Deliverable

D6.5 Pilot Testing Cycle Report 3

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Reviewers:	Lieven Raes, Jurgen Silence (AIV) IMEC (Koen Triangle) ATC	
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1.0	16.11.2022	Margarida Campolargo	OASC	Final version

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Executive Summary

The final DUET testing cycle, also referred to as the Candidate release testing cycle, is described in this report, along with its methodology, outcomes and final recommendations. Together with pilot representatives and the project consortium, the testing activities were co-designed and implemented between June and November 2022.

The testing cycle was created to evaluate the DUET platform from both a professional and citizen standpoint. Therefore, the set of activities included Focus Groups, surveys, observation sessions and workshops, which involved pilot representatives, citizens, policy makers and other relevant stakeholders both at local, national and international levels.

Each of the tools served a specific purpose in addressing KPIs by testing metrics that address them. The implementation of a Testing Survey, which led testers through a use case and gathered input on their experience. Most of the focus groups and activities also had a plenary feedback session where more information from the users' experience was gathered. Concerning the focus groups, a mixture of participants from the three DUET pilots as well as other interested stakeholders attended the sessions in English. In addition to this, each pilot conducted a separate DUET Test Clinic in the regional tongue.

The testing process produced beneficial and tangible results regarding the enhancements required to make DUET a valued and usable tool for end users. The desire to enhance the user experience and interface consistently comes up in participant comments. This report includes the results of the testing cycle activities and the main feedback, comments and suggestions.

To complete the set of testing cycle activities that were held throughout the project lifetime, this testing cycle included similar activities to the Open Beta testing cycle, which enabled the comparison of results. In addition this testing cycle introduced new metrics to address, namely the practical usability KPI which was not addressed in the previous testing cycles.

The final testing cycle was successful overall, yielding a wealth of verified tangible recommendations that, if followed by the project team, should produce a valuable tool that is much sought after by both professional and citizens user groups.

1. Introduction

The DUET Digital Candidate release Version was tested during the third DUET Testing Cycle, which is summarized in this report (see Figure 1). The report's objective is to gather and compile feedback from the testing activities and to make suggestions for enhancing the DUET Digital Twin platform and promote its future use.

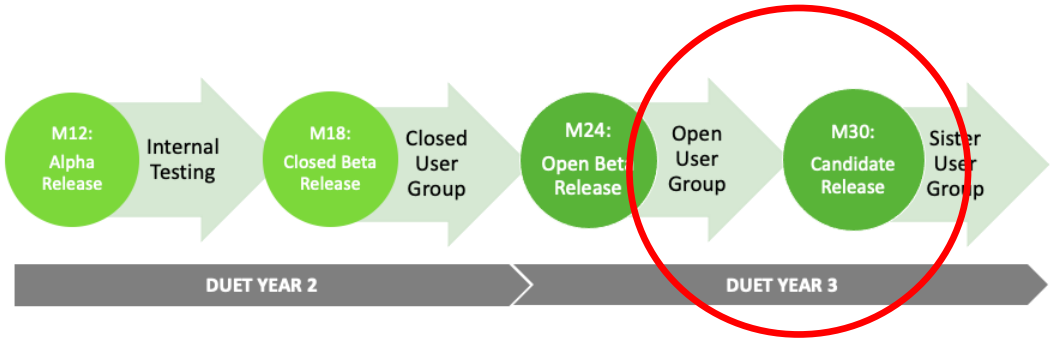


Figure 1: Overview of DUET Testing Cycles

The results outlined in this report largely contribute to a successful delivery of a functional and user-friendly future urban digital twin platform, by validating and adding suggestions to the current version. An overview of the methodology and the results of the testing cycle are provided in the next chapters:

- The methodology applied for the user testing of the closed beta version;
- The results of the user testing of the prototype and their analysis;
- Specific recommendations for the development of user-friendly digital twins;
- An outlook for the upcoming second pilot testing cycle.

The main objectives of this third testing cycle were to test and validate the new platform version and to give inputs to enhance future use. This task was achieved by testing the DUET use cases in the pilot cities and regions of Athens, Flanders and Pilsen with both internal and external participants.

This last testing cycle provides an overview of the general acceptance of the project's concept and usability of the DUET platform. The goal of this deliverable is to demonstrate the extent to which the DUET project was able to develop a useful, easy to use and satisfying solution that provides policymakers, city officials, citizens and local ecosystems with access to their local urban digital twin displaying information on how their city operates and how it can be impacted by different decisions and policies. The insights from this testing cycle also contributes to the sustainability of the platform and its future exploitation, giving valuable knowledge to the development and coordination team.

2. Methodology

In this chapter, we outline the methodology that the task leaders (OASC and IMEC-SMIT) and the Pilot representatives jointly designed. Based on the previous testing cycles and the KPIs defined by the project, the methodology and tools were designed and developed with the bi-monthly Pilots meetings serving as the key platform for this process.

2.1. Rationale

For the third testing cycle, the plan was outlined based on the previous testing cycle activities, as part of the iterative process adopted throughout the project. As the last testing cycle of the project, the goals are not only to validate the platform but to understand its evolution throughout the project lifecycle.

The methodology developed took into account the need to evaluate functional and non-functional features and is based on the premise that the first phase of the functional testing (namely the unit testing) was carried out by the development team.

In deliverable "6.4 – Pilot testing cycle report", some recommendations were made for this testing cycle, namely the following four which were included in the conclusions:

- General improvements to platform vs specific pilots
- Improving UI /UX
- Testing with citizens
- More Focus Groups and targeted interviews with experts

These four topics were contemplated in the design of the testing cycle and in the improvement of the platform in this final phase of the project, as described in this report.

The third testing cycle activities started in May 2022 with a set of meetings dedicated to the design of the methodology and definition of use cases.

The testing cycle kicked off in December 2021 with several discussions focused on the methodology. For this purpose, all the project partners were asked to collaborate in the definition of the most appropriate methods and tools to test the DUET platform. This process included the design, planning, implementation and closure phases as described in the next pages.

2.2. Scope and objectives

The testing cycle activities were designed to support the evolution of the project concept on the one hand, and the DUET Platform on the other hand. To be able to validate the platform with the key stakeholders a set of KPIs and goals were outlined to guide the activities. Naturally the target group

of this process included internal and external stakeholders, with a special attention to the pilot partners and local actors. Concerning the external users, the ambition was to reach a multilevel and multidisciplinary set of experts (professional) users and non-expert (citizen) users.

The success criteria defined at the beginning of the project includes the following elements:

- User acceptance
- Minimum satisfaction
- User experience
- User ability to understand
- Practical usability

This set of criteria was refined and detailed as the starting point of the third Testing Cycle.
To be able to address each specific criteria and its corresponding KPI, a clear definition of each of the criteria and its components was needed. For the remaining of this document, we consider the following concepts and their stated definition

- **User Acceptance** is the subject of debate and diversity in the literature. In this document, we take the point of view of Kulviwat et al. (2007) and Nadal et al. (2020) in defining acceptance as the intention to use (adopt) a technology after initial use.
- **Minimum Satisfaction:** is related to the subjective perception and attitude of the user towards the platform.
- **User ability to understand** is measured in this testing cycle by using the "ease of use" metric.
- **User Experience** is the overall experience of a person when using the platform. We consider the subjective evaluation made by the user, based on their perception and response resulting.
- **Practical Usability** refers to the user performance measured through observation.

It is important to clarify that Usability is understood, within the scope of this project as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11). Usability includes "user performance" and "user experience" as described in the table below. Therefore, Practical usability and user experience gathered constitute Usability.

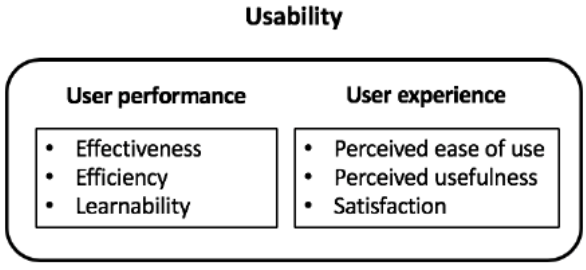


Figure 2: Usability components and metrics

By testing the platform usability, we aim at:

1) Determining whether testers can complete tasks successfully and independently;
2) Assessing the performance and mental state of the testers as they try to complete tasks, to see how well the design works;
3) Seeing how much testers enjoy using it;

4) Identifying problems and their severity;
5) Finding solutions.

For the purpose of this testing cycle, and to support the definition of KPIs and metrics that match the criteria described above, we defined a set of complementary metrics divided into two groups: performance and experience. The definition of each metric is described in table 1.

Performance metrics		Measure
Effectiveness	Completing a task with success (where success is defined for each task).	Observation (% task completion)
Efficiency	Amount of effort required by a user to complete a task.	Observation (% task success)
Learnability	The extent to which something can be learned.	Observation (differences from T1 to To for task success and completion)
Experience metrics		
Perceived ease of use	The degree to which the user believes that using a particular system would be free of effort.	Survey (USE scale)
Perceived usefulness	The degree to which the user believes that using a particular system would enhance his or her job performance.	Survey (USE scale)
Satisfaction	The user's subjective assessment of the system.	Survey (USE scale)
Attitude	The user's positive or negative feelings about performing the target behaviour.	Survey
Acceptance	The degree to which the system does not undermine the intention of its use.	Survey (intention to use)

Table 1: performance and experience metrics description

2.3. Use cases

The pilot representatives suggested that each pilot test will consist of at least two use cases, one aimed at professional testers and the other at citizen testers, as the testing cycle was being designed.

There was a considerable interest in learning how these two main user groups engage with and react to the DUET platform because some of the functionality and use cases targeting citizen and professional testers are somewhat different.

Drafting their individual use cases fell to the pilot teams. The DUET platform's landing page (https://citytwin.eu/) now features a number of use cases that were built as a result of this process, which needed numerous rounds of engagement. The majority of DUET stakeholders and users view this landing page as their primary "point of entry" into the system. Representatives for the pilot have the option to keep revising and expanding their use cases while also introducing new ones.

N°	Pilot	Target user	Case Title	Link to case
AC1	Athens	Citizen	Citizen feedback on the closure of Stadiou	https://citytwin.eu/athens-citizens-feedback-on-green-routing/
AP1		Professional	Closure of a street in the center (Stadiou) for pedestrians and results on air and noise pollution	https://citytwin.eu/athens-creation-of-a-pedestrian-and-cycling-route-in-stadiou-street/
AP2			Monitoring traffic data in the center through Athens Dashboard	https://citytwin.eu/athens-dashboard-traffic-load-on-stadiou-street/
AP3			Partial reduction of traffic in Vas. Konstantinou and results on traffic in the area	https://citytwin.eu/athens-partial-reduction-of-traffic/
FC1	Flanders[1]	Citizen and Professionals	simulation closure Contributie bridge	https://citytwin.eu/ghent-simulation-closure-contributie-bridge-iii/
PC1	Pilsen	Citizen and Professionals	Map for tactical exercise	https://citytwin.eu/map-for-tactical-exercise/
PP1		Professional	New development in Nepomucka street	https://citytwin.eu/pilsen-new-development-in-nepomucka-street/

Table 2: Use cases included in the Final Testing Cycle

Based on the approach undertaken during the Open Beta testing Cycle, table 2 illustrates the use cases prepared by the pilot representative to be tested during this testing cycle. Each case is identified with an identifier consisting of an initial corresponding to the pilot city or region (Athens, Flanders and Pilsen), followed by the letter “C” or “P” for use cases targeting Citizen vs Professional users respectively, followed by 1 or 2, referring to the first or second case for a certain pilot and target user group. For example, “AC1” refers to Athens Citizen Case 1, while “AP2” refers to Athens Professional Case 2.

1 Note: All three use cases developed for the Flanders pilot (two cases for citizens and one for professionals) were focused on the city of Ghent. This is why this report speaks primarily to findings from the “Ghent” pilot (use cases), rather than Flanders. But just because only Ghent use cases have been tested in this current cycle, it doesn't mean this will be the case for the final testing cycle, which might incorporate use cases from other Flemish cities, or the region more broadly.

