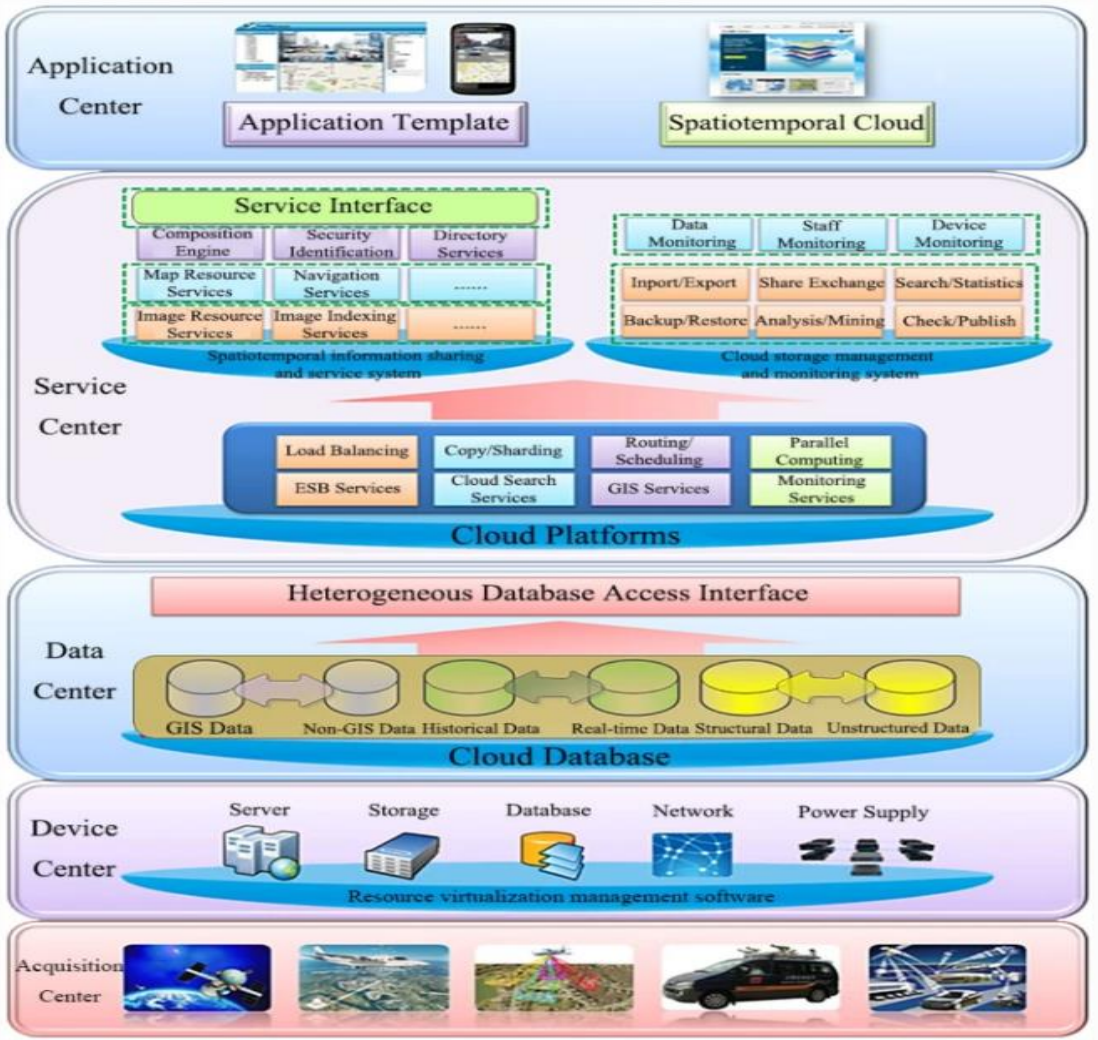
Globally, investment in digital twins is already starting to pay off. A 2021 report by global tech firm ABI Research estimates cities will save $280 billion by 2030 "by using digital twins for more efficient urban planning." According to another report from accounting and consulting firm PwC, digital twins can also help with sustainability efforts, one of the original aims of the "smart city" movement.

https://www.abiresearch.com/press/use-digital-twins-urban-planning-yield-us280-billion-cost-savings-2030/

https://www.pwc.com/m1/en/publications/documents/how-digital-twins-can-make-smart-cities-better.pdf

Digital Twin Smart City System Description (Deren et al. 2021)

Fig. 2



Schematic diagram of the structure of a smart city public information cloud service platform based on digital twins

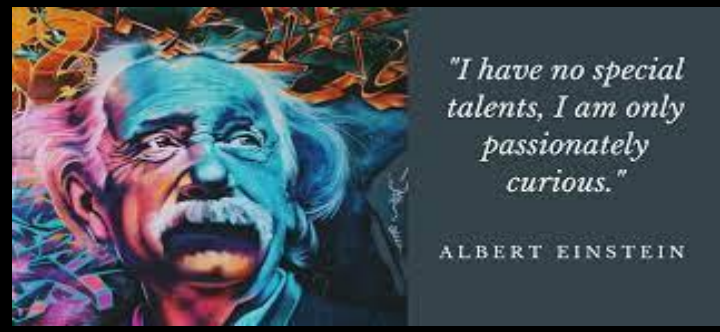
Smart City –ranking in year 2023 (IMD World Competitiveness Center 2023)

