ELISE action
Webinar Series

Digital Twins – Are they ready to embrace the benefits of Location Information?

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European Location Interoperability Solutions for e-Government

Enabling Digital Government through Geospatial and Location Intelligence

ISA² Programme & ELISE action

European Interoperability Programme

cross-border *and* ***cross-sector*** *Interoperability solutions*

for ***public administrations, businesses*** *and* ***citizens***

54 different actions tackling **interoperability** from different angles

ELISE action is the **only** action focusing on the **location dimension**

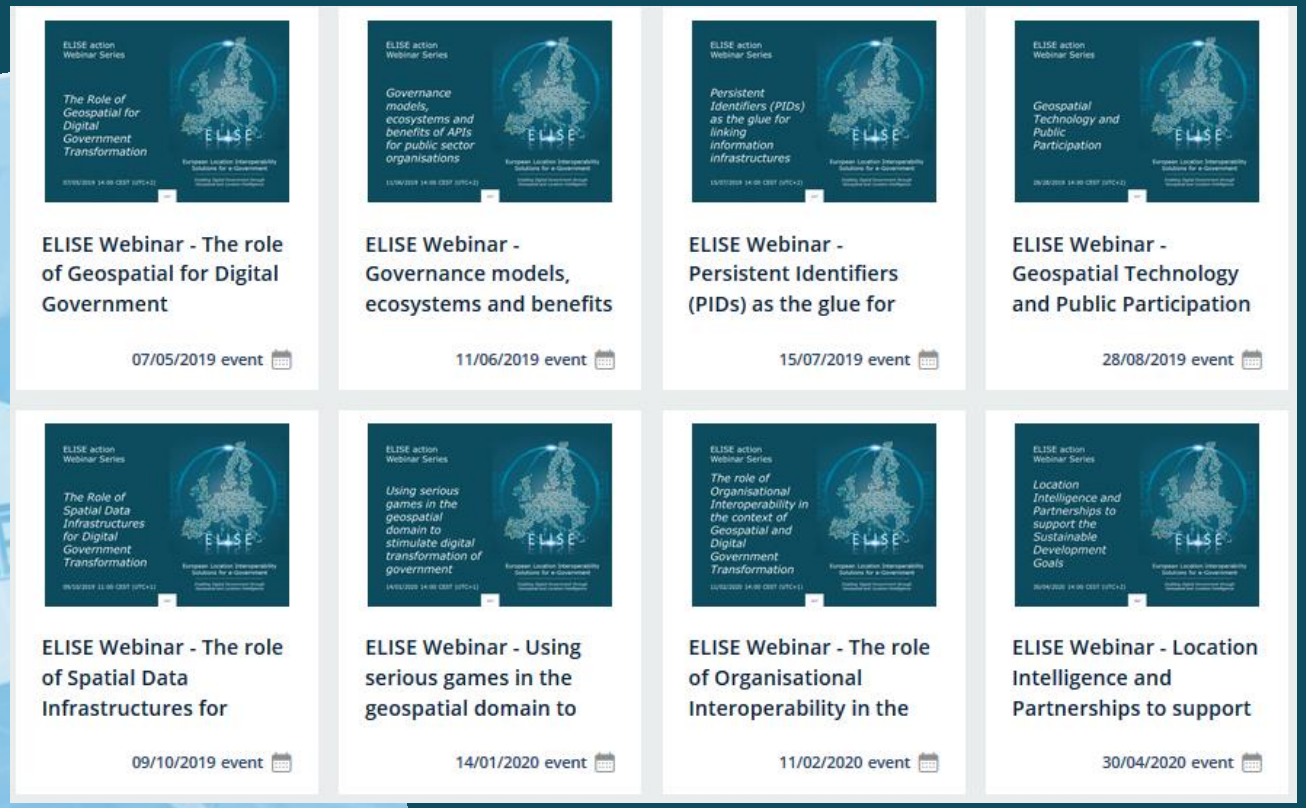
European Location Interoperability Solutions for e-Government

Enabling Digital Government through Geospatial and Location Intelligence

ISA²

ISA²

Welcome to the ELISE webinar series



ELISE **Knowledge Transfer** activities

Purpose:

- engage in **an agile way**
- with **topics** of relevance to the **Digital Transformation**
- **by harnessing the use of spatial data and technology**.

https://europa.eu/!nP74ph

Digital Twins – Are they ready to embrace the benefits of Location Information?

Picture of the Helsinki's Kalatasama Project

Our speakers

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The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

ISA²

What we will cover today

1. Context, definitions & frameworks
2. Digital twin initiatives & applications
3. Interoperability challenges of digital twins
4. Key take-away messages and conclusions

Key messages of this presentation

1. All ‘digital twin’ applications **are influenced by location**, and digital twins **strongly rely on ‘data’** (from many different sources)

2. Geospatial data, technologies and standards **provide key building blocks** of digital twins

3. **Existing spatial data infrastructures** & **ecosystems** should **be further upgraded** to better enable the creation and use of digital twins

Geospatial intelligence and interoperability are key enablers of the creation and management of digital twins

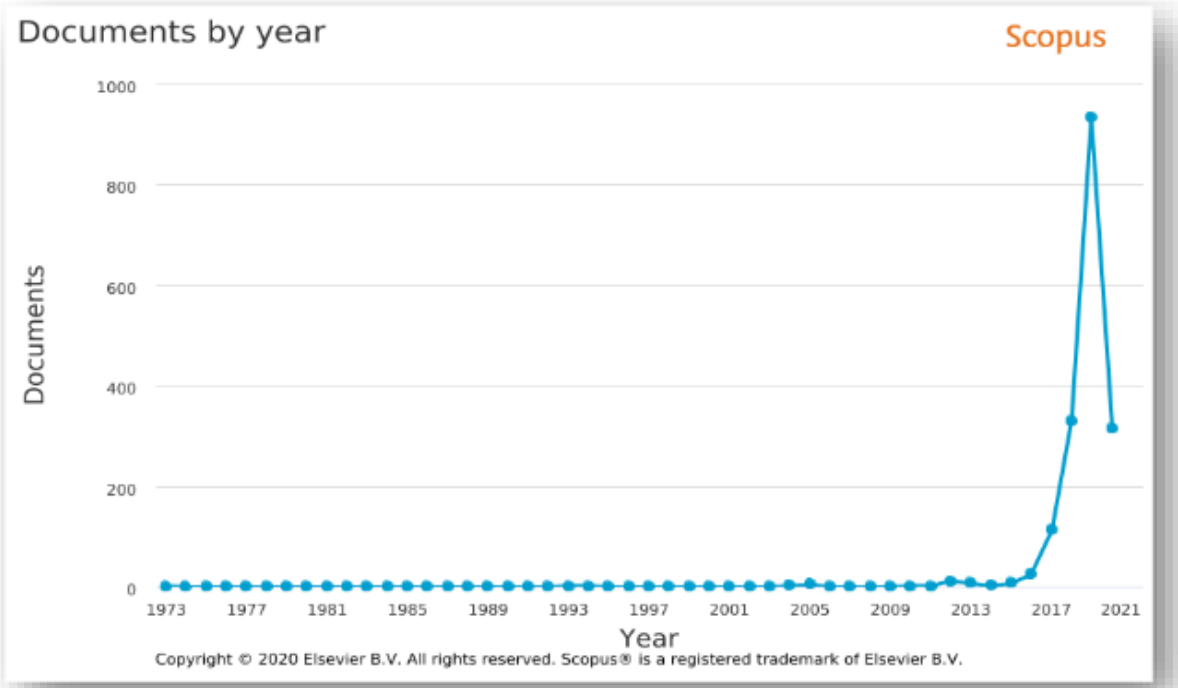
1

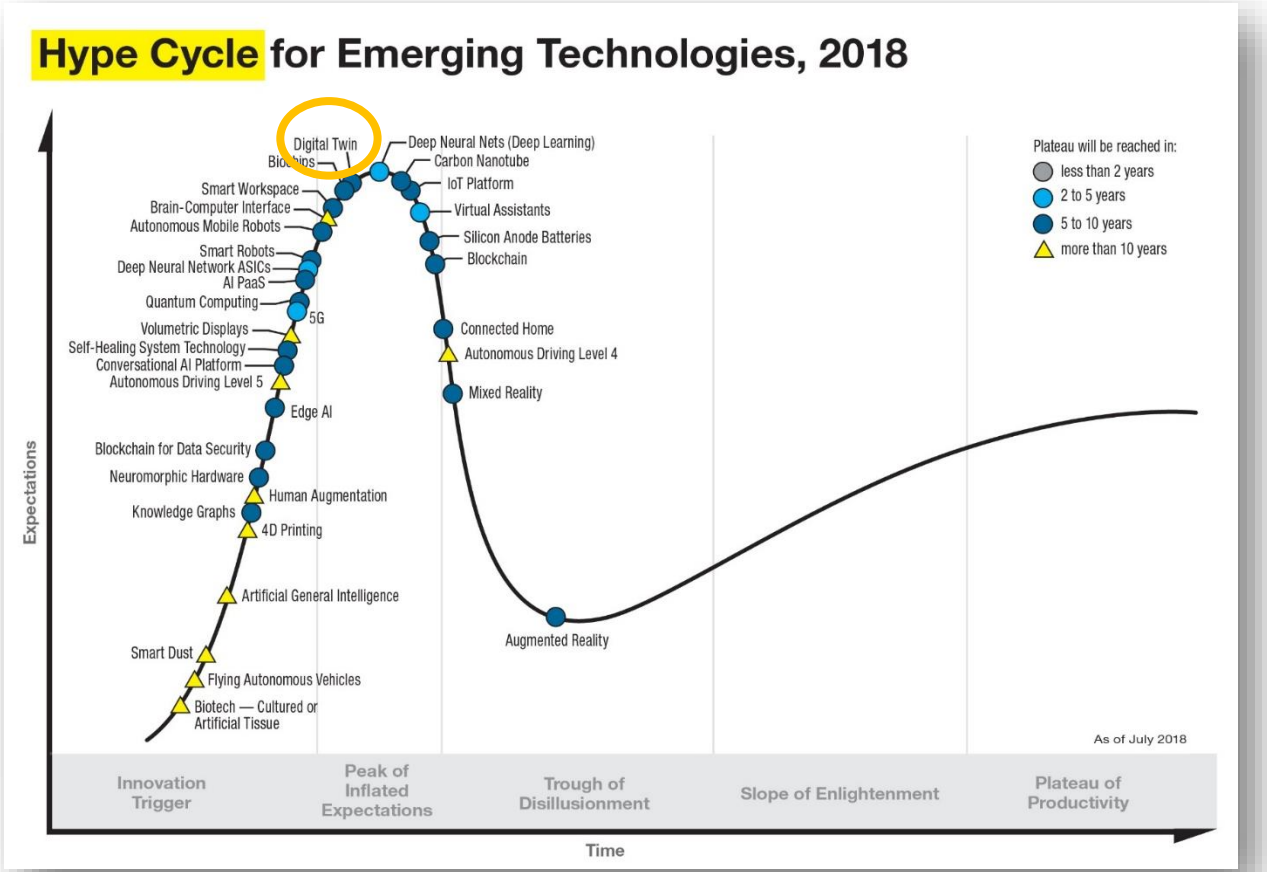
Context, definitions & frameworks

> *Data will fuel the wide implementation of transformative practices such as the use of digital twins. Digital twins create a virtual replica of a physical product, process or system. The replica can for example predict when a machine will fail, based on data analysis, which allows to increase productivity through predictive maintenance.*

A European Strategy for data (2020)

