Deliverable

D6.2 Personalising the Digital Twins

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1.0	31.05.2021	Lea Hemetsberger	OASC	Final Version

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Executive Summary

In the past 6 months since the very first version of DUET has been released (DUET Alpha Version), the project team was focused on personalising the Alpha Version to deliver the next stage of DUET: Connected, but locally different sister digital twins for the three pilot sites Flanders, Pilsen and Athens.

The project has been operating with an agile approach based on the early activities carried out as part of Work Package 2 to work out the user stories based on each pilot's strategic priorities. These user stories have evolved into what we call epics in DUET: Epics are a way to structure the input received from the pilots and organise the technical work. The epics help us to break down work while continuing to deliver the project vision. The project has structured the epics highlighting the primary user group of the digital twin, the expected function, and the expected impact.

Based on the input from the first year of DUET and following meetings and discussions since the Alpha release of both project internal and stakeholders in the pilot regions, a list of generic epics has been defined jointly. These generic epics will be deployed in all three pilot regions. Now, this is where the personalisation of the alpha release comes into play. While the twins are connected behind the scenes to cater for the generic epic, each pilot site needs to feed their local data sources for the twins to come to life. Next to the data sources, the data models to simulate the impact of traffic, noise and air pollution - as expressed the need for in the generic epics - need to be implemented, integrated and connected. This was another focus of the personalisation phase of DUET.

Next to the generic epics jointly developed by all three pilots, Pilsen and Athens additionally have defined pilot-specific epics. These were not yet addressed as part of the personalisation but will guide the way towards the next milestone in about 6 months: The release of the open beta DUET Digital Twins.

Overall, the personalisation of the Alpha Version of the DUET Digital Twin has been going mostly according to plan, with prototypes and proof of concepts now live for the first testing phase, including also non-consortium members. A project wouldn't be a project without occasional hiccups and unexpected challenges. Nevertheless, we have taken the first critical steps in our journey towards a successful European Digital Twin solution - based on open standards, interoperability mechanisms and dedicated cities and regions willing to improve the policy-making process with the support of data and visualisation tools. We demonstrate that digital twins are for every city and region, no matter the size or location. And we are proving that with interoperability and openness as a driving force, we can develop a customisable platform that can be personalised by any city, town or rural area in Europe.

The following report provides an overview of the personalisation journey that we have undergone so far.

1. Introduction

The second year of DUET marks the start of a critical and exciting phase, in which the successfully delivered Alpha Version of the DUET Digital Urban Twin is now being tailored to the pilot cities' and regions' specific needs and requirements, while retaining interoperability and scalability between the Sister Twins. While during the first year, we have thoroughly prepared and laid the foundations for the pilot roll-out of DUET (See D6.1), all preparations now come together for the launch of the Closed Beta Version of the DUET Digital Twin, which will be released in M18 for further testing and improving in the pilot cities' and regions. In the following document, we will report on the activities performed for the personalisation of the DUET Alpha Version.

1.1. Purpose and Scope

This report provides an overview of the work carried out to personalise the DUET Alpha version of the digital twin for each of the three pilot regions and cities: Athens (Greece), Flanders (Belgium) and Pilsen (Czech Republic). The personalisation of the digital twin is rooted in the epics and has focused on the integration of data sources identified in the pilot operations plan (D6.1), as well as the data models provided by WP4 and external stakeholders in each pilot city or region. This personalisation of the Alpha Version of DUET has led to the creation of the Closed Beta Version. The Closed Beta Twin, in essence, is a set of three digital twins, one for each pilot region and city. The twins, however, are not fully separated. They are "digital sister twins" connected thanks to the open architecture (D3.2, D5.1) applying minimal interoperability mechanisms and open standards. What makes them different are the pilot specific data sources integrated and the pilot specific epics.

To map out how we have personalised the Alpha Version, this report will first provide a brief recap of the approach taken to arrive at the generic epics that are guiding the project team in the delivery of DUET Digital Twins. Then, we will also outline the approach used to define the visualization tools for each epic, which was based on the methodology already successfully applied in the [PoliVisu project](https://www.polivisu.eu/public-deliverables)[1]. Then, a detailed account will be given of the generic and pilot-specific epics, data sources integrated, and data models applied. And as a last step, an outlook will be provided on the upcoming testing cycles for the Closed Beta DUET Digital Twins. But before that, we will briefly explain how the work to personalise the DUET Digital Twin links to the work carried out by the other work packages.

1.2. Relation to other Work Packages

As mentioned before, this report provides an overview of how all work packages (WPs) have contributed to the successful personalisation of the Alpha Version and how the outputs have been applied. Therefore, we are outlining the key deliveries of the relevant work packages as well as the WPs benefitting from the release of the closed beta version:

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[1] See deliverable D8.9 White Paper Report (https://www.polivisu.eu/public-deliverables)

- WP2 has provided the foundations for the work to elaborate the epics together with the pilot regions for the DUET Digital Twins particularly through D2.2 and D2.3.
- WP3 ensures the technical interoperability of data, models, and finally, the digital twin solution.
- WP4 provides the user-facing front-end and 2D/3D visualizations, ensuring all data relevant are integrated as well as the interaction of the data simulation models.
- WP5 oversees the overall technical implementation of all components. WP5 and WP6 are closely working together for efficient coordination between technical teams and pilot partners.
- WP7 will promote the advances the team has made by personalising the DUET digital twins to drive further the maximum impact - and replication - of the DUET Digital Twins. The DUET project is already well represented as one of the few projects delivering on the promise of Local Digital Twins in industry as well as policy-oriented events and workshops. Interest is high for DUET from European cities and beyond.

Following the introduction to this report, the approach for the personalisation of the Alpha Version will now be explained in more detail.

2. Approach

The personalisation of the DUET digital twins follows the epic approach: Together with the pilots Athens, Pilsen and Flanders, a set of generic epics have been co-created and prioritised (see Table 1). The epics and their associated user stories have served as a guideline for the technical development of the DUET Digital Twins, i.e. the integration of data sources and data models for each pilot region.

2.1 Generic Epics

The DUET generic epics, which will be implemented in all three pilot regions, are focusing on the mobility and environmental aspects of city management. The focus of the epics is based on the pilot's policy-making priorities. These priorities are pertaining to the improvement of traffic management, impact of urban planning, and reducing noise as well as air pollution. A detailed description of all generic epics is available below, highlighting the main user group (as a...), the function (I want to...), and the impact (so I can...). Table 1 also specifies the envisaged ambition level for each epic. A short definition of the ambition level is provided below:

- A **Proof of Concept** is defined within the DUET consortium as ambition to "show the possibility that it can work without the use of relevant data. The Proof of Concept is software oriented."
- As a **prototype**, we understand "basic functionalities realized, based on available datasets that show the overall reliability in terms software and policy outcomes

In this report, we will focus only on the generic epics which have been further developed and personalised for the beta version and partially for Year 3.

