

Local Digital Twins

Optimising data, shaping policies, transforming lives...

Abstract

This policy brief explores the potential of local digital twins for data-supported decision making in a time when cities are under pressure to deliver more sustainable policies, optimise service performance and grow local economies, all while keeping people safe, reducing budget spend and managing a wide range of socio economic challenges.

Digital twins already play an important role in industrial transformations as they help users better understand and have control over their assets.

For example, in an engineering context, by connecting engineers to the right data and processes, they can derive greater end-to-end insights and intelligence about their resources.

As a result, engineers can quickly determine the best actions needed to deliver sustainable system performance improvements.

DUET (Digital Urban European Twins), a European innovation initiative, transferred the concept of digital twins

Key Points

Local Digital Twins (LDTs) offer public administrations a cost-effective and strategic way to improve urban operations, the environment and economic outcomes through real-time decision support modelling and impact prediction.

The LDT business case is its ability to be a central repository for data across a whole city or region, providing an inherent understanding of complex systems for all stakeholder communities to use to address common goals which transcend across multiple domains.

Despite a range of benefits, important challenges in LDT adoption include issues of trust and transparency especially around data quality, therefore starting with a single use case and focusing on data and modeling standardisation is a key to successful and sustainable growth.

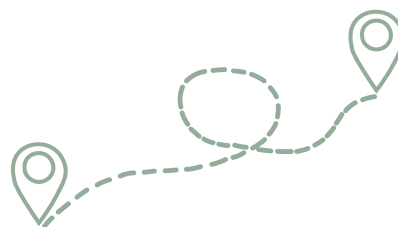
DUET LDT pilots - Athens, Pilsen, Flanders - provide a range of findings, resources, and real-life data-supported policy case studies which can help cities on their digital twin journeys no matter where their starting point may be.

from an industrial setting to the public sector domain, creating a technology called Local Digital Twins (LDT), also known as urban digital twins. Replicating a city's physical assets, processes and systems using data, analytics and machine learning, DUET created virtual replicas of the cities of Athens, Pilsen and the Region of Flanders that automatically updated and changed in real-time as the physical cities themselves changed. Through a 2D and 3D interface policy makers, city managers and stakeholders were able to simulate, model and explore the predicted impact of different policy options on their city, before making better informed decisions.

Recommendations

I. Understand that Local Digital Twins are a method and a journey, not an end goal. Cities should start from a relevant policy issue and use it to define a policy case. This will ensure that their journey is driven by real needs instead of just a focus on having perfect 3D models which have little to offer beyond eye-catching visualisations. As a city's confidence in developing and using LDTs grows, more use cases may be added to the mix to take advantage of the tool's cross-domain policy simulation capabilities.

II. Take advantage of existing city data to get started and focus on ensuring data quality. LDTs are data hungry. The insights you get are as good as the data used to feed LDTs. Having the right data will make a difference between an experimental policy case and one that can have a real-life application. With the data issue settled, think about the kind of predictive analysis you want to perform using a LDT.



III. Collaborate and break down silos to drive the LDT business case. LDTs reach their full potential not when they are used behind closed doors by a single department but when they are deployed as a collaborative tool to engage internal and external stakeholders, including citizens. To achieve that, a multi-actor governance approach is needed, one that promotes cooperation and knowledge sharing between different administrative units, and at the same time keeps the wider community informed and engaged in local policy processes.

Introduction to Local Digital Twins

What is a Digital Twin? A smart, continuously evolving digital model of a real-world system where two-way interaction allows the twin to monitor and improve a system's performance and at the same learn from the real-world counterpart to become a better representation of its properties and processes.

What is a Local Digital Twin? The Digital Twin concept applied on a city scale. Current LDT applications focus on urban areas, but as the concept evolves, there is no doubt that LDTs will include new places (rural areas) and scales (regional, national, European).

In theory, a LDT would be as close as possible to a real city, mirroring urban life in all its complexity: at the level of different systems and subsystems, above and below ground, indoors and outdoors, at time scales ranging from seconds and hours (high-frequency city) to

days, months and even years (low-frequency city). If such LDT is to emerge one day, after overcoming all the ethical, data and computational challenges, it would be not a single twin but an ensemble of cooperating, lower-level twins representing a myriad of sectors, domains and activities that make up the urban fabric.