Increasing attention and popularity





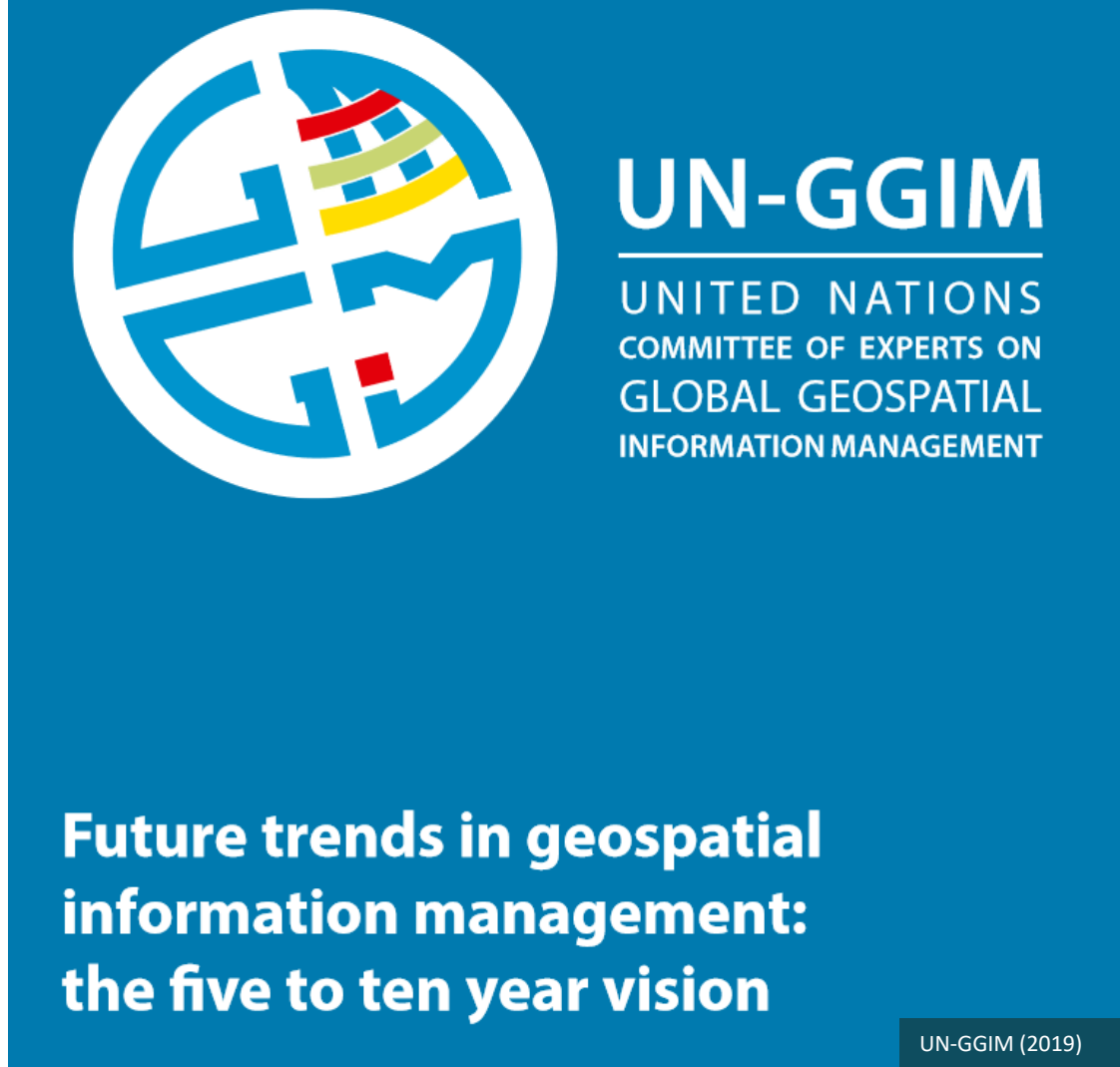
Scopus (2020)

Gartner (2018)

UN-GGIM Future Trends in geospatial information management

- Technology plays a prime role in disrupting the geospatial: further automation, Internet of Things, Big Data, Artificial Intelligence, immersive technology and **the rise of Digital Twins**
- Digital Twins and data exchange enhance and optimize the real-world by **monitoring and simulating scenarios** to mitigate risks and increase resilience, and may also allow real-time information intervention
- The **future of smartcities** will be significantly less effective without the digital representation and related context of geography

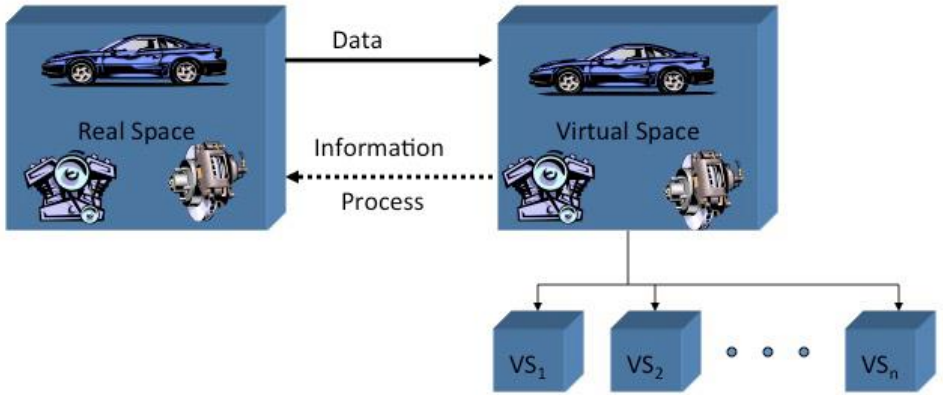
Broad global consultation on the draft Future Trends report (third edition) until **26 June 2020**

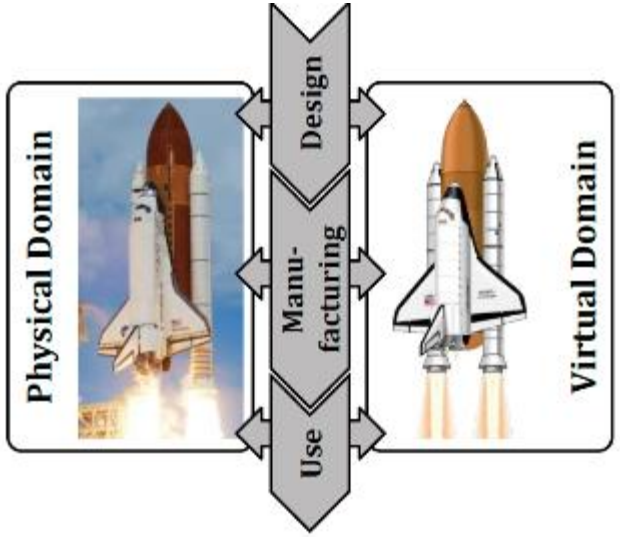


Origins of the digital twin concept

Grieves' 'Mirred spaces model' (2005) had all the elements of the Digital Twin: *real space, virtual space, the link for data flow from real space to virtual space, and the link for information flow from virtual space to real space*

Grieves, M. (2016)





Wagner et al (2019)

NASA's interest was in its requirement to operate, maintain and repair physical systems that are in space. For the **Apollo 13 rescue mission**, NASA relied on a mirrored system on earth that allowed engineers and astronauts *to determine how they could rescue the mission*

Examples and application domains and sectors

Manufacturing, industry 4.0, space & aerospace, energy, construction, transport, healthcare, sports, …

Location is relevant in some way to each of these 'digital twin' application domains (but for some of them it is more crucial)

Pictures: Medium, Networkworld, Shutterstock, Norlean, RINA

Digital Twin: a definition and key elements

An integrated **simulation of a real-life system** that **uses models, sensor information and input data**, **to mirror, predict and control the activities and performance** of its corresponding physical twin.

Two **increasingly important elements** stand out:

1. The **connection** between the physical model and the corresponding virtual model or virtual counterpart
2. This connection is established by **generating real-time data** (e.g. through using sensors)

Definition based on Kraft (2016)

Digital Twin: what's new?

The idea of using virtual models **to optimize processes, products, or services** is not new.
However, over the course of the last decade, deployment of digital twin capabilities has accelerated due to a **number of factors**:

- **1 - Simulation**
- **2 - New sources of data**
- **3 - Interoperability**
- **4 - Visualization**
- **5 - Instrumentation**
- **6 - Platform**

Deloitte (2020)

Models, shadows, twins

Different levels of integration:

Digital model

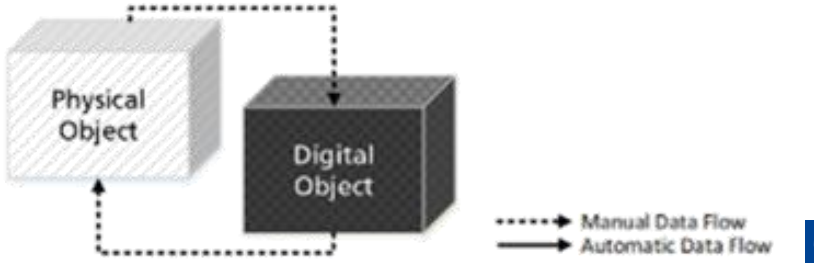
- no automated data exchange

Digital shadow

- automated one-way data flow between the physical object and a digital object

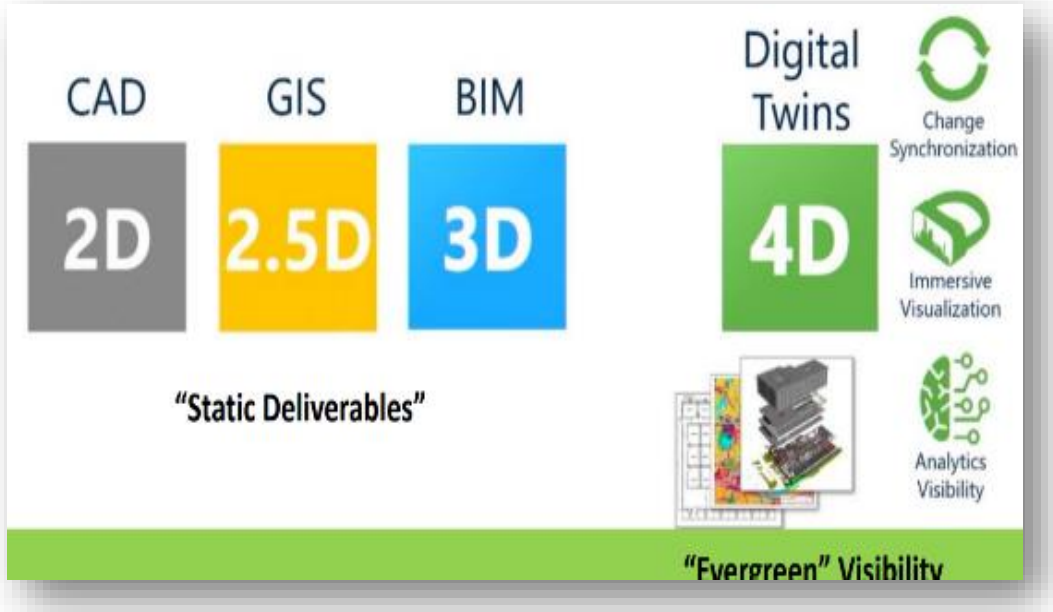
Digital twin

- data flows fully integrated in both directions



Kritzinger, W. et al (2018)

2D, 3D & 4D



Bentley (2019)

