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The HARMONY project – Study for the harmonization of data in the public transport network and road network

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Abstract

Urban mobility challenges are complex and involve many different aspects. A central issue is the management of mobility data in the cities, lacking a common structure for multimodal data and access interfaces to the data. The European Commission initiatives such as the ITS Directive 2010/40/EU and the Implementing Decision 2016/209 established some lines along which these issues should be addressed. A special focus is put on the Multimodal Information Services and Systems (MISS).

The HARMONY project is a CEF joint initiative by Indra and the Technical University of Madrid, created as a direct continuation of other urban mobility European efforts. It focuses on the promotion of multimodality, while improving efficiency in the use of the available network capacity. A pilot with the involvement of a public transport operator INTER-BUS, road traffic authorities and service providers is already under way in the northeast part of Madrid.

The different use cases considered in the project are:

- Public Transport fleet management. Addresses the integration of static and real-time public transport information, and the potential exchange of this information to third parties. This currently involves the implementation of solutions based on GTFS, GTFS-RT and SIRI.
- Urban Traffic monitoring. Addresses the integration and exchange of information on road incidents between operators, and again the provision of this information to third parties. This involves the implementation of solutions based on DATEX II.
- Transit information provision. The key aspect here is the provision of real-time information to public transport passengers and mobility users in general. Several solutions are being currently investigated.

HARMONY is aligned in time and objectives with some of the aspects highlighted by the European Commission in the field of urban mobility, and with the corresponding efforts in different ISO and CEN standardization groups. The added value of the project should be the progress in the identification of the particularities of each city and their impact on the specification and deployment of urban mobility solutions.

Keywords: Public Transport, Mobility in Smart Cities, Mobility as a Service, Information Systems, Integration of Transport/IT Systems.

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Nomenclature

DATEX Road Data Exchange protocol (CEN Technical Standard)
GTFS General Transit Feed Specification
IFOPT Identification of Fixed Objects in Public Transport (prCEN Technical Standard)
ITS Intelligent Transport Systems
MISS Multimodal Information Services and Systems
NeTEx Network Timetable Exchange (CEN Technical Standard)
SIRI Service Interface for Real-time Information (CEN Technical Standard)

1. Introduction

Mobility stakes are increasingly important in today's fast-growing urban centres all over the world, but particularly in the European Union where 75% of the inhabitants live in urban areas. The 21st century is indeed the century of the cities where we also find the bulk of economic development and innovation potential.

The challenges faced by cities and metropolitan areas can be considered as a five-dimension prism with the following dimensions: Accesibility, Environment, Urban areas quality of life, Urban freight and Public space management.

After forty years of massive investments, infrastructure networks inter-connections have become a priority to ensure urban population growth and economic development. This was introduced in transport public policies through the concepts of inter-modality, multi-modality and co-modality. Moreover in the 1990s information and communication technologies applied in the transport fields allowed the deployment of network management systems and user information services.

Conclusions drawn from these previous investments are rather positive but still modest in light of the long term modal shift objectives. These objectives require strong and coordinated actions. Implementation plans should gather a large range of cooperating stakeholders from every transport mode at local or regional level to emphasize the effects of the network and users.

At the same time environmental and financial constraints have greatly limited the capacity to build new transport infrastructure. Thus a new logic based on a service approach and on the optimization of existing infrastructure has emerged to meet the increasing mobility demand.

These strategies usually include different ITS, which in turn integrate three main components: data collection, data processing and elaborated data (services) provision. The ITS services related with urban mobility management rely heavily in the collection of data in enough quality and quantity for the corresponding transport modes and areas.

The 2010/40/EU ITS Directive describes the framework of functional and technical specifications, of organizations and services to advance on the compatibility, interoperability and continuity of ITS solutions in the European Union. One of the particular actions is related to the development of standards towards the harmonization of Multimodal Information Services & Systems (MISS). The absence of a harmonized structure of multimodal data has already been proven to be one of the major obstacles to the development of MISS, and therefore any initiative addressing the improvement in the management of these data is considered necessary.

