Deliverable

D7.6 Business and Exploitation Scenarios v1

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Executive Summary

Exploitation is a means to ensure that project results are fully internalised and rigorously used by existing beneficiaries in pilot locations (multiplication) and that they are scaled beyond the scope of initial use cases to reach new places and contexts (mainstreaming). We are using it to accelerate the adoption of the DUET framework, standards and tools by public administrations across Europe and beyond to make DUET a leading voice in the nascent local Digital Twin community. The exploitation and commercialisation of the DUET project cover **three different areas**: the exploitation of the pilot sites, the exploitable results beyond the consortium and the commercialisation for the partners. This first version of the deliverable mainly focused on exploiting the pilot sites and providing an overview of the exploitable results beyond this project.

The **exploitation model of the pilot sites** is divided into two distinct phases: phase 1 explores the different focus areas of the Digital Twin pilot sites (M18), and phase 2 defines exploitation roadmaps beyond the project (M36). For phase 1, the insights of D2.4 “Cloud-based business model analysis” of the Digital Twin typologies were utilised as a starting point to set up exploratory workshops with the pilot sites, in which 5 to 6 use cases were discussed based on the scenarios in the typology and the maturity roadmap of Urban Digital Twins.

The different pilot sites had use cases with examples of each type of Digital Twin. The scenarios were applied on the use cases, not on the pilot site, as each pilot site had at least examples of 2 types of Digital Twin typologies. Based on this typology, different building blocks have been identified for the further development of the Digital Twins:

- Data governance: ensuring the quality of the data and identifying data sources,
- Integration in the policy process: making policymakers utilise the Digital Twin in their daily tasks,
- Open data: operationalisation of the ‘open by default’ principles in the Digital Twin,
- Citizen engagement and participation: ensuring and governing the participation and engagement of the community,
- Data ecosystem governance: governing the ecosystem of data providers and data collaborators,
- Regional collaboration: knowledge exchange and collaboration between the local and regional levels.

The outcomes of the exploitation models will be utilised in phase 2 to determine exploitation roadmaps for the Digital Twin pilot sites.

Successful exploitation, however, requires clarity as to what can be **exploited beyond the consortium**, why, and how. For that reason, this deliverable will also identify a list of project results that can be exploited in different ways during and after the project duration.

In addition to the main digital twin solution, there are five exploitable results, including the e-book, online course, policy brief, and the starter kit. The book is one of the main non-technical results that we will use as a medium for knowledge sharing and issuing practical recommendations. We are considering two e-books, one self-published on Amazon, another published through Springer. The course will be a learning resource for anyone with interest in Digital Urban Twins. The course will be published on CxC Academy managed by OASC to reach the main audience in cities, towns and rural areas across the EU and beyond. The policy brief will be a short note summarising DUET's approach to urban challenges using Digital Twins, complete with recommendations for data-driven policymaking. At the same time, the kit will be a collection of different components that will be carefully curated to provide valuable tips and advice for would-be adopters.

The **commercialisation of DUET** by the commercial partners in the consortium will be elaborated on by identifying the relevant business models for individual partners.

1. Introduction

In order to enable Urban Digital Twins to have a sustainable impact on evidence-based policymaking, exploitation plans are of high importance to provide a vision for the future. This task aims to identify exploitation scenarios for DUET outside of the project scope. Based on the initial business model analysis performed in task 2.4, this task will identify exploitation scenarios for DUET. This means taking the insights gathered in task 2.4 and applying them to the innovative characteristics of DUET, in order to ensure sustainability of the developed solutions, after the project has run its course. Using a business model sustainability framework, different potential and realistic exploitation scenarios will be developed, based on input from the project partners and the DUET community.

The exploitation scenarios are being developed in two distinct phases. In the first phase, exploratory workshops were held with the three DUET pilot sites to identify the desired exploitation scenarios based on the use cases. In the second phase, which will be included in the next version of this deliverable at the end of the project, business model workshops will be held to determine and validate the exploitation scenarios used to develop an exploitation roadmap.

Successful exploitation, however, requires clarity as to what can be exploited, why, and how. For that reason, this deliverable will also identify a list of project results that can be exploited in different ways during the project and after. A Digital Twin starters kit, online course and book will be developed later in this deliverable.

Section two in this deliverable describes the methodology used for developing the exploitation roadmap. In section three, the exploitation roadmap for each pilot site is described, and section four compares each pilot site's outcomes to determine an overall roadmap for the exploitation of the DUET pilot sites. Section five describes the tools that will be developed beyond the scope of the project consortium to scale the insights of the pilot locations.

2. Methodology - Exploitation Roadmap

2.1. Exploitation Scenarios Timeline

The exploitation scenarios are being developed in two distinct phases, as can be seen in Figure 1. In the first phase, exploratory workshops were held with the three DUET pilot sites to identify the desired exploitation scenarios based on use cases developed in the pilot site. The goal of these sessions is to identify the desired exploitation scenarios and to identify the potential challenges in these scenarios. The outcome is part of the first version of the deliverable in month 18 and will showcase a first overview of the exploitation scenarios.

In the second phase, which will be included in the next version of this deliverable at the end of the project in month 36, business model workshops will be held with the pilot sites. The goal of these business model workshops is to determine and validate the exploitation scenarios. These are used to develop an exploitation roadmap. The outcome is part of the final version of the deliverable and will include a finalised exploitation roadmap including the different Urban Digital Twin use cases.

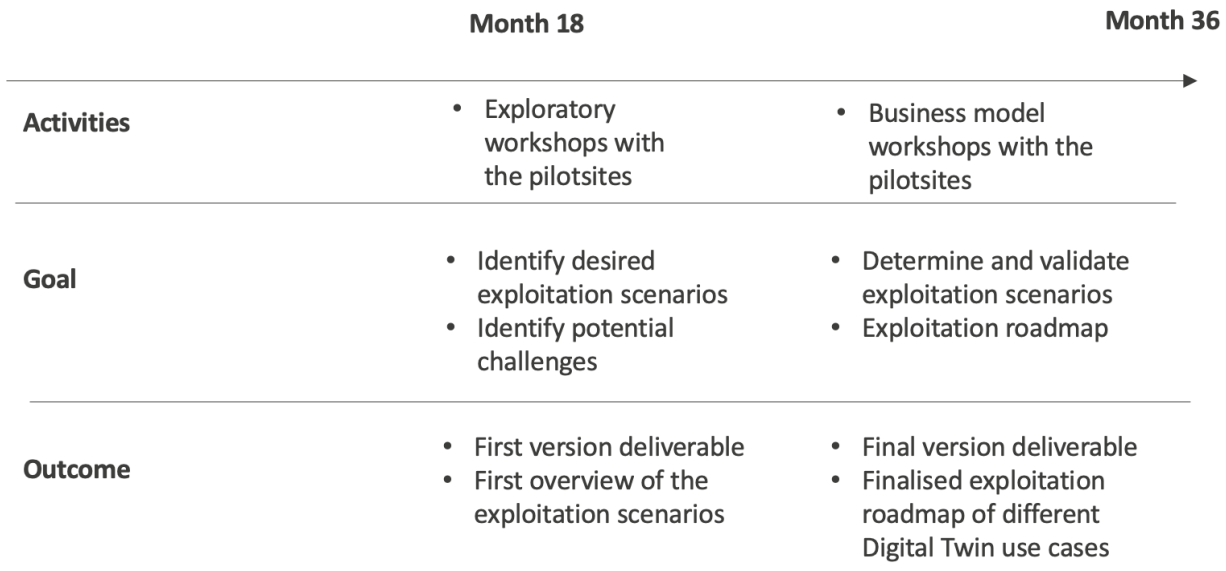

Figure 1: exploitation scenarios timeline.

2.2. Phase 1: Exploitation Scenarios of Digital Twins

In the deliverable D2.4 of task 2.4 Cloud-Based Business Model Analysis, different scenarios for business models of the Digital Twins were established based on interviews with a selection of existing Urban Digital Twins (Helsinki, Örebro, Rotterdam, Vienna and Amsterdam). Based on these interviews, a typology (see figure 2) has been developed, including four different types of Digital twins:

1. an **Inside-In Urban Digital Twin** used for policymaking and based on governmental data resources. The government is controlling the data resource. An example could be a Digital Twin on mobility data entirely based on governmental data, which the government can use for making mobility policy decisions.
   a.
2. Second, an **Inside-Out Urban Digital Twin** is used to engage with the ecosystem based on governmental data resources. The government is controlling the data resources. An example of such a Digital Twin would be the same example as above, where the Digital Twin is also used as a basis for citizen participation where the citizens could see the outcomes of the Digital Twin.
   a.
3. An **Outside-Out Urban Digital Twin** is used to engage with the ecosystem based on data resources of the ecosystem. The ecosystem is controlling the data resources. In the same example, the data might be based on governmental data and data from companies, IoT data, data of transportation companies, etc., and thus be based on data from the ecosystem.
   a.
4. Last, the **Outside-In Urban Digital Twin** is used for policymaking based on data resources of the ecosystem. The ecosystem is controlling the data resources. In the previous example, this would be a digital twin based on ecosystem traffic data, which is also opened for citizen participation.

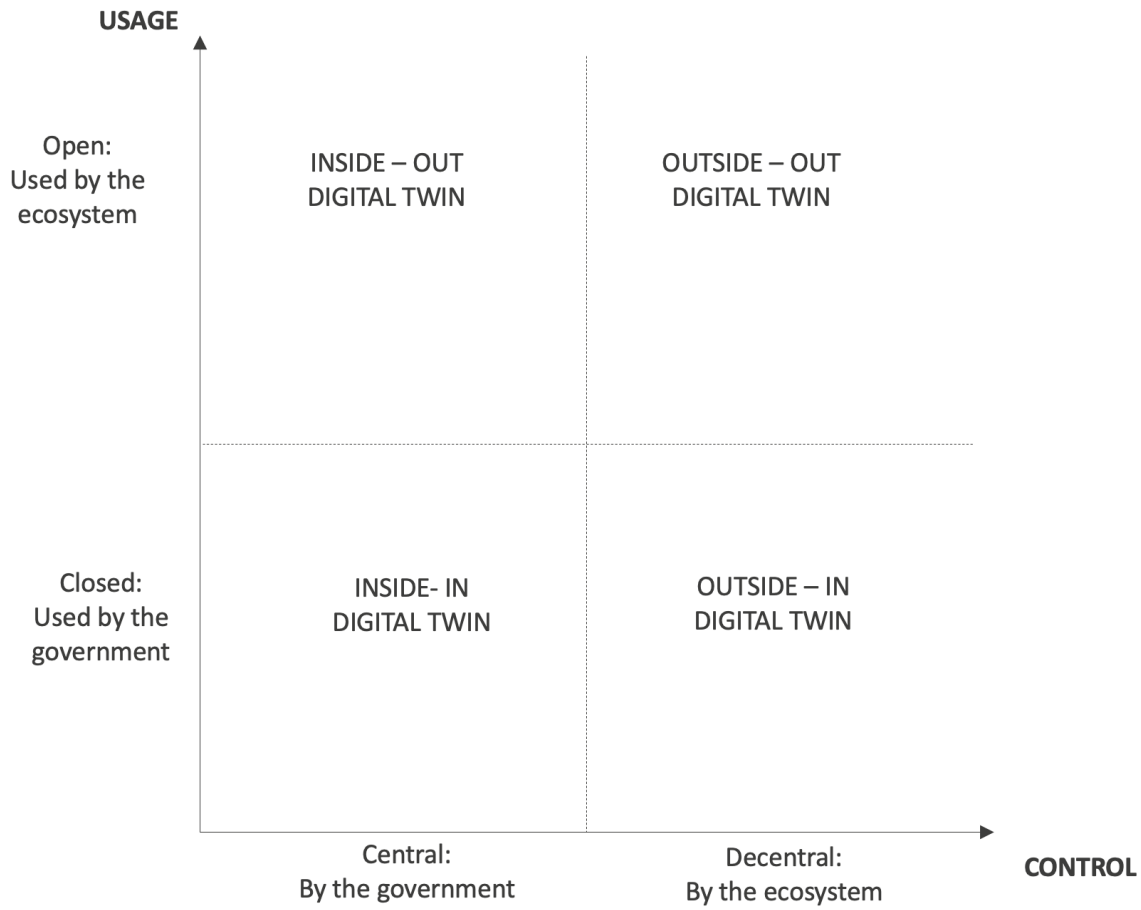

Figure 2: business model scenarios of Urban Digital Twins.