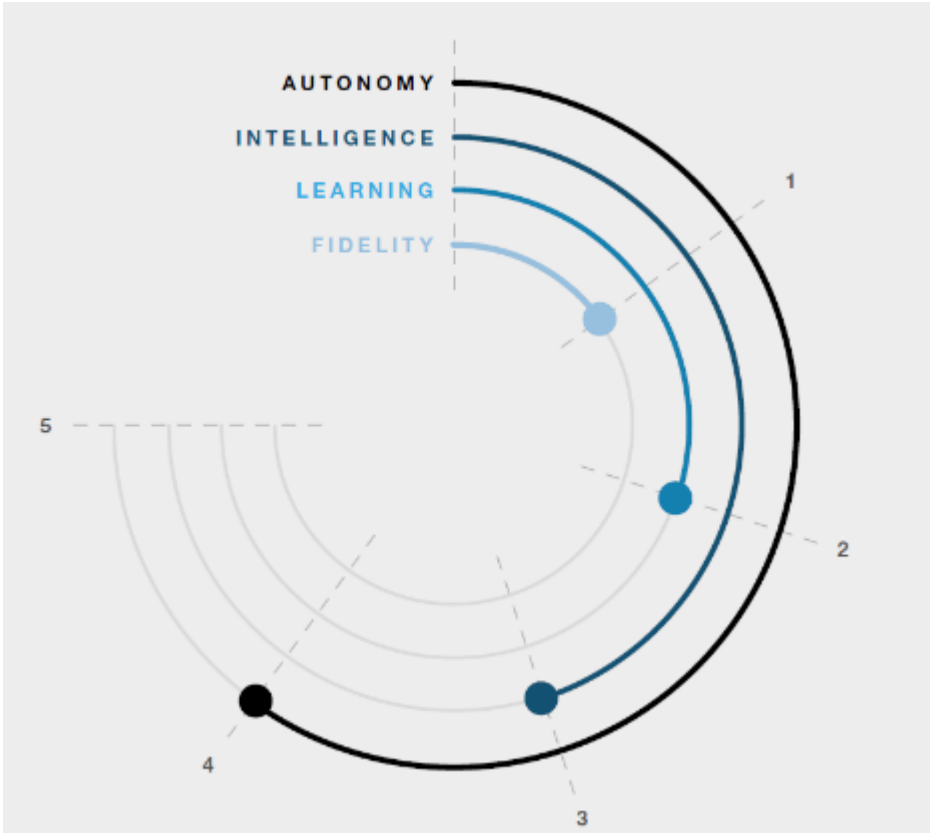
Digital twin maturity

When does a simple data model become a digital twin?

Maturity element (logarithmic scale of complexity and connectedness)	Defining principle	Outline usage
0	– Reality capture *(e.g. point cloud, drones, photogrammetry, or drawings/sketches)*	– Brownfield (existing) as-built survey
1	– 2D map/system or 3D model *(e.g. object-based, with no metadata or BIM)*	– Design/asset optimisation and coordination
2	– Connect model to persistent (static) data, metadata and BIM Stage 2 *(e.g. documents, drawings, asset management systems)*	– 4D/5D simulation – Design/asset management – BIM Stage 2
3	– Enrich with real-time data *(e.g. from IoT, sensors)*	– Operational efficiency
4	– Two-way data integration and interaction	– Remote and immersive operations – Control the physical from the digital
5	– Autonomous operations and maintenance	– Complete self-governance with total oversight and transparency

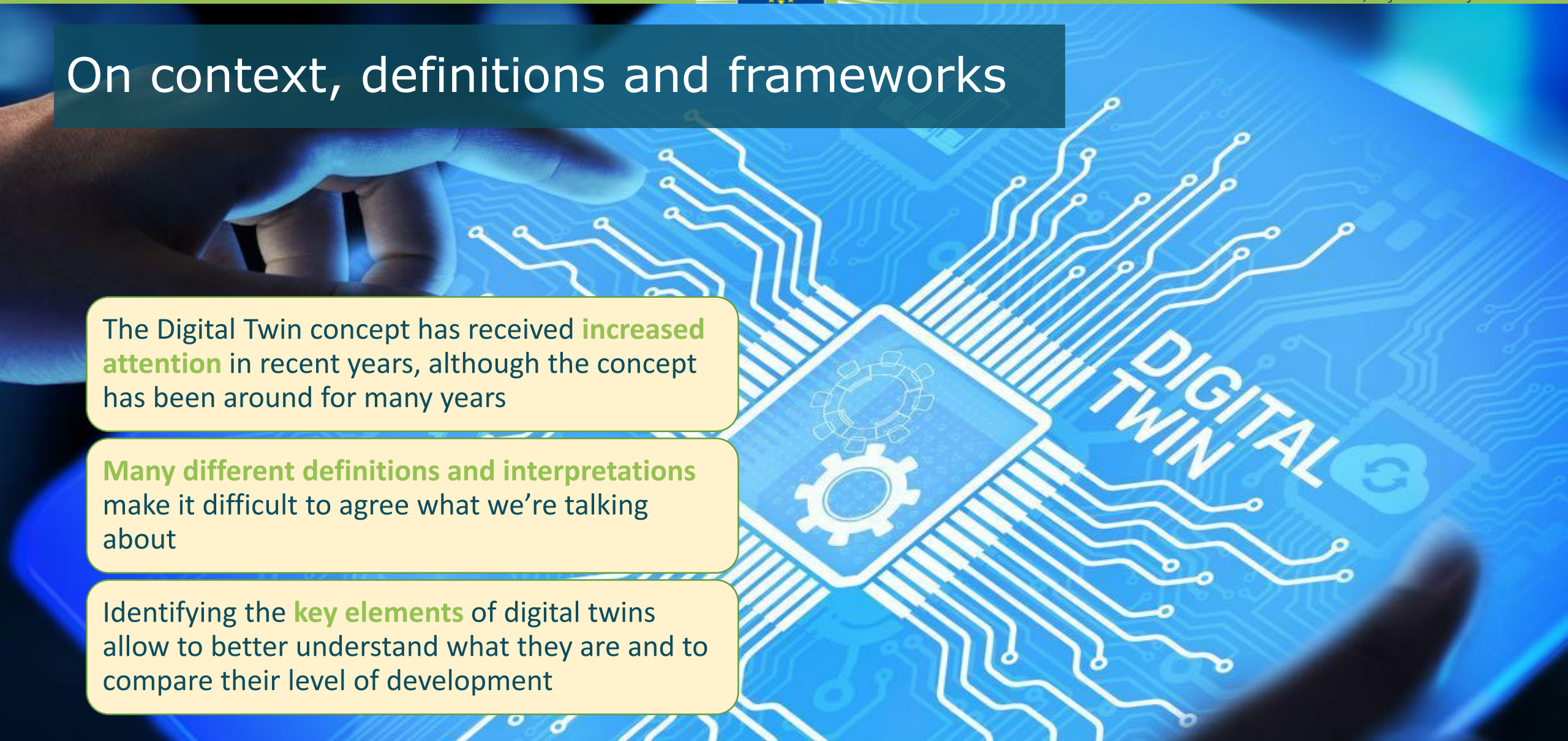
IET & Atkins. (2019)

Arup (2019)



There are several elements differentiating simple models or twins from the **most advanced digital twins**

On context, definitions and frameworks



The Digital Twin concept has received **increased attention** in recent years, although the concept has been around for many years

Many different definitions and interpretations make it difficult to agree what we're talking about

Identifying the **key elements** of digital twins allow to better understand what they are and to compare their level of development

2

Digital twin initiatives & applications

A European Strategy for Data

The Commission will support the establishment nine common **European data spaces**, including a **Common European Green Deal data space**

The "GreenData4All" and 'Destination Earth' **(digital twin of the Earth)** initiatives will cover concrete actions.

Data will also fuel the wide implementation of transformative practices such as **the use of digital twins in manufacturing**.

Digital Twin of the Ocean

New automated **sensors** and autonomous platforms

Big data and **artificial intelligence** technologies

Development of **what-if scenarios**

Co-creation and inter-disciplinary approaches

Data **infrastructures** and e-infrastructures

Delivering information to **citizens**

Picture: ESA

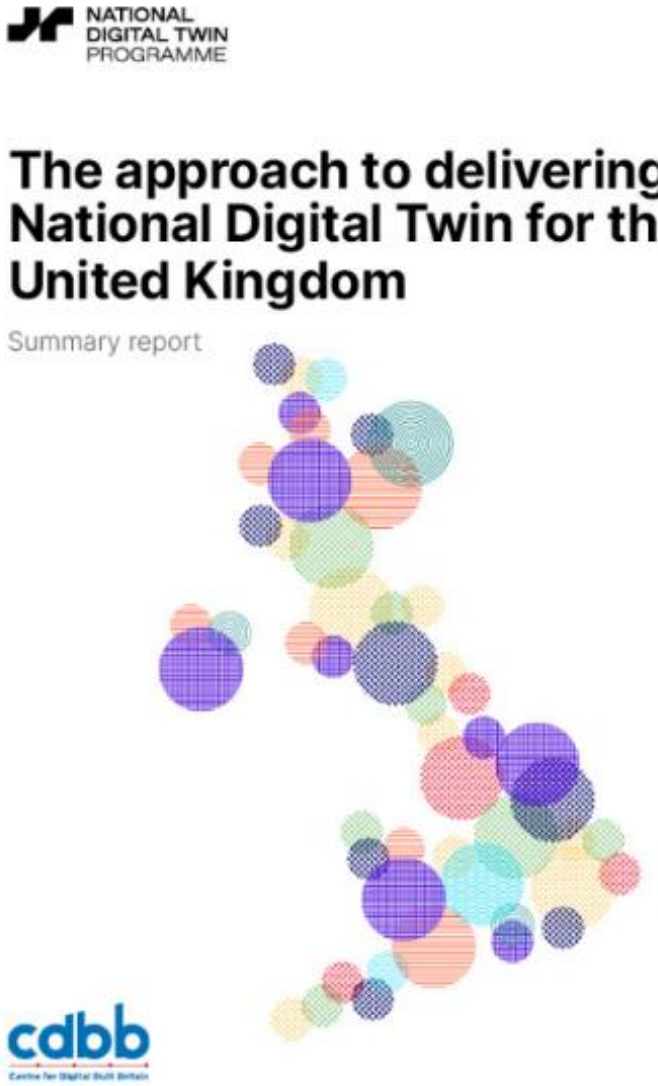
Digital twin initiatives at the national level

Initiatives ongoing in:

- United Kingdom,
- Australia,
- the Netherlands

Common elements but also **important differences**

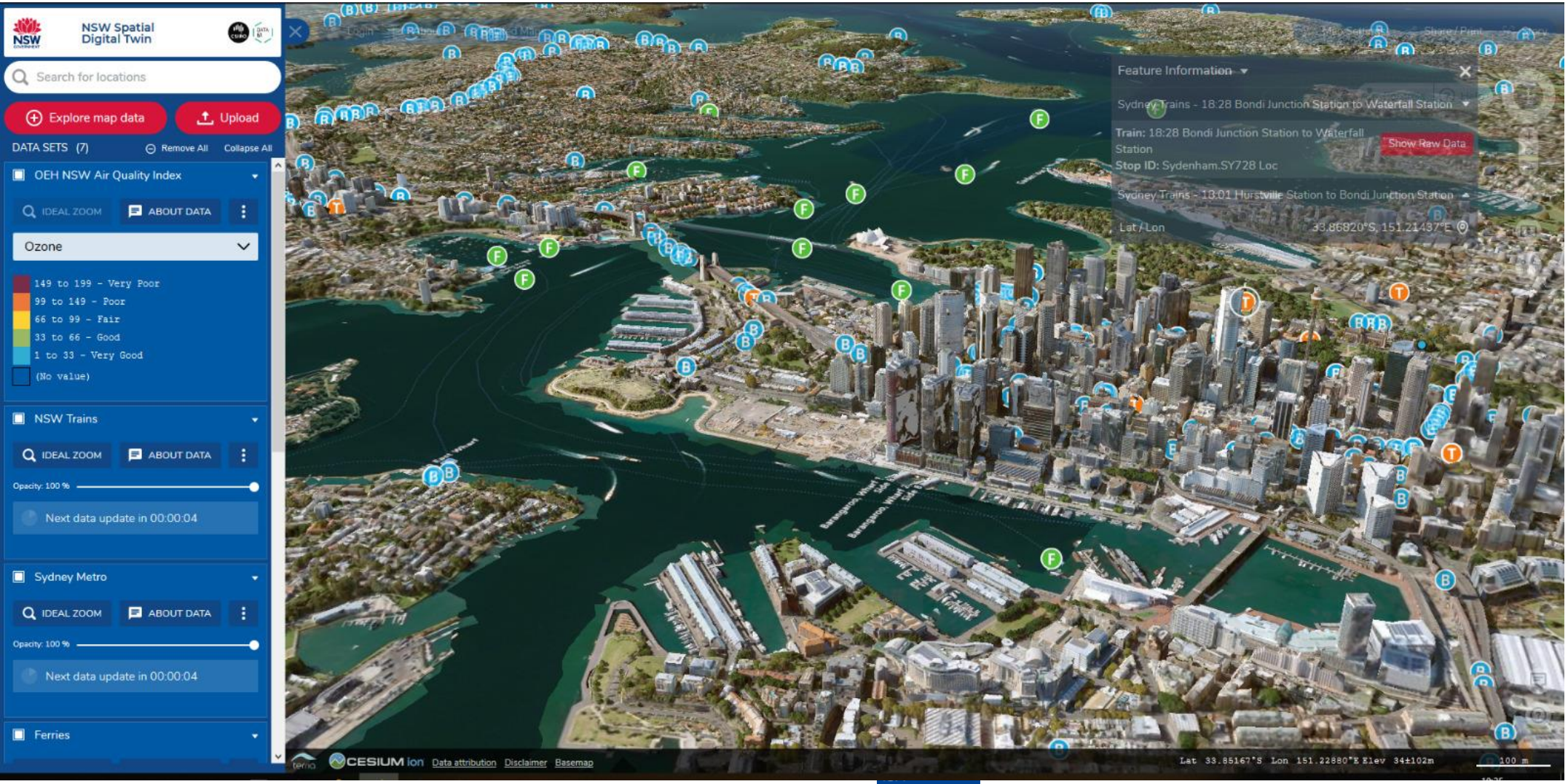
Picture: Centre for Digital Built Britain



Centre for Digital Built Britain (2020)

European Commission

Digital twin at regional level



New South Wales (NSW) State

NSW Spatial Digital Twin

https://nsw.digitaltwin.terria.io/

Digital twins of cities

Digital twin technologies can make **smart cities** even smarter

Several well documented cases: **Helsinki, Antwerp, Zurich, Amsterdam**, …

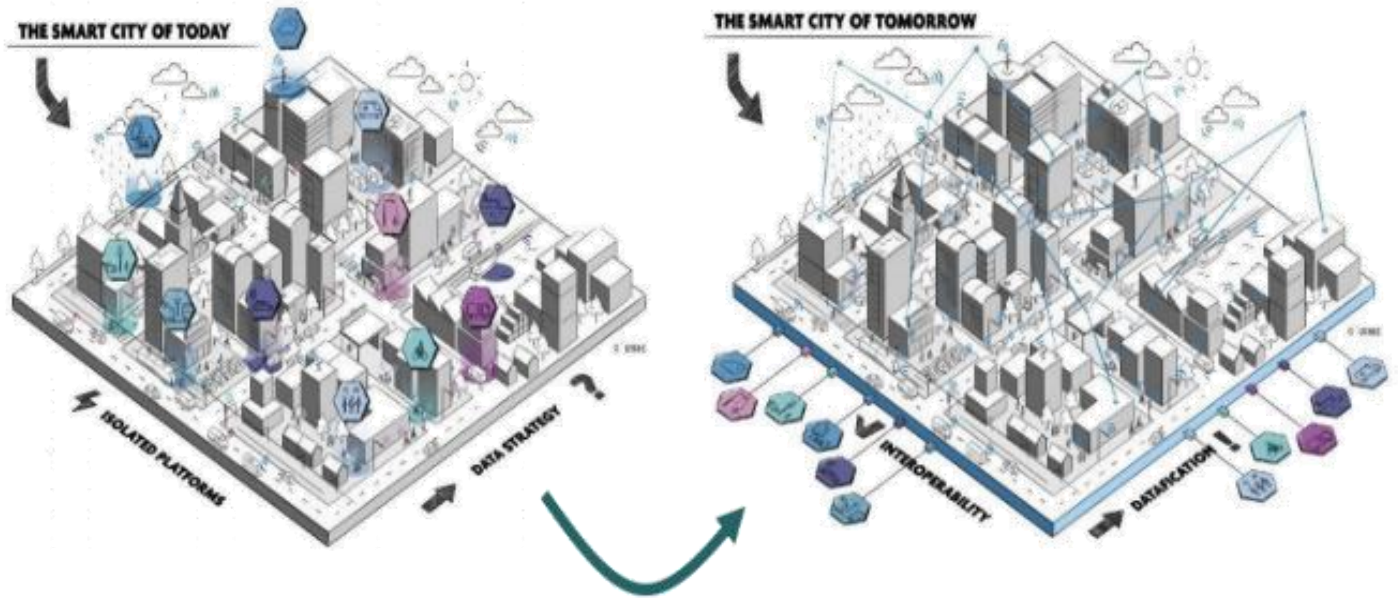
Different **scope** and levels of '**maturity**'

Towards collaboration and joint approaches

JOIN, BOOST, SUSTAIN

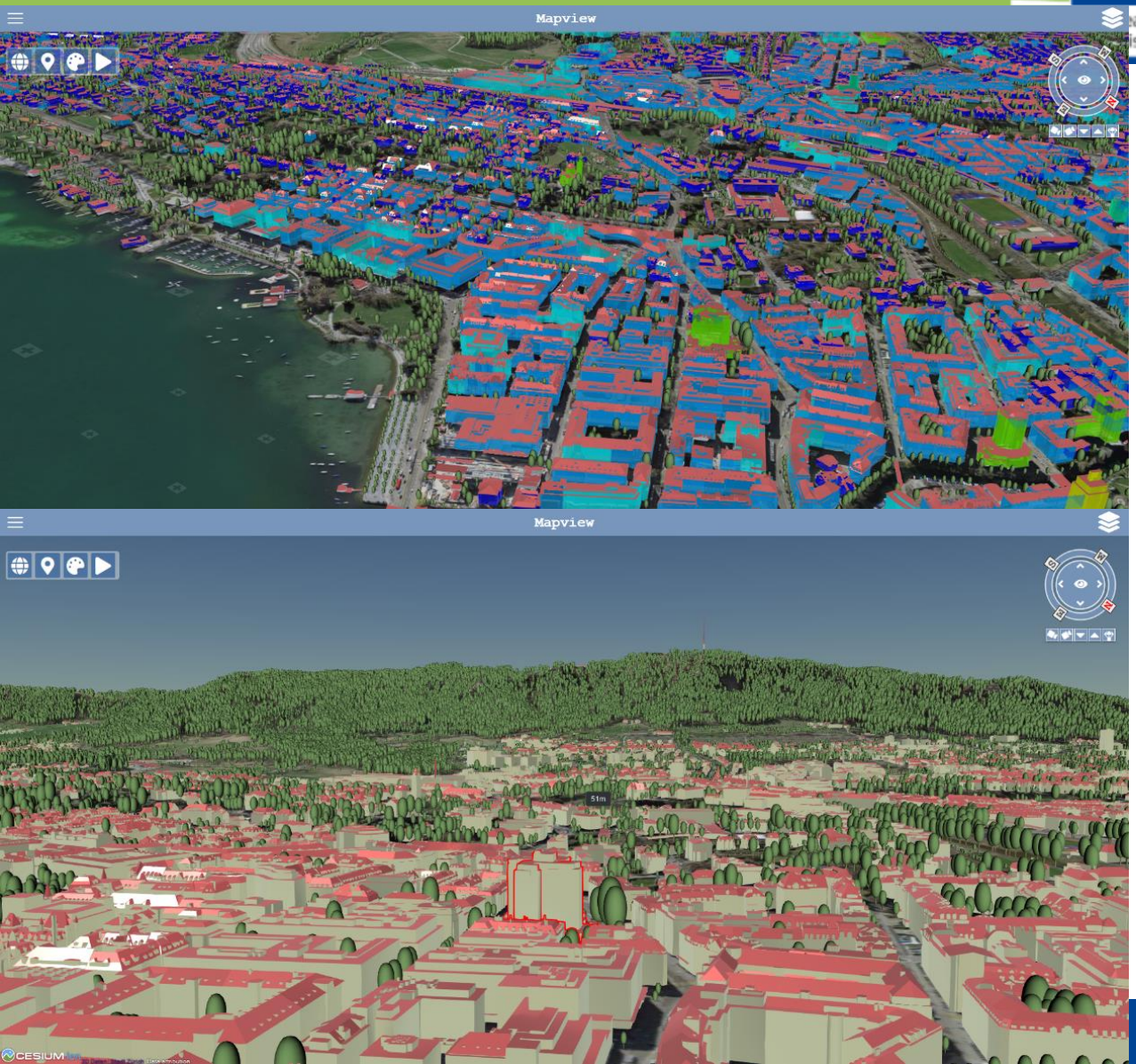
Declaration on joining forces to boost sustainable digital transformation in cities and communities in the EU

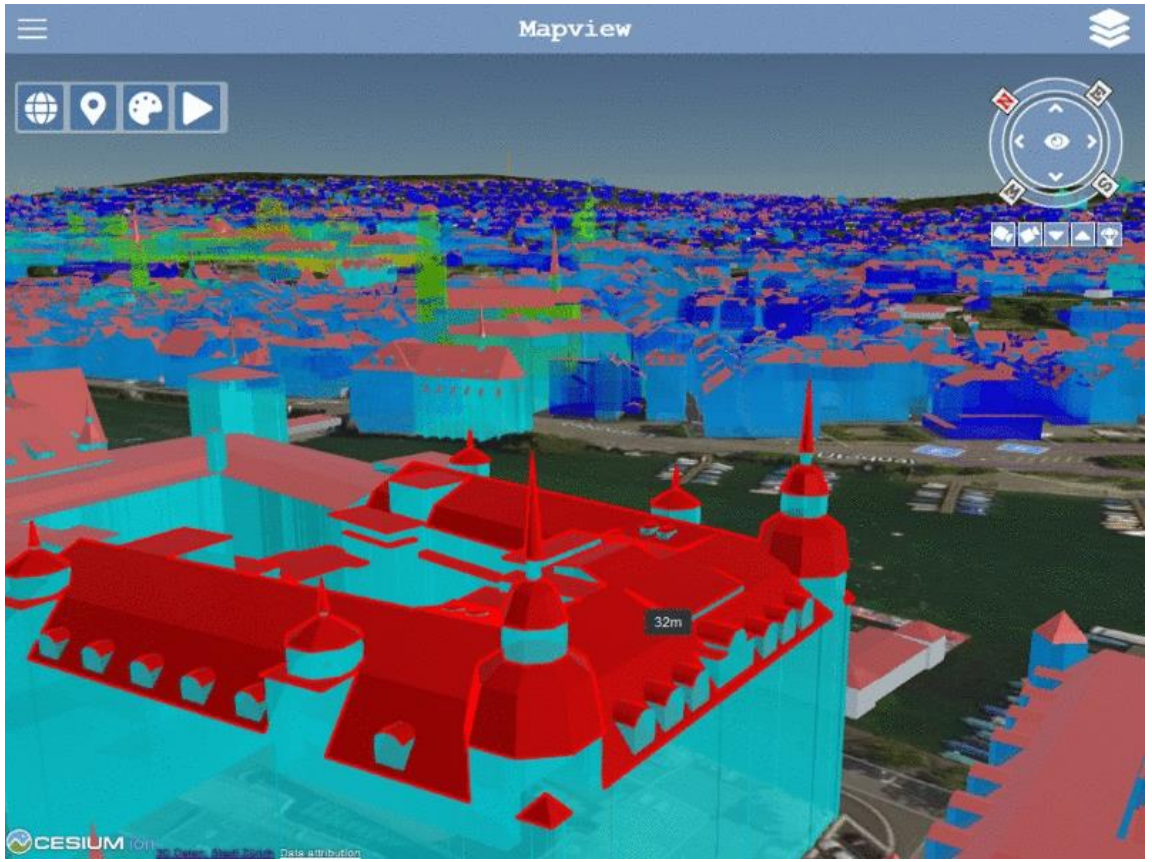
Lefever et al (2020)



