Smart City Digital Twins

Älykäs kaupunkikehittäminen digitaalisten kaksoismallien pohjalta

5.3.2024

PROGRAM

SMART CITY DIGITAL TWINS 5.3.2024

10:05 Managing complexity in cities with predictive digital twins
Bart Vuijik, Innovation partnership manager,
TNO Innovation for life, Netherlands

10:25 Exploring Smart City Digital Twins
Dr Jari Kaivo-oja, Research Director, Adjunct Professor,
Finland Futures Research Centre
& the SCDT team

11:10 A way forwards for city digital twins
Mark Enzer, Strategic Advisor,
Mott MacDonald and Visiting Professor at the University of Cambridge and Imperial College London

11:30 Panel discussion – From Challenges and Opportunities to Real World Implementation and Impacts
Moderator Tero Villman, Development Manager, Finland Futures Research Centre, Turku School of Economics, University of Turku

11:50 Final Thought – How to build from the Smart City Digital Twin project?
Dr Jari Kaivo-Oja, Research Director, Adjunct Professor
Finland Futures Research Centre, Turku School of Economics, University of Turku

12:00 Ending

Co-funded by the European Union

Exploring Smart City Digital Twins

Älykäs kaupunkikehittäminen digitaalisten kaksoismallien pohjalta

Final Seminar, March 5, 2024

Jari Kaivo-oja, Adjunct Professor, Research Director
Tero Villman, Development Manager
Tolga Karayel, Project Researcher
Laura Pouru- Mikkola, Development Manager

Finland Futures Research Centre
Turku School of Economics
University of Turku

Michael Lindholm, Network Manager, TechTurku, Business Turku
Eero Immonen, Principal Lecturer, Turku University of Applied Sciences

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Why should
Smart City Digital Twins
be at centre of sustainable
transitions amidst
future uncertainties?

Smart City Digital Twins Project

April 2023 – April 2024

BACKGROUND

CITY OF TURKU is a member of Nordic Smart City Network and contributed to smart city developments

Nordic Smart City Network: **https://nscn.eu**

A collaboration of City Labs

NORDIC SMART CITY NETWORK

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Smart City Digital Twins Project

APRIL 2023 – APRIL 2024

OVERVIEW

Aims to leverage SCDT for sustainable urban futures via mapping study.

Collaborative approach with academia, cities, businesses, and research to enhance digital twin capabilities, promote innovation, and align with Finland's smart specialization strategy.

Seek to demonstrate the potentials of Digital Twins in improving urban life, emphasizing the importance of open data utilization and addressing matching problems in smart urban development.

Boost smart city development in Finland with new insights and approaches..

Create **Smart City Digital Twin Marketplace**
https://www.b2match.com/e/smart-city-digital-twin

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GDAŃSK · Interizon · ITCORNER · ARAW · VILNIUS · LIC LITHUANIAN INNOVATION CENTRE

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SCDT PROJECT RESEARCH DESIGN

LITERATURE REVIEW

SURVEY STUDY*

Current Survey Results
22 Respondents (CIO, COO, Directors, Entrepreneurs & Managers)

There is no solid and feasible SCDT visions or strategies on national and local level

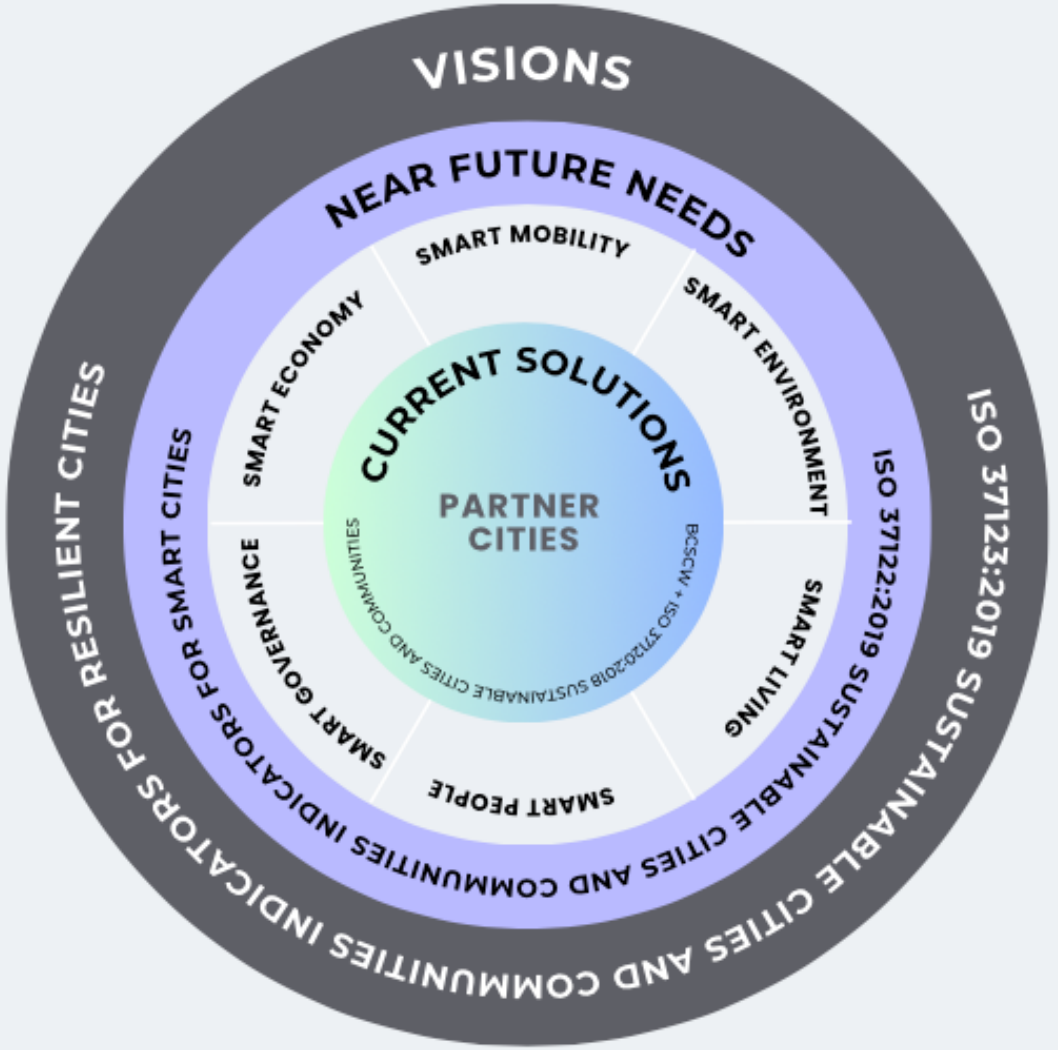
Lack of consistent analysis on citizens' expectations AND city needs for smart city digital twin development projects.

