



J R C T E C H N I C A L R E P O R T S

Recommendations to Harmonize Travel Behaviour Analysis

OPTIMISM WP2: Harmonisation of national travel statistics in Europe

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OPTIMISM's scope is to provide a scientifically documented insight of the transport system and people's travel choices via the study of social behaviour, mobility patterns and business models. The overall aim of OPTIMISM project is to define which of the future changes in the travel system would lead to a sustainable way of travel-ing, as people could travel more efficiently, cleaner and more safely, without compromising mobility.

The OPTIMISM project consists of six work packages (WPs):

- Work Package 1: Management
- Work Package 2: Harmonisation of national travel statistics in Europe
- Work Package 3: Demand and supply factors for passenger transport and mobility patterns – status quo and foresight
- Work Package 4 : Analysing measures for decarbonisation of transport
- Work Package 5: Elaborating on strategies for integrating and optimising transport systems
- Work Package 6: Dissemination and Awareness

OPTIMISM is a project partially financed by The European Commission under the framework programme. It is coordinated by the Coventry University Enterprises (UK). The consortium includes partners from different EU Member States and Associated Countries such as Zürcher Hochschule für Angewandte Wissenschaften (Switzerland), Signosis (Belgium), DLR – German Aerospace Center (Germany), Forum of European National Highway Research Laboratories (Belgium), Università Degli Studi di Roma La Sapienza (Italy), Transport & Mobility Leuven (Belgium), CE Delft (Netherlands) and the IPTS Joint Research Centre (European Commission)



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Table of Contents

Acknowledgement	2
Table of Contents	3
List of Abbreviations	4
List of Tables	6
1. Introduction.....	7
1.1. The OPTIMISM Project	7
1.2. OPTIMISM WP2: Harmonization of national travel statistics in Europe - Summary findings of the previous tasks	8
1.3. The aim and the structure of the deliverable.....	9
2. Review on past travel surveys at European level and studies on harmonization of travel data	11
3. Policy objectives for passenger transport, data needs and gaps	16
3.1. Policy Objectives for Passenger Transport.....	16
3.2. Main Data Needs and Gaps.....	18
4. Recommendations to collect and report travel data for policy making	25
4.1. A short list of recommendations to harmonize NTS in Europe	25
4.2. Alternative sources of information for travel data	27
4.3. Potential role of ICT in travel data collection	32
4.4. Data items in NTS to be covered by ICT	36
4.5. Recommendations for a Europe-wide travel survey in terms of current data needs.....	37
5. Concluding remarks.....	38
References.....	42
Appendix: OPTIMISM stakeholder workshop documents	46

List of Abbreviations

AI	Artificial Intelligence
ANPR	Automatic Number Plate Recognition
CAPI	Computer Assisted Personal Interview
CATI	Computer Assisted Telephone Interview
CO ₂	Carbon dioxide
COMPASS	Optimised Co-modal Passenger Transport for Reducing Carbon Emissions
COST	European Cooperation in Science and Technology
DATELINE	Design and Application of a Travel Survey for European Long-distance Trips Based on an International Network of Expertise
DG CLIMA	Directorate-General for Climate Action
DG ENER	Directorate-General for Energy
DG JRC	Directorate-General Joint Research Centre
DG MOVE	Directorate-General for Mobility and Transport
DG REGIO	Directorate-General for Regional and Urban Policy
DG RTD	Directorate-General for Research and Innovation
DSRC	Dedicated Short Range Communications
ETIS	European Transport Policy Information System
EU	European Union
EUROSTAT	Statistical Office of the European Union
GALILEO	European Global Navigation Satellite System
GHG	Greenhouse Gas
GIS	Geographical Information Systems
GLONASS	Global Orbiting Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

GSM	Global System for Mobile Communications
ICT	Information and Communication Technologies
KITE	Knowledge Base for Intermodal Passenger Travel in Europe
MEST	Methods for European Surveys of Travel Behaviour
NFC	Near Field Communication
NHTS	National Household Travel Survey
NST/R	Standard goods classification for transport statistics/ Revised
NTS	National Travel Surveys
NUTS	Nomenclature of Territorial Units for Statistics
OPTIMISM	Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility
Pkm	Passenger Kilometres
RFID	Radio Frequency Identification
SHANTI	Survey Harmonisation with New Technologies Improvement
TDA	Travel Diary Application
TEN-T	Trans-European Transport Network
TERM	Transport and Environment Reporting Mechanism
TEST	Technologies for European Surveys of Travel Behaviour
UIC	International Union of Railways
UNFCCC	Framework Convention on Climate Change
Vkm	Vehicle Kilometres
Wi-Fi	Wireless Fidelity
WP	Work Package

List of Tables

Table 1: Transport White Paper Policy Initiatives and Corresponding Data Needs ...	17
Table 2: Travel survey differences in reference period and population	20
Table 3: Transport Indicators needed by modellers, researchers and policy makers....	21
Table 4: OPTIMISM data gap analysis on NTS in Europe – A summary of the findings	23
Table 5: Main Characteristics of NTS in Europe	25
Table 6: Alternative data sources by main subject areas	28

1. Introduction

1.1. The OPTIMISM Project

The OPTIMISM (Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility) project aims to propose a set of strategies, recommendations and policy measures, through the scientific analysis of social behaviour, mobility patterns and business models, for integrating and optimising transport systems based on the impact of co-modality and information and communication technologies (ICT) based solutions for passenger transport.

OPTIMISM project is based on three main blocks of activities:

- Identifying the gaps and harmonisation of data in travel behaviour. This will lead to a unified set of data that will serve as reference material for future exploitation of existing studies and baseline information (or data),
- Defining demand and supply factors that shape the transportation system and mobility patterns. This will aim to give an outlook on future developments by modelling and scenario simulation, and
- Defining the potential decarbonisation of the passenger transport system and ensuring the sustainability of the system. The decarbonisation potential and co-benefits of best practices and solutions will be based upon an analysis of ICT and co-modality options with an impact assessment of the research results.

These activities are carried out in several work packages (WPs) as following:

WP1 Management: to manage and coordinate all different activities within the OPTIMISM project and to secure that the project consortium can deliver the results while at the same time fulfil contractual obligations.

WP2 Harmonisation of national travel statistics in Europe: to describe social behaviour, mobility patterns and business models through analytical insights into the data of Europe-wide national travel statistics – aiming to harmonise possible differences of the identified data.

WP3 Demand and supply factors for passenger transport and mobility patterns – status quo and foresight: to provide insights into the factors and key drivers shaping the transportation system and mobility patterns concerning passengers – aiming to give an outlook on future development.

WP4 Analysing measures for decarbonisation of transport: to provide a broad overview of ways to enhance co-modality, with a focus on ICT-solutions and to identify best practices for passenger transport.

WP5 Elaborating on strategies for integrating and optimising transport systems: to develop roadmaps including strategies, technologies and methodologies for integrating and optimising transport systems for passengers with the help of several policy papers.

WP6 Dissemination and Awareness: to ensure that the project's practical outcomes are widely disseminated to the appropriate target communities, at appropriate times, via appropriate methods.

1.2. OPTIMISM WP2: Harmonization of national travel statistics in Europe - Summary findings of the previous tasks

One of the main objectives of the OPTIMISM project is to gather, analyse and harmonise national travel data statistics in Europe, which are based on different methodologies identified within WP2. More specifically:

- to research, identify, gather and process relevant information and key factors about general conditions of national travel behaviour,
- to compile and analyse the identified data in order to understand differences in the individual national context of transport and mobility,
- to identify the different methodologies used for elaborating national statistical data,
- to determine the need of harmonizing national travel data,
- to identify and assess various methods of harmonizing statistical data,
- to develop a methodology to collect and report data on travel behaviour,
- to give guidelines and recommendations for harmonizing differences of statistical data and scientific analysis on travel behaviour.

In order to achieve these objectives, three tasks are identified of which the first two have already been accomplished in the first year of the project. A brief description of these preceding tasks and their findings are given below:

Task 2.1 Gather and analyse national travel statistics

The main objectives of this task were: I) to establish what countries are collecting in National Travel Surveys (NTS), II) to identify the information and travel data collected in those NTS, III) to examine how the surveys are designed in terms of classification of data, sampling and survey implementation, and IV) to analyse if travel data from the different countries can be compared. Within the task, an extensive questionnaire has been developed and sent to relevant authorities, responsible for conducting the NTS in 29 countries across Europe. The survey

covered a large set of questions regarding purpose, scope, methodology, quality and availability of data in the different NTS. The results revealed that there is much variation between the types of data collected by NTS across European countries. Purpose and methodologies used to collect data (including sampling of populations, frequency of data collection, types of data collected, etc.) vary significantly across countries. Consequently, harmonisation of NTS in Europe is difficult given the current survey methodologies and approaches. Different baseline years, methodologies and types of data collected vary considerably within the European Union and are therefore difficult to compare. It is concluded that a consistent system should be developed and agreed on by Member States and a core set of data items should be collected in order that transport movements and trends can be analysed. The results of the survey and recommendations based on the analysis of NTS can be seen in OPTIMISM Deliverable 2.1 (Ahern et al., 2012).

Task 2.2 Develop a methodology to harmonise travel statistics

Moving towards to the harmonisation of national travel statistics, the information collected in task 2.1 was further analysed for 15 countries. The main objectives were: I) to analyse the data gaps in NTS, II) to identify potential data formats that can be used for data collection in NTS, and III) to propose a data collection methodology and common standardized structure for NTS in Europe. As a result of this task, a set of 48 parameters has been identified for which information needs to be collected in order to properly analyse the most important European transport policies that are linked to passenger transport. This set of parameters with proper format and collection procedures can be considered as a starting point of the harmonisation of data collection for travel behaviour. The proposed methodology to harmonize travel statistics can be seen in OPTIMISM Deliverable 2.2 (Akkermans et al, 2012).

The outputs of the tasks 2.1 and 2.2 are further analysed and discussed in the subsequent sections of this deliverable to construct a list of recommendations on travel data collection and reporting in Europe.

1.3. The aim and the structure of the deliverable

Policy making in transportation requires data from a wide range of areas. In general, travel demand and its dependent socio-economic factors, transport infrastructure with relevant attributes and basic characteristics of travel behaviour have been the main servants of this requirement for decades. However, rapid and radical changes in technological, social and economic life within a continuously changing mobility environment bring different needs and require numerous approaches for better data collection and data gathering. Although availability and widespread use of new technologies (e.g. GPS, GSM, GIS technologies, internet, smart cards etc..) give important opportunities to collect, store and retrieve data with lower costs and in greater detail, the problems with geographical inconsistencies, format and definition mismatches and heterogeneous data collection methodologies bring many difficulties to proper interpretation and usage of collected travel data. The problems widen when it comes to monitor and implement transport policies at European level and

where up to date comparable travel data for several countries are crucial for policy assessments.

Among several other efforts to identify data needs and harmonize travel surveys, this deliverable aims to define recommendations to collect and report travel data with the identification of main data needs and gaps, and with the analysis of alternative sources of information and new data collection techniques. Based on the findings of the previous tasks and a stakeholder workshop, and after a brief review of past studies in the same direction, this report starts from a list of variables which are needed for policy making but are unavailable/insufficient in the context of existing data collection methodologies especially with respect to NTS. The report then, explores alternative sources of information, potential use of modern data collection techniques (mainly ICT applications such as GPS and smart phone technologies) and options to merge them with NTS data. Finally, it discusses recommendations for a Europe-wide travel survey considering the current data needs for policy making.

A stakeholder workshop was held in March 2013 which discussed existing data collection techniques across Europe, elaborating the problem areas, gaps and needs for harmonization of the NTS; and identifying alternative sources of information and new data collection techniques with the help of experts from the public and private sectors. The workshop was organized in three sessions including open discussions at the end of each session: the first session consisted of presentations including findings of the OPTIMISM project on NTS and data gaps in Europe; the second session focused on experiences of collecting and reporting travel behaviour data and explored data needs for policy making, alternative sources of information and data collection techniques using ICT; and the last session consisted of an open discussion on design issues of a Europe-wide travel survey in terms of current data needs. Several Commission services (DG MOVE, DG REGIO, DG RTD, EUROSTAT, JRC) as well as the transport experts from universities and the private sector were represented in the workshop. The agenda of the workshop, the list of participants, key questions/discussion topics and the minutes from the discussion sessions can be seen in the Appendix.

The main sources of input for this deliverable are: the findings of the two previous deliverables of the OPTIMISM project on harmonization of NTS and data gaps; the stakeholder workshop on data needs and new data collection techniques; the COMPASS project (based on the collaboration agreement with the OPTIMISM project) findings on the role of ICT in travel data collection; and desk research on the scientific literature and the past projects focusing on travel statistics and surveys. The following section of the deliverable gives a brief review of past travel surveys at European level and recent studies on harmonization of travel surveys. Section 3 demonstrates policy objectives for passenger transport and data needed for policy making and then identifies main data gaps. Section 4 includes recommendations to collect and report travel data. The recommendations on harmonization of NTS, alternative sources of information and potential role of ICT in travel data collection are presented in this section as well as the recommendations on the main components of a Europe-wide travel survey in terms of current data needs. Finally, concluding remarks are given in section 5 with a summary list of recommendations.

2. Review on past travel surveys at European level and studies on harmonization of travel data

Over the past decades, there have been several international projects, initiatives and studies dealing with European level travel survey design and large scale data collection, harmonization and gathering. One of the main purposes of these efforts is to improve comparability of travel data among countries and regions while measuring and monitoring the impacts of international transport policies. It is clear that the problems associated with the lack of a European level travel survey, heterogeneous NTS and incomparable data, is not new. Already in the 1990s, several EU projects were dealing with this problem with a focus on travel survey designs and co-operation of Member States for travel data gathering. Two important examples are the MEST (Methods for European Surveys of Travel Behaviour) and the TEST (Technologies for European Surveys of Travel Behaviour) projects from the EU 4th framework programme conducted between 1996 and 1999. Starting from the MEST and the TEST projects, a brief review of past and recent studies with their main aims and scopes is presented here.

The MEST project formulated important guidelines and recommendations for NTS in order to improve coordination and data gathering quality in the EU Member States. It had a focus on long-distance journeys (MEST, 1999a). A survey was designed with a combination of computer assisted telephone interviews (CATI) and computer assisted personal interviews (CAPI) which gave high response rates. Although a combined approach was used, telephone surveys were given higher importance. During the interviews, three reminders were used for interviewees if no initial answer was received, and all missing items and non-responses were carefully documented. The sample included all persons aged 6 or older, vehicle based details were also collected. MEST had a person-based sampling approach, but concluded that a household based sampling would lead to additional, useful information on the respondents. Technological developments in the future were also considered and highlighted. It was suggested that the survey methodology should be continuously updated with the newest technologies like recording with GPS devices (MEST, 1999b).

The TEST project also aimed for improved data quality and cost efficient survey designs through the use of new technologies for European level travel surveys. The focus was on innovative, computer based travel diary applications (TDA) and geographical information systems (GIS) to improve accuracy of the travel data. It also used artificial intelligence (AI) for correcting data and for dealing with missing values and errors. A web based solution for disseminating the survey results was also part of the TEST project (TEST, 1999b). Field results from four countries in the TEST project showed that the use of the computer based TDA was successful in journey data gathering, except in the case of some elderly and female respondents. It was suggested that the bias related to these respondents could be solved through more user friendly web access. The use of GIS also provided good results, especially for geocoding of areas and semi-automatically calculating the distances between places. Additionally, AI helped to decrease errors in data collection, and web based open

access application for the dissemination of the survey results proved to be suitable for the publication of data. Making everything open to the public increased transferability and accessibility of data to all interested parties. The TEST project recognized the importance of continuous technical updates in combination with field tests which improves quality of the travel data used for policy making. The TEST project suggested the use of GSM and GPS devices for tracking more accurate routes at the end of the 1990s approximately ten years later the first surveys have been started to use portable GPS devices or internet applications for tracking routes in Europe (TEST, 1999a).

Another important EU project following the MEST and the TEST projects was DATELINE (Design and Application of a Travel Survey for European Long-distance Trips Based on an International Network of Expertise), conducted between 2000 and 2003 as a part of the EU 5th framework programme. The goal of the project was to create a survey design for a coordinated Europe-wide travel survey to be used in all of the 15 EU Member States, at the time of the project. The DATELINE travel survey design aimed to collect data only for long-distance trips. The main objective was to create an integrated database in both national and EUROSTAT contexts as an input to transport planning activities (DATELINE, 2003).

The project started with specific definitions of trips and journeys, their separate purposes and an appropriate cut-off distance (100 km as the crow flies). A journey was defined as a series of trips starting and ending at home or a temporary location whereas a trip was defined as the transport activity that connects only a single origin and destination. A classification into journey types according to trip purposes was also proposed: holiday journeys, other private journeys, business and commuter journeys. The DATELINE survey was conducted over a year, drawing a new sample every day to eliminate the seasonal differences. The sampling method chosen was random sampling, calculating individual samples for NUTS 1 zones. The total sample size funded by the European Commission was about 60,000 persons. However, it was extended in some countries and, in the end, a total of 86,969 persons were surveyed with 66% response rate in the first and 85% in the second phase. It was suggested to use a combined approach with postal, telephone and face-to-face interviews together with a two phase survey design to reduce respondents' burden. It was of highest priority not to overburden the respondents with confusing and unnecessary information. The first phase of the survey included data collection on socio-economic aspects as well as data capturing on basic travel data (origin, destination, duration, journey date) on the journey types. The second phase included more detailed questions about long-distance journeys and especially multi-day and multi-modal journeys with several destinations (Brög et al., 2003).

The DATELINE project showed that it is possible to create a survey standard which can be applied in countries with different cultures and needs. Based on the results of the DATELINE project a further initiative called European Transport Policy Information System (ETIS) was established (DATELINE, 2003). The ETIS project, being a follow up project to DATELINE, aimed to provide input to policy makers and researchers for monitoring and analysing transport related strategic developments in Europe. The objective was to create an integrated database from heterogeneous

travel data collection regimes including EUROSTAT, Member States, international organizations and EU projects. The main focus was given to the set of policy needs and issues surrounding the TEN-T policy. The ETIS was a several yearlong research project consisting of 3 work packages (ETIS-LINK, ETIS-AGENT, ETIS-BASE). In addition to traditional travel data, socio-economic data and external factors of the transport sector were also considered as part of data collection. Coherent transport related indicators for all EU Member States were also given importance in order to compare and analyse transport related policies (ETIS, 2005). The need for continuing update of the ETIS project led to the ETIS PLUS project in subsequent years. The ETIS PLUS project, as a part of the EU 7th framework programme continued the work on establishing a common transport policy database to be used by policy makers and by analysts and modellers at European level. It was created also an online platform for accessing the transport data which provides a one-stop-portal for accessing the database and for finding project and data related documentation. It is publically available and includes harmonized, observed and modelled freight and passenger transport data from European regions for the years 2005 and 2010. As suggested in the first ETIS project, socio-economic data are also included in the database. The online tool allows users to explore data in tables, graphics or maps which are available for downloads. The available data can be filtered based on selected parameters, areas and trip purposes (ETISPLUS, 2013; ETIS-VIEW, 2013).

The KITE Project has also established a standardized travel survey in Europe with a focus on intermodal long-distance travel. The main objective of the KITE project was the provision of a knowledgebase on intermodal travel together with a suitable survey methodology for Europe. This knowledgebase was to comprise all relevant information about passenger intermodality, which can be easily accessed and allows stakeholders to develop and evaluate intermodality-related transport measures (KITE, 2007).

The Eurobarometer surveys on transport also provide significant amounts of information at a European level, especially in the fields of monitoring passenger needs and attitudes and evaluating their reactions to some certain changes in mobility patterns. Two recent Eurobarometer surveys need mention in this respect. Commissioned by the Directorate-General for Energy & Transport (DG MOVE) of the European Commission, and carried out under the Flash Eurobarometer framework and coordinated by The Gallup Organization, they are:

- Flash Eurobarometer on *Attitudes on issues related to EU Transport Policy*: Conducted in 2007, covering all 27 Member States of the European Union with a randomly selected sample of over 25,767 individuals of at least 15 years of age. The survey included 13 questions apart from demographic information. In each country, telephone interviews were used as surveying method, with the exception of some countries where face-to-face interviews were conducted additionally. The study was primarily designed to (European Commission, 2007):
 - Follow up car and other transport usage patterns
 - Understand to what extent citizens link car type and its usage to the environment and to the traffic situation

- Ask what people think about methods for reducing traffic
 - Explore what activities people are involved in to reduce CO₂ emissions in road transport
 - Assess opinion on what are the costs of damaging the environment and who should bear them
 - Ask what respondents think about the security controls at the airports and if they are aware of their rights as air passengers.
- Flash Eurobarometer on *Future of transport*: Conducted in 2010, covering all 27 Member States of the European Union with a randomly selected sample of 25,570 individuals of at least 15 years of age. Included 5 multiple-choice questions apart from the demographic information. The interviews were conducted predominantly through fixed-line telephone and the target sample size in most countries was 1.000 interviews. The survey was focused on various transport policy issues and asked EU citizens for their views on the following topics (European Commission, 2011a):
 - the level of support for “pay-as-you-drive” policies
 - peoples’ readiness to buy a “cleaner” vehicle as opposed to a traditional one
 - car users’ reasons for not using public transport
 - ideas for making public transport easier to use
 - ideas that could encourage car users to consider reducing the amount they use their car.

Considering the harmonisation of NTS in Europe, one important initiative is the SHANTI (Survey Harmonisation with New Technologies Improvement) COST Action (European Cooperation in Science and Technology), which had a five year (2008-2012) action plan and aims to develop guidelines for harmonizing national travel surveys in Europe. SHANTI consists of four working groups. The first one focuses on travel survey methods and tools in order to identify best practices, the second works on technological solutions for travel surveys, the third analyses the possibilities for vehicle-based surveys in Europe instead of household-based ones and the fourth one focuses on current national household travel surveys (NHTS) and the comparability issues related to these surveys. Through harmonized travel survey designs, it aims to improve data quality and comparability which enable Europe-wide detailed transport analysis over time. The SHANTI action also establishes strong relations between European countries and brings academia, transport society and practitioners together. As a result of SHANTI project detailed guidelines for survey harmonization will be created. The project was finished recently, however the final results have not yet been published (SHANTI - COST Action, 2013a; 2013b).

Finally, the COMPASS Project has analysed existing travel surveys in Europe with regard to available data concerning long-distance, rural and urban travel. Funded by the EU 7th framework programme, COMPASS identified solutions to improve availability of travel behaviour data and explored opportunities for harmonisation of the data collected. Especially, Deliverables 3.1 and 4.2 of the COMPASS project included a list of indicators needed by transport demand models, and reviewed the potential role of ICT in collecting these indicators and other relevant travel data

(COMPASS,2012; Enei, 2012; Shibayama and Lemmerer, 2013). The important findings of the COMPASS project are further evaluated in the section 3 and section 4 of this deliverable.

There are also several academic studies exploring the issues related to data gathering and standardization, travel survey designs and their comparability in Europe and in the rest of the world. For instance, Stopher and Greaves (2007) reviewed the recent history of household travel surveys in several countries and identified problems that contemporary surveys were encountering. They also explored data demands for emerging transport models and identified potential future data collection techniques. They emphasized the need for improved extent, quality and accuracy of travel data and pointed out decreasing response rates and increasing costs of the traditional surveys. As a solution *GPS devices* were suggested to be used as supplements or even replacements for traditional surveys to reach an improved accuracy of travel routes. According to them, another alternative would be *a panel design* for general travel data collection. A panel could be used to follow changes in travel patterns monitoring the panel members behaviour over a longer period of time (Stopher and Greaves, 2007). Another study analysed current travel data gathering tools and suggested usage of smart phone applications as a solution for low-cost, accurate and time saving travel data gathering. Through an automatic data collection, which would include single trips, complete routes and the modal choice, manual questionnaires and data entries should not be necessary. Due to increasing use of smartphones such applications could be broadly used and would unify data collection methods and improve the results achieved (Nitsche et al., 2012). Finally, it is worth mentioning a study conducted by the Transportation Research Board of the National Academies (TRB, 2008) which includes a collection of best practices in travel survey standardization and gives recommendations towards harmonised travel survey design, data collection and preparation.

The majority of the reviewed projects and studies mainly focus on harmonizing travel surveys at national level instead of having a European level survey design. Harmonization of existing travel surveys will remove many inconsistencies in comparing travel patterns among countries and will lead to more manageable results compared with large scale surveys which are more difficult to conduct and manage. Developing a Europe-wide single travel database requires substantial funding and takes several years; faces several challenges such as difficulties of managing large amounts of data, keeping information up to date, validating data and dealing with various local characteristics. Eurobarometer type surveys with a short questionnaire seem more efficient at the moment for collecting appropriate type of data for individual policy analysis at European level. Finally, considering the technical side of the survey designs, a trend towards automatic, GPS and Smartphone based designs together with the manual, traditional surveys can be seen. GPS based routing has already been tested and used as a support for travel data collection in some European countries like Switzerland, Denmark and Finland. If representative samples can be drawn from the residential population, such ICT applications may improve the accuracy and the availability of travel data which is further discussed in this respect in section 4.

3. Policy objectives for passenger transport, data needs and gaps

3.1. Policy Objectives for Passenger Transport

The White Paper on Transport (European Commission, 2011b) set ten objectives for a competitive and resource efficient transport system in Europe and defined a roadmap including 40 concrete initiatives *"... to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. By 2050, key goals will include: No more conventionally-fuelled cars in cities; 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions; A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport; all of which will contribute to a 60% cut in transport emissions by the middle of the century"* (DG MOVE, 2012b). Among the 40 initiatives, fourteen initiatives are directly linked to passenger transport in OPTIMISM WP2, which contribute basically to the following White Paper objectives (European Commission, 2011b, p. 9-10):

- Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO₂-free city logistics in major urban centres by 2030.
- By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.
- A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.
- By 2020, establish the framework for a European multimodal transport information, management and payment system.
- By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. Make sure that the EU is a world leader in safety and security of transport in all modes of transport.
- Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport investments.

As a starting point of our analysis on data needs and gaps, the selected initiatives of the White Paper are shortly described in Table 1 together with the corresponding data needs for monitoring and evaluating relevant transport policies. The data categories or domains are remained same with the previous task of the project as (Akkermans et al., 2012): I) Demographic information, II) emission and cost information, III) vehicle usage, IV) general mobility information, V) infrastructure, quality of mobility and multi-modality, and VI) accidents, injuries and fatalities.

Table 1: Transport White Paper Policy Initiatives and Corresponding Data Needs

White Paper Initiatives	Short Description*	Main Data Needs
Towards a 'zero-vision' on road safety (initiative 16)	Harmonise and deploy road safety technology, develop a comprehensive strategy of action on road injuries and emergency services, focus on training and education of all users, promote the use of safety equipment, pay particular attention to vulnerable users such as pedestrians, cyclists and motorcyclists.	Accidents, injuries and fatalities Infrastructure, quality of mobility and multi-modality
Passenger's rights (initiative 21)	Develop a uniform interpretation of EU legislation on passenger rights and a European standard of protection for the citizens, improve the quality of transport for elderly people, passengers with reduced mobility, complete the legislative frameworks on passenger rights covering passengers on multimodal journeys with integrated tickets.	Demographic information Infrastructure, quality of mobility and multi-modality
Seamless door-to-door mobility (initiative 22)	Define measures for further integrating different passenger transport modes to provide seamless multimodal door-to-door travel, promote the development and use of intelligent systems for interoperable and multimodal scheduling, information, online reservation systems and smart ticketing.	General mobility information Infrastructure, quality of mobility and multi-modality
Mobility continuity plans (initiative 23)	Ensure the definition of mobility plans to ensure service continuity, address the issue of prioritisation in the use of working facilities, the cooperation of infrastructure managers, operators, national authorities.	Vehicle usage
A technology roadmap (initiative 24)	Clean, safe and silent vehicles for all different modes of transport, technologies to improve transport security and safety, a sustainable alternative fuels strategy including also the appropriate infrastructure, integrated transport management and information systems, intelligent infrastructure to ensure maximum monitoring.	General mobility information Infrastructure, quality of mobility and multi-modality
An innovation and deployment strategy (initiative 25)	Deployment of smart mobility systems, open standard electronic platform, development of a plan for investment in new navigation, traffic monitoring and communication services.	Vehicle usage Emission and cost information
A regulatory framework for innovative transport (initiative 26)	Define appropriate standards for CO ₂ emissions of vehicles in all modes, vehicle standards for noise emission levels, ensure rapid up take of new technologies, rules on the interoperability of charging infrastructure for clean vehicles, specifications and conditions for transport related smart charging and payment systems.	Demographic information General mobility information Infrastructure, quality of mobility and multi-modality /
Travel information (initiative 27)	Promote awareness of the availability of alternatives to individual conventional transport (drive less, walk and cycle, car sharing, park & drive, intelligent ticketing etc.).	Vehicle usage Emission and cost information
Vehicle labelling for CO ₂ emissions and fuel efficiency (initiative 28)	Review the labelling Directive to make it more effective, support the market take-up of fuel efficient, safe and low-noise tyres beyond the existing performance requirements.	General mobility information Infrastructure, quality of mobility and multi-modality
Eco-driving and speed limits (initiative 30)	Include eco-driving requirements in the future revisions of the driving licence directive and take steps to accelerate the deployment of ITS applications in support of eco-driving.	Vehicle usage Emission and cost information
Urban mobility plans (initiative 31)	Establish procedures and financial support mechanisms at European level for preparing Urban Mobility Audits, as well as Urban Mobility Plans, link regional development and cohesion funds to cities and regions that have submitted a current, and independently validated Urban Mobility Performance and Sustainability Audit certificate.	General mobility information Infrastructure, quality of mobility and multi-modality
An EU framework for urban road user charging (initiative 32)	Develop a validated framework for urban road user charging and access restriction schemes and their applications, including a legal and validated operational and technical framework on vehicle and infrastructure applications.	Vehicle usage Emission and cost information
A core network of strategic European infrastructure (initiative 34)	Define a core network of strategic European infrastructure integrating the eastern and western part of the European Union, concentrate on the TEN-T network, deploy large scale intelligent and interoperable technologies to optimise the capacity and the use of infrastructure, take into account energy efficiency needs and climate change challenges.	General mobility information Infrastructure, quality of mobility and multi-modality
Smart pricing and taxation (initiative 39)	Revise motor fuel taxation including energy and CO ₂ components, develop guidelines for the application of internalisation charges to road vehicles, covering social costs of congestion, CO ₂ , local pollution, noise and accidents.	Emission and cost information Vehicle Usage

* Summarized from the White Paper on Transport, European Commission (2011b)

3.2. Main Data Needs and Gaps

European transport faces several challenges especially with unsustainable trends in greenhouse gas (GHG) emissions, fossil fuel dependency and congestion. These trends have to be reversed with safer, cleaner and innovative transport policies as well as a better use of transport infrastructure. During the OPTIMISM stakeholder workshop, The European Commission's Directorate General for Mobility and Transport (DG MOVE) presented four items which cover emergent actions in this direction and support White Paper initiatives (Grzeszczyk, 2013):

- *Internal Market:* Create a genuine Single European Transport Area by eliminating all residual barriers between modes and national systems.
- *Innovation:* EU research needs to address the full cycle of research, innovation and deployment in an integrated way.
- *Infrastructure:* EU transport infrastructure policy needs a common vision and sufficient resources. The costs of transport should be reflected in its price in an undistorted way.
- *International:* Opening up third country markets in transport services, products and investments continues to have high priority.

Especially, the two of the White Paper goals related to passenger mobility are given high importance by DG MOVE:

- Halve the use of conventionally fuelled cars in urban transport by 2030; phase them out in cities by 2050.
- By 2050 the majority of medium distance (> 300 km and < 1,000 km) passenger transport should be by rail.

In order to reach these goals, it is necessary to have informed, evidence based policy analysis which requires statistical evidence to support policy making and to monitor the effects of policies. Additionally, transport modelling is an important tool used in the preparation of impact assessments at European level. A reference scenario is prepared at regular time intervals with joint initiative of European Commission's DG CLIMA, DG ENER, and DG MOVE and in association with DG JRC. The reference scenario serves as a benchmark for assessing the impacts of new initiatives in several energy, transport and climate policy areas and is subject to extensive consultation of the Member States. The quality of the results is dependent on available inputs, detailed and reliable statistics especially in model calibration phase. However, resources devoted to the collection of statistics are limited. Therefore, the priority should be given to usage of already existing statistical sources while in particular increasing the comparability (Grzeszczyk, 2013).

The main data needs for monitoring and analysing these two specific goals, halving the conventionally fuelled cars and increasing the share of passenger transport by rail, can be summarized as following (Grzeszczyk, 2013).

- Transport activity in urban areas, expressed in passenger kilometres (Pkm) for various modes (buses, passenger cars and vans, powered two-wheelers, rail, tram and metro) and by technology of vehicles (for passenger cars)
- Transport activity by distance class (> 300 km and $< 1,000$ km) in Pkm for all passenger modes (coaches, passenger cars, passenger vans, powered two-wheelers, rail, aviation, and inland navigation)

Considering the data availability in Pkm by vehicle type in urban areas for instance, there are inconsistencies in vehicle typologies. There is no common terminology and no distinction between different vehicle technologies (e.g. in hybrid and hydrogen technologies) moreover, there are no statistics available with an urban/non-urban distinction. In addition, when considering transport activity by distance classes, this is not completely covered by NTS and no sources are readily available. It is necessary to develop a common methodology with relevant indicators to measure travel patterns with different distance classes (Grzeszczyk, 2013).

Emerging statistical needs reported to EUROSTAT by various services and agencies of the European Commission are also important in identifying main data needs and gaps in passenger transport. According to EUROSTAT (2011a), main indicators required by transport policy makers can be summarized in the following domains:

- Indicators on transport safety and congestion
- Emission measures (GHG, pollution and noise)
- Co-modality, intermodality, logistics and performance indicators
- Road traffic and passenger transport, with urban/non-urban separation

In order to collect periodical travel data in some of the above mentioned areas, EUROSTAT has been started a study called "Support for passenger mobility statistics" 2012. It aims to produce collection of available results as well as methodological information from NTS on passenger mobility. Three reports are compiled twice a year including: an up-to-date inventory of national surveys on passenger mobility; non-harmonised database of main national results; a methodological report on passenger mobility statistics (see AGILIS, 2012a; 2012b; 2012c). In this study, two questionnaires are distributed to the EU 27, the EU candidate and EFTA countries mainly to measure the following key transport indicators:

- Share of trip makers (of the total reference population during one day)
- Daily trips modal share
- Average number of trips/person/day
- Average travel distance (km)/person/day
- Average total travel time (min)/person/day
- Average travel time & distance by purpose of travel
- Average travel time & distance by mode of travel

Regarding the information collected by EUROSTAT, there are many inconsistencies between countries which do not permit the comparison of the information and the construction of a concrete overview of their common characteristics. The surveys are generally designed for national needs and lack a harmonised methodology (AGILIS, 2012c). The main inconsistencies in coverage among surveys are given below and can also be seen with country details in Table 2 (Cheneby, M., 2013, p.9):

- modes of transport
- distance classes
- survey frequency
- inconsistencies in the compilation of indicators
- reference population
- reference period
- breakdown variables

Table 2: Travel survey differences in reference period and population

Country	Name of survey	Reference year	Period where the indicators refer to	Population where the indicators refer to
CY	Short distance passenger mobility survey	2009	One working day and a weekend	Households and persons interviewed
DE	Mobility in Germany	2008	-	German residents
DK	Danish national travel survey	2010	365 days of the year	Danish residents aged 10–84 years
FI	Finnish national Travel survey	2005	365 days of the year	Total population aged 6 years and over
FR	French national travel survey	2008	Weekday	Resident population aged 6 years and over
HU	Passenger mobility survey	2009	Weekday	Total Hungarian population
IE	National travel survey	2009	-	Resident population aged 18 and over who are in the country at the time of the survey
LV	Mobility survey of Latvian population	2008	Specific days of the week	Resident population aged 5 years and over
NL	Dutch travel survey	2007	Weekday	Permanent resident population except from those living in institutions
NO	Norwegian personal travel survey	2005	Any day of the week	Permanent residents aged 13 years and over
RO	Transport by passenger cars	2010	One working day and a day in the weekend	All permanent residents
SE	Swedish national travel survey	2006	Whole week	Permanent residents aged 8-84 years
CH	Micro census on travel behaviour	2005	365 days of the year	Swiss residents aged 6 and over
TR	Passenger mobility survey	2010	Whole week	All private households in settlements located in Turkey
UK	National travel survey (NTS)	2009	365 days of the year	UK residents in private households

Source: Towards harmonised indicators on passenger mobility, Cheneby, M. (2013, p. 9)

The COMPASS project also explored important indicators for transport modelling which gives useful insights for better understanding of data needs. In WP4 of the project, several demand forecasting methods and models such as ASTRA, PTV Viseva/PTV Visum, MOSAIC, MARS, TRANS-TOOLS, OmniTRANS, ETIS and ETIS plus were examined in order to identify main transport indicators needed for travel demand forecasting and further policy analysis. After being presented with a list of indicators, transport experts, modellers and policy makers were asked to grade these indicators according to their importance with an online survey. They were also asked to report any missing or unavailable indicators.

The results of the survey are summarized in Table 3 including important/less important and missing indicators for travel demand models. The findings indicate that the modal shares and intermodality, trip origin/destination and trip purposes, travel time and cost together with the accessibility to services are given high importance by transport modellers and researchers on the one hand; and seasonal, monthly, weekly trip interactions, modal split, waiting time and average costs for any transport activity are reported as missing indicators on the other hand (Shibayama and Lemmerer, 2013).

Table 3: Transport Indicators needed by modellers, researchers and policy makers

Important Indicators	Less Important Indicators
<ul style="list-style-type: none"> ▪ Modal split ▪ Modes used in a single trip ▪ Number of trips per person ▪ Number of trips starting in a zone ▪ Number of trips ending in a zone ▪ Number of trips zone-to-zone (OD matrix) ▪ Number of trips (by mode, aggregated) ▪ Trip purpose ▪ Trip length (door-to-door) ▪ Percentage of intermodal trips ▪ Travel time ▪ Household transport expenditure ▪ Passenger trip costs (user cost) ▪ Generalised cost ▪ Walking time to the closest PT stop ▪ Accessibility (number/ratio of people accessible to a place/PT stop/zone/node within certain time) ▪ Number of people with car access 	<ul style="list-style-type: none"> ▪ Ratio of trips requiring long-term parking ▪ Percentage / number of people with driving license ▪ Percentage of employed and residents owning a driving license for cars and motorcycles ▪ Walking time to the parking place ▪ Value of time ▪ Average time needed to find a parking place at the destination
Missing/Unavailable Indicators	
<ul style="list-style-type: none"> ▪ Seasonal, monthly, weekly, daily trip fluctuation; ▪ Modal split (preferable to refer to the distance to cover and the available modes); ▪ Modal split for specific journey purposes (notably commuting and travel to school); ▪ Waiting time (if "travel time" is not included); ▪ Public expectation of travel and waiting time; ▪ Average monthly costs for transportation; ▪ Average number of cars per household in a given area. 	

Source: The role of ICT in travel data collection, Shibayama and Lemmerer (2013, p. 16-17)

Referring to the stated policy objectives and initiatives on passenger transport and based on the OPTIMISM survey on NTS currently available in EU Member States, (Ahern et al., 2012), a data gap analysis was carried out within OPTIMISM (Akkermans et al., 2012). The focus of this gap analysis was clearly on data collected through NTS, resulting data items, respective data formats and, finally, the feasibility of NTS data comparison and harmonisation. Several relevant subject areas were identified to be considered for analysis in order to support European transport policy making.

For each of these areas a set of required parameters and variables was identified, and for each of these parameters and variables, amongst other things, the suitability to be collected via NTS was also assessed. The data gaps were identified with respect to trip details (origins and destinations), trip chains, vehicle occupancy rates, multimodal trips, congestion, the use of travel management systems, emissions, the internalisation of external costs, or the rail infrastructure (Akkermans et al., 2012).

Table 4 gives summary results of OPTIMISM data gap analysis for 15 countries analysed in detail through their NTS. It provides information on the availability of parameters and existence of format mismatches among countries. Some transport parameters needed for policy making, but excluded from the NTS analysis (not suitable for NTS), are also included in the table. Considering the full availability of parameters, only Pkm per trip per mode, number of trips per day per purpose, trip lengths, number of accidents/injuries and the main demographic characteristics are readily available today. These are shown in grey within the table.

In more detail (Akkermans et al., 2012; Akkermans, 2013):

- Demographic information: Mostly available, but major differences exist in the amount of information collected (e.g. only for the respondent, or for the entire related family).
- Vehicle usage: Car occupancy rates are only partly collected.
- General mobility information: Basic information (Vkm and Pkm) is readily available, but more detailed information on the trip motives, regions, fuel types, etc. is not.
- Infrastructure, quality of mobility & multi-modality: Information on trip duration is available, but not for time loss, congestion, travel management systems, multi-modality options, assisting technologies, etc.
- Accidents, injuries and fatalities: Accidents and injuries are only scarcely reported in NTS but available through European legal acts or voluntary based sources.
- The parameters for which the use of NTS is not suited: For some of them, databases exist. For others, additional information needs to be gathered.

Table 4: OPTIMISM data gap analysis on NTS in Europe – A summary of the findings

Parameter Groups	Name of Parameters	Available through NTS	Partly available through NTS	Available through European Legislations or other Agreements	Not Available through NTS and European Legislations	Existence of format mismatch among NTS
Demographic Information	Respondent age	+				Yes
	Respondent sex	+				No
	Additional age		+			Yes
	Additional sex		+			No
	Vehicle ownership	+				No
	Car fuel	+				No
	Level of education	+				No
	Current employment	+				No
	Income		+			Partly
	Home location	+				No
	Work location	+				No
Information on Transport Quality	Duration of trips	+				No
	Lost time per trip (Congestion Time)				+	NA
	Use of travel management systems				+	NA
	Use of travel man. sys. on % of trips				+	NA
Information on Multi-Modal Transport	Availability of trans. inf. for multi-modal assistance				+	NA
	Availability of integrated ticketing system				+	NA
	Number of multi-modal trips		+			Partly
	Number of multi-modal chains				+	NA
	Accessibility of public transport		+			Partly
Information on Transport Safety	Total number of accidents			+		NA
	Number of accidents per vehicle type (per mode)			+		NA
	Number of accidents per region				+	NA

	Total number of injuries			+		NA
	Number of injuries per vehicle type (per mode)			+		NA
	Number of injuries per region				+	NA
Information on Vehicle Usage	Car occupancy rate		+			Partly
General Mobility Information	Vkm per trip		+			Partly
	Vkm per transport mode		+			Partly
	Vkm per vehicle type		+			Partly
	Vkm per fuel type		+			Partly
	Vkm per region type		+			Partly
	Vkm per trip motive		+			Partly
	Pkm per trip	+				No
	Pkm per transport mode	+				No
	Pkm per vehicle type	+				Partly
	Pkm per fuel type		+			NA
	Pkm per region type		+			NA
	Pkm per trip motive		+			NA
	Number of trips per day	+				No
	Number of trips per transport mode	+				Partly
	Number of trips per vehicle type	+				Partly
	Number of trips per region type		+			Yes
	Number of trips per trip motive	+				No
	Number of trips per chain		+			Yes
	Trip length	+				No
	Trip length per vehicle type		+			Yes
	Chain length		+			Yes
Parameters Not Suitable for collecting with NTS						
<ul style="list-style-type: none"> CO₂ emissions per vehicle / per person CO₂ emissions per fuel type External costs internalised Percentage of the external costs internalised? 		<ul style="list-style-type: none"> Vehicle occupancy rates per trip Trip chaining information Origin-Destination information Rail network length 		<ul style="list-style-type: none"> Rail network length per usage type Use of Travel Management Pkm for multi-modal trips, per vehicle type Total number of fatalities / per vehicle / per region 		

Source: Compiled from the NTS analyses carried out in OPTIMISM Deliverable 2.2 (Akkermans et al., 2012).

4. Recommendations to collect and report travel data for policy making

This study aims to define recommendations to collect and report travel data with the identification of main data needs and gaps, and with the analysis of alternative sources of information and new data collection techniques. Past studies on travel data collection in Europe, current data needs for policy making and main data gaps were reviewed and highlighted in the preceding sections. Recommendations to harmonize NTS, to use alternative data sources, to utilize ICT in travel data collection and recommendations for a Europe-wide travel survey in terms of current data needs are given in this section.

4.1. A short list of recommendations to harmonize NTS in Europe

NTS are important data sources for transport policy analysis, modelling and planning at national level. At international level, it is necessary to harmonize NTS for maintenance of data quality and for improvement of data comparability. In general, establishing standardized procedures for travel surveys has the following benefits (NCHRP, 2002, p. 4): I) assurance that a minimum standard of survey practice is employed in data collection, II) assurance that a certain quality of product is achieved, III) clarification of which factors and threshold values, are used to describe a standard or assess data quality, IV) clarification of the data, V) opportunity to compare among data sets, and VI) accessibility of data for third parties.

Considering NTS in Europe, several factors bring various biases and inconsistencies in cross-country analysis of transport policies. These are mainly due to differing survey years/timeframes, methodological heterogeneity and national traditions/local characteristics of NTS. Based on the findings of OPTIMISM task 2.1 (Ahern et al, 2012), the main characteristics of NTS in Europe can be summarized as follows:

Table 5: Main Characteristics of NTS in Europe

<p>similar purposes of use and similar user groups</p> <ul style="list-style-type: none"> policy makers, government agencies (i.e. planning authorities), research communities and municipalities (at regional or local level) <p>heterogeneous frequency of data collection</p> <ul style="list-style-type: none"> 60% regular basis, but at different intervals (e.g. quarterly, annually, every 10 years) most recent surveys conducted between 2006 and 2011 <p>different sampling approaches and frames</p> <ul style="list-style-type: none"> e. g. population registry, postcode address files <p>different instruments for data collection</p> <ul style="list-style-type: none"> questionnaires and interviews (PAPI, CATI, CAWI, CAPI, F2F) only 2 countries used GPS devices to collect trip data 	<p>(micro) data availability for third parties:</p> <ul style="list-style-type: none"> only 8 countries provide access to micro data after registration <p>different groups of respondents are covered</p> <ul style="list-style-type: none"> differing age groups (e.g. all vs. no children); complete households vs. individuals <p>wide range of differing trip purposes, also reflecting national/cultural particularities</p> <ul style="list-style-type: none"> inconsistent categories/overlaps <p>mainly trip-based data collection</p> <ul style="list-style-type: none"> focus on the main purpose and main mode limited information on multi-stage trips and trip chains <p>pre-aggregation of data items</p> <ul style="list-style-type: none"> during data collection (irreversible) or post-processing age groups, trip lengths, trip durations
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Source: Evaluation of National Travel Surveys in Europe: Evidence from 29 European Countries, Schulz, A. (2013, p. 3-4)

The recommendations to solve some of the above mentioned problems and to improve data quality and data comparability among countries are already discussed in OPTIMISM Deliverables 2.1 and 2.2 (Ahern et al, 2012; Akkermans et al., 2012) in detail. These recommendations can be summarized here as follows:

- A core set of parameters should be developed to properly analyse the most important European transport policies. Based on the EU White Paper goals, a set of parameters was proposed in OPTIMISM task 2.2 as indicated in Table 4,
- A proper data grouping, data format and units of measurement should be defined for the parameters. The suggested grouping in OPTIMISM WP2 is: I) demographic information, II) emission and cost information, III) vehicle usage, IV) general mobility information, V) infrastructure, quality of mobility and multi-modality, and VI) accidents, injuries and fatalities,
- Clear methodologies and methodological frameworks for all NTS should be put in place and the main purposes of surveys should be conformed;
- EUROSTAT can lead the activities to construct necessary groupings in relation to different data sets and develop a fixed methodology with clear frameworks of data collection in the Member States,
- It is necessary to identify an adequate frequency for repeating NTS to guarantee data continuity and comparability. It is suggested that data are collected regularly on a yearly basis, a time period of more than 5 years is not recommended for comparison reasons,
- The sampling composition should be consistent among countries. It is suggested to use the population registries in the Member States to compose representative population samples. Apart from this, the confidence interval for samples should not be less than 95%,
- Sample sizes should be large enough to facilitate detailed analyses for smaller sub-samples (e. g. for particular socio-demographic groups living in certain regions etc.),
- Alternative sources should be used together with NTS to enrich awareness of travel patterns and to validate collected data through the NTS,
- New technological advances (e.g. GPS, GSM, GIS technologies, internet, smart cards etc..) should be used to complement NTS; their potential role in data collection should be further investigated,
- At the time being, it is not recommended to abandon the use of traditional instruments (pen and paper, telephone and face-to-face interviews, etc.) for the collection of data through NTS. The parallel usage of traditional and new technologies would allow for improved data collection, mutual data validation (checking for consistency) and a swifter data flow.

4.2. Alternative sources of information for travel data

Despite the undisputed value of NTS for transport research in terms of basic analysis and subsequent modelling and/or planning of the transport system, they are not the only data sources available in this field. Besides, there are many other sources on the empirical/statistical background, all of them providing more or less detailed insight into travel behaviour.

Given the importance of the transportation sector for national economies, a large part of this data is collected by national statistical offices, ministries or subordinated administrative bodies on a statutory basis. These official data sources are supplemented by numerous non-official data providers such as research institutes or transport providers (Schulz, 2005). The collection of transport statistics on behalf of the European Union usually takes place at national level and is induced by a number of European legal acts (DG MOVE, 2012a) adopted by the Member States. EUROSTAT, as Directorate General of the European Commission, is responsible to compile harmonised statistical information. It provides respective key figures related to various transportation issues on annual basis; data are disseminated via printed publications, e. g. the Statistical pocketbook 2012 – EU transport in figures (European Commission, 2012) or directly online via the EUROSTAT website (EUROSTAT, 2011b). Specific transport data on passenger and freight transport are complemented by general economic information or transport-related data on energy consumption or environmental impact. Most figures are provided separately according to single transport modes.

Although usually highly aggregated either by major socio-economic regions (NUTS 1), or by basic regions for the application of regional policies (NUTS 2), or, rather rarely, by small regions allowing for specific diagnoses (NUTS 3), official data provided by national or regional statistical offices are most comprehensive. Available statistical series usually are broken down by:

- transport mode (e. g. railway, road, inland waterways, sea, air),
- type of transport according to distance (national, international),
- commodity classification (e. g. according to the Standard Goods Classification for Transport Statistics NST/R 2007),
- geographical scope (NUTS regions), or the
- kind of transport (transport for hire or reward, transport on own account).

Alternative Data Sources

In addition to official transport statistics, there are numerous other data sources to be expected of substantial value for quantitative and qualitative analysis of the current mobility system in order to support policy decisions. Table 6 provides an overview of alternative data sources associated with the main subject areas or data categories identified within the OPTIMISM Task 2.2 (Akkermans et al., 2012). While many of these data are clearly related to transport and mobility issues, the usefulness of other sources may not immediately be apparent, as they are produced for particular purposes other than transport research or policy and are not explicitly intended to be used in that way (e.g. employment statistics). Data that are expected

to be generated by means of new technologies are excluded, as they will be considered separately in the subsequent section. The data categories or domains are remained same with the previous task.

Table 6: Alternative data sources by main subject areas

Subject Area	Alternative Data Sources*
Demographic information	<ul style="list-style-type: none"> ▪ population statistics/projections ▪ household statistics/projections ▪ time-use surveys ▪ income statistics/surveys/projections ▪ family expenditure surveys ▪ driving license registers ▪ vehicle registers ▪ employment and commuter statistics ▪ macro/ micro census data
General mobility information	<ul style="list-style-type: none"> ▪ mileage surveys ▪ commuter statistics ▪ time-use surveys
Transport infrastructure	<ul style="list-style-type: none"> ▪ infrastructure availability ▪ infrastructure accessibility
Transport quality	<ul style="list-style-type: none"> ▪ congestion indices ▪ public transport performance
Multi-modal transport	<ul style="list-style-type: none"> ▪ time-use surveys ▪ public transport performance
Environment and emissions	<ul style="list-style-type: none"> ▪ vehicle registers ▪ fuel sales/consumption (per fuel type) ▪ mileage surveys ▪ TERM indicators
Cost internalisation	<ul style="list-style-type: none"> ▪ income statistics/ surveys ▪ family expenditure surveys
Safety	<ul style="list-style-type: none"> ▪ accident statistics ▪ regular inspection for cars ▪ TERM indicators
Vehicle usage	<ul style="list-style-type: none"> ▪ vehicle registers ▪ traffic counts

* The table contains duplication as some data sources provide information related to more than one subject area.

Generally, official (long-term) statistics, in particular at national level, provide a reliable quantitative framework as reference data for modelling and analysis at lower spatial level. Although *demographic* and *general mobility information* can easily be collected by NTS, further useful information might be derived from surveys and statistics not directly focused on mobility issues. *Population* and *household statistics* together with respective long-term projections provide the framework for the development of future mobility (demand) scenarios: In-depth knowledge about the current mobility behaviour or even the underlying individual motives of distinct groups (such as the elderly, households with small children, or migrants) are usually only available for representative, but small samples. Depending on both the available

forecast period and the level of detail of population/household statistics, these figures may facilitate the transfer of contemporary behaviour to future populations by means of modelling or scenario techniques. Given the close relation between disposable income, the allocation of expenditures to the transport sector and resulting mobility behaviour (including, e. g., car ownership), *income statistics* as well as *expenditure data* may also facilitate development and elaboration of future mobility scenarios, in particular in conjunction with population data and genuine mobility data generated by dedicated travel surveys (such as NTS). However, respective long-term projections are available only in exceptional cases.

Time-use surveys may provide detailed insight into activity schedules of individuals or entire households including any interdependencies between family members. Usually, trips are considered as particular activity connecting other activities. If *employment and/or commuter statistics* contain spatial information on residential as well as on working places, resulting origin-destination matrices may provide information on the extent of spatial interrelations and potential transport demand. Official *vehicle registers* provide detailed information on the current stock of motor vehicles including important vehicle characteristics such as manufacturer, make, vehicle type, engine and fuel types, or the vehicles' EURO emission standard (EURO 1-6). In addition to information on first registrations, re- and de-registrations by registration district, some characteristics of vehicle owners are provided such as age, sex, or –in case of commercial registrations– the owner's affiliation to a particular economic sector.

Mileage surveys, usually based on vehicle samples, provide detailed data on vehicles (such as vehicle type, engine type) in conjunction not only with the actual mileage of each vehicle, but also characteristics of its owner. In particular the combination of mileage and engine type allows for emission estimates (noise and exhaust emissions). Depending on survey design, origin-destination matrices at different spatial levels (down to NUTS 3) may be available. Using NTS data, *greenhouse gas and other emissions* can – at best – only be calculated indirectly based on reported trip lengths in conjunction with the type of vehicle or engine used for these trips. Moreover, several influencing factors usually remain unknown such as actual driving behaviour and speed or the actual type of fuel as these items usually are not queried in NTS. In order to assess the *environmental impact of transport* other data on fuel consumption in terms of sales or average specific consumption by type of vehicle have to be used.

Fuel sales (per fuel type) can be used not only to assess resulting mileage, but also, if combined with vehicle fleet data, to calculate the respective environmental impact in terms of exhaust emissions. With respect to high shares of cross-border and transit traffic in some countries (e. g. Austria, Germany) the risk of underestimating or misallocating the overall mileage has to be taken into account as fuel purchases may take place elsewhere outside these transit countries. *Emission data* such as provided by the European Environment Agency (EEA) are based on the EU Greenhouse Gas Monitoring Mechanism and the UN Framework Convention on Climate Change (UNFCCC) process. The main aim of the *Transport and Environment Reporting Mechanism (TERM)* is to monitor the progress and effectiveness of

transport and environment integration strategies on the basis of a core set of indicators (European Environment Agency, 2011; 2012). In addition to TERM, the EEA also addresses other specific transport and environment issues such as transport emission inventories or transport subsidies by mode. It has to be noted, that data are partly modelled.

Data on *transport infrastructure* are available from different sources. The main focus of official statistics is on the infrastructure such as the extent of networks (in particular road and rail). Public transport providers and respective associations (e. g. UIC – International Union of Railways or national counterparts) do provide corporate data related to their transport services, but in aggregated form. Usually, these corporate data may include the specific *vehicle stock in service* such as buses, coaches, or aircrafts (including number of available seats), the extent of available line networks as well as the number of maintained stops and stations, and the number of operated lines/ routes (all of them by means of transport). *Performance data* may include the overall number of seat/passenger kilometres within each network, average seat occupancy rates (by means of transport), or the number and type of tickets sold to customers. In addition to these purely economic figures, data on punctuality allows for quality assessments of the public transport system's efficiency. Especially with respect to multimodal mobility behaviour, the diversifying market for professional bike- and car-sharing or similar rental systems have to be taken into account, as they potentially may alter modal choice behaviour. However, as corporate performance data are often particularly considered as confidential, these data are available in highly aggregated format, if at all.

Besides its mere availability, the accessibility of transport infrastructure is just as important. *Accessibility indicators* such as distance to the nearest bus stop or train station or the average travel time to the nearest slip road to a motorway may be used to assess either the overall extent and quality of territorial coverage by public transport within a particular region or existing 'windows of opportunity' for the residential population to use these infrastructures. Using both *GPS based historic and real-time in-vehicle navigation and tracking data*, a mapping of actual road congestion over time allows for the development of *congestion indices* (e. g. TOMTOM, 2013) in order to assess a road network's quality and performance by reported travel times (compared to free flow conditions) and average time delays per hour driven. In order to assess a transport system's overall *safety standard*, usually the number of accidents and resulting injuries or fatalities are used as indicators. Typically, *accident statistics* are officially compiled by region, by mode, by type of road, or by type of involved vehicles and transport users. Specialised surveys may provide more detailed information about causalities (in particular the influence of alcohol and other drugs, medicines, speed, and road conditions).

Usability of alternative data sources

Primary statistical data such as population or employment statistics are collected periodically at regular intervals within (national) legal frameworks. Secondary data instead derive from data collected for administrative purposes such as vehicle registration, albeit again on the basis of legal obligation. In most cases, for research,

planning and policy purposes, these official statistics are easily accessible for most European countries.

On the contrary, various non-official data sources produced by independent research institutions or (public) transport providers and related associations are fragmentary in nature and hardly comprehensive in terms of subject, geographical and temporal coverage. Moreover, genuine research data are often regarded as intellectual property and therefore remain 'hidden' at least for a certain time, despite possible public funding. Corporate data are rarely made public as they usually are considered as business secrets. In both cases, only the most highly aggregated data are available.

Quite similar to NTS (Ahern et al., 2012), comparable limitations based on differing data collection purposes and methodological particularities will arise when using data from different sources:

- In particular non-official data will not be available for each European country.
- Despite considerable standardisation efforts made by the EU and supported by corresponding legislation, the level of standardisation throughout European countries is still uneven, quite often resulting in limited cross-country comparability.
- As empirical data necessarily rely on particular concepts and definitions, considerable differences are likely to be observed when comparing international data.
- Highly aggregated data often proves inappropriate to describe and assess mobility behaviour that usually takes place at local and/or individual level.
- Official statistics as well as independent surveys may differ in terms of their reporting period. Given the influence of many other factors on transport and mobility (e. g. economic crisis, severe weather conditions etc.), data may be biased considerably.
- Methodological approaches to collect data may considerably differ, even when statistics and surveys are quite similar to each other in terms of overall objective and scope. Methodological biases must be expected in terms of sampling, response behaviour (selectivity), variable format, or under-/overestimation.
- Available variable formats may hamper or even obstruct adequate post-processing aiming on comparative analysis. This is particularly the case when data were collected in an aggregated manner (e. g. age groups).
- With respect to data privacy concerns, many data sources related to individual trips do not contain precise spatial information. Geolocalisation cannot be taken for granted; if collected and made available for third parties, quite often

geocodes are aggregated at higher municipal or even regional levels (e. g. NUTS 3 level).

It is also worth mentioning that commercial data providers exploit many of these data sources. Based on data processing and/or modelling they maintain comprehensive databases in order to offer tailored information in various formats and for various purposes. Depending on the respective provider, more or less detailed metadata describing both origin and processing of input data are provided; in case of insufficient metadata it may be hard to comprehend the underlying process of data generation as well as to assess data quality and validity.

4.3. Potential role of ICT in travel data collection

Today, information and communication technologies (ICT) play a significant role in everyday life. In the transport sector, ICT are applied in various areas (WP4 of the OPTIMISM project is dedicated to the ICT in transport sector). One of the important options to apply ICT in the transport sector is to use them for collection of travel data. This section examines the potential role of ICT with respect to travel surveys. This issue was also the main focus of D4.2 of the simultaneously-running COMPASS project. Therefore it was decided at the kick-off meeting that the COMPASS project would focus on the role of ICT in travel data collection, while the OPTIMISM project would focus on the possibilities to harmonise (European) travel surveys and to identify data needs and alternative sources.

For that reason, potential role of ICT in travel data collection discussed in this section is based on the results of the analyses carried out in the COMPASS project (Shibayama and Lemmerer, 2013) with a focus on data needs and gaps identified within the OPTIMISM task 2.3. In the remainder of this section, the following ICT applications are briefly discussed: I) GNSS (Global Navigation Satellite System), II) Mobile device localisation, III) RFID/NFC/DSRC and IV) Camera and sensor-based technologies.

Global Navigation Satellite System (GNSS)

GNSS is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world. Currently, two GNSS systems are in operation: the Global Positioning System (GPS) managed by the United States and the Russian Global Orbiting Navigation Satellite System (GLONASS). Additionally, also Europe (GALILEO) and China (Beidou) are working on GNSS systems that will become fully operational in the coming years.

Satellite-based navigation systems use a method of triangulation to locate the user, by using information from a number of satellites. Each satellite transmits signals at precise intervals, which could be received by passive receivers. Based on the signals of several satellites, the horizontal and vertical location (as well as the error) of the receiver is calculated. Signals at least four satellites are needed to provide an accurate localisation. GNSS/GPS systems provide direct information on the location of the receiver (coordinate and altitude), date and time and several accuracy measures. Travel data that could be derived from GNSS/GPS receivers are:

- *Trip*: the beginning/end of a trip is detected by a long time of staying within a certain temporal and spatial threshold (often 2 minutes and 50-200 metres).
- *Travel mode*: detection of travel modes is mainly based on the average speed of the vehicle (has high reliability). However, detecting public transport (particularly rail transport) is difficult (has low reliability).
- *Trip purpose*: by combining the data from GNSS/GPS receivers and GIS applications trip purposes could be estimated. Accuracy is low and validation by other survey techniques is needed.

Additionally, using GNSS/GPS for travel surveys have several advantages (Shibayama and Lemmerer, 2013; Marchal and Pham, 2013):

- GNSS/GPS provides more specific information in terms of spatial and temporal resolution;
- GNSS/GPS limits forgotten trips, which is a known shortcoming in data collection with conventional surveys;
- The relatively low burden for the respondents allows substantially extended survey duration: at least one week with GPS, compared to one or two days with a conventional questionnaire.
- In cases where mobile phones are used as GPS receivers, the cost of data collection is lower than with conventional survey methods.

However, the use of GNSS/GPS for travel surveys also have some drawbacks/limitations (Shibayama and Lemmerer, 2013; Marchal and Pham, 2013):

- Since GNSS/GPS needs the signals of at least four satellites to accurately calculate the location of the receiver, the accuracy of the position determination deteriorates significantly in urban areas (high buildings) and heavy artificial structures (tunnels, underground, large building complexes). Also GNSS/GPS receivers on board of public transport vehicles could be difficult to detect for the same reasons.
- GNSS/GPS receivers need a short time to calculate the location when started (cold start) or when brought outside from an unreachable area (e.g. building). This may reduce the accuracy of the data gathering process.
- Collecting transport data by using GNSS/GPS requires that travellers use the receiver devices in a proper way. This implies that the receiver should be switched on and the battery should be charged. Additionally, users should always carry the receiver with them when leaving their house.

GNSS/GPS technologies do not provide direct data on trips, trip purposes and travel modes used. As mentioned before, these data could be estimated by using

algorithm's based on the data that are provided by GNSS/GPS. However, particularly in case of trip purposes and travel modes used this may result in rather inaccurate data. For example, the accuracy of rail vehicle detection is low compared to road vehicles. Finally, it is worth mentioning the representativeness/selectivity problem of GNSS/GPS technologies while collecting travel data. Although traditional surveys have the same problem, the usage of these technologies for data collection may shift or even enlarge the risk of selectivity with respect to particular target groups hard to reach such as low income, non-motorized and elder population groups. Therefore GNSS/GPS technologies needed to be used for some certain measures and together with traditional surveying techniques until widespread usage by all population segments.

Mobile device localisation

By localising mobile devices (e.g. mobile phones, personal data assistants) data of travel patterns could be gathered. The main advantage of this technology is that it provides precise location information. Different technologies could be used to detect these mobile devices, the most important ones are:

- *Mobile phone masts*: by using triangulation from one or more mobile phone masts, the location of mobile devices could be determined. The accuracy of this method range from several meters to over a mile depending on the number of base stations in range (Kansal et al., 2007). Therefore, this option could only be useful for gathering data on travel patterns in certain areas.
- *Wi-Fi-based localisation*: this technology is based on measuring the intensity of the received signals from Wi-Fi base stations. Based on the strength of the signal received (RSS: Received Signal Strength), the distance of the mobile device to the Wi-Fi base station could be estimated by using the functional relationship which states that the signal strength decays exponentially over distance (Scheerens, 2012). Subsequently, the location of the mobile device could be calculated based on the location information of the Wi-Fi stations. The latter data could be gathered by using so-called cloud sourcing techniques. The accuracy of this technology depends strongly on the number of Wi-Fi stations in the area and hence this technology is only useful for gathering data on travel patterns in urban areas.
- *Bluetooth*: an option quite similar to Wi-Fi based localisation is Bluetooth. As Wi-Fi it is also a wireless networking technology and it also transmits radio signals at the same frequencies as Wi-Fi does, so many of the localization principles for Wi-Fi are also applicable for Bluetooth (Scheerens, 2012). The accuracy of this technology with respect to localisation is estimated at about one meter (Fisher et al., 2004; Martin et al., 2010), but as for Wi-Fi-based localisation depends strongly on the number of base stations in the area. Therefore, this option is only useful as data gathering technique for certain (urban) areas.

To conclude, mobile device localisation could provide valuable travel data for certain areas/circumstances. Particularly Wi-Fi-based localisation could be useful in urban areas where GNSS/GPS based localisation is not possible. However, this technology is not (yet) able to fully identify survey transport patterns in a country.

Radio Frequency Identification (RFID), Near Field Communication (NFC) and Dedicated Short Range Communications (DSRC)

Different short-range communication technologies could potentially be used to gather travel data. A first option is RFID: a technology to apply a wireless contactless system to transmit a small amount of data from a tag to an object (Shibayama and Lemmerer, 2013). RFID technology is widely applied in the transport sector, mainly in (multi-modal) smart cards for public transport (see OPTIMISM Deliverable 4.1, CE Delft, 2012). A technology closely related to RFID is NFC. By applying this technology in mobile phones, these devices could be used in the same way as smart cards. DSRC is a two-way short-to-medium-range wireless communications technology that permits very high data transmission (RITA, 2013). This technology is expected to be widely applied for vehicle-to-infrastructure and vehicle-to-vehicle communication, which could provide main advantages in terms of road safety and congestion reduction.

Both RFID/NFC and DSRC technologies require some kind of sensors as part of the infrastructure or in vehicles. With respect to public transport these sensors could be located at train stations/bus stops or in the vehicles themselves. With respect to private transport these sensors should be located in vehicles and/or along the roads. For that reason applying these technologies to private transport will result in rather high costs and hence implementing them only for travel survey purposes seems not feasible. However, if these technologies are implemented for other purposes (e.g. improving road safety) they could also be used for gathering travel data.

Camera and sensor-based technologies

A final group of ICT that could be used to gather travel data are camera and sensor-based technologies. These technologies could be used to obtain unprocessed data (like the number of cars passing a point) and hence have often to be processed to get useful transport data. An important camera technology is the automatic number plate recognition (ANPR), which is in transport used for traffic speed management and toll charging (e.g. the London Congestion charge make use of ANPR technology). Next to camera technologies also sensor technologies could be used to collect travel data. An example of this kind of technology is the loop detector that is used to count the traffic on the route.

A main disadvantage of camera and sensor-based technologies is that significant investments in infrastructure are needed to realise a network of cameras or sensors covering a whole area. Therefore these technologies should be considered as supporting instruments to collect travel data rather than instruments that could replace the traditional travel surveys.

Conclusion

Based on the results in this section we could conclude that GNSS/GPS technology is the most appropriate ICT option to collect travel data for the time being. This technology could provide a lot of reliable travel information at relatively low cost. However, as mentioned before, this option also has some disadvantages (less accurate in urban areas with high buildings or heavy artificial structures, lower accuracy due to time needed to calculate location, requires appropriate usage, limited reliability with respect to trip purposes and travel modes used). These disadvantages could be overcome by combining this technology with conventional survey techniques (as back-up and control mechanism) and/or other ICT technologies (e.g. mobile device localisation in urban areas). For urban areas, also mobile device localisation technologies could be useful in collecting travel data, although also this option should preferably be combined with conventional survey techniques. RFID/NCF/DSCR technologies as well as camera and sensor-based technologies could be useful for collecting data on specific types of transport, e.g. public transport. Finally, travel data from (multimodal) personal travel information systems and journey planners could also be an additional source of information.

As indicated in Shibayama and Lemmerer (2013), when using ICT options for travel surveys, some general disadvantages of these options should also be considered. First, people who are less familiar and unable to access ICT or people with high privacy concerns may not be captured very well in the survey compared to other groups. This may result in comparability and representation inconsistencies with respect to (earlier) transport surveys. The comparability to earlier/other transport surveys may also be challenged by the fact that other measurement methods are used. For example, it is often claimed that the number of trips reported by conventional survey techniques is lower than in case ICT based survey technologies are applied. Finally, ICT based survey technologies may be subject to cybercrime, resulting in additional costs and loss of credibility of surveyors (and hence acceptability of travel surveys by the public).

4.4. Data items in NTS to be covered by ICT

The use of ICT-based data collection techniques has already been started in some European countries by the national statistical institutions. They have been found to be more effective in terms of cost. Many countries tend to employ surveys using several traditional techniques with a combination of new technologies and/or for benchmarking purposes (OPTIMISM, 2013).

OPTIMISM task 2.1 (Ahern et al., 2012) suggested that a number of data items in NTS could be collected using ICT and that this should be explored in greater detail. In particular, the use of GPS to collect data on trip characteristics should be explored. The type of data that could be collected includes: trip frequency, trip duration and trip length. In addition, travel data about public transport could also be collected through the use of ICT for those passengers that use smart cards/mobile phones. The data that could be collected with smart card/mobile phone usage can be listed as following: frequency of public transport use, trip length, trip duration, public transport modes used, station use, occupancy rates, delay times.

4.5. Recommendations for a Europe-wide travel survey in terms of current data needs

As mentioned in section 2, establishing a single comprehensive Europe-wide travel survey faces several challenges such as difficulties in managing the large amounts of data, keeping information up to date, validating data and dealing with various local characteristics in detail. More importantly, it requires considerable budgets and several years of activity by large consortiums. In order to remove data gaps in transport policy analysis, the priority should be given to harmonization of NTS because of the several benefits listed in the previous sections. However, specific Europe-wide travel surveys separately designed for some certain policies or policy groups can also help to eliminate numerous data gaps in travel behaviour. The two previous Eurobarometer surveys designed with a short questionnaire to measure passenger preferences in some certain areas can be seen as a starting point for the survey design. There might be several surveys, each collecting appropriate type of data for individual policies or policy groups described within the White Paper on Transport.

Considering the emerging data needs for evidence-based policy analysis and monitoring, a Europe-wide travel survey today could focus separately on the following three transport domains: *transport demand*, to identify trends in lifestyles that affect transport activity; *transport quality*, to define obstacles and areas for improvement in transport infrastructure or in services; and *transport technology*, to estimate potential changes that new technologies may bring. These three domains which is recommended in terms of current data needs can be further elaborated as following:

Transport demand

- Duration of trips
- Multimodal trips/trip chains
- Trips per purpose (incl. holidays)
- Trip/chain length
- Trip frequency per purpose (incl. commuting/teleworking)
- Car ownership

Transport quality

- Time lost to congestion
- Assistance for multimodal trips
- Integrated ticketing systems
- Accessibility to public transport
- Passenger rights, security and comfort

Transport Technology

- Intention to purchase electric vehicles
- Reason (not) to buy electric vehicles
- Use of travel management systems
- Use of ICT applications

5. Concluding remarks

Europe is looking for efficient and innovative solutions for a cleaner, safer and more sustainable transport system. In order to achieve this goal for passenger transport several policies and many initiatives have been developed lately. Success in these efforts depends particularly on proper analysis of proposed policies and effective monitoring of their impacts. Therefore, availability of high quality, comparable travel behaviour data with minimum required detail is crucial today. In this respect, it was aimed to define recommendations to collect and report travel data in this deliverable.

At first, a brief review of past and recent studies was presented. It can be concluded that the majority of the projects and studies in Europe mainly focus on harmonizing travel surveys at national level instead of having a European level survey design. A harmonization of existing travel surveys has the potential to prevent many inconsistencies that currently complicate the comparison of travel patterns among countries. Harmonized data collected at national level will lead to more manageable results compared to a pan-European large scale survey.

Then, policy objectives for passenger transport and corresponding data needs were identified. Two policy objectives can be highlighted: halving the conventionally fuelled cars and increasing the share of passenger transport by rail which require at least the following groups of data: transport activity in urban areas, expressed in Pkm for various modes and by technology of vehicles and transport activity by distance class in Pkm for all passenger modes. This finding was followed by a data gap analysis. Information on the availability of selected parameters and the existence of format mismatches among countries were evaluated based on the OPTIMISM survey on NTS. The results show that considering the availability of parameters, only Pkm per trip per mode, number of trips per day per purpose, trip lengths, number of accidents/injuries and the main demographic characteristics are readily available today. The rest of the parameters/statistics are partly or fully missing and not available for policy analysis.

Finally, recommendations to harmonize NTS, to use alternative data sources, to utilize ICT in travel data collection and recommendations for a Europe-wide travel survey in terms of current data needs were defined in detail. In conclusion, the following recommendations are underlined again and listed as follows:

Recommendations to harmonize NTS in Europe

- A core set of parameters should be developed to properly analyse the most important European transport policies. A proper data grouping, data format and units of measurement should be defined for the parameters. The OPTIMISM suggestion for grouping is: I) demographic information, II) emission and cost information, III) vehicle usage, IV) general mobility information, V) infrastructure, quality of mobility and multi-modality, and VI) accidents, injuries and fatalities,
- Clear methodologies and methodological frameworks for all NTS should be put in place and the main purposes of surveys should be conformed, EUROSTAT can lead the activities to construct necessary groupings in relation to different

data sets and to develop a fixed methodology with clear frameworks of data collection in the Member States,

- It is necessary to identify an adequate frequency for repeating NTS to guarantee data continuity and comparability. It is suggested that data are collected regularly on a yearly basis, a time period of more than 5 years is not recommended for comparison reasons,
- The sampling composition should also be consistent among countries. It is suggested to use the population registries in the Member States to compose representative population samples; sample sizes should be large enough to facilitate detailed analyses for smaller sub-samples.
- Alternative sources should be used together with NTS to enrich awareness of travel patterns and to validate collected data through the NTS; new technological advances (e.g. GPS, GSM, GIS technologies, internet, smart cards etc..) should be used to complement NTS; their potential role in data collection should be further investigated,
- At the time being, it is not recommended to abandon the use of traditional instruments (pen and paper, telephone and face-to-face interviews, etc.) for the collection of data through NTS. The parallel usage of traditional and new technologies would allow for improved data collection, mutual data validation (checking for consistency) and a swifter data flow.

Recommendations to use alternative sources of information for travel data

- In addition to official transport statistics and NTS, there are numerous other data sources to be expected of substantial value for quantitative and qualitative analysis of the current mobility system in order to support policy decisions,
- Population and household statistics together with respective long-term projections can provide a framework for the development of future mobility (demand) scenarios,
- Income statistics as well as expenditure data may also facilitate development and elaboration of future mobility scenarios, in particular in conjunction with population and mobility data generated by dedicated travel surveys,
- Employment and/or commuter statistics, if contain spatial information on residential and working places, resulting origin-destination matrices may provide information on the extent of spatial interrelations and potential transport demand,
- Time-use surveys may provide detailed insight into activity schedules of individuals or entire households including any interdependencies between family members,
- Mileage surveys, usually based on vehicle samples, may provide detailed data on vehicles (such as vehicle type, engine type) in conjunction not only with the actual mileage of each vehicle, but also characteristics of its owner,
- Fuel sales (per fuel type) can be used not only to assess resulting mileage, but also, if combined with vehicle fleet data, to calculate the respective environmental impact in terms of exhaust emissions,
- Using GPS based historic and real-time in-vehicle navigation and tracking data, and mapping of actual road congestion over time allows for the development of congestion indices,

- Finally, commercial data providers exploit many of these data sources. Based on data processing and/or modelling they maintain comprehensive databases in order to offer tailored information in various formats and for various purposes.

Recommendations to use ICT in travel data collection

- Global Navigation Satellite System (GNSS), Global Positioning System (GPS), Mobile device localisation, Radio Frequency Identification (RFID), Near Field Communication (NFC), Dedicated Short Range Communications (DSRC), and camera and sensor-based technologies are the most important ICT options to collect travel data,
- For the time-being GNSS/GPS technology is the most promising ICT option in travel data collection. It provides large amounts of travel information at relatively low cost. However, they can be used for some certain measures and together with traditional surveying techniques until widespread usage by all population segments,
- For urban areas, also mobile device localisation technologies could be useful in collecting travel data, although this option should also be combined with conventional survey techniques,
- RFID/NCF/DSCR technologies as well as camera and sensor-based technologies could be useful for collecting data on specific types of transport, e.g. public transport; travel data from (multimodal) personal travel information systems and journey planners could also be additional sources of information,
- When using ICT for travel surveys, some general disadvantages of these options should also be considered: people who are less familiar and unable to access ICT or people with high privacy concerns may not be captured sufficiently in the survey compared to other groups. This may result in comparability and representation inconsistencies with respect to (earlier) transport surveys.

Recommendations on data items in NTS to be covered by ICT

- A number of data items in NTS could be collected using ICT. The type of data that could be collected with ICT includes: trip frequency, trip duration and trip length,
- In addition, travel data about public transport could also be collected through the use of ICT for those passengers that use smart cards/mobile phones. These are, frequency of public transport use, trip length, trip duration, public transport modes used, station use, occupancy rates, delay times.

Recommendations for a travel survey at European level

- In order to remove data gaps in transport policy analysis, the priority should be given to harmonization of NTS because of the several benefits listed. However, specific Europe-wide travel surveys separately designed for some certain policies or policy groups can also help to eliminate numerous data gaps in travel behaviour,

- The two previous Eurobarometer surveys designed with a short questionnaire to measure passenger preferences in some certain policy areas can be seen as a starting point for the survey design. There might be several surveys, each of them collecting appropriate data items for individual policies or policy groups described within the White Paper on Transport,
- Considering the emerging data needs, a Europe-wide travel survey today could focus separately on the following three transport domains: *transport demand*, to identify trends in lifestyles that affect transport activity; *transport quality*, to define obstacles and areas for improvement in transport infrastructure or in services; and *transport technology*, to estimate potential changes that new technologies may bring.

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Appendix: OPTIMISM stakeholder workshop documents



OPTIMISM
**Optimising Passenger Transport Information to Materialize Insights
for Sustainable Mobility**

**OPTIMISM Workshop on Collecting and Reporting
Travel Behaviour Data**

Alternative Sources of Information and New Data Collection Techniques

14 March 2013 – BRUSSELS

Centre Albert Borschette, CCAB - Rue Froissart, 36, Room AB-5B

Organized by

EUROPEAN COMMISSION - JOINT RESEARCH CENTRE (JRC)

Institute for Prospective Technological Studies (IPTS)

Economics of Climate Change, Energy and Transport Unit

*Joint
Research
Centre*

OPTIMISM Workshop on Collecting and Reporting Travel Behaviour Data
Alternative Sources of Information and New Data Collection Techniques

14 March 2013 - BRUSSELS
Centre Albert Borschette, CCAB - Rue Froissart, 36, Room AB-5B

Agenda

10:30 – 10:45	Opening and Welcome	EC – DG JRC, Institute for Prospective Technological Studies, OPTIMISM Project Partner
Session 1	Evaluation of National Travel Surveys and Harmonization of Travel Statistics	
10:45 – 11:00	Evaluation of National Travel Surveys in Europe: Evidence from 29 European Countries	German Aerospace Centre (DLR), OPTIMISM Project Partner
11:00 – 11:15	Data gap analysis for National Travel Surveys and guidelines for harmonisation of travel statistics	Transport & Mobility Leuven (TML), OPTIMISM Project Partner
11:15 – 12:00	Open Discussion: Recommendations to harmonize NTS and to remove data gaps in Europe Moderator: Angelika Schulz (DLR)	
12:00 – 13:00	Lunch Break	
Session 2	Data Needs for Policy Making and Alternative Sources of Information and Data Collection Techniques	
13:00 – 13:15	Passenger mobility data needs for transport policy making in the context of the White Paper goals	EC – DG MOVE
13:15 – 13:30	EUROSTAT activities in the area of passenger mobility statistics	EC – DG EUROSTAT
13:30 – 13:45	Methods learnt from the two recent surveys: Attitude of European car drivers towards electric vehicles: a survey Driving and parking patterns of European car drivers - a mobility survey	EC – DG JRC, Institute for Energy and Transport
13:45 – 14:00	The potential roles of ICT in travel data collection	Vienna University of Technology (TU Wien), COMPASS Project Partner
14:00 – 14:45	Open Discussion: Data Needs for Policy Making and Alternative sources of information and data collection techniques Moderator: Lars Akkermans (TML)	
14:45 – 15:00	Coffee Break	
Session 3	Design Issues of a European-wide Travel Survey	
15:00 – 15:15	Framework presentation for a European-wide Travel Survey	EC – JRC, Institute for Prospective Technological Studies, OPTIMISM Project Partner
15:15 – 15:45	Open Discussion: Design Issues of a European-wide Travel Survey Moderator: Panayotis Christidis (EC – DG JRC)	
15:45 – 16:00	Concluding Remarks	EC – JRC, Institute for Prospective Technological Studies, OPTIMISM Project Partner

OPTIMISM Workshop on Collecting and Reporting Travel Behaviour Data
- Information Note for the Workshop: Background, Aim and Scope -

OPTIMISM project (partially funded by EC, FP7 - <http://www.optimismtransport.eu>) will propose a set of strategies, recommendations and policy measures, through the scientific analysis of social behaviour, mobility patterns and business models, for integrating and optimising transport systems. This will be based on the assessment of the impact of co-modality and ICT solutions for transport.

One of the objectives of the OPTIMISM project is to gather, analyze and harmonise national travel data statistics in Europe, which are based on different methodologies. More specifically:

- to research, identify, gather and process relevant information and key factors about general conditions of national travel behaviour,
- to compile and analyze the identified data in order to understand differences in the individual national context of transport and mobility,
- to identify the different methodologies used for elaborating national statistical data,
- to determine the need of harmonizing national travel data,
- to identify and assess various methods of harmonizing statistical data,
- to develop a methodology to collect and report data on travel behaviour,
- to give guidelines and recommendations for harmonizing differences of statistical data and scientific analysis on travel behaviour.

In order to achieve these objectives, following three tasks are identified which of first two have already been accomplished in the first year of the project:

1) Gather and analyse national travel statistics: Within this task, an extensive questionnaire has been developed and sent to relevant authorities, responsible for conducting the national travel surveys (NTS) in the respective countries across Europe for 29 countries. The survey covered a large set of questions regarding purpose, scope, methodology, quality and availability of data in the different NTS. The results revealed that there is much variation between the types of data collected by NTS across European countries. Purpose and methodologies used to collect data (including sampling of populations, frequency of data collection, types of data collected, etc.) vary significantly across countries. Consequently, harmonisation of National Travel Surveys in Europe is problematic under the current survey methodologies and approaches. Different baseline years, methodologies and types of data collected range considerably over the European Union and are therefore difficult to compare. It is recommended that a consistent system is developed and agreed

by member states and that a core set of data items are developed in order that transport movements and trends can be analysed and used as a basis for future European and national policies.

2) Develop a methodology to harmonise travel statistics: Moving towards to harmonisation of national travel statistics, the information collected in the previous task were analyzed further for 15 countries. The main objectives were: i) to analyse the data gaps in national travel surveys, ii) to identify potential data formats that can be used for the data collection, and iii) to propose a data collection methodology and common standardized structure for national travel surveys. As a result of the task, a set of parameters has been identified for which information needs to be collected in order to properly analyse the most important European transport policies that are linked to passenger transport. This set of parameters with proper format and collection procedures can be considered as a starting point of the harmonisation of data collection for travel behaviour.

3) Define recommendations to collect and report data on socio-economic drivers of travel behaviour: The aim of the final task is to propose a methodology to collect and report travel data with the identification of main data needs and gaps, and the analysis of alternative sources of information and new data collection techniques. Based on the findings of the previous tasks, it will start from a list of variables which are needed for policy making but unavailable/insufficient with the existing data collection methodologies. Then, it will investigate potential use of modern data collection techniques (e.g. GPS and smart phone technologies) and their association possibility with the NTS.

The workshop, as being held within the final task of the work package, aims to discuss existing data collection techniques across Europe elaborating the problem areas, gaps and needs for harmonization of the NTS; and to identify alternative sources of information and new data collection techniques with the help of stakeholders and experts from the public and private sectors of travel statistics.

For the purpose, the workshop is organized in three sessions including open discussions at the end of each session: the first session consists of presentations including very recent findings of OPTIMISM project on NTS and data gaps in Europe; the second consists of experiences on collecting and reporting travel behaviour data and explores data needs for policy making and alternative sources of information and data collection techniques using ICT; and the last session consists of a open discussion on design issues of a European-wide travel survey with the use of new technologies after a short framework presentation.

OPTIMISM WORKSHOP ON COLLECTING AND REPORTING TRAVEL BEHAVIOUR DATA ALTERNATIVE SOURCES OF INFORMATION AND NEW DATA COLLECTION TECHNIQUES

14th March 2013

Venue: Centre Albert Borschette, rue Froissart, 36,
Room AB-5B, B-1040 – Brussels, Belgium

European Commission (EC), Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Economics of Climate Change, Energy and Transport Unit (ECCET)

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**OPTIMISM WORKSHOP ON COLLECTING AND REPORTING TRAVEL
BEHAVIOUR DATA
ALTERNATIVE SOURCES OF INFORMATION AND NEW DATA COLLECTION
TECHNIQUES**

14 MARCH 2013 - BRUSSELS

– KEY QUESTIONS AND DISCUSSION TOPICS –

Session 1: Recommendations to harmonise NTS and to remove data gaps in Europe

Moderator: Angelika Schulz (DLR)

In order to make recommendations for harmonising future NTS, a clear knowledge of actual data needs of relevant user groups is essential. Focusing on NTS, the following questions outline potential issues to be discussed. They may encourage you to share your particular perspective especially in terms of data needs and usage, but also regarding methodological issues.

Purpose of Data Usage

- What are the main research questions to be answered based on NTS data in order to serve European policy needs? What are your primary data needs?
 - General mobility behaviour in its broad sense and/or transport demand in its narrow sense?
 - Particular areas of interest besides standard key figures (e.g. O-D-matrices, driving forces for transport demand)?
 - Monitoring of the transport's environmental impact (e.g. CO₂ emissions)?
 - Monitoring of measurements' impact (e.g. ICT or other measures)?
 - Any other particular data needs (maybe not addressed in NTS yet)?
- What level of (dis-)aggregation do you require? Do you need data at European / national / regional / local level or for NUTS regions? Do you need data for particular population segments (e.g. age groups, employed / unemployed, socio-demographic groups etc.) or transport modes (e.g. individual / public; road / rail / air)?
- In which respect a European 'mobility benchmarking' is required?
 - Are main key figures sufficient or is there a need for in depth analyses of various aspects?
 - Is a comparison of intra-national mobility sufficient or should cross-border mobility also be covered?
- Which other data and/or information sources are already used by European agencies?

Practical Issues of Data Usage / Data Format

- Where do you see the main obstacles for policy makers and practitioners to use NTS data properly and efficiently? Which pieces of information do you currently miss?
- Based on your experience: Which recent NTS can be regarded as "best practice" in terms of content, methodology, and data provision / dissemination? Why?
- In which "harmonised format" are survey outcomes required to be published in to be of efficient use for European agencies (and other third parties)?
 - Harmonised tables providing key figures only?
 - Detailed written reports?
 - Micro-data allowing for individual analyses?

NTS Data Collection

- Which part of the NTS data collection process (e.g. survey frequency, sampling, questionnaire, coding, post-collection data processing) do you regard as most important with respect to survey harmonisation?
- Which ICT techniques could be applied to provide/ enhance relevant data?
- How could the information about intermodal transport be improved in future NTS?

Harmonisation Activities

- Have you been involved in activities to harmonise NTS (data collection, post-processing, analysis)? In which context these activities took/take place? Who was/is involved in these initiatives? What were/are the main results of this effort, what were/are the main difficulties?
- With respect to future initiatives of NTS harmonisation: What should be the organisational / institutional framework of such an initiative? Who should be in charge of organising such an initiative? Who should be involved?
- What are the critical issues / challenges regarding to the harmonisation of NTS?
- What are the main outcomes of the current COST SHANTI action? Are there any further activities planned for the near future?
- What is the current situation with the "Common Questionnaire on Transport Statistics" developed by UNECE, ITF and EUROSTAT? Are there any plans for its further development?

Session 2: Data Needs for Policy Making and Alternative sources of information and data collection techniques

Moderator: Lars Akkermans (TML)

- NTS are a suitable data collection methods for some types of information (demographic information, user experiences, mobility diary information, vehicle ownership and usage, modal usage, etc). However, for some data types, they are not. Do you know of, or currently use, databases, methodologies, etc that do deliver and collect relevant information which is not fully covered by NTS?
- What are the main data needs for policy making? O/D matrixes, transport activities (unit/km), network attributes, services (number of trains, flights and fares), are there any initiatives to collect this type of data? What is the status with ETIS-PLUS project or other similar projects?
- Including or combining different information sources and data collection techniques can create new problems. For example: methodological problems on a very detailed level (data definitions & formatting) but also on a higher level (privacy issues, database linking & merging, etc.). What are your experiences? Do you know, or have you encountered such problems, and have you found possible solutions?
- Public vs. private data-ownership: how to work with that? Some data sources are owned by (for example) insurances, transport companies/operators, brokers, etc. Others are the result of public projects. How to combine those? What is your experience with this (contract, management, data exchange, etc.)?
- Considering the ICT-based data collection, what are the promising techniques and alternative sources of information?
- What are the main methods to protect privacy during the ICT-based data collection?
- What could be the methods to solve representativeness problem with the ICT-based data collection?

Session 3: Design Issues of a European-wide Travel Survey

Moderator: Panayotis Christidis (EC – DG JRC)

- Which kind of survey (both in terms of methodology and content) do we need compared to traditional NTS, even if these NTS would be harmonised?
- For which purposes you may want to use the outcome a European-wide travel survey?
- What will be the mayor obstacles for a European survey? How can they overcome?
- Do we need a comprehensive or a specific survey for some certain data needs?
- Should it be included only long-distance/inter-city/inter-country trips or short-distance/intra-urban/national trips should also be included?
- How should it be, pubic/semi public or restricted?
- What is learnt from MEST, TEST, DATELINE, ETIS-BASE and ETIS-PLUS projects starting from the FP4 through the FP7? What is next?
- What are the other existing databases that can be used in parallel or for cross-check purposes?
- What would be the cost of an European-wide travel survey? What are the important factors that affect the cost?
- How should it be formulized/designed in terms of:
 - Sample size and unit
 - Sampling technique and geographical scope
 - Interview technique (telephone, web-based ..)
- Should it be an one-time effort (e.g. for calibration/benchmarking of the national travel surveys) or repeated regularly?

OPTIMISM WORKSHOP ON COLLECTING AND REPORTING TRAVEL BEHAVIOUR DATA ALTERNATIVE SOURCES OF INFORMATION AND NEW DATA COLLECTION TECHNIQUES

14 MARCH 2013 - BRUSSELS

– MINUTES FROM THE WORKSHOP –

Session 1- Presentations Evaluation of National Travel Surveys and Harmonization of Travel Statistics

DLR	Evaluation of National Travel Surveys in Europe: Evidence from 29 European Countries
TML	Data gap analysis for National Travel Surveys and guidelines for harmonisation of travel statistics

Session 1- Discussion

- DG REGIO → Data needed at sub-national level (link to European classification system is essential). Especially for the analysis of Cohesion policy and other sustainable/energy efficient mobility policies.
A separation between urban/rural areas needed (concerns on definition are required: What is considered as urban? What is not?).
Type and size of urban areas /cities (= degree of urbanization) matter a lot.
Comparing NTS is difficult if not impossible (depending on research / policy question to be addressed).
Trips made by foot/bicycle/motorcycles are sometimes ignored in NTS.
Currently, NTS are generally used to check modal shares/public transport status etc.
- TRT → Transport modellers also needs data, if available micro data.
It has to be discussed (already started) how to use new techniques in data collection.
- EUROSTAT → Many European agencies are asking for data for their policy analysis.
Eurostat is the only link with the National Statistics Institutes / Transport Ministries.
There might be some legislation at European level which is not clear so far.
At national level the cost of surveys and the maintenance of time series data are the most important factors.
Many countries cannot even provide the basic information needed due to methodological particularities.
There might be some pilot questionnaires that Eurostat can support for urgent data needs.
- COMPASS → Mentioned about case studies and expert consultations on main transport indicators which can be found in the COMPASS deliverables (<http://www.fp7-compass.eu/>).
- DG MOVE → No need for very detailed data, but certain key indicators at European level are required.
NTS such as in UK could be a good example.
- COST SHANTI → Currently, several (15) NTS are on-going in Europe.
Only harmonization of some tables/parts is possible, for all figures it is not feasible at all.
It is focused on some key tables.
NTS need guidelines in order to fulfil the basic requirements of transport policy making.

Session 2 - Presentations Data Needs for Policy Making and Alternative Sources of Information and Data Collection Techniques

DG MOVE	Passenger mobility data needs for transport policy making in the context of the White Paper goals
EUROSTAT	EUROSTAT activities in the area of passenger mobility statistics
JRC PETTEN	Driving and parking patterns of European car drivers - a mobility survey
COMPASS	The potential roles of ICT in travel data collection

Session 2 Discussion:

- DG MOVE → Mentioned Transport White Paper Strategy and the 40 initiatives. Two important goals related to mobility which needs to be monitored. There are no additional available data sources for the time being. NTS needs harmonization and there are also reliability problems for some NTS. Distinction between urban-non urban areas and the distance classification is required. There will be some legislative acts to collect certain type of data such as on vehicle technologies in the near future at national level. It will be voluntary base at the beginning and then it will be mandatory. Privacy and Legislative issues of ICT should also be considered.
- EUROSTAT → It is needed a template and a guideline/manual for NTS. Some of the countries are already asking for information from EUROSTAT. Other countries already have a functioning NTS but are willing to consider changes. There are many problems in terms of comparability of country statistics. Use of ICT-based data collection techniques are already started in some countries. It is found more effective in terms of cost. Many countries tend to prefer / to establish surveys using several traditional techniques with a combination of new technologies. There is a feasibility study on GSM implementation on data collection. New methods are generally used for benchmarking purposes. Potential synergies for tourism (GSM tracking) and long distance transport should be used.
- DG REGIO → GPS data is already used for congestion studies (e.g. TeleAtlas data). Some of the countries have not enough data including GPS, network etc... There is not enough subscribers. Google provided data is also suitable for some purposes, for example linking or merging data with public transport information. Correctness of data varies from one city to another.
- GEO SOL. → Mentioned data unavailability of some countries especially for the ICT based data.
- JRC SEVILLA → ICT-based data is generally biased which need to be solved; for example. Underrepresentation of elderly population (used to be overrepresentation). For some purposes it is not a problem but for the rest it is an important problem.
- JRC PETTEN → Design issues of a recent European survey was presented; having appropriate sample size, sufficient response rate; problems with different languages and comparison with the NTS are some of the critical issues to follow up.
- COMPASS → Transport operators/Services have large data sources but it is not (easily or readily) available. The problem is how to use/acquire this data (EUROSTAT/DG MOVE do not use this data but realize that there is some value in private data).

Session 3 - Presentation: Designing an EU-wide Travel Survey

JRC SEVILLA	Framework presentation for a European-wide Travel Survey
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European Commission

EUR 26245 – Joint Research Centre –Institute for Prospective Technological Studies

Title: Recommendations to Harmonize Travel Behaviour Analysis

Author(s): Mert Kompil, Angelika Schulz, Tiina-Maria Seppänen and Arno Schroten

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Abstract

Among several other efforts to identify data needs and to harmonize travel surveys in Europe, this report aims to define recommendations to collect and report travel data with the identification of main data needs and gaps, and with the analysis of alternative sources of information and new data collection techniques. Based on the findings of the previous tasks and a stakeholder workshop in OPTIMISM project, and after a brief review of past studies in the same direction, this report starts from a list of variables which are needed for policy making but are unavailable/insufficient in the context of existing data collection methodologies especially with respect to NTS. The report then, explores alternative sources of information, potential use of modern data collection techniques (mainly ICT applications such as GPS and smart phone technologies) and options to merge them with NTS data. Finally, it discusses recommendations for a Europe-wide travel survey considering the current data needs for policy making in transportation.

The research has been conducted under the OPTIMISM project which was received funding from the European Union's Seventh Framework Programme (FP7/2007-2013), grant agreement n° 284892. The report has been produced as the OPTIMISM project deliverable 2.3: Recommendations to Harmonize Travel Behaviour Analysis.

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