At present, however, LDT development is more pragmatic. It is driven less by a desire to create an all-encompassing twin than a need to find optimal solutions faster, safer, cheaper, using predictive modeling and simulations.

Just as in manufacturing Digital Twins are used across the entire product lifecycle, from design to servicing, similarly in an urban context Digital Twins have a role to play in how cities are planned, built, and managed. The benefits are generally use case-specific and include:



Urban planning:

- Ability to create optimal designs that adhere to planning regulations and wider policy ambitions regarding sustainability, accessibility, livability
- More efficient and model-based, as opposed to paper-based (as remains widely the case today) process of applying and issuing building permits
- Greater acceptance by a local community through direct involvement of citizens in the design process



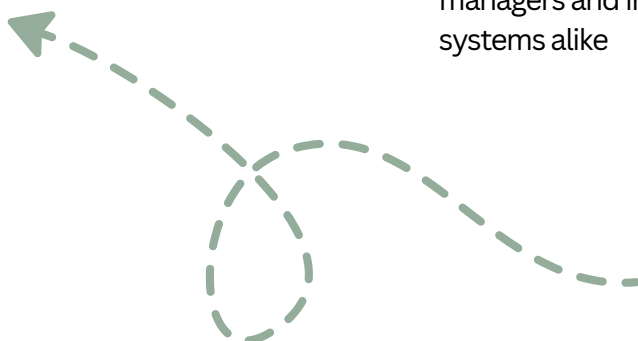
Construction:

- An integrated approach for connecting various stand-alone construction assets, objects and processes with the goal of improving safety and reducing common construction risks e.g. cost and time overruns
- Movement of workers, deliveries, transport network, performance of tower cranes and other equipment, as well as the overall construction progress, can be better monitored and synchronised to guide decision making by site managers and intelligent systems alike



City management:

- Complete, up-to-date information on the building stock (e.g. materials used, past renovations) showing which units are due for a retrofit. Running a simulation in the next step can help estimate the potential of energy efficiency improvements in reducing carbon emissions
- Heavy rain can cause sewers to overflow. Digital Twins can estimate flow predictions and propose control strategies to be implemented by human operators or automatically
- The impact of road closures can be explored more holistically by looking at how changes in traffic affect air quality and noise pollution in the area



Why Adopt Now?

In addition to the benefits listed above, acting now to start establishing a LDT will help early adopters achieve:



Cost savings: According to some estimates (ABI Research), early adopters of LDTs will be able to achieve cost savings of up to \$280 billion by 2030. These will come mainly from the 'first-time right' designs that eliminate the need for expensive modifications later on, from a more resilient infrastructure that can withstand damage from natural disasters and other shocks, and from optimised utilities that can do more with less input.

More equal partnership: Critical infrastructure assets like public roads are often owned by municipalities, but the question about who owns a twin of such roads is not clear-cut. One thing that is certain, however, is that many tech companies are fast establishing a foothold in this space in a bid to offer all kinds of data-driven services on *their* terms. With a city-led Digital Twin programme, local authorities will have more say on how these digital assets should be managed, balancing commercial interests and public value.



Connected Smart City: A city can have numerous applications in a wide range of domains (e.g. traffic models, flooding models, virtual reality games) but unless they are interconnected in some way, the value of a truly connected smart city may never be realised. Through a Digital Twin, different smart city applications and services can become part of an ecosystem that augments the value of individual solutions and deliver better insights and more exploitation opportunities across the board.



Policy Recommendations

I. Understand that Local Digital Twins are a method and a journey, not an end goal

Many believe that to benefit from Local Digital Twins, the city needs to be visually recreated in detail in 3D which will provide in-depth knowledge, understanding and control of all urban assets and their effect on city systems and processes. Yet this is a common misconception; starting with just one use case, for example managing traffic, or measuring air quality, which can be visualised and analysed equally well in 2D is a strong starting point. Starting small enables cities to experiment with the technology, learn quickly and then scale fast once a better understanding of how LDTs work and the benefits they can bring emerges.