The use cases were defined according to the new functionalities of the platform available to be tested.
The Use Cases are described below:

Pilot	Case Title	Description	Approach	Expected outcome	Data models used
Athens	Citizen feedback on the closure of Stadiou	As an active citizen I want to evaluate and share my feedback on the future decisions of the city and their impact on my daily mobility within the city.	Evaluation and feedback sharing by the case of transforming Stadiou street to a pedestrian route. Citizens will solicit feedback on whether they can alternatively walk, cycle and/or use public transport for their daily mobility in the overall area around Stadiou str.	imulate a decision making process which ccommodates citizens and other takeholders' feedback to a great expect iming at an optimized urban planning and n eco-friendly manners.	Municipal data (e.g. terrain, trees location, 3D data of buildings, districts limits etc), sensors data (data.gov.gr),Traffic data (OpenStreetMap) Air pollution Noise pollution
	Closure of a street in the center (Stadiou) for pedestrians and results on air and noise pollution	As a city official I want to evaluate the impact in the close by traffic load of transforming Stadiou street in the center of Athens to a complete pedestrian and cycling route.	In order to simulate the creation of a green route in the center of Athens that includes high traffic congestion, the closure of a central street will be tested and evaluated, namely Stadiou street.	If the result in nearby traffic load is forecatsted to be acceptable in terms of congestion then the green routing can actually be planned and implemented by the city. Alternatively it can be tested the closure of Stadiou is specific time slots or parts.	
	Monitoring traffic data in the center through Athens Dashboard	As a policy maker in the field urban traffic I would like to have an overview and compare the traffic load in Stadiou street in order to better design the traffic arrangements in the Athens center	The Athens Dashboard provides the feature of comparing sensors (individuals or grouped) located in the center (e.g. Stadiou street) for 2 time periods: for example one referring to an average working week (1-5 November 2021) and a second one referring to an average vacations week (2-6 August 2021).	The insight on traffic distribution during the day hours for the 2 compared weeks can provide valuable input for decisions and traffic arrangement (e.g. traffic lights automization, street lighting planning, road cleaning, bus lanes etc).	
	Partial reduction of traffic in Vas. Konstantinou and results on traffic in the area	As a city official I want to evaluate the impact of reducing the traffic in a road in the center, indicatively close the traffic by 25% or in one lane etc. The aim is to exploit this section of the road for alternative routing e.g pedestrian, cycling route, micro mobility etc.	Your goal is to simulate the extension of a pedestrian road e.g., the extension Great walk pedestrian until Kallimarmaro Stadium and see the result in the traffic flows.	If the result in nearby traffic is forecasted to be low then the policy can be enhanced and promoted for implementation by the city.	

Flanders	simulation closure Contributie bridge	Ghent is one of the major cities of Flanders and is home to 265,000 inhabitants. In spring 2022, a new bicycle tunnel was constructed near the city centre. The impact of the planned works on traffic was fairly large and well researched. With DUET, we want to test the effects of the closure of the bridge and the adjacent first road segment of the Nieuwewandeling street.	By using the DUET solution, we investigate three scenarios: bridge closure in the direction towards the city center (scenario A), bridge closure in the direction away from the city center (scenario B), bridge closure in both directions (scenario C). For each simulation, a delta map is created showing increase and decrease of traffic volumes in an intuitive way. The case and its 3 scenarios are presented to the visitors on the landing pages (DUET Flanders cases). Visitors can easily switch from one scenario to another in the viewer, so they get a clear idea of the delta differences. After this exploration, they can vote on the scenario they think is the best.	Since this bridge is heavily used (over 1000 motorized vehicles during rush hour for both directions together), the closure may have a high impact on traffic.	gent 3D Buildings level of detail 2 semantically qualified Vlaams hoogtemodel Gent road network
Pilsen	New development in Nepomucka street	The City of Pilsen is planning to carry out several large-scale construction projects throughout the city in the coming years. Planning and city development is the responsibility of several city organizations that coordinate the city's plans. The DUET application helps to plan new development and facilitate communication between the authorities and the public. The DUET application allows the insertion of custom 3D data into an existing 3D model of the city. Thus, urban planners can visualize how the new development will look in the context of the existing one, try out the different project variants considered (e.g. height differences, variant building layouts, etc.), use the application's functions to	Use the DUET application to import different variants of residential buildings in Nepomucka Street. Use existing layers (3D city model, noise pollution, air pollution, traffic model) and application features to assess the appropriate variant of the planned development.	The map visualization of the 3D model of the new development and the existing 3D buildings of the city, together with other layers available in DUET, will provide a new view of the location. The created visualizations are a suitable basis for presenting (communicating) the project to citizens, urban experts and policymakers to address issues related to the planned development (construction of new roads, parking lots, public transport stops, public lighting, playgrounds, planting new trees, etc.). As a result, a suitable project option should be proposed.	Plzen – 3D Buildings LOD2, Plzen – 3D Trees, Plzen – 3D Terrain model, Data of new buildings, Plzen – Public Transport Lines, Plzen – Public Transport Stops, traffic model, air pollution model, noise pollution model

		solve the shading of the existing development, find out information about traffic intensity, noise and air pollution in the area of the new development, try out new viewing perspectives created by the new development, draw their own 3D objects in the map composition, etc.			
	Map for tactical exercise	The city of Pilsen was one of the pilot cities of the S4AllCities EU project during which a 3D model of the Pilsen football stadium was created. Together with the DUET application, the model was used in a tactical exercise that took place at the stadium within the project. The map layers available in DUET, including a detailed 3D model of the football stadium, facilitate the planning of tactical exercises of the Integrated Rescue System. The digital twin can be used to simulate the closure of the "Rychtářka" crossroad which is an entry/exit point for the rescue vehicles to/from the stadium during the tactical exercise. Total or partial closure of the crossroad and its impact on the surrounding traffic can be simulated. DUET application can also be used to assess the placement of roadblocks and equipment, to find the ideal locations for the drones to take off (in relation to the trees in the park) and places in the shade that would be a suitable site for the injured. Locations of hospitals in which the injured were taken can also be found in DUET.	Use the DUET application and its features to visualize a 3D model of the football stadium and other existing layers (traffic model, 3D city model) to plan the tactical exercise.	The tool can be used to plan future tactical exercises of the integrated rescue system and visualize the impact of the "Rychtářka" crossroad closure on the traffic.	Plzen – 3D Buildings LOD2, Plzen – 3D Trees, Plzen – 3D Terrain model, Plzen stadium detailed 3D model, traffic model

Table 3: Description of the Use Cases developed for the final testing cycle

2.4. Testing tools

In the first testing cycle (Closed Beta), two main methods were considered: one-on-one interviews and self-guided exploration and survey. The second testing cycle (Beta testing) introduced the focus groups, which were used as the main tool of this phase. For the third and last testing cycle (Candidate testing) four methods were put in place to address the metrics and KPI´s, described in the previous chapters, but also to give useful feedback for the final release. These tools support the iterative process designed by the project. By promoting repeated testing cycles (3 in total) through the different stages of its development the DUET platform evolved in a positive way as this report will demonstrate. Therefore, the tools chosen for this final testing cycle follow the framework defined for the previous testing cycle activities, to be able to compare results and show the evolution of the platform and its metrics.

The table below identifies the tools used in this process and their co-relation with the success criteria.

Tool	Target group	Goals	Outputs	Success criteria
Survey	Citizens Policy makers Tech teams Service departments Experts	● Determine whether testers can complete tasks successfully and independently; ● Assess the performance and experience of the testers as they try to complete tasks, to see how well the design works; ● See how much testers enjoy using it; ● Identify problems and their severity; ● Find solutions.	Users' answers	● User Acceptance ● Minimum satisfaction ● User experience ● Practical Usability
Focus groups	Citizens Policy makers Tech teams Service departments Experts	● determine the knowledge of digital twins ● understand the importance of the DUET concepts for the users ● identify possible end users and future adopters ● list possible new features ● identify possible challenges	Users feedback	● User Acceptance ● Minimum satisfaction ● User experience ● User ability to understand ● Practical Usability
User observation	Citizens Experts	● determine the capability of the users to navigate the platform ● understand the practical usability of the platform ● identify specific challenges ● observe the complete process of usage of the Platform	● Number of steps to complete a task; task completion per unit of time ● Percentage of successful participants for a defined task ● users feedback	● User experience ● User ability to understand ● Practical Usability

Workshop for future users	Policy makers Tech teams Experts	● understand the importance of the DUET concepts for the users ● identify possible end users and future adopters ● list possible new features ● identify possible challenges	Users feedback	● User Acceptance ● Minimum satisfaction

Table 4: identification of the methods and tools selected, their outputs and the success criteria they contribute to

The chosen methods and tools include both qualitative and quantitative approaches. In fact, diversification in tools, within this last testing cycle, has the purpose of collecting insights, findings and suggestions as well as gathering the right metrics to address the KPIs.

2.4.1. Testing Survey

The design of a survey to gather information about the user experience with the DUET platform was a key component of the testing cycle. A survey is a systematic method that gathers information from a sample of a population with the aim to construct internally and externally reliable quantitative descriptors (i.e., statistics) of a phenomenon (Groves et al., 2011). This tool was used in 2 different ways: in-person and remote test activities. In the first case users were invited to take part in focus groups within the Pilots. In the remote approach, users were contacted by email, and could respond online, on their own.
In both cases the online platform Qualtrics[2] was used to create and carry out the survey. There were five main parts within the survey in accordance to the surveys developed for the Beta Testing:

- The first part of the survey consisted in the identification of the user (as a citizen or a professional) and the selection of the pilot case: Athens, Flanders or Pilsen.

- In the second part, the user was introduced to a specific use case, according to his choices in the previous part of the survey. The tasks indicated in this part corresponded to the use case assigned (when there were several use cases available for the same profile the platform made a random assignment to the user). The user had to navigate through the platform, completing the set of tasks indicated by ticking a box whenever the task was completed successfully.

- The filling of the survey proceeds with part three, where we evaluate user experience components, i.e., satisfaction, perceived ease of use, and perceived usefulness. Following the Beta testing cycle approach, the survey was based on the USE scale. Lund created the scale to buck the trend of performance indicators being ignored in favor of subjective reactions (Lund, 2001). The acronym USE encompasses the three key facets of the user experience and stands for Usefulness, Satisfaction, and Ease of use. This scale has been extensively used to examine the acceptability and utility of technology in many fields (e.g., Ben-Zeev et al., 2014; Huang et al., 2012; Kelly et al., 2008; Kiselev & Loutfi, 2012; Kulviwat et al., 2007). Different items graded on a 5-point Likert scale, from strongly disagree to strongly agree, are used to

[2] https://www.qualtrics.com/

analyze each of the three elements. The scale's original composition had 30 components total—eight rating utility, fifteen measuring ease of use, and seven measuring satisfaction. The number of items was decreased to five per concept in order to make the survey short and enhance the possibility that it would be completed, resulting in the list presented in table 5. To make sure that the scale was still fitting, we conducted an analysis of the Cronbach's Alpha[3].

Concept	Item
Perceived usefulness	I can see it helping me be more effective
	I can see it being useful
	I can see how it would make the things I want to accomplish easier to get done
	I can see it meeting my needs
	It does everything I would expect it to do
Perceived ease of use	It is easy to use
	It is user friendly
	Using it is effortless
	I don't notice any inconsistencies as I use it
	It is easy to learn to use it
Satisfaction	I am satisfied with it
	I would recommend it
	It is fun to use
	It works the way I want it to work
	It is pleasant to use

Table 5: Key elements tested during the Open Beta Testing Cycle

An open question was asked after each set of questions to provide participants the opportunity to suggest ways the platform may be made more helpful, simple to use, and satisfying, correspondingly.

