

## 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 adapted from 1.

Building on definitions from the manufacturing field<sup>2</sup> 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 interconnections<sup>4,5</sup>.

**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 data<sup>24</sup>.

## Smart City

**Smart City**: A broad concept comprised of physical, social and knowledge infrastructures<sup>6</sup> often depicted as "utilizing cyber-physical intelligence to improve city functions, job creation, and public satisfaction"<sup>7</sup>.

An evolution of this concept is the **Cognitive City** that adds the ability to learn and adapt cities behavior based on past experiences adapted from 9.

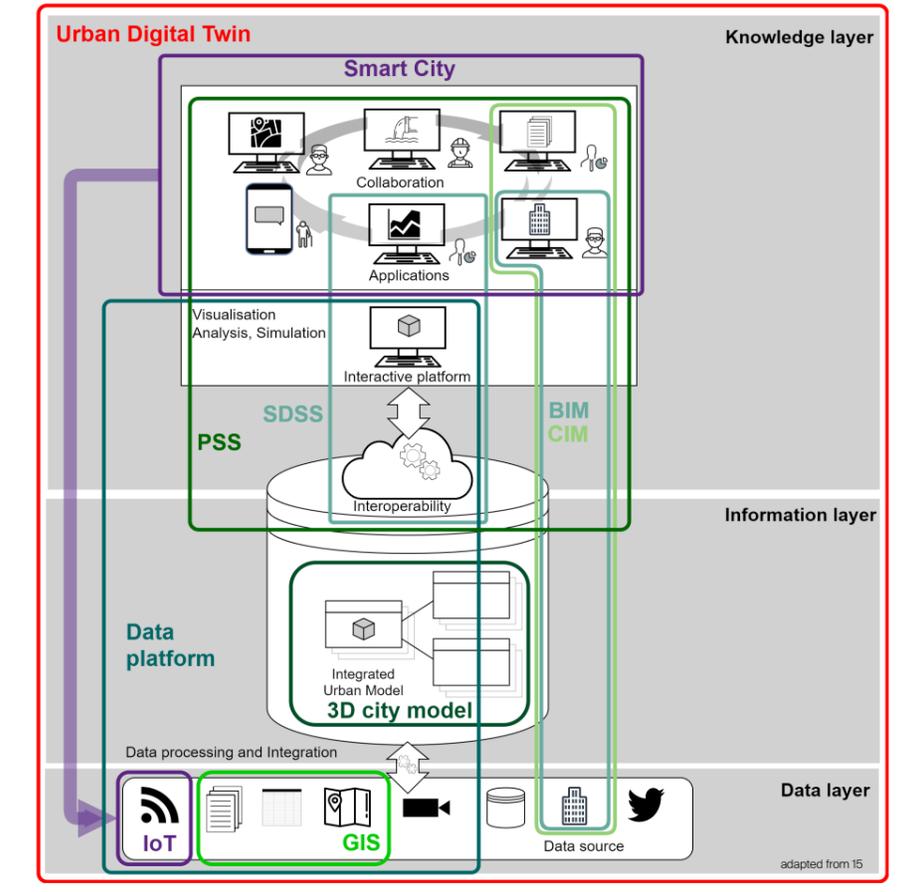
**A critique:** Is the Smart City making the city become a digital marketplace, instead of more resilient and inclusive? Detractor of the Green Growth approach are concerned with Smart City, which they understand as an urban strategy aiming to push technological solutions to urban challenges, expanding the market for technology products and services but disregarding wider political and environmental impacts<sup>8</sup>.

## Urban Digital Twin

A **virtual replica** of the **physical city**, which collects data from the infrastructure, processes and services using connected devices and sensors<sup>19</sup>.

- Fuzzy concept**: The definition of urban digital twin is not totally clear in the literature, and this concept is often misused<sup>13</sup>.
- Synonyms**: Urban Digital Twins concept has also been branded **City Digital Twin<sup>18</sup>**, **Virtual City<sup>19</sup>**, **Urban brain<sup>18</sup>**.
- 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**" adapted from 13.

- 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 review<sup>14</sup> 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"<sup>21</sup>.

## 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 processes<sup>8,9</sup>.

**Wait, BIM is not a Building Digital Twin ?!** No! While BIM does provide standard semantic representation of buildings, it does not support interaction between physical and virtual model in realtime<sup>6,14</sup>. Plus BIM lacks semantic completeness in certain domains (control systems, social systems and urban artefacts beyond buildings), which are the realm of Urban Digital Twin<sup>5</sup>.

**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."<sup>15</sup>

**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 Twins!** In many cases, the 3D model of a city serves as a basis upon which more complex modules of Urban Digital Twins are built<sup>14</sup>.

**Planning Support Systems PSS**  
Any computer-based tools that modern urban and regional planners use for rational planning decision making, at the strategic-level<sup>12,13</sup>.

**Spatial Decision Support System SDSS**  
Subcategory of **PSS**, geographically explicit, and with clear operational aims<sup>17</sup>.

**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 adapted from 23.

Stakeholders	Public administration   Citizens   Asset owners   Asset managers   Researchers				
Service / actuation	Urban planning asset mgt.	Mobility, roads infra., noise	Water supply, sewage, flooding	Energy mgt.	Pollution, climate prediction
Simulation	3D simulation ...	Machine learning...	Logic operations...	Machine learning...	3D simulation ...
Digital modeling	City info. model	Mobility simulation	Fluid dynamics	Energy simulation	Meteorological, pollutant
Data acquisition	Sensors	Sensors	Sensors	Sensors	Sensors
Physical world	City	Mobility, road infra.	Gaz, sewage water supply	Electrical grid	Pollution weather, climat

adapted from 14

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