DIGITAL TWINS FOR INTEGRATED PLANNING

FACTSHEET

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Introduction

The Digital Twin concept is being increasingly applied to different domains, and urban planning is not an exception. This short document targeted towards city administrations, practitioners and service providers, addresses the main considerations around Digital twin applications for integrated urban planning, with an accent on its potential for improving collaborative aspects, and is intended as a scene-setter for workshop discussion.

General information

What is integrated planning?

The key concept of integrated planning is a holistic approach to preparing and executing smart, sustainable and climate-neutral city projects. The Smart City Guidance Package composed by the Action Cluster Integrated Planning, Policy and Regulations provides guidance for how to ensure a holistic perspective in the development of plans and strategies for climate-neutral and smart cities. A summary has been published recently.

The Smart City Guidance Package addresses integrative aspects of different time horizons, engagement of multiple sectors and disciplines, a combination of several technologies, engagement of and agreement between various stakeholders, and integration of financial and other aspects and benefits from an early stage.

TIME:

Policies and actions usually focus on the timeframe of the current political cycle, therefore a long-term perspective on the life cycle of the built environment is a prerequisite to take the right short-term actions, meet obligations and make plans resilient.

SECTORS AND DISCIPLINES:

Often many governments or business departments and sectors, working within different domains and disciplines are involved, but mutual connections are weak. For that reason, a holistic, multi-disciplinary, cross-domain perspective is key to overcome silos and exploit synergies between different domains

TECHNOLOGIES:

Smart and climate-neutral urban solutions often integrate several technologies; however, the performance of the entire system is usually difficult to predict. How technologies might affect each other should therefore be part of plan preparation.

STAKEHOLDERS:

Many interdependencies exist among stakeholders in terms of ownership, mandates, rights, responsibilities and liabilities, and at the same time, citizens & local businesses might lack awareness or have different priorities. Thus, alignment of stakeholders through the development of co-designed and co-created plans and commitment to responsibilities and mandates agreed upon, not only during preparation but also during implementation and management phases of the project, is needed.

FINANCIAL ASPECTS AND CO-BENEFITS:

Many smart and climate-neutral solutions have less attractive business cases and business models, and financial aspects are usually discussed rather late in the process. Integration of financial aspects and co-benefits from the beginning helps to exploit new value chains and business opportunities, and include co-benefits in the equation.

What are digital twins?

A digital twin is a digital representation of a physical process, person, place, system or device. Digital twins were originally designed to improve manufacturing processes using simulations with highly accurate models of individual components.

However, with increasingly large and accurate building information models (BIM) and city modelling, combined with big data generated from IoT sensors in a smart city, it is now possible to create digital twin smart cities.

In the urban context, a digital twin is a virtual replica of the main elements of the city and its critical infrastructures connected to databases and sensors. This model of the city and its processes allows analysing, modelling, simulating and predicting scenarios or elaborating what-if questions for better decision-making on urban planning and management, in multiple domains and in an integrated way.

What is more, it allows virtual forms of designing, testing, and applying new strategies, technologies, products and connected innovative solutions.

Figure 1 Two representation of the Digital Twin of Rotterdam: detailed buildings and attributes of objects above, and utility networks and other objects as trees below.
Source: Future Insight

Which domains can digital twins cover?

Urban digital twins can be used, both for planning and operational management in several urban domains, such as:

→ Built environment

→ Infrastructures

→ Transport and accessibility

→ Land use and spatial planning

→ Environmental quality and pollution

→ Climate change, prediction of extreme weather patterns

→ Climate change adaptation, management of climate risks

→ Energy efficiency and renewable energy sources

→ Maintenance/asset management

Within these domains, several use cases and applications can be mentioned, such as the following:

→ Traffic control and related applications;

→ Physical security and anti-intrusion systems;

→ Biometric recognition and people tracking;

→ Energy optimization of buildings and grids;

→ Satellite image analysis for land and soil management;

→ Monitoring of critical infrastructures;

→ Big data analysis for urban logistics optimization;

➔ Public administration support systems;

➔ Sustainable mobility with unmanned vehicles.

## What tools exist that could facilitate the use of digital twins?

Several tools are available to create and work with 3D models and digital twins. Some examples applied in the case study include:

➔ Rotterdam 3D Tool – 3D Digital Twin of Future Insight

➔ Urban Strategy of TNO

➔ AugmentCity/OSC in Ålesund

➔ IES Intelligent Communities Lifecycle

➔ ESRI 3D visualisation tools

How can digital twins facilitate planning and accelerate urban transition?

The use of digital twins in urban planning allows the connection and relationship between the real world and simulation models (AI and Big Data). This facilitates georeferencing of information (such as city structure, the location of services or accessibility restrictions, air pollution) through 3D geospatial models.