#	Description	DUET Version	Priority	Ambition
G1	**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	closed beta	1	Prototype
G2	**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	closed beta	1	Prototype
G3	**As a** public servant of the mobility or environmental protection department, **I want to know** the level and impact of noise pollution when certain roads would be closed,	closed beta	1	Prototype

	so I can discover causes of noise pollution and the impact on citizens well-being in the city			
G4	**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	closed beta	1	Prototype
G5	**As a** citizen, **I want to** be able to vote and give feedback about scenarios related to new city developments,calculated using functionality based on other epics, **so I can** participate in those designs	open beta	2	Prototype
G6	**As a** citizen, **I want to** see the current traffic flow in the city based on the model and available sensors **so I can** inspect the current traffic density	closed beta	1	Prototype
G7	**As a** citizen, **I want to** see the current noise pollution in the city based on the model and available sensors **so I can** inspect the current level of noise pollution	closed beta	1	Prototype
G8	**As a** citizen, **I want to** see the current air pollution in the city based on the model and available sensors **so I can** inspect the current level of air pollution	closed beta	1	Prototype
G9	**As a** citizen, **I want to** see the historic traffic flow in the city based on the model and available sensors **so I can** inspect the historic situation and evaluate the impact of past measures	Y3	3	Prototype
G10	**As a** citizen, **I want to** see the historic noise pollution in the city based on the model and available sensors **so I can** inspect the historic situation and evaluate the impact of past measures	Y3	3	Prototype
G11	**As a** citizen, **I want to** see the historic air pollution in the city based on the model and available sensors **so I can** inspect the historic situation and evaluate the impact of past measures	Y3	3	Prototype

G12	**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	Y3	3	Prototype
G13	**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.	closed beta	1	Proof of concept
G14	**As a** citizen, **I want to** have the possibility to contribute with data I can collect, **so I can** provide more data sources	Y3	3	Proof of concept
G15	**As a** DUET admin, **I want to** be able to **connect** data sources **so I can** be sure that the necessary data and information is available	open beta	2	Prototype
G16	**As a** DUET admin, **I want to** be able to **restrict** the access to data sources **so I can** be sure confidential data is not made publicly available	open beta	2	Prototype
G17	**As a** citizen, **I want to** **see** only the data sources that are relevant **so I** don't see confidential information	open beta	2	Prototype
G18	**As a** DUET admin, **I want to** be able to monitor platform status **so I** can adjust resource allocation and investigate logged errors or misuse	open beta	2	Prototype

Table 1: DUET Generic Epics - Overview & Expected Delivery.

In this first phase to personalise the Alpha Version, only consortium partners have been involved in the co-design activities. The pilot partners have been aligning internally to provide feedback and input where necessary and requested. As part of the continuous evolution of the DUET Digital Twin solution, more partners external to the project will be invited to testing and co-design activities. The specific next steps will be elaborated in chapter 4.

As part of the agile approach that the DUET project is applying to deliver the best possible Digital Twin solution. The DUET consortium partners have provided constant feedback following open sprint meetings, where the latest developments have been presented to the DUET pilot partners. An open feedback from (link) allowed for lightweight, fast and structured input from pilot partners for the technical partners.

Additionally to the regular, bi-weekly pilot calls the project has instigated from Day 1, co-design sessions with each pilot partner were organised in January 2021 with Athens and Pilsen (26 January 2021) and Flanders (25 January) to further refine the generic and pilot specific epics. Generic hereby refers to cross-pilot epics, while pilot specific epics are only deployed in one (or maximum two) DUET pilot regions and cities. In addition to the meetings among project members mentioned before, the pilots have also regularly met with internal stakeholders to further refine the user stories and define the final epics - both generic and pilot-specific.

In order to receive structured input from the pilot partners to define the epics, a specific approach has been adopted. The six steps that this approach comprises will be described in the following section.

2.2 Towards Visualization: An Approach in Six Steps

The methodology to break down both the pilot-specific as well as the generic epics into actionable work items and essential building blocks is based on the already successfully applied 6-Step approach, which has been used for the PoliVisu H2020 project.

2.2.1 Methodology

The methodology helps to select the appropriate visualization for the selected, pre-defined epics. After selecting the epic (Step 1), the goals for the visualization are elaborated (Step 2). From there, the data needed (Step 3), techniques for visualization (Step 4) and functional specifications (Step 5) are formulated, before a set of visualizations can be defined (Step 6) to achieve the previously defined visualization goals. The methodology can be combined with a co-creation process. This 6-Step-Approach is broken down and explained in Figure 1 and in detail in the following:
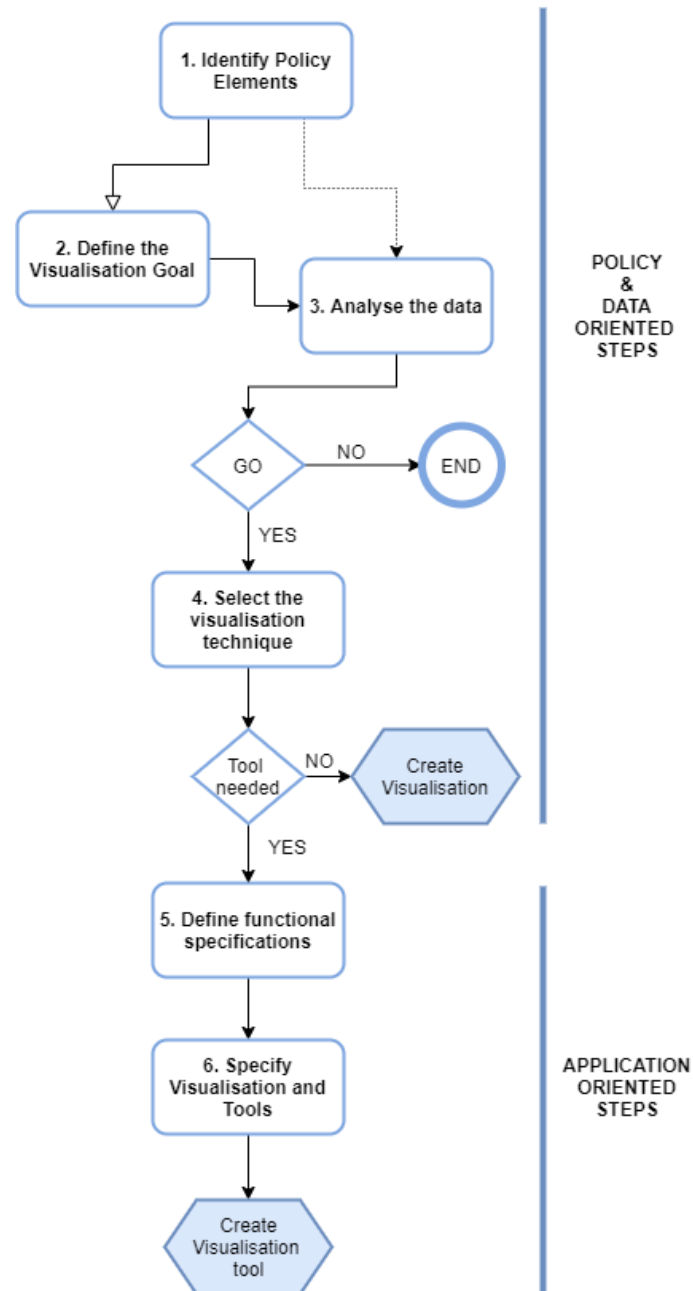
Figure 1: Approach towards Visualization - Flowchart.