The overview of the different scenarios of Digital Twins was utilised to develop an exploitation roadmap to identify the focus areas Urban Digital Twins face in the development of maturity of an Urban Digital Twin (Figure 3). The core challenge of any Urban Digital Twin is **data governance**, which is the foundation for developing the Digital Twin. It concerns the organisation of the governmental departments and the changing workflows. It also concerns setting up a shared Digital Twin architecture encompassing different departments, requiring the introduction of data standards. Third, it includes the quality and availability of data. Thus, data governance is the basis of any Digital Twin.

Once the data governance is set in place, the following challenge can be to **open up the data** to the entire ecosystem as in the Outside-Out and Inside-Out Digital Twins. This requires a classification system of the data to determine which data can be shared with the ecosystem and which data needs to remain closed as well as an identity management solution. **Ecosystem governance and** trust is the last challenge when the data supply and control of the data includes increasingly the ecosystem in the cases of the Outside-Out and the Outside-In Digital Twin, another new challenge is the governance of the ecosystem, ensuring trusted data ecosystems and ecosystem governance models.

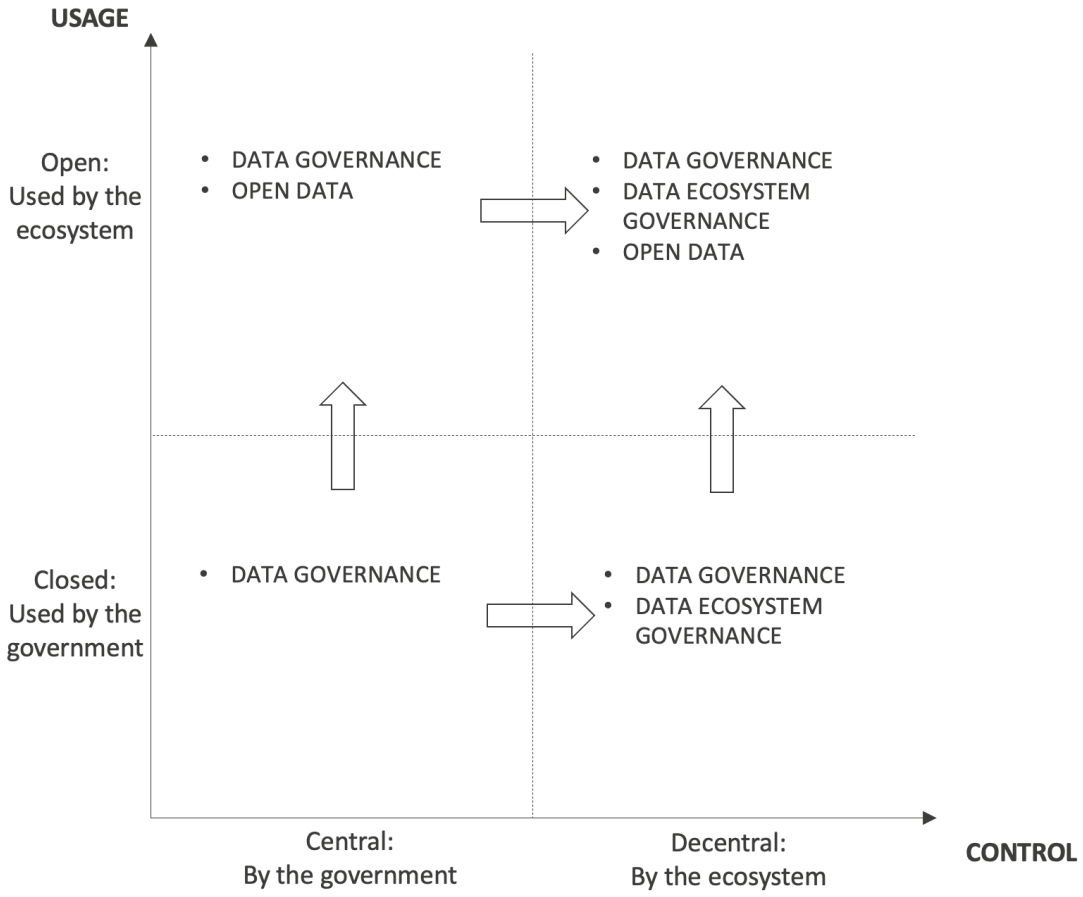

Figure 3: Urban Digital Twin - maturity roadmap.

In the initial workshops with the Urban Digital Twin pilots of DUET in Flanders, Pilsen, and Athens, the scenarios were used to determine the type of use cases the Urban Digital Twins aim to set up and what is the required exploitation roadmap to develop these use cases. An analysis was made on the different use cases of the Digital Twins based on the overview of the epics each pilot site aims to cover. Prior to the workshop, the researchers made a selection of use cases (3 common use cases covered in each pilot site, and two pilot specific use cases). The common use cases were selected to be able to compare differences between the pilots, and the two other use cases were identified to include specificities of each pilot site. The selection was sent to the pilot sites before the meeting, and the pilot sites were asked to give feedback. The following use cases were discussed in each pilot site:

Use Case	Pilot site(s)	Epic
As a public servant of a relevant department (mobility, spatial planning and environmental department,...) I want to see the **difference in density of traffic in the area of interest** of a scenario where I closed traffic in a set of roads versus the base density, so I can assess the impact of changes to the local situation on the traffic in my area of interest	Flanders, Pilsen, Athens	G1
As a public servant of the mobility or environmental protection department, I want to know the **level and impact on air pollution when certain roads would be closed** so I can discover causes of air pollution and the impact on citizens well-being in the city	Flanders, Pilsen, Athens	G2
As a citizen, I want to understand the predicted **impact of scenarios related to new city developments**, calculated using functionality used for what-if analysis, so I can give feedback about scenarios	Flanders, Pilsen, Athens	G4
As a citizen, I want to see the **predicted air pollution based on the model, sensors and predicted weather** in the city based on the model and available sensors so I can inspect the near future situation of air pollution	Flanders	G12
As a citizen, I want to be able to v**ote and give feedback about scenarios related to new city developments**,calculated using functionality based on other epics, so I can participate in those designs	Flanders	G5
As a policy maker, I want to make the 3D data of the city available as open data (see data section for already opened data), so I can **engage the techie community** and students to enrich the data and develop new services with the data. The city balances the relevance of opening the data with policy objectives, the price, the relevant level of granularity and so on.	Pilsen	P8
As an urban planner or 3D expert I want to **import/export the 3D buildings or objects (incl. high-resolution 3D models of selected public buildings or areas**, e.g. the cathedral or football stadium) from/to the Digital Twin so I can further enrich and keep the Digital Twin up to date	Pilsen	P9
As an urban planner, I want to understand **trends in the historical noise levels** (at various spatiotemporal resolutions) and predict/model future scenarios, with the goal to take measures to reduce noise levels (such as sound walls, rerouting traffic, green space, physical interventions, noise absorption materials).	Pilsen	P11
As a citizen, I want to **express interest as a volunteer tester of green routes** proposed by the city so I can validate the expected results and contribute prior to the actual implementation.	Athens	G13
As a city official, I want to see the **public transport in the city** based on static datasets (Urban transport datasets includes timetables, routes and locations of stations) so I can	Athens	A1

assess the situation and elaborate on new strategic plans for interconnecting public transport		

Table 1: overview of selected Digital Twin use cases.

2.3. Phase 2: Approach for Digital Twin Workshops

For the workshops in the second phase of the exploitation scenarios (month 32), an adaptation of the so-called Service Dominant Business Model Radar (Grefen et al., 2017) was made in order to make it more suitable for use in data ecosystems. The Service Dominant Business Model Radar DBM/R (Figure 4) has a network-centric design at its core, allowing the composition of service design in multi-party business networks. It defines how the actors in the business ecosystem participate in value co-creation and what the cost–benefits distribution is around a focal co-created value in use.

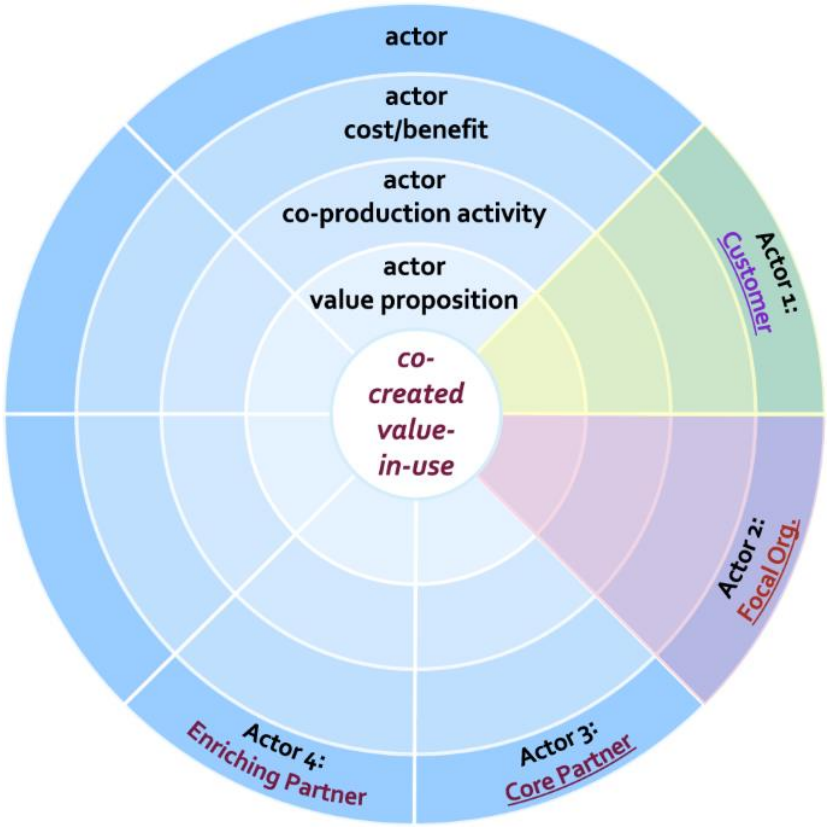

Figure 4: Service Dominant Business Model Radar.

For the use case in data ecosystems, such as the Urban Digital Twin, the Service Dominant Business Model Radar has some shortcomings as it:

1. does not include the data flows required for a data ecosystem,
2. does not include roles of the actor regarding data, and additionally,
3. does not indicate who the data owner and controller is and lastly,
4. it does not cover the accessibility of the data.

