HARMONY

Holistic Approach for Providing Spatial & Transport Planning Tools and Evidence to Metropolitan and Regional Authorities to Lead a Sustainable Transition to a New Mobility Era

D9.5 Evaluation of the HARMONY metropolitan areas engagement and demonstration activities - Final

Submission date: 28/02/2023

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SUMMARY SHEET

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
ADS-B	Automatic Dependent Surveillance - Broadcast
ADR	Automated Delivery Robot

ATM	Air Traffic Management
AV	Autonomous Vehicle
BEB	Battery Electric Bus
BIP	Biglietto Integrato Piemonte (Piemonte's e-ticketing system)
CAA	Civil Aviation Authority
CAV	Connected and Autonomous Vehicle
CDT	Comune Di Torino
DRT	Demand Responsive Transit
EUR	Erasmus University Rotterdam
FLARM	Flight alarm
GPS	Global Positioning System
GROT	Gemeente Rotterdam
GZM	Górnośląsko-Zagłębiowska Metropolia
ITL	Intelligent Traffic Lights
KPI	Key Performance Indicator
LSP	Logistics Service Provider
LUTI	Land Use and Transport Interaction
MaaS	Mobility-as-a-Service
MS	Modelling Suite
NGO	Non-Governmental Organization
OASA	Athens Urban Transport Organisation
OBU	On Board Unit
OCC	Oxfordshire County Council
OFS	Operational Freight Simulator
OMM	Oxfordshire Mobility Model
RAI	Rijwiel en Automobiel Industrie (Bicycle and Automotive Industry)

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RTL	Return to Launch
SFM	Servizio Ferroviario Metropolitano (Turin Metropolitan Railway service)
SME	Small and Medium size Enterprises
SORA	Specific Operations Risk Assessment
SP	Stated Preference
SUMP	Sustainable Urban Mobility Plan
TFS	Tactical Freight Simulator
TO	Transport Order
TSP	Transport Service Provider
TUD	Technical University of Delft
TUL	Torino Urban Lab
UAM	Urban Air Mobility
UAV	Unmanned Aerial Vehicle
UCL	University College London
ZE	Zero Emissions

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EXECUTIVE SUMMARY

Aligned with the main goals of the project, HARMONY WP9 envisages and is efficiently organizing co-creation and demonstration activities. In this framework, the objective of task 9.8 is to evaluate and compare the activities conducted within the HARMONY metropolitan areas. To enable a proper evaluation and comparison across the demonstration cases, it is necessary to systematise all the work that has been performed and therefore a framework analysis has been necessary to be established from the onset.

In line with deliverable 9.1, which describes general guidelines for the setting up, operation, evaluation, and knowledge exchange of the six HARMONY co-creation labs, as well as deliverables 9.3 and 9.4, where the progress performed with respect to the results of the engagement activities and demonstrations, has been reported, the current deliverable 9.5 aims at presenting the remaining progress of these activities. It summarises previous efforts, as well as at evaluating the final results of the engagement activities and demonstrations, across with any potential political or governance barriers faced. This pertains to the activities carried out until the end of the project. All the co-creation labs contained a set of activities aiming at contributing to the further development of the innovative approaches to the mobility services on the local level, as well as to contribute to the HARMONY modelling activities. Next to it, three of the co-creation labs carried out physical demonstrations too.

The main input for this deliverable relates to the case studies' set-up, management, and cross-metropolitan activities and more specifically to changes in the objectives and scope of the co-creation lab and/or demonstration, activities carried out, barriers (in relation to the activities carried out), crucial success factors, the lessons learnt and key stakeholder engagement moments. Additional input is provided by the results of all three demonstrations which have been carried out during the project. To this end, an evaluation has been performed for the demonstration cases so as to bring together and evaluate the results and also compare the achievements.

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1. Introduction

1.1 Aim of the project

Nowadays, new mobility services and technologies are presented as possible solutions to reduce greenhouse gas emissions and energy consumption in metropolitan areas. However, authorities face several challenges when it comes to harmoniously integrating these developments into spatial and transport plans to improve citizens' wellbeing and achieve environmental targets. Given rapid technological advances and the emergence of new mobility services, metropolitan authorities are often in need of expertise, knowledge, and tools for multiscale spatial and transport planning.

In view of this background, HARMONY's vision is to enable different city or regional authorities to lead a sustainable transition towards a low-carbon new mobility era. This is guided by its harmonised spatial and multimodal transport planning tools, which comprehensively model the behavioural and operational dynamics of the changing transport sector as well as metropolitan areas' spatial organisation.

HARMONY has set ambitious targets for the co-creation of metropolitan scenarios, informing updated spatial and transport planning tools. Therefore, a strict and stable planned coordination is mandatory to ensure the quality of the results and findings of each area and, also, to allow comparisons across the six different geographic areas. The consortium's intention is to ensure the best experience of the implementation of the HARMONY concept in each area and its exchange, not only across the HARMONY metropolitan areas, but also across other EU and international areas.

1.2 Objectives of the deliverable

Within HARMONY, WP9 is responsible for ensuring that demonstration activities are efficiently organized, contributing to achieve the main goals of the project. Specific objectives of WP9 are to:

- Develop the guidelines on setting up the co-creation labs, the stakeholder engagement activities, and the demonstrations, to make sure that all the areas follow the same approaches and can be comparable.
- Organise the aforementioned activities and demonstrations and assist in their operation.
- Organise cross-metropolitan activities for experience and knowledge exchange.
- Collect the secondary data and recruit participants for the primary data collection. To evaluate the engagement activities, the demonstrations and the barriers faced in each area.

In this framework, task 9.8 has focused on evaluating and comparing the activities conducted within T9.2 to T9.7. To enable a proper evaluation and comparison across the pilot cases it is necessary to systematise all the work that has been performed and, therefore, a framework analysis has been established from the onset. The approach taken for evaluation has been adapted to enable the communication with the cities, bring together the results, compare their achievements and finally evaluate their results. In line with the above, the main objective of the current deliverable is to present, evaluate and compare the activities that took place in each area, elaborating on the findings, the barriers and opportunities faced.

1.3 Structure of the deliverable

Deliverable 9.5 starts with this introductory chapter 1, then a recap of the orchestration approach of the co-creation labs and demonstrations is being provided in chapter 2. Following, in chapter 3, an overall presentation of the latest activities in each co-creation lab, as well as a final evaluation of those, constitutes the core of this deliverable, together with chapter 4 which focuses on the HARMONY areas with physical demonstration activities. Finally, the deliverable is completed with a summary of the process and impact evaluation of the activities of the different HARMONY metropolitan areas.

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2. Orchestration approach of the co-creation labs and demonstrations

In this chapter, we provide a summary of D9.1, adapted as presented more recently in D9.3, for the sake of completeness, related to the current state of the art of the HARMONY co-creation labs and what had to be orchestrated there. All the HARMONY metropolitan areas developed co-creation labs, varying in objectives and scope, depending on the area and its needs. Alongside modelling use cases, physical demonstrations have taken place in Trikala, Rotterdam, and Oxfordshire. HARMONY co-creation labs in the above-mentioned areas as well as in Turin, Athens and Katowice have mainly focused on stakeholder engagement activities necessary to fulfil their identified scope of activities.

2.1 Setting up the co-creation labs

The objectives and scope of each co-creation lab have been clearly defined and presented in D9.1, including information on the core co-creation lab team, the selection of an appropriate governance model and the preparation of the co-creation lab, identifying the potential demonstrations and activities to carry out, with an indicative planning.

Once the preliminary ideas were identified, team members needed to further develop them within a co-creation lab. Thus, per each of them, it is necessary to clarify on:

- Concrete objectives and ambitions.
- Expected results.
- External to co-creation lab stakeholders necessary to fulfil the demonstrations (who, why, what do we expect from them, their input, and their benefit from the pilot).
- Planned co-creation strategies/sessions during demonstrations.
- Stakeholder engagement milestones (why, who, where, expected result).
- Demonstration location and test environment preparation (what is necessary to prepare there, who is involved, planning).
- Operational preparation for demonstrations (what is necessary, concrete actions, who is necessary for it).
- Potential risks, barriers, and mitigation strategies.
- Potential facilitators.
- Baseline measurement (if any, based on the evaluation framework developed).

Analysis of the ecosystem defined by the above allows to identify early enough what are the potential risks and opportunities from the direct co-creation lab environment. It is also necessary to carry out the analysis of legal and ethical issues and mitigation measures that can be undertaken. It serves as a check whether the co-creation lab goals can be developed and achieved in real life without raising legislative, social, political, or ethical issues.

The whole setting up phase was finalised with the development of the indicative planning for the co-creation lab. It should encompass both demonstrations carried out in the labs, as well as activities supporting them. This action plan documents key agreement points: objectives, scope, expected results to be achieved, operational and geographical scope of the lab, core co-creation lab team, concrete ideas for the demonstrations and activities to be carried out within the lab, risks and opportunities that were identified and which should be monitored throughout the whole lab process. The pre-selected

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demonstrations are documented via the process evaluation forms (see Appendix A: Periodic process evaluation report template).

In this deliverable, we present what has possibly changed with respect to the initial objectives and scope of each co-creation lab, the key activities that have been carried out, the barriers faced (in relation to the activities carried out), the crucial success factors and the lessons learnt during the whole period of the operation of the co-creation lab, as well as the key stakeholder engagement moments.

2.2 Operation of the co-creation labs

The steps necessary to operate the co-creation lab, with some concrete steps to be performed, have been described in D9.1, specifically for each approach, regarding a) the operation of the physical demonstration (for Rotterdam, Oxfordshire, and Trikala) and b) the operation of other activities of the co-creation lab. Stakeholder engagement processes are important in both cases and are at core to operation of any co-creation lab as well as an essential requirement for a successful co-creation process.

2.3 Evaluation of the co-creation labs

The evaluation is a necessary step to draw conclusions on the experiences of the co-creation labs and their activities, as well as lessons learnt from them. In task 9.8 of HARMONY project, evaluation of the validation area activities takes place. To enable a proper evaluation and comparison across the labs, it is necessary to establish concrete procedures and processes according to which the evaluation processes will be organized during the HARMONY duration. The character of activities performed within HARMONY co-creation labs suggests two types of evaluation processes. For each of the co-creation labs a process evaluation is applied, that allows to reflect on the experiences of the co-creation lab and get the lessons learnt from their processes. Next to it, Rotterdam, Trikala, and Oxfordshire are developing a set of key performance indicators (KPIs) in order to evaluate the results of the physical demonstration. The specific KPIs are introduced and described in the following chapter, for both the co-creation and the demonstration activities. Evaluation of the co-creation lab includes three key steps:

- Development of the evaluation framework.
- Data collection processes.
- Data collection analysis.

The key objective of the HARMONY task 9.8 is to conduct evaluation of the six co-creation labs. Looking at the character of activities performed, within each co-creation lab, the evaluation framework, as has been presented in deliverable 9.1, consists of two main pillars: (1) Periodical progress evaluation of the co-creation lab, and (2) Evaluation of the physical demonstrations.

Periodic progress evaluation has been established for all the co-creation labs, in the form of open questions (see Appendix A: Periodic process evaluation report template), reflecting on:

- Progress/ changes on the objectives and expected results of the co-creation lab.
- Activities carried out during the established period.
- Barriers and success factors encountered during this period.
- Key stakeholder engagement moments.
- Activities planned for the next progress report period.

Objectives and expected results from the co-creation labs, as well as concrete activities that are planned to be carried out in order to achieve those, are the starting point of the progress evaluation. At the end

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of the project, it will be assessed, whether these objectives and results were achieved and what was the process, facilitating factors and barriers that led to it or not. Chapter 5 of the current deliverable assesses the overall co-creation activities for each lab, including the three demonstrations that took place.

Evaluation of the physical demonstrations (2) will be performed according to the set of the co-creation performance indicators developed on the level of each individual demonstration. Indicators to evaluate the results of the physical demonstrations include, for example:

- Performance, including process and impact-related, indicators.
- Public acceptance and adoption indicators.
- Business model and technological readiness of solutions indicators.

Key performance indicators (KPIs) were established for usage in the evaluation of the co-creation and the demonstration activities by the cities. Two lists were formulated respectively, meant to serve as a consultation for the municipalities while no obligation towards them was established. These can be found in Appendix B: Tables for KPIs for the evaluation of this deliverable.

The co-creation KPIs are classified into context, involvement and process indicators (which relate to main events taking place). The list is non-exhaustive, and the KPIs could be potentially used to measure the evaluation of co-creation activities. Also, the list brings a focus on the most relevant ones which would allow for adequate information.

Second, the demonstration KPIs are subdivided in performance indicators (and further into process and impact); public acceptance and adoption; and business model and technological readiness indicators. The list focuses itself on drones demonstrations and were used in the demonstration in one of the cities, which will be described further on.

In the same sense as the co-creation KPIs, the demonstration ones are also part of a non-exhaustive list that could be used for measuring a drone or other mobility innovation demonstration. It is relevant to highlight at this stage that it has not been possible to obtain all of the results from the indicators in the table presented in Appendix B: Tables for KPIs for the evaluation, from all the demonstrations, either due to lack of data collection or guaranteed validation of the results (e.g. results come from a short-term pilot instead of a long term or larger scale one).

Data collection processes differ in form and timing for either physical demonstration or other activities carried out within each co-creation lab. For the overall co-creation lab activities, approximately every six months the process evaluation form is being sent to and collected from the HARMONY co-creation labs core partners. Regularity of the data collection from the physical demonstration depends on the specific demonstration case and can take the form of interviews, on-site counting's, automated data collection, etc. It is also possible that physical demonstration evaluation might require baseline measurements data collection, in order to be able to compare business as usual situation, with the situation after the introduction of the innovative solution.

Data analysis is performed throughout the co-creation lab in order to make sure that the lessons learnt from each evaluation period are well integrated into the future development of the lab.

Specifically, for the physical demonstration, findings will be assessed in order to compare the before and after situations. Based on the suggested evaluation framework, the following assessments are considered as useful to perform:

- Of the co-creation indicators to evaluate the efficiency of the solution/ technology compared to the co-creation lab goals.
- Of the adoption indicators to evaluate users' feedback and public acceptance of the innovative solution/ technology.
- Of the business model and technological maturity of the solution/ technology.

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2.4 Knowledge exchange

As mentioned in D9.1, several activities and physical demonstrations are running in parallel within co-creation labs. Therefore, the operation of the co-creation lab needs to consider how the knowledge from individual activities, within individual co-creation lab, is combined and transferred to other project co-creation labs, as well as how the knowledge generated in the different co-creation labs will be exchanged beyond the HARMONY project. The main objective of the knowledge and experience exchange is to liaise with different stakeholder groups and to ensure interoperability of the project results with other innovative solutions in the field of sustainable transport and mobility. The knowledge and experience exchange activities are closely linked to WP10 Dissemination, Exploitation and Innovation Management, more specifically to T10.1 communication and dissemination activities and 10.3 Engagement activities and collaborations. Detailed and concrete approach to the envisaged knowledge exchange strategies and activities within HARMONY is therefore described in the corresponding to these tasks' deliverables. In summary, in relation to the knowledge exchange, HARMONY commits to:

- Avoiding duplication of work with other projects and platforms, especially within the CIVITAS network, aiming mostly to align our evaluation related work with the other CIVITAS projects, in order to exchange knowledge and experience.
- Aligning with other activities in order to integrate HARMONY in the wider field of sustainable regional mobility and spatial and transport planning.
- Allowing others to build on HARMONY results.

With respect to the abovementioned points, several CIVITAS special sessions have been organized, where HARMONY has participated and presented the evaluation framework, as well as the activities carried out so far in terms of evaluation.

Regarding internal communication, knowledge, and experience exchange among the different cities, regular WP9 meetings are being organized, with all the six HARMONY areas and the partners involved in co-creation and demonstration activities, being present. In parallel one-to-one meetings are also organized between WP9 leader and each of the cities, i.e., the tasks 9.2 to 9.7 leaders. In addition to that, the periodic process evaluation report (see Appendix A: Periodic process evaluation report template) is being regularly filled in by the areas to provide their updates and make an archive of those.

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3. Case studies' set-up, management and cross-metropolitan activities

3.1 Rotterdam

3.1.1 The Rotterdam co-creation lab

The initial objective of the Rotterdam co-creation lab was to understand the potential impacts emerging from the integration of autonomous vehicles (AVs) into the local mobility system, specifically the urban freight transport component. To support (and promote) the further integration of the AVs into the local mobility system, the municipality of Rotterdam needs to have a clear picture of the potential effects and impacts from the AVs integration: e.g., in terms of the economic growth, jobs market, impact on the total vehicles within city borders, infrastructure and urban space requirements, impact on the IT and public communication systems capacity. This has been planned to be done through 1) the Harmony modelling activities (application of the tactical freight simulator to the city logistics system of Rotterdam and identification of the impact of the AVs on the Rotterdam city transport network) and 2) physical pilots with AVs. However, due to several reasons, these plans have been adjusted as it is described in the following section 3.1.2.