DUET's LDT Maturity Model helps cities understand the potential journey/stages a city can go through in their LDT journey, and what kinds of questions they should be asking in order to grow and improve their LDT capabilities for better data-supported policy making.

City of Pilsen, Czech Republic

“Before DUET, we had some idea about the power and scope of LTDs’ potential use. Thanks to the project we have been able to use Digital Twins effectively for the benefit of the city. This required us changing established practices and being willing to try to do things differently than before. LDT adoption requires buy-in from key stakeholders, so we had to convince local decision makers to give their endorsement, by showcasing the technology’s benefits using real-life examples.

Building a digital twin is a gradual, step-by-step process. Cities should start with available data in one or two domains (e.g. traffic, environment, 3D data), focusing on high-quality datasets, including IoT data, and subsequently add other domains to the mix. The next step would be to move from data analysis and visualisation towards predictive models. If done correctly, LDT outputs can provide powerful data-based evidence for policy making.



It’s important to involve organisations within a city that influence key operations and decisions, such as those responsible for GIS, IT, urban planning, energy, mobility, security. Their engagement is needed to both design an effective LDT solution, and to ensure its successful exploitation afterwards. At the same time, it is necessary to look for funding and secure financial resources to be able to successfully transition from PoC to advanced prototype to an operational product.

Finally, if you embark on this journey, be patient and don’t expect immediate adoption by different city organisations. Changing the established working routines of public servants is a long process that can take years.”

II. Take advantage of existing city data to get started and focus on ensuring data quality

Once a city has decided upon its first use case, it needs to look for data to support the use case, as well as determining what type of predictive analytics (simulation models) to use, bearing in mind that analytics, whilst providing multiple benefits for data-supported decision making, can also bring some ethical risks to the table. These range from the need to manage personal data and privacy, to biases in algorithms, and even poor data quality which will not deliver meaningful results. To overcome data quality challenges cities should ensure they (a) start with existing trusted data sources and then explore how to fill the data gaps with private, crowdsourced or citizen generated data, (b) have the skills needed to ensure that data meets quality standards and (c) focus on ways to ensure the data and analytics is interoperable and transparent to help raise trust.

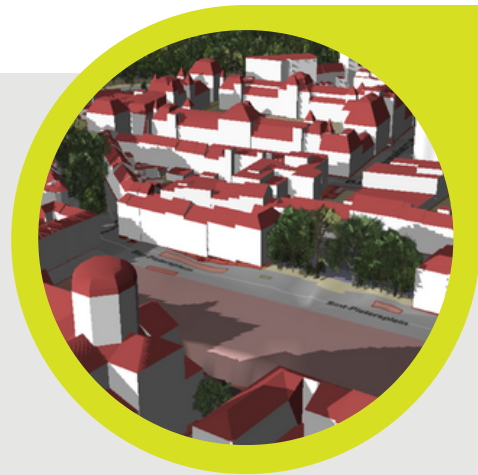
DUET's Cities Guide to Legal Compliance for Data-Driven Decision Making provides help with the process of selecting datasets and models for decision-making use, and the analysis/reporting activities related to the selection.

Region of Flanders, Belgium

“Realising a LDT for policy support requires a system of systems that brings together existing solutions that previously were not linked into one cooperating whole. For example, the same use case (or policy questions) can be pursued by different cities. Cities may want to understand how a bridge closure will affect traffic in nearby streets, what will happen to air pollution, and so on. This requires different datasets and simulation models.

In DUET, we were able to make these different components “talk to each other” via a complex system that consists of several standards-based subsystems. This standards-based interoperability ultimately facilitated communication between primary city data (e.g. street networks, buildings, elevation models), IoT sensor data, and various simulation models linked to traffic, air quality, noise.

One of the highlights of our pilot has been the integration of local and regional models, systems and datasets e.g. the use of Flanders traffic model in Ghent, the fusion of regional



air quality models (from VITO) with local 3D LOD2 data, and the merger of local and regional sensor networks for better coverage/granularity. This required extensive cooperation between different departments (e.g. data and information, mobility, environment) especially in the field of roadworks.