Therefore, the same model was used, while some adaptations were made in the model (Figure 5):

- **Actor co-production activity** was divided into two parts:
    - ***Data in - data out***: in a data ecosystem, an overview is required of which data will be subject to the business model and which data is required. In this parameter, an indication is given.
    - ***Role/activity***: what are the activities the actor plays, and what is the role it plays in the overall ecosystem.
- ***Data Owner and controller***: in a data ecosystem, it is important to identify who owns the data and who are the players who have control over the data. This creates an overview of who holds power, and who needs to be included in the data ecosystem.
- ***Data type***: indication on whether the data is open, closed or shared (ODI, 2018).
    - Open data: the data can be accessed by anyone
    - Shared data: the data can be shared based on conditions
    - Closed data: the data cannot be opened or shared

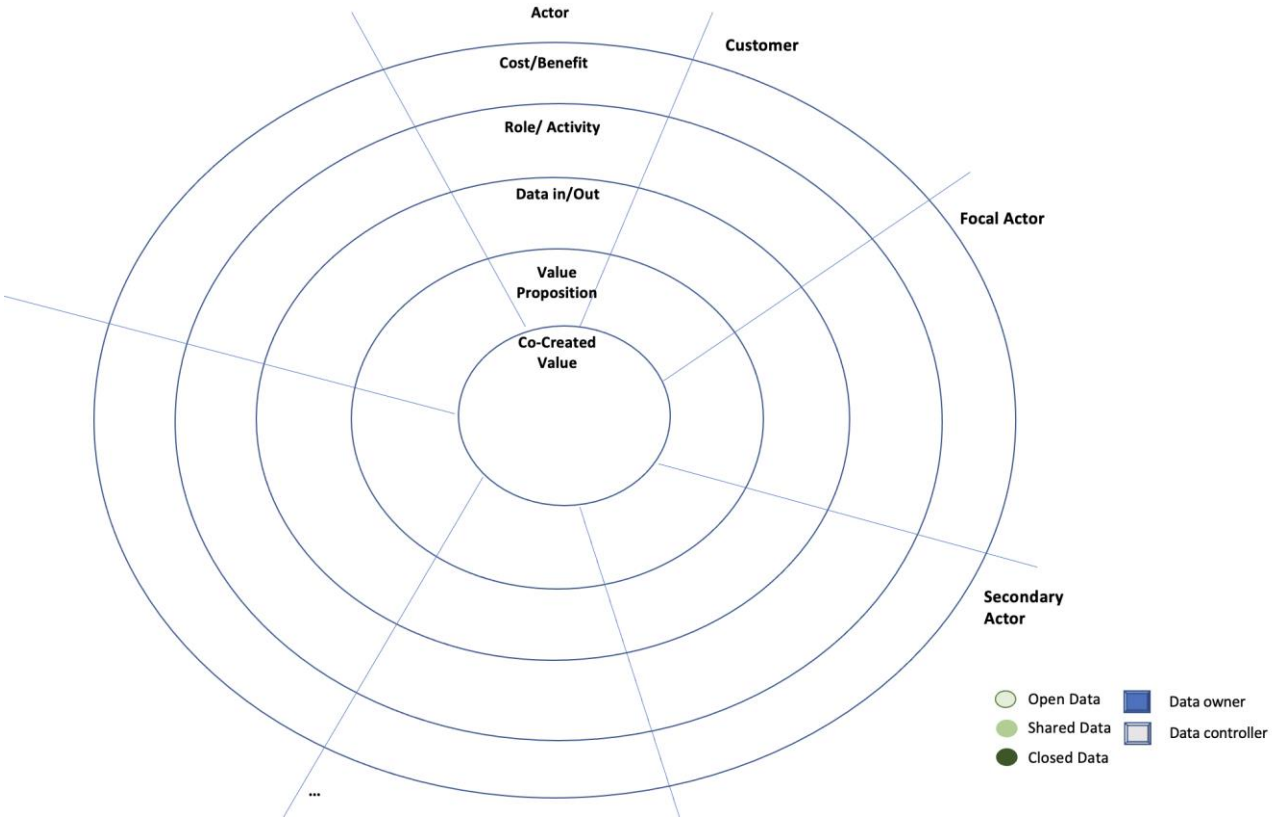

Figure 5: Data Ecosystem Business Model Mapping.

This model in figure 5 will be used as a methodology in the second phase of the exploitation of the results for the next version of this deliverable in M36.

3. Exploitation Scenarios - Pilot Sites

3.1. Flanders Pilot Site

The following use cases were discussed in the workshop with the Flanders Pilot site in the exploratory workshop.

Use Case	Epic
As a public servant of a relevant department (mobility, spatial planning and environmental department,...) I want to see the **difference in density of traffic in the area of interest** of a scenario where I closed traffic in a set of roads versus the base density, so I can assess the impact of changes to the local situation on the traffic in my area of interest	G1
As a public servant of the mobility or environmental protection department, I want to know the **level and impact on air pollution when certain roads would be closed** so I can discover causes of air pollution and the impact on citizens well-being in the city	G2
As a citizen, I want to understand the predicted **impact of scenarios related to new city developments**, calculated using functionality used for what-if analysis, so I can give feedback about scenarios	G4
As a citizen, I want to see the **predicted air pollution based on the model, sensors and predicted weather** in the city based on the model and available sensors so I can inspect the near future situation of air pollution	G12
As a citizen, I want to be able to v**ote and give feedback about scenarios related to new city developments**,calculated using functionality based on other epics, so I can participate in those designs	G5

Table 2: overview of selected Digital Twin use cases in Flanders.

3.1.1. Exploitation Scenarios

The different Digital Twin use cases in Flanders were identified as Inside-In Digital Twins (use case G1 and G2 and Inside-Out Digital Twins (use case G4, G12, G5) in figure 6. This means that in all the use cases the data sources were located in the government, added in some cases by external data. Use Case G1, G2,G4 and G12 depend on the traffic model of Flanders. In order to be able to apply the traffic model on the level of a city, additional data sources are required as it is not yet sufficiently reliable to predictions on the level of a city. Thus data might need to be purchased. For use case G4 and G12, air quality data is added to the traffic model, but the air quality model is more reliable to date. Citizen science data might need to be added to this data. In use case G5 the data is primarily governmental, but citizens could potentially vote on city proposals, leading to ecosystem involvement.

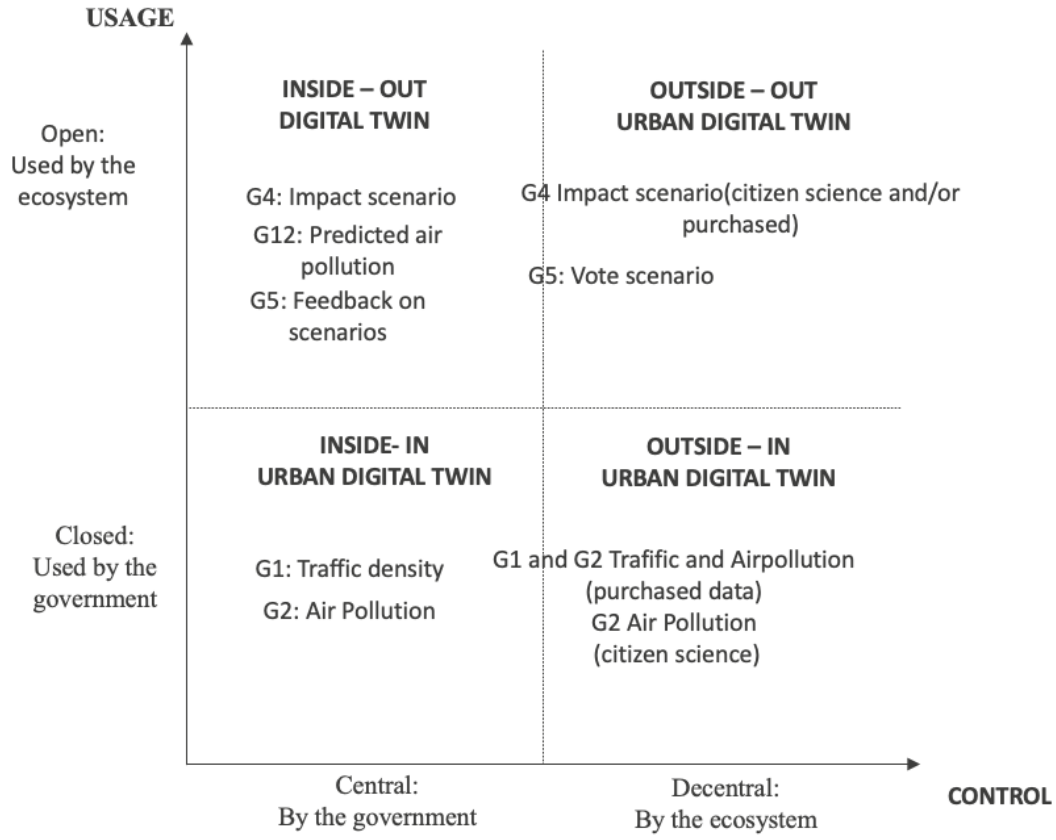

Figure 6: Flanders use cases digital focus areas.

3.1.2. Exploitation Challenges

Data Governance

Flanders is a region with different governmental authorities who have data that might be useful for the Digital Twin. There is data on the Flemish governmental level and data spread in the different cities on the local level. Therefore, the spread of data among different actors in different (local and regional) governments is a significant challenge. This concerns the quality of the data, granularity of the data and the regularity of the influx of data. There are challenges regarding the accessibility of the data as well, in cases where the data is provided by third parties (companies) who cannot or do not want to give access to all the desired granularities of the data. Additionally, some data is legally not allowed to be accessed or is not qualitative enough.

Traffic model

Use Cases G1, G2, G4 and G12 are based on the traffic model of the Flemish government. There are doubts about the effectiveness of the traffic model on whether the data is qualitative enough to enable analyses on the local level. First, the traffic model is made on a regional level, but for the Digital Twin it needs to be able to provide local insights. Second, the base data is not qualitative enough, as it has a limited amount of measurements that are not frequent or recent.

One way to improve the data would be to purchase commercial data (floating car data) to calibrate the existing data, added with Automatic Number Plate Recognition data. A major roadblock is the different approach to build the model, as the Flemish Mobility Model is a statistical model contrary to the commercial model, which requires different assumptions and calibrations. A second way forward is to utilise as much as possible local traffic models of cities, but this data is challenging to attain at the regional level. The local traffic models are often built by commercial companies, who are not inclined to share the origin destination matrices. They only want to share the outcomes, not the base models. Additionally, the models are composed of different formats and assumptions to make predictions and handle the data. In G1 the traffic model is the only model that is used.

Some of the use cases require additional data combined with the traffic model. In use case G2 and G4, the traffic model is used together with the air quality model. Thus, the challenges are the same in these use cases, complicated even more with challenges related to the air quality model (see below). In some cases, additional data is required from authorities that are not allowed to open the data, such as examples given police data. This data cannot be opened due to legal reasons.

Air Quality Data

In use cases G2 and G4, the traffic models are combined with the air quality models. A challenge in this model is that a consortium partner of DUET (TNO) is developing an air quality model, while the Flemish government is developing another air quality model (VITO in collaboration with the Flemish Environmental Agency). Thus, both models might need to be combined or connected, which is still under discussion.

The VITO model (OPAQ) has around 60 high-quality measurement stations to measure air quality, which ensure the data quality, and is combined with lower quality air quality models spread in different cities and locations based on data from cheaper sensors. A challenge for the future is to combine the high-quality sensor data with the cheaper data sources. Additionally, the data might be combined with citizen science data of lower quality data sources that are spread throughout the region (e.g., the IRCELINE project). For the use case on ‘real-time air quality’ (use case G8) the IRCELINE project will serve as an input for real-time data through sensors.

Open data

Traffic Model

The traffic models are not open data. Thus, the results can be shown, but the source data or model cannot be shown. A city can request the data for a study, and consultancy firms can work on it, but it cannot be opened.

Air Quality Model

The data that the sensors of the air quality measurement of VMM produce are open, but the model of VITO that produces it is not open. Thus, one can see the results, but there are no APIs to the prediction data which can be integrated into a model, which is a common issue regarding weather satellite data.

Citizen Engagement and Participation

Citizen Engagement

Some governments are concerned about opening the data, as it might show conclusions which the governments do not want to be seen in the ecosystem. If the users can also interact with the data, they will be much more inclined to give feedback on the data. In some cases, the citizens are involved (they are able to look at the data) or committed (the citizens can provide feedback). This leads to a different engagement of the citizens in the policy process and might evolve into more critical remarks by citizens, which not all governments are ready to do (yet). Additionally, the visualisation of the data towards the citizen raises questions on how the data can be visualised in a neutral way and which data can be shown.

Citizen Participation

In the use cases G12 and G5, governmental data is opened and communicated with the citizens, especially of governmental and urban planning projects, and opened in a portal. Thus, a government is making the simulation on what he perceives as the best options, yet this raises questions on the objectivity of the data that can be shown. The government still plays an important role in 1) which scenarios will be shown to the public and which not, given a coloured context, 2) which data and models are used and shown and 3) the basic policy questions which were requested. The citizens can only debate based on several scenarios which might already be pre-defined by the policymakers.

If this discussion is based on incorrect data or data that is based on different uncertainties, citizens might debate about incorrect data. Example given, in the case of the traffic model of the Flemish region it might be a challenge to provide sufficiently correct data within the cities themselves, thus it might lead to incorrect data if used in the debate of a local mobility policy.

An additional challenge concerns how governmental officials will be willing to communicate this data. This relates to a large extent to the culture in the government, whether the government wants to create a support base for certain decisions or whether it wants to move fast and additionally on the sensitivity of the subject.

3.1.3. Exploitation Scenarios and Conclusion

In order to implement the Digital Twin for the Flanders Region, different challenges will need to be overcome, which will be the core focus in the Digital Twin in the Flanders region. Figure 7 gives an overview of what the major focus areas will be for the Digital Twin, which is mainly Inside-In (controlled by government and used by government) and Outside-Out (controlled by ecosystem and used by ecosystem), but might have some cases where the data is controlled by the ecosystem if citizen science and/or purchased data will be utilised. Challenges for Flanders are particular because the digital twin will be deployed for an entire region, covering multiple governmental levels (regional and local).

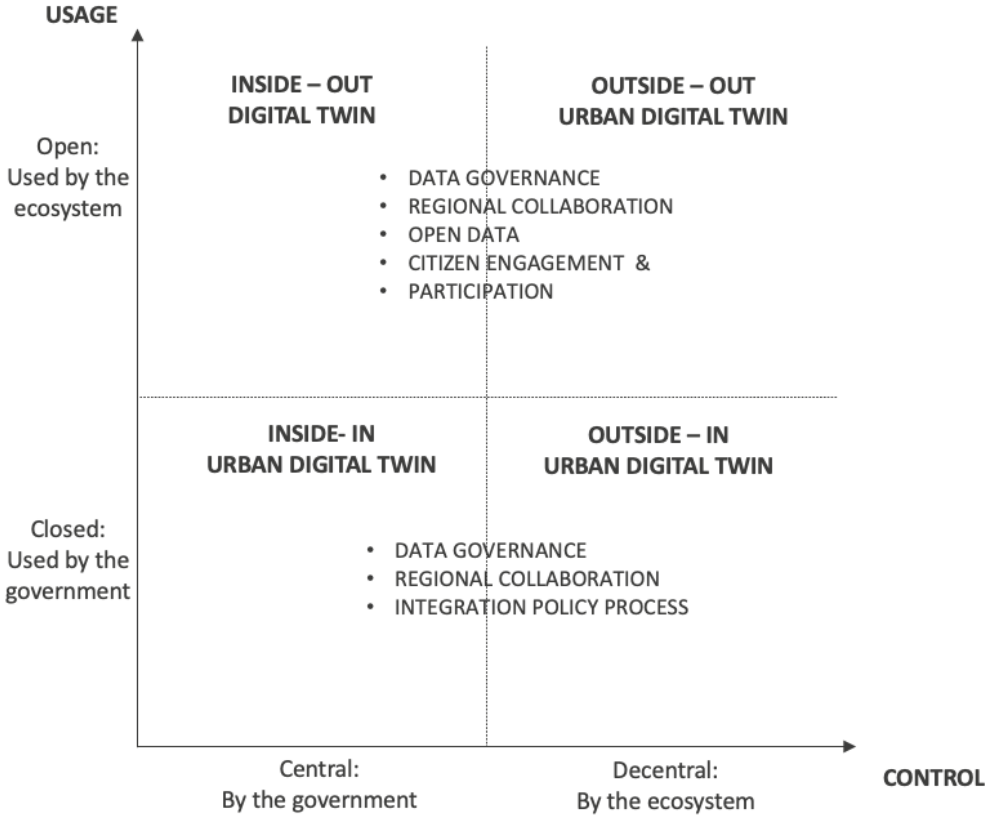

Figure 7: Flanders use cases digital focus areas.

Similar to other Digital Twins, data governance is crucial to ensure the reliability of data and models. The quality, regularity and granularity of the data needs to be ensured, and therefore the access to data is crucial. Currently, the data is spread over different locations, which needs to be overcome. Additionally, the requirement to potentially acquire commercial data is raised. When data is already purchased by cities, it sometimes causes challenges to access the base model, as the companies keep control over that data.

The engagement and participation of citizens increase the need for reliable data. Additionally, it requires an adaptation of the policy process and even culture, as cities need the willingness to open the data, and need to raise the trust of the citizens in the data.

In the case of Flanders, a specific focus area is the regional collaboration, as Flanders can be seen as one region with 6,7 million inhabitants. Therefore, the region of Flanders should not be seen as an 'Urban Digital Twin", but as a 'Local Digital Twin" or even a set of Local Digital Twins, as it concerns both insights on the regional level as well as the local level. All the different independent cities impact and influence each other. Thus, insights should be seen at a very local level, while it needs to consider the regional implications of policies. Therefore, a major challenge for the Flanders Digital Twin is the collaboration between the cities and to ensure access to the data sources from the different cities. Even in relatively rural areas, it requires access to sensors, or maybe the use of different technologies, such as satellite data.

3.2. Pilsen Pilot Site

The following use cases were discussed in the workshop with the Pilsen pilot site in the exploratory workshop.

Use Case	Epic
As a public servant of a relevant department (mobility, spatial planning and environmental department,...) I want to see the **difference in density of traffic in the area of interest** of a scenario where I closed traffic in a set of roads versus the base density, so I can assess the impact of changes to the local situation on the traffic in my area of interest.	G1
As a public servant of the mobility or environmental protection department, I want to know the **level and impact on air pollution when certain roads would be closed** so I can discover causes of air pollution and the impact on citizens well-being in the city.	G2
As a citizen, I want to understand the predicted **impact of scenarios related to new city developments**, calculated using functionality used for what-if analysis, so I can give feedback about scenarios.	G4
As a policy maker, I want to make the 3D data of the city available as open data (see data section for already opened data), so I can **engage the techie community** and students to enrich the data and develop new services with the data. The city balances the relevance of opening the data with policy objectives, the price, the relevant level of granularity and so on.	P8
As an urban planner or 3D expert I want to **import/export the 3D buildings or objects (incl. high-resolution 3D models of selected public buildings or areas**, e.g. the cathedral or football stadium) from/to the Digital Twin so I can further enrich and keep the Digital Twin up to date.	P9
As an urban planner, I want to understand **trends in the historical noise levels** (at various spatiotemporal resolutions) and predict/model future scenarios, with the goal to take measures to reduce noise levels (such as sound walls, rerouting traffic, green space, physical interventions, noise absorption materials).	P11

Table 3: overview of selected Digital Twin use cases in Pilsen.

3.2.1. Exploitation Scenarios

The different Digital Twins were identified as Inside-In Digital Twins (use case G1, G2 and P11), as Inside Out Digital Twins (use case G4) and Outside-Out (use case P8 and P9) in figure 8. This means that in the Inside-In and Inside-Out, the data sources were located in the government, while for the Outside-Out use case (use case P8 and P9) the data sources came from the ecosystem. The use case G1, which is based on the traffic model, is already finished, while the other use cases will be developed throughout the DUET project. Similar to other Digital Twins, the traffic model might be improved by adding external data sets (for use cases G1, G2, G4 and P11) and complemented with air quality data (G2 and G4) and noise data (use case P11). In use case P8 and P9, the city aims to develop a community of contributors who can add 3D data sources to the model, thus engaging with the ecosystem (the model will be used by the government and ecosystem, and the data sources will be based on the input of the community and on the governmental 3D data).

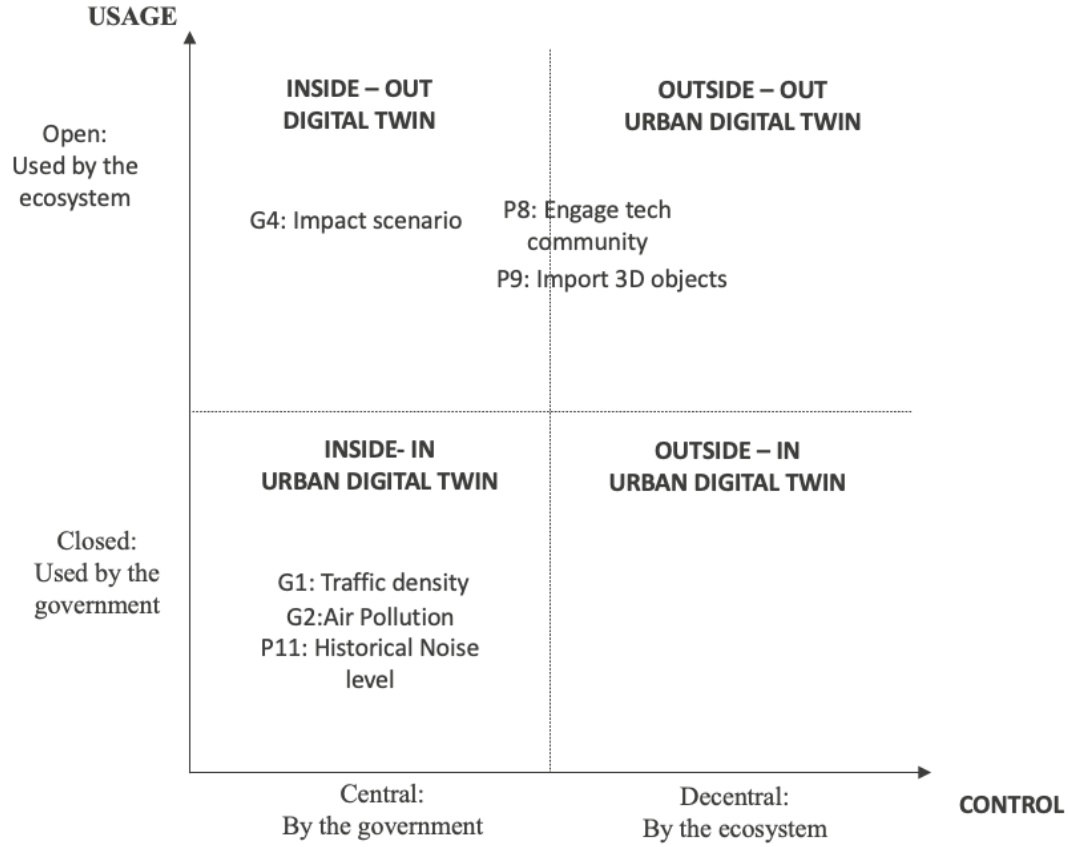

Figure 8: Pilsen use cases exploitation scenarios.

3.2.2. Exploitation Challenges

Integration Policy Process

The use case G1 is currently already finished, and it can be used by the urban planning department, and has support from politicians in the city, but is not yet utilised by the governmental officials who need to integrate the use case into their daily work. As it requires changes in their current workflow, this implementation time, even though it has been used as a tool for planning the renovation of a tram depot. Thus, the user-friendliness of the Digital Twin, as developing training for the teams who will implement the use cases are still required in the following stages.

Data Governance

For the development of the Digital Twin, the Pilsen pilot site relies on a traffic model (use case G1,G2, G4 and P11), and will develop a noise (P11) - and air quality model (G2 and G4). The models are developed in other teams besides the team building the Digital Twin. Additionally, it will develop a 3D model for a 3D community (use case P8 and P9).

Traffic Model Use case

Use cases G1, G2, G4 and P11 make use of the traffic model. Currently, the traffic model makes use of records from traffic sensors. It is focused on the main streets and roads of Pilsen. The traffic model has been adequate and usable, but there is still room for improvement. Some data sets are already present for which connectors need to be built, and the data sets need to be validated on whether they will be useful. In the future, the team responsible for the traffic model in Pilsen wants to add more sensors, ANPR cameras and free-floating car data as an input to improve the dynamic generation of the model. The free-floating car data is acquired through a tender by the Czech national government, and each city can use of this data if they apply. The floating car data provides data on speed, and it supports the use cases utilising the traffic model. The city will also investigate to include ANPR cameras or data from mobile operators, which will need to be acquired. The ANPR and mobile data will need to comply with the GDPR, so therefore, certain data will need to be aggregated and anonymised. For the use cases where there will be simulations on closed roads (use case G1 and G2) data of the government on which roads need to be closed still need to be provided by the relevant department.

Air Quality model

The air quality models (used in G2 and G4) are based on the traffic model. Thus, limitations of the traffic model will also apply to the air quality model. Additionally, as the traffic model is based on free-floating car data, it does not incorporate public transport data, data about factories. The data is calibrated based on six air quality measurement stations in Pilsen, which provide high-quality data.

Noise model

The noise models (used in P11) are also related to the traffic model but more complicated as no sensors capture noise. This could be solved by simulating noise based on traffic models. Nevertheless, this would only include the noise of cars passing. Thus, it might also include, e.g. timetables of public transport to simulate passing trams and trolleybuses. Second, for use case P11, the city also would like to integrate 3D objects (such as a sound wall, change traffic flows, green spaces,..) to model the impact of urban planning changes. Therefore, data of new objects need to be included, by e.g. the urban planning department, architects,... on the data regarding these objects.

3D model

The city will also build a 3D model, especially for use cases P8 and P9. Therefore, there is the need to define the 3D data formats used in the model. In the 3D model, it will be possible to remove or add objects. Standards on the formats which will need to be importable are required. The model will also enable different actors to add 3D objects into the 3D model of the city of Pilsen. Therefore, the 3D model will need to only import one object instead of the entire data sets. The 3D formats will need to be interoperable with the BIM models in the architecture sector and real estate community in Pilsen, enabling them to update data in the model.

Open data

In the use cases G1,G2, G4 and P11, the traffic model used is open data, as long as the city signs a contract with the Czech national government to open the free-floating data. Thus, the data can be opened to the public, even though only actors who have signed the contract can access the APIs.

In the use cases P8 and P9, the city has acquired 3D data to enable the city's visualisation. When opening this data to the public, the city will need to balance the relevance of opening the data with policy objectives, the price, the relevant level of granularity. The data was purchased from a public procurement tender. The price offer depends on the license one has as a city to use the data (own use or to make it available for other partners). If a city wants to make the data open and freely downloadable, the company will not be able to sell this data anymore, thus comes with an additional cost for the city.

Ecosystem Governance

In use case P8, the city of Pilsen aims to support technical education, start-ups and business education by allowing the community to utilize the 3D data model, in, e.g. the school program or in hackathons. Also, real estate investors could promote their data through the 3D model. The city has purchased 3D data, and the city aims to open this data to make it downloadable by anyone in the open data portal. This way, people could play and enrich this data, build their own 3D models, and import their 3D objects to the main city model. To enable this, ecosystem governance is required to approve that a contributor can publish something, to control and approve the quality through a process that still will need to be developed. A benefit for the Digital Twin team is that this way, data could also be enriched through the contributions by the community. The city will start with designers and start-ups who can add the data to set up the community.

Use case P9 has a similar goal, as different players in the community could add 3D objects. It would be possible to update one 3D object in these use cases instead of an entire dataset. This way, the 3D model can also be maintained by the community, example given by 3D start-ups, architects, external companies who have access to many data, which can be helpful in the 3D model. This will reduce the need for the 3D model team to maintain the datasets. It also should be possible to make simulations by adding and removing 3D objects in the current model.

3.2.3. Exploitation Scenarios and Conclusion

Figure 9 shows the different focus areas on which the Digital Twin of Pilsen will focus if it wants to exploit the outcomes of the different use cases. In the Pilsen Digital Twin case, the different use cases were inside-in, inside-out and outside-out Digital Twins.

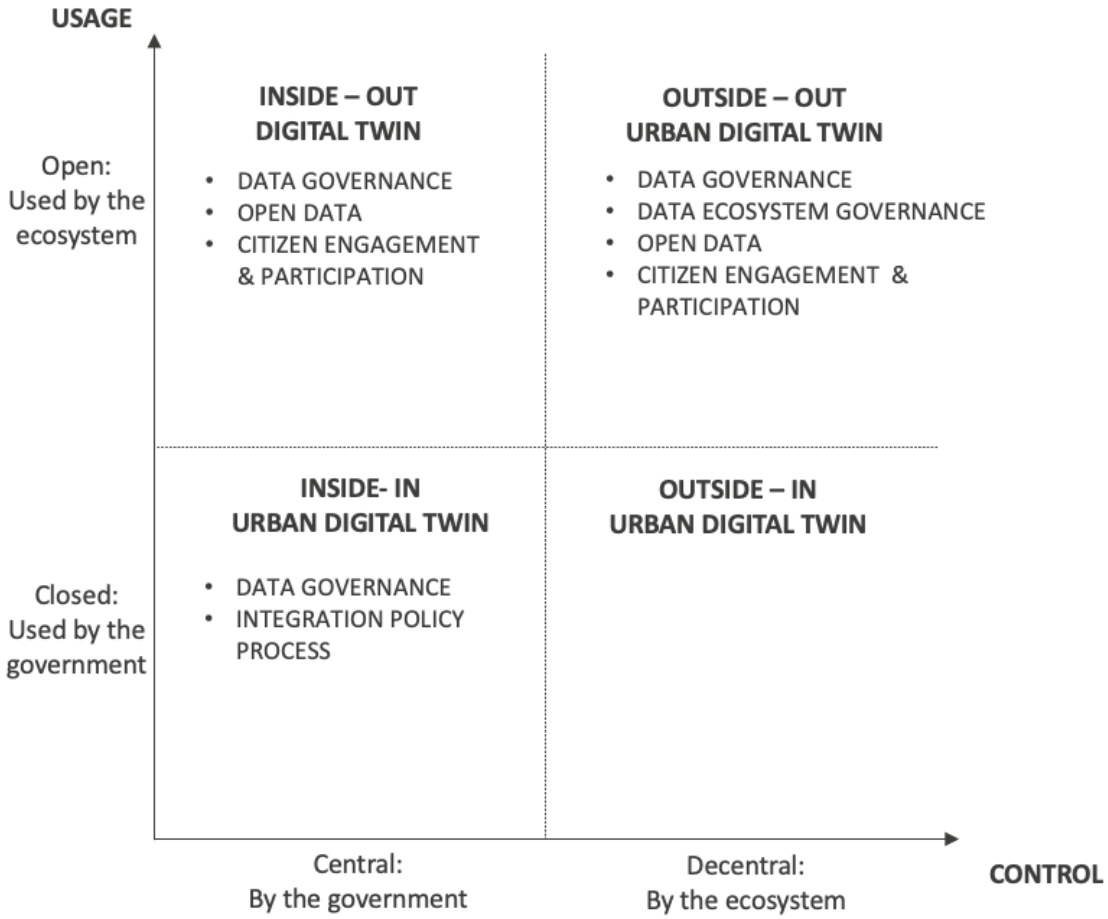

Figure 9: Pilsen use cases digital focus areas.

In the Pilsen Digital Twin, data governance will be of significant importance and a building block for all the use cases. Additionally, once the Digital Twins are ready, the integration in the policy processes of the governmental users will be of high importance. The first steps to make the Digital Twin used is to focus on ensuring that the city officials will use the Digital Twins more in their daily tasks. This will be done by sharing the Digital Twin results as much as possible to integrate them into the policy process.

As this digital twin aims to engage citizens and the data ecosystem to a large extent. It is good to present such a solution of the city to the public and engage citizens with the Digital Twin development. It also will help to ensure that the community will maintain the 3D data model. This will result in the governance of the ecosystem and the engagement of the citizens.

3.3. Athens Pilot Site

The following use cases were discussed in the exploratory workshop with the Athens pilot site**.**

Use Case	Epic
As a public servant of a relevant department (mobility, urban planning and environmental department,...) I want to see the **difference in density of traffic in the area of interest** of a scenario where I closed traffic in a set of roads versus the base density, so I can assess the impact of changes in the traffic in my area of interest	G1
As a public servant of the mobility or environmental protection department, I want to know the **level and impact on air pollution when certain roads would be closed** so I can discover causes of air pollution and the impact on citizens' well-being in the city	G2
As a citizen, I want to understand the predicted **impact of scenarios related to new city developments**, calculated under the what-if analysis functionality, so I can give feedback on scenarios	G4
As a citizen, I want to express interest as a **volunteer tester of green routes proposed by the city** so I can validate the expected results and contribute prior to the planning of my city.	G13
As a city official, I want to see the **public transport in the city** based on static datasets (Urban transport datasets includes timetables, routes and locations of stations) so I can assess the situation and elaborate on new strategic plans for interconnecting public transport	A1

Table 4: overview of selected Digital Twin use cases in Athens.

3.3.1. Exploitation Scenarios

The different Digital Twin use cases in Athens were identified as Outside-Out Digital Twins (use case G4 and G13) and as Outside-In Digital Twins (use case G1, G2 and A1) in figure 10. This means that in all the use cases the data sources were located in the ecosystem (in the Athens case, several data sources were governmental, while others are foreseen to be purchased or located in the ecosystem). This was due to data availability, as the city needs to gather data from external sources. This will be further discussed in depth below.

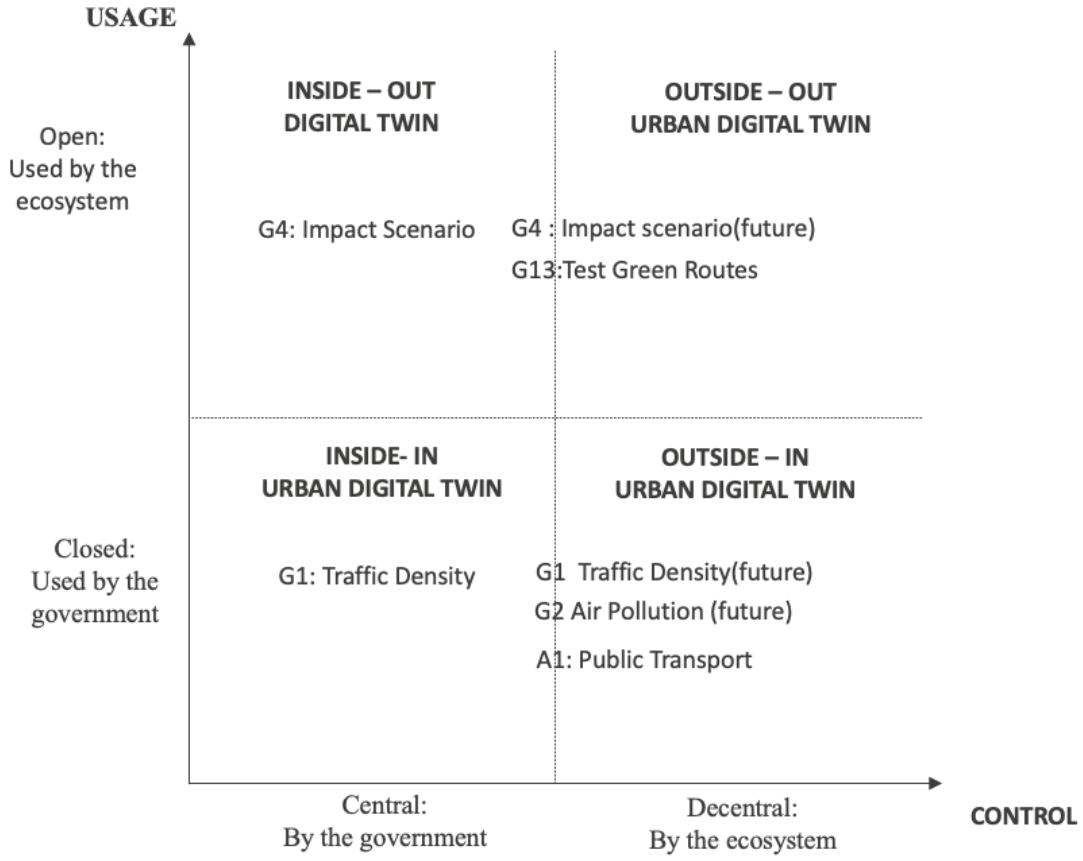

Figure 10: Athens use cases exploitation scenarios.

Initially, the Athens pilot site will focus on use cases G1 and G2. They both are based on the traffic model, which is the main bottleneck since it is under development from DUET technical partners. Therefore, DAEM aims to facilitate the development by purchasing external data sources (purchased from companies) and using datasets available from the ecosystem, next to the governmental data. Also, use case G4 follows on use cases G1 and G2, as it requires opening up the data from use cases G1 and G2. Therefore, the use cases G1 and G2 need to be ready before this use case can be launched.

Use case G13 (referring to citizens voting on green routes proposed by the city) is specific to the pilot site of Athens and is thus of high importance for future exploitation by the city. There is much buy-in from the urban planning department, as this use case can provide an additional tool in citizen participation for urban planning projects. Also, use case A1 is specific for Athens (visualising public transport for strategic plans). This data is available and mainly (semi-governmental), and thus it does not expect significant hurdles.

3.3.2. Exploitation Challenges

Data Governance

DAEM aims to propose the Digital Twin concept in the city of Athens through participation in the DUET project. Thus, this concept is highly innovative for the Athens city-ecosystem. Therefore, a lot of attention and challenges occurred in identifying and locating the data within sources that are either governmental, municipal or publicly available at a national level with open access. Many data within the city are not ready to be opened yet, as there are different blocking factors regarding data availability from diverse bodies. One of the factors is the scarcity of data sources and the lack of data unification. In order to reach the goal of data collection for the Digital Twin, a unification of the data sources is required with a pool of existing data from various sources. Once the data is available, there have not been any significant issues identified with formatting the data. However, the data is not always up to date, and it is challenging to identify real-time data.

Traffic model

In order to be able to develop use cases G1 and G2, and to a lesser extent use case G4, the traffic model of Athens is a core challenge. This is currently still under development from the technical partners of DUET. At the moment, there is a requirement to use traffic data from sources beyond the government, as the government data requires to be calibrated. Therefore, the pilot site is looking into open street map data (communities) and purchased data: from private companies to develop a more accurate traffic model for Athens. Not much traffic data was released as open data, and the data could also be outdated data and not real-time data. Since November 2020, the city has daily access to traffic data in the Attica region, including Athens.

Pedestrian routes

In use case G13, essential datasets are about decisions on pedestrian routes that the city elaborates to implement. For this to be implemented, the city has decided on the pedestrian route plans that can be utilized for this use case. The data availability will not be a significant challenge for this use case. Nevertheless, some pedestrian routes are not implemented due to bureaucracy, collaboration with other national organizations, the need for further analysis etc., thus the municipality will need to prioritize them.

Public transport

Use case A1 requires visualising public transport timetables, routes and locations. This data is already available and open, as it is data owned by public-private organisations which operate by the open by default principle. Thus, the data is already available in the central government open data portal.

Open Data

The city of Athens operates under the “open by default principle”. However, the opening of data, in general, is an ongoing process for the city of Athens. Different departments are not always inclined to open data, mainly due to lack of resources, the lack of time, technical challenges and lack of support. Additionally, in some cases, the GDPR legislation might be a blocking reason to open the data. Currently, there are no consequences for departments that do not open the data. However, in cases where training has been provided, the different departments respond. Thus, the available data sets are expected to increase in the future.

If the data is purchased or obtained from the ecosystem, the opening of data could be a challenge as this might require specific licensing for the use of the data depending on the contracts with the providers.

Ecosystem Governance

To date, the pilot site does not predict significant challenges in collecting the data from the ecosystem. In some cases, there might be a need to purchase some data (use case G1, G2, G4), and this will be a matter of negotiating the agreements with the companies. In use cases G1, G2 and G4, the City might also integrate data from OpenStreetmap, which also will not pose significant challenges. The essential criteria will be to create an added value for the companies who want to share the data, as there is no legislation that obliges the companies to share their data.

In case G13 (voting for green routes), the citizens will be involved in a co-creation process with the city. As there are already several citizen groups very active in the city's development, this will not pose a problem to engage them. Citizens can show their interest as volunteer testers for green roads. They can validate the expected results and evaluate the impact that DUET technology is proposing. The citizens will provide feedback/input about their experience, and this will be taken into account before implementation takes place.

Integration in the policy process of the governmental departments

A potential challenge for the use cases might be integrating the Digital Twin in the policy process. This is the case in the use cases G1, G2 and A1. A first challenge regarding the integration in the policy process is the lack of data literacy. Due to this reason, the Digital Twin solution needs to be very easy to use and adopt in the everyday workload. Another challenge is that the introduction of the Digital Twin concept is quite innovative and new for the city officials, and it may not be easily adopted.

Therefore, the city of Athens performs a consultation for the visualisation/interface with the city officials. In this consultation cycle, it is essential to identify to which extent the use of the Digital Twin will be a burden for the officials and how the process can be included in their daily tasks. It is also aimed to provide tools to support the officials regarding training and documentation.

3.3.3. Exploitation Scenarios and Conclusion

In order to implement the Digital Twin in the Athens pilot site, different challenges need to be overcome, which will be the core focus of the Digital Twin for the coming months. In Athens, the Digital Twins are mainly Inside out Digital Twins (and might be Outside-Out when data is purchased or utilised from the community) and Inside-In (or again Outside-In) if purchased data is used. Figure 11 gives an overview of the major focus areas for the Digital Twin in Athens.

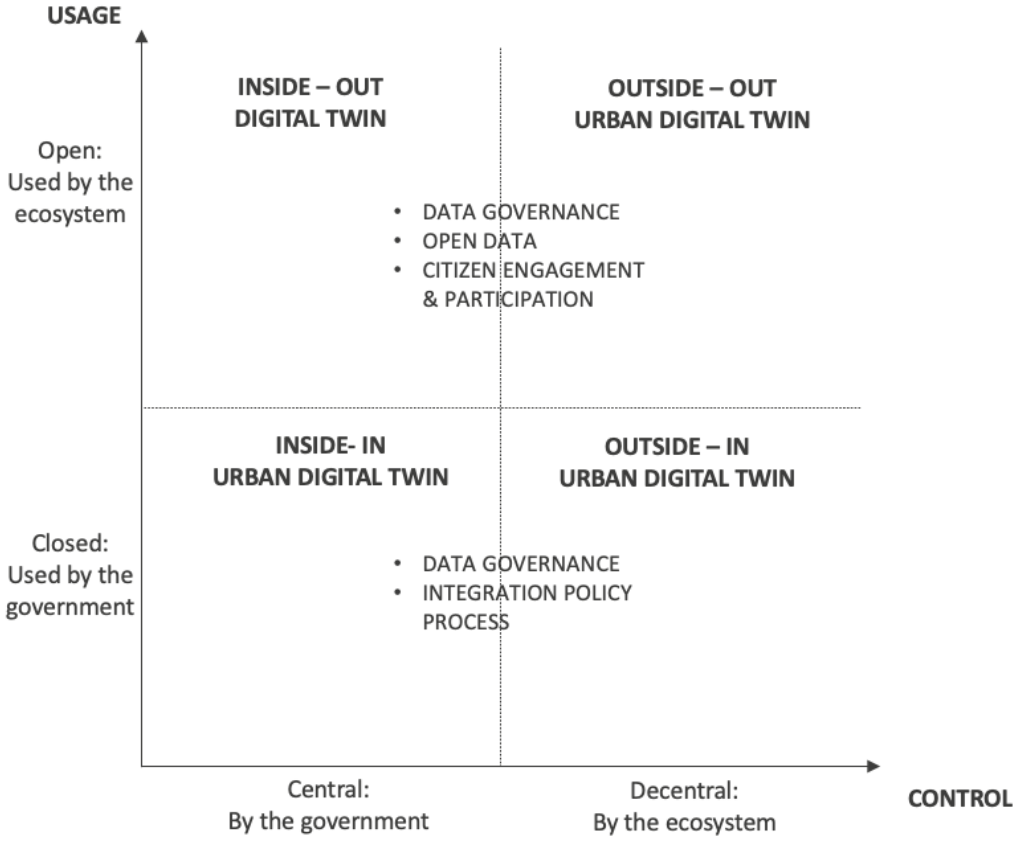

Figure 11: Athens use cases digital focus areas.

The main focus of the Urban Digital Twin will be to ensure the availability of the data for the Digital Twin to ensure that most of the data will be opened for the public and for internal use. Therefore, the city aims to look as much as possible at opening the data in internal data sources, and where needed, it will extend the data availability through data from the ecosystem or through purchased data.

Another crucial focus for the city will be integrating the Urban Digital Twin into the policy process, as different departments might be interested in utilising them, but user-friendliness and integration in the daily tasks will be crucial.

The engagement of the ecosystem will be essential, as different use cases require the active engagement of citizens in the process to provide feedback. Thus, collaboration over the borders of the Urban Digital Twin is of high importance.

4. DUET Exploitation Roadmap

Figure 12 provides an overview of the DUET roadmap for exploitation of the Digital Twins. The different types of Digital Twin use cases provide focus areas that can guide Digital Twins to design their Digital Twin. The focus areas depend on the type of Digital Twin.

The base building block for each type of Digital Twin is **data governance**, which ensures data quality, collaboration, organisation, and standards for implementing the Digital Twin.
It also needs to ensure a 3D data infrastructure that can be implemented in all use cases.

In the Digital Twins that are utilised within the government (Inside-In and Outside-In), another focus is the integration of the Digital Twin in the **policy process** of the city. For Digital Twins, which are opened by the ecosystem (Inside-Out and Outside-Out), this requires efforts in **engaging the citizens and participation**. Cities need to make sure the government's role is defined, engage the citizens, ensure a neutral role, and make sure the data is qualitative, as it can become part of the crucial societal discussion. Additionally, these Digital Twins need to ensure the **data can be opened**. If a city operates on "open by default" principles, this is mainly centred on operationalising these principles.

For Digital Twins where the ecosystem controls the data, another main focus area is to ensure the **data ecosystem governance** - to ensure the data can be shared, to determine different roles in the ecosystem and to ensure the trusted facilitation of data sharing.

The development of a Digital Twin should not be seen in isolation of one single city, but in some cases (especially in Flanders) this needs to fit within the development of the entire region. Therefore, **a regional collaboration** between different governmental levels (regional government, local governments) is required. This can be done by agreeing on standards, sharing and opening data, knowledge exchange, and standard procurement practices.

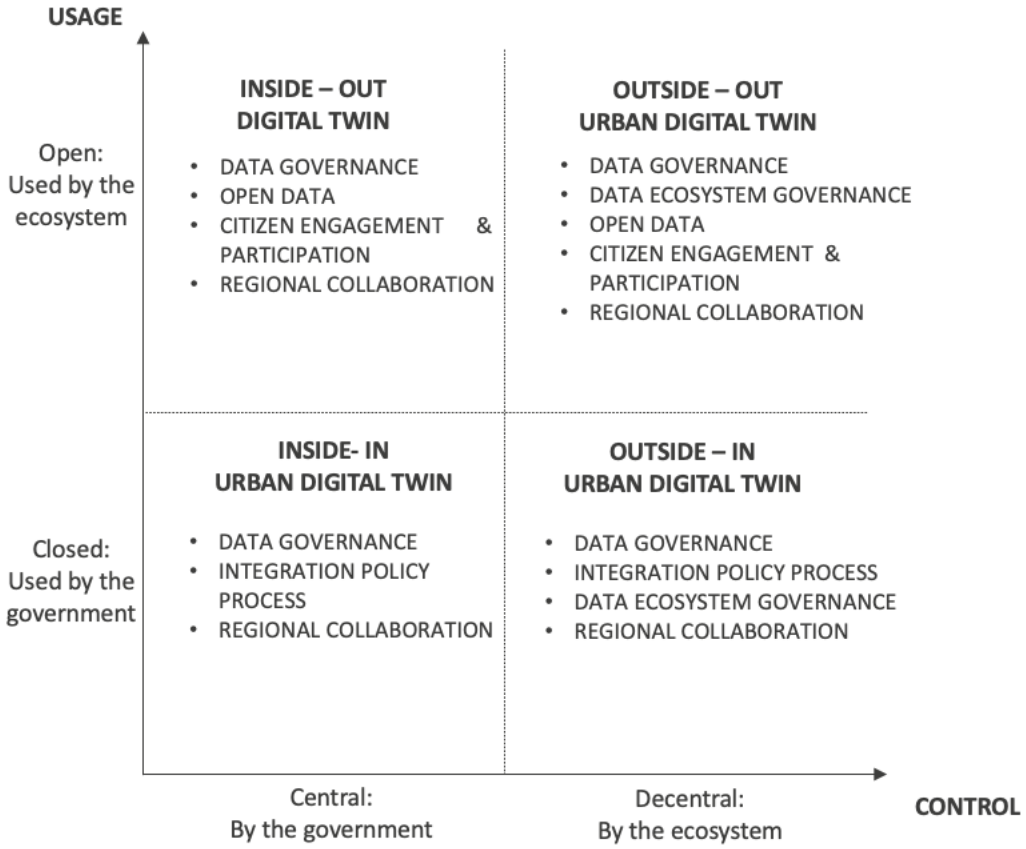

Figure 12: DUET exploitation roadmap.

5. Exploitable results beyond the consortium

The main exploitable results beyond the consortium are the Digital Twin solution, e-book, online course, policy brief and the starter kit. These will be based on the further outcomes of the exploitation scenarios of the pilot sites and other deliverables within the project.

The exploitation aims to stimulate demand among various stakeholders who may be interested in adopting DUET's approach. Because needs are an appreciation of the benefit associated with a particular tool or asset, we would like to describe the added value that our solution may bring to potential adopters in the next few paragraphs.

DUET provides a digital replica of the city, its many processes and dynamics. It allows for integrating various data streams to facilitate decision making across disciplinary boundaries within city administrations. The merging and calibration of multiple data resources in a single environment ensures that they are up-to-date, interoperable and include all the attributes necessary for both effective operational decision making and longer-term policy planning.

Policymakers and their support staff can perform different types of analyses (trend analysis, what-if analysis etc.) to inform urban planning decisions. Analytical insights can facilitate a better understanding of the impact different measures/factors may have on outcome indicators (e.g. noise level), enabling users to select an optimal intervention strategy in some sense (e.g. sound walls, green space).

Digital twins can also raise awareness about new environmental initiatives (e.g. green routes) and eventually stimulate change in citizen attitudes and behaviour.

5.1. Digital twin

Our Digital Twin is a digital replica of urban systems and processes created as a decision support tool for policymakers. Other potential beneficiaries include journalists, citizen scientists, researchers and NGOs.
DUET is a use case driven project. We use actual data to address real-world problems, not some experimental datasets to answer abstract research questions detached from reality.

The project offers a scalable solution to advance policy-making on different levels (town-level, city-level, regional-level). The primary architecture is built using international standards, such as those curated and developed by OASC, OGC, and FIWARE, for greater interoperability. This means that our Digital Twin if transferred to a new context, can be easily integrated with pre-existing systems and services so long as they comply with similar frameworks.

The modular architecture supports experimentation with different models in a 'plug-and-play' fashion. Models can be added or removed based on need, enabling users to explore causal links between different phenomena under investigation, e.g. how changes in traffic affect air pollution and noise level. If the architecture is modular, it means it is reusable. Another city could use it as a basis even if they had to replace all the models. This could be a faster and safer way to go than to start from a blank sheet of paper.

Unlike other local Digital Twins, DUET's solution is accessible to the wider public, including citizens. Users can upload datasets and visualise them on a map along with other sources to provide a multi-dimensional view of the city's dynamics. This option is handy for citizen scientists who often collect large amounts of data on traffic and air quality but do not necessarily have the means to disseminate their findings to a broader audience.

Given its degree of openness, the DUET solution must comply with strict privacy and security requirements. To that end, and in order to make DUET compliant with the GDPR, we provide dynamic consent management whereby users can not only see which Digital Twin services use their data but also grant or revoke access to it as they wish.

The Pilots of Athens, Flanders and Pilsen are the main beneficiaries of our Digital Twins. If we are to succeed with our exploitation efforts, pilots should continue using the technology after the project has ended. For this to happen, our Digital Twins must be valued by end-users they were designed to help[1]. The Digital Twin needs to be valued by the municipal leadership so that they will continue using it, even after the close support of the project has ceased and even after the key individuals involved in the project have moved on.

To achieve this, the solution must be advanced enough to provide credible findings but not so complex that it becomes hard to manage for people and computers. Pilot leaders, for their part, must ensure they provide enough opportunities for the priority groups to test the technology and provide feedback on both usability and usefulness of results while the project is still running. Such an iterative way of working will enable the technical teams to make the necessary improvements in line with user requirements before the final solution is rolled out for public use.

As regards other stakeholders, pilots should raise awareness about Digital Twins in their national language, inviting journalists, academics, researchers and many others from the value network to try out the technology and contribute to local Digital Twins as data providers. It is advisable to use an influence-interest matrix throughout the stakeholder engagement process. The idea is to classify stakeholders according to their interest in the subject and influence over processes, e.g. policymaking and data collection. It will help identify key stakeholders that should be targeted (e.g. high interest, strong influence) or modified (e.g. low interest, strong influence) by attempting to increase their level of interest. Ultimately, this would ensure that relevant people are surveyed, interviewed, invited to the workshops and other activities.

[1] Priority groups are senior policy makers, civil servants, department managers and their support staff that have to deal with issues like traffic, air and noise pollution.

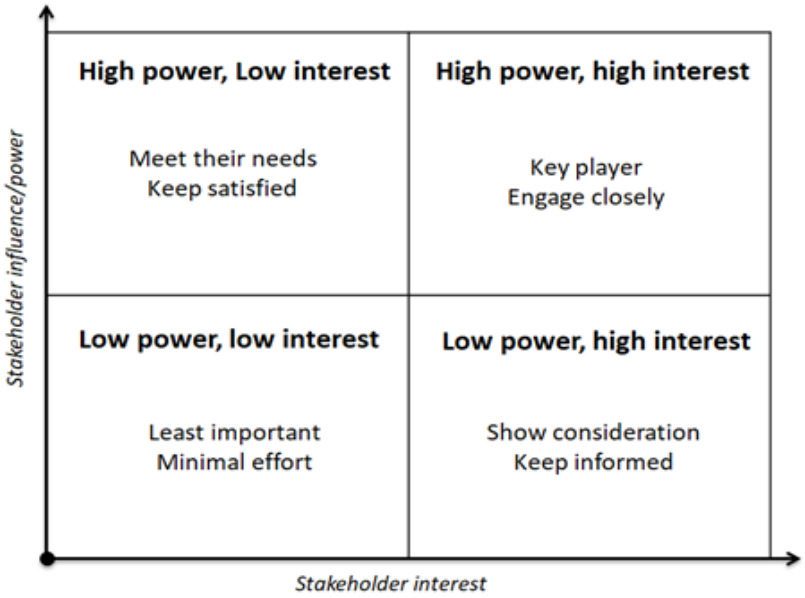

Figure 13: influence/interest matrix.

5.2. Book

The book is one of the main non-technical results that we will use as a medium for knowledge sharing and issuing practical recommendations. This will be a digital book containing text, images and links to datasets used in DUET Digital Twins. We are considering two e-books, one self-published on Amazon, another published through Springer.

With Amazon's self-publishing services, we can keep control of our work and reach millions of readers worldwide through Amazon.com and Amazon's European websites. Amazon provides free building tools. Publishing on Amazon is relatively easy; the whole process takes only a few minutes; the book then appears on Amazon sites within a couple of days. Additionally, the book can be optimised for all Kindle devices and free Kindle reading apps.

Another alternative is to publish the book through SpringerLink as Open Access. There are certain benefits associated with this route. For instance, SpringerLink receives around 285 million visits each year from 127 million unique visitors[2]. In addition to SpringerLink, the book can be listed on Web of Science, Scopus, OAPEN Library, Directory of Open Access Books, and PubMed's NCBI Bookshelf. Inclusion on these sites can significantly enhance the visibility and discoverability of our work.

Readers can access the research free of charge in PDF, ePub and HTML formats from SpringerLink and through other platforms and indexers that Springer partners with, including MOBI through Amazon.
The book will be peer-reviewed to ensure that published research is rigorous and meets international quality standards.

[2] https://media.springernature.com/full/springer-cms/rest/v1/content/15297600/data/v4

The target audience for the book is similar to audiences identified for other results. With the book, however, we are aiming at a more geographically diverse readership. In particular, open access can help reach wider audiences in regions where people may not be able to afford a print edition. Additionally, we hope that our open access book can pique interdisciplinary interest in our work. For example, the Digital Twin concept is gaining popularity in new areas like rural development and cultural heritage. So, potentially we may see interest in DUET's framework from rural/mountainous regions, museums and creative industries, to name just a few.

It remains to be seen whether two books will be published or just one. At the moment, preparations are being made to submit a proposal to Springer Nature. The working title is "Open and Interoperable Urban Digital Twins for Smart Decision Making."

The book includes ten chapters divided across three parts. The outline below is preliminary and subject to change.

Part 1: Digital twins for policymaking

This part will start with a definition of Digital Urban Twin, aiming to answer what the concept means and how it can create value for government, industry and society. From a policy perspective, the main question is how the technology can contribute to the policy cycle and support decision making in the short (operational) and long term (planning) while breaking down institutional and technological silos?

- Chapter 1. Digital city twins: desires, expectations, challenges and drawbacks
- Chapter 2. Digital city twins: a tool for advancing evidence-based decisions and forward-looking policies
- Chapter 3. Breaking down the silos: Digital urban twins and the use of unified interactive models
- Chapter 4. Implementing citizen-centred Digital Twins

Part 2: Implementing a reusable Digital Twin

This part focuses on the different building blocks required for the creation of Digital Urban Twins. It will present the added value of semantics and the role of open, interoperable standards, such as those developed by OASC, OGC and FiWare, in facilitating the adoption of technology by cities worldwide. Additionally, it will explain the importance of event exchange amongst models, design principles and implementation frameworks for open and proprietary frameworks.

- Chapter 5. Interoperable Digital Urban Twins
- Chapter 6. Towards an open architecture for Digital Urban Twins
- Chapter 7. Big data exchange and the design of interoperable model standards
- Chapter 8. The role of standards organisations

Part 3: Business models for re-usable and open Digital Urban Twins

The final part will give an overview of business models and exploitation scenarios for Digital Twins that can lend continuity to the technology. Here we will present the DUET exploitation framework designed to help cities big and small readily deploy the Digital Twin technology in a cost-effective way to achieve their policy objectives.

- Chapter 9. Business models for open and reusable Digital Urban Twins
- Chapter 10. Implementation examples from DUET pilots

5.3. Online course

The course will be a learning resource for anyone with interest in Digital Urban Twins. To the best of our knowledge, no course on Digital Twins, let alone local Digital Twins, has yet been published. This gives DUET a first-mover advantage, which, if leveraged effectively, will make DUET an authoritative voice in this field. We intend to make the course informative and fun. Different formats will be used (textual, audio-visual), and we will add various interactive features, such as forums and quizzes, to improve the learning experience.

The course's structure and content will be developed later in the project. In this paragraph, we simply want to give a flavour of the kind of topics we would like to explore. For instance, it may be beneficial to start with a critical review of the Digital Twin concept, stressing that hiding behind the buzzword is an umbrella term that brings together several mature technologies which became fashionable in the last decade or so, e.g. IoT, smart city, data visualisation, HPC. A brief literature review focusing on current Digital Twins in cities like Helsinki, Antwerp, Vienna and Amsterdam can help set the context and better position DUET in the local Digital Twin market. Once this is achieved, students can start learning about the project and its implementation in Athens, Flanders and Pilsen. The introductory part can be followed by more topic-specific modules dealing with the technical architecture, domain models, interoperability standards, data privacy and security.

We think DUET's course will appeal to various audiences, including policy officers, urban planners, researchers, students, academics, journalists, citizen scientists and consultants. The course will be published on CxC Academy[3] managed by OASC to reach the main audience in cities, towns and rural areas across the EU and beyond.

[3] https://citybycity.academy

5.4. Policy brief

The policy brief will be a short note summarising DUET's approach to urban challenges using Digital Twins, complete with recommendations for data-driven policymaking. Our policy brief will explore how local Digital Twins can be used to address urban challenges related to traffic, air and noise pollution. Its primary audience is government policymakers and others interested in formulating or influencing policy.

Policy briefs come in different formats, ranging from one-pagers to longer briefs of up to 3,000 words. Our deliverable will fall somewhere between these two extremes. Even with 5,000 words, it will not be possible to cover everything in detail. So, our brief will be short and to the point. It will share information on different alternatives (e.g., IoT testbeds, visualisation dashboards), but will provide evidence using international best practice to support one specific option, i.e., Digital Twins. While we are going to argue in favour of Digital Twin adoption, the brief itself will be objective in that we will try to give balanced information for policymakers to make up their mind. For instance, as well as highlighting the benefits of Digital Twins, we will explain why their successful implementation can be challenging, e.g. issues with data governance, cost, lack of IT infrastructure, skills.

As well as using official project channels to promote the brief (e.g., project website, newsletter, social media), we will leverage the channels of our partners, as well as third-party sites (e.g., Cordis, Zenodo, Horizon Results Platform) to reach wider audiences and maximise impact.

5.5. Starter kit

The kit serves as a capacity-building tool for those who want but are unsure how to start an urban Digital Twin project. It is not a single resource but a collection of different components that will be carefully curated to provide valuable tips and advice for would-be adopters. For example, there will be an FAQ section answering questions like "Where do I start?" Public administrations that believe a Digital Twin solution is exactly what their city needs should determine what type of a Digital Twin is needed. Some cities may require a digital replica of infrastructure objects. Some may want to see energy, traffic and pollution all simulated in a single environment. Others may already have a large-scale IoT testbed, so for them, a health-oriented Digital Twin could be a priority. Once this is settled, stakeholders will have a better understanding of what information is needed to power the digital twin and, based on that develop an appropriate data governance strategy. This is just an example of the kind of answers we may provide in this section.

In addition to the FAQ pages, there will be a section on essential ingredients needed for a digital urban twin. Here, we would like to use interactive graphics to explain better the contents and relationships between the following: data governance, simulation models, interoperability standards, data visualisation, stakeholder buy-in, ethics, privacy, and security. Regarding non-technical elements like ethics, privacy and security, these are essential to a successful Digital Twin. Giving other municipalities a "starter" may accelerate their Digital Twin adoption more than technical elements. Ethics and privacy debates could hold up project initiation by months (or years!), whereas once the policy approval has been given, the technical elements tend to be solved relatively quickly.

Some people may browse the kit to find tested and validated use cases demonstrating the benefits of urban Digital Twins. To meet the needs of these visitors, we are going to maintain a curated collection of best practice examples from DUET's pilot locations and beyond. For our case studies, we will provide additional information in the form of inspiring interviews with local policymakers from Athens, Pilsen and Flanders.

6. Commercialisation

The different commercial partners in the DUET consortium have their own avenues for commercialisation and monetisation beyond the project. This mainly concerns the creation of tools, consulting services, potential spin-offs after the project,... In D7.7 “Business and exploitation scenarios (final)” we will focus on the development of suitable business models for the commercialisation of the DUET tools developed by the different partners. Most of the different partners in the DUET project provide advisory services, which would add Urban Digital Twin services as a part of a broader offering. This will make it easier to bring their expertise to the market but will make the return on investment hard to measure.

7. Conclusion and next steps

The exploitation and commercialisation of the DUET project cover **three different areas**: the exploitation of the pilot sites, the exploitable results beyond the consortium and the commercialisation for the partners. This first version of the deliverable mainly focused on exploiting the pilot sites and providing an overview of the exploitable results beyond the project.

The **exploitation of the pilot sites** is focused on developing value propositions of the use cases in each pilot site and developing an exploitation roadmap to deliver on these promises of the Digital Twin use cases. In this deliverable version, the exploitation roadmap is defined by the main building blocks of the maturity roadmap (as defined in deliverable 2.4 "Cloud Business Model Analysis"). The principal building blocks of the pilot sites are defined in figure 14. The core building block is data governance. Depending on the type of Digital Twin of the use case, the building blocks can be to integrate the Digital Twin in the policy process (Inside-In and Outside-In) or in citizen engagement and participation and open data (Inside-Out and Outside-Out). Regional collaboration is also a crucial building block, which manifests itself in all the pilot sites, but is a significant building block in Flanders.

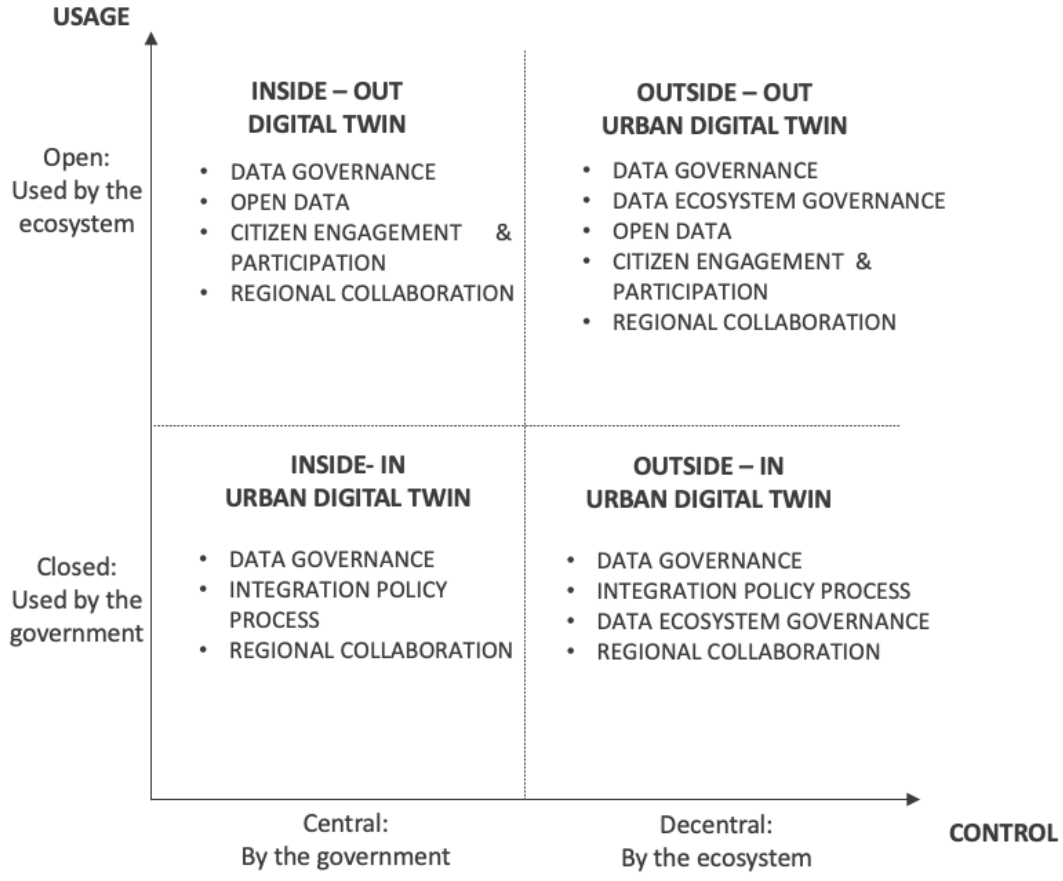

Figure 14: DUET exploitation roadmap.

The next version of the deliverable will focus on the development of business cases of the Digital Twin use cases using the methodology defined in section 2.3 and will elaborate on the developed exploitation roadmap.

The **exploitable results beyond the consortium** are the development of the DUET digital twin solution, the DUET book and online course, the policy brief and the starter kit; These will be developed and elaborated on in the next version of this deliverable. Last, the **commercialisation of DUET** by the commercial partners in the consortium will be elaborated on by identifying the relevant business models for individual partners.

8. References

https://theodi.org/article/the-role-of-data-in-ai-business-models/

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