City	Rank 2023	Rank 2021	Rank 2020	Rank 2019
Zurich	1	1	1	1
Oslo	2	2	2	2
Canberra	3	–	–	–
Copenhagen	4	5	3	4
Lausanne	5	4	–	–
London	6	3	10	3
Singapore	7	7	7	10
Helsinki	8	9	5	6
Geneva	9	6	8	7
Stockholm	10	11	9	9
Hamburg	11	8	6	–
Beijing	12	17	22	30
Abu Dhabi	13	12	14	16
Prague	14	10	4	8
Amsterdam	15	13	11	11
Seoul	16	18	20	23
Dubai	17	14	19	13
Sydney	18	29	32	22
Hong Kong	19	33	34	38

Theme 3: Workshop Challenges

Challenges:

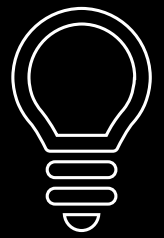
-Culture of Curiosity
-Culture of Openness
-Many What If -questions
-To have much fun and big time together!



Key Challenges to Futures & Foresight Workshops: Creating the Culture of Curiosity

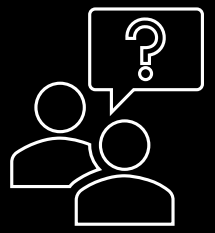
The Ability to Listen to Other People

The Ability to Find New Perspectives to Topical Issues

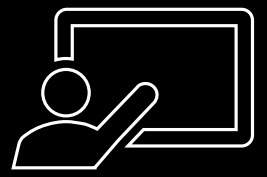


A Culture of Curiosity

The Ability to Make Questionmarks and See Complexity Issues



The Ability to Interact with Other People



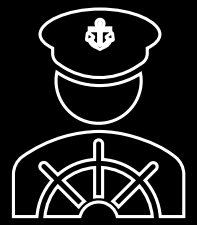
Key Challenges to Futures & Foresight Workshops: Creating the Culture of Openness

Openness to focus on new issues and challenges

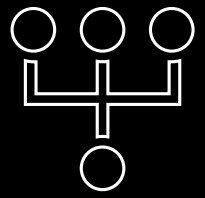
Openness to be flexible and agile in new changing situations

A Culture of Openness

Openness to futures thinking and navigation lines

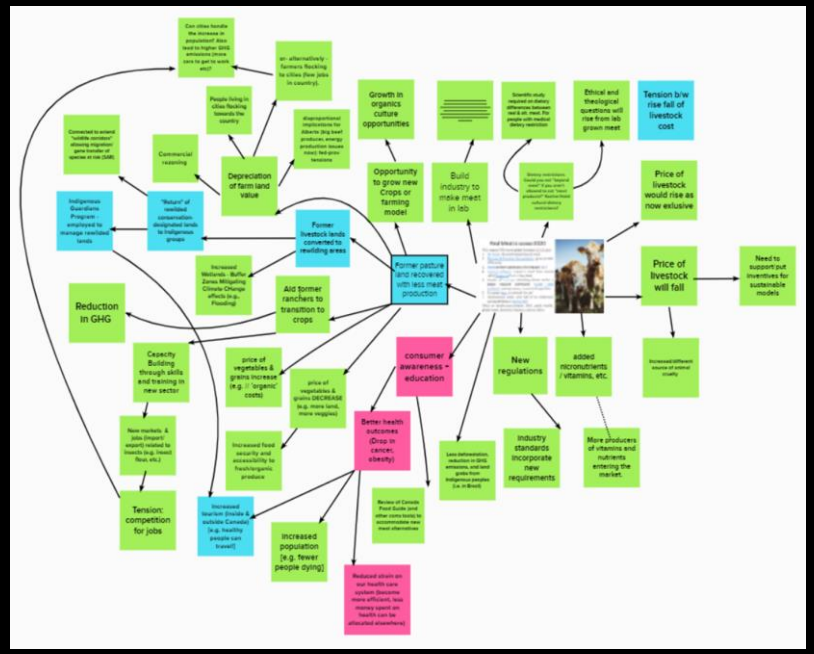


Openness to think alternatives and strategic options



Summary: Key Behavioral Issues in Futures/Foresight Workshops

- Listening
- Create New Ideas and Perspectives
- Make Questions
- Interact
- Think about futures and alternatives openly
- Focus on new issues and challenges
- Pay attention to flexibility/agility
- Think new and old alternatives



Visionary Thinking and *a Visionary Leader*: Typical personal aspects

- Have some emotional intelligence.
- Visionary Leader is a creative person.
- Visionary Leader has communication skills.
- Visionary Leader is resilient and sustainable.
- Visionary Leader has courage.
- Visionary Leader does strategic risk-taking in strategic operations.
- Visionary leader has good collaboration skills.
- Visionary leader has a growth mindset.