At the same time, it provides intuitive visualization and interaction with the urban space that helps to understand the simulation results and the impact of decisions.
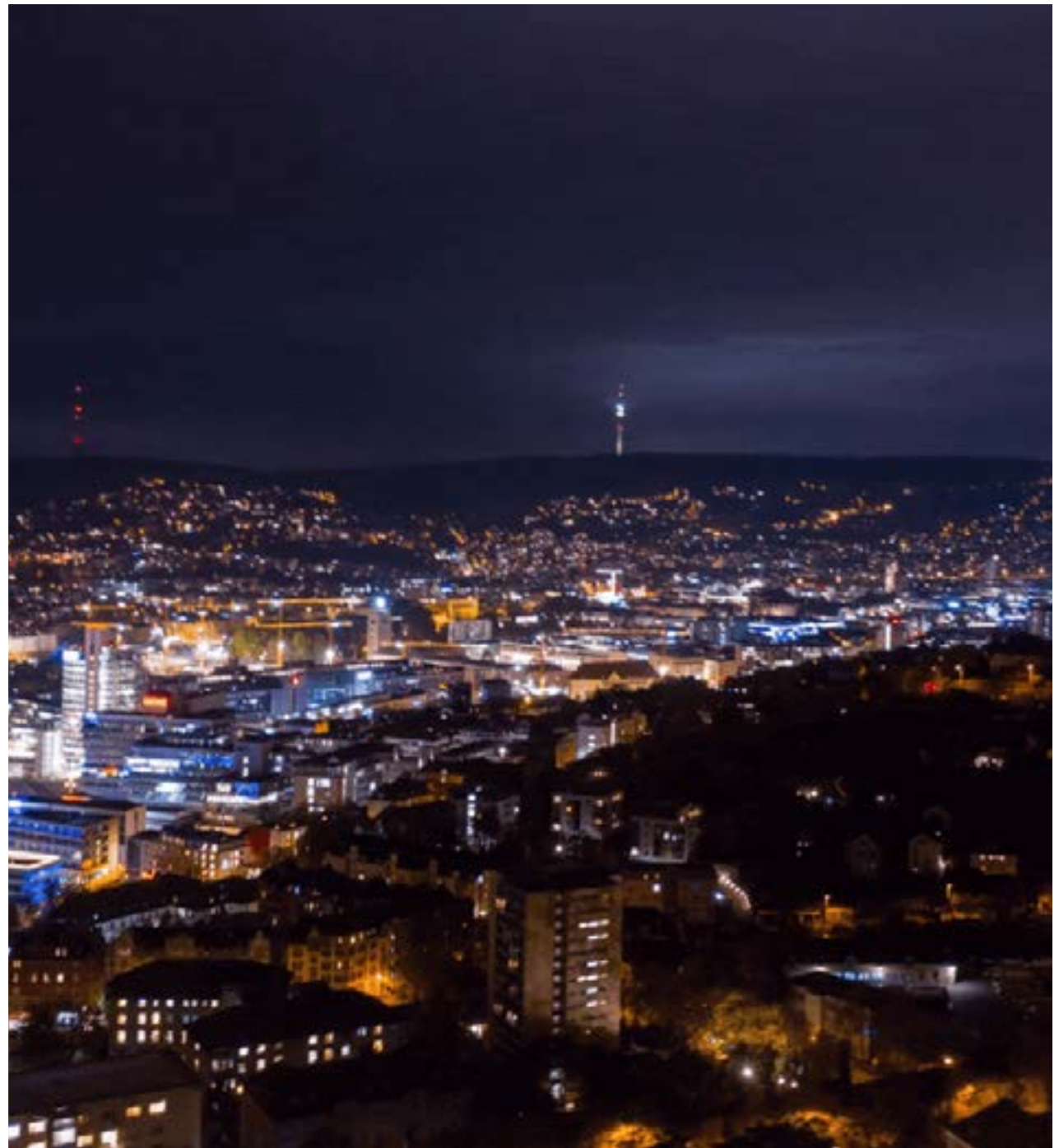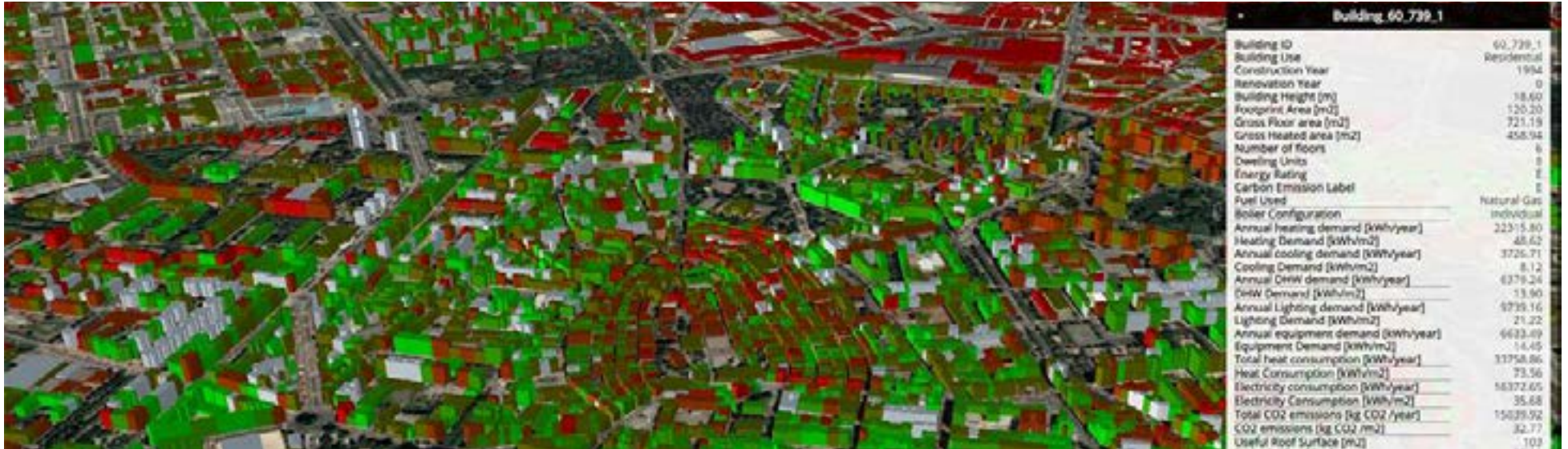
Digital twins can be of an enormous help to support integrated planning for every integrative aspect mentioned earlier through co-design, co-creation and co-realisation within the local ecosystem:

TIME: digital twins can simulate how the built environment and urban infrastructures will develop over time, given specific assumptions or in particular scenarios. It can also show the effects from the short to the long run of management and investment decisions taken now. This long-term perspective helps to visualise the effects of urban developments, policies and decisions which helps to define the right short-term actions within the current political cycle.

SECTORS AND DISCIPLINES: by providing intuitive visualisation and interaction in a shared virtual environment, stakeholders and practitioners of different backgrounds and disciplines can work in the same virtual environment. This helps to bring citizens and practitioners on the same page, overcome siloes and detect potential synergies between different domains, e.g. by combining functions or integrating different sector policies.

TECHNOLOGIES: digital twins offer the possibility to play with the combination of different solutions and technologies within a specific area, and simulate the effect on e.g., air pollution and CO_2 emission.

STAKEHOLDERS: by using digital twins, citizens and local businesses become aware of the impact of developments, e.g., climate change, population dynamics, or increased traffic flows. What is more, both stakeholders and practitioners discover how many interdependencies exist between them in urban areas in terms of ownership, mandates, rights, responsibilities and liabilities. This awareness helps to align stakeholders during co-design and co-creation of plans and commit themselves to the preparation and implementation of these plans.

FINANCIAL ASPECTS AND CO-BENEFITS:
digital twins can help to visualise the costs and benefits of investments of plans for the built environment and urban infrastructures, but also demonstrate co-benefits, for example, less air pollution and improved road safety due to mobility as a service. Early discussion of these aspects definitely helps to build better business cases and business models, agreed upon by key stakeholders.

Figure 2 Source TecnaliaResearch & Innovation: *Georeferenced information on buildings (age, construction materials, accessibility…) and calculation capabilitires for energy efficiency and RES potential allow for improved decision* making. Source Tecnalia Research & Innovation

Societal & Citizen aspects

How can citizens, small businesses and other stakeholders contribute? Which data is needed? How about privacy?

Citizens, local businesses and other stakeholders as schools can contribute by sharing their data, if willing and allowed. They can also participate in sessions, festivals and events to share their opinion on their living and working environment, and make proposals for interventions and investments to realise climate-neutral and smart cities.

For a digital twin to be useful in the urban environment, it needs to be populated by diverse data, often coming from different sources, not all of them being from the public sector. Often, data from stakeholders and citizens are needed to this end. However, to do this properly, sound and transparent strategies for data collecting and sharing amongst stakeholders need to be developed, taking special care of sensitive issues such as data security and ownership, as well as ensuring data privacy for all contributors. Similarly, the public sector can share its information.

What are the benefits for citizens, the cities, society? How can the added value for society be proven?

➔ Better presentation of complex information to practitioners and non-practitioners alike, reduction of complexity of abstract notions such as energy efficiency and sustainability helps to increase the support for plans.

➔ Digital twins can help users, through devices like web, mobile, touchscreens, and digital billboards, to intuitively visualise and explore 2D, 3D, GIS and other data aligned with the reality of the city; the use of such technologies lead to improvements in stakeholder and citizen engagement and higher quality input to planning processes.

