



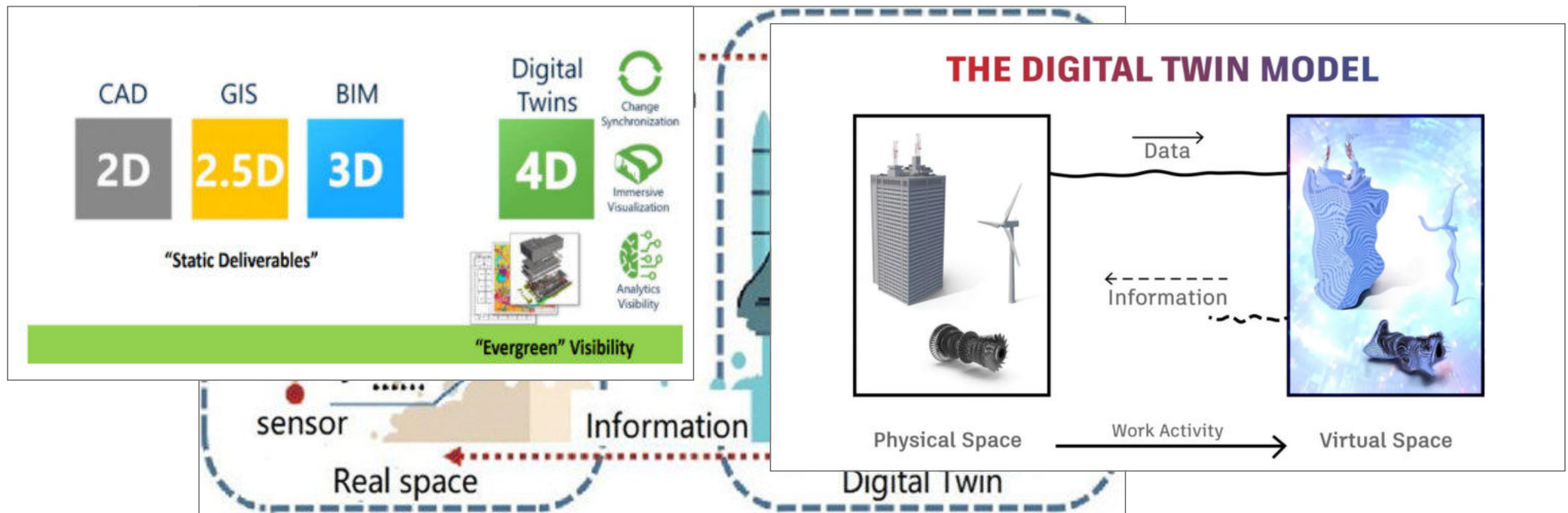
Role of Digital Twins within the “Swiss Geoinformation Strategy ”

Agenda

- ▶ General Introduction- Digital Twin
- ▶ Definition and Challenges of Digital Twin- Swiss Geoinformation Strategy

What is a Digital Twin?

Different Definitions



Sources:
<https://www.google.com/url?sa=i&url=https%3A%2F%2Ffredshift.autodesk.com%2Farticles%2Fwhat-is-a-digital-twin&psig=AOvVaw0WWM669-7Zy3OB2Tgy2U3-&ust=1669914637359000&source=images&cd=vfe&ved=0CA4QjhxqFwoTCLiq-fiy1vsCFQAAAAAABAM>
<https://www.google.com/url?sa=i&url=https%3A%2F%2Fflink.springer.com%2Farticle%2F10.1007%2Fs11042-022-12536-5&psig=AOvVaw0WWM669-7Zy3OB2Tgy2U3-&ust=1669914637359000&source=images&cd=vfe&ved=0CA4QjhxqFwoTCLiq-fiy1vsCFQAAAAAABAH>

What are Digital Twins used for?

