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

D10.11- Policy Adaptation and Standardization Recommendations – Final version

Submission date: 22/03/2023

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SUMMARY SHEET

PROJECT

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
CSV	Comma-Separated Values
DFM	Demographic forecasting model
LDM	Land Development Model
NUTS	Nomenclature of Territorial Units for Statistics
PNG	Portable Network Graphics
REM	Regional economy model
SDOs	Standards Developing Organisations
SFS	Strategic Freight Simulator
SHP	Shapefile shape format
TFS	Tactical freight simulator
TPS	Tactical passenger simulator
XLSX	Microsoft Excel Open XML Spreadsheet

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EXECUTIVE SUMMARY

The HARMONY project consortium recognises the importance of standardisation and policy adaption as part of the future adoption of the solutions developed as part of the project, and as such it carried out a number of activities related to both these aspects. This deliverable provides the findings from the implementation of the following:

- Analysis of standardisation related issues from the developers of the different models and tools that were integrated in the HARMONY MS.
- Interviews with stakeholders from the participating cities for evaluating the potential of the HARMONY MS to support policy adaptation.
- Questionnaire surveys with the participants of the training workshops delivered in Delft, Athens, London and Barcelona.

In terms of standardisation, it was revealed that it can improve interoperability, provision of transferability, integration, and application of models to different places as well as foster the removal of ambiguities in the models themselves. Primary challenges for standardisation included, (i) data availability and transferability due to the mathematical underpinnings of the various models; (ii) the sources of the data, as in many cases secondary data used by the tools were collected from various organisations and were represented in formats according to internal requirements; (iii) complexity of the platform's structure in terms of the different layers and the level of data aggregation required by each layer; and (iv) differences in data representations due to the fact that are culturally determined by the place and people involved.

In the area of policy adaptation and how the HARMONY MS can support authorities in the future it was revealed that all stakeholders perceived the functional and potential of HARMONY MS positively. Furthermore, a number of recommendations were derived following the interviews with the stakeholders. Highlights include: (i) the implementation of extensive and intensive stakeholders engagement and debate on the subject of the risks versus benefits of HARMONY MS platform; (ii) emphasis needs to be placed on both upskilling and also ensuring the next generation of transport planners and professionals are more "digitally" able to use HARMONY MS platform; and (iii) consideration must be given to future funding models, procurement, and the potential for hybrid data, including sharing, storage, and management models so that additional transport models and services can be integrated to the platform.

From the questionnaire results, it was clear that wider awareness-raising across public and private sector organisations is arguably needed. The ability to integrate with other systems was identified as one of the most useful features of the HARMONY MS platform. Additionally, one of the key benefits of the platform is its ability to allow stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, medium and long-term effects on air-pollution, carbon footprint, noise and land-use. To meet the skills and knowledge gaps for the uptake of the HAMONY MS, consultants and universities should incorporate integrated spatial and transport planning into the learning objectives of transport planning related subjects. This may lead to new courses focused entirely on HARMONY MS, necessary to fill the skills gap in the industry.

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1. Introduction

This report aims to present the findings of activities undertaken as part of T10.4 “Standardisation activities” of HARMONY. The report is expanding D10.6 “Policy adaptation and standardization recommendations Version 1” and discusses the findings from a series of studies targeting the definition of the standardisation potential of the HARMONY MS, as well the perception of planners and practitioners regarding the platform’s usefulness in policy adaptation and formulation.

1.1 Standardisation

According to Erlinghagen et al., (2015), standards can be defined as “rule(s) for common and voluntary use, decided by one or several people or organisations.” This broad definition includes both open and proprietary standards. A standard is also a document, established by a consensus of all interested stakeholders and should be based on the consolidated results of science, technology, and experience, and aimed at the promotion of the optimum community benefits. A standard is approved by a recognised body i.e., a standardisation body. Standardisation bodies exist on a national, European, and international level (Seelinger et al., 2020). It is considered fair to say that the whole basis of global communications and modern international trade would be impossible without standardisation. The standardisation is an important factor in driving down costs and therefore, working to common standards (e.g., the internet, satellite navigation, oil refining and shipping containers) is obviously a part of the world in which we live (How, 2010). Standards represent common agreements that enable direct (in the case of Information Technology (IT) standards) and indirect communications (in the case of all other standards). Additionally, standardisation is the process of standards creation (creators) and this may exclude those who implement the standards (implementers) and those who use them (users) (Krechmer, 2005).

Standardisation and standards are important elements for research, development, and innovation. Therefore, standardisation and innovation are firmly linked, and standards play a considerable role in the development of innovation and support the diffusion of technology transfer by regulating the state of the art. Thus, a failure to standardise in a proper manner may slow down the diffusion of a new technology (Koch and Blind, 2020). The results of research could have a significant impact on the subsequent use of those results by other researchers and industry if they are transferred into one or more standards. This transferring process may highlight issues that may have not been previously clear since standards development is done in cooperation with other experts in the field. Furthermore, standardisation can verify and ensure the trueness and precision of the results obtained (Hatto, 2013).

Standardisation is a powerful tool to achieve or improve interoperability, in particular between old and new technologies. It is the process of developing and implementing technical specifications based on the consensus of different parties such as users, interest groups, firms, government authorities, and standards developing organisations (SDOs). Standards provide a recognised way for assuring quality, interoperability, safety and reliability of processes, services, and products. Also, standards support appropriate regulation, commercialisation, markets and market development. It has been recognised that voluntary, consensus-based standards can contribute far more to society and business than simply technical specifications, testing methods, and measurement protocols.

In this report, section 2 discusses the need for standardising the HARMONY MS. It focuses on information regarding the data types, data uses and data formats adopted by the different components of the platform, as well as it investigates the potential, usefulness and effort required for standardising the various types.

1.2 Policy adaptation

The term ‘policy’ is associated with a course of action and therefore a government’s program is described as public policy (Bacchi, 2009). ‘Policy’ is used for describing a plan, defining objectives, setting priorities and specifying decision rules (Hill, 1997). Therefore, policy can be defined and

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described in many different ways as it may refer to a goal, an intention, an outcome, a decision, something policymakers to address or not to address. There are several policy processes which are complex and include the problems which policy-makers face, policy-makers' behaviour and the results of their decisions (Cairney, 2019).

A policy is considered as 'good' when it serves the agenda, vision and interest of the policymaker (i.e. government). However, policy analysis and evaluation may serve many different purposes. Policy evaluation process follows the policy implementation phase in the traditional policy cycle framework. It represents the learning about the effects and impact of policy and therefore it informs the policymakers what is working and what is not. This policy evaluation is normally followed by policy refinements, improvements and learning. It has been assumed that achieving policy success is largely related to the policy adaptation and learning. Depending on the evaluations and learning form the policies, policy success is the incremental adaptation of existing policies (McConnell, 2010).

In section 3 of this report, the potential of the HARMONY MS to support policy adaptation, challenges for policy adaptation and lessons learnt are discussed from cities perspectives.

1.3 Deliverable Objectives

The HARMONY MS is composed of numerous models and tools, spanning across different application levels (strategic, tactical and operational) and therefore an appreciation of data standardisation practices in relation to the platform was required. To this extend, detailed information (at single data input/output level) was collected from the developers of the platform's components as to define the standards adopted at the point of integration, as well as the potential, usefulness and effort required for future standardisation attempts. Semi-structured interviews with the model developers resulted in the collection of qualitative data to support the above-mentioned information.

In terms of policy adaptation and the usefulness of the HARMONY MS to support decision makers in planning and policy making two separate tasks were performed:

1. a questionnaire study with the participants of the HARMONY MS training courses, allowed the investigation of aspects related to the relevance of the models in current practices and the usefulness of the platform's components in supporting planners and policy makers.
2. interviews with policy makers from the cities where the integrated platform was applied, allowed the analysis of the platform's potential in advancing policy adaptation.

Standardisation facilitates new integrated solutions and economies of scale. On the other hand, policy adaptation assures, to the extent possible, a minimum level of service quality can increase the chances that an intervention or service will be effective. This deliverable seeks to provide an overview of the various achievements of HARMONY in relation with standardisation and policy adaptation through diverse activities and channels. The project results are presented with particular emphasis on the adoption and implementation of the HARMONY MS for integrated spatial and transport planning.

1.4 Deliverable Structure

The sections of this report are organised as follows:

- Section 2 presents the findings of activities related to the description of the standardisation potential of the HARMONY MS.
- Section 3 provides an insight on the policy adaptation process and explains the synergies between HARMONY's activities and existing policies in the different pilot sites. Furthermore, it describes the expected adaptation in the policies following the application of the HARMONY concept.
- Section 4 describes the evaluation of HARMONY MS for integrated spatial and transport planning.
- Section 5 draws the conclusions from the deliverable.

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2 HARMONY Standardisation Evaluation

This chapter of the deliverable presents the findings from two project activities that targeted the investigation of standardisation issues related to the implementation and operation of the HARMONY MS. Developers of the platform's components were requested to provide standardisation-related information for their respective component(s) and were also interviewed for the collection of qualitative data for issues pertinent to standardisation.

2.1 HARMONY MS standardisation analysis

The HARMONY MS integrates various tools for offering a holistic framework that covers strategic, tactical and operational modelling and simulation needs for transport planning. The integration of the different components requires considerations regarding the types of inputs that the different models require, as well as the outputs they produced. The latter is of particular importance in the cases where the output of one model becomes the input of another one. This section of the report presents the findings of an analysis made regarding the standardisation status of the final version of the HARMONY MS. The analysis incorporated information about inputs and outputs required by different models/components of the platform. The specific components were selected due to:

a) the diversity of data types required/produced.
b) the number of inputs/outputs.
c) the coverage of data types used by the entire platform (i.e. same data types were used by other models).

The information requested by the developers of the model/components for each input/output was:

- the data format.
- a description of the data entity.
- if the data entity is based on an existing standard.
- if the representation of the data entity was created in-house, or by an external third-party.
- the potential of standardising the data entity for future use of the platform.
- the usefulness of standardising the data entity for future use of the platform.
- the effort required for the standardisation of the data entity.

2.1.1 Tactical passenger simulator (TPS)

The standardisation information collected for the TPS can be found in Appendix A1. Table 1 below provides the details of the data formats utilized by the tactical passenger simulator.

Table 1: Tactical Passenger Simulator data file formats

Data file format	Data type name
XLSX	• Skim with travel times
SHP	• Links • Nodes • Zones • List of available travel modes in the area
CSV	• Socio-economic data • Synthetic Households synthesized by the Population Synthesis module • Attraction points of interest in zones • Different agent classes • List of activities and participants of each activity • List of available travel modes in the area • Parameters from Mobility Tool Ownership model • Rules to define household and individual budget • List of steps to apply model parameters to the synthetic population files and generate outputs

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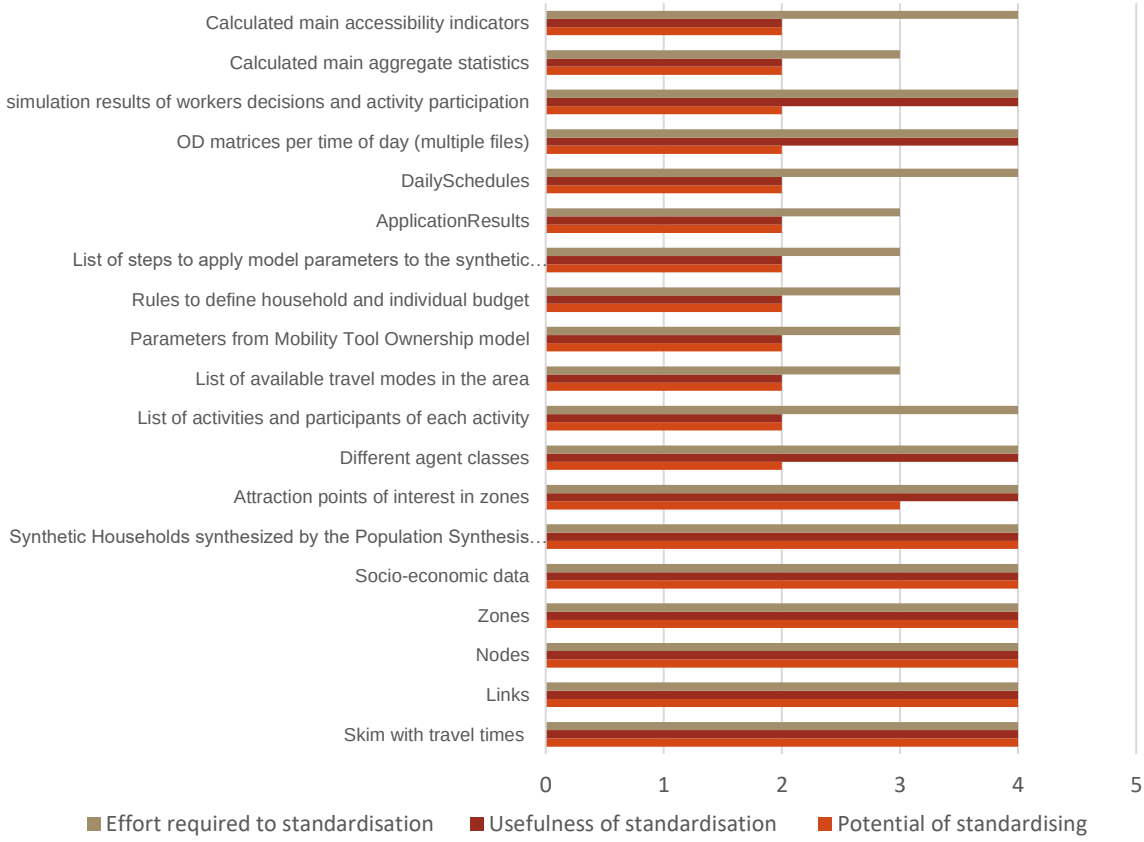
	• Application Results • Daily Schedules • OD matrices per time of day (multiple files) • Simulation results of workers decisions and activity participation • Calculated main aggregate statistics • Calculated main accessibility indicators

From Table 1, it is evident that the majority of the data formats are Comma-Separated Values (CSV) files, while network geometry is supported in a shapefile format (SHP). A CSV file is a delimited text file that uses a comma to separate values and where each line of the file is a data record. CSV files have a simple structure, are human-readable and can be easily read/written by software programs, thus are a good fit for getting data out of one application and into another one. A shapefile is an Esri vector data storage format for storing the location, shape, and attributes of geographic features.

Figure 1 shows the findings from the analysis regarding the three standardisation metrics for the TPS. For inputs, although network geometry and zonal definition data score high in all metrics, the potential and usefulness of data related to socio-economic factors, activities and modal availability are characterized as low. Furthermore, the effort for standardising the latter is considered to be high. In terms of the key output of the component, the activity schedules, the potential for standardisation is low, regardless the usefulness of having this standardized for the future operation of the HARONY MS. This can be attributed to the fact that activity based models are in their infancy (compared to the conventional demand models).



Scale: 1 – Very Low; 2 – Low; 3 – Neutral; 4 – High; 5 – Very High

Figure 1: Tactical Passenger Simulator – standardisation metrics

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2.1.2 Tactical freight simulator (TFS)

The standardisation information collected for the TFS can be found in Appendix A2.

Table 2: Tactical Freight Simulator data file formats

Data file format	Data type name
Binary	• Skim with travel times • Skim with travel distance • Trips van construction • Trips van service
SHP	• Links • Nodes • Zones • Parcel nodes
CSV file / Shapefile	• Links loaded • Tours Shipments • Parcel demand • Parcel schedules
CSV file	• Socio-economic data • Super zones • Commodity matrix SFS • Firms SFS • Distribution centers (DCs) • Make distribution • Use distribution • CEP shares • Departure time parcels • Emission factors (rural roads - empty vehicle) • Emission factors (rural roads - full vehicle) • Emission factors (highways - empty vehicle) • Emission factors (highways - full vehicle) • Emission factors (urban roads - empty vehicle) • Emission factors (urban roads - full vehicle) • ZEZ consolidation • ZEZ scenario • Cost per vehicle type • Cost sourcing • Parameters - Time of day • Parameters - Shipment size and vehicle type • Parameters - End tour first • Parameters - End tour later • Parameters - Parcel demand B2C • Parameters - Distance decay • MRDHtoNUTS3 label • MRDHtoCOROP label • NUTS3toMRDH • NSTR to logistic segment • Vehicle capacity • Logistic flowtypes • Shipments (after scheduling) • Trip matrix • Trip matrix parcels

As in the case of the TPS and as shown in Table 2, the majority of the data formats used by the TFS are encoded in CSV files. Similarly, network geometry information is represented in the form of

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shapefiles. The TPS supports a number of international standards including, nomenclature of territorial units for statistics (NUTS) for the representation of zones, standard goods classification for transport statistics (NSTR) for the representation of cargo and EN 16258 for calculating and declaring energy consumption and GHG emissions; as well as national standards such as CBS for representing employment sectors.