[3] The Cronbach's alpha is an index of reliability regarding the scale being used (Reynaldo & Santos, 1999). It translates the fact that the used scale elicits consistent and reliable responses through subjects and time.

- The fourth part of the survey aimed at collecting more specific information about the DUET platform characteristics according to the user's profile and point of view. The added value to the user was evaluated with questions regarding the platform's potential in their daily lives (if the user is a citizen) or for professional purposes (if users selected professional as their profile). Whether the respondent was a citizen, they were questioned if the platform was a useful tool for learning about their city, if it helped analyze data, or if they thought it was pointless to try to visualize data using the DUET platform. If, on the other hand, the user was a professional, he was asked if DUET could aid in urban planning, if the platform was an effective way to learn about his city, if the platform was useful for interpreting data, or if they thought trying to visualize data through the DUET platform was a waste of time, and if DUET was a complement to other tools they were already using. Lastly, they were questioned in three different ways about how much they would utilize the platform if it were made accessible to them in the future.

- The sociodemographic data, which included the user's gender, age, and professional sector, made up the survey's last section of the survey. Users were also asked about the web browser they used to carry out the testing in a separate question. The participants had the opportunity to contribute any further comments or suggestions they might have had regarding the DUET platform in response to a final open-ended question.

2.4.2. Focus Groups

The main benefit of the focus group method, used by the pilots, is that it enables users to get a quick introduction to and demonstration of the DUET platform prior to conducting the test. Given that the testing featured users who were exposed to the product for the first time, and some that had already been in contact with the platform, it was crucial to provide the essential context and framing for the DUET platform and project. This approach allows users to take the test individually but, at the same time discuss the results and experiences within the group, which enables a more in-depth reflection.

The goal was to implement at least one focus group per pilot with about 10 to 20 participants.
These testing activities had the following structure:

- Welcome and introduction
- Short description of DUET and the pilot case
- Testing of the Digital Twin
- Open discussion and feedback
- Conclusions

The focus groups included the usage of the survey and the creation of a set of questions using Mentimeter[4]. These questions aimed at launching the discussion and collecting additional feedback and suggestions for improvement of the platform.

[4] https://www.mentimeter.com/

2.4.3. User Observation

The User Observation technique was added to this testing cycle as it enables us to better understand the usage of the platform and to evaluate its effectiveness, efficiency and learnability. To reach this goal, two groups of users were foreseen to test and record their usage of the platform, enabling the analysis according to the following outputs: time to achieve a task number of errors and success in achieving that same task.

To implement this method, following the planning phase, each pilot recorded a use case to set the baseline for the analysis. Three use cases were made available for testing as described in table 6.

N°	Pilot	Target user	Case Title	Link to case
AC1	Athens	Citizen	Citizen feedback on the closure of Stadiou	https://citytwin.eu/athens-citizens-feedback-on-green-routing/
AP1		Professional	Closure of a street in the center (Stadiou) for pedestrians and results on air and noise pollution	https://citytwin.eu/athens-creation-of-a-pedestrian-and-cycling-route-in-stadiou-street/
PC1	Pilsen	Citizen and Professionals	Map for tactical exercise	https://citytwin.eu/map-for-tactical-exercise/

Table 6: use cases included in the observation test

In a group on the 26th of October a group of 4 people made a test of the platform, in a remote and unmoderated session. Another group of 11 people were asked to take the same test on their own being that 3 of them had participated in the previous session.

2.4.4. Workshop for future users

The goal of the workshop for future users is to assess the added value of the project and the platform and the potential of future adoption by potential future users. This session was integrated in the *Annual Conference of Major cities of Europe*[5]. The programme of this 90 minute session was the following:

- Introduction and audience survey (geography, workplace, knowledge of the topic)
- Platform and case study overview
- A guided tour of the case study cover all the steps from login to simulation of road closure
- Individual use & reflection (people that had laptops could explore on their own or, in case not, follow the guided tour)
- Audience feedback about the tool

[5] https://www.majorcities.eu/

- Breakout sessions to discuss various aspects of the Digital Twins
- Wrap-up

This workshop used different testing and interactive methods, constituting a solid approach to analyzing the interest of future users: presentation, demo, focus group, Mentimeter-based survey, a task-based activity, small-group work.

3. Results & Analysis

This chapter provides an overview of the results and analysis of the activities carried out during the third testing cycle. In the table below (table 7) are identified the events carried out during this process. Adding to these events it is important to consider the online, remote activities such as the online surveys and the user observation activities carried out in parallel.

Workshop	Date	Nr of Participants	Communication channels	Short Summary
Test clinic/Local pilot focus group Athens	15/09/2022 27/09/2022 29/09/2022 30/09/2022	37	internal communication, meeting, physical meeting	Internal meeting with City representatives, online focus groups, presentation in public event Workshop "Digital Twins to Future-Proof Europe's Buildings and Neighbourhoods" participation and promotion of final testing in European Urban Resilience Forum (EUREFSO) to promote the online survey through leaflets including the QR code, social media posts to promote the online survey and its QR, email communication to stakeholders to invite them to participate in the online survey individually
Test clinic/Local pilot focus group Flanders	16/09/2022 22/09/2022 11/10/2022	65	Live presentation, live workshops on the Digital Flanders booth (Trefdag 2022) and e-mail to expert group.	Internal live meeting with smart data experts of the Digital Flanders Department where the test case was presented. Parallel live workshop sessions on the Digital Flanders Trefdag 2022 (3000 visitors) on a booth: general introduction, step by step presentation of the case and invitation to fill out the questionnaire. Three employees supervised the workshops. E-mail invitation with clear indications how to participate in the questionnaire. Sent to a targeted group of professional civil servants.
Test clinic/Local pilot focus group Pilsen	09/09/2022 19/09/2022 22/09/2022	34	internal communication, meeting, on-line web meeting	Three focus groups were developed and implemented with the presentation of the platform, testing and the survey.
External testing clinic	26/10/2022 3/11/2022	12	internal communication, meeting	The external testing included 2 phases: one where 4 users where invited to explore the platform on their own and the other where 11 users were involved in a workshop followed by the exploring of the platform.

Workshop for future users	03/11/2022	50	Internal communication from both DUET project and MCE 2022 conference in Larissa	This workshop included a presentation of the concept and the platform, a demonstration of the platform features and testing activities as well as the collection of feedback from potential future users.

Table 7: Overview of the physical testing cycle activities

3.1. Survey results

3.1.1. Descriptive analysis

In total, 203 persons participated in the survey conducted during 8 different Test Clinics which were hosted online and offline, in the local pilot languages and in English (here summarized in English). In the following section, we analyse the results provided by participants who completed at least 75% of the survey, which corresponds to **80 participants**.

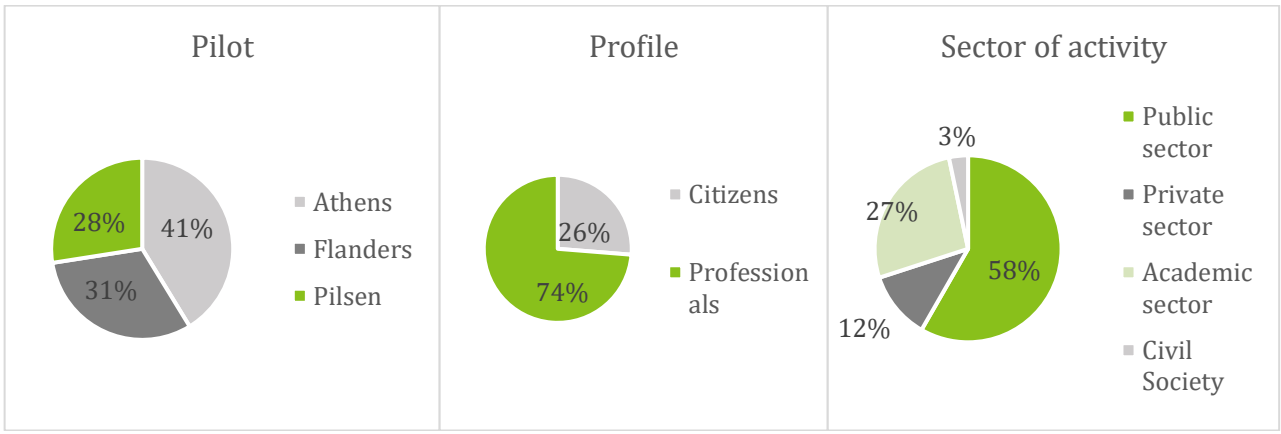


Figure 3: Survey's descriptive statistics (pilot, profile, sector) in percentages

Participants of the sample came from all three pilots in similar proportion, with 33 (41,3%) from Athens, 25 participants from Flanders (31,3%), and 22 (27,5%) participants from Pilsen. Most of the participants identified as professionals (74%, n=59) and 26,3% (n=21) as citizens. From the professional group, the majority were from the public sector (58%, n=35), followed closely by the academic sector (26,7%, n=16). Fewer participants were from the private sector (11,7%, n=7) and the civil society (3,3%, n=2).

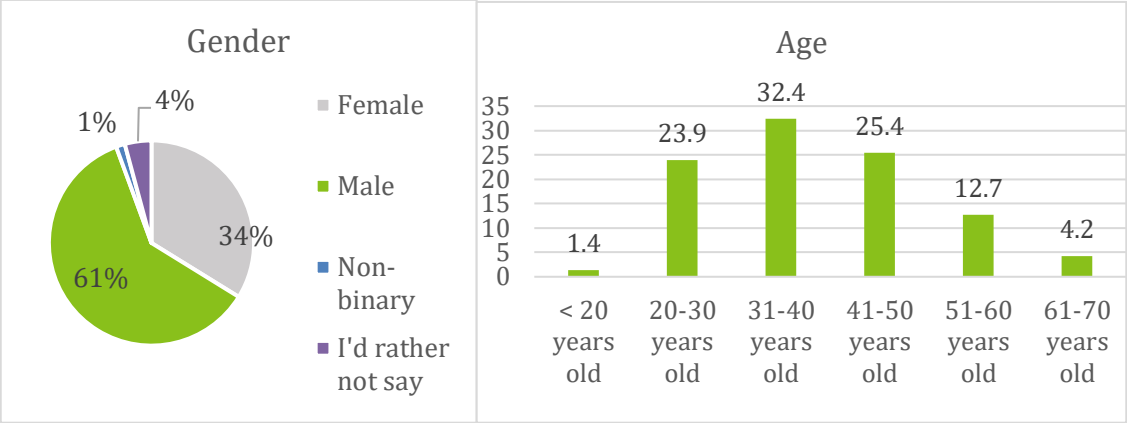


Figure 4: Survey's descriptive statistics (gender, age) in percentages

The sample displays a small imbalance in terms of gender with 61% of participants identifying as male (n=43) and 34% identifying as female (n=24), while one person identified as non-binary (1,4%) and three did not disclose that information (4,2%). In terms of age, we observe that the majority of the participants are between 20 and 50 years old (81,7%, n=58).

3.1.2. User experience

For evaluating the user experience criteria, as indicated in the section 2.2 of this report, the project identified 3 indicators: the perceived ease of use, the perceived usefulness and the overall satisfaction of the platform. The results of the analysis of the survey answers have fairly improved since the Beta testing cycle.

Ease of use	Athens	Flanders	Pilsen	Total
Citizens	3,44	4,20	2,70	3,57
Professionals	3,41	4,52	3,47	3,81
Total	3,42	4,45	3,4	**3,76**

Table 8: Perceived ease of use, mean scores

The perceived ease of use, detailed in table 9 can be considered positive with an overall score of 3,76/5. In the scale of measurement (5-point Likert scale), where participants had to indicate the extent to which they agreed with some statements, ranging from 1 – Strongly disagree to 5 – Strongly agree, 3,76 ≅ 4 is considered as a positive response as it corresponds to "somewhat agree". The perceived ease of use is slightly higher in the professional group ($\bar{x}$= 3,81) than in the citizens group ($\bar{x}$= 3,57).