Initiatives like the OPTICITIES project within the 7th Framework Programme aimed at looking at the mentioned challenges from a global vision. The main objective of the project was the optimization of the urban transport and mobility management infrastructures, based on the development of ITS services, the integration of passenger and freight transport management resources, and the joint development or innovation and research strategies with the private sector.

One of the basic aspects for the deployment of MISS is the consolidation and integration of multiple sources of multimodal urban data sources, and the support for the definition of a European standard for this consolidated data

structure and its access interfaces amongst public authorities, transport infrastructures operators and service providers. On the other hand, an interesting results of these initiatives is that this consolidation and integration has strong local particularities, and depends largely on the context of each city, as pointed out in Alfonso and Duquesne (2016).

In this sense, the HARMONY project aims to progress in the specification and implementation of this consolidated data structure, focusing in the particular case of Madrid, from three points of view:

- Mobility aspects
- Management aspects
- Data exchange interoperability aspects

1.1. Problem definition

We have already established that one of the basic requirements for the development and particularly the deployment of multimodal information services is the consolidation of a harmonized multimodal data structure, including its interfaces with different information services. This structure must facilitate the collection and exchange of urban mobility information from different operators and service providers, and in turn, provide it through standardized interfaces or access points.

This allows mobility managers and service providers to handle data in every city and provide services to the users. Different European standardization groups have been working in the issues related with the development of this harmonized data structure, and on the other hand, different research initiatives have been contributing to both this standardization work, and to the identification of factors related with the implementation and deployment of this multimodal data structure (European Commission, 2016).

However, there is one factor that adds to the complexity of the multimodal information services deployment, which is the fact that there are a number of *de facto* data exchange standards providing similar functionalities to European and international multimodal data structures. This is more relevant considering that there is a relevant number of entities and services providers in the urban mobility environment that have implemented components, systems and services based on these *de facto* standards. This is obviously one of the aspects that is being analyzed in the HARMONY project, in its difficulties to integrate with other systems and solutions, as well as in the impact that this integration has on the deployment of the MISS (Alfonso and Duquesne, 2014).

1.2. Objectives of the paper

The development of a harmonized multimodal data structure is necessary for the deployment of urban and interurban mobility services. But it is also necessary that in the specification of this structure, and even more, in the implementation and deployment of the mechanisms to make use of the structure, the particularities of each city and region are critical. From a technical point of view, one of the main obstacles is the need to consider not only the CEN/ISO specifications and exchange profiles for multimodal data, but also the specific systems for each operator and entity, which do not necessarily follow those same specifications.

The HARMONY project will be introduced in its role of relevant initiative for the deployment of an integrated solution for MISS in the region of Madrid, and as a relevant contributor to the analysis of different aspects that have an influence in the development of the underlying multimodal data structure.

2. The HARMONY project

The HARMONY project is conceived as a direct follow-up of other European and national initiatives that in the past have addressed the issue in the improvement in the development and deployment of urban and interuorban multimodal transport solutions, including multimodal information systems.

The general objective of the project is to promote multimodality while at the same time improving the efficiency in the use of the transport capacity available and the planning of infrastructures and mobility services to better adjust to the needs of the passengers. This general objective is detailed into 4 specific objectives:

- Contribution to the adoption of multimodal information systems in Madrid

- Develop the mechanisms and tools to support and automate the exchange of multimodal data between different entities
- Contribute to the consolidation of ongoing standardization works in relation to the specification of profiles for standards on multimodal information and geographic references
- Elaborate recommendations on the use of multimodal information systems in general, and contribute to the creation of business models which exploit the proposed harmonized data structures.

The following activities are planned within the project:

- **Activity 1. Specification of the study scope.** Sets up the framework in which the rest of the activities of the project will be carried out. Includes aspects such as a preliminary definition of the target scenarios, evaluation methodology and test design.
- **Activity 2. Pilot deployment.** This activity focuses in the execution of the proof of concept tests around the harmonized multimodal data structure. These tests will consist in the deployment of a real-time multimodal information system in which a number of relevant entities and users will be involved.
- **Activity 3. Pilot evaluation.** In this activity, the impact of the solution deployed in the pilot will be performed. This impact analysis will include the assessment of both functional and non-functional aspects of the pilot –e.g. impact on overall mobility or sustainability parameters.