FORESIGHT WORKSHOPS

INSPIRED BY BOYD COHEN'S SMART CITY WHEEL
Smart City 6 Dimensions
THEMES
CURRENT SOLUTIONS
VISIONS
NEAR FUTURE NEEDS

Done in Gdansk, and Wroclaw - Poland, Vilnius - Lithuania and Turku, Finland
Total 99 Participants

DATA GATHERING



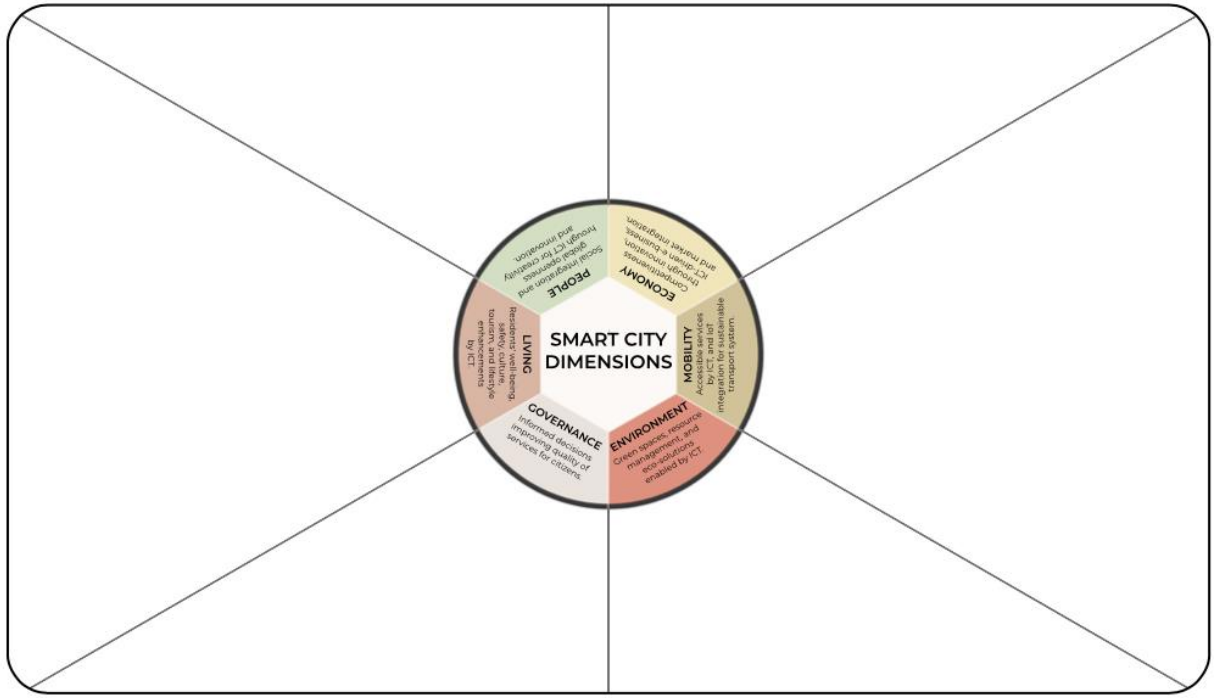
ANALYSIS

Smart City Digital Twins Project

FORESIGHT WORKSHOP METHOD

Boyd Cohen's Smart City Wheel

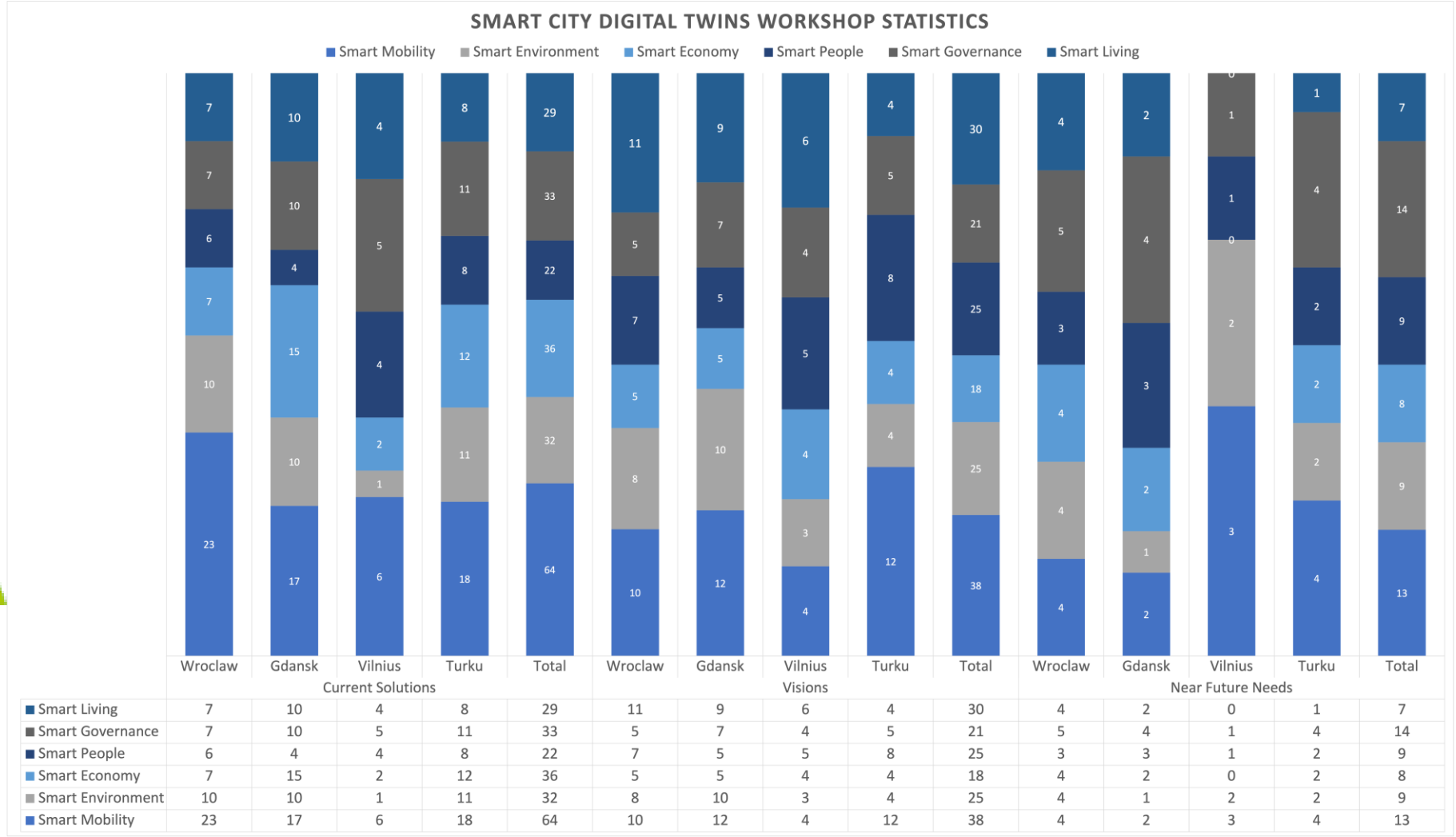
Smart City Benchmarking and assessment tool with 6 Dimensions, 18 sub-dimensions, 62 Indicators



Source: Qonita, M., Giyarsih, S.R. Smart city assessment using the Boyd Cohen smart city wheel in Salatiga, Indonesia. *GeoJournal* **88**, 479–492 (2023). https://doi.org/10.1007/s10708-022-10614-7

Smart City Digital Twins Project: Smart Wheel Analysis Data Summary

KEY FINDINGS



	Current Solutions					Visions					Near Future Needs				
	Wroclaw	Gdansk	Vilnius	Turku	Total	Wroclaw	Gdansk	Vilnius	Turku	Total	Wroclaw	Gdansk	Vilnius	Turku	Total
Smart Living	7	10	4	8	29	11	9	6	4	30	4	2	0	1	7
Smart Governance	7	10	5	11	33	5	7	4	5	21	5	4	1	4	14
Smart People	6	4	4	8	22	7	5	5	8	25	3	3	1	2	9
Smart Economy	7	15	2	12	36	5	5	4	4	18	4	2	0	2	8
Smart Environment	10	10	1	11	32	8	10	3	4	25	4	1	2	2	9
Smart Mobility	23	17	6	18	64	10	12	4	12	38	4	2	3	4	13