The individual analysis of the pilots indicates that the perception is quite different from one to the other. Pilsen scores the lowest in what concerns the citizens group with 2,7/5. This is quite interesting as in the Beta testing cycle this was the group that had higher results ($\bar{x}$= 3,71/5). The participants

suggested a few ideas to improve their perception of the ease of use of the DUET platform especially based on the improvement of the user experience approach.

On average both Athens and Pilsen have the same results, about 3,40/5, which is a neutral result. Flanders, on the other hand, has positive feedback approaching the 4,50/5. The comments and suggestions, in this case, are related to the amount of information that is quite slow to charge on the platform.

Usefulness	Athens	Flanders	Pilsen	Total
Citizens	3,71	3,96	3,90	3,80
Professionals	3,81	4,03	3,74	3,86
Total	3,77	4,01	3,76	**3,85**

Table 9: Perceived usefulness, mean scores

In what concerns the perceived usefulness the general score is quite positive with 3,85/5. Although they vary between pilots, all of the scores are higher than 3,7/5. This is an improvement since the last testing cycle. Both citizens and professionals evaluate the platform in a similar way with a mean score for the Citizens of 3,8/5 and for professionals 3,86/5.

In Pilsen the mean score is of 3,76/5 which is positive and corresponds to the general comments which see added value in the solution and the features it offers although the User experience is pointed out as an element to improve. As indicated in the Beta testing cycle, the GUI (Graphical user interface) could be improved. Most of the other comments are related to legends and warnings displays that could support the users in the navigation process. On the other hand, the titles and layouts that were a concern in the previous testing cycle are no longer pointed out as an issue. According to the users, the layers on the map should be accompanied by a clear legend and during the calculation process all the phases should be identified “Clearly announce that the calculation has been completed e.g. in the process of analysis and we can close the window.”.

The Athens users evaluated the platform positively with a mean score of 3,77/5. In this case the suggestions for improvement are related to the citizen engagement and notification to involve them in the decision making process in a more effective way. The general opinion seems to be that the platform is useful although it might require a few specific improvements e.g. “*In conclusion, I can see real value in the platform since it would be a solid tool to use for the impact evaluation in different scenarios and policy recommendation at city level*.”

Flanders shows the most positive score reaching 4,01/5. This is in line with the comments and suggestions which seem to point to expanding the tool to other data analysis sets and to being informed, as a citizen, about the evolution of the decision-making process through email.

	Mean score
The DUET platform can be of help for urban planning	4,49
The DUET platform is helpful to interpret data	4,38
The DUET platform is an efficient means of gaining information about my city	4,15
The DUET platform complements other tools I am currently using	3,49
Trying to visualise data through the DUET platform is a waste of time	1,98

Table 10: Specific evaluation of the perceived usefulness

The DUET platform's ability to assist with data interpretation and its effectiveness as a way for people to learn more about their community are both highly praised by participants. According to table 10, participants do not believe that trying to display data with DUET is a time-wasting endeavor. Professionals agree that the DUET platform can aid in urban planning, but they were only somewhat positive about how well DUET works with other technologies professionals already use.

The User experience KPI improved considerably since the last testing cycle. In fact, the current 87,7% corresponds to an increase of 18,3% regarding the 69,4% that were the result in the Beta testing cycle.

KPI acceptance		N Participants	% Participants
Intention	**Positive (> 3/5)**	64	**87,7%**
	Neutral (3/5)	2	2,7%
	Negative (< 3/5)	7	9,6%

Table 11: User Experience, frequency (KPI)

With a consensus mean score of 3,96/5, the DUET platform is generally considered satisfactory. The main improvement since the last testing cycle occurred in Flanders where the mean score went from 2,93/5 to 4,47/5. This is not only a considerable evolution, but also an achievement that puts the platform satisfaction in a very positive level. These numbers are consistent with the rest of the indicators, showing a very positive response from the Flanders pilot. The main comment on Flanders side about the improvement of satisfaction is related to the expansion of the platform: “I would love the possibility to use the models and software to map other types of data, such as socio-economical data to test the limits of the possibilities, although that might be outside of the scope”.

Satisfaction	Athens	Flanders	Pilsen	Total
Citizens	3,60	4,32	3,60	3,81
Professionals	3,78	4,51	3,68	4,00

Total	3,72	4,47	3,68	**3,96**

Table 12: Satisfaction, mean scores

In the other two pilots, Athens and Pilsen, the scores are very similar. In Athens, similarly to what happened in Flanders, the score increased since the last testing cycle. The comments in this section referred to the suggestion to a more curated information in what concerns legends, "*e.g. how the categories in the legend are calculated. What are the assumptions of the models used?*".

The users who tested the case in Pilsen hold a less satisfactory vision on the platform, not only compared to the other pilots but also to the previous testing cycle. The slight decrease of satisfaction in this pilot is not very significant, and it appears to be related, mainly to the geographical representation and to the speed of data loading.

KPI satisfaction		**N Participants**	**% Participants**
Satisfaction	**Positive (> 3/5)**	62	**86,1%**
	Neutral (3/5)	6	8,3%
	Negative (< 3/5)	4	5,6%

Table 13: Satisfaction, frequency (KPI)

The global satisfaction level reaches 86,1% which is higher than the 80% threshold foreseen at the beginning of the project. This evolution from the 72,2% obtained in the previous testing cycle might be the result of the improvements made to the platform and that can be consulted in Annex 1.

3.1.3. Acceptance

The intention to use criteria, following up the trend observable in the metrics analysed in the previous subchapters, has increased since the Beta testing cycle. Within the framework of this testing cycle, "intention to use" refers to "acceptance". With a general score of 4,16/5, all the pilots score above 4/5 which reinforces the platform potential for future users. In this context, citizens score slightly higher than professionals, strengthening the idea that this platform could be relevant for different types of users in the decision making process.

Intention	Athens	Flanders	Pilsen	Total
Citizens	4,27	4,40	4,33	4,31
Professionals	4,09	4,24	4,00	4,11
Total	4,15	4,28	4,03	**4,16**

Table 14: Intention to use, mean scores

The participants from Flanders show the higher intention to use, with a score of 4,28/5 and the Pilsen users rated their intention to use with a mean score of 4,03/5. In the case of Flanders the comments and suggestions for future usage are more related to the potential of the platform to integrate new cities, case studies and mora data and citizen engagement. In the Case of Athens users reinforce the need to improve even further the user experience and make the platform lighter and faster. In the case of Pilsen most of the comments refer to the geographical representation and data analysis capacity of the platform.

Overall the acceptance criteria scores high with a 93,1% KPI, being higher than the threshold foreseen.

KPI acceptance		N Participants	% Participants
Intention	**Positive (> 3/5)**	67	**93,1%**
	Neutral (3/5)	4	5,5%
	Negative (< 3/5)	1	1,4%

Table 15: Acceptance, frequency (KPI)

3.2. Pilot focus groups results

This section is a summary of the findings from pilot focus groups that were held in the native tongue. Annex 2 contains all comments and suggestions made during the focus groups and pilot surveys.

3.2.1. Athens

Four online focus groups were organized by the Athens pilot during the month of September. During these sessions gathered city representatives and local stakeholders and were one of the main motors for filling and disseminating the online survey (for which the results have been described in the section 3.1 of this report).

During these sessions different tools served to collect feedback from the users. The surveys were used to gather specific information on the platform, a discussion took place to create a list of most relevant comments and suggestions and, additionally Mentimeter added another layer of relevant feedback.

From the open discussion the main points are summarized here:

- target future usability tests to actual people who live or work at neighborhood level and create user profiles
- useful app for saving financial resources in terms of city planning
- useful for saving time

- acceptability depends on multistakeholder (city, prefecture, state levels) use of the tools
- in the future it is proposed to be provisioned a data broker to integrate new functionalities
- need to cover multiple sectors (energy, climate, mobility) with the appropriate models
- local use of DT in neighbourhoods where locals can decide on smaller scale projects rather than closing a central street in the center
- user friendly since all necessary information is depicted
- proposed to insert a legend indicating air pollution and noise pollution data sources
- the map could be appeared as google earth in order to become less heavy for a pc, so as not to include a spherical view of the map
- generally find ways to make it lighter for a pc
- High usability for pedestrians walks in the city
- IT literacy of the citizens that will use it, it requires high literacy as a tool to use
- a technical benchmarking could be provisioned targeting the scalability in order the users/city officials have the possibility to develop more tools based on the DT
- this tool should be operating as a stand-alone tool for Athens
- in an operational level of everyday life the DT should include as users of the DT other entities and not only the municipality such as ministries, region, transport agencies etc. Generally any entity cooperating with the city
- great tool for decision making and planning
- potentiality to add more layers and sources of input from sensors
- if a scenario is implemented in a small area of the city, then the visualization could load only this area and not the whole domain or model, this could make the loading time of a result faster. The user could select, before starting a scenario, a box in the map where he/she wants to see results for. Then the calculation is for the whole Athens but not all data are fetched, only the ones referring to the geographical area "box", that could make the DT faster
- for a simple user that does not have a "fast" laptop/PC, the process for scenarios' implementation is slow. A suggestion would be to integrate a 'light' version and more features would be added
- the landing page of the DT should cache the location and load in the first page the DT of the relevant city (Athens in that case). Currently the DT loads Flanders in the main page. Alternatively, a pop up message to select a city can appear. In that way, when more cities will be added, it would be more convenient to have the feature of a drop down list of cities.
- the messages during re-calculation of the model must be updated. It is obvious that the process is going both through the blue pop-up and when you open the data tabs. But it would be better if there is an estimation message on the time of calculation e.g. still … minutes remaining or re-calculation …% etc.
- the DT modelling and visualization is great and the fact that the DT calculates all the results and delta layer automatically is a pro
- it has a great potentiality the integration of air pollution and noise pollution data

- a user is interested in integrating data sets on water re-use and sewer mining data and sees the potentiality to add underground water layer in the DT e.g. watering of green places, fountains etc

A specific list was elaborated in the second session with the policy makers:

- the DT should be hosted in DAEM's servers and further developed in more projects
- also locally can be experimentally used

Potential Policies to be explored emerged from this discussion, having a perceived benefit from the users point of view:

- pedestrian creation to a whole area in the center including many roads
- use of the DT at a neighborhood level e.g. closing a street only at the hours of schools starting/finishing

The Mentimeter was used to understand the best and least usable features of the DUET platform and the feedback from the users was the following:

1. What do you think was the best feature of DUET tools for Athens?
   - Data Catalog & Data Model
   - Simulation and operation of the platform
   - The visualization of data and results
   - The update of citizen of an upcoming change
   - data integration on visualisation layers
   - the integration of simulation models is excellent - and shows the way to additional computational layers and services
   - The provision of information on the map, the visualisation on the road. The options to make small changes in traffic etc
   - The potential of coupling multiple models to explore the different effects of a scenario
   - Even at this (relatively modest) dataset integration the number of questions that can be posed and answered is impressive - one can only imagine what additional open data could enable!