Thank your attention! Have a nice day!

Research Director, Adjunct Professor Jari Kaivo-oja

Researcher, MSSc. (Futures Studies) Tolga Karayel

Smart City Digital Twin Project in Collaboration with Turku, Gdansk, Wroclaw (Poland) and Vilnius (Lithuania)

European Regional Development Fund (ERDF)/Turku ecosystem agreement

Finland Futures Research Centre

Turku School of Economics

University of Turku

Co-funded by the European Union

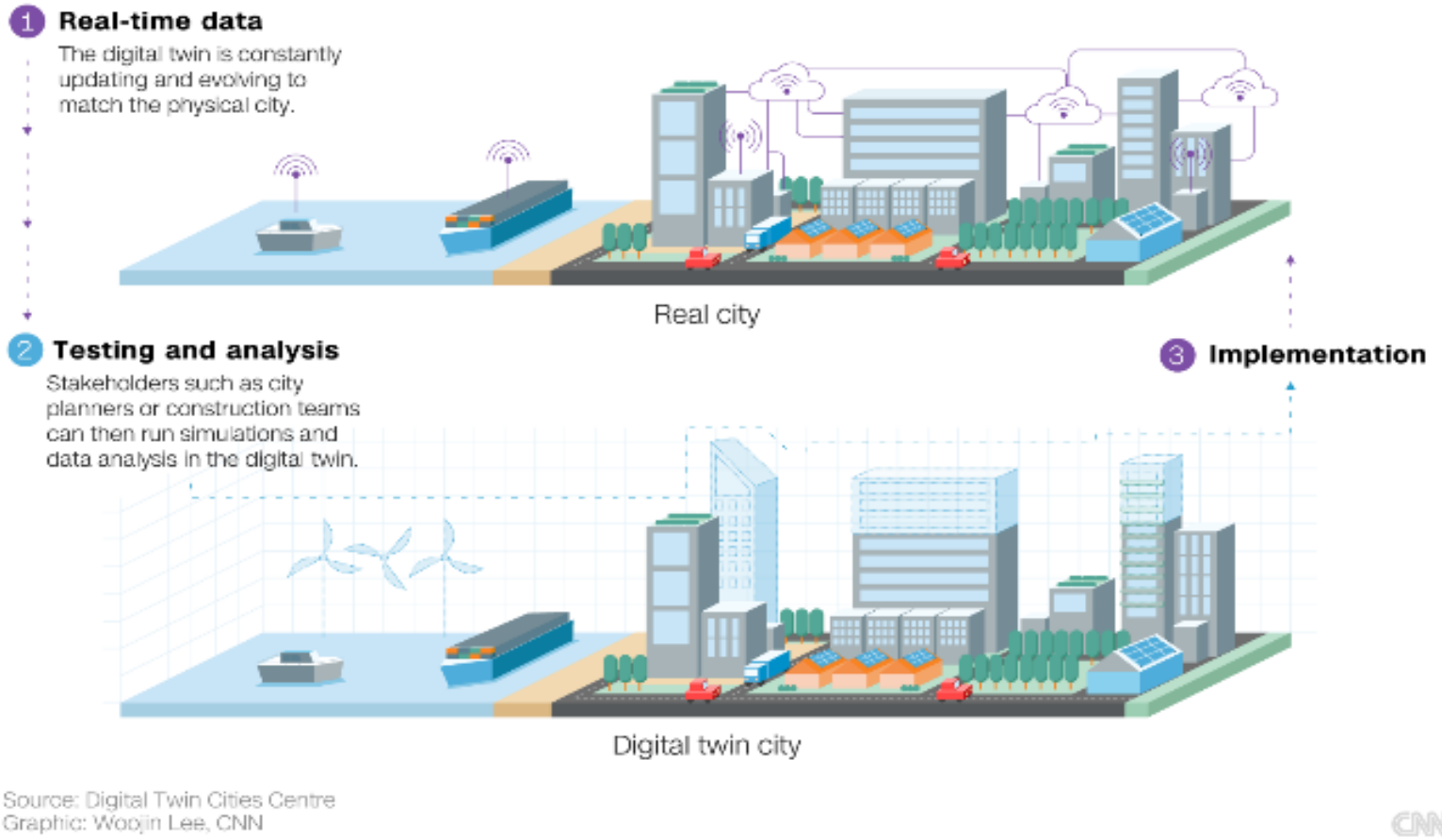
Extra Bonus Smart City Digital Twin Materials