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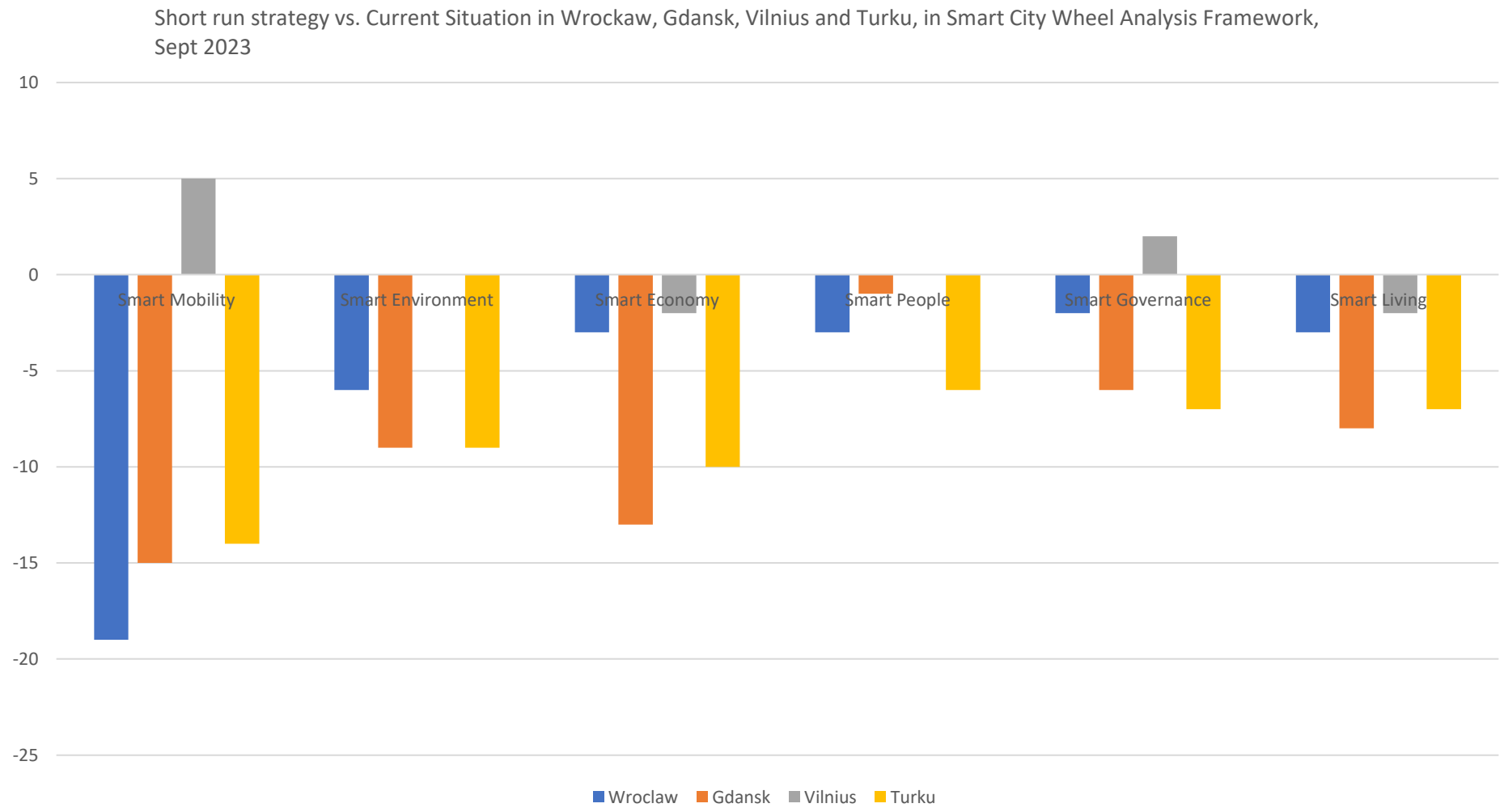
Short run strategy vs. Current Situation in Wroclaw, Gdansk, Vilnius and Turku, in Smart City Wheel Analysis Framework, Sept 2023



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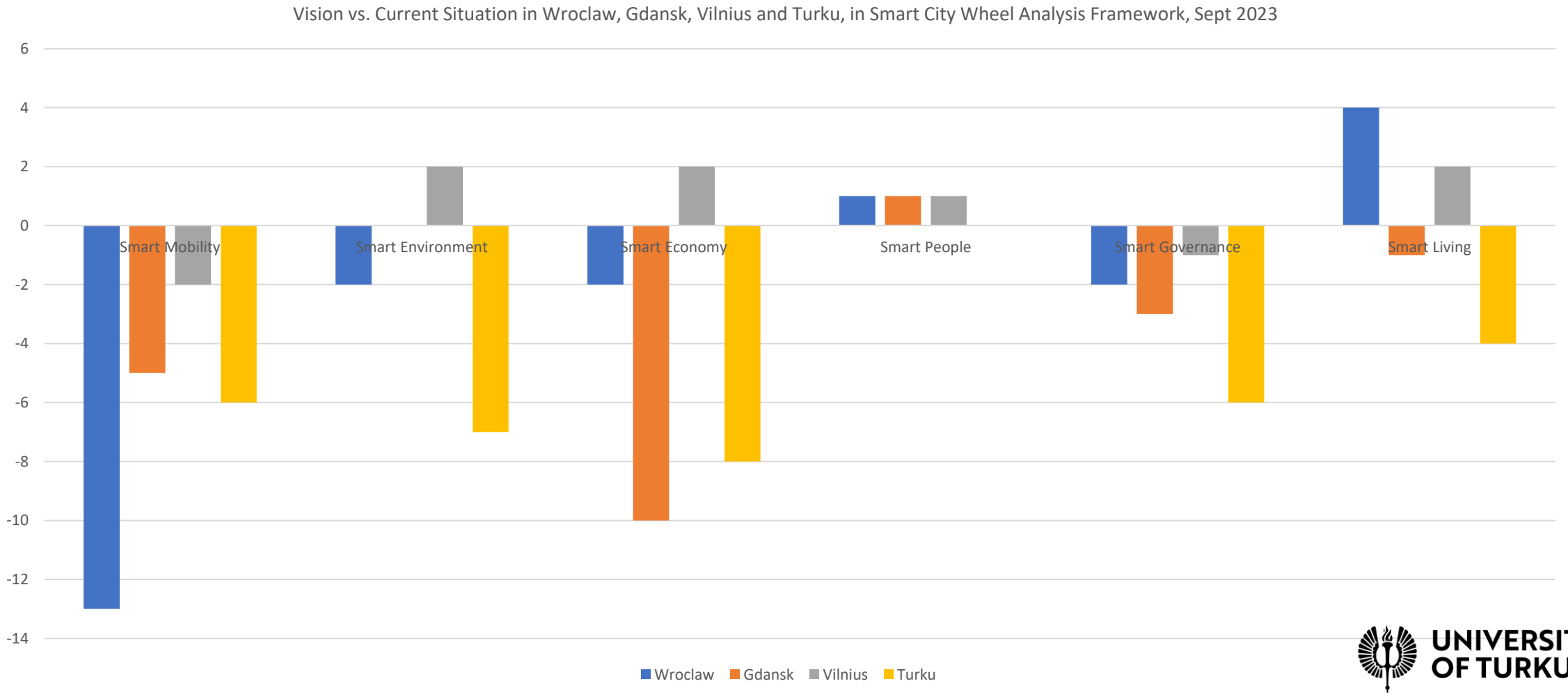
Vision vs. Current Situation in Wroclaw, Gdansk, Vilnius and Turku, in Smart City Wheel Analysis Framework, Sept 2023