2. What do you think was the least usable feature of DUET tools for Athens?
   - GUI, Navigation
   - Navigation - no need for spherical view, it could look like more like Google Earth
   - I had to run the model again. I selected the whole Stadium and it had an issue with the display of the results
   - Had a hard time using the interface, but I am a complete newbie
   - The time of analysis was long for Stadiou scenario, but the pending process pop-up window provides an assurance for the user that something is happening, there is something to expect

- Analysis completion rate and waiting time. The content menu could be more user friendly, at least in my experience it was difficult to navigate through the available options
- Analysis time

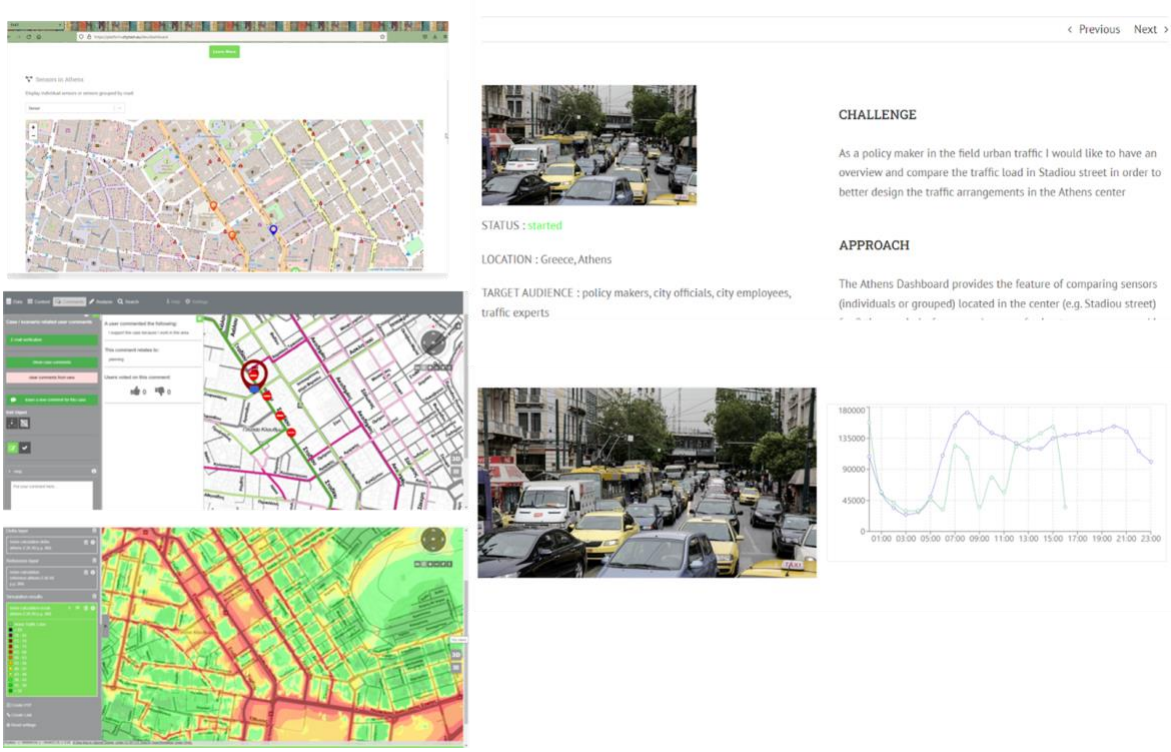


Figure 5: the Athens use cases

The feedback collected during these sessions complemented the responses that the users gave in the survey about the Athens use case:

Q29 - Do you have any suggestions to make the DUET platform more useful to you?

- Actual values would be of use (I suppose behind the qualitative results that can be found in the legend there are values)
- I can see the platform giving value to urban planning departments at city level. It is fairly easy to use, although a bit of effort should be made to make it more user friendly. The simple scenario that was run required a lot of time since the platform is a power hoarder, and some people may be discouraged to use it in the end. The information is provided in a comprehensive manner, easy to read. In my view, a more complex scenario would be more of a hassle to manage, a menu with more options to "play" with would be more suitable for urban planners that are called to solve problems in populated areas with heavy traffic and present multifaceted parameters. In conclusion, I can see real value in the platform since it

would be a solid tool to use for the impact evaluation in different scenarios and policy recommendation at city level.

- Adding some pop-up windows with navigating instructions during the analysis and reading of results can improve a lot the User experience
- I am still a bit confused by the results when turning on and off the filters. As a citizen I think I need a better understanding of why and how the results change
- Most importantly, since we talk about a Design Solution, that refers to citizens and according to CoDesign principles, it should include the opinion of citizens who are directly affected. For example, if we block Stadiou street, we should ask for opinions from people who live or work in Stadiou Str. or in nearby streets, since they will deal with the results of that action. Also they know the road and the place better than people, who just pass by Stadiou in order to go to their destination.
- So local citizens should be included mainly, who will be more affected by every action we commit."
- Integration is the key: all information about traffic etc should be introduced in the DT regardless of whether it may fail. Proper ML methods for data imputation could be of help.
- In cases where this tool moves from mere visualization tool to a decision-making enabler, the quality of information and granularity is important. From the running of traffic related scenarios the information needs to be in a much more concrete transport/mobility contexts and be evaluated for its relevance and reliability, so as to be meaningful."
- It never worked. I did not see the layer. It was forever "in progress"
- It is not clear how you submit a comment. There was no submission button.

Q31 - Do you have any suggestions to make the DUET platform easier to use?

- The platform seems quite heavy and response is slow. I work with Mozilla via a quite strong desktop and internet line.
- It is not easy to understand if the analysis is running. It would be good to see the information related to the scenario and to make it clear in the Interface that the Process is running (perhaps the expected time as well) More friendly GUI and Navigation
- User friendly tools for introducing data (by clicking on the map)
- Information and parameterisation of the models that are running in the back
- More context and coverage are necessary for network level assessments
- A more generic map without so many information could make it more user friendly
- Well the previous ones actually. And maybe make it more clear how layers work. It took me a while

Q33 - Is there anything that would make you more satisfied with the DUET platform?

- More curated information e.g. how the categories in the legend are calculated. What are the assumptions of the models used?
- a bit slow but it depends on one's Internet connection

Q38 - Now that you have had a first feel of the DUET platform, what would you expect from it in the future? What need of yours could the platform fulfill, what questions would you like it to answer and how?

- I would like the platform to be lighter, i.e. respond faster to my actions (zoom, selection of segments). Many times the process stalled, seemingly for good, so stability of the system is crucial. Actual values behind the legend should be available to the user. Overall curation of the information is needed (e.g. the features are indeed road segments). Smaller points: I cannot search for roads. The blue pop-up message should be more visible, not at the bottom-right corner. The coloring of the traffic legend is confusing.
- If the platform achieves to make a more user friendly UI, a menu to evaluate more complex scenarios, keeps updating the databases behind it, a faster response in planning a scenario - interventions (not the calculation time), I believe it would be the perfect tool for the design of mobility interventions within a city. It is useful, however I feel it needs a bit more effort to reach the next step.
- A change in the user experience to better understand the steps, related data and results would be useful.
- Time of analysis, although reasonable it creates some uncertainty about what happens during that time. Perhaps it would be preferable to add the pending pop-up window right after the analysis.
- More cases to be implemented in the future
- Long term changes of traffic interventions
- Best GUI and Nanigation. Include people who are directly affected by our changes, in accordance with CoDesign, if you want to co-create a platform. We don't know the real needs of the people who will be more affected and that is crucial, in order to deal with the problems that will appear.
- "Ability of complete mapping or resources regardless of its availability
- Adding by a simple click new data on the DT
- Plug and play models for assets and resources management"
- “1.Is there a way to get the same results but per sensor? Without having to click at each one sensor and run the visualization for it.

  2. It would be useful to have an initial name for the visualization files (PNG) so that in case there are multiple, the user can have an idea which file corresponds to each graph.

3. Information on average delay.

4. Information on pedestrian (and eventually bicycles)"

- to provide data on air pollution

Q44 - Would you like to add anything regarding the DUET platform?

- This is a very good effort, and it is impressive how many models were incorporated to analyze the available data. It will be very useful in many applications for the urban environment and its better design.
- Great effort. My best!
- It is an important tool. I hope that the data collected will be exploited in the future strategic design of the city center.
- My first attempt to load DUET was through Chrome and it didn't work. It may be due to plugins not allowing some elements to load.
- The visualization button didn't work for me

Figure 6: Online promotion of Athens final testing and printed brochures for the EURESFO event.

Figure 7: DUET presentation and Athens DT testing in EURESFO event.

3.2.2. Flanders

On September 22nd, Digital Flanders participated in the yearly Trefdag Digitaal Vlaanderen event (Flanders Expo Hall, Ghent). This year, over 3000 visitors participated, 40 info sessions were given, and 90 on-site company booths were available. One of these booths was the *Digital Flanders booth*.

During 2,5 hours, the DUET project and the Flanders "Contributie bridge closure" case were presented in parallel by three DUET colleagues to individual visitors and groups of up to 5 members. DUET features to be tested were explained beforehand, so some first-time experiences were not captured.
Following the parallel workshop sessions, visitors were invited to complete the questionnaire for citizens and specialist/civil servant target groups. Sometimes, questionnaires were filled out together by groups.
We didn't count the number of workshop participants, but we estimate it to be 50 individuals at least.

During this session (both online and offline) surveys were distributed and the feedback collected about the Flanders use case was the following:

Q29 - Do you have any suggestions to make the DUET platform more useful to you?

- The possibility to use the modelling tool and software to map and test other data
- Questions are quite vague sometimes.
- I work in another domain and I don't use stuff like this. But it looks good.
- I'd like it to be coupled with a general follow up system so that as a citizen I know what the follow up actions regarding the intervention will be (can be a simple email).

Q31 - Do you have any suggestions to make the DUET platform easier to use?

- I don't know if common users can use this easily. I do, but I'm used to similar things.
- Easy to learn as a professional, don't know how less skilled visitors experience this.
- Was a bit slow. Maybe a slow internet connection.
- data heavy thus bit slow
- In cases where high usage is expected (for example when a local government evaluates certain possibilities through public voting), set up cashing at some point in the data flow to make sure people don't avoid using it because of latency.

Q33 - Is there anything that would make you more satisfied with the DUET platform?

- I would love the possibility to use the models and software to map other types of data, such as socio-economical data to test the limits of the possibilities, although that might be outside of the scope
- See previous remark

Q38- Now that you have had a first feel of the DUET platform, what would you expect from it in the future? What need of yours could the platform fulfil, what questions would you like it to answer and how?

- Nice tool! And I find it user-friendly.

- more detailed traffic information, what for a situation where only motorised traffic is blocked off?
- Evaluate if providing more bike friendly infrastructures would lower car traffic
- Dutch translation
- I hope citizens can use it to investigate policy problems themselves.
- More cases from other cities please!
- Future: more datasets, more models, more cases from non-pilot cities and other projects.
- I like. Do you have other data like air quality?
- Citizen participation

Q44: Would you like to add anything regarding the DUET platform?

- Good work, make it public!
- Thank you, nice to explore this product.
- No

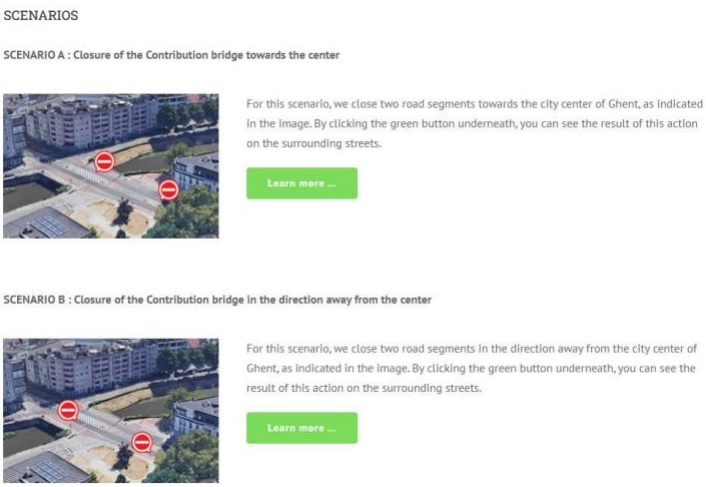
Q53: Do you have any suggestions to make the case presentation better?

- Don't know much about voting as a way to gather opinions
- More cases for Flanders
- "In case people don't vote logically, it would be interesting to know why they voted, possibly with (optional) multi-select of common reasons and a short-answer for 'other'. This could also help avoid overlooking things.
- Voting results might be better to show only after people have voted, both to incentivise voting and to avoid biases."
- more explanation about the models
- I would appreciate to compare the 3 scenario by instantly switching from a map to the other, without needing to let the system recalculate
- Make a concise overview of main model outputs available in table form just before voting (with e.g. closure duration, AQ increase/decrease ... etc)
- No, it is fine like this
- No, works great

Besides the comments from the questionnaire, we captured the following extra, verbally communicated feedback.