Co-funded by
the European Union

TwinNets 2022 Belfast Conferene Agenda of international discussions

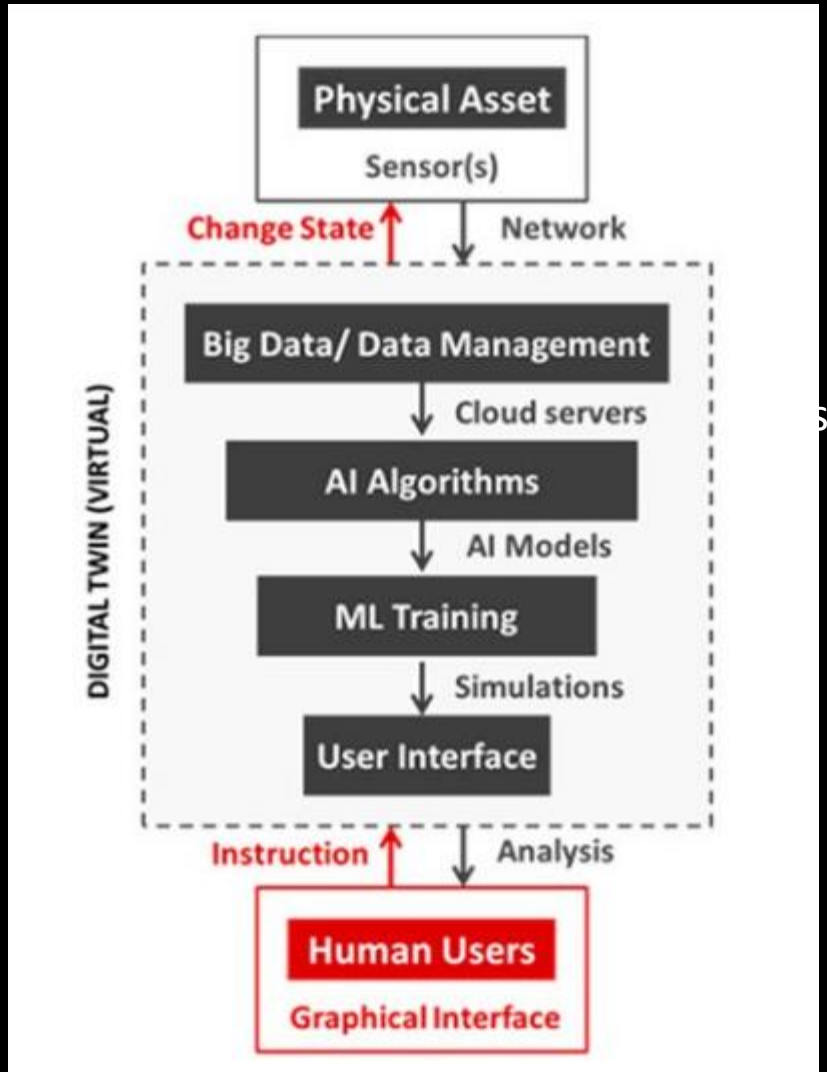
- The technical topics of interest to the workshop include, but are not limited to:
- Network Digital Twins Properties, Modelling and Definitions
- Reference Architecture for Network Digital Twins
- Cyber-Physical Interaction between Networking Assets and Digital Twins
- Digital-Twins Life Cycle
- Digital Twins in Software Defined Networking and Network Function Virtualization
- 5G/6G Digital Twins
- Digital-Twin-oriented approaches and cyber-physical interaction applications
- Networking emulation and simulation through Digital Twins
- Digital Twins to support Networks Data acquisition, Big-Data processing, and AI modeling
- Digital-Twins Management and Orchestration
- Optimized Networking Decision Making
- Edge/Fog/Cloud Network Digital Twins
- Privacy and Security Issues and Opportunities
- Digital Twins Platforms & Interoperability Issues
- Real-World Deployments and Experimentations
- Evaluation and analysis of experimental data
- Creation and sharing of datasets of broad interest to the community
- Application of Digital Twins towards a Predictive Internet
- Massive Digital Twinning requirements and applications
- Testing and Validation of Digital Twins - approaches, frameworks, testbeds
- Quality of Service for Digital Twins
- Digital Twins as a Service
- Design of Digital-Twin-based applications