Indra and the Universidad Politécnica de Madrid are part of the HARMONY project consortium. With a 1.3M € budget and a duration of 3 years, HARMONY is part of the Connecting Europe Facility (CEF) Programme, the largest investment plan of the European Commission for the development of transport infrastructures. In Spain, this programme is coordinated by the Ministry of Public Works, with the objective of completing the Trans-European transport network.

3. The HARMONY use cases

The use cases considered in the HARMONY project as the conceptual basis for the deployed pilot follow strictly the different points of view mentioned in the introduction.

3.1. Points of view considered in HARMONY

- **Mobility**
  Any incident in the road has a significant impact in the general environment of the public and private transport. When this happens, transport services and operations are affected in the following ways:
    - Those services operating under scheduled routes may suffer delays, or even modifications in their routes.
    - Indirectly, demand of other public transport modes may be affected.
- **Management aspects**
  It should be mentioned that at the moment there is no completely normalized information exchange process across different mobility operators in the region of Madrid. This would allow a more efficient response to incidents, and this is one of the aspects that is indeed specifically addressed in the HARMONY project.
- **Data exchange interoperability aspects**
  In the context of the urban mobility applications, standardization provides a guarantee in the capabilities to develop and deploy applications and systems. It contributes to the reduction in the dependence on information silos. During the last decades, different initiatives have tried to specify a reference architecture for multimodal data structures and systems, and the issues have been partially solved. In the case of Madrid, the objective is the integration of different data providers and service operators in a single specification for data structures and access points. This will imply considering both existing components and systems as well as new deployment, and consider at the same time a variety of different data types and formats, as described in Alfonso and Duquesne (2014, 2015).

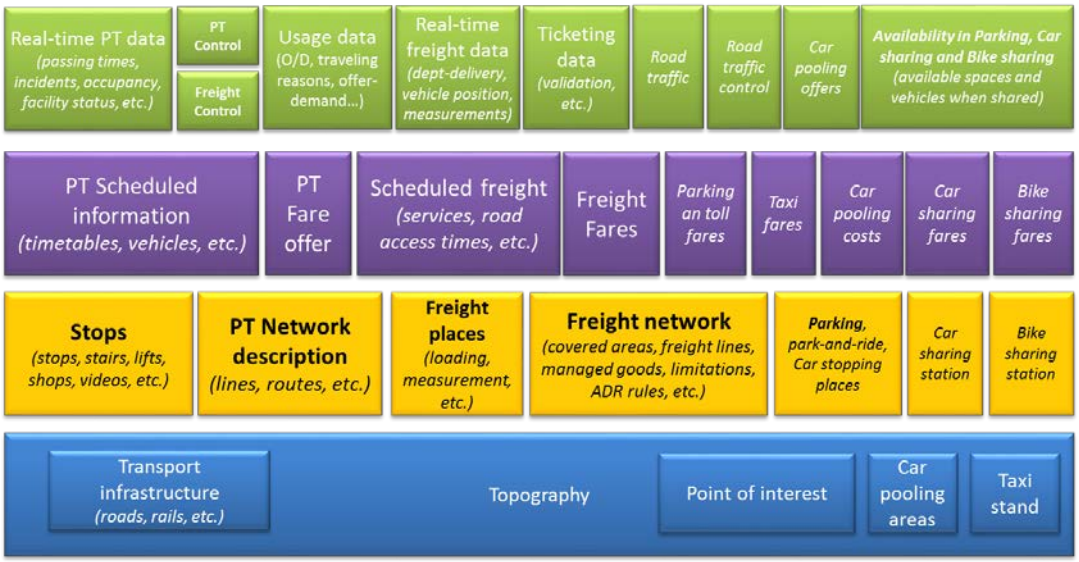

Fig. 1. Public Transport static and real-time data categorization proposal.