Step 1: Identify Policy Elements

The "Identify Policy Elements" will set the starting point for the visualisation clear from the start. This starting point, called a policy element, in DUET can be a problem[2], a goal[3], an objective[4], a strategy[5] or an action[6]. These elements are entities from the policy domain model that require information. This requirement can be for policy agenda setting, for policy design, for evaluating different options, for persuading policymakers or the public, etc.

Identifying policy elements can be part of the agenda-setting process in a co-creation session. In DUET, defining policy elements was part of a joint exercise with city stakeholders previous to the visualisation methodology.

Step 2: Define the visualization goal

As a second step, we formulate specific visualization goals based on the identified policy elements in step 1. In this step, we avoid references to implementations and visualization techniques but instead focus on what information the visualization should provide and what knowledge is there to be gained, rather than how the visualization will provide it. The visualization goal defines what knowledge is displayed, not how it is structured. To arrive at the visualization goal, a set of questions has been used and tested. Six questions were considered as most relevant in the definition process:

- What need for information does the visualization fulfil?
- What values and data dimensions are relevant in the visualization context?
- What relationships need to be communicated?
- What action will be taken if the information required is met?
- What is the intent of the visualization (informative or persuasive)?
- What is the targeted audience of the visualization (experts, public, policymakers)?
- What is the reference framework behind the visualization (is the visualization language in line with size of the subject)?

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[2] By problem in DUET we refer to policy-relevant problems, considering that not all the problems experienced in mobility are such to require a policy intervention. Policy-relevant problems are those whose conditions ask for interventions that overcome routinary management actions. Usually, policy-relevant mobility problems are those requiring: the creation of incentives for behavioural changes; developments of new norms and rules; implementation of information campaigns to affect the public awareness; construction of new strategic mobility infrastructures.

[3] The goal of a policy is the policy purpose towards which the policy endeavour is directed; it is what you want to accomplish in the end and specifically depends on how a problem manifests itself in a context (e.g. reduce urban center congestion, reduce traffic related pollution,...).

[4] The objective of a policy identifies the extent to which policy goals are to be achieved. Any objective is specific, measurable, and has a defined completion date. It represents the targeted scenario of the policy initiatives (e.g. Reduce road congestion by 25% in 10 years in the entire municipal territory).

[5] A policy strategy is the broad approach identified to achieve the objective and therefore the goal. It represents one possible pathway (e.g. make public transport cheaper) towards the solution of the problem and can be implemented through different individual actions.

[6] A policy action is one measure to implement to achieve the policy goal in coherence with the identified strategy. It defines the operational change to be introduced in the context the policy is defined for (e.g. Introduce a Low Emission Zone -LEZ- or Reduce public parking in the city center).

Defining the visualization goals can also be a part of a co-creation session. As part of the co-creation sessions with the cities in Flanders, a brief exercise about what you want to visualise was organised. The questions above can be used as a guideline.

Step 3: Analyse the data

In this third step, that can be in parallel with the second step; we investigate the data (and data dimensions) that are required to meet the visualization goals.

- What data is needed?
- What data is available?
- What is the shape of the data?
- What are the main data fields (or dimensions) that need to be visualized?
- What is the data source, and what is the reliability of the data?
- Are there other (alternative) data sources that are relevant?

Step 4: Select the visualization techniques

After understanding the shape of the data, including understanding the consequences of using the data related to the policy elements and visualization goal, we analyse which visualization techniques are best suited to encode the key data dimensions. Certain visualization techniques (encodings) are better suited for certain types of data than others. For example, if your data is "ordered" one should use a visualization technique like the position (on an axis), the size (of a circle) or the length (of a bar) because the human brain can decode them as "ordered". Using colour to represent ordered data is not advisable because the colour is not naturally ordered in the brain (red is not higher than yellow, or pink does not come before green).

Step 5: Define functional specifications

If applicable, the functionality required for the user to interact with the visualization (tools) needs to be specified. This is mainly valid for those data visualizations that are used for exploratory explanation.
In DUET we mainly consider the explanation and exploratory exploration of data visualization types, because they are relevant in the context of providing information and evidence for the policy-making process. Exploration, on the other hand, plays an important role in the data analysis and data science phase and is as such important in the problem setting phase. Existing visualizations and analysis tools are used to explore the available (big) data.
Defining the functional specification with users can be part of a co-creative process to design the visualisation specifications. On a high level, this can comprise defining the level of information, the level of interaction, the way the visualisation will be communicated.

Step 6: Specify visualizations and tools

Finally, we can then define a set of visualizations that will meet the predetermined visualization goals. They will provide the necessary information and possibly the functionality to interact with the data to explore and gain new insights. Visualizations and tools are specified using mock-ups and functional specifications in the form of user stories.

IMPORTANT NOTE REGARDING STEPS 5-6

For the open beta version release, epics will be detailed and concretised in so-called **cases**. In this perspective, a **case** can best be described as a detailed entry into the DUET solution, which requires a set of suitable visualizations for a certain analysis, discussion, policy action/decision, etc. Depending on the case, the best suitable visualization option(s) will be selected, a specific location and zoom level will be defined, data sources will be selected, settings will be filled in, and so on.

