Final Publishable Summary Report

February 2015
Table of Contents

EXECUTIVE SUMMARY .................................................................................................................. 3

1. PROJECT CONTEXT AND OBJECTIVES ............................................................................... 4
   1.1 BACKGROUND AND MOTIVATION ............................................................................... 4
   1.2 THE EUNOIA PROJECT: OBJECTIVES ......................................................................... 7

2. MAIN SCIENTIFIC AND TECHNICAL RESULTS ................................................................... 8
   2.1 OVERALL VIEW ............................................................................................................. 8
   2.2 URBAN MOBILITY POLICY MODELLING: CHALLENGES AND OPPORTUNITIES ..... 8
   2.3 EUNOIA DATA REPOSITORY ...................................................................................... 11
   2.4 ANALYSIS OF URBAN ACTIVITY AND MOBILITY PATTERNS ....................... 13
   2.5 TYPOLOGY AND MODELS OF URBAN MOBILITY PATTERNS ...................... 20
   2.6 SOCIAL NETWORKS AND TRAVEL BEHAVIOUR ................................................. 20
   2.7 MODELLING AND SIMULATION PLATFORM: THE NEW MATSIM MODULES ... 21
   2.8 VISUALISATION TOOLS ............................................................................................. 23
   2.9 CASE STUDIES ........................................................................................................... 25
   2.10 CONCLUSIONS AND LESSONS LEARNT ................................................................. 27

3. IMPACT, DISSEMINATION AND EXPLOITATION OF RESULTS ........................................ 29
   3.1 POTENTIAL IMPACT ................................................................................................... 29
      3.1.1 Scientific/technical impact .................................................................................... 29
      3.1.2 Impact on innovation and competitiveness ......................................................... 29
      3.1.2 Impact on policy and governance ...................................................................... 29
   3.2 DISSEMINATION AND EXPLOITATION OF RESULTS ........................................... 30

4. WEBSITE AND CONTACT DATA ....................................................................................... 31
   4.1 PROJECT WEBSITE .................................................................................................... 31
   4.2 CONTACT DETAILS ..................................................................................................... 31
      4.2.1 Project coordination ............................................................................................ 31
      4.2.2 List of participants and contact names ............................................................... 32
Executive Summary

The quest for environmentally sustainable urban transport is a common and urgent challenge for all major cities in Europe. EUNOIA is a research project funded under the European Union’s Seventh Framework Programme aiming to take advantage of the opportunities brought by smart city technologies and the most recent advances in complex systems science to develop new urban models and ICT tools empowering city governments and their citizens to design better mobility policies. The specific objectives of the project are the following:

1. to investigate how new data available in the context of smart cities can be exploited to understand mobility and location patterns in cities;
2. to characterise and compare mobility and location patterns in different European cities;
3. to improve the understanding of the interdependencies between social networks and travel behaviour;
4. to enhance urban land use and transportation models, by integrating the role of the social network and new models of joint trips and joint resource use into state-of-the-art agent-based models;
5. to develop useful policy interfaces and methodological procedures for the use of simulation tools in multi-stakeholder, collaborative assessment of urban transport policies;
6. to apply the new models and methodologies to several case studies of interest for policy makers.

The first task of EUNOIA was to identify and analyse the present and future challenges for urban models in the three areas tackled by the project, theory, data, and policy interfaces, in order to focus the research questions tackled within the subsequent activities. Considerable effort was then devoted to data collection, including conventional data sources (census, transport surveys) as well as different non-conventional ICT-based data such as geolocated tweets, mobile phone records, smart card data, credit card use records, etc. We analysed these data to study location and mobility patterns in different cities, studying aspects such as the organisation of hotspots or the interdependencies between social networks and activity-travel patterns. Some of the behaviours found in the data analysis, such as decision making within groups of joint travellers, were then modelled and implemented into the agent-based transport simulation tool MATSim. Finally, the data analysis and visualisation tools and the MATSim modules developed within the project were tested through three case studies conducted in collaboration with the cities of London (a megacity), Barcelona (a large metropolitan area) and Zurich (a medium sized city).

The results of EUNOIA will have an impact at different levels. At the scientific level, EUNOIA has contributed to the development of new methods for the analysis of spatio-temporal databases for the purpose of understanding urban activity and mobility patterns; it has shown the potential of new, non-conventional data sources for the calibration and validation of urban simulation models; and has contributed to advancing the state-of-the-art in transport modelling. At the policy level, the methods and tools developed by EUNOIA will be of value for the planning and management of urban transport systems. The EUNOIA case studies, focused on public bike sharing systems, have illustrated the potential of extending the MATSim model to deal with such alternative modes of travel. Finally, the work done in EUNOIA has opened the door for the development of innovative products and services for the transport sector.
1. Project context and objectives

1.1 Background and motivation

More than 60% of the European population lives in urban areas of over 10,000 inhabitants. Cities are key to growth and development, with around 85% of the European GDP being generated in cities. To support their economy and the welfare of their citizens, cities need adequate infrastructure. One of the cornerstones of such infrastructure is urban transport. Urban transport is essential for citizens to perform their daily activities, but at the same time constitutes one of the major sources of urban pollution (GHG emissions, local air quality, noise), directly affecting citizens’ health and well-being. Urban traffic produces 40% of CO₂ emissions and 70% of emissions of other pollutants (CO, NOx, SOx, particulate matter) produced by road traffic. Traffic accidents are also increasing, with two thirds of the accidents and one third of the victims taking place in cities. The quest for environmentally sustainable urban transport, while ensuring competitiveness and addressing social concerns such as health problems or the needs of persons with reduced mobility, is a common and urgent challenge for all major cities in Europe.

Policy context

The European Commission’s first policy proposals in the area of urban mobility were issued in the 1990s and were mainly based upon a best practice approach. The Commission’s 2001 ‘White Paper on Transport’ aspired to change the direction of EU transport policy to deal with the increasing challenges of congestion, noise, pollution, and accidents, largely caused by excessive use of the private car. The White Paper aimed to break the link between transport and economic growth by urging a shift towards more sustainable transport modes and promoting the modernisation of public transport. With the continued rise in transport demand, the Commission’s mid-term review of the White Paper in 2006 shifted the focus from curbing overall transport growth to decoupling transport growth from its negative effects, and emphasised the concept of comodality. The 2006 Green Paper ‘Towards a New Culture for Urban Mobility’ opened a broad consultation on the key issues of urban mobility. Following the consultation results, in 2009 the European Commission ‘Action Plan on Urban Mobility’ proposed twenty measures to encourage and help local, regional, and national authorities in achieving their sustainable mobility goals. With the Action Plan, the Commission presented for the first time a comprehensive support package in the field of urban mobility. In parallel, a high emphasis has been placed on fostering the exchange of good practices at European level, leading to different initiatives — e.g. POLIS (http://www.polis-online.org/), CIVITAS (http://www.civitas-initiative.org), or ELTIS (http://www.eltis.org), to mention but a few examples — aiming at the exchange of experiences and the transfer of knowledge between European local and regional authorities, global coordination of policies, and increased dialogue between policy makers and other actors such as industry, academia, and NGOs.

Urban models for transportation and spatial planning

To tackle the challenge of sustainable urban mobility, urban planners need models, decision support tools, and input data allowing the assessment of policies and their resulting effects. Cities have been treated as systems
for several decades, but only recently has the approach changed from aggregate equilibrium systems to complex, evolving systems of systems. Different types of urban models have been developed, from the static and aggregate land-use-transportation interaction (LUTI) models first developed in the 1960s, to recent, bottom-up, activity-based microsimulation models which seek to represent cities in more disaggregate and heterogeneous terms.¹ ² ³

In recent years, quantitative models for transportation and spatial planning have received a renewed attention, largely motivated by the new challenges faced by cities in the 21st century. Urban development along the last two centuries has been driven by an increasing mobility of people and goods facilitated by relatively cheap energy. The growth of urban areas, the increasing concerns about sustainable development, and the challenges posed by energy scarcity and climate change raise new questions, such as the influence of higher transport costs on mobility and location patterns (e.g., will distances to workplaces, shops, services and leisure be reduced?) or the impact of new policies (e.g., promotion of more efficient vehicles, transport demand management, anti-sprawl legislation) aiming at fostering a more sustainable mobility behaviour⁴. In parallel, the emergence of new social media and electronic communications is leading to profound changes in social relationships, which is in turn modifying location and mobility patterns in cities. This new landscape makes it necessary to develop new models, tools, and methodologies empowering city governments and their citizens to design sustainable mobility policies.

Urban models serve various purposes. First, models help achieve an enhanced understanding of urban dynamics (in an explanatory role). Second, they enable virtual experimentation allowing the prediction of the impact of new infrastructures, technologies, or policies (in a predictive role). Finally, models are powerful tools to facilitate participatory processes for collaborative decision making (in policy and design roles). Despite significant effort carried out in the last two decades, urban models still require progress along several axes to fully satisfy these three objectives, and ultimately to support the assessment of urban mobility policies in terms of a comprehensive set of economic, social, and environmental sustainability indicators. Further research is needed in three main directions:

1. **Data.** Urban modelling is a data-intensive task. The development and validation of improved models critically relies on the availability of data. Despite significant progress in this area in recent years, the EC acknowledges that there are still big gaps in urban mobility statistics at the EU level, and that urban modelling research can greatly benefit from additional international effort in standardising, collecting, and sharing data. Data collection efforts have traditionally been focused on trip data (origin-destination, travel time, mode, etc.), but there is still a lack of appropriate data especially on non-motorised modes

---

and on factors determining mobility behaviour, such as attitudes and lifestyle, which are particularly important for developing demand management concepts aiming to influence mobility decisions. There is also a need for further progress in the development of standard definitions, indicators, and data collection methods allowing comparative studies of urban transport planning throughout Europe.

2. **Theory.** In October 2007, the FP6-funded Coordination Action ‘European Research Forum for Urban Mobility’ (EURFORUM) presented a ‘Strategic Research Agenda’ for urban mobility, highlighting a number of areas where further research is needed, from both the demand and supply perspective. On the transport demand side, many questions are still open, such as the social determinants of mobility behaviour, i.e. norms, social perception, age and demographic, personal security, or comfort; the activity patterns underlying human travel behaviour, including questions such as the interaction between mobility patterns and social networks, and the modelling of travel decisions when these are planned jointly by two or more people who meet together; the impact of information campaigns on user behaviour; the social acceptance of transport systems and mobility policies, e.g. how to increase the acceptance of pricing policies; the expectations that transport systems have to meet to be accepted and successful without inducing new travel needs; or the relationship between land use and transport demand, and how to quantify the contribution of transport infrastructure to land value. As for the transport supply side, research must be undertaken to investigate the potential of technological progress to supply integrated mobility services and transport systems. Particularly interesting are questions such as the impact of ICT-based services, like travel information, on the interaction between demand and supply; new services with the potential to improve urban mobility, e.g. how to make car and bike sharing schemes more appealing; the integration of transport systems and intermodality; or the alternatives to private, fossil fuel-based car such as electric and hybrid.

3. **Link between modellers, decision makers, and societal actors.** The use of system models in policy making and planning is very heterogeneous. Many cities do not use any quantitative models at all; among the cities using simulation models, traditional LUTI models are still the most applied. The use of more advanced, state-of-the-art models (particularly of agent-based models) for policy-making purposes is still scarce, and in many cases the potential users do not have the skills to use such models or are not convinced of the benefits. To bridge this gap, the development of the models needs to be user-driven and account for the requirements of the policy makers. The link with societal actors is also a field where there is significant room for improvement. Testing the acceptance of novel ideas by social communities often implies high costs and requires large amounts of time, which makes the testing process difficult to afford. The use of system models in a policy decision context will only be successful if the development of these tools is accompanied by user-model interaction methodologies facilitating a smooth integration into the decision-making processes.

**Smart cities: opportunities for improved planning and decision-making**

The term ‘smart city’ has become widely spread in the last few years. While more technocentric concepts, such as ‘digital cities’, are built around ICT infrastructures, the concept of smart city — even if still not clearly delimited — is now generally understood as a holistic concept encompassing not only the use of modern technology (including modern transport or energy technologies, in addition to ICT), but also the investment in human, social, and environmental capital, to create sustainable development and high quality of life. Though
the smart city concept goes beyond ICT, it is clear that ICT remains a key element to enable sustainable urban development. When it comes to urban models and policy support tools, the increased penetration of ICT, the rise of the Big Data movement, and the emergent concept of smart cities open new opportunities to make progress in the three directions previously identified:

1. Modern ICT, such as smart phones, e-transactions, Internet social networks, or smart card technologies, allow the automatic collection of spatial and temporal movement data that can complement and enhance the data collected by using traditional methods (census data, travel surveys). Yet, the collected data have to be analysed, making it necessary to develop new data analysis techniques in order to obtain useful knowledge about urban mobility and improve our understanding of cities.

2. This improved understanding can in turn inform the modelling of the mechanisms behind observed mobility patterns, helping develop new theory and better models for the quantitative assessment of different scenarios and policy options.

3. Finally, ICT opens the door to the development of new tools which facilitate the interaction with stakeholders (e.g., visualisation tools) and enable collaborative, multi-stakeholder policy assessment and decision making processes.

1.2 The EUNOIA project: objectives

EUNOIA is a research project funded under the European Union’s Seventh Framework Programme aiming to take advantage of the opportunities brought by smart city technologies and the most recent advances in complex systems science to develop new urban models and ICT tools empowering city governments and their citizens to design better mobility policies. The specific objectives of the project are the following:

1. to investigate how new data available in the context of smart cities can be exploited to understand mobility and location patterns in cities;

2. to characterise and compare mobility and location patterns in different European cities;

3. to improve the understanding of the interdependencies between social networks and travel behaviour;

4. to enhance urban land use and transportation models, by integrating the role of the social network and new models of joint trips and joint resource use into state-of-the-art agent-based models;

5. to develop useful policy interfaces and methodological procedures for the use of simulation tools in multi-stakeholder, collaborative assessment of urban transport policies;

6. to apply the new models and methodologies to several case studies of interest for policy makers.

The project has been executed by a Consortium composed by the Institute for Cross-Disciplinary Physics and Complex Systems (Project Coordinator), a joint research unit between the University of the Balearic Islands (UIB) and the Spanish National Research Council (CSIC); Nommon Solutions and Technologies; the Centre for Advanced Spatial Analysis (CASA) at University College London; the Institut de Physique Théorique (IPhT) of the Commissariat à l’Énergie Atomique et aux Énergies Alternatives (CEA); the Institute for Transport Planning and Systems (IVT) at the Swiss Federal Institute of Technology in Zurich (ETHZ); Antonio Lucio Gil (Independent Consultant); and the Barcelona City Council. The project started on 1 October 2012 and has run for 26 months.
2. Main scientific and technical results

2.1 Overall view

The first task of the project was to identify and analyse the present and future challenges for urban models in the three areas tackled by the project, theory, data, and policy interfaces, in order to focus the research questions tackled within the subsequent project activities. Considerable effort was then devoted to data collection, including conventional data sources (census, transport surveys) as well as different non-conventional ICT-based data such as geolocated tweets, mobile phone records, smart card data, credit card use records, etc. We analysed these data to study mobility and activity patterns in different cities and find common features in terms of travel demand, including the spatial organisation of hotspots and the interdependencies between social networks and activity-travel patterns. Some of the behaviours found in the empirical work, such as decision making within groups of joint travellers, were then modelled and implemented into the multi-agent, activity-based transport simulation tool MATSim (www.matsim.org). Finally, the data analysis and visualisation tools and the MATSim modules developed within the project were tested through three case studies conducted in collaboration with the cities of London, Zurich and Barcelona.

2.2 Urban mobility policy modelling: challenges and opportunities

The first task of the project was to identify and analyse the present and future challenges for urban models. In particular, we aimed to:

- define a set of key performance areas (KPAs) and key performance indicators (KPIs) allowing a comprehensive assessment of the impact of urban mobility policies, infrastructures, and technologies;
- identify the most relevant policy questions in the field of urban mobility;
- identify the main shortcomings and need for improvement of the policy assessment models and methodologies currently in use in policy decision contexts.

For this purpose, we conducted an extensive literature review and a consultation addressed to urban mobility policy makers and urban modellers from 24 European cities. Policy makers are to be understood as those responsible for urban mobility planning and decision making, while urban modellers are those technical experts who manage transport and/or land-use models.

Indicators of sustainable urban mobility

A review of the main urban mobility policy documentation at European level (e.g., Green Paper on Urban Mobility 2007, Action Plan on Urban Mobility 2009), European guidelines (e.g., Eltis+ guidelines), European research projects and relevant research papers was carried out. From this review, a consolidated list of sustainable urban mobility objectives was defined, whose validity and completeness was verified through the consultation with European cities.
Once the general mobility objectives were identified, more specific and measurable objectives were defined within each of the general objectives. For example, within the general objective “Improve air quality”, specific objectives such as “reduce NOx” or “reduce CO” are defined. For each of these specific objectives, proper indicators (comprehensive, measurable, target relevant, quality of available data, easy to understand, independent) are proposed. We distinguish between two types of indicators: outcome indicators, which measure the progress towards a specific objective; and intermediate indicators, which provide information about the transport systems that is useful to obtain proxy measures of outcome indicators.

From the stakeholder consultation, a significant gap in the use of proper indicators was detected. One third of the cities pointed out that the relation between their objectives and outcome indicators was not clear, and most of the cities mentioned the same problem in the relation between outcome and intermediate indicators. EUNOIA has consolidated previous efforts in the definition of proper mobility indicators, contributing to the European objective of setting up a European Urban Mobility Scoreboard based on common targets.

The main results of the work are:

- A consolidated list of sustainable urban mobility objectives.
- A set of specific objectives within each of the general objectives.
- A comprehensive set of indicators and metrics for the assessment of sustainable urban mobility policies.

---

Figure 1. Analysis of present and future challenges for transport modelling: methodology

---

Current and future policy trends

There is abundant documentation on urban mobility policies, including documents which provide a comprehensive set of measures and policies to achieve sustainable mobility objectives, studies that analyse the application of a specific set of measures in a particular city, or reports reviewing case studies in order to draw general conclusions. We carried out a detailed literature review in order to provide an overall view of the most widespread measures and policies and propose a comprehensive policy framework. The documentation reviewed encompasses policy documentation, reports based on the real application of different measures, transport databases, national guidelines and research papers.

Measures and policies have been classified into 10 groups:

1. modal shift policies,
2. car use optimisation,
3. low-emissions / low-carbon,
4. safety and security,
5. transport demand management,
6. traffic management,
7. company mobility management,
8. land use planning,
9. educational and awareness campaigns,
10. infrastructure.

The results of the stakeholder consultation show that promoting and improving collective transport, parking management, and fostering cycling and walking are among the most relevant policies for European cities and these have guided us in extending our models to deal with such policies.

Review of methods and tools

Numerous models have been developed over the last fifty years, both models of land-use/transport linkages and standalone travel-demand models. 24 such models have been studied in depth to understand their inputs/outputs, why they occupy their niche and their likely availability and benefit to a project like EUNOIA. Different reports, both from academic and public-sector sources, have been examined and summarised, with their categorisation of models being consolidated and listed. Stakeholders have been identified and outlined, and issues raised on the potential adoption of the more advanced models have been discussed.

MATSim (www.matsim.org), a modern agent-based modelling engine, was identified in the project specification as a key model, suitable to be adapted and used in subsequent phases of the EUNOIA project, and hence it received a particularly detailed review.
2.3 EUNOIA data repository

Data provided by municipal authorities

Different data regarding mobility and land use were obtained for the three cities considered in the case studies. The access to these datasets required the signature of agreements of collaboration and/or non-disclosure with several local and national administrations.

We obtained origin-destination matrices for Barcelona, London and Zurich. In the case of Barcelona, the information comes from a mobility survey carried out by the City Council and the Catalan Government in 2006. Over 45,000 people from the Barcelona metropolitan area participated in the survey. These numbers allow a significant separation of the mobility data in trips occurring during workdays or weekends. The datasets for London and Zurich come instead from the 2000 census and mainly provide information about commuting trips. Besides the OD matrices, we have obtained GIS data concerning the location of services in the cities. These data include aspects such as bus and metro stops, bike sharing stations, restaurants, businesses, schools and universities, hospitals, sport centres and stadiums, etc., as well as bus routes, metro lines and the main access roads to the three cities. Regarding traffic, we obtained information on metro use in London, bike sharing in Barcelona and London, and taxi use in Barcelona.

Data from online social networks

The main source of these data was the micro blogging service Twitter. A system was developed at IFISC to collect tweets from the general Twitter streaming using the site’s API. The tweets are filtered to select those geolocated in one of the three cities of interest. The history of the users emitting geolocated tweets is downloaded a posteriori to complete as much as possible the information that we get in terms of mobility and social interactions. The system is satisfactorily working and it has already detected over 100,000 users sending geolocated tweets in London and over 20,000 in Barcelona (see Figure 2 with all the cumulated located tweets of the first project year in Barcelona and London). The numbers for Zurich are relatively low instead.

Figure 2. Geolocated tweets in Barcelona and London during the first 5 months of data collection
Data from other electronic records

Several partners of EUNOIA signed agreements with Telefónica (the main telecommunication company in Spain) and BBVA (the second largest Spanish bank). The purpose was to get access to records of mobile phone and credit card use, which would then be used to characterise urban mobility patterns, find centres of activity in the city and analyse the use that the citizens give to public spaces.

Egocentric-life course survey

The intention of this task was to complement the information obtained through other channels with specific surveys in the Barcelona metropolitan area. The questions revolve around the life-course experience of the participants regarding urban mobility and we included also a request of social contacts. The objective was to follow these contacts to analyse whether mobility habits are conditioned by the social environment.

Data from other public repositories

Extra information was collected from public repositories as census offices and, in some cases, from local authorities. These data comprehend cartographic files with information on the location of services and transport centres in the cities, population levels in each area and schedules and routes for buses, metro, trams and trains.

Project repository

Most of the collected datasets (essentially all those not protected by special non-disclosure agreements) have been shared between the projects members through an intranet project repository.

![Figure 3. Screenshot of the EUNOIA data repository](image)
2.4 Analysis of urban activity and mobility patterns

New data sources for the analysis of activity-mobility patterns

Several previous studies have used different ICT data sources to study human mobility. In EUNOIA, we have performed a cross-check analysis by comparing the spatial organisation of journeys extracted from data collected from three different sources: Twitter, census and cell phones. Our analysis has focused on the urban areas of Barcelona and Madrid, for which data of the three types were available. We have assessed the correlation between the three datasets on different aspects: the spatial distribution of people concentrations, the temporal evolution of the density of people, and finally the commuting (journey to work) patterns of individuals. Our results show that the three data sources provide indeed comparable information on the commuting flows in the city. Even though the representativeness of Twitter geolocated data is lower than that of mobile phone and census data, the correlations between the population density profiles and mobility patterns detected from the three datasets are close to one, at a spatial scale of analysis where the activity data in the city is mapped on a regular grid of cells of 4km$^2$ and 1km$^2$. The observed levels of correlation support the feasibility of interchanging the three data sources — at the spatio-temporal scales considered — when one wishes to analyse the organisation of mobility at the city scale. These results confirm the reliability of the analyses based on a single ICT dataset and constitute an important basis for the subsequent data analysis work.

![Figure 4](image-url) Correlation between the spatial distribution of Twitter users and mobile phone users for weekdays (Monday to Thursday) and from noon to 1pm for the metropolitan area of Barcelona (cells of 4km$^2$). (a) Scatter-plot composed by each pair (Number of Twitter users, Number of mobile phone users), the values have been normalised (dividing by the total number of users) in order to obtain values between 0 and 1. The red line represents the perfect linear fit with slope equal to 1 and intercept equal to 0. ((b)-(c)) Spatial distribution of Twitter users (b) and mobile phone users (c).

After having strengthened our confidence that ICT data provide almost identical information when compared to transport surveys, we inspected mobility patterns with various ICT datasets. In the remainder of this section we describe six examples of such work: (i) the extraction of origin-destination matrices from mobile phone call records; (ii) the extraction of a ‘mobility footprint’ from OD matrices; (iii) the analysis of the influence of sociodemographic characteristics on mobility patterns using credit card usage records; (iv) the characterisation of transport networks using Twitter data; (v) the use of credit card usage data for the calibration of different types of retail models; and (vi) the use of phone call records to characterise the spatial organisation of cities.
Extraction of origin-destination matrices from mobile phone data

We designed novel algorithms to extract OD matrices from mobile phone records, which were validated through comparison with travel surveys, showing that mobile phone data can be used as a cheaper and continuously updated alternative to travel surveys.

Figure 5. Comparison of OD matrices obtained from mobile phone record and travel surveys

From OD matrices to an urban mobility footprint

While exciting, the enormous amount of individual mobility data available brings some new problems. A central one is the extraction of synthetic and useful information from these enormous datasets. In particular we were interested in extracting coarse-grained information and stylised facts that encode the essence of the phenomenon under study — in our case individual human mobility in cities — and that any reasonable model should reproduce. Such meso-scale information should help us understand the system, compare different cities, and also propose models able to explain the processes under study. To address the problem of extracting a simple footprint of the mobility structure in the city, we took inspiration from simple classifications of commuting flows and city forms proposed by city planners. These classifications are constructed on one hand
on the identification of main/secondary centres, and on the other hand on a distinction between the commuting flows arriving and departing from centres, and the rest of the flows (noise). Taking these ideas as a starting point, we developed a general method named ICDR that captures the structure of mobility in the city by measuring the importance of four different categories of commuting flows: integrated flows, convergent flows, divergent flows and random flows. The method served us to compare the structure of commuting in the 31 biggest Spanish urban areas. We applied our method to journey-to-work OD matrices extracted from the individual mobile phone data for the entire country, identifying several properties of journey-to-work mobility at the city scale. We found that the proportion of integrated flows (of individuals that live in main residential centres and commute to main employment hotspots) decreases when the population size of the city increases. We also detected several spatial properties of commuting, notably that the average distance of convergent flows (of individuals living in the suburbs and commuting to employment centres) increases faster than the distance of other types of flows when the city size increases. This confirms that the bigger the city, the more residences are decentralised when compared to jobs and activities. Interesting information was also provided by the comparison of the distances of commuting flows measured in the data with average distances measured in random OD matrices generated by a null model of random commuting flows (preserving the in and out degree of each node). For all types of flows the distances measured in the data are in fact shorter than those generated by the null model. This highlights the importance of the travel time budget in the choice of a residential location. We also found that the bigger the city, the farther is its commuting structure from a random one, and the shorter the commuting distances compared to what they would be if flows occurred at random. These results highlighted the lesser importance of spatial organisation at shorter spatial scales.

We then applied the ICDR method to Transport for London’s Oyster card data, in order to (i) study the evolution of the structure of mobility in a megacity during an entire week; and (ii) extract stylised facts from these data that could be useful to calibrate the simulation model developed for London. We measured the ICDR values of London for each 15-min timeslot available in the data, during an entire week. We observed that the proportion of integrated flows (I) and random flows (R) changes little during the course of the week, and stays in a small interval of values, [0.35-0.4] for R, and [0.15-0.2] for I, which constitutes a signature of the organisation of commuting in the city. While a bigger city than Barcelona and Madrid, it is remarkable that the values for London confirm our observations when comparing mobility structure in Spanish cities through ICDR values: the main flows are the ‘random’ flows (R) between stations that are neither origin nor destination hotspots. One can also notice that in the course of the day, the proportion of convergent flows decreases at the benefit of divergent flows. The proportion of convergent flows (from small and medium-sized origin stations to major destination stations) reaches its maximum in the morning peak (7-9 am), and then decreases all along the day, while the dynamics are opposite for divergent flows, whose weight is maximal in the evening peak (5-7 pm). It is also remarkable that in the end of the day, we observe an increase of the proportion of integrated flows, from main origin stations to main destination stations, indicating that the journeys in the last hours of the day are more concentrated between a fewer number of stations. It is also remarkable that we observe the same pattern during the weekend. Such coarse-grained, structural information is of great value to calibrate a simulation model at the city-scale.
Sociodemographic characteristics of mobility

A lot of previous work exists on the statistical and spatial properties of individuals’ mobility in urban environments. But generally no information is associated with the anonymous individuals, and previous studies based on phone data, GPS, tweets, etc. couldn't inspect the influence of socio-demographic characteristics on mobility behaviour. Thanks to the partnership with BBVA, we analysed a credit card database containing over 40 million bank card transactions in order to explore consumption habits and mobility patterns in Barcelona and Madrid, according to three demographic characteristics: gender, age and occupation. We used two classic indicators of the mobility literature: the distance travelled by an individual between two consecutive transactions, and the radius of gyration, i.e. how far in an individual moves around her/his centre of mass. Three main differences related to socio-demographic characteristics were observed. First, women travel shorter distances than men and their trajectories stay closer to the centre of mass. Second, the average distance travelled between two consecutive positions and the radius of gyration decreases with age. Finally, an opposition between active and inactive individuals was found, showing that unemployed, retired and homemakers seem to travel shorter distances and stay closer to their centre of mass than the other customers.

![Figure 6. Distribution of the distance travelled by a customer between two consecutive transactions according to customer's demographic characteristics in Barcelona. (a) Probability density function of the distance travelled by a customer between two consecutive transactions. (b) – (d) Probability density function of the distance travelled by a customer between two consecutive transactions according to the gender (b), the age (c) and the occupation (d). The insets show the boxplot versions of the plots, the black point represents the average](image-url)
Characterisation of transport networks using Twitter data

We analysed a Twitter database containing over 5 million geo-located tweets from 39 European countries with the aim of exploring the use of Twitter in transport networks. Two types of transportation systems have been considered across the continent: highways and trains. We showed that there is a significant number of tweets following the main roads and train lines, so even those roads that go through relatively low population areas can be clearly discerned. To identify the tweets on the road/rail we considered all the tweets geo-located less than 20 meters away from a highway (both directions) or a railway. Then, each tweet on the road/rail was associated with the closest segment of road/rail. Using this information, we computed the percentage of road and rail segments covered by the tweets and obtained an estimation of modal split.

Credit card data and retail models

The analysis of retail expenditure in systems started to grow around 50 years ago with the development of gravity models. Since then, the topic has attracted more research and, perhaps more importantly, a number of commercial enterprises appeared that used retail models to assess the growth of many companies. One of the main inputs to the model is the transaction data in order to calibrate them. What this information usually includes is the location of the residence of people and the location of the retail centres they shop to. This is also called catchment data. These data are usually produced via surveys and hence, its representativeness is usually not very high due to the cost of these surveys. During EUNOIA, we have taken the opportunity to use card transaction data collected throughout 2011 and 2012 to test how traditional models perform with a more comprehensive sample. During this research stream we run retail models for Madrid and Barcelona, using their metropolitan areas to estimate how well the model adjusts to the observed expenditure flows during one year. The areas of analysis within the cities are the postal areas (369 areas for Barcelona and 271 for Madrid).

The models we have tested are:

- entropy maximising doubly constrained model,
- entropy maximising production constrained model,
- Gargiulo-Lenormand model, similar to a relaxed form of the doubly constrained model.

In order to use these models, other variables had to be defined, such as:

- total spend coming out of each postal area,
- total revenue attracted by each postal area,
- travel costs associated between each pair of postal areas (in our case, driving travel time in seconds).

We have used the same inputs for all three models to further strengthen the comparison. The results from this exercise can be summarised by using two evaluation criteria:

- the use of the Sorensen-Dice goodness of fit measure, which quantifies the overall common part of the flow between each single modelled flow and its observed counterpart, and
- the comparison of the resulting trip length distributions of the observed data and the three models for each city.
Table 1 Sorensen-Dice index results between observed and model spend flows in 2011

<table>
<thead>
<tr>
<th>Area</th>
<th>Singly-constrained</th>
<th>Gargiulo-Lenormand</th>
<th>Doubly-constrained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>0.6891</td>
<td>0.6899</td>
<td>0.7154</td>
</tr>
<tr>
<td>Madrid</td>
<td>0.6856</td>
<td>0.6801</td>
<td>0.7166</td>
</tr>
</tbody>
</table>

Figure 7. Trip length distribution from the observed expenditure flows and the three models for Barcelona (left) and Madrid (right)

Table 1 and Figure 7 show that all three models capture the expenditure behaviour observed in the data quite well. The Sorensen-Dice indices produced, which range between 0 and 1 (1 being a perfect fit) show that the best performing model is the doubly constrained model. The trip length distributions from the three models compare rather well with the behaviour from the observed trip length distributions.

**Mobility patterns and spatial organisation of cities**

Given their spatial and temporal resolution, mobile phone data are also a great source of knowledge for studying not only the properties of individuals’ mobility, but also the spatial organisation of cities. Contrary to other sources of data informing us on the densities of people in the city, mobile phone data also have a temporal dimension that allows measuring how the form of a city evolves according to the hour of the day and to different days of the week (e.g., weekday vs. weekend day). The full density is a complex object and we had to extract relevant and useful information. In particular, we focused on particular locations that display a density much larger than the others. These locations — the hotspots — give a good picture of the city by showing where most of the people are. The hotspots thus contain important information about points of interest and activities in the city. The determination of these hotspots from density data is a classic problem in urban economics that has been broadly addressed during the last twenty years but it still didn’t result in a satisfactory general solution. We have proposed a new method to identify these hotspots, based on the Lorenz curve of the density. Rather than returning a single number of hotspots, our method returns a pair of numbers, both a lower bound (the number of places whose density is bigger than the average value of the density...
distribution) and an upper bound (a smaller number, based on the curvature of the Lorenz curve). All other possible methods would essentially return a value comprised in this interval, between the average criterion and our criterion. Applying this method to the 31 largest Spanish urban areas, we showed that the number of daily activity hotspots in cities scales sub-linearly with the population size of the city. Additionally we proposed original measures of the evolving spatial structure of these hotspots, and of the stability of their hierarchy, including a “city’s heart” distance — average distance between the city’s permanent hotspots — along with a dilatation index that characterises how the city “breathes” during the day. These measures allowed us to identify different families among Spanish cities. We also asserted the robustness of our results against the arbitrariness of the hotspot identification method.

Figure 8. Numbers of hotspots versus population size for the 31 Spanish cities studied. (a) Number of residential hotspots vs. population size of the city (b) Number of work hotspots vs. population size of the city. Both scaling relations are sublinear, indicating an "economy of scale" in the spatial organisation of cities. The exponent is remarkably smaller in the case of the work/main daily activity hotspots, which means that in Spanish cities the number of important places that concentrate many jobs and daily amenities, grows slower than the number of important residential places.

An important issue regarding land use in cities refers to the methods employed to estimate it. Public registers, surveys or satellite images have been used in the past to this end. The emergence of geo-located ICT technologies introduces extra capabilities to directly measure the use that citizens make of each urban space. We explored land use patterns in the five most populous urban areas of Spain — Madrid, Barcelona, Valencia, Sevilla and Bilbao. Land use information was obtained from mobile phone records using a new framework based on network theory. We observed that in the five cities under study, between 98% and 100% of the cells are covered with only 4 groups — Residential, Business, Logistics/Industry and Nightlife. Through entropy measures, we also revealed some common spatial organisation patterns in the five cities. Finally, we proposed a model inspired by Schelling’s segregation model, able to reproduce these results with simple interaction rules for land use types. We also compared our results to a null model in which the land use types are distributed at random, keeping the real proportions, to show that ignoring the interactions between the different land use types does not allow the reproduction of the curves obtained with the data.
2.5 Typology and models of urban mobility patterns

The extracted ICDR signature of the cities’ OD matrices allowed clustering Spanish urban areas with respect to the structure of their commuting patterns. We have measured the Euclidian distance between the cities’ ICDR signatures and have then performed a classification. Four well-separated clusters of cities are identified. Remarkably the classification shows that largest cities are grouped together and are characterised by a larger proportion of ‘random’ flows (R) of individuals both living and working in parts of the city that are neither dominant residential nor activity centres. This increasing proportion of random flows can be interpreted as an increased facility, in bigger urban areas, to commute from any part of the city to any other part.

2.6 Social networks and travel behaviour

We inspected the relationship between travel behaviour and social networks using mobile phone data. We determined the individual’s social network from her/his communication data. An egocentric network approach was used for this purpose. It was assumed that a relationship exists between two different users if the phone communication between them is reciprocal. Therefore, the social network of an ego comprises all alters who have at least one reciprocal call with that ego. We then estimated the locations in which each individual is performing its activities, either a social activity or not. If a given individual and one of her/his contacts are in the same place at the same time, it is assumed that they are performing a social activity.
The results obtained from the joint analysis of user’s social network and travel behaviour provide relevant information to enrich activity-based models. Indeed, one important challenge for operational daily mobility models is the prediction of location choice for discretionary (as opposed to mandatory) activities: while home and work locations can typically be obtained from reliable sources, such as census, the high flexibility of discretionary types makes them much more difficult to handle, the tendency being to underestimate travelled distances for those purposes. The interaction patterns between social network and travel behaviour obtained from the mobile phone data analysis may help account for this aspect in travel demand models, for instance using the following steps:

1. consider as possible destinations the frequent locations of agent’s social contacts;
2. look into the intersection between isotims of the social network (line of equal transport cost), in order to find possible destinations (probably non-frequent destinations) that maximise users utility;
3. use the patterns obtained from the mobile phone data analysis to calibrate/validate the model.

2.7 Modelling and simulation platform: the new MATSim modules

A natural continuation of the work on social networks and travel behaviour was to integrate social relationships into a transport simulation platform. More specifically, EUNOIA aimed at furthering the state-of-the-art in transport simulation by integrating two main elements: social components of traveling and new-shared schemes for transportation media. For this purpose we used the multi-agent activity-based model MATSim. MATSim (www.matsim.org) is a software framework aiming at representing interactions between transport supply and mobility behaviour with a high level of detail. It is based on the convergence of three established streams of research, namely:

- activity-based mobility behaviour analysis, that explicitly looks at travel as a consequence of the desire of individuals to perform activities, to represent demand;
- microscopic traffic simulation methods, allowing the representation of complex but important effects in traffic flows, such as queue spillback, as well as other effects of individuals’ interactions, such as crowding of public transport vehicles;
- game theory and co-evolutionary computation methods, which provide a theoretical ground for modelling the interactions between supply and demand, as well as practical and efficient ways to find approximate solutions for the resulting theoretical model.

![Figure 10. MATSim evolutionary process](image)
The software is implemented in the Java programming language, which is multi-platform and relatively easy to learn for modellers with little programming background. It is free and open-source, meaning that any interested researcher or modeller can analyse it, use it or extend it for his or her use, and it is designed to allow usage in large-scale simulations, in particular by adopting a minimal yet powerful traffic flow model.

Integration of the social network: interface development

To be valid, a simulation of social relationships requires an accurate synthetic social network, reproducing the most salient characteristics measured by means of data collection techniques such as snowball sampling or CDRs. A method to generate a synthetic social network, using snowball sample data, was developed by Arentze et al.\(^6\), using a snowball sample collected in Switzerland. This approach was however never used for the large number of agents one needs for a real-world application. In EUNOIA, the approach was implemented in a way directly compatible with the MATSim data structures, and applied for the first time to a population as large as a 10% sample of the Swiss Population. In addition, data structures to represent bike sharing supply where also added to the MATSim framework, in order to enable the three EUNOIA case studies, focused on the study of bike sharing systems (see section 2.9).

Integration of joint choice and joint use

Two important processes have been integrated in the MATSim software: joint decisions, that is, explicit coordination between social contacts; and joint usage of joint resources, namely bike sharing. In order to represent joint decisions, a game theoretic framework was formulated that extends the game theoretic model embedded in the basic MATSim process. A generalisation of the MATSim process, designed to solve the generalised problem, was then implemented, with a focus on modularity and maintainability. Instead of searching for an uncoordinated equilibrium, where no agent can unilaterally change his plan and improve its expected utility, it searches for states without improving coalitions, that is, were no group of social contacts can all improve their expected utility by simultaneously changing their daily plans. Two important aspects of mobility behaviour were in focus:

- intra-household coordination and its impact on activity planning and joint travel;
- joint leisure activities with social contacts, and their influence on travelled distance and joint travel.

The validity of the approach for these two aspects was tested on two Zurich scenarios, with household information from the census and with a generic social network.

- In the case of households, escorting to school emerged from the constraints specific to households.
- In the case of leisure travel, the approach, together with a desire to meet social contacts at leisure activities, had a positive influence on the travelled distances forecasts, in particular for the car passenger mode.

2.8 Visualisation Tools

Visualisation and visual analysis contribute to facilitating the interpretation of data and the understanding of complex relationships, the evaluation of the impact of (a set of) policies in a more effective way, and the communication between citizens and policy makers.

One of the objectives of EUNOIA was to develop user-friendly visualisation tools to interact and ease the interpretation of the MATSim simulation results. MATSim provides some plots to visualise the simulation results, such as travel distance statistics or the comparison between simulated and real data counts, and there exists a visualisation tool called VIA (http://senozon.com/products/via) that provides additional visualisation features. Most of these visualisations are mainly focused on disaggregated information (agent trips, link road analysis, etc.), being the analysis and the interaction with aggregated data developed to a lesser extent. The objective of the EUNOIA visualisation was to improve the manner in which aggregated data are analysed, focusing on generation and attraction of trips by zones and the distribution of these trips between zones.

The EUNOIA visualisation consists of a web solution constructed using three core web technologies: HTML, CSS and JavaScript. Two JavaScript libraries (jQuery and D3) and a JavaScript API to Google maps have been used.

The visualisation has four main interface elements:

- The map of the city, where the mobility patterns are represented.
- The zones, represented by their geometric centroids as coloured circles.
- The links (or trips) between zones, represented as lines connecting the zones.
- The messages when hovering over a zone or tabulated at the bottom left corner when clicking on a zone.

In order to represent the generation and attraction of trips per zone, we use coloured circles of different sizes located at the centroid of the zone. The colouring differentiates between areas that generate a lot of trips (bright green colour) and those that attract a lot of trips (bright red colour) passing through the ones that are balanced (blue colour). When clicking on a zone, a bar graph containing all the departures and arrivals per hour for that zone is displayed at the bottom right corner of the screen.

The distribution of trips is represented by means of coloured lines connecting zones. The colour gives information about the predominant direction of the trips, indicating whether there are a lot of trips from the selected zone to the other one (bright green colour) or a lot of trips from the other zone to the selected zone (bright red colour) passing through the balanced situation (blue colour). There are also some zones that might generate or attract some trips from or to the selected zone, but not a lot (darker green and darker red respectively). The size of the lines is proportional to the total number of trips in both directions, being a greater number a thicker line. When hovering over a line, information about the link is displayed through a modal text area. The information represented is the total number of trips between the two zones and the departures and arrivals from and to the selected zone.
The user controls allow the user to tune or adjust the way the visualisation is presented. The main user controls in our visualisation are:

- The city selector, which allows the selection of the city to be visualised.
- The time picker, to select the hour range to visualise.
- The number of trips filter, which allows the restriction of the zones to be visualised to the ones generating/attracting over a certain number of trips.
- The animation button, which starts an animation of the whole day visualisation.

The developed visualisation has been successfully tested with different city representatives to analyse different datasets (e.g., measured and simulated use of the Barcelona’s bike sharing scheme), and has been proved to be a simple and meaningful way of representing generation and attraction of trips by zones and the distribution of these trips between zones.

Figure 11. Visualisation tools
2.9 Case studies

The main goal of the case studies was to demonstrate the capabilities of MATSim — once enhanced with the results obtained by EUNOIA — to test specific mobility policies at the three cities participating in the project either as partners (Barcelona) or through the EUNOIA Advisory Board (London and Zurich). After discussion with different representatives of the Mobility Department of the Barcelona City Council, Transport for London and the Division of Transport at the City of Zurich, we decided to focus the simulation effort on the analysis of different configurations of the public bike sharing schemes of the three cities. The reason for this choice had both a scientific/technical justification and a policy rationale.

From a scientific/technical perspective, the proposed case studies have allowed the evaluation of some of the main project results:

- In terms of the data sources used to build, calibrate and validate the model, one of our objectives was to make use of different combinations of conventional (e.g., travel surveys) and non-conventional, ICT-based data. The London case study provides an application for the use of the Oyster card data made available by TfL, as well as for the usage of data collected on the London bike sharing scheme; the Barcelona case study includes two main novelties: the use of phone call records for generating agents’ activity plans, and the use of the data from the public bike sharing smart card for the calibration of the travel demand model; finally, the Zurich case study is built using more conventional, survey data.
- In terms of modelling and simulation, we have used a novel MATSim bike-sharing module, which constitutes one of the first attempts to include public bike sharing systems in travel demand models. The bike sharing scheme module has been enabled in MATSim for the three case study cities: London, Zurich and Barcelona. To our knowledge, MATSim is the only assignment model allowing the implementation of bike sharing schemes at this level of detail.
- Finally, the case studies have made use of the new visualisation tools described in section 2.8 with the aim to provide clear and meaningful interactive information about public bike sharing usage flows.

From a policy perspective, this is a subject of interest for the three cities: the public bike sharing schemes of Barcelona (Bicing) and London (popularly known as Boris Bikes, named after Boris Johnson who has been the Mayor of London during most of the time when the scheme has been in operation) have been in operation since 2007 and 2010 respectively, and the need to optimise the operation of the system (e.g., the bike relocation strategies) is a common concern for both cities; in the case of Zurich, there is not a public bike sharing system yet, but there is a plan for its implementation. Therefore the subject allows the analysis of problems that are common for London and Barcelona, as well as of the differences between both systems, and can in turn be useful to inform the deployment of the Zurich system.

The case studies should be looked at in terms of the specificities of each case study. In short, while the Zurich case study dedicated much of the time to the preparation and testing of the two specific modules on joint choice and joint use within MATSim, the Barcelona and London case studies spent much time on the preparation of sensible inputs and the various MATSim settings in order to set up the base year case study. The main achievements of each case study are listed next.
Case study 1: London

- A travel demand has been produced for London using activity-based principles. This approach was encouraged by TfL and is being further developed beyond the project life.
- A method to use Oyster card data to refine the travel mode preferences of agents within MATSim has been formulated.

![Figure 12. Geographic comparison between the home-work travel demand in the data and the London model estimate](image)

Case study 2: Zurich

- An implementation of joint choice has been tested in Zurich resulting in agents actively engaging together in leisure and education related activities. The latter one is particularly promising, as it emerged naturally from the module formulation.
- Zurich has tested the impacts around a new bike sharing scheme in the city. It focuses on identifying stations that might cause major difficulties when putting the redistribution process into place, given the topographical properties of the City of Zurich. Elevation in the city plays an active role in this test.

![Figure 13. Bike sharing stations in the Zurich model](image)
Case study 3: Barcelona

- We have designed a method to produce realistic activity-based travel demand from mobile phone data.
- The bike sharing scheme module has also been activated for Barcelona using MATSim; the impact of elevation on uphill/downhill trips is also an important input to this implementation.

Figure 14. Bicing stations in Barcelona. These locations were introduced in the MATSIM model

2.10 Conclusions and lessons learnt

Thanks to the proliferation of smart devices and interconnected services allowing the automatic collection of a vast amount of spatial and temporal data, research on cities can now rely on large-scale, detailed longitudinal (dynamic) data. The potential is huge, but it does come with a number of challenges: we have more data, but often with lower explanatory power about the underlying behaviour of individuals, and larger sample sizes usually come at the expense of low quality, noisy or biased data, calling for the development of new methods and tools to mine, blend and analyse data.

EUNOIA has explored the opportunities offered by big data to contribute to the foundations of a new science of cities. Using a variety of non-conventional data sources, we have investigated activity and mobility patterns in a variety of European cities of different sizes, and have looked more in detail at the three cities involved in the project: a megacity like London, a big city like Barcelona, and a medium sized city like Zurich. We have identified some spatial features that seem to be independent of each city’s cultural specificities, such as the scaling of the number of hotspots or the proportion of integrated and random commuting flows; but also some behavioural differences that seem to be driven by cultural aspects, such as the differences in the use of geolocated devices across Switzerland, UK and Spain.
Most of the analysis methods developed within the project can be generalised to other countries; whether some of the behavioural parameters found by EUNOIA — such as those regarding social networks and travel behaviour — are valid for other cities is however a question that will require further research.

Finally, the empirical work conducted by EUNOIA has been used to inform the development of improved urban models and decision support tools. Findings from the construction of trip matrices from mobile phone data records (or from other geolocated data), or the ability, for the first time, to use highly detailed, disaggregated data for the calibration of state-of-the-art multi-agent travel demand models like MATSim, set the basis for the development of innovative models and tools and ultimately for new approaches to the way cities are understood, planned and managed. These tools, models and applications are continuing to be developed under continuing projects.
3. Impact, dissemination and exploitation of results

3.1 Potential impact

3.1.1 Scientific/technical impact

At the scientific level, EUNOIA has contributed to the development of new methods for the analysis of new spatio-temporal databases for the purpose of understanding urban activity and mobility patterns, it has shown the potential of new, non-conventional data sources for the calibration and validation of urban simulation models, and has contributed to advancing the state-of-the-art in transport modelling.

These results have led to a significant number of scientific publications and have opened new research avenues that will be further explored in other research projects in which the EUNOIA partners are currently involved, such as the FP7 project INSIGHT (www.insight-fp7.eu).

3.1.2 Impact on innovation and competitiveness

The work done in EUNOIA has opened the door for the development of innovative products and services.

The Consortium includes a research-intensive SME, Nommon, which will benefit from the project results for the development of new products, in the frame of its business strategy in the area of smart cities and urban mobility. Nommon is already exploiting commercially the algorithms developed for the extraction of OD matrices from phone call data and has recently launched several pilot projects in this area with public and private customers.

Other project results, such as the new MATSim modules and the newly developed visualisation tools, can also lead to innovative solutions.

3.1.2 Impact on policy and governance

At the policy level, the methods and tools developed by EUNOIA will be of value for the planning and management of urban transport systems. The EUNOIA case studies, focused on public bike sharing systems, have illustrated this potential.

The cities of Barcelona, London, and Zurich, as well as other cities with whom the Consortium members collaborate or will be collaborating in the future, will be able to make use of the project results to inform their transport planning practices. Discussion with end users involved in the project, such as Transport for London or the Barcelona City Council, has been kept beyond the project life to exploit these results in a more applied policy decision context. Similar opportunities are being explored with other stakeholders potentially interested in the project results.
3.2 Dissemination and exploitation of results

The strategy to bring about these impacts has based on a comprehensive communication and dissemination plan, targeting the actors that can benefit from, implement, or further develop the project results, including the scientific community, transport and urban planning practitioners, and policy makers.

The main dissemination activities carried out during the project are the following:

- Project website: www.eunoia-project.eu.
- Web 2.0 and social networking tools. Web 2.0 and social media offer a well-established and cost-effective channel for dissemination, networking, and informal exchange of information. Twitter and LinkedIn have been extensively used to raise awareness about the project and to inform about the latest news.
- Communications and press releases in national and international media.
- Scientific publications. The project has produced 12 articles in international leading peer-reviewed journals, addressing the different research communities potentially interested in the project results.
- Participation in existing events, conferences, and workshops. The members of the EUNOIA Consortium have presented the key findings of the project at various conferences, and also at less formal policy and academic meetings. We have also organised a number of parallel sessions specifically devoted to the subjects addressed by EUNOIA, such as the satellite workshops UrbanNet 2013 and CitiNet 2014 organised at the European Conference on Complex Systems.
- EUNOIA Final Event: a free, half-day event organised on 11 November 2014 at the facilities of the BBVA Innovation Center in Madrid to present the main results of EUNOIA. The webcast of the talks is available at: https://www.youtube.com/watch?v=M85_x247odg.

The project deliverables and all the dissemination material produced by EUNOIA can be consulted at the project website.
4. Website and contact data

4.1 Project website

The EUNOIA website can be found at the following link:

http://www.eunoia-project.eu/

4.2 Contact details

4.2.1 Project coordination

Project Coordinator:
Maxi San Miguel
Instituto de Física Interdisciplinar y Sistemas Complejos, Universitat de les Illes Balears
maxi@ifisc.uib-csic.es

Deputy Scientific Coordinator:
José Javier Ramasco
Instituto de Física Interdisciplinar y Sistemas Complejos, Universitat de les Illes Balears
jramasco@ifisc.uib-csic.es

Deputy Management Coordinator:
Ricardo Herranz
Nommon Solutions and Technologies
ricardo.herranz@nommon.es
4.2.2 List of participants and contact names

Instituto de Física Interdisciplinar y Sistemas Complejos, Universitat de les Illes Balears
Website: http://ifisc.uib-CSIC.es/
Contact point(s): Maxi San Miguel (maxi@ifisc.uib-CSIC.es), José Javier Ramasco (jramasco@ifisc.uib-CSIC.es)

Nommon Solutions and Technologies S.L.
Website: www.nommon.es
Contact point(s): Ricardo Herranz (ricardo.herranz@nommon.es)

Centre for Advanced Spatial Analysis, University College London
Website: http://www bartlett.ucl.ac.uk/casa
Contact point(s): Michael Batty (m. batty@ucl.ac.uk)

Institut de Physique Théorique, Commissariat à l’Énergie Atomique et aux Énergies Alternatives
Website: http://ipht.cea.fr/en/
Contact point(s): Marc Barthélemy (marc.barthelemy@cea.fr)

Institut für Verkehrsplanung und Transportsysteme, Eidgenössische Technische Hochschule Zürich
Website: http://www.ivt.ethz.ch
Contact point(s): Kay W. Axhausen (axhausen@ivt.baug.ethz.ch)

Antonio Lucio Gil
Website: https://www.linkedin.com/pub/antonio-lucio-gil/14/2bb/99a
Contact point(s): Antonio Lucio (aluciog@gmail.com)

Institut Municipal d’Informàtica, Ajuntament de Barcelona
Website: http://w110.bcn.cat/portal/site/Ajuntament
Contact point(s): Alex Serret (aserretg@bcn.cat)