

Urban Digital Twins: guidelines for local policymakers



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1. Introduction

In recent decades, the growing availability of data and the evolution of techniques to analyse it have led to the development of a global movement advocating for evidence-based policy making. This movement proposes using scientific evidence to determine what works and what doesn't in order to improve citizens' quality of life and translate it into effective public interventions.

Evidence-based public policies are implemented in the European Union and the public administrations of its member states, as well as in the United States, the United Kingdom, Australia, Canada, and increasingly in Latin American countries. This is not a passing trend, but the logical evolution of technology as a tool that spans all fields of knowledge.

The analysis of data in social sciences has advanced enough to generate relevant evidence for public policy making. While it is true that political debates go beyond facts only, data can nonetheless be used to support solid arguments. They are a powerful tool for defending ideas, designing public interventions, and gaining legitimacy for political decisions. Therefore, decision-makers who want to influence the public agenda and maximise impact of institutional action will have a comparative advantage if they are familiar with the use of data and scientific evidence. At the same time, the use of data and evidence to support policy decisions promotes transparency and richer public debate on policy issues.

Urban policy design involves high costs and requires long implementation processes. Currently, its effectiveness is often assessed only after years of execution, which means that resources that could have been used to address citizens' needs more effectively may end up being misallocated or even wasted. Data-driven digital technologies offer an opportunity to improve this situation by providing decision-makers with tools that allow for real-time monitoring, scenario analysis, and predictive modelling. Among these, Urban Digital Twins (UDTs) stand out as an innovative approach that integrates data from multiple sources into a geographic reality to simulate urban interventions before they are implemented. By doing so, they provide a risk-reduction mechanism, enabling policymakers to explore different courses of action and their expected impacts before committing public resources.

While the concept of Urban Digital Twins is gaining traction, their development and adoption remain at an early stage, with cities implementing vastly different approaches based on their capacities and objectives. In some cases, a UDT is no more than a basic 3D visualisation of the city, with minimal data integration. Other cities aim for a fully integrated, real-time simulation that incorporates multiple urban data flows — such as traffic, energy consumption, water management, air pollution, and district heating — into a geospatially accurate model. However, current advancements in data availability and integration capacities mean that most UDTs are still limited in scope. Many focus on specific geographic areas (a district, a street, or a block), while others prioritise specific variables (e.g., traffic congestion over air pollution, or municipal service locations over accessibility metrics). Some are restricted to specific time frames, rather than enabling continuous, real-time monitoring. In practice, most UDT use cases currently face at

least one of these limitations. Cities must determine their approach based on their institutional capacities, the role of digital twins in their governance framework, and available financial resources.

Therefore, this document does not aim to provide a step-by-step guide on how to develop a UDT use case, as this depends on context-specific factors such as local governance structures, available datasets, and institutional capacity. Instead, it offers insights and guidance to policymakers who are considering whether a UDT could be beneficial for their city. It serves as an introductory guide, particularly for those unfamiliar with digital twins, helping them determine whether the investment is worthwhile and how a UDT could change the way policies are designed and implemented in their municipality. To achieve this, the document addresses key questions such as: What is an Urban Digital Twin? What can it be used for? What should policymakers consider when deciding to develop one?

The structure of the document follows the logical progression of decision-making in this field. It first outlines the fundamental role and added value of UDTs, explaining when and why they can be useful. It then describes the UDT cycle, offering an overview of the different steps involved in their implementation. The following sections provide guidance on working with external providers and integrating UDT insights into decision-making, highlighting both opportunities and challenges. The document concludes with a commented action plan, providing a practical reference for municipalities planning to develop their own UDT use case.

This guidance is based on the expertise of the Barcelona Supercomputing Center (BSC) and Eurocities teams, as well as discussions held during the 2024 edition of the BSC-Eurocities Academy training “Urban Digital Twins: Towards Evidence-Based Decision-Making?”. The content reflects real-world experiences from city officials, researchers, and digital twin practitioners, ensuring that the recommendations provided align with the realities of urban governance.

2. A people-centred approach to Urban Digital Twins

An Urban Digital Twin (UDT) is a virtual replica of a city. Given that UDTs are recent developments, the term has been used to refer to different ways of implementing this virtual replica. In some cases, an UDT may be limited to a static, three-dimensional (3D) digital representation of a city. In other instances, it includes dynamic data sources that allow for observing the current state of urban phenomena, such as mobility or accessibility.

In our understanding, an UDT integrates various data sources to simulate and visualize urban policy scenarios. It allows for generating different possible urban intervention scenarios and understanding the impact of each one on other areas of the city. For example, it can be used to observe the current state of bike lanes in the city and evaluate the impact of adding a new bike lane in a particular section on other modes of mobility, access to public services, and air quality. In any case, this is bounded by the 2D or 3D construction of the digital twin, but rather by the static or dynamic nature of the data that is fed to the model.

In its technological dimension, an UDT:

- **Integrates** data from different sources such as sensors, social media, or directly from structured databases.
- **Simulates** the components and subsystems of a city (mobility, sustainability) based on these data sources.
- **Visualizes** different possible scenarios and their impact on other components of the city through an interface designed to facilitate the understanding of complex systems.

However, UDTs are not just technological tools — they are ultimately designed to improve urban governance and quality of life. This means they must be developed with a socio-technical approach (*Nochta et al., 2021*), ensuring that their design and implementation respond to real urban challenges and engage the people who will use them.

A key element of this socio-technical approach is that it puts people in the center and technology as a tool to serve a specific social goal. In the case of an UDT, the guiding principle should be improving urban governance and, ultimately, the quality of life of citizens. So, the development of an UDT should not be limited to delivering a ready-made platform to city officials. Instead, it should involve continuous collaboration with decision-makers throughout the entire process — from conceptualisation to deployment and capacity-building. vCity, a project developed by the Barcelona Supercomputing Center (BSC), follows this principle by incorporating city stakeholders at every stage of the UDT's development. This engagement ensures that the digital twin is aligned with local governance needs and can be effectively integrated into policymaking.

Another relevant point to consider when developing tech with this perspective is that an UDT should be adaptable to the needs of its users. A digital twin that does not reflect the specific governance, operational, and data constraints of a city risks being underutilised. For this reason, its development should include participatory processes, where local officials, planners, and even citizens contribute to shaping its functions. vCity, for instance, has been designed as a tool to support democratic decision-making in urban policy, leveraging data modelling, simulation, and visualisation to enhance participatory governance.

Finally, digital twins must be embedded in broader digital policies. A UDT is not just a one-time project —it should be part of a city's long-term strategy for data governance and digital transformation. By ensuring that UDTs are built in collaboration with policymakers, used as decision-support tools, and integrated into existing governance frameworks, cities can fully harness their potential to drive more transparent, participatory, and effective urban policies.

Overall, it is relevant to embed the development of an UDT into a broader policy for ethical tech in city governments. Governments collect and store vast amounts of data, including personal information. In this context, data collection, storage and processing must be done in compliance with privacy regulation (with GDPR as the main framework in the EU), in a way that respects individual privacy and minimises the risk of data misuse. These include ensuring data privacy and consent, while maintaining transparency in data collection processes, among many other measures.