In terms of the three standardisation metrics (Table 2) the majority of the data types used by the TFS have very low potential and usefulness for standardisation. These data types include all outputs which represent schedules, tours and trips of freight vehicles. The very low potential/usefulness for standardisation can also be attributed to the fact that several data inputs relate to parameters and data mappings specific to the tool. Data types for representing network geometries and energy use/emission factors have been characterised with high potential and usefulness of standardisation. However, it has been identified that most of the data types (92%) require high, or very high effort for being standardised.

Figure 2: Tactical freight simulator - standardisation metrics

2.1.3 Strategic Freight Simulator (SFS)

The standardisation information collected for the SFS can be found in Appendix A3.

The file formats (Table *3*) for the different inputs and outputs align with those used by the TFS and include CSV files for the data required/generated with the exception of the definition of zones which is performed using a shapefile. Correspondently the standardisation metrics explored (Figure *3*), follow a similar pattern as the ones of the TFS. The majority of the data types have low, or very low potential and usefulness of standardisation, while the effort for standardising them is defined as high, or very high. Exceptions are data used for defining distribution centres and their characteristics.

Table 3: Strategic freight simulator data file formats

Data file format	Data type name
SHP	Zones
CSV file	Socio-economic data Commodity matrix Distribution centers (DCs) Surface of DCs (m2) per NUTS3-region. Parameters - Production SIF Parameters - Attraction SIF MRDHtoNUTS3 label NUTS3toMRDH label SBI-sector to segs-sector Firm size distribution Firms Commodity matrix NUTS3

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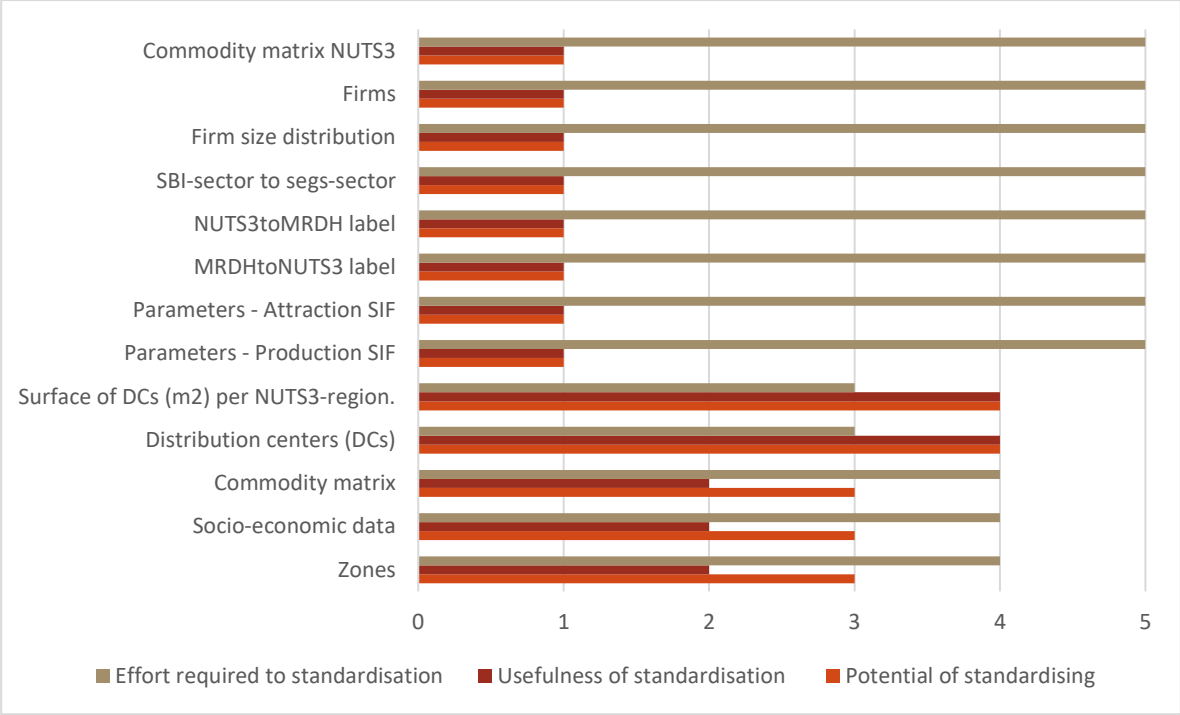

Scale: 1 – Very Low; 2 – Low; 3 – Neutral; 4 – High; 5 – Very High

Figure 3: Strategic freight simulator - *standardisation metrics*

2.1.4 Demographic forecasting model (DFM)

The standardisation information collected for the DFM can be found in Appendix A4.

The inputs and outputs supported by the DFM all support CSV data file formats (Table 4). Furthermore, the data are standardised using segmentations defined by EUROSTAT and therefore the component can be characterised as standardised. In terms of the other two standardisation metrics, both the potential and usefulness for standardisation have been defined as high (Figure 4).

Table 4: Demographic forecasting model data file formats

Data file format	Data type name
CSV file	Households HouseholdsRate Population PopulationRate MacroZone Years UnivHousing UnivShare YearsToExport Results Households Results Population Total population by year Population distribution at base year Population distribution at middle/final year of projections Population distribution at final year of projections School pupils distribution at base year School pupils distribution at middle/final year of projections

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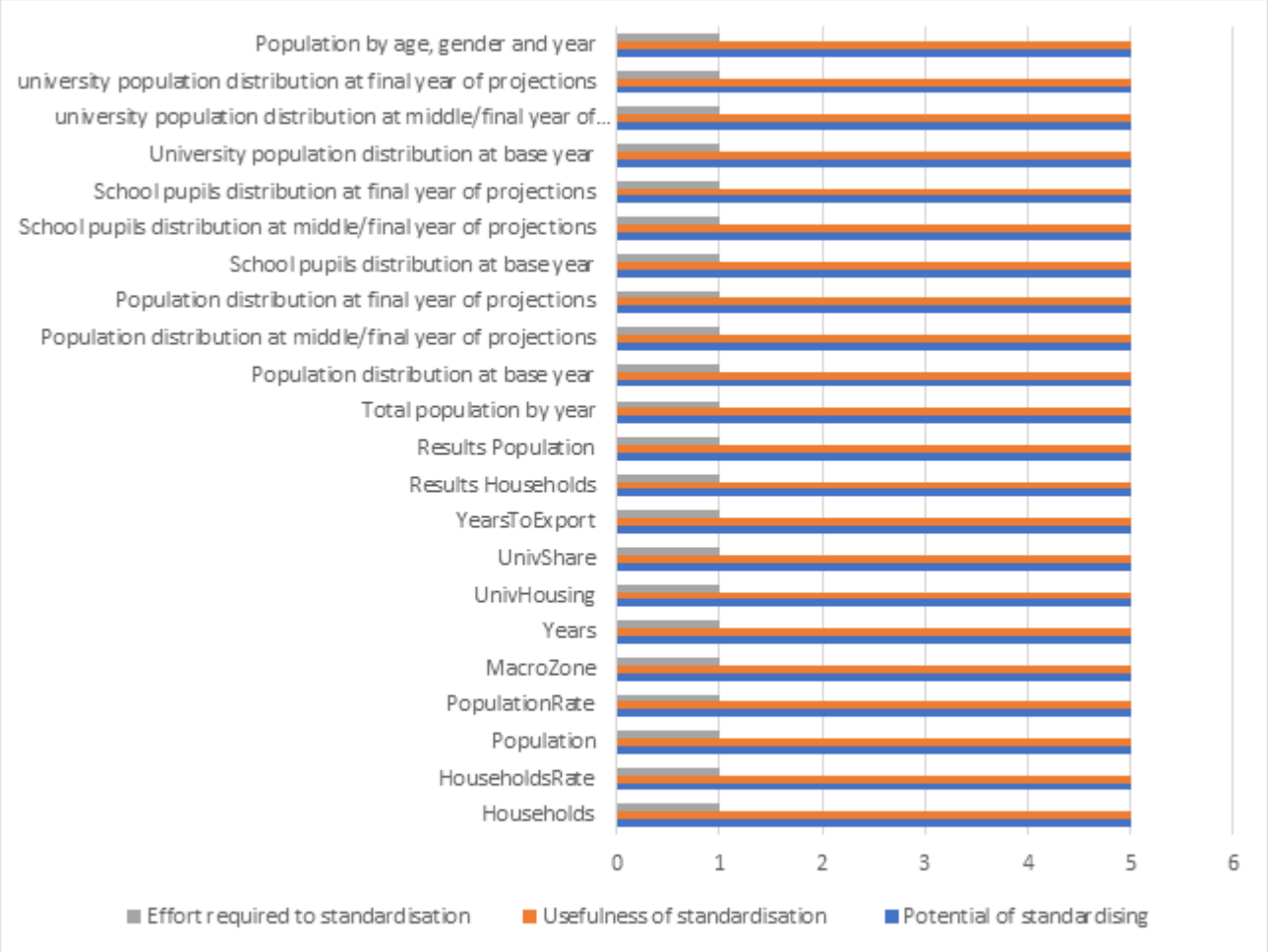
	School pupils distribution at final year of projections University population distribution at base year university population distribution at middle/final year of projections university population distribution at final year of projections Population by age, gender and year



Scale: 1 – Very Low; 2 – Low; 3 – Neutral; 4 – High; 5 – Very High

Figure 4: Demographic forecasting model - standardisation metrics

2.1.5 Regional economy model (REM)

The standardisation information collected for the REM can be found in Appendix A5. As in the case of the DFM, all data support the CSV file format, with the exception of base jobs which are encoded in a shapefile (Table 5). Standardised data include the use of NUTS3 for the definition of zones, and NACE-2D for the definition of economic sectors. As far as the standardisation metrics is concerned, the standardisation effort required for the majority of the data entities is considered to be high, while there is a neutral opinion regarding the usefulness and potential for standardisation (Figure 5).

Table 5: Regional economy model data file formats

Data file format	Data type name
SHP	Base Jobs
CSV file	Beta Coefficients Macro Economic Trends Micro Economic Trends

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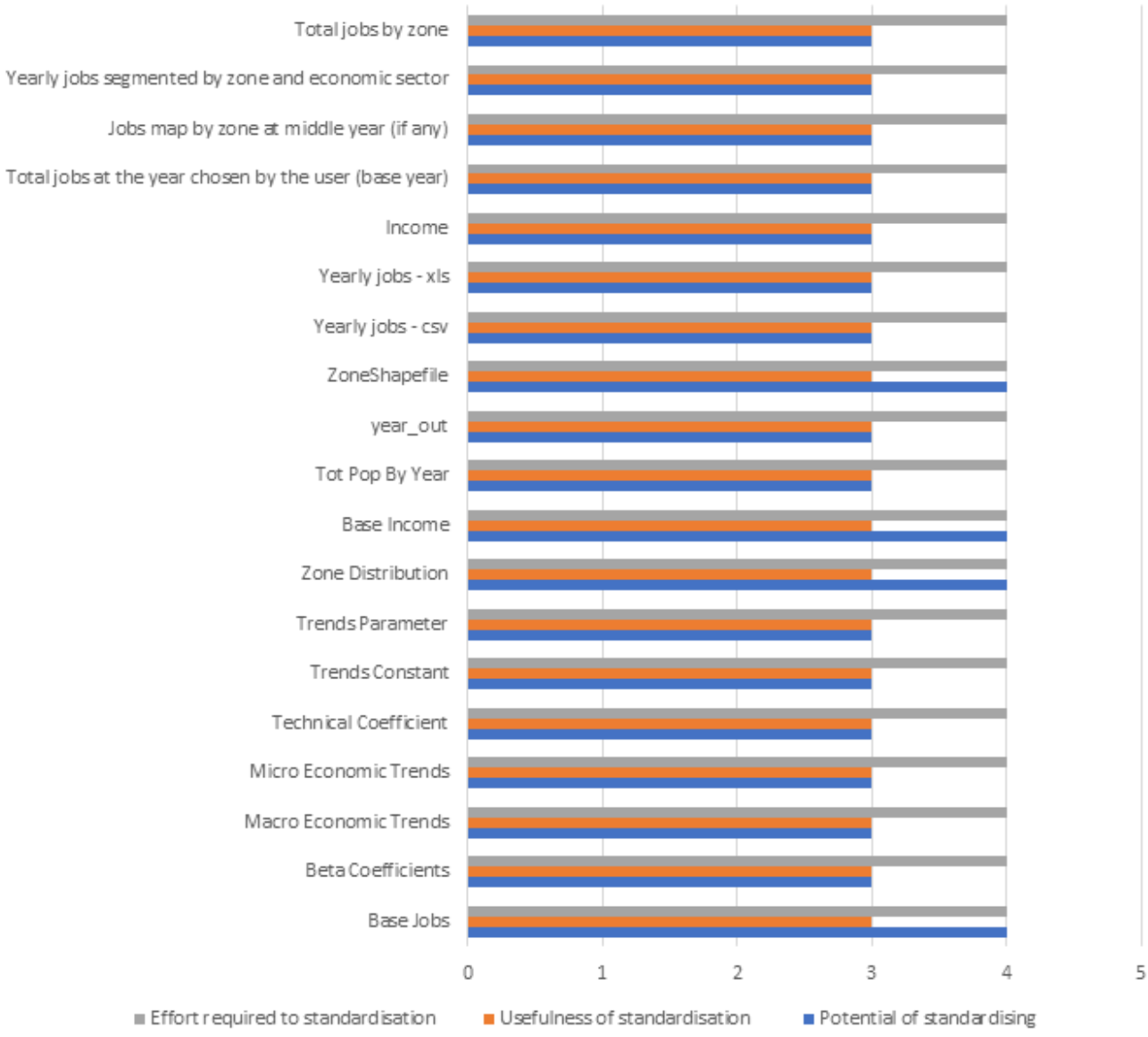
	Technical Coefficient Trends Constant Trends Parameter Zone Distribution Base Income Tot Pop By Year year_out ZoneShapefile Yearly jobs - csv Yearly jobs - xls Income Total jobs at the year chosen by the user (base year) Jobs map by zone at middle year (if any) Yearly jobs segmented by zone and economic sector Total jobs by zone



Scale: 1 – Very Low; 2 – Low; 3 – Neutral; 4 – High; 5 – Very High

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Figure 5: Regional economy model - standardisation metrics

2.1.6 Land Development Model (LDM)

The standardisation information collected for the LDM can be found in Appendix A6. From Table *6*, it is clear that the majority of the data entities used by the LDM support CSV file formats, while certain outputs are exported to Portable Network Graphics (PNG) files. In terms of the standardisation metrics investigated, the potential and usefulness of standardising the data is characterized as neutral, while the effort required as high (Figure 6).

Table 6: Land Development Model data file formats

Data file format	Data type name
PNG	• Land Desirability • Sc1Diff1945 • Land Suitability
CSV file	• High Risk Flood zones • Oxfordshire boundaries zones • Historical conservation areas • Conservation areas • Sites of special scientific interest • Areas of Outstanding Natural Beauty (AONB) • Job accessibility • Housing Accessibility • Population • Natural nature reserves • Flood zones • Greenbelt • Athens boundaries zones • Surface water • Highways • Protected areas • NATURA 2000 Areas • Parks and gardens • Slope • Population Density • GS2500 • Turin FUA • BDTRE railcover • DEM slope • PAIfloodzone • PTC forest cover • PRG cemetery • Turin LUTI Geopackage • PRG industry • PTC urban green • PPR conservation area • Housing accessibility

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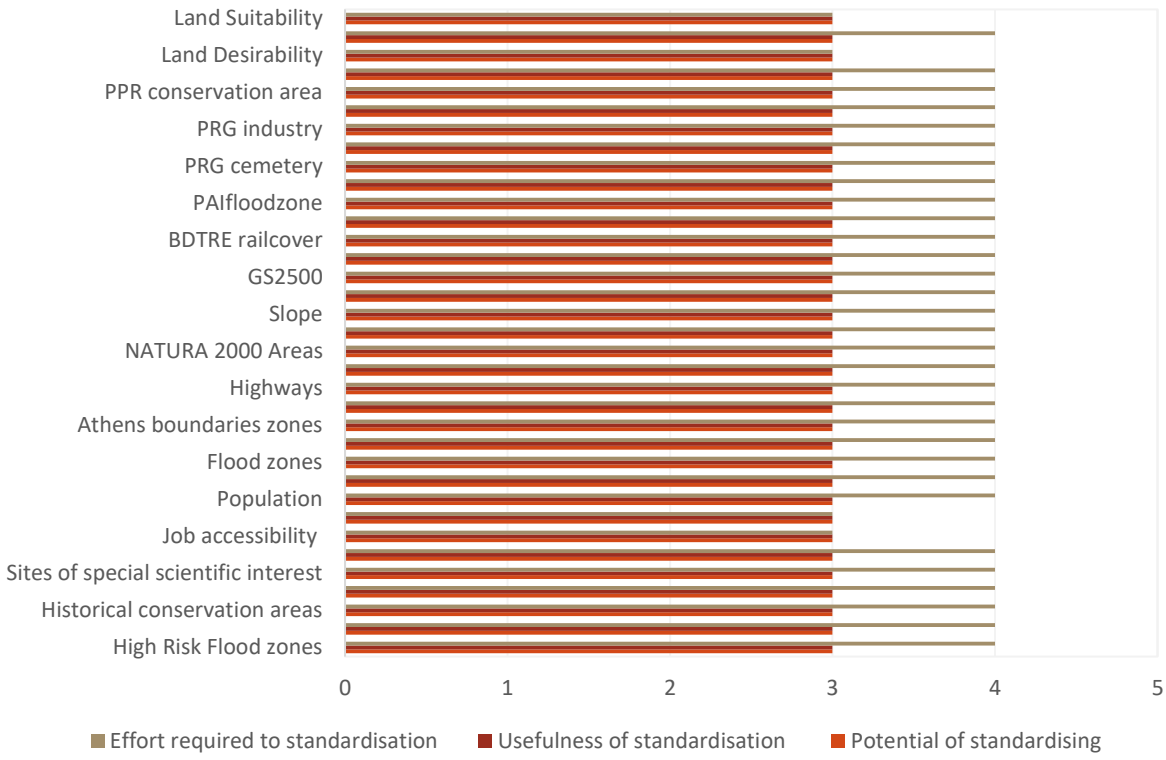

Scale: 1 – Very Low; 2 – Low; 3 – Neutral; 4 – High; 5 – Very High

Figure 6: Land Development Model - standardisation metrics

2.1.7 Land-use transport-interaction model (LUTI)

The standardisation information collected for the REM can be found in Appendix A7. As it can be seen in Table 7, The LUTI model utilises CSV and SHP files for data inputs, while PNG is the preferred format for data outputs. The zonal system adopted is derived from national practices and this is the only standardised data used.

Table 7: Land-Use Transport-Interaction model data file formats

Data file format	Data type name
GEOJSON	• JtW flows (arrow vectors)
SHP	• Zones shapefile • Zones centroids shapefile • Main roads shapefile • MSOAs shapefile • Road Network shapefile • MSOA centroids shapefile • Zones shapefile • Results shapefile
PNG	• Population change • Housing accessibility change (public) • Housing accessibility change (private) • Jobs accessibility change • JobsTijPublic FlowMap • Population change • Housing accessibility

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	• Jobs accessibility change • Flows map jobs • Population change • Housing accessibility change • Jobs accessibility change • Results shapefile • Flows map jobs
CSV file	• Zones codes • Zones coordinates • Intra-zones distances • Cij • Employment • Households floorspace • Geolytix supermarket data • Population • Lookup population • Oxfordshire MSOAs • Cost matrix • Observed flows • Oxfordshire new housing developments • Employment data • Number of dwellings • Oxfordshire Postcodes • Primary Schools data • Calibration data for roads • Population • Hospitals • Primary schools capacity • Data schools pupils • Job accessibility • Housing accessibility • JtW table • JtW flows • Job accessibility • Housing accessibility • JtW table • JtW flows • Job accessibility • Housing accessibility • JtW table • JtW flows

The analysis of the standardisation metrics for the LUTI model is depicted diagrammatically in Figure 7 below. As it can be seen, the neutral option dominates all three metrics, while certain data inputs have low/very low potential for standardisation despite the fact that the usefulness of this is high/very high. Examples in this group of data types include observed flows, employment data, attributes for different services such as hospitals and schools, as well as network geometry related information.

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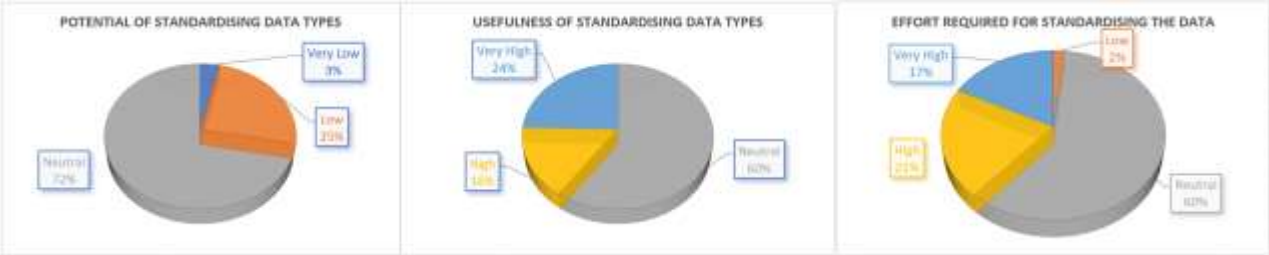

Figure 7: Land-use transport-interaction - standardisation metrics

2.2 Standardising the HARMONY MS

2.2.1 Need for standardisation

This section of the report discusses issues and opportunities in standardising modelling and simulation tools for a harmonised operation as part of platform such as the HARMONY MS. The findings presented were derived from semi-structured interviews (questions can be found in Appendix D) with all the developers\modellers of the HARMONY MS consortium, who were also responsible for the implementation of the tools that were integrated in the platform.

Standardization is a key strategic tool to agree on terminologies, methodologies, requirements, quality criteria, etc. in a specific field to make a product, process, or service fit for its purpose. Thereby standardization can drive innovations e.g., as it can be agreed on product requirements including safety, health, compatibility, etc. and guidance on how to archive them can be provided (Seelinger et al., 2020).

According to Hess et al., (2009), standardization is a key requirement for the proliferation of the information and communication technologies (ICTs). It enables interoperability of technology components from different suppliers and interworking of systems operated by different providers and transport system operators. Moreover, standardization is a basis for a regulatory framework that takes into account the interests from all system stakeholders.

Technology standards for data exchange and interoperability are essential (Costa-Pérez et al., 2013; Erlinghagen et al., 2015). Anysz et al., (2016) noted that managing various data assets requires clear standards and procedures to ensure the data serves its intended purpose of supporting the planning, decision making, and operations. Seelinger et al., (2020) noted that standards play a vital and sometimes invisible role in supporting not only economic growth but also competitiveness, innovation, and societal welfare is acknowledged. The convergence of communications, computing and media content is bringing technologies from different industries together, pushing for the definition of common standards (Costa-Pérez et al., 2013).

Standards can be expected to enable interoperability, reduce costs through economies of scale and create mass markets (Erlinghagen et al., 2015). In accordance, the findings of this study confirm that the need for standardising the HARMONY MS, because it is designed for applicability in different use cases. The interviewees noted that standardisation would improve efficiency, transferability, and to enhance the various components connectivity and interoperability. However, the findings reveal that standardisation of such complicated simulation system is very challenging. Therefore, it is advisable to have realistic expectations with the standardization. One of the interviewees noted that:

> *"Full standardisation of such complicated simulation system, of course is not possible. Of course, you can never reach a stage where it's so standardized that it's a matter of downloading some data from Internet and it's updated or transferable, so it will always require data processing and data handling."*

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Hess et al., (2009) noted that in a world of converging yet diverse technologies, complex systems must communicate and interwork on all levels. This is generally known as interoperability. One well-proven and cost-effective approach to achieve interoperable standards, and subsequently interoperable products, is through interoperability events. Provision of transferability, integration, and application of models to different places as well as the removal of ambiguities in the models themselves. Another interviewee noted that:

> *"…a fully standardised system, would allow the application of models to different places in that sense, many more places, let's say. … the other benefit of standardization is the removal of ambiguities in the models themselves."*

Mahajan et al., (2022) noted that data standards models should share a common standard for input and output data. Similar to the emergence of public transport datasets after the emergence of General Transit Feed Specification (GTFS), this could lead to more publicly available network models in the future. Open standards like GTFS have helped increase the usability and interoperability of public transport data. Similarly, General BIkeshare Feed Specification (GBFS) is a relatively new step towards sharing data from new mobility forms, such as bike-sharing (Mahajan et al., 2022). Moreover, common standards facilitate the diffusion of new technologies and the development of entire technological fields (Erlinghagen et al., 2015). In accordance, this study results indicate that standardisation could enable data exchange of inputs and outputs. For instance, one of the interviewees noted that:

> *"…so, in my opinion standardization, will help data exchange of inputs and outputs among various models of HARMONY MS".*

Furthermore, Costa-Pérez et al., (2013) noted that successful standards allow a large number of players to interoperate and innovate resulting in expanding commercial business, faster technology progress and end users enjoying wider choice range, richer functionality and lower costs. For instance, another interviewee noted that:

> *"...modellers usually decide on the file format on the basis of convenience. Therefore, it would be a good idea to harmonise different data formats for standardising the inputs and outputs of the HARMONY MS as a whole"*

This study results indicate that standardisation would also enable harmonisation of different files format. Moreover, the open matrix (OMX) format was developed in 2013 and allows transport modellers to share and read different models' matrices. More recently, the General Modelling Network Specification (GMNS) was developed and promoted as an open format for network data explicitly designed for transport models (Smith et al., 2020; Mahajan et al., 2022).

2.2.2 Challenges for standardisation

Erlinghagen et al., (2015) noted that it can be very challenging to arrive at a common standard. The authors emphasised that the literature on standardization reports many cases of firms and governments struggling about standards. This study findings reveals that data availability and transferability is one of the major challenges to data standardisation as it affects the mathematical formulations used by the models. For instance, one of the interviewees noted that:

> *"…I would say that data availability is the main challenge when it comes to transferability of our models because of the impact on mathematical formulations"*

Absence of data is another challenge to data standardisation activities as revealed by another interviewee:

> *"In Athens and Turin, we didn't get any retail data or for the Greek case study, we didn't have access to school data. So, in that case, the problem was absence of data."*

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Countries will naturally have different ways of representing information (e.g., different zoning systems). Consistency in the ways the same information is represented in different countries is another challenge for data standardisation activities. Therefore, there is a need for model adaptation exercises. This issue was identified by an interviewee who stated that:

> *"… so, you might end up with zones that are geographically spatially similar, but attributes like number of populations, number of people living is very different and these effects HARMONY MS adaption exercise in particular to transport interaction model."*

Differences in data representations due to the fact that are culturally determined by the place, and the people represent another challenge for data standardisation. For instance, an interviewee noted that:

> *"One of the big issues in transport modelling, or any kind of modelling to be honest, is that data representations are very culturally determined by the place and the people. So, for example, the way we do things here in terms of our census data."*

The findings indicate that all these aspects make standardisation a very complex and challenging task. Another interviewee stated that:

> *"So, the question of standardization at this level is very problematic and it's not likely to change. It's not likely to change because there's so much historical determination as to what the categories are and as to where the data is actually collected...."*

An interviewee noted that another challenge is related to the fact that data is collected by other organisations for their own conveniences and purposes.

> *"… do collect quite a lot of a data for their own purpose and conventions. They have their own standards too. If we need to use this data for HARMONY MS data transformations are required and this process is not always straightforward."*

Thus, the findings indicate that, standardisation of HARMONY MS needs to take place and integrate different teams at different levels of models within strategic, tactical, and operational levels, which represent another key challenge. Nonetheless, the need to exchange different data formats is a key challenge for standardising HARMONY MS.

2.3 Recommendations for standardisation

As revealed in this section, standardisation of data can improve interoperability, provision of transferability, integration, and application of models to different places as well as the removal of ambiguities in the models themselves. Furthermore, data availability and transferability are major challenges for data standardisation. Absence of data is another challenge followed by data formats. Use of data that is collected by other organisations for their own conveniences poses additional challenges in the data standardisation activities. It is concluded that standardising such a holistic solution is a complex process. It is recommended that further standardisation of the HARMONY MS needs to consider tighter integration of the different teams working on models at the different levels of the platform. This is important as the need to exchange different data formats is a key challenge for standardising the HARMONY MS. Before embarking on standardisation journey, decision makers must understand what they would like to achieve with their standardisation programme and what value it needs to add to their needs.

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3 HARMONY MS for Policy Adaptation

This section of the report presents the findings of interviews with stakeholders from the different cities that participated in the HARMONY project. These stakeholders had been actively engaged with the HARMONY MS and therefore were in a position to provide feedback regarding the usefulness of the platform in supporting policy adaptation in their organisations. Appendix C has the semi-structured interview questions which aimed to capture insights related to the overall usefulness and shortcomings of the platform in policy making and adaptation, the features and tools of the platform that can be most useful for their role within the organisation as well as the use cases for which the HARMONY MS was perceived as being most beneficial for.

3.1 Potential of the HARMONY MS to support policy adaptation.

The findings highlighted the importance of Harmony MS as a tool for enhancing and enabling evidence-based both short-term, and long-term policy development. One of the interviewees highlighted that:

> *"It's a very useful platform to use."*

Similarly, another interviewee stated that:

> *"In the city they are focusing on the mobility sector and the urban planning, and it would be very useful to that. The decision making would be also based on the qualitative and quantitative data. So, based on the real data that we have, because now we have a lot of sensors in the city and that are collecting different type of data either environmental or atmospherically or data on the mobility of vehicle. So far of the buses of automated of the also they know that they've systems that we have. So, all this data and could provide some scenarios."*

HARMONY MS could also enhance collaboration and interconnection between different departments in the policy field. For instance, interviewees noted that:

> *"… it would involve the colleagues from the Economic Department to also organize their work around it that way. So, the connection between mobility and economic development and the same goes for social development and urban planning. That there's a very important interconnection between these policy fields."*

However, some efforts need to be directed towards organising and enhancing the collaboration between the different components.

> *"But they really need to be very well organized and organic whole- … and they should actually then have been involved in harmony from the start to also make sure that all these components could be used by them to support their work."*

The interviewees highlighted the importance of Harmony MS for enhancing decision making, and the importance of standardisation for the model.

> *"It could also be used to help us with better decision making. I mean the mobility data and the modules collect and manage … from all these sources, allows us to have a comprehensive review of our mobility system and make more informed decisions regarding the development of transport".*

The HARMONY MS integrates many models; it offers immediate access to variable models. From city planning perspective, it could be useful for organisations to help access to multiple models at the same time and to compare different scenarios and different aspects and different parameters. From a city perspective, for instance, it could help in new city planning in Athens in the next decade plans. HARMONY MS can help in providing proposal regarding the transportation development planning. In this perspective it can be used by policy makers.

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Additionally, the findings suggest that HARMONY MS is a valuable tool for sustainable transport planning, in terms of the assessing cost of interventions.

> *" … dealing with the sustainable transport planning as we are, I think this is a valuable tool in terms of assessing cost of transport interventions. Sometimes the buses or trams are just moving empty, right? So, this is not what we want to achieve.*

In terms of highlighting which model suits with Athens development, the interviewee noted that Athens is currently under a vision of planning of the city, this investment is expected to bring huge changes in the landscape of the city and also in business transportation etc., The expected development is going to take place in the northern part the city. At the moment, the land use/transport interaction model is quite useful for Athens. Also, for Trikala, the air pollution and noise models were considered very useful.

In terms of indicating whether the model is important for policy adaption, one of the interviewees highlighted a case study of autonomous vehicles operated in the city. The study of the autonomous vehicles operating in the city was carried out at rates, from 0%-100% of autonomous vehicle operating. According to the findings, the operation of the autonomous vehicles increases the theoretical capacity of the road, and thus it allows for lower travel times on the network. However, the interviewee added that *"in terms of implementation, certainly, it is not in the near future."*

There is a need for the HARMONY MS as it could provide potential support to achieve sustainable transportation system policy goals. From city and especially form transportation and mobility perspective, it could help mobility systems development to prepare and to adapt to the ongoing changes. For instant, one of the interviewees noted that:

> "So, our main interest for the testing was what is the potential of these new types of transportation for to contribute to. The policy goals we have for sustainable mobility. According to the harmony philosophy, the project philosophy we need to prepare and constantly adapt to the changes in society and the tools we use for."

Another interviewee noted that:

> *"Developing the city, also from the mobility perspective, need to be up to date and be able to include new developments such as potentially self-driving vehicles also in the domain of city logistics."*

In terms of freight transportation systems, one of the interviewees highlighted that their main interest in HARMONY MS will be on the models concerning freight transport. And to support sustainable freight from policy perspective, how it can be implemented, observed, and measured. Further, the interviewee noted that:

> *"Freight transport is sustainable from an urban policy point of view when we have confidence, and we can actually observe and measure that it's carried out as efficiently as possible and with the minimum burden on the environment in terms of noise and emission of greenhouse gases and air pollution. In this respect, the HARMONY MS can be a valuable tool."*

However, the findings indicate that at freight operational management level, there is a need for more details with technical simulators. Another interviewee noted that:

> *"You need, of course, sometimes more detail than can be established with the tactical freight simulator. That said, there are limits. That's why we were also interested in being involved in the operational freight simulator."*

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3.2 Challenges for policy adaption

The findings revealed various challenges regarding the potential of the HARMONY MS to support policy adaption. As highlighted by one of the interviewees, one of the challenges is the need to try or check the tool to get into details for urban and city planners who are aware of the tools for planning urban space.

Challenges related to the integration and collaboration between different departments are also highlighted in the findings. For instance, one of the interviewees noted that:

> *"… the awareness of what are my colleagues actually doing, what are their priorities are and how can my priorities are connected to them, in which way, and how can we make consistent policy efforts for the city as a whole."*

Other interviewees noted that:

> *"… but we think it's essential that in developing good policy you need to be in a dialogue with the stakeholders concerned not to just making a regulation that serves their needs, but just to be aware of what it means for them, and which are the critical aspects of that. So, what you need to default attention to."*

Costs associated with the use of the suite represent another challenge and it is one of the factors determining whether to use the model or not. With the public sector it is always difficult in terms of the budget and available funds. For instance, one of the interviewees noted that:

> *"With the public sector it's always difficult to involve money when you have no clarified description of what you are buying, because spending public money is like spending it with the highest respect and sometimes cities are really in need of money, so they are not spending them on everything proposed."*

Challenges to inputs and outputs, limited data availability, as well as fragmentation of the available data are also highlighted as key challenges for the potential use of HARMONY MS to support policy adaption in freight transportation systems. For instance, one of the interviewees noted that:

> *"Standardizing in freight transport is very complicated because of the limited and fragmented availability of data, so sometimes there is data at national level very aggregate. Sometimes there's local very detailed data but incomplete because it's only dealing with construction logistics."*

In addition, to the fact that different country data collection systems exist, and used definitions or terminology are different. Another interviewee stated that:

> *"… also, you have different types of data available in different countries like maybe in one country you have a detailed trip data set of some observed trips made. And then in another country you don't have such data. And then maybe in another country they also have a detailed data collection, but they use some very different definitions"*

Moreover, the challenge to obtain data from private sector companies and to overcome data policy is highlighted by another interviewee.

> *"And of course, we have to see the data policy and how we can gather it as for the freight sector data are often held by private companies. So, we would like to see how we could collect data from these companies that are confidential and that these companies would really share with the city."*

Training of employees is another challenge for supporting policy adaption highlighted by one of the interviewees.

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> *"… the training of the employees and the new way to work through this evolution of the technologies and the modelling is challenging."*

Other interviewees also highlighted the need for training to support planning:

> *"Training might be valuable for the planners because they will know, they can integrate their own tools with the new one. Then they will know. Do they really need the new tool?"*

When asked about the limitations or shortcoming from policy adaptation perspectives, one of the interviewees stated that the complexity of decision making as well as the need to obtain approval from various bodies is a key challenge for them.

> *"Decision making is a complex process, the responsible authority of that is the ministry of transport and the municipalities, along with other authorities like the ministry of environment, the central government. HARMONY MS provide different perspectives. But the decision of policy adaptation requires mutual agreement on that."*

On answering the question regarding areas of improvements, integration is highlighted as the key aspect by one of the interviewees.

> *"No experience, but integration is very important aspect, that is to be able to integrate data from the whole area of analysis.."*

Moreover, the interviewee highlighted that, especially when it comes to the public sector, the decisions to decide to buy the tool is quite complicated. Therefore, there is a need to be sure that the tool is useful for its purposes.

> *"To pay for the licence, the organizations need to be sure that the program they are going to buy is going to be useful for its purposes. For the public sector, it is not easy to decide to use the tool as it requires additional payment. Especially that the discussion (October) about the tool was held after the budget for the next year was already planned (September)."*

Therefore, it is recommended that pricing issues need to be addressed and discussed with the partners. Free license might be given to academic institutions. For example, the findings suggested offering a demo version for the public stakeholders to try the tool, as an approach to encourage them to invest in it. For instance, one of the interviewees noted that:

> *"It would be great to have some "demo" versions or some basic tool for the public stakeholders, for the academia, especially for technical universities, so this can give the possibilities to use it and to encourage the public officials to invest in that."*

3.3 Recommendations for policy adaption

- HARMONY MS brand trust and confidence is crucial. Official endorsement of the platform and services is an important determinant of future successful deployment of the HARMONY MS. Clear systems to facilitate trust and confidence need to be put in place.
- More extensive and intensive stakeholders engagement and debate on the subject of the risks versus benefits of HARMONY MS platform needs to be undertaken to address concerns around security and safety of the system.
- Greater emphasis needs to be placed on both upskilling and also ensuring the next generation of transport planners and professionals are more "digitally" able to use HARMONY MS platform. Digital and data driven transport models needs to be a feature of undergraduate and postgraduate education and training programmes.

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- Guidance is required to shape and support transport planners and decision makers adopt HARMONY MS platform. Consideration must be given to future funding models, procurement, and the potential for hybrid data, including sharing, storage, and management models that permit additional transport models and services to be integrated to the platform.
- There is a need to promote HARMONY MS across transport departments and a culture of long-term sustainable transport planning. Instability and constant change can be a deterrent to resources investment and hinders implementation in the digital transport space.
- Strategic, tactical and operational modules interoperability of HARMONY MS needs to be prioritised and, if necessary, incentivized to ensure the scaling up of the platform across systems and regions. This includes technical standards for data, data publication and metadata, interfaces and exchange standards. There needs to be better access points to current standards knowledge for those on the ground implementing data services.
- HARMONY MS platform services need to be more accessible by those whose first language is not English. There is a need to invest in further awareness raising and upskilling of HARMONY MS platform if the true potential of it to be fully realized by transport sector stakeholders.

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4 Evaluation of the HARMONY Model Suite for Integrated Spatial and Transport Planning

4.1 Introduction

This section explores the evaluation of the HARMONY Model Suite for integrated spatial and transport planning based on online surveys (questionnaire can be seen in Appendix B), which were conducted as part of the training workshops offered during the project. The training workshops were hosted in Delft, Athens, London and Barcelona and attracted participants from industrial, academic and public organisations. The goal of these surveys was to evaluate a software-agnostic multiscale/multi-dimensional simulation platform for spatial and transport planning of the future.

This section explores the awareness, importance and benefits of the HARMONY MS on decision making process. Further it explores the benefits of the new system from a policy adaption perception. To gain better insight from the survey respondents' statistical analysis was performed on the questionnaire results using IBM SPSS software. This made it possible to quantitively analyse the data to identify trends within the results, which helped to draw conclusions and recommendations.

4.2 Methodology

According to Collis and Hussey (2013) research methodology can be defined as the overall approach to the research process, from the theoretical underpinnings to the collection and analysis of the data, so research methodology in social enquiry refers to far more than simply the methods adopted. It should encompass the rationale and philosophical assumptions that underlie a particular study. These, in turn, influence the methods that are used to investigate a problem and to collect, analyse, and interpret data. Given the unexplored nature of the research problem at hand, a quantitative method was adopted to collect and analyse data. The philosophical underpinning of this is based on objectivist-positivist paradigms. According to Bourque and Fielder (2003) questionnaire survey instruments have many advantages in the data collection process. They provide a larger geographical coverage for the sample population than case studies or semi structured interviews could provide and are cost-effective, efficient, and permit anonymity. The latter helps ensure that individuals' responses reflect their true beliefs and feelings—especially important in research involving attitudes. Because the researcher is not conversing directly with participants, they are unlikely to influence respondent answers. The questionnaire survey also provides a uniform situation for data collection, because each person is presented with the exactly the same method of inquiry, in the same manner (Bell et al., 2018).

A web-based, online survey was used to collect data. This offers many advantages including low cost, speed, and ability to reach respondents globally (Punch, 2005). A robust questionnaire survey design is fundamental to obtaining reliable survey results and an appropriate response rate. Hence, these aspects are further explained in the following sections (Bell et al., 2018). Questionnaire variables used in the study were derived from discussion with the project stakeholders and technical experts. The specific questions were written with focus on the response process, the utility of individual questions, and the overall structure and appeal of the questionnaire. The cover page introduced the research project and provided critical information such as a confidentiality statement and important notes for completing the questionnaire. The study included scaled items for opinion questions. The final page of the questionnaire provided an option for respondents to offer any further general comments relating to the area of research. Fellows and Liu (2015) noted that Likert items are concerned with determining respondents' degrees of agreement or disagreement with a statement, usually on a 5-point or 7-point scale. Renukappa et al., (2017) noted that a general problem occurs in the application of opinions or attitude scales in questionnaire surveys: respondents tend towards the neutral position. That is, when asked to strongly agree or strongly disagree on a 5-point or 7-point scale, many respondents would prefer to choose "neither agree nor disagree." Analysts often exclude neutral responses from their analysis, thereby risking the exclusion of valid responses. The disadvantage of this among surveys is

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that it reduces the quantity and quality of remaining data. Therefore, a 4-point Likert item was used in the study to avoid this.

Survey invitations were e-mailed and shared to respondents during HARMONY MS workshops and training programmes requesting that they submit their views via an online survey hosted at https://survs.com/survey/fjwhfm6o6a. After preliminary analysis of the data, the number of usable responses amounted to 31 from small and medium enterprises (SMEs) and 25 from large organizations. Overall, a total of 56 fully completed and usable questionnaires were received. Of the usable questionnaires, 45% were from male and 47% were female respondents. However, 8% of the respondents prefer not to answer their gender. A relatively large percentage (60%) of respondents were from cities decision makers and 40% respondents were from the technical consultants. Based on professional background, it is reasonable to infer that respondents held adequate knowledge of the HARMONY MS.

4.3 Results and Analysis

The following presents the analysis, results, and discussion from the questionnaire survey.

4.3.1 Level of Awareness of the HARMONY MS

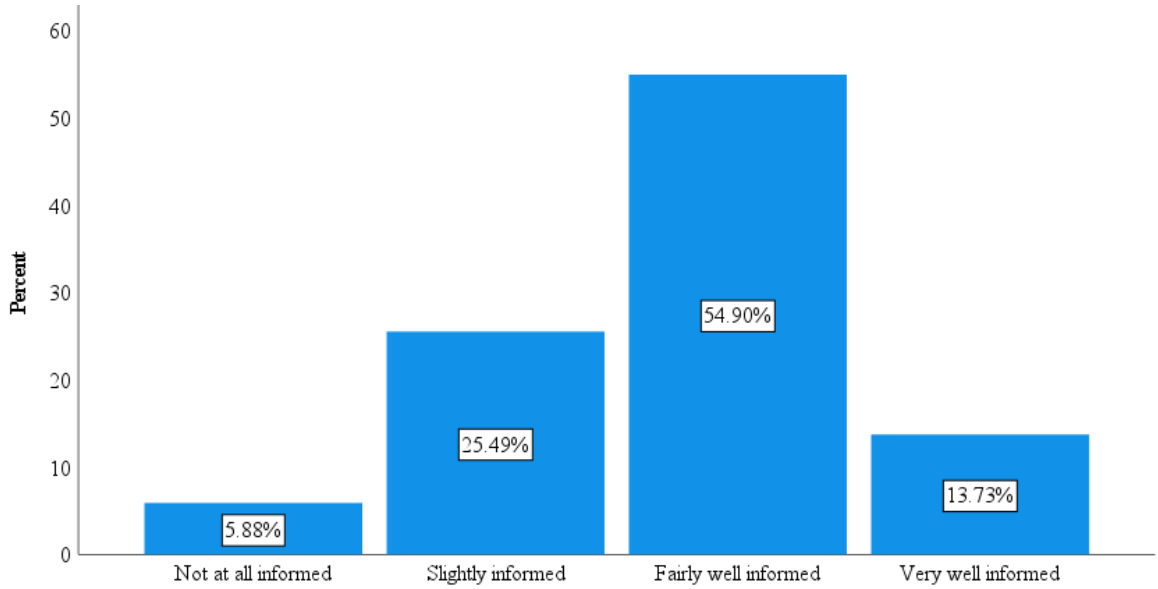

Figure 8: Level of awareness of the HARMONY MS platform

Respondents were asked to indicate their level of awareness of the HARMONY MS platform on a 4-point Likert item: “very well informed,” “fairly well informed,” “slightly informed,” and “not at all informed”. It is possible that having an awareness of the HARMONY MS platform contributes highly to the development of a successful implementation strategy, so this was asked of respondents. As Figure 8 shows, nearly 14% respondents indicated they were very well informed of the HARMONY MS platform. However, nearly 55% respondents indicated they were fairly well-informed, whereas 25% of the respondents indicated that they were slightly informed and 6% claimed that they had not been informed at all. Results suggest this relatively high level of awareness is welcome progress within the transport industry. These results suggest that overall, degrees of awareness are high, although 39% of respondents felt they held little or no information in this respect. For successful adoption of the HARMONY MS platform, wider awareness-raising across public and private sector organisations is arguably needed. Individuals and companies who are not yet familiar may therefore benefit from beginning a process of using the HARMONY MS platform.

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Perhaps city-wide awareness-raising program on the HARMONY MS platform needs to be developed and deployed. Guidance and awareness-raising could combat some of the practical difficulties in implementing the new platform. Furthermore, continuing professional development (CPD) programs and executive training programs may be other valuable ways to raise awareness.

4.3.2 Relevance of the functionality of HARMONY MS models

Through the online survey, respondents were asked to indicate the relevance of the functionality of HARMONY MS models on a 4-point Likert item: “Very Relevant” (4), “Fairly Relevant” (3), “Relevant” (2), “Not Relevant” (1). It is apparent from Table *8* that the five most important HARMONY MS models are: land use/transport interaction model (3.33), demographic forecasting model (3.12), land supply and development model (3.11), tactical passenger simulator (3.57), and strategic freight simulator model (3.06).

Table 8: Difference of opinion in relevance of HARMONY MS models between SMEs and Large organisations

HARMONY MS Models	Overall Mean	Rank	SMEs Mean	Large Mean	t_{cal}	Significant value(ρ)
Land use/Transport interaction model	3.33	1	3.33	3.32	0.061	0.951
Demographic forecasting model	3.12	2	3.00	3.32	-1.468	0.149
Land supply and development model	3.11	3	2.96	3.36	-1.745	0.088
Tactical Passenger Simulator	3.10	4	3.07	2.91	0.455	0.652
Strategic freight simulator model	3.06	5	3.04	3.10	-.212	0.833
Energy and Emissions model	3.02	6	3.11	2.62	1.473	0.074
Vehicle stock, energy and emission model	2.98	7	2.89	2.62	0.886	0.190
Tactical Freight Simulator model	2.97	8	3.00	2.92	0.238	0.813
Long-term households and individual choices model	2.96	9	2.78	3.18	-1.423	0.161
Regional economy model	2.95	10	2.81	3.14	-1.434	0.158
Synthetic population model	2.94	11	2.78	3.18	-1.825	0.074
Operational Freight Simulator model	2.93	12	3.04	2.69	1.053	0.299

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Operational Passenger Simulator model	2.90	13	3.08	2.46	1.837	0.074
Vehicle ownership model	2.86	14	2.93	2.82	0.401	0.690
Scheduling Module	2.82	15	2.93	2.46	1.474	0.073
Noise model	2.70	16	2.44	2.77	-0.905	0.371
Nowcasting model	2.69	17	2.89	2.31	1.893	0.066

For instance, in this project, overall mean value of 3.33, land use/transport interaction model is the most relevance of the functionality of HARMONY MS models. The relationship between urban development and transport is not simple and one way but complex and two way and is closely linked to other urban processes, such as macroeconomic development, interregional migration, demography, household formation, and technological innovation. Integrated models of urban land use and transport, which explicitly model the two-way interaction between land use and transport to forecast the likely impacts of land-use policies, such as zoning or building density or height constraints, and of transport policies, such as transport infrastructure investments, public transport improvements, or taxes or user charges, for decision support in urban planning (Fischer and Nijkamp, 2019). Therefore, it is evident that land use/transport interaction model is significantly important relevance of the functionality of HARMONY MS platform.

In this study, overall mean value of 3.12, demographic forecasting model is the second most important relevance of the functionality of HARMONY MS platform. Booth (2006) noted that the complexity of demographic behaviour would suggest that disaggregation and decomposition is an appropriate and potentially useful approach, at least in the short to medium-term. The increased understanding of demographic life-course processes and their determinants, combined with increased computer power, facilitates added dimensions of disaggregation and decomposition and the development of both increasingly detailed multistate (macrosimulation) models and individual level microsimulation.

The t-test for equality of means was carried out to investigate whether there were any significant differences between participants of ‘SMEs’ and ‘large organisations’ insights on the relevance of functionality of HARMONY MS platform models (at the 0.05 significance level) (refer Table *8*). According to Black et al. (2010), in the t-test, a significant value (ρ) below 0.05 indicates a high degree of difference of opinion between groups on that variable (in this case, between participants of ‘SMEs’ and ‘large organisations’). Results here show that all functionality and relevance of HARMONY MS platform models are not significant (>0.05), and therefore, there are no significant statistical variations between the responses of the ‘SMEs’ and ‘large organisations’.

Table 9: Difference of opinion in relevance of models of HARMONY MS between Cities decision makers and Technical consultants

HARMONY MS Models	Overall Mean	Rank	Cities decision makers Mean	Technical Consultants Mean	t_{cal}	Significant value(ρ)
Land use/Transport interaction model	3.33	1	3.38	3.26	0.476	0.636
Demographic forecasting model	3.12	2	3.33	2.93	1.950	0.057

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Land supply and development model	3.11	3	3.33	2.89	1.960	0.056
Tactical Passenger Simulator	3.10	4	3.21	3.00	0.751	0.456
Strategic freight simulator model	3.06	5	3.17	2.96	0.812	0.421
Energy and Emissions model	3.02	6	3.00	3.04	-.129	0.898
Vehicle stock, energy and emission model	2.98	7	3.17	2.78	1.574	0.122
Tactical Freight Simulator model	2.97	8	3.13	2.81	1.184	0.242
Long-term households and individual choices model	2.96	9	3.13	2.81	1.133	0.263
Regional economy model	2.95	10	3.13	2.78	1.601	0.116
Synthetic population model	2.94	11	3.08	2.81	1.225	0.226
Operational Freight Simulator model	2.93	12	2.88	3.00	-0.457	0.650
Operational Passenger Simulator model	2.90	13	2.88	2.93	-0.179	0.859
Vehicle ownership model	2.86	14	2.96	2.78	0.698	0.488
Scheduling Module	2.82	15	2.96	2.70	0.931	0.357
Noise model	2.70	16	2.96	2.44	1.751	0.086
Nowcasting model	2.69	17	2.71	2.67	0.152	0.880

The t-test for equality of means was carried out to investigate whether there were any significant differences between participants of 'cities decision makers' and 'technical consultants' insights on the relevance of HARMONY MS platform (at the 0.05 significance level) (refer Table *9*). Results here show that all functionality and relevance of HARMONY MS platform models are not significant (>0.05), and therefore, there are no significant statistical variations between the responses of the 'cities decision makers' and 'technical consultants'.

4.3.3 Useful features of HARMONY MS platform

Through the online survey, respondents were asked to indicate the importance of the usefulness of the features of HARMONY MS on a 4-point Likert item: "Very important" (4), "Fairly important" (3), "Important" (2), and "Not at all important" (1). It is apparent from Table 10 that the three most important useful features of the HARMONY MS are: ability to integrate with other systems (3.57), ease of use (3.31), and ability of users to collaborate for carrying out different functions (3.24). Whereas the

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three least important useful features of the HARMONY MS are level of completeness of the Harmony MS in terms of available models (3.12), cost effectiveness (3.14), and overall performance (3.23).

'Integration' is defined as 'an act or instance of combining into an integral whole'. According to White (1990), 'integration' refers to the activity of combining several implemented system elements and activating the interfaces to form a realised system (product or service) that enables interoperation between the system elements and other systems in the environment to satisfy system requirements, architecture characteristics and design properties. In addition, 'integration engineering' is seen as a set of activities that define, analyse and execute integration across the lifecycle, including interactions with other lifecycle processes. In this context, HARMONY MS as a set of cohesive tasks and ability to integrate with other systems easily. Similarly, the usability function of the HARMONY MS is rated very high. The international standard ISO 9241 (Part 11), defined "usability of a product is the extent to which the product can be used by specific users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specific context of use." Also, collaboration, coordination, and cooperation lie at the core of the HARMONY MS activities.

Table 10: Difference of opinion in relevance of importance in usefulness of the HARMONY MS between SMEs and Large organisations

Usefulness of the HARMONY MS platform	Overall Mean	Rank	SMEs Mean	Large Mean	t_{cal}	Significant value(ρ)
Ability to integrate with other systems	3.57	1	3.41	3.85	-2.471	0.009*
Ease of use	3.31	2	3.41	3.38	0.090	0.929
Ability of users to collaborate for carrying out different functions	3.24	3	3.04	3.62	-2.070	0.045*
Logic flow of the Harmony MS	3.22	4	3.19	3.38	-0.936	0.355
Overall performance	3.23	5	3.26	3.31	-0.189	0.851
Cost effectiveness	3.14	6	3.15	3.13	0.010	0.999
Level of completeness of the Harmony MS in terms of available models	3.12	7	3.11	3.23	-0.406	0.687

Table 11: Difference of opinion in relevance of importance in usefulness of the HARMONY MS between Cities decision makers and technical consultants

Usefulness of the HARMONY MS platform	Overall Mean	Rank	Cities decision makers Mean	Technical Consultants Mean	t_{cal}	Significant value(ρ)
Ability to integrate with other systems	3.57	1	3.58	3.56	0.146	0.884

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Ease of use	3.31	2	3.38	3.26	0.520	0.605
Ability of users to collaborate for carrying out different functions	3.24	3	3.38	3.11	1.124	0.266
Logic flow of the Harmony MS	3.22	4	3.17	3.26	-0.510	0.612
Overall performance	3.23	5	3.13	3.30	-0.834	0.408
Cost effectiveness	3.14	6	3.21	3.08	0.553	0.583
Level of completeness of the Harmony MS in terms of available models	3.12	7	3.08	3.15	-0.281	0.780

The t-test for equality of means was carried out to investigate whether there were any significant differences between participants of 'SMEs' and 'large organisations' insights on the importance in usefulness of the HARMONY MS (at the 0.05 significance level) (refer

Table *11*). Results here show that all functionality and relevance of HARMONY MS platform models are not significant (>0.05), apart from ability of users to collaborate for carrying out different functions, are not significant (>0.05), and therefore, there are no significant statistical variations between the responses of the SMEs and large organizations. Similarly, there are no significant statistical variations between the responses of cities decision makers and technical consultants (refer Table 11). HARMONY MS platform helps integrating supply and demand models with feedback loops, customized interface for modellers/planners and decision makers, ability to connect existing models (i.e., Aimsum / PTV / Sumo etc.), comparison of scenarios, visualised KPIs and ability to compare/cross-check KPIs, and state-of-the-art: developed by researchers and offered to practitioners in a simple and user-friendly way.

4.3.4 Benefits of HARMONY MS on decision making

Through the online survey, respondents were asked to indicate the level of beneficial of HARMONY MS in improving decision making process of cities, regional and national authorities and spatial planners with evidence of long term impacts of innovative transport technologies and business models on a 4-point Likert item: "Very Beneficial" (4), "Fairly Beneficial" (3), "Beneficial" (2), and "Not at all Beneficial" (1).

It is apparent from Table 12 that the five most benefits of HARMONY MS on decision making include: allows stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, -mid and –long-term effects on air-pollution, carbon footprint, noise and land-use (3.44); supports decision makers with policy appraisal (3.39); the strategic, tactical, and operational simulators allows thorough exploration of impacts allowing decision makers to assess numerous scenarios, strategies and identify the most promising ones in terms of competitiveness, sustainability, social cohesion, equity, and citizen well-being of the metropolitan areas (3.38); offers spatial and transport planning capabilities for metropolitan areas by integrating simulators for strategic, tactical and operational levels providing short-, mid- and long-term impact assessment (3.34); and helps in prioritisation and efficiency of investments for new forms of mobility (3.24). Whereas the three least benefits of HARMONY MS on decision making include increases inter modality and higher resilience of the transport system between the metropolitan region and the neighbouring cities and rural areas (3.00); creates an opportunity for mobility service providers, start-ups and transport authorities to develop, demonstrate and evaluate new mobility services based on

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technological advancements and newly available forms of mobility (3.10); and offers adaptors to integrate existing spatial or transport models to the suite making it a software-neutral platform (3.18).

Table 12: Difference of opinion in relevance of beneficial in improving decision making process of cities, regional and national authorities and spatial planners with evidence of long term impacts of innovative transport technologies and business models between SMEs and Large organisations

Benefits of HARMONY MS platform on decision making process	Overall mean	Rank	SMEs mean	Large mean	t_{cal}	Significant value(ρ)
Allows stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, -mid and –long-term effects on air-pollution, carbon footprint, noise and land-use	3.44	1	3.33	3.31	0.114	0.910
Supports decision makers with policy appraisal	3.39	2	3.52	3.15	1.643	0.109
The strategic, tactical, and operational simulators allows thorough exploration of impacts allowing decision makers to assess numerous scenarios, strategies and identify the most promising ones in terms of competitiveness, sustainability, social cohesion, equity, and citizen well-being of the metropolitan areas	3.38	3	3.37	3.08	1.067	0.293
Offers spatial and transport planning capabilities for metropolitan areas by integrating simulators for strategic, tactical and operational levels providing short-, mid- and long-term impact assessment	3.34	4	3.41	2.77	2.339	0.025*

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Helps in prioritisation and efficiency of investments for new forms of mobility	3.24	5	3.26	2.85	1.512	0.139
Offers adaptors to integrate existing spatial or transport models to the suite making it a software-neutral platform	3.18	6	3.15	3.08	0.253	0.801
Creates an opportunity for mobility service providers, start-ups and transport authorities to develop, demonstrate and evaluate new mobility services based on technological advancements and newly available forms of mobility	3.10	7	3.19	2.77	1.606	0.117
Increases inter modality and higher resilience of the transport system between the metropolitan region and the neighbouring cities and rural areas	3.00	8	2.96	2.92	0.133	0.895

Table 13: Difference of opinion in relevance of beneficial in improving decision making process of cities, regional and national authorities and spatial planners with evidence of long term impacts of innovative transport technologies and business models between Cities and Technical Experts

Benefits of HARMONY MS platform on decision making process	Overall Mean	Rank	Cities decision makers Mean	Technical Consultants Mean	t_{cal}	Significant value(ρ)
Allows stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, -mid and –long-term effects on air-pollution,	3.44	1	3.52	3.37	0.826	0.207

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carbon footprint, noise and land-use						
Supports decision makers with policy appraisal	3.39	2	3.35	3.41	-0.312	0.756
The strategic, tactical, and operational simulators allows thorough exploration of impacts allowing decision makers to assess numerous scenarios, strategies and identify the most promising ones in terms of competitiveness, sustainability, social cohesion, equity, and citizen well-being of the metropolitan areas	3.38	3	3.35	3.41	-0.267	0.791
Offers spatial and transport planning capabilities for metropolitan areas by integrating simulators for strategic, tactical and operational levels providing short-, mid- and long-term impact assessment	3.34	4	3.35	3.33	0.061	0.951
Helps in prioritisation and efficiency of investments for new forms of mobility	3.24	5	3.22	3.26	-0.183	0.855
Offers adaptors to integrate existing spatial or transport models to the suite making it a software-neutral platform	3.18	6	3.17	3.19	-0.051	0.960
Creates an opportunity for mobility service providers, start-ups and transport authorities to develop, demonstrate and evaluate new	3.10	7	3.04	3.15	-0.464	0.645

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mobility services based on technological advancements and newly available forms of mobility						
Increases inter modality and higher resilience of the transport system between the metropolitan region and the neighbouring cities and rural areas	3.00	8	3.22	2.81	0.1.738	0.089

The t-test for equality of means was carried out to investigate whether there were any significant differences between participants of 'SMEs' and 'large organisations' insights on the benefits of HARMONY MS on decision making (at the 0.05 significance level) (refer Table 12). Results here show that benefits of HARMONY MS on decision making are not significant (>0.05), apart from offers spatial and transport planning capabilities for metropolitan areas by integrating simulators for strategic, tactical and operational levels providing short-, mid- and long-term impact assessment, are not significant (>0.05), and therefore, there are no significant statistical variations between the responses of the SMEs and large organizations. Similarly, there are no significant statistical variations between the responses of cities decision makers and technical consultants (refer Table 13).

4.3.5 Benefits of HARMONY MS on policy adaptation

Through the online survey, respondents were asked to indicate the level of beneficial of HARMONY MS on policy adaption on a 4-point Likert item: "Very Beneficial" (4), "Fairly Beneficial" (3), "Beneficial" (2), and "Not at all Beneficial" (1). It is apparent from Table 14 that the five most benefits of HARMONY MS on policy adaption include: integration of Multimodal transport services (3.45), new public transport infrastructures (3.45), widespread deployment of new mobility services (3.31), zero emission zones (3.29), and sustainable mobility, including electro-mobility, bike-sharing, etc. (3.24). Whereas the five least benefits of HARMONY MS on policy adaption include widespread deployment of Autonomous Vehicles, including as part of new mobility services (2.84), remote working practices (3.04), land use development (3.10), urban vehicles access regulation measures (3.14), and last-mile logistics interventions (3.16). HARMONY MS enables end-users to analyse a portfolio of regional and urban interventions for both passenger and freight mobility: policies and capital investments, land-use configurations, economic and sociodemographic assumptions, travel demand management strategies, and new mobility service concepts. HARMONY MS is an important tool for local administrators to reduce emission zones.

Table 14: Difference of opinion in relevance of HARMONY MS will be in adapting policies between SMEs and Large organisations

Benefits of HARMONY MS platform on policy adaptation	Overall Mean	Rank	SMEs Mean	Large Mean	t_{cal}	Significant value(ρ)
Integration of Multimodal transport services	3.45	1	3.37	3.33	0.149	0.882

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New public transport infrastructures	3.32	2	3.30	3.08	0.699	0.489
Widespread deployment of new mobility services	3.31	3	3.33	3.00	1.146	0.259
Zero emission zones	3.29	4	3.22	3.25	-0.106	0.916
Sustainable mobility, including electro-mobility, bike-sharing, etc.	3.24	5	3.19	3.25	-0.230	0.819
Last-mile logistics interventions	3.16	6	3.11	3.33	-0.886	0.381
Urban Vehicles Access Regulation measures	3.14	7	3.15	3.17	-0.710	0.944
Land use development	3.10	8	3.04	3.08	-0.158	0.875
Remote working practices	3.04	9	2.93	3.00	-0.238	0.813
Widespread deployment of Autonomous Vehicles, including as part of new mobility services	2.84	10	2.81	2.42	1.344	0.187

Table 15: Difference of opinion in relevance of HARMONY MS will be in adapting policies between cities decision makers and technical consultants

Benefits of HARMONY MS platform on policy adaptation	Overall Mean	Rank	Cities decision makers Mean	Technical Consultants Mean	t cal	Significant value(ρ)
Zero emission zones	3.29	4	3.23	3.33	-0.518	0.607
Widespread deployment of Autonomous Vehicles, including as part of new mobility services	2.84	10	2.77	2.89	-0.459	0.649
Integration of Multimodal transport services	3.45	1	3.41	3.48	-0.368	0.715

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Widespread deployment of new mobility services	3.31	3	3.23	3.37	-0.622	0.537
New public transport infrastructures	3.32	2	3.14	3.44	-1.315	0.195
Remote working practices	3.04	9	3.00	3.07	-0.295	0.769
Land use development	3.10	8	3.23	3.00	1.008	0.319
Urban Vehicles Access Regulation measures	3.14	7	3.18	3.11	0.319	0.751
Last-mile logistics interventions	3.16	6	3.14	3.19	-0.226	0.822
Sustainable mobility, including electro-mobility, bike-sharing, etc.	3.24	5	3.36	3.15	0.999	0.323

The t-test for equality of means was carried out to investigate whether there were any significant differences between participants of ‘SMEs’ and ‘large organisations’ insights on the benefits of HARMONY MS on policy adoption (at the 0.05 significance level) (refer Table 14). Results here show that benefits of HARMONY MS on policy adoption are not significant (>0.05), and therefore, there are no significant statistical variations between the responses of the SMEs and large organizations. Similarly, there are no significant statistical variations between the responses of cities decision makers and technical consultants (refer Table 15). The effectiveness and potential of HARMONY MS to address a complex zero emission city logistics scenario with multiagent model permits assessment of different transition paths to zero emission vehicles for each logistics segment, to better account for the heterogeneity in preferences of different actors. This provides a better empirical basis for informed decision making on, for example, the planned size of a zero emission zone, and in planning support for urban consolidation centers to ensure accessibility to all stakeholders (Figure *9*: Level of agreement on use the HARMONY MS to enable the transition to a low carbon new mobility era in a sustainable manner).

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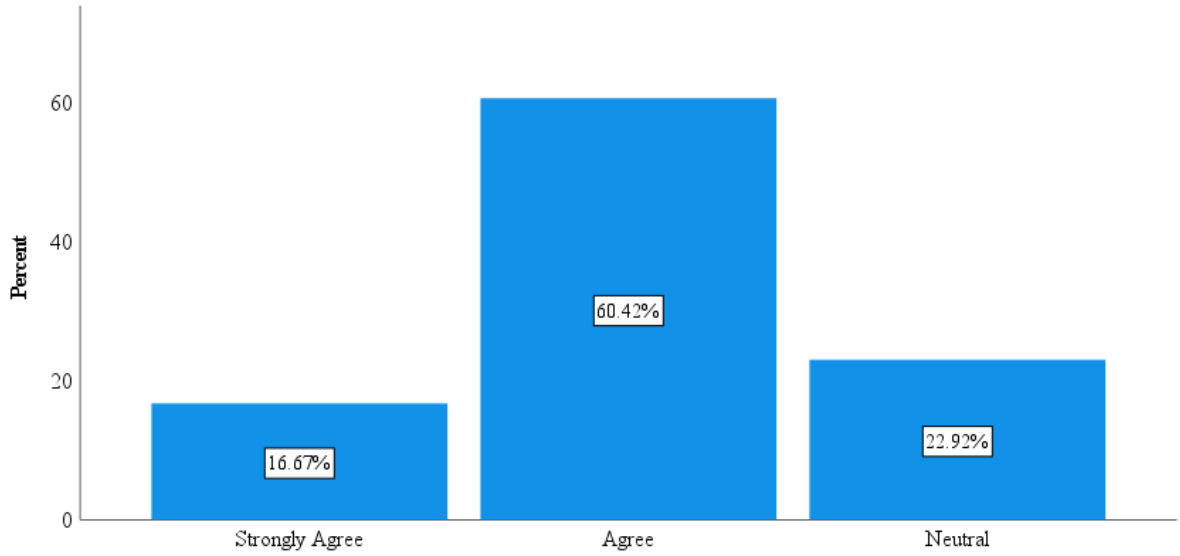

Figure 9: Level of agreement on use the HARMONY MS to enable the transition to a low carbon new mobility era in a sustainable manner

4.4 Summary and recommendations

The 'Future of Transport' is an emerging and evolving concept which envisages citizens having their journey needs met by systems of interconnected transport modes and resources that are available 'as required' as a single item. This system of transport suppliers and users requires that data exchanged between them can be unambiguously requested and understood. Standards provide agreed good practice on how things should be done and as such, standards underpin this interoperability. The HARMONY project have developed a new generation of harmonized spatial and multimodal transport planning tools, which will comprehensively model the dynamics of the changing transport and mobility sectors and impacts of new technologies and services. This section has explored the awareness, importance and benefits of the HARMONY MS on decision making process. Furthermore, it investigated the potential benefits of the new system from a policy adaption perspective. From the questionnaire results, it is clear that relatively high level of awareness among the survey respondents. For successful adoption of the HARMONY MS platform, wider awareness-raising across public and private sector organisations is arguably needed. Land use/transport interaction model was identified as the most relevance model whereas the nowcasting model was identified as the least relevance model of the HARMONY MS platform. Ability to integrate with other systems was identified as one of the most useful feature of the HARMONY MS platform. To allow stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, -mid and –long-term effects on air-pollution, carbon footprint, noise and land-use was identified as a most benefits of HARMONY MS on decision making whereas integration of multimodal transport services was identified as a most important benefits of HARMONY MS on policy adaption. To meet the skills and knowledge gap for uptake of the HAMONY MS, consultants and universities should incorporate integrated spatial and transport planning into the learning objectives of transport planning related subjects. This may lead to new courses focussed entirely on HARMONY MS, necessary to fill the skills gap in industry. However, it is also recognised that specific training is required specific to individuals job roles.

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5 Conclusion

This deliverable provides an overview of activities that aimed to evaluate the standardisation status and potential of the platform, as well as how the platform can be used to support stakeholders in policy adaptation initiatives. The key findings derived for these two important aspects for the future utilization of the HARMONY MS were:

- It is concluded that standardising such a holistic solution is a complex process and therefore, it is recommended that further standardisation of the HARMONY MS needs to consider tighter integration of the different teams working on models at the different levels of the platform. This is important as the need to exchange different data types and formats is a key challenge for standardising the HARMONY MS.
- HARMONY MS brand trust and confidence is crucial. Official endorsement of the platform and services is an important determinant of future successful deployment of the HARMONY MS. Clear systems to facilitate trust and confidence need to be put in place.
- More extensive and intensive stakeholders engagement and debate on the subject of the risks versus benefits of HARMONY MS platform needs to be undertaken to address concerns around security and safety of the system.
- There is a need to promote HARMONY MS across transport departments and a culture of long-term sustainable transport planning. Instability and constant change can be a deterrent to resources investment and hinders implementation in the digital transport space.
- The HARMONY MS can support stakeholders to evaluate and adapt policies related to the integration of multimodal transport services, new public transport infrastructures, widespread deployment of new mobility services and zero emission zones.
- The HARMONY MS offers many benefits to planners and these have been recognised by the participants of the training workshops organised as part of the project.
- External stakeholders recognised useful features of the platform including its ability to integrate with other systems, its ease of use and the ability of users to collaborate for carrying out different functions.

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APPENDIX A1: Tactical passenger simulator – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY MS operation (if None in column E)	Effort required for standardising the data for the developed component/model (if None in column E)
Skim with travel times	Input	XLSX	A matrix with travel times (in minutes) between all zones of the TPS. In excel format (.xlsx)	No	Yes	- OpenStreetMap API - Google Maps API	High	High	High
Links	Input	SHP/ZIP	The links of the road network. In shapefile (.shp) or zip (.zip) format	Regular format of the links/nodes/zones shapefiles	No	- OpenStreetMap API - Google Maps API	High	High	High
Nodes	Input	SHP/ZIP	The nodes of the road network. In shapefile (.shp) or zip (.zip) format	Regular format of the links/nodes/zones shapefiles	No	- OpenStreetMap API - Google Maps API	High	High	High
Zones	Input	SHP/ZIP	The zones of the TFS. In shapefile (.shp) or zip (.zip) format	Regular format of the links/nodes/zones shapefiles	No	- OpenStreetMap API - Google Maps API	High	High	High
Socio-economic data	Input	CSV file	Information about each zone, e.g. population and employment. In comma separated (.csv) format	Depends on city (census source standard varies across countries)	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	High	High	High
Synthetic Households synthesized by the Population Synthesis module	Input	CSV file	The synthetic households of the TPS including all variables needed for travel models. In comma separated (.csv) format	No	Yes	None	Low	High	High
Attraction points of interest in zones	Input	CSV file	A shapefile containing the atractions in the zones of the study area (education, work,	osm data	No	- OpenStreetMap API	Low	High	High

			leisure, etc.) In comma separated (.csv) format			- Google Maps API			
Different agent classes	Input	CSV file	Categories in which the simulators splits the agents into (e.g. full time worker, student, etc.) In comma separated (.csv) format	No	Yes	None	Low	High	High
List of activities and participants of each activity	Input	CSV file	List of the activities produced by the TPS and the corresponding person classes who participate. In comma separated (.csv) format	No	Yes	None	Low	Low	Neutral
List of available travel modes in the area	Input	Shapefile	List of travel modes in the area for which the TPS produces trips. In comma separated (.csv) format	No	Yes	None	Low	Low	Neutral
Parameters from Mobility Tool Ownership model	Input	CSV file	List of the estimated parameters from the Mobility Tool Ownership model. In comma separated (.csv) format	No	Yes	None	Low	Low	Neutral
Rules to define household and individual budget	Input	CSV file	List of the rules to define household and individual budget. In comma separated (.csv) format	No	Yes	None	Low	Low	Neutral
List of steps to apply model parameters to the synthetic population files and generate outputs	Input	CSV file	List of steps to apply model parameters to the synthetic population files and generate outputs. In comma separated (.csv) format	No	Yes	None	Low	Low	Neutral
ApplicationResults	Output	CSV file	The results of the applied parameters to the synthetic population for all models, as a CSV-file	No	Yes	None	Low	Low	Neutral
DailySchedules	Output	CSV file	Main output of the TPS: the detailed, daily agent activities and travel in a scheduled sequence	No	Yes	None	Low	High	High

OD matrices per time of day (multiple files)	Output	CSV file	The agent schedules aggregated into OD matrices per mode (multiple files) as a CSV-file	OMX library	Yes	- OpenStreetMap API - Google Maps API	Low	High	High
simulation results of workers decisions and activity participation	Output	CSV file	The passenger demand in the study area, as a CSV-file	No	Yes		Low	High	High
Calculated main aggregate statistics	Output	CSV file	Modal split, pkms, flows, as a CSV-file	No	Yes	None	Low	Low	Neutral
Calculated main accessibility indicators	Output	CSV file	Main accessibility indicators, as a CSV-file	No	Yes	None	Low	Low	High

APPENDIX A2: Tactical freight simulator – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY MS operation (if None in column E)	Effort required for standardising the data for the developed component/model (if None in column E)
Skim with travel times	Input	Propertiary data format (binary)	A matrix with travel times (in seconds) between all zones of the TFS	None	Yes	None	Very low	Very low	Very high
Skim with travel distance	Input	Propertiary data format (binary)	A matrix with travel distances (in meters) between all zones of the TFS	None	Yes	None	Very low	Very low	Very high
Links	Input	Shapefile	The links of the road network	None	No	- OpenStreetMap API - Google Maps API	High	High	High

Nodes	Input	Shapefile	The nodes of the road network	None	No	- OpenStreet Map API - Google Maps API	High	High	High
Zones	Input	Shapefile	The zones of the TFS	None	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Socio-economic data	Input	CSV file	Information about each zone, e.g. population and employment	None	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Super zones	Input	CSV file	The external or 'super' zones of the TFS	NUTS3 zones	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Commodity matrix SFS	Input	CSV file	The flows of tonnes between larger (NUTS3) regions, coming from the Strategic Freight Simulator (SFS)	NUTS3 zones, NSTR commodity types	No	- NUTS zones - Administrative units (provinces, municipalities,	Neutral	Low	High

						postcode areas) - NSTR commodity types - NST commodity types			
Firms SFS	Input	CSV file	The synthetic firm population, coming from the Strategic Freight Simulator (SFS)	CBS employment sector	Yes	None	Very low	Very low	Very high
Distribution centers (DCs)	Input	CSV file	Centers for the distribution of freight.	None	No	- OpenStreet Map API - Google Maps API	High	High	Neutral
Make distribution	Input	CSV file	The probability of goods of type NSTR [row] being made by a firm of sector [column].	NSTR commodity types, CBS employment sector	No	- NSTR commodity types - NST commodity types	Neutral	High	Neutral
Use distribution	Input	CSV file	The probability of goods of type NSTR [row] being used by a firm of sector [column].	NSTR commodity types, CBS employment sector	No	- NSTR commodity types - NST commodity types	Neutral	High	Neutral
Parcel nodes	Input	Shapefile	The centers for last-mile delivery of parcels. In shapefile (.shp) or zip (.zip) format.	OpenStreetMap API	Yes	- OpenStreet Map API - Google Maps API	High	High	Neutral
CEP shares	Input	CSV file	The market shares of the parcel couriers. In comma separated (.csv) format.	None	No	None	Very low	Very low	Very high
Departure time parcels	Input	CSV file	Cumulative probabilities of departure hours for parcel tours.	None	Yes	None	Very low	Very low	Very high
Emission factors (rural roads - empty vehicle)	Input	CSV file	Emission factors per vehicle type, for rural roads with an empty vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel)	High	High	High

						- EN16258 (well-to-wheel)			
Emission factors (rural roads - full vehicle)	Input	CSV file	Emission factors per vehicle type, for rural roads with a fully loaded vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel) - EN16258 (well-to-wheel)	High	High	High
Emission factors (highways - empty vehicle)	Input	CSV file	Emission factors per vehicle type, for highways with an empty vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel) - EN16258 (well-to-wheel)	High	High	High
Emission factors (highways - full vehicle)	Input	CSV file	Emission factors per vehicle type, for highways with a fully loaded vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel) - EN16258 (well-to-wheel)	High	High	High
Emission factors (urban roads - empty vehicle)	Input	CSV file	Emission factors per vehicle type, for urban roads with an empty vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel) - EN16258 (well-to-wheel)	High	High	High
Emission factors (urban roads - full vehicle)	Input	CSV file	Emission factors per vehicle type, for urban roads with a fully loaded vehicle.	EN16258 (tank-to-wheel)	No	- EN16258 (tank-to-wheel) - EN16258 (well-to-wheel)	High	High	High
ZEZ consolidation	Input	CSV file	Consolidation potential in the Zero Emission scenario, per logistic segment.	None	Yes	None	Very low	Very low	Very high
ZEZ scenario	Input	CSV file	Transitions of vehicle/combustion types in the Zero Emission scenario, per logistic segment.	None	Yes	None	Very low	Very low	Very high
Cost per vehicle type	Input	CSV file	Costs per hour and kilometer, per vehicle type.	None	No	None	Very low	Very low	Very high

Cost sourcing	Input	CSV file	Costs per hour and kilometer, regardless of vehicle type.	None	No	None	Very low	Very low	Very high
Parameters - Time of day	Input	CSV file	Model coefficients for the time-of-day choice model of the Shipment Synthesizer module.	None	Yes	None	Very low	Very low	Very high
Parameters - Shipment size and vehicle type	Input	CSV file	Model coefficients for the shipment-size/vehicle-type choice model of the Shipment Synthesizer module.	None	Yes	None	Very low	Very low	Very high
Parameters - End tour first	Input	CSV file	Model coefficients for the 'End tour first' choice model of the Tour Formation module.	None	Yes	None	Very low	Very low	Very high
Parameters - End tour later	Input	CSV file	Model coefficients for the 'End tour later' choice model of the Tour Formation module.	None	Yes	None	Very low	Very low	Very high
Parameters - Parcel demand B2C	Input	CSV file	Model coefficients for the ordered logit model of the Parcel Demand module.	None	Yes	None	Very low	Very low	Very high
Parameters - Distance decay	Input	CSV file	Model coefficients for the distance decay function of the Service module	None	Yes	None	Very low	Very low	Very high
MRDHtoNUTS3 label	Input	CSV file	Mapping between MRDH and NUTS3 zones	None	Yes	None	Very low	Very low	Very high
MRDHtoCOROP label	Input	CSV file	Mapping between MRDH and COROP zones	None	Yes	None	Very low	Very low	Very high
NUTS3toMRDH	Input	CSV file	Mapping between NUTS3 and MRDH zones	None	Yes	None	Very low	Very low	Very high
NSTR to logistic segment	Input	CSV file	Mapping between NSTR goods types and logistic segments.	None	Yes	None	Very low	Very low	Very high
Vehicle capacity	Input	CSV file	Carrying capacity (kg) per vehicle type.	None	Yes	None	Very low	Very low	Very high

Logistic flowtypes	Input	CSV file	Shares of the logistic flowtypes, per logistic segment.	None	Yes	None	Very low	Very low	Very high
Shipments	Output	CSV file / Shapefile	The synthesized shipments from/to/in the study area	None	Yes	None	Very low	Very low	Very high
Shipments (after scheduling)	Output	CSV file	The synthesized shipments from/to/in the study area, enriched after the Tour Formation module.	None	Yes	None	Very low	Very low	Very high
Tours	Output	CSV file / Shapefile	The tours that transport the synthesized shipments.	None	Yes	None	Very low	Very low	Very high
Trip matrix	Output	CSV file	The number of trips between the zones.	None	Yes	None	Very low	Very low	Very high
Parcel demand	Output	CSV file / GeoJSON	The parcel demand in the study area.	None	Yes	None	Very low	Very low	Very high
Parcel schedules	Output	CSV file / GeoJSON	The parcel tours in the study area.	None	Yes	None	Very low	Very low	Very high
Trip matrix parcels	Output	CSV file	The number of trips between the zones for parcel delivery.	None	Yes	None	Very low	Very low	Very high
Trips van construction	Output	Propertiary data format (binary)	The number of van trips for construction purposes between all zones.	None	Yes	None	Very low	Very low	Very high
Trips van service	Output	Propertiary data format (binary)	The number of van trips for service purposes between all zones.	None	Yes	None	Very low	Very low	Very high
Links loaded	Output	CSV file / Shapefile	The links of the road network with intensities and emissions.	None	Yes	None	Very low	Very low	Very high

APPENDIX A3: Tactical freight simulator – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY	Effort required for standardising the data for the developed

								MS operation (if None in column E)	component/model (if None in column E)
Zones	Input	Shapefile	The zones of the TFS	None	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Socio-economic data	Input	CSV file	Information about each zone, e.g. population and employment.	None	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Commodity matrix	Input	CSV file	The flows of tonnes between larger (NUTS3) regions.	NUTS3 zones	No	- NUTS zones - Administrative units (provinces, municipalities, postcode areas)	Neutral	Low	High
Distribution centers (DCs)	Input	CSV file	Centers for the distribution of freight.	None	No	- OpenStreet Map API - Google Maps API	High	High	Neutral
Surface of DCs (m2) per NUTS3-region.	Input	CSV file	Surface of DCs (m2) per NUTS3-region.	None	No	- OpenStreet Map API	High	High	Neutral

						- Google Maps API			
Parameters - Production SIF	Input	CSV file	Model coefficients for the production regression model of the Spatial Interaction Freight module.	None	Yes	None	Very low	Very low	Very high
Parameters - Attraction SIF	Input	CSV file	Model coefficients for the attraction regression model of the Spatial Interaction Freight module.	None	Yes	None	Very low	Very low	Very high
MRDHtoNUTS3 label	Input	CSV file	MRDHtoNUTS3 description	None	Yes	None	Very low	Very low	Very high
NUTS3toMRDH label	Input	CSV file	NUTS3toMRDH description	None	Yes	None	Very low	Very low	Very high
SBI-sector to segs-sector	Input	CSV file	Coupling table between the SBI-sectors and the sectors in the 'segs' file.	None	Yes	None	Very low	Very low	Very high
Firm size distribution	Input	CSV file	Distribution of firm sizes per SBI-sector.	SBI sectors	No	None	Very low	Very low	Very high
Firms	Output	CSV file	The synthesized firms in the study area.	None	Yes	None	Very low	Very low	Very high
Commodity matrix NUTS3	Output	CSV file	The freight flows between NUTS3-regions.	None	Yes	None	Very low	Very low	Very high

APPENDIX A4: Demographic forecasting model – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY MS operation (if None in column E)	Effort required for standardising the data for the developed component/model (if None in column E)
Households	Input	CSV file	This file contains the households at base year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low

HouseholdsRate	Input	CSV file	This file contains the yearly households rates.	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Population	Input	CSV file	This file contains the population at base year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
PopulationRate	Input	CSV file	This file contains the yearly population rates.	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
MacroZone	Input	CSV file	This file contains the zones to macro zones mapping.	*any*	No	NUTS3 zones	High	High	Very low
Years	Input	CSV file	This file contains the years used in the model	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
UnivHousing	Input	CSV file	This file contains the people who lives in university housings	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
UnivShare	Input	CSV file	This file contains the share of the people who is studying at university	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
YearsToExport	Input	CSV file	This file contains the years that you want to export as separate output files	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Results Households	Output	CSV file	This file contains the households results	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Results Population	Output	CSV file	This file contains the population results	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Total population by year	Output	CSV file	This file contains the total population by year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Population distribution at base year	Output	CSV file	This file contains the population distribution by zone at base year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Population distribution at middle/final year of projections	Output	CSV file	This file contains the population distribution by zone at middle/final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low

Population distribution at final year of projections	Output	CSV file	This file contains the population distribution by zone at final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
School pupils distribution at base year	Output	CSV file	This file contains the school pupils distribution by zone at base year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
School pupils distribution at middle/final year of projections	Output	CSV file	This file contains the school pupils distribution by zone at middle/final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
School pupils distribution at final year of projections	Output	CSV file	This file contains the school pupils distribution by zone at final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
University population distribution at base year	Output	CSV file	This file contains the university population distribution by zone at base year	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
university population distribution at middle/final year of projections	Output	CSV file	This file contains the university population distribution by zone at middle/final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
university population distribution at final year of projections	Output	CSV file	This file contains the university population distribution by zone at final year of projections	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low
Population by age, gender and year	Output	CSV file	This file contains the population by age, gender and year, aggregated for the whole study area. The main goal of this output is to use it for the demographic pyramid graph	EUROSTAT Segmentation	No	EUROSTAT Segmentation	High	High	Very low

APPENDIX A5: Regional economy model – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY MS operation (if None in column E)	Effort required for standardising the data for the developed component/model (if None in column E)
Base Jobs	Input	Shapefile	This file contains the total jobs by economic sector at base year	aggregation of NACE-2D economic sectors	No	aggregation of NACE-2D economic sectors	High	High	High
Beta Coefficients	Input	CSV file	This file contains the coefficients for the beta parameter (TrendsPar) in the model equations	None	No	None	Neutral	Neutral	High
Macro Economic Trends	Input	CSV file	This file contains the macro economic trends used in the model equations	None	No	None	Neutral	Neutral	High
Micro Economic Trends	Input	CSV file	This file contains the micro economic trends used nt he model equations	None	No	None	Neutral	Neutral	High
Technical Coefficient	Input	CSV file	This file contains the coefficient about the inter-sector interation	None	No	None	Neutral	Neutral	High
Trends Constant	Input	CSV file	This file contains the model calibration constants	None	No	None	Neutral	Neutral	High
Trends Parameter	Input	CSV file	This file contains the model calibration parameter for each economic sector	None	No	None	Neutral	Neutral	High
Zone Distribution	Input	CSV file	This file contains the zone distribution of the jobs by economic secotr for the study area	aggregation of NACE-2D economic sectors	No	aggregation of NACE-2D economic sectors	High	Neutral	Very low
Base Income	Input	CSV file	This file contains the mean personal income at base year. It is not mandatory	None	No	None	High	Neutral	High
Tot Pop By Year	Input	CSV file	This file contains the population for each year	None	No	None	Neutral	Neutral	High

year_out	Input	CSV file	If you want to export specific years of jobs estimation, you can specify here, as list of int	None	No	None	Neutral	Neutral	High
ZoneShapefile	Input	CSV file	Zone shapefile used to plot the model results	NUTS3 zone	No	NUTS3 zone	High	High	Very low
Yearly jobs - csv	Output	CSV file	Yearly jobs by economic sector, in csv format	aggregation of NACE-2D economic sectors	No	aggregation of NACE-2D economic sectors	Neutral	Neutral	Very low
Yearly jobs - xls	Output	Excel file	Yearly jobs by economic sector, in csv format	aggregation of NACE-2D economic sectors	No	aggregation of NACE-2D economic sectors	Neutral	Neutral	Very low
Income	Output	CSV file	Total income per year	None	No	None	Neutral	Neutral	High
Total jobs at the year chosen by the user (base year)	Output	CSV file	Total jobs at the year chosen by the user (typically base year)	None	No	None	Neutral	Neutral	High
Jobs map by zone at middle year (if any)	Output	CSV file	Jobs map by zone at middle year (if any)	None	Yes	Non	Neutral	Neutral	High
Yearly jobs segmented by zone and economic sector	Output	CSV file	Yearly jobs by economic sector, segmented by zone	aggregation of NACE-2D economic sectors	No	aggregation of NACE-2D economic sectors	Neutral	Neutral	Very low
Total jobs by zone	Output	CSV file	yearly jobs by zone, aggregated on the economic sectors	None	No	None	Neutral	Neutral	High

APPENDIX A6: Land development model – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY MS operation	Effort required for standardising the data for the developed component/model

								(if None in column E)	(if None in column E)
High Risk Flood zones	Input	CSV file	This file contains the high risk flood zones	None	No	None	Neutral	Neutral	High
Oxfordshire boundaries zones	Input	CSV file	This file contains the administrative boundaries of the case study	MSOA, LSOA, OA	No	MSOA, LSOA, OA	Neutral	Neutral	High
Historical conservation areas	Input	CSV file	This file contains the historical conservation areas of the case study	None	No	None	Neutral	Neutral	High
Conservation areas	Input	CSV file	This file contains the conservation areas of the case study.	None	No	None	Neutral	Neutral	High
Sites of special scientific interest	Input	CSV file	This file contains the sites of special scientific interest of the case study	None	No	None	Neutral	Neutral	High
Areas of Outstanding Natural Beauty (AONB)	Input	CSV file	This file contains the Areas of Outstanding Natural Beauty (AONB) of the case study	None	No	None	Neutral	Neutral	High
Job accessibility	Input	CSV file	This file contains the job accessibility	None	Yes	None	Neutral	Neutral	Neutral
Housing Accessibility	Input	CSV file	This file contains the Housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
Population	Input	CSV file	This file contains the population density of the case study	None	No	None	Neutral	Neutral	High
Natural nature reserves	Input	CSV file	This file contains the natural nature reserves of the case study	None	No	None	Neutral	Neutral	High
Flood zones	Input	CSV file	This file contains the flood zones with return period: 100 years.	None	No	None	Neutral	Neutral	High
Greenbelt	Input	CSV file	This file contains the green belts in the case study	None	No	None	Neutral	Neutral	High

Athens boundaries zones	Input	CSV file	This file contains the administrative boundaries of the case study	None	Yes	None	Neutral	Neutral	High
Surface water	Input	CSV file	This file contains the surface water (rivers and lakes) of the case study	None	No	None	Neutral	Neutral	High
Highways	Input	CSV file	This file contains the highways of the case study	None	No	None	Neutral	Neutral	High
Protected areas	Input	CSV file	This file contains the protected areas of the case study.	None	No	None	Neutral	Neutral	High
NATURA 2000 Areas	Input	CSV file	This file contains the Areas protected under Natura 2000 (the largest coordinated network of protected areas in the world) of the case study	None	No	None	Neutral	Neutral	High
Parks and gardens	Input	CSV file	This file contains the parks and gardens of the case study	None	No	None	Neutral	Neutral	High
Slope	Input	CSV file	This file contains the slope degree of the case study	None	No	None	Neutral	Neutral	High
Population Density	Input	CSV file	This file contains the population density of the case study	None	No	None	Neutral	Neutral	High
GS2500	Input	CSV file	This file contains the 2500m distance from green spaces of the case study	None	No	None	Neutral	Neutral	High
Turin FUA	Input	CSV file	This file contains the Turin Functional Urban Area	None	No	None	Neutral	Neutral	High
BDTRE railcover	Input	CSV file	This file contains the BDTRE rail cover	None	No	None	Neutral	Neutral	High
DEM slope	Input	CSV file	This file contains the slope of the case study are	None	No	None	Neutral	Neutral	High
PAIfloodzone	Input	CSV file	This file contains the PAI floodzone	None	No	None	Neutral	Neutral	High

PTC forest cover	Input	CSV file	This file contains the PTC forest cover	None	No	None	Neutral	Neutral	High
PRG cemetery	Input	CSV file	This file contains the cemeteries	None	No	None	Neutral	Neutral	High
Turin LUTI Geopackage	Input	CSV file	This file contains the Turin LUTI Geopackage	None	No	None	Neutral	Neutral	High
PRG industry	Input	CSV file	This file contains the PRG industrial sites	None	No	None	Neutral	Neutral	High
PTC urban green	Input	CSV file	This file contains the urban green areas	None	No	None	Neutral	Neutral	High
PPR conservation area	Input	CSV file	This file contains the PPR conservation areas	None	No	None	Neutral	Neutral	High
Housing accessibility	Input	CSV file	This file contains the Housing accessibility by public transport of the case study 2045	None	No	None	Neutral	Neutral	High
Land Desirability	Output	PNG	This file contains Land Desirability	None	No	None	Neutral	Neutral	Neutral
Sc1Diff1945	Output	PNG	Sc1Diff1945 description	None	No	None	Neutral	Neutral	High
Land Suitability	Output	PNG	This file contains Scenario's Land Suitability	None	No	None	Neutral	Neutral	Neutral

APPENDIX A7: Land-use/transport interaction model – standardisation information

Data type name	Data use	Data format (or file_format)	Description	Supported Standard (enter None if no standard)	Data representation developed in-house	State any known standards for this data type	What is the potential of standardising this data type (ie, location specific, country specific codes, etc.)	Usefulness of standardisation for HARMONY	Effort required for standardising the data for the developed

								MS operation (if None in column E)	component/model (if None in column E)
Zones codes	Input	CSV file	This file contains the zone codes	None	No	None	Neutral	Very high	Very high
Zones coordinates	Input	CSV file	This file contains the zone coordinates	None	No	WGS84	Neutral	Neutral	Low
Intra-zones distances	Input	CSV file	This file contains the intra-zones distances	None	No	None	Neutral	Very high	Neutral
Cij	Input	CSV file	This file contains the cost matrix for private and public transportation	None	Yes	None	Neutral	Very high	High
Employment	Input	CSV file	This file contains employment data	None	No	None	Neutral	Very high	High
Households floorspace	Input	CSV file	This file contains households floorspace	None	No	None	Low	Very high	High
Zones shapefile	Input	SHP file	This is a zip file that contains three files, a shapefile ending in SHP containing the zoning system for this application, as well as a SHX and a DBF file	None	No	Census zoning system (different for each country)	Low	Very high	Very high
Zones centroids shapefile	Input	SHP file	This shapefile contains the centroids of the zoning system for this application	None	Yes	None	Neutral	Neutral	Neutral
Main roads shapefile	Input	SHP file	This shapefile contains the main roads for this application	None	No	None	Neutral	Very high	Very high
Geolytix supermarket data	Input	CSV file	This is the open data version of the Geolytix restricted data regression - uses linear regression parameters derived from restricted data that we can't release	None	Yes	None	Very low	Very high	Very high
Population	Input	CSV file	Census data: population per zone	None	No	By census zoning system	Neutral	Very high	High

						(different for each country)			
Lookup population	Input	CSV file	Lookup table containing geographical information for zones	None	Yes	None	Neutral	Neutral	Neutral
Oxfordshire MSOAs	Input	CSV file	List of MSOA zones in Oxfordshire	MSOA zones	No	MSOA zones	Low	Very high	Very high
Cost matrix	Input	CSV file	Roads cost matrix from QUANT (travel times in minutes)	None	Yes	None	Very low	Very high	Very high
Observed flows	Input	CSV file	Observed flows from QUANT	None	Yes	None	Low	Very high	Very high
Oxfordshire new housing developments	Input	CSV file	This file contains the table of new housing developments in Oxfordshire	None	Yes	None	Neutral	Neutral	Neutral
Employment data	Input	CSV file	This file contains the employment data by sector and by MSOA zone in Great Britain	None	No	ONS	Low	High	High
Number of dwellings	Input	CSV file	This file contains a table with the number of dwellings per zone in Oxfordshire	None	Yes	None	Low	High	High
Oxfordshire Postcodes	Input	CSV file	This file contains the postcodes of the Oxfordshire County	None	Yes	None	Neutral	Neutral	Neutral
Primary Schools data	Input	CSV file	This file contains primary schools data (locations and capacities) for England, Wales and Scotland	None	No	None	Neutral	High	High
MSOAs shapefile	Input	SHP file	Shapefile containing the zoning system adopted for the case study area	MSOA zones	No	MSOA, LSOA, OA for UK case studies	Low	Very high	Very high
Road Network shapefile	Input	SHP file	Shapefile containing the road network for the case study area	None	No	None	Low	High	Very high
MSOA centroids shapefile	Input	SHP file	Shapefile containing the MSOA centroids for the case study area	None	Yes	None	Neutral	Neutral	Neutral

Calibration data for roads	Input	CSV file	This file contains the roads calibration data (observed/modelled flows) for the journey to work model	None	No	None	Low	High	High
Population	Input	CSV file	This file contains population data	None	No	By census zoning system (different for each country)	Low	High	High
Hospitals	Input	CSV file	This file contains hospital data	None	No	None	Low	High	High
Primary schools capacity	Input	CSV file	This file contains primary schools capacities	None	No	None	Low	High	High
Data schools pupils	Input	CSV file	This file contains schools' pupils data	None	No	None	Low	High	High
Zones shapefile	Input	SHP file	This shapefile contains the zoning system for this application	None	No	MSOA, LSOA, OA for UK case studies	Low	Very high	Very high
Job accessibility	Output	CSV file	This file contains the job accessibility	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility	Output	CSV file	This file contains the housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
JtW table	Output	CSV file	This table contains all the flows for all the modes of the Journey to work model together with jobs and housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
JtW flows	Output	CSV file	This file contains the journey to work public flows probabilities	None	Yes	None	Neutral	Neutral	Neutral
Population change	Output	PNG file	This file contains a map of the population change	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility change (public)	Output	PNG file	This file contains a map of the housing accessibility (public) change	None	Yes	None	Neutral	Neutral	Neutral

Housing accessibility change (private)	Output	PNG file	This file contains a map of the housing accessibility (private) change	None	Yes	None	Neutral	Neutral	Neutral
Jobs accessibility change	Output	PNG file	This file contains a map of the housing accessibility change	None	Yes	None	Neutral	Neutral	Neutral
JobsTijPublic FlowMap	Output	PNG file	PNG of JobsTijPublic FlowMap	None	Yes	None	Neutral	Neutral	Neutral
Job accessibility	Output	CSV file	This file contains the job accessibility	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility	Output	CSV file	This file contains the housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
JtW table	Output	CSV file	This table contains all the flows for all the modes of the Journey to work model together with jobs and housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
JtW flows	Output	CSV file	This file contains the journey to work roads flows	None	Yes	None	Neutral	Neutral	Neutral
JtW flows (arrow vectors)	Output	GEOJSON file	This file contains the journey to work roads flows arrow vectors	None	Yes	None	Neutral	Neutral	Neutral
Population change	Output	PNG file	This file contains a map of the population change	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility	Output	PNG file	This file contains a map of the housing accessibility change	None	Yes	None	Neutral	Neutral	Neutral
Jobs accessibility change	Output	PNG file	This file contains a map of the housing accessibility (roads) change	None	Yes	None	Neutral	Neutral	Neutral
Results shapefile	Output	SHP file	This shapefile contains the results in the for of a map	None	Yes	None	Neutral	Neutral	Neutral
Flows map jobs	Output	PNG file	This shapefile contains the commuting flows map	None	Yes	None	Neutral	Neutral	Neutral
Job accessibility	Output	CSV file	This file contains the job accessibility	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility	Output	CSV file	This file contains the housing accessibility	None	Yes	None	Neutral	Neutral	Neutral
JtW table	Output	CSV file	This table contains all the flows for all the modes of the Journey to work model together with jobs and housing accessibility	None	Yes	None	Neutral	Neutral	Neutral

JtW flows	Output	CSV file	This file contains the journey to work roads flows	None	Yes	None	Neutral	Neutral	Neutral
Population change	Output	PNG	This file contains a map of the population change	None	Yes	None	Neutral	Neutral	Neutral
Housing accessibility change	Output	PNG	This file contains a map of the housing accessibility (roads) change	None	Yes	None	Neutral	Neutral	Neutral
Jobs accessibility change	Output	PNG	This file contains a map of the housing accessibility change between	None	Yes	None	Neutral	Neutral	Neutral
Results shapefile	Output	PNG	This shapefile contains the results in the for of a map	None	Yes	None	Neutral	Neutral	Neutral
Flows map jobs	Output	PNG	This shapefile contains the commuting flows map for roads 2019	None	Yes	None	Neutral	Neutral	Neutral

APPENDIX B

Evaluation of the HARMONY Model Suite for Integrated Spatial and Transport Planning - Final

Purpose of the Survey

This online survey is implemented as part of the H2020 HARMONY project, which envisages developing a new generation of harmonised spatial and multimodal transport planning tools aiming at enabling metropolitan area authorities to lead the transition to a low carbon new mobility era in a sustainable manner. The goal of this survey is to evaluate a software-agnostic multiscale/multi-dimensional simulation platform for spatial and transport planning of the future. The project aims to address the following multi criteria objective.

1. How to satisfy planners and decision makers' need to have a tool that evaluate the impact of investments, policies, new technologies and mobility services.

2. How to capture their potential "ripple effect".

3. How can strategic (land-use) and tactical (demand) choices as well as operational (network performance) modelling can be brought together for predicting future economic, societal and environmental impact.

4. Potential figure of how a policy may have an impact of different scales and their connections.

Before starting this survey, you need to consent to participate in the study. By not giving consent for any one of the elements below you may be deemed ineligible for the study.

For any concerns or suggestions, please do not hesitate to contact us via email: suresh.renukappa@wlv.ac.uk

It takes 10 to 15 minutes to complete this survey.

The HARMONY consortium really appreciates your participation! Thank you!

Participant's statement

- There are no right or wrong answers to the questions in this survey. Select the most appropriate answer for each question based on your view/experience.

- There may be questions which appear irrelevant or impertinent. However, it is necessary in this study that all questions are answered, as the questionnaire is designed to achieve particular research objectives, and it is hoped not to offend respondents in any way. If there are questions which you are unwilling or unable to answer, skip them and continue answering the remainder of the questions.
- Remember that both your identity and that of the company/organisation you work for will remain strictly confidential and anonymous.
- I understand that participation is entirely voluntary. If I decide I no longer wish to take part in this research I can withdraw at any time before submitting the answers to the survey, without giving a reason, and any data I have provided will not be used.
- I understand that my data gathered in this study will be stored anonymously and securely. It will not be possible to identify me in any publications.
- I understand that the data will not be made available to any commercial organisations but is solely the responsibility of the researchers undertaking this study.
- I understand that I will not benefit financially from this study or from any possible outcome it may result in the future.
- I am aware of who I should contact if I wish to lodge a complaint.

Consent to Participate

1.

I confirm that I have read and understood the above statements and I consent to participate in this study:

- ○ Yes
- ○ No

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Part 1 - General Information

2.

Please indicate your organisations line of business:

3.

Please select the perspective or position which best identifies you as a survey respondent.

- Regional Transport Planning Authorities
- Consultant
- Local Transport Planning Authorities
- Local Highway Authorities
- Regional Development Agencies
- Passenger Transport Authority
- Public Transport Operators
- Transport Systems Analyst
- Freight Transport Operator
- Transport Services Integrators
- Other, please specify

4.

What is your gender?

- Male

- Female
- Other
- Prefer not to answer

5.

Which country do you work in?

6.

Please indicate your age:

- 18-24
- 25-30
- 31-40
- 41-50
- 51-60
- 60+
- Prefer not to answer

7.

What is the size of the organisation you work for?

- Micro (< 10 employees)
- Small (10 to 49 employees)
- Medium (50 to 249 employees)
- Large (>250 employees)

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Part 2 - Awareness of the HARMONY Model Suite (HARMONY MS)

8.

How informed would you say you are about the HARMONY MS?

- Not at all informed
- Slightly informed
- Fairly well informed
- Very well informed

Part 3 - Functionality of the HARMONY MS

9.

Please rate the following functionality of Strategic Models of HARMONY MS on a scale of how relevant you believe they are for being successful in your role? Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very Relevant; 3 = Fairly Relevant; 2 = Relevant; 1 = Not Relevant

	Very Relevant	Fairly Relevant	Relevant	Not Relevant
Land use/Transport interaction model (i.e., Explains the location of economic and demographic activities at a scale usually above Traffic Analysis Zones)	○	○	○	○
Demographic forecasting model (i.e., Predict aggregated population change of spatial zones)	○	○	○	○
Land supply and development model (i.e., Simulates aggregate patterns of land use and location)	○	○	○	○
Regional economy model (i.e., Generate future employment (including services and health activities))	○	○	○	○
Strategic freight simulator model (i.e., Capture the organization of distribution processes)	○	○	○	○
Synthetic population model (i.e., “Translator” of aggregate to disaggregate data, synthesising households and agents to fit aggregate data distributions).	○	○	○	○
Vehicle ownership model (i.e., To predict vehicle ownership by household and population type)	○	○	○	○

Long-term households and individual choices model (i.e., Enrich the synthesised population with long-term household and individual-level mobility choices).	○	○	○	○

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10.

Please rate the following functionality of Tactical Models of HARMONY MS on a scale of how relevant you believe they are for being successful in your role? Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very Relevant; 3 = Fairly Relevant; 2 = Relevant; 1 = Not Relevant

	Very Relevant	Fairly Relevant	Relevant	Not Relevant
Tactical Freight Simulator model (i.e., Establishing a comprehensive multi-agent simulation of the logistic decision making).	○	○	○	○
Tactical Passenger Simulator (i.e., The generation-allocation models and the daily schedule models).	○	○	○	○

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11.

Please rate the following functionality of Operational Models of HARMONY MS on a scale of how relevant you believe they are for being successful in your role? Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very Relevant; 3 = Fairly Relevant; 2 = Relevant; 1 = Not Relevant

	Very Relevant	Fairly Relevant	Relevant	Not Relevant
Operational Passenger Simulator model (i.e., Handle mid-term and short-term people demand and supply interactions and decisions respectively).	○	○	○	○
Operational Freight Simulator model (i.e., Emulates the decisions of logistics operators to meet the daily demands.)	○	○	○	○
Nowcasting model (i.e., Real-time traffic and incident data being utilised as part of operational simulations)	○	○	○	○
Noise model (i.e., Assess environmental noise and its impact on human health, enabling reporting of strategic noise maps)	○	○	○	○
Vehicle stock, energy and emission model (i.e., Uses as input the transport performance by vehicle type from the network model, in order to estimate the related environmental impacts.)	○	○	○	○

Energy and Emissions model (i.e., To quantify the lifecycle energy and emissions impact from passenger and freight vehicle movements)	○	○	○	○
Scheduling Module (i.e., Dynamic routing and re-routing decisions, potential modal shifts and activities re-scheduling according to a range of events.)	○	○	○	○

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Part 4 - Importance and usefulness of the HARMONY MS

12.

Please rate the level of importance you place in the usefulness of the following features of HARMONY MS: Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very important; 3 = Fairly important 2 = Important ; 1 = Not at all important

	Very important	Fairly important	Important	Not at all important
Ability to integrate with other systems	○	○	○	○
Logic flow of the Harmony MS	○	○	○	○

Level of completeness of the Harmony MS in terms of available models	○	○	○	○
Ease of use	○	○	○	○
Overall performance	○	○	○	○
Ability of users to collaborate for carrying out different functions	○	○	○	○
Cost effectiveness	○	○	○	○

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Part 5 - Benefits of HARMONY MS on decision making

13.

Please rate the following features of HARMONY MS on a scale of how beneficial they are in improving decision making process of cities, regional and national authorities and spatial planners with evidence of long term impacts of innovative transport technologies and business models? Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very Beneficial ; 3 = Fairly Beneficial ; 2 = Beneficial ; 1 = Not at all Beneficial

	Very Beneficial	Fairly Beneficial	Beneficial	Not at all Beneficial

Supports decision makers with policy appraisal	○	○	○	○
Offers adaptors to integrate existing spatial or transport models to the suite making it a software-neutral platform	○	○	○	○
Helps in prioritisation and efficiency of investments for new forms of mobility	○	○	○	○
The strategic, tactical, and operational simulators allows thorough exploration of impacts allowing decision makers to assess numerous scenarios, strategies and identify the most promising ones in terms of competitiveness, sustainability, social cohesion, equity, and citizen well-being of the metropolitan areas	○	○	○	○
Offers spatial and transport planning capabilities for metropolitan areas by integrating simulators for strategic, tactical and operational levels providing short-, mid- and long-term impact assessment	○	○	○	○
Allows stakeholders to co-create various sustainable transport and spatial planning scenarios, while providing quantifiable evidence on their short, -mid and –long-term effects on air-pollution, carbon footprint, noise and land-use	○	○	○	○
Increases inter modality and higher resilience of the transport system between the metropolitan region and the neighbouring cities and rural areas	○	○	○	○

Creates an opportunity for mobility service providers, start-ups and transport authorities to develop, demonstrate and evaluate new mobility services based on technological advancements and newly available forms of mobility	○	○	○	○

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Part 6 - Benefits of HARMONY MS on policy adaptation

14.

In the course of HARMONY a number of use cases for evaluating different transport policies/measures have been defined and trialled. Please state how beneficial do you believe that HARMONY MS will be in adapting policies. Using the table below, please indicate by ticking the appropriate box.

Meaning of scale:
4 = Very Beneficial ; 3 = Fairly Beneficial ; 2 = Beneficial ; 1 = Not at all Beneficial

	Very Beneficial	Fairly Beneficial	Beneficial	Not at all Beneficial
Zero emission zones	○	○	○	○
Widespread deployment of Autonomous Vehicles, including as part of new mobility services	○	○	○	○
Integration of Multimodal transport services	○	○	○	○

Widespread deployment of new mobility services (i.e., Mobility as a Service, On-demand transport, etc.)	○	○	○	○
New public transport infrastructures	○	○	○	○
Remote working practices	○	○	○	○
Land use development (i.e., housing, retail, etc.)	○	○	○	○
Urban Vehicles Access Regulation measures	○	○	○	○
Last-mile logistics interventions (i.e., introduction of micro-mobility hubs, use of drones, etc.)	○	○	○	○
Sustainable mobility, including electro-mobility, bike-sharing, etc.	○	○	○	○

15.

Please state your level of agreement on the following statement.

My organisation should use the HARMONY MS to enable the transition to a low carbon new mobility era in a sustainable manner.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree

Strongly Disagrees

Please provide any further comments about improving the HARMONY MS in the space below:

Thank you very much for taking the time to complete this questionnaire.

APPENDIX C

SEMI-STRUCTURED BASELINE INTERVIEW QUESTIONS - CITIES

1	In your view, is there a need for your organisation to use the HARMONY MS?
2	In your view, which features of the HARMONY MS do you consider advantageous compared to the tools currently being used by your organisation?
3	From the job role and responsibilities that you perform in this organisation, please, describe how HARMONY MS may benefit your organisation in decision making regarding policy development/adaptation?
4	From your experiences with the HARMONY MS which model(s)/functionality do you believe will be more useful for your organisation for supporting policy adaptation?
5	Please describe for which use cases implemented within the project, or future policies, do you believe that HARMONY MS could be more beneficial?
6	In your view, what are the limitations, or shortcomings, of the HARMONY MS in supporting policy adaption within your organisation?

APPENDIX D

SEMI-STRUCTURED BASELINE INTERVIEW QUESTIONS – MODEL DEVELOPERS

1.	In your view, is there a need for standardising the HARMONY MS?
2.	Can you describe the benefits of standardising different data inputs/outputs for the components of the HARMONY MS?
3.	Can you describe the key challenges you may face in standardizing data inputs/outputs for your component as part of the HARMONY MS?
4.	Based on your experience in the HARMONY and other projects, can you describe how important standardisation is considered when developing transport models?
5.	Based on your experience in the HARMONY project, can you share some of the lessons learnt when integrating your components to the HARMONY MS?

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