New Urban Planning Process



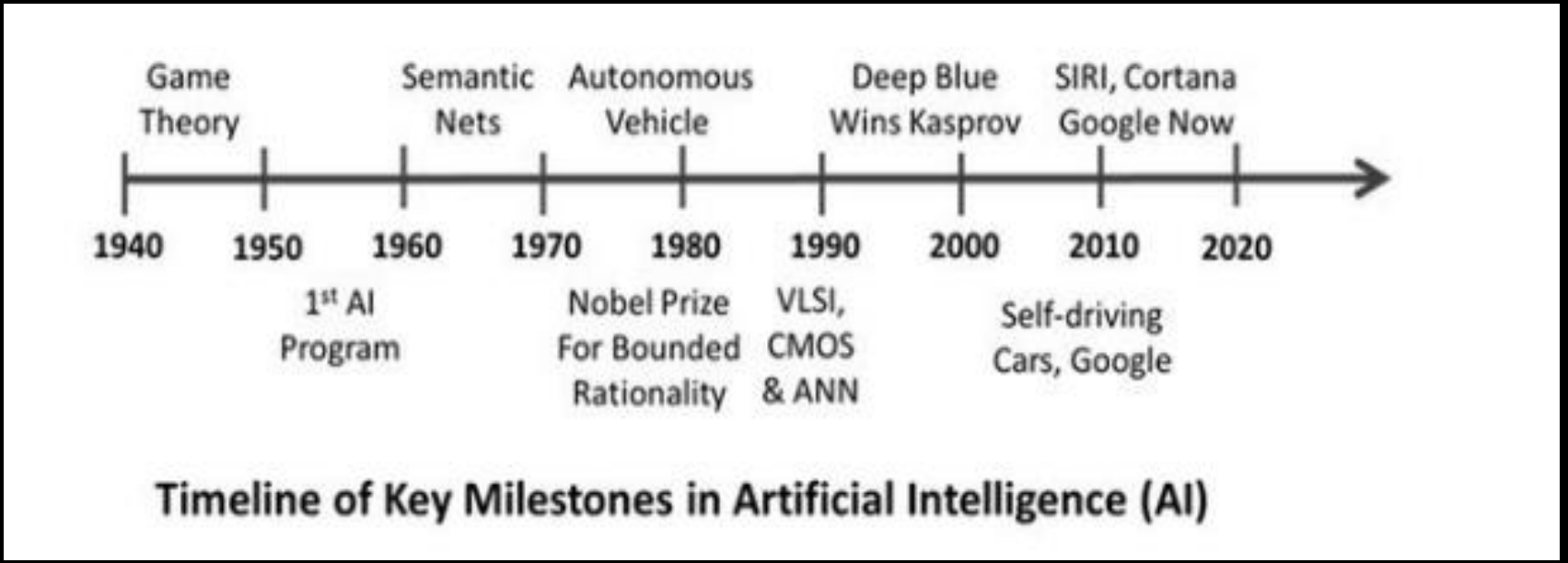
Globally, investment in digital twins is already starting to pay off. A 2021 report by

Digital Twin Thinking and Apps (E Scholarly Encyclopedia 2023)



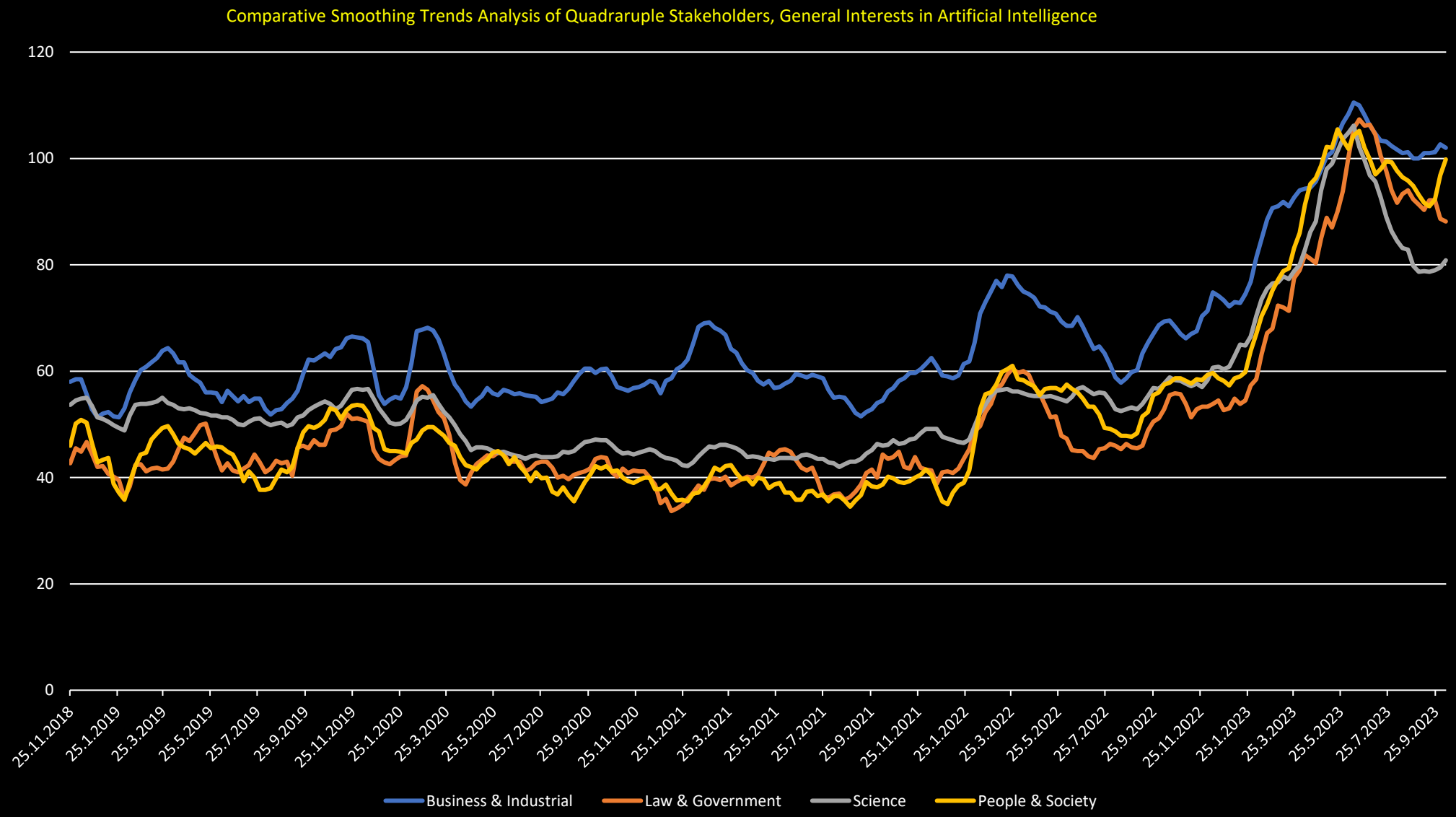
s. Lisää [Evolution of Digital Twins | Encyclopedia MDPI]