As regards lessons learned, we found that although there is fairly broad support for using LDT results in policy communication, evidence of their effective and consistent use in policy preparation and evaluation with citizens is still lacking. In addition, use of LDTs in the development of policy scenarios (design phase) is equally limited. Further research would help uncover the underlying reasons (is it due to political culture, quality of model predictions, data quality, or something else?) and possible solutions.”

III. Collaborate and break down silos using data to drive the LDT business case

LDTs help people explore the current state of the city in real-time and enable them to model and predict the potential outcome of changes to infrastructure or system processes. As such, over time, LDTs will become a trusted urban data collector and/or repository of city information which stakeholders from various different domains and backgrounds can use to support better informed decisions and improve urban situations. In this way the business value of an LDT will grow exponentially through collaboration between administrations, government, industry, academia and society. A governance approach including internal cooperation and management amongst administrations and a communication and dissemination strategy to the local community is a necessity for success.

DUET's Governance Model helps cities to determine requirements for cloud business models, by exploring what type of network level ecosystem a city will need to achieve its goals. Four categories of network model are explored with use cases from Orebro, Helsinki, Amsterdam, Vienna and Rotterdam.

City of Athens, Greece

“The city of Athens sees Digital Twin as a driver to speed up adoption of evidence-based policy making. This requires, among other things, leveraging available data sources, such as municipal GIS data (terrain, trees location, 3D building models etc.), public transport data, including positions of stops and moving vehicles, wider traffic data, pollution data, and noise data.

One of the challenges and main lessons learned concern the openness, accessibility, quality and format of available datasets. In Greece, local open data is only starting to gain traction. Many datasets are not aggregated, provided in non-compatible formats or simply closed (private). We tackled these issues by investing in IoT and low-cost sensor networks, and by tapping into available resources/datasets at an EU level.

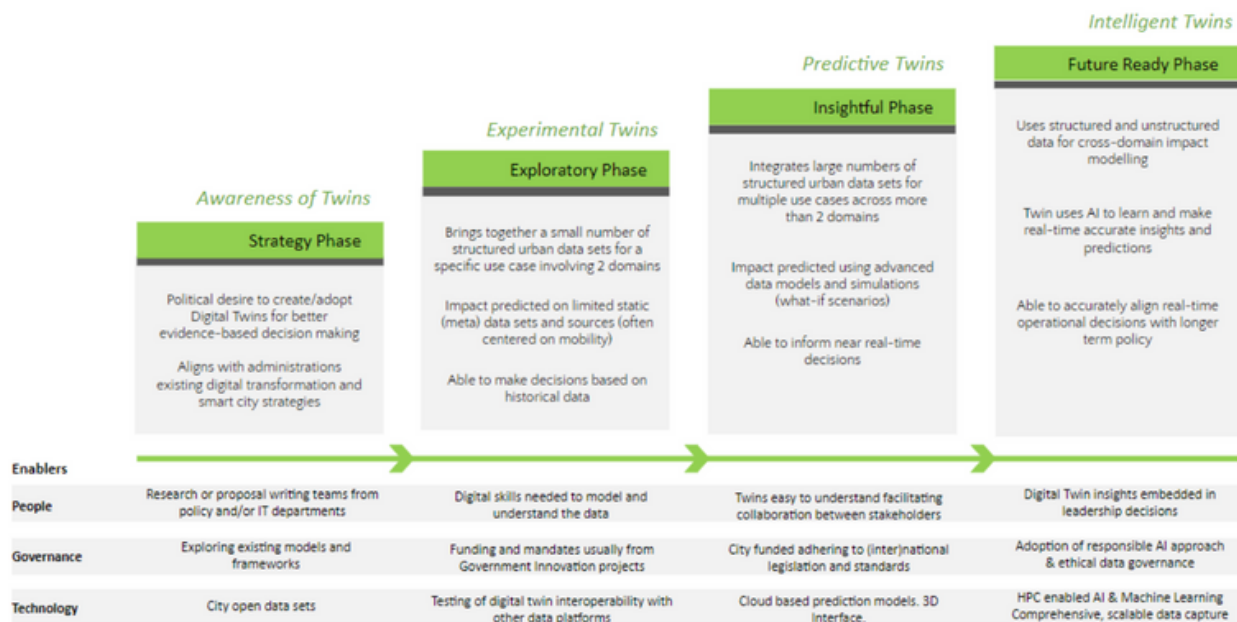
Through local testing cycles involving citizens, businesses, academia and policy makers, we gathered feedback on the Athens twin.