➔ By enabling the integrative perspective on a city and its functions, digital twins can also help to identify co-benefits for owners and users of the built environment and urban infrastructures, or develop broader plans also encompassing other aspects. For instance, upgrading a public space and making a playground while also putting PV on roofs.

➔ These technologies can enhance discussion and help to build a consensus among stakeholders in a collaborative planning processes.

of each local context and respecting/protecting each specific cultural and historical heritage that make the Identity of each city and community.

Standards, regulations and policies

Which standards and regulations are in place?

Standardised "tools" will not only support compliance with regulatory frameworks but also contribute to behaviour changes and motivate co-creation. Standards ensure interoperability and alignment, as well as a collection of case studies and best practices towards replication and scaling-up, and thus they boost smart and sustainable development and "harmonization" of ways towards.

This is a major aim, while ensuring consideration

In terms of support towards smart and sustainable development for cities and communities, standardisation development is a relevant tool. ISO 37101 (management system), that has been a common driver of the Smart City Guidance Package (SCGP), through guiding), guides cities and communities in their journey towards smartness sustainability and resilience, through the setting of a long-term vision, related strategies and roadmaps with targets to meet the vision.

Then, the urban digital twins approach will be of a real support towards Integrated planning – enabling to select roadmap's options towards operational management. However, there is a key need for open data.

Indeed, open standards play an essential role in urban digital twins. They contribute in a significant manner to improve accessibility and operationality as well as to reduce costs and increase value. If several advance open data related models and standards are available and used, further standardisation development is the basis for keeping a holistic approach while monitoring, and analysis to ensure the follow-up of progress against is expected in support of urban Digital Twins, such as for linking data models, as well as collecting, then sharing specific sectorial data sets in an open data concept (i.e. for energy, water, infrastructure, mobility, Climate Change, …). objectives to the related improvement measures.
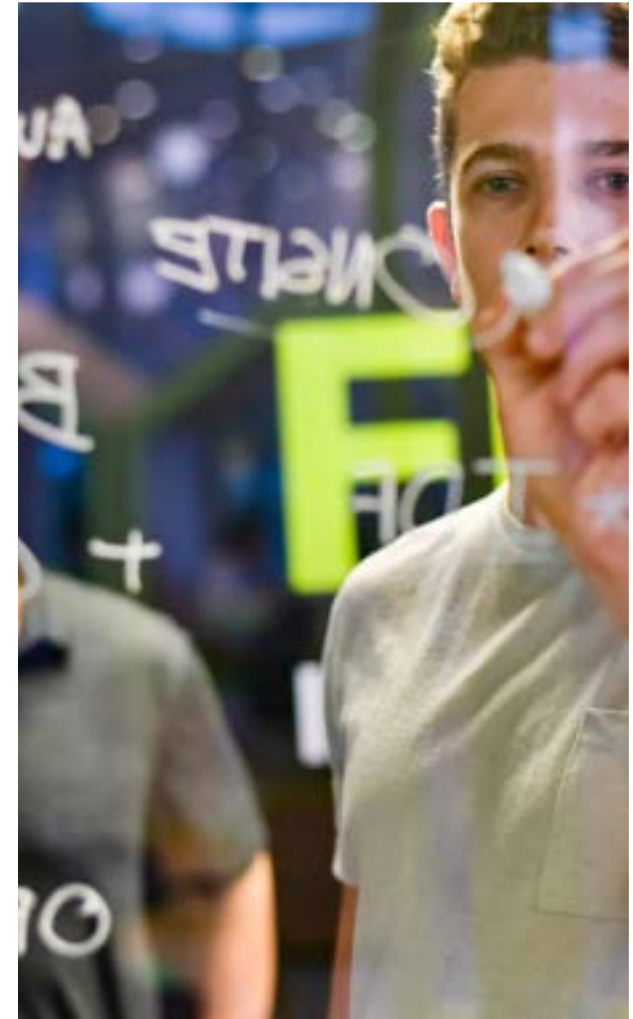
While the regulation framework sets conditions and requirements, as well as a level of responsibilities among different levels of Authorities, other commitments and strategies pave the ways to sustainable development, such as EU Climate Change strategies, Adaptation to the Climate Change. Standards must comply with these objectives by supporting the regulations' implementation and thus ease the challenges cities are facing. In that context, open data is an essential driver towards meeting our targets and the needs expressed by cities. This is reinforced by the needs expressed by the New EU legislation on Artificial Intelligence, for instance. ISO 3712x series of standards are in support of setting KPIs towards monitoring and data collection for benchmarking, supporting decision-making and investment processes thanks to – among others – alignment of understanding and targeted expectations. It creates confidence and trust among all stakeholders, including citizens.