Historical Development of Artificial Intelligence: Before AI Hype (E Scholarly Encyclopedia 2023)

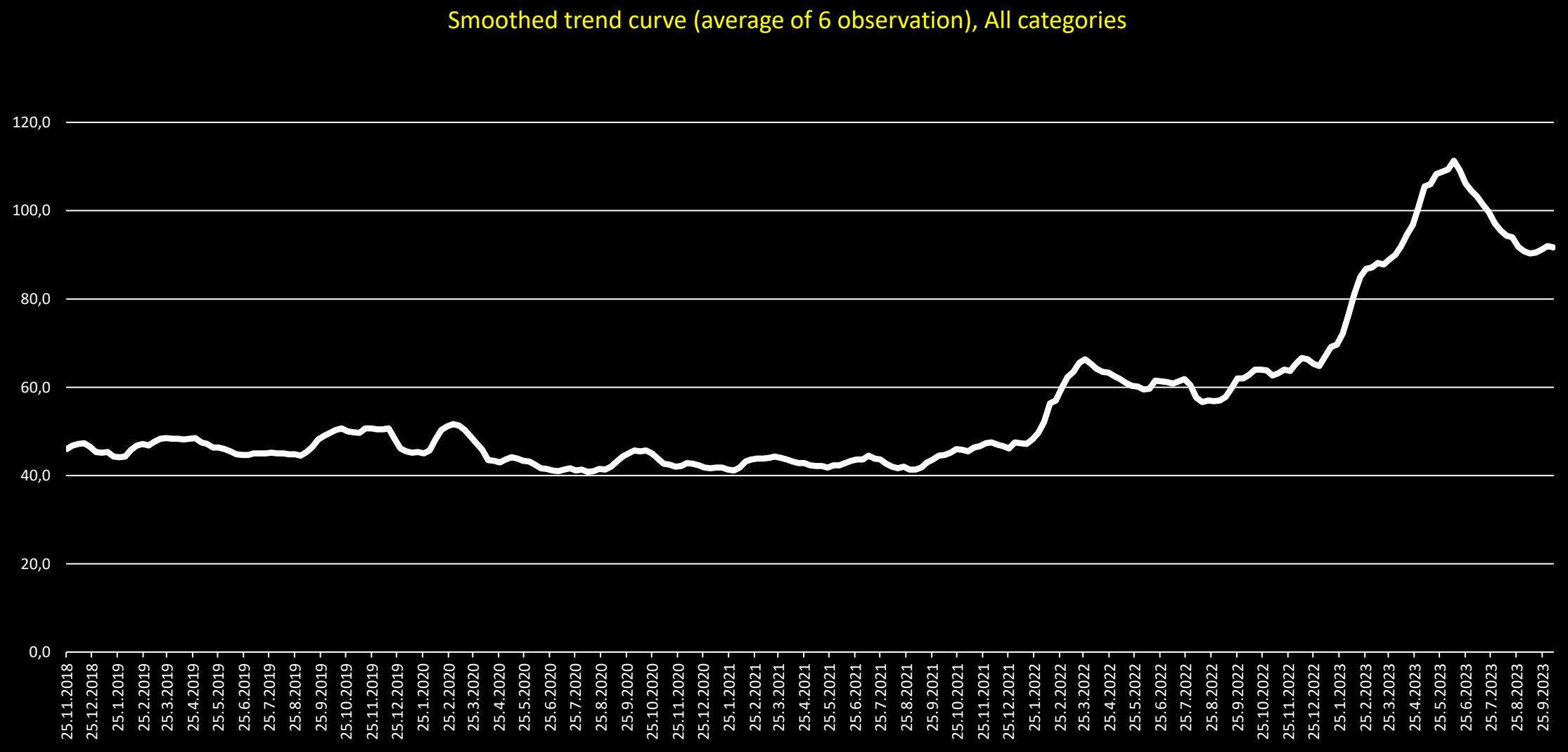


Timeline of Key Milestones in Artificial Intelligence (AI)

AI Hype among the Quadraruple Helix Actors, Oct 2018-Oct 2023 (Google Trends Data Oct 2023)



Global interest in AI, Smootged Trend Curve, Oct 2018-Oct 2023 (Google Trends Data Oct 2023)



Smart City- development and key modules (European Commission 2014)

Figure 3 : The relationship between components and characteristics of Smart Cities