- All visitors like the landing pages and the way cases are presented. They also like the pilot/project-specific pages concept, but they wonder why there is no connection between the general landing page and pilot/project-specific pages.
- Finding a case on the landing pages was experienced as straightforward. Two attendees wondered if the word tag cloud contained relevant tags.

- The test case is well-documented on the case-specific page but the button connecting the map viewer was not always found immediately.
- Scenarios are presented in a well-organised and understandable way. People like the supporting visuals (already revealing what the scenario is about).
- People like the LOD2-buildings in Ghent. Specialists think LOD3-buildings of a part of Ghent are available at this moment.
- Visitors liked the delta visuals with four categories (all "*minor/major increase/decrease*"-combinations), but they didn't always find the corresponding explanatory legend.
- Lots of questions were asked about the KULeuven traffic model used to simulate traffic updates after the closure of one or more road segments. Four visitors wanted to know if the initial situation (before closure) is based on *live data*.
- *Cesium* software navigation works well when using a mouse. Without a mouse however, it is perceived as challenging to use.
- We received many comments about the voting functionality. Since the voting was IP-restricted and only one IP address was foreseen in the conference location, most visitors received the message "you voted already". Voting results, however, could be consulted by all participants.
- Visitors like the feedback option on the case detail pages, but two visitors found it challenging to comment in the DUET viewer for a specific location. Not all participants tested this feature.



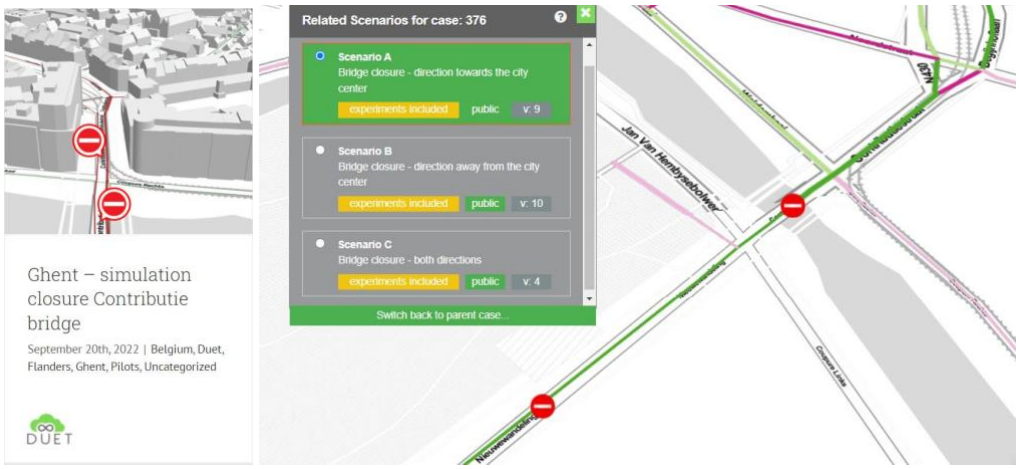


Figure 8: the Flanders use case

Figure 9: Flanders pilot workshop sessions during the Digital Flanders Trefdag 2022

3.2.3. Pilsen

In the Pilsen pilot there were 3 focus groups organized with the local stakeholders. A total of 34 participants joined these three sessions.

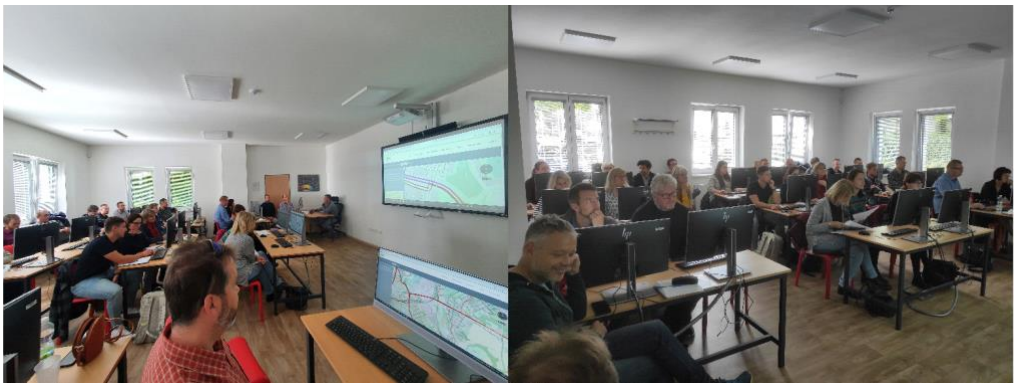


Figure 10: Pilsen Focus groups

The structure of these focus groups were the same in the three pilots. In the case of Pilsen, after the introduction and platform presentation, the participants were asked to contribute with suggestions and remarks to identify possible issues or improvements.
In relation to the comments registered in the previous testing cycle, the errors were corrected, still there are a few recommendations for the platform next steps:

- Integrate a complete legend including an explanation of the values in each layer.
- Add snapping to the map – to be used in measuring or new objects design
- When creating models, the user should be informed that the calculation is in progress;
- The possibility of modelling the intensity of new traffic constructions on the road network.
- Changes in traffic intensities could be more interactive- hourly intensities expressed numerically
- Additional information for ArcGIS analyses
- This platform could serve us as a tool for territory analysis, better design, and data interpretation.
- Basic interpretation of city data
- Verification of the proposed development in the existing structure of the town
- More sophisticated legend and connection to ArcGIS
- Viewing your own buildings
- Assistance in creating and presenting 3D models

The results gathered in the focus groups contribute to the creation of a list of suggestions that can be added to the survey comments that are translated into english below:

Q29 - Do you have any suggestions to make the DUET platform more useful to you?

- It would be nice to have an integrated legend. It would be nice to make it more obvious that a calculation is in progress. The "thinking" message can be hidden when the view is scrolled differently. Clearly announce that the calculation has been completed e.g. in the process of analysis and we can close the window.
- Integrated legend, improve user interface (visibility of the legend and interaction after clicking on the element - data clarity)
- Clear legends must be part of each layer.
- legend display (e.g. for noise) is missing, missing points snapping (when drawing and measuring) - drawn objects, their location or measured values are indicative only

- Complete the legend including an explanation of the values in each layer. Add snapping to the map – to be used in measuring or new objects design
- More user-friendly GUI, better user information during analysis.

Q31 - Do you have any suggestions to make the DUET platform easier to use?

- Improve UX
- More accessible legends and information about features on the map.

Q33 - Is there anything that would make you more satisfied with the DUET platform?

- Better graphical representation, data loading is slower and freezes.
- Add the possibilities of its use to the currently used mapping applications (e.g. ArcGIS).
- Better map documentation, such as an aerial image

Q38- Now that you have had a first feel of the DUET platform, what would you expect from it in the future? What need of yours could the platform fulfil, what questions would you like it to answer and how?

- The possibility of modelling the intensity of new traffic constructions on the road network.
- Changes in traffic intensities could be more interactive- hourly intensities expressed numerically
- Additional information for ArcGIS analyses
- This platform could serve us as a tool for territory analysis, better design, data interpretation.
- Basic interpretation of city data
- Verification of the proposed development in the existing structure of the town
- More sophisticated legend and connection to ArcGIS
- Viewing your own buildings
- Assistance in creating and presenting 3D models

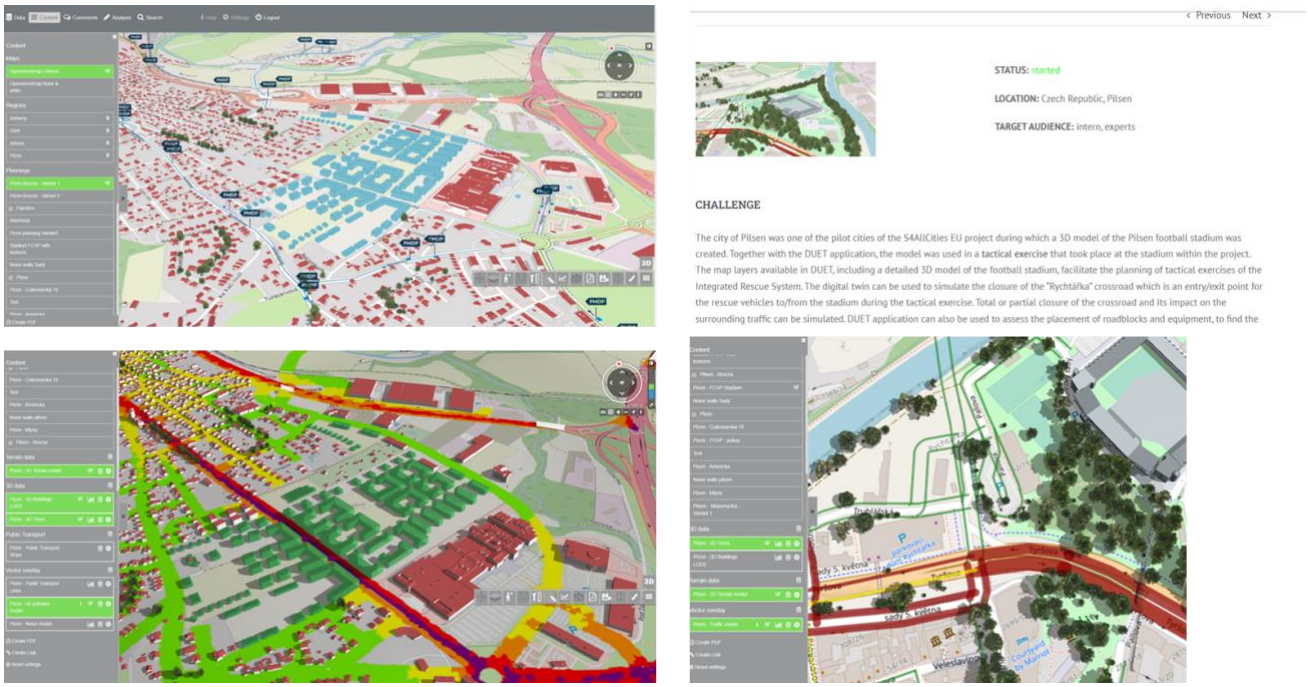


Figure 11: the Pilsen use cases

3.3. User Observation results

To implement the observational test, two approaches were undertaken. The first was to create groups of 4 users, on the 26th of October which were invited to explore the platform on their own by recording the test in a remote and unmoderated test. The second activity consisted in a session with 11 users (3 of them had participated in the first group of 4), where the users were introduced to the concept of DUET and explored the platform at the same time.

To analyse the results according to the outputs designed we considered:

- The time per task, comparing the time of the user´s group to the one of an expert of the team. This calculation was made in the following way:
  Task Time= (Time of user 1+Time of user 2+Time of user X)/number of users
- The task success metric (= efficiency, as described in table 1) corresponds to the tasks achieved without errors. The number of errors was calculated in a binary system - considering that one task that had been completed or not, but that showed one error or more errors corresponded to one error. This means that the raw error counts 1 (if the user has committed at least one error) or 0 (if the user has committed no error) to complete the task. We are aware that this is a simple approach but based on the needs of the testing cycle we consider it to be sufficient. Errors can be considered for example as clicking on different buttons, or a task that is not completed successfully in the first attempt (e.g. login).
- The task completion (=effectiveness, as described in table 1) metric analyses if the user was able to reach the goal of the task independently of the number of errors he committed.

From the first observation test, most of the users can interact fairly easily with the platform and even demonstrated curiosity in exploring it by themselves. In fact, 3 out of the 4 users tested more than one use case.