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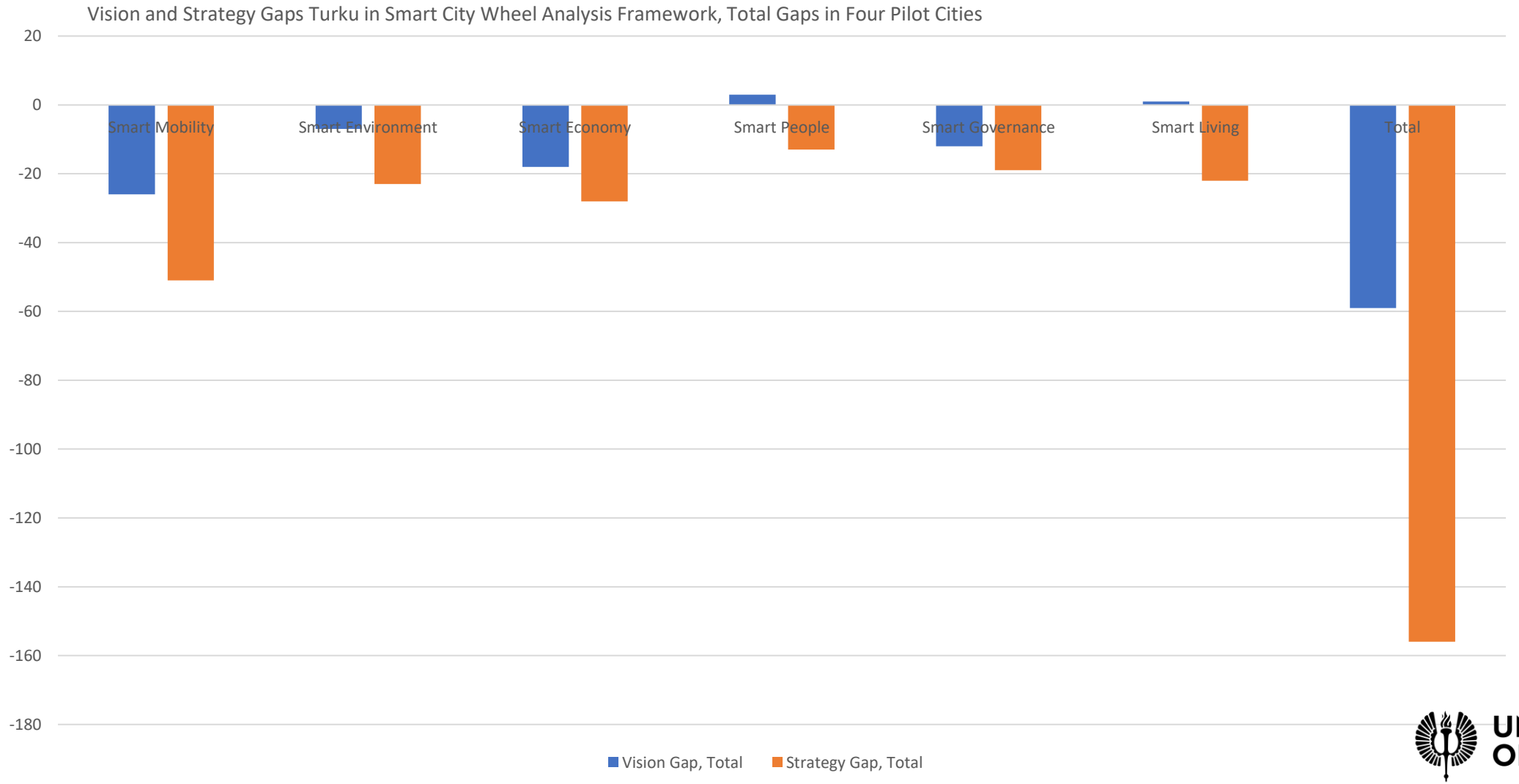
Vision and Strategy Gaps Turku in Smart City Wheel Analysis Framework, Total Gaps in Four Pilot Cities, Sept 2023



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Smart City Digital Twins: Opportunities

OPPORTUNITIES

Real-time Monitoring

Predictive Analytics What-IF Analysis

Simulation and Modelling against future uncertainties

Resource Optimization & Environmental Sustainability

Citizen-Centric Public Engagement

Disaster Preparedness and Long-Term Planning

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Smart City Digital Twins

Key Concepts “Cyber-Physical Systems-Thinking”

Cyber Space

ICT

Physical Space

Layer 5 Virtual Digital Twins Apps & Platforms
Bidirectional Data Flow with Layer 4

Layer 4 Digital - Smart City Apps
Collects data from layers 0 – 3 via enabling technologies (IoT, sensors, connected-devices) to manage and monitor city systems and services

Layer 3 City System
Movements of people and goods and organizational structures in the city

Layer 2 Infrastructure

Layer 1 Buildings
(Artefacts)

Layer 0 Terrain
(Natural)

(Modified from; Lu et al., 2019; Mylonas et al., 2021; White et al., 2021)
Graphic esri.com

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Smart City Digital Twins Project
CASES: Turku, Vilnius, Wroclaw, Gdansk

OVERVIEW

CURRENT SOLUTIONS

Working on improving the built environment and mobility, with initiatives like smart lighting, green spaces, and efforts to reduce pollution and congestion.

NEAR FUTURE NEEDS

Environmental education and infrastructure development.
Mobility: Infrastructure expansion and development.
Governance: Legal and regulatory changes, data privacy, and more affordable solutions.
People: Behavioral change, education, and ethical considerations for AI and data.

VISIONS

Environment: Focus on sustainability and reduced carbon footprint.
Mobility: Integrated mobility systems and autonomous transportation.
Economy: Shift to digital and online services.
People: Advancements in AI, virtual reality, and metaverse.
Living: Smart cities with unified ecosystems and safety monitoring.
Governance: Transition to e-governance and data management.

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Smart City Digital Twins Project
CASE: Gdansk, Poland

GDANSK POLAND

CURRENT SOLUTIONS

- Waste management and monitoring systems.
- Autonomous transportation options.
- Various economic project fundings.

NEAR FUTURE NEEDS

- Need for interconnected transport options.
- Parking improvements.
- Air, soil, and water monitoring.
- Sustainable start-up ecosystem.
- Focus on ethical AI and data governance.

VISIONS

- Visions include reducing carbon emissions, enhancing automation, and promoting green solutions.
- Transition to a smart, connected city with autonomous transportation.
- Shift towards digital payments and services.
- Creation of unified systems for city living and governance.

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Smart City Digital Twins Project
CASE: Wroclaw, Poland

WROCLAW POLAND

CURRENT SOLUTIONS

- Emphasis on ambient technologies & smart lightning.
- Mobility solutions, including sharing economy and autonomous cars.
- Economic initiatives for revenue management and citizen benefits.
- Governance improvements through electronic services.

NEAR FUTURE NEEDS

- Expanding AR and VR usage.
- Use of sensors and simulations for infrastructure.
- Infrastructure funding models.
- Collaborative efforts between universities and companies for technology innovation.

VISIONS

- A vision of a sharing economy and the role of infrastructure.
- Autonomous vehicles and the impact on urban traffic.
- Transition to digital, paperless bureaucracy.
- The potential of the metaverse and AI in society.

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Smart City Digital Twins Project
CASE: Vilnius, Lithuania

VILNIUS LITHUANIA

CURRENT SOLUTIONS

- Growing bicycle roads and green city development.
- Smart parking solutions.
- Use of smart city lights.
- Car sharing and sharing economy.

NEAR FUTURE NEEDS

- Infrastructure needs for the sharing economy.
- Mindset change regarding digital payments and paperless bureaucracy.
- Ethical considerations for AI and data usage.
- Standardized platforms and data.
- Regulatory changes for AI and social media

VISIONS

- Focus on a green city and automated environmental monitoring.
- A future with shared, autonomous transportation.
- Transition to digital and avatar-based economic systems.
- Predictive AI systems for optimizing city life.

