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2020 CiVITAS
Cleaner and better transport in cities

DESTINATIONS

D8.3

Guidelines for the design of ITS solutions supporting project measures

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Abstract

As the CIVITAS DESTINATIONS project shows, Local Authorities and transport operators shall adopt concrete measures and strategies in order to enhance service operation, organization and monitoring and to achieve a higher level of quality and reliability for the provided services. In this context technologies and, in particular, ITS (Intelligent Transport Systems) are one the key tools in the hands of decision-makers and service providers for the improvement of public transport and sustainable mobility services. Therefore ITS products/services have increasingly captured the interest of the main public agencies, PT companies and mobility stakeholders.

For this reason, the CIVITAS DESTINATIONS Project has planned a Task (Task 8.3) for providing expert support to sites (Sites Managers and Measure Leaders) for the design, implementation and operation of ITS supporting demonstration measures.

This deliverable is one of the results of sub-task 8.3.1 targeted to the ITS design.

The deliverable provides key guidelines to be taken on board by Site Managers and Measure Leaders in the design of ITS supporting the demonstration measures planned for CIVITAS DESTINATIONS.

Into details, the deliverable:

- Resumes the role of Task 8.3.1 in workpackage 8 and in the whole project and clarifies how CIVITAS DESTINATIONS Site Managers and Measure Leaders can exploit the provided guidelines and recommendations (section 2);
- Specifies the methodology adopted in Task 8.3.1 and the activities carried out to date (section 3) according to the following objectives:
    - To identify the ITS supporting sites demonstration measures;
    - To define a classification of ITS into categories (i.e. ITS for Traffic Management, ITS for Public Transport, etc.) and sub-categories (i.e. Traffic Management, Traffic sensors, Infomobility, e-ticketing, platform for the management of sharing services, etc.). This will allow to reduce the wide range of different ITS involved in CIVITAS DESTINATIONS and to find the common ground to provide the guidelines for design and to foster experience exchange among the sites
    - To identify a “core group” ITS on which the guidelines will be focused.
- Provides the guidelines and related set of recommendations for the “core group” ITS identified:
    - Common data layer (section 4);
    - Infomobility APP (section 5);
    - User information on Public Transport (section 6);

- AVM/SAE/AVL – Fleet Monitoring (section 7);
- E-ticketing (section 8);
- Management of vehicle (car) sharing (section 9);
- Parking Management System (section 10).

Each section presents a similar structure: recommendations are provided:

- To identify common approach to system architectural design and how to tailor it to sites objectives and context;
- To identify key functionalities to be provided by the system and how to tailor it to sites target and operational procedures;
- To identify key choices in the design process;
- To highlight standard when (applicable).

The two last sections of the deliverable provide indications for the integration/cooperation of ITS for the improvement of mobility governance and smart cities approach (section 11) and highlight the impacts of operational and organisational issues on ITS performances during the operation.

Document History

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1 EXECUTIVE SUMMARY

The measures in CIVITAS DESTINATIONS include a large panel of technologies among which Intelligent Transport Systems (ITS) solutions are identified. These specific technologies are often considered as one of the key tools to achieve real results, better performances and enable the introduction of new-customer facing services in transportation systems. Nevertheless, if their potential is validated and recognized, experts point out different risks of failure in the implementation phase associated to insufficient planning or a lack of operational accompaniment in the deployment.

To address these risks and ensure the sustainability of the measures, the CIVITAS DESTINATIONS project has planned as part of its horizontal workpackages (WP8) a specific task to provide Site Managers with guidance and technical expertise regarding ITS design. The Deliverable D8.3 has been compiled following the methodology developed in task T8.3.1. The full methodology is detailed in the first sections of the document. The approach is based on a deep analysis of measures components in terms of ITS, functionalities and objectives. This analysis led to the definition of a set of “homogeneous” recommendations to be used by Site Managers which can be used by Site Managers regardless the state of deployment at local level (please see section 2.4). The recommendations for ITS design relate to: the architecture and main components, the main functionalities, the key choices for the design. Standards have been included where necessary. In addition of the provision of design guidelines related to the identified “core group” ITS, relevant examples of possible integration levels of ITS for improving mobility governance and introduce “smart cities” concepts are provided. This perspective is particularly relevant for CIVITAS DESTINATIONS as one key objective of the project is to demonstrate how a coordinated and cross-related set of measures can contribute to improve the mobility for tourists and residents: this implies that the related ITS must be designed taking into account the requirement/target of a future cooperation/integration.

2 ROLE OF WP8 AND D8.3 IN CIVITAS DESTINATIONS

The Workpackage 8 "**Innovation management for growth**" in CIVITAS DESTINATIONS is a horizontal workpackage working on three main levels:

- Guidelines and training on stakeholders' involvement;
- Guidance in developing business cases through training, user needs analysis and service design;
- Operational guidelines, trainings and technical assistance to guarantee the effectiveness and high quality performances of ITS/smart technology solutions.

It involves three main tasks:

- **Task 8.1 Stakeholder engagement and cooperation;**
- **Task 8.2 Service design and business modeling;**
- **Task 8.3 Smart technologies and ITS implementation.**

Task 8.3 is dedicated to the technical support to different CIVITAS DESTINATIONS sites in the development of measures involving advanced technologies and ITS systems. It aims to guide the site technology activities from the design phase to the implementation and sign off-of ITS and has been structured in this end with four-sub-tasks: common guidelines for the design, implementation and testing (T8.3.1), prescriptions to manage the procurement and contracting (T8.3.2), ITS implementation (T8.3.3), ITS performance indicators (T8.3.4). MemEx acts as expert CIVITAS DESTINATIONS partner to provide technical support to Site Managers along all these tasks.

The approach used to provide supporting activities in Task 8.3.1 "Systems Design" is described in section 2.2. In order to put into practice the horizontal role of the task the following objectives have been considered to design T8.3.1 approach:

- To group ITS supporting the operation of site demo measures under common categories in order to foster synergies and exchange of experience among the sites;
- To provide Site Managers and Measure Leaders with recommendations for ITS design including:
    - Common guidelines for the design of technologies supporting CIVITAS DESTINATIONS demo measures;
    - Definition of a common/similar architecture specifications and the identification of a core of common functionalities among sites;
    - Identification of the different options in terms of solutions and technologies available on the market in order to make Site Managers and Measures Leaders aware of the key principles to be used in ITS design process;

- Identification of the most relevant standards to be adopted in designing ITS;
- Guidelines how different ITS can cooperate (be integrated) for the provision of added value services for mobility growth.

D8.3 represents the main output of CIVITAS DESTINATIONS Task 8.3.1 activities carried out in the period September 2016 – March 2017 and it has been developed also on the basis of the outcomes of the webinar held on the 11th of January 2017 and coordinated by MemEx (see section 2.2 for details).

2.1 WHY THESE GUIDELINES ARE NECESSARY ?

The efficient governance (planning, monitoring and management) of urban mobility is one of the key priorities of Local Authorities in European cities despite their dimensions, in order to reduce the negative impacts of traffic congestion (on the different aspects of energy, environment and social costs), to improve the overall city accessibility and connections to peripheral areas and to enhance the overall urban livability and citizens quality of life. This approach is also promoted by the European Union, which has stressed the need for tangible measures in this direction in several official documents (i.e. the WHITE PAPER (2011), the INTEGRATED MOBILITY PACKAGE launched in December 2013, the COVENANT of Mayors for sustainable European towns (2010), etc.) financing different programmes and specific large multi-sectors projects. This approach clarifies that solutions for the improvement of public transport and mobility governance must be designed considering all the involved aspects (social, behavioural attitudes, economics, infrastructures, technologies, cooperation/institutional, operational/organizational, etc.),

As the CIVITAS DESTINATIONS project shows, Local Authorities and transport operators shall adopt concrete measures and strategies in order to enhance service operation, organization and monitoring and to improve the quality and reliability of mobility services. In this context, technologies and, in particular, ITS (Intelligent Transport Systems) are one of the key tools in the hands of decision-makers and service providers. They allow on the one hand, to improve service control procedures and reliability and, on the other, to implement a wide range of added-value services (i.e. infomobility services). Indeed, the current ITS market offers a wide range of technologies, systems and solutions for the management of the different processes related to mobility, traffic and collective public transport services. The available products can be basically divided into 4 macro-categories:

- Systems for vehicle traffic management;
- Systems for travel and user information;
- Systems for collective public transport management (i.e. AVM systems, integrated faring systems, etc.);
- Inter-modal systems and logistics platforms (i.e. park&ride systems).

