Door to Door Information for Air Passengers

D2.1 Market analysis report

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Executive Summary

The goal of this deliverable is to give an insight to the current situation of mobility information solutions and analyse the market of door-to-door transport information services addressing air passengers. The outcomes of this document will inspire Task 2.3-Definition of Use Cases, and will be a required input in deliverable D.2.4 Technical and legal requirements. At the end, the global analysis of desk research findings, results of in-depth interviews with market experts, user surveys feedback and final conclusions of the SWOT analysis developed here, will later shape the DORA system requirements in a robust and well-structured way.

As a result of the SoA review, several existing mobility information services and technologies are already in place. However, current route planners lack many functions that will be developed and integrated within the DORA project, such as terminal processes, incident management, real-time traffic information, parking information at the terminal or user group specific information.

Existing techniques to analyse people count, queue length and waiting time have been reviewed and compared. As a result, in the DORA project, a video analysis system will be integrated in the airports to measure passenger’s behaviours and to deliver accurate and consistent data.

The DORA Indoor Positioning System (DIPS) will be primarily based on Wi-Fi techniques and on specifically designed equipment to provide additional coverage for the positioning algorithms. As far as the DIPS software platform is concerned, the fact that there is not any open product to be used indoor, so DORA will develop a dedicated one. Thus, the navigation algorithm might be able to provide door-to-door routes within airports and alternative ways according to passenger’s requirements.

Available airport apps in the market provide comprehensive mobility information, but none of them offers a range of functions as targeted in DORA. On the contrary, some special features have been identified and might be considered for a further elaboration of the DORA app.

Analysing the market of specific door-to-door transport information services addressing air passengers, several aspects were considered: market segments trends and changes, market overview and evolution, drivers and barriers, new roles and business models, distribution channels, market growth rate and forecast.

Due to delays in the implementation of user surveys, in-depth interviews and an internal workshop, that have been duly justified along the document, a new release of this deliverable will be issued and submitted by January 2016, which will include the results and final conclusions obtained with these activities.
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## Abbreviations

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<th>Explanation</th>
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<td>AGR</td>
<td>Annual Growth Rate</td>
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<td>D</td>
<td>Deliverable</td>
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<td>DIPS</td>
<td>DORA Indoor Positioning System</td>
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<td>EC</td>
<td>European Commission</td>
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<td>GDS</td>
<td>Global Distribution System</td>
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<td>GPRS</td>
<td>General Packet Radio Service</td>
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<td>H2020</td>
<td>Horizon 2020 Programme for Research and Innovation</td>
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<td>M</td>
<td>Million</td>
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<td>MMI</td>
<td>Multimodal Information</td>
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<td>NFC</td>
<td>Near Field Communications</td>
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<td>OAS</td>
<td>Operation Assistance System</td>
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<td>OTA</td>
<td>Online travel agency</td>
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<td>RPK</td>
<td>Revenue Passenger Kilometer</td>
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<td>SoA</td>
<td>State of the art</td>
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<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities, and Threats</td>
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<td>WP</td>
<td>Work Package</td>
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1 INTRODUCTION

The aim of this section is to introduce the purpose and background of the DORA project and of the deliverable D2.1 Market analysis report. The contents of the deliverable are summarized in this section as well as to provide navigation guidelines.

1.1 Background

Implementation of DORA project activities is organised in seven work packages to be completed during 36 months. Whereas WP1 and WP7 are devoted to the project management as well as dissemination and exploitation activities respectively, the technical work will be done within WP2 – WP6:

WP2- DORA Requirements and Use Cases
WP3- DORA Concept Specification
WP4- Software Development and Integration
WP5- Pilot Execution
WP6- Usability and Evaluation

The objectives of work package 2 are to define the set of technical and legal requirements for the development of DORA system and for each of its core components: intermodal router, waiting time detection, indoor location and routing and mobile smart phone application. For this purpose, the specific objectives are to analyse the market of integrated Information services for passengers, define user groups according to identified mobility profiles and describe use cases involving all the relevant actors, goals and processes. Four deliverables are planned in the work package 2, namely: D2.1 Market analysis report, D2.2 Users groups and mobility profiles, D2.3 Use cases manual, and D2.4 Technical and legal requirements.

1.2 Purpose of the Document

D2.1 is the outcome of Task 2.1- Market Analysis, whose aim is to provide an insight to the current situation of mobility information services and the different technologies supporting them. As a starting point, a state of the art review on existing solutions and trends will be done. Special attention will be paid to video recognition technologies and in-door location and routing solutions. This includes a detailed analysis of the existing systems and services in the pilot sites.

Following the state of the art, an analysis of the market of specific door-to-door transport information services addressing air passengers will take place. It will be comprised of four different approaches: Desk research, In-depth interviews with market experts, Users surveys and Workshops. The main objective is to identify air passenger’s needs in terms of transport information and the availability of solutions giving answer to these needs.
The analysis will take into account demand and supply points of views and both qualitative and quantitative aspects will be considered:

- From demand point of view: Definition of the market segments (including passengers and other potential users such as transport operators, traffic information centers); Typology, profile and travelling behaviour of the existing segments (fulfilled or unfulfilled needs; set of values, motivation, selection/decision criteria, suppliers, etc...); Trends and changes lately occurred in demand; Market barriers (technological, cultural, legal, etc...); Market growth rate.
- From supply point of view: Situation of the relevant market (supply size, producers, types of services on offer, brand names, prices, market share, how target users will be interested in DORA solution, etc...); Potential competitors; Strengths and weaknesses of current solutions; Distribution and marketing channels (existing channels, relative importance, past and future evolution).

In short, deliverable 2.1 will describe the main results of the state of the art review and the market analysis carried out. Relevant findings will be structured in three main parts: Demand analysis, Supply analysis and integrated SWOT Analysis.

The outcomes of this deliverable will inspire Task 2.3- Definition of Use Cases (for different scenarios of DORA system deployment). Moreover, they will be a key input in deliverable D.2.4 Technical and legal requirements, which consists on a report on the technical and legal issues to take into account for the development and integration of the components of DORA information system.

1.3 Structure of the Document

The following document has been structured based on the DORA description of action and approved by project partners involved in task 2.1:

1. Introduction: background, purpose, description of DORA implementation
2. Analysis of existing solutions and trends in mobility information services: SoA in DORA pilot sites; SoA regarding route planners, waiting time detection solutions, indoor navigation technologies and airport apps.
3. Market analysis of specific door-to-door transport information services addressing air passengers: approach and methodology, demand and supply analysis, market analysis and SWOT analysis.
4. Conclusions

1.4 Description of a typical DORA implementation

The DORA project is aiming at design and establishment of an integrated information system that helps passengers to optimise travel time from an origin of the travel to the airplane at the departing airport as well as from the arrival airport to the final destination. With it, the DORA integrated information system, which will be created within the project together with necessary software platforms and end user applications, is aiming at
reduction of overall time needed for a typical European air travel including necessary time needed for transport to and from the airports.

To ensure this, the DORA system will provide mobile, seamless, and time optimised route recommendations for the travels to the airport and time optimised routing within the airports, leading the passengers through terminals to the right security and departure gates. The DORA will integrate all necessary real time information on disruptions in the land transport environments and on incidents in the airport terminals to provide the fastest route alternatives, ensuring the accessibility of airport and airplane at any time in accordance with individual passengers’ requirements. The DORA system will be designed in a generic way, to ensure that it can be widely adopted independently on passengers and airports locations.

In the project, the DORA system will be implemented and tested in realistic environments involving cities of Berlin and Palma de Mallorca as well corresponding airports in both cities with involvement of at least 500 real end users – passengers – in the trials. To support the passengers’ route optimisation, the DORA project will investigate and design technologies for recognition of waiting queues and indoor location services in airports, which will be integrated into the DORA system and tested within the project trials.

The DORA solution is a combination of offered product (user application) and related services. For the end customer, DORA offers simple and free to use digital application for phones or tablets. The application may include different features, as a result of a structured process consisting in the definition of system requirements and specifications, the development of new software and, finally the integration with existing solutions.

Depending on the partners, implemented features and the specific business model DORA enables multiple revenue streams from different sources which may imperfectly align with the traditional notion of a single identifiable “customer”. Importantly, DORA is a service platform that represents a multi-sided market situation [1] which has distinct implications to its adoption behaviour. As with all two- or multi-sided markets, the adoption of DORA solution by the air passengers is dependent on how many service providers (e.g. transport operators, airports, shops) join the platform. On the other hand for these service providers the motivation to join and remain committed is dependent on the number of passengers that DORA is able to attract and keep. Therefore the core service of DORA at a basic level is provided to the air passengers free of charge to facilitate reaching a critical mass of users. While the air passenger is in many respects the main customer, he may not pay for the service at all. Instead, potential revenue streams could include, among others, transport operators paying for the data and increased level of service and efficiency enabled, shops paying for promotion and marketing services, premium users (corporate or individual) paying extra for added services or other options. These issues will be explored more in depth in deliverable 3.5 Analysis of suitable Cooperation and Business models.
2 ANALYSIS OF EXISTING SOLUTIONS AND TRENDS IN MOBILITY INFORMATION SERVICES

To define state of the art, mobility information services were to be gathered from existing information sources. This section was produced by using Desk research as the main research technique. Desk research is a method to acquire basic information on state of the art of the research object and to benchmark further research process.

Following information resources were used:

- Online resources—results were gathered by using search engines to find results for following keywords: intermodal routers, waiting time detection, indoor location and routing, airport smartphone applications. Search results were filtered evaluating separate, specific papers by type of paper (guidelines, research paper, project/initiative description); by author or publishing organization.

- Research paper database –dedicated scientific databases were browsed using relevant keywords (please see previous paragraph) to identify existing solutions and trends in mobility information services.

However, for the review of systems, services and technologies at pilot sites, the corresponding DORA partners were required to describe in detail what are the systems and services put in place in each pilot site (prior to DORA system development), as well as the technologies that enable them.

Apart from including a classification of the findings about existing solutions and the related functional analysis, it is important to highlight pros and cons of each existing solution, in order to shape how DORA solution will go beyond current limitations. Therefore a section analysing and summarising the conclusions of the state of the art review is included.

2.1 Review of existing systems, services and technologies at pilot sites

2.1.1 Berlin

There are several existing mobility information services and technologies already in place in Berlin. This chapter will focus on giving an overview about the existing services specifically available in and for Berlin; (inter-)nationally available information services with no specific focus on Berlin are left out in this chapter and will be described in 2.2. This overview starts with the existing services for the landside mobility part and later describes the systems in place for the airport-focused part of the travel chain.

2.1.1.1 Traffic Information Center and Traffic Control Center

Two important elements for the provision of mobility information in Berlin are the Traffic Information Center (TIC) and the Traffic Control Center (TCC). The Role of the Traffic
Control Center is to monitor and - when necessary - manually activate the traffic lights in Berlin at about 2,000 intersections, to operate nine Variable Message Sign Systems (VMS) mainly on the Berlin motorways and to observe the traffic situation on more than 1,500 km of roads with Traffic Eyes Universal (TEU)\(^1\) and cameras. The Berlin TCC is one of the biggest state-of-the-art traffic control centers in Europe. It is of particular importance for the work of the Berlin Traffic Control. By collecting all traffic information in one place, the Berlin Traffic Control is able to directly influence the traffic situation in and around Berlin and to minimise or even completely avoid disturbances.

![Traffic Control Center Berlin](image)

**Figure 1: Traffic Control Center Berlin**

The traffic information generated in the TCC is processed to the Traffic Information Center which is responsible for providing real-time traffic information to the citizens of Berlin. All information on current traffic disruptions, road works, congestion etc. is made publicly available on the website of the TIC (www.viz-info.de). The real-time information about the current traffic situation on over 1,500 km of roads is generated by combining data from road detection with Floating Car Data (FCD) from TomTom. Further channels of Traffic information provided by the TIC are the traffic forecast for media and more than 30 dynamic information panels on Berlin’s main roads as well as Mobility Monitors (MoMo) at different locations such as Berlin Tegel Airport or Berlin Südkreuz railway station which inform passengers in real-time about all available transport options in the vicinity.

\(^1\) Traffic Eye Universal is a stand-alone detection device that collects detailed data on the current traffic flow on main roads. It receives its power from a small solar panel or a back-up battery respectively. The recorded data is forwarded to the Traffic Information Centre where the current aggregated traffic situation is calculated.
Another important mobility information system in place, especially in the context of DORA, is the **AIRVIS system** (Airport-Related Traffic Information System) as a component of the Traffic Information Center. In cooperation with Berlin airports and the Berlin-Brandenburg transport association VBB, VMZ developed a project concept to secure access to the new airport BER. The concept is based on the coordination of control and information measures between the concerned traffic control centers of the Federal States of Berlin and Brandenburg. Air- and landside transport incidents, disruptions or delays will be centrally collected and processed for routing suggestions which are made available for passengers via different channels. Passengers intending to go to the airport will be provided with information relevant for the airport access in public transport stations and vehicles, on dynamic on-street information panels and via mobile services. The development of AIRVIS has been completed; until the new Berlin airport BER opens, the system will be running in a slightly modified version for Berlin-Schönefeld airport (SXF). The AIRVIS system will play a crucial role when integrating an incident management into the DORA system.
A further information system at hand is called iQ Traffic. The iQ Traffic system monitors the quality of traffic in Berlin. Besides the quality of traffic, the system also monitors the level of air and noise pollution as well as accidents. In case of a permanent deterioration of traffic quality in specific road sections, iQ Traffic enables the analysis of causes (e.g. incidents, roadwork) and the formulation of appropriate countermeasures. The respective information is provided to the end users via the TIC distribution channels.

There are different Berlin specific route planners available, both smartphone- and web-based. The Traffic Information Center provides a route planner on its website www.viz-info.de which is mainly focused on private car users but also shows public transport, biking and walking. Another route planner which is based on the data of the TIC is a mobile application which was developed in the context of the EU-project MOLECULES (Mobility based on electric connected vehicles in urban and interurban smart clean environments). The MOLECULES app is an intermodal route planner which focuses on the topic of electromobility. It combines the offers of the (e-)car sharing provider DriveNow with information about the location and availability of charging stations in Berlin. In addition, real-time information about the public transport and motorized individual traffic are provided which is also part of the app’s intermodal routing service. The suggested routes can be filtered by duration, costs, and CO₂-emissions of the trip. The intermodal routes provided take into account different transport modes such as private car, private bike, walking, public transport, bike sharing and car sharing.
2.1.1.2 Public transport associations VBB

Further Berlin specific route planners in place are the mobile and web-based applications of the public transport associations VBB (Verkehrsverbund Berlin-Brandenburg), S-Bahn Berlin and BVG (Berliner Verkehrsbetriebe). These public transport operators run together a network of among others ten underground, 22 tram, 15 S-Bahn as well as more than 800 bus lines. The mentioned applications provide the user with modal routes specifically focused on public transport. The suggested routes take into account real-time information such as delays or other operational disturbances and give an accurate description of walking distances and durations when switching buses/trains. Furthermore information is provided for the mobility impaired people regarding accessibility of stations and vehicles, as well as functionality of elevators. Start and destination can be displayed in maps, in both web-based and mobile routing applications. All three systems are based on the same data platform and use the same routing core. VBB established since 1997 a huge data base for planned time table data. This platform contains the data of 42 public transport operators in the two federal states of Berlin and Brandenburg. Most of the operators deliver the updated timetable data every week to the VBB systems. That data includes timetable changes, due to construction works or other reasons, by a forecast of three weeks. Also replacement services are integrated. Not only for the customer needs, getting always the correct planned timetable information’s, keeping the data platform updated is crucial for the use of real-time data. The reason for this is that these planned data must be mapped by the routing core with the real-time data. Weekly updated, VBB ensures an independent use of this information by operators, authorities and third parties. In the case of needs, e.g. strikes, accidents and unplanned construction works, VBB will provide additional updates, if operators deliver new data. Mostly during the night from Thursday to Friday, the whole travel planner system will be updated.
As mentioned, the VBB platform contains also real-time data. From the early 2000s until now VBB has worked on the integration of these data into the travel planner. Started with regional operators with limited amount of vehicles, the data base is now nearly complete. All the large operators now deliver their data to VBB systems. The interfaces are defined and standardized by a recommendation of the national association of operators. These collected data are used in the travel planner, as well for other operator needs. So operators will interchange real-time information with each other by using the VBB system as a data relay. In result, they can provide connection management with other operators and would display real-time schedules of other operators on own departure boards.
Another information, which has become more and more important, is the short text information. Additional to planned and real-time data, this kind of information is an unsharp element. It explains, station-, line- or trip based, specific situations in operation, planned changes of timetables or important announcements of operators. Taken from operator systems or established by a web based tool, the operators are more and more using this opportunity to give explaining information to their customers. VBB is trying to encourage more and more operators to provide this kind of information. For tendered rail operators is the use mandatory by contract.

Figure 7: Routing display

Figure 8: Routing display with incident notifications
Based on this data base, customer information services are designed and established. Due to technical progress in information technology, enhancements and improvements on that services will steadily established. An important task for VBB is to use national and European research and development projects to set up with industrial partners new passenger related services. Examples are the successful finalized project EU-SPRIT, or the barrier free travel planner out from the BAIM project. On that condition, the centralized passenger information in VBB area is highly developed. The DORA project focuses on mobile services, and in this field VBB has a lot of experiences and existing solutions. Very early in the last decade, VBB began to open the information systems for third parties by API. In collaboration with industrial partners, with interests to set up own mobile services in the Berlin-Brandenburg region, VBB was often involved as an advisor in functional terms. For example, VBB supported NOKIA in the developing process of the user interface of the former “transit” service on S40 and S60 platforms in late 2000s. To open a second way to support third parties, VBB decided, to provide an openGTFS (General Transport Feed Specification) interface for dedicated google services and private developers. In that case as well, VBB collaborated with third parties to assist in technical and design questions. For that reason VBB and the open knowledge foundation (OKFN.org) have organized in 2012 the first national hackday with over 130 participants from the developer community and industry. Besides of google transit, citymapper.com or moovitapp.com are well known users of VBB’s open data set. For all interested people, VBB provides the web site www.vbb.de/lab, to address and encourage interested potential partners and help them to get in touch with VBB.

Based on those experiences, the domestic apps of BVG, S-Bahn and VBB are now very sophisticated developed. Subscription services in case of changes or delays, alternative routing by broken connections, barrier free routing option, network plans and region wide maps with live view, mobile ticketing are only few examples. Especially mobile ticketing was a huge step forward to meet the customers’ requirements. After the decision in 2013 it took round about a year to issue the ticketing system on smartphones. The approach was, to integrate a ticket library in the existing native apps of VBB. One advantage of this concept was, to avoid any efforts to communicate several apps, e.g. one for ticketing and one for information services. From summer 2014 both apps (Android and iOS) were able to sell mobile tickets. In the first step, until now, the system will only issue single tickets or additional fares to existing travel documents. At present the purchase of tourist tickets is in an integration process. In further steps it is planned to issue weekly or monthly tickets. In fact, the whole region Berlin Brandenburg is covered by VBB ticketing system. BVG has integrated another ticketing system in their app. Due to the local customer range as a local operator, BVG offers a limited locally assortment on tickets.
Nowadays VBB is working on intermodal routing services to offer the customer more mobility services than the well-known product of public transport. Based on an appropriate backbone (integrated mobility platform) from VMZ, VBB will integrate different modes of transport into the mobile travel planner. As first step, in autumn 2015, it is planned to launch a multi modal live map, the complete intermodal routing service will follow up in 2016.

2.1.1.3 Routing service m4guide

Another routing service in place is called m4guide, currently being developed in a research project with the involvement of the Senate Department for Urban Development and the Environment, focused on partially sighted and blind people, which allows a safe guidance from door to door. The aim of the project has been to develop an integrated travel information and route guidance system using commercially available smartphones. For about 145,000 blind and 1,200,000 partially sighted people in Germany there is so far no consistent and cross-modal navigation system that locates the exact position and leads accompanied by real-time information securely to the goal. A navigation system which fulfils the extensive requirements of blind and partially sighted people is transferable to almost any other group. The m4guide navigation system provides the developers with three major challenges:

1. The exact location of the person outside of buildings.

For the outdoor location a Global Navigation Satellite System (GNSS) is used, that uses different satellite signals (GPS, GLONASS, and later: Galileo). Data of the Germany-wide SAPOS service function as correction data. Reflections (multipath effects) of close road development in cities impede the exact GNSS positioning in the walkway area. Therefore, the inertial sensor is additionally (compass, accelerometer) used to ensure consistent reliable positioning of m4guide users.
2. The precise indoor positioning and navigation with seamless transition from outdoor to indoor use. Here solutions are pursued, where a foot sensor provides information to the walking direction, change of direction and distances travelled. Moreover eBeacons are used to calibrate the position data.

3. To develop a solution for the calculation of the overall route (pedestrian routes inside and outside buildings and in public transportation) and synchronize all the data in a multi-modal routing. The public transport route is computed by existing route planning systems. In cooperation with Berlin Transport Authority (BVG) and Verkehrsverbund Berlin-Brandenburg (VBB), latest timetable information are available. It should be noted that the routing considers real-time information and uses vehicle identification functions.

2.1.1.4 Berlin airport services

Flughafen Berlin Brandenburg GmbH operates the airports Schönefeld and Tegel in Berlin. In 2014, the two airports handled just under 28 million passengers, making Berlin the third-largest airport location in Germany. In order to create the capacities required for the future, the new Berlin Brandenburg Airport Willy Brandt is currently being built in Schönefeld. All air traffic in Germany's capital region will be concentrated in the south-east of Berlin.

Apart from route planners, there is also mobility information included in the existing services of the Berlin airports (SXF and TXL). The “Berlin Airport” app gives the passenger access to specific flight details and general airport information for Tegel and Schönefeld. Furthermore, the customer can use the “My Flight” function to receive push notifications on his smartphone about check-in, gate and boarding details as well as any changes or delays affecting a particular flight. The app also includes message templates that can be used to send family and friends the personal flight details. Furthermore, the app provides zoomable terminal maps to help the passenger find his bearings. An active Internet connection is required for updating the flight details, but the customer can access the general airport information without going online. Travellers automatically receive notifications about “Vouchers and Specials” offered by retailers and restaurants. In addition, all of the airlines flying from Schönefeld and Tegel are now listed with website links and telephone numbers; a phone call can be initiated with a single click. The public transport live display, which is shown in the figure below, is also integrated in the website of Berlin airport. As already mentioned, there are Mobility Monitors (MoMo) installed at the luggage belts, so that passengers can inform themselves at a glance about their mobility options at the airport while waiting. In addition the TIC route planner is integrated into the website of Berlin Airport to provide passengers with suitable routes for their way to/from the airport also taking into account the real-time traffic situation and traffic disruptions.
With the aid of beacons positioned around the airport, app users can receive location-based push notifications. Passengers who have entered their flight in the app receive a push notification the moment they enter the terminal building with instructions on the fastest route to their gate. Before passing through security screening, they will also get updates with the latest duty-free special offers. Arriving passengers are welcomed at the baggage carousel and receive tips on free Wi-Fi services or information on using public transport.

2.1.2 Palma de Mallorca

There are several existing mobility information services and technologies already in place in the city of Palma de Mallorca. This section will focus on giving an overview about the existing services specifically available in Palma de Mallorca; (inter-)nationally available information services with no specific focus on the city are left out in this section and will be described afterwards in 2.2.. This overview starts with the existing services for the landside mobility part and later describes the systems in place for the airport-focused part of the travel chain.

2.1.2.1 Palma de Mallorca city council services

Palma de Mallorca is the capital of Mallorca Island and the region of Balearic Islands. It is located in the Mediterranean Sea and southwest of the Mallorca Island and covers an area of 208.63 Km². It is the eighth largest city in Spain with 427,973 inhabitants (2015). Besides Mallorca is a major holiday destination with over 9 M tourists a year.
The island has a high car ownership rate (900 vehicles per 1000 inhabitants). Mobility culture is based on private car (58 % modal share). The EMT urban bus is the main public transport mean in Palma de Mallorca. Most of the non-motorized trips in Palma de Mallorca are made on foot. In 2011, a new public bicycle system called BiciPalma was launched.

The traffic in Palma de Mallorca is managed by means of a **Distributed Urban Traffic Control System** developed by ETRA Group, called SDCTU. Its main functionalities are:

- Gather traffic data from traffic sensors on the road.
- Store traffic data in data bases.
- Generate data and reports about traffic status and traffic evolution.
- Analyse and process the whole of mobility data.
- Support to define mobility policies and traffic control strategies.
- Benefit public transport by strategies offering traffic lights priority.
- Control traffic on the road by Traffic Controllers, Traffic Ligths, and Variable Messages Signals.
- Information panels and variable messages signals on streets show information to drivers about traffic congestion, recommended itineraries.

![Figure 12: SDCTU interface for Variable Messages Signals management](image)

The SDCTU has a physical architecture with a flexible and scalable configuration. Thus, in the Traffic Control Centre, there are the following elements:

- Communications Server
- Traffic Server
- Other control systems servers (Public Information System, etc.)
- Operators workstations with GUIs
MobiPalma, a free app from the city council provides information on the public transport service (including EMT and BiciPalma), car parks and real-time traffic info of Palma de Mallorca. MobiPalma was 50% co-financed with European funds and is part of the Civitas Dynamo project. Its main objective is to facilitate the citizens the access to all the information to get around in the city easily and in a sustainable way. The app is available in Catalan, Spanish and English, and will be available in German language. Users do not need to know the bus stops, the lines or the name of the streets, since it includes offline location maps, increasing its speed. Among its functionalities, it allows consultation of the EMT buses arrival time, check the information concerning all its lines and bus stops, set alerts, calculate routes, check the real-time traffic conditions by means of the municipal public cameras, as well as to know the number of free and occupied spaces in each public car park and in each BiciPalma station.

![MobiPalma mobile app](image)

**Figure 13: MobiPalma mobile app**

### 2.1.2.2 Palma de Mallorca bus services

EMT is the municipal company for collective urban passenger transport in the city of Palma de Mallorca and surroundings. The company serves around 39 M passengers annually with a workforce up to 630 people. The bus fleet consists of 180 vehicles offering transport services, organized in 31 city bus lines / routes and an infrastructure of 102 information panels at stops.

Particularly, the **EMT routes operating from/ to Palma Airport** are both line 1 (airport - Palma city center) and line 21 (airport - S'Arenal), with a frequency of 13 and 22 minutes respectively.
In the EMT website (http://www.emtpalma.es/EMTPalma/Front/index.en.jsp) the passengers can find static information about the service, such as: routes, timetables, fares, maps showing all routes, etc. On the other hand, there is also dynamic information available to the passengers, for example: incidents announcement (disruptions or temporary changes in the service), arrival time per stop (entering the bus stop number to know the waiting time for the next two buses) and a journey planner.

Figure 14: EMT Palma de Mallorca route map

Figure 15: EMT web-based journey planner
EMT offers to the passengers a free **smartphone app** that provides real-time bus arrival to each stop. This application is available since May 2013. Nowadays it receives an average of 120,000 daily queries.

![Figure 16: EMT smartphone app](image)

**Operation Assistance System (OAS) in EMT bus fleet**

Generally speaking an OAS is a comprehensive control and exploitation system of resources, applied to a network of public transport buses. It provides the means to control and manage real-time operation of available resources. Through available regulation tools, the OAS can act continuously on the routes in order to maintain quality of service. The data collected and processed by the OAS is used to inform passengers, operators and managers of public transport. Thus, the OAS is not just a tracking system.

ETRA developed and implemented an OAS in EMT Palma de Mallorca in 2009: SAE NT v4 and its components: OAS basic, Information at stations, Planning Tool, Statistics, SW Communications GPRS multisystem information panels, Ticketing.
First of all, OAS provides **valuable real time information to the passenger** by means of:

- **Information panels at stops:**
  - Continuous vehicle estimate
  - Estimated time of arrival and destination of the bus
  - Periodic oral information and / or requested by the passenger

- **Information panels inside the bus:**
  - Destination
  - Next stop
  - Detour information
  - GPS date and time
  - Oral information

- **ISAENET system** that is an OAS surround system providing information to other external systems, such as:
  - Passenger interaction with GSM-SMS, voice messages or WEB
  - It provides transition times for each stop
  - Scalable to other services provided by the SAE NT

Second of all, OAS provides **information to the bus operator** by means of the Operator interface. This kind of information provides some benefits for the network exploitation such as:

- Improving the regularity and reliability of the bus service
- Providing the necessary information on operation and service planning
- Enabling act promptly on the service depending on their status
- Adapting human and material resources to the current transportation needs
- Providing information on the status of vehicles, improving their maintenance
Finally, the OAS improves the working conditions of the bus driver, by means of the distributed information through the Drivers interface:

- Improved resource allocation
- Create a permanent channel of information between control center and driver
- It keeps the vehicle located at any time, streamlining interventions on it
- It improves driver safety
- Informs driver about the service status (lead / delay) and the corrective actions

2.1.2.3 Palma de Mallorca airport services

AENA is the world’s leading airport operator per passenger volume (195.9 M passengers managed in Spain during 2014). It manages 46 airports and 2 heliports in Spain. The three major airports in the network are: Adolfo Suárez Madrid-Barajas, Barcelona-El Prat and Palma de Mallorca.

Palma de Mallorca Airport, located 8 km from the city, is the gateway for the millions of tourists who visit the island. Airport traffic is primarily international and reaches its greatest levels during the summer season. There are also numerous connections to the mainland. The most important connections are to Barcelona, Madrid-Barajas and Dusseldorf, with over one million passengers, and Cologne, which handles over 800,000 passengers per year. By nationality, Germany accounts for the largest number of passengers, followed by Spain and the United Kingdom. In 2014, the airport closed the year with a total of 23,115,499 passengers.
The AENA website (http://www.aena.es/csee/Satellite/HomeAena/en/) offers information services to the passengers by choosing an airport from the AENA network, in the following categories, among others:

- **Flight info** searcher with information on scheduled flights 2 hours before and 24 hours after the time of the query. Provides real-time info on: Check-in desk, Gate and Flight Status. The flight information on this website is the most up to date available. It is based on confirmed flight information and the estimates provided by the airlines to AENA.

- **Road access.** It allows to check out the route for entering or leaving the airport by car. Routing services and real-time traffic qualitative information provided by Google Maps.

- **Parking.** It provides static information on parking facilities (including prices). Booking car parking space in advance is an option.

- **Transport.** It shows static information on public transport access (transport mode, routes, timetables, estimated travel time, prices, etc.) and links to the public transport operators’ web sites.

- **Airport maps.** It offers 3D maps of the passenger terminals showing where are located all airport services.

- **Car rental**

![AENA airport maps](image)

**Figure 19: AENA airport maps**

The AENA app developed for smartphones, offers all the information on flights across the AENA network. Passengers are able to plan outbound and inbound flights at Spanish airports and be updated with real-time notifications of any changes in flights. With just one click, the barcode of the boarding card can be loaded and the information of your flight in the planner. One can search and locate at detailed maps, all the leisure services
offered at the airport. Its detailed functionalities will be described below in section 2.2.6. Airport Smartphone Applications.

![Figure 20: AENA smartphone app](image)

### 2.2 Review of other existing systems, services and technologies related to:

#### 2.2.1 Multimodal routers

Multimodal route planners provide users with route suggestions for a trip taking into account different modes of transport such as car, bike, walking, metro, public transport etc. Unlike intermodal routers the transport modes are not combined for a trip as this requires a different route calculation algorithm. Most of the existing route planners belong to the either the group of monomodal routers (only one transport mode integrated, for example TomTom or INRIX for car routing) or multimodal routers, which are described in this section. Many of the multimodal routers are available both as browser-based service as well as mobile application. The selection of route planners in this section is the result of a desk research trying to give an overview about the most state-of-the-art multimodal routing services in place. Different criteria are taken into account for this analysis such as regional focus, type of application, integrated transport

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2 For the classification of multimodal and intermodal routers it is important to point out that local public transport is here regarded as one single mode. A route combining a bus trip with a metro trip operated by the same transport association would be regarded as a monomodal trip. Long-distance public transport in contrast is regarded as a different transport mode.
modes, availability of real-time traffic information, trip ordering criteria or integration of booking functions or ticketing.

Waymate is a multimodal routing service for long distance traffic. It is available as both web-based and mobile application (only iOS). The integrated transport modes include train, flights, long-distance buses and taxis. Waymate has a regional focus on Germany but wants to extend its services to European level for long-distance connection. One of the strongest partners is Deutsche Bahn for long-distance trains. Real-Time information for trains is provided. Waymate does provide city-to-city information but not from door to door.

Ally is a mobile routing application focusing on local transport. As Ally cooperates with many local public transport companies, they have access to real-time information for public transport routes which is taken into account for routing. Real-time information is also provided for the availability of car sharing cars of car2go and DriveNow. For local traffic a wide range of mobility options is integrated but the content lacks some of the local car sharing providers. Routes can be optimized by price and duration of the trip. The app allows an integrated reservation of car sharing cars; Ticketing for public transport is not yet included.

Figure 21: Waymate web-based routing application
Moovel is a web-based and mobile application for urban transportation and a full subsidiary of Daimler Financial Services. It provides urban mobility information for various transportation modes. As of today, Moovel has integrated public transport, car sharing operators, bike sharing, ridesharing, taxi and regional trains. Moovel has included real-time information about the availability of car sharing and bike sharing vehicles. Not all local car sharing operators are integrated though and real-time information for public transport is not provided. As trip ordering criteria it can be chosen between cost and duration of the trip.
The short-distance multimodal routing service **Citymapper** is available as mobile and web-based application as well as Apple Watch application. It provides information for biking, walking, taxi and public transport routes but does not combine the transport modes. Door-to-door information is provided but only for short-distance trips. Other local mobility options such as car sharing, ridesharing, bike sharing are not integrated. Real-time information on public transport is provided for a part of the cities for which the app is available. Routes can be filtered by duration and, as a special feature, spent calories in kcal. Booking functions are not provided by Citymapper.

![Figure 24: Citymapper short distance web-based routing application](image)

### 2.2.2 Intermodal routers

Intermodal routing systems are defined through combining different transport modes for one single trip. The number of intermodal routers is much lower than of multimodal or monomodal routers. In this section some of the most used intermodal route planners are briefly presented.

**Google Maps** is one of the most used existing route planners. It provides traffic information for both long-distance and local traffic in a browser-based and a mobile application. For long distance traffic the router shows trip information for long-distance trains, car and flights. The car routing takes into account the current traffic situation on highways. Booking of flights is not directly integrated but an app-to-website or website-to-website link to the Google Flights search is provided. For local traffic the routing system integrates car routes, public transport and walking routes. Additional urban mobility options such as taxi, car sharing or bike sharing are not included. The long-distance trip information as well as the local transport information, are provided in the same application and can be combined so that a door-to-door information with the integrated modes of transport can be received by the user. As long-distance trains and short-range public transport is combined for a door-to-door route, Google Maps can be called an intermodal route planner although it is focused on multimodal mobility.
information. Real-time public transport information is available for a few cities. Tickets or reservations cannot be bought/made through the application. Trip ordering criteria are duration of the route, number of changes for a public transport route and short walking distances.

Another much used intermodal routing service is Qixxit, a full subsidiary of Deutsche Bahn AG (Germany’s main railway company). The Qixxit routing service covers both long-distance and local transport in one application. The following transport modes are integrated for intermodal routing: short-range public transport, long-distance trains, air traffic, ridesharing, car sharing, rental cars, bike sharing, and taxis. With this range of mobility options Qixxit offers one of the greatest varieties of route combinations. Tickets and reservations can be bought or made for a few transport modes such as flights, taxis or long-distance trains via app-to-app links. Through the integration of long- and short-distance traffic, door-to-door information can be provided for European routes. The number of flight connections that are considered for long-distance journeys is still small though. Trips can be ordered by duration and price of the connection. The intermodal routing system does basically combine all integrated transport modes for a trip, only leaving out combinations which are not useful such as bike with air traffic.
GoEuro is a long-distance intermodal router available as web service and smartphone application. It focuses on city-to-city connections and does not provide door-to-door routing information. It integrates long-distance and regional trains, air traffic, and long-distance buses. Bookings can be made for all the mentioned transport modes through app-to-app and app-to-website links. Real-time traffic information is provided for trains and buses but not for flights. The routing functions are available with the full range of functions and mobility options for UK, Germany, Spain, Netherlands, Belgium, and Switzerland. Trip ordering criteria are price and duration as well as the combination of both.
RouteRank is an only web-based intermodal long-distance route planner. It provides city-to-city, but not door-to-door route suggestions. It only has integrated air-traffic, private car, and long-distance trains and is in this regard quite limited. It also does not operate with real-time traffic information but with target data. A special feature of RouteRank is to order suggested routes by CO$_2$-emissions. It is also possible to offset CO$_2$-emissions via app-to-website-link. Bookings for the suggested routes can be made via app-to-website-links.

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</tr>
</tbody>
</table>

Figure 28: RouteRank web-based long-distance routing application

Rome2rio is a popular Australian-based long- and short-distance router which is available as web-based service and smartphone-app (only iOS). It provides door-to-door information with a very broad geographical coverage. Even intercontinental routes are provided from door to door. The integrated transport modes include air-traffic, private car, trains, long-distance busses, ferries and local public transport. Local, city-specific mobility options such as car sharing or bike sharing are not covered. Real-time information about flights and public transport including delays or disruptions is not provided. Bookings can be made via app-to-website-links. Prices and duration of routes are shown, but routes cannot be filtered by these or other criteria.

Figure 29: Rome2Rio intermodal long-distance web-based routing application
2.2.3 Comparison routing systems vs. DORA

The presented multimodal and intermodal routing systems show that a wide range of mobility information for short- and long-distance transport can be accessed by possible commuters or travellers. All these applications have a different regional focus, different integrated transport modes, routing functions or target groups. The complexity of the systems vary considerably, some of quite simple, some more complex with door-to-door information even for long-distance trips and integrated booking functions. However, it can be stated that the presented existing solutions for route planning lack some important features in comparison to the targeted DORA system.

For long-distance door-to-door routes by plane, the existing systems don’t consider terminal processes for the entire trip chain. By providing precise information about indoor terminal mobility and processes the DORA system will contribute towards reducing the overall trip duration in comparison to the described long-distance routing system. Another added value of DORA is the integrated incident management for airport accessibility. If there are disruptions on the land-side part of the trip (street, public transport) the DORA system will inform the user accordingly and integrate this information in the routing. Additionally, only a few of the existing route planners integrate real-time traffic information for their routing. Being informed about possible delays of public transport or traffic congestion on the highways to the airport is a very important aspect for arriving at the airport on time. The existing multi- and intermodal route planners also lack customized mobility information for special air-traffic user groups such as business travellers, families or mobility-impaired people.

Altogether, the existing routing systems partly provide a wide variety for door-to-door mobility information but lack many functions that will be developed and integrated in the DORA project such as terminal processes, incident management, real-time traffic information, information for parking at the terminal or user group specific information.

2.2.4 Waiting time detection

2.2.4.1 Introduction

Managing queues is important for many businesses, to improve service efficiency and thus improve customer satisfaction. Many techniques have been developed to achieve efficient queue management.

Various techniques are and have been used to analyse people count, queue length and waiting time. A classification of these techniques could be as follows:
- **Image analysis based techniques**
  - Video analysis
  - Thermal analysis
  - Stereo Video
  - Facial recognition
- **Beam sensors**
- **Device tracking with Wi-Fi or Bluetooth**

There is a significant market for queue waiting time detection for businesses in general and more specifically for airports, but the variety of techniques employed proves the market is still not stabilized, with a very diverse set of technologies used that need to be monitored and assessed over time. In the DORA project, a video analysis system will be integrated in the airports to measure passenger’s behaviours and to deliver to the DORA platform accurate and consistent data.

### 2.2.4.2 Existing technologies and related work

Following the previous categorization of the techniques used for measuring waiting time detection, below there is a short description of each one. Afterwards, the different techniques will be compared, besides their pros and cons. It is also important to remark that techniques can be combined, depending on requirements or for a greater accuracy.

**Video analysis**

Algorithms calculate or estimate the number of persons in a queue with a high degree of accuracy. State-of-the-art algorithms and intelligent video analysis engines provide estimated waiting times for passengers and thus can inform them of the optimal route through the airport.

**Thermal analysis**

Thermal counters detect people by the heat of their body and can therefore count the number of persons passing simultaneously in a certain zone. This is a very good solution for general people traffic counting and frequenting figures in many industries, but has some specific issues in airports.

**Stereo Video**

In addition to video analysis, depth sensing capability of stereo cameras is used to estimate and monitor the waiting time of travellers. Depth image analysis provides valuable visual hints, since the measured depth ordering reveals how the persons are spatially arranged within the queue. Combining depth information with video analysis techniques provides reliable tracking of queues, thus characterizing queue dynamics and providing information with respect to an estimated waiting time.

**Facial recognition**

Anonymous facial images of passengers entering a certain area are captured, then these images are used with facial recognition techniques to track passengers through other
areas, thus giving statistical information about time taken between the different areas. From the information issued from facial image matching in-between way-points, is inferred waiting time in queues.

**Beam sensors**

Electronic sensors are located at queue entry points, then emit and detect an infrared beam, counting interruptions when a person crosses the beam. Sensors need to be deployed and mounted in specific areas, with a reflector opposite. Such a technique is accurate and has great performance in people counting, whereas it gives limited information regarding queue trends.

**Device tracking with Wi-Fi or Bluetooth**

Device tracking is performed via GSM, Bluetooth and/or Wi-Fi tracking to measure waiting times. Receivers are placed to track GSM, Bluetooth and/or Wi-Fi signals within a given area. Further device tracking areas are defined and by preforming a central analysis of the data, it is possible to infer reporting and analytic information on the flow of passengers within a given area.

**Pros and cons of the different techniques**

Measuring waiting time detection requires to do well with accuracy and consistency features. The technology used should properly measure people’s behaviour across a range of environments and volumes in a variety of space layouts and be capable of delivering multiple accurate metrics. Privacy, sensor deployment, image variations with sunshine or shadows, large volumes of traffic, temperature variations, even what people are wearing can impact the accuracy of measurement depending upon the technology used.
<table>
<thead>
<tr>
<th>Technology</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video analysis</td>
<td>Ease of deployment</td>
<td>Difficulty to get definitive information</td>
</tr>
<tr>
<td></td>
<td>Well suited for queue time</td>
<td>Light variations can affect performance</td>
</tr>
<tr>
<td></td>
<td>Many image processing algorithms can provide cross-check information</td>
<td></td>
</tr>
<tr>
<td>Thermal analysis</td>
<td>Accuracy of counting</td>
<td>Specific issues related to wide areas, like airport terminals</td>
</tr>
<tr>
<td></td>
<td>Bi-directional counting capability</td>
<td>Limited performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitive to thermal variations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Queue length and waiting time is derived data, thus creating inaccuracies</td>
</tr>
<tr>
<td>Stereo Video</td>
<td>Well suited for gate camera placement</td>
<td>Specific camera set-up</td>
</tr>
<tr>
<td></td>
<td>Accuracy of the measurements because of 3D information</td>
<td>Depth measurement capability is limited in long queues</td>
</tr>
<tr>
<td>Facial recognition</td>
<td>Ease of deployment</td>
<td>Though anonymously performed, facial recognition can raise privacy issues</td>
</tr>
<tr>
<td></td>
<td>Gives definitive information</td>
<td>Wide crowded areas can be difficult to cover</td>
</tr>
<tr>
<td>Beam sensors</td>
<td>Accuracy of counting in specific areas</td>
<td>Cost of deploying and maintaining a beam infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitive to light variations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only basic persons’ traffic trend is measured</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difficulty to count in wide areas, such as airports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Queue length and waiting time is derived data, thus creating inaccuracies</td>
</tr>
<tr>
<td>Device tracking with Wi-Fi or Bluetooth</td>
<td>Very good analytic and reporting of the information provided in the covered areas</td>
<td>Though anonymously performed, device recognition can raise privacy issues, or enrolment requirements similarly to cookies’ acceptance on web sites.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Device tracking can cover an area of around 10 meters. Placement issues can occur, both in wide areas (airport halls or wide waiting zones) and narrow areas (differentiating a priority or crew queue from a general queue).</td>
</tr>
</tbody>
</table>

The **DORA project choose to implement video analysis**, as this technique is easy to deploy and does not require large and complex sensor deployment, moreover is not
intrusive and presents limited privacy issues when doing device tracking, such as mac addresses.

2.2.4.3 Market Analysis

The current market status for queue waiting time detection is mostly composed of different implementations and solutions issued from a wide range of technologies. The large number of actors, combined with the number of technologies used tend to prove the market is not established yet, and offers opportunities to new entrants and innovative approaches, such as open-source solutions.

### Table 2: Waiting time detection products and offerings

<table>
<thead>
<tr>
<th>Website</th>
<th>Technique</th>
<th>Description</th>
<th>Product page</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.nemo-q.com/">http://www.nemo-q.com/</a></td>
<td>Device tracking with Wi-Fi or Bluetooth</td>
<td>Queuing system</td>
<td><a href="http://www.nemo-q.com/virtual_queuing_systems.html">http://www.nemo-q.com/virtual_queuing_systems.html</a></td>
</tr>
<tr>
<td><a href="http://www.3dcounting.fr/">http://www.3dcounting.fr/</a></td>
<td>Stereo Video</td>
<td>3D stereo sensor analytics</td>
<td><a href="http://www.3dcounting.fr/notre-technologie">http://www.3dcounting.fr/notre-technologie</a></td>
</tr>
</tbody>
</table>
It is important to remark that the accuracy, the metrics and the acceptance provided in this table varies significantly for several reasons:

- Accuracy in people counting is not necessarily linked to waiting time detection, as the waiting time is, in some cases, a derived information
- Accuracy in distinguishing between people, objects and the background of the space is a challenge
- Identify the direction of travel (entering or exiting)
- Some technologies can be very accurate, but require large sensor deployment, which may not well be suited to the DORA project
- Some technologies may be part of a broader framework, such as waiting time detection performed in the EU FASTPASS project (https://www.fastpass-project.eu/sites/default/files/ABC_final.pdf)
- Some technologies imply privacy issues and/or user acceptance, both varying from country to country
- Ease of technology deployment is also an important success-factor within the DORA project
- Robustness of the technology regarding environment issues, such as light, sunlight, shadows or heat variations, as well as sensor placement.

Worthwhile to mention that the variety of technologies used for waiting time detection is broad, meaning the market is not mature enough and stabilized leaving opportunities for new entrants. Moreover, there is a lack of open source implementations regarding queue analysis. Fruitful contribution to OpenCV (http://opencv.org/) will be analysed in detail as part of the solution implementation in the DORA project.

2.2.5 Indoor navigation

2.2.5.1 Introduction

Navigation is the process of accurately establishing the user’s position and then displaying directions to guide them through feasible paths to their desired destination.

For outdoor environments, the Global Positioning System (GPS) is the most common used satellite navigation system. Many aerial (aircraft), maritime (ship) and terrestrial (car, lorry, bus) vehicles make use of GPS technology. Even pedestrians are able to self-locate as their mobile phones (smartphones) include a GPS unit, and there are location-based mobile applications such as geofencing and automotive navigation for the common user.

For indoor environments, there is typically no GPS signal available and alternative methods have to be considered to provide indoor navigation. Several radio technologies are possible, such as Wi-Fi, Bluetooth, wireless sensors or even inertial sensors.

There is a huge market regarding indoor navigation applications. Tourists, for instance, would have a better experience if they could navigate in a building (museum, gallery, shopping mall, etc.) without assistance. In the DORA project, such a system will be integrated in airports to navigate passengers from the entrances to their boarding gates (and vice versa).
2.2.5.2 Existing technologies and related work

Nowadays developing indoor navigation systems for the common user is a hot topic. Researchers have explored several alternatives of indoor positioning systems that use Wi-Fi signal intensity to estimate position [2] [3] [4]. Other wireless technologies, such as Bluetooth [5] [6] [7], UltraWideband (UWB) [8] [9] and radio frequency identification (RFID) [10] [11] have also been proposed. Another innovative approach uses geomagnetism to create magnetic fingerprints to track position from disturbances of the Earth’s magnetic field caused by structural steel elements in the building [12] [13].

Other alternatives for dealing with the problem of indoor localisation are the (combined) use of inertial sensors [14] [15], exploiting the smartphone accelerometer and gyroscope to build a reliable indoor positioning system without any infrastructure assistance.

Besides academic research, it is also important to look at existing commercial indoor navigation systems available. Such company providers are described and evaluated in next sections. Here it is important to consider not only the technology behind, but also the end user mobile application (user interface). For example, the American Museum of Natural History released a mobile app (amnh.org/apps/explorer) for visitors to act as their personal tour guide (based on BT and Cisco technology).

Table 3: Pros and cons for potential indoor technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>Moderate to high outdoor accuracy</td>
<td>Low to minimal indoor accuracy</td>
</tr>
<tr>
<td></td>
<td>High availability</td>
<td></td>
</tr>
<tr>
<td>A-GPS</td>
<td>Moderate outdoor accuracy</td>
<td>Minimal indoor accuracy</td>
</tr>
<tr>
<td>Pseudolite GPS</td>
<td>High indoor and outdoor accuracy</td>
<td>Very expensive equipment</td>
</tr>
<tr>
<td>Cell tower</td>
<td>Long range</td>
<td>Highly inaccurate for both indoors and outdoors</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>Readily available throughout most buildings</td>
<td>Network strength can vary due to multipath propagation</td>
</tr>
<tr>
<td></td>
<td>Minimal costs for implementation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium range</td>
<td></td>
</tr>
<tr>
<td>Bluetooth</td>
<td>Low power</td>
<td>Moderate to low range</td>
</tr>
<tr>
<td></td>
<td>Low financial cost</td>
<td>High cost of implementation</td>
</tr>
<tr>
<td>Infrared</td>
<td>Moderate to high accuracy</td>
<td>High costs for implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sunlight can affect outcome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low range</td>
</tr>
<tr>
<td>Ultra-wideband (UWB)</td>
<td>High accuracy</td>
<td>High cost for implementation</td>
</tr>
<tr>
<td></td>
<td>Low power density</td>
<td>Not commonly used</td>
</tr>
<tr>
<td></td>
<td>Wide bandwidth</td>
<td></td>
</tr>
</tbody>
</table>
2.2.5.3 Indoor positioning techniques

In order to navigate within a building, one must first determine the user’s current location. There are two different methods for implementing a positioning system: self and remote positioning. In self-positioning, the physical location is self-determined by the user’s device using transmitted signals from terrestrial or satellite beacons. The location is known by the user and can be used by applications and services operating on the user’s mobile device. In remote positioning, the location is determined at the server side using signals emitted from the user device. The location is then either used by the server in a tracking software system, or transmitted back to the device through a data transfer method.

The performance of a positioning and navigation system is typically rated on four different aspects that civil aviation authorities have defined for their systems: accuracy, integrity, availability and continuity [16]. These parameters focus on addressing the service quality for the mobile user including navigation service and coverage area:

- The accuracy of a system is a measure of the probability that the user experiences an error at a location and at a given time.
- The integrity of a system is a measure of the probability that the accuracy error is within a specified limit.
- The availability of a system is a measure of its capability to meet accuracy and integrity requirements simultaneously.
- The continuity of a system is a measure of the minimum time interval for which the service is available to the user.

In the table below there is a list of available positioning technologies based on external beacons. Some of them will be commented separately.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell of Origin</td>
<td>Base stations exist (cell towers)</td>
<td>Highly inaccurate</td>
</tr>
<tr>
<td></td>
<td>Base stations never move</td>
<td></td>
</tr>
<tr>
<td>Angle of Arrival</td>
<td>Moderate accuracy with appropriate hardware</td>
<td>Requires directional antenna(s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Requires knowledge of orientation</td>
</tr>
<tr>
<td>Angle Difference of Arrival</td>
<td>Doesn’t require knowledge of orientation</td>
<td>Requires and additional base station</td>
</tr>
<tr>
<td>Time of Arrival</td>
<td>Moderate indoor performance</td>
<td>Base stations must be synchronized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low overall accuracy</td>
</tr>
<tr>
<td>Time Difference of Arrival</td>
<td>Moderate indoor performance</td>
<td>Low overall accuracy</td>
</tr>
<tr>
<td>Triangulation</td>
<td>Very simple</td>
<td>Requires determination of angles</td>
</tr>
<tr>
<td>Location Fingerprinting</td>
<td>High accuracy</td>
<td>High calibration time requirement</td>
</tr>
</tbody>
</table>
Location Fingerprinting

Location fingerprinting is a mechanism which compares the Received Signal Strength (RSS) from each wireless access point (other devices might also be possible) in the area with a set of pre-recorded values taken from several locations. The location with the closest match is used to calculate the position of the mobile unit. This technique is usually broken down into two phases:

- **Offline sampling**: consists in measuring and storing the RSS from different wireless devices at selected locations in the area.
- **Online location**: consists in collecting the RSS at runtime and using the data from the offline samples to determine the location of the mobile device.
- With a great deal of calibration, this solution can yield very accurate results. However, this process is time consuming and has to be repeated at every new site.

It is important to note the difference between RSS and RSSI. Wireless devices have the capability to measure the strength of this signal. This strength is converted to a number, known as Received Signal Strength Indicator (RSSI). A user’s device can detect the RSSI and MAC address of multiple routers at one time. RSSI is a dimensionless metric that is used by systems to compare the strength of signals from multiple access points. There is no standard conversion between RSSI and the actual received signal strength (RSS); many manufacturers have their own conversion schemes. Important characteristics of RSSI to RSS conversions include:

- The maximum and minimum RSSI values (dimensionless integers),
- The maximum and minimum RSS values that can be represented (dBm),
- The resolution of the conversion (value in dBm represented by one RSSI unit).

Trilateration

Location trilateration involves calculating the relative distance of a mobile device from a wireless device (typically base station) and using these estimates to trilaterate the user’s position. Distance estimates are made based on the RSSI received from each base station. In order to resolve ambiguity, a minimum of three base stations are required. In free space, the received signal strength is inversely proportional to the square of the distance from the station to the device. Signal strength is affected by numerous factors such as interference from objects in the environment, walking, multipath propagation, etc. Therefore, in non-ideal conditions, different models of path attenuation need to be considered.
2.2.5.4 Indoor propagation models

To accurately determine an indoor location using wireless signals as references, an accurate model of signal propagation is necessary. Received signal strengths are affected by walls, people, furniture, and other objects, as well as multipath phenomenon. To accurately simulate these effects, multiple models are considered:

- Free Space Model
- One Slope Model
- Multi-wall model
- New Empirical Model
  - Angle Dependence of Propagation Model
  - Break Point Phenomenon

Previous models have been listed from least to most complex and real. It is not necessary to fully describe them, as it involves progressive complicate formulae, but a summary list is provided in the Table below.

<table>
<thead>
<tr>
<th>Propagation Model</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Space Model</td>
<td>Computationally simple</td>
<td>Ignores surrounding environment</td>
</tr>
<tr>
<td>One Slope Model</td>
<td>Computationally simple, Differentiates between indoor and free space</td>
<td>Treats surrounding environment as homogenous</td>
</tr>
<tr>
<td>Multi-wall model</td>
<td>Accounts for walls and floors and free space</td>
<td>Ignores multipath effects and angle dependencies</td>
</tr>
<tr>
<td>New Empirical Model</td>
<td>More accurate than Multi-Wall model, Models breakpoint</td>
<td>Computational cost, No diffraction or reflection modelled</td>
</tr>
</tbody>
</table>
2.2.5.5 Custom position markers

Markers can be designed to meet certain application requirements. Besides encoding the position coordinates, they could be extended to encode additional objects that allow the calculation of the user's orientation at the point of scanning. Here we need to define an encoding technique as well as develop a scanning application to decode the marker data. In order to extract key features and interpret the scanned image, computer vision techniques need to be applied.

2.2.5.6 Inertial systems

An Inertial Navigation System (INS) is a navigation system that estimates the device's current position relative to the initial position by incorporating the acceleration, velocity, direction and initial position. An INS system typically needs an accelerometer to measure motion, a gyroscope or similar sensing devices to measure direction, and a computer to perform calculations. The position relative to initial position can be calculated from the accelerometer measurements, which provides movement information relative to a previous location. With the accelerometer alone, the system could detect relative motion. The use of additional hardware such as a compass is necessary to tell the direction of movement.

The output of the accelerometer is a measure of the acceleration in three dimensions; the velocity in an inertial reference frame can be calculated by integrating the inertial acceleration over time. Then the position can be deduced by integrating the velocity. The INS is usually subjected to “integration drift,” which is the error in measurement of acceleration and angular velocity. Since these errors are integrated each iteration, they will be compounded into greater inaccuracy over time. Therefore, INS is often used to supplement another navigation system to provide a higher degree of accuracy.

Dead reckoning

Dead Reckoning (DR) is the process used to estimate the position of an object relative to an initial position, by calculating the current position from the estimated velocity, travel time and direction course. Modern inertial navigation systems depend on DR in many applications, especially automated vehicle applications.

A disadvantage of dead reckoning is that the errors could be potentially large due to its cumulative nature. The reason is that the new position is estimated only from the knowledge of a correct previous position; therefore any probability of error will grow exponentially over time. Another challenge of this approach is that while it is used widely for inertial navigation systems, implementation on personal device is difficult due to the low quality sensors available. The sensor noise will blur the signal and increase the potential error. A method developed by the Geodetic Engineering Laboratory of EPFL utilizes a low cost inertial system that detects human steps and identifies the step length based on biomechanical characteristic of the step. The type of step can depend on different factors such as gender, age, height and weight of the person. Their model is
constructed and tested with blind people whose steps vary greatly depending on familiarity with the area.

**Map matching**

Map matching is a method for merging data from signal positioning and the digital map network to estimate the location of the mobile object that best matches the digital map. The reason that such techniques are necessary is that the location acquired from positioning techniques is subject to errors. Map matching is often helpful when the position is expected to be on a certain path, such as in the problem of tracking a moving vehicle on the route of GPS device.

The digital map data is not a graphical picture representation of an area but often in the form of a list of polylines in a graph. The positioning estimates are often not on the polyline provided, but scattered due to errors in the positioning system. The map matching process will produce outputs that lay on the polyline. An example output is a GPS device in a driving vehicle that matches the position of the car to the nearest road.

There are two forms of map matching algorithms: online and offline. The online map matching algorithm deals with situations in which only current and past data available to estimate the position similar to the GPS device in a car. The offline map-matching algorithm is used when there is some or all future data is available, such as a recorded track of a moving object.

The process of matching often involves three different phases: nomination, selection and calculation. In the nomination phase, with the given positioning data, the algorithm will choose all the potential polylines in the graph that the position could be on. The criterion for choosing a polyline is the normal distance between the point and the polyline. If the distance is within the considered threshold, the polyline will be chosen for the next step. The purpose of the nomination is to filter out all the polylines that are too far away and unlikely to be the correct one. In the selection phase, a best polyline will be chosen from the set of polylines filtered in the previous phase. This is the important part of the algorithm to determine which one is the correct polyline. The criteria to consider can include last positions, last correct polylines, estimation of future position, normal distance between the points and the line. After a polyline is chosen, in the last phase, calculation, the estimated position on the polyline of the point is computed and is given as the output of the process.

**2.2.5.7 Mapping techniques**

Mapping a building involves gathering information that describes the building’s layout and converting this information into a form that is usable by other processes. Types of data typically extracted include:

- The location and size of walls, hallways, doors, floors, staircases, elevators, windows, etc.
• Position of the map relative to other locations (latitude and longitude, elevation, floor number, orientation)

The navigation process finds the shortest path from the current location determined by positioning techniques to a desired destination within an unfamiliar area.

Mapping information formats

There are currently two common formats for building mapping information:

• Two-dimensional map images are often posted to provide aid in navigation or to show fire escape routes. The appearance of these maps varies depending on the software used to create them or applicable building standards. The information that can be gathered from a map image is primarily the floor plan of a building. The scale and coordination are generally not present, but can be found in more technical maps such as printed blueprints.

• Three-dimensional building models are available for structures constructed recently that were designed with 3-D modelling utilities. This form of building mapping stores much more information than the two dimensional images. Scale, Height, and connections to other floors are all available. These models do not provide information regarding the location and orientation of the building. The primary limitation of this file format as a resource is that it is available for few buildings.

Map creation techniques

To make map images or models useful in software applications they are often converted into a new data structure, which provides the necessary information in an accessible format. There are four aspects of spatial relationship that a map data structure often needs to represent: connectivity, proximity, intersection and membership. Different map data structures may focus on some aspects more than others. If the raw data is a CAD file, the process is simpler because the structure has already been decomposed into simple elements. Less complex processing techniques are necessary. If the map layout is in an image format such as .jpg, .png, or .pdf the process of converting from raw data to a primitive data structure requires the use of image processing techniques including object recognition and data filtering. If a lower quality format is obtained (i.e. a photograph) further steps to correct skewed perspectives or discolouring could be necessary.

Graphing representation

In order to perform graphing algorithms to determine the shortest path between two locations, it is necessary to convert the representation of a map data structure from layout with walls, halls, and doors structure into nodes and links. In graphing representation, small rooms, intersections, staircases, elevators and other building units are typically represented by nodes while hallways and large rooms might be represented by links that connect between nodes. A node might also carry information related to the
location including coordination, and a link to a software database so that a user can get more information. A link between two nodes represents an existing path in the building where a person can walk between two locations directly. The assignment of the nodes is constructed so that every link must be a straight line and represents the actual direct line of sight path.

Routing algorithms

Routing techniques use algorithms that find the shortest path between two locations. Typically a link relationship between nodes in a graph will be represented by a two dimensional matrix. The relationship between nodes is the weight or the cost of traveling from one to the other such as distance, time, or degree of convenience. The relationship can also be represented by a list of edges. The choice of data structure will affect the size of the database as well as the performance of the algorithm. Some common algorithms are Dijkstra [17], Ford-Bellman [18], and A* [18]. The table below summarizes pros and cons of each technology.

<table>
<thead>
<tr>
<th>Routing algorithm</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dijkstra’s</td>
<td>High speed, Optimal</td>
<td>Doesn’t work with negative weights graph</td>
</tr>
<tr>
<td>Bellman-Ford</td>
<td>Optimal Work with negative weight</td>
<td>Low Speed</td>
</tr>
<tr>
<td>A*</td>
<td>Highest speed</td>
<td>Not always optimal</td>
</tr>
</tbody>
</table>

2.2.5.8 Market Analysis

The current market status for indoor navigation and positioning systems is mostly composed of several different implementations and solutions. Most of them rely on radio signal fingerprinting (Wi-Fi and/or Bluetooth) combined with device sensor data (MEM Sensors), and some use a classical approach (triangulation/trilateration) or even a hybrid (mixed) method. Typical IPS architectures are based on a client-server paradigm, where all positioning calculations are made at server side, although some companies offer the possibility of working without the need of a server (offline mode).

For the client side almost all available products have their own application/SDK tool to deploy on mobile platforms, typically iOS and/or Android.

The following table shows an overview of the current market situation.
<table>
<thead>
<tr>
<th>Product</th>
<th>Website</th>
<th>Description</th>
<th>Client platform</th>
<th>Radio Signals</th>
<th>MEM Sensors</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>9Solutions</td>
<td>9solutions.com</td>
<td>Custom Bluetooth tags and beacons fingerprinting. (Requires external infrastructure)</td>
<td>• Bluetooth</td>
<td></td>
<td></td>
<td>Fingerprinting</td>
</tr>
<tr>
<td>AINSI</td>
<td>ainsi.pro</td>
<td>Positioning for lone workers via MEMS sensors (compass and accelerometer) and fingerprinting (if available).</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Fingerprinting + Sensor data</td>
</tr>
<tr>
<td>AIONAV</td>
<td>aionav.com</td>
<td>Precise positioning in 3D based on inertial technology without any external infrastructure.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Fingerprinting+ Sensor data</td>
</tr>
<tr>
<td>CSR</td>
<td>csr.com</td>
<td>SiRFstarV sensor fusion chip.</td>
<td>• Wi-Fi • GNSS</td>
<td></td>
<td></td>
<td>Mixed</td>
</tr>
<tr>
<td>Indoo.rs</td>
<td>indoo.rs</td>
<td>Wi-Fi and Bluetooth fingerprinting. Now integrates MEM sensor data. Supports offline mode.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Fingerprinting+ Sensor data</td>
</tr>
<tr>
<td>Indoor Atlas</td>
<td>indooratlas.com</td>
<td>Geomagnetic Indoor Positioning. Now also integrates Bluetooth and Wi-Fi location information.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Insiteo</td>
<td>insiteo.com</td>
<td>Insiteo provides accurate indoor location using Wi-Fi, Bluetooth and Sensors. Supports offline mode.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Fingerprinting + Sensor data</td>
</tr>
<tr>
<td>Lighthouse Signal</td>
<td>lighthousesignal.com</td>
<td>Wi-Fi fingerprinting. Now can integrate Bluetooth as well. Supports offline mode.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Barometer</td>
<td>Fingerprinting</td>
</tr>
<tr>
<td>Locata</td>
<td>locata.com</td>
<td>Terrestrial GPS-like constellation of radio transceivers. (Requires external infrastructure)</td>
<td>2.4 GHz open ISM band</td>
<td></td>
<td></td>
<td>Triangulation</td>
</tr>
<tr>
<td>Loctronix</td>
<td>loctronix.com</td>
<td>Mobile Explorer Platform for indoor positioning</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • GNSS • Cell</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Mixed + Sensor data</td>
</tr>
<tr>
<td>Navizon</td>
<td>navizon.com</td>
<td>Also has a crowdsourced Wi-Fi fingerprint database.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi • Bluetooth</td>
<td>• Compass • Accelerometer • Gyroscope • Barometer</td>
<td>Fingerprinting</td>
</tr>
<tr>
<td>NextNav</td>
<td>nextnav.com</td>
<td>Terrestrial GPS-like constellation of radio transceivers. (Requires external infrastructure)</td>
<td>Unspecified</td>
<td></td>
<td></td>
<td>Triangulation</td>
</tr>
<tr>
<td>Name</td>
<td>Website</td>
<td>Description</td>
<td>Platforms</td>
<td>Bluetooth</td>
<td>Wi-Fi</td>
<td>GNSS</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>-------------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Pointr</td>
<td>pointrlabs.com</td>
<td>Real time true location using Bluetooth with navigation, messaging and analytics</td>
<td>• Android • iOS</td>
<td>• Bluetooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pole Star</td>
<td>polestar.eu</td>
<td>Positioning by combining GPS, Wi-Fi, Bluetooth and sensor data.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi</td>
<td>• Bluetooth</td>
<td></td>
</tr>
<tr>
<td>Senionlab</td>
<td>senionlab.com</td>
<td>Wi-Fi and Bluetooth fingerprinting combined with sensor data. In-app positioning.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi</td>
<td>• Bluetooth</td>
<td></td>
</tr>
<tr>
<td>Sensewhere</td>
<td>sensewhere.com</td>
<td>Crowd-sources and cross-references RF access point data via users' own devices.</td>
<td>• Android</td>
<td>• Wi-Fi</td>
<td>• Bluetooth</td>
<td>• GNSS</td>
</tr>
<tr>
<td>Shopkick</td>
<td>shopkick.com</td>
<td>Places audio transmitters in retail stores to verify user location via smartphone microphone. Now also uses Bluetooth beacons. (Requires external infrastructure)</td>
<td>• Android • iOS</td>
<td>• (Audio)</td>
<td>• Bluetooth</td>
<td></td>
</tr>
<tr>
<td>Skyhook</td>
<td>skyhookwireless.com</td>
<td>GNSS, Wi-Fi, Cell and sensor hybrid solution.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi</td>
<td>• GNSS</td>
<td>• Cell</td>
</tr>
<tr>
<td>Trueposition</td>
<td>trueposition.com</td>
<td>Combines cell and Skyhook's Wi-Fi solution. Offers low energy transmit-only Wi-Fi beacons.</td>
<td>• Wi-Fi • Cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WalkBase</td>
<td>walkbase.com</td>
<td>Focused on providing context, not mapping-overlaid positioning.</td>
<td>• Android</td>
<td>• Wi-Fi</td>
<td>• Bluetooth</td>
<td></td>
</tr>
<tr>
<td>Wifarer</td>
<td>wifarer.com</td>
<td>Wi-Fi and Bluetooth fingerprinting.</td>
<td>• Android • iOS</td>
<td>• Wi-Fi</td>
<td>• Bluetooth</td>
<td></td>
</tr>
</tbody>
</table>

Note that the accuracy provided by previous products listed in the previous table may vary significantly, but average accuracy is about 5 – 15 meters; however, this mostly depends on (i) the fingerprint resolution and (ii) the number of deployed beacons. It is also affected by the algorithm used for the positioning estimations.

It is important to highlight that there is a lack of open source implementations regarding indoor navigation and positioning (there are some outdated solutions, such as RedPin).

All previous products listed above offer indoor positioning techniques, but only some of them include indoor navigation as an added value (e.g. Indoor.rs, Wifarer). Linked to indoor navigation there are other related services such as indoor map creation, beacon installation, server application deployment and custom client application development. Some companies (Pointr, Skyhook) include a complete solution.

In recent years there is a growing interest in providing iBeacon standalone solutions, with several vendors offering various products. The following table summarizes their characteristics.
2.2.5.9 DORA Proposed Indoor Positioning and Navigation System

Hardware Platform Concepts

Indoor positioning in DORA is approached in a manner that will enable fast deployment of equipment as well as seamless integration with existing infrastructure. As far as the deployment in user equipment is concerned the concept remains the same. The techniques should be easily supported over the widest possible variety of user equipment being at the same time as battery friendly as possible. Additionally, the produced outcome should be at a TRL level close to final product in order to increase its exploitation potential beyond the end of the project.

For these reasons, the DORA Indoor Positioning System (DIPS) is intended to be primarily based on Wi-Fi techniques without excluding the possibility of a hybrid solution combining both Wi-Fi and BLE radio signals.

On the one hand, the Wi-Fi availability in almost any kind of user equipment along with the already existing Wi-Fi based positioning systems (IOS and Android SDKs and Maps) provide ample room for seamlessly applying DORA techniques without any restrictions on passengers phones. In any indoor environment, however, the density of the Wi-Fi networks as well as their signal propagation may not be sufficient enough to cater for

### Table 8: List with currently available iBeacon products/platforms

<table>
<thead>
<tr>
<th>Vendor/Brand</th>
<th>Other Features</th>
<th>Cost/pieces</th>
<th>Battery</th>
<th>Batter y Life</th>
<th>Cloud Platform/SDK</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kontakt.io</td>
<td>Smart Beacon</td>
<td>$81.00/3 (min. order) $110.00/50</td>
<td>CR2477</td>
<td>2 years</td>
<td>Yes/Yes</td>
<td><a href="http://kontakt.io/">http://kontakt.io/</a></td>
</tr>
<tr>
<td>Cloud Beacon: WiFi for mesh management</td>
<td>$79.00/1</td>
<td>LiPo Cells</td>
<td>4 years</td>
<td>Yes/Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEACONinside</td>
<td>€479/25 €1790/100</td>
<td>2xAA</td>
<td>1 year</td>
<td>Yes/Yes</td>
<td><a href="http://shop.beaconinside.com/">http://shop.beaconinside.com/</a></td>
<td></td>
</tr>
<tr>
<td>Blue Sense Networks</td>
<td>£20.99/1-4 £13.99/1000+ CR2450</td>
<td>2 years</td>
<td>Yes/Yes</td>
<td><a href="http://bluesensenetworks.com/">http://bluesensenetworks.com/</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glimworm Beacons</td>
<td>USB power i/f</td>
<td>€99.00/4</td>
<td>CR2450</td>
<td>1 year</td>
<td>Yes/Yes</td>
<td><a href="http://glimwormbeacons.com">http://glimwormbeacons.com</a></td>
</tr>
<tr>
<td>Sensorberg</td>
<td>Out of stock currently – no details available</td>
<td></td>
<td></td>
<td>Yes/Yes</td>
<td><a href="http://www.sensorberg.com/">http://www.sensorberg.com/</a></td>
<td></td>
</tr>
<tr>
<td>Infsoft</td>
<td>No sales info – no details available</td>
<td></td>
<td></td>
<td>Yes/Yes</td>
<td><a href="http://www.infsoft.com/Products/Indoor-GPS-Hardware">http://www.infsoft.com/Products/Indoor-GPS-Hardware</a></td>
<td></td>
</tr>
<tr>
<td>Estimote</td>
<td>$99.00/3</td>
<td>3-5 years</td>
<td>Yes/Yes</td>
<td><a href="http://estimote.com/">http://estimote.com/</a></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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indoor positioning accuracy. Such a situation should be possible to be handled by the installation of additional low power Wi-Fi Beacons to provide the required coverage for the proper fingerprinting, triangulation or trilateration techniques. This kind of installation is not possible to be done by using commercial-of-the-self (COTS) Access Point equipment since it is restricted by several factors ranging from power supply issues to discreet installation and interference issues. Therefore DORA takes position regarding this aspect by designing and developing a new product (Wi-Fi Beacons) not apparently available in the market.

On the other hand, the adoption of proximity and up to a certain extend location solutions based on BLE iBeacons cannot be neglected. Therefore the development of a hybrid solution to cater for both radio signals will be pursued. Having opted for a BLE only based solution might have excluded existing user equipment without such capabilities but also it might have posed an additional power consumption demand beyond the regular power-profile of the users.

**Hardware Platform Ambition**

Having analysed COTS solutions and systems, the approach we will follow in DORA starts from a quite ambitious plan with respect to the hardware platform capabilities. This wish list presented here will be revised and probably narrowed down in the course of the design, development and integration so as to reach an optimum balance that will allow the production of added value equipment without excessive requirements with respect to materials cost, processing and power consumption.

The first key aspect that will be pursued beyond the minimum required functionality for the indoor positioning algorithms, is energy harvesting. The installation of the DORA Beacons in airports can potentially exploit the fact that these environments are both noisy and well lit. Such energy source may prove beneficial for the battery life.

Another feature that has to be considered is the use of the Beacons as a standalone platform for emergency information propagation beyond mobile phone standard data connections. Similarly, the Beacons can be used to some extend for collecting various data (temperature, noise, light, presence) acquired through sensing components forming simultaneously a sensor network that can allow for future application scenarios and usages.

In the context of positioning, two main aspects will be also evaluated. The first regards the possibility to have a self-organized grid of Beacons that can aid significantly the installation and bootstrapping of an IPS infrastructure. This can be based on measurements performed by the Beacons during their physical installation in a building. The second relates to the propagation/broadcasting of positioning data that may allow the devices to easily resolve positions without even the need for a back-end system to be always accessed.

Finally, IoT and M2M concepts will be also considered so that no limitation with respect to other potential usages is posed by the initial design.
Software Platform Concepts

Besides hardware, the software employed in the DORA solution should be able to provide positioning and navigation services seamlessly for any kind of device (typically mobile phones and tablets). Similar to existing commercial techniques and products, the DORA software platform will provide a REST API able to offer positioning and navigation information to passengers. As there is no open product to be used in indoor environments, there is a need to develop our own one within the project. Even if we utilize a commercial product, we would need to act in the internals of the navigation algorithm, as the costs from node to node within the navigation might change in airports due to queues, for example. Though currently some commercial products provide an SDK to customize particular applications, the functionality provided is somehow limited and there is no direct access to the employed algorithm. Therefore significant effort will be placed in the DORA indoor navigation software platform to provide:

- Indoor positioning considering RSSI measurements and previous location (memory-based algorithm).
- Indoor navigation, considering the maps of the different airports, the different navigation nodes and real-time information related to queue length (mean time queue time).

The software platform will be primarily based on fingerprinting techniques, commonly used in commercial products, as it is the most accurate one for indoor controlled environments, such as airports. Other techniques, such as trilateration, might be quite inaccurate as they require a really good propagation model within the indoor environment, which might be more difficult to generate than using fingerprinting.

The first step in achieving indoor positioning and navigation will be based on measurements collected with Wi-Fi beacons (fingerprinting). Later on we will include Bluetooth beacons, if available. However, we will also investigate the introduction of inertial measurements from mobile phones, in order to increase short term accuracy. Note that due to the drift one cannot rely on measurements arriving from inertial systems for a long time.

Indoor navigation requires the use of maps. There is no standard way to generate maps, set up the nodes and the costs among them. Thus the DORA software platform will have a feature to allow an easy integration from common map standards (DGN, JPG, PDF) into a geolocated map to be used by the navigation algorithm. In fact we just need to geolocate the navigation nodes, which will be part of the map.

Navigation nodes will also be categorized to customize and enhance the navigation. The software platform will support different categories for general and specific purposes. For example, nodes categorized as connectors refer to doors, stairs, lifts, etc. that connect different sites and floors. But nodes can also be categorized as POIs (Points of Interest) to offer a certain facility to users (e.g. toilets, shopping, restaurants). Thus the navigation algorithm might be able to provide not only door-to-door routes within airports, but alternative ways according the passengers requirements or wishes.
2.2.6 Airport Smartphone Applications

In this section an overview is given about the existing mobile applications of airports. Airport apps are probably the most closely existing solutions to the targeted DORA application as they partly provide information for the landside part of the trip chain, for processes inside the terminal as well as flight information. The existing airport apps and the integrated services regarding mobility information are presented and compared in the following table. Altogether 14 airport apps are compared in the table which includes the AENA mobile application for Spanish airports, the airport apps of the five most important airports in Germany and the mobile applications of eight more major European airports.

The table is split into three sections regarding mobility information: the journey to and from the airport, mobility inside the airport and flight information. The journey to and from the airport again is split into the following aspects: dynamic car routing service, dynamic public transport information, dynamic parking information, integrated booking or ticketing functions. “Dynamic” for the mentioned categories means that real-time information such as current time, delays, traffic situation, current occupancy rates of parking facilities etc. are integrated. The section “At the Airport” is divided into the categories “Indoor Location and Navigation”, “Waiting Time Detection”, “Interactive Indoor Map”, and “Luggage Belt Information”. The third section regarding flight information includes the categories “Dynamic information for Departures and Arrivals” and “Push-Notifications for Selected Flights” in case of delays or changes of gates. Of course this list of categories does not include every aspect of mobility information for a door-to-door trip, but includes some of the most-important and not yet ubiquitous functions towards an ideal mobility information system from our perspective. For each category, the first line of analysed apps is selected when this particular function is available. In case of remarkable features for any of the three superior sections, a short description of this attribute is added in a second line.
### Table 9: Overview on airport apps regarding mobility information

<table>
<thead>
<tr>
<th>Airport</th>
<th>Journey to and from the Airport</th>
<th>At the Airport</th>
<th>Flight information</th>
<th>Rating (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All AENA airports</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Booking car parking space service</td>
<td>3D maps of the passenger terminals showing all airport services.</td>
<td>Flight info: check-in desk, gate and flight status and estimated departure time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SXF/TXL</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Real-time info on public transport arrivals and departures in list format</td>
<td>Indoor location via beacon: passengers receive a push notification when they enter the terminal building with routing info or their selected flight</td>
<td>Flight info can be entered in the calendar and shared by e-mail or text message</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Static parking assistant which shows the most suitable parking facilities depending on parking duration, link to Google maps navigation</td>
<td>Indoor navigation for check-in-counters, gates, parking facilities and POIs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>DUS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Dynamic info on parking facilities</td>
<td>Static information on luggage belt number</td>
<td>Information about exit number available for selected flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Routing services for private transport (link to Google maps) and public transport (link to bahn.de)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAM</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Dynamic info of parking capacities (not working at time of testing)</td>
<td>Waiting time detection for security check (in min)</td>
<td>Detailed dynamic indoor map</td>
<td>Static information on luggage belt number</td>
<td></td>
</tr>
<tr>
<td>MUC</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>• Detailed information for returning rental cars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Parking space memorizer with integrated photo function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airport</td>
<td>Route:</td>
<td>Book Parking</td>
<td>3D Maps</td>
<td>Book Parking</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>--------------</td>
<td>---------</td>
<td>--------------</td>
</tr>
<tr>
<td>LHR</td>
<td>✔️</td>
<td>✗</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>AMS</td>
<td>✗</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>CDG</td>
<td>✗</td>
<td>✗</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>ZRH</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>ATH</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>CPH</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>BRU</td>
<td>✗</td>
<td>✔️</td>
<td></td>
<td>✗</td>
</tr>
<tr>
<td>VIE</td>
<td>✔️</td>
<td>✗</td>
<td>✔️</td>
<td>✗</td>
</tr>
</tbody>
</table>
The review of existing airport applications shows that some apps are quite advanced in providing useful mobility information, but none of the analysed apps provides a range of functions as targeted in the DORA system, especially with regard to a door-to-door-trip. The highest ratings regarding the full range of functions are achieved by the apps of Vienna, Copenhagen, London-Heathrow and Dusseldorf airports with 6 out of 10 points. Whereas most of the apps provide dynamic flight information and push-notifications, the services of landside transport and indoor mobility information are somewhat not covered. Only a few airports provide indoor navigation (Wi-Fi, Beacon Technology, QR-Code-Scan, GPS) and waiting time detection, though not in very advanced states, and dynamic routing services for car and public transport are mostly not available, especially as in-app solution. In-app ticketing functions don’t exist for public transport. Booking functions for parking spaces, on the other hand, are provided in some of the analysed apps. Some special features could be identified during this review, such as parking-space-memorizers or interactive 3D maps, that might be considered for a further elaboration of the targeted DORA app.

2.3 Conclusions of the SoA review

There are several existing mobility information services and technologies already in place in Berlin and in Palma de Mallorca. It is worth mentioning the AIRVIS system, whose aim is to secure access to the new airport BER. Thus, passengers will be provided with information relevant for the airport access in public transport stations and vehicles, on dynamic on-street information panels and via mobile services. The AIRVIS system will play a crucial role when integrating an incident management into the DORA system.

Comparing current route planners vs. DORA system, the existing routing systems partly provide a wide variety for door-to-door mobility information, but lack many functions that will be developed and integrated in the DORA project, such as terminal processes, incident management, real-time traffic information, information for parking at the terminal or user group specific information.

Various techniques are and have been used to analyse people count, queue length and waiting time. In the DORA project, a video analysis system will be integrated in the airports to measure passenger’s behaviours and to deliver to the DORA platform accurate and consistent data. The reasons to choose this technology are: easy deployment, does not require large and complex sensor deployment, moreover is not intrusive and presents limited privacy issues when doing device tracking, such as mac addresses.

There is a plethora of indoor positioning platforms that are based on Bluetooth Low Energy (BLE) hardware. In most of the cases there is need for establishing a complete infrastructure to assist user applications. Furthermore, it is not guaranteed that all the pieces of user equipment, especially older models, support BLE, while BLE based positioning requires activation of the related circuitry that may not be also part of the usage profile. Therefore, the DORA Indoor Positioning System (DIPS), aiming at being integrated in the most seamless way, will be primarily based on Wi-Fi techniques and on specifically designed equipment to provide the additional coverage wherever this is necessary for the positioning algorithms. As far as the DIPS software platform is concerned, the fact that there is not any open product to be used in indoor environments,
DORA will develop a dedicated one within the project to support different categories for general and specific purposes so that the navigation algorithm might be able to provide not only door-to-door routes within airports, but alternative ways according to the passengers requirements or wishes.

Available airport apps in the market provide comprehensive mobility information, but none of the analysed apps offers a range of functions as targeted in DORA system. Only a few airports provide indoor navigation, waiting time detection, and dynamic routing services for car and public transport. On the contrary, some special features have been identified during the review, such as parking-space-memorizers or interactive 3D maps, that might be considered for a further elaboration of the DORA app.
3 MARKET ANALYSIS OF SPECIFIC DOOR-TO-DOOR TRANSPORT INFORMATION SERVICES ADDRESSING AIR PASSENGERS

3.1 Approach and methodology

The information gathering and analysis process for the market of specific door-to-door transport information services addressing air passengers is described in this section. It will be comprised of four different approaches in order to get feedback from the targeted stakeholders in each research aspect: Desk research, In-depth interviews with market experts, User surveys and Workshops.

As mentioned in section 1.2, the outcomes of this deliverable will inspire Task 2.3-Definition of Use Cases (for different scenarios of DORA system deployment). Moreover, they will be a key input in deliverable D.2.4 Technical and legal requirements, which consists on a report on the technical and legal issues to take into account for the development and integration of the components of DORA information system. Thus, the global analysis of desk research findings, results of in-depth interviews with market experts, user surveys feedback and final conclusions of the SWOT analysis, will allow DORA partners to shape the DORA system requirements in a robust and well-structured way.

3.1.1 Desk research

It is also known as Secondary research and involves the summary, collation and/or synthesis of existing research rather than primary research, where data is collected from, for example, research subjects or experiments. The term is widely used in market research. In this context, secondary research is taken to include the re-use by a second party of any data collected by a first party or parties.

Some of the benefits of desk research methodology include:

- Secondary data is easily accessible and will save time and cost.
- It will help the researcher to understand the research problem, generate hypotheses and determine the most effective methodology and sample for future research.
- It gives a basis for evaluation and allows for comparison over time.

For DORA purposes in the market research of specific door-to-door transport information services addressing air passengers, desk research will be the selected methodology to determine the following aspects: Definition and profile of the market segments, Trends and changes lately occurred in demand, Overview and Market Evolution, Drivers and Barriers, Information and distribution channels, New roles and Business Models, Market growth rate and forecast.

A variety of secondary research sources have been used, and at the secondary research conducted by DORA, where applicable, all secondary research resources are appropriately cited within this report.
3.1.2 In-depth interviews with market experts

In order to gather valuable information on the Situation of the relevant market, Potential competitors and market share; several in-depth interviews with market experts will be conducted. The DORA Advisory Group will be represented by 10-20 influential expert members from beyond the consortium that comprise multiple types of stakeholders across the value chain (i.e: airports, airlines, passenger associations, public transport bodies, cities/regions, standard setting bodies, businesses or even academic expertise). Thus the DORA Advisory Group will be reached for the individual interviews.

This methodology allows a short data collection period (get feedback in weeks, not months), whereas the data obtained are not statistically valid and requires a skilled interviewer. All in all, for the aim of this task, in-depth interviews with market experts have been considered the best method to gather the required data.

3.1.3 User surveys

Market research surveys are the stock in trade for gathering any sort of market information. The aim is to gather information from a small sample of a market in order to be able to predict what the whole market wants. For qualitative research, the aim is not measurement but exploration. Qualitative surveys are about exploring an issue with people. Consequently sample size is less of an issue. Of more importance is to get a complete picture of how a market works. However, statistical theory assumes that a sample of 100 respondents or more provides statistically reliable results.

Therefore, user surveys will be conducted to gather information on User needs. The survey will evaluate current mobility behaviour and passenger expectations on a door-to-door journey planner with enhanced services (DORA system). An important issue will also be the general acceptance of such a system by potential customers. The user survey will be performed both as online and face-to-face surveys at the airport premises covering, at least, the pilot sites. The link to the online user surveys will be included in the DORA project webpage.

Questionnaires with closed and open questions to air passengers will be prepared for this purpose. Translations into Spanish and German will be provided in order to get valuable feedback. Target group is air passengers, but distributed into user groups and mobility profiles such as passengers with disabilities or reduced mobility, families travelling with children, elderly people, frequent and infrequent travellers. The aim of this segmentation is to get valuable feedback for task 2.2 Definition of User Groups and Mobility Profiles also included in WP2 of the DORA project. So, the users’ surveys will be also a key input for deliverable 2.2. User Groups and Mobility Profiles.

As starting point, the DORA partner FBB (Flughafen Berlin Brandenburg GmbH) provided its standard questionnaire for air passengers and suggested specific questions for DORA purposes (in German language). This standard passenger survey is being conducted regularly and interviews passengers in face-to-face interviews on basis of a structured questionnaire addressing purpose of the travel, travel conditions, airport access, social-demographic data, etc. Another project partner, TUB (Technische Universität Berlin)
translated questionnaire into English, and finally, ETRA (WP2 leader) and TUB made a review on them, adding questions that describe briefly DORA system functions and explore the potential interest of air passengers on it (see Annex B.1).

3.1.4 Workshops

An internal workshop with WP2 partners will be arranged to develop the SWOT Analysis for DORA purposes. The aim is to analyse air passenger’s needs in terms of transport information (identified in the previous tasks by means of user surveys), and the availability of solutions giving answer to these needs (identified in the previous tasks by means of in-depth interviews with market experts and desk research).

The final results of the SWOT Analysis will give a clear vision on what and how DORA system could cover current gaps on existing solutions (transport information), whilst meeting the user needs.

SWOT Analysis is a useful technique for understanding Strengths and Weaknesses of a product or service, and for identifying both the Opportunities and the Threats the product or service is facing. Originated by Albert S Humphrey in the 1960s, the tool is as useful now as it was then. The method of SWOT analysis is to take the information from an environmental analysis and separate it into internal (strengths and weaknesses) and external issues (opportunities and threats). A SWOT analysis can be carried out for a product, place, industry or person. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favourable and unfavourable to achieve that objective. Users of SWOT analysis need to ask and answer questions that generate meaningful information for each category (strengths, weaknesses, opportunities, and threats) to make the analysis useful and find their competitive advantage.

3.2 Demand analysis

3.2.1 Definition and profile of the market segments

The door to door information for air passenger is characterized for being a more complicated market. For providing an “intermodal door to door real-time travel information” service, it is required to take into account not only several transport modes, but also a growing number of new service providers, different industrial sectors and state-of-the-art technologies.

That is why for the demand study, it has been carried out a market segmentation taking into account obviously the passengers, as targeted customers for the travel information service, and also all those stakeholders in the air transport industry who are directly or will be directly involved in the travel information generation, information management, value-added-complementary information generation, and also in fostering the real-time travel information availability for new business models and service offerings.

To sum up, it has been considered for giving a global demand analysis the following stakeholders aimed at providing value-added information for passengers, improving the
traveller experience and promoting intermodality: passengers, airports, airlines, shared-used service operators and online travel agencies.

### 3.2.1.1 Passengers

The characterization of the customer segment "passengers" can be performed in response to social-economic factors, under a traditional perspective, or according to psychological-emotional factors targeting to analyse and assess both expectations and experiences of passengers.

From a **traditional point of view**, taking into account only economic factors, one can speak in general terms about two groups. Those **passengers travelling for work or those doing it for leisure**, where in the latter case, there are groups travelling on vacation or tourism, and others aiming at visiting family and friends.

According to CNMC, The Spanish National Commission of Market and Competition, in its report “Estudio aeroportuario integrado 2014” [19], the passenger classification could be carried out in two categories following what is made in the economic literature. And, as it has been described before, the groups are travellers for leisure and business travellers; and also, those who may be between such aforementioned groups travelling for visiting friends and relatives. The differentiation of traveller groups rely on several aspects. Mainly: price, connections to reach the destination airport and flexibility in arrival times.

Regarding fares, the segment for leisure passengers has a greater elasticity than the business travellers as it is reflected in the report. The leisure passengers are more sensitive to this variable, and they are willing to modify their destinations routes if there are changes on fares. These kinds of passengers are also willing to make longer commutes to reach the destination, preferring in many cases secondary airports rather than the main ones. Also, they are more flexible to timetables than business travellers who are able to pay a high amount of money for accessing a specific timetable.

The graphic below shows the growth rate of these passenger groups among five European countries at different periods of time [19].

![Figure 31: Passenger Shares by Type of Travel among Five European Countries](image)
Practically, the same classification is considered in the report published in 2007 by the entity Amadeus [20]. The publication is focused on a future vision of the main consumers in 2020 in the air transportation. While categorizes passengers, differentiating those travelling for business or for leisure reasons, the study considers highly important the retired citizens too. They represent a subset, within the group, motivated by leisure with high economic resources and with expectations in having their time for enjoying free time, improving their quality of life and for health. This is an important group, due to the aging population trend and the increase of the average age of life expectancy. On the business side, because of the current and future new work styles trends, such as teleworking, other new passenger roles appear in the business scope, those travellers who live and work in different geographical areas.

Before addressing the possibilities in passenger grouping, according to their expectations and experiences, one can point out that there are other analyses and characterizations made in the mid-way between traditional social-economic and customer satisfaction perspectives. On where, it is mainly analysed by social-demographic factors, and where variables such as sex, age, level of studies or professional category, among others, are assessed.

An example of this methodology of assessment is the study carried out by the Spanish Institute of Tourism (IET) titled “Informe Anual 2013 de Compañías Aéreas de bajo coste” [21]. The report focus lies on highlighting what are the main differences among tourists visiting Spain in aircraft through low cost companies or traditional ones. The report shows as the most major group, in both types of companies, the tourists between 25 and 44 years old. The number of passengers with high level of education is the parameter with the highest growth variation (from 68% in 2012 to 69.6% in 2013). Comparing the type of passengers travelling through those two kinds of companies, the study reflects that the level of education of passengers in traditional companies is higher than in the low-cost companies. Figures from 2013 show respectively 76.5% and 65.2%. The volume of tourists being male or female, sex variable, is another parameter with low variation. Although, it is said in the report, that the proportion of women travelling in low-cost companies is higher.

From a most innovative point of view, there are classifications according to psychological-emotional parameters or psycho-graphic studies. On where, it is scaled up from 3 or 4 traditional groups of passengers to a total of seven new profiles, as Amadeus’s report shows in “Future Travelers Tribes 2030” [22]. At the report, groups of passengers are analysed according to their expectancies when travelling, and also taking into account the passenger experiences through the different steps in a travel (from booking to destination arrival), which are considered positive or negative by each one of the groups. New profiles or categories could be:

a) Simplicity Searchers: This group values above everything else smooth, ease and transparency in their planning and holidaymaking. They are willing to outsource their decision-making process to third parties (confidence entities), to avoid having to go through extensive research process themselves. They are most willing to travel for having a breath, resting, visiting relatives or for health improvement. Crosschecking this profile with the traditional classification of passengers, this “tribu”, as it is named at the report, would join in retired people group and in passenger travelling for leisure.
b) **Cultural Purists**: This group values travelling for breaking themselves with their ordinary life-styles and for being able to engage with other cultures and different ways of living. Their enjoyment of the experience depends on the realism brands can create for customers of being a true-native. Moreover, this group is well-known for no pre-planning and for changing their bookings at last minute. Therefore, they avoid traditional research sources for planning their travels, and they prefer worth-of-mouth as an ideal source of inspiration. They will be interested in more flexible and economic tariffs. And they may prefer to fly to secondary or peripheral airports and also add to their commuter other transport modes, such as train, boat, ferry,... behaving themselves like the natives. That is why they will contract with touristic providers or travel agencies that looking for their desires. This group matches with the traditional profile of passengers travelling for business that are working and living in different regions.

c) **Social Capital Seekers**: The choices made by this group about, where and how to travel are shaped by their focus on having the maximal social reward. They use new technologies and social networks for enriching and informing about their experiences, and they also structure their plans taking into account their on-line audience or followers. Moreover, they will be characterized in a short-term future for expecting to be awarded with deals, discounts, VIP services, etc... as a return of investment for how much influence they have on social networks and on the customers. They consider also necessary to be continuously plugged to their devices and connected with the cloud (internet).

d) **Reward Hunters**: They may be the luxury passenger in the future, seeking a return on the investment they do every day in their busy style of life. Mostly, their choices target wellness, physical and mental self-improvement seeking the “must have” experience. When planning a travel, they want very little to no personal effort to be expended creating the experience, so they outsource the travel management to travel agencies or personal assistants. These passengers are those who expect to enjoy VIP services at the airport, for example, be taking directly to the aircraft without check-in, baggage drop-off or security control.

e) **Obligation Meeters**: They make their choices for travelling to meet bounded objectives. For example, business passengers are one of the main subgroups within this category. Their core needs and behaviours are mainly shaped by the need to be in a certain place in a certain time without fail. They can put restrictions in budgets or payment methods. Furthermore, they will prefer to have information for lowering their waiting times at airports. They also take into account software applications (apps), for example those which handle information related to the operation of transport modes or timetables for itinerary that allows them to make changes and bookings if connections are missed. This group will expand the characteristics of the traditional passenger profiles both for business and leisure aimed at visiting their families.

f) **Ethical Travellers**: This group allows their conscience to be their guide in their travel experience shaping their choices and behaviours. They have awareness about environmental issues, politics or about the ways their tourism spend contributes to local economies. This group values apps that show the brand’s transparency (corporate information, environmental commitments, carbon footprint, etc.) and also, they use social networks as information sources for planning their travel experiences. This profile matches with traditional passenger groups of retired people.
The following picture shows the mapping between customer profiles under both social-economic and psychological factors. Types of passenger listed inside the hexagon fit with roles under social-economic point of view. The business passengers are represented for global executives and also commuters; as it has been previously mentioned, passengers who travel for business reasons and specifying separately the subgroup of passengers who live and work in different geographical areas. With respect to travellers for leisure or holidays, the picture represents both active seniors and the passengers aimed at travelling for holidays and for visiting relatives or friends. The external six roles in the hexagon match with the new roles forecasted by the Amadeus entity in 2030 based on psychological factors.

![Figure 32: Tribus or Passenger groups](image)

Among all aforementioned classifications, it could be added another one that may be transversal for all of them. The “digital passenger”. This new category, also recognized in the “Passenger IT Survey 2015” report drafted by SITA, is related to passengers who are using smartphones continuously, and who would like to use their phones for being guided inside the airport, for payments or for storing their electronic boarding passes. As it is mentioned in the report, more or less % of the surveyed passengers recognize themselves as members of this new category.

Before concluding with the passenger overview, in lines below, it is described the travelling experience of air passengers:

- The worst valued processes are those for which passengers feel more stressed, that is to say, security control and baggage claim respectively by 36% and 31% of respondents.
- At the airport the most relaxing waiting times for respondents are those before boarding.
- Surveyed passengers associate most positive feelings at earlier phases of the travel, such as searching flights and fares or booking. For example, the booking experience is valued as positive by 81% of respondents, check-in process is considered positive too by 81% of respondents, and for those passengers who did it through web by 97% and instead for those who did it via the airport desk by 83%.
• There are still services on what human treatment is preferred. For example, the bag-drop self-service it is considered positive by 53% of respondents, far below the percentage of respondents that prefer the traditional service.

• Passengers prefer to use their own devices instead of the ones offered by the airlines. And the mobile phone is the most used among all. Passengers also prefer to stay connected with the ground during the flight, so they want to send and receive emails by 60% and being in social networks by 56%.

• The services, on what passengers are interested in accessing via mobile at airports, are: flight information updates by 72% of respondents. About 63% of surveyed passengers would like also to have more information about wait time for bag collection. 60% of respondents are willing to use mobile phones for boarding or enter to lounges. And, using the mobile phone as personal identification media would be considered positive by 59% of respondents.

3.2.1.2 Airports

Airports are multi-product companies offering a variety of services, such as provision of infrastructure for take-off and landing of aircraft carrying cargo and passengers, ground-handling services, central infrastructure, rental space, parking and shopping facilities for end-customers at the airport. The degree of competition for these types of services varies. In many cases the airport is likely to be the only provider of take-off and landing services in a certain area, but may face competition with respect to other services. For instance, as far as the provision of parking facilities is concerned, an airport is likely to compete with more distant areas or alternative modes of transportation (i.e. public transportation).

Current economy dynamic in airport sector is defined as a two-way market, that are equally influential revenues of airlines and passengers (through revenues from non-aeronautical services). Competition between airports in terms of passenger service is one of the issues of greatest development in recent years, especially in the case of airports with a large number of connecting flights and smoother passenger services delivery such as: shorter transfers and connections, lower queues at security controls and luggage drop-off.

The definition of Airport categories according to “Federal aviation Administration” (USA) are as follows:

**Commercial Service Airports**: are publicly owned airports that have at least 2,500 passenger boardings each calendar year and receive scheduled passenger service. Passenger boardings refer to revenue passenger boardings on an aircraft in service in air commerce whether or not in scheduled service. The definition also includes passengers who continue on an aircraft in international flight that stops at an airport in any of the 50 States for a non-traffic purpose, such as refuelling or aircraft maintenance rather than passenger activity. Passenger boardings at airports that receive scheduled passenger service are also referred to as Enplanements.

**Non primary Commercial Service Airports** are Commercial Service Airports that have at least 2,500 and no more than 10,000 passenger boardings each year.

**Primary Airports** are Commercial Service Airports that have more than 10,000 passenger boardings each year.
**Cargo Service Airports** are airports that, in addition to any other air transportation services that may be available, are served by aircrafts providing air transportation of only cargo with a total annual landing weight of more than 100 million pounds. An airport may be both a commercial service and a cargo service airport.

**Reliever Airports** are airports designated by the FAA to relieve congestion at Commercial Service Airports and to provide improved general aviation access to the overall community. These may be publicly or privately-owned.

The remaining airports, are commonly described as **General Aviation Airports**. The category also includes privately owned, public use airports that enplane 2500 or more passengers annually and receive scheduled airline service.

### 3.2.1.3 Airlines

Very concisely, an airline is defined as an air transportation system including its equipment, routes, operating personnel, and management.

The basic market categories of airlines according to IATA are:

- **Scheduled (fixed times and routes) and Non-scheduled**
- **Passenger, Cargo or Passenger-Cargo**
- **Intercontinental, International, Domestic**

According to the business models that airline companies may utilize, the airlines’ segmentation may be [24]:

![Figure 33: Airline Business Design Segmentation](image_url)
3.2.1.4 Shared-use mobility service operators

Shared-use mobility comprises transportation services that are shared among users, include traditional public transit; taxis and limos; bike sharing; car sharing (round-trip, one-way, and personal vehicle sharing); ridesharing (car-pooling, van-pooling); ridesourcing; scooter sharing; shuttle services; neighbourhood jitneys; and commercial delivery vehicles providing flexible goods movement.

New services represent innovative responses to the demand for new options, and offer an opportunity to:

- Provide more mobility choices
- Address last mile and first mile solutions
- Reduce traffic congestion
- Mitigate various forms of pollution
- Reduce transportation costs
- Reduce fossil fuel consumption
- Reduce pressures on parking spaces
- Improve efficiency
- Identify choices for those who cannot afford to buy and maintain a vehicle

These new services that complement the classic fixed line- and timetable-bound public transport services and, together with walking, they form a complete and coherent mobility solution, a “combined mobility solution”. That means, combined mobility is the result of public transport in synergy with shared mobility modes. Combined Mobility can compete with the privately owned car in terms of convenience and cost-structure and thus can help improve the quality of life in cities. Moreover, public transport should no longer consider these forms of shared mobility services as competitive, but rather as services that can be mutually beneficial.

This illustration shows the different transport modes and mobility services classified by collective or individual use, and public or private access [25]. Orange: Mobility services that are clearly within the scope of the Combined Mobility. Blue: Mobility services that are closer to public transport but could contribute to a Combined Mobility offer.
At the core of combined mobility is coordination among transit agencies and providers of other modes. The degree of integration varies: it may be primarily information-sharing about timetables and the availability of other modes, such as bicycles and cars, or it can extend to actual shared control or public ownership of the alternative mode.

Some examples of market deployments publicly initiated are:

**Table 10: Market deployments publicly initiated**

<table>
<thead>
<tr>
<th>Entity</th>
<th>Mobility Service Program</th>
<th>Deployments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Provider</td>
<td>Car sharing</td>
<td>Bologna, Munich, Wuppertal, Dresden (German rail has launched its own program “DBC car sharing”)</td>
</tr>
<tr>
<td>Transit Agencies</td>
<td>Bike Sharing</td>
<td>Deutsche Bahn “call a bike”, Transport for London “Barclays Cycle Hire”</td>
</tr>
</tbody>
</table>

This is a general overview of main features of transport authorities around the world analysing market competition and their competences [26]:

**Figure 35: Transport Authorities Compared (2014)**

But nevertheless, other programs are privately initiated and operated, for example, New York City’s Citibike.
While service integration can take many forms, there are several strategies that most programs share:

- **Media and information sharing**
- Unified payments systems
- Institutional integration

Focusing on Media and information sharing, because of it is the topic targeted on this market research, nowadays the market solutions are characterized by combining mobility initiatives that rely on the near-ubiquitous access to cell phones, the internet and forms of social media. These initiatives include everything from using a computer, cell phone or other mobile device to get real-time information about schedules, service and bike share/car share availability; to making reservations for rentals, taxis and transit; to arranging in real-time passenger rides with drivers in exchange for payment, using apps like Lyft, Uber and Sidecar.

Some examples of market initiatives are:

The Deutsche Bahn Call A Bike system uses electronic locks controlled by embedded microcontrollers activated from one’s cell phone. In Zurich, the “urban mobility information system” Mobil includes a map at all transit stops that has status information, not only about all of the transit lines, but about pedestrian areas, bicycle paths and car parks. In Vienna, the Wiener Modellregion’s “e-mobility on demand” research project aims to integrate various e-mobility options – electric vehicles, the charging infrastructure, the optimal combination of types of transport and access to them by means of a multimodal mobility ticket for users – into a new paradigm of intermodal urban mobility.

In May 2009 the City of Vienna launched its Intelligent Transport System with the goals of improving traffic management and providing regional travellers an accessible trip- or route planning tool. More recently, as a next generation effort for ITS, the City of Vienna, with funding from the Climate and Energy Fund, released its project SMILE (Smart Mobility Information and ticketing system Leading the way for Effective e-mobility services). This personal mobility assistance app represents a prototype of a comprehensive multimodal mobility platform for all of Austria. Through the SMILE app on their smartphone, travellers will be able to view real-time travel alternatives for getting to their destinations, and can reserve and pay for their trips as well. SMILE was working with 20 vendors and providers, during test phase, ranging from local and long distance train operators to car sharing and taxi companies.

### 3.2.1.5 Online travel agencies

Travel agents offer a variety of services; the most important one is allowing the traveller or the travel buyer to compare offers from different transport operators, and issue tickets. Increasingly, and in particular in the Business to Client space, travellers search for information via an online travel agency (OTA) or a meta-search engine. OTAs act like traditional travel agencies that predominantly use GDS\(^3\)s to offer the best possible journey proposition to their clients, but sometimes also “web scrape” transport operators’

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\(^3\) GDS is a network operated by a company that enables automated transactions between third parties and booking agents in order to provide travel-related services to the end consumers.
websites to acquire content. Meta-searches, unlike travel agencies, do not provide payment or ticketing, but refer the traveller to a provider’s website for completing a transaction. Unlike other search engines, OTAs do not primarily rely on advertisements to monetize their service. Instead, they add service fees to the client, and in some cases, particularly for hotel bookings, receive commission for products sold. Fares offered via travel agencies may differ from transport operators’ direct offers. Online travel agencies may also sell the allotments of seats and tickets on their own behalf, booked in advance with transport operators.

3.2.2 Trends and changes lately occurred in demand

3.2.2.1 Passengers

Changes on the needs and demands of the passengers, and also in their interests and behaviours directly influence the industry, when the companies develop their services to increase its business volume and at the same time are willing to improve the passenger experience.

Nowadays, the main challenges to be tackled by the industry related to air transport, with regard to the needs and demands of passengers are:

- Making easier, smoother and faster the search of travel options, the booking or the payment process through customer-oriented services and options.
- Providing real-time information to the passengers that not only is focused on flight operation. Improve the communication with the passengers.
- Improving the passenger experience in transit at the airport and also during the flight.
- Offering solutions to manage both changes and unforeseen incidents.

Surveys carried out by stakeholders of the air transport sector, for example the ones conducted by IBM as it is indicated in the report “A Road Map Document to prepare for tomorrow’s passenger- Simplifying the Business Program” drafted by IATA [27], point out that none of the respondents were able to complete their travel booking needs in one website visit. Moreover, they require shorter time for searches, analysis and booking. Some data from the study reveals that 25% of leisure passengers spent more than 4 hours shopping or booking. Business passengers are the most efficient ones, but nevertheless more or less the 40% of the surveyed passengers spent more than 2 hours in booking tasks.

For filling the gap existing in the lack of communication with the passengers, respondents desire not only having real-time information, but also being able to access the information from any device when needed. As it is mentioned in the report “Passenger IT survey 2015” [23] , fill the gap will allow passengers enjoying a travel experience lowering their stress; that is why stakeholders, such as airports, are increasingly investing in IT technologies in solutions and systems based on Wi-Fi, NFC, Beacons or Bluetooth technologies among others. Today’s background is that passengers suffer from uncertainty and stress associated with flight delays, cancellations and bag mishandling. And also today, the lack of information creates frustration not only for consumers but also for airlines and airport staff. Among the most popular solutions for respondents are:
delivering messages to customers and accessing meaningful information through kiosks at the airport.

Related to incidents, there is today none interaction between booking tools or applications used for planning a travel when making changes or cancellations. That is, in case of an unforeseen situation there isn't any interoperability and it is necessary to go into each one of the different tools. For a door-to-door travel without problems, it is needed an exchange of information and, therefore an investment on the development of standard protocols for data exchange.

**Trends related to today's passengers** are:

One of the most globally adopted trends by the different groups of passengers is **the use of web applications and services based on Cloud**. And the most famous one is the on-line booking service, either through third parties or self-service. The figure below shows the evolution of direct sales via internet for the European market from 2006 to 2011 [19], indicating that the volume of sales in the market segment of leisure passengers (black line) is higher, whereas direct sales via internet of business passengers (blue line) remain far below it.

![Figure 36: Booking on-line by travel purpose](image)

Another trend is the **use of technology**, as it is mentioned in the “Passenger IT trends survey 2015” by SITA [23]. Passengers proactively involved in the use of new technologies prefer to use their own electronic devices than the ones provided by the airlines. And across the whole diversity of devices, **the mobile is already positioned as the most used one**.

In more detail, it is significant:

- **Mobile Apps and Web browsers:** The use of mobile apps is most preferred for check-in by 8% of the passengers. And it is expected to have a growth rate of 90% in coming years. On the other side, the use of web browsers is growing more slowly currently being used by 3% of surveyed passengers.
- **Mobile devices:** Today the use of smart phones by passengers is widespread; reaching a rate of 83% compared with 81% at the previous year, and more or less,
the 13% of travellers use or carry with them more than three mobile devices (tablet, phone, laptop). For example, 26% of passengers have booked their last flight through a mobile device, rate that could grow to the 36% for the next year. Interestingly, bookings made through tablets are growing faster than through smart phones. When passengers use tablets, they prefer booking via web browser but when they use smart phones, most of them prefer doing so via apps.

The worst travel experiences valued by travellers are: baggage claim, transfer, queues at check-in counters, at security control and also at boarding (Source: “Happy passengers. Successful airports. Positioning paper” by SITA [28]). That is why trends for those processes are characterized by:

- Check-in: around 57% of surveyed passengers use one of these options for online check-in; web browser, kiosk or mobile app. Instead of directly use the check-in airport counter. Online check-in via mobile phone is forecasted to be used by 26% of passengers by 2016. This device is considered the fastest one, and it is more common to use mobile Apps than web browsers. When a laptop is used for booking, the rate is around 32% at the same period.
- Boarding pass via mobile phone: it is still widespread, that travellers get their boarding passes at airport counters. But today, the number of people using new technologies for getting it, is increasing. It is forecasted to grow from 20% to 26% for in-house printing of boarding passes, and also to reach 18% in the use of mobile boarding passes (QR codes, ...) in a year.

3.2.2.2 Airports

Airports nowadays are dealing with three main challenges: improving the passenger experience, optimizing their operational processes and increasing their financial performance. To this end, trends are aimed at the use of innovative technologies to achieve these goals.

Delivering a smooth, rapid and stress-free travel through the airport to a growing number of increasingly demanding passengers remains an important challenge for airports. The use of new technologies is the measure adopted by the majority in response to this need for achieving the challenges. It is significant, according to “Happy passengers. Successful airports. Positioning paper” [28], 59% of airport respondents have a priority to improve the passenger experience through IT investments they make.

On the business side, market competition over passenger services is one of the airports' issues with greatest development in recent years, especially in the case of airports with a large number of connecting flights. Providing ways to passengers for shorter transfers, for lowering the time for connecting flights or security control processes and for delivering secure and ease luggage handling are differentiation policies between competitors airports. Airports also should prepare for the intermodal transport competitors due to their better geographical location and their most accurate services delivering, less delays, shorter waiting times and most centric location.

These challenges shape the trends in airports through the use of new technologies and airport IT spending focusing on both improving passenger experience and optimizing airport’s infrastructure and processes.
The majority of airports are putting passengers first by prioritizing IT&T (IT & Telecommunications) investment that can improve their time at the airport. Passenger processing projects remain the main focus of IT&T investment with 59% of airports rating it a high priority. Another passenger-related activity, security, also figures high on the IT&T agenda. While just outside the top three priorities, baggage management is also closely connected to the passenger experience.

**Airports are aiming to provide infrastructure and services that can deliver more convenience, control and a connected experience for passengers.** Over the next three years, it is forecasted that more than 80% of airports plan a major investment or an evaluation project in either the self-service and/or mobile areas. Business intelligence initiatives, which will open the way for airports to provide contextual, real-time information and services to passengers and staff, are also a serious investment area with 41% of airports planning major projects.

Many airports are evaluating the business case for new technologies with trials and projects. Cloud services get the most attention with 71% of airports planning either a major program or running a pilot project over the next three years. Geo-location technologies, such as Bluetooth and Wi-Fi, which can be used to improve passenger flows and provide location-based services are also high on the agenda. By 2017, 60% of airports plan to invest in a major or pilot Bluetooth program and 52% in Wi-Fi.

New technologies that have yet to get much widespread uptake include Near Field Communications (NFC) and digital tags for asset and baggage tracking. Both remain largely at the evaluation stage with few major projects being initiated. While it is still in an early stage, two technologies predicted to make an impact within the airport environment are iBeacons and wearable technologies, such as smartwatches and Google Glass. Among the top 50 airports with the highest passenger numbers, the majority plan to run projects with iBeacons over the next three years, while 19% plan to look at wearable technologies.

Airports also continue to invest heavily in providing self-service options to passengers and trying to connect those options together into a seamless journey from home to aircraft. Nearly two in five airports (37%) plan to increase the number of check-in kiosks, while 23% of airports are planning to increase the availability of kiosks for other uses. With check-in
largely taken care of the self-service focus for airports has shifted to making baggage processing easier for passengers.

With regard to new services for connected travellers, mobile investment continues to be a major airport IT strategy and a prime means to develop a closer relationship with airport users. By far the most common mobile service available is flight status notifications, with 50% of airports offering the service and this will become industry wide by 2017 with a further 40% of airports planning to provide it by then. The availability of other services through mobile apps is relatively low in comparison, but over the next three years more than half of all airports are planning to introduce airport-focused notifications, including queue times, more personalized information, such as opt-in services and customer service initiatives, as well as retail services.

One area where mobile technology can make a huge difference is in managing disruption, or irregular operations, as it is known in the industry. Today, just over 30% of airports surveyed are able to provide real-time information to passengers via mobile should a disruption happens, with a further 35% planning to do so over the next three years. Among the fifty largest airports, where disruption can have greater consequences, the trend is stronger with the majority (52%) already able to provide real-time information to passengers via mobile. By 2017, this will have increased to 82% of airports. There is also a strong regional dimension, with Europe and Asia-Pacific leading investment in this area with 7 out of 10 airports planning to provide real-time information by 2017 [29].

![Figure 38: Deployment of disruption management solutions in airports](image)

### 3.2.2.3 Airlines

This chapter focuses on emerging trends and technologies that are set to transform the airline industry in the years to come. Business intelligence, mobile travel and passenger management are at the forefront of this change. But many other emerging and established trends should be tracked such as industry IT spending.

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4 An opt-in policy requires a potential customer to self-select the services they wish to subscribe to, and how any information they provide may be used. The benefit of this approach is that a user who has actively considered the offering before signing-up, is a more qualified potential customer.
The following described insights are based on the “Airline IT survey 2015” carried out by SITA company [30]. The survey represents the views and insights of over half of the top 100 carriers, providing a clear insight into IT strategic thinking and developments for the industry. The respondents are passenger airlines including low cost operators, together with carriers representing important players in the regional and leisure sector. The survey is truly a global one and has received a significant response from major carriers in every geographical region. The figures below show the split of respondents:

![Figure 39: Airline IT survey distribution of respondents (2015)](image)

Technology investments by airlines have made a big difference to the travel experience, but up to now much of that has been based on a one-size-fits-all approach. Personalization opportunities for passengers are still fairly limited, offered by less than 20% of airlines, according to the report. However, there are indications that many airlines are starting to address personalization by offering passengers a growing list of technology-based options to tailor their travel both at the airport and during the flight. In fact, **82% of airlines will be investing some resources to improve personalization over the next three years**.

In particular, personalization of the journey has been given a kick start by the strong adoption of smartphones, which allows anytime, anywhere interaction with passengers. **Over 75% of airlines plan major programs to deliver passenger services through smartphones in the next three years**. Such is the focus on mobile solutions that 67% of airlines will offer a highly personalized smartphone booking experience compared to today.
Figure 40: Technology investments by airlines

Smartphone apps will offer personalized options before and during the travel. Flight discovery is already a well-established mobile-based service, but information updates relating to baggage and customer service apps that can resolve travel issues will also become more common with 64% of airlines expecting to offer the service by 2018.

Kiosks and beacons will also play a part in delivering a personalized journey within the airport. Passengers, for instance, will be able to download content for the flight, including books and films, from media kiosks to their tablets or smartphones. More than one fifth (22%) of airlines are expecting to offer this service by 2018. Also in its infancy is a ‘virtual concierge’ for passengers delivering airport shopping to gates and lounges. Around one of five airlines plans to introduce such a service over the next three years.

As it has previously been shown, passengers typically want a stress-free trip and airlines are deploying more technology-based services to meet that demand. In particular, passengers are switching to mobile apps and the web, which give them less stress and more convenience. According to the worst and most stressed experiences for passengers such as check-in or baggage drop-off, low cost carriers (LCC) are driving the change in behaviour. Today the proportion of LCC passengers using mobile check-in (23%) is already close to the predicted global average for all airlines in 2018. Also, today 22% of airlines have deployed the automatic check-in system being used by around 4% of passengers. By 2018, 68% of carriers will have automatic check-in on some routes with 10% of passengers expected to use it. Airlines are addressing the frustration by upping bag-drop implementations too. Forecasting shows that the number of carriers offering bag drop is expected to rise to 74% of airlines by 2018.

About services on-board, by the end of 2018, the majority of airlines (66%) will offer wireless internet and multi-media services on passenger devices, giving passengers greater ability to choose their own in-flight relaxation and entertainment. Mobile apps giving passengers the opportunity to book destination services, such as onward travel from the airport, are also set to increase rapidly from 6% currently to 44% in 2018, while in-flight duty free shopping apps will also increase sharply from 11% to 47%.
Flight status notifications are already well established and will be offered by almost all airlines by 2018. The next wave of information services will evolve rapidly towards a much more interactive approach for the majority of airlines. The focus of these new services over the next three years will be to use location-based information to solve baggage issues. By 2018, 70% of airlines plan to keep passengers up to date with the location of their baggage, up from just 10% today. Airlines will also develop information services by using passenger location to ensure on-time boarding with notifications based on their location. One-tenth of airlines provide these notifications today, rising to 65% over the next three years. Kiosks are also developing from their traditional check-in role to offer a growing range of information and reporting services to assist passengers, in areas such as lost baggage, transfer and in times of disruption.

While newer technology trends, such as cloud computing, have already moved center stage within industry, Internet of Things, wearables and beacon technology are going to shape the air travel of the future. Beacons, which use Bluetooth as the underlying technology, are a recent addition to a list of proximity sensing solutions, including cellular, Wi-Fi, and NFC, which are being used within the airport to provide a connection to passenger’s mobile devices. Currently, around 9% of airports have experimented with beacons, mostly in the check-in area, but also at places in the airport where passengers dwell and transfer between flights. The most common service provided by airlines is the delivery of flight and gate information. Such is the potential of beacons, the number of
 airlines starting beacon projects is expected to soar nearly five-fold to 44% over the next three years, with wayfinding from check-in to gate as the most common service planned.

![Figure 42: Airlines’ beacons plan](image)

The Internet of Things (IoT) is still in its infancy within air travel, but is expected to mature fast over the coming years. Today, 86% of airlines expect the IoT to provide clear benefits over the next three years, while only 9% strongly agree that the IoT presents clear benefits today. Consequently, airlines are taking a careful approach to investments in this area with only 16% planning a major project, while 41% will make some R&D investment. Check-in is predicted to be the early beneficiary of the IoT with 42% of airlines rating this as their top priority and 56% would put it in their top three areas to benefit. Two out of five airlines also put bag-drop within their top three areas of the customer journey that will benefit from IoT technology. Another technology new to the industry is wearables, which a number of airlines are starting to trial. In fact today only 7% of airlines have so far looked at their potential to date and this cautious approach will continue over the next three years. Uncertainty over the market and products makes it difficult for airlines to plan and so it is no surprise that the vast majority of airlines are taking a wait and see approach to this technology. Those that do have plans are mostly only going to evaluate wearables as an R&D project.

### 3.2.2.4 Shared-use mobility service operators

Changing technology and changing attitudes are enabling an expanded range of transport modes for cities when they consider combined mobility. The still evolving list already includes taxis, car sharing providers, short-term car rental, bicycles, bicycle sharing, bicycles on transit and shuttle buses. Trends are focused on:

**Car**

Park-and-ride facilities have always played a role in bringing riders to the public transport system, but the design and integration of these facilities are getting increased attention.
In recent years, car sharing has also expanded hugely, with operations in 27 countries across five continents, counting almost 1.8 million members and more than 43,550 vehicles, with near term expansion into seven additional countries around the world. This expansion is due to a softening in the demand for car ownership among affluent urban professionals who are increasingly cost- and environment-conscious. It is also spurred by the technological innovations that make transactions fast and easy. **Car sharing recently has begun to integrate with public transit offerings to provide travellers a seamless door-to-door trip.** The heightened accessibility and popularization of car sharing also has led to the **development of alternative formats, most notably in personal vehicle sharing (also referred to as peer-to-peer car sharing),** as well as station car programs—in which dedicated vehicles stand at transit stations for the express purpose of last mile mobility to riders’ final destinations—and vehicle and corporate innovations, for example branding cars with third-party advertising. Similarly, car sharing fleets are an ideal platform for experimentation with specialized technologies such as electric-powered and autonomous self-driving cars. **Car sharing organizations may be private, for-profit companies or they may be organized as a non-profit organization, a member-owned cooperative, a subsidiary of a transit agency, or an experimental or research based effort.**

Some examples of next-generation car sharing formats would be the autonomous vehicles e.g. BMW’s DriveNow electric vehicles, Test program in Australia between the University of New Wales and car sharing company GoGet or the e-mobility project Wiener Modellregion.

**Main trend of the successful car sharing arrangements rely on information technology to facilitate transactions.**

But, for taking mobility integration even a step further, it is needed to highlight the company Mobility Mixx, because the company expanded from a car sharing provider to a full-range mobility service provider, including rental cars, public transport reservations, park and ride, trip scheduling and payment. In addition, Mobility Mixx incorporated a package of business travel options; besides the car pool and train at the location, it offers access to Mobility Mixx OV-bicycle taxi, P+R parking, rental cars, the electronic processing of mileage claims and the management of personal mobility budgets. Travel advice from door to door - via Internet and call center - allows employees to choose and combine.

**Bike and Ride**

The bicycle is increasingly seen as mode of choice for first-mile/last mile connections. There has been a huge proliferation of bicycle sharing programs across the globe. In May 2011 there were around 375 schemes comprising 236,000 bicycles. As of April 2013 there were around 535 bike sharing programs around the world, made of an estimated fleet of 517,000 bicycles, a doubling of bicycle sharing programs in two years.

As with the car sharing programs described above, **bike sharing increasingly is seen as an essential aspect of combined mobility and transit providers are creating the same kinds of cooperative arrangements as they have with car sharing initiatives.** One of the pioneers was the Velib bike sharing solution in Paris.

**Combined Mobility can be accomplished also by linking bicycles and cars.** If downtowns are configured effectively for cycling and a city can offer strategically-located parking with a calculated fee structure, then it might have a formula for reducing downtown car traffic.
The city of Calgary used exactly this approach, providing free parking about five miles from downtown along a bicycle trail leading into the downtown.

**Taxi**

Taxis may be considered a form of transportation, but traditionally, they have not been considered a mode of transit. The utility of on-demand service is outweighed by higher cost and the uncertainty of availability in more sparsely populated places. Combined mobility, however, makes taxi services more affordable for the user by promoting shared taxis, and makes taxi services more efficient for the provider by using information technology to rationalize trip requests. This rationalization may start out informally and then, by degrees, become more of a standardized approach. For example, in Santiago de Chile, shared taxis contribute to mobility by working certain routes at certain frequencies in a framework regulated by the city. The vehicles have distinctive signage and travel between set destinations. Along the way, passengers may board or disembark at will. The transit authority coordinates with the taxi agency, and the pick-up and drop-off locations are often at metro stops or bus stops. At present, direct integration in terms of schedules, payment or information sharing does not exist, but this is easy to envision as a next step.

One of the best examples of **taxi-as-transit** comes from the Brussels region. The public transport operator, STIB, collaborated with a private taxi company, Taxis Verts, to create Collecto, a demand-responsive transport service offered at an affordable flat rate. Users request taxi service by phone from among 210 office pick-up points to any destination in Brussels. Collecto departure points usually correspond with the STIB stops. The STIB - Taxi Verts public-private collaboration also worked to redesign the Brussels night bus service through optimizing schedules and enhancing cost efficiency of existing night bus lines.

### 3.2.2.5 Online travel agencies

Better mechanisms for tracking trends and competitive positioning (tracking perception of travellers of deals available and own positioning), is something that OTAs need to be always aware of as it is constantly changing in such a dynamic and fast changing environment. **OTAs need to devise measures to stay ahead in terms of being a first mover with the best offer, for the trendiest destination, which will also help in terms of brand awareness.**

Some changes are required to OTAs for matching customer needs, increasing turnover and adapting themselves to air market trends. For example, the study published by Hermes in 2010 which analyses ways to optimise the OTAs’ Business in Europe highlights the following main challenges:

- **Customer experience enhancement**: While travellers are literally ‘spoilt for choice’, OTAs need to stand out in terms of offering savvy travellers an experience that will make them want to book and come back. Overall mid-sized OTAs should make sure their technology can respond quickly to trends, such as travellers seeking inspiration when searching for holidays rather than booking with a pre-defined trip in mind. OTAs should also remember the importance that travellers attach on the ease of use of a website. The figure below highlights the reasons
why a consumer will book online or decide to go offline if wishes aren’t fulfilled [31].

![Figure 43: Reasons to book online](image)

- OTAs should be also prepared for **the growth of the mobile phone use and for last-minute booking**: Specific mobile trends can’t be ignored as mobile bookings are growing and by 2015, a fifth of all online travel bookings are expected to take place via smartphone or tablet. For example, booking.com generated more than $8 billion in mobile bookings in 2013, up from $3 billion in 2012 and $1 billion in 2011 - and it has invested heavily in making the user experience a seamless one. Around a quarter of all hotel bookings are now made on the same day and 60-80% of those same day bookings are made on a mobile device.

Key trends shaping the current – and ever-changing – online travel agency environment, and how European OTAs are navigating them are:

**Google-ITA**

OTAs are taking a “wait and see” attitude toward the Google-ITA merger, but remain on alert. Search, more than social media, is driving traffic and conversions for OTAs now – so much so that OTAs are concerned they are getting too dependent on an ever more powerful Google. While the merger with ITA is not seen as a direct threat to OTAs, it is expected to impact metasearch sites more fundamentally. This concerns those OTAs that view themselves as shopping engines as well as booking engines. They see the potential for Google-ITA to divert traffic away from their sites, and are keeping a watchful eye on the situation.

While there is certainly room to improve travel search, it remains to be seen how broadly Google’s travel offering impacts traveller behaviour. An open-ended, text-based approach, while innovative, may not add value in all instances, particularly among travellers who already know where they want to go. After all, less than 50% of trips taken by French, German and U.K. travellers are to an independently selected destination. With Google’s reach and record of innovation, however, OTAs must pay close attention as these two search powerhouses combine forces.
Metasearch engines

Metasearch continues to bring mixed results for OTAs. Sites such as Skyscanner and Travelsupermarket have been successful driving traffic to air products, but are much less effective for hotels and packages, which make up a growing part of their business. Performance also varies tremendously between markets across Europe. Metasearch engines can be a substantial source of traffic in some places. But even in markets where they carry hefty weight, there is no comparison to general search and in particular, Google. As a result, the general consensus is where and when metasearch works, OTAs will utilize it.

Social Media

For the most part, OTAs take social media very seriously, but admit they have not fully exploited its potential. Most are in the “test and learn” mode, using social media primarily for customer engagement (e.g., Facebook Fan pages, Twitter, blogs, live chat, photo sharing, etc.). Though the power of social media is evident, it is not yet driving significant traffic or conversion – at least not in any measurable way. Few have dedicated staff.

Some consider leveraging Facebook Connect, integrating social media into search results, or adding booking engines to their Facebook page to drive transactions. OTAs are at the very least committed to keeping the social media communication points open, and most will continue to experiment to find new ways to engage consumers and (eventually) impact bookings. Because social media empowers consumers to communicate about their travel experiences in a highly visible way, it can play a significant role in building customer loyalty. OTAs have an unprecedented opportunity to interact with their customers, but the traditional drivers of loyalty – superior value and customer service – still reign supreme. OTAs should view social networks as a powerful tool, but like any tool, not an end in itself. The secret sauce resides in how social networks are used to engage customers and demonstrate differentiation – games, deals and contests (often available through a mobile platform) are just some of the vehicles best-in-class companies use.

Mobiles

Yet all OTAs see the importance mobile will have in their strategies going forward and the need to step up their offerings to stay competitive. By enabling OTAs to engage consumers throughout the trip process (including on-route and post-trip) via last minute offers and location-based services, mobile offerings are enhancing the traveller experience. Already, OTAs offering mobile transactions are seeing a significant uptick in same-day bookings. All see the need to eventually leverage more sophisticated capabilities that the mobile platform unlocks, such as time- and location sensitive services. Significant opportunities exist for OTAs to exploit social media, location, and itinerary and context-awareness to provide travellers with a seamless mobile experience spanning all stages of the travel process. But these opportunities are based on a core set of functionality that needs to be built out, and this core is where most OTAs are investing right now. The web versus app debate is alive and well, as some take sides and others do both.
Direct distribution channel

While OTAs are well aware of airlines’ direct connect strategies, they express confidence that their GDS partners will solve the technical challenges required to aggregate and distribute air content. While many remain open-minded about the possibilities, they are not convinced of the value of wide-scale direct connect airline initiatives.

Personalization

Most OTAs have search algorithms based on a variety of criteria, including popularity, margin, promotions/exclusive deals, and conversion. Ultimately, however, price is the critical factor determining what sells. Perhaps that is why few OTAs have implemented loyalty programs or sophisticated customer relationship management (CRM) tools into their algorithms. Of course, no one claims that results cannot be enhanced or made more relevant by incorporating historical behaviour.

3.2.3 User needs

The main aim of this task is to identify air passenger’s needs in terms of transport information. It will lead to obtain a picture of the development of user needs by means of air passenger surveys. Some aspects will be gathered with passengers such as fulfilled or unfulfilled needs, set of values, motivation, selection/decision criteria, etc.

As mentioned in section 3.1.3 of this deliverable, user surveys will be performed both as online and face-to-face surveys at the airport premises covering the DORA pilot sites.

However, due to time constraints at the beginning of DORA project and summer vacation period, the implementation of user surveys with air passengers will be delayed until September 2015.

User surveys results will be further analysed and discussed within the consortium in order to provide insights on air passenger’s needs about transport information, whilst being a required input for the forthcoming SWOT analysis on the DORA system.

3.3 Supply analysis

As explained in section 3.1.2 of this deliverable, in-depth interviews methodology will be the approach to develop the supply analysis for the market of specific door-to-door transport information services addressing air passengers.

Due to time constraints at the beginning of DORA project and summer vacation period, the DORA Advisory Group has not yet been established (although contacts with potential candidates have been initiated), therefore the implementation of in-depth interviews with market experts will be delayed until October 2015. Afterwards, the feedback of implemented interviews will be further analysed and discussed within the consortium. The aim is to provide valuable insights on the current status of market supply (see following sub-sections for more detail), whilst being a key input for the subsequent SWOT analysis on the DORA system.
3.3.1 Situation of the relevant market

In this section some aspects related to supply such as market size, producers, types of services, brand names, prices, etc..., will be gathered by means of in-depth interviews with the DORA Advisory Group members.

3.3.2 Potential competitors and market share

An overview of potential competitors and market share will be gathered by means of in-depth interviews with the DORA Advisory Group members.

3.4 Market Analysis

3.4.1 Overview

Multimodal travel information and planning services provide better quality solutions to address travellers’ mobility needs. With the internet and smartphones leading to growth in highly personalized information and transportation services, information that spans different forms of transport — multimodal information — is an important factor for smart and seamless door-to-door mobility.

The potential societal, environmental and economic benefits of multimodal travel information and planning services are huge:

- Allowing travellers to make better informed choices by making them aware of all possible travel options, and helping them to complete their journey successfully by providing reliable information before and during the trip.
- Promote more inclusive mobility by making information easily available, tailored to the needs of special traveller groups, such as people with disabilities and passengers with reduced mobility.
- Better modal integration and more sustainability by enabling travellers to select the most suitable combination of modes of transport for the journey.
- More flexibility in the event of congestion: travellers can be given information on options for different routes, allowing for better use of existing transport infrastructure and more resilience in the event of major disruptions.

Nowadays, more than 100 multimodal journey planners already exist in Europe and yet information provided to travellers is incomplete (due, for example, to the fragmentation of existing information supply geographically and in terms of the modes of transport covered, or the lack of real-time information), according to the report of the European Commission about a roadmap for delivering EU-wide multimodal travel information, planning and ticketing services published in 2014 [32]. At the moment, therefore, travellers cannot make fully informed choices suited to their needs. However, information services remain very fragmented in what they offer, both in geographical scope (limited to cities, regions or countries; only covering neighbouring countries in exceptional cases) and coverage of modes of transport; they rarely provide cross-border travel information. Real-time status information for public transport (e.g. bus, metro, and
rail) and multimodal real-time traffic information systems exist in several urban and ‘extra urban’ areas in Europe and worldwide, either as prototypes or fully operational systems. However, existing services do not offer travellers real-time information across all stages of a multimodal trip. Travellers increasingly expect real-time vehicle location, and predictions (e.g. of arrival times) and notifications of travel disruptions on public transport, particularly while the journey is taking place, and on mobile devices [33].

Traveller information deals with long information and business chains involving many actors, as described in the following diagram. The traditional value chain for travellers information services are:

![Traditional value chain for traveller’s information services](image)

**Figure 44: Traditional value chain for traveller’s information services**

In multimodal information services, the service is provided by combining different information chains for each transport mode which is making it even more complex, and involving different actors:

- **Content Providers** who are in charge of the collection of raw data through monitoring means.
- **Service Operators** are in charge of processing the raw data to generate information. They are usually private entities that work under the frame of public contracts for public bodies.
- **Network Operators** who provide the communication channels needed to deliver the information to the end user and interconnect the actors involved.
- **Service Provider** that provides the direct interface to the end user with the purpose to offer services including traffic information. They are mainly public (mobility manager and information service providers) with some private actors (information services providers).
- **End User** is the customer of the service provider.
Having a look to the role of key players in the market on the basis of door-to-door intermodal travel information, it is worthy to pint-point:

- Online travel agencies already enable customers to compare offers from different transport operators, and they will be interested in developing and using multimodal information to attract and hold additional customers and to strengthen their market position in the value chain.
- With regard of transport operators, they act at different geographical levels of the market. Airlines distribute via Global Distribution Systems (GDSs) to provide travel information and booking solutions. In the rail industry, passenger rail service operators act mainly at a national level and over the last decade, also to a certain extent at international (European) level. At the moment, the various national railway undertakings mostly rely on their individual solutions for schedule information, bookings, etc. This is also true for international and national long distance bus services. The attitude of transport operators in the market towards multimodal information may differ. It depends on the current structure of their distribution value chain, the role of online travel information for customer service and the sales strategy of the particular company. For example, airlines may be interested in becoming involved with multimodal travel information, because these systems will offer additional services for travellers, especially with respect to the first and last mile. For other public transport operators, despite of their no initial predisposition, there may be some opportunities, because rolling-out more innovative information services will improve the visibility of their product and attract additional customers and thus more revenues.
- As local transport authorities are responsible for public transport in their region, they are mainly interested in their local solutions for travel information.

3.4.2 Market Evolution

The future of mobility is ‘green’, ‘integrated’ and ‘interoperable’ transport infrastructures and modes. One can also say, that the future of mobility lies in a multi modal dynamic solution combining a journey from A to B through seamless integration of different forms
of transport and with one single “digital ticket”. And also in a mid-term future ‘Travel’ is about door-to-door connectivity; thus promoting new market players offering integrating various modes to travel.

As it is reflected in the picture above, the future mobility is not just about vehicles, it is a convergence of different industry sectors that is interacting seamlessly. And the new roles in the market will offer various types of mobility solutions to complement commuters’ inter-modality and multi-modality.

In summary two key concepts will represent the mobility market evolution in the coming years:

- Integrated Door-to-door multi-mobility
- The market will see new players termed “mobility integrators”

To enable mobility integration to happen, several industries are beginning to converge and collaborate including the automotive sector, transport operators, technology service and payment providers to name a few. Frost & Sullivan [34] also said that “we are beginning to see the development of an integrated transit system that has public transport services at its core, with last and first mile connectivity being provided by ancillary services such as micro transit and shared mobility services; all accessed through the same platform”.

That is why cross interoperability and co-operation between the different entities in the ecosystem to be the crux that makes or breaks future of mobility integration.
Market evolution will be also shaped by an ever expanding integrated value chain:

Stakeholders in an ever expanding integrated value chain taking the role of mobility integrators in the quest for totally integrated multimodal door-to-door connected travel.
The figure above shows that NS Business card is the only full-fledged mobility integrator. But it is forecasted that it will be easier for the transport companies to become the mobility integrators.

The future focus is moving towards integrated mobility with a number of mobility concepts and disruptive business models. One snapshot of existing mobility integration examples can be seen in the following figure:
3.4.3 Drivers and Barriers

Factors that promote the growth of the market according to the different studies and sources cited throughout the various sections of this document are:

- Growing middle class in emerging economies such as China or India.
- Awareness of the use of new technologies and IT investments that promote sharing and performance of existing infrastructure at airports to improve the operability and performance as well as the experience of passengers, such as self-service systems or shared communications. Some examples are “common use terminal equipments” for check-in shared environments, or “common use self-service” as self-service systems for check-in and baggage drop-off.
- Meet the needs of digital passengers.
- Increasing penetration of smartphone use by passengers; according to industry surveys, it is currently at a rate of 83% compared to 81% last year, and approximately 13% of the passengers wear or carry more than three mobile devices (tablet, phone, and portable or laptop).
- Cross-interoperability and co-operation between the different entities in the ecosystem to be the crux that makes or breaks future of mobility integration.
- Designing systems that are user-friendly and consider heterogeneity of user groups. All user requirements and needs (in terms of content and form of information) in order to make the service as widespread and inclusive as possible.
- The impact of social networks has caused a paradigm shift in the role of travellers: from being pure recipients of a service, travellers have become a source of information. By contributing collectively to the pool of information available and to the quality and reliability of the service on offer.

Whereas the market barriers could be listed as follows:

- In most airports ICT infrastructures are ready for personnel and not for passengers.
- Airport operators do not have information on where passengers spend their time and if they are where they should be, or about how long they spend in areas bottlenecks as check-in desks, security control or baggage claim.
- Today information services remain very fragmented in what they offer, both in geographical scope and coverage of modes of transport.
- Existing services do not offer travellers real-time information across all stages of multimodal trip.
- For door-to-door multimodal journeys information may exit a regulatory framework to make sure that private service providers have access to travel and real-time traffic information. Legislation governing access to data does not address all relevant aspects for the development of a genuine door-to-door multimodal travel.
- There is no availability of public and private public travel and traffic data of good quality, static and dynamic, regularly updated, covering all modes of transport and their combinations.
- There is not a common specification for data formats, data exchange protocols and interconnection of existing solutions.
Some private companies are reluctant to open up access to their data due to commercial interests. They participate in cooperation schemes that are based on bilateral agreements that allow accessing data under well-defined conditions. This leads to difficulties for smaller players (SMEs) to enter the market, since they do not have access to the data essential to develop new services.

3.4.4 Information and distribution channels

With reference to multimodal journey planning, the internet is most likely the strongest and most important channel for information and distribution. Internet represents a fast-growing channel for travel information and sales. One main characteristic of online channels is a strong increase in market transparency, as the online channel provides a wider choice for the comparison of different offers, and reduces transaction costs for the customer.

The online channel is divided into desktop, mobile and tablet access. Desktop access holds the strongest stake in national and international journey planning and booking. More than 50% of the European travel market is booked via desktop computers or laptops, either home or office-based. In recent years, the percentage of desktop use has decreased due to new devices such as smartphones (mobiles) and tablet computers. Since 2007, the year Apple introduced the iPhone, the market for mobile services has developed extremely intensely. In the context of travel, a study from 2013 by the European Travel Commission [35] states that the number of leisure travellers using a smartphone for searching travel information has increased from under 10% in 2009 to nearly 40% in 2012. As the figure below shows, the growth of travellers who use mobile devices to search for travel information is even larger in business travel.

![Figure 51: Percentage of Travellers who use a Mobile Device to Search for Travel Information](image)

Previously included in mobile statistics, tablet computers are meanwhile widely used as home-based devices to access the Internet. Therefore, they need to be regarded as a new kind of privately-used computer. Since 2009, the number of tablet computers has grown to about 33 million devices in Western Europe. A study by Forrester, polling 13,000 customers in France, Germany, Italy, Netherlands, Spain, Sweden and the UK, estimates that this number might grow to more than 147 million devices in 2017. Regarding this
massive number of devices, **tablets need to be taken into account as a proper channel for online information.** According to a study by eMarketer published in 2013, the revenue gained through tablets in the UK will generate twice the revenue gained through smartphones by 2017.

### 3.4.5 Technology

The 2014 report or survey SITA Airport IT Trends [29], shows that 2/3 of respondents airports have planned to increase their annual investment in IT in 2014, and increase them even more in 2015. Most IT investments are aimed at systems or self-service solutions. By 2017 the share of airports with kiosks for check-in is expected to grow to 90%, with many of them implementing additional services, as label printing to check luggage, airport maps, or flight information and gates. Other investments in IT are related to the handling of large volumes of information from passengers through Business Intelligence solutions. Finally and most importantly IT services should send real-time information to mobile phones of the passengers.

**Main technological trends in the market** are:

- Apps for passenger information in real time: (Happy passenger report) over 50% of airports offer apps to provide updated real-time flight status information. Many of them hope in three years, to deliver additional information such as "way-finding" for lounges or parking reservations for example. At present 30% of airports already have channels of communication with passengers alerting them of excessive queues for example in safety controls or delays or flight cancellations. It is expected that in 2017 the rate will grow to 66%. Challenges in this regard are to provide mobile ground staff to handle situations of delays or cancellations (outages), the report said most airports will have this option in three years [28].

- Beacons: not only used to launch operations and offers to passengers or interesting content and information but also for operation of indoor navigation solutions. One example is Miami airport, which is the first to have a fully operational solution.

- Wi-Fi: also used to determine both the flow of passengers and their positioning in areas of the airport to optimize personnel assigned in different areas. That is, a geo-location at the airport, through the use of wireless communications and infrastructure deployed at the airport. (Example of implementation in Copenhagen Airport made between SITA, CISCO and City Airport).

Examples of the most common solutions where mobile phone use is promoted by passengers (tending to improve information, shop, and security control) are: parking payment by mobile wallets (mobile wallets), check-in via mobile phone or web app or through confirmation of gates and time of departure through the apps of airports, besides sending gate change alerts or shop offers. Even if there were cancellations you could make a change to a new flight booking through the app.

On the passenger side, the most fostering technologies for door-to-door intermodal travel information growth have been: NFC, Smartphones, IoT.
3.4.6 New roles and business models

Frost & Sullivan [34] has defined a new concept “mobility integrator” as a step closer to totally integrated, multi-modal door-to-door travel. Frost & Sullivan has identified a number of scenarios, business models and early examples of this concept, whereby one or several organizations combine various modes of transportation and products to offer such a solution. This could be through using a mobile or web-based platform, to bring together technological advances in data processing or analytics and combine real time information and ticketing options through a smartphone, or smartcard, for example.

This is already beginning to interest several stakeholders across industries, particularly transport operators, technology providers, car manufacturers and fleet leasing companies, all of which are starting to offer products and services further away from their core business models.

Mobility integration and door-to-door travel, is not restricted to a single sector, player or industry. It offers several opportunities in an ever-growing supply chain and requires a collaborative effort between a number of different players and stakeholders for the benefits to be realised. However, this also presents one of the key challenges for successful mobility integration: either increased industry convergence is required, or a third party operator willing and able to enhance the opening of data, and to leverage the enhanced technology available, to piece it together. Solutions include journey planning and mobile applications, integrated ePayment methods and location-based services. But generally mobility integration must be underpinned by a flexible, convenient option of travel that optimizes the available infrastructure. Early examples of this in the business to consumer (B2C) market can be seen in France, where transport operator Veolia Transdev’s Urban Pulse mobile application combines travel planning and ride sharing with city-based shopping deals, local events, and information on the location of friends via geo-localization.

Also in the Netherlands, the NS-Business card, launched by NS trains, allows all modes of travel to be placed on a single invoice, again providing significant administrative benefits, and, more importantly, convenient travel across the entire country, whilst also allowing use of additional services such as short-term office space rental, or access to business class lounges. These solutions represent the most comprehensive mobility integration solution currently on the market.

Frost & Sullivan [34] has also identified three different business models, namely Mobility Integrator (MI), Mobility Aggregator (MA) and Mobility Player (MP). Each model differs primarily on the role that a particular stakeholder in a value chain plays, and also on the host of mobility services that are offered.

A Mobility Integrator would link every mode of transport, whether it operates them or not, and would be seen by the consumer as the point of reference for their journey and associated services. For example, the aforementioned NS-Business card allows users to rent office space from Regus, as the MI – this service would be seen to be offered by NS, rather than Regus. Therefore, mobility integrator will be an entity or combination of entities in the value chain which provides the right combination of various modes of transportation to offer an integrated, multi-modal door-to-door mobility solution using a mobility platform by leveraging technological expertise, operational excellence, infrastructural advancements and innovative business propositions.
A Mobility Aggregator would provide several travel related services: for example, a leasing firm offering rental of all types of vehicles, integrated with public transport networks.

A Mobility Player would be relatively more conservative, offering services close to the current business model.

### 3.4.7 Market growth rate and forecast

The air transport market in general currently has a **growth rate of approximately 5% annually**, according to “Happy passenger successful. Successful airports. Positioning paper” by SITA [28].

Related to Air Transport forecast, EUROCONTROL produces forecasts of growth in IFR\(^5\) flight movements in Europe. Growth is expected to be +2.6% per annum from 2015 to 2020, reaching 11.2 million annual flights in 2020 in the baseline forecast. EUROCONTROL have produced high and low case forecasts with between 10.1 million and 12.1 million flights in 2020. Growth rates are expected to be lower in the mature markets of Western Europe and higher in Eastern Europe and Turkey. In absolute terms, Turkey is expected to contribute the most additional flights by 2020, followed by the large markets of France and Germany. EUROCONTROL expects airport capacity constraints to limit growth, predicting that demand for 144,500 annual flights will not be accommodated by 2020, dampening growth by a total of 1.3%. Air travel demand is also reduced by an equivalent of 51,000 annual flights by 2020 due to expected substitution of short haul air travel by high speed rail [36].

Airbus’ Global Market Forecast for 2015-2034 [37] offers a forward-looking view of the air transport sector’s evolution – accounting for factors such as demographic and economic growth, tourism trends, oil prices, development of new and existing routes, and ultimately highlighting demand for aircraft. This new forecast – which serves as a reference for airlines, airports, investors, governments, non-government agencies and others – anticipates that air traffic will grow by 4.6 per cent annually. The market growth according to the Airbus’s vision will be shaped by a two-speed economic world.

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5 Instrument Flight Rules, i.e., flights required to file flight plans with EUROCONTROL
As the image above reflects, the economic growth is highest in expanding regions. According to the study, emerging/developing economies (China, India, Middle East, Asia, Africa, CIS, Latin America, Eastern Europe) will grow with an AGR $+5.8\%$ from the 6.3 billion people in 2014. Meanwhile in advanced regions (Western Europe, North America, Japan) the expected RPK growth is $+3.8\%$ from the 1 billion people in 2014. It will also exist a higher propensity to travel in these countries, in the near future it is expected that 74\% of the population will take a trip in 2034.

Before concluding the Airbus’ vision forecasts, the following figure indicates that the air traffic volume will double in the next 15 years.
On the airlines side, according to IATA, it is expected that the number of passengers will grow to 1.5 billion in 2017. Additionally, in its first 20-year passenger growth forecast [38], the company projects that passenger numbers are expected to reach 7.3 billion by 2034. That represents a 4.1% average annual growth in demand for air connectivity that will result in more than a doubling of the 3.3 billion passengers expected to travel this year.

Among the highlights of the report is the expectation that China will overtake the United States as the world’s largest passenger market (defined by traffic to, from and within) by 2030. Both markets, however, are expected to remain the largest by a wide margin. In 2034 flights to, from and within China will account for some 1.3 billion passengers, 856 million more than 2014 with an average annual growth rate of 5.5%. Traffic to, from and within the US is expected to grow at an average annual growth rate of 3.2% that will see 1.2 billion passengers by 2034 (559 million more than 2014).

The report, produced by IATA in association with Tourism Economics, analyses passenger flows across 4,000 country pairs for the next 20 years, forecasting passenger numbers by way of three key demand drivers: living standards, population and demographics, and price and availability. **Highlights for the air transport market** are:

- **Future growth trends**
  By 2034 the five fastest-increasing markets in terms of additional passengers per year will be China (856 million new passengers), the US (559 million), India (266 million), Indonesia (183 million) and Brazil (170 million).
  Eight of the ten fastest-growing markets in percentage terms will be in Africa with Central African Republic, Madagascar, Tanzania, Burundi and Kuwait making up the five fastest-growing markets.
  According to IATA’s CEO Tony Tailer, “it is an exciting prospect to think that in the next 20 years more than twice as many passengers as today will have the chance to fly. Air connectivity on this scale will help transform economic opportunities for millions of people. At present, aviation helps sustain 58 million jobs and $2.4 trillion in economic activity. In 20 years’ time we can expect aviation to be supporting around 105 million jobs and $6 trillion in GDP”.

![Figure 55: World Annual Revenue Passenger Kilometre (RPK)](image-url)
• Analysis of the 10 largest air passenger markets defined by traffic to, from and within for the period 2014-2034
  o The United States will remain the largest air passenger market until around 2030, when it will drop to number 2, behind China. Cumulatively over the next 20 years the US will carry 18.3 billion more passengers and China 16.9 billion.
  o Currently the ninth largest market, India will see a total of 367 million passengers by 2034, an extra 266 million annual passengers compared to today. It will overtake the United Kingdom (148 million extra passengers, total market 337 million) to become the 3rd largest market around 2031.
  o Reflecting a declining and ageing population, Japanese air passenger numbers will grow just 1.3% per year and decline from the 4th largest market in 2014 to the 9th largest by 2033.
  o Germany and Spain will decline from 5th and 6th position in 2014 to be the 8th and 7th largest markets respectively. France will fall from 7th to 10th while Italy will fall out of the top 10 altogether in around 2019.
  o Brazil will increase passenger numbers by 170 million and rise from 10th to 5th. Its total market will be 272 million passengers.
  o Indonesia will enter the top ten around 2020 and attain 6th place by 2029. By 2034 it will be a market of 270 million passengers.

• Regional growth highlights
  o Routes to, from and within Asia-Pacific will see an extra 1.8 billion annual passengers by 2034, for an overall market size of 2.9 billion. In relative terms it will increase its size compared to other regions to 42% of global passenger traffic, and its annual average growth rate, 4.9%, will be the joint-highest with the Middle East.
  o The North American region will grow by 3.3% annually and in 2034 will carry a total of 1.4 billion passengers, an additional 649 million passengers a year.
  o Europe will have the slowest growth rate, 2.7%, but will still cater for an additional 591 million passengers a year. The total market will be 1.4 billion passengers.
  o Latin American markets will grow by 4.7%, serving a total of 605 million passengers, an additional 363 million passengers annually compared to today.
  o The Middle East will grow strongly (4.9%) and will see an extra 237 million passengers a year on routes to, from and within the region by 2034. The UAE, Qatar and Saudi Arabia will all enjoy strong growth of 5.6%, 4.8%, and 4.6% respectively. The total market size will be 383 million passengers.
  o Africa will grow by 4.7%. By 2034 it will see an extra 177 million passengers a year for a total market of 294 million passengers.

• Analysis of domestic air passengers markets
  o The fastest-growing domestic market will be China, which will grow at 5.6% per year and by 2034 will account for 1.0 billion passengers (691 million additional domestic passengers compared to today).
  o The United States domestic market will expand by 3.2% per year, to 822 million passengers, an additional 384 million passengers annually compared to 2014.
The Indian and Brazilian domestic markets will grow at 6.9% and 5.4% respectively. India will be adding 159 million extra passengers and Brazil 147 million. Their total domestic air markets will be 215 million and 226 million.

Indonesia will be the fifth largest domestic market. It will grow at 6.4%, adding an extra 136 million passengers a year by 2034. The total Indonesian domestic market will be 191 million.

The remaining top ten domestic markets will be Turkey (annual growth of 5.3%), Philippines (5.9%), Mexico (4.6%), Colombia (6.0%), and Vietnam (6.2%).

- Demand drivers

With regard the three main key drivers considered for drafting the forecast, they are characterized by:

- Living standards have a known effect on the propensity to fly. Countries on a growth curve up to approximately US$20,000 per capita see correspondingly faster increases in the number of flights taken per person per year.

- Population and demographics reflects not just population trends over the next 20 years, but also measures such as the old-age dependency ratio. On these measures, countries such as Japan, Russia, and Ukraine are expected to undergo significant population decline. African nations, on the other hand, are set for rapid population growth. Typically, the nations with growing populations also have younger populations, and working-age groups are more likely to fly than over-65s.

- Price and availability looks to predict future trends of the price of air travel and the extent of future air connectivity. The unit cost of air transport has fallen by a factor of four since 1950. However, the past decade has seen prices bottom out, largely due to the increased cost of oil. In the coming two decades, the downward trend in the real cost of air travel is expected to resume, at a rate of around 1 – 1.5% per year. Air connectivity is expected to increase with the addition of new longer-range mid-size aircraft. Greater liberalization of air markets has the potential to increase global air traffic growth by over 1 percentage point per year.

According to a forecast by eMarketer from September 2012, the percentage of online travel sales in the European travel market is growing steadily and will probably reach 50% in 2016.

### 3.5 SWOT Analysis

As already mentioned in section 3.1.4 of this deliverable, an internal workshop with WP2 partners will be arranged to develop the SWOT Analysis for DORA purposes.

Nevertheless, this analysis will be performed during November 2015, due to previous delays getting key inputs to develop this SWOT Analysis, namely air passenger’s needs in terms of transport information (identified by user surveys), and the availability of solutions giving answer to these needs (identified by means of in-depth interviews with
market experts). Then, final results of the SWOT Analysis will give a clear vision on what and how DORA system could cover current gaps on existing solutions, whilst meeting the user needs.
4 CONCLUSIONS

The following sub-sections provide an overview how the results from this deliverable may be of use for the DORA project and the scientific community.

4.1 Relevance of the Gained Cognitions to the Related / Following Work Packages

The outcomes of this deliverable will inspire Task 2.3- Definition of Use Cases (for different scenarios of DORA system deployment). Moreover, they will be a required input in deliverable D.2.4 Technical and legal requirements, which consists on a report on the technical and legal issues to take into account for the development and integration of the components of DORA information system.

Therefore, the global analysis of desk research findings, results of in-depth interviews with market experts, user surveys feedback and final conclusions of the SWOT analysis, will allow DORA partners to shape the DORA system requirements in a robust and well-structured way.

Due to delays in the implementation of user surveys, in-depth interviews and an internal workshop, that have been duly justified in previous sections of this document, a new release of this deliverable will be issued and submitted by January 2016, which will include the results and final conclusions obtained with these activities.

4.2 Scientific Use of the Gained Cognitions

As a result of the SoA review in DORA pilot sites, there are several existing mobility information services and technologies already in place. It is worth mentioning the AIRVIS system, which will play a crucial role when integrating an incident management into the DORA system.

Nowadays, more than 100 multimodal journey planners already exist in Europe and yet information provided to travellers is incomplete. Comparing current route planners vs. DORA system, the existing ones partly provide a wide variety for door-to-door mobility information, but lack many functions that will be developed and integrated in the DORA project, such as terminal processes, incident management, real-time traffic information, information for parking at the terminal or user group specific information.

Existing techniques to analyse people count, queue length and waiting time have been reviewed and compared. As a result, in the DORA project, a video analysis system will be integrated in the airports to measure passenger’s behaviours and to deliver to the DORA platform accurate and consistent data.

A review on existing indoor positioning technologies and solutions has been done. Those based on Bluetooth Low Energy (BLE) hardware are of interest for DORA purposes. So, the DORA Indoor Positioning System (DIPS), aiming at being integrated in the most seamless
way, will be primarily based on Wi-Fi techniques and on specifically designed equipment to provide additional coverage for the positioning algorithms. As far as the DIPS software platform is concerned, the fact that there is not any open product to be used indoor, so DORA will develop a dedicated one. Thus, the navigation algorithm might be able to provide door-to-door routes within airports and alternative ways according to passenger’s requirements.

Available airport apps in the market provide comprehensive mobility information, but none of them offers a range of functions as targeted in DORA. On the contrary, some special features have been identified during the SoA review, such as parking-space-memorizers or interactive 3D maps, that might be considered for a further elaboration of the DORA app.

Analysing the market of specific door-to-door transport information services addressing air passengers, several aspects were considered: market segments trends and changes, market overview and evolution, drivers and barriers, new roles and business models, distribution channels, market growth rate and forecast. Remarkable conclusions are summarized below:

Main factors that promote the market growth:

- Meet the needs of digital passengers.
- Increasing penetration of smartphone use by passengers.
- Cross-interoperability and co-operation between the different entities in the ecosystem for mobility integration.
- Designing systems that are user-friendly and consider heterogeneity of user groups.
- Social networks impact has caused a paradigm shift in the role of travellers: they have become a source of information.

Whereas the main market barriers are:

- ICT infrastructures in most airports are ready for personnel, but not for passengers.
- Airport operators lack information on where and how long passengers are located in bottleneck areas (check-in desks, security control or baggage claim).
- Information services remain fragmented (geographical scope and coverage of transport modes).
- There is no availability of public and private travel and traffic data of good quality, static and dynamic, regularly updated, covering all modes of transport and their combinations.
- There is not a common specification for data formats, data exchange protocols and interconnection of existing solutions.
References


[3] Chirakkal, V.V.; Myungchul Park; Dong Seog Han, "Indoor navigation using WiFi for smartphones: An improved Kalman filter based approach," Consumer Electronics (ICCE), 2015 IEEE International Conference on , vol., no., pp.82,83, 9-12 Jan. 2015, doi: 10.1109/ICCE.2015.7066328


**ANNEX A  LOW POWER WI-FI CHIPSETS AND MODULES**

**A.1  Market survey on low power Wi-Fi Chipsets/Modules**

It is summarized below the main characteristics of various chipsets/modules to be considered in the design of the low power Wi-Fi Beacons for DORA project.

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<tr>
<th>Vendor</th>
<th>Part Number</th>
<th>Additional Features</th>
<th>Power Consumption</th>
<th>CPU/MCU Availability - On-board Stack</th>
<th>Tx Power</th>
<th>AP/SoftAP Mode</th>
<th>Radio</th>
<th>Indicative Price</th>
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<tr>
<td>Microchip</td>
<td>RN1723</td>
<td></td>
<td>130mA (0dBm) 185mA (+10dBm)</td>
<td>Yes – Yes</td>
<td>0dBm to +12dBm</td>
<td>Yes</td>
<td>802.11 b/g</td>
<td>15.68$</td>
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<td>Microchip</td>
<td>RN171</td>
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<td>130mA (0dBm) 185mA (+10dBm)</td>
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<td>0dBm to +12dBm</td>
<td>Yes</td>
<td>802.11 b/g</td>
<td>26.25$</td>
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<tr>
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<td></td>
<td>130mA (0dBm) 185mA (+12dBm)</td>
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<td>0dBm to +12dBm</td>
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<td>802.11 b/g</td>
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<td>Yes</td>
<td>802.11 b/g</td>
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<td>240mA</td>
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<td>3-760 μA (3 μA with RTOS in MCU)</td>
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<td>N/A</td>
<td>802.11 b/g/n</td>
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<td>11.2dBm</td>
<td>Yes</td>
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<td>24.49$/1ku</td>
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<td>Yes</td>
<td>802.11a/b/g/ n</td>
<td>21.49$/1ku</td>
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<td>223mA</td>
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<td>14.5dBm</td>
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<td>8.615$/1ku</td>
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<td>802.11b/g/n</td>
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<td>No – No</td>
<td>12.7dBm</td>
<td>Yes</td>
<td>802.11b/g/n</td>
<td>11.995$/1ku</td>
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<td>Company</td>
<td>Model</td>
<td>Current (mA)</td>
<td>Wireless</td>
<td>Audio</td>
<td>Bluetooth</td>
<td>Temperature</td>
<td>Price</td>
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<td>12.28$/1ku</td>
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</tr>
<tr>
<td>GainSpan</td>
<td>GS2011M</td>
<td>802.15.4 (7)</td>
<td>No - Yes</td>
<td>15dBm</td>
<td>Yes</td>
<td>802.11b/g/n</td>
<td>22.5$</td>
<td></td>
</tr>
<tr>
<td>RedPine</td>
<td>RS9113 – N(XY)</td>
<td>X=B =&gt; BLE</td>
<td>Yes - Yes</td>
<td>Up to 18dBm</td>
<td>Yes</td>
<td>802.11a/b/g/n</td>
<td>25.15$-39.43$ (depending on BLE and antenna)</td>
<td></td>
</tr>
<tr>
<td>RedPine</td>
<td>RS9110</td>
<td>-</td>
<td>No - Yes</td>
<td>-</td>
<td>No</td>
<td>802.11a/b/g/n</td>
<td>30.46$</td>
<td></td>
</tr>
<tr>
<td>Qualcomm</td>
<td>QCA4002 /4</td>
<td>115</td>
<td>Yes – Yes</td>
<td>0dBm – 18dBm</td>
<td>Yes</td>
<td>802.11a/b/g/n</td>
<td>~5.00$</td>
<td></td>
</tr>
</tbody>
</table>
ANNEX B USER SURVEYS AND EXPERT INTERVIEWS

B.1 Air Passenger Survey Questionnaire

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer Categories</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey Airport</td>
<td>open</td>
<td>nominal</td>
</tr>
<tr>
<td>2</td>
<td>Gate</td>
<td>open</td>
<td>interval</td>
</tr>
<tr>
<td>3</td>
<td>Destination</td>
<td>open</td>
<td>nominal</td>
</tr>
<tr>
<td>4</td>
<td>Flight Number</td>
<td>open</td>
<td>interval</td>
</tr>
<tr>
<td>5</td>
<td>Airline</td>
<td>open</td>
<td>interval</td>
</tr>
<tr>
<td>6</td>
<td>Gender</td>
<td>- male</td>
<td>ordinal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- female</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>How often do you fly, at an average, in a year? Please include/count the Return (to the outward flight together) as a single flight!</td>
<td>open</td>
<td>interval</td>
</tr>
<tr>
<td>8</td>
<td>How have you checked in today?</td>
<td>- at check-in kiosk</td>
<td>ordinal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- at the counter</td>
<td></td>
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<td></td>
<td></td>
<td>- online on PC</td>
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<td></td>
<td></td>
<td>- online on a mobile device (Tablet PC, Smartphone, etc.)</td>
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<td></td>
<td></td>
<td>- I am on a transfer flight and have not checked in here today</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>How many people are traveling / flying with you today?</td>
<td>- alone,</td>
<td>ordinal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- together with other [number] people,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- not specified</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>How long has your journey to the airport taken today approximately?</td>
<td>[open] min</td>
<td>ratio</td>
</tr>
<tr>
<td>11</td>
<td>How much time prior to your scheduled departure time have you arrived at the airport?</td>
<td>[open] min</td>
<td>ratio</td>
</tr>
<tr>
<td>12</td>
<td>By what means of transport have you arrived at the airport?</td>
<td>- motor vehicle,</td>
<td>ordinal</td>
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<tr>
<td></td>
<td></td>
<td>- taxi</td>
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<td></td>
<td></td>
<td>- car</td>
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<td></td>
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<td>- car sharing</td>
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<td>- subway</td>
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<td>- metro</td>
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<td></td>
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<td>- regional train</td>
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<td>- long-distance train</td>
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<td></td>
<td></td>
<td>- transport bus</td>
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<td>- remote bus</td>
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<td></td>
<td></td>
<td>- charter / tour bus</td>
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<td>- airport shuttle</td>
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<td></td>
<td></td>
<td>- aircraft</td>
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<td></td>
<td></td>
<td>- limo / chauffeur service</td>
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<tr>
<td></td>
<td></td>
<td>- other___</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- no information</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td>Ordinal Type</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Have you parked your car at the airport for the travel duration, or have you been brought to the airport?</td>
<td>-subject to fee off for the duration at the airport, -subject to fee off for the duration outside the airport, -been brought / Cars parked briefly free, -been brought / Cars parked briefly costs, -been brought / car is returned immediately, -not specified</td>
<td>ordinal</td>
<td></td>
</tr>
<tr>
<td>Have you used a car prior to arrival with this transport and parked in the surrounding area of the airport?</td>
<td>-Yes, -No, -Not specified</td>
<td>nominal</td>
<td></td>
</tr>
<tr>
<td>Before you used the (insert answer Q13), have you used one or more other transport for the journey? If so, please state them in the chronological order.</td>
<td>-motor vehicle, -taxi, -car, -car sharing, -metro, -subway, -tram, -regional train, -long-distance train, -transport bus, -remote bus, -charter / tour bus, -airport shuttle, -aircraft, -other, what [mode of transport]</td>
<td>ordinal</td>
<td></td>
</tr>
<tr>
<td>Are you going to take the same means of transport for your return journey from the airport/Have you taken the same means of transport to reach us, as your took for your outward/return flight?</td>
<td>-Yes, -No, -On a one way flight</td>
<td>nominal</td>
<td></td>
</tr>
<tr>
<td>By what means of transport are you going to come back from the airport to your final destination / By what means of transport have you come to the airport in your last outward flight?</td>
<td>-motor vehicle, -taxi, -car, -car sharing, -metro, -subway, -tram, -regional train, -long-distance train, -transport bus, -remote bus, -charter / tour bus, -airport shuttle, -aircraft, -other, what [mode of transport]</td>
<td>ordinal</td>
<td></td>
</tr>
<tr>
<td>What is the main reason of your today's air travel?</td>
<td>-Professional event, -Private occasion</td>
<td>ordinal</td>
<td></td>
</tr>
<tr>
<td>We are interested a little more precise in the actual reason of your today's air travel. You told us, that you are traveling on business. What is exactly the cause of your today's air travel? Multiple answers possible.</td>
<td>-Fair / Congress, -Business meeting / Meeting, -Conference / Meeting, -Work, -Other business reasons [reason], -Not specified</td>
<td>ordinal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
<td>Type</td>
</tr>
<tr>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>21</td>
<td>We are interested a little more precise in the actual reason of your today's air travel. You told us, that you are traveling for private issues. What is exactly the cause of your today's air travel? Multiple answers possible.</td>
<td>-Visiting trip (friends, acquaintances), -Holiday / vacation trip, -City Break, -Event (concert, exhibition, etc.), -Private without specifics, -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>22</td>
<td>Where have you booked your flight / your trip?</td>
<td>-Directly with the airline, -On a travel portal, -Travel agency, -Company travel office, -Other [location of booking], -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>23</td>
<td>How have you booked your flight / your trip?</td>
<td>-Online on the internet, -By phone, -Personally, -Other [way of booking], -Do not know, -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>24</td>
<td>What is your marital status?</td>
<td>-Unmarried with partner, -Single without partner, -Married and living together, -Married and living separately, -Divorced / widowed with partner, -Divorced / widowed without a partner, -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>25</td>
<td>How many people live in your household including you (and all children who live there)</td>
<td>open</td>
<td>interval</td>
</tr>
<tr>
<td>26</td>
<td>What is your highest academic qualification?</td>
<td>-Secondary school, -High school, -University, -Technical college, -Completed college / Vocational training, -University degree study (university, college, academy, polytechnic), -No degree, -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>27</td>
<td>Are you currently employed?</td>
<td>-Yes, employed, -No, not working, -Housewife / houseman, -Students, -Military / civil service, -Retired, -Seeking employment, -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>28</td>
<td>What is your personal monthly income?</td>
<td>-Below 1.500 EUR, -1.500-2.000 EUR, -2.000-3.000 EUR, -3.500-4.000 EUR, -4.000-4.500 EUR, -4.500-5.000 EUR, -More than 5.000 EUR -Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
<td>Data Type</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>29</td>
<td>What is the whole monthly net income of your household?</td>
<td>- Below 2.000 EUR, - 2.000-3.000 EUR, - 3.500-4.000 EUR, - 4.000-4.500 EUR, - 4.500-5.000 EUR, - More than 5.000 EUR, - Not specified</td>
<td>ordinal</td>
</tr>
<tr>
<td>30</td>
<td>What age group do you fall into?</td>
<td>- Younger than 18 years, - 18-29 years, - 30-50 years, - Older than 50 years</td>
<td>ordinal</td>
</tr>
<tr>
<td>31</td>
<td>Do you have a mobile device? If yes, of which type is it?</td>
<td>- I have no mobile device, - Smartphone, - Tablet, - Internet enabled mobile phone, - Others [device]</td>
<td>ordinal</td>
</tr>
<tr>
<td>32</td>
<td>Which of the following sources of information do you use for the arrival to the airport?</td>
<td>- Website and information material from the airport, - Website and information material of the airline, - Website and information material of the public transport operator, - Internet search engines. Please name one: [search engine], - Navigation system in the vehicle. Please name one: [navigation system], - Apps from various suppliers. Please name one: [other Apps], - Others, - None</td>
<td>ordinal</td>
</tr>
<tr>
<td>33</td>
<td>Which of the following sources of information do you use for the departure from the airport?</td>
<td>- Website and information material from the airport, - Website and information material of the airline, - Website and information material of the public transport operator, - Internet search engines. Please name one: [search engine], - Navigation system in the vehicle. Please name one: [navigation system], - Apps from various suppliers. Please name one: [other Apps], - Others, - None</td>
<td>ordinal</td>
</tr>
<tr>
<td>34</td>
<td>Which of the following additional sources do you use to inform yourself about your flight from home / office?</td>
<td>- Airport website, - Mobile airport website, - Airline Website, - Airport App, Airline App, - Third-party app, - Others, - None</td>
<td>ordinal</td>
</tr>
<tr>
<td>35</td>
<td>Which of the following sources do you use to inform yourself about your flight on the way?</td>
<td>- Airport website, - Mobile airport website, - Airline Website, - Airport App, - Airline App, - Third-party app, - Others, - None</td>
<td>ordinal</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
<td>Scale</td>
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<td>--------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>36</td>
<td>How often do you use this app?</td>
<td>-Each time I travel, -Sometimes when I travel, -Rarely</td>
<td>ordinal</td>
</tr>
<tr>
<td>37</td>
<td>How great is your interest in an app that supports you with information and services related to your flight?</td>
<td>-Low, -Medium, -High</td>
<td>ordinal</td>
</tr>
<tr>
<td>38</td>
<td>Please rate the following services of an app with your priority (1 – unimportant to 5 – very important)!</td>
<td>-Multimodal journey real-time information to/from the airport, -Parking reservations, -Directions in the terminals (indoor navigation), -Display of waiting time before the departure at check in counter, security control and at the gate -Display of waiting time after the arrival at luggage belt -Real-time flight info</td>
<td>ordinal</td>
</tr>
<tr>
<td>39</td>
<td>Would you like further services in the app in addition to the previous ones?</td>
<td>-Yes [service], -No</td>
<td>nominal</td>
</tr>
<tr>
<td>40</td>
<td>What is important to you in an app for transport and traffic? (1 – disturbing to 5 - very important)</td>
<td>-Information availability, -Information accuracy, -Information content, -Design, -Free App</td>
<td>ordinal</td>
</tr>
<tr>
<td>41</td>
<td>Which criteria are most important for you to make the choice on how to travel from your place of residence to the airport (1=important; 5=unimportant)?</td>
<td>-Reliability, -Travel time, -Comfort, -Barrier-freedom, -Price -Safety -Environmental Impact / Sustainability (low CO2 emissions, low energy consumption etc.)</td>
<td>ordinal</td>
</tr>
<tr>
<td>42</td>
<td>Which criteria are most important for you to make the choice on how to travel from your destination airport to your hotel / venue (1=important; 5=unimportant)?</td>
<td>-Reliability, -Travel time, -Comfort, -Barrier-freedom, -Price -Safety -Environmental Impact / Sustainability (low CO2 emissions, low energy consumption etc.)</td>
<td>ordinal</td>
</tr>
<tr>
<td>43</td>
<td>Do you have any kinds of physical impairments? If yes which?</td>
<td>-Slight walking impediment (problems to walk longer distances, to climb stairs), -Walking impediment (wheelchair, rollator), -Visually impaired, -Hearing impaired, -Other [impairment]</td>
<td>ordinal</td>
</tr>
<tr>
<td>44</td>
<td>Do you establish an Internet connection with your mobile device when you are abroad?</td>
<td>-Generally yes, -Generally no, -Only in Europe</td>
<td>ordinal</td>
</tr>
</tbody>
</table>