At the same time, policymakers working on the development of UDTs need to beware of the fact that digital twins are based on algorithms and models (which in turn are fed data). Therefore, equity, inclusion and safety criteria must apply to these AI applications: data biases must be mitigated to prevent unfair outcomes (e.g. inaccurate representation of lower income neighbourhoods), and there must be clear accountability for decision-making based on UDT insights – just as for any other AI-powered governmental action.

3. The UDT cycle

The Urban Digital Twin (UDT) cycle provides a structured process for cities considering the development of a digital twin use case. This general framework helps policymakers understand the steps involved—from identifying the need for a digital twin to integrating its insights into decision-making. However, cities should tailor this cycle to their specific context, taking into account local governance structures, available data, and technical capacities.

Step	Description	Actors Involved
Identifying the Policy Challenge	The process begins with defining the urban problem that a digital twin can help address. This involves assessing existing challenges, such as traffic congestion, air pollution, or inefficient infrastructure use, and determining whether a UDT can provide valuable insights.	<p>Inside Municipality: Policy departments (e.g., Transport, Environment, Housing), Digital/IT agency, City leadership.</p> <p>Outside Municipality: Research institutions, private sector experts, citizen groups.</p>
Defining Objectives and Expected Outcomes	Once the challenge is identified, the city sets clear goals for the digital twin, such as reducing congestion by a specific percentage or improving public space planning efficiency. Expected outputs, such as predictive models and scenario analyses, are also defined.	<p>Inside Municipality: Policy departments, IT agency, Urban planning office.</p>
Stakeholder Engagement and Governance Setup	Cities must identify key stakeholders, both internal and external, and establish governance mechanisms for collaboration. This includes defining roles and responsibilities between policy departments, IT agencies, and external providers, in order to determine who will be involved in developing and using an UDT, and how it will be inserted into the decision-making process.	<p>Inside Municipality: Deputy mayors, City council, Policy departments, IT/data office.</p> <p>Outside Municipality: Universities, private sector partners, NGOs, citizen representatives.</p>

<p>Assessing Data Needs and Infrastructure</p>	<p>A city must evaluate what data is required, whether it is already available, and what additional data collection infrastructure may be needed. This also includes ensuring interoperability with existing municipal systems, as well as developing data-sharing agreements with other institutions, and ensuring a safe data storing strategy.</p>	<p>Inside Municipality: Data management teams, IT/data department, Policy departments.</p> <p>Outside Municipality: Regional/national data owners, private data providers.</p>
<p>Procuring the UDT Solution</p>	<p>The municipality determines whether to develop the digital twin in-house or procure it externally. Procurement must follow public procurement rules, ensuring transparency, open competition, and interoperability, and must not compromise future capabilities.</p>	<p>Inside Municipality: Procurement office, IT department, Legal office, City leadership.</p> <p>Outside Municipality: Technology providers, consultants, open-source communities.</p>
<p>Developing and Implementing the Use Case</p>	<p>The city, together with its partners, builds and deploys the digital twin. This includes integrating data, setting up simulation models, and ensuring usability for decision-makers. A phased or pilot-based approach is often recommended.</p>	<p>Inside Municipality: IT department, Policy teams, Smart city office.</p> <p>Outside Municipality: Technology firms, research institutions, civic tech groups.</p>
<p>Embedding UDT Insights into Decision-Making</p>	<p>Insights generated by the digital twin must be translated into actionable policy recommendations. This requires ensuring that policymakers have the capacity to interpret and apply the data, and a commitment to evidence-based decision-making.</p>	<p>Inside Municipality: Policy departments, Decision-makers, City leadership.</p> <p>Outside Municipality: Research institutions, citizen advisory groups, media.</p>
<p>Monitoring, Evaluation, and Scaling</p>	<p>The city tracks the impact of the digital twin on policymaking and service delivery. Lessons learned inform future use cases and potential expansions of the digital twin's capabilities.</p>	<p>Inside Municipality: Evaluation teams, Policy analysts, Digital twin coordinators.</p>

4. Why is an UDT useful?

Urban policymaking is increasingly complex, requiring decisions that balance competing policy and political interests, anticipate long-term impacts, and integrate diverse information sources. Traditional data modelling approaches often fail to capture the dynamic nature of cities, limiting their ability to support proactive, evidence-based policy. Urban Digital Twins (UDTs) provide an advanced alternative by combining real-time data, simulation, and interactive visualisation to support decision-making.

The role of UDTs in policy and decision-making

UDTs enable policymakers to transition from static data analysis to dynamic, scenario-based urban planning. Static analysis relies on historical data and fixed assumptions, providing a snapshot of past or present conditions without accounting for real-time changes. In contrast, dynamic analysis incorporates live data streams and predictive modelling, allowing cities to simulate different policy scenarios and anticipate future developments before implementing decisions.

Unlike conventional data models, which provide insights for a given place and time, UDTs offer a holistic and interconnected view of urban systems. Their primary contributions to policy and governance include (*Hämäläinen, 2021*):

- **Data-driven decision-making:** UDTs integrate various urban data sources—such as mobility patterns, environmental conditions, and infrastructure performance—to provide a comprehensive evidence base for decision-making. This allows city leaders to make informed choices rather than relying on assumptions.
- **Experiential learning and simulation:** By modelling different policy scenarios, UDTs allow decision-makers to understand the consequences of interventions before implementing them.
- **Public service improvement:** UDTs enhance service delivery by optimising urban infrastructure and resource allocation.
- **Co-creation and collaboration:** UDTs foster collaboration between different city departments, private sector stakeholders, and citizens by providing a shared platform for data and analysis.

To achieve their role in policymaking, UDTs perform three 'core' functions that relate to key aspects of city government (*Hämäläinen, 2021*):

1. **Data integration:** UDTs consolidate real-time and historical data from multiple sources, ensuring that policymakers have access to the most accurate and up-to-date information.
2. **Dynamic monitoring:** Unlike traditional models that provide static snapshots, UDTs offer continuous monitoring of city systems. This allows for real-time adjustments in areas such as traffic management, environmental monitoring, and emergency response.

- 3. Enhanced transparency and accountability:** By making urban data more accessible and understandable, UDTs help governments communicate their decisions more effectively, increasing trust in public administration.

Compared to traditional urban modelling approaches, UDTs offer significant advantages by integrating real-time data and establishing continuous feedback loops. While classic models often rely on historical datasets and static projections, UDTs allow cities to respond to emerging trends as they unfold. This real-time responsiveness can enhance urban management, particularly in dynamic environments where traffic conditions, environmental hazards, and population movements change rapidly.

Another key distinction lies in the interactive and adaptive nature of UDT visualisations. Rather than static maps or reports, UDTs provide an interactive interface where decision-makers can explore different urban scenarios and understand the interdependencies between various policy choices. This interactivity enables policymakers to anticipate unintended consequences and adjust their strategies accordingly.

Furthermore, UDTs enhance contextual awareness by linking multiple datasets to physical spaces, allowing for a more comprehensive understanding of urban dynamics. By integrating infrastructure data, environmental indicators, and social factors into a single analytical framework, UDTs facilitate more balanced and evidence-based policymaking. This is particularly relevant when cities must navigate trade-offs between sustainability goals, economic growth, and social equity.