Schrotter & Hürzeler (2020)

Digital twin of the city of Zurich





https://zuerich.mapview.ch/

Digital twins of buildings

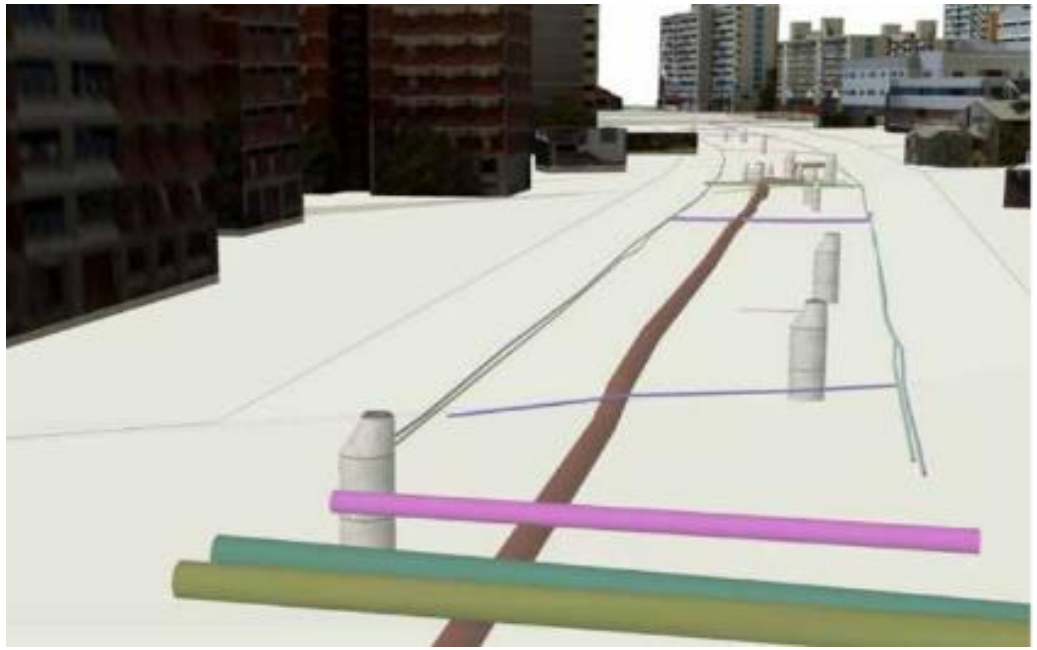
Creation of digital twins of various types of buildings and other constructions

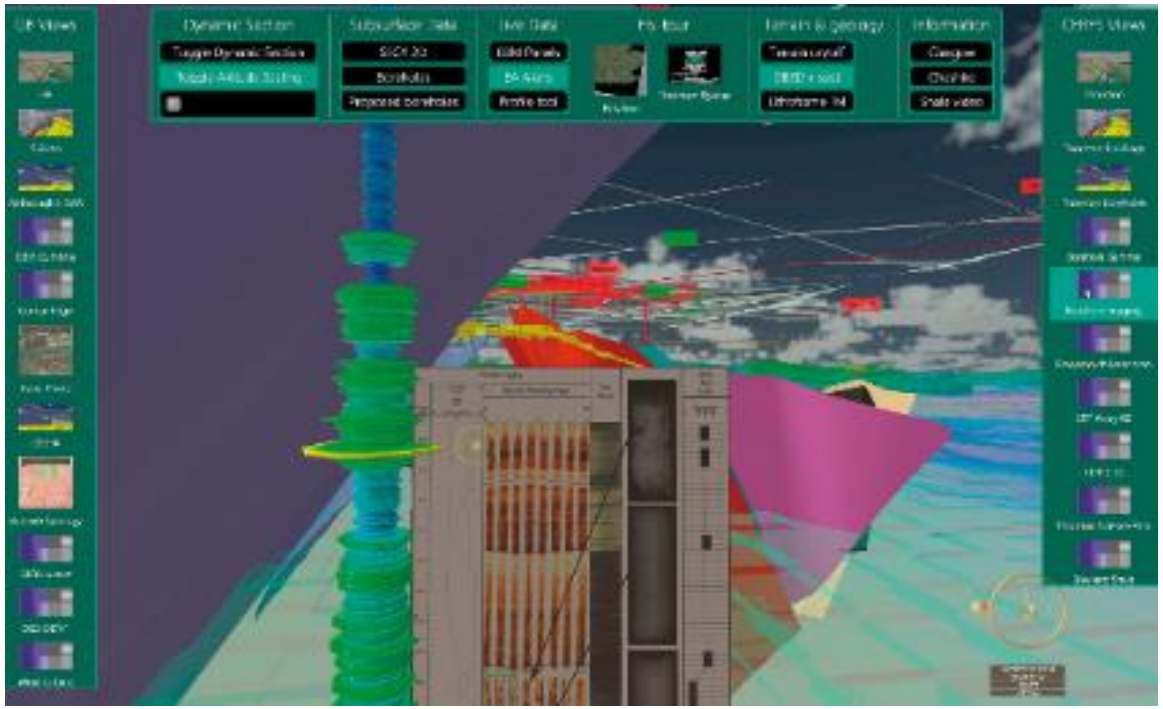
Considering the **relationships** between **places**, **people** and **devices**

Pictures: Strategic BIM, SITA, 2B1st Consulting

When digital twins go underground

Digital Underground is dedicated to the establishment of a reliable map of subsurface utilities in Singapore

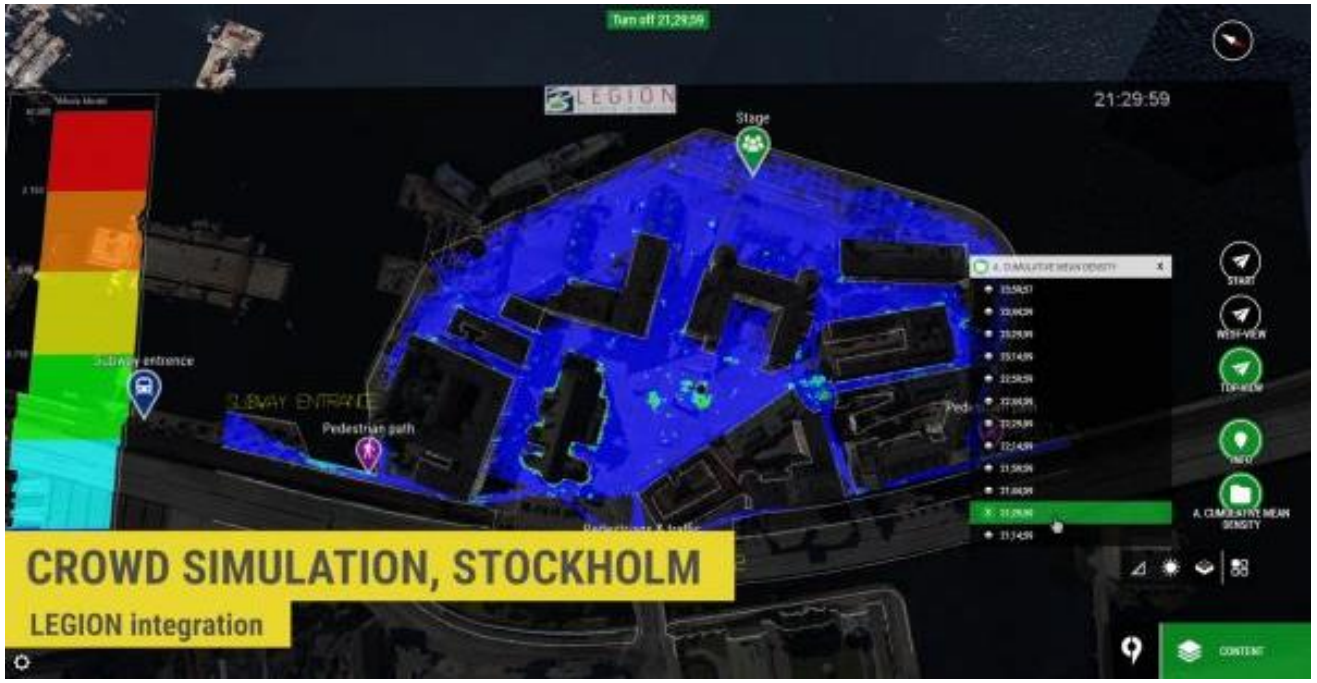


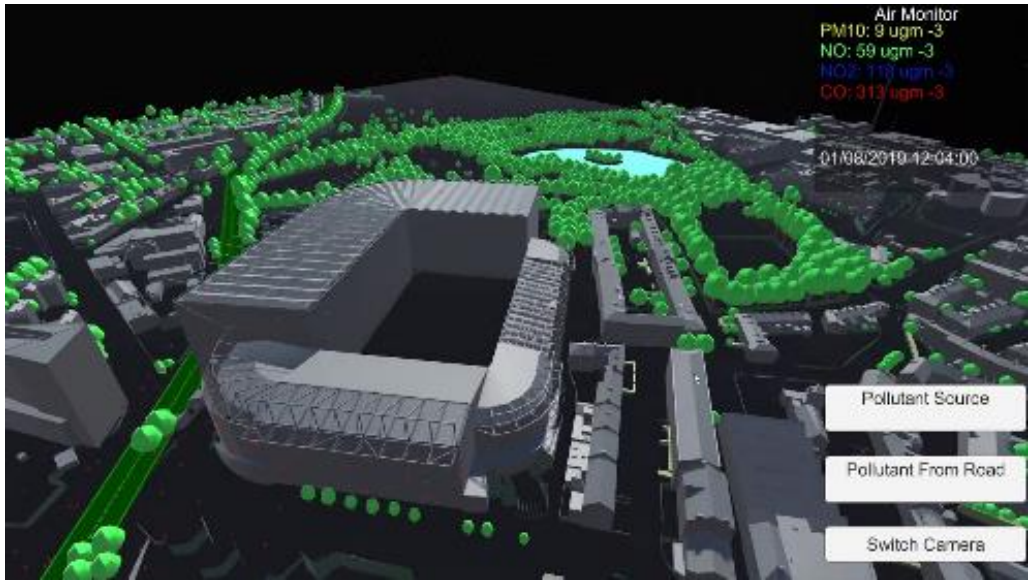


OneGeology 4.0: Digital twins for the next generation of geoscience prediction and understanding