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Smart City Digital Twins Project
CASE: Turku, Finland

CURRENT SOLUTIONS

TURKU FINLAND

A strategic focus on economic growth, environmental sustainability, effective government, efficient mobility, and raising citizen quality of life characterizes the participants' approach to SCDT

NEAR FUTURE NEEDS

- **Digital Twin Strategy and Research Funding:** Workshop insights emphasized the necessity for significant financing for research into both the fundamental and applied elements of digital twin technology
- **Economic Strategies**: The workshop data highlights the importance of creating viable growth plans and business models in the context of digital twins
- Necessity for **flexible legislation**, particularly in the context of autonomous mobility, and highlights **innovation clusters** as requiring specific mobility planning.
- The necessity for a **trained workforce** in the creation of Smart City Digital Twins (SCDT)

VISIONS

- **Smart National API Strategy:** Because there is no standardized Smart National API approach, interoperability and smooth integration across diverse smart city efforts are difficult.
- **Data Repository Management against Smart City Cyber Attacks:** The closure of some data repositories owing to national security concerns may cause disruptions in the operations of firms that rely on these repositories

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Standardization for SCDTs

- Regardless of application, **standardization always aims at “not reinventing the wheel”**

- For SCDTs, standardization refers to **modular** software and hardware solutions that are
  - Reusable
  - Interoperable
  - Low-complexity (relatively speaking)
  - Can be rapidly and collaboratively developed in isolation of the end application
  - “Plug-and-play”

- For SCDTs, standardization **benefits**
  - Flexibility – use any suitable module,
  - Maintainability – modifications and upgrades at module level
  - Scalability

–> **Managing the growth of smart city information systems!**

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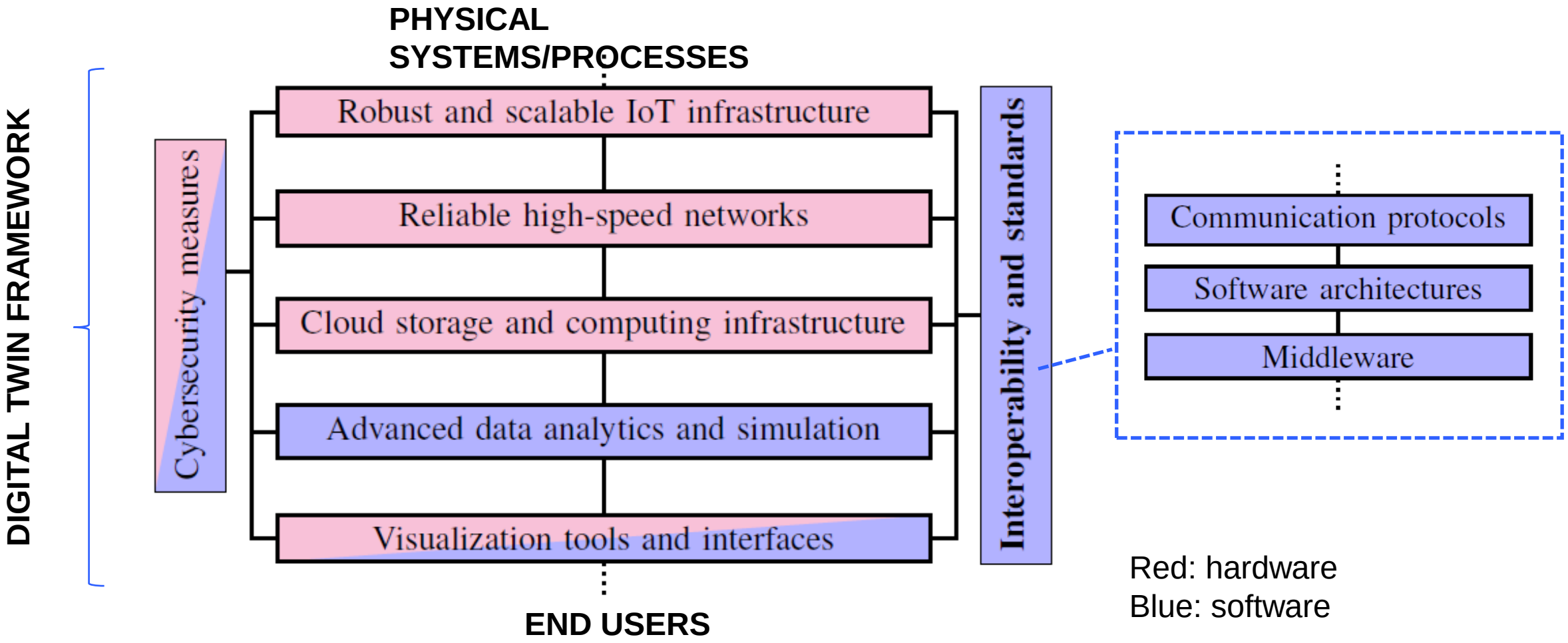
Taxonomy of SCDT standardization



Red: hardware
Blue: software

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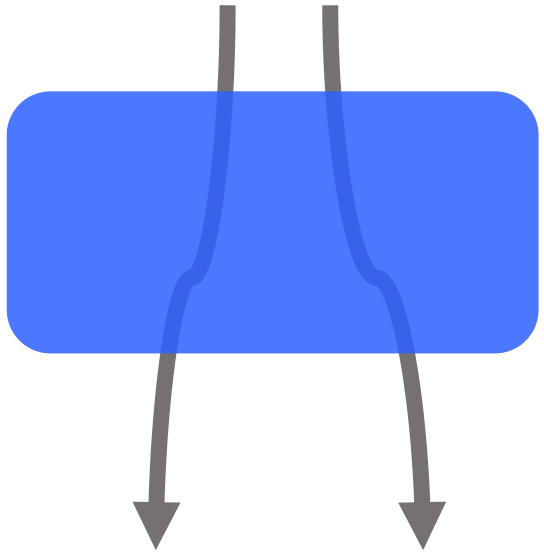
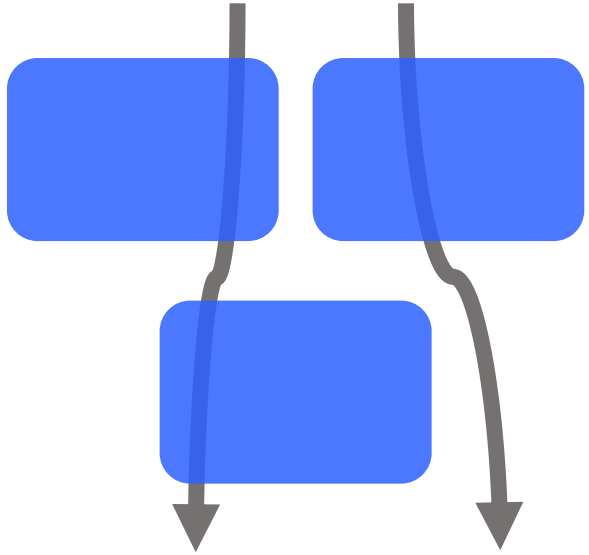
Modularity and Smart City Digital Twins

Monolithic design



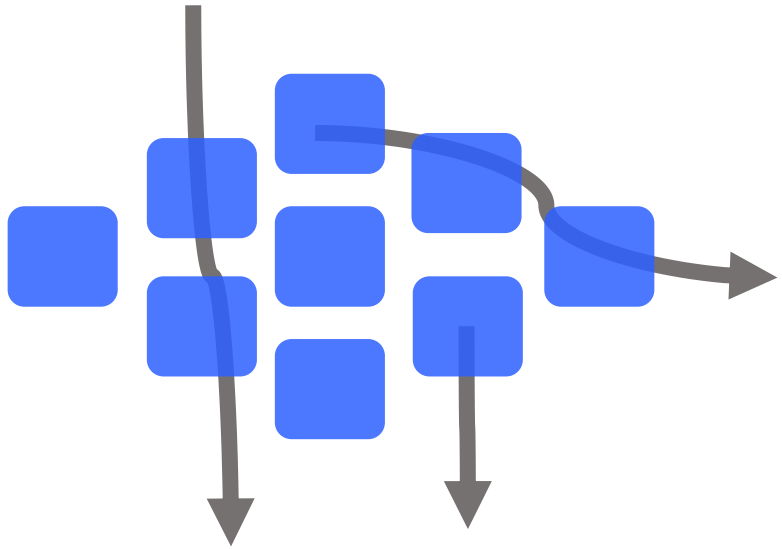
Impossible to design Digital Twins for cities with this design