Use Case	participants	%task success (without errors)	% Task Completion	Users average time per case (min)	Expected time per use case
AC1	4	83,33%	66,66%	5:03	4:15
AP1	3	75%	83%	29:35	27:51
PC1	2	80%	100%	9:08	8:02
total		80,43%	78,26%	43:46	36:08

Table 16: number of participants and tasks successfully completed by use case

Although on average the time spent per task is higher than the time initially foreseen, it is important to take into account that, for example in the use case AP1, the time of calculating the analysis makes the final result vary (in total, for the 3 cases we have about 7 minutes more in the test than in the experts videos). Overall, the number of errors and compliance registered a success of 80,43% and 78,26% which is positive, corroborating the user's feedback which is quite positive, in general, considering that the platform could be useful to them. It is important to point out that in the use case AC1 task completion is lower than task success. This is due to the fact that there were 2 tasks which were interdependent. In this case, the users were not able to enter the platform with their email and, therefore the second task of commenting with their username was not completed. This justifies the low results of the task completion (66,66%). The errors in this case were just considered in the first of the two related tasks, this is why it did not impact in the same way the task success.
The overall comments registered concerned the user interface and the lack of information during the calculation periods as well as the fact that the platform speed could be improved.

Figure 12: Second observation session

What we can conclude from the second activity (session with 11 users) is that there is a clear improvement in the platform usage for the 3 users that had already tested it (even though the case tested was different from the one they had previously used) with 100% of the tasks achieved and no

errors during the process. For the other 8 users the tasks were all achieved successfully but some doubts arose namely the fact that in some browsers the username and password could not be copied and pasted, they had to be written directly in the form. If we compare the general results there were more errors in this second session, but more tasks successfully completed. The time of the test was not taken into account in this case as the time for calculation was considerably more extensive than initially foreseen. This would potentially distort the results of the test, so the option was not to consider this metric in the last session.

Use Case	participants	% task success (without errors)	% Task Completion
AP1	11	75%	100%

Table 17: results of the second observation session

Some conclusions emerged from this second session that are worth sharing:

- the errors in the first task were related to the browser that was in use which did not allow to copy paste the information of the username and password, it had to be directly inserted in the form;
- the calculation of the analysis was longer than 10 min, on average it lasted 15-20 min;
- in task 2 most of the users explored information on data available besides what was requested, as they shared, they had interest in better understanding the platform as they used it;
- in task 3 some of the users took a bit longer to identify the road to close and the fact that it had to be closed segment by segment.

It is important to note that the 3 participants who were doing the test for the second time were quicker in performing the tasks and made no errors while completing all the tasks, even in the case where the user had not tested this use case before.

Comparing the results of the 2 tests we can conclude that the Practical usability increased in the second test with a total of 87,5%.

Use Case	participants	%task success (without errors)	% Task Completion	Practical usability
Session 1	4	80,43%	78,26%	79,34%
Session 2	11	75%	100%	87,5%

Table 18: practical usability results of the observation test

3.4. Workshop for future users' results

On the second day of the MCE 2022 conference in Larissa, DUET partners held a workshop in which almost 50 participants had a chance to see and play with the citytwin.eu platform. We had a truly international audience in the room as can be seen from the word cloud below (Figure 13).

Figure 13: Geographic spread of participants

The vast majority were working at a local administration, while the distribution of other stakeholders was more or less equal. See Figure 14.

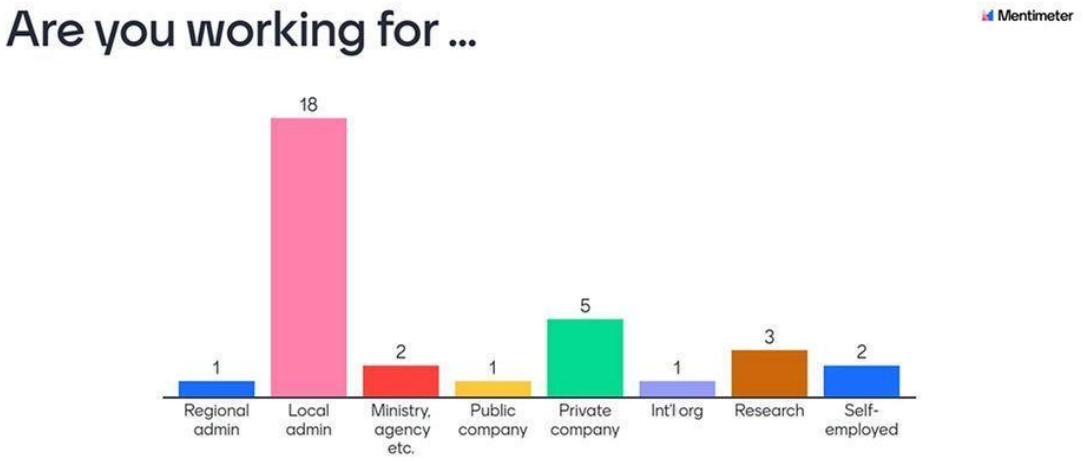


Figure 14: Professional background of participants

An interesting finding was that the Digital Twins concept was new to most people in the room. Only a few considered themselves to be experts on the subject or had previously worked on a Digital Twin project (Figure 15).

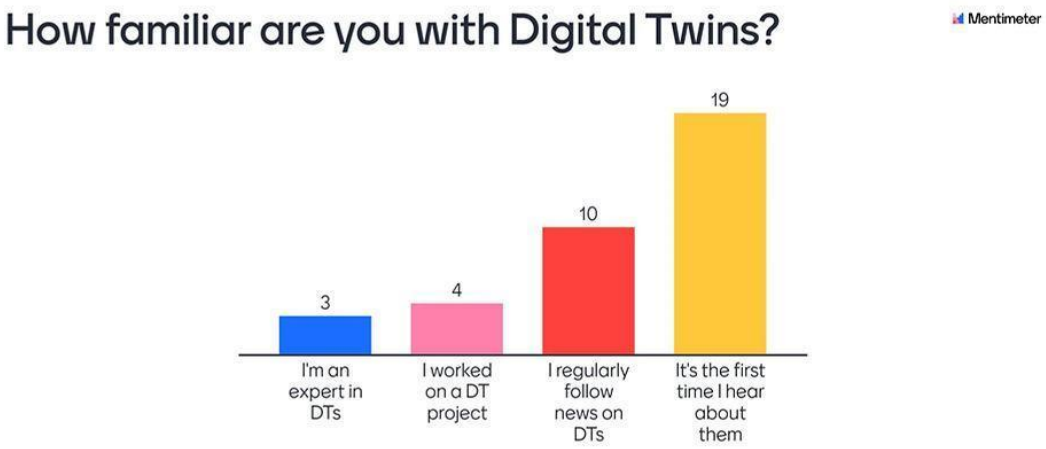


Figure 15: Participants' familiarity with Digital Twins

The use case that was selected for the experiment was the "Athens partial reduction of traffic". During a demo, those with a laptop were able to login and cast themselves as an urban planner with a powerful tool under their fingertips. At the end of this session, participants were asked whether they would like to have this tool for their city. Overwhelmingly people said yes (Figure 12).

Figure 16: Participants' interest in the DUET solution

After the demo, the audience split into three groups to explore various aspects of Digital Twins.

The first group discussed the use of a Digital Twin for policy making on a neighbourhood level, the integration of local sensors in a Digital Twin, the pros and cons of a Digital Twin solution, and the link with open data and citizen science initiatives.

The second group discussed the barriers to adoption of Digital Twins, focusing mainly on data availability and quality. The group also explored various requirements linked to the interoperability of systems and skilled personnel.

The discussion in the third group centered around several topics, including the need for qualitative data and models, the indisputable extra value of real-time data streams and dataset combinations, the rising demand for scalability and target-group customisation, and how historic datasets can trigger self-learning in an optimal Digital Twin setting. In addition, this group explored the increasing security challenges and the volatility of visualisations and interpretations in a fast-changing world.

The workshop was one of three activities performed by the consortium in Larissa. The other two were dissemination at the booth and a plenary speech. You can read more about them in this blog.

4. Discussion and Recommendations

The most significant and common ideas for improvement are highlighted in this section for the project consortium to take into account when the group moves into the final development cycle. The key issues that were brought up by several testers and are expected to advance the DUET platform as a whole are highlighted (rather than focusing on improvements relevant for any specific pilot).

To systematize the approach the recommendations were organized into groups:

- **Platform expansion**: most of the comments under this topic are related to the integration of new use cases, new cities or sets of data. This is usually linked to a positive perception of the platform potential. From the Athens workshop the suggestion to extend the platform to other level entities e.g. regions, transport agencies, corroborates the idea that was shared by different users that this tool is a good support for decision making.
- **Improve the Information loading speed**: in general the users consider that the platform should be faster and lighter. This feedback appears as one of the most relevant, not only by the number of comments that mention it but also due to the fact that it was already pointed out in the previous testing cycle.
- **User experience improvement**: engaging more users and citizens specially by addressing the user experience and user interface needs. IT literacy is namely pointed out as one of the needs for the platform adoption. The general user experience should be improved through different elements, colours, additional information boxes (e.g. informing about the model calculation time remaining, add legends to the layers).
- **User interface and navigation**: in this topic a few users identify the general quality of the models and the navigation as good, nevertheless some improvements could be made, namely in the geographical representation.

5. Conclusions

The final testing cycle provides essential information on the DUET project and Platform. Besides the encouraging results of the usability tests, which provide an interesting insight on the work developed and the acceptance by the users, it also enables the consortium to better understand what could be improved in the future to ensure the long term sustainability. The scores achieved are quite high and they match the KPIs that the project committed to. The table below(table 19) illustrates the KPIs performance from the final testing cycle.

Success Criteria	KPI	Testing cycle score
User acceptance	90%	93,1 %
Minimum satisfaction	80%	86,1 %
User experience	80%	87,7%
User ability to understand	80%	77,8%
Practical usability	80%	87,5%

Table 19: Overview DUET KPIs and results from testing cycle

In general the feedback from the users is very positive and the KPIs were met, except for the User ability (based on the “ease of use” from the survey) to understand which is very close to the foreseen score. Although the concept of digital twins is still quite new to many of the participants (naturally the ones that did not participate in previous testing cycles) the project purpose and the platform are perceived as useful and there are several users that show interest in future adoption.

Following up the previous testing cycle recommendations, and the results of the final testing cycle, we summarize a few key findings and considerations:

- **General improvements to platform vs specific pilots:** in the previous testing cycle an extended list of issues was reported. It was not possible to address all the issues during the project lifecycle that is why a set of features were prioritized, based in the general vision instead of the particular pilot specificities and tested within this final testing cycle. Future improvements would benefit the platform but the results presented in this report illustrate the improvements of the features implemented.
- **Improving UI /UX:** this is probably the most relevant feedback from the users. To prepare the sustainability of the platform and future adoption this is one of the elements that will need most work. The platform would clearly benefit from a dedicated UX/UI designer to improve it even further. All the sessions provided feedback on this topic and they are underlined by the different user profiles.

Besides these two main elements, other specific points of improvement should be taken into consideration such as the speed and stability of the model, additional data sets integration, improvements of navigation and data models, as described in the Recommendations chapter.

The final testing cycle points out the benefits, positive results and possible improvements of the DUET platform. With about 200 people involved in the testing cycle in 13 activities, where 7 use cases were tested, this testing cycle helped to reach out the KPIs defined by the project which included, namely the number of collaborators in sessions about 350 in total.