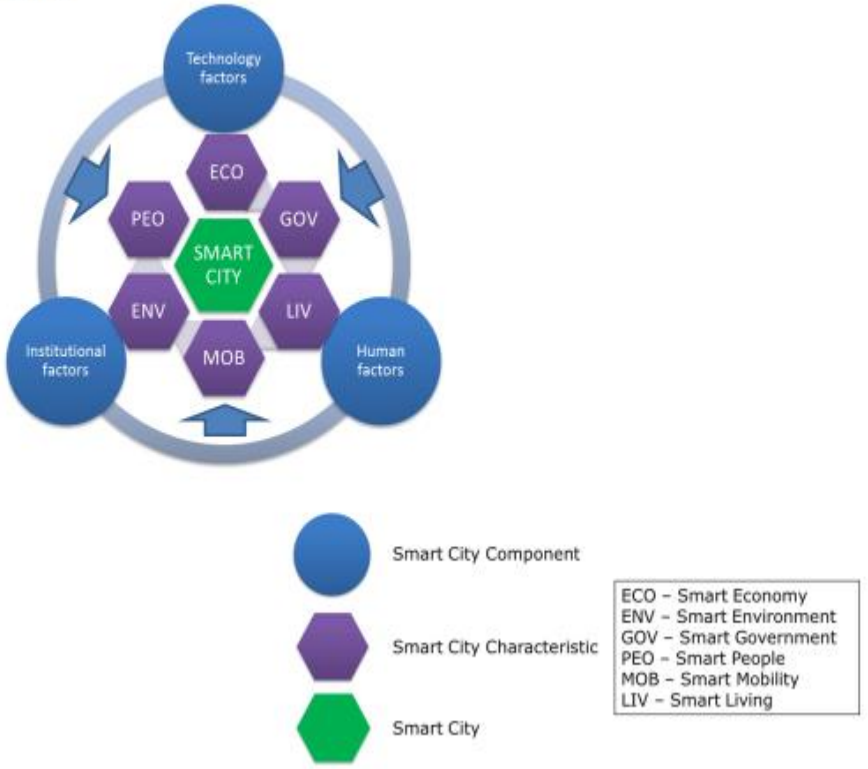
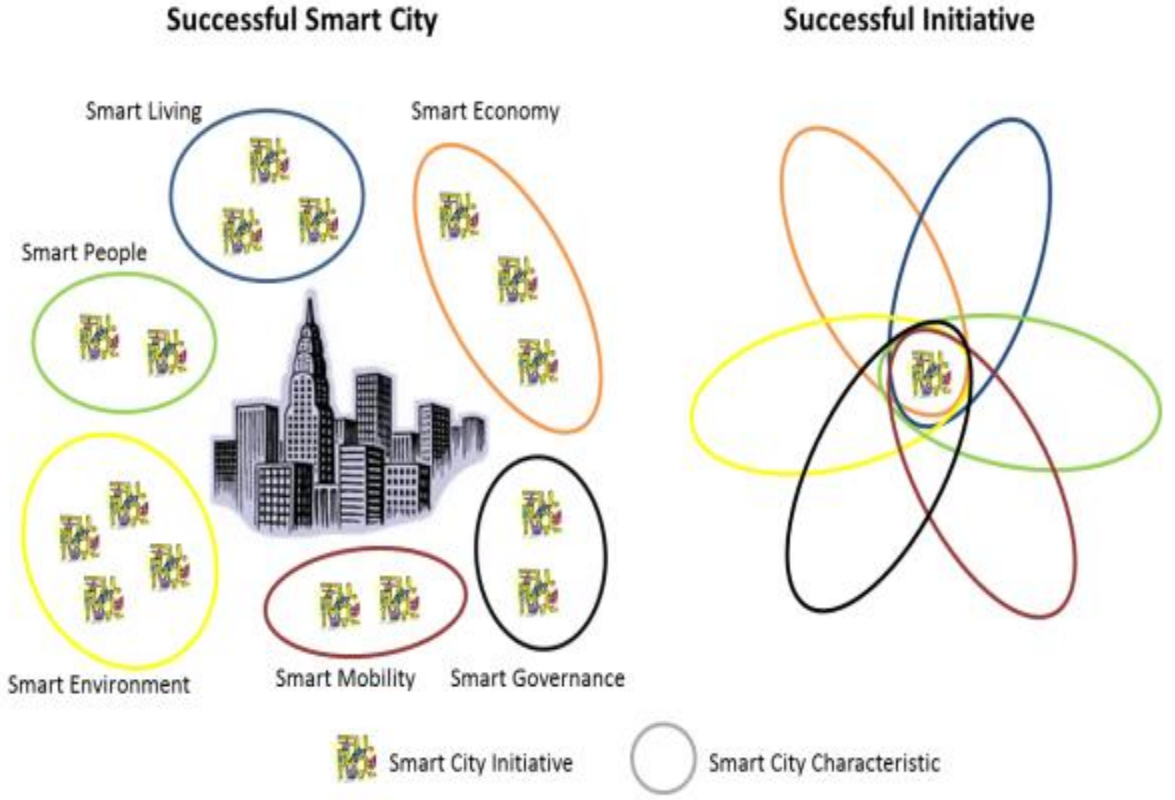
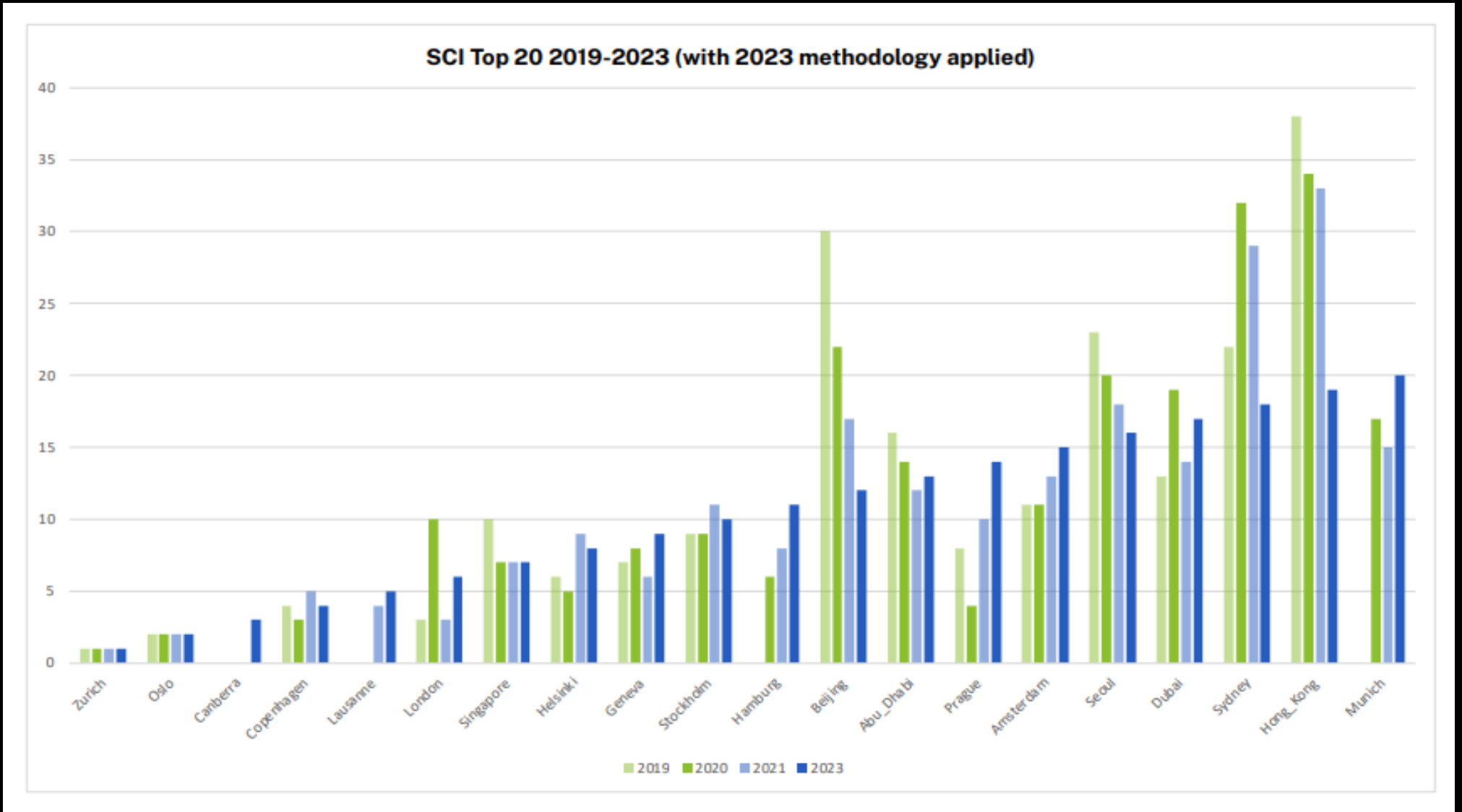


Figure 21: Diagrams of a successful Smart City and a successful initiative



Smart City –rankings in 2019-2023 (IMD World Competitiveness Center 2023)



Typical elements of visionary leadership

- Develop a Vision Statement and Share and Communicate a Vision to Stakeholders
- Develop a Short Vision Slogan and Challenge Others
- Always Seek Small and Big Improvements Toward a Vision Showing Enthusiasm
- Challenge a Process If Results Are Not Satisfying
- Share the Vision with Other Key Stakeholders and Help Them Reach Milestones
- Be Detailed Enough with Good Examples to Implement Vision in Reality - Build a Roadmap ”from Vision to Action”
- Use Vision as a ”Empowering Resource Magnet” during Tangible and Intangible Resource Mobilisation of Vision Implementation
- Improve Human Performance Gradually Towards Reaching Vision with Communication, Motivation and Feedback Mechanisms
- Celebrate Success Steps Towards the Vision
- Use Numbers and Narratives in Visionary Communications