- ▶ Simulation of What-if scenarios
- ▶ Bring information to citizens
- ▶ better insights-> better decisions-> better outcomes

Digital Twin in context Swiss Geoinformation Strategy

Strategie

Geoinformation Schweiz

Version 2, November 2020



Geoinformation as Common Good

...In the digital age, geographical space is increasingly being represented in digital form, to a certain extent as a **“digital twin”**. The better the description of geographical space and the integration of digital technologies, the more useful the **knowledge gained** from linking these two aspects. **This expands on our ability to make decisions and helps us to improve processes.**

What is a Digital Twin? – Context Swiss Geoinformation Strategy

EPFL

Urban Digital Twins & City Data Platforms - A simple glossary of key concepts

ENAC-IT4R



V10 - 22.05.2022

Data Platform

While the Digital Twin can be understood holistically as a concept, a Data Platform refers generally to a specific tool.

- **Database (Data Bank):** store data, retrieve data.
- **Data Repository:** store data, retrieve data, preserve data, discover data. A Generic term for database that is publicly accessible online, that allows to read, write, and possibly query/analyse/visualise the data through a front-end and/or APIs.
- **Data Catalog (Data Index):** retrieve data, discover data. Stores only metadata, links to repositories to access the actual data.
- **Data Analysis Platform:** run code, manipulate, analyse and visualize data.
- **Data Archive:** store data, preserve data. A database intended for long-term and/or secure data storage (can be set up as a repository - accessible online - or as a simple database).

Digital Twin

A virtual representation of a physical system (and its associated environment and processes) that is updated in real-time through the bi-directional exchange of information between the physical and virtual systems ^{adaptation 1}.

Building on definitions from the manufacturing field² arguing that the definition of a digital twin depends on the level of data integration between the digital and physical counterparts, we draw the following definitions:



⚠ Not a new term! The term "Digital Twin" first emerged in the 90s and is now just resurfacing, being re-branded with the explosion of big data, sensors (IoT) and technological interconnections³.

⚠ IoT (Internet of Things) is a network of physical devices, embedded with electronics, software, sensors, actuators, and connectivity enabling these objects to connect and exchange data⁴.

Smart City

Smart City: A broad concept comprised of physical, social and knowledge infrastructures⁵ often depicted as "utilizing cyber-physical intelligence to improve city functions, job creation, and public satisfaction".

An evolution of this concept is the **Cognitive City** that adds the ability to learn and adapt cities behavior based on past experiences ^{adaptation 2}.

⚠ A critique: Is the Smart City making the city become a digital marketplace, instead of more resilient and inclusive? Detractor of the Green Growth approach are concerned with Smart City, which they understand as an urban strategy aiming to push technological solutions to urban challenges, expanding the market for technology products and services but disregarding wider political and environmental impacts⁶.

Urban Digital Twin

A virtual replica of the physical city, which collects data from the infrastructure, processes and services using connected devices and sensors⁷.

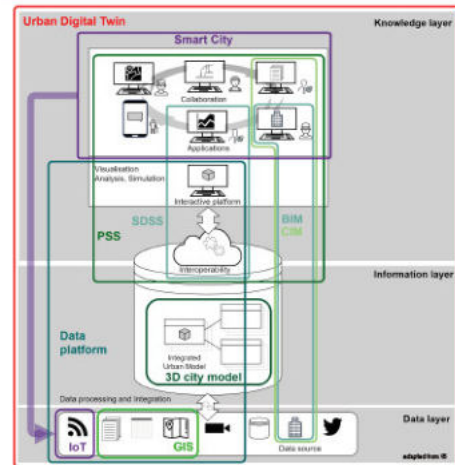
Fuzzy concept: The definition of urban digital twin is not totally clear in the literature, and this concept is often misused⁸.

Synonyms: Urban Digital Twin: concept has also been branded **City Digital Twin⁹**, **Virtual City¹⁰**, **Urban brain¹¹**.

Holistic view: "city digital twins not only model, mirror and interact with the physical aspect of the city but also aim to centered on the social and economic aspects" ^{adaptation 3}.

⚠ **Cloud computing:** on-demand remote servers hosted on the internet to store, manage, and process data.

⚠ **Edge computing:** distributed computing paradigm that brings computation and data storage closer to the data sources.



Urban Digital Twin as interlinked modules
A recent review¹⁴ of existing Urban Digital Twins, attempting to identify common characteristics of urban digital twins, concludes that they vary widely though the core generally contains:

- **Digital models** of the physical city + **sensors** and **actuators** for bi-directional interactive capabilities.
- **Interoperable modules** built on this core, to integrate other infrastructures, services and systems (with their own models, data sources and actuators).

To go further, some argue that "developing several digital twins for the city may be more feasible than developing one model for the whole city's systems and processes"¹⁵.

CIM, BIM, GIS, 3D models ...

Geographical Information System GIS
A database or software that captures, manages, stores, analyzes and maps spatial data.

Building Information Modeling BIM
Use of a shared digital representation of a built asset to facilitate collaborative design, construction and operation processes¹⁶.

⚠ Wait, BIM is not a Building Digital Twin? Not While BIM does provide standard semantic representation of buildings, it does not support interaction between physical and virtual model in realtime¹⁷. Plus BIM lacks semantic completeness in certain domains (control systems, social systems and urban artefacts beyond buildings), which are the realm of Urban Digital Twin¹⁸.

City Information Modeling CIM
Extension of the BIM concept to the city. CIM is argued to facilitate various stages of urban design and planning from its strategizing, conceptualization, legislation, execution, construction and monitoring.

⚠ A definition highlighting openness of data & tools: "City Information Modeling is the practice of using interactive digital technologies in the process of urban planning, by all actors and stakeholders, to collaboratively deliver the vision of a Smart City: a sustainable, inclusive, healthy, prosperous and participative city. CIM consists of an ecosystem of interoperable (open source) tools from different knowledge domains, for data processing, urban analysis, design, modeling, simulation and visualization. These tools are connected via shared ontologies to a semantically rich City Information Model, based on open standards, in a multiscale and multi-temporal database, that integrates a wide range of big open data sources representing the full range of urban features, systems and processes."¹⁹

Digital 3D City Models
Digital model of urban areas that represent terrain surfaces, sites, buildings, vegetation, infrastructure and landscape elements in three-dimensional scale.

⚠ Often the base for Urban Digital Twin! In many cases, the 3D model of a city serves as a basis upon which more complex modules of Urban Digital Twins are built²⁰.

Planning Support Systems PSS
Any computer-based tools that modern urban and regional planners use for rational planning decision making, at the strategic-level²¹.

Spatial Decision Support System SDSS
Subcategory of PSS, geographically explicit, and with clear operational aims²².

⚠ What about the Metaverse? The metaverse expands the concept of digital twin by creating an inhabited mirror world where the physical dimensions and rules of time and space do not necessarily apply ^{metaverse 23}.



Sources:
Study by EPFL-ENAC-IT4R, 2022 (mandated by SGS)

What is a Digital Twin?

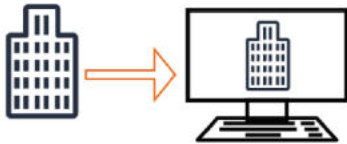
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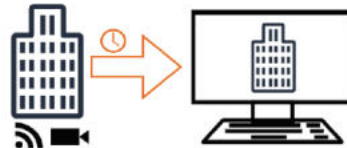
Digital Model

Virtual reflects physical



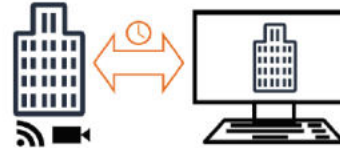
Digital Shadow

Virtual reflects physical realtime



Digital Twin

Bi-directional data flows



Sources:
Study by EPFL-ENAC-IT4R, 2022 (mandated by SGS)

What are the Components of a Digital Twin?

Urban Digital Twin as interlinked modules

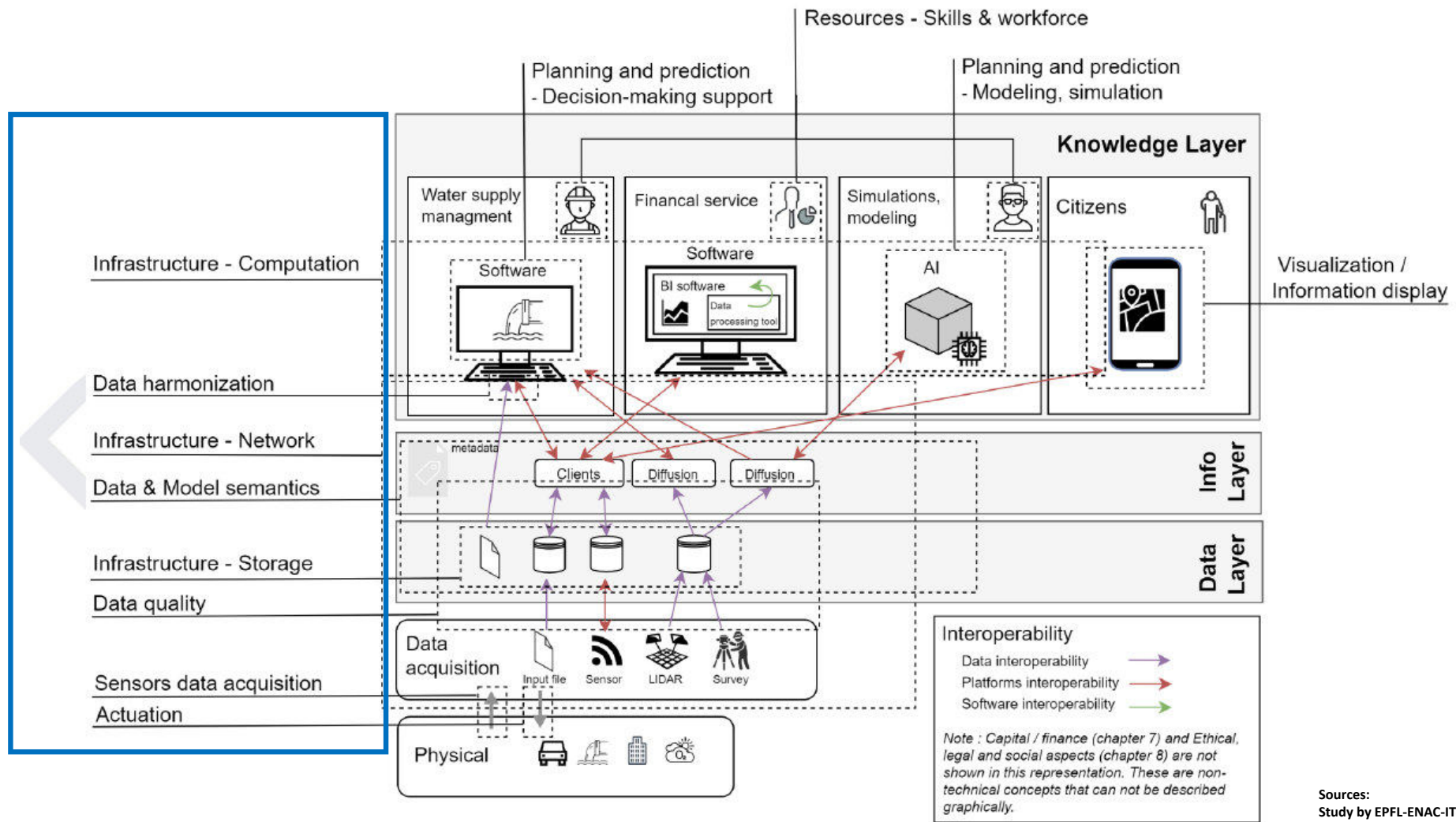
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Challenges of Digital Twin



Sources:
 Study by EPFL-ENAC-IT4R, 2022 (mandated by SGS)
 Original: J. Ferré-Bigorra, M. Casals, M. Gangolells, 2022

Digital Twin in the Swiss Geoinformation Strategy?





Strategie Geoinformation Schweiz Stratégie suisse pour la géoinformation

GKG KGK
GCS CGC

<https://www.geo.admin.ch/strategie>