EU Climate Change strategies, especially Adaptation to Climate Change, as well as UN SDGs, in addition to the sectorial regulatory framework (i.e EED, EPBD) must be also considered.
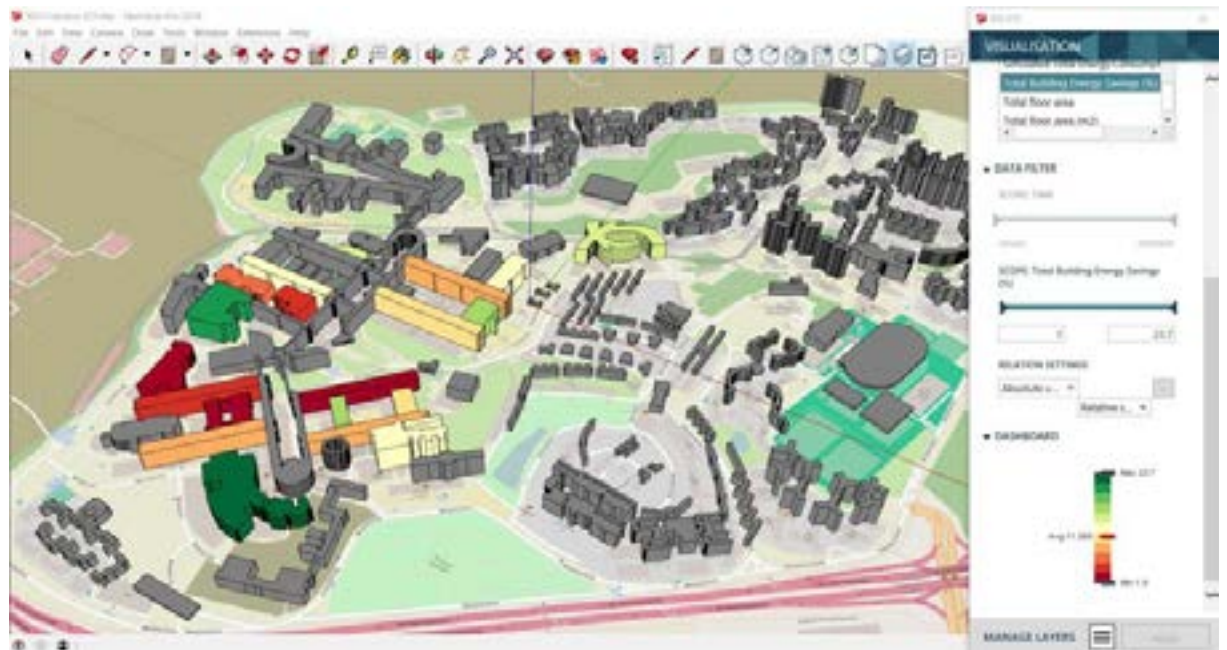
**A few data related references are listed hereafter for further consideration:**

★ European Public Procurement Directive 2014/24/UE, Art. 22 states: "For public tenders and designing bids the member states may ask the use of specific electronic instruments like electronic simulation instruments for the constructions information or similar instruments" (EC, 2014c).

★ ISO 3712x series of standards in support of setting KPIs towards monitoring and data collection for following implementation's progress and benchmarking, supporting decision-making and investment processes

thanks to – among others – alignment of understanding and targeted expectations.

★ GDPR when personal data are used.

★ National and European rules on open data and data protection.