The DUET solution is subdivided into two main parts:

● On the DUET **landing pages**, pilot cases can be published. Via different search options (clickable map, word cloud, full list), cases can be found and explored in detail by the visitors of the WordPress landing pages. On the detailed case sheet, visitors can be linked to VCS map visualizations and internal/external dashboards, storytelling tools and/or gamification tools using unique URLs.

Figure 2: detail of the VCS map viewer enabling the creation of a unique URL from a pre-set visual.

● The password-protected DUET **platform** enables pilot administrations to create and manage user accounts, cases, and case-related visualizations.

For the closed beta version release, we focused on the technical/functional development of the landing pages, the development of the platform back-office functionalities, and the settings of the VCS map viewer environment (see also D4.4 DUET Visualization Components). Further, we investigated the integration of dashboards, storytelling tools and gamification elements (see also D4.5 DUET standard reports and data analysis tools) into the DUET solution, still to be worked out in more detail. This approach is entirely in line with our agile way of working throughout the project.

Having most conditions set after the upcoming closed beta release, we now can start to integrate real pilot cases. Cases can be set up in the platform back-office by various pilot administrations and pilot users. Clear visuals can be created using the best-fitting visualization tools (steps 5 and 6 in the approach towards visualization above). And the most compelling cases can be published on the DUET landing pages for dissemination purposes.

2.2.2 Example

Based on previous research and co-creation during the DUET project (D2.2), the DUET project has defined a set of epics which are generic or pilot-specific based on the policy-needs and priorities in each. Each epic serves as the starting point for the 6-step approach.

In the following, we'll take a closer look at how the methodology has been applied based on the example of the generic epic G1 "*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*".

This epic has been selected for demonstration of the approach based on its high importance for all three pilots and therefore also for the personalisation of the Alpha Twins. Due to the fact that there is an existing difference in data maturity and availability between the different pilots, these differences also become apparent during the application of the visualization methodology.

Example: Visualization Methodology

Epic G1: *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*

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

Step 1: Identify Policy Elements

Goal/Objective:
I can assess the impact of changes to the local situation on the traffic in my area of interest.

Step 2: Define the visualization goal

- What information needs does the visualization fulfil?
  Need to see the changes in traffic volumes and traffic flows
- What values and data dimensions are relevant in the visualization context?
  - Capacities
  - Change in capacities
  - Combination between the capacity and change in capacity

- What relationships need to be communicated?
  Relation between calculated capacity and total capacity
  Change in capacity between the situation before and after the simulated road changes
- What action will be taken if the information required is met?
  Decision that lead to a traffic deviation and/or infrastructural change
- What is the intent of the visualization (informative or persuasive)?
  Informative and persuasive (especially when comparing what-if analysis results)
- What is the targeted audience of the visualization (experts, public, policymakers)?
  Experts and policy makers (analysis), and public (outcomes)
- What is the reference framework behind the visualization (is the visualization language in line with size of the subject)?
  Yes, proven traffic model visualization techniques will be used (see step 4)

Step 3: Analyse the data

- What data is needed?
  - (static) Traffic model including underlying data (necessary)
  - Road network (OSM)
  - Historical (aggregated) road sensor data (optional)
- What data is available?
  Detailed information can be consulted in the DUET database (link)
- What is the shape of the data?
  Detailed information can be consulted in the DUET database (link)
- What are the main data fields (or dimensions) that need to be visualized?
  - Simulated road situation (simulated volume and speed)
    Road segment volumes and volume/capacity ratio
    Indication of measures (blocked road, narrowed road,...)
- What is the data source, and what is the reliability of the data?
  The Flanders traffic model is based on traffic count data and census data that has some drift. The model isn't refined enough on itself to be used as a reliable source on a city or local community level.
- Are there other (alternative) data sources that are relevant?
  - Traffic count data from ANPR cameras
  - Traffic count data from traffic lights
  - Combining traffic count data with floating car data (for calibration purposes)

Step 4: Select the visualization techniques

- What do we want to visualize?
  Traffic density and the way it changes as a result of simulated traffic measures.
- Technique
  Classic traffic model visualization featuring varying line thickness to identify different levels of traffic volumes and colours suggest the percentage of the maximum capacity. Alternative color schemes will be used to visualize the difference in capacity before and after the simulation.

Step 5: Define functional specifications

The functional design is based on the TraMod visualization as realized for the city of Pilsen during the PoliVisu project. The following visualizations were specified:

- visualization of the 'as is'-situation
- visualization of the 'to be'-situation
- visualization of the delta
- Slider between (to go back and forth) the 'as is'- and 'to be'-situation (optional)

Step 6: Specify visualizations and tools

The DUET Digital City Twin platform visualization component will be used as a visualization component. According to the functional design specifications adaptations will be made.

3. Personalisation: From Alpha to Closed Beta

The personalisation of the Alpha version does not only mean that local data and simulation models are applied for the local digital twins, but also the opportunity for the implementation of pilot-specific epics is possible. This means that an epic can be implemented in one of the three pilot cities and regions only.

As we have applied an epic-driven, agile approach to the DUET project, we will detail the personalisation efforts based on the jointly defined epics. First, an overview of the generic epics is provided, as these epics have the highest priority for implementation. We will provide an overview of specific data sets and data simulations already integrated or in process of integrating. It has to be mentioned that the data sets outlined here in this chapter are not exhaustive. We have selected the ones that are relevant for the personalisation efforts. The project is using a shared document to keep track of all available data sets, detailing the use for the epics, both generic and pilot-specific, links to data sets and other relevant information. The document is continuously updated with new sources as well as new developments pertaining to the possible re-use of these data sets.

After providing an overview of the work on integration and linking the simulation models, we also touch upon the state of play concerning additional features such as gamification, dashboards, 2D/3D visualizations, and other functionalities.

3.1. Generic Epics

For the personalisation of the digital twins, the following generic epics have been selected for implementation across all pilots as a prototype or Proof of Concept as part of the Closed Beta Release.

Generic epics have the same goals across all three pilot cities and regions. This is what specifically sets them apart from the pilot-specific epics. While generic epics have the same goal, they are tailored to each pilot region based on pilot-specific data availability, data structure, size and scale of data, varying degree of policy elements, as well as available simulation models. Therefore, for each pilot, a specific functional design and analysis will be applied.

The selection of the generic epics for the implementation towards the closed beta version of DUET followed a prioritisation approach[7] taking into account five dimensions from 1) data availability, 2) potential legal hurdles, 3) expected support from local policy makers / decision makers to 4) technical complexity and feasibility as well as 5) alignment with the project ambitions (assess the similarities and differences between the cases). This approach has also led to the establishment of the generic and pilot-specific epics, as the original user stories were selected and bundled into larger scoped epics.