ITS (Intelligent Transport System) products/services had increasingly captured the interest of the main public agencies, PT companies and mobility stakeholders. This is largely driven by the common perception that implementation of ITS can immediately achieve real results and better performances, enables the introduction of new customer-facing services, while at the same time decreasing the amount of human resources required (e.g. in on-street control and administration functions), resulting in overall costs savings. This interest is also motivated by the decreasing cost trends of different devices and subsystems, and by the wider availability of telecommunications and internet platforms.

While this potential certainly exists and is well-achieved in some cases, it is necessary to introduce a strong note of caution at this point.

In a wide range of countries, the actual experience with ITS applications shows that expected or claimed performances and/or benefits are often not realized because of insufficient feasibility study to base/structure the ITS design and deployment or a lack of organizational and operational measures in the implementation. The technology itself does not solve problems; it needs to be used wisely and in an appropriate manner, notably in considering the local context.

ITS solutions must be tailored to the specific stakeholder's objectives and functional requirements. While there are common elements and similarities to guide ITS design and deployment, there is no 'one size fits all' solution which can be introduced everywhere. The design and deployment must be carefully and duly customized based on requirements, constraints and available resources.

These assumptions have driven the definition of T8.3.1 approach (detailed in section 2.2): the design of ITS solutions are deeply influenced and cross-related with local context and needs; anyway a list of key recommendations and choices can be provided allowing to drive the whole process and implement it according to the local practice.

2.2 ROLE OF T8.3.1 IN CIVITAS DESTINATIONS

As mentioned above, the task producing this deliverable (T8.3.1) is part of CIVITAS DESTINATIONS WP8 whose role is to provide expert (methodological and operational) assistance to Site Managers and Measures Leaders for the design of ITS supporting the operation of demo measures to be demonstrated in WP2-WP7.

T8.3.1 will act at two parallel levels:

- It provides methodological assistance on ITS design highlighting key principles for the identification of the most suitable technological solutions available on the market and key options to be evaluated in the design process. The milestones related to this methodological assistance were:
    - The webinar organized by MemEx on the 11th of January (see section 2.2 for details);

  - This deliverable as consolidation of the expert assistance provided through the webinar and consolidated in the following contacts with the Site Managers and Measures Leaders;

- It provides "on demand" provision of expert assistance in all the technical and operational issues dealing with ITS design. This activity includes revision of documents provided by partners, provision of expert opinions, etc. This activity has been carried out on the basis of the requests forwarded to MemEx by site partners and is on-going as it will last over the whole period of the design of ITS supporting the operation of demo measures in CIVITAS DESTINATIONS sites. This activity will be guaranteed also after the release of these guidelines.

In particular, the webinar gave the opportunity to present the task approach (see section 2.3) and to clarify the two-level activities carried out by MemEx: the methodological assistance (guidelines and recommendations) supporting the ITS design process and the expert assistance provided on request. The mapping of ITS under common categories was presented to Site Managers for review and consolidation. The "core group" of ITS selected among all the identified categories (see section 2.3) have been introduced with a first set of key recommendations (draft of the contents of this document). Comments and feedback from Site Managers have been received, in particular specific requests for the design of "core group" ITS have been included in this deliverable and specific requests on other ITS have been solved bilaterally.

2.3 APPROACH USED IN T8.3.1

In the CIVITAS DESTINATIONS project, a wide range of different ITS is planned to support the operation of measures to be demonstrated.

Taken together, CIVITAS DESTINATIONS demo measures belong to different mobility services covering various areas (PT, Traffic Management, Infomobility, Service Management Platforms, Parking Management Systems, etc.). Furthermore, the objectives of measures (even when the mobility service is similar) can be slightly different both in terms of context/background, local requirements and services to be provided to local Public Authorities, Mobility Stakeholders and end-users/citizens. Finally, the design/implementation stage of ITS can be different: in some cases ITS to be introduced is new in the local context whereas, in other cases, the demo measures require an adaptation/updating/integration of ITS already operated at local level.

The methodological approach used in T8.3.1 was based on the following steps:

- Identification of ITS supporting local demo measures in the sites (see section 3.1);
- Mapping ITS into categories and sub-categories (see section 3.2);
- Identification of a "core" group of ITS which are more relevant in CIVITAS DESTINATIONS perspective (see section 3.3);

- Recommendations for the design of ITS not included in the “core” group have been provided through bilateral contacts between MemEx and the involved partners.

D8.3 is based on the consolidation of the design guidelines for “core” group of ITS identified in T8.3.1.

2.4 HOW SITES CAN USE D8.3 GUIDELINES

CIVITAS DESTINATIONS sites have different perspectives/needs:

- Demo measures where ITS are new at local level;
- Demo measures where ITS are an extension/improvement of existing systems.

Analyzing the description of demo measures in the Inception Report, it was also clear that the progress status of design activities of ITS at the beginning of the project was different site by site and measure by measure: in some cases the ITS functionalities have been already identified needing for a detail/specifications during the project; in other cases the systems were identified but functionalities needed to be detailed.

Accordingly these differences among the CIVITAS DESTINATIONS sites, the deliverable D8.3 aims:

- To provide guidelines for ITS specifications – new systems, design activities at initial stage;
- To identify key principles for the verification of the specifications and design of the systems to be improved/extended.

3 METHODOLOGY IMPLEMENTED IN T8.3.1

In this section the methodology implemented in T8.3.1 (briefly resumed in section 2.4) are detailed.

3.1 IDENTIFICATION OF ITS SUPPORTING PROJECT LOCAL DEMONSTRATION MEASURES

A first analysis of the site measures (using the last description provided in the amendment version) has been carried out identifying two main categories:

- The demo measures where ITS role is more relevant (for the success of the measure);
- The ones where ITS role is less relevant.

Moreover, a specific analysis of the complexity of the design of ITS has been carried out identifying the demo measures where the design of ITS is more critical in terms of architecture/functionalities and options/impacts and the ones for which the design of ITS is less critical.

3.2 MAPPING OF ITS SUPPORTING PROJECT LOCAL DEMO MEASURES

In general, at city level, different systems can be considered for the possible implementation in order to achieve an overall sustainable mobility governance, in particular:

- MODELLING AND SIMULATION TOOLS;

- TRAFFIC LIGHT COORDINATION (UTC);
- TRAFFIC DATA COLLECTION;
- VARIABLE MESSAGE SIGNALS (VMS)
- INTEGRATED PARKING MANAGEMENT;
- ACCESS CONTROL and CONGESTION/ROAD PRICING;
- MOBILITY SUPERVISORY and OBSERVATORY;
- PARKING MANAGEMENT SYSTEM (PMS);
- FLEET MONITORING SYSTEM (AVM);
- INTEGRATED TICKETING SYSTEM;
- INFOMOBILITY PLATFORM/PORTAL;
- GOODS DISTRIBUTION PLATFORM.

These systems can be classified (categorized) as:

- ITS for traffic management;
- ITS for Public Transport (PT) services operation;
- ITS supporting other mobility services (logistics, cat/ride sharing services, multimodal infomobility, etc.).

Public Transport plays a key role also in the accessibility and quality of medium-small size urban areas as planned in CIVITAS DESTINATIONS sites, therefore the specific ITS (AVM, e-Ticketing User information, passengers counting) are fundamental not only to support Public Transport services operation but also to improve the overall city accessibility and integration of different mobility services (first of all Parking system). As example the smart cards used for payment of Public Transport are extended to other mobility services.

The following Table 3.1 shows the classification of ITS (supporting the operation of demo measures) into the main categories and sub-categories. A second level of classification map the different ITS grouped by the abovementioned categories in more homogeneous groups (i.e. traffic sensors, road safety, supervision and management, parking management, etc. for traffic or fleet monitoring, ticketing, etc, for PT). The following Table 3.2 and 3.3 show the final results of the classification process providing the sub-categories identified for traffic management (Table 3.2) and others (PT and other mobility services, Table 3.3), in particular:

- The column “ITS role” (HIGH, MEDIUM, LOW) indicates the relevance of ITS implementation for the operation of demo measure;

- The column “Complexity of user needs analysis” (HIGH, MEDIUM, LOW) indicates the level of complexity of the design of the ITS in terms of available options and impacts with user needs analysis, site background, operational procedures and organization structure;
- The column “ITS category” indicates the category (Traffic, PT, others) and the related sub-categories.