SOA, Coarse grained



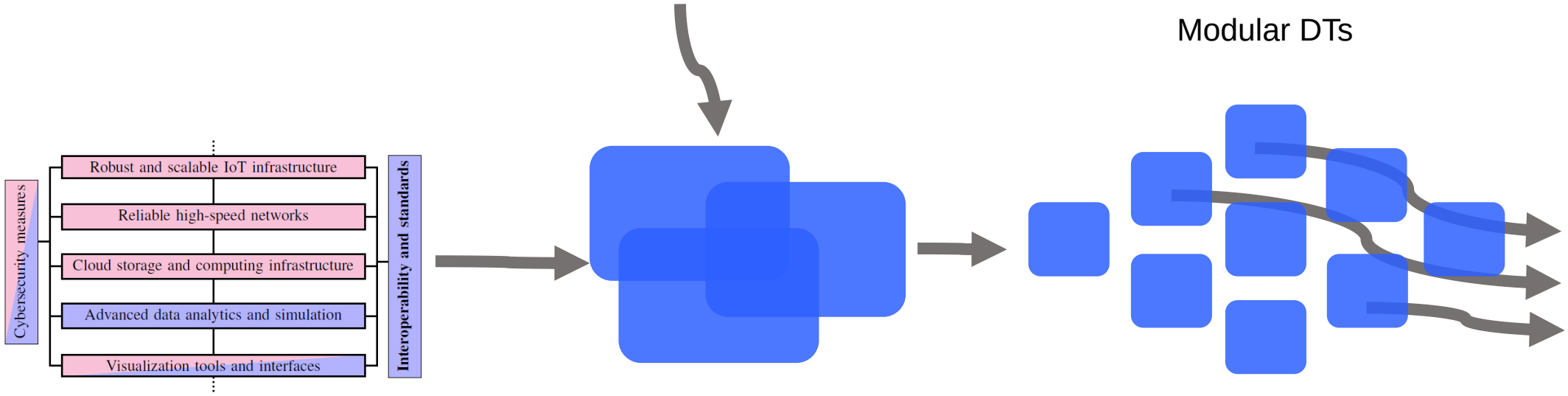
Current Digital Twins design developed in silos

SOA, Coarse grained



Future Digital Twins design goal: Modular and reusable

Modularity, standards and Smart City Digital Twins

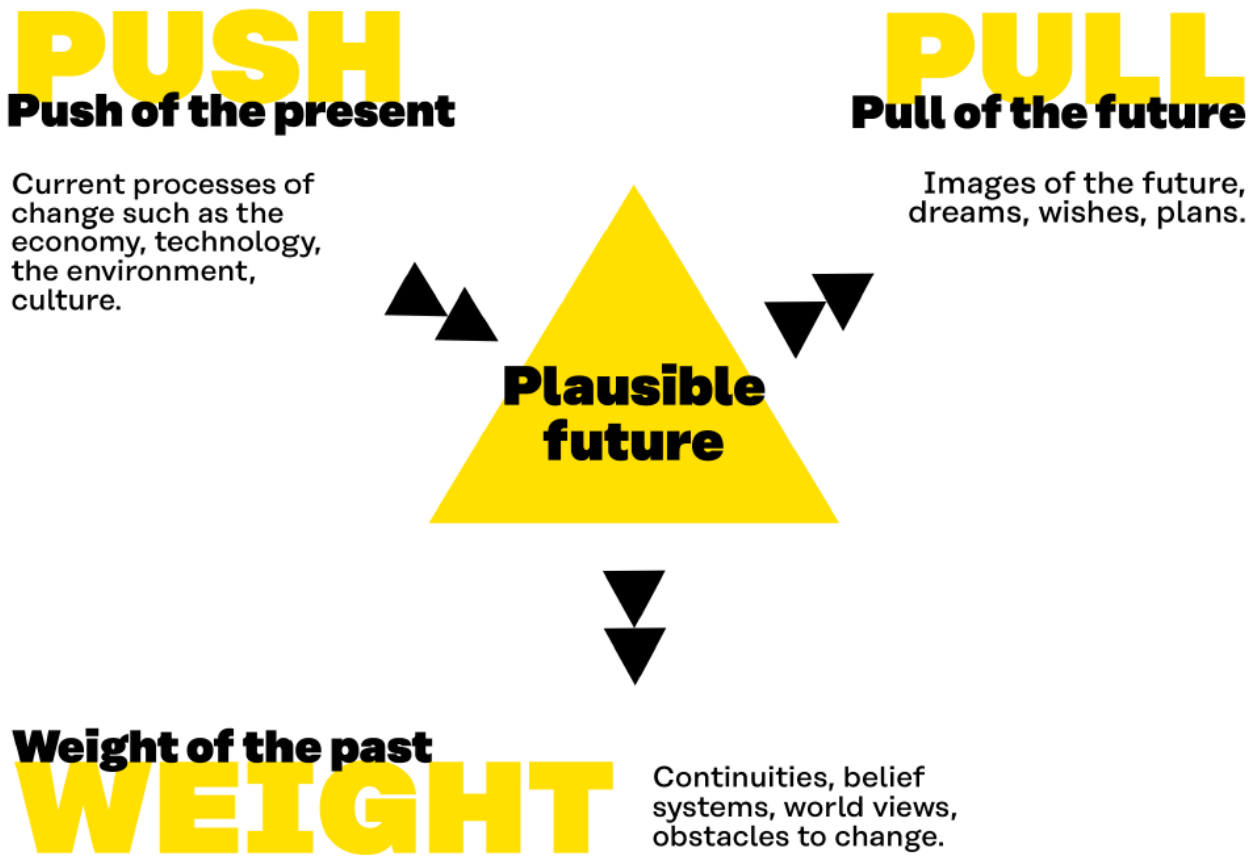


Data collection

Data conversion / Data Structures / External data

DT data and functionality sharing

Futures Triangle Analysis



SITRA

Based on Inayatullah 2008

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Push of the present

Urbanization, aging population, climate crisis, new technologies:

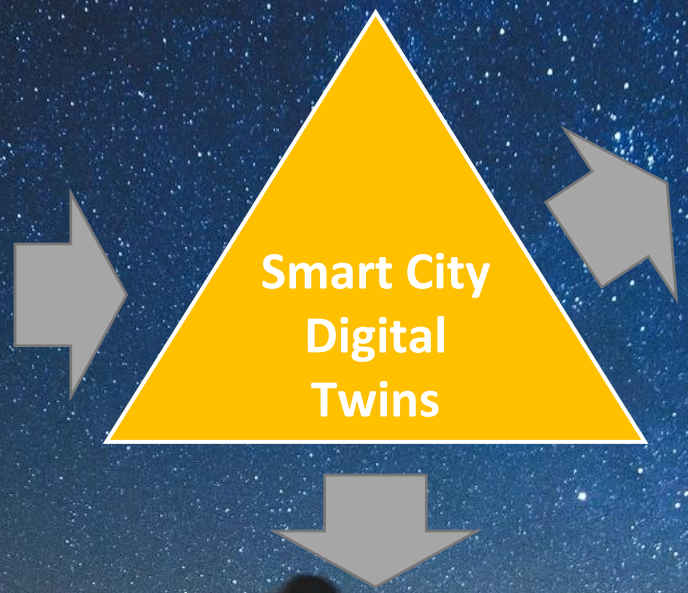
→ **Better services** (digitalization)

→ **Better living environments** (pollution, safety, social network)

→ **Resource optimization** (money, energy, water)

→ **Transportation and mobility management** (smarter traffic)

→ **Urban planning** (more informed decisions)



Pull of the future

-Some sector-specific visions but no comprehensive SCDT plans

Weight of the past

- **Knowledge & Communication**: Siloed administration in the cities; lack of citizen engagement in SCDT development; lack of collaboration between public, private and research sector
- **Engagement of private sector:** Lack of knowledge and financial incentives
- **Adoption of new technologies**: Security concerns, ethical questions, standardization
- **Mindset** : Behavioural patterns and mental models of human beings