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[7] See deliverable D2.3: Final list of user requirements for the DUET solution
(https://www.digitalurbantwins.com/deliverables)

3.1.1. Data

For the cross-pilot epics, comparable data sets from all three pilot sites need to be available and integrated with the local digital twins. With *comparable data sets*, we mean data that is similar in availability, scope and structure. In the following, an overview is provided of the data sets that have been integrated per pilot per epic. Fields marked green indicate full integration of the data sets, field marked red, indicated a challenge with relation to obtaining data sets for the DUET Digital Twins. Where no colour is indicated, data is either not relevant for the specific epic or not yet integrated into the digital twin.

3.1.1.1. Flanders

The region of Flanders has been progressing well with the integration of relevant data sets to develop the generic epics for Flanders. The pilot has successfully integrated the spatial data for the region of Flanders and the two cities Antwerp and Ghent. The pilot is currently in exchange with several agencies in Flanders as well as with the cities to receive permission to re-use data sets related to noise levels. While weather data and air quality data have already been partially implemented for some of the relevant generic epics. Due to GDPR, it has proven challenging to obtain the data collected by the federal police and local authorities pertaining to automatic number plate recognition (ANPR). ANPR data is of high value due to the amount of origin/destination information it carries related to cars driving into the Flanders region and cities.

Information includes pseudonymized environment-related data of vehicles (including cars, vans, lorries) like the exhaust (CO_2, NOX), the vehicle type, engine type. It also provides origin-destination data coming from more than 3000 measuring points in the region. This information would be valuable for all traffic-related and air quality epics. Table 2 provides an overview of the status of integration of data sets in the Flanders pilot. This overview provides a snapshot of the current situation.

Data	G1	G2	G3	G4	G6	G7	G8	G13
Spatial Data								
GBR LOD 1	🟩	🟩	🟩		🟩	🟩	🟩	
GRB 2D Base layer	🟩	🟩	🟩		🟩	🟩	🟩	
Digital height model Flanders		🟩	🟩			🟩	🟩	
Orthofoto high scale (10cm)	🟩	🟩	🟩		🟩	🟩	🟩	
Antwerp LOD 2 model	🟩	🟩	🟩		🟩	🟩	🟩	
Gent LOD 2 model	🟩	🟩	🟩		🟩	🟩	🟩	
Road Network (Mid scale) - 2D	🟥	🟥	🟥		🟥	🟥	🟥	
Traffic-related Data								

Data								
Road works (ongoing and planned) - GIPOD	🟩	🟩	🟩		🟩			
Loop-based traffic data - Detection loops	🟥	🟥	🟥		🟩			
Traffic light traffic counts detection loops	🟥	🟥	🟥		🟩			
Anonymized/Pseudonimized ANPR data - Federal police platform	🟥	🟥	🟥		🟥			
Anonymized/Pseudonimized ANPR data - Local data platforms (local police or city)	🟥	🟥	🟥		🟥			
Trajectory control zones					🟩			
Environmental Data								
AIR quality sensors (official sensors VMM/Irceline)		🟥					🟩	
AIR quality Citizen Science sensors (Luftdaten Pumpe)		🟥					🟩	
VMM Meteo information							🟩	
Official Noise Sensors			🟥					
Citizen science Noise sensors			🟥					

Table 2: Data Availability & Status of Integration: Flanders Twin.

3.1.1.2. Pilsen

Similar to the Flanders pilot, Pilsen has a good foundation of data sets available and partially integrated during the personalisation phase of the Alpha version. Most notably, the spatial data, including 3D models of city buildings, a digital surface, and a digital terrain model, is forming the basis for the Pilsen twin.

In addition, the city has integrated data from traffic detectors measuring the number of vehicles passing through certain areas of the city as well as floating car data provided by the Czech national directorate of roads. The latter is provided in real-time and informs the generic epics G1 and G6-7.

What concerns data pertaining to the public transport in Pilsen, the city is still in talks with the local public transportation company to negotiate re-use of data sets for the DUET project.

With a view on air quality data, Pilsen has six high-quality sensors deployed in the city. The sensors provide high-quality data - both real-time and historical. In addition, the city has decided to experiment with so-called Do It Yourself (DIY) sensors. For testing purposes, the city has installed one DIY sensor in proximity to a high-quality sensor. While the quality assessment is still ongoing, first results have shown that the DIY sensor is not as reliable. Particularly a high variability and peaks in measuring certain levels of air pollution have been detected. Therefore, it is still to be decided whether or not data from the DIY sensor can and will be integrated in the Pilsen Digital Twin pending the final assessment from the national meteorological institute. Table 3 provides an overview of the data availability and status of their integration in Pilsen.

Data	G1	G2	G3	G4	G6	G7	G8	G13
Spatial Data								
3D model of the buildings	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
Digital surface model	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
Digital terrain model	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
Traffic-related Data								
Traffic detectors	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
Floating car data	🟩				🟩	🟩	🟩	
Real-time position of public transport					🟥			
Public transport routes					🟥			
Public transport stops					🟥			
Environmental Data								
Air quality sensor data (Meteorological Institute)		🟩		🟩			🟩	
Air quality sensor data (DIY)		🟥					🟥	

Table 3: Data Availability & Status of Integration: Pilsen Twin.

3.1.1.3. Athens

The Athens pilot has also integrated a variety of data sets to personalise the city's digital twin. The priority for Athens was firstly, to integrate relevant spatial data as the basis for the digital twin. Secondly, following Athen's priority on making the city greener and encouraging amore pedestrian and cyclist friendly city, the focus was on obtaining the relevant data sets from local, regional and national authorities for re-use in the DUET Digital Twin. Currently, a range of traffic-related data has been integrated for the closed beta version. As a next step, following the release of the closed beta version, the focus will be to integrate sensor data collecting information about air pollution.

Data pertaining to real-time traffic information is currently not yet available in Athens. The city is, however, currently deliberating about purchasing sensors and/or floating car data. In addition, the city is considering purchasing additional air pollution sensors. The pilots Athens and Pilsen are in close contact on this subject to exchange experiences also pertaining to the test deployment of DIY sensors in Pilsen. Contacts have been made and offers collected. A final decision is pending.