3.1.2 Changes in the objectives and scope of the activities

There have been no changes in the objectives and the scope of the co-creation lab per se for Rotterdam, however, these could no longer be met via the physical pilots with AVs. First, due to COVID-19, it had not been possible to have the physical pilot finished before the modelling had started. Next to that, the decision by the former consortium partner ARRIVAL to withdraw from participation in the Rotterdam demonstration, necessitated the drawing up of an alternative plan within a short timeframe, considering the factors that led to ARRIVAL's decision. Additional time has been available to collect and analyse data from stakeholders which can be applied to improve the modelling activities, while an alternative plan for a physical pilot has been set up, details for which are provided in section 4.1.

3.1.3 Activities carried out

Overall, the Rotterdam co-creation lab has been carried out in close engagement with logistics stakeholders, via Logistics 010, which is a knowledge hub located in Rotterdam. Below are some of the main activities carried out during the project:

- Gathering primary data for the Tactical Freight Simulator (TFS), the development of which is being constantly done in close partnership with the Technical University of Delft (TUD).
- Preparatory actions on using global positioning system (GPS) devices, questionnaires, and serious gaming to obtain additional data.
- Questionnaires for Small and medium size enterprises (SMEs), specifically those using delivery vans have been sent out. A couple of specific questions have been added which help to improve the TFS input. Results have been delivered to TUD in Q2 of 2022.
- Results from recent surveys by Evofenedex (branch organisation of transporters) and RAI association (branch organisation of vehicle importers and dealers) regarding the transition to zero-emissions (ZE) freight transport have been made available.
- Rotterdam has put big efforts in close cooperation with the industry to make sure that the implementation of the ZE zone in 2025 will go as smoothly as possible.
- Regarding modelling of use cases, preparations have been made for the Operational Freight Simulator (OFS) use cases.

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- Further, an important workshop and a consultation meeting have taken place as part of the Rotterdam co-creation lab activities, details of which are presented in Table 1.

Table 1 Main co-creation events Rotterdam

Process indicators (per event)	Type of event	Event 1: Co-creation workshop	Event 2: Mobilizing and analysing the Ecostars database
	Purpose	1. To inform stakeholders on the city's draft policy for charging infrastructure, specifically the heavy duty charging for logistics 2. To get feedback from the stakeholders 3. Demonstrating how the city uses the simulation tool for policy development. 4. To call upon the stakeholders to set up/ participate in initiatives to gain experience with (joint) use and exploitation of heavy-duty charging facilities	Calibration and validation of the simulator input describing the behaviour of the logistical agents.
	Type of co-creation process	Creation of data/knowledge	Creation of data/knowledge
	Number of stakeholders involved in the session	20	more than 120
	Type of stakeholders involved	Traffic modellers, LSPs-TSPs, grid operator, charging service providers, transport authority, financial service provider	Companies in various logistic segments, model developers, municipality
	Objectives event	Increasing stakeholders' involvement; Gaining more effectiveness	To use the consultations to stimulate the individual companies; Gaining more effectiveness; Increasing stakeholders' involvement
	Outcome	1. Stakeholders have been informed by the presentation of the draft policy document 2. Feedback received and processed in final version (established Q4-2021); English version available 3. Presentation of a heatmap (computed with the HARMONY-TFS), indicating transport energy demand at depots, destinations, and en-route. 4. Stakeholders have not taken initiatives yet.	Due to involvement in HARMONY, the relevant information from the available reports (the number of which is still growing) was extracted and was made it available to TUD for analysis and processing. Data from companies in ECOSTARS database on vehicle fleet size and usage have been made available.

3.1.4 Barriers in relation to the activities carried out

COVID-19 has caused many delays also in the co-creation lab of Rotterdam, while a further barrier were the delays occurring from the partner ARRIVAL which would provide the vehicle to be used for the AV demonstration. Eventually, as mentioned before, this partner has withdrawn from the project, hence bringing up a bigger barrier in the process. This means the effort of Rotterdam to support the

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pilot needed to be done in a much shorter timeframe than foreseen, due to the timeframe of the project, while having to look for an alternative demonstration plan. Details on this issue are provided in section 4.1.

Some barriers with respect to the demonstration activities relate to finding a suitable supplier of a delivery vehicle that would have the desired functionalities. In addition, testing on public roads has been a barrier, because legislation and regulations in the Netherlands do not allow easy testing of these types of innovations without an operator.

3.1.5 Crucial success factors and lessons learnt

The city of Rotterdam has tried to stay in close contact with the other consortium partners and their project activities, however, as has been discussed, unfortunately limited knowledge could be gained from or shared with other cities.

Lessons learnt, from the HARMONY Model Suite (MS) point of view are that very few cities use simulation of urban freight transport at city level as an instrument for knowledge development and policy analysis. Further, keeping the numerous input data for the simulation up to date requires considerable effort. For a structured approach of this task, the MS is a suitable tool.

In general, lessons learnt in terms of the maturity level of technologies such as autonomous vehicles have been gained. Further, it has been noticed that not all research partners and consultants in the field of automated delivery vehicles are as aware as would be expected of either policy requirements and public responsibilities or market potential of delivery-AV exploiters. There appeared to be an imbalance between technology push and market pull.

Overall, it seems already hard enough to develop realistic policies regarding the transitions to emission free and efficient city logistics (especially for users of heavy-duty vehicles; for van users there is more reason for optimism). The introduction of AV into the equation seems premature, as additional difficulties must be overcome, specifically for authorities. A sound business case for the substitution of regular delivery vehicles with drivers by AV equivalents is a primary requisite.

3.1.6 Key stakeholder engagement moments

Several meetings and activities have taken place. For the ZE zone, there have also been discussions over the goals and means. Specifically, the following moments are the most interesting ones, some of which have been described in more detail in section 3.1.3:

- A co-creation workshop, organized by the municipality of Rotterdam, aiming at informing stakeholders on the city's draft policy for charging infrastructure, getting feedback, demonstrating how the city uses the simulation tool for policy development and calling upon the stakeholders to set up initiatives to gain experience with (joint) use and exploitation of heavy-duty charging facilities.
- The development of (domestic) waste transport module for the TFS, for which five different stakeholders were engaged. In view of the anticipated growth in space and transport capacity resulting from the city's policy on circularity (Zero Waste by 2040), it was considered relevant to take first a step of integrating this component of city logistics in the simulation tool. Legally, domestic waste collection is a public responsibility, while private parties provide waste collection services for the rest of the city. The first step in development of a waste transport module for the TFS was finalized by a MSc student in the beginning of April 2022. Future use cases may comprise the determination of efficiency gain through combined collection of domestic and non-domestic waste and the spatial and logistic impact of circular economy on waste collection and re-use process.
- Cooperation with knowledge partner Hogeschool Rotterdam in development and application of simulators, in an action to promote the application of the TFS and OFS.

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- Mobilizing and analysing the Ecostars database, with companies in various logistic segments, model developers and the municipality participating in a discussion on the calibration and validation of the simulator input describing the behaviour of the logistical agents.
- Rotterdam has attended the "LEAD Futureshop: Hyperconnected city" of the EU-project LEAD in Delft-The Hague, in March 2022. During the event, cargo bicycle carrier Cycloon has expressed their willingness to share operational data for validation of the use case. Also, MyPup, a logistic service provider participating in the Futureshop event, expressed interest in expanding its business to Rotterdam and has been welcomed as a covenant partner in Rotterdam as of February 2023.

Overall, the collaboration with Logistiek 010 is still alive and active, while also other covenant partners are going to form an advisory group for logistics in Rotterdam. More than 20 partners have been actively involved in developing and evaluating policies by providing input and comments. It needs to be noted that this was happening already in the city of Rotterdam, but it has been further developed and simulated via the involvement in the HARMONY project.

3.2 Oxfordshire

3.2.1 The Oxfordshire co-creation lab

The HARMONY Oxfordshire co-creation lab aims to contribute to the demonstration of urban air mobility solutions in UK and use Harmony modelling activities to further contribute to the development of the regional spatial and transport planning strategies. The major expected results of the HARMONY co-creation lab are:

- To integrate HARMONY project recommendations on new urban air mobility technologies into the regional spatial and transport planning strategies.
- To carry out drone demonstration and evaluate the feasibility and viability of this urban mobility solution.
- Possibly, to carry out autonomous vehicle demonstration and to evaluate the feasibility and viability of this urban mobility solution.

Other co-creation lab activities contain either activities supporting the demonstration (e.g., air traffic management controller), or are connected to the development of HARMONY Model Suit (MS).

3.2.2 Changes in the objectives and scope of the activities

There are no changes in the objectives and scope of the Oxfordshire co-creation lab to be reported. However, there have been some major changes in the demonstration plans which are reported in section 4.2, due to resignment of ARRIVAL, the partner developing the vehicles, similarly as for the case of Rotterdam. The initial scope had been to include autonomous vehicle in the drone flying and parcel delivery demonstration. Eventually, the demonstration involved a drone and an electric vehicle. Furthermore, engagement of Oxfordshire City Council (OCC) in airspace management was limited.

3.2.3 Crucial success factors and lessons learnt

The success factors that Oxfordshire expressed were in relation to the synergies with other projects (e.g., MultiCAV) that were running in parallel, the convergence of region's long-term urban mobility plans with objectives of the project and a comprehensive internal mobility model – the Oxfordshire Mobility Model (OMM) being linked with HARMONY MS to help identifying gaps and shape the use cases. Great support and engagement from all the bodies involved in a demonstration plan and execution has also been noticed as a crucial success factor in the effort to make the event possible.

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When it comes to the lessons learnt during the period, remarks were identified to more contingency plans needed to be considered depending on the Governing body, which was CAA in this case. Also, Oxfordshire mentioned that the discussions with CAA should have started at the beginning of the project. The lead time application was six weeks, however the amendments and changes that were requested at each step of the process were unexpectedly time consuming. Another lesson learnt is the consideration of delays when it comes to adaptation of use cases, which may vary over the time the project evolves and, sometimes, the ability to react from aviation side can be limited. Lastly, more management support/attention would have been helpful to gain further visibility.

3.2.4 Activities carried out

One of the main activities carried out has been the re-procurement to find survey companies to conduct the Travel Demand Surveys (using MOBY App) as the initial round of tendering did not provide Oxfordshire with any interested parties. Beginning of April 2022, a company was eventually identified, and the contract was signed. There has also been an internal testing of the travel demand survey application to provide feedback to app developers, via on-boarding sessions with MOBY. The data collection was completed beginning of summer 2022, resulting in data collection from around 800 users of the app and around 6000 verified trips. The data were used to feed mainly WP5 and the modelling activities with respect to the use cases for Oxfordshire, results of which are reported in D2.5. Further, two important workshops have taken place during the Oxfordshire co-creation lab activities, details of which are presented in Table 2.

Regular (virtual) meetings were held to align on use cases, content and details of the demonstration. A thorough pre-check on premises has been done (nicely supported by Milton Park Management, Oxford City Council and RUAS, the commercial drone service provider), which was a key event to grant safe execution of all flights/use cases. Further, Oxfordshire has fulfilled the following activities:

- Identification of optimal partners for unmanned aerial vehicle (UAV) trial.
- Supported partners in CAA approval applications.
- Made introductions to the CAA to consortium partners.
- Supported the UAV partners in creating and sense checking their safety case.

Table 2 Main co-creation events Oxfordshire

Process indicators (per event)	Type of event	Event 1: Workshop	Event 2: Workshop
	Purpose	Explain the capabilities of the HARMONY MS and understand how it can work together with existing internal models. Help to identify gaps in models being built within the County Council that could potentially be filled by HARMONY.	Internal planners at OCC interested in understanding more about the Land use and transport interaction (LUTI) model being developed by UCL CASA. Detailed demonstration of the model and provision of clarity to the planners on potential use cases was given.
	Duration	2 hours	2 hours
	Type of co-creation process	Co-initiation	Creation of data/ knowledge, design

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	Number of stakeholders involved in the session	15	10
	Type of stakeholders involved	Local transport planners, policy makers at Oxfordshire County Council	Transport planners, HARMONY modellers
	Objectives event	To explain the HARMONY modelling suite and its capabilities.	Increasing stakeholders' engagement and understanding
	Outcome	• 2050 forecasting is very important • Web TAG compliance status • Active Travel what-if scenarios are essential • Can the planners get details of the algorithms used, especially on carbon emissions? • Version controlling of models, network is needed Due diligence of model must be internal	History of LUTI model: • Technology challenges in scaling up the model • Discussion on Interfaces • Dis-aggregation Consistency between models

3.2.5 Barriers in relation to the activities carried out

In the short term, one of the biggest barriers was the short time window to identify a new AV/van operator. This operator would need to integrate with the drone trials being conducted at Milton Park as planned.

Another barrier faced was that the data collection for travel diaries had not started as the sampling strategy requirement for the companies was too complicated.

Other barriers as experienced during the project period, Oxfordshire reported the Civil Aviation Authority (CAA) response rate and application process, and the contingency plan that was needed for partner changes or amendments in planning process.

The aerial delivery part of HARMONY has not been its own Work Package, so it was only considered as a side topic in some work packages. Air part was not integrated into the HARMONY Model Suite (MS) solution. None of the proposed Use Cases were considered from HARMONY team (probably for the reason of concentration to solve issues and focus work on ground traffic and transport at first).

3.2.6 Key stakeholder engagement moments

These are some of the key stakeholder engagement moments that have taken place:

- Extensive discussions with CAA on regulatory approval application process. These were held to set up a feedback pipeline between demo partners and CAA.
- Discussions with OCC transport model users. These were held to understand HARMONY model architecture better and provide feedback on use cases and requirements.
- Multiple discussions with transport modelling partners on data sharing, data licensing and third-party data integration.
- Collaboration with OCC Procurement team to set up the public tender for finding survey companies to conduct Travel Demand Surveys (using MOBY app).
- Multiple discussions with external partners on use cases for UAV trials.
- Multiple discussions on use cases for connected and autonomous vehicles (CAV) and unmanned aerial vehicles (UAV) trial synergies and future opportunities for the interaction of the two technologies, both considering unmanned aerial system UAV, CAV, and others.

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- Several discussions on the different drone operators.
- Managed site visit for drone operator at Milton Park to identify landing spots and flight paths for the trials.
- Coordinating drone partners to set up timelines for the trials as well as pre-demonstration work integration.

3.3 Trikala

3.3.1 The Trikala co-creation lab

The Trikala co-creation lab is focusing on a pilot with drones within HARMONY. The aim of the co-creation lab is to foster co-creation, social embracement, and public acceptance for such a new mobility concept. The local pharmaceutical warehouses and the pharmacies are crucial stakeholders in the project that shape the core community of the co-creation lab. In this direction, the demonstration is co-created between them along with the technical team and the Municipality of Trikala. In particular, the Medical Association of Trikala and the Medical Association of Greece have provided requirements for the design of the demonstration. Along with the Medical Association of Trikala, the geographical routes served by drones have been planned. The demonstration has been shaped through their input and, thus, the process is characterized as bottom-up rather than a technical top-down procedure. It should be highlighted that for the safe and successful implementation, different stakeholders and authorities that have never worked together in the past, had to collaborate. In that context, co-creation lab was the only methodological tool to be used in order to have tangible results.

3.3.2 Changes in the objectives and scope of the activities

The main objective and scope of the activities has been, since the beginning, the provision of improved mobility systems and services to older and vulnerable groups that live in rural areas. By using UAM Systems and Services and going to the 3rd dimension, freight transportation could be improved in a very efficient way in the city of Trikala. UAM could be useful for the bypass of some routes for medical supply delivery for urgent cases. This use-case could later on be extended to similar fields that are time-critical. Handling the transferring of crucial goods (such as medicines) by air, decreases the delivery time, since no traffic congestion is confronted in the third dimension and the route is optimized to a straight line if possible. Cost is reduced since the delivery is conducted by electric self-piloted drones.

It should be noted that there is a new short-term objective added to the objectives agenda, which is the aim to provide a COVID-19 response in the mobility sector in order to create societal confidence in shared services and healthcare. By using autonomous drones with remote operation from a support Control Room, everyone is kept safe, ensuring social distancing. This is currently important in order to quickly face the COVID-19 crisis and any other crisis that could emerge in the future and transform the everyday life of elderly population to a much safer and convenient landscape. Concluding, UAM can be a safer, greener, smarter, cheaper and faster solution that could potentially replace the traditional freight mobility regime.

3.3.3 Activities carried out

The main activities within the Trikala co-creation lab are two events related to the start of the drones' demonstrations, which took place the last months, in three different locations in Trikala area. The purpose has been to launch the demonstration and start an initial dialogue with the local ecosystem on UAM. Two events took place for the first two series of flights, while there was no big event planned for the third demonstration. More details are provided in Table 3.