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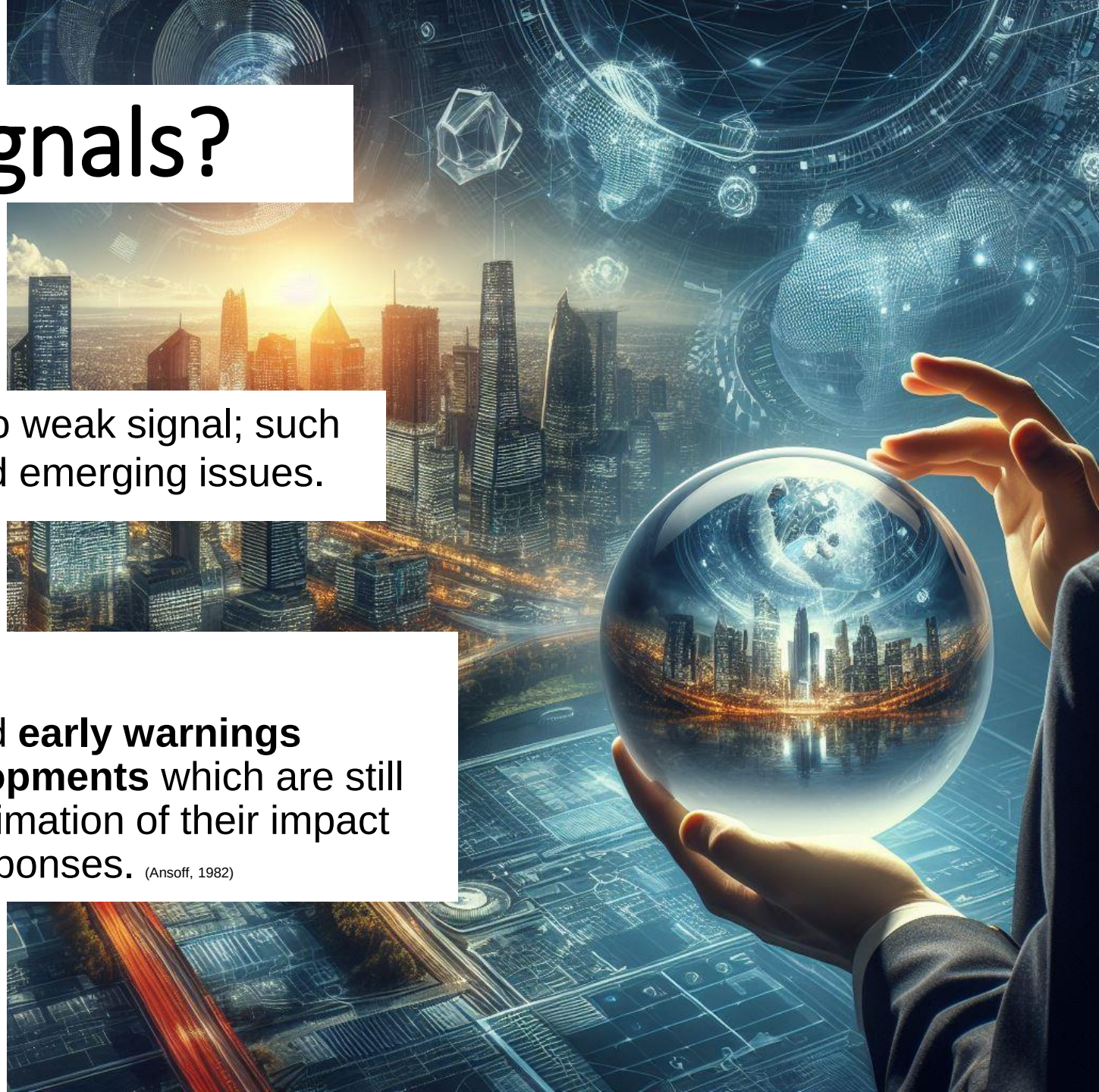
What are Weak Signals?

Definitional Challenge

The issue is caused by concepts close to weak signal; such as future sign, early warning signals, and emerging issues.
(Dufva et al, 2022; Hiltunen, E., 2008)

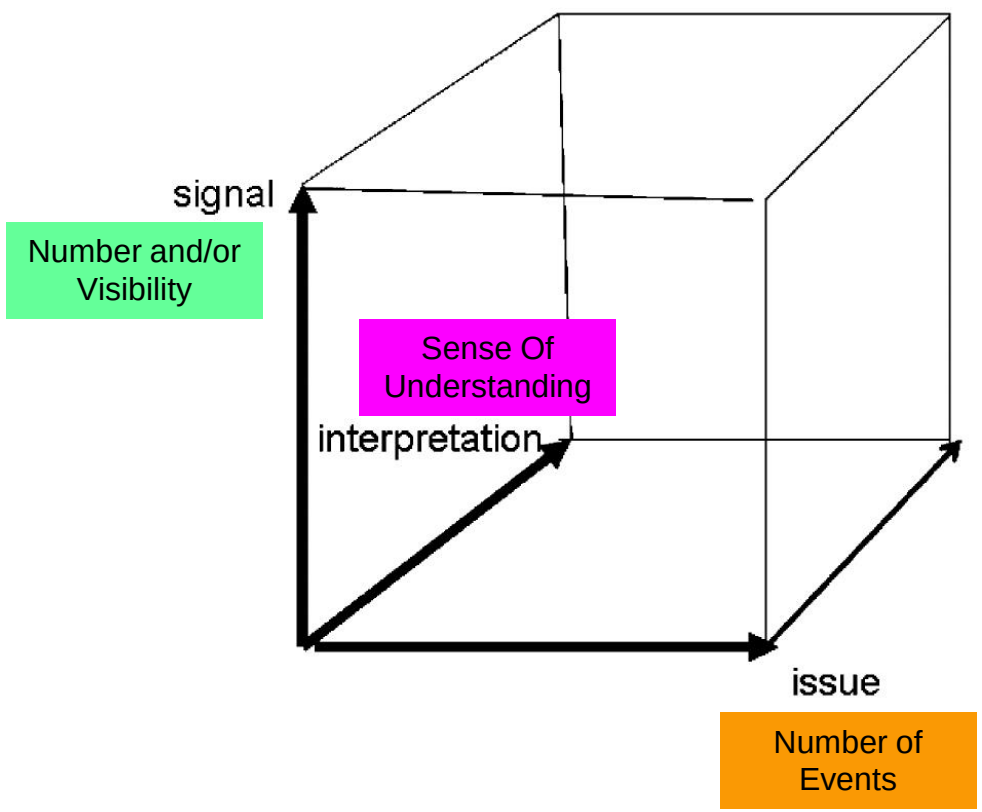
Briefly, **Weak Signals** are;

Messages and **signs** usually associated **early warnings** (external or internal), **events** and **developments** which are still too incomplete to permit an accurate estimation of their impact and/or to determine their full-fledged responses. (Ansoff, 1982)