In-focus. Why cities see value in Urban Digital Twins

When asked why their city needs a digital twin and how it can improve current decision-making systems, representatives from 12 municipalities that took part in the 2024 edition of the BSC-Eurocities Academy training, highlighted the following key benefits:

- Linking data to the physical geographies of the city
- Ensuring interconnection between different datasets and maintaining data quality
- Strengthening communication and persuasion, both internally (with decision-makers) and externally (with citizens)
- Providing a transversal approach to city analysis, offering a holistic view
- Enhancing transparency in decision-making and ensuring consistency over time
- Enabling live monitoring of city conditions, allowing for quicker reactions
- Promoting internal cooperation across city departments
- Supporting scalability and evaluation of future policy and project options
- Balancing ambitions with available capabilities
- Improving policy visualisation for better understanding and engagement

When to consider a UDT?

A UDT is most useful when:

- A policy decision involves multiple interdependent factors and requires a holistic analysis.
- There is a need to visualise and communicate the impact of urban interventions to non-experts (e.g., political leaders, residents).
- The city aims to improve data integration and real-time monitoring capabilities.
- Decision-making requires the ability to test different scenarios before committing public resources.

However, UDTs are not a universal solution: they are costly, and implementable in the mid- and long-term. Their value depends on the quality of available data, the city's digital infrastructure, and the specific challenges at hand. Furthermore, an UDT requires a careful process of data collection, data curation and integration of different sources and formats. Needless to say, the simulation models require to be built and tested according to specific considerations depending on the context.

Cities should carefully assess whether a UDT aligns with their policy needs before investing in its development, considering that, most likely, they will need to choose between the following enhanced features: geographical scope, number of variables, and data timeframe (or even live data).

The value of UDTs for community engagement

UDTs can play a crucial role in fostering community engagement by making urban planning more transparent, inclusive, and participatory. In many cities, public involvement in decision-making is hindered by the complexity of urban data and the lack of accessible tools to interpret it. In short, municipalities often lack tools to involve communities in complex decision-making, in particular when it comes to presenting the implications of the different policy alternatives. UDTs can bridge this gap by transforming raw data into intuitive visualisations, allowing residents to better understand proposed urban interventions and their potential impacts.

In Herrenberg, Germany, a digital twin was developed with a strong emphasis on citizen participation (*Dembski et al., 2020*). Through a virtual reality interface, residents were able to explore different planning scenarios and provide feedback on proposed developments. This not only empowered citizens by giving them a tangible way to engage with urban policy but also improved the quality of decision-making by incorporating local knowledge and preferences.

Beyond structured engagement processes, UDTs can also be integrated into interactive workshops and participatory design sessions. Cities use digital twins to allow citizens to test different urban planning scenarios in real time, helping them to visualise trade-offs and co-create solutions. This not only enhances democratic participation but also strengthens the legitimacy of policy decisions by ensuring they reflect diverse community perspectives.

In this context, UDTs serve as a powerful tool for consensus-building. In Helsinki, the digital twin was used to bring together transport planners, environmental experts, and business representatives to align their perspectives on key urban projects (Tartia and Hämäläinen, 2024). By providing a shared, data-driven foundation for discussions, the UDT helped resolve conflicts and foster more collaborative policymaking.

By transforming complex urban data into an accessible and interactive format, UDTs enable more inclusive decision-making, promote trust in public administration, and ensure that policies are shaped by a broad spectrum of voices. In doing so, they provide city leaders with a unique tool to bridge the gap between technical expertise and community needs, ultimately leading to more resilient and citizen-centric urban policies.

In-focus. The value of UDTs for decision-making and community engagement

Urban Digital Twins (UDTs) are not only powerful tools for, but also valuable instruments for improving public understanding and participation in urban planning. Below are perspectives from two case studies that highlight the impact of UDTs on decision-making and citizen engagement.

Enhancing Decision-Making – Helsinki, Finland (Hämäläinen, 2021)

In Helsinki, UDTs have been recognised as a means to improve urban governance by providing clearer, more interactive decision-support tools. A city official noted, *"If you make an analysis, you are able to visualise and illustrate things and build up certain services so that one can understand big and small issues and their relations and connections."* This ability to connect data with spatial realities has been particularly useful for urban planning committees, where members may not have technical expertise. As one planner explained, *"The large-scale urban development case X contains multiple decision-making points. For the members of the local urban planning committee, who are mostly laypeople, this is a highly visual presentation of the subject matter on which they should make a decision during the meeting. [For them it is easier] to evaluate whether we should vote for this city plan/scenario or another. And if it is possible to enter financial information, timetables and environmental implications [into the 3D city model], then that is better."*

Beyond simplifying decision-making, UDTs also improve scenario analysis. Officials emphasised that *"With visual analysis, we are able to illustrate how [different alternatives and scenarios] influence real views, wind, microclimate, services, traffic, etc. We are able to depict the case in more detail and avoid emotional assessments."* This

capacity for more objective, data-informed discussions has made UDTs an integral part of urban policy development in Helsinki.

Strengthening Citizen Engagement – Herrenberg, Germany (Dembski et al., 2020)

In Herrenberg, Germany, UDTs have been instrumental in making urban planning more accessible to residents. Citizens who engaged with the city's digital twin reported that it allowed them to see urban issues from multiple perspectives, stating that *"situations/circumstances can be presented in many perspectives."* The ability to visualise potential changes also helped citizens grasp the real-world impact of planning decisions, with participants noting that they gained a *"better imagination of consequences/implications"* and that *"complex planning processes can become more concrete."*

By presenting urban transformations in an intuitive, visual format, the UDT enabled citizens to better engage with and understand policy discussions. One resident commented, *"One can better imagine the spatial impact,"* while another highlighted that the simplicity of digital twin presentations made urban plans more understandable for everyone: *"Simple presentation, everyone can imagine the plans better."*

These cases demonstrate that UDTs not only enhance technical decision-making but also serve as a bridge between city governments and residents, fostering greater transparency and inclusivity in urban planning.

5. Working with external providers

The development of a digital twin use case requires internal governance arrangements to ensure coordination (for instance, for data-sharing among different departments) and political leadership. This is context-specific and is not addressed in this document. However, it will also most likely require working with external providers, as cities most often lack the internal capacities (infrastructure, skills) to develop the digital twin on their own.

Indeed, procuring an UDT requires a strategic approach that aligns technological requirements with municipal governance structures and public procurement regulations. City officials must navigate complexities such as selecting the right technology stack, defining procurement strategies, and ensuring interoperability. This section provides guidance on working with external providers to acquire the necessary components for a UDT while maintaining transparency, efficiency, and, ideally, long-term sustainability – while prioritising public sector capabilities and protecting the public interest.

Before engaging with external providers, cities must define what they need to procure. UDTs require a combination of hardware, software, and data sources, which can be broadly categorised as follows:

- **Hardware:** Sensors for data collection, communication networks for data transmission, and storage solutions for managing city data. Leveraging existing infrastructure can reduce costs and enhance interoperability.
- **Software:** Data processing tools, analytical engines, and visualization platforms that enable simulation and decision-making. Prioritizing open-standard solutions helps avoid vendor lock-in.
- **Data:** Utilizing internally generated data and establishing data-sharing agreements with other public institutions is preferable to purchasing third-party datasets, ensuring cost efficiency and compliance with public sector data governance frameworks.