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP2	Madeira	MAD2.2	Smart metering and user generated content to improve urban mobility planning and services	HIGH	Functions are: counting (cars, people, cyclists), monitoring (meteorological information, emissions and air quality), collect users feedbacks and needs. Wireless networks and crowd-source data will be central resources to test and implement (50 traffic sensors installed at main 4 axis)	MEDIUM	Traffic Management - Traffic sensors PT -Passengers counting Crowdsourcing tools
WP2	Rethymno	RET2.2	Smart systems for urban planners, PT operators and users	HIGH	IT online platform development for real-time data collection/analysis of PT use/traffic loads. Sensors for mobility and environmental data	HIGH	Traffic Management – data aggregation platforms Supervision/control Traffic sensor
WP2	Elba	ELB2.2	Elba Open data layer	HIGH	Integrated data layer composed by the data generated by different devices/services which exposes open data service for third party implementation	HIGH	Infomobility – data aggregation platforms
WP2	Malta	MAL2.2	Sustainable urban mobility plan award	NO			
WP2	Las Palmas	LPA2.2	Smart CIVITAS DESTINATIONS	HIGH	Electronic devices that recording consumption of energy technological platform that will be used to collect, integrate, store and analyze local data with a global perspective Provision of infomobility + tourist info services	HIGH	Infomobility – data aggregation platforms
WP3	Rethymno	RET3.1	Active healthy and inclusive mobility for all	LOW	Systems targeted for blind and deaf people systems to be installed at traffic light crossings to increase safety	LOW	Devices for people with disabilities
WP3	Elba	ELB3.1	Increased level of safety of pedestrian crossing	HIGH	Devices to increase safety at crossing points	LOW	Road safety Devices for people with disabilities

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP3	Elba	ELB3.2	Sustainable and safe accessible bike and pedestrian route design	LOW	ITS as part of the solution to increase safety and accessibility for pedestrian and bike lanes	LOW	Road safety
WP3	Limassol	LIM3.1	Increase cycling and walking in combination with special interest tourist activities as an integrated product	NO			
WP3	Limassol	LIM3.2	Accessibility for disabled and visually hearing impaired	LOW	Guidance system for people with disabilities	LOW	Devices for people with disabilities
WP3	Madeira	MAD3.1	Innovative solutions for safe and secure public spaces	LOW	CCTV for urban spaces monitoring	LOW	Video Surveillance
WP3	Las Palmas	LPA3.1	Attractive, safe and accessible public space at major attraction	NO			
WP3	Limassol	LIM3.3	Safe routes to school in Limassol	NO			
WP3	Limassol	LIM3.4	Attractive and accessible public places to promote intermodal leisure trips	NO			
WP3	Elba	ELB3.3	Requalification of main taxi station area in Portoferraio	NO			
WP3	Madeira	MAD3.2	School and foreign students awareness campaign package	NO			
WP3	Rethymno	RET3.2 (merged in RET3.1)	Mobility plan for schools/university's communities				
WP4	Rethymno	RET4.2	Building a share mobility culture	HIGH MEDIUM	Web based platform for sharing service Extension of bike sharing system with e-bikes Behavioural change tool	HIGH LOW	Platform to manage a range of sharing service

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP4	Elba	ELB4.1/4.2/4.3/4.4	Shared mobility services and mobility Agency in Elba	HIGH	Platform for the coordinated management of different mobility services both individual and collective	HIGH	Platform to manage a range of sharing service Infomobility – data aggregation Mobility Portal providing info-services
WP4	Limassol	LIM4.1	Electric car sharing connecting the Limassol area-airports-port	HIGH	Platform for the management of the service On-board equipment	HIGH	Platform to manage a single sharing service
WP4	Las Palmas	LPA4.1	Public e-bike system	HIGH	Platform for the management of the service APP for info-services Extension of the system already operated	MEDIUM	Platform to manage a single sharing service
WP4	Limassol	LIM4.2	Expansion of public bike sharing system including e-bikes	HIGH	Platform for the management of the service Extension of the system already operated	LOW	Platform to manage a single sharing service
WP4	Malta	MAL4.1	Promoting e-bike sharing and car sharing	NO			
WP4	Madeira	MAD4.1	Promote the uptake of clean vehicles by fleet operators	MEDIUM	Information platform, available through a mobile and desktop application, regarding the location of available charging points. Monitoring system to measure electric vehicle consumption for transport	MEDIUM	Management system of electrical charge points
WP4	Las Palmas	LPA4.2	Fast charging EV	LOW	Installation of new charging stations Operation of new electrical mini-van for SAGULPA fleet	LOW	Management system of electrical charge points
WP4	Rethymno	RET4.1	Powered charging infrastructures in Rethymno	LOW	Installation of new charging stations	LOW	Management system of electrical charge points

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP4	Limassol	LIM4.3	Promote the uptake of electric vehicles (charging infrastructures for cars and two-wheelers). Campaign on e-mobility	LOW	Implementation of new EV- chargers supported by renewable energy sources Introduction of e-bike	LOW	Management system of electrical charge points
WP4	Elba	ELB4.5	EV legislation revision and charging infrastructures in Elba	NO	Implementation of new EV- chargers (out of project funding)		
WP5	Madeira	MAD5.1	Smart and clean urban freight logistics at tourist CIVITAS DESTINATIONS	LOW	Monitoring of load/unload parking spaces	MEDIUM	Parking Management
WP5	Las Palmas	LPA5.1	Smart Distribution System	HIGH	Fleet monitoring system for optimizing distribution process, with communication of realistic delivery times to the clients. Three access level on APP/web desk for drivers, customers and traffic managers	HIGH	Logistics Management Systems Fleet Monitoring System
WP5	Rethymno	RET5.1	Implementation of a pilot logistics system in Rethymno	HIGH	On-line platform to coordinate freight distribution processes among the different actors (feasibility)	HIGH	Logistics Management Systems
WP5	Elba	ELB5.1	Island freight logistics for tourist services	HIGH	Tool for scheduling the delivery service	HIGH	Logistics Management Systems
WP5	Limassol	LIM5.1	Limassol city centre Urban Freight Logistic Action Plan	HIGH	Online platform for managing freight transportation. APP as users interface	HIGH	Logistics Management Systems
WP5	Malta	MAL5.1	Last Mile delivery of goods	HIGH	Logistics Platform (feasibility)	HIGH	Logistics Management Systems
WP5	Rethymno	RET5.2	Setting up of a chain from used cooked oil to biodiesel	NO			
WP5	Limassol	LIM5.2	Promotion and creation of network for collecting of used cooking oil	NO			

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP6	Madeira	MAD6.3	Mobility planning for tourism related companies	MEDIUM	Regional specialized platform to manage and share information related to public transport: instant info to and from major POI's, events, schedules, itineraries, etc.	HIGH	Infomobility – data aggregation platforms
WP6	Rethymno	RET6.1	(RET 6.1.a) - Sustainable mobility agency for tourists/visitors, Sustainable Mobility campaign & Eco-drivers capacity building (RET 6.1.b) - New products combining tourism and mobility	HIGH	Online platform for promoting sustainable mobility plan for selected routes. Travel planner functionalities. APP as users interface.	HIGH	Infomobility – data aggregation platforms
WP6	Elba	ELB6.1	Combined products for tourism and mobility	NO			
WP6	Limassol	LIM6.1	Awareness on the use of sustainable mobility modes for leisure trips	NO			
WP6	Limassol	LIM6.2	Business cases for combined tourist and mobility products	LOW	Self-service ticket machines	MEDIUM	PT – e-ticketing
WP6	Malta	MAL6.1	Green Mobility Hotel Award	NO			
WP6	Madeira	MAD6.1	Gamification as a way to induce behavioural change in Mobility	HIGH	Interactive installation at bus stops	HIGH	Systems for behavioural change
WP6	Madeira	MAD6.2	Green credits: a Business Model for Mobility, Sustainability and Tourism	HIGH	Platform to gather data from different sources of information, integrate and display them Management of green credit scheme	HIGH	Systems for behavioural change
WP6	Las Palmas	LPA6.1	Green Credits Scheme	HIGH	Green credit scheme integrated in the e-ticketing system operated by GUAGUAS	LOW	System for behavioural change
WP6	Limassol	LIM6.3	Bicycle challenge: competition between employees of companies	NO			