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Table 3 Main co-creation events Trikala

Process indicators (per event)	Type of event	Event 1: Demonstration	Event 2: Demonstration
	Purpose	Start of demonstrations: Launch the demonstration and start an initial dialogue with the local ecosystem on UAM	Start of demonstrations: Launch the demonstration and continue the initial dialogue with the local ecosystem on UAM
	Duration	1 day	1 day
	Delays	no	no
	Type of co-creation process	Events for implementation	Events for implementation
	Number of stakeholders involved in the session	11 (Citizens, Hellenic Civil Aviation Authority, UCL, MobyX, University of Aegean, Union of Pharmacists in Trikala, Pharmacists (individuals), e-Trikala, Municipality of Trikala, Depot of Pharmacists, Drone Provider)	7 (Citizens, Union of Pharmacists in Trikala, Pharmacists (individuals), e-Trikala, Municipality of Trikala, Depot of Pharmacists, Ministry of Digital Governance, Drone provider)
	Type of stakeholders involved	1. Knowledge institutions; 2. Citizens; 3. Policy makers; 4. Industries (drone provider and pharmacists)	1. Citizens; 2. Policy makers; 4. Industries (drone provider and pharmacists)
	Objectives event	4. Increasing citizens involvement; 5. Increasing stakeholders' engagement and understanding	4. Increasing citizens involvement; 5. Increasing stakeholders' engagement and understanding
	Outcome	A new service (UAM service)	A new service (UAM service)

3.3.4 Barriers in relation to the activities carried out

The general lockdown has been an essential barrier given that trips between different regions and thus physical meetings with stakeholders were not allowed for a very long period of the project. This has been a bottleneck for the potential operator and drone provider as well as for engagement activities. All physical meetings and workshops have taken place virtually.

This has further contributed to low participation in stakeholder engagement activities/co-creation labs and surveys as well as a multi-phased authorisation process by the Civil Aviation Authority. The risk is owned by the co-creation lab coordinator in the city of Trikala, in our case e-Trikala. The capacity to

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engage stakeholders in this context is under question. E-Trikala has strong networks with stakeholders that have been used to maximise participation in workshops and ensure the right stakeholders attend.

Further, it has been recognized that technical support is needed as well as in the legislative procedures for further activities on the topic, while drone ownership and training of personnel to become drone operators is also necessary. Moreover, the procurement for a drone provider has not been an easy procedure.

With respect to the latest activities, which also include the distribution of two evaluation questionnaires, the following barriers have been noticed. First, lack of interest as some people do not see the value in taking the time to fill out the questionnaire, especially if they do not believe it will have a direct impact on their lives. However, this was tackled through a concrete strategy in disseminating the project's demonstration and results. Second, the complexity of the questionnaire had initially discouraged some people from filling it out as they had found it long and complicated. For that, the team of e-Trikala has written the questionnaire in the local language and also rephrased the basic questions in a way that it would be widely understood. Lastly, time constraints have been noticed as many people seemed too busy to take the time to fill out the questionnaire. For that reason, the questionnaire was as short as possible.

3.3.5 Crucial success factors and lessons learnt

Co-creation in the case of Trikala has been a key aspect, as well as a lesson learnt itself. The various actors have provided input for all the processes that had to be followed. The knowledge that can be shared until this point is the initial integration of Urban Air Mobility (UAM) solutions and services into the transport planning framework. Another lesson learnt has been the process of building public acceptance in the field of urban air mobility, correlating with the medical sector. People trust that their responses will be used in a meaningful way and are not worried about the privacy of their answers. They are proud of their city being a pilot for new technologies and want to be a part of that as well.

In addition, the public engagement with the citizens and stakeholders, which is the only way to develop and implement a UAM project, given the multitude of stakeholders that take part, has been a success factor so far, despite the complexity of the process. Difficult to make a liaison but physical events helped in sharing experiences, good network of cities. At least in this project there was and is constant communication with other cities.

Regarding lessons learnt in the questionnaires process, the key to increasing response rates has been to understand the motivations and challenges of the target audience and to design the questionnaire in a way that is accessible, meaningful, and relevant to them. In addition, the process of co-creation for exploring and using pioneer mobility systems and services was very useful and the only way to proceed effectively with the pilot.

For Trikala, HARMONY has been the first project on UAM, and it has influenced the city in many different levels. At the policy level, the city did not even have a Sustainable Urban Mobility Plan (SUMP) and now drones are integrated. By performing an initial feasibility study and setting some priorities, some first challenges could be dealt with. Then, gradually, the plan became more concrete, especially via the demonstrations. First time deliveries were completed with drones, in the procurement level, on the legislation level, also on the collaboration between different departments, while the personnel of E-TRIKALA were trained for drone usage, which is a big success. Citizens have also become more aware of the drone services. Several concerns exist in terms of safety and noise but of course drones have been a more disruptive concept compared to other mobility solutions and it needs further testing and assessment.

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3.3.6 Key stakeholder engagement moments

Engagement processes, continuous bilateral contacts and consultations with several stakeholders (in particular the National Union of Pharmacists and Union of Pharmacists in Trikala, as well as specific pharmacists) have taken place. The goal was to promote and boost (i) the pharmacists' acceptance in transferring medicines served using UAM services and (ii) the pharmacists' agreement on which villages should be served using drones. In addition, their input has been collected regarding the number of urgent cases per day that could be served by drones. The results achieved was the vivid interest of the sector for the pilot demonstration as well as for this service after the life cycle of the project. The engagement with the citizens has been achieved mainly through the social media and press releases and the national media of Greece. There had been physical meetings before the relevant period.

The key stakeholder engagement moments for the city of Trikala took place during the drone demonstrations, the preparation and the launching of them. Not many physical events have been held due to COVID-19, thus mostly online consultations with the crucial stakeholders have taken place. No event in a city level before the demo has been organized, but the first flight has been part of an open event. In the beginning most of the actors were quite reluctant about feasibility, safety etc. Eventually, it seems that good connections are now established e.g., with the Aviation authority and the technology providers.

Further activities have taken place during the last months of the project which relate to quantitative data deriving from online questionnaires, distributed to pharmacists (as end users of the drone service in the pilot) and citizens of Trikala area. Results of those are reported in 4.3.2 and also in Appendix C: Trikala Drones questionnaires.

3.4 Turin

3.4.1 The Turin co-creation lab

The Turin municipality pursues the goal of rebalancing the demand for transport between collective and individual, in order to reduce congestion and improve the accessibility to the various urban functions. The SUMP of the Turin municipality in 2010 has been designed to embrace this vision, that is likely to be continued in the new SUMP, covering the whole metropolitan area, which is currently under definition and planned to be presented in 2021.

The Turin pilot goals within the HARMONY project are focused on the territorial impacts generated by the new public transport infrastructure (such as the new metro line) and the new Mobility-as-a-Service (MaaS) mobility paradigm on the Turin Urban Functional Area, with particular reference to its integration with the Metropolitan Railway System (known as SFM).

Furthermore, the HARMONY MS could be used to simulate some of the specific strategies and scenarios of the new SUMP of the Metropolitan City of Turin. In this sense, the engagement of stakeholders is in progress and the topics mentioned above would be integrated by the outcome of the co-creation labs. The upcoming co-creation labs will focus on two main aspects: on the one hand, analysing the Turin mobility in the wider context of the city's emerging trends and vision for the future, on the other hand, exploring the potential opportunities offered by the MaaS mobility paradigm from various points of view.

3.4.2 Changes in the objectives and scope of the activities

During the whole project period, there were no important deviations from the initial objectives and scope to be reported. The necessary postponement of passenger survey nevertheless caused some delay in some of the co-creation activities originally planned.

3.4.3 Activities carried out

The main activities carried out in the Turin co-creation lab, during the course of the HARMONY project are presented below:

- In Torino, on 17th of December 2020, a co-creation workshop with about 30 participants took place online. With all AUCM colleagues, a fun and engaging presentation with the Mentimeter application was created. Interesting suggestions to implement Turin traffic model were acquired.
- Before summer 2021, involvement into two different dissemination activities during Next Generation Mobility event are to be reported:
    - Into Mobility as A Service (MaaS) session, a brief introduction about Harmony project and Turin study case activities was presented.
    - With UrbanLab colleagues, a web on-air session with other mobility experts was organized to speak about shared mobility and Harmony Turin study case.
- Definition of the use cases for the HARMONY MS application for Turin has been completed.
- CDT together with TRT prepared the tender for recruiting individuals (passengers), which was published officially in July 2021 and closed at beginning of September 2021.
- TRT tested the App and supported MOBY for improvements. A pilot with 30 users was launched at end of November. Then, feedback and analysis were performed to improve and prepare for the second and main part of the survey.
- In February 2022, the survey has been launched in two batches of about 235 participants. The planning was revised and delayed by two weeks due to a new COVID-19 wave (original plan was to perform it in January 2022).
- Passenger survey with MOBY App (sample managed by IPSOS company) has been completed at the end of February 2022.
    - Recruiting about 580 valid participants (verifying at least 4 days, filling at least two SP questionnaires).
- Passenger survey with MOBY App open for voluntary participation, launched on March 14th until April 10th, 2022.
    - 113 download of the App, 61 users tracking at least 1 day.
    - 28 users verifying at least 1 day, 16 users verifying at least 4 days.
    - 19 users filling at least 2 SP questionnaires (in addition to the intro questionnaire).
- Analysis of data collected with both the IPSOS survey performed in February 2022 and open survey, to support modelling activities, mainly as part of WP5, reported in D2.5.
- Data collection/ elaboration to support modelling applications (Demographic forecasting model, agent-based model, VISUM network model and use cases).
- Synergies with other on-going projects in Turin, related to transport topics of HARMONY (Buoni mobilità – MaaS, CIVITAS Handshake). Workshop on survey results on September 19th in Turin (during the European Mobility Week)
- HARMONY MS demonstration workshop in Turin on November 14th

Below, in Table 4, some more details are provided for the workshop mentioned as part of the Turin co-creation lab, as well as for the Urban Lab on Air, a broadcasted event with media coverage, using formulated process performance indicators.

Table 4 Main co-creation events Turin

Process indicators (per event)	Type of event	**Event 1: Turin co-creation lab (Dec 2020)**	**Event 2: Urban Lab on Air (May 2021)**	**Event 3: Workshop on survey results on September 19th in Turin (during the**	**Event 4: HARMONY MS demonstration workshop in Turin on November 14th**

				European Mobility Week)	
	Purpose	workshop	media coverage (broadcasted)	workshop	Workshop to demonstrate the HARMONY MS operation and survey results
	Duration	2 hours	1 hour 20 minutes	2 hours on HARMONY (within a 1-day workshop)	4 hours
	Delays	delayed due to COVID	-	delayed due to COVID	-
	Type of co-creation process	creation of data/knowledge, design	Creation of data/ knowledge	creation of data/knowledge	Creation of data/ knowledge
	Number of stakeholders involved in the session	20+	50	50+	32
	Type of stakeholders involved	Knowledge institutions, policy makers	general public	Knowledge institutions, policy makers, general public	Knowledge institutions, policy makers, general public
	Objectives event	description of HARMONY MS and Turin case study, explore topics for use cases	Increasing citizens involvement, discuss mobility topics explored in HARMONY	description of survey results in Turin case study, explore topics of HARMONY use cases	Increasing citizens and institutions involvement, present the application and mobility topics explored in HARMONY
	Outcome	Better shared or new knowledge; New or better policy for the modelling suite	Better shared or new knowledge; New or better policy for the modelling suite	Better shared or new knowledge; feedback on results of the survey	Better shared or new knowledge; New or better policy for the modelling suite

3.4.4 Barriers in relation to the activities carried out

With respect to data collection and access to models, the main barrier has been the lack of direct access to traffic data and software license, while the partners have to sign different official agreements. Next to that, COVID-19 emergences have slowed down some meetings and approval of some agreements between partners, as well as have caused some issues for the survey, which had to be re-scheduled. Another barrier in the process of using the MOBY App has been the necessary survey data cleaning due to the app structure and the user contribution. In line with this, from the MOBY App user's perspective, it has been reported that the app does not seem so friendly and easy to use for validating process and questionnaires.

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3.4.5 Crucial success factors and lessons learnt

A success factor of the project has been the possibility to exchange knowledge and lessons learnt with the other HARMONY metropolitan areas, with reference to co-creation labs and stakeholder engagement. In addition, the case study is taking benefit of finding synergies and sharing information with other research projects that are currently exploring new mobility services in Turin. These projects are the BIPforMaaS (home-en - BIPforMaaS), MaaS vouchers and Smart Mobility (Smarter Italy).

Regarding the primary data collection, testing extensively the MOBY App (TRT) has been essential to allow supporting users and consequently analyse and clean the data. Further, the need of support during the survey extends also to solving any occurring issues, improving the survey, finding features to be implemented for future surveys, and evaluate pros and cons of such an app-based survey.

The main lesson learnt is that COVID-19 pandemic has reduced the possibility of stakeholders' engagement and many people were often unavailable due to job retention period. Business contacts and public participated events, that are typical situations where sharing opinions and ideas is possible, have been strictly limited and this has affected the activities related to co-creation labs.

3.4.6 Key stakeholder engagement moments

Co-creation activities have taken place in order to define the use cases for the HARMONY MS application for Turin. In the second half of March 2022, a passenger survey with MOBY App, open for voluntary participation to collect additional data, was launched. Subsequently, co-creation activities, which were originally planned at the end of 2021, were re-scheduled after the end of the survey and analysis of data so as to present results. Therefore, eventually, a workshop on the survey results was held on September 19th, 2022, in Turin, during the European Mobility Week, among a discussion panel with institutions, experts and professionals, where also major future projects were presented. In the meantime, potential synergies with other on-going projects in Turin on MaaS and Autonomous vehicles have been explored. Lastly, a key engagement moment has been the HARMONY Model Suite demonstration workshop, held in Turin on November 14th, 2022, where the HARMONY MS was presented, together with an application for Turin. Additionally, a summary of the MOBY App survey for modelling and selected use cases of simulation and the results were presented.

3.5 Athens

3.5.1 The Athens co-creation lab

Athens conducted two co-creation labs in the framework of the HARMONY project. During the first co-creation lab, the main goals aspired to: (a) the provision of input for the strategic, tactical and operational-level transportation planning and modelling for the greater Athens metropolitan area, and (b) the assessment of the impact of various sustainable urban mobility solutions and services on the network. However, since the transportation services that were proposed through the questionnaires were quite innovative and had never been applied to Athens before, the most relatable objective was to gain some insight into the standpoint of the stakeholders on those services, along with the expression of some of their problems, needs and preferences.

The main expected results from the Athens co-creation lab were: (a) to understand the stakeholders' problems, needs and points of view on different transportation-related issues, (b) to allow the stakeholders to express their proposals and preferences with respect to those issues, and (c) to possibly implement some of the stakeholders' proposals in the scenarios that would be examined as part of the project.

With respect to the second Athens co-creation lab, the main scope was the evaluation by the stakeholders of the results obtained through the modelling of certain innovative mobility scenarios within

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the project's framework. These included the electrification of public transport, the integration of micro-mobility schemes in network operation and the operation of AVs. Selection of the scenarios to be modelled was based on their importance to the Athens Urban Transport Organization (OASA) as public transport electrification is an initiative that is going to be realized in Athens over the next couple of years and integration of micro-mobility and other soft mobility measures in everyday network functioning is a well-established proposal in all SUMPs. As for the AV scenario, despite it being quite far-fetched for the current Athens transportation reality, it was deemed useful to examine it with respect to its implications in the future.

The lab was expected to provide an ultimate assessment of the scenario testing results as well as the updated opinions of the stakeholders on these mobility solutions based, this time, on actual simulation data. The feedback can be used as an evaluation benchmark and a starting point for associated short-, mid- and long-term planning purposes.

3.5.2 Changes in the objectives and scope of the activities

There have been no changes with respect to the scope and the objectives of neither the first nor the second Athens co-creation lab. Slight modifications of the timeline of the second lab are the only changes to be reported. More specifically, the second co-creation lab was initially planned to take place in late 2021, however, it was decided that it would better be postponed until autumn 2022, on the grounds of the completion of all models as well as the MS platform until the second quarter of 2022. In this way, OASA would be able to provide the stakeholders with more information on the topics discussed and with some tangible results from the testing of the scenarios. The lab was eventually conducted in the end of 2022, in a virtual form, with the results extracted by January 2023.

3.5.3 Activities carried out

During the course of the HARMONY project, OASA started by updating the Athens transportation model in its supply- and demand-related parameters in order for it to be ready to be used during scenario application. Scenarios tested over the Athens area were decided upon and finalized in their parameters after a series of meetings OASA had with other project partners and WP teams. In this regard, OASA provided the respective partners and WP teams with all the data needed for the construction of the Athens strategic-level models and also obtained data from the Hellenic Statistical Authority. On the operational level, OASA, following fruitful communication and cooperation with other project partners, proceeded in the simulation of the three finalized scenarios (electrification of public transport, electrification of public transport plus micro-mobility schemes, autonomous vehicles) over the greater Athens metropolitan area. On top of that, OASA conducted two co-creation labs and hosted the second HARMONY review meeting in Athens on July 04th to 6th, 2022. In this regard, all activities foreseen in the Grant Agreement were conducted by OASA with due diligence, within the specified timeframe and along all the predicted axes. The description of the two co-creation labs, using formulated process performance indicator, is provided in Table 5.

Table 5 Main co-creation events Athens

Process indicators (per event)	**Type of event**	**Event 1: Athens's 1st co-creation lab**
	Purpose	The purpose of the lab was to investigate the standpoint of various stakeholders on various innovative transportation services on the Athens network as well as record some of their problems, needs, preferences and recommendations

		with respect to transportation issues in general and the scenarios examined.
	Duration	The lab took place in a virtual form. Invitations to the stakeholders and the filling out of questionnaires by them was conducted from April 2020 till mid May 2020. Analysis of the findings took place from June to July 2020.
	Delays	No delays are to be reported with respect to the Athens 1st co-creation lab. However, due to the coronavirus pandemic and the restrictions imposed, the lab had to take place in a virtual form.
	Type of co-creation process	Due to the coronavirus pandemic, the co-creation lab was held in a virtual manner. The scope was to gain some general insight on innovative transportation services that had never been applied to Athens (nor to Greece) before.
	Number of stakeholders involved in the session	On the basis of the four types of questionnaires prepared (four scenarios examined) the number of stakeholders that replied are: 19 (Demand Responsive Transit (DRT)), 4 (Battery Electric Buses (BEBs)), 5 (Micro-mobility), 7 (Autonomous Vehicles (AVs)). All questionnaires had a common Introduction section to them, which was filled out separately. The total number of Introduction questionnaires that were returned was 14.
	Type of stakeholders involved	As already listed above: municipalities, the police, the Ministry of Transport and DEDDIE, OASA also contacted academics, other transport organizations (AMETRO, STASY, TRAINOSE, ATTIKES DIADROMES), consultants and citizens.
	Objectives event	The general objectives of the 1st Athens co-creation lab can be briefly summarized in: (a) the provision of input for the strategic-, tactical-, and operational-level transportation planning of the greater Attica region, and (b) the assessment of the impact of various sustainable urban mobility solutions and services on the Athens metropolitan network. However, since the transportation services that were proposed through the questionnaires are innovative and have never been applied to Athens before, the most relatable objective was to gain some insight into the standpoint of the stakeholders on those services, along with the expression of some of their problems, needs and preferences.
	Outcome	The main expected results from the Athens co-creation lab were: (a) to understand the stakeholders' problems, needs and points of view on different transportation-related issues, (b) to allow the stakeholders to express their proposals and preferences with respect to those issues, and (c) to possibly implement some of the stakeholders' proposals in the scenarios that will be examined as part of the project.
	Type of event	**Event 2: Athens's 2nd co-creation lab**

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Process indicators (per event)	Purpose	The purpose of the lab was to obtain some evaluation metrics on the results extracted from the transportation scenarios examined on the Athens network. In addition, the lab aimed at getting some updated viewpoints on different aspects relating to the implementation of these scenarios.
	Duration	Stakeholders were invited to fill in an on-line questionnaire consisting of three parts (one for each scenario examined (public transport electrification, public transport electrification plus micro-mobility schemes, autonomous vehicles)) in December 2022. OASA decided to receive responses from the stakeholders until mid-January 2023, while the results from the co-creation lab were extracted at the end of January 2023.
	Delays	The lab was initially planned to take place in late 2021, however, it was decided that the lab would better be postponed until autumn 2022 on the grounds of the completion of all models as well as the MS platform until the second quarter of 2022. In this way, OASA would be able to provide the stakeholders with more information on the topics discussed and with some tangible results from the testing of the scenarios. The lab was eventually conducted in the end of 2022 in a virtual form, with the results extracted by January 2023.
	Type of co-creation process	Due to the limited amount of time left until the end of the project, the co-creation lab was decided to be held in a virtual manner. The main scope was for the stakeholders to share their opinions on the results obtained from the testing of the scenarios as well as their updated viewpoints on those services examined.
	Number of stakeholders involved in the session	In this co-creation lab, there was only one questionnaire prepared for the stakeholders to fill in, which consisted of three parts (one for each scenario examined). The questionnaire was available on-line. The total number of replies received was 28.
	Type of stakeholders involved	Different types of stakeholders participated in the second Athens co-creation lab. These included: municipalities, academics, other transport organizations (AMETRO, OSY, STASY, TRAINOSE, ATTIKES DIADROMES, NEAODOS), consultants, bicyclist groups and citizens.
	Objectives event	The main scope of the second Athens co-creation lab was the evaluation by the stakeholders of the results obtained through the modelling of certain innovative mobility scenarios within the project's framework. These included the electrification of public transport, the integration of micro-mobility schemes in network operation and the operation of autonomous vehicles (AVs). Selection of the scenarios to be modelled was based on their importance to the Athens Urban Transport Organization (OASA) as public transport electrification is an initiative that is going to be realized in Athens over the next couple of years and integration of micro-mobility and other soft mobility measures in everyday network functioning is a well-established proposal in all Sustainable Urban Mobility Plans (SUMPs). As for the AV scenario, despite it being quite far-fetched for the current Athens transportation reality, it was

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		deemed useful to examine it with respect to its implications in the future.
	Outcome	The lab was expected to provide an ultimate assessment of the scenario testing results over the greater Athens area as well as the updated opinions of the stakeholders on the mobility solutions investigated, based, this time, on actual simulation data. It is deemed that the feedback can be used as an evaluation benchmark and a starting point for associated short-, mid- and long-term planning purposes.

3.5.4 Barriers in relation to the activities carried out

The coronavirus outbreak was a major impediment in the planning and organization of the first Athens co-creation lab. In addition, during the first lab many stakeholders appeared to be hesitant in replying, with the municipalities being the ones most difficult to engage. The organizations that were most willing to participate were those that would not be directly involved in the implementation of the scenarios examined. Moreover, certain types of questions (open questions, questions regarding the collaboration with other entities) were not answered.

In relation to the second Athens co-creation lab, the problems experienced regarded minor delays in the development of the Athens strategic-level models and the completion of the HARMONY MS platform. These can, to some extent, be attributed to: (a) the more aggregated data types that the Hellenic Statistical Authority was able to provide as opposed to the very disaggregated data types that the respective models needed, and (b) the delay of the Hellenic Statistical Authority to quickly process the data asked for due to the 2021 population census taking place between the months November 2021 and February 2022. Eventually, these problems were circumvented through the development of more aggregated land use models for the Athens region.

In general, co-creation activities have recently been established in the Greek state-of-practice as a tool towards integrated planning, also corresponding to the principles of equity and social inclusion. Incorporation of such activities in projects and participation in them familiarize the authorities and the stakeholders with a new way of mutual thinking and decision-making, making it progressively easier for people to engage. As such, the experience gained by OASA in this area is deemed to be an asset for the organization of similar activities in the future. Finally, physical attendance is considered to be advantageous compared to remote participation, as it favours interpersonal contact and the vivid exchange of opinions between the participants.

3.5.5 Crucial success factors and lessons learnt

During the project, OASA participated in meetings regarding the gradual progress in every HARMONY aspect, as indicated by the different WPs, the MS platform and of course the Athens modelling effort, contributing in this way to a vivid exchange of opinions with all the involved WP members. This resulted in a closer collaboration with all team members, in the transfer of knowledge and expertise between the partners and in stronger interpersonal relationships with reference to co-creation labs and stakeholder engagement. All this contributed to the successful completion of the HARMONY project and to possible pursuit of further collaborations between the partners in the future.

Another crucial success factor in the final modelling outcome for Athens was the careful selection of the scenarios to be investigated which were of special interest to the Athens transportation stakeholders. In the case of public transport electrification, the scenario was based on the actual initiative taking place right now in the city of Athens, enabling, thus, OASA in the acquisition of real planning data. In the case of micro-mobility schemes, investigation was based on currently existing bicycle paths on the Athens network as well as proposed ones through the municipalities' SUMPs.

Finally, in the AV scenario, the methodology followed was provided to us by AIMSUN since it was developed by another research program (Levitate project).

On the downside, the COVID-19 pandemic as well as data collection problems related to data disaggregation levels had an impact on model formulation for Athens, which was especially prevalent on the strategic level. This resulted in scheduling fluctuations for the second Athens co-creation lab, with the lab finally taking place in December 2022. Even so, the lab was successfully held, with the stakeholders being able to review some tangible results from the testing of the HARMONY scenarios and to provide their evaluation of them.

Moreover, it would be interesting and useful if the project could involve more pilot cities, and especially if it involved investigation of alternative public transport planning options. This would facilitate the familiarization of the authorities with innovative concepts and technologies that take place in other parts of Europe and to possibly compare how such solutions could be implemented in one's own city. Overall, the project is evaluated as a very positive experience for OASA, which has contributed to its expansion of knowledge in integrated transportation planning.

3.5.6 Key stakeholder engagement moments

During the HARMONY project, OASA has had several meetings with stakeholders involved in transportation-related subjects. Communication and cooperation mainly regarded the scenario of public transport electrification, which, as explained earlier, is based on the actual initiative that is going to take place in Athens over the next couple of years. In this case, OASA has cooperated with a wide range of public and private entities that play a key role in the planning of operation and the actual implementation of battery electric buses (BEBs) on the network (municipalities, ministries, the European Investment Bank etc.). Moreover, OASA has an active role in the development of the municipalities' SUMPs and the specification and evaluation of mobility measures that are proposed as part of them. These of course include soft mobility measures and micro-mobility schemes, as the ones investigated in one of the Athens' scenarios. Last, OASA contacted many stakeholders during the first and second Athens co-creation lab, for them to share their opinions on current transportation challenges and proposed mobility solutions. Many of them responded to the questionnaires sent; engagement in co-creation activities is progressively becoming embedded in the Greek way of thinking and decision-making. In this respect, OASA has made progress in this area and has gained valuable experience for organizing similar events in the future.

3.6 Katowice

3.6.1 The Katowice co-creation lab

The main objective of the Katowice (GZM) co-creation lab is to a have citizen-driven approach to the process of SUMP creation, with a focus on the social acceptance of UAM use cases. Next to it, within the co-creation lab, the opportunities of transport modelling software for the public transport network planning, are being investigated. In line with this, expected results from the co-creation lab are:

- Created SUMP reflects the needs of citizens in terms of the problems and challenges addressed and solutions proposed.
- There is a clear picture on the mobility patterns within and between different districts of the GZM agglomeration (urban, rural, intercity).
- Knowledge about transport modelling software and its potential application for GZM is produced.
- Transport modelling software is tested with input data from GZM, and concrete user experience results are available.
- HARMONY MS is tested by GZM.

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There was no physical demonstration planned within GZM co-creation lab, but a set of concrete activities have been performed, related to engaging and working with stakeholders and citizens to investigate their requirements in terms of spatial and transport planning and new mobility services (WP1, WP9); transferring results from the HARMONY MS application to assist the authority to plan for the metropolitan-wide transport, introduce new forms of mobility and update their SUMP (WP8).

3.6.2 Changes in the objectives and scope of the activities

As mentioned in D9.3 and D9.4, the topic, and the scope of the co-creation lab in Katowice had to be reinvented to align to its SUMP process. Specifically, topics of social acceptance research have been narrowed to Urban Air Mobility. Since then, work is continued within GZM's co-creation lab objectives under T9.7 to solicit stakeholder feedback on preferences for types of drone operations.

3.6.3 Activities carried out

The main activities related to the GZM co-creation lab pertain to a general preparation and investigation phase that will lead to a proper design of it, aligned with the overall scope of the project and the objectives of the SUMP of the city. So far, the specific objectives of the co-creation lab and the definition of the framework are being explored in collaboration with UCL and discussed during online workshops with several stakeholders. On this basis, a survey for planning and testing citizens participation phase of SUMP, including topics related to new technologies and new mobility, has been created.

In line with the above, the co-creation lab, in collaboration with UCL, has conducted activities related to the Drone Deliveries Game survey (see also Figure 1). In this game, which has the format of a stated preference experiment (SP), several scenarios have been developed, where drones deliver goods, considering different conditions related to the delivery area, their certifications, the type of goods to be transferred and their noise levels. The focus has been on understanding citizens' preferences for UAM services, and more specifically for drone deliveries when the citizens are either bystanders or the recipients of the drone services. The online survey was conducted on a group of 1,000 respondents, and the data necessary for the implementation of the Polish version of the survey tool were translated. Preliminary results of the survey, as have been analysed by UCL, have shown that citizens prefer drone services for medicines deliveries, while they do not prefer drones for surveillance and clothes, illegal items, mail, and organs deliveries. Higher noise, an unregistered drone or an unlicensed operator has negative impact on preferences, while rural or villages are the preferred delivery areas.

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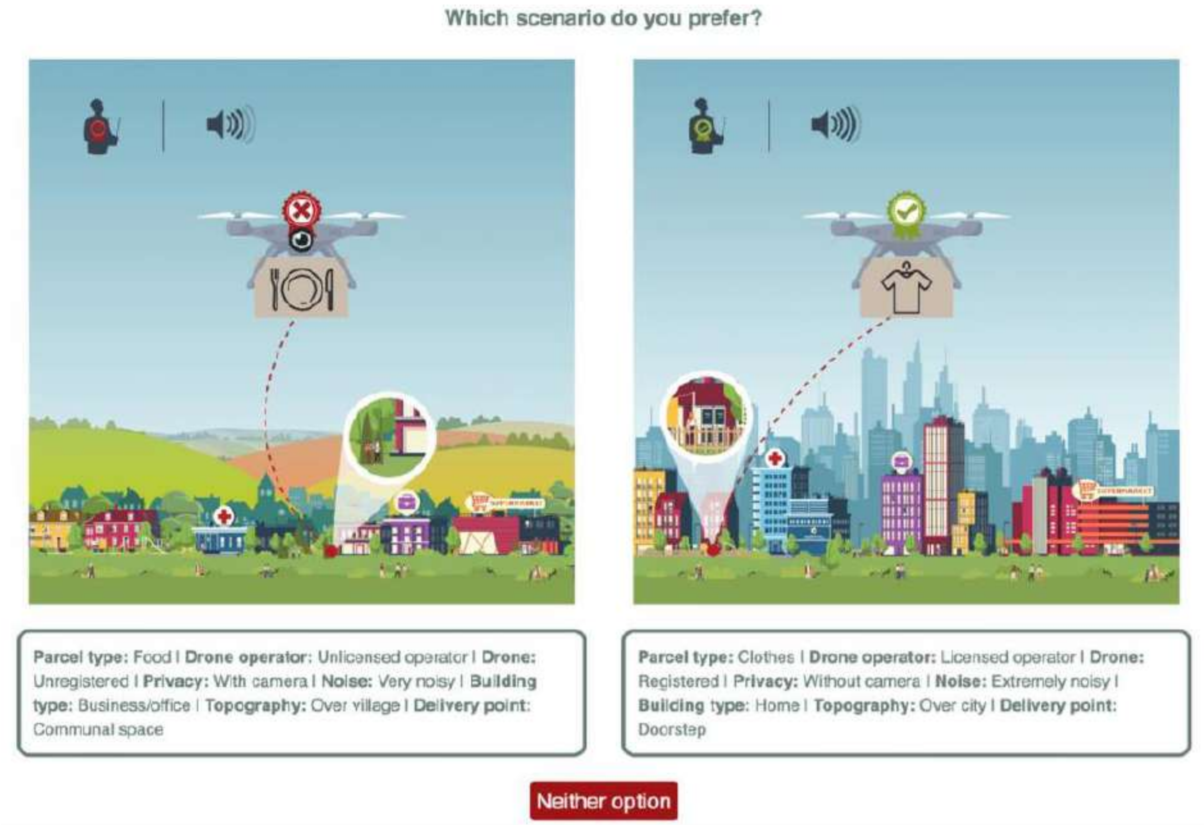

Figure 1 Example of the SP experiment in the Drones Delivery Game.

Another main activity carried out in GZM was the workshop titled “Flying taxis? Drones as a component of modern urban mobility”, details for which are provided in Table 6. This workshop took place in Poland, in December 2020, together with UCL. In June 2022, another workshop took place, as part of the 11th session of the World Urban Forum in Katowice (WUF-11). This HARMONY workshop was led by the project coordinator, the University College London (UCL), and two project partners, the Netherlands Organisation for Applied Scientific Research (TNO) and Oxfordshire County Council (OCC).

Table 6 Main co-creation events Katowice

Process indicators (per event)	Type of event	Event 1: Co-creation workshop “Flying taxis? Drones as a component of modern urban mobility”	Event 2: Conditions for drones in cities - public acceptance workshop
	Purpose	Bring together stakeholders in the Urban Air Mobility sector to update them on the region’s efforts to promote the safety implementation of drones. Capture stakeholders’ ideas regarding drones in use cases. Understand who are the involved actors, what are the preconditions and the implementation flow. Identify additional requirements outside the functional	The main goal of the workshop was to conduct an analysis of: -potentials and concerns related to selected services provided by urban UAVs opportunities -risks, and boundary conditions for acceptance of modern urban development technologies, -opportunities, risks, the likelihood of implementation, and conditions for acceptance of human transportation

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		requirements the system is expected to perform.	based on the HARMONY Drone Delivery Game.
	Delays	No delays	No delays
	Type of co-creation process	Creation of data/ knowledge	Creation and sharing of knowledge
	Number of stakeholders involved in the session	29	30 participants both on-site and online
	Type of stakeholders involved	Stakeholders from NGOs in the field of mobility, representatives of national and local governments, crisis management services, the R&D and academia, financing institutions, representatives of the drone industry	Residents, NGOs, municipal and academic partners, pupils and students. Keynote speakers: Maria Kamargianni (HARMONY Leader, UCL); Eleni Charoniti (WP9 Lead, TNO), Sridhar Raman (T9.3 Lead, OCC)
	Objectives event	Top 3 issues selected to be discussed: Drone missions as support for rescue missions. Transport of medicines / medical samples. Transport of documents between municipal offices and passenger transport	The attendees received a general overview of the HARMONY project but also of its validation areas: orchestration, engagement, and demonstrations.
	Outcome	List of opportunities and threats for every one of the abovementioned issues discussed.	Principles for conducting social acceptance activities developed in cooperation with residents and international partners.

Further activities in the Katowice co-creation lab regarded the organization of the HARMONY MS Demonstration, which took place on 18.10.2022, in Katowice. Additionally, the presentation and discussion of international mobility projects was the subject of a meeting held at the headquarters of the Metropolis GZM. The meeting was attended by more than 20 representatives of the cities and municipalities of the GZM from the areas of transport and urban planning, environmental protection, and crisis management, as well as experts associated with international consortia.

3.6.4 Barriers in relation to the activities carried out

A barrier that has been identified in the process of developing a co-creation lab is that there is not enough support and knowledge on how to initiate it. The area of interests in initial plans has been too wide which hinders the procedures. Further, there have been internal changes with resource management in GZM, which required rethinking of goals of the co-creation lab. It was also hard to start with any activities since leadership was changed inside GZM and there was no plan for activities

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previously. There have also been some technical issues for workshops, related to translation and the need for a better tool for online workshops.

Another barrier related to the area of Katowice is the direct outreach to potential study participants. By making the survey available, inter alia, in the social media of GZM and direct mailing to a base of over 400 stakeholders, including institutional partners of GZM for further dissemination, 199 responses from users with a Polish IP address were acquired by the beginning of March 2022. Further, there was a barrier with respect to the technical difficulties in implementing the survey with the support of a professional opinion polling company. It took four months to carry out the procedures related to the implementation of the survey, as well as the integration of IT tools to provide results in line with the expected amounts regarding age, gender, place of residence. Work on the implementation of the survey could only be carried out with a second contractor.

On top of that, due to COVID-19, there was limited interest of stakeholders from the group of local government authorities and municipal services in participation in additional activities i.e., the workshops.

Additional organizational difficulties existed due to Poland's geopolitical situation - the threat of hostilities due to the war in Ukraine and the resulting migration crisis, which was addressed on a huge scale by local authorities and local government organizations. Additional responsibilities of the aforementioned significantly hampered the involvement of stakeholders in project activities.

The war situation was particularly important for the scope of the project and public acceptance activities, also changing the perception of UAVs.

3.6.5 Crucial success factors and lessons learnt

A crucial success factor for GZM has been the continuous knowledge and experience exchange with the rest of the HARMONY areas, especially the ones dealing with UAM. Exchange of good practice with other WP9 partners and learning from the demonstrations carried out has been valuable. The support of UCL, the lead partner in the preparation of the content and research tools, has been essential to successfully carry out the task. Regarding the potential to increase the reach of the survey, a crucial success factor was its availability in different languages. Further, GZM partners and survey respondents appreciated the interesting, non-standard formula of the survey with respect to choosing the more acceptable option of drone use based on various variables presented in two parallel pictures. Another benefit of the added value of the study is its universal character and the topicality of the issues. The online format allows for wide dissemination. This has resulted in building a network of GZM stakeholders, including local authorities of 41 cities and municipalities of the GZM, urban mobility experts (departments responsible for urban planning and transport) and mobility NGOs

Regarding the workshop, applying a formula well suited to the subject matter made it possible to achieve the intended effects of the co-creation lab, i.e., analysis of opportunities and threats for various types of drone services in cities from the point of view of various stakeholder groups, including NGOs, local governments, crisis management services, and scientific communities. Further, the following can be noted:

- Positive effect of joint mobility and drone Metropolis teams working together on the project. Access to both drone and mobility groups of interest.
- Attaching the obligatory questionnaire to the recruitment form achieved the expected result. This not only allowed to analyse the expectations of various social groups regarding the use of drones in urban space, but also allowed to increase the participants' identification with the discussed subject matter, strengthened the involvement of the workshop participants in its work.
- Due to the high level of specialization and knowledge in various areas on the part of the participants, it is worth considering working in workshop groups only for 1 use case. Thanks to this solution and the increasing dynamics of the group's work, it is possible to achieve the desired results in the form of comprehensive scenarios.

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An important lesson learnt is that an established network between partners and strong support from the scientific ones is needed to start anything. Support has been offered from both WP9 and WP10 in the duration of the project. Especially UCL has offered great support in the process of developing a co-creation lab/workshop. With respect to the survey, the complexity that characterizes it, gives an indication that the desired results, on the preferences for drone operators, based on a variety of specified criteria, become difficult to be obtained. Further, several challenges have been identified, such as reaching respondents directly when conducting an online survey. Also, the challenge of conducting an online survey in cooperation with a professional subcontractor on the tool provided is to integrate the tool, as well as to consider the substantive and technical comments of subcontractors. Additionally, when pricing the services ordered on a ready research platform, many challenges arise related to checking the subcontractor's actual technical readiness to conduct the survey.

With respect to stakeholder involvement, although more difficult, it can be much more effective when activities are carried out on the ground. Local authorities have expressed interest in solving problems in the area of land-use planning and transport management using modern tools such as the HARMONY MS and applications for data collection like the MOBY App. Public stakeholders have quite advanced knowledge and information needed for the above solutions. Issues of public acceptance of new forms of mobility including UAM are perceived by residents as important and requiring their involvement/involvement in the consultation process.

Overall, for the Katowice co-creation lab, looking at what is being developed in other cities was very useful. For GZM this was the first EU project, so it was experienced as a good learning process. As a following city, they had also opportunity to first time cooperate with other cities which was very valuable to learn activities for the mobility sector in general, not just for drones.

3.6.6 Key stakeholder engagement moments

Some of the needs to explore social acceptance have been met during general research of mobility habits in the SUMP process. In addition, several deep interviews were performed during the European Mobility Week, including discussions about new and future mobility. Several meetings of Council for New Mobility and three workshops with citizens as a part of SUMP meeting have taken place. In addition, strong cooperation is continued between UCL and GZM in developing and translating the survey content into Polish (until July 2021). The direct distribution of the survey by the GZM to over 400 stakeholders - partners of the GZM followed, until October 2021. Public procurement and cooperation with UCL and two other companies in turn to integrate the tools until March 2022 has also been completed.

Other key stakeholder engagement moments involve the activities as described in section 3.6.3. These relate to the Drones Delivery Game, which has been completed by 1,000 respondents, the “Conditions for drones in cities - public acceptance” workshop during the World Urban Forum event and, lastly, the HARMONY MS demonstration day in Katowice. In all the cases described above, it was possible to achieve the intended objectives by involving dedicated stakeholders in the tasks.

Overall, Katowice has reported that very valuable co-operations have been developed during the HARMONY project, while the stakeholders involved seemed quite happy about the results and the engagement. The stakeholders have provided essential input for the survey built with UCL, while the local stakeholders also had the chance to be presented with the EU perspective during this project.

After COVID-19 it seems that drones have gained attention, are more acceptable and have become more visible. There is an obvious difference between projects that started later on, during 2021. Thus, it is expected that more use cases will continue to be generated.

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4. Physical demonstrations activities

4.1 Rotterdam

4.1.1 The last-mile delivery robot

In line with Rotterdam's key field of interest in the project, the choice has been made to stick to a demonstration with a self-driving delivery vehicle. The original plan for Rotterdam was to perform AV demos in Delft and Rotterdam, in The Netherlands, using three Level 4 electric autonomous vans, provided by ARRIVAL. Due to ARRIVAL withdrawing from the project, the demo could no longer continue as planned. However, an alternative plan was prepared in order to make up for the delays that occurred, while also maintaining the purpose of the demonstration and achieving the goals and objectives, to the extent possible, as these had been formulated in the beginning of the project.

The new planning involved 'Rosie' (Robot On Site Erasmus), an automated delivery robot (ADR), used for last mile logistics. In collaboration with partners such as SPAR supermarket at the Erasmus University Rotterdam (EUR) campus, the feasibility of self-driving delivery robots for food delivery on the campus site was investigated. The delivery robot Rosie 1.0 was tested in the Erasmus University Campus at the end of 2021, as part of another project, which focused on people's reaction to AVs. This has taken place in a closed campus environment, in a private fenced off test facility.

As part of the HARMONY project, Rosie 1.0 became Rosie 2.0 and focused on last-mile delivery and the impact of innovative technologies in multiple traffic situations. Between August and November 2022, tests have been performed on the Future Mobility Park of Rotterdam, as well as on a section of public road. Before the start of the pilot, learning questions were defined by the various partners and these have been answered, as far as possible, in collaboration with, among others, research institutes. These learning questions concern technical, operational, economic, legal, and social questions on the closed park. However, the academic research performed during the pilot is mainly focused on the interaction between the robot and the environment, and not directly on city logistics. Furthermore, The Netherlands has no practical experience with the use of delivery robots on public roads. Based on the 'learning by doing' attitude, the plan was to tackle the issues jointly by conducting tests with the city of Rotterdam and other stakeholders on a test site and the public road.

For the Rosie demonstrator the city of Rotterdam has attempted to answer the following learning questions:

1. How can automation with Rosie 2.0 positively contribute to the Rotterdam Mobility Approach (RMA) and Zero Emission Mobility (NEM) in terms of city logistics?

2. What can we expect from these new self-driving robots and the associated services as a city and what will our role as a municipality become (as a road asset manager and in other roles)?

3. Can self-driving delivery robots provide insights to future traffic models for city logistics to be adequately represented in (freight) traffic simulation tools?

4. What is the energy consumption of Rosie 2.0 compared to a delivery van?

Some operational questions were developed too, focused on stopping, navigating, overtaking, communicating, crossing, road layouts and different surfaces.

Based on evaluation conducted by the city of Rotterdam, the Future Mobility Network and the Dutch Automated Mobility, some general results and conclusions can be presented. First, for Rotterdam, the tests with the self-driving logistical robot in mixed traffic presented results for about 13 different research questions, with different conditions applied to each one of them.

Regarding more specific results achieved with Rosie 2.0, it is worth to be noted that, within the applied conditions and limitations, the robot seems to always give priority to other traffic actors and always

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stops when an obstacle is present, even when the distance between them is large. However, when inserted in a scenario of mixed traffic with moving traffic elements, Rosie 2.0 behaves hesitantly by driving slowly and with several breaks. In this sense, it could cause delays and high energy consumption in real-life scenarios.

The robot has also been tested in various conditions including different slopes and curbs, in both dry and wet weather conditions. In the case of climbing curbs, the robot can perform it by being remotely controlled up to 16 cm (and 12 cm in wet conditions), however, in autonomous driving mode, Rosie sees them as obstacles and stops. The robot improves the performance in the case of climbing down, being able to perform in both remotely (up to 18 cm) and autonomously controlled (9 cm).

In her current setup, Rosie 2.0 does not have an On-Board Unit (OBU) and thus is unable to connect to an Intelligent Traffic Light (ITL), preventing the robot to drive when the command was given from the control room. Overall recommendations for future research and test should take into account further testing in public areas and more land coverage, slopes, windy conditions, with an OBU and ITL and with alternative robot designs.

Figure 2 The Rosie delivery robot in action.

When it comes to energy consumption, the robot presents different levels depending on the number of obstacles that were in its way and also the weight it carries. When more obstacles were in the way of the delivery (back and forth), the energy consumption rises. With the current results of this trial, it is recommended for modelling and forecasting to use the average of the highest level of energy use for a delivery robot for busy sidewalk areas on public roads. For suburbs, a lower value can be used, because of less stops needed to be made on sidewalks and in those areas less obstacles are encountered. In general, a more careful and extensive analysis and comparison with alternative modes, such as vans, needs to be made, considering the energy requirements, volume capacity, distance driven and the fact that robots carry less packages and drive slower compared to vans.

Rosie can adapt well in different traffic situations, can communicate with traffic lights, can drive on different road conditions and is low in energy consumption. However, some actions are very slow, but there is certainly potential in self-advancing robots. the possibility of testing on public roads has also been mentioned. In addition, the questions learned have been answered.

One important remark brought by Rotterdam is that, since traffic models currently do not include delivery robots in their scope, there are several ways that they could be considered. For that, different parameters need to be considered in the models, depending on the place that the robots are going to be added, such as bike lanes, sidewalks or by restructuring the public roads.

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After tests and research have been performed with delivery robots, the municipality should focus on informing the population about the roles that those robots could have, in terms of awareness of how future mobility could look like in Rotterdam. In the effort to connect the expectations to usage preference, working towards the needs from the population and the aspiration of the municipality of Rotterdam is necessary, to develop certain areas in terms of smart city and mobility developments. The city's role as road asset manager for including delivery robots is primarily determined by national legislation. There is currently no legislation for delivery robots since delivery robots have not yet been defined as a vehicle or a machine. Therefore, the scope of cities' intervention for the admission of these applications remains uncertain. Before investing in regulatory measures to accommodate self-driving delivery vehicles in traffic management, cities should have a strong case for their contribution to sustainable and efficient freight policy goals. In a general sense, the city remains neutral in allowing self-driving vehicles on public roads, as these types of innovations are in the initial and exploratory phase and their potential still needs to be further studied. For this reason, such exploratory projects like HARMONY have been of great importance.

4.2 Oxfordshire

In Oxfordshire, one demonstration was being planned, combining freight and passenger transport (CAV) with drones (UAV). The changes that had to be made, have also been reported in 3.2.1. The partner ARRIVAL has withdrawn from the project; thus, no AVs have been provided by them for demonstration purposes. Several alternatives for another AV or even replacement with conventional vans were being considered. Eventually, it was decided that an electric van would replace the AV, while the original plan to have a combined freight van and UAV demonstration remains the same. However, no passenger transport demonstration was performed, due to time constraints because of the delays and time pressure.

4.2.1 The drones and electric van demonstration

The delays and the need for a plan B led to the planning and execution of airspace management and flight coordination (services) in the "Drone flight and EV (electrical vehicle) trials" in Oxfordshire, and to be more precise in the innovation centre at Milton Innovation Park (see map of the area and the routes in Figure 3). The use cases included parcel delivery of gifts, tools and medical equipment.

The demonstration dates were between 19th and 21st of August 2022, including a rehearsal on the 20th before the actual demonstration on 21st. Oxfordshire transitioned to a new drone operator (RUAS) due to GRIFF facing difficulties to conduct the operations in UK. RUAS is a UK-based drone operator and has already approval from the CAA to conduct trials and they handled the operations as well as the (small) drones.

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Figure 3 The Milton Park area and the routes.

For the preparation and execution of the Drone Flight Demo, the following steps were considered:

- Agreement on Use Cases and drone demo execution details.
- Confirmation on feasibility (from RUAS, GRIFF, Milton Park Administration, UK CAA).
- Plan flight route(s) to an accuracy of 1 m.
- Interface setup to RUAS/GRIFF.
- Interface setup to AIMSUN.
- Interface definition to Traffic Office.
- Integration of flight alarm (FLARM), Automatic Dependent Surveillance - Broadcast (ADS-B) receiver (for full air picture).
- Testing and final setup.
- Simulate the full scenario.

Next, the pre-demo-day execution considered, receiving Transport Order (TO) from AIMSUN system, convert into trajectory, executing Safety Flight (with a small (toy) drone) and validate if all system functions were working correctly. Finally, for the demo-day execution Oxfordshire:

- Received (pre-planned) transport request from AIMSUN simulator/simulation.
- Automated conversion of the received data from the TO into transport flight/mission (Airspace allocation (internally), trajectory calculation, data exchange with ground station(s), flight plan generation).
- No Specific Operations Risk Assessment (SORA), no U-Space-Services.
- Performed the Execution of the flight(s) as planned.
- Monitored of the flight(s)/air situation.
- Reported of the successful execution.

The flights realised in Oxfordshire used a M300 plane for the delivery of cardboard boxes. In total, 10 recordings that correspond to one test round trip and three other round trips were obtained. The test flight occurred in 20th of August 2022 while the other round trips were made in 21st of August 2022. In Figure 4, the drone and the electric vans used during the demo days are shown, together with the HARMONY team from OCC, Airbus and RUAS.

Figure 4 The drone and electric van during the demo in Milton Innovation Park in Oxfordshire.

In general, the flights varied around 100 to 101 meters altitude, and each flight had a different mileage, varying around 1.100 m to 2.000 m. In addition, although at a certain point all the round trips reached a maximum speed around 10 m/s, the average stayed around 5,5 m/s.

The following Table 7 provides information on general performance indicators, such as distance, altitude and speed. Also, information on the battery power is available. All the indicators are divided by flight and some of them carry information about the roundtrip. As seen in the table, data on take-off and landing battery have been left out for the first flight due to incorrect logging of it.

Table 7 Information for the drone flights during the Oxfordshire demonstration days.