★ CityGML and related tools have been developed as a reference for open data by Open Geospatial Consortium (OGC).
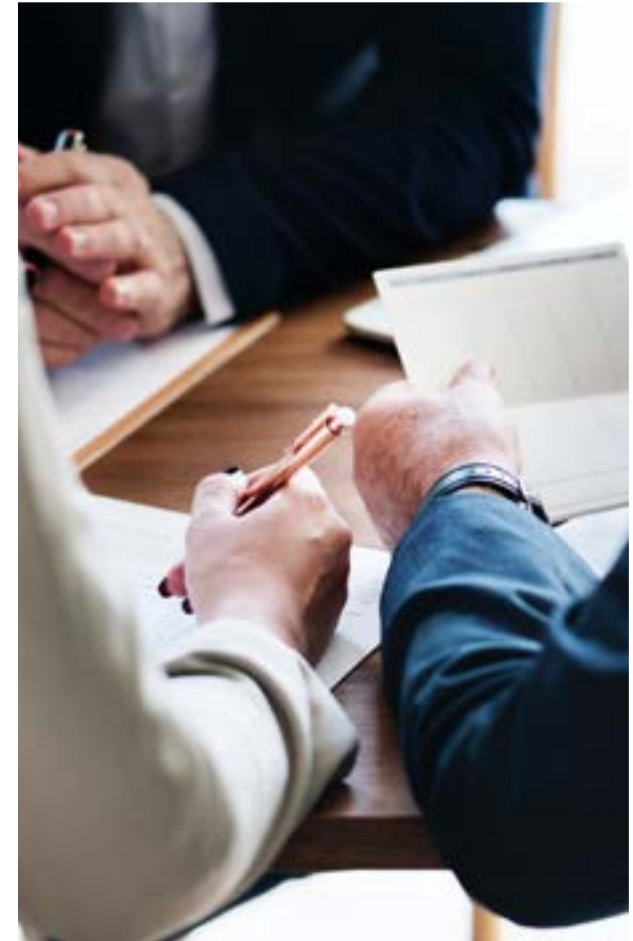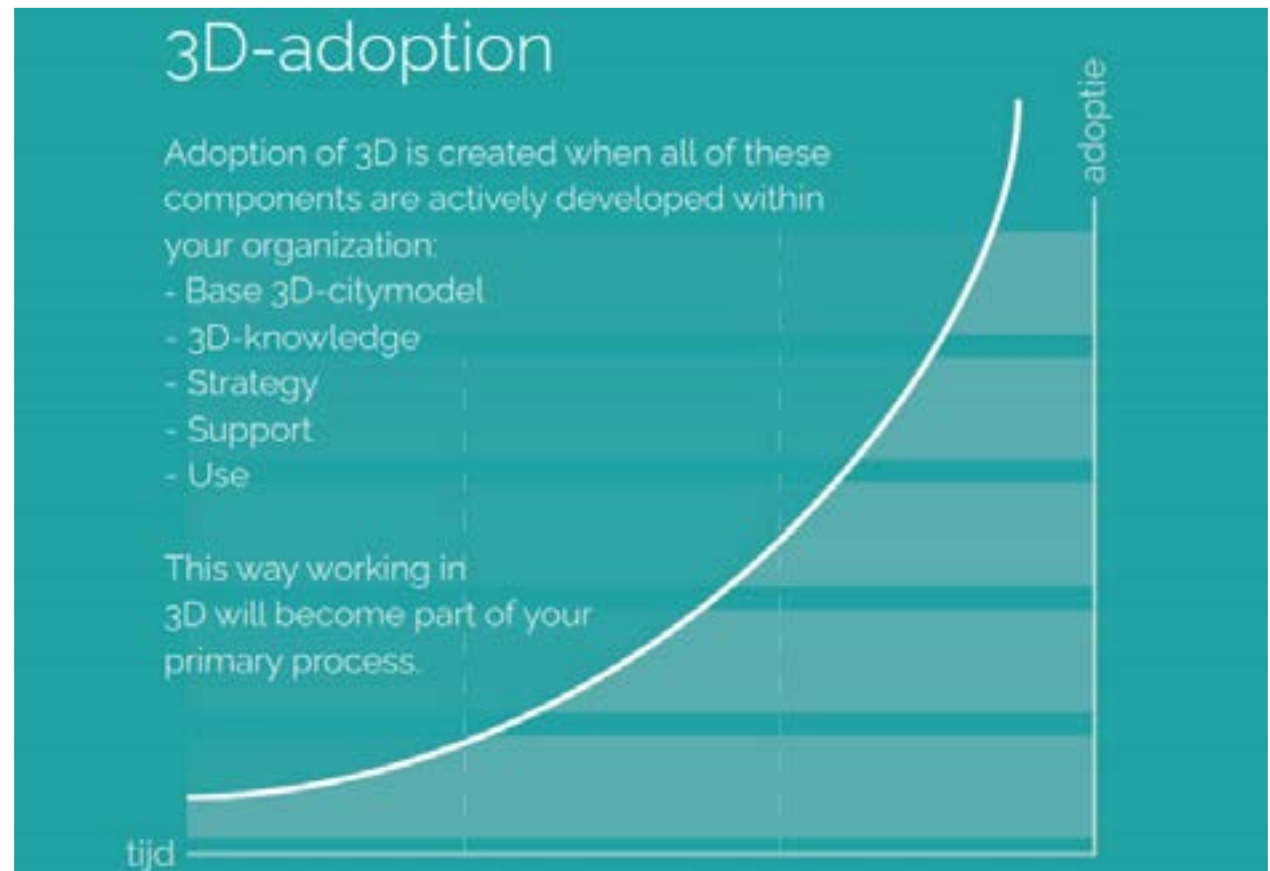
What is the outlook for regulatory frameworks in the long run?

The fast development of IT and its applications forces frequent changes and updates in related regulations. One example is the need to deal with the complexities related to the growing amount of open data generated by multiple sources. This pressure applies not only to IT-related regulations but inevitably expands into other domains, including regulations on spatial planning.

An added complication is the fact that national regulations might differ, adding a layer of complexity to the replication potential of certain technologies.