A fourth category, knowledge, can be identified, as developing the capacities to govern and utilize the digital twin is crucial. This includes training personnel, establishing governance frameworks, and creating operational procedures. These capabilities may not be provided by the same vendors supplying technological components and may require partnerships with educational institutions or specialized consultants.

Municipalities as buyers

Municipal budgets are typically organized by sectors, as data, hardware, knowledge and leadership usually come from different vertical departments and hierarchical levels. This can complicate IT-related procurement. Determining where the digital twin budget should be allocated requires coordination across city departments to prevent fragmented efforts and ensure that all stakeholders' needs are considered.

Municipalities must also adhere to public procurement principles enshrined in EU legislation, including:

- **Transparency:** Ensuring that procurement processes are open and clear to all stakeholders. This involves publicizing procurement opportunities and decisions to foster trust and accountability.
- **Equal treatment:** Providing all potential suppliers with the same information and opportunities, ensuring no discrimination. This principle mandates impartiality throughout the procurement process.
- **Open competition:** Encouraging a competitive market by allowing all qualified suppliers to participate, which helps achieve value for money.
- **Sound procedural management:** Conducting procurement activities in a systematic and efficient manner, following established procedures to ensure fairness and integrity.

The primary EU directives governing these principles are Directive 2014/24/EU on public procurement and Directive 2014/25/EU on procurement by entities operating in the water, energy, transport, and postal services sectors.

Procuring UDT components: key considerations

When procuring UDT components, cities may adopt an incremental approach rather than attempting to deploy a fully integrated system from the outset – which means delimiting the use case in data timeframe, geographical scope, or number of variables (urban dimensions) considered. Each use case for a digital twin will have different computational requirements and expected returns on investment. A phased implementation strategy guided by a master plan (see Annex. Action Plan template) allows cities to scale the project effectively while minimizing risks.

In terms of data collection, cities should prioritize the use of existing datasets and deployed sensors to avoid unnecessary investments. If new sensors are required, they should be interoperable with current systems and, where possible, installed on existing city-owned infrastructure with available connectivity.

For data processing and visualization, municipalities must decide between cloud-based and on-premise solutions. Cloud-based solutions offer scalability and flexibility, while on-premise solutions provide greater control over data security and compliance. Whichever approach is chosen, it is essential to integrate new systems with existing municipal IT infrastructure to maximize efficiency and avoid duplication of resources.

To prevent vendor lock-in and ensure sustainability, cities should procure UDT solutions that adhere to open standards. Open standards are publicly available specifications that ensure systems can communicate and operate with each other, regardless of the vendor. In practice, this means selecting software and hardware that comply with established protocols and data formats, facilitating interoperability and future scalability.

Additionally, reusing as much existing data as possible is crucial. Leveraging current datasets not only reduces costs but also ensures continuity and consistency in data analysis. Establishing data governance policies that promote data sharing and reuse across departments can enhance the effectiveness of the UDT.

Knowing what not to procure or outsource is as important as identifying what to acquire. This discernment ensures the efficient use of public resources and investment in public capabilities. Municipalities should avoid:

- **Procuring their own data:** Data generated internally or by city contractors should be considered a municipal asset, not something to be purchased from third parties.
- **Buying data from other public administrations:** Instead of purchasing datasets from regional or national government bodies, cities should establish formal data-sharing agreements to facilitate collaboration.

- **Relying on third-party data where unnecessary:** While some external datasets may be useful, cities should aim to develop their own data ecosystems to maintain control and ensure long-term sustainability.

By carefully considering what not to procure, municipalities can focus resources on building internal capacities and infrastructure, leading to greater self-reliance and more sustainable urban digital twin initiatives.

6. Integrating UDT insights into decision-making

The use of Urban Digital Twins (UDTs) does not end with their implementation; rather, the challenge lies in effectively integrating their insights into policymaking. While UDTs can generate valuable data and simulations to support urban planning, the reality of decision-making is often more complex. This section provides a reality check on what policymakers can expect from UDTs, exploring the nature of evidence-based policymaking, the context in which decisions are made, the barriers to using UDT-generated evidence, and the strategies to overcome them.

Evidence-Based Policymaking: The Ideal vs. Reality

In principle, evidence-based policymaking (EBPM) is about ensuring that decisions are informed by the best available data rather than ideology, political expediency, or short-term pressures. However, in practice, policymakers often operate under conditions of time pressure, competing priorities, and institutional constraints. Rather than systematically analysing all available evidence, they frequently rely on quick assessments to generate policy options.

Policymakers typically use two shortcuts to make decisions in complex environments (*Cairney, Oliver and Wellstead, 2016*). The first is rational, in which they pursue clearly defined goals and prioritise certain types of information that align with their objectives. The second is irrational, where decisions are shaped by emotions, ingrained beliefs, habits, and familiar reference points rather than systematic evidence. This blend of rational analysis and instinctive judgement means that even when high-quality data from a UDT is available, it may not be the primary factor driving a policy choice.

Ideally, EBPM means that decisions are based on a rigorous assessment of the best available data. However, in many cases, policymaking follows a policy-based evidence approach, where decisions are made first, and then data is selectively used to justify them. As one Cairney (2017) puts it, *"biased politicians decide first what they want to do, then cherry pick any evidence that backs up their case"*.

The Context of Policymaking: A Complex and Unpredictable Environment (*Cairney, 2017*)

Policymaking does not take place in a vacuum. It is shaped by political, social, and economic factors that influence how evidence is interpreted and used. One defining feature of policymaking

is its unpredictability — priorities shift rapidly due to political cycles, public opinion, and emerging crises. Attention spans within government structures are often short, leading to fragmented decision-making where issues gain and lose prominence quickly.

Another challenge is that policy is made within networks of actors, including politicians, bureaucrats, private sector representatives, and advocacy groups. These actors have different interests and levels of influence, making it difficult to integrate new forms of evidence, such as UDT insights, into well-established decision-making frameworks.

Moreover, the rules of the game take time to learn—successful evidence integration requires an understanding of the formal and informal mechanisms that shape how decisions are made. For example, technical data from a UDT may be compelling, but unless it is aligned with political priorities or presented in a way that resonates with decision-makers, it risks being ignored.

Barriers to Evidence-Based Policymaking (Oliver et al., 2014)

Despite the potential of Urban Digital Twins (UDTs) to provide robust, data-driven insights, multiple barriers hinder their effective integration into policy processes. These barriers stem not only from technical limitations but also from the broader political, institutional, and cultural contexts in which policymaking takes place.

Cultural barriers

One of the main challenges in integrating UDT insights into policy lies in the cultural divide between policymakers and researchers. These two groups operate within distinct professional environments, each with its own priorities, incentives, and expectations. As a result, fundamental differences in how evidence is produced, communicated, and used can hinder the adoption of data-driven policymaking.