Performance Indicators		*Test Round Trip*		*Round Trip 1*			*Round Trip 2*		*Round Trip 3*		
General	Flight number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
	Take-off	*01:51PM*	*02:00PM*	*11:46AM*	*11:51AM*	*12:02PM*	*12:24PM*	*12:33PM*	*12:58PM*	*01:03PM*	*01:09PM*
	From - To	Take-off - Pin 5	Pin 5 - Take-off	Take-off - Pin 1	Pin 1 - Pin 2	Pin 2 - Take-off	Take-off - Pin 5	Pin 5 - Take-off	Take-off - Pin 3	Pin 3 - Pin 4	Pin 4 - Take-off
	Log duration (air + on the ground)	03m51s	02m34s	02m35s	05m19s	01m35s	03m55s	02m10s	04m12s	02m22s	02m54s
	Air duration time	03m51s	02m31s	02m35s	05m16s	01m32s	03m55s	02m07s	04m12s	02m19s	02m51s
	Total duration - round trip	*Approximately 11 min*		*Approximately 17 min*			*Approximately 11 min*		*Approximately 13 min*		
	Total mileage (m)	823	828	400	278	436	827	818	841	200	1020

	Total mileage (m) - round trip	*1651*		*1114*			*1645*		*2061*		
	Maximum distance (m)	815	819	396	246	429	816	818	823	1006	1011
	Maximum altitude (m)	101	100,5	101	100,5	100,4	101	100,6	101	100,6	100,4
	Maximum speed (m/s)	5,3	10,3	5,19	5,23	10,29	5,3	10,31	5,28	5,2	10,36
	Average speed (m/s)	5	7,1	4,5	3,8	5,2	4,9	6,4	4,8	3,5	7,4
	Average speed (m/s) - round trip	*6,1*		*4,5*			*5,7*		*5,2*		
	Take-off battery	-	85% (24.1 V)	67% (21.9 V)	59% (22.7 V)	41% (22.1 V)	96% (23.0 V)	84% (24.2 V)	71% (22.4 V)	59% (22.7 V)	52% (22.4 V)
	Landing battery	-	79% (22.8 V)	60% (7.4 V)	42% (21.3 V)	36% (21.3 V)	85% (23.1 V)	78% (22.8 V)	60% (22.2 V)	52% (21.9 V)	44% (21.6 V)
Power	Efficiency - Minutes per battery	1,71	38,91	1,94	34,07	28,09	49,07	35,34	56,15	77,05	35,77
	Efficiency - kilometres per battery	0,37	12,73	0,3	1,79	7,95	10,34	13,63	11,22	6,66	12,75
	Min temperature (Celsius)	28,9	33,8	25,9	35,8	39,8	25,7	33,2	37	38,5	39,5
	Max temperature (Celsius)	33,7	36,2	35,4	39,6	41,2	30,9	35,2	38,3	39,2	40,6
	Initial capacity (mAh)	4217	10520	4023	10038	10038	10536	10536	10536	10536	10536

On top of the described flights before, Oxfordshire also performed a flight using a Matrice 600 to deliver a defibrillation, which left the take-off location at 15:20 PM and took 14 minutes. The flight is represented in the following map in Figure 5, by the roundtrip from Pin 6 to Pin 6a. In addition, the map also demonstrates the routes from the flights described in Table 7.

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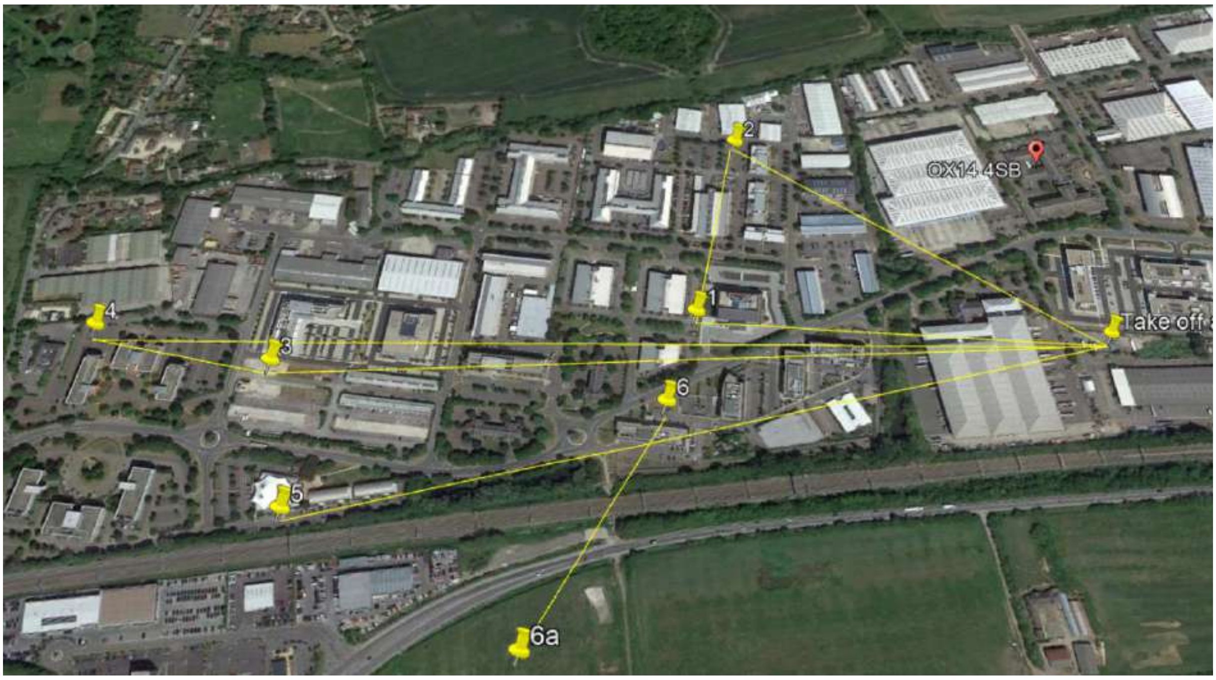

Figure 5 Routes in Milton Park during the Oxfordshire demonstration

The concept developed in HARMONY, i.e., the combination of a drone with an electric van for parcel delivery, can be seen as a connection between (smart) city management and aviation services. The provided tools are a re-use from airspace management and air traffic management (ATM) solutions, which have proven to work reliably and safely in the aviation sector. Integration into the HARMONY MS could be a future add on, which allows for safe and reliable airspace planning and also for very low-level drone flight planning according to the city's needs. In Figure 6, the drone traffic coordination where the management and the control of the demonstration took place is shown.

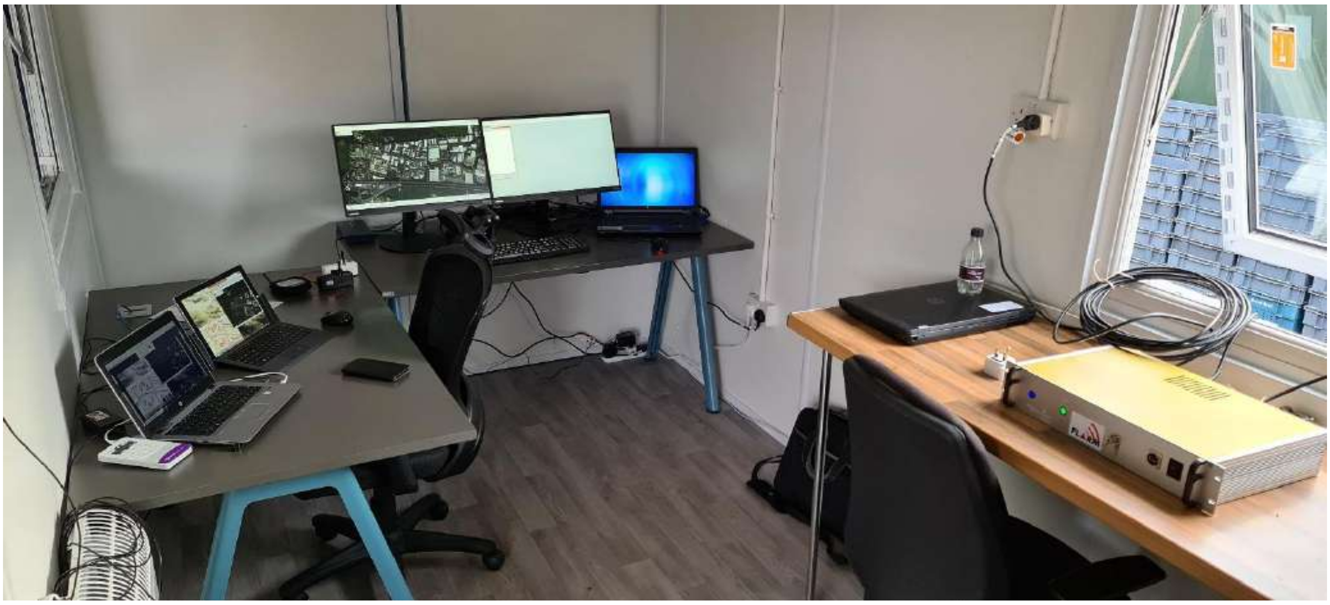

Figure 6 Drone traffic coordination centre in Milton Innovation Park.

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4.3 Trikala

4.3.1 The drones demonstration

The drone's demonstration in the city of Trikala involved a preliminary case study focusing on a pharmacy shop that delivers medicines to elderly houses through drones. Eventually, an adapted case study has been formulated, due to legislation restrictions, focusing on a pharmacy logistic centre that delivers medicines to pharmacy stores through drones. Afterwards, each pharmacy store can deliver the medicines to elderly groups through ground mobility modes.

In total, pilot drone flights have been conducted in three peri-urban areas of the city of Trikala, in Greece. Eight (8) flights have been conducted to each one of the destinations. The landing took place in the pharmacy area of Leptokaria, in the football area of Megalo Kefalovriso and in the football area of Mikro Kefalovriso.

Figure 7 Pharmacists using the drone service during the Trikala demonstration.

During the flights, several data was collected and impact assessment results, in the form of various KPIs, are presented here. During the whole pilot, 24 flights were performed, a total distance of 170km was covered, while the total duration of the flights was 632 min (10.5h), on an average speed of 10m/s.

Table 8 Process KPIs for the drone demonstration in the city of Trikala

Peri-urban areas of the city of Trikala	Leptokaria	Megalo Kefalovriso	Mikro Kefalovriso
Process KPIs			
Lessons learnt	value of co-creation, safety challenges in urban areas and public areas, traffic models needed, cybersecurity		
Facilitators/ Drivers/ Success factors	Structured co-creation process		
Deviation from expected results		Change of land and take-off location	Change of land and take-off location
Risks and barriers	approach Urban Environment, Municipality and user/stakeholders' acceptance, absence of		

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	technological equipment and investment, lacking U-space monitoring tools and methods		
Mitigation strategies	Evacuation, work with local and national authorities		
Deployment plan	Yes	Yes	Yes
Technical feasibility	Yes	Yes	Yes
Economic feasibility	Yes	Yes	Yes
Operational feasibility	Yes	Yes	Yes
Workshops for user instruction	Yes	Yes	Yes
Data requirements	Yes	Yes	Yes
Number of infrastructure/sensors that the drone interacted with	0	0	0
Communication data security	Yes	Yes	Yes
Privacy protection	Yes	Yes	Yes

The value of co-creation has been pointed out for a successful process in setting up and carrying out such a demonstration. Also, safety challenges in urban and public areas, the need for traffic models and cybersecurity have been identified and highlighted as lessons learnt. Moreover, a structured co-creation process is indicated as a success factor. Regarding risks and barriers in the process, the following have been noted: approach in an Urban Environment, acceptance from the municipality and user/stakeholders, the absence of technological equipment and investment and lacking U-space monitoring tools and methods.

Moving from process to impacts, Table 9 presents several performance-related indicators for the impact assessment of the drone demonstration. In the same table, indicators related to public acceptance and adoption, as well as business model and technological readiness of solutions, are also presented and have been filled in, to the extent possible. Results based on questionnaires can be found in Appendix C: Trikala Drones questionnaires.

Table 9 Impact KPIs for the drone demonstration in the city of Trikala

Impact KPIs	Leptokaria	Megalo Kefalovriso	Mikro Kefalovriso
Number of flights	8	8	8
(total) Duration (in minutes)	177	210	245
Average flight duration (in minutes)	22	26	30
Number of errors during the testing phase	0	0	0
Time for error fixing	0	0	0
Average speed	10m/s	10m/s	10m/s

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Speed variation (St. dev. of speeds)	plus or minus 1m/s	plus or minus 1m/s	plus or minus 1m/s
Stops	1	0	0
Distance per flight	2,4km	5,8km	13km
Total distance	19,2km	46,8km	104km
Freight kilometres	19,2km	46,8km	104km
Number of cargo transported	2	2	2
Weight and size of cargo transported	100x15x50 (300g)	100x15x50 (300g)	100x15x50 (300g)
Energy consumption	800Wh	900Wh	1100Wh
Pollutant emissions/ Air quality	Air quality is satisfactory and air pollution poses little or no risk	Air quality is satisfactory and air pollution poses little or no risk	Air quality is satisfactory and air pollution poses little or no risk
Noise level	40Db	40Db	40Db
Accuracy	plus or minus 5m	plus or minus 5m	plus or minus 5m
Max video transmission distance in meters	20000	20000	20000
Maximum wind resistance in Km/h	50Kph	50Kph	50Kph
Communication (all types)	2,4Ghz	2,4Ghz	2,4Ghz
Identification	Yes	Yes	Yes
Failure mode	RTL, Parachute	RTL, Parachute	RTL, Parachute
Security/ cyber security	Yes	Yes	Yes
Real time capability	Yes	Yes	Yes
Object classification	Yes	Yes	Yes
Interoperability (with manned aviation and other stakeholders)	Yes	Yes	Yes
Detection	Yes	Yes	Yes
Adoption willingness	Relatively low willingness to pay for the service		
Perceived usefulness	General agreement in terms of drone advantages		
Political acceptance	Yes		
Drone operator satisfaction	Yes		
Customer / Recipient satisfaction	‘Moderate/ Very’ answered by around 65% of the sample.		
Feeling of safety of the recipient/ Risk perception	‘Moderately/ Very safe’ as answered by almost 70% of the sample.		

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Number of use cases tested	3
Business models developed	1
Total costs	40k for renting equipment and demonstration field works
Usability evaluation	Checked through online survey

In order to perform a proper evaluation of impacts, more data would be desired to have, ideally from a longer and larger scale pilot. Factors, such as e.g., the energy consumption, need to be compared to, for instance, other drones in the market. Further, limitations in the types of analysis need to be considered, considering the different levels at which our evaluation can be carried out, i.e. the measure, the city or site, the project, etc. it has to be kept in mind that this particular demonstration has been implemented in a short period of time, in a low scale, i.e. few itineraries with limited cargo, therefore large-scale impacts cannot be extracted from the collected data as they would lack validity. Having noted that, the initial objective and scope of the activities, which has been to provide improved mobility systems and services to older and vulnerable groups that live in rural areas, should be kept in mind when assessing the pilot results. Compared to D9.4, Trikala now has some results related to public acceptance, for a more extended evaluation. Therefore, for the indicator on usability evaluation, based on results as presented in Appendix C: Trikala Drones questionnaires, we can say that people seem to find it a useful service considering faster delivery time by avoiding traffic jams, while it seems as an advantage that accurate tracking location of drones and more efficient route adjustments could be achieved. However, respondents seem concerned regarding the weather dependency, the flight range and eventually the limited carrying capacity. Thus, overall, we cannot claim that usability of drones is rated as quite high at this moment.

As has been mentioned, legislation restrictions did not allow for direct delivery to elderly people, thus, it can be claimed that this objective has been only partially met. By using UAM Systems and Services and going to the third dimension, freight transportation could be improved in a very efficient way, however the efficiency at the level of the whole city of Trikala is difficult to be measured considering the type of demonstration, therefore we can only refer to usefulness locally. It can be claimed that UAM could be useful for the bypass of some routes for medical supply delivery for urgent and time-critical cases. What can be further claimed is that handling the transferring of crucial goods (such as medicines) by air, decreases the delivery time, since no traffic congestion is confronted in the third dimension and the route is optimized to a straight line if possible.

Air quality can be described by the level of pollutants in the air. The main air pollutants considered are Sulphur dioxide (SO2), Nitrogen dioxide (NO2) and Particulate matter (PM2.5 and PM10). Air quality seems to be satisfactory and air pollution poses little or no risk. The indicator 'Noise level' is used to capture the outdoor sound level caused by human activities, including transport. A safe or acceptable noise level for constant exposure is 68 dB or below, therefore we can claim that the 40dB measured during the demonstrations satisfy this threshold. Lastly, no errors were noted during the testing phase, hence no time for error fixing has been needed, which is a positive output.

4.3.2 User acceptance questionnaires

Regarding the user acceptance of drones, questionnaires were developed, which were distributed to citizens (elderly people) and pharmacists (or focus groups). UAegean, e-Trikala and MobyX prepared the collection of data (questionnaires) that has been used for the public acceptance of drones as a new mobility service. Following, some information is provided with respect to the respondents, which were 45 people in total, after necessary cleaning of the data.

- 69% of the participants are Trikala residents
- Almost 95% of the participants know what a drone is
- 75% of the participants know that drones can be used to transport cargo in cities and villages
- 82% of the participants are interested in the idea of drones delivering medicine if access to a local pharmacy is limited
- 75% of them are willing to use their own smartphone to access such a service, while 70% of them are willing to use a call center to access this service

Regarding willingness-to-pay, less than 30% are willing to pay for such a service, of which a big percentage is willing to pay a limited price (this was an open question). People are generally willing to pay from a very small amount (or percentage of the actual price of the delivered good), ranging from a few cents, to maximum 5 euros. There are a few outliers citing 10-12 euros. An interesting finding is the distribution of the time they are expecting the delivery to happen. 30% of the participants are expecting the delivery within a few hours (ranging from half an hour to three hours). Another significant portion, cite a day. Then a smaller portion (~15%) are willing to wait up to three days if there is an emergency. Regarding additional services by drone, including delivery of products such as clothing and food, almost half of the sample is positive on such drones' usage. Results have been visualized in bar charts and can be found in Appendix C: Trikala Drones questionnaires.

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5. Summary of evaluation

Deliverable 9.5 has summarized, based on D9.3 and D9.4, and extended, the reporting of the activities carried out in the six HARMONY metropolitan areas during the whole project period. Similarly, to D9.3 and D9.4, the most important events and activities which were carried out, in the process of initialization, development and operation of the co-creation labs, in the six different HARMONY areas, including key stakeholder engagement moments, barriers faced, as well as success factors and lessons learnt, have been outlined.

Overall, the COVID-19 pandemic had strong impacts in all the activities of the project for around two years. Also considering the nature of the activities of WP9, which included stakeholder engagement and physical demonstrations, as well as data collection from travellers, one can realise what a major barrier this has been. The planning, the organization, and the execution of several activities of the HARMONY areas, especially during 2021, have been negatively affected, causing several delays, due to job retention periods and to general sharing of opinions which would normally take place in several physical meetings and events. Issues related to adequate stakeholder engagement have been raised, as well as changes to the planning of data collection activities have been made to make sure that the information collected is meaningful, since, as an example, during a lockdown period, the validity of travel-related data would decrease.

Stakeholder engagement processes have been at the core of each co-creation lab and were of crucial importance to reach its results. Every co-creation lab was continuously in the process of contacting stakeholders, while looking into how to increase potential efficiency of the whole process, collecting feedback, and integrating the views of the key stakeholders into their co-creation lab activities has been essential. Remarkably, although the communication with many stakeholders was often hindered due to COVID-19 pandemic having a strong impact on physical meetings, still quite many interviews have been held, surveys have been distributed successfully and participation in various events has been possible. Overall, the co-creation activities ended up varying quite a lot in format. However, all cities learnt and benefit from the process, while the co-creation approach is desirable to be adopted and continued in their future work. As success factors, cities have mentioned the possibility to find synergies and share knowledge with other projects. The importance of collaborating with professional and experienced partners has been identified as well. With respect to lessons learnt, the cities recognized the necessity of having contingency plans for the locations of the demonstrations but also the importance of identifying multiple partners from other projects as well that can provide complementary benefits. Further, the knowledge that can be shared via a co-creation lab and the process of public engagement with the citizens and stakeholders is proven to be a fundamental way to develop and implement a demonstration activity.

Regarding the physical demonstrations, there has been an essential barrier for the cities of Rotterdam and Oxfordshire, where it has not been possible to perform the AV pilots, as ARRIVAL, the partner developing the vehicle, withdrew from the project during the last year. However, both cities have developed alternative plans for a demonstration activity, which could still satisfy the objectives of the co-creation lab, to the extent possible. In Trikala, the third city with a demonstration including drones, the flights have been successfully completed and relevant data for impact assessment have been collected. A complete evaluation of impacts could now be presented, to also include questionnaires on ex-post evaluation for public acceptance.

Overall, most of the demonstrations performed, somewhat differ from the initial plans, but are still innovative and offered the opportunity to explore their potential, while learning from the process. Small scale impact evaluation has still been possible, but it has been difficult to apply existing methodologies in a structural way for evaluation, considering the differences among the activities and timing issues, apart from the size and scale of the demonstrations. Effort has been put in formulating common sets of key performance indicators and this has been achieved to some degree.

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To summarize the efforts of the six HARMONY metropolitan areas, it is fair to mention first that the areas were since the beginning categorized into trailblazing (Rotterdam and Oxfordshire), aspiring (Athens and Turin), and followers (Trikala and GZM). To start with the innovators, both Rotterdam and Oxfordshire learnt a lot about the technological, but also political readiness of autonomous vehicles. Rotterdam had eventually a demonstration with a self-driving delivery robot, focusing on understanding how the robot reacts to different environments and other moving and non-moving obstacles, within different traffic situations and on a public road. Self-driving robots are relatively new; thus, it has been extremely valuable to test them during this project. The results show that these robots certainly have a future, however, the city of Rotterdam is not planning on active promotion based only on this demonstration as further research on their potential benefits is needed. In the case of Oxfordshire, the alternative demonstration included a drone and an electric van for delivery of small packages. It was a rather short, timewise, demonstration, in closed environment conditions. Nevertheless, it was interesting to see the feasibility to connect air and road traffic management. The goal of such a demonstration was to showcase the potential of electric vehicles and drones in real-world conditions by integrating them with traditional modes of transportation and this has been achieved to a satisfying degree.

The city of Athens carried out no demonstration activities, but rather focused on setting up two co-creation labs, while big efforts were devoted to the modelling activities of the relevant scenarios with respect to the future of transportation for the city. For Athens, these were the first steps in co-creation approach, which resulted in big steps regarding the electrification of public transport process. Very important modelling activities were performed during the project, although no interface of their software (VISUM) was eventually included in HARMONY MS due to time constraints. In Turin, the focus was also on co-creation activities, and as part of the project, the definition and execution of (most of) the use cases for the HARMONY MS application for Turin has been completed, while broad data collection via the MOBY App has been achieved. More information on stakeholder engagement and formulation of scenarios can be found in D1.4, while results of the modelling activities of the various cities have been reported in various other project deliverables, such as D2.5, D6.4 and D7.6.

Moving to the “follower” cities, the Trikala co-creation lab focused on drone demonstrations for medical purposes. Trikala is a European city in transformation and the participation in HARMONY has offered valuable insights into pulling off a demonstration of such a disruptive concept like drones. It was a rather small-scale pilot, but on an important use case (urgent medical deliveries). What would have been interesting but still challenging and difficult would be the translation to a model, for an impact assessment in a scaled-up situation. Katowice, also as a following city, has pointed out that a lot of knowledge has been gained during the project, while essential first steps in stakeholder involvement and crucial discussions on SUMPs have been completed. Setting up a survey with UCL and having some first insights into citizens’ preferences for drone usage has been one of the key activities for the GZM co-creation lab.

With respect to the link between the demonstration activities and the modelling ones, the example of Rotterdam is the finest, in the sense that, although the initial plans of having a demonstration with an AV changed, simulation of a use case with delivery robots was performed (see D6.4), ensuring that there was alignment between the input and assumptions used in the model and the real world information with respect to the robot used in Rotterdam. For the rest of the cities, this has not achieved to the desired degree, however, for Trikala this was never the intention. Regarding Oxfordshire, since the alternative plan involved drones and not AVs, this was not part of the modelling scenarios, but nevertheless, important input has been provided to the modelling activities such as the travel survey data collection and of course secondary data from the city.

The identified challenges for the implementation of the demonstrations have been mentioned under the individual sections for every HARMONY area, but a summary is also provided here. In this regard, the most important challenges as recognized by the different cities are related to: the geo-morphological landscape, to re-arrangement of ground mobility services for integration of more innovative modes, to institutional frameworks in EU and national level, to political support and public acceptance, to technological barriers, to investment in both physical and digital infrastructure, to cordoning locations during trials, to operational requirements and technological set up. In general, through the process, the cities had the chance to learn about technologies and certainly better understand the various technical and operational issues, the opportunities, and the challenges. A key finding from the lessons learnt is that co-creation and demonstrations are the best ways to engage a variety of community members and bring them onboard into a new experience. With respect to future successful implementation, although several potential benefits of the services tested in HARMONY demonstrations, such as drones and delivery robots, can be easily identified, while various stakeholders have expressed interest in experimenting with such innovative concepts, it is a matter of fact that the added value of regular usage is hard to be recognized due to their limited delivery range, as well as their limited capacity. The question remains regarding what are the potential unmet needs that they would really be able to fulfil. Just a few days or weeks of demonstrations was not a long enough timeframe to integrate well with local stakeholders, establish new delivery services, as well as a customer base, but opportunities for community engagement and staff learning were provided and accomplished even in a shorter time.

Overall, the planned demonstrations have been successfully pulled off, although it has been a rather challenging and demanding procedure for the cities. Valuable learnings have been provided, which is also a desired outcome of a project like HARMONY. All cities have reported gaining a better understanding of the amount of effort and work it takes on both supply and demand sides to realize a demonstration, while adopting a truly co-creation approach. Participation in such big EU projects, facilitates the process towards stakeholder engagement and involvement in exploring via testing new technologies.

Lastly, this deliverable is extended to also cover the overall approach for actions coordination and communication within WP9. All the HARMONY areas participated in monthly or bimonthly WP9 meetings to track the development of the demonstrations, the data collection and, in general, the individual co-creation lab activities. Mid-and end-of-demonstrations one-to-one discussions with Rotterdam, Oxfordshire and Trikala were planned, as well as with Athens, Turin, and Katowice to get continuous updates on the activities. Some important limitations, with respect to the evaluation process, also need to be mentioned at this point. Considering that all demonstrations were physically based in different locations and that the ability to travel, due to the pandemic, was strictly limited, we had to rely on the information and data shared by the stakeholders directly involved, regular meetings, and individual discussions to establish our findings and draw conclusions. It should also be mentioned that each demo city was piloting a rather different technology (although e.g., drones were part of two different demos), under different conditions. Further, stakeholders and project members to oversee the pilots varied from place to place, which resulted in inconsistent data collection efforts across the cities, with more information being available about some of the demonstrations and less about others. As an example, user acceptance questionnaires were distributed only in Trikala and not in Rotterdam and Oxfordshire. Further, there were much less deliveries completed in Oxfordshire compared to the other two cities, due to the shorter duration of the demonstration. The conclusions we can draw with respect to impacts, as well as business models, are rather limited by the low scale of the demonstrations. As a result, the core of our evaluation has been process-oriented.

References

HARMONY D1.4 Stakeholder requirements and scenarios for regional spatial and transport planning-Final Version

HARMONY D2.5 Spatial and transport planning scenarios simulation results

HARMONY D6.4 Applications of the freight tactical simulator and forecasting

HARMONY D7.6 Applications of the operational simulator and forecasting

HARMONY D9.1 The HARMONY area's orchestration, engagement plan and data collection guidelines.

HARMONY D9.3 HARMONY areas engagement activities and demonstrations – First version

HARMONY D9.4 HARMONY areas engagement activities and demonstrations – Second version

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Appendix A: Periodic process evaluation report template

City/ area:
Partner:
Name:
Date:
Reporting period:

Were there any changes in the objectives and scope of the co-creation lab and/or demonstration?	
Please describe the activities carried out during the reporting period:	
Which barriers (in relation to the activities carried out) have you experienced during this period?	
Please identify crucial success factors (if any) that helped you to achieve the results during this period:	
What were the lessons learnt during this period?	
Please list and describe the key stakeholder engagement moments that took place during this period (stakeholder groups, quantity, co-creation strategy, results achieved, etc):	
Please provide an indicative planning for the upcoming period of the project (3-6 months).	

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Appendix B: Tables for KPIs for the evaluation

Table 10 Co-creation KPIs

Sub-category	KPI	Description	Measurement
Context indicators	Objectives	Objectives met/ changed	Descriptive
	Expected results	(Expected) Results achieved	Descriptive
	Record of communications	Conversations, discussions, interviews, negotiations and agreements	Descriptive
	General barriers	Barriers in the process of the co-creation lab	Descriptive
	General facilitators	Facilitators in the process of the co-creation lab	Descriptive
Involvement indicators	Number of stakeholders	Number of stakeholders contacted/ involved	Quantitative
	Users involved	Users involved for execution of operations or process (including for example subcontractors)	Descriptive
	Users involved	Users involved for planning of operations	Descriptive
	Other stakeholders	Other stakeholders to involve	Descriptive
	Other relevant developments	Other relevant developments that help to scope the lab	Quantitative
	Type of stakeholders involved	knowledge institutes, citizens, civil society organisations, policy makers, industries	Descriptive
	Total number of events	Total number of major events carried out	Quantitative
	Key stakeholder moments	Events such as workshops with the different stakeholders involved	Quantitative
	Number of surveys	Number of surveys conducted	Quantitative
	Number of interviews	Number of interviews conducted	Quantitative
	Type of event	Description of the type of event	Descriptive

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Sub-category	KPI	Description	Measurement
Process indicators (per event)	Purpose	Type of service, policy, other	Descriptive
	Duration	Duration of the event	Quantitative
	Delays	What is the delay and the reason of it	Quantitative
	Type of co-creation process	Co-initiation, creation of data/knowledge, design, implementation	Descriptive
	Number of stakeholders	Number of stakeholders involved in the session	Quantitative
	Type of stakeholders involved	1. Knowledge institutions; 2. Citizens, civil society organisations; 3. Policy makers; 4. Industries (including sub-categories; mobility policy makers, type of industries, etc.)	Descriptive
	Objectives event	1. Gaining more effectiveness; 2. Gaining more efficiency; 3. Gaining customer satisfaction; 4. Increasing citizens involvement; 5. Other, namely	Descriptive
	Outcome	1. A new initiative; 2. Better shared or new knowledge; 3. A new product; 4. A new service; 5. New or better policy; 6. Other.	Descriptive

Table 11 Demonstration KPIs

Sub-category	KPI	Description	Measurement
Performance indicators	*Process*		
	Lessons learnt	Lessons learnt while setting up the demonstration	Descriptive
	Facilitators/ Drivers/ Success factors	Facilitators, drivers and success factors while setting up the demonstration	Descriptive
	Deviation from expected results	Possible deviations from the expected results	Descriptive
	Risks and barriers	Risks and barriers while setting up the demonstration	Descriptive
	Mitigation strategies	Possible mitigation strategies taken	Descriptive
	Deployment plan	Deployment plan of the demonstration	Descriptive
	Technical feasibility	Technical feasibility of the demonstration	Descriptive
	Economic feasibility	Economic feasibility of the demonstration	Descriptive

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Sub-category	KPI	Description	Measurement
	Legal feasibility	Legal feasibility of the demonstration	Descriptive
	Operational feasibility	Operational feasibility of the demonstration	Descriptive
	Workshops for user instruction	Number of workshops to provide instructions to the user	Quantitative
	Workshops organized to set up the demos	Number of workshops with stakeholders to set up the pilots	Quantitative
	Data requirements	Data needed for performing the demo	Descriptive
	External data sources used for the drone demo	To measure what and how many external data sources was required for the vehicles to operate in the real-world environment	Descriptive
	Number of infrastructure/sensors that the drone interacted with	Number of infrastructure and which infrastructure the drone interacted with	Quantitative
	Communication data security	Communication throughput including data security number of treated messages per time; Number per time unit; Collection method: self- assessment from solution provider	Descriptive
	Privacy protection	Is privacy ensured according to law/ GDPR, i.e., no info about localization and real-time speed transmitted to the cloud?	Descriptive
	Impact		
	Number of flights	Number of flights performed for the whole demonstrations	Quantitative
	(total) Duration	Total time tested	Quantitative
	Average flight duration	Average time per flight	Quantitative
	Number of errors	Number of errors during the testing phase	Quantitative
	Time for error fixing	Time required to fix an error during the demo	Quantitative
	Average speed	Average speed during the flight/ trip	Quantitative
	Speed variation	Standard deviation of speeds	Quantitative
	Stops	Number of stops per flight	Quantitative
	Total distance per flight	Total distance travelled per flight	Quantitative
	Freight kilometres	Ratio of the distance with cargo onboard	Quantitative

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Sub-category	KPI	Description	Measurement
	Amount of cargo transported	Average number of units of cargo transported per ride	Quantitative
	Weight and size of cargo transported	Maximum size and weight that can be delivered	Quantitative
	Energy consumption	Total energy consumption	Quantitative
	Pollutant emissions/ Air quality	Air quality' is the healthiness and safety of the atmosphere which can be described by the level of pollutants in the air. The main air pollutants considered are Sulphur dioxide (SO2), Nitrogen dioxide (NO2) and Particulate matter (PM2.5 and PM10)	Descriptive
	Noise level	The indicator 'Noise level' is used to capture the outdoor sound level caused by human activities, including transport.	Quantitative
	Accuracy	altitude, position	Quantitative
	Max video transmission distance	Max video transmission distance in meters	Quantitative
	Maximum wind resistance	Maximum wind resistance in Km/h	Quantitative
	Communication	Communication (all types) in Ghz	Quantitative
	Identification	Identification	Descriptive
	Failure mode	Failure mode	Descriptive
	Security/ cyber security	Security/ cyber security	Descriptive
	Real time capability	Real time capability	Descriptive
	Object classification	Object classification	Descriptive
	Interoperability	Interoperability (with manned aviation and other stakeholders)	Descriptive
	Detection	Detection	Descriptive
Public acceptance and adoption indicators	Adoption willingness	Ratio of number of customers relative to the total number of people/companies that were invited to adopt the solution.	Descriptive
	Adoption rate	Adoption rate	Quantitative
	Perceived usefulness	Perceived usefulness	Descriptive

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Sub-category	KPI	Description	Measurement
	Political acceptance	Political acceptance	Descriptive
	Drone operator satisfaction	Satisfaction – 7-point Likert scale	Quantitative
	Customer / Recipient satisfaction	Satisfaction – 7-point Likert scale	Quantitative
	Feeling of safety of the recipient/ Risk perception	expressed on a Likert scale, e.g., 1–7, very dangerous – very safe	Quantitative
Business model and Technological readiness of solutions indicators	Number of use cases	Number of use cases tested	Quantitative
	Business models	Business models developed	Quantitative
	Total costs	Total costs for the demonstration, including the purchase costs of the vehicle and the digital infrastructure	Quantitative
	Capital costs	Capital costs	Quantitative
	Cost of purchased Drone	Cost of purchased Drone (market price, monetary value)	Quantitative
	Operational and maintenance costs	Operational and maintenance costs	Quantitative
	Usability evaluation	survey, behaviour observations, other relevant methods	Descriptive

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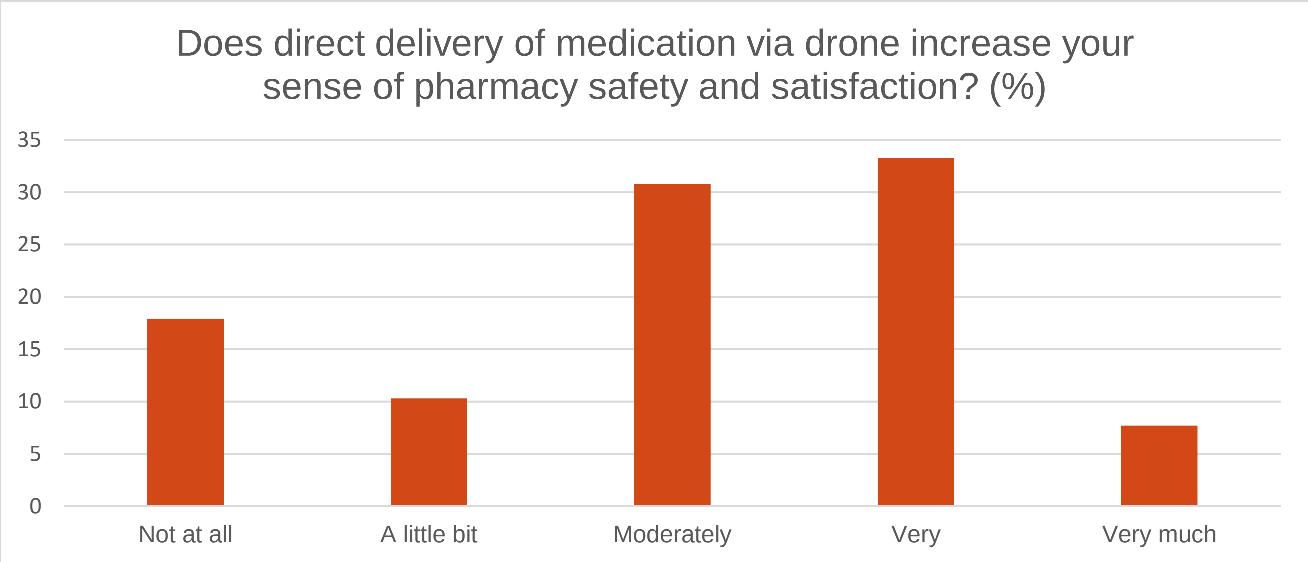
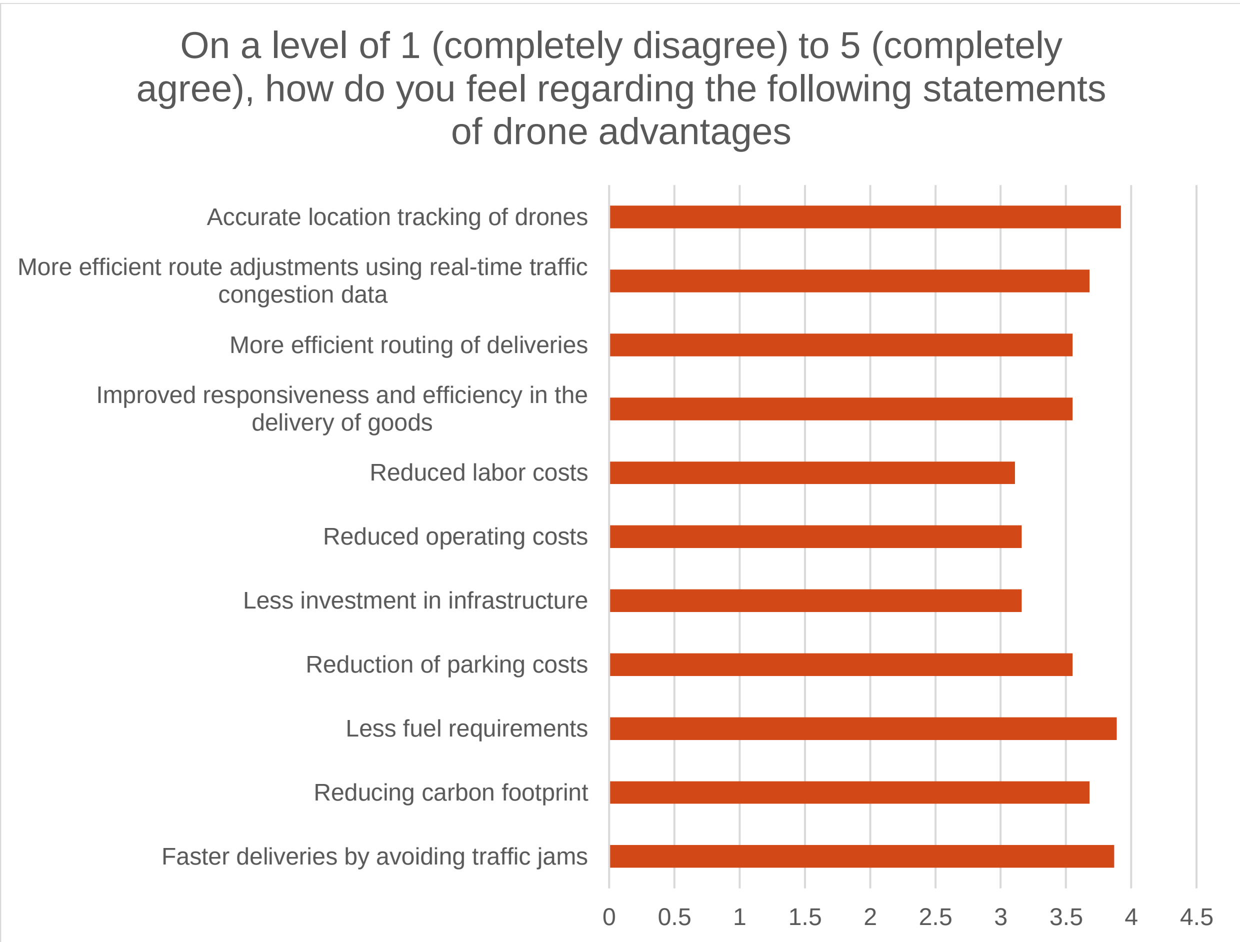
Appendix C: Trikala Drones questionnaires

Below, the results of the user acceptance questionnaires distributed in Trikala, after the drone demonstrations, are presented in the form of graphs, as provided from analysis by UAegean.





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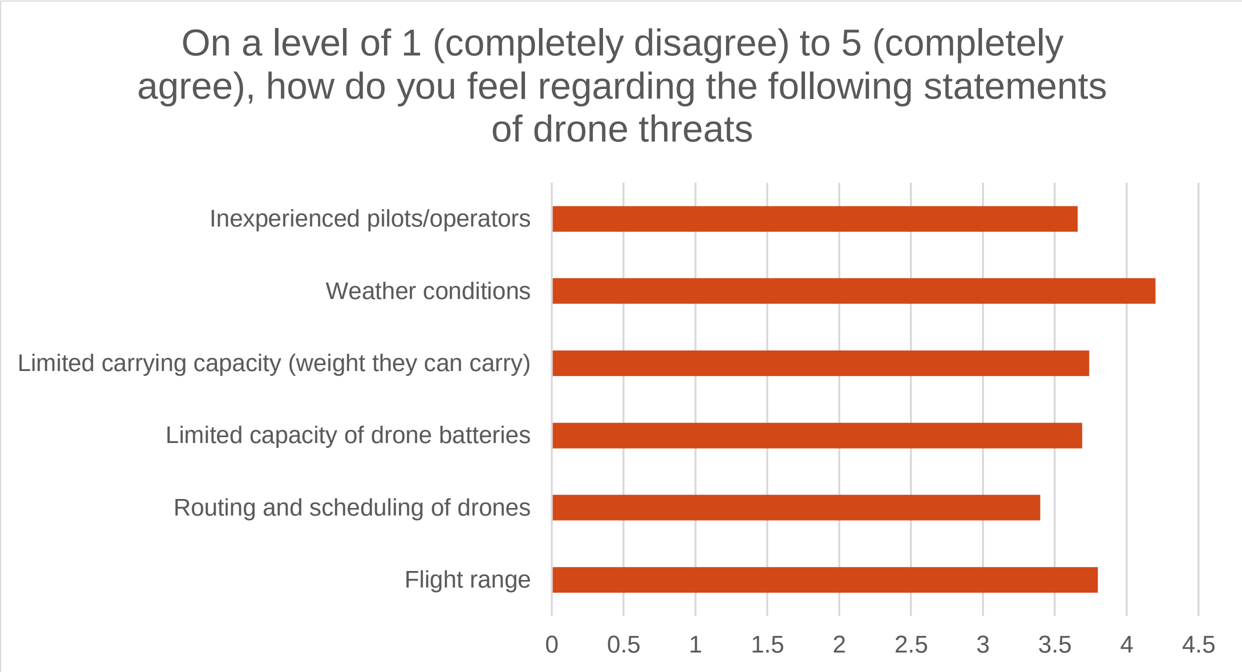

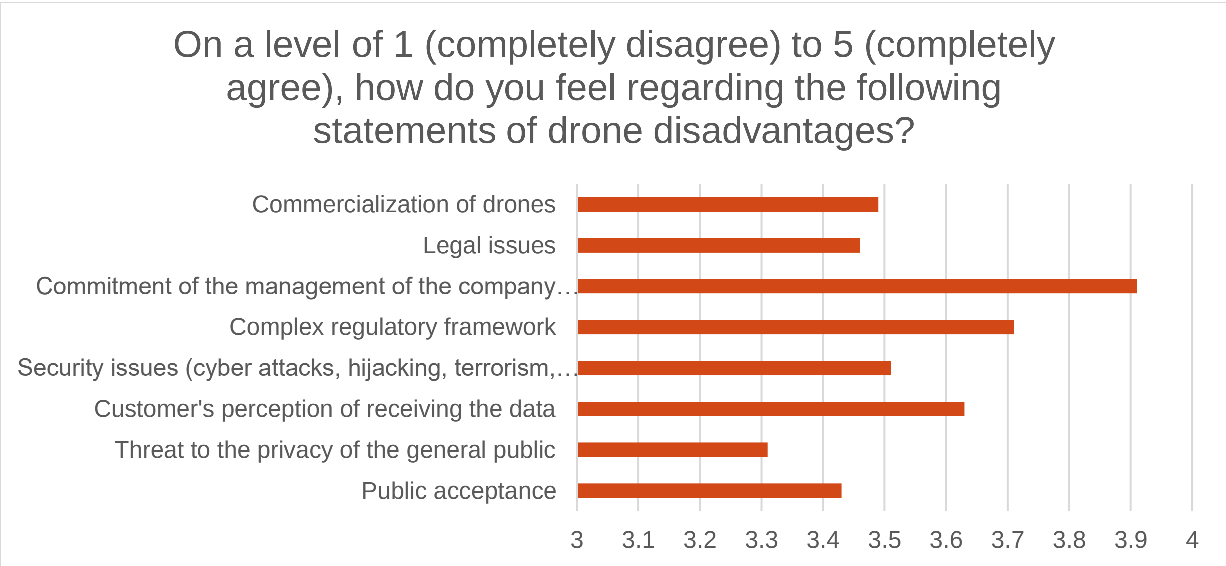

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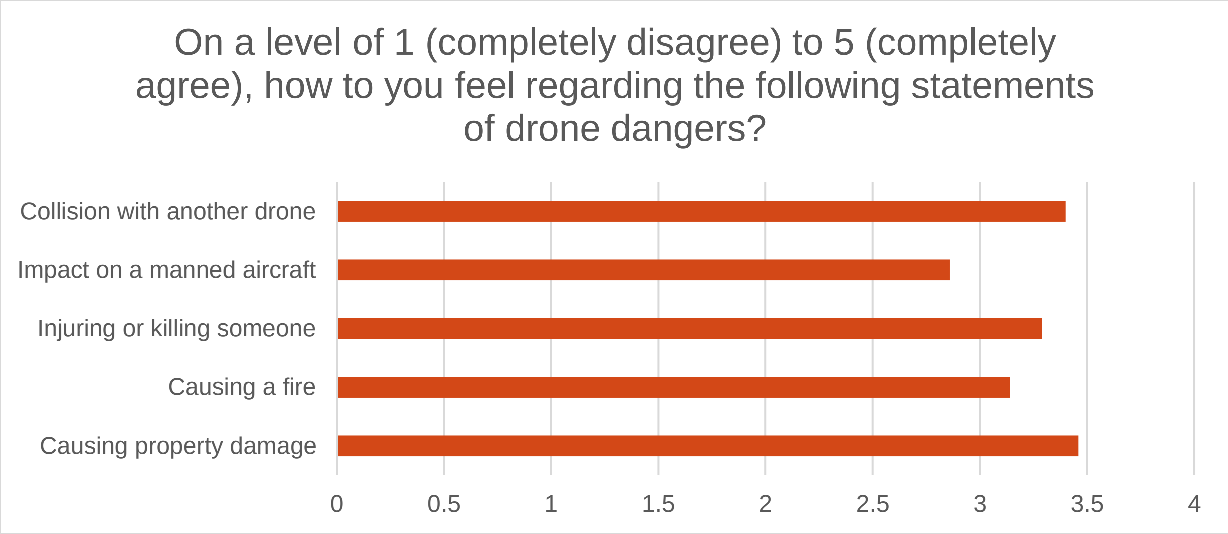

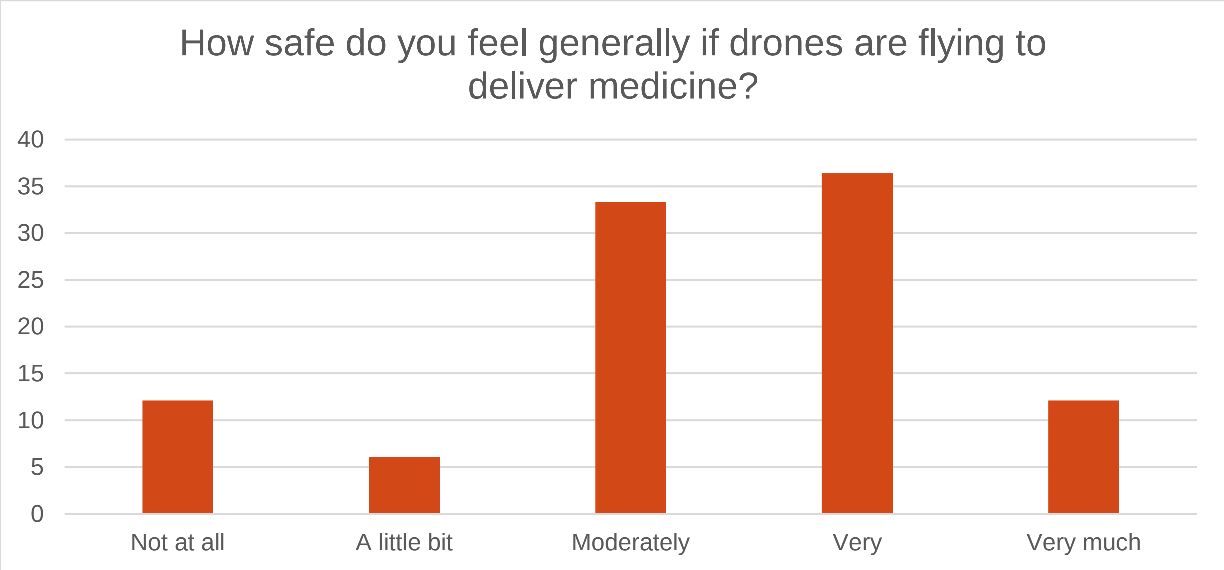

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