HARMONY
SPATIAL & TRANSPORT PLANNING FOR A NEW MOBILITY ERA

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

D10.4- Market and business ecosystem analysis

Submission date: 01/09/2020

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SUMMARY SHEET

PROJECT

Project Acronym:	HARMONY
Project Full Title:	**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**
Grant Agreement No.	815269 (H2020 – LC-MG-1-2-2018)
Project Coordinator:	University College London (UCL)
Website	www.harmony-h2020.eu
Starting date	June 2019
Duration	42 months

DELIVERABLE

Deliverable No. - Title	D10.4 – Market and business ecosystem analysis
Dissemination level:	Public
Deliverable type:	Report
Work Package No. & Title:	WP10 – Dissemination, Exploitation and Innovation Management
Deliverable Leader:	ENIDE
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DOCUMENT HISTORY

Version	Date	Released by	Nature of Change
0.1	04/06/2020	ENIDE	ToC
0.2	23/07/2020	ENIDE	Input received by all partners
1.0	04/08/2020	ENIDE	First draft submitted
1.1	05/08/2020	ENIDE	Annexes added

DISCLAIMER

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AFV	Alternative Fuel Vehicle
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
CAAS	Civil Aviation Authority of Singapore
CAV	Connected and Automated Vehicle
D	Deliverable
EC	European Commission
EU	European Union
GIS	Geographic Information System
GUI	Graphical User Interface
ICAO	International Civil Aviation Organisation
KPI	Key Performance Indicator
LARA	Local And sub-Regional Airspace management
LAU	Local Administrative Units
LSP	Local Service Provider
M	Month
MaaS	Mobility as a Service
MOOC	Massive Open Online Course
MS	Model Suite
NGO	Non-Governmental Organisation
NUTS	Nomenclature des Unités Territoriales Statistiques
RP	Revealed Preferences
S&T	Scientific and Technical
SUMP	Sustainable Urban Mobility Plan
SWOT	Strengths, Weaknesses, Opportunities, Threats
TBD	To Be Defined
TFS	Tactical Freight Simulator
TUD	Technical University of Delft
UAEGEAN	University of the Aegean
UCL	University College London
UoW	University of Wolverhampton
UTM	Unmanned aircraft system Traffic Management
VLL	Very low level
WP	Work Package
ZE	Zero Emissions

Executive summary

This deliverable introduces a first analysis and preliminary insights into the Market and Business Ecosystem for HARMONY's exploitable solutions. The document analyses the current approaches addressing HARMONY challenges and estimates the potential market for the project technologies and services clustered in four main exploitable assets:

- Model Suite
- Air traffic network controller
- Data collection tools
- Material for training courses

Therefore, the document analyses the current business ecosystem in order to identify trends and formulate hypothesis of scenario evolutions in the future. Additionally, this deliverable benchmarks the current stakeholders' business models against the business ecosystem to foretell their evolution in the "to be" HARMONY ecosystem.

1. Introduction

1.1 Aim of the project

Nowadays, new mobility services and technologies present a possible solution 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, emergence of new mobility services and changing urban sprawl, metropolitan authorities often lack sufficient expertise, knowledge and tools for multiscale spatial and transport planning.

Against this background, HARMONY's vision is to enable metropolitan area authorities to lead a sustainable transition to a low-carbon new mobility era. This will be possible thanks to its harmonised spatial and multimodal transport planning tools which comprehensively model the dynamics of the changing transport sector and spatial organisation.

HARMONY has set ambitious targets for the creation of updated spatial and transport planning tools. Therefore, a well-briefed and consistent innovation management is of paramount importance for the maximisation of the market potential of HARMONY solutions. The consortium's intention is to support the exploitation of HARMONY solutions not only within Europe but also internationally, in order to highlight Europe as a major force worldwide in the relevant scientific and industrial fields.

1.2 Purpose of document

Besides spreading information about the project outcomes, the objective of WP10 "Dissemination, Exploitation & Innovation Management" is to guarantee a thorough management of HARMONY innovations to support their market uptake.

As part of this WP, this document provides an updated analysis of the market and business ecosystem for HARMONY solutions aimed at supporting a sound exploitation plan for the different involved stakeholders. In particular, this deliverable will:

- Review, assess and benchmark current approaches and solutions addressing HARMONY challenges;
- Estimate the market potential of HARMONY technologies and services;
- Analyse the current stakeholders' business models, their relationships, their roles and their evolution in the "to be" HARMONY ecosystem.

1.3 Intended audience

This market and business ecosystem analysis is a public deliverable, i.e. it will provide coordinated feedback abreast of the business environment to the other WPs to direct technical developments towards business-relevant solutions. This deliverable will be available on the HARMONY website and open repository.

1.4 Relationship to other deliverables and roadmap

This report is an initial step towards an in-depth analysis of the business ecosystem and the business opportunities that might arise for HARMONY. The document is supported by the environmental and market analysis preformed in D1.1 encompassing a review of new mobility services, technologies, business models and critically assessing the existing project appraisal. D1.2. D1.4 enrich our insights about stakeholders and their requirements. We also base ourselves on the inputs coming from D1.3, D2.1 and D9.1 to understand the technical aspects, conceptual architecture, and area´s orchestration

of HARMONY MS. These inputs will enable us to compile an initial list of commercial and non-commercial/knowledge assets of Harmony and development of business cases.

Figure 1 The relationship of D10.4 with other WPs and Deliverables.
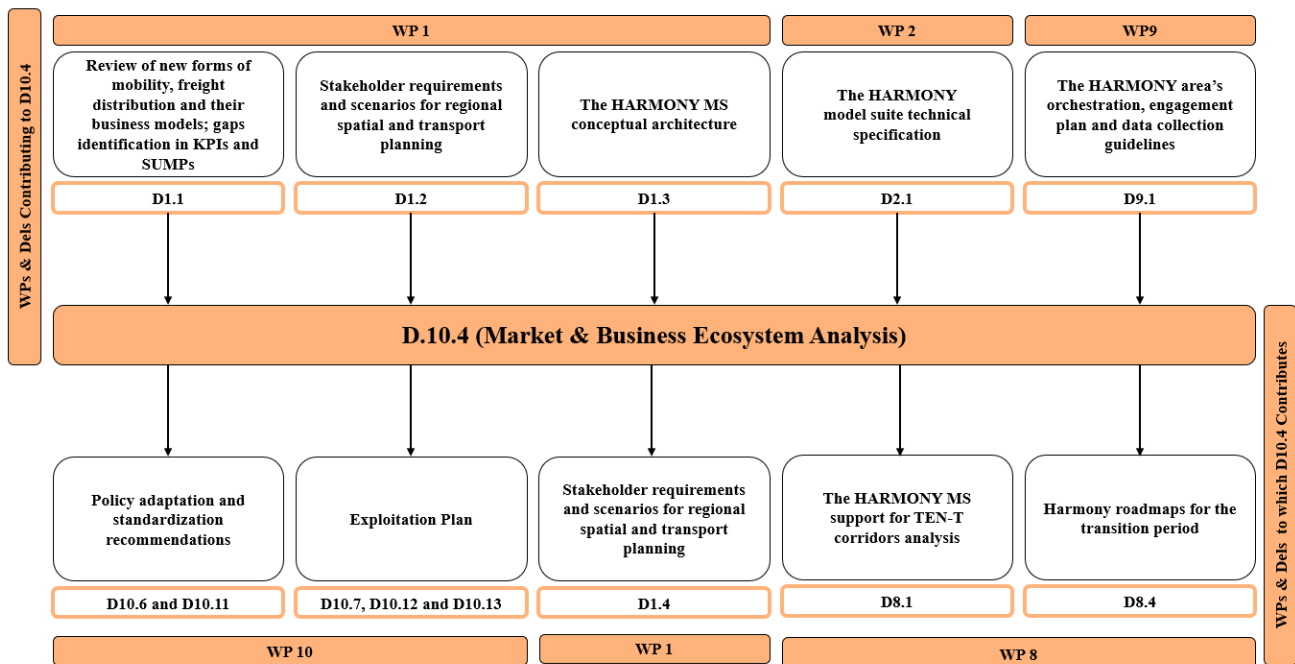
The outputs of D10.4 also contributes to the tasks in other WPs and Deliverables. This report is closely related to D10.7, D10.12, and D10.13. An update of the results and further analysis of the market and business ecosystem for HARMONY solutions will be provided through these deliverables. We are working closely with UCL and other partners to understand the financial viability of the solutions. Some business questions related to the market, willingness to pay for HARMONY solutions (both the product and services) and preferences of the customers regarding the software are planned to be included in the COVID survey implemented in Oct 2020. The results will be presented in D10.7.

The questions are:

- Does your organisation have or plan to develop an integrated land-use and transport model for regional or urban spatial and transport planning scenario analysis?

- What type of spatial and transport planning scenarios has your organisation analysed or is planning to analyse using models? Please, select all that apply.

- Does your organisation develop spatial and transport planning models internally or outsource the task to relevant consultancies?

- What type of software tools do you prefer working with for regional and urban spatial and transport planning within your organisation?

- Does your organisation cover the expenses for training courses?

- Up to which amount does your organisation usually cover for a training course?

- Has the budget for training courses of your organisation been affected due to the Covid-19 outbreak?

We also foresee including some business questions in a survey that is planned under D1.4 which will be implemented during the cross-metropolitan workshop (Q3 2021) to understand better the stakeholder's requirements, preferences, challenges, and perspectives. The results will be presented in D1.4 and will also provide important insights to the exploitation of results (D10.7, D10.12, D10,13).

Moreover, some in-depth interviews are planned under Task 10.5- WP10-D10.7, with the pilot cities to obtain more information about the needs of clients, their expectations, requirements, and wiliness to pay. The results of the interviews will be presented in D10.7.

Figure 2 demonstrates a road map of the deliverables that are closely related to D10.4. The first two stages have been covered in D1.1 and D1.2 and will be updated in D1.4-M36. The scope of this report is the third and forth stages. The results will be updated and further developed in the fifth and sixth stages (Exploitation and IP Strategy, and Implementation).
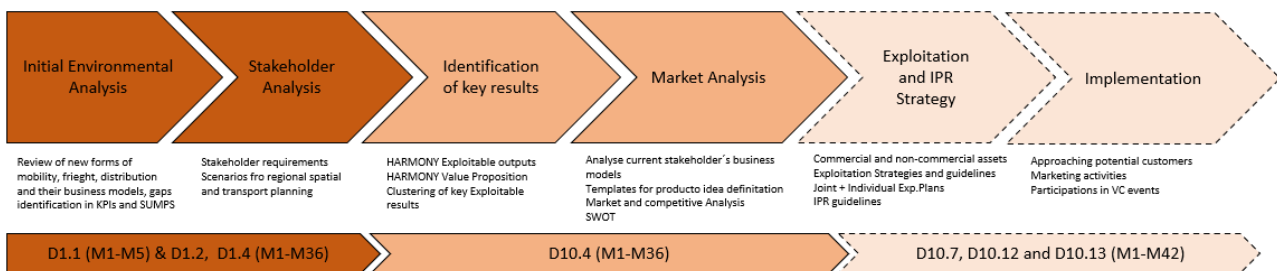
Figure 2 The roadmap of deliverables

The results of D10.4 can also contribute to D10.6 and D10.11, policy adaptation and standardization recommendations, D8.1 ¨The HARMONY MS support for TEN-T corridors analysis¨ and ¨Harmony roadmaps for the transition period¨.

This deliverable identifies an initial list of HARMONY assets (both commercial and non-commercial), current stakeholder´s business models. It clusters the commercial results of HARMONY under 4 business cases. Then, market and competitive analysis is performed for each business case followed by a SWOT analysis. Also, an exploitation Handbook is delivered to the partners as part of this deliverable.

1.5   Structure of the document

This document consists of seven main sections. After a brief introduction in Section 1, HARMONY solutions will be listed and described in Section 2. Consequently, Sections 3 to 6 will focus on a specific cluster of solutions – namely Model Suite, Air traffic network controller, Data collection tools and Material for training courses - providing an overview of business cases, analysing the business ecosystem and finally assessing the market approach for each of them. Some final remarks in section 7 will conclude the document.

2. HARMONY solutions

HARMONY solutions can be divided in two main sub-groups:

- Assets – 12 belong to asset type, and
- Knowledge – 6 belong to knowledge type.

Although both types are exploitable and as such identified in the project and will be exploited by project partners, they do not share the same characteristics from the Market and Business Ecosystem point of view that is the main focus of this deliverable.

In this sense, assets represent all HARMONY technologies and services that have an evident market potential. Hence, this deliverable analyses Market and Business Ecosystem for these assets.

Furthermore, some of the assets share other common characteristics, for example they have similar technical characteristics or they are dependent on each other and/or complement each other in a way that one would not have the same market potential without the other (or it simply would not work properly).

Accordingly, taking into consideration the mentioned characteristics they have in common; they are further grouped into the following clusters:

1. Model Suite
2. Air traffic network controller
3. Data collection tools
4. Material for training courses

It is important to note that assets from different clusters are of course interconnected and provide certain information to each other, but for the sake of creating as an accurate deliverable as possible with adequate quality, such clustering proved to be the best approach.

From the table below, it is evident that some of the clusters consist of more than one asset, such as Model Suite cluster that consist of 9 assets (e.g. as simulators, controllers, models, etc.) that complement each other and add value to the cluster, hence making it complete, while other clusters consist of only one asset.

One of the examples for such ¨one asset¨ cluster is ¨Material for training courses¨. The main reason for such grouping is that, although such materials are tightly connected to HARMONY Model Suite, and would not have value without it, further analyses showed that the users and/or clients of this asset do not always follow the one of Model Suite and its Business Models are not necessarily the same. Hence it was worth further analysing it in a separate cluster to omit some important information on its market potential.

On the other hand, as mentioned above, HARMONY consists of 6 knowledge assets that do not have a market potential as such. Of course, they do have high exploitation potential (as explained in the HARMONY initial exploitation strategy) and will be highly useful and interesting to scientific and industry communities, as well as to relevant public stakeholders. However, it is important to highlight that exploitation potential of assets is not part of this deliverable and will not be further analysed. This will be done in other deliverables further along the project, such as D10.7 Preliminary exploitation plans (due in month 24 of the project), as well as D10.11 Final exploitation plan (due in M42 of the project).

Further information about the HARRMONY solutions analysed in this deliverable is provided in Table 1 below:

Table 1 HARMONY Assets and Knowledge bases description and clustering (grouping)

No.	Cluster	Name	Type	Lead Partner	Description
1	Model Suite	Strategic simulator	Asset	UCL (UCL CASA)	Offers capabilities for simulating strategic decisions regarding house/firm location choice, job location choice, land development, vehicle ownership, areas of economic activities, market transactions, infrastructural needs of new mobility services and their integration with traditional modes. It covers strategic decisions both for passengers and freight.
2	Model Suite	Demand models for passengers (Tactical simulator - Passengers)	Asset	UAEGEAN	Offers capabilities for simulating agents' day-to-day and with-in the day travel demand and activities incorporating modules specifically for new mobility services and regional planning. It covers tactical decisions both for passengers.
3	Model Suite	Demand models for freight (Tactical simulator – Freight)	Asset	TUD	Offers capabilities for simulating agents' day-to-day and with-in the day travel demand and activities incorporating modules specifically for new mobility services and regional planning. It covers tactical decisions for freight.
4	Model Suite	Energy and emission models	Asset	UCL (UCL ATS Lab)	Energy and emission models that include passenger and freight transport modes focusing particularly on new mobility technologies (AVs and drones).
5	Model Suite	Noise models	Asset	UAEGEAN	Noise models which take into account new mobility technologies (AVs and drones). The models will have detailed source geometry, over a large geographical area (metropolis).
6	Model Suite	Multimodal integration controllers for passengers	Asset	UCL (UCL MaaSLab)	simulating and integrating the operation of innovative mobility services, connected vehicles and telematics platforms. Offers capabilities for co-ordination and operation of different transport modes, while also testing several operational scenarios, such as fleet-size, waiting times etc. It

					also offers nowcasting capabilities regarding agents' behaviour and networks conditions.
7	Model Suite	Multimodal service controllers for freight	Asset	UoW	The HARMONY freight controller will facilitate the modelling and simulation of innovative freight mobility services, such as crowdshipping.
8	Model Suite	Transport and spatial data warehouse	Asset	ICCS	The data warehouse of the HARMONY model suite that will offer input and output interfaces for data to be used at any spatial and transport context (not only specific to HARMONY model suite)
9	Model Suite	Multimodal network models	Asset	AIMSUN	The multimodal network model will have the capability to simulate demand and supply at the operational level of the HARMONY MS, representing within-day interactions of simulated agents.
10	Air traffic network controller	Air traffic network controller	Asset	AIRBUS	An air traffic management system to manage low altitude air mobility (urban air mobility; drones, air taxi/passenger vehicles) that will satisfy EU's flight standards ready to be applied in EU.
11	Data collection tools	Data collection tools	Asset	MOBYX	Smartphone based travel survey tools for passengers and freight enhanced with gaming techniques and customised to collect data for regional mobility and integration of traditional and new mobility services.
12	Material for training courses	Material for training courses	Asset	ENIDE	Audio-visual and electronic-based textbooks for applying and using the MS. The textbooks will present the state-of-the-art methodologies that have been developed for integrated regional spatial and transport planning and incorporation of new mobility services.
13		Knowledge base	Knowledge	TRT	Knowledge base with requirements (opportunities and barriers) of new mobility services and their integration with traditional modes in terms of

					infrastructural needs, funding, energy, data exchange and security, noise, emissions and air-quality.
14		Co-creation labs	Knowledge	TNO	HARMONY metropolitan and cross-metropolitan co-creation labs
15		Recommendations for a new generation of SUMP framework	Knowledge	TRT	Guidelines for a new generation of SUMP framework will be proposed that will take into account the dynamics of the new mobility services and their requirements.
16		Business models & cases for investment	Knowledge	TNO	Based on the HARMONY MS simulation results, the most eco-rational solutions and services will be identified. For these, prototype business models and business cases will be developed to be used for attracting funding.
17		HARMONY roadmaps	Knowledge	TNO	The roadmaps will support metropolitan authorities in the government of the transition period to the new mobility services era and assist them with integrated regional spatial and transport planning guidelines.
18	Model Suite	Applications of MS	Knowledge	UCL (UCL MaaS Lab)	The HARMONY MS will be applied for four EU cities.

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3. HARMONY Model Suite

3.1 Market Analysis

Market overview and Size

According to Growth Market Report the global traffic simulation systems market was valued at USD 13,694.3 million (€ 11,611.03 million)[1] in 2019 and is projected to reach USD 33,648.6 million (€ 28,529.75 million)[2] by 2027, with a CAGR of 11.9% during the forecasted period (Figure 3).[3] The need for effective traffic management systems, as well as the reduction of carbon emissions and the creation of improved roads and transportation networks, are some of the key growth drivers.

TRAFFIC SIMULATION MARKET VALUE 2019-2027

13694.3 15323.0 17145.4 19184.5 21466.1 24019.1 26875.7 30072.1 33648.6
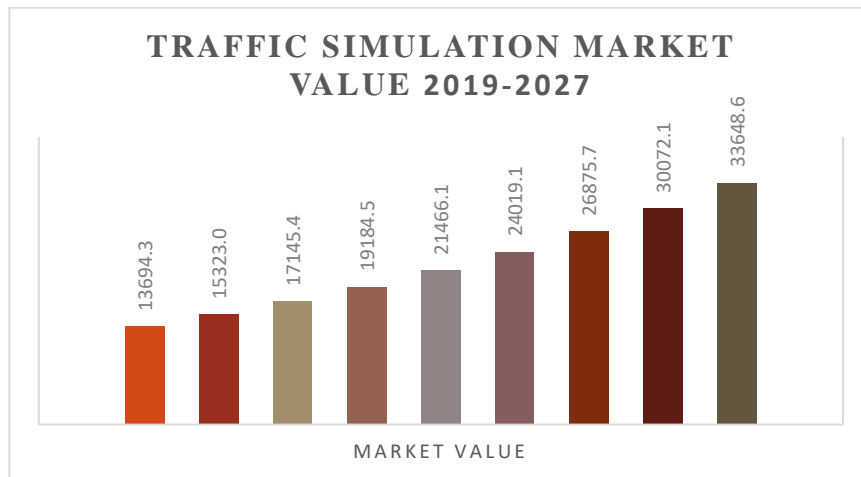
MARKET VALUE

Figure 3 HARMONY MS target Market value

The rise of connected vehicles, which necessitate seamless communication networks, is expected to accelerate the adoption of intelligent traffic management systems. This, in turn, is expected to drive demand growth in the traffic simulation systems as well.

Market segmentation by region

The global traffic simulation systems market is divided into five regions: North America, Europe, Asia Pacific, Latin America, and the Middle East and Africa. As some of the key market players are in the USA and Canada, North America leads the market and is followed by Europe (a more detailed analysis can be found in the HARMONY MS competitive analysis). Countries like the United Kingdom, France, and Germany are expected to drive substantial market growth in the following years.

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[1] Conversion rate USD 1= 0.85 Euro
[2] Conversion rate USD 1= 0.85 Euro
[3] Growth Market Report (2020), Traffic Simulation Systems Market- Global Industry Analysis, Size, Share, Growth, Trends and Forecast. Retrieved from: https://growthmarketreports.com/report/traffic-simulation-systems-market-global-industry-analysis

Figure 4 Market segmentation of key players by region

North America is focusing on efficient traffic flow control, as well as the introduction of advanced technologies that reduce the impact of unforeseen disasters as of Covid-19, allowing for rapid response. This is one of the most recent developments in the market for traffic simulation systems. Furthermore, the existence of various safety and mandatory inspection requirements for the development of traffic simulation systems in europe reasons for the industry's development.

Market segmentation by application

The global interdependence of nations has been highlighted by the COVID-19 pandemic, which has set in motion new developments that will reshape the transportation landscape. The industry is at a crossroads, with immediate concerns about the pandemic as well as longer-term concerns about everything from supply-chain design and globalization trends to shifts in consumption and investment habits, an increasing focus on risk management and resilience-building, and a heightened global sustainability and low-carbon agenda..
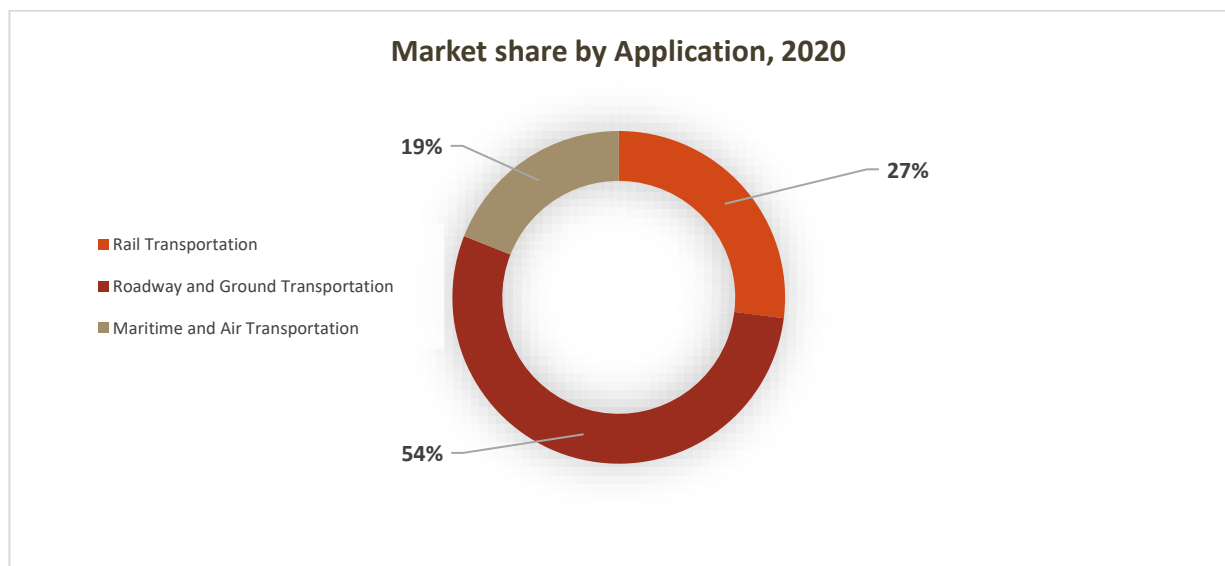
Figure 5 Market share of traffic simulation systems by application

As it can be seen in Figure 5, the global traffic simulation systems market has been divided into three categories based on application: 1) Rail transportation, 2) Roadway and Ground

Transportation, and 3) Maritime and Air Transportation. While roadway and ground transportation account the highest market share by application, expansion of maritime and air transportation services is crucial for the long-term growth of tourism and trade. These services serve as economic drivers by assisting the economy in moving services and goods rapidly and effectively, as well as generating new business opportunities. A well-functioning transportation system will boost trade, and a higher level of trade can lead to increased demand for transportation network investments. The pandemic has highlighted the importance of air and maritime transportation as a vital sector for the continued delivery of critical resources and global trade during times of crisis and recovery.

Market Segmentation by Type

Furthermore, the market can be divided into four broader types/areas of applications based on different simulation models: microscopic models, mesoscopic models, macroscopic models, and traffic planning models.

Individual vehicle characteristics and interactions are simulated using ¨**Microscopic models**¨**.** They basically create the trajectories of moving vehicles through the network. In these models, algorithms and rules explain how vehicles travel and communicate. ¨**Mesoscopic models**¨ simulate individual vehicles. Traffic is represented by small groups of traffic entities whose interactions are defined in medium detail. Traffic flow is simulated by ¨**Macroscopic models**¨. They look at the relationships between traffic characteristics (speed, flow, and density). These models are based on flow conservation equations and traffic disruptions in the transportation system. As a result, they can be used to forecast the spatial and temporal congestion in a road network induced by traffic demand or accidents. ¨**Traffic Planning Models**¨ might encompass one or more types of models. Modern traffic planning software packages assist the user in setting up the simulation scenario, such as displaying a graphical representation of the area of interest or defining/importing traffic assignment zones using well-established spatial data formats (Daniel Krajzewicz et.al, 2019).[4]

Source: Elaborated by authors based on data from GMA[5]
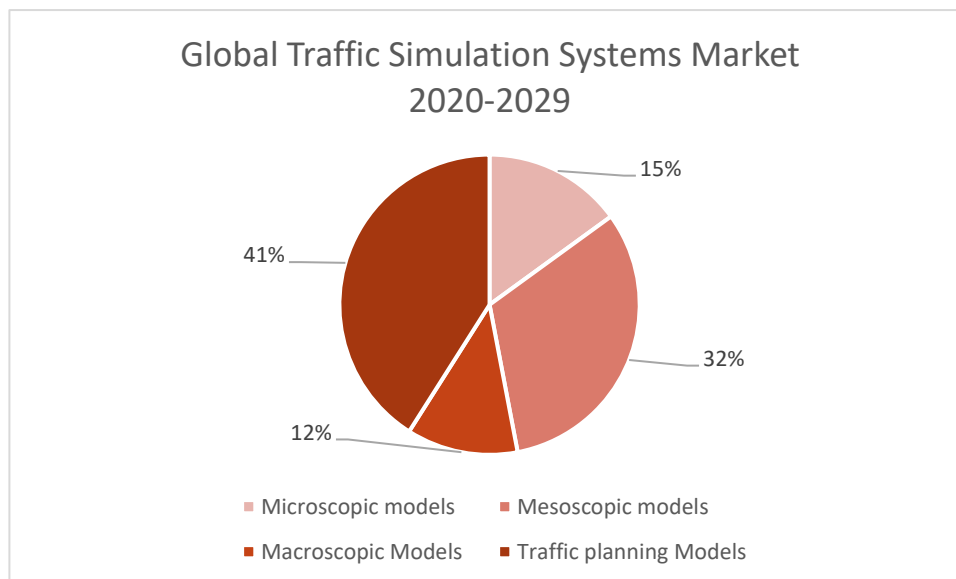
Figure 6 Market share of traffic simulation models by types, 2020-2029

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[4] SUMBA (2019), GUIDANCE FOR TRANSPORT MODELLING AND DATA COLLECTION.
[5] Retrieved from: https://primefeed.in/news/5046153/traffic-simulation-systems-market-investment-analysis-anylogic-incontrol-its/

As it can be seen in Figure 6, traffic planning models acquire the highest percentage of the market followed by mesoscopic simulation models. There is a demand for more microscopic and macroscopic simulation models, something that HARMONY can contribute to.

Sustainable Urban Mobility Plans (SUMPs) in the EU and Traffic simulation systems

Our cities' lifeblood is mobility: every day, metropolitan transportation networks move people to work and play; vehicles deliver food and vital goods, as well as haul away waste. Our cities' ability to work is dependent on mobility. According to Statista, by 2035, the global demand for urban mobility platforms is projected to hit about $25 billion. With a volume of about 12.4 billion dollars, Europe is projected to be the largest region.[6]

Table 2 Size of the urban mobility platforms by region, 2030.
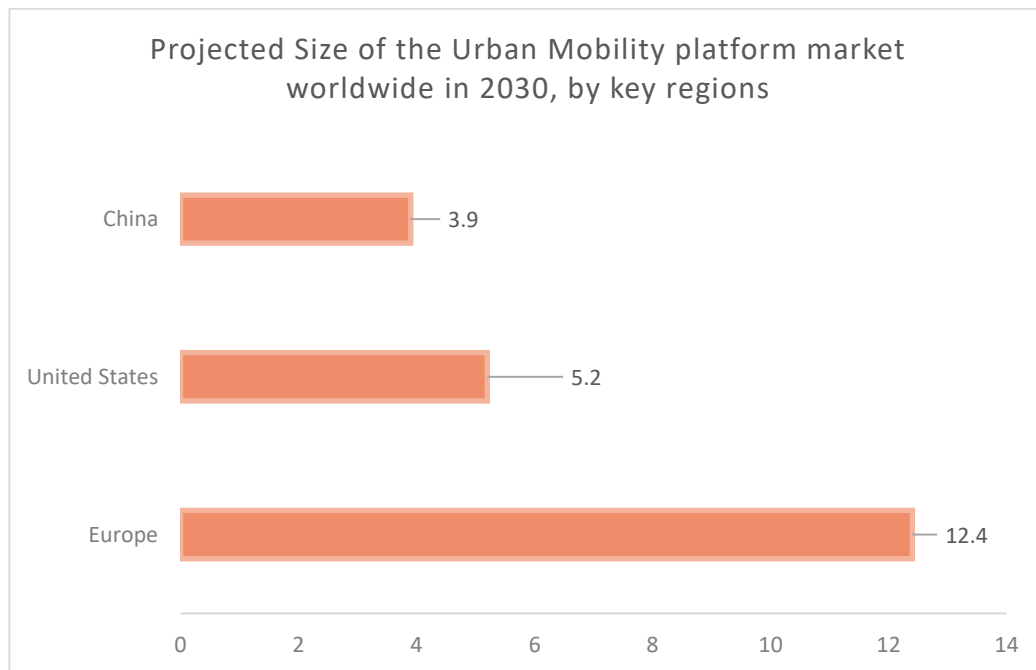
Source: Statista (2021)

In the last years, a lot of attention has been given to sustainability of urban mobility. With its 2013 Urban Mobility Package, the European Commission introduced the idea of Sustainable Urban Mobility Planning (SUMP) to ensure EU´s future prosperity and its competitiveness by investing in a competitive and resource efficient transport system. While in 2013, Urban Mobility Directive found that most European cities are faced with urban mobility challenges, in 2020 the situation has changed dramatically.

In a study performed by the SUMPS-Up project funded by European Commission, it was found out that more than 1000 SUMPs have been adopted so far in the EU. The study also highlights that 290 SUMPs are second and third generation, meaning that prior to the SUMPs currently approved, they

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[6] Statista (2021), Projected size of the urban mobility platform market worldwide in 2035, by key regions. Retrieved from: https://www.statista.com/statistics/1156044/urban-mobility-platform-market-size-worldwide-regions/#:~:text=Projected%20size%20of%20the%20urban%20mobility%20platform%20market%20worldwide%20by%20region%202035&text=The%20worldwide%20market%20for%20urban,about%2012.4%20billion%20U.S.%20dollars.

had approved one or several SUMPs already. The results of the survey also show that most of the stakeholders are ¨mostly familiar¨ or ¨highly familiar¨ with SUMPs concept.[7]

The high interest of EC in having more SUMPs in Europe and the pressure on the cities to adopt a more sustainable urban mobility system opens new opportunities for projects as HARMONY. A more sustainable and efficient urban mobility enables Europe to be more competitive and improve its economy.

	Number of adopted SUMP	Number of 1rst SUMP elaboration	SUMP of 2d or higher generation
Austria	4	2	0
Belgium / Brussels Capital Region	1	0	1
Belgium/Flanders	307	1	210
Belgium/ Walloon	12	1	8
Bulgaria	9	2	0
Croatia	6	1	0
Cyprus	1	3	0
Czech Republic	3	7	0
Denmark	6	5	2
Estonia	0	0	0
Finland	3	15	0
France	97	29	49
Germany	13	/	/
Greece	20	/	0
Hungary	6	9	0
Ireland	0	8	0
Italia	16	54	0
Latvia	0	5	0
Lithuania	9	9	0
Malta	1	1	1
Netherlands	10	?	
Norway	4	5	4
Poland	10	30	1
Portugal	9	10	0
Romania	65		0
Slovakia	3	5	0
Slovenia	65	6	2
Spain/Catalonia	115	39	8
Spain (excluding Catalonia)	30	0	0
Sweden	75	100	Yes (number unknown)
UK – England	85	0	0
UK - Scotland	32	/	4
Total	**1017**	**347**	**290**

Notes :
- Sweden : between 50 -100
- UK / England : including 4 SUMP in Wales

Source: SUMPs-UP (2018), SUMPs in member states.

Figure 7 Number of cities engaged in a SUMP (2017).

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3.2 Business cases overview

The following overview of the Business Case provides the rationale for developing the HARMONY MS from a business point of view. It constitutes the starting point for business ecosystem analysis and market analysis.

Table 3 HARMONY MS Target Market sector and client profile

Target Customer
Target Customer: Focusing on the definition of the MS, any local/regional/national public administration, as well as other infrastructure owners and operators are the potential part of the market. Focusing on Europe, the current NUTS[8] classification, effective from 1 January 2018 (now updated to current members as of 2020), lists 92 regions at NUTS 1, 244 regions at NUTS 2, 1215 regions at NUTS 3 level, and 99,387 local administrative units (LAUs) **Customer profile:** The target customers are the individuals who, inside mobility sector organizations, have decision making powers on mobility planning and operation, on strategic, tactical, and operational level. As the MS includes a list of assets, they are facing several stakeholders as potential customers typologies: • Transport Planning departments • National/Regional authorities and City councils (e.g. ministry of transport, regional departments of transport, land transport authorities, traffic control and management centers) • Public Transport Operators • Physical land Use Planner and Urban Designers • Research institutions (universities, research, and technology institutes) • Companies providing transport modelling and simulation services • Mobility service providers, transport operators, fleet operators, or car manufacturers • Consultancy companies (from small engineering companies up to global consultancies) • Logistics service providers, carriers, providers of parcel and express services. • Infrastructure investors • Companies providing transport modelling and simulation services • Car manufacturers (focusing on noise reduction technologies and effect of urban noise pollution) • Data providers (open and private)
Problem to solve and business opportunity

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[8] **NUTS** (French: *Nomenclature des unités territoriales statistiques;* English: Nomenclature of Territorial Units for Statistics) is a geocode standard for referencing the subdivisions of countries for statistical purposes.
https://en.wikipedia.org/wiki/Nomenclature_of_Territorial_Units_for_Statistics

Problem to solve:

Support tools for sustainable urban transport planning, and optimal infrastructure and service design, inclusive of different fleet mixtures and new transport modes and operators.

This leads to the following problems:

- Optimal Service design – for service operators
- Sustainable urban (land-use and transport) planning and transport planning
- Development Control: Zoning and Development Plan preparation
- Insufficient political/social maturity for acceptance, willingness-to-pay, overall demand and short and long-term impact of novel transport modes and mobility services
- Some transport modes are not present in the transport network and still may considered futuristic such as MaaS, AFVs or CAVs
- Mobility Service Operators have room to optimally design their services, fleet management and optimal operational strategies
- Need of tools helping policy makers test and analyse the effectiveness of possible solutions, including effects of freight transport.
- Need of reduction of greenhouse gas emissions and noise pollution
- Commonly data required to run transport simulation models are fragmented and dispersed with varying data formats.
- Solutions providing structured records of results and functionalities to easily search / retrieve available results are not widespread.
- Advances in computing and sensory technologies are not readily available to existing platforms and solutions

Business opportunity:

Based on the analysis carried out in WP1 and WP9, it can be observed that there are currently in Europe favourable political and socio-economic conditions to the creation of evolved SUMPs including new forms of mobility and take advantage of large amounts of information, opening up opportunities for HARMONY Model Suite application:

- Creating an integrated simulator for land use, population, traffic, transit, infrastructure, employment, including new forms of mobility (drones and autonomous vehicles) and transport services, providing a useful tool for local government across the world to make projections about the future of their communities
- Demand models for novel transport modes and innovative mobility services are scarce to the date. This is a gap we should be able to fill
- Demand for transport in the era of COVID-19: Balancing sustainability, responsibility and accessibility
- Inclusion of freight transport behaviour of logistics agents in local, national and regional models
- Freight transport authorities are looking for tools to help them design policies towards decrease the related environmental impacts and congestion created.

Value Proposition and Solution

Value Proposition:

Harmonised spatial and multimodal transport planning tools for metropolitan area decision makers to comprehensively model, analyse, decide, and justify investments in infrastructure and

operations related to transport sector and spatial organization, in a sustainable manner to minimize risk, time and effort.

The HARMONY Model Suite solutions enables metropolitan area mobility authorities and providers to:

- Capture long-term decisions and behaviours in the housing market, real-estate market, transport infrastructure and job market including housing and job (re)location, demographic and employment transition sub-models, annual commodity production/consumption and supplier selection and transport infrastructure locations.
- Exploring aspects of travel behaviour spherically, utilizing state-of-the-art models and tools, focusing on new mobility forms and the disruptive effects of the recent pandemic
- Simulate the demand for urban freight transport on the tactical level
- Computes energy use and emissions of the transportation system
- Modelling urban noise pollution and potential to reduce or eliminate noise pollution
- Static and Dynamic Service operations optimization
- Optimal design of disruptive Human-Drive, Autonomous Mobility and Mixed on demand services
- Mobility as a Service Controller - Enabler of sustainable personalized multimodal mobility
- model and simulate innovative mobility services for freight transport
- Integrated Transport Data Warehouse and Knowledge Management Hub for transport simulation software.
- Computationally fast estimation of traffic state
- Adaptable algorithm, to meet specific customer needs and data
- Customizable KPI and GUI for decision making
- Enables application of the multiple various traffic data sources

Solution:

The HARMONY MS is a new generation of integrated tools, which comprehensively model new forms of mobility for freight and people, and their business dynamics in metropolitan areas. The MS integrates:

1. Strategic models (land-use, economic growth),
2. Tactical models (people/freight activities),
3. Operational models (multimodal land- and air-network) allowing for multi-scale spatial and transport planning.

The MS provides simulators/functions about:

1- Strategic Simulator, as the most upstream component of the HARMONY MS, the one with the highest level of abstraction and the longest timeframe. The Strategic simulator is composed of different sub-models:

- Regional Economy model
- Demographic Forecasting model
- Land-use Transport-interaction model
- Spatial Freight interaction model
- Long-term Mobility Choice models.

The Strategic Simulator has a long-term time dimension and its main outcomes are: disaggregate spatially-referenced household and firm population, aggregate commodity flows between employment sectors and long-term mobility choices of individuals (agents) including car-ownership or subscriptions to different mobility services.

2- Tactical Passenger Simulator that consists in agents which can model agents' choices on a day-to-day level. The activity-based passenger demand modelling framework considers

individuals, households and the interaction of individuals within the same household, focusing specifically on capturing their activity choices throughout a day and the corresponding travel decisions

3- Tactical Freight Simulator consists of two core modules:1) the shipment synthesizer that simulates decisions in the long term; 2) and the scheduling module that simulates decisions on a more short-term tactical level. It also includes a module that calculates KPIs such as emissions, travel time etc., that permits to quantify the effect of different scenarios. In parallel it includes a parcel demand module that simulates the demand for parcels and a parcel scheduling module that simulates the allocation of parcels to vehicles and creates delivery tours.

4- Vehicle Energy and Emissions models to quantify the lifecycle energy and emissions impact from passenger and freight vehicle movements as they result from the traffic flow simulator. The vehicle performance model is essentially a post-processor, which operates at the very end of the simulation. We intend to use the NREL-developed, open-source model FASTSim, which takes as inputs vehicle technology and movement characteristics.
The key outputs then consist of lifecycle energy use and CO_2 emissions on a trip level, household level and for the urban area as a whole in addition to tailpipe emissions of NOx and particulates

5- Noise maps will be created using the GIS software and other noise modelling software similar to the CadnaA noise prediction software which is used for the calculation, presentation, assessment and prediction of environmental noise. Noise maps are created to visualize the propagation of one or several noise sources, which in most cases is road traffic noise. Alterations regarding information involving traffic flow, speed limitation and noise emission data, could lead to different outcomes regarding the acoustic conditions of an area, thus allowing strategy plans regarding noise reduction to take place

6- Multimodal Passenger Service Controller system that will be based on agent- and event-based architectures enabling the representation of operators, travellers and vehicles as well as their potential states in the system. The main functionalities of the Controller system and its sub-components are aligned with service-specific operational requirements as well as realistic app-based service provision models. On the one hand, service operators are mainly responsible for making strategic and operational decisions, such as:
   - where to locate stations,
   - what fleet sizes are needed for efficient service,
   - how to optimally assign vehicles to users' requests,
   - how to efficiently relocate the fleet, or
   - how to dynamically price their service.

On the other hand, users are often presented with a menu of options from which they can choose either a trip by a specific type of service (or combination of them) or a location to pick-up and drop-off a shared vehicle (car, van, bike, scooter).

7- Freight controller that will be responsible for simulating different freight services at operational level. In particular, a suite of models will be developed to emulate the decision making of logistic operators, as well the operation of innovative freight distribution approaches. The proposed approach will consider the interaction between the different actors and services involved in the last-mile delivery of the logistics operations. Several sub-components will be included: crowd shipping trip generator; Crowd shipping route optimizer; Land-Air Freight integrator; Single-actor micro-freight; Multi-actor micro-freight optimizer; as well as a Freight services orchestrator

8- Scalable Database systems storing transport data; data operators transforming/processing available data when needed; and data models describing the available data and harmonized data formats for data exchange between transport simulators.

9- <u>Multimodal network models</u> will have the capability to simulate demand and supply at the operational level of the HARMONY MS, representing within-day interactions of simulated agents.

Table 4 HARMONY MS use needs vs, solutions

User Needs vs. Solution	
Target User needs	**Solution's benefits**
Long term land-use decisions impacts on urban mobility evaluation	Predictions and scenarios testing
Long term demographic changes impacts on urban mobility and land-use evaluation	Predictions and scenarios testing
Explore and quantify acceptance and overall demand for new mobility services	State-of-the-art demand models including such options in the choice-set
Explore and quantify willingness-to-pay for new mobility services	State-of-the-art demand models including such options in the choice-set
Explore all aspects of changing travel behaviour including the correlation between long-term life choices, such as: remote working and residential choice and travel behaviour.	Set of models which are co-dependent and share variables and information as a part of the Tactical Passenger simulator in HARMONY
Assess environmental impact of urban transportation system	Open-source code integrated into the overall HARMONY model system
Model the effect of new vehicle technologies and fleet mixture in noise pollution	Set of models which are co-dependent and share variables and information as a part of the Tactical Passenger simulator in HARMONY
Explore and quantify noise pollution under various future scenarios	Set of models which are co-dependent and share variables and information as a part of the Tactical Passenger simulator in HARMONY
Explore urban noise pollution reduction strategies	Set of models which are co-dependent and share variables and information as a part of the Tactical Passenger simulator in HARMONY
Optimal fleet sizing and composition	Optimisation based framework
Optimal service infrastructural allocation	Optimisation based framework
Optimal fleet management	Optimisation based framework
Optimal demand management	Optimisation based framework

Need to model innovative mobility services for freight operations.	Modelling and simulation of different fleet operators for urban logistics.
Need to integrate mobility of goods and people as part of a simulation platform (ie, crowd-shipping).	Analysis of passenger/freight demand for optimal implementation of crowd-shipping and relevant services.
Need to access harmonized datasets of cities/areas s/he want to model and run simulations	Open and extendible data schemas that allow easy access to data.
Need to process data when needed.	Data operators transforming/processing available data when needed
Need to store simulation outcomes in a format that allows later retrieval and processing	Data model for describing simulation scenarios and storing related results in a harmonised manner

Table 5 HARMONY MS competitive analysis

Competitive analysis
Competitive analysis: We are not aware of any software/platform on this scale, though parts of the modelling suite do have analogues that exist in isolation. The focus of the HARMONY project is to provide integration between aggregate and disaggregate while ensuring consistency, macro and micro activities at the relevant scales, that has not been attempted before. Competition on the MS components include commercial and open source solutions such as SUMO, SimMobility, PTV-VISUM, Vissim, TransModeler, Matsim; TRANSTOOLS, SimAgent and TRIMODE.
Competitive positioning
Competitive positioning means comparing key features of a solution with competing products, to explore alternative differentiation strategies. This can be done by identifying the key characteristics of the solution that are valuable for the user and using these to differentiate from competition. The table below shows the names of alternative products and compares them with the new product according to the selected features.

We have done an intensive search of both open-source and non-open-source solution that might compete directly or indirectly with HARMONY MS. Below, in Table 6 you can find a list of products that are commercialized by companies. PTV, AIMSUN, and IVU Traffic Technologies are some of the key players in Europe.

Table 6 Commercial products in the market that compete directly or indirectly with HARMONY MS

No.	Company	Product/s	Description	Strat	Tac	Oper	Market
1	INTRO	Emme	Transportation forecasting system for planning the urban, regional and national movement of people.	√			North America

		Dynamic	Traffic Simulation Model	√	√		
		CityPhi	Data Visualization and Visual Analytics for large-scale mobility and geospatial datasets	√			
2	PTV	PTV Visum	The leading software for multimodal transport planning & macroscoping traffic simulations	√			Europe North America
		PTV Vissim	Realistically and vividly simulate multimodal and microscopic traffic	√	√		
		PTV Vistro	Multimodal and microscopic traffic	√	√		
		PTV Optima	Manage entire Traffic Network in real-time	√	√		
		PTV Viswalk	Simulate and display the behavior of pedestrians	√	√		
		PTV Vistad	Simulate and analyze traffic accident data	√	√		
		PTV MaaS Modeller	Calculate preformance of Maas	√		√	
		PTV Balance & PTV Epics	Optimize Traffic lights and implement a Traffic-adaptive control system		√		
		PTV Route Optimizer	Routing and Scheduling as well as Route Optimization taking into account all truck attributes and restrictions	√	√		
		PTV Map&Guide	Efficient truck route planning and transport cost calculation	√			
		PTV xServer	The developer's toolkit for customisable and integrated route optimisation, map visualisation, geocoding and more	√	√		
		PTV Map&Market	Analyze territories and locations and plan optimized routes for field service	√	√		
		PTV Navigator	Professional Navigation - Guide trucks and vans quickly and safely to their destinations	√		√	
		PTV Drive&Arrive	Reliably calculate estimated arrival times (ETA) of transports and increase efficiency from shipper to ramp		√	√	
		PTV Maps and Data	Leverage the full potential of your PTV Software with our customised maps and data bundles	√	√		
3	Bentley	Cube	CUBE Voyager for macroscopic movement of people and vehicles	√			North America
			CUBE Avenue for mesoscopic traffic modeling	√			
			CUBE Cargo for freight modeling	√			
			CUBE Land for land-use modeling	√			
			CUBE Dynasim for microscopic traffic simulation	√	√		
			CUBE Access for metrics on people's accessibility to valued destinations, such as employment, health services, transportation hubs, and entertainment.	√	√	√	
		Streetlytics	Streetlytics measures and scales billions of observed trips to provide detailed analytics of today's travel from place to place for every road segment in the United States and Canada.	√	√		
4	Caliper	TransCAD	TransCAD Transportation Planning Software combines GIS and state-of-the-art methods for solving problems in transportation planning, management, and operations	√	√	√	North America
		Maptitude	Maptitude Mapping Software gives you all of the tools, maps, and data you need to analyze and understand how geography affects you and your business.	√			
		TransModeler	TransModeler Traffic Simulation Software and TransModeler SE Traffic Analysis Software are the most advanced traffic simulation and impact analysis solutions	√	√		

5	City Explianed, Inc	CommunityViz	Scenario planning, decision analytics and visualization	√	√		North America
6	McTrans	HCS	Implement animation and simulation using Transmodeler SE microsimulation tool for TWSC and AWSC intersections as well as freeways.	√			North America
		TSIS-CORSIM	Microscopic traffic simulation software package for signal systems, freeway systems, or combined signal and freeway systems	√	√		
7	AIMSUN	Live	Microscopic Traffic Flow Simulation Active transportation and demand management, Arterial management / traffic signal operations, Congestion pricing,Real-time transportation information,Road weather management, Traffic incident and events management, Work zone mobility and safety, Air quality management	√	√		Europe
		Auto	Microscopic Traffic Flow Simulation Software platform for large-scale design and validation of path planning algorithms for self-driving vehicles.	√	√		
		Ride	Aimsun Ride simulates Mobility as a Service (MaaS), Demand Responsive Transportation (DRT), and City Logistics applications.	√	√		
		Next	Aimsun Next software allows to model transportation networks small and large: from a single intersection to an entire region. It can be used to build a digital twin of a city or highway, then simulate the trips that people want to make, and match them with the available transportation options such as taxis, buses, car-shares, bikes or even walking.		√	√	
8	Quadstone Paramics	Quadstone Paramics	Microscopic traffic and pedestrian simulation software	√	√		Europe
9	Trapeze	Bus	Workforce & Operations Management, Enterprise Asset Management, Intelligent Transportation Systems, Payment,Traveler Experience, Fixed Route Scheduling, Mobility Planning, Data & Analytics, Yard Management, Mobility-as-a-Service			√	North America
		Rail	Workforce & Operations Management, Enterprise Asset Management, Intelligent Transportation Systems, Payment,Traveler Experience, Scheduling for Rail, Data & Analytics, Mobility-as-a-Service			√	
		Paratransit	Mobility-on-demand, Traveler Experience, Data and Analytics			√	
10	IVU Traffic Technologies	IVU Suite	IVU.suite offers the right support for all fields of activity of bus and rail companies: from planning, dispatch, fleet management, ticketing and passenger information through to the settlement of transport contracts.	√	√	√	Europe

Table 7 lists some open-source projects that can compete with one or more models of HARMONY MS. Projects as SimMobility, SUMO, TRANSIM, and MATSim have many similarities with HARMONY MS and should be followed closely by partners to see if integration of any features can benefit HARMONY MS and can be incorporated in the platform.

Table 7 Open-source projects competing with HARMONY MS

No.	Organization	Product/s	Description	Strat	Tac	Oper	Licence

1	MIT	MITSIMLab	MITSIMLab is a simulation-based laboratory that was developed for evaluating the impacts of alternative traffic management system designs at the operational level and assisting in subsequent design refinement. Models are: Microscopic Traffic Simulator (MITSIM), Traffic Management Simulator (TMS), Graphical User Interface (GUI)	√	√		Open Source
		DYNAMIT	Real-time computer system designed to effectively support the operation of Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS) at a Traffic Management Center (TMC)	√	√		Open source
		SimMobility	It integrate various mobility-sensitive behavioral models with state-of-the-art scalable simulators to predict the impact of mobility demands on transportation networks, intelligent transportation services and vehicular emissions. The platform enables the simulation of the effects of a portfolio of technology, policy and investment options under alternative future scenarios. Specifically, SimMobility encompasses the modeling of millions of agents, from pedestrians to drivers, from phones and traffic lights to GPS, from cars to buses and trains, from second-by-second to year-by-year simulations, across entire countries.	√	√	√	Open source (Creative Commons)
2	The German Aerospace Center (DLR)	SUMO	It is a full featured suite of traffic modeling utilities including a road network capable to read different source formats, demand generation and routing utilities from various input sources (origin destination matrices, traffic counts, etc.), a high performance simulation usable for single junctions as well as whole cities including a "remote control" interface (TraCI) to adapt the simulation online.	√	√	√	open source (Eclipse licence)
		UrMoAC	Accessibility Measures Computation Tool		√		Open source (GPL v3)
3	Technical University Berlin	MATSim	Transport simulation package-Assignment Model		√		Open Source (GPL v2)
4	TU Delft	OpenTrafficSim	Microscopic-Traffic Flow Simulation that combines micro-simulation, macro-simulation and meta-simulation in a single environment		√	√	open source (MIT licence)
5	Los Alamos National Laboratory (LANL)	TRANSIMS	TRANSIMS is an integrated set of tools to conduct regional transportation system analyses based on a cellular automata microsimulator. It uses a new paradigm of modeling individual travelers and their multi-modal transportation based on synthetic populations and their activities.		√	√	Apache License 2.0
6	MARG-SimTRAVEL	MALTA/DynusT	A dynamic traffic assignment model system that routed trips and simulated vehicular movements through networks based on time-dependent shortest path computations		√	√	Open source
		UrbanSim	A land use microsimulation model system that captured dynamics in real estate markets and household and business location choices	√	√		Open Source
		openAMOS	An activity-based microsimulation model system that simulated daily activity-travel patterns for all individuals and households in a synthetic population of agents		√	√	Open Source

7	Modelistica	TRANUS	LUTI Model- It is used to simulate and evaluate public policies in the areas of transportation, urban, and regional planning. TRANUS has been applied to a large number of cities and regions throughout the world, in Latin America, USA, Europe and Asia	√				Open source (Creative Commons)
8	UrbanSim	UrbanSim	UrbanSim is a simulation platform for supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment.	√	√			Open Source
9	Technical University Munich	SILO	SILO is a microscopic discrete choice land use model. The model simulates demographic change, household relocation and the housing real estate market.	√	√			Open source (GPL v2)

3.3 Business ecosystem analysis

3.3.1   Key stakeholders in the business ecosystem

Table 8 Key stakeholders in the business ecosystem of the HARMONY MS

Stakeholder type	Role in the value chain	Partners / External stakeholders
Industry (operators, providers)	Private transport firms may be offered contracts to provide public transport based on projections from the model. Producers of goods may employ drones or autonomous vehicles based on scenarios set out in the model.	TBD
Research Institutes and Universities	-Use the MS as a basis for further modelling of future mobility, beyond drones and autonomous vehicles. - Apply the MS results for research - Improve the models included in the MS - Use the MS of educational purposes	Technical University of Delft UCL University of the Aegean University of Wolverhampton
Public Sector (different NUTS administrations and departments)	-Local and national governments could use projections from the modelling suite to plan future infrastructure investment and public transport schemes. -Implement the MS to check various policies	City of Rotterdam Oxfordshire County Council City of Torino Athens Transport Authority (OASA)
Consultancy companies	Apply MS and use results to provide consultancy services to clients	Significance TNO MOBY X Software
Environmental NGOs	Evaluate the effect of the implementation of various policies. Lobby authorities accordingly.	TBD

3.3.2 Hypotheses on business ecosystem evolution

Based on the above-indicated impact on current stakeholders Business Models, some hypotheses on the possible business ecosystem evolution have been identified.

Table 9 Hypothesis on business ecosystem evolution of HARMONY MS

Hypothesis	Description	Business questions
Use of the MS by a local government to make future transport and demographic projections.	A local government makes use of the model suite for these purposes to plan future investment in an informed way.	What features would the MS require to make it: a) sufficiently user-friendly for use by third parties in this way; b) sufficiently flexible to be applied to different locations easily. Is it at all feasible to insert any of these features?
A transport authority decides to design and implement a new freight transport policy (i.e ZE zones, development of urban consolidation centres).	The authority implements the policy scenario in the MS.	How this new policy modifies the demand for freight transport? What will be the effect of the policy on the KPIs? How will the new policy affect freight traffic in the transport network?
A transport authority decides to make a big investment in transport infrastructure.	The location of the new infrastructure is modelled in the MS.	What will be the demand for this new infrastructure? How will this new infrastructure affect the KPIs and the passenger/ freight traffic in the network?
An LSP, carrier or parcel and express service provider want to offer a new service.	The new service is modelled in the MS/TFS.	What will be the demand of this new service? How will this new service affect the demand for other services? Which should be the attributes of this service that would lead to an optimal demand?
Competition between several on-demand service operators in one market	On-demand service providers will need to provide more reliable and competitive services than their respective competitors in the market by optimally: • Price their service • Size their fleet • Allocate service infrastructure • Manage their fleets	Allow operators to: • Increase market share • Increase revenue and profits • Increase service reliability • Increase service efficiency • Reduce operational costs

	• Provide attractive service alternatives and trip options	
A transport authority wants to use a sustainable and financially viable MS implementation.	HARMONY MS should be financially viable (CAPEX and OPEX).	What is the associated business model? What are the revenue streams? What is the cost structure? What are the development costs? What are the operational costs? What is the margin? What is the pricing strategy? Is it a financially viable solution for the customer?
The customer is willing to pay for the product and services.	Explore the willingness to pay for HARMONY MS and services (training and consultancy) of customers through some surveys and interviews.	Are the potential clients interested in HARMONY solution? How much is the customer willing to pay for a solution similar to HARMONY MS? Are the potential clients willing to pay for training and consultancy services? How much is the willingness to pay of the potential client for the associated services of HARMONY MS?

3.3.3 SWOT Analysis

Table 10 HARMONY MS SWOT analysis

SWOT analysis	
Strengths • Multimodal • Regional / Metropolitan planning • Integrated spatial and transport planning • Integration of demand and supply • Modular • Software agnostic • Strong methodological background • Solid research expertise • Automated procedures • Simple interpretation of results via the KPI module.	**Opportunities** • Improve urban and transport planning • Captive product, with limited competition in the market • Take advantage of MS for the acquisition of national and EU projects • Improve transport planning • Optimise fleet management • Sustainable development • Net-zero emissions
Weaknesses • Modelling Complexity • Market maturity	**Threats** • Potential users may feel that such a large integrated modelling solution would be less

• All components strongly linked to the success of the HARMONY MS • Calibration of the TFS requires data which are not always available • Different size of Passengers and Freight modelling markets	useful to them than a smaller modelling solution, based only on one aspect of their problem (e.g. last mile delivery optimisation does not necessarily require medium term demographic projection). Such smaller scale modelling solutions may already exist, or – where they do not – could be created more quickly and easily than developing such a large integrated model. • Competitors could develop a more advanced solution • Post-Covid-19 situation • Volatile transport market

4. Air traffic network controller

Foreword

In the HARMONY project the main task of Airbus together with GRIFF Aviation is to provide a demonstration of a delivery flight with a drone, to contribute to the traffic and transport simulation of future smart cities and also to relate to the third dimension (i.e. the *very low level* (VLL) airspace). Hence, the budget is mainly allocated to setup and perform the drone demonstration flight and not to a product development. However, in order to take maximum benefit from the drone flight demonstration, Airbus with GRIFF Aviation will transfer findings and know-how on VLL air traffic into the HARMONY concept, further to the drone flight demonstration, through contributions with relevant papers and deliverables. In this sense both companies and the whole HARMONY project team are working at concept level to identify options, solutions and opportunities for an efficient connection between the future smart city and VLL aviation.

Therefore, work is carried out in support of the HARMONY project to derive requirements for connecting efficiently smart city ground/surface traffic & transport system(s) to urban air traffic management. In other words, smart city planning and execution solutions and services will be (conceptually and at prototype level) connected to a (future) UTM[9] / U-Space[10] System. Any development of technical aspects of UTM / U-Space systems is out of the scope of the HARMONY project and HM suite environment; these technical aspects are addressed by dedicated H2020 and SESAR JU funded projects.

To this end, Airbus and GRIFF Aviation will bring latest views on UTM / U-Space knowledge into HARMONY. As the development of UTM / U-Space technical aspects is not part of HARMONY, these will not be considered for the completion of this questionnaire (deliverable 10.4).Therefore, the information in the following chapters will refer to the smart-city-interface with VLL air traffic (and not to UTM / U-Space development). Where necessary, references to UTM / U-Space (development) will be clearly stated. Further evolution is the AIRBUS UTM, a digital air traffic management solution which

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[9] UTM (Unmanned aircraft system Traffic Management) is an air traffic management ecosystem under development for autonomously controlled operations of unmanned aerial systems (UAS). The concept is developed in the US strongly pushed by FAA (Federal Aviation Administration) and NASA (National Aeronautics and Space Administration).

[10] U-Space is a concept for service identification and provision to unmanned aerial systems (UAS), to grant safe and secure flight / traffic coordination in vll (very low level) airspace. Published by EASA (European Union Aviation Safety Agency) for Europe.

will enable the next age of (VLL) urban aviation. This solution will in future supersede the Fortion®1Sky UTM software.11

4.1 Market Analysis

Market overview and Size:

According to Markets and Markets, the air traffic management market is expected to expand at a CAGR of 12.6 percent between 2020 and 2025, from an estimated USD 9.7 billion in 2020 to USD 17.6 billion by 2025. The market is expected to expand due to the resumption of global economic development, a rise in passenger traffic, the need for airspace management, and the modernization of air traffic management infrastructure.[12]
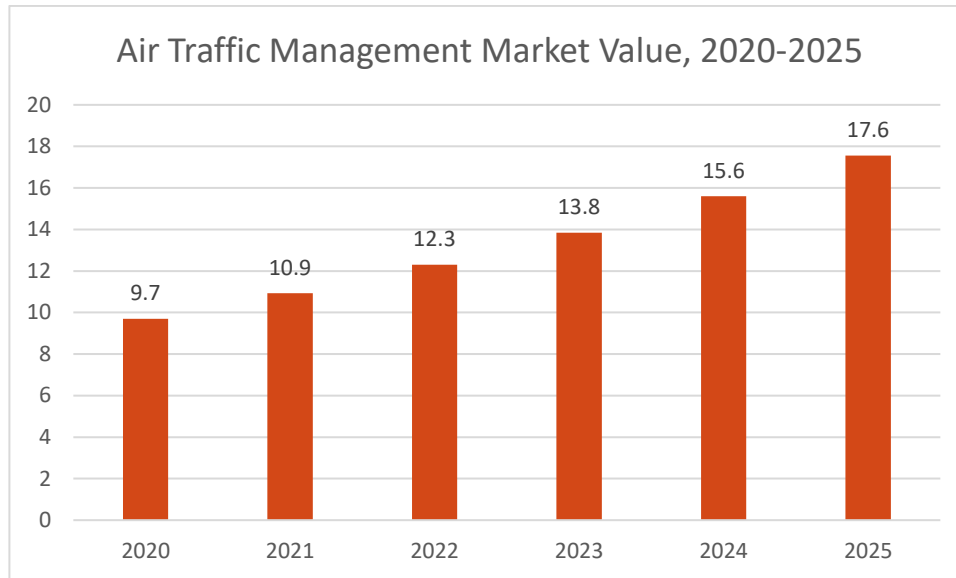
Source: Elaborated by authors based on data from Market and Markets

Figure 8 Air Traffic Management Market Value, 2020-2025

Market Segmentation by Region

Though Asia Pacific is expected to account for the largest share in 2020, the European air Traffic management market is anticipated to grow at an over 5% CAGR over the forecasted period.[13] The development of air traffic management systems in the area is also aided by the implementation of favourable aviation policies in the European Union (EU). The EU's Single European Sky ATM Research (SESAR) technical program, for example, aims to enhance the efficiency of air traffic management (ATM) systems across Europe by modernizing and harmonizing them. During the

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[11] Here is a short video which describes what is UTM: https://www.youtube.com/watch?v=YjtvN-qi3QQ

[12] Markets and Markets (2020), Air Traffic Management Market by Airspace (Air Traffic Services, Flow Management, Airspace Management, Aeronautical Info Management), Offering, Application, Services, End Use, Investment Type, Airport type and Region - Global Forecast to 2025. Retrieved from: https://www.marketsandmarkets.com/Market-Reports/air-traffic-management-market-160955838.html

[13] Mordor Intelligence (2020), EUROPE AIR TRAFFIC MANAGEMENT MARKET - GROWTH, TRENDS, COVID-19 IMPACT, AND FORECASTS (2021 - 2026). Retrieved from: https://www.mordorintelligence.com/industry-reports/europe-air-traffic-management-market

forecast period, the United Kingdom would retain its dominant market share, followed by Germany and France.

Europe Air Traffic Management Market Share by Country, 2019
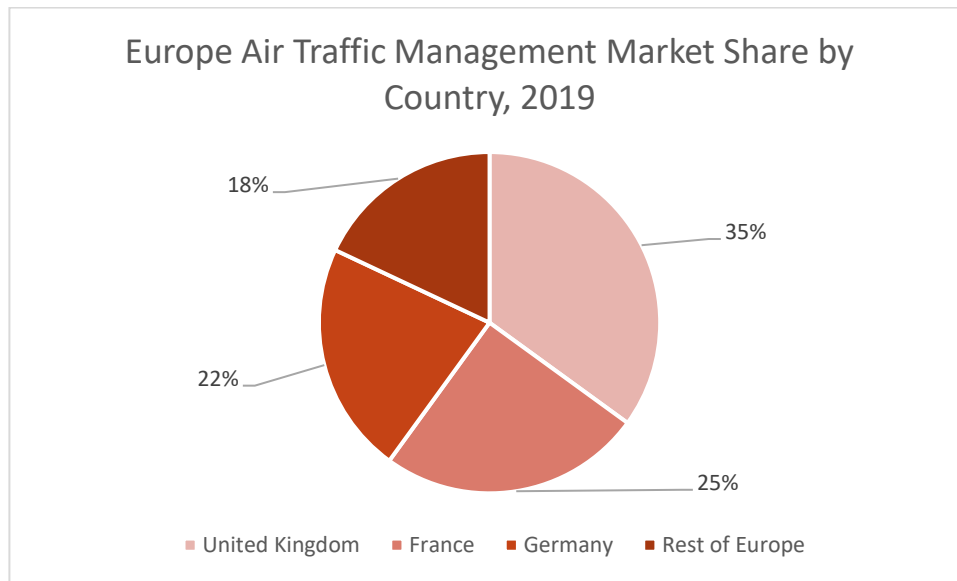
Source: Elaborated by authors based on data from Mordor Intelligence

Figure 9 Air Traffic market share by countries in Europe, 2019

The gap in the market

The problems which the Fortion®1Sky UTM tries to solve are:

- o Providing needed reliable data, based on existing aviation standards, to enable VLL traffic planning and management in the future for (smart) cities.
- o Providing a prototypical demonstration to support the derivation of requirements for efficiently interfacing smart city surface and air traffic systems. In specific on how smart cities can:
  - manage "their" airspace (i.e. VLL airspace management or geofencing/geo-awareness)
  - allow drone (and future air taxi) operators to benefit from "Smart City VLL Airspace Planning".
  - coordinate ground-based traffic and transport with aerial transportation in future smart cities.
  - coordinate VLL air traffic to flight operations of the nearest airport(s).

- By enriching the HARMONY model suite and smart city concepts with aviation elements and know how, an interface between future smart cities and VLL air traffic management will be created.
  - o This newly created portion of traffic & transport interface towards VLL air traffic management overpopulated areas (so called UTM or U-Space) will enable future business, like
    - Airspace planning (support) services for smart cities,
    - noise calculation and warning services for smart cities,
    - data provision on (vertical) landing sites, aerial infrastructure and city topography to UTM / U-Space,
    - coordination of ground transport with aerial traffic and transportation.

- This market is widely complementary to UTM / U-Space. It will be essential for smart cities, to manage the VLL airspace above "their" territory and to coordinate with ground infrastructure where needed. Although not part of the delivery for HARMONY, the following details are widely agreed as "common knowledge" amongst stakeholders on the development of future UTM / U-Space solutions:

    o This market is new.
    o The new market will be eventually formed over the coming years by the outcome of the developing dialogues among technology providers, regulators and responsible authorities (incl. cities and their citizens' needs) in the form of policies and legislation put in place.

      The market is growing in Europe and worldwide.
    o For UTM / U-Space there is a prospect for high volume in 10+ years from today. Airbus is present in this new market with
        ▪ the Skyways project at Singapore (https://www.youtube.com/watch?v=iW5VWU4V20c).
        ▪ Its LAANC service in the US; this is about automatic Low Altitude Airspace Authorizations and Notifications Capability (LAANC). This service digitizes the time-consuming paper application process that allows drone operators to receive official airspace authorizations in minutes (https://www.youtube.com/watch?v=wrhlNeUarDs).

Similar kind of services might in future be run by the owner of the VLL airspace above cities territory.

Today no concrete business offer is available. Business for cities, local companies and mainly U-Space providers can and will grow upon establishment of a smart city interface towards VLL aviation.

Examples of future business offers can be:

- Traffic optimizing app: What traffic means to use to get fast and cost efficient to "my" destination (taxi, bus, train, airtaxi)
- Cargo optimizing app: What route and what transport device to use for fast delivery of goods (car, motorcycle, bicycle, drone)
- When designing the VLL airspace over the city, what will be the impact on noise, ground traffic? A simulation service can support decision making.

What ground infrastructure changes will be needed to be able to provide electrical power, wifi, lighting, space, wind/weather information, security, etc. to each VertiPort

It should be acknowledged at this point that the size and scope of future business/market in the domain of managing the urban airspace (air traffic) will depend on the interfaces and requirements for optimising existing, or future, surface mobility solutions of smart cities (e.g. logistics, passenger transport) as well as on the requirements for totally new services enabled by the use of the third dimension. In other words, it is about seeking synergies with other modes of transport in view of meeting EU's Green Deal and UN's SDG goals.

4.2   Business cases overview

The following overview of the Business Case provides the rationale for developing Air traffic network controller from a business point of view. It constitutes the starting point for business ecosystem analysis and market analysis.

Table 11 HARMONY Air traffic network controller target market sector and client profile

Target Customer

Target Customer:

Division of the market in clearly identifiable segments having similar needs, wants, or demand characteristics.

HARMONY is not to define UTM / U-Space but the smart city interface between traffic & transport and UTM / U-Space. Marked clients for smart city interface to U-Space will be:

- City councils
- Citizen
- Local companies
- Governmental services (Police, Fire Brigade, Medical Services, …)
- U-Space providers
- Potentially: ANSPs or Airports

Customer profile:

Initial customers might be aviation authorities, who are launching first projects to foster evolution of the systems related to smart city VLL airspace management and daily operations.

Cities or city councils might want to be in charge of a rolling airspace use plan above "their" territory. Or they might outsource this function to competent companies.

Air Navigation Service Providers (ANSPs) might expand their capabilities towards VLL airspace management above the cities.

U-Space Operators might have to pay when using the airspace over a city for a transportation flight (cargo or passenger).

Problem to solve and business opportunity

Problem to solve:

From UTM / U-Space perspective:

- Safety, at a high number of aircraft in a small volume with no human in the loop is initially solved by airspace segregation, not to have 2 aerial vehicles in the same volume of airspace.
- Automatization is needed to take the human out of the loop and enable high number of safe air movements.

From HARMONY / Smart City perspective:

- Bridging from smart city planning and management towards VLL aviation and VLL air traffic management and coordination, whilst understanding the needs of the drone (and future air taxi) operators.
- Enable smart city ground and air traffic coordination, where it is required.
- Enable smart cities to share their preferable airspace structure in alignment with aviation constraints (nearest airport, VFR-(Visual Flight Rules) traffic, VLL traffic).

Business opportunity:

- Hampered to slow regulatory evolvement.
- Hampered to many lobbyists and controversy discussions.
- Public acceptance and clear statements of societal benefits not in place yet.

- When all cities / smart cities will start to plan their VLL airspace in a dynamic way, in order to enable VLL air traffic above "their" territory, there will be a need for export know how and support in this domain.
- Helping the cities to build "aerial roads" will enable future business and provides a basis for UTM / U-Space implementation.

Value Proposition and Solution

Value Proposition & Solution:

Core values of the Fortion®1Sky UTM product for HARMONY are:

- Available solution, accepted by CAAS (Civil Aviation Authority of Singapore)
- Providing safe airspace management to the cities
- Providing a web-interface to airspace management system (like LARA (Local And sub-Regional Airspace management) solution from Eurocontrol.
- Enable future business in combining air traffic management with city traffic & transport planning and systems.
- Build on aviation standards.
- Provide proven interfaces to global civil aviation.

HARMONY will pave the way for future value creation at the interface of smart city with aviation VLL operations.

Services

- Provide aeronautical data for smart city planning purpose of future aerial traffic.
- Provide GIS (Geographic Information System) solution following aviation standards for easy interface options between VLL aviation and smart city planning and simulation processes.
- Enable ground to air traffic & transport coordination.
- Provide air situation awareness (which is clearly a UTM / U-Space service).

Table 12 HARMONY Air traffic network controller user needs vs solution

User Needs vs. Solution	
Target User needs	**Solution's benefits**
Manage VLL airspace above city territory	Flexible airspace planning option, with interface to disseminate in order to align with global aviation
Optimise the city layout and ground infrastructure to coordinate in the future many drones/air taxi	Highly automated solution for tracking and monitoring (although this is more a UTM / U-Space function and not a HARMONY smart city development target).
Interface with ATM, police,	Dissemination of airspace structure, dynamic airspace use plan, planned drone trajectories and aerial vehicle tracking data to the related stakeholders.

Competitive positioning
Competitive positioning means comparing key features of a solution with competing products, to explore alternative differentiation strategies. This can be done by identifying the key characteristics of the solution that are valuable for the user and using these to differentiate from competition. The table below shows the names of alternative products and compares them with the new product according to the selected features.

Table 13 HARMONY Air traffic network controller competitive positioning

Relevant features	Solution 1	Our Solution
Building on aeronautical data / standards	For example: AirMap and UniFly provide U-Space solutions which are not yet based on aviation standards.	We provide proven technology from existing ATM solutions, which can be brought to certification.
Airspace Management and dissemination	Other solutions (in UTM) are not build on aviation standards.	Our solution follows existing ATM standards and regulations and has been qualified for limited operations.
Trajectory	Format for Trajectories in other systems are proprietary.	It is represented by an international (ICAO) flight plan, which can be easily disseminated and understood by all aviation facilities.
Dissemination, Tracking Monitoring.	Dissemination is not possible towards other systems or competitors. Tracking is not done according to aviation standards. Monitoring is not automated.	Dissemination of dynamic Airspace reservation is possible into updated airspace Use Plans. Tracking is based on aviation standards. Monitoring is automated by integration of computed comparison of real-time position with pre-calculated flight plan position.

4.3 Business ecosystem analysis

4.3.1 Key stakeholders in the business ecosystem

Key stakeholders in the business ecosystem represent organisations playing a key role in the application of the Air traffic network controller to achieve the benefits described above in Business Cases Overview.

For each stakeholder, the table below describes its role in the solution's value chain, i.e., which of the stakeholder's activities are essential for the solution to deliver value according to its expected benefits. Other activities, not related to the solution's application, are excluded from our analysis.

Table 14 Key stakeholders in the business ecosystem of the HARMONY Air traffic network controller

Key stakeholders in the business ecosystem		
Stakeholder type	**Role in the value chain**	**Partners / External stakeholders**
City or City council	Responsible for: - VLL Airspace Management - Noise abatement over the city - Environmental protection of the city - Connecting city infrastructure to VLL air traffic (e.g. at VertiPorts or Emergency Landing Sites - Coordinating multi-modal transportation System can be offered to public and private actors (ANSP or private companies)	Name the partner(s) / External stakeholders - Oxford City Council - Rotterdam City - Trikala
ANSPs	Responsible for: - Safe operations of global ATM (Air Traffic Management) - Coordination of air traffic in controlled airspace	Name the partner(s) / External stakeholders - e. g. NATS (in UK)
Airports	Responsible for: - Smooth air(port) operations - Coordination of passenger stream from the city to the airport. - Coordination of commercial air traffic with unmanned aerial systems in vicinity of the airport.	
Citizens	- Use or not the services offered by drones (e.g. commercial logistics, medical logistics) and air taxi (passenger, ambulance air services) - Accept or not the safety risk and noise of VLL aerial traffic	

4.3.2 Hypotheses on business ecosystem evolution

The following Table 15 lists the main hypotheses on the business ecosystem evolution. These hypotheses have to be validated in the next project iterations, by answering the relevant business questions as listed in the table.

Table 15 Hypothesis on business ecosystem evolution of HARMONY Air traffic network controller

Hypothesis	Description	Business questions
Hypothesis 1: The cities will be (made) responsible for the VLL airspace above their ground.	The cities will implement solutions to be able to • manage "their" airspace • enhance aviation related ground infrastructure planning • Provide U-Space providers and drone operators with airspace information (basically where to fly and where not to fly), also named geo-awareness • coordinate VLL unmanned flight operations with traffic and transport systems	• Protect citizen from noise harassment. • Optimise freight and passenger transport and coordinate ground with aerial transportation. • Coordinate passenger and cargo stream with nearest airports • Assess weather effect on aerial traffic and impact on ground traffic.

4.3.3 SWOT Analysis

Table 16 HARMONY Air traffic network controller SWOT analysis

SWOT analysis	
Strengths *Indicate the internal strengths of the company and of the product / service* • Aviation related solution, from long-term aviation know how • (Aviation) standardised approach • Qualified and proven system • Airworthiness certifiable system • Available and working interfaces towards todays ATM (Air Traffic Management; analogue-based solutions used today in commercial aviation) • Learn from ATM to UTM • Learn from UTM to ATM	**Opportunities** *Indicate the opportunities existing outside the company and its product / service* • Smart City to VLL Aviation can become a growing market. • Smart City to VLL Aviation can save lives (by enhanced police and rescue services.
Weaknesses *Indicate the internal weaknesses of the company and of the product / service*	**Threats** *Indicate risks external to the company and to the product / service*

• Long term ATM know how might hinder fast evolvement towards more modern solutions • Investment needed to transfer into new technologies (cloud, IoT, web-services, etc.)	• Small agile companies might be capable of providing adequate solutions ignoring the high level of quality efforts requested for aviation products, so they will be fast and cheap(er).

5. Data collection tools

5.1 Market Analysis

The market of the freight controller is that of the HARMONY MS.

While we didn´t find any information on the data collection tools market size, the global data extraction market was valued at $2.14 billion in 2019 and is projected to reach $4.90 billion by 2027, according to a study published by Allied Market Research, with a CAGR of 11.8 percent from 2020 to 2027.[14]

The global data extraction market is growing due to the increased adoption of big data analytics software by multiple organisations, the increased need for dedicated storage systems, and the various benefits provided by data extraction solutions. Complexity and concerns about data quality problems, on the other hand, limit development to some degree.

Market Segmentation by Deploying Model

The on-premise segment accounted for more than half of total business sales in 2019 and will continue leading the market through 2027. At the same time, from 2020 to 2027, the cloud segment is expected to rise at the fastest pace, with a CAGR of 13.1%.[15]

Data extraction solutions are being disrupted by Artificial Intelligence (AI) and Machine Learning (ML) technologies. The use of AI and ML enables a smart data extraction and warehouse that uses machine learning to automatically optimize and transform data to meet user requirements.

Market Segmentation by Region

Geographically, North America had the largest share in 2019, accounting for almost half of the global market. Asia-Pacific, on the other hand, will have the fastest CAGR of 14.7 percent by 2027. LAMEA and Europe are also among the fast growing regions and follow North America in market share.

The gap in the market

The data collection tools of HARMONY could be used by:

- Market research firms,
- Transport operators and public transport authorities
- In general, entities and organisation that are interested on collecting data regarding individuals travel patterns.

Though the main market will be transport operators, infrastructure owners and public transport authorities willing to run simulations and use real data for design or redesign transport networks.

Table 17 HARMONY Data collection tools market characteristics, size, growth and trends

Transport operators and public transport authorities market	
Market Characteristics	-City Councils/regional authorities are public bodies, operating under different incentives from private companies. -Public sector organisation which are the most likely clients work with adjudications which could probably be a long process.

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[14] Allied Market Research (2020), Global Data Extraction Market Is Expected to Reach $4.90 Billion by 2027: Says AMR. Retrieved from: https://www.alliedmarketresearch.com/data-extraction-market-A06797

[15] Allied Market Research (2020), Global Data Extraction Market Is Expected to Reach $4.90 Billion by 2027: Says AMR. Retrieved from: https://www.alliedmarketresearch.com/data-extraction-market-A06797

Market Size	Theoretically this market extends to all local/regional government across the world. Data collection techniques are used around the globe: Australia, Singapore, Toronto, or San Diego are examples of cities outside Europe using it
Market Growth	The market is stable (see NUTS distribution for Europe). In general, a trend the population is increasingly concentrating in urban areas, increasing the mobility challenges
Market Trends	The trend over the last 50 years has been towards using more models in local government (for obvious reasons), and this model could theoretically be part of that trend. These kinds of models are predictively poor like all social and economic modelling in that they are used to inform and structure debate.
Consultancy firms' market	
Market Characteristics	Consultancy firms could offer advice to local governments on their data collection policy. They could also use the data collection asset to offer advice to passenger transport companies or those involved in delivery, who could benefit for optimizing routes, frequencies or other characteristics.
Market Size	There is a large set of companies who could benefit from these services.
Market Growth	Local municipalities who are the prime clients for such work will be cash strapped (as they have been) for many years to come due to COVID-19. However, the pandemic could force to redefine transport network and force to look for solutions
Market Trends	Trend over past decades has been to know better the citizens behaviour.
Research and education	
Market Characteristics	Research and educational institutions are usually non – profit organisations.
Market Size	The market is stable. However, there is an increased interest in a more sustainable use of transport networks and smart city design
Market Growth	Growing as the worries regarding urban mobility and its impact grows, which is reflected in the attention the EC is focusing on it (for instance in the COVID recovery funds or in the GreenDeal initiative).
Market Trends	AI tools required data to train systems. This data has could be collected by tools like the one described by this asset

5.2   Business cases overview

The following overview of the Business Case provides the rationale for developing data collection tools from a business point of view. It constitutes the starting point for business ecosystem analysis and market analysis.

Target Customer	

Target Customer:

MOBY X app is used within HARMONY for data collection in two of the pilot areas, while within HARMONY is further enhanced to improve user experience.

Mobile data collection tools for travel behaviour research is a relatively new market that is growing.

These technologies equip the information gathering process with a powerful tool that can be used to improve data collection speed, reduce cost, and increase quality. For institutions engaged in longer term projects or programs, the ability to collect data faster, potentially in real time, allows for increased responsiveness to changes on the ground.

Customer profile:
The product could be used by market research firms, transport operators, public transport authorities and in general entities and organisation that are interested on collecting data regarding individuals travel patterns.

Problem to solve and business opportunity

Problem to solve:

- Decisions taken from transports operators and planners, transport infrastructure owners and operators are based on information/data collected regarding individuals travel patterns, in addition to other sources
- Traditional survey tools for travel data add a lot of burden to the respondents thus limits the response rate. In addition, the data collected are not that accurate, since respondents tend to misreport their trips and travel behaviour.

Business opportunity:
- It is a rather new market with low competition.
- There is an increased pressure to use public funds in a more efficient way (both economics and environment approaches)

Value Proposition and Solution

Value Proposition:

Efficient and accurate data collection from travellers, easy management of the data collection effort, customizable questionnaires to the users' needs.

Solution:

Solution is focused on designing questionnaires, preparing and customising the existing smartphone-based travel survey tool for collecting primary data, designing the survey participants support interfaces (helpdesks), and the according sampling strategies. The questionnaires for passengers will collect quantitative and qualitative RP data about individual and household socio-economic characteristics, mobility tool ownership, attitudes and perceptions towards multimodality, traditional and new mobility services.

Table 18 HARMONY Data collection tools competitive positioning

Relevant features	Xing (MMM)	Akvo	Our Solution
Use of advanced mobile sensing technologies	High	Medium	High
Use of Machine Learning	High	Low	High
Multi-day behaviour	High	High	High
For passengers and freight	High	Medium	High

5.3   Business ecosystem analysis

5.3.1   Key stakeholders in the business ecosystem

These are the organisations playing a key role in the application of the new solution to achieve the benefits described above in Business Cases Overview.

For each stakeholder briefly describe its role in the solution's value chain, i.e., which of the stakeholder's activities are essential for the solution to deliver value according to its expected benefits.

Table 19 Key stakeholders in the business ecosystem of the HARMONY Data collection tools

Key stakeholders in the business ecosystem		
Stakeholder type	**Role in the value chain**	**Partners / External stakeholders**
Citizens (passengers and freight workers)	Provide information regarding its travel behavior	Citizens
City/regional authorities	Aiming to know the behaviour of citizens travels, visiting areas	Participant cities and regions
Data collection tech providers	Collect the information from citizens using precision tools and Machine learning technologies	MobyX
Data use tech providers; consultacies and research institutions	- Doing analysis of data - Using data for simulations and planification	Aimsum, TNO, Significance, UCL, UAEGEAN, UoW

5.3.2 Hypotheses on business ecosystem evolution

Based on the above-indicated impact on current stakeholders Business Models, some hypotheses on the possible business ecosystem evolution have been identified. As this is a component of the integrated HARMONY MS, the business ecosystem is that of the integrated platform.

Table 20 Hypothesis on business ecosystem evolution of HARMONY data collection tools

Hypothesis	Description	Business questions
A city/regional authority aims to know its citizens behaviour	A city/regional authority aims to know its citizens travel behaviour tracking a meaningful set of citizens	- Which behaviours - How to enrol citizens - Which tech solution - How to use the collected information
A company/ consultancy firm perform the process	Public authorities rely on industry to perform the collection design and process	- What is the level of detail required? - How to link with the rest of city systems - Solutions' providers
Post-collecting process	After (static) or during (dynamic) collecting citizens behaviours, the data should be analysed and shared with other systems	- What use of data is aimed? - How to link with other simulation/planning tools?

5.3.3 SWOT Analysis

Table 21 HARMONY Data collection SWOT analysis

SWOT analysis	
Strengths • Few competitors • Main competitor seems to focus in US and Asia market	**Opportunities** • Trends in our favour • Need for fast and accurate travel data
Weaknesses • Competitor started years ago	**Threats** • COVID crisis may delay the availability of funds from Public Administrations

6. Material for training courses

Material for training courses, as the asset of the HARMONY project is tightly connected to Model Suite, since the materials to be created, such as audio-visual and electronic-based textbooks, are intended for applying and using the MS.

Accordingly, without the MS, market value of training materials would not exist. As it is further explained in tables bellow, the training materials targets future clients and users of MS.

For every user to be able to use MS properly, they will need to go through a training and (optionally) receive a certificate.

6.1 Market analysis

According to a survey conducted by CIVITAS PROSPERITY in countries, regions, and cities where SUMP adoption is poor, there is a need to develop professional capacity through peer-to-peer exchange programs and custom-tailored training programs on various aspects of SUMPs and/or creative approaches to sustainable urban mobility. More than 52% of the respondents believe that providing guidance, expertise, and training is crucial for SUMPs development in the EU countries and there is a need for support from the national governments in this regards (Figure 10). Almost all representatives of countries participated in this study, reported a lack of knowledge of SUMPs, a SUM planning strategy, or transportation-related challenges as the main challenges they are faced with.[16]
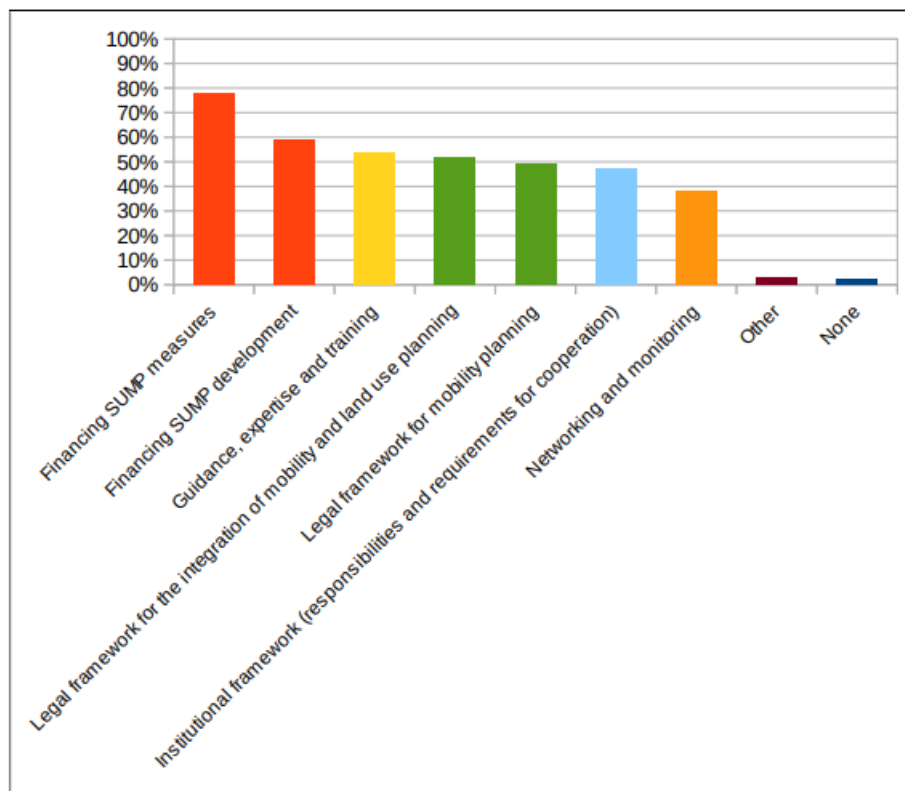

Figure 10 Support needed from national government for SUMP development for EU countries.

Target markets
The market is composed by the customers of the HARMONY's solutions. i.e., based in public administrations and transport infrastructure managers. In addition, this involves segmentation in geographical areas.
Main target market
Training is related to the HARMONY solutions (mainly MS) deployment. So, the potential clients are public administrations, and/or HARMONY solutions providers (in the form of join offers to public tenders).

Market Characteristics, size, growth and trends

Table 22 HARMONY Material for training courses market characteristics, size, growth and trends

Market Segment 1	
Market Characteristics	Public sector (including transport infrastructure managers) Typically, these organizations work based in adjudications, which could be a long process
Market Size	Market size is related to the size of the complete HARMONY MS solution. As initial values regarding potential market, currently in EU there are:

Cities size	# Num
More than 1 million inhabitants	21
Between 1 million and half million	34
Between 250.000 and half million	75
Between 100.000 and 250.000	320
Total + 100.000	**450**

Regions / NUTS (2018)	# Num
NUTS Level 1	92
NUTS Level 2	244
NUTS Level 3	1.215
Local Administrative units (LAU)	99.387

Market Growth	Related to the complete HARMONY MS solution and as such, follows the MS Solution Market Growth.
Market Trends	Related to the complete HARMONY MS solution and as such, follows the MS Solution Market Trends.

6.2 Business cases overview

The following overview of the Business Case provides the rationale for developing the MS from a business point of view. It constitutes the starting point for business ecosystem analysis and market analysis.

Target Customer

Target Customer:
 	
Above all, educational institutions and training centres (universities, various institutions, centres organizing courses, and centres organizing issuing certificates after knowledge demonstration.
 	
Additionally, departments for training inside the organization of the targeted customers (list below) using provided material.
 	
Training and education are mature markets, where some of the HARMONY's partners have experience.
 	
Client profile:
Customers (the ones who pay for it):
 	
  - City councils
  - Local governments (regional, municipal)
  - Ministries (e.g. ministry of transport)
  - Public transport providers (bus, rail, metro)
  - Private companies
 	
Users:
 	
  - Public/civil servants and employees inside the organizations
  - Representatives of NGOs and citizen groups collaborating with the customer organizations
  - General public interested (e.g. city council pays for trainings and invite interested individuals to apply and receive "scholarship" –training free for them – paid by city council)
  - General public interested in improving its own careers

Problem to solve and business opportunity
Problem to solve: HARMONY is creating a MS and other results which are complex to use without proper training.

In this sense a training covering different usage scenarios is required to obtain correct and valuable results from them.

Business opportunity:

Since HARMONY results are new tools including additional features to existing ones, it is important to ease the training process of a set of persons able to use it, as well as a mechanism to have this group growing quickly in new implementations. Another important aspect is to standardize the training process, so that users across different institutions have the same understanding of the MS solution, which will lead to optimal results.

The training aspects are strongly linked and complementary to the deployment of the different solutions. If the implementation of the solutions growths, the related training should grow accordingly.

Value Proposition and Solution

Value Proposition:

Provide material and courses to train future users of HARMONY results, as well as allowing users to prove the possessing of such knowledge (through official certification).

Solution:

Solutions have a few variants, and accordingly different revenue streams:

- "in person" courses/trainings + related materials
    - Planned courses, in groups with dates set in advanced
    - "à la carte" courses
- Electronic courses:
    - eLearning type
    - MOOC type
- Exams needed to receive certification

Table 23 HARMONY material for training courses user needs vs solution

User Needs vs. Solution	
Target User needs	**Solution's benefits**
Organization (cities and others) are implementing HARMONY's solution, but their personnel do not have trained personnel	Presential and/or training courses provide the needed knowledge to use HARMONY results
Employees wants to progress in their career.	Employees can take courses to acquire knowledge necessary to use HARMONY results and can prove it by receiving the certification.

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Organizations requires a confirmation that a person knows the HARMONY results and how to use it.	Certifications ensures the knowledge about HARMONY results are acquired by professional instructors.

Competitors analysis
Competitors analysis: **Competitor 1:** Generic or specific training centres, such as mobility-academy.eu **Competitor 2:** -   Internal training departments for large organizations/administrations **Competitor 3:** Other **SUMPs** (Sustainable Urban Mobility Plans) or equivalent developed internally by public bodies (e.g. city council already developed it´s solution). Main motivation to use their own solutions: • These solutions may be **less complex** (but also not solving all problems or not as efficient as MS) • On the other hand, may be **cheaper** • **Lack of will** to implement a new solution (funds have already been spent to develop internal SUMP – which needs to be justified)
Competitive positioning
Competitive positioning means comparing key features of a solution with competing products, to explore alternative differentiation strategies. This can be done by identifying the key characteristics of the solution that are valuable for the user and using these to differentiate from competition. The table below shows the names of alternative products and compares them with the new product according to the selected features.

Table 24 HARMONY material for training courses competitive positioning

Relevant features	**Mobility Academy**	**Solution M**	**Our Solution**
Specific Orientation to HARMONY solutions	*low*	*low*	*High*
Official Certification available	*low*	*low*	*High*

6.3   Business ecosystem analysis

Key stakeholders in the business ecosystem represent organisations playing a key role in the application of the Material for training courses to achieve the benefits described above in Business Cases Overview.

For each stakeholder the table below describes its role in the solution's value chain, i.e., which of the stakeholder's activities are essential for the solution to deliver value according to its expected benefits.

6.3.1   Key stakeholders in the business ecosystem

Table 25 Key stakeholders in the business ecosystem of the HARMONY Material for training courses

Key stakeholders in the business ecosystem		
Stakeholder type	**Role in the value chain**	**Partners / External stakeholders**
MS solution providers	Responsible for: - Provide, host, maintain and evolve the solution - Implement it in the cities and others	
Training centres	Responsible for: - Execute the local trainings (also in local languages)	Local training centres in the specific markets
Person inside the customer organization that approves the budget to pay for MS solution	Responsible for: - Detect the personnel requirements - Look for a budget - Choose the preferred option (presential, on-line) - Follow-up the execution and certifications	Refers to person inside the organization, not to a specific organization

6.3.2   Hypotheses on business ecosystem evolution

Based on the above-indicated impact on current stakeholders Business Models, some hypotheses on the possible business ecosystem evolution have been identified.

Table 26 Hypothesis on business ecosystem evolution of HARMONY material for training courses

Hypothesis	Description	Business questions

An organization decides to implement a HARMONY solution	An organization (city, transport infrastructure operator, etc) is decided to implement a HARMONY solution (MS or other)	After implementation, who will use the results? and which training is required for them? How this training will be achieved? Can we obtain trained persons from outside the organization?
Decide the training preferences	Organization have to take decisions regarding how to train their personnel or include trained personnel	Which type of training? Can personnel take advantage of MS?

6.3.3   SWOT Analysis

Table 27 HARMONY Material for training courses SWOT analysis

SWOT analysis	
Strengths • *Strongly linked to the MS characteristics* • Validated throughout the project duration (valuable feedback from HARMONY partners that share some characteristics with target clients) before being released to market Will be widely disseminated and communicated by the project partners, which represents market advantage from the beginning of product life cycle	**Opportunities** • Captive product, with none or few competition at the beginning • Certification as differentiation • Possibility of public subventions for implementation (Interreg, EuropeAid, national or regional ones)
Weaknesses • Strong link to MS means success are tied to the success of the MS • Focusing attention and company´s business models on assumption that HARMONY MS will be widely accepted and have market success can have negative consequences (committed resources, such as financial resources and time) if it doesn´t prove right • Potentially long time-to-market	**Threats** • Competitors doing reverse engineering for training • Geographic dispersion causing additional complexity • Potential change of legislation on European/National/Local level affecting HARMONY MS, and thus directly affecting training materials Appearance of new open-source solution

7. Conclusions

A well-briefed and consistent innovation management is of paramount importance for the maximisation of the market potential of HARMONY solutions. As such, this document provides an updated analysis of the market and business ecosystem for HARMONY solutions, in view of the future exploitation and innovation management activities of the project.

In the first place, this deliverable has reviewed and assessed HARMONY's assets and knowledge bases to identify exploitable solutions. In the second place, the document estimated the market potential for four main HARMONY's solutions, namely Model Suite, Air traffic network controller, Data collection tools and Material for training courses. Finally, the analysis focused on the current stakeholders' business models and their expected evolution in the HARMONY ecosystem of the future.

The document aims at coordinating and guiding S&T WPs within HARMONY in the development of business-relevant solutions that address the need for efficient, inclusive, sustainable and responsible regional transport, especially in this time of COVID-19 pandemic.

Additionally, the drafting of policy adaptations and standardization recommendations (D10.6 and D10.11) and the elaboration of specific exploitation plans for HARMONY's solutions (D10.7, D10.12, D10.13) will benefit from the preliminary analysis provided in this deliverable and from the guidelines available in Annex I.

D10.4 will ultimately contribute to the identification of challenges and opportunities in terms of urban and regional transport planning, multimodality and integration of traditional and new mobility services at the European level. Therefore, local and regional public authorities will be supported by HARMONY's solutions as adequate tools for informed decision-making and data-driven investing towards updated SUMPs improving smart mobility in their regions.

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Annex I: Exploitation handbook

Introduction

The objective of this Exploitation Handbook[17] is to provide guidelines to support the HARMONY partners in preparing, discussing and presenting plans for the exploitation of the project's solutions and results.

This Exploitation Handbook provides an approach to develop plans for new businesses based on HARMONY results based on three phases:

1. **Ideation -** where potential business ideas are identified and convincingly formulated, looking at HARMONY solutions from the point of view of user needs from the market. The proposed methodology is based on the "job to be done" concept, that describes a new product idea in terms of customer, need and circumstance. By looking at certain "jobs" that are not satisfactorily addressed for a customer in certain circumstances, opportunities for new products and services are found. Also important is to identify the features the customer looks for when looking for a solution to that particular problem, and at the barriers that customers face in trying to solve the problem with existing products.

2. **Strategy -** where a product or service idea is translated into an innovative proposition which is appealing to the customer, clearly differentiates from competition and addresses the right market segments. This is done by identifying competing products, i.e., the set of common solutions currently used to get the job done and positioning our solution against competition. At this point a detailed business model is developed, including decisions on customer relationships, sales channels, revenue flows, value chain configuration and partnerships, key activities and resources, and finally on the foreseen cost structure.

3. **Implementation -** where concrete plans and detailed estimations are prepared to support the transition from idea and value proposition to business implementation. This phase includes planning in detail the next development stages to bring the product on the market, and the investments required. Marketing activities have also to be planned, and sales volumes estimated according to a set strategy for expansion on the market. The cost structure has to be quantified based on assumptions about the needed resources and organization, the investments required and the expected market growth. In this way a forecast financial plan is prepared that covers industrialisation of the business idea, launch on the market and business operation, over a 5 years period. This allows to assess the financial performance of the new business over a sufficiently long time-horizon. To this purpose, financial indicators are calculated that allow company managers, partners and investors to evaluate the business idea potential and risks. Two main indicators are proposed, well known to the business community: the Net Present Value (NPV), an estimation of an investment worth based on actualized cashflow estimations, and the Internal Rate of Return (IRR), a measure of an investment's profitability to be used for comparison with other forms of investment.

A recommended approach and methodology to be applied for the exploitation planning process into three main phases, respectively aimed at:

    i)   identification of the HARMONY business solutions that will be exploited by different partners in the consortium;

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[17] Part of the information presented in this Exploitation Handbook is developed by Paganelli, Paolo. (2018). Exploitation Handbook. Zenodo. Available online at: https://zenodo.org/record/3470893#.XyvJOCj7TIU

ii)   positioning of the partners in the HARMONY business ecosystem for each identified solution;

iii)   preparation of the business and investment plans for each partner to bring the solution on the market.

For each phase, a set of guidelines, instruments and examples that should be applied by the partners to address the main questions arising in the subsequent methodological steps

Detailed guidelines on the recommended state-of-the-art approaches, business planning and business modelling tools

Intended audience

The main audience that should be interested in this Exploitation Handbook are all HARMONY partners interested in industrial and commercial exploitation of the project results. This includes mainly the industrial partners but also research organisations intending to exploit the knowledge developed in the project in market-oriented activities (e.g., university spin-offs launched to exploit research results).

Exploitation approach overview

The approach proposed in the present document takes a different perspective on exploitation planning, compared to the methods commonly applied in other EU projects. Typically, exploitation tends to focus mostly on preparing business plans, as traditionally made of sales forecasts and marketing plans and financial simulations. Innovation is seen mostly from a company's internal perspective, following approaches such as Porter's Value Chain, Balanced Scorecard and Boston Group Matrix.

Although we recognize the importance of the above aspects, we are convinced that innovations as envisioned in the HARMONY project require a collaborative approach in all stages, from formulation to implementation of the business idea. In our project, innovation is not an individual company exercise, but must be undertaken with the involvement of all the relevant actors participating in designing and implementing HARMONY solutions.

In HARMONY, exploitation approach includes **three main phases:**

1. **Ideation**: In this phase potential ideas of products and services are identified, based on HARMONY solutions and starting from user needs from the market. Here the goal is to identify, prioritize and formulate promising ideas for successful exploitation on the market.

2. **Strategy:** In this phase the most promising business ideas are selected and refined through performance attributes analysis and utility testing. Here the focus is on translating the original idea into an innovative proposition which is appealing to the customer, clearly differentiates from competition and addresses the right market segments with the right price. This phase is carried out collaboratively by group of partners who are all involved, with different roles, in the commercial exploitation of a certain business idea.

3. **Implementation:** In this phase the right implementation model and plan are defined for each of the selected business ideas, through the steps of business model formulation, business planning and evaluation of alternative plans. This phase is carried out individually by each partner according to its intended role in the exploitation of the business idea, according to the partner's own target market, its assets (including intellectual property) and planned investments.

Questions to be answered in each phase

The following table lists the **main questions to be addressed** by the involved stakeholders in each phase, and the corresponding content to be produced in the Exploitation Plan in reply to those questions. The three phases of exploitation planning process should be carried out in sequence.

Phase	Questions to be answered	Content to be produced
1. Ideation	• Who are your target customers? • What products and services are you offering? • Why are these products and services relevant to customers?	• Target customers and needs identification • Value proposition formulation • Features and Barriers identification
2. Strategy	• How do you intend to position your product on the market? • How do you differentiate from competitors? • What is your intended business model? • What role do you intend to play in the HARMONY ecosystem?	• Competitors identification • Competitive positioning • Business Model description
3. Implementation	• What is needed to make the product market-ready? • How will you promote and sell the product? When will you start and how much do you intend to sell? • How will you protect your IPRs? How will you manage joint IPRs with your business partners?	• Technical development plan

Summary

The exploitation process of HARMONY consists of three main phases. It begins with product idea definition and it is followed by business strategy definition and business implementation planning.

Each phase consists of several actions that should be carried out in order to proceed consistently to the next phase. Most important is the identification of potential business ideas since the initial stages of the project, and of the relevant partners who will have to be involved in the exploitation of the idea.

As each partner has different products, markets, visions, objectives, strategies and business plans, they will take an individual perspective on the exploitation. Nevertheless, for some business ideas to work on the market, different collaborating partners will be needed. In these cases, it is highly recommended that joint exploitation plans are produced even, if necessary, involving external stakeholders if these are essential to the exploitation.

Actors in the business ecosystem may need to change their business models to take advantage of the innovative solutions developed in the project. This should be taken into account by the partners

when preparing their exploitation plans. They should first identify their role in the business ecosystem and then consider whether a change of business model is needed to achieve their ambitions.

This exploitation handbook is meant to provide an overall frame for the exploitation process but ultimately each participant may and should apply tools, methods and metrics of their own preferences.

Additionally, it is important mention that Exploitation of the HARMONY solutions will be further analysed and defined along the project in 2 deliverables focusing specifically on Exploitation, namely: D10.7 - ¨Preliminary exploitation plans¨ (M24 of the project) and D10.11 - ¨Final exploitation plan¨ (month 48 of the project).

Annex II: Questionnaire template

Several HARMONY's partners have contributed to this deliverable (the full list of responsible co-authors is available in the summary sheet) by filling a questionnaire related to the HARMONY's solution they are developing. A copy of this questionnaire is provided below.

Business Cases Overview

D10.4 Provides an overview of the Business Case, i.e., the rationale for developing an identified solution from a business point of view. It constitutes the starting point for business ecosystem analysis and market analysis.

Target Market Sector and Client profile
Market sector: *Indicate the **target market of your solution**, i.e., the community of customers that are experiencing the problem you are trying to solve with your solution.* - *Is it a niche **or** high-volume market?* - *Is it a mature **or** growing market?* - *Are you already present on the market **o**r is it a new one for you?* **Customer profile:** *Identify **who will use the product / service (user**) and **who will pay** for the product / service (**customer**). Often user and customer coincide, but in some cases they may not.* *Describe the **key characteristics of the customer** that make him/she the ideal target for the solution you are proposing.*
Problem to solve and business opportunity
Problem to solve: *Describe the problem that exists in the target sector, that your solution intends to solve, e.g., a social, economic, environmental or safety problem.* *Be careful to look at the problem **not from your viewpoint** as the solution provider but **from the customer viewpoint**: this is his/her problem you are trying to solve.* **Business opportunity:** *Describe the business opportunity that is there on the market for your solution:* - *Is there a gap in the market that nobody has filled before?* - *Are there market opportunities not yet exploited?* - *Are there favourable conditions to approach the market? Try to demonstrate why is it worth investing in the solution and why now.*
Value Proposition and Solution
Value Proposition: *What is the core value delivered by your solution? The core value is to be communicated to and acknowledged by the market.* *A value proposition is a statement which identifies clear, measurable and demonstrable benefits*

customers get when buying a service or product.

Solution:
*Describe the product / service which constitutes your solution to the customer's problem.
Describe it accurately in its main parts (components, services...) and its key features.
The solution's features should directly refer to the problem to be solved and the business opportunity.*

User Needs vs. Solution	
Target User needs	**Solution's benefits**
*Specify the needs of target users. These are **specific problems (or "pains")** the customers feel and have willingness to pay to see them solved.*	*Specify how your solution meets the specific customer need, motivating the customer to buy your product / service.*
User Need 1	
…	
...	…

Competitors analysis
Competitors analysis: *Describe whether the product / service has **direct or indirect competitors** on the European and global market.* *Does **similar solutions** or solutions that **solve that same problems** already exist on the market? If so, specify how big they are, their approximate market share and how much they can hinder the entry of your new product / service.* Competitor 1: - Main characteristics of competitor 1 - ... - ... Competitor N: - Main characteristics of competitor N - ...
Competitive positioning
Competitive positioning means **comparing key features of your solution** with competing products, to explore alternative differentiation strategies.

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This can be done by **identifying the key characteristics** of the solution that are valuable for the user and using these to differentiate from competition.

Indicate how your product differs from the competition in terms of key performance attributes (e.g.: costs, ease-of use, functionality, benefits for the users and the society, etc)

Use the table below with the names of alternative products and compare them with the new product according to the selected features.

Relevant features	Solution 1	...	Solution M	<u>Our Solution</u>
Feature 1	*Assign a relative score to the solution on this feature (**e.g., low/average/high compared to the other solutions**). Motivate the score.*	*...*	*Assign a relative score to the solution on this feature (e.g., low/average/high compared to the other solutions). Motivate the score.*	*Assign a relative score to the solution on this feature (e.g., low/average/high compared to the other solutions). Motivate the score.*
Feature 2				
...	...	...	...	...
…	…	…	…	…

Business Ecosystem Analysis

Key stakeholders in the business ecosystem

These are the organisations playing a key role in the application of the new solution to achieve the benefits described above in Business Cases Overview.

For each stakeholder briefly describe its role in the solution's value chain, i.e., which of the stakeholder's activities are essential for the solution to deliver value according to its expected benefits.

Key stakeholders in the business ecosystem
Identify project stakeholders, which may be: *Users or customers of the product / service, cities/regions, logistic companies, public and private transport operators, mobility-related companies, key external consultants, government agency officials (who must, for example, provide important authorizations for the project), representatives of local authorities (e.g. cities, municipalities, regional authorities), media, etc.*   *Triple helix model (or even Quadruple/ Quintuple) could be used to help identify relevant stakeholders for your solution and their roles in the value chain.*   *For **each of the previous stakeholder categories** you should try to mention some names or, even better, some contacts. If these contacts do not exist, describe a plan to obtain this information.*

Stakeholder type	Role in the value chain	Partners / External stakeholders

| Stakeholder type 1 | Describe in short what is the main role of the identified stakeholder. Responsible for: - … - … | Name the partner(s) / External stakeholders - |
| Stakeholder type 2 | Describe in short what is the main role of the identified stakeholder. Responsible for: - … - … | |

Hypotheses on business ecosystem evolution

Based on the above-indicated impact on current stakeholders Business Models, identify main hypotheses on the possible business ecosystem evolution.

Hypothesis	Description	Business questions
e.g. Acceptance of the solution/asset by Stakeholder X (e.g. public transport operator in city Y)	e.g. Stakeholders X will adopt Solution X, to solve the problem of _____ by _____.	e.g. Using bullet points identify which tangible and quantifiable advantages are there for Stakeholder X (e.g. ease of use, lower costs, more efficient planning, etc) / Try to put yourself in place of stakeholder and ask question that will help predict the evolution of business ecosystem for your solution /
Hypothesis 1	…	•
…	…	•
…	…	•

Market approach

Market segmentation

Market segmentation represents the process of dividing a market of potential customers/clients into groups or segments, based on characteristics and common needs.

Market segmentation can be done based on several types of characteristics, such as Demographic (by age, gender, income, etc.), Behavioral, Geographic (by region, are, rural/urban, etc.), Psychographically (social class, lifestyle, etc.)

Target markets
*Division of the market in **clearly identifiable segments** having similar needs, wants, or demand characteristics.*
Main target market
*List and describe the group/s who are the **mostly likely clients** of the business offer*

Market Characteristics, size and trends

*Describe market characteristics, size and trends for **each identified market segment:***

Market Segment 1	
Market Characteristics	*e.g.* *Typically, for companies belonging to this market segment is characteristic:* •
Market Size	*e.g. 1* *- For defined market segment, European market is concentrating on X big companies / manufacturers / service providers (possibly name them, indicating market share).* *Try to predict potential market share of your solution.* *e.g.2:* *Market segment is focusing on users in X cities/municipalities.* *Number of potential users for each:*
Market Growth	*Is the identified market segment growing significantly? Or has a slow and steady growth? Or third scenario?*

Market Trends	*e.g.* • *there is an evident trend of users adopting e.g. Sustainable transport solutions* • *Growing popularity of MaaS solutions* • *Social responsibility affecting consumer decisions...* • *Trends regarding urban/suburban/rural living and commuting* • *…*
Market Segment 2	
Market Characteristics	
Market Size	
Market Growth	
Market Trends	

SWOT analysis

SWOT stands for

- Strengths,
- Weaknesses,
- Opportunities, and
- Threats.

Please provide a basic, straightforward model of the strengths, weaknesses, opportunities and threats of your solution.

SWOT analysis	
Strengths *Indicate the internal strengths of the company and of the product / service (for example: X years of experience in the sector, patented product, contact with major networks in the sector).* • *Strength 1* • *Strength 2* • *…*	**Opportunities** *Indicate the opportunities existing outside the company and its product / service (for example: growing market, low barriers to entry, few competitors, state incentives...).* •
Weaknesses *Indicate the internal weaknesses of the company and of the product / service (for example: lack of financial resources, lack of staff, long time-to-market).* •	**Threats** *Indicate risks external to the company and to the product / service (for example: change of European directives, entry of new competitors, non-perceived product / service value...).*

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