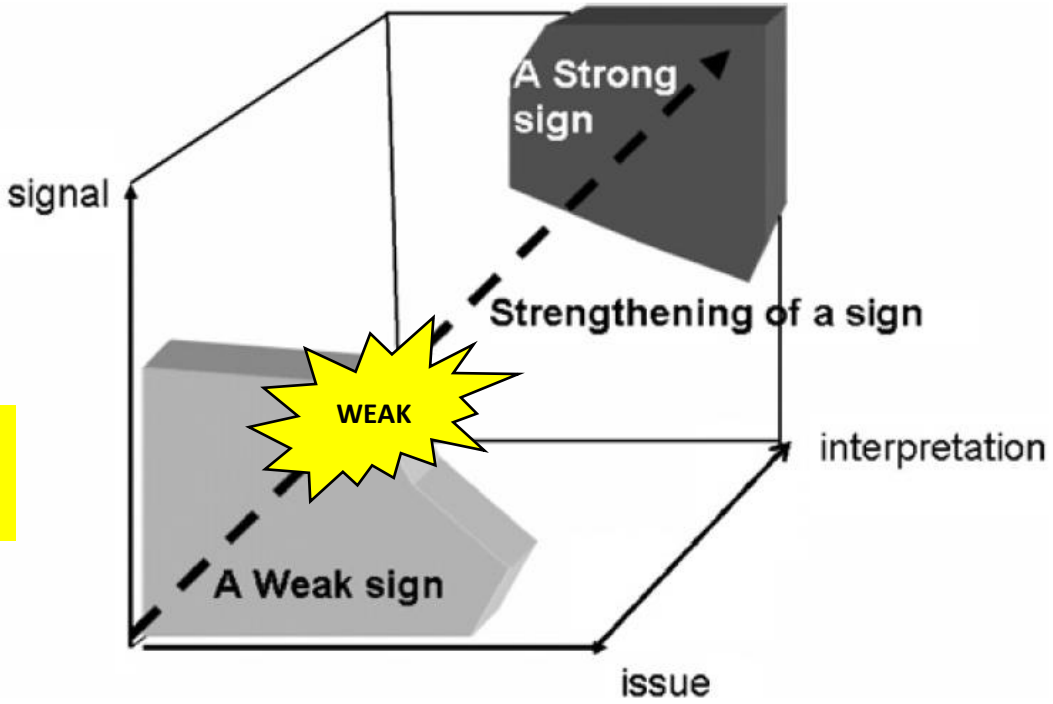
Weak Signals

Dimensional Interpretation



CASE

Autonomous Delivery in Cities



Sources: Hiltunen, E., (2008)

SCDTs Mapping Study: **Weak Signals**

Hard Domains (Mobility | Economy | Environment)

SIGNALs

Check the number and/or visibility of those signals

MOBILITY

An **Autonomous Delivery** robot stuck in the snow.

ECONOMY

Cities sealed terrariums

ENVIRONMENT

Simulation and What IFs scenarios via Digital Twins (DTs)

SCDTs
HARD DOMAINS
(Infra-Intensive)

SIGN

EMERGING ISSUEs

Internal assessment of the number of events.

MOBILITY

Future-oriented Autonomous Delivery investments

ECONOMY

Self-reliant Cities (Samso, Denmark)

ENVIRONMENT

DTs, Simulations showcase at Barcelona SCWC 2023

INTERPRETATIONs

What Ifs: **Interpret those signals' meaning AND early warnings.**

MOBILITY

Shift to autonomous delivery in **aerial space** and on-ground: Cities with **Autonomous Swarms**

ECONOMY

All cities become self-sufficient?

ENVIRONMENT

All counterparts of city-systems connected with IoT, 5/6G, AI, DTs for informed and simulated decisions

SCDTs Mapping Study: **Weak Signals**

Soft Domains (Governance | People | Living)

SIGNALs
Check the number and/or visibility of those signals

GOVERNANCE
Closing some parts of **open data platforms** due to **national security**

PEOPLE
AI-Assistance, wearable gadgets, XR etc.

LIVING
City Apps (Mobile Pay, HLS, Foli, Easypark, VR, etc) needed in Finland: 50

SCDTs
SOFT DOMAINS
(Human Social Capital-Intensive)

SIGN

INTERPRETATIONs
What Ifs: **Interpret those signals' meaning AND early warnings.**

GOVERNANCE
Smart City Attacks locks down all **operatable open data platforms?**

PEOPLE
Every individual comprehends the power of AI and advanced techs?

LIVING
Every city has one **SuperApp** for all?

EMERGING ISSUEs
Internal assessment of the number of events.

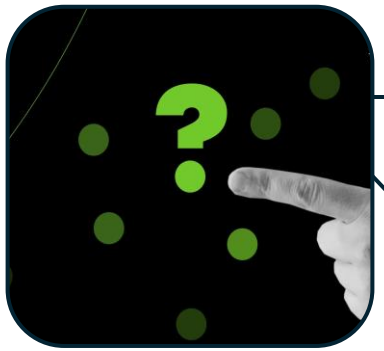
GOVERNANCE
Business was inoperable in **Turku** due to **restricted access** to cities **open data platform**

PEOPLE
Brain-reading devices allow paralysed people to talk using their thoughts

LIVING
SuperApps can consolidate and replace multiple apps for citizens and customer use and support a composable business/city ecosystem

SCDTs Mapping Study: **Weak Signals**

Conclusion



SIGNALs

Check the number and/or visibility of those signals at your city, assess its strength (weak or strong) at your organization/unit and citizen level.

SCDTs Final Seminar

SIGN

INTERPRETATION

What IFs…

Based on your understanding interpret those signals' meaning at your organization and unit point of view.

EMERGING ISSUE

Internal assessment of the number of events. A variety of other units that describe the diffusion of the phenomenon are also possible

Go to www.menti.com

Insert code: 6247 3526

Answer the question:
What needs to be done next? In order to advance the development of Smart City Digital Twins.

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PANEL DISCUSSION

From Challenges and Opportunities to Real World Implementation and Impacts

Moderator
Tero Villman
Development Manager,
Finland Futures
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Turku School of Economics,
University of Turku

Juhani Anttonen
Director of Service
Management
City of Turku

Sirkku Huisko
COO
Landscape architect
Lundén
Architecture
Company

Kari Bäckman
CEO
Benete Oy

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NEXT STEPS

Final Thoughts – How to Build from the Smart City Digital Twin project? Key Issues and Challenges

- **1 Human-centric Smart City Thinking and Associated Novel Models**
- Benchmarking with the Society 5.0 Approach of Japan and Industry 5.0 Approach in European Union
- Use the Best Available Technological Apps with Human-centric Approach
- Creative Social, Technological and Business Ideas, Inventions and Innovations
- **2 Knowledge Management about the Most Interesting Pathbreaking Possibilities**
  - New Adaptive Smart City Digital Twins and business/platform models
  - Bench-marking, Bench-learning and Bench-action Work in Global Smart Cities Networks
- **3 Taking Sustainability and Resilience Challenges Seriously**
- Future oriented scenario sustainability and resilience modelling, sustainability and resilience simulations and predictive analyses in Finland and Partner Cities, Standards of Resilience and Sustainability Indicators
- A Special Challenge of Novel AI-based Solutions and City-planning Models (AI Learning in Smart Cities, AI Language Barriers in Smart Cities and AI Visual Image Issues in Smart Cities)

Final Thoughts – How to Build from the Smart City Digital Twin project?

- **1 National Development of Smart City Network Collaboration in Finland**
  - Reporting, New e-Book report with Detailed Policy Recommendations and Policy Briefs, New City Development R&D projects
  - New R&D platforms (Metaverse City Development)
  - Implementation of National Metaverse Strategy (https://www.digitalfinland.org/)

- **2 Continuation of Nordic and Baltic Sea Smart City Collaboration**
  - New adaptive Smart City Digital Twins and business/platform models
  - Bench-marking, Bench-learning and Bench-action Work in Smart Cities
  - Development of Smart City Metaverse Models and New Frontline Apps and Smart City Development Platforms (Turku Kupittaa Arrow Development Project etc.)
  - A Joint International Smart City Conference in Finland with Japanese and European Partners and Top Experts

- **3 Development of Future-oriented Smart City Knowhow**
  - Metaverse modelling, automation of routines, paperless bureaucracy, utilisation of economics of scale advantages, Full Advanced Operationalisation of Smart City Wheel Model
  - Future oriented scenario modelling, simulations and predictive analyses in Finland and Partner Cities

Smart City Digital Twins

Thank you!

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Wroclaw Agglomeration Development Agency

VILNIUS

LIC LITHUANIAN INNOVATION CENTRE