Figure 5Different phases in 3D and digital twin adoption.
Source: Future Insight

Figure 4: Source: Integrated Environmental Solutions Limited.

3D-adoption

Adoption of 3D is created when all of these components are actively developed within your organization:
- Base 3D-citymodel
- 3D-knowledge
- Strategy
- Support
- Use

This way working in 3D will become part of your primary process.

adoptie

tijd

Finance

Where is the added value in the entire chain?

Faster and better collaboration reduces costs of plan preparation and increases the acceptance and overall success rate of plans. Besides, digital twins can help to optimise internal processes in the city that can lead to more efficiency or better services to citizens…
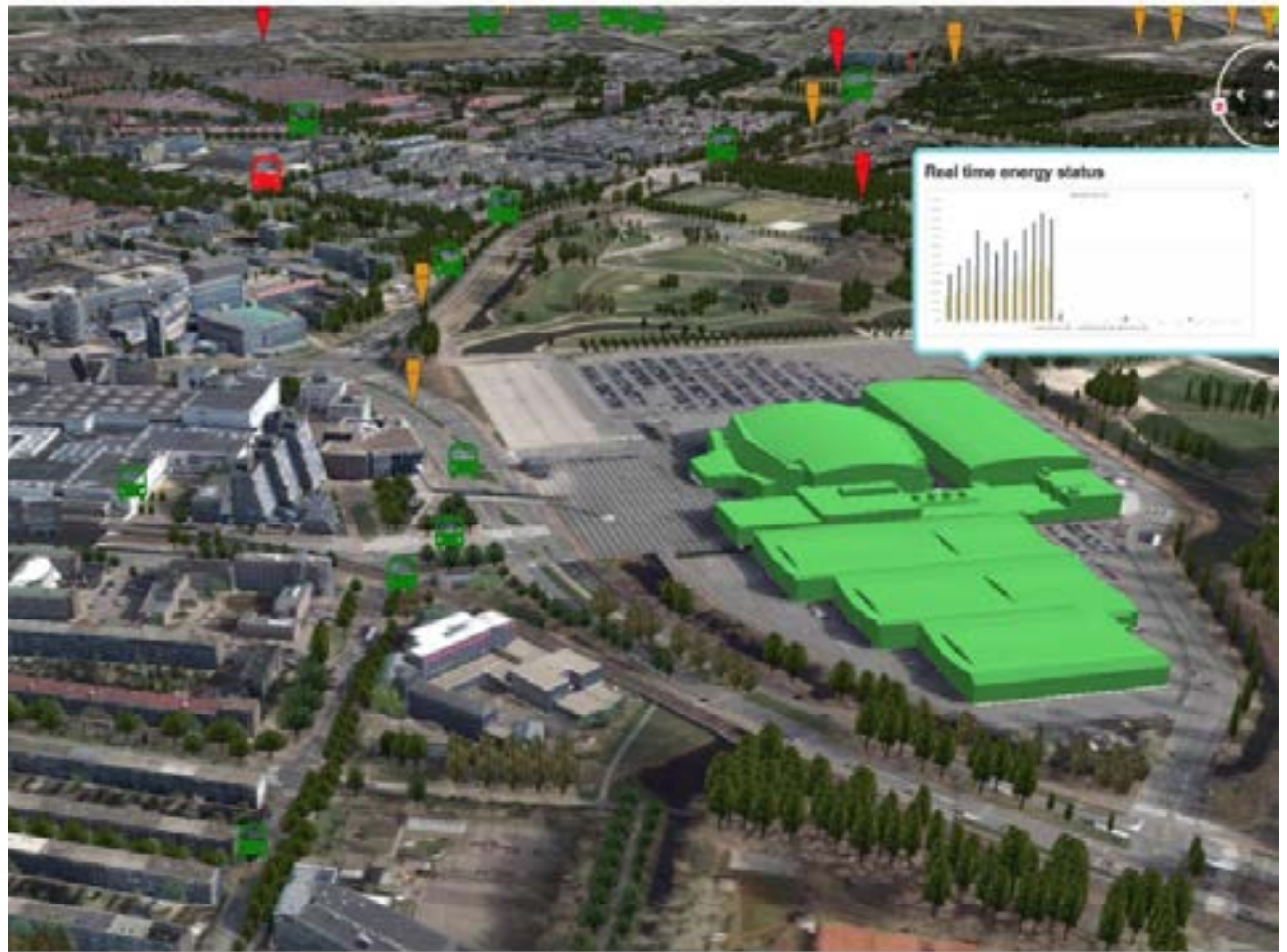
What are the costs?

Depending upon ambitions, required functionality and quality of data available, the costs for creating and using digital twins can vary immensely. For less than 25.000 Euro, a simple digital twin with a 3D viewer can be realised, set up in an organisation including the training of staff. An influential factor for the costs is the availability and quality of data. For a large city, the costs of data collection and preparation can range from 250.000 Euro to 1 Million Euro, mainly due to staff costs.