3.2. Description of HARMONY Use Cases

The pilot deployed in the HARMONY project consists of three use cases which aim to facilitate the access to information to different stakeholders, to improve their management operations, the quality of their services, and in general, the mobility information solutions to different entities and users. An additional use case is a study which will address the conceptual problem of integration of systems that use information structures based on CEN and ISO standards (e.g. NeTEx and SIRI) and systems using other structures, such as GTFS and GTFS-RT. As part of this additional use case, the project aims to provide a complete draft profile for an important mobility interchange in Madrid, the Plaza de Castilla interchange.

3.2.1.1. Use Case 1 – Public Transport management

The first of the use cases is a real-time management system of a public transport fleet. Route schedules, real-time vehicle tracking and a number of different scenarios in terms of routes, operators, stops, etc. will be considered.
The key in this use case is the definition of mechanisms to collect relevant public transport fleet information and share it with other operators and authorities. In the end, it is about providing traffic authorities with real-time urban/interurban public transport information, to complement the information already available for public authorities in their tasks of mobility coordination and management.

3.2.1.2. Use Case 2 – Urban Traffic monitoring

The focus in this case is the integration of traffic information and public transport information. Traditionally, these two datasets have not been developed in an integrated or connected way, and this is again one of the ongoing activities in different standardization groups at the moment.

Particularly, the information considered in this case is related specifically with incidents, both traffic incidents as well as public transport incidents. A platform integrating in a consistent way these types of incidents in the urban and regional environment will be really useful for transport operators, authorities and mobility agents, and of course for the users.

3.2.1.3. Use Case 3 – Transit Information provision

The third of the use cases is a simple real-time transit information provision, with the addition of a mechanism by which the user can in turn provide feedback to the management system. The final objective is to check how available real-time information about incidents and other circumstances of the trip can affect the users' travel decisions.

4. The HARMONY pilot

4.1. Pilot scenario

For the tests and system validation for the use cases described, the HARMONY project will deploy a pilot in the area of San Sebastián de los Reyes – Plaza de Castilla, to the northeast of Madrid. In the following figure a simple diagram of the public transport network in the area considered for the pilot can be seen.

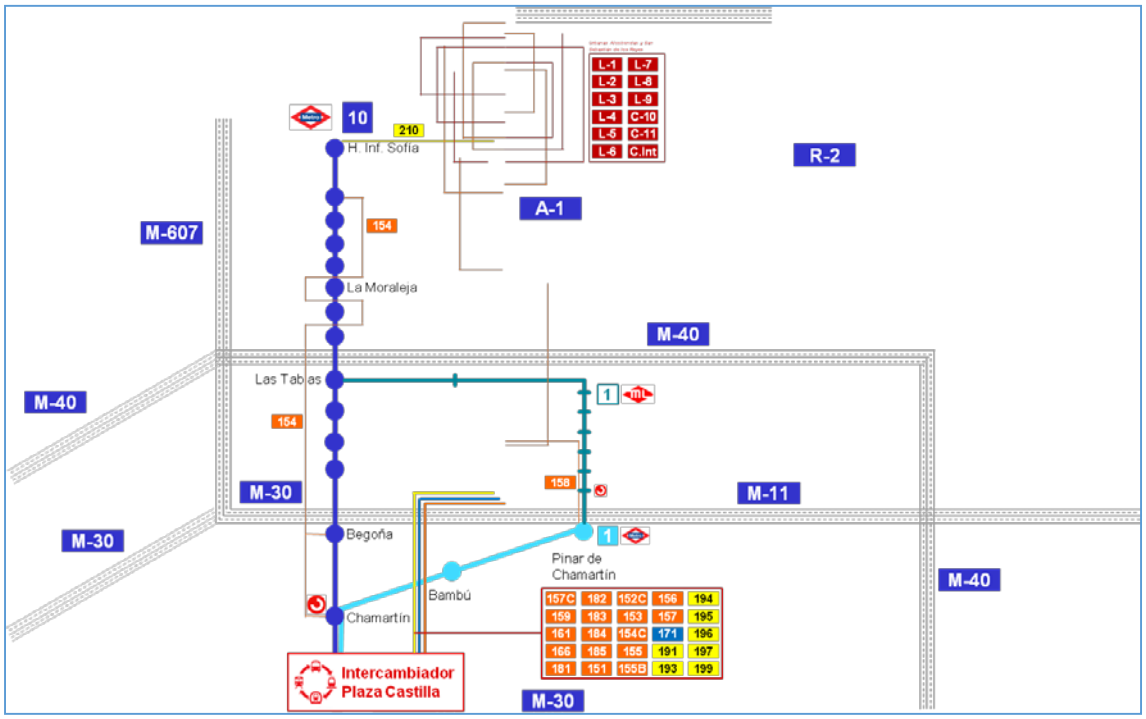

Fig. 2. Public transport network diagram in the HARMONY pilot area.

In the specific case of the HARMONY pilot, the selected stretch is a part of the inward A1 motorway. The A1 motorway is one of the entry roads to Madrid which registers some of the most acute congestion problems during peak hours. These problems are caused mainly because of a number of important industrial and commercial centres along the road in San Sebastián de los Reyes and Alcobendas (some 20Km away from Madrid), and the fact that the A1 gives direct access to the Castellana north-south axis of Madrid and M30 Madrid belt, as well as to the M607 motorway to Tres Cantos in the north of Madrid. In the deployment of the pilot, the INTERBUS interurban bus operator cooperates with part of the fleet and the control centre. Other stakeholders are planned to be incorporated in later stages of deployment.

4.2. Data exchanges – Introduction

The foundation of the integration of heterogeneous information in the proposed solution is the specification of mechanisms that can make use of different existing data structures. On one hand, the European Commission recommends the use of data structures based on CEN and ISO standards, as guarantee of interoperability between systems in different European cities (European Commission, 2016). But on the other hand, it cannot be ignored that the number of systems and solutions implemented using *de facto* specifications like Google GTFS and GTFS-RT is big enough so that this should be considered in the study. In fact, most of the public transport static and dynamic information in the case of the region of Madrid uses the GTFS and GFTS-RT specifications.

Google GFTS is a specification which focuses in the description of static information about the public transport network: topography, network description, fixed objects description, etc. Includes elements like routes, stops, schedules, etc. It is in this sense similar to the CEN NeTEx standard. GTFS-RT on the other hand, focuses in real-time information: service deviations, incidents, etc. It is similar to the CEN SIRI standard.

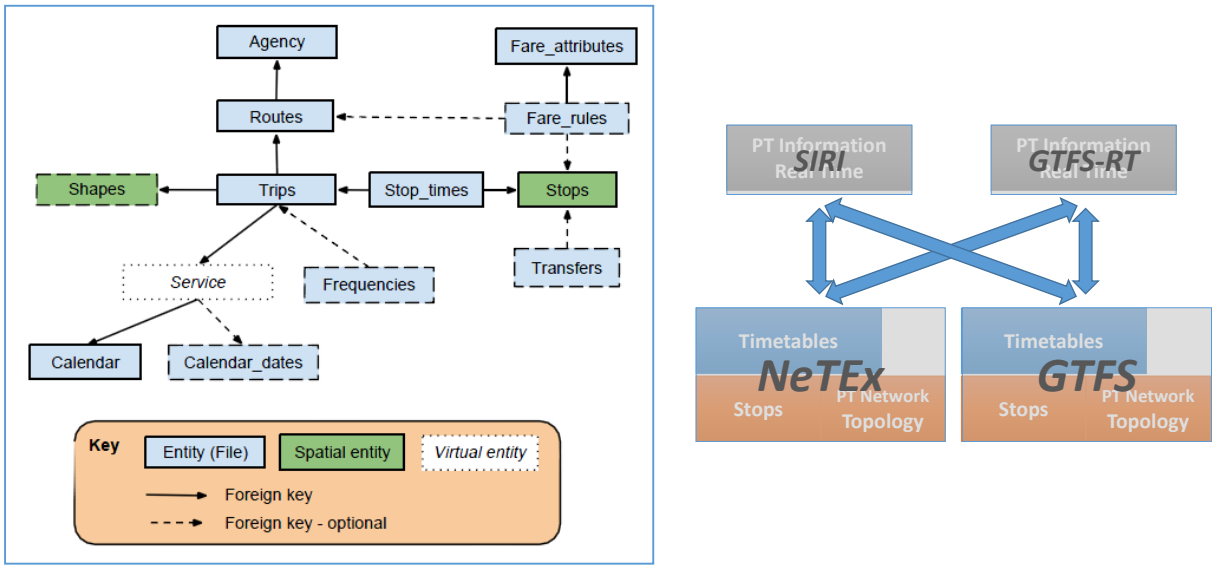

Fig. 3. (a) GTFS Data model (b) HARMONY pilot cross-interoperability scope

The HARMONY project is assessing the implication in the use of any of these standards or combination thereof, in terms of interoperability and scalability of the solutions. This implies a careful analysis of the specifications of information elements in each of them, and the identification of potential differences in the implementation and deployment of solutions based on these structures, at least for the scope considered in the HARMONY pilot.

4.3. Data exchanges – Static public transport information: NeTEx

Defined in the standards series CEN TS 16614, NeTEx is an information exchange format based on XML, and additionally, a number of services dedicated to the description and exchange of public transport static information. It is based on Transmodel and IFOPT standards structures and it is defined to cover most of the requirements of public transport operators (including passenger information systems, planning systems, vehicle monitoring and fare management).

4.4. Data exchanges – Real-time public transport information: SIRI

Defined in the standards series CEN EN/TS 15531, SIRI is a real-time public transport information exchange format, also based in Transmodel. Even though it was initially oriented to inter-centre exchanges, it was completed in 2014 with end-user information provision capabilities.

In a similar way to GTFS-RT, SIRI defines real-time exchanges as any modification in the static information in any given day that the system has about any of its elements. In other words, SIRI does not provide a complete description of the public transport environment (that is the objective of NeTEx), but only changes in this environment, assuming therefore that the main elements describing this network environment are already defined.

SIRI defines a number of web services (SOAP) to access the information. Some of the services considered in the HARMONY pilot are: *Vehicle Monitoring Service, Stop Monitoring Service, General Messaging Service* or *Situation Exchange Service.*

4.5. Data exchanges – Road traffic information: DATEX II

Defined in the standards series CEN TC 16157, DATEX II is a road network and traffic information exchange format. Designed for flexibility and initially traffic management inter-centre information exchanges, DATEX II is widely accepted amongst public authorities.

DATEX II includes a wide range of data structures, for road and traffic related events, operator actions, non-road event information, etc. but in the case of the HARMONY project, the focus will be in incident description.

5. Results and conclusions

The tasks related to the Activity 1 and Activity 2 have been almost concluded in relation to the first two use cases. Design and implementation of the mechanisms to collect static information from public transport operator and integration of real-time information. These components have been implemented using GTFS and GTFS-RT/SIRI structures, and have been integrated in the information system of the INTERBUS operator at their control centre.

The milestones defined in the project for the pilot development and deployment are thus followed:

- **Milestone 1 – Integration of public transport operators static information.** The first stage of the pilot focuses on the integration of static data from a public transport operator. Static data includes network topologies, routes and timetables, etc. This has been done using the GTFS format, and the mechanisms to collect the data have already been implemented and integrated at the control centre, where the operators have been using the tool seamlessly in conjunction with their management and control system.
- **Milestone 2 – Integration of public transport operators real-time information.** The second stage of the pilot focuses on the integration of real-time information from different operators and modes. Addressing essentially real-time vehicle tracking and incidents in the public transport network, this has been done using GTFS-RT and SIRI formats, and has been integrated again at the control centre for the operators.
- **Milestone 3 – Integration of road traffic real-time information.** In this still developing stage, the pilot focuses on integrating real-time road traffic incident information. This is being done using the DATEX II format, and will be integrated at the control centre for the operators.
- **Milestone 4 – Information provision mechanisms.** Also still under development, the idea is to incorporate to the system the mechanisms that will allow the provision of information (direct or elaborated) to entities, operators, passengers or users in general.

In terms of the standardization use case, there is an ongoing activity of defining the standards profiles for static and dynamic information for selected INTERBUS network elements, and also in the case of the NeTEx profile for the Plaza de Castilla interchange.

The Plaza de Castilla interchange is a major mobility infrastructure in the Northern part of the city. It links the interurban bus lines (37) coming from the Northern part of the region of Madrid, via the A1 and M607 motorways, the lines 1, 9 and 10 of Metro, and several urban bus lines (21). It also has a public parking with 400 available parking places. With 4 levels, including a surface level, it serves over 20 million passengers a year. Elaborating the profile for this facility is a very complex task, the procedure of which includes from the different NeTEx frame model selection, to the definition of the relevant model hierarchies, links between models, specification of elements, and finally the implementation of the XML schemas for the elements. The basic elements for description can be seen in the appendix.

The basic definition of the Plaza de Castilla interchange model in NeTEx and the transferability guidelines for other similar infrastructures will be one of the major contributions of the HARMONY project to the standardization of multimodal information systems, and will complement the activities carried out in France, Germany or Italy.

Together with the activities closer to the pilot deployment, the evaluation activities have also started, with the definition of the questionnaires that will be given to stakeholders and users to evaluate the expectations and at a later stage the impact of the solution proposed in terms of improvement in the mobility efficiency, safety, ease of use and comfort, amongst others.

Acknowledgements

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Appendix – Plaza de Castilla interchange schematics

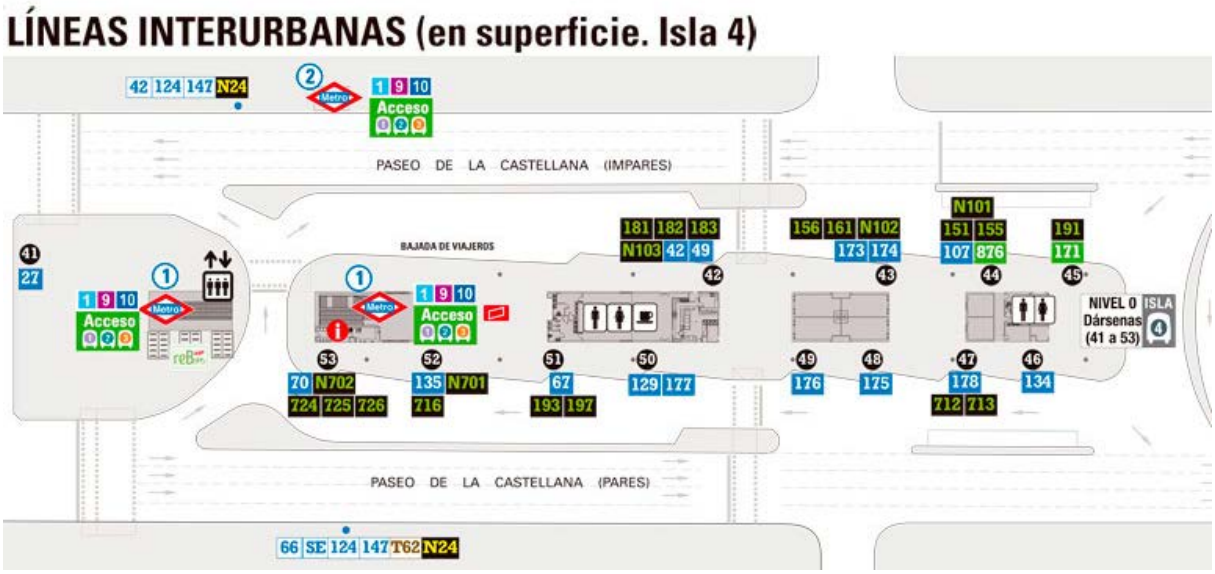

Fig. 4. Plaza de Castilla interchange Surface Level (0) diagram

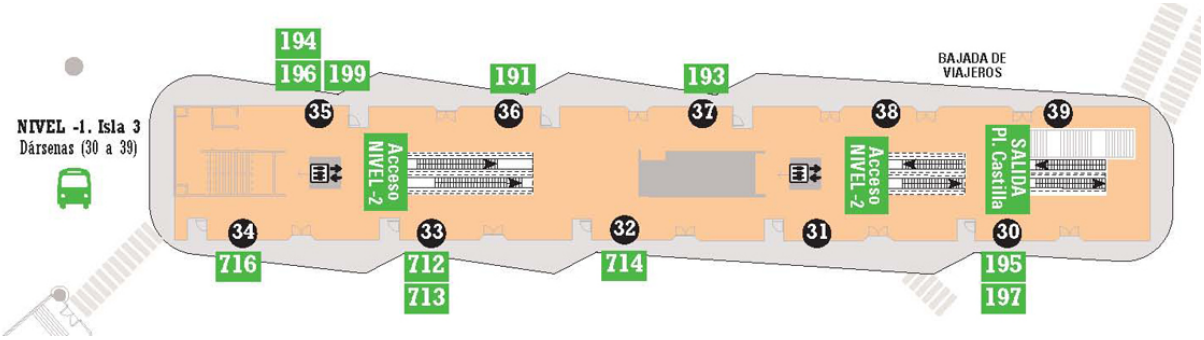

Fig. 5. Plaza de Castilla interchange Level -1 diagram

Fig. 6. Plaza de Castilla interchange Level -2 diagram

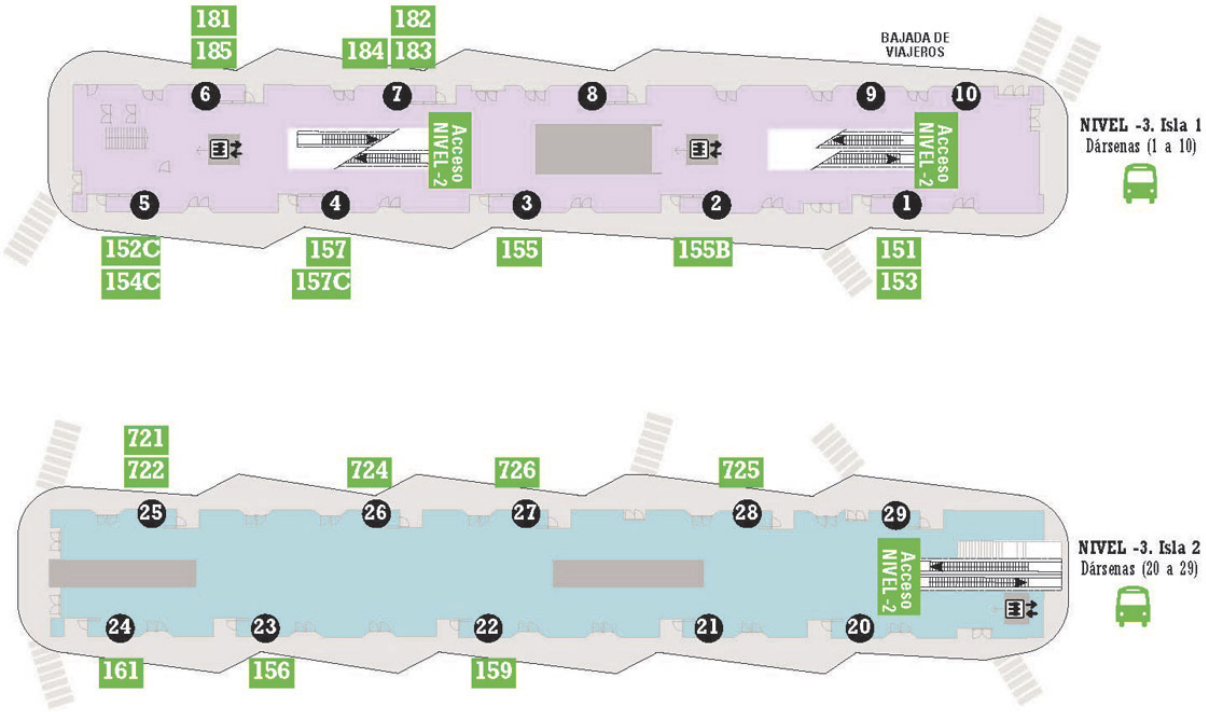

Fig. 7. Plaza de Castilla interchange Level -3 Quay 1 and Quay 2 diagram

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