Data	G1	G2	G3	G4	G6	G7	G8	G13
Spatial Data								
Athens 3D LOD 1	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Athens Tree Location Data (3D)	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Athens Terrain	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Open Street Map	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Services of the City of Athens	🟩							
	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Traffic-related data								
Public Transit Metro Stations	🟩				🟩			
Athens Bus	🟩				🟩			
Athens Charging	🟩				🟩			
Road Traffic Attica Region	🟩				🟩			
Floating car data	🟥				🟥			
Environmental Data								
Air quality index		🟥					🟥	
Air pollution report		🟥					🟥	
Air quality sensor data		🟥					🟥	

Table 4: Data Availability & Status of Integration: Athens Twin.

3.1.2. Data Models

As important as the integration of data to personalise the digital twins for each pilot site is the integration of data models to enable the functionality of making predictions of policy-decision. As part of DUET, three types of modelling will be integrated in the local digital twins. Modelling capacities will be able to simulate traffic, air quality and noise levels in the pilot cities and regions. The focus of the technical development leading up to the release of the closed beta version was to enable the interaction between the data models. Nevertheless, a range of local data models have been explored and partially already integrated. The overview is provided below per pilot site.

3.1.2.1. Flanders - Data Models

Traffic Simulation Model

With regards to Flanders, the Flemish multi-modal traffic model has been integrated based on a license agreement for the epics G1-G3. It is a strategic multi-modal model of passenger and freight transport in the region of Flanders and is managed by the Flemish Mobility Department (MOV). In addition, the MatLab Traffic Toolbox, a traffic simulation model provided by DUET partner KU Leuven complements the epics G1-G3.

Noise Model

A noise model realized by the University of Gent has the potential to be included in epics (G3).

Air Quality Model

Atmostreet, Atmoplan, Opaq models (G2)

The Flanders pilot is currently in talks with the Flemish Environmental Agency (VMM) and the Flemish Technology Institute (VITO) to negotiate the re-use of the air quality models. The models provide assessment (including what-if functionalities) and forecasting functions regarding air quality based on four main factors: Emission resources, weather, chemical processes in the atmosphere and the movement of air pollution. The Opaq model supports up to 72 hours forecast in time. The Atmoplan and Atmostreet models support the creation of air pollution maps on a local or regional scale on the one hand and very local air quality impact calculations on the other hand. A decision is pending.

3.1.2.2. Pilsen - Data Models

Traffic Simulation Model

Pilsen has already successfully implemented the data model to simulate traffic flows in the city to support the generic epics G1-6. The traffic model consists of the traffic model data, backend, and web application for real-time traffic modelling.

3.1.2.3. Athens - Data Models

Traffic Simulation Model

The development and integration of a traffic simulation model has originally been planned as part of the closed beta release of the Athens Digital Twin, but due to various factors has not yet been successfully completed. Athens originally had no traffic simulation in place, which required the development of a model by the DUET technical team. Partner KU Leuven is currently constructing the traffic demand generation tool and is focusing on fine tuning the so-called parameter estimation based on the data available from Pilsen and Flanders. From the moment this step is successful this framework should be applicable for the selected Athens region in order to get an improved version of the earlier trial model.

The partners in Athens have already provided relevant data to be used for validation and calibration purposes. The work on the traffic model is now foreseen for the open beta version, together with the integration of additional sensor data.

3.2. Pilot-Specific Epics

Further to the generic epics, the pilot cities Athens and Pilsen have selected pilot-specific epics which will only be featured in their local version of the DUET Digital Twin. The region of Flanders has not selected additional pilot-specific epics. The epics are listed here to complete the view on what will further follow to develop and personalise the local digital twins in the pilot regions. All pilot-specific epics are in the medium priority range and will not be implemented for the closed beta release. In the following, the pilot-specific epics for the personalisation of the Alpha Version of DUET are described in more detail.

3.2.1. Athens

As part of the digital and sustainability strategies of Athens, the city also wants to evaluate the current public transport system with support from local digital twins. A particular focus hereby lies on the better connection between existing public transport in the future based on the evaluation and to be able to offer more effective and faster transport connections. Relevant data for the pilot-specific epic has already been identified. Table 5 shows the epic in more detail.

#	Description	Ambition
A1	**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	Prototype

Table 5: Athens - Pilot-Specific Epic.

3.2.2. Pilsen

The City of Pilsen has a strong focus on urban planning and has therefore selected several pilot-specific epics to cater for this internal need. Those have not been implemented for the closed beta version, but implementation is foreseen for the open beta which will be released at the end of year 2. Table 6 outlines the pilot-specific epics for Pilsen.

#	Description	Ambition
P1	**As an** urban planner **I want** to see all existing attributes for buildings and objects in 3D representation of the city **so I can** work with different data sources in a single environment	Prototype
P2	**As an** urban planner **I want** to see all existing attributes for public space such as surfaces, public green, tree informations (tree type, height, diameter of trunk, diameter of treetop) **so I can** work with different data sources in a single environment	Prototype
P3	**As an** urban planner	Prototype

	I want to see Z dimension for all objects and surfaces (streets, pavements etc.) **so I can** work with the z dimension as it is not supported by current GIS solution used by city.	
P4	**As an** urban planner **I want** to style object based on available attributes **so I can** make custom analysis and visualizations	Prototype
P5	**As an** urban planner **I want** to make the digital twin data compatible (=viewing/browsing; importing; editing; exporting data from/into 3D model) with ESRI GIS Environment, i.e. ArcGIS Desktop, ArcGIS Pro, ArcGIS Online, and also with AutoCAD and Google Sketchup, **so I can** work on my creations seamlessly in other software environments	Proof of concept
P6	As a **policy maker,** **I want to** motivate investors of major development projects to provide 3D data during the building planning and permission process, **so I can** (i) inform citizens of the future evolution of the city and (ii) achieve a higher architectural quality of the urban space.	Proof of concept
P7	**As an investor,** I **want to** provide 3D data (as well as BIM data) of my envisaged major construction project to the city, thus allowing the city administration to assess my project in 3D, **so I can i**nform citizens about my project in the official digital twin of the city (under the 'future' view).	Proof of concept
P8	**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.	Proof of concept
P9	**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	Prototype

Table 6: Pilsen - Pilot-Specific Epics.

3.3. Digital Twin Reporting Tools

As pointed out in the report D4.5[8], the DUET approach to local digital twins based on openness and interoperability supports a variety of tools to manage locally available data. The following table provides an overview of what has been already implemented as a prototype for the generic epics presented above in the process to personalise the DUET Digital Twin. Fields marked green indicate that tools are already available. Yellow indicates that the basic functionalities are already available, with more specialised functionalities becoming available at following releases of DUET. Fields marked red indicate that the work has not yet started but will be launched following the closed beta release. What concerns gamification it needs to be highlighted that at the current stage, this is only relevant for the generic epic 5 (see Table 1). This epic has a lower priority and is foreseen for the open beta release at the end of this year.