A major obstacle is language and jargon. Researchers use technical terminology and highly specialised vocabulary to ensure precision and rigour in their work. For them, complexity is a necessary feature of scientific discourse. In contrast, policymakers require clear, concise, and actionable insights that can be easily communicated to non-experts, including political leaders and the general public. Scientific language that is too complex or nuanced can be perceived as inaccessible or impractical for decision-making.

Another issue is the low incentive for engagement between these two groups. Researchers are primarily rewarded for academic outputs, such as peer-reviewed publications and citations, rather than for translating their findings into policy impact. Engagement with policymakers is often seen as secondary or even as a distraction from scientific work. Conversely, policymakers operate under intense time constraints and competing priorities, making it difficult for them to dedicate time to engaging with new research. Without structured incentives or institutional support, meaningful collaboration between the two remains limited.

Differences also emerge in the perception of what constitutes valid and useful knowledge. Researchers emphasise methodological rigour, empirical validation, and the progressive accumulation of knowledge through systematic inquiry. In contrast, policymakers often require immediate, practical insights that fit within existing governance structures. While researchers prioritise long-term, evidence-based conclusions, policymakers are often forced to make decisions in response to short-term political, economic, or social pressures, leading to a reliance on easily digestible, high-level summaries rather than comprehensive studies.

One of the starkest contrasts is the way each group handles uncertainty. Researchers see uncertainty as an inherent part of the scientific process. They continuously test and refine theories, challenge assumptions, and acknowledge limitations in their findings to ensure robustness. However, policymakers operate in an environment where political and public expectations demand a sense of certainty. They need to present policies as clear, justified, and implementable, often reconciling new data with pre-existing narratives. While researchers are comfortable with ambiguity and ongoing debate, policymakers tend to seek definitive answers to justify decisions and maintain public trust.

Finally, there is a perception gap in how decisions are made. Many researchers believe that policymakers rely too heavily on personal experience, ad hoc expert advice, and informal networks rather than on systematic scientific evidence. Policymakers, on the other hand, see these informal mechanisms as essential, given the constraints they face. They often work under high-pressure conditions, requiring rapid decision-making based on available knowledge, intuition, and trusted advisors rather than waiting for comprehensive academic studies. This fundamental difference in approach can lead to frustration on both sides: researchers may see policymakers as disregarding rigorous evidence, while policymakers may view researchers as disconnected from the practical realities of governance.

Competing Pressures

Even when policymakers recognise the value of evidence, they must navigate competing pressures that often take precedence over data-driven insights (Cairney, 2017). Political considerations, including electoral cycles and party ideologies, frequently shape policy decisions more than scientific evidence.

Financial constraints are another major barrier. Evidence-based policy options may be sidelined if they require significant investment or do not align with existing budgetary priorities. The media also plays a role, as policymakers may prioritise policies that are politically advantageous or align with dominant media narratives rather than those backed by robust evidence.

Additionally, vested interests and lobbying efforts can strongly influence policy choices, sometimes overshadowing objective, evidence-based recommendations. Powerful stakeholders – such as industry groups or advocacy organisations – may push for specific policies that align with their agendas, even if they contradict data-driven insights.

Finally, unclear decision-making practices and institutional inertia can limit the uptake of new forms of evidence. Many policy decisions are made through informal networks and bureaucratic procedures that are difficult to navigate for those outside the system. Without clear mechanisms for integrating scientific insights into policy, even the most advanced tools, such as UDTs, may struggle to influence decision-making.

Overcoming Barriers: Strategies for Effective Evidence Integration

Despite these challenges, there are concrete strategies that policymakers can use to enhance the impact of UDT insights on decision-making. The following strategies were identified by participants in the 2024 cohort of the BSC-Eurocities Academy training on Urban Digital Twins:

- 1. Building a narrative around facts:** Data alone is not enough to convince decision-makers. UDT insights must be framed within compelling narratives that align with political priorities and resonate with policymakers' concerns.
- 2. Using engaging storytelling:** While data-driven arguments are important, policymakers are often influenced by stories, case studies, and real-world examples. Presenting UDT findings in ways that highlight human impacts can make them more persuasive.
- 3. Demonstrating cost-benefit advantages:** Policymakers are more likely to adopt evidence-based recommendations if they can see clear economic justifications. UDTs can help quantify the financial implications of different policy choices, making them more attractive for decision-making.
- 4. Clarifying needs and impact:** Clearly defining what the UDT insights are intended to address and how they relate to policy goals can help bridge the gap between data and action.
- 5. Highlighting reversibility to reduce risk:** Policymakers are often hesitant to adopt new approaches due to fear of unintended consequences. Demonstrating that UDT-based interventions can be adjusted or reversed can lower resistance to change.
- 6. Ensuring transparency about data and analysis:** Policymakers are more likely to trust UDT insights if the data sources, methodologies, and assumptions are made clear and accessible. Open communication about uncertainties and limitations can increase credibility.
- 7. Aligning with political timelines:** Policymaking operates on specific electoral and legislative cycles. Ensuring that UDT-generated evidence is available at the right moments—such as during budget negotiations or strategic planning sessions—can enhance its impact.

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Annex. Action Plan template

The Action Plan is a key learning component within the UDT training programme. It is designed to help participants apply the programme's learnings directly to their city's context, ensuring that the theoretical knowledge acquired is translated into practical strategies. This document will be developed gradually throughout the programme, allowing participants to continuously refine and expand their plans as they gain new insights and get feedback from trainers and peers. By the end of the programme, the Action Plan will provide a framework that cities can build upon for future UDT use cases.

In this context, the Action Plan is intended to be an informal, working document. It does not require formal approval by the city government before the end of the programme. Instead, it serves an exercise in strategic planning, providing a foundation for cities to develop more formalised plans post-training.

The structure of the Action Plan is designed to be completed in stages, aligning with different moments of the training programme. For instance, project objectives should be drafted before the in-person training, while other sections will be filled in as the programme progresses. This iterative process ensures that the Action Plan evolves in response to ongoing learning and collaboration. The document includes key sections such as the city's vision for digital twins, detailed project objectives, stakeholder analysis, diagnosis of potential bottlenecks, strategic actions, and a roadmap for implementation.

This is a proposed structure for each city's Action Plan. However, it can be adapted by participants so that it best fits its needs. The template includes a fictional example (in *Italics*) to illustrate each section.

City: Eurocity

Challenge: Reduction of traffic congestion and pollution in Downtown District

1. Executive summary

- a. Overview.** *Briefly describe the purpose and scope of the Action Plan, including the urban challenge it wishes to address.*

The Action Plans aims to address traffic congestion and pollution in Eurocity's Downtown District using a digital twin. This involves creating a real-time model to simulate traffic patterns and pollution levels. The model will help city planners and decision-makers in the city council, through its Transport Department and Environmental Agency understand and manage urban mobility and environmental impact more effectively.

- b. Objectives.** *State the main goals the city aims to achieve with this Action Plan.*

The primary goals are to reduce car use by 20% and decrease emissions of NO₂ and PM_{2.5} by 25% in the Downtown District over the next three years. These targets will contribute to a cleaner, healthier and more sustainable urban environment in Eurocity.

- c. Key stakeholders.** *Identify the main stakeholders involved in the project, including internal department and external partners, as well as their role in it.*

- City departments and agencies:
 - o Transportation Department: Oversees the development and implementation of traffic management strategies. Will be one of the primary users of the digital twin, and will also integrate mobility data to it.
 - o Environmental Agency: monitors pollution levels and integrates data into the digital twin.
 - o Digital Agency: coordinates digital initiatives, ensures data interoperability, and will be in charge of the development of the digital twin, by procuring it to TechSolutions
 - o City leadership: the deputy mayors for Mobility and Environment will be making the final decisions on traffic restrictions, designed based on the insights produced by the digital twin.

- External stakeholders:
 - o TechSolutions: technology provider responsible for developing the digital twin infrastructure and applications, under the leadership and in coordination with the Digital Agency.
 - o Regional government: owns part of the air quality data, as it is the owner of the air quality monitoring stations and mobile sensors in the city.
 - o Eurocity University: provides research support and expertise in data analysis and modelling to the city government.
 - o Downtown District's residents and local businesses: beneficiaries of improved traffic conditions and air quality.

2. City information

Provide basic information about the city:

- **Number of inhabitants:** 1.2 million
- **Size of the municipal budget:** €2.5 billion annually
- **Main city challenges:** Eurocity faces significant challenges related to traffic congestion and air pollution, particularly in the Downtown District. The high volume of vehicles not only causes severe traffic delays but also contributes to elevated levels of nitrogen dioxide (NO₂) and particulate matter (PM2.5), which pose health risks to residents.
- **Overall role of digital twin in the city's strategy:** The digital twin is an integral part of Eurocity's strategy to enhance urban sustainability and quality of life. By providing real-time data and predictive analytics, the digital twin will enable city officials to optimize traffic management and implement effective pollution control measures. This initiative aligns with the city's broader goals of reducing carbon emissions, improving public health, and promoting sustainable urban mobility.

3. A vision for the digital twin

Articulate your city's vision for the digital twin as a tool for evidence-based policy-making. What are the main challenges and opportunities you aim to address the digital twin? How do you envision the digital twin supporting your city government's policy goals? Who will be the primary users of the digital twin (which departments or policy areas), and how will it benefit their work? What outcomes do you expect from implementing the digital twin? How will the digital twin integrate with existing city data and systems?

Eurocity's digital twin aims to address the critical challenges of traffic congestion and air pollution in the Downtown District. By leveraging real-time data and predictive analytics, the digital twin will optimise urban mobility and environmental management, providing a robust tool

to enhance city planning and operational efficiency. This initiative offers an opportunity to improve the quality of life for residents by reducing traffic and emissions.

The digital twin supports Eurocity's policy goals of enhancing sustainability, improving public health, and increasing urban efficiency. It will inform evidence-based policy-making and strategic planning, aligning with broader objectives to create a more livable and sustainable urban environment. The primary users of the digital twin will be the Transportation Department and the Environmental Agency, who will use the system to monitor traffic patterns, manage congestion, track pollution levels in real-time, and simulate the effects of policy interventions (e.g. traffic restrictions, street pedestrianisation) before actually implementing them.

The digital twin will transform policy-making by providing city officials with a comprehensive view of urban dynamics and the possibility to assess public interventions' impact before implementing them. For instance, it will simulate the impact of proposed traffic regulations, such as congestion pricing or new bike lanes, and infrastructure changes like road expansions or public transit improvements. This allows policymakers to predict outcomes and optimise strategies before implementation. It will also facilitate scenario planning, enabling the city to prepare for emergencies, such as pollution spikes or traffic incidents, by testing various response strategies. Additionally, by integrating data from multiple sources, the digital twin will help identify correlations and causal relationships, supporting more effective and targeted policy interventions.

4. Project objectives

The purpose of this section is to help participants start defining the specific challenge they would like to develop and focus on during the training programme. This involves identifying the concrete urban challenge the digital twin aims to solve, the expected outcomes, and the key elements necessary for successful implementation.

a. Problem description. *What is the specific problem or challenge you want to address through a digital twin use case? Why is this problem relevant for your city?*

Eurocity's Downtown District suffers from severe traffic congestion and elevated levels of nitrogen dioxide (NO₂) and particulate matter (PM2.5) pollution. These issues cause significant delays for commuters, increase the risk of respiratory illnesses among residents, and negatively impact the overall quality of life. The digital twin aims to address these problems by providing real-time traffic and pollution data, allowing city officials to develop targeted strategies to reduce congestion and improve air quality. This problem is relevant to Eurocity as it affects both public health and public space use, making it essential to find sustainable solutions.

- b. Expected output.** *What data and insights do you expect the digital twin to produce? How will these outputs help in solving the identified problem?*

The digital twin is expected to produce comprehensive data on traffic patterns, vehicle counts, and pollution levels in the Downtown District. It will generate predictive analytics to forecast traffic congestion and pollution hotspots, and provide scenario simulations for proposed traffic management and pollution reduction measures. These outputs will enable city planners to implement more effective traffic regulations, optimise public transportation routes, and design better urban infrastructure, thereby directly addressing the identified problems of congestion and pollution.

- c. Target audience.** *Who are the primary users of the information produced by the digital twin? Which municipal department or policy-makers will benefit most from these insights?*

The primary users of the digital twin will be the Eurocity Transportation Department and the Environmental Agency. These departments will use the digital twin to monitor real-time traffic and pollution data, develop and test new traffic management strategies, and assess the effectiveness of environmental policies. Additionally, policymakers and urban planners will benefit from the insights provided by the digital twin, allowing them to make informed decisions that improve urban mobility and air quality.

- d. Data required and owners.** *What data is required to produce the expected outputs of the digital twin? Who are the owners of these data sources, and how will you access them?*

To produce the expected outputs, the digital twin will require traffic data from street sensors, CCTV cameras, and GPS data from public transportation. This is owned by the city, through its Transportation Department. Pollution data will be sourced from air quality monitoring stations and mobile sensors deployed throughout the Downtown District. These air quality monitoring stations and mobile sensors are owned by the regional government, which also owns the data produced by them. Therefore, a data-sharing agreement and protocol will need to be established with the regional government to ensure access to this crucial data. The Transportation Department and the Environmental Agency will collaborate with the regional government to ensure data accuracy and availability. Within the city, the Transportation Department will provide mobility data, while the Environmental Agency will focus on pollution data. Data integration will be ensured by the Digital Agency.

- e. Digital twin governance.** *Who will be responsible for developing and managing the digital twin? Which municipal department will oversee its development and use? How will collaboration between the municipal department in charge of development and the one that will be making use of the information produced?*

The development and management of the digital twin will be overseen by the Eurocity Digital Agency. The Transportation Department will lead the integration of mobility data, while the Environmental Agency will handle pollution data. Collaboration between these departments and the company TechSolutions, the technology provider, will be crucial for the successful implementation of the digital twin. A taskforce will be set up to facilitate regular coordination meetings that ensure alignment and delivery of goals by all stakeholders.

- f. Funding.** *How much do use case might cost? What are the potential sources of funding for your digital twin project? How will you secure the necessary financial resources?*

The estimated cost for the digital twin project is €2 million. Potential funding sources include the municipal budget, grants from the European Union, and partnerships with private sector stakeholders. The Eurocity Digital Agency will secure the necessary financial resources by applying for relevant grants, negotiating partnerships, and allocating municipal funds dedicated to urban innovation and sustainability projects.