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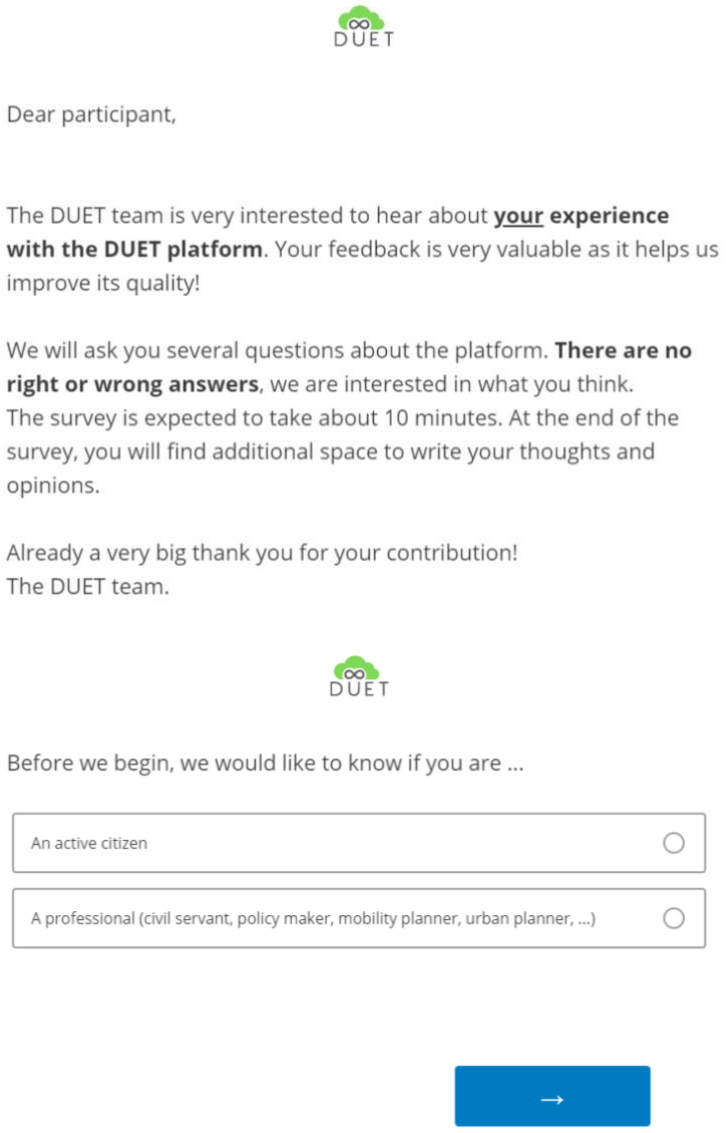
Annex 1: Survey questions

Example of the survey conducted for the Athens' pilot for the professional user group.



Dear participant,

The DUET team is very interested to hear about **your experience with the DUET platform**. Your feedback is very valuable as it helps us improve its quality!

We will ask you several questions about the platform. **There are no right or wrong answers**, we are interested in what you think.
The survey is expected to take about 10 minutes. At the end of the survey, you will find additional space to write your thoughts and opinions.

Already a very big thank you for your contribution!
The DUET team.

Before we begin, we would like to know if you are ...

- An active citizen
- A professional (civil servant, policy maker, mobility planner, urban planner, ...)

→

DUET

You will now start the evaluation of the DUET platform. Please read carefully the instructions available via the link.

As a city official for the city of Athens, you want to evaluate the impact of transforming a street in the center of Athens to a complete pedestrian and cycling route on the air pollution and noise pollution indicators. In this case you will evaluate the closure of Stadiou street. Your goal is to simulate the creation of a green route in the center of Athens in Stadiou street that includes high traffic congestion and see the result in the environmental conditions of the center. If the result in nearby air and noise pollution is forecasted to be low then green routing can be enhanced and promoted for implementation by the city.

Follow the instructions here to explore how the DUET Digital Twin can support you in evaluating this impact, and check the boxes as you go. If you are unable to accomplish one of them, leave the box unchecked.

- [ ] Go to the DUET platform by clicking on the green button "See this case live on DUET" at the end of the instructions
- [ ] You first log into the back-end of the DUET platform where you can run various simulations. You do this via the "Login" tab where you add the credentials:
- [ ] Full name = Athens User
- [ ] Email = athens@citytwin.eu
- [ ] Password = Athens@123
- [ ] The Digital Twin will load the map of Athens with the traffic centered in Stadiou street. Go to the upper left menu at the option "Analysis"
- [ ] Select a road segment where you want to simulate the closure of traffic, in case you find Stadiou street or another street. Choose "Block this road segment(s) and choose "integrate air model results"
- [ ] Click on "Start Analysis". The DUET traffic model now starts calculating the new situation and a blue pop up message informs you that calculation is ongoing.
- [ ] You have to wait for 7-10 min for the re-calculation of the traffic and air results.
- [ ] The result can be found in the "Data" section of the main menu, in the tab "air model results." Activate the layer by clicking the plus symbol in the upper right corner of the layer.
- [ ] By clicking the "content" button, the overview of all data layers is added on the left side. Now you can switch on/off layers as you like to investigate your simulation in detail.

- [ ] To see the effect of the changes on air pollution, a delta layer is calculated.
- [ ] Experiment by activating/deactivating the layer of Reference, Result and Delta
- [ ] By clicking on the "i" in each layer you can monitor the explanation of the results
- [ ] For example, have an overview of the result on air pollution according to the road you selected, as explained in the legend greener areas refer to less NO2 after the limitation of traffic.
- [ ] For monitoring the noise pollution results, choose again "Analysis".
- [ ] Select a road segment where you want to simulate the closure of traffic, Choose "Block this road segment(s) and "integrate noise model results"
- [ ] Click on "Start Analysis". The DUET traffic model now starts calculating the new situation and a blue pop up message informs you that calculation is ongoing.
- [ ] You have to wait for 5-7 min for the re-calculation of the traffic and noise results.
- [ ] The result can be found in the "Data" section of the main menu, in the tab "noise model results."
- [ ] Activate the layer by clicking the plus symbol in the upper right corner of the layer.
- [ ] By clicking the "content" button, the overview of all data layers is added on the left side. Now you can switch on/off layers as you like to investigate your simulation in detail.
- [ ] The result can be found in the "Data" section of the main menu, in the tab "noise model results."
- [ ] Activate the layer by clicking the plus symbol in the upper right corner of the layer.
- [ ] By clicking the "content" button, the overview of all data layers is added on the left side. Now you can switch on/off layers as you like to investigate your simulation in detail.
- [ ] To see the effect of the changes on noise pollution, a delta layer is calculated.
- [ ] Experiment by activating/deactivating the layer of Reference, Result and Delta
- [ ] By clicking on the "i" in each layer you can monitor the explanation of the results
- [ ] For example, have an overview of the result on noise pollution according to the road you selected, as explained in the legend greener areas refer to less noise after the limitation of traffic.

Done? Great! Go to the next page to answer a few questions about your experience using the DUET platform.

DUET

Below, you can find several statements regarding the extent to which you find the **DUET platform** **useful**. Please indicate to what extent you agree with each statement from "strongly disagree" to "strongly agree".

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I can see it helping me be more effective	○	○	○	○	○
I can see it being useful	○	○	○	○	○
I can see how it would make the things I want to accomplish easier to get done	○	○	○	○	○
I can see it meeting my needs	○	○	○	○	○
It does everything I would expect it to do	○	○	○	○	○

Do you have any suggestions to make the DUET platform more useful to you?

DUET

Below, you can find several statements regarding the **DUET platform's** **ease of use**. Please indicate to what extent you agree with each statement from "strongly disagree" to "strongly agree".

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
It is easy to use	○	○	○	○	○
It is user friendly	○	○	○	○	○
Using it is effortless	○	○	○	○	○
I don't notice any inconsistencies as I use it	○	○	○	○	○
It is easy to learn to use it	○	○	○	○	○

Do you have any suggestions to make the DUET platform easier to use?

DUET

Below, you can find several statements regarding your **satisfaction** with the **DUET platform**. Please indicate to what extent you agree with each statement from "strongly disagree" to "strongly agree".

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am satisfied with it	○	○	○	○	○
I would recommend it	○	○	○	○	○
It is fun to use	○	○	○	○	○
It works the way I want it to work	○	○	○	○	○
It is pleasant to use	○	○	○	○	○

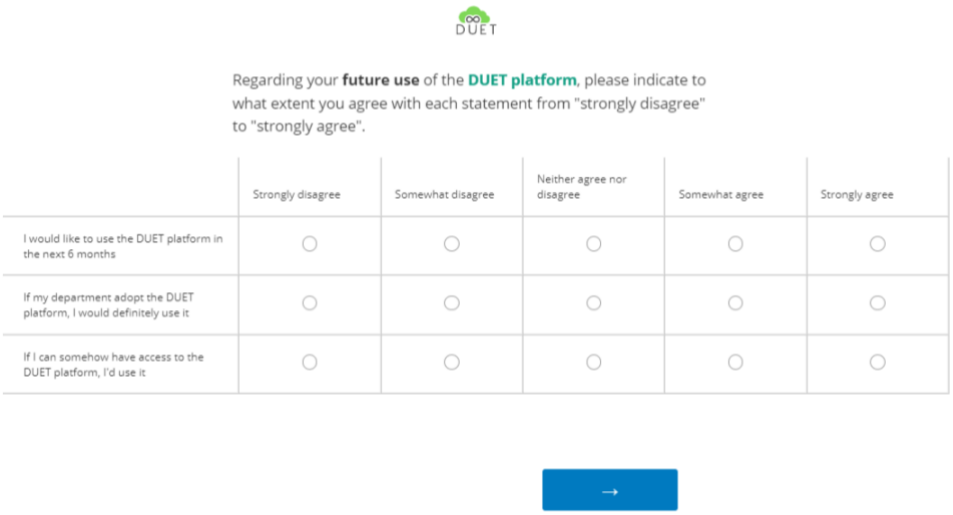
Is there anything that would make you more satisfied with the DUET platform?

DUET

Below, you can find several statements regarding the **DUET platform**. Please indicate to what extent you agree with each statement from "strongly disagree" to "strongly agree".

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The DUET platform can be of help for urban planning	○	○	○	○	○
The DUET platform is helpful to interpret data	○	○	○	○	○
The DUET platform is an efficient mean of gaining information about my city	○	○	○	○	○
Trying to visualise data through the DUET platform is a waste of time	○	○	○	○	○
The DUET platform complement other tools I am currently using	○	○	○	○	○

→



DUET

Regarding your **future use** of the **DUET platform**, please indicate to what extent you agree with each statement from "strongly disagree" to "strongly agree".

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I would like to use the DUET platform in the next 6 months	○	○	○	○	○
If my department adopt the DUET platform, I would definitely use it	○	○	○	○	○
If I can somehow have access to the DUET platform, I'd use it	○	○	○	○	○

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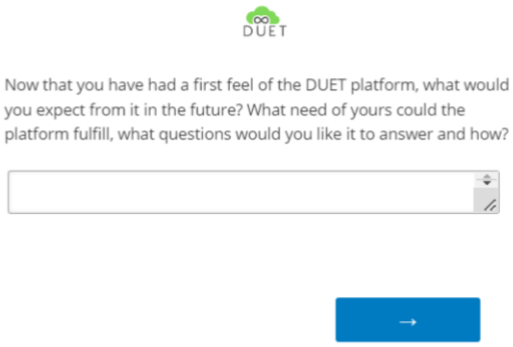

DUET

Now that you have had a first feel of the DUET platform, what would you expect from it in the future? What need of yours could the platform fulfill, what questions would you like it to answer and how?

→

Thanks for your input! We would like to know a bit more about yourself.

Which web browser did you use for the test?

- Firefox
- Chrome
- Edge
- Safari
- Other

You are ...

- Female
- Male
- Non-binary
- I would rather not say

You are ...

- < 20 years old
- 20 - 30 years old
- 31-40 years old
- 41-50 years old
- 51 to 60 years old
- 61 to 70 years old
- > 70 years old

You indicated filling in this survey as a professional. Please select the category that best apply to you:

- Public sector (civil servant, policy maker, etc.)
- Private sector (mobility industry, urban planner, etc.)
- Academic sector (professor, researcher, etc.)
- Civil society (NGO, citizen association, etc.)

Would you like to add anything regarding the DUET platform?

→

We thank you for your time spent taking this survey.
Your response has been recorded.