For a detailed overview of all tools and their relevance for user groups and epics, please refer to D4.5.

#	Description	2D/3D - map visualization	Dash-boards	Story-telling	Gami-fication
G1	**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				
G2	**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				
G3	**As a** public servant of the mobility or environmental protection department, **I want to know** the level and impact of noise pollution when certain roads would be closed, **so I can** discover causes of noise pollution and the impact on citizens well-being in the city				
G4	**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				

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[8] See deliverable D4.5: DUET Standard reports and data analysis tools (https://www.digitalurbantwins.com/deliverables)

G6	**As a** citizen, **I want to** see the current traffic flow in the city based on the model and available sensors **so I can** inspect the current traffic density				
G7	**As a** citizen, **I want to** see the current noise pollution in the city based on the model and available sensors **so I can** inspect the current level of noise pollution				
G8	**As a** citizen, **I want to** see the current air pollution in the city based on the model and available sensors **so I can** inspect the current level of air pollution				
G13	**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.				

Table 7: Overview of Tools - Closed Beta Version.

4. Personalisation: Planning for Open Beta

With the launch of the Closed Beta Digital Twin following the personalisation of the Alpha release, we have started the preparations for the first testing cycle. The aim of this first testing cycle is to arrive at an improved Open Beta DUET Digital Twin. This testing cycle is an opportunity for each pilot to test their personalised DUET Digital Twin with a small number of city colleagues across relevant departments, such as mobility, environment, and spatial planning, to explore the usability and functionalities of the digital twin.

4.1. Involvement of User Groups

As a first step following the launch of the Closed Beta, the testing will be broadened to include city stakeholders who are not part of the DUET project as well as interested citizens. The scope to included citizens will be expanded over the duration of the project related to all citizen-facing epics. Specifically, we aim to engage the relevant domain stakeholders in the cities and regions for example colleagues from the environment, urban planning, or mobility departments in addition to the consortium partners to test and assess the Closed Beta DUET Digital Twin.

User Groups	Testing Focus	Methods
Consortium Partners - Internal Project owners in the pilot sites	● Functionality ● Usability	● **Briefing** The closed beta version will be presented to the consortium. ● **Online Workshop** Leveraging the ongoing bi-weekly pilot meetings and the already existing feedback form, the pilot partners will be invited to feedback on the closed beta version
Pilot sites - External City Domain Experts	● Functionality ● Usability	● **Local (Digital) Workshops** Following the briefing and internal meetings, the project leads in each pilot site are carrying out local meetings to gather feedback from the domain experts in their cities and regions.

Table 8: Overview of User Groups for Testing Cycle 1.

Organisation of local (digital) workshops

As described in the pilot operations plan (D6.1), a briefing will be prepared, and a local online workshop will be organised to inform colleagues about the current state of the DUET project and its vision. To support the collection of feedback from the local meetings, WP6 will prepare a simple, yet effective method to collect feedback on functionality and usability of the closed beta version. The method is called " I like, I wish, What if" (Link). It invites your users to provide open feedback by coming up with three kinds of statements.

Firstly, the users will be introduced to the current prototype and are invited to explore it themselves. Following this exploration phase, the meeting lead will share an online whiteboard prepared in advance, where the users are invited to write down short statements about what they particularly liked about the prototype ("I like"), and what they would like to change or improve in the current prototype ("I wish"). Lastly, in "What If…" statements, the users can suggest new ideas that might not have a direct link to the prototype. This opens possibilities for new ideas to be explored in future iterations of prototypes.

The exercise can be used both during a physical meeting if the current situation allows. For physical meetings, a wall, sticky notes in varied colours and felt-tip pens are required on site. The approach has been successfully applied in other projects during large meetings, for example during the SynchroniCity project.
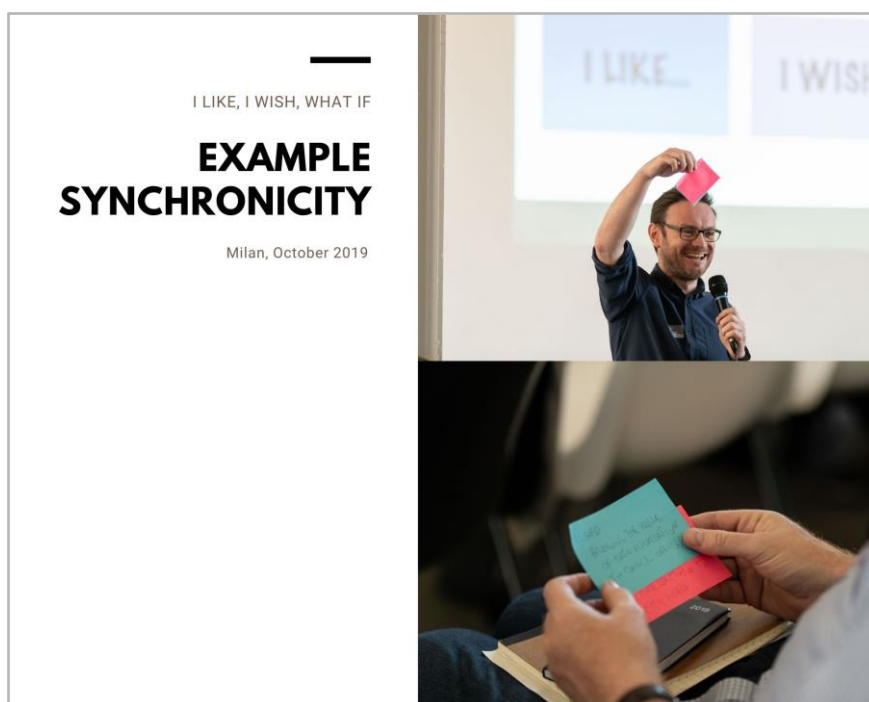

Figure 3: example of application of I wish, I like, what if, during SynchroniCity meeting 2019.