- g. Other stakeholders involved.** *Who are other key stakeholders (inside and outside the municipality) that might need to be involved in the use case? What roles these stakeholders play in the development, implementation and use of the digital twin?*

Key stakeholders in the digital twin project include Eurocity University, which will provide research support and expertise in data analysis and modelling. Local businesses and residents of the Downtown District will also play a crucial role, as they will be the primary beneficiaries of improved traffic conditions and air quality. Regular stakeholder engagement sessions will be conducted to gather feedback and ensure that the project meets the needs of the community.

5. Diagnosis: bottlenecks and obstacles

The purpose of this section is to help participants identify potential bottlenecks and obstacles that could hinder the implementation of the Urban Digital Twin (UDT) use case outlined in the previous section. This involves assessing whether the necessary requirements and capacities are present within the city administration. By identifying these challenges early, participants can develop strategies to address them, ensuring a smoother implementation process.

- a. Vision.** *Is there a shared vision for, and understanding of, the digital twin among all key departments and stakeholders involved within the municipality (political and technical offices; data/IT department; user departments...)? How will you align different understandings to ensure a cohesive approach and buy-in of the initiative?*

Our departments have different understandings of the digital twin's potential. The Transportation Department views it as a tool to optimise traffic flow, while the Environmental Agency focuses on monitoring pollution levels only. The Digital Agency sees it as an opportunity to enhance data integration and smart city initiatives, through citizen participation. These varying perspectives create a challenge in aligning our goals and ensuring all departments are on the same page. Overcoming this requires structured workshops to unify our vision and demonstrate the comprehensive benefits of the digital twin.

- b. Digital twin governance.** *Who is responsible for decision-making related to the digital twin use and applications? How are roles and responsibilities distributed? Are there the coordination mechanisms in place between the department in charge of developing the digital twin and the department that will be making use of its insights? Is there a space for coordinating efforts between different departments and external partners?*

We face a challenge in defining clear roles and responsibilities for the digital twin project. The Transportation Department will lead on traffic data, the Environmental Agency on pollution data, and the Digital Agency on overall coordination. However, bureaucratic silos and lack of inter-departmental communication are hindering progress. Establishing a robust governance framework with regular coordination meetings and clear decision-making protocols is essential – and we currently lack this. Additionally, aligning our internal resources with those of TechSolutions, the external technology provider, requires planning and cooperation.

- c. Political leadership.** *Are key political leaders committed to the project? Do they understand the potential of digital twins? If not, why not?*

Securing strong political support is critical but challenging. Currently, the decision sits with two different Deputy Mayors: the one in charge of digital and mobility, and the one responsible for environment. The Deputy Mayor for mobility and digital recognises its potential to improve urban management. The Deputy Mayor for Environment, however, is sceptical, concerned about the cost and the potential lack of immediate results. This scepticism stems from a lack of understanding of the digital twin's benefits and fear of political backlash. Continuous engagement with political leaders, in particular with the Deputy Mayor for Environment, showcasing short-term wins, and aligning the project with broader political agendas are necessary to maintain commitment and support.

- d. Internal alignment.** *Are all relevant departments engaged and working together? Are there any conflicts or silos between the departments involved that could hinder the project? How is inter-departmental cooperation facilitated? What resources will be provided to support internal alignment and ensure that all departments have a clear understanding of their role?*

Ensuring all relevant departments are engaged and working together is challenging. The Transportation Department and Environmental Agency often have conflicting priorities, with one focused on mobility and the other on environmental health. These conflicts hinder our progress. Facilitating inter-departmental cooperation involves creating a unified vision, setting shared goals, and providing resources for joint initiatives. A clear political direction, which is currently lacking, would also facilitate things. In general, regular workshops and cross-departmental exchange sessions can help foster a collaborative environment. Moreover, clarifying roles and responsibilities through detailed documentation and structured communication channels is essential to prevent misunderstandings and overlaps.

- e. External partnerships.** *Does the city have the internal capacities to develop the digital twin on its own, or does it require external support? Do you have established partnerships with relevant external stakeholders (e.g. research institutions, private providers)? What is the role of these external partners? Are there any potential conflicts of interests or challenges in working with external partners?*

Our city lacks the internal capacity to fully develop the digital twin and relies heavily on external support from TechSolutions and, to a lesser extent, Eurocity University. TechSolutions focuses on delivering a technically sound product but may have commercial interests that conflict with our budget constraints. Ensuring data ownership and avoiding vendor lock-in are critical. Eurocity University provides research support but may prioritise theoretical research over practical solutions, potentially misaligning with our urgent needs. Establishing clear agreements on data sharing, roles, and responsibilities, alongside regular communication and mutual accountability, will help align our goals and manage potential conflicts.

- f. Embedment into policymaking process.** *Are there established procedures in the city government for using data-driven insights in decision-making? How will the insights from the digital twin be integrated into the policymaking process by the user department? Are there any barriers (administrative or political) to ensure that data-driven insights are incorporated into decision-making? What support will policymakers need to effectively use digital twin insights?*

There is a lack of tradition in the city administration to use data-driven insights for policymaking. Strategic and political decisions on traffic congestion, which directly impact emissions, are usually based on political agendas and community demands rather than data and evidence. This approach hinders the effective use of digital twin insights.

To integrate these insights, we need to develop comprehensive training programmes for policymakers and establish streamlined processes for incorporating data into decision-making. Demonstrating the effectiveness of data-driven approaches through pilot projects and fostering a culture of innovation within the administration will contribute to overcome this barrier.

- g. Funding.** *Is there sufficient funding allocated for the digital twin project or use case? Are the sources of funding secure (can they be sustained over time)? Are there any financial constraints that could limit the project's scope or sustainability? What alternative funding sources (grants, EU funding, partnerships...) can be explored?*

Securing and sustaining sufficient funding for the €2 million digital twin project is challenging due to competing budget priorities like housing and infrastructure maintenance. To ensure budget allocation, strong political buy-in is essential. This requires making a compelling financial case by demonstrating cost savings and improved public health outcomes, and politically aligning the project with city priorities. Engaging political leaders, showcasing pilot successes, and aligning the initiative with the city's strategic vision are crucial. Alternatively, potential public-private initiatives include partnerships with tech companies like TechSolutions (which might invest in the project with certain data- and technology-ownership conditions), collaborations with local businesses. EU grants might also be considered for pilots.

h. Data.

- i. Data infrastructure.** *Is your city's data infrastructure capable of supporting the digital twin, including collecting, integrating and processing increasing data volumes and complexity? If not, what capacity is needed?*

Our current data infrastructure is not fully capable of supporting the digital twin's requirements due to limited data storage capacity, outdated processing systems, and inadequate data integration capabilities. We require significant investment in high-capacity servers, advanced data processing software, and enhanced network infrastructure to handle large volumes of real-time data efficiently. Additionally, we need technical expertise to manage these upgrades and ensure seamless integration. Collaboration with TechSolutions can facilitate this process by providing cutting-edge technology solutions and expert knowledge in data infrastructure, ensuring our systems are robust and scalable. TechSolutions will also assist in training our staff to manage and maintain the new infrastructure, ensuring long-term sustainability.

- ii. Data ownership and governance.** *Does the municipality have full control over the data required to develop, implement and maintain the digital twin? Is there any agreement with the stakeholders (public or private) that own the data? What are the protocols for data access and sharing with external stakeholders (either data owners or processors)?*

We need to ensure availability of and access to data required for the digital twin, and a crucial part of it is on the regional government's hands. Our municipality must establish comprehensive agreements with the regional government, which owns the air quality monitoring stations and mobile sensors, to ensure seamless data access. These agreements should include clear terms on data sharing, ownership rights, usage limitations, and responsibilities for data maintenance. Protocols need to ensure data integrity and legal compliance by outlining standards for data accuracy, security measures, and privacy protections. All stakeholders, including city departments and external partners, will be bound by these protocols. The data governance framework must include representatives from the Transportation Department, Environmental Agency, Digital Agency, and legal advisors. This framework should define roles, responsibilities, and procedures for data management, ensuring consistent and lawful data handling practices.

- i. Regulations and legal considerations.** *Are current data-related process in the municipality GDPR-compliant? Are there local or national regulations that must be considered to implement the digital twin (related to e.g. data-sharing, data ownership)?*

Ensuring compliance with GDPR and other regulations is a major challenge due to the complexity of data protection laws and the significant penalties for non-compliance. One particularly challenging local regulation is the "Data Sovereignty Act," which mandates that all data collected within the city must be stored on servers physically located within municipal boundaries. This requirement complicates the integration with cloud-based services used by TechSolutions and increases infrastructure costs. Compliance involves conducting thorough legal reviews, developing robust data protection strategies, and implementing secure data storage solutions. Establishing a dedicated legal team to monitor compliance and address legal issues is essential. Engaging with legal experts and consulting with regulatory bodies early in the project can help navigate these challenges and ensure smooth implementation.

- j. Procurement.** *If the municipality requires the services of an external provider for the development of the digital twin, what criteria are used to evaluate bids and select suppliers? Are these criteria aligned with your project goals and needs? What are the operational responsibilities of the external providers? How is data ownership, technology ownership and control over the information produced managed in the procurement contracts?*

The procurement process for Eurocity’s digital twin project is challenging due to an outdated framework that is not suited for cutting-edge technology acquisition. Lengthy bidding processes often favour providers who meet bureaucratic criteria over technological fit. Current evaluation criteria focus on cost over innovation, risking selection of cheaper, less capable providers. In addition, procurement contracts inadequately address data ownership and technology control, leading to vendor lock-in and vague operational responsibilities. To overcome these issues, we need a revamped procurement process with clear, tech-focused evaluation criteria, enhanced transparency, and detailed contracts outlining data ownership, technology control, and specific operational responsibilities, supported by legal and procurement experts.

6. Strategic actions and timeline

This section outlines the strategic actions required to address the challenges identified in Section 4 and achieve the goals outlined in Section 3. Participants should identify and devise concrete actions and works lines by analysing the specific challenges and opportunities within the city context. For this, participants may consult with colleagues and key stakeholders, review best practices from other cities, and incorporate the learnings and insights gained during the training. Strategic actions should be procedural, beginning with foundational steps and progressing through to final implementation and evaluation stages.

	Timeline	Goal	Action
Develop a unified vision for the digital twin	Months 1-3	Ensure all departments and partners are aligned in their understanding and objectives for the digital twin, as well as on the initial role distribution. For instance, the Transportation Department will focus on optimising traffic flow, while the Environmental Agency will prioritise reducing polluting emissions.	Conduct workshops and meetings with all key municipal stakeholders, including the Transportation Department, Environmental Agency and Digital Agency to develop a unified vision for the digital twin project.

<p>Establish a governance framework</p>	<p>Months 2-4</p>	<p>Facilitate coordinated efforts and clear accountability across all involved parties. For instance, the Digital Agency will coordinate data integration, while TechSolutions will handle technical implementation.</p>	<p>Create a governance task force comprising representatives from the Transportation Department, Environmental Agency, Digital Agency, TechSolutions, Eurocity University, and legal advisors. Define roles, responsibilities, and decision-making protocols.</p>
<p>Secure political buy-in and funding</p>	<p>Months 1-6</p>	<p>Ensure sustained financial and political support for the project. For example, securing a €500,000 grant from the EU's Horizon Europe programme and a €1 million investment from the local business GreenTransport.</p>	<p>Present the digital twin project to political leaders, highlighting its benefits such as reducing traffic congestion and improving air quality. Apply for grants from the European Union, establish public-private partnerships with local businesses like GreenTransport, and allocate municipal funds.</p>
<p>Upgrade data infrastructure</p>	<p>Months 3-9</p>	<p>Build a robust and scalable data infrastructure capable of supporting the digital twin. For instance, upgrading the city's data centre to handle real-time traffic and pollution data from thousands of sensors.</p>	<p>Invest in high-capacity servers, advanced data processing software, and enhanced network infrastructure. Collaborate with TechSolutions for technology solutions and staff training.</p>
<p>Establish data sharing agreements and protocols</p>	<p>Months 4-10</p>	<p>Ensure seamless access to all necessary data while maintaining data integrity and legal standards. For example, creating a data-sharing agreement with the regional government for access to air quality data from 50 monitoring stations.</p>	<p>Negotiate and formalise data-sharing agreements with the regional government and other external data owners. Develop protocols for data access, security, and compliance.</p>

Enhance data governance	Months 5–12	Ensure consistent and lawful data handling practices. For example, establishing a data governance board to oversee data quality, privacy, and security.	Set up a centralised data governance framework with clear policies for data management, involving representatives from the Transportation Department, Environmental Agency, Digital Agency, and legal advisors.
Align procurement processes	Months 12–18	Secure the best possible partners and technology solutions for the project. For instance, updating procurement policies to prioritise vendors with proven experience in smart city solutions and data analytics.	Revise procurement criteria to focus on technological innovation, long-term value, and alignment with project goals. Ensure transparency and fairness in the selection process. Develop detailed contracts outlining data ownership, technology control, and operational responsibilities.
Train policy-makers	Months 12–24	Build capacity for data-driven policy-making within the city administration. For example, conducting workshops for city council members on using digital twin data to formulate sustainable mobility policies.	Develop and deliver training programmes for policymakers to utilise data-driven insights effectively. Include practical sessions on integrating digital twin outputs into decision-making processes.
Develop the use case and implement measures	Months 18–30	Showcase short-term wins and build confidence among stakeholders. For example, digital twin-informed traffic restrictions in a specific area like the Central Business Area to optimise traffic light timing and reduce congestion.	Implement small-scale traffic and mobility measures to demonstrate the digital twin's capabilities and benefits. Use these projects to gather feedback and refine the system.
Monitor and evaluate progress	Months 18–36	Ensure the project stays on track and meets its objectives, allowing for continuous improvement. For example, generate monthly reports on project performance.	Establish monitoring and evaluation frameworks to track the progress and impact of the digital twin project. Use key performance indicators (KPIs) such as reduction in traffic congestion, decrease in NO ₂ and PM2.5 levels, and public satisfaction surveys.

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