Apart from the availability and needed preparation of data, a fully-fledged digital twin can be operated for around 60.000 Euro per year.

A growth model is advocated in general. In the start phase, the solution provider will advice and support a lot, while the costs of the technology are limited. Once there is a fully-fledged digital twin, the costs for advice and support will be much lower, but the costs for technology are usually higher, for example, for links to sensors and actuators (see also below).

Requirements and barriers

What is required to start working with digital twins?

It is advocated to start small and use a growth model to evolve into a more detailed digital twin with more functionality. Step by step, the digital twin can be developed by adding more detail, better data and extend functionality. Also, this will eventually result in changes in the internal work processes, as making use of these data makes staff aware of new opportunities based on the digital twin for doing things more effectively and efficiently, or delivering better services.

How to use digital twins for co-creation in an integrated planning process?

It is crucial for a successful introduction of digital twins in co-creation and co-design processes to start with the main underlying question: which problem do you want to solve? It is usually not successful to introduce digital twins solely as a technology as experiences learned that the majority of those projects fail. A gradual development can be organised by doing a

Which technologies are necessary?

Technologies that come into play:

→ Data acquisition and processing: 3D scanning, sensor deployments, cameras, Internet of Things, Volunteered Geographic Information

→ Data analysis: Artificial Intelligence, Machine Learning, simulation engines, big data

→ Data Visualization: Urban (semantic) models (CityGML, GIS3D), Virtual Reality, Augmented Reality, others.

→ Communication: 5G, links to mobile platforms, surveys...

Figure 8 Integration of sensors providing real-time data in the Ruggedised smart city lighthouse project. Source: Future Insight

What are the data requirements?

Data is at the heart of the digital twins concept. A big amount of data coming from different sources is needed to turn a digital twin into a useful tool. Fortunately, more and more open data is becoming available. Careful consideration must be given to data acquisition, management and governance aspects such as:

★ Data ownership and privacy

★ Standardised data formats

★ Protocols and standards for interoperability

★ Data aggregation

★ Data structure, interoperability

What are the barriers?

Implementation of digital twins presents a number of challenges, some of which are common to disruptive technologies. Some of the main identified barriers are listed below:

★ The need for data

★ Data governance

★ Lack of standards

★ Challenges of multi-stakeholder cooperation

★ Lack of competent experts within city staff to prepare and operate digital twins

How to guarantee interoperability and avoid vendor lock-in?

★ (open) Standard development and adoption, adherence to de facto and industry standards.

★ Development of interfaces where needed, such as APIs

★ Multi-stakeholder cooperation.

★ Conditions in contracting and procurement by cities ensuring interoperability (for instance, requiring tenderers to propose common industry standards)

What are some use cases?

Helsinki – Kalasatama digital twin

Singapore – virtual Singapore

NTU Singapore

Limerick Digital Twin in +CityXchange project

Rotterdam 3d

Ålesund – SDGs

URBANAGE project

Open and Agile Smart Cities project DUET

Deep dive: read more about this subject

Borsboom-van Beurden. J., Kallaos, J., Gindroz, B., Costa, S., Riegler, J. (May 2019). Smart City Guidance Package. A Roadmap for Integrated Planning and Implementation of Smart City projects. NTNU/European Innovation Partnership on Smart Cities and Communities, Action Cluster Integrated Planning/Policy and Regulation. Brussels: EIP-SCC.

Borsboom-van Beurden, E. Kruizinga, J. Rodrigues de Almeida, J. Kallaos, B. Gindroz (2020). Climate-neutral and Smart City Guidance Package – A Summary. Fast-tracking financially viable projects in an integrated and inclusive way. Brussels, Smart Cities Marketplace.

Agnostelli, S., (2021). Cognitive Digital Twin for Building Management systems: a case study in Rome authors. Chapter in: F. Cinquepalmi, Towards (R)evolving Cities - Urban Fragilities and prospects in the 21st century, pp. 293-306. Florence, Didapress/University of Florence.

Join the community of the Action Clusters and Initiatives of the Smart Cities Marketplace

The community consists of a number of action clusters and initiatives with a variety of activities to help to shape the market for smart cities in Europe. They are assemblies of partners committing to work on specific issues related to smart cities, by sharing the knowledge and expertise with their peers, providing added-value with their national and local experience and identifying gaps that need to be filled at the European level. The work of each Action Cluster is collected under thematic initiatives.

An Initiative pools the work of the various partners around a particular objective, promoting learning beyond the project and geographic borders, and opening the results to the world at large. Links with EU-funded projects allow results to be consumed by the thousands of people active on the Marketplace. Each Initiative is led by an Action Cluster.

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Designed with love by Agata Smok, Th!nk E