What-if scenarios and simulations

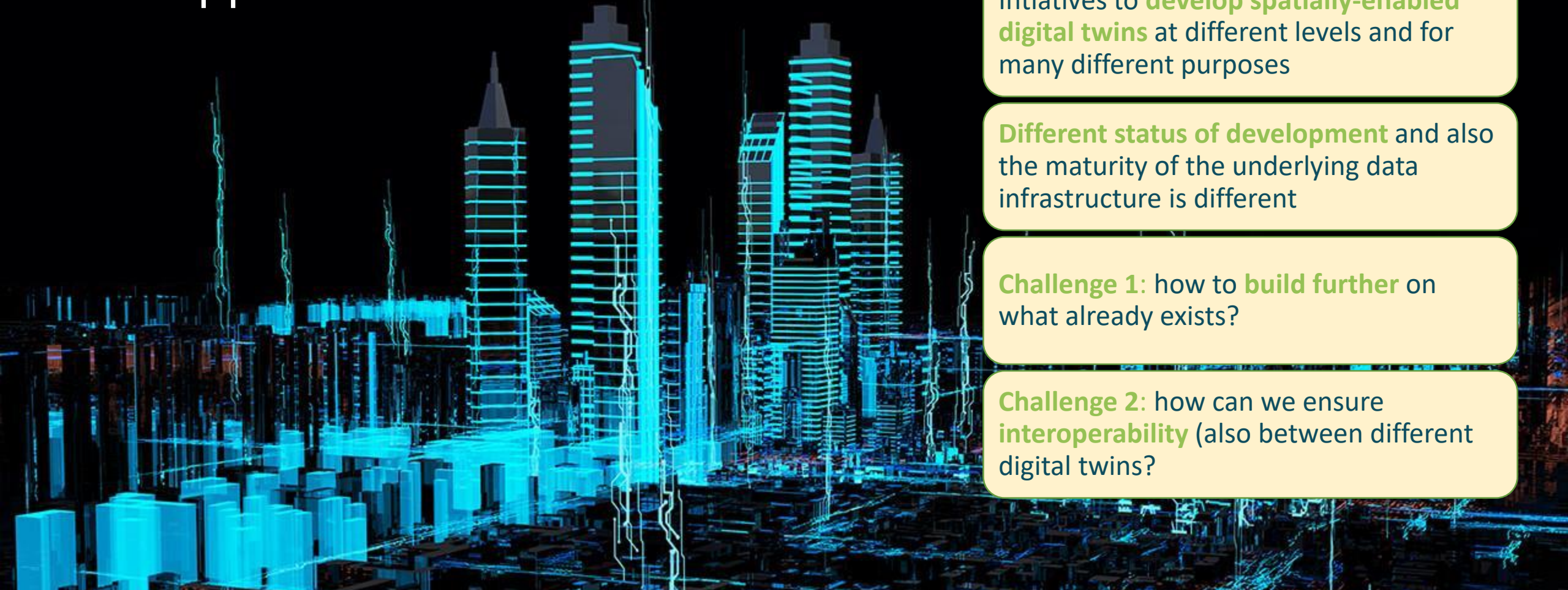
What would happen if we change this…?





Pictures: GIM International

On digital twins initiatives and applications



Intiatives to **develop spatially-enabled digital twins** at different levels and for many different purposes

Different status of development and also the maturity of the underlying data infrastructure is different

Challenge 1: how to **build further** on what already exists?

Challenge 2: how can we ensure **interoperability** (also between different digital twins?

3

Interoperability challenges of digital twins

Data for Digital Twins

Spatially enabled digital twin: A digital twin containing - amongst others - spatial and location data, covering a defined geographic space above and below ground.

Achieving spatially enabled digital twins will require 3D and 4D (temporal) spatial data.

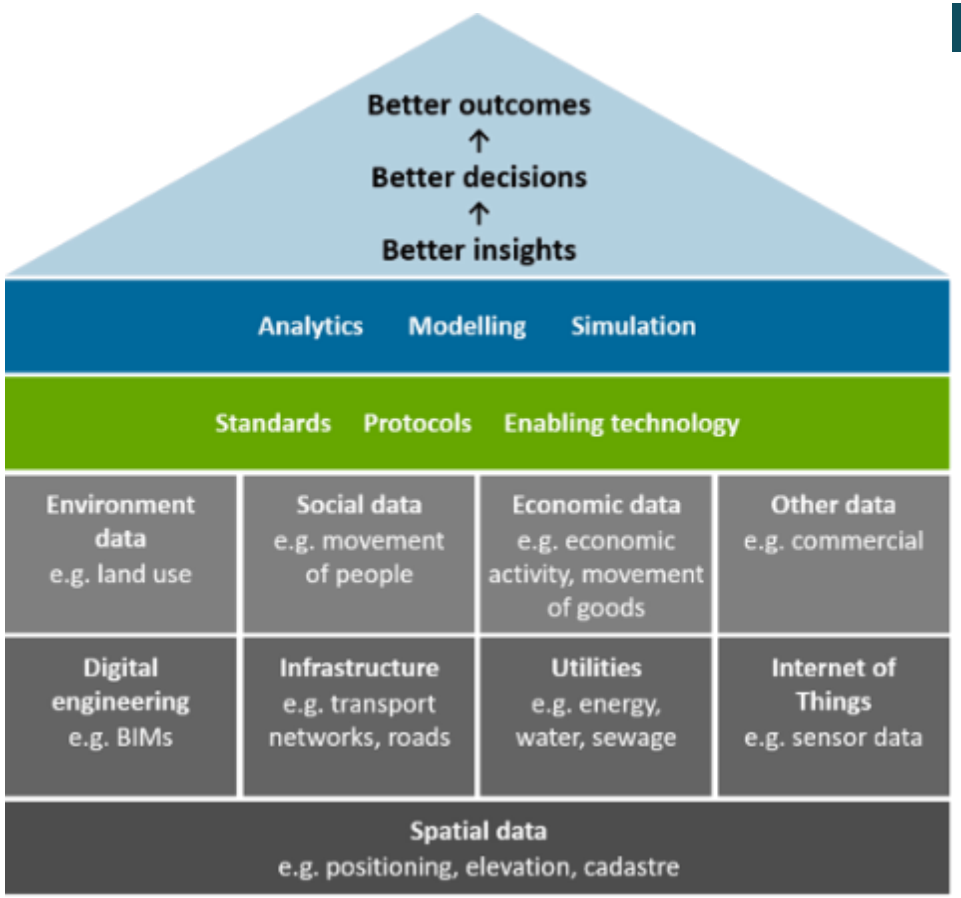
*"As a minimum, a Digital Twin must ingest the following **data sets**:*

- *Geometric and graphical data*
- *Geospatial reference data*
- *Asset attributes (natural, physical, social, economic)*
- *Management data*
- *Real-time asset performance and utilisation data"*

Smart Cities Council (2020)

Principles for Spatially Enabled Digital Twins

ANZLIC (2019)



Digital Twin Capabilities

A Digital Twin is not a Digital Twin until it provides the following **minimum five capabilities**:

- **CONNECTED** - there is a **'live'** connection between the digital replica and the physical world
- **INTEGRATED** - it checks and links **multiple data sources**
- **VISUALIZE** - it provides **advanced visualization** of real-time multisource data
- **ANALYSIS** - federated data sets can be processed, modeled, analysed … **simulations and predictions** can be made
- **SECURE** - information is managed in a way that reduces its risk of being compromised

Sensors & sensor web enablement

Spatial Data Infrastructures (SDI)

Geo-visualization

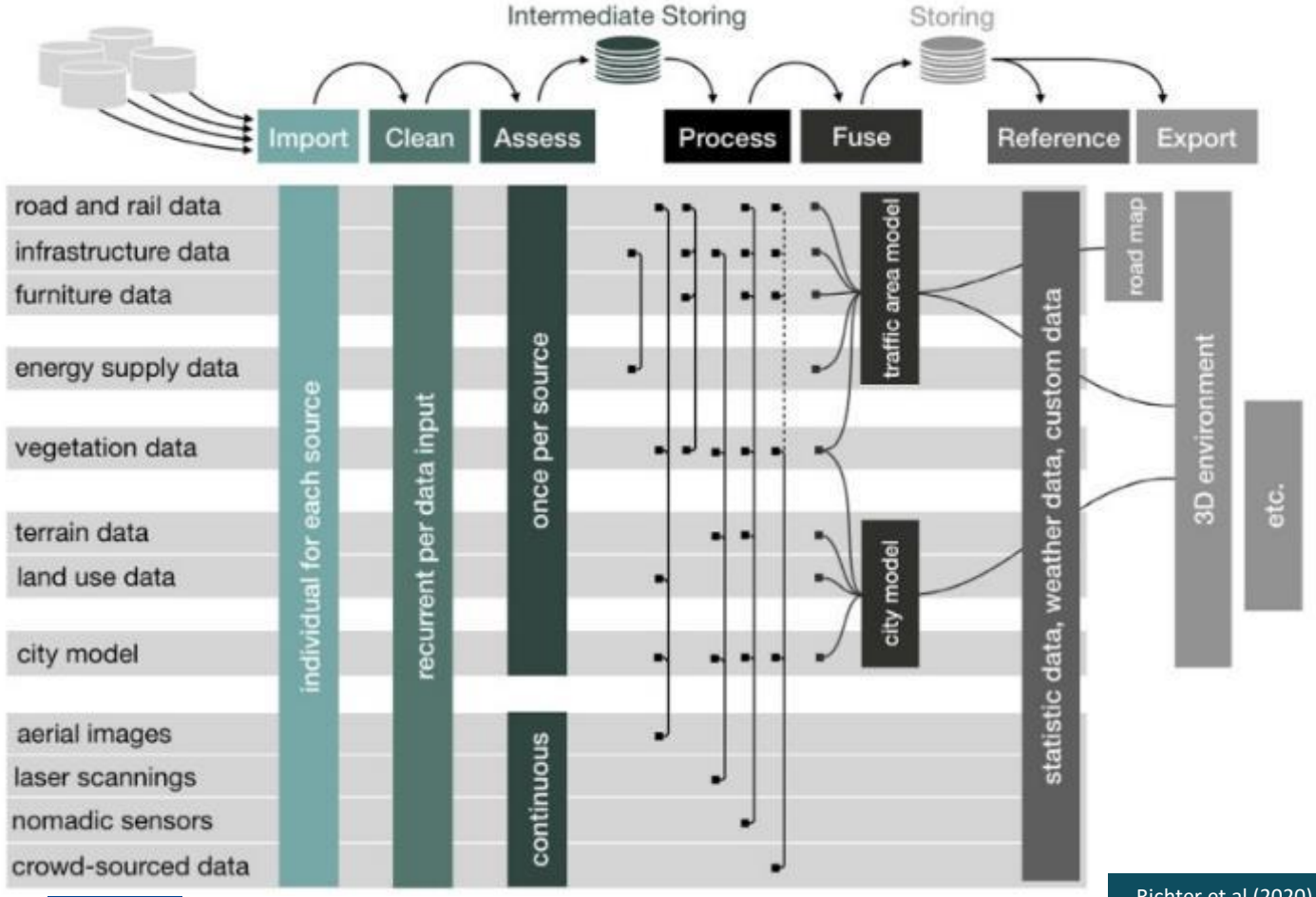
GeoAI

Secure access mechanisms (AAA)

Digital Twins: new ways of data handling

Static and dynamic data combined, 2D – 3D – 4D …, **interaction** between the elements … model, simulate and predict … power needed