Many participants expressed confidence that the solution has strong potential to facilitate the visualisation of proposed policies, provide a ground for citizen participation in urban decision making, and effectively predict the impact of a proposed policy measure on multiple domains.

At present, the Athens Digital Twin correlates traffic data with data on air and noise pollution. This is then used to create scenarios for green routing and traffic monitoring within the city. In addition, it provides the feature of feedback collection from citizens/users on available what-if scenarios in the form of comments/suggestions.”

Get Started with DUET LDT Maturity Model



Phase 1: Strategy Development (Awareness): Builds on a city's existing digital transformation strategy and leverages political will to prepare the groundwork for Digital Twins. Questions to address at this stage: What is a Digital Twin? How can a Digital Twin support better evidence based decisions? Who else has implemented Digital Twins? What case studies are available?

Phase 2: Experimental Twins (Exploratory): Digital Twin capabilities are created around a defined use case involving a small number cross-domain datasets to test interoperability. Questions to address at this stage: What outcomes will be achieved through the use case? Is there willingness from relevant stakeholders to contribute domain-specific data and models? What licences and restrictions apply, if any? Does data require a lot of processing, cleaning, and formatting? What existing analytics tools would deliver the best insight?

Phase 3: Insightful Twins (Predictive): Digital Twins acquire new capabilities to predict policy impact based on advanced what-if simulations covering three or more domains. Questions to address at this stage: What kind of visuals are needed for the use case? What is the frequency of available data? What kind of prediction models are needed to meet use case requirements? What security and access controls should be put in place? Should the twin interface be 2D or 3D? How will Digital Twin outputs be integrated into existing public sector processes?

Phase 4: Intelligent Twins (Future-Ready): Digital Twins can ingest and use both structured and unstructured data for cross-domain impact modelling and prediction of future states of urban systems in near real-time. Questions to address at this stage: What city do we want to live in in the next 5 years? What ethics principles are guiding the use of AI to minimise bias? Who should hold the ultimate ownership of a Digital Twin, human operators or AI?

Conclusion

LDTs are at an early stage of development for public sector transformation, yet early adopters will reap many benefits for their foresight including cost savings, better partnerships and collaboration, and the ability to turn their cities into digital test beds for policy experimentation and data-informed decision making.

Due to the newness of the concept for the public sector, cities are advised to explore the DUET Digital Twin Maturity Model and start their digital twin journey with a solution centered around a specific use case involving stakeholders from at least two different domains. This approach will enable cities to start small but scale fast as they leverage tried and tested principles from DUET around

governance, standardisation and ethical use. Jumping straight into complex 3D modeling and platform deployment is not necessarily advantageous for delivering sustainable policy outcomes – issues around data quality, interoperability and use need to be addressed first. 2D modelling provides a sufficient foundation for exploring approaches before embarking on an ambitious digital twin solution.

To learn more about the benefits of twins, the technology used and the standards involved, sign up for receipt of the forthcoming Local Digital Twin Springer publication, edited by the DUET team. Just add your email address to the subscription box at the bottom of the DUET website (digitalurbantwins.com).



Further Information on LDTs

- DUET project website and CityTwin platform with case studies and LDT access
- Local Digital Twin Maturity Model published by the DUET project
- Governance Model for Cloud Based Digital Twins published by the DUET project
- Living-in.eu: a European way of digital transformation in cities and communities
- Gemini Principles for National Digital Twin Development published by the Centre for Digital Built Britain

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