The exercise is equally possible to carry out during digital workshops. Therefore, a shared whiteboard tool such as Miro, Mural or Conceptboard can be used to work on the exercise as effectively as on-site. Figure 4 provides an example of how the digital whiteboard can be prepared.
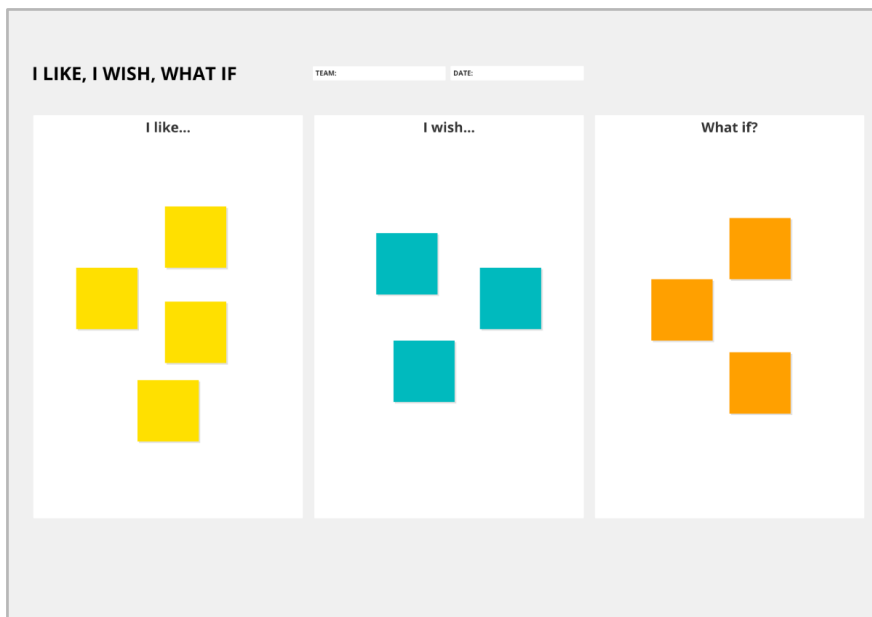
Figure 4: example of digital application of I wish, I like, what if approach.
Source: conceptboard.com.

The findings from the local digital workshops will be synthesized by the task lead in WP6 and discussed during the regular bi-weekly meetings following the feedback cycles proposed in D6.1 (see figure 5). A detailed report will provide an overview of the process and results (D6.3).
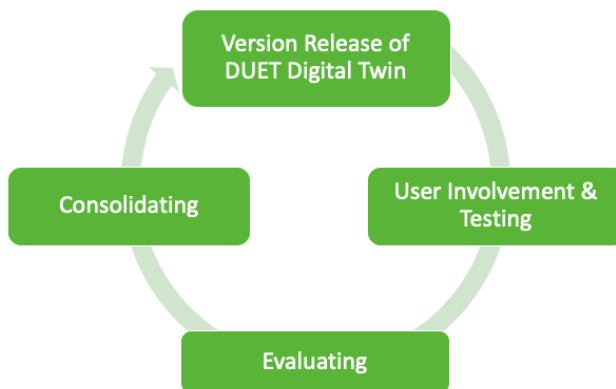

Figure 5: DUET Testing Cycle.

Online end-user and citizen feedback

The road towards the open beta version will also see the addition of including end-users, in particular also citizens in the testing loop. During a dedicated open beta kick-off workshop organised online on 1 June 2021, where the team discussed citizen-focused epics and the connected technical approaches/solutions. Following the agile methodology, user-friendly feedback and testing mechanisms will be further concretised with pilot and technical partners in Jira tasks and leveraging design and prototyping tools to experiment with clickable prototypes to allow for larger-scale testing.

4.2. Planning Open Beta: Epics

As we have adopted an epic-based approach to DUET and while the work on the general epics listed earlier in this report will continue to evolve, the DUET project is preparing the work on further epics. The additional epics that are planned to be part of the open beta release of DUET at the end of this year have been assigned a medium priority and are therefore planned for implementation at a later date. Table 9 provides an overview of the generic epics for the open beta version.

#	Description of Epic	Version	Priority	Ambition
G5	**As a** citizen, **I want to** be able to vote and give feedback about scenarios related to new city developments,calculated using functionality based on other epics, **so I can** participate in those designs	open beta	2	Prototype
G15	**As a** DUET admin, **I want to** be able to **connect** data sources **so I can** be sure that the necessary data and information is available	open beta	2	Prototype
G16	**As a** DUET admin, **I want to** be able to **restrict** the access to data sources **so I can** be sure confidential data is not made publicly available	open beta	2	Prototype
G17	**As a** citizen, **I want to see** only the data sources that are relevant **so I** don't see confidential information	open beta	2	Prototype
G18	**As a** DUET admin, **I want to** be able to monitor platform status **so I** can adjust resource allocation and investigate logged errors or misuse	open beta	2	Prototype

Table 9: Generic Epics for Open Beta Version.

The pilot-specific epics (see table 6 and 7 in chapter 3), falling under medium priority, are tentatively marked for the open beta release as well. Whether they will be included already in the open beta version at the end of this will be jointly decided based on the availability of relevant data and depends on the progress in other work packages.

Following the epic approach, a main piece of work towards the open beta version will be the integration of more data, particularly sensor data to power the simulation models.

5. Conclusion

In the past 18 months, and specifically in the lead-up to the release of the closed beta version of DUET, we have arrived at the first implementation of digital twins for the pilot sites Flanders, Pilsen and Athens. The epic-based approach has guided the delivery of work throughout the process, for which the basis has been provided during the first year based on the WP2 insights. Another helpful tool in bringing the closed beta twins on the way is the visualisation methodology and the experience of working with it from the Polivisu H2020 project. This methodology will be further applied to refine the work currently being carried out and support the upcoming epics for implementation by November 2021.

While we have advanced in personalising the Alpha version of DUET, there is still work to be done. The next chapter of DUET is now starting to focus on delivering more epics, integrating more local (sensor) data, and connecting and implementing the necessary simulation models to bring the local digital twins to life. This process will be supported by user testing that involves - for the first time - users beyond the project partners. We also aim to include citizens better and earlier in the upcoming testing cycles. While initially, the broader public was only to be involved in the testing process during the last testing cycle, we strive to present the twins with an opportunity to test and interact at an earlier stage (as part of the open beta release). How this interaction will take place strongly depends on the COVID-19 situation. To get started with the testing cycle with stakeholders external to the project, we have prepared a simple and lightweight approach to capture their feedback on usability and functionality and bugs. The idea behind the process is that testing at an earlier stage will help incrementally improve the experience of using the local digital twins before presenting and testing the twins in the open beta cycle with the broader public.

This approach aligns well with the agile development approach in the DUET project and supports the product owner and extention of the whole consortium to be aware of the wishes and demands of the customers and, in the end, the overall quality of the DUET Digital City Twin solution.