The need for **data ethics, data literacy**

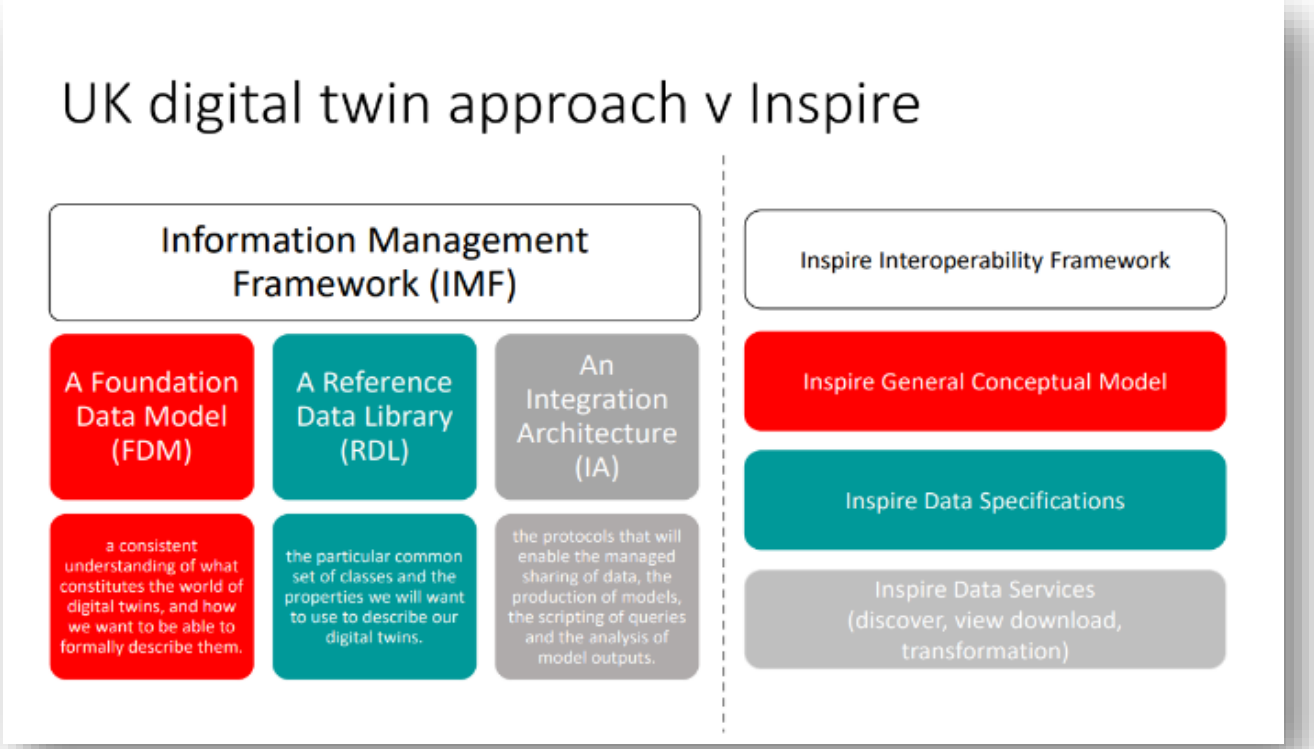


Richter et al (2020)

Interoperability challenges

SDIs, INSPIRE and other data infrastructures and communities provides answers and solutions to several of these interoperability challenges

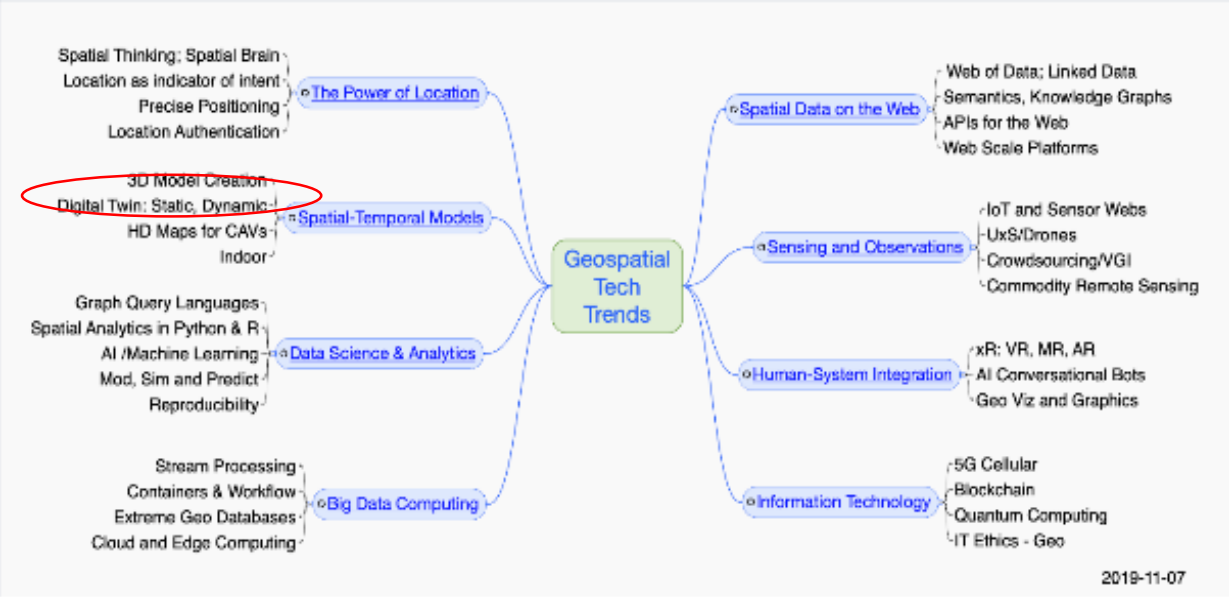
- Interoperable models and standards for structuring data
- A data model that extends beyond the purely physical/functional representation
- Manage the spatial and temporal (and other) changes over the physical asset's life cycle
- Information management and governance policies and processes
- Protocols for managing, securing and controlling access to information
- …

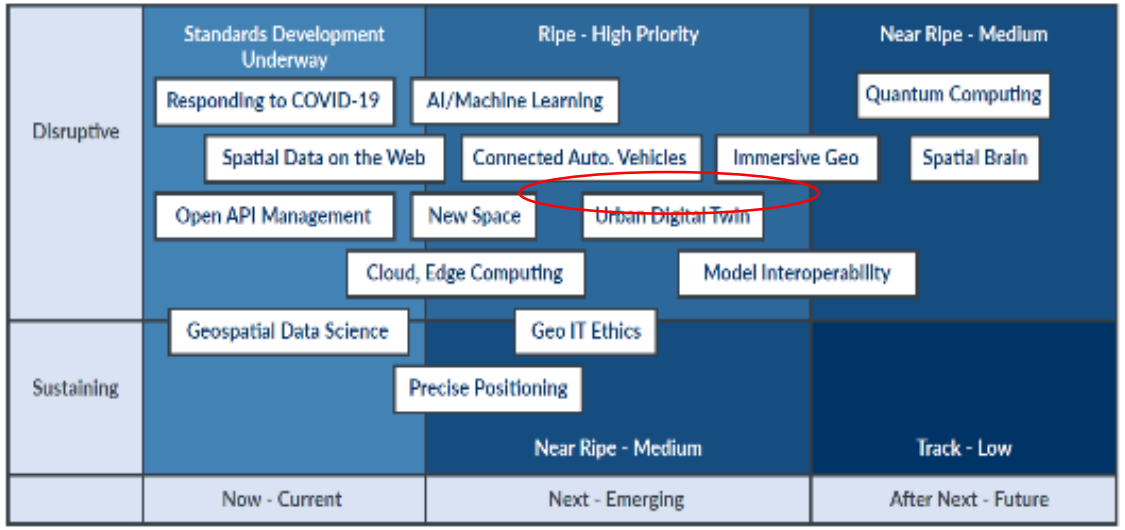


Millard (2020)

OGC Technology Trends

The OGC Tech Trends activity surveys and characterizes trends across information and communication technology as well as the science and technologies that support the collection, processing, and understanding of geospatial information.





Mindmap Technology Trends

OGC = Open Geospatial Consortium

OGC (2019) & OGC (2020)

3DIM DWG identified in the OGC Tech Trends watch as primary DWG to discuss and review geospatial interoperability issues related to Digital Twins

Citizen Science

Simulation & Gaming

OGC®
Making location count.

Sensor Web Enablement DWG: real time integration of heterogeneous sensors and the IoT into information infrastructures and Digital Twins: flood gauges, air pollution sensors, mobile heart monitors, Webcams, robots as well as space and airborne earth imaging devices

Artificial Intelligence in Geoinformatics DWG aims to identify use cases and applications related to AI in geospatial domains with its reliance on IoT or 'digital twins'

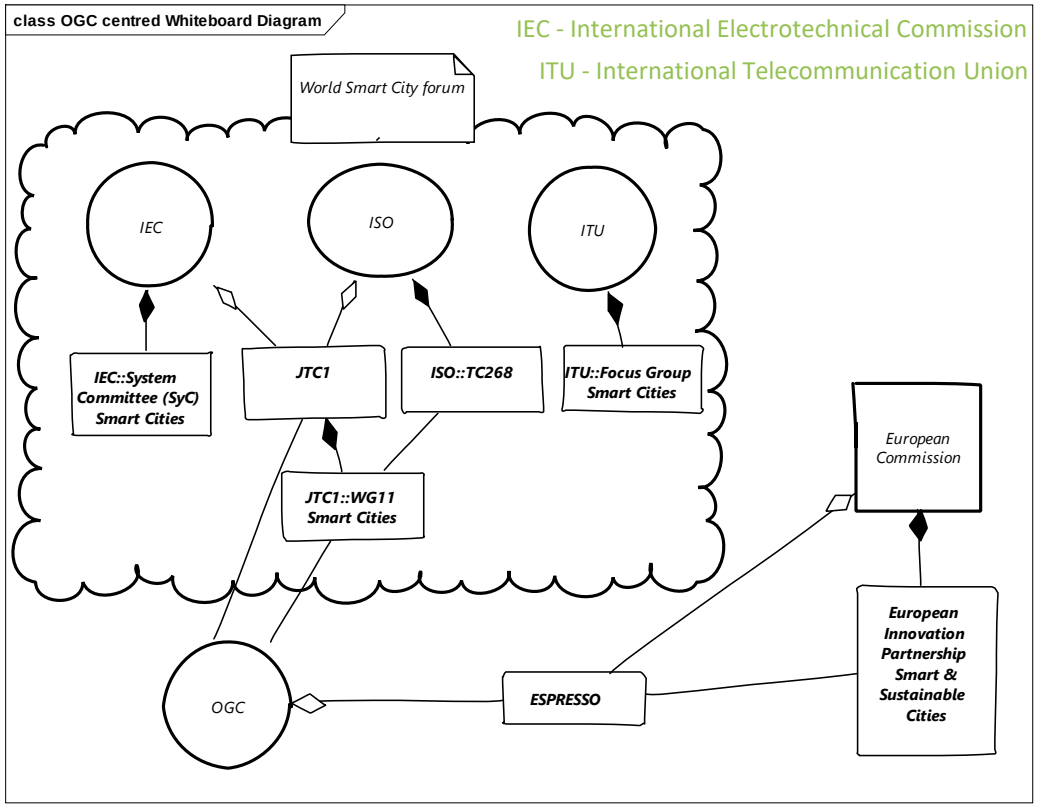
Point Cloud

...

Smart Cities DWG and the 2015 Release of the **OGC® Smart Cities Spatial Information Framework** as a spatial information framework for urban spatial intelligence based on open standards

DWG – Domain Working Group

International organisation for standardisation (ISO)



Parslow, P. (2018)

Bringing SDO's together …

ISO/IEC JTC 1/AG 11 Digital Twin

- 1 - Provide a description of **key concepts and relevant terminology**
- 2 - Identify **current technologies and reference models** deployed in Digital Twins
- 3 - Creating **awareness** of JTC 1 activities on Digital Twins outside JTC 1
- **4 - Assess the current state of standardization activities** relevant to Digital Twins within JTC 1, in other relevant ISO and IEC Committees, in other SDOs and in consortia
- 5 - Identify the **relevant standardization issues of Digital Twin** to be addressed by JTC 1, covering at least foundational areas, ICT standardization needs, etc.
- **6- Engage with standards setting organizations** that are involved in Digital Twins standardization
- **7- Prepare a report and recommendations to JTC 1**, which may include proposed New Work Items

SDO = Standards Developing Organisations

Example of DUET (Digital Urban European Twins)

Leveraging HPC and Cloud for better decisions

… to help public sector decision-making become more democratic and effective. By creating digital replica's of a city, people, no matter their background, can use the Digital Twins 3D and 2D interfaces for easy policy impact exploration and experimentation across entire cities and regions …

Three pilots

- Athens
- Pilsen
- *Flanders*

https://www.digitalurbantwins.com/

Flanders
Regional Mobility Plan &
Environmental Plan

Explore and **simulate** correlations between mobility, air polution and health issue

Combine international national, regional datasets with local datasets

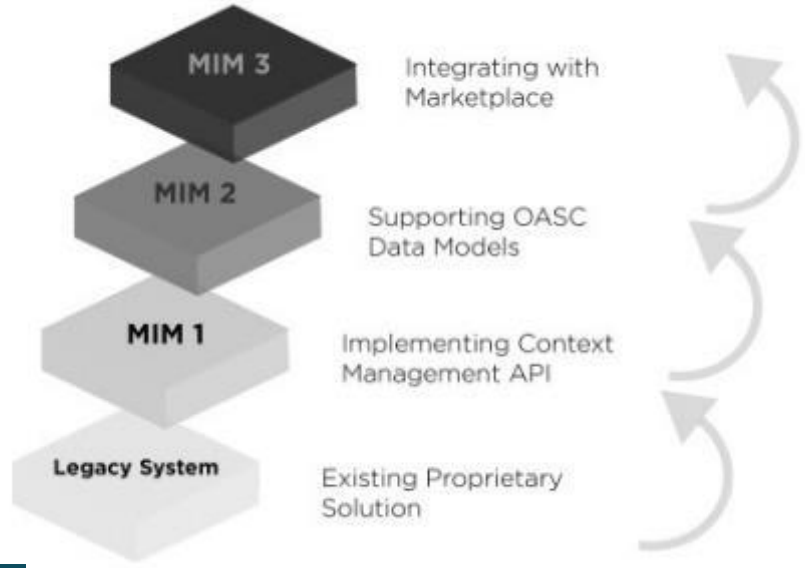
Based on **OSLO** semantic standards which use **ISA² core vocabularies**

OSLO = Open Standards for Local Administrations in Flanders

Open Agile Smart Cities (OASC)

Minimal Interoperability Mechanisms (MIMs)

… are universal tools for achieving interoperability of data, systems, and services between cities and suppliers around the world (…) based on an inclusive list of baselines and references, MIMs take into account the different backgrounds of cities and communities and allow cities to achieve interoperability based on a minimal common ground.



OASC (2019)

MIM	Name	Standards & [Baselines]	Reference
1	OASC Context Information Management MIM	ETSI NGSI-LD API[1], OMA NGSI, ITU- T SG20/FG-DPM [FIWARE NGSI]	Reference Architecture for IoT-Enabled Smart Cities (SC-D2.10)
2	OASC Data Models MIM	[SAREF, FIWARE, GSMA, schema.org, SynchroniCity RZ + partner data models]	Guidelines for the definition of OASC Shared Data Models (SC-D2.2) Catalogue of OASC Shared Data Models for Smart City domains (SC-D2.3; to be released)
3	OASC Ecosystem Transaction Management MIM	[TM Forum Business Ecosystem API, FIWARE Business Ecosystem and Marketplace Enabler API, SynchroniCity API]	Basic Data Marketplace Enablers (SC-D2.4) Guidelines for the integration of IoT devices in OASC compliant platforms (SC-D2.6)

Digital Twins
interoperability challenges

- Digital Twins are based on **many, diverse and dynamic data sources** that needs to be combined, visualized and understood
- Interoperability - **technical, semantic, organizational** … - is a key challenge
- This requires good **collaboration between SDO's**
- It requires also **'simplified' standards** and **common building blocks**

4

Key take-away messages & conclusions

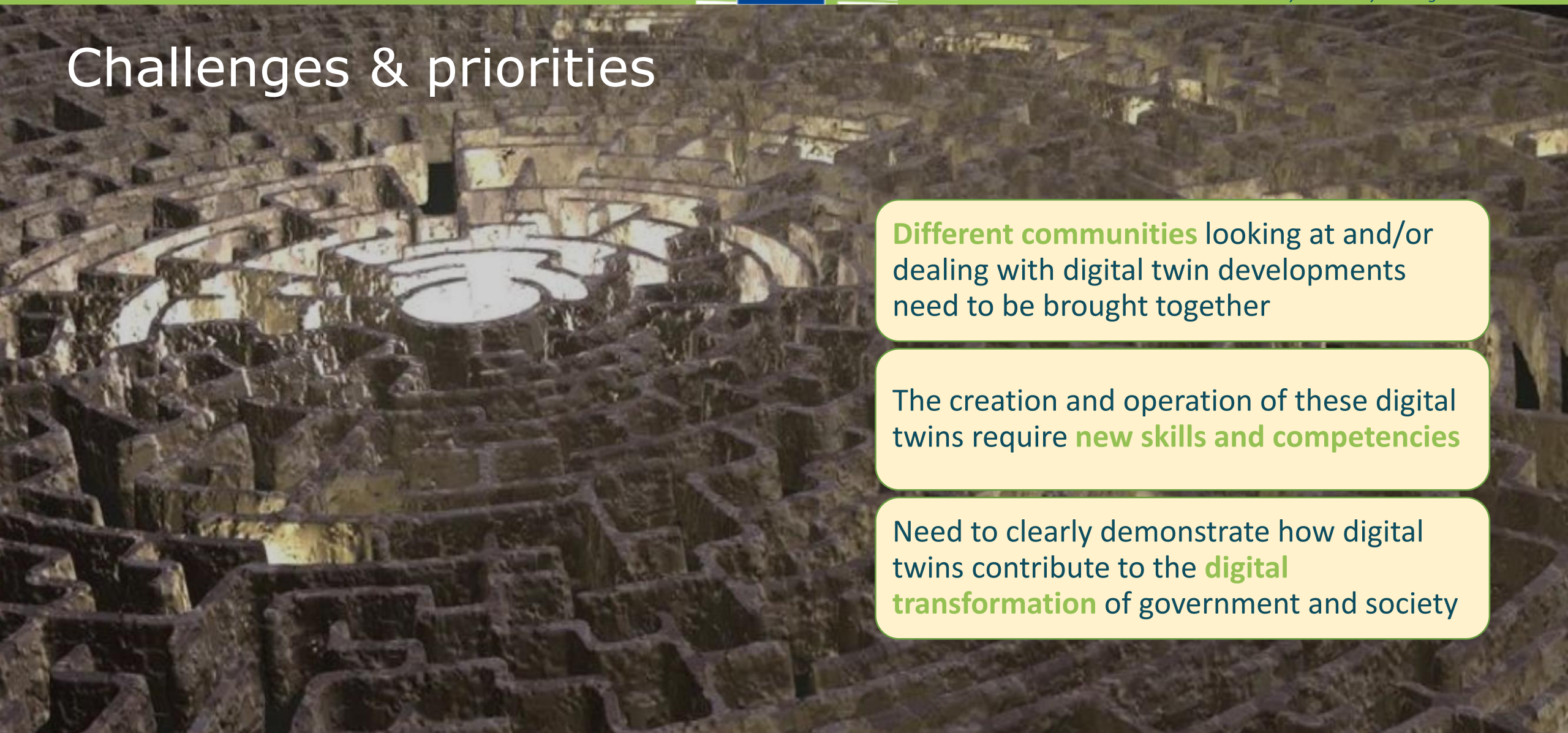
Concluding remarks

Geospatial data, tools and technologies as the **fuel to digital twins** at different levels and in different domains

Assessment needed of **the current state of geospatial data**, standards and technologies relevant to Digital Twins

Existing **spatial data infrastructures & ecosystems should be further upgraded** to better enable the creation and use of digital twins

Challenges & priorities



Different communities looking at and/or dealing with digital twin developments need to be brought together

The creation and operation of these digital twins require **new skills and competencies**

Need to clearly demonstrate how digital twins contribute to the **digital transformation** of government and society

5 References

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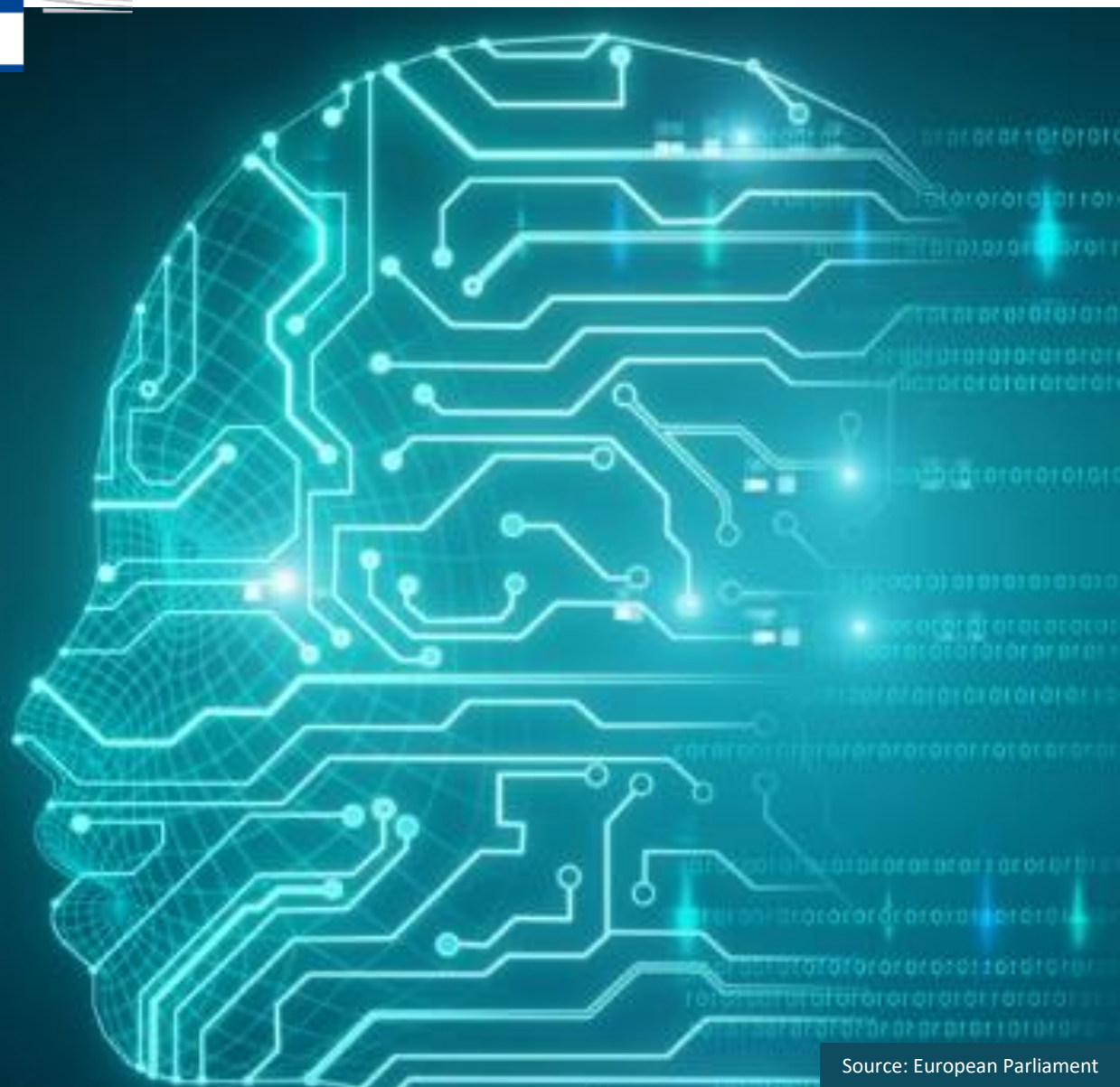

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