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP6	Malta	MAL6.3	Promoting sustainable mobility among tourists	HIGH	Development of app to provide integrated mobility solutions and collect user needs	HIGH	Infomobility – data aggregation platforms Crowdsourcing tools
WP6	Rethymno	RET6.3	Green mobility awarding scheme in Rethymno	NO	Development of green credit scheme		System for behavioral change
WP6	Madeira	MAD6.4	Low emission zones and smart parking management	HIGH	Adaptive traffic lights PT priority Platform for traffic monitoring	MEDIUM	Traffic Management – Traffic lights & priority
WP6	Limassol	LIM6.4	Smart Parking Guidance System	HIGH	Parking Guidance System	MEDIUM	Infomobility – Parking Guidance
WP6	Malta	MAL6.2	Curbing High Polluting vehicles from the road	HIGH	Extension of the control access system already operated. Application of crowdsourcing techniques through the use of an APP	MEDIUM	Traffic Management – Road Pricing & Access Control Management Crowdsourcing tools
WP6	Rethymno	RET6.2	Strategic study for car free zone in the historic city centre of Rethymno	HIGH	Access Control System	MEDIUM	Traffic Management – Access Control Management
WP7	Madeira	MAD7.2	Attractive public transport	HIGH	Installation of interactive panels On-line selling platform	MEDIUM HIGH	Infomobility PT – e-ticketing
WP7	Las Palmas	LPA7.1	Communication for the introduction of the Bus Rapid Transit (BRT)	NO			
WP7	Rethymno	RET7.2	Improved public transport services for tourist and residents in Rethymno	LOW	Real time travel information APP to collect user needs on PT	MEDIUM	Infomobility Crowdsourcing tool
WP7	Elba	ELB7.1	Improve PT services for tourists on ELBA	NO			

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP7	Limassol	LIM7.1	Improvement of PT routes, time tables, ticket procedure and bike transportation on buses to make the service more attractive	NO			
WP7	Malta	MAL7.1	Further integrate ferries into the Public Transport network	LOW	Installation of VMS signals with timetable of ferries and buses.	LOW	Infomobility – on road
WP7	Madeira	MAD7.1	Electrical vehicles and clean fuels for public transport and urban fleet	MEDIUM	Introduction of eco-driving system	LOW	PT – Eco-driving
WP7	Las Palmas	LPA7.2	Hybrid buses in the urban bus fleet	NO			
WP7	Rethymno	RET7.1	Electric shuttle bus and eco-driving in Rethymno	MEDIUM	Introduction of eco-driving system	LOW	PT – Eco-driving
WP7	Limassol	LIM7.2	Creation of an electric bus hop on hop off service in the old town	NO			
WP7	Malta	MAL7.1	Integration of ferries into the Public Transport	NO			

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP7	Madeira	MAD7.3	Smart PT traveller information service	HIGH	Improvement of information about public transport and others sustainable modes on the websites (tourist services, etc.) Integration of other bus operator and other transport modes into the HF journey planner Installation of new information panels and provision of infomobility services on APP (including services for visually impaired users) Automatic tickets vending machine	LOW MEDIUM MEDIUM LOW	Infomobility – data aggregation PT – e-ticketing
WP7	Madeira	MAD7.4	Public Transport Smart Multi-task Ticketing System, in open standards	HIGH	A new Smart and Dematerialized interoperable Ticketing System combining several selling options (internet, mobile, virtual wallet) and ticket validation (NFC, QR codes). Clearing system Data collection on passengers trips for feeding Smart City Management System	HIGH	PT – e-ticketing
WP7	Las Palmas	LPA7.3	Real time mobility and tourism information services	MEDIUM	Extension of the on-road infomobility system already operated upgrading it with solar cells, smart card reading functionality and voice speaking for visually impaired people	LOW	PT – e-ticketing Infomobility – on road
WP7	Las Palmas	LPA7.4	Integrated payment solutions for mobility and tourism	HIGH	Extension of the e-ticketing system already operated to new BRT and implementation of new pricing policies	MEDIUM	PT – e-ticketing

WP	*Site*	*Measure Code*	*Measure Title*	*ITS role*	*Which ITS*	*Complexity of UNA and its design in the local context*	*ITS category*
WP7	Elba	ELB7.2	Integrated payment	HIGH	Technical feasibility for integrated payment solutions for Elba island. Operation of the chosen solution. Implementation of SMS vending channel	HIGH	PT – e-ticketing
WP7	Elba	ELB7.3	APP for user real time information	HIGH	Demonstration of a “light” AVM system. Adoption of a tool for service validation (validation of data collected by “light” AVM during the operation). Infomobility service included in ELB4.4	HIGH	PT – Fleet Monitoring Infomobility – APP/web
WP7	Limassol	LIM7.3	PT Traveller Information System	HIGH	On-board info-system (next stop announcement, public advise, news on the service and the network, etc.) On-road info-system	HIGH	PT – Fleet Monitoring Infomobility – on road Infomobility - on board
WP7	Limassol	LIM7.4	Mobility application and travel planner for smart phones to provide real time information	HIGH	Platform to aggregate data from different sources and provide multimodal info on APP	HIGH	Infomobility – data aggregation

Table 3.1: Classification of ITS supporting demo measures in CIVITAS DESTINATIONS sites

The following Table 3.2 resumes the mapping of ITS involved in CIVITAS DESTINATIONS project and targeted to Traffic Management category.

ITS category	*Traffic Management sub-category*							*Video Surveill.*
Site	*Traffic sensors*	*Road Safety*	*Devices for people with disabilities*	*Supervision and control platform*	*Parking mgmt*	*Traffic lights & Priority*	*Road pricing & Access Control*	
Madeira	X			X	X	X		X
Las Palmas								
Elba		X	X					
Malta							X	
Rethymno	X		X	X			X	X
Limassol			X		X			

Table 3.2: Classification of ITS (supporting CIVITAS DESTINATIONS demo measures) related to Traffic Management

The following Table 3.3 resumes the mapping of ITS involved in CIVITAS DESTINATIONS project and targeted to Public Transport and other services (multimodal infomobility, ride-car sharing platform, logistics and management of electrical recharge points).

ITS category	*Data aggregation + Infomobility*	*Public Transport ITS sub-category*			*Platform for multiple sharing services*	*Platform to manage a single sharing service*	*Crowd-sourcing tools*	*Systems for behavioural change*	*Logistics Management Platform*	*Electrical charge system*
		Ticketing	*Users information*	*Passengers counting*						
Madeira	X	X (interoperable)		X			X	X		X
Las Palmas	X	X	X (on road)			X (bike sharing, extension)		X	X	X
Elba	X	X (feasibility)	X (APP/web)+ light "AVM"		X				X	
Malta	X		X (on road)				X		X (feasibility)	
Rethymno	X	X (?) (interoperable with other mobility services)	X (on road)		X	X Extension of e-bike currently operated	X	X	X (feasibility)	X
Limassol	X	X (self vending machine)	X (on-board, on-road)			X (car sharing) Extension of e-bike currently operated				X

Table 3.3: Classification of ITS (supporting CIVITAS DESTINATIONS demo measures) related to Public Transport and others mobility services

3.3 IDENTIFICATION OF A "CORE" GROUP OF ITS

The identification of the "core" group of ITS has been carried out on the basis of the following criteria/elements:

- Relevance of ITS in supporting the operation of demo measure or service;
- Relevance of ITS for contributing to the integration of services, interoperability/co-modality, etc;
- Complexity of architecture/functionalities design phase;
- Wide presence in various sites.

The following "core group" of ITS have been identified:

- Aggregation of data into a common middleware/data layer (from the data collected by the different on field systems to the data availability and accessible level.);
- Multimodal travel APP;
- PT users info + AVM;
- Ticketing;
- Platform for the management of sharing services (i.e. car sharing);
- On-road parking management system.

In the following the key recommendations will be provided for each the "core group" ITS systems identified. The following sections are divided into:

- An introductive session of the key features of ITS allowing to set the ground for the provision of following recommendations and key design choices/scenarios;
- Description of architectural options and recommendations for its design;
- Identification of common functionalities and recommendations for their design;
- Key choices to be considered/faced in design process.

Standards are considered where relevant.

4 COMMON DATA LAYER PLATFORM

Common data layer platforms are dedicated to collect and integrate the data coming from different sources/database and systems in order to integrate them into a common middleware layer under a unified/specific format which could enable the following objectives:

- Monitoring/supervision of the mobility situation (i.e. events on the network, traffic flows, operation state of systems providing the data, etc.);

- Provision of multimodal aggregated infomobility services on different platform (i.e., info-panels, infomobility web portal, APP, SMS, “open” data, etc.).

In the following, the description focuses the infomobility (provision) objective as it is largely present among the CIVITAS DESTINATIONS sites.

The process of data collection and info-services provision can be ideally depicted as in Figure 4.1.

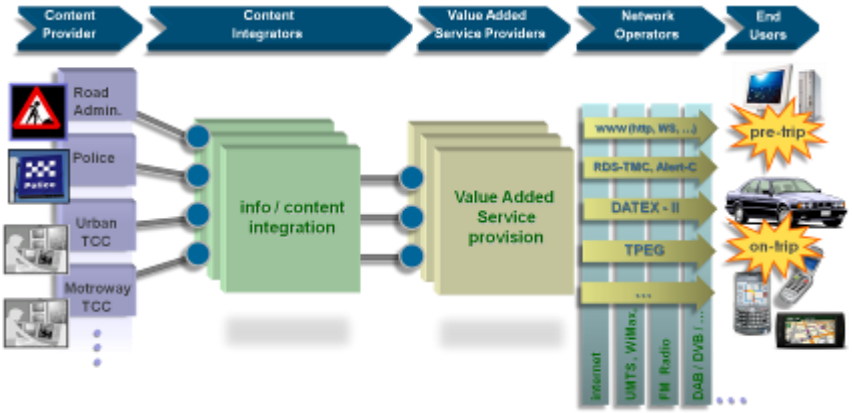


Figure 4.1: Common data layer

On the left side there are the systems acting as data providers, on the right side are presented the multimodal infomobility services provided.

Examples of data/contents which can be used for aggregation are the following:

- Map and Point of Interest;
- Scheduled timetable, lines, bus stops;
- Tariff;
- Event on network (road work, etc.);
- Bus real-time transit;
- Traffic data (sensors);
- Occupancy level of parking lots, bike sharing stations;
- Current state of car sharing vehicle and e-charge points (booked, etc.).

On the other side, examples of multimodal integrated services which can be generated and provided on the different channels are:

- Static PT services (timetable, lines routing, bus stops localization, etc.);
- Dynamic PT services (real arrival time of PT vehicles at bus stops based on the current status and operation conditions of the service);
- Static Traffic services (road works, road closure scheduling, etc.);

- Dynamic Traffic services (traffic conditions);
- Static Parking services (localization of parking areas, name of the parking area, total number of lots per area/street, tariffs, opening hours, special services, etc.);
- Dynamic Parking services (real time availability of lots);
- Journey Planner;
- News;
- Customized alerts/notifications;
- Users feedbacks;
- Weather services.

The various steps for the provision of multimodal integrated infomobility services from data contents can be synthesized in the following ones:

- Data generation/availability: single ITS system, aggregating DB, open data, etc;
- Data acquisition and centralization;
- Data integration and processing to generate aggregated contents for end-users provision;
- Service provision on various channels;
- Management of end-users interface.

4.1 Architectural options and main components

The two different architectural models usually can be adopted as shown in Figure 4.2 and Figure 4.3.

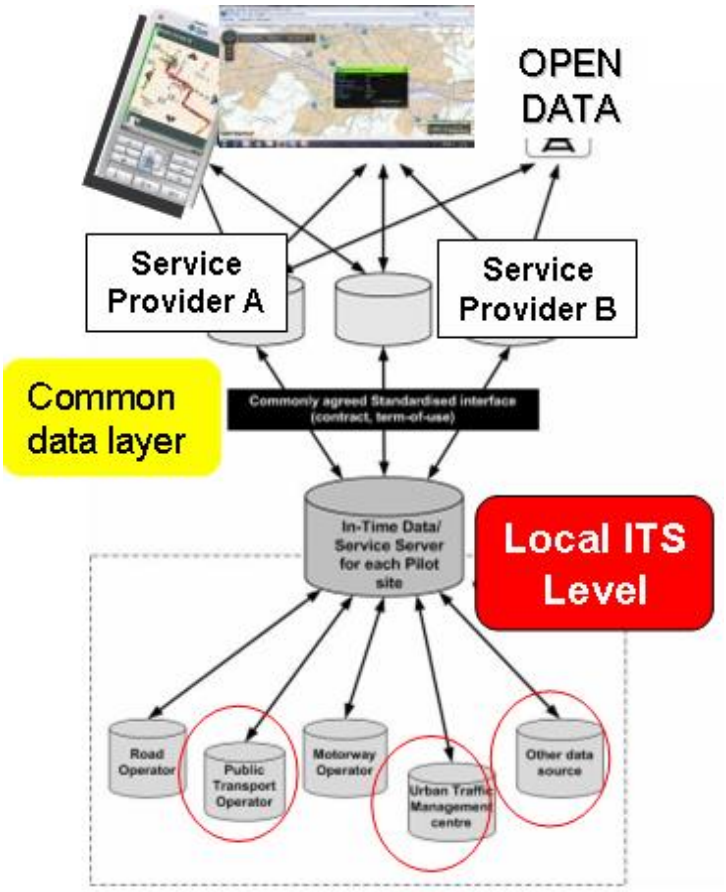


Figure 4.2 Data acquisition from single ITS

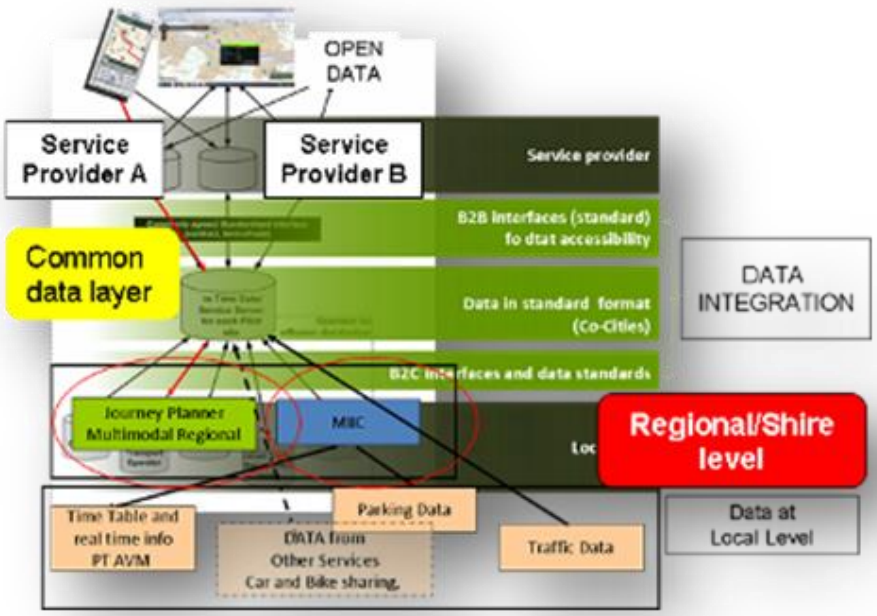


Figure 4.3 Data acquisition from single ITS and intermediate regional/shire level

The Figure 4.2 shows the architecture realized and adopted for example, in the town of Florence (Italy) in the European In-Time project (CIP-ICT-PSP-2008 Nr.238880, 2009-2011). In this scenario data/contents are gathered directly from each ITS system/services operating at site level as the following ones:

- Tools for the planning of PT scheduled services (bus stops, lines, timetable, etc.);
- AVM system (for real time info);
- Parking Management System;
- LTZ access control;
- Platform for the management of bike sharing services;
- Platform for the management of car sharing services;
- Taxi Management System;
- Electrical points Management System;
- Traffic detectors System;
- Weather forecasting System/Alerts and Emergency System.

Usually each of these systems is under the responsibility of different actors/entities as: PT operator, Parking/Mobility Agency, Municipality, Police Department, Traffic Management Centre, etc.

The Figure 4.3 shows the architectural model adopted, for example, by the Tuscany Region in the former Co-cities project (CIP-ICT-PSP-2010 Nr.270926, 2011-2013).

In this case, there is an integrated database already available at local level: this database collects data from the various ITS and integrate them at city/shire/region level. Typically, the integrated database is managed by a Public Authority (Municipality, Shire, Region). The common data layer platform is connected with this database and not with the specific ITS.

Clearly solutions based on a mixed architecture between the two above mentioned cases could be defined and designed.

The trade-off of advantages/disadvantages between the two different architectural options can be synthesized as follows:

- The access to the single ITS is more performing in terms of data reliability and updating but it requires to interface multiple data sources with their own features (data format, technical features, etc.);
- The access to the integrated database present critical factors in terms of reliability (as any lack of communication in the data flow between the single ITS and the integrated database or between the integrated database and the common data layer platform affect the overall chain) and updating (as the total delay time in data refresh is equal to the sum of the delay

time between the single ITS and the integrated database and the delay time between the integrated database and the common data layer platform). The efforts to integrate the system is reduced as all the data (or a large part of them) are already available in a single data source under a common format.

The common data layer platform consists of the following main components:

- Adapting interfaces (adapters) to allow the data access from data sources;
- Map/Location Based Service modules;
- Aggregating and elaboration/processing modules with local database;
- Modules providing services for data publication towards external info-service providers;
- Back office module to manage content management, feedback reporting, administration functions.

The above mentioned components are shown in Figure 4.4.

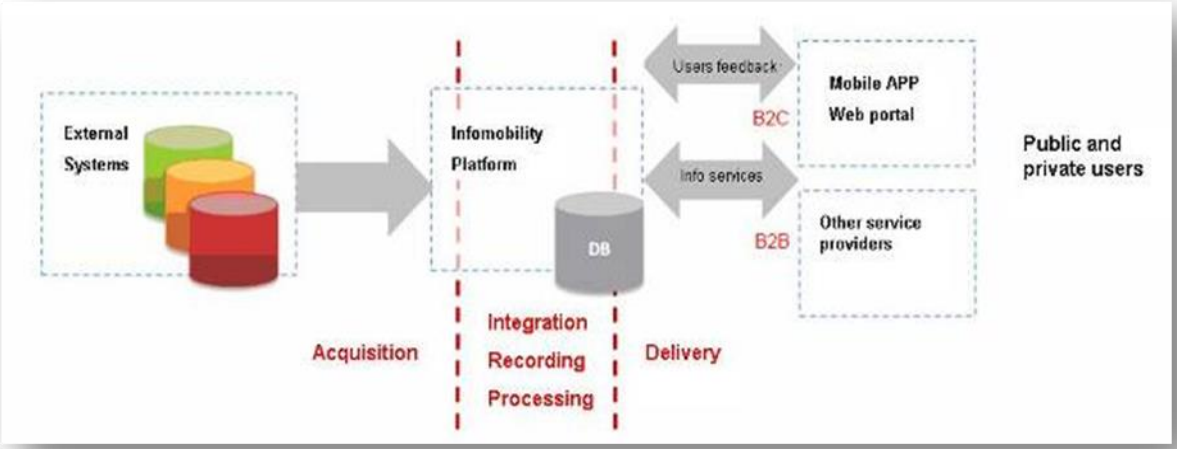


Figure 4.4: Main components of common data layer platform

Adapters for data exchange must allow the modularity of the aggregating platform in terms of data sources and info-channels: this means that each adapting interface must be separated from the others. The future scale up of the aggregating platform should require the implementation of a new specific adapter in both the following cases:

- A new data source is added;
- A new infomobility channel for the provision of multimodal info-services is required.

The presence of a local database for the aggregating platform is required by the caching mechanism to be implemented to reduce data communication flow and prevent continuous access to data sources (i.e. most recently asked data, etc.).

4.2 MAIN FUNCTIONALITIES

The main functionalities of the common data layer platform are:

- Data acquisition from data sources (through adapting interfaces);
- Provision of Map/Location Based Service services to be used for info provision over different info-channels;
- Local storage of data more commonly accessed or recently accessed from data sources;
- Data/contents elaboration/integration;
- Data formatting under standardized data model;
- Data provision (through adapting interfaces) to be displayed over different info-channels and end-users devices;
- Management of communication flow:
    - From end-users devices/applications (info request) to data sources (data request);
    - From data sources (data access/availability) to end-users devices/applications (info provision/info request answer).

4.3 KEY CHOICES FOR THE DESIGN

The main actions to be carried-out in the design phase are the following ones:

- Survey of the different data sources already available for the integration and info-services (or supervision/control) management;
- Identification of data sources and technical solutions for data access;
- Definition of services to be provided by aggregating/elaborating base data;
- Identification of the requirements for the platform;
- Definition of platform architecture and functionalities.

The main key choices to be carried out are related to the design of data adapters and the identification of the proper communication procedures for data exchange.

The first choice is between the adoption of a push or pull communication procedures. Adopting the push communication procedure all the data are imported by the common data layer platform at pre-defined scheduled times whereas in the pull procedure the common data layer platform access and import only the data required “on demand”. Push procedure is suitable for medium-low sized data sources with long updating time whereas the pull procedure is suitable for large sized data sources with reduced updating time.

The design of adapting interfaces must be focused on guaranteeing the suitable quality of the data accessed by the common data layer platform. High quality services for end-users (in the case of the provision of infomobility services) requires the availability of high quality data coming from the on filed systems.

High quality data means that the following indicators must be duly assessed:

- Coverage – percentage of territorial coverage for which data is available (number of PT lines, parking areas, etc.);
- Timeliness – maximum time between two refreshes of data at ITS level;
- Reliability – percentage of operating time of ITS where data is available;
- Precision – maximum error in data produced by ITS.

The design of adapting interface consists of the following actions:

- Identification of data sources to be considered;
- Analysis of data sources:
    - Which data structure/format?
    - Is available documentation describing data format and meaning?
    - Which is the data owner or responsible?
    - Where data are stored/available?
    - Are they already exposed as data service?
    - How often are they updated?
- Analysis of data quality according to the above mentioned indicators.

4.4 STANDARDS

Standards to be considered are:

- The one defined by standardization committees (i.e. ISO committee) including standards on data format which are sometime restricted to certain data domain as SIRI, IFOPT, Transmodel (PT+Journey Planner), DATEXII (traffic) and on geo-coding services: OGC, WMS/WFS/WCS, GML
- “De facto”, widely recognized by the market including data communication technologies as Service Oriented Architecture (SOA), web service, XML etc.

5 INFOMOBILITY APP

The infomobility APP represents one of the possible media channels to be used for providing info-services to end-users (citizens) once the aggregation of data/contents collected from various sources has been realized (see section 4). The logic scheme connecting common data layer platform and the various info channels (one of these being the APP) is shown in Figure 5.1.

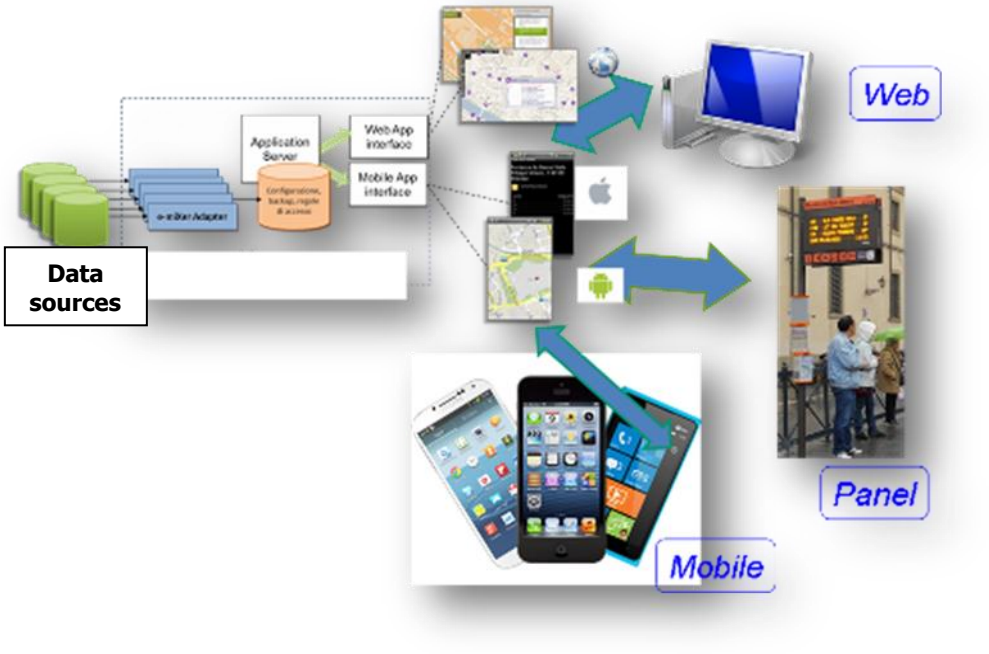


Figure 5.1: Logic schemed of data provision from data sources to info-channels

Taking into considerations the possible infomobility services, APP can be classified as:

- Institutional (City/Shire/region) APP – in this case the info-services generally includes Public Transport and mobility (traffic, parking, etc.) sectors. Usually they are managed by Public Authorities (Municipality, Metropolitan Authority, Shire, Region);
- Transport/Mobility Operator (company) APP – in this case the info-services are restricted to a certain number of domains (Public Transport, Parking Operator, etc.). Public Transport Operators offers services built on their own data as Mobility Operator as well.

5.1 ARCHITECTURE AND MAIN COMPONENTS

The architectural schemes representing the “backstage” of infomobility APP are the ones indicated in the previous Figure 4.2 and Figure 4.3.

In general, the backstage of company APP follows the In-Time Florence site model (Figure 4.2) whereas the backstage of institutional APP can include the access to integrated database (Figure 4.3).

Figure 5.2 shows the detailed architecture of Tiemme Company APP "Tiemme Mobile" for the provision of info-services on Public Transport. Tiemme is the 8th biggest bus company in Italy (around 650 buses more than 40 million of yearly passengers, operating urban, interurban and peripheral/rural services in southern and eastern areas of Tuscany Region for a total of 14.00 skm).

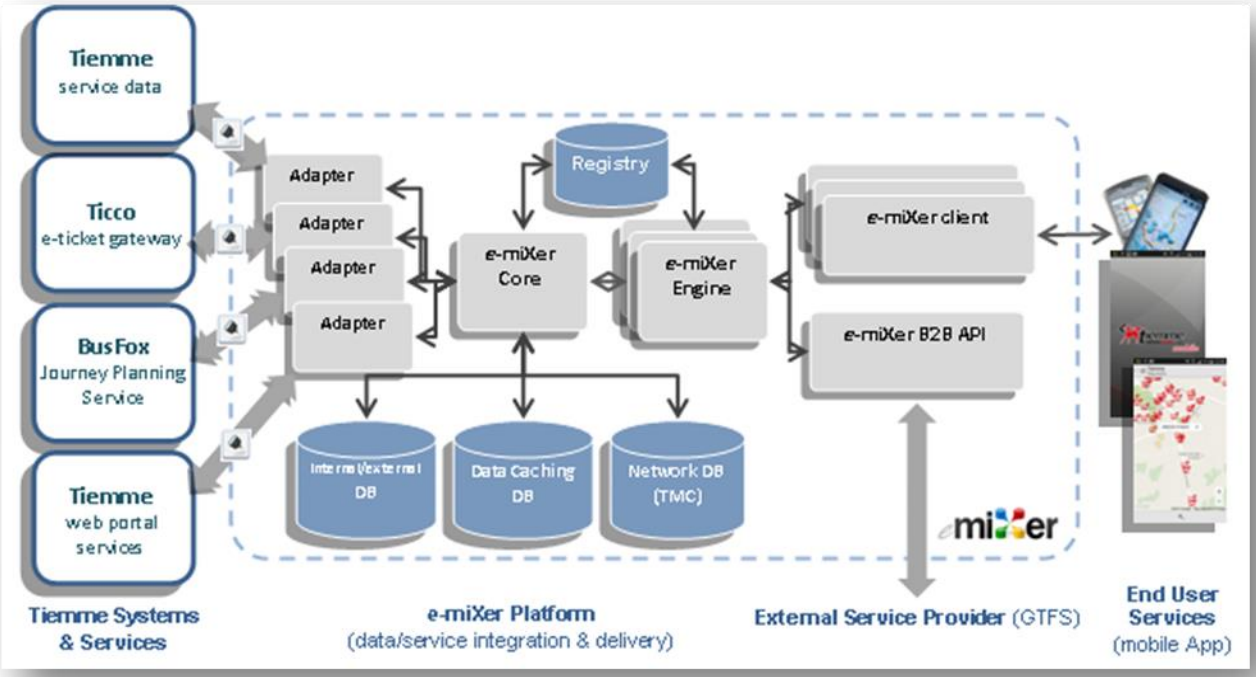


Figure 5.2: Architecture of Tiemme mobile APP

The main components are the same previously indicated in section 4.1. In the following, details of the technical choices adopted for the implementation of Tiemme Mobile are provided as examples.

The adapting interfaces have been developed as a set of software components connected to local systems and providing web service interfaces along the Co-Cities data model specifications. All nodes (local systems and the adapting interfaces software components) are connected to each other via the Internet or by means of dedicated connections depending on local constraints. A custom connection from a local system to the adapting interfaces is typically necessary because of security policies.

Custom connections include:

- Custom web services available or developed on top of local systems and invoked by the adapting interfaces, through a VPN (if necessary);
- Datasets available via HTTP requests, over a VPN (if necessary).

The technological choices for the integration of the components underlined by the above points can be summarized as follows:

- Use and configuration of a WMS/WFS Server platform for data services;

- Set up of a temporary DB (Data Base) jointly with the WMS/WFS Server;
- Local data adaptation achieved through the development of a mapping scheme between the existing data format and the model adopted for data integration;
- Local Service adaptation by means of a layer added in top of the existing services, able to wrap and adapt them to the data model for integration;
- Custom implementation of feedback services.

For Location Based Service B2B provision, OGC WFS data services are used. The GeoServer platform[1] can be used to develop the OGC service interface. GeoServer works jointly with a supporting DB in Postgres technology[2] (see Figure 5.3).

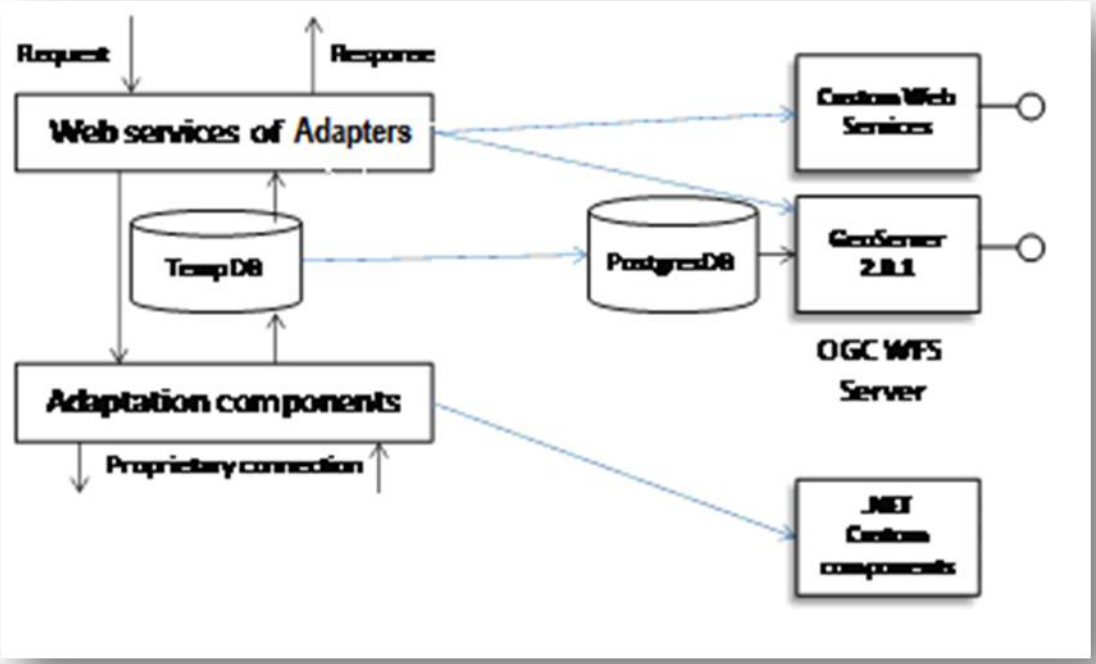


Figure 5.3: Example of a possible technological solution adopted for OGC WFS

Data adaptation through WFS / WMS services is obtained by a specific GeoServer set-up using the XSD schemas. At the same time, the Postgres DB temporarily stores all datasets which have to be provided through the WFS server. The DB is filled by data fetchers, adaptation components built as .NET Custom entities. These are responsible for retrieving data from local systems and to adapt/store them in Postgres DB.

[1] GeoServer is an open source software server written in Java and a reference implementation of the OGC Web Feature Service (WFS), Web Map Service (WMS) and Web Coverage Service (WCS).

[2] GeoServer includes an extension, called Application-Schema which enables a two-ways mapping of simple features into complex ones. This is especially useful in order to use the Co-Cities XSD-based specification where objects are often represented by means of complex features.

5.2 MAIN FUNCTIONALITIES

The services/functionalities provided by the APP are the ones indicated in the two following different examples: the first ones (Figure 5.4) relates to the APP TreviMOve developed by MOM, Public Transport and Mobility Operator in Treviso Shire including PT services on the whole shire and parking services on the urban area of Treviso: news on mobility are provided by the Municipality which collaborates with MoM. The second example (Figure 5.5) is related to Tiemme Mobile APP which is restricted to bus services operated by Tiemme in the reference area.

Figure 5.4: Functionalities of Trevimove APP

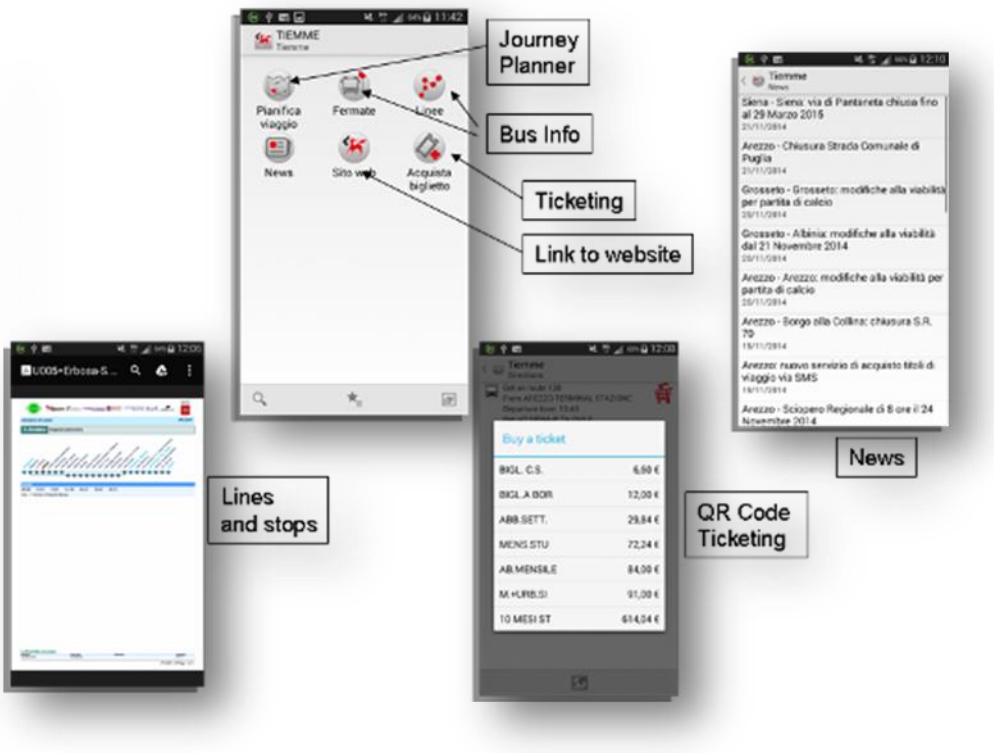


Figure 5.5: Functionalities of Tiemme mobile APP

The APP should guarantee the following main use cases:

- Access services through a unique menu for selection;
- Display information on table format or on map representation;
- Manage “location based” services supporting the various functionalities provided by the APP: i.e. search for bus stop and visualization of the result as list ordered by distance from the current position or request of a trip planning using the current position as departure point;
- Customize the access to services through the use of "Preferences" and "Widget";
- Access a sub-menu for each service, allowing:
    - Search for PoI by text or current position;
    - Display them on the map with related info (i.e. bus arrival time for bus stops);
    - Selecting the PoI and:
        - use it as "departure" or "destination" point of a trip to be planned;
        - add it to a preferences list;
        - link it to a widget;
- Within the map representation, zoom and navigation through the touch screen of the device;
- View news and click on linked services (payment, QR code, website, etc.);

- Send feedbacks as comments on the APP and its usability, level of quality of each service, quality of data provided, new event notifications.

5.3 KEY CHOICES FOR THE DESIGN

Key choices in the design of the APP are the following:

- Optimization of layout and graphic for both smartphone and tablet version;
- Identification of compliant OS environment and version (i.e. Android, iOS, Windows platforms) by guaranteeing a “minimum level” of compatibility with former OS versions;
- Identification of functionalities in terms of operational use case;
- Definition of solutions to improve the usability/interactions by end-users;

6 PT INFORMATION SYSTEM

Public Transport Information system can include a number of different communication channels to distribute service information to passengers, including:

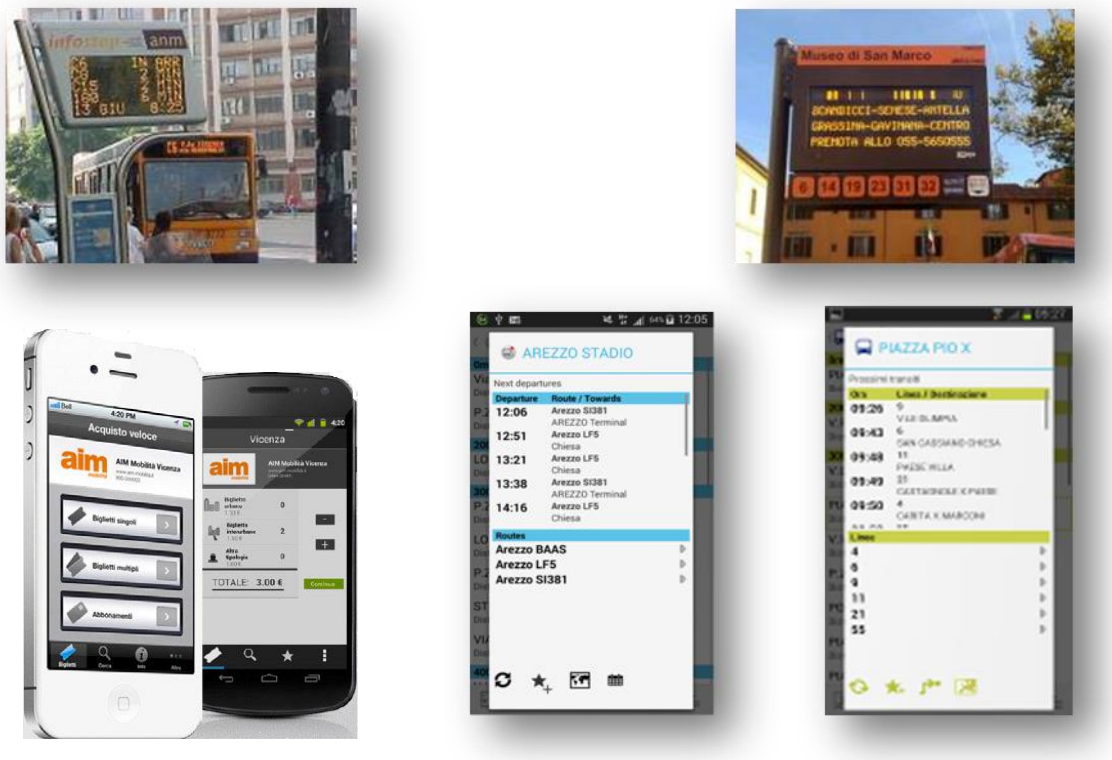
- Various types of displays and variable message signboards at stops and service interchange infrastructures;
- Touch screens for self service at kiosks and info points (e.g. in customer offices, at stops, public buildings, etc.);
- Internet/web;
- Telephone (interactive voice response systems);
- APP for delivery of information ‘on the move’

User information provided can be classified in two main categories:

- Pre-trip information (website, road panels, etc.);
- On-trip information (on-board information, SMS, APP).

Figure 6.1 shows examples of info channels: on-road panels in Naples and Florence, APP (Vicenza and Arezzo), web portal (Siena, displayed by tablet).

In this section the description focuses on panels/devices to be installed on the road, at the bus stops (under the shelters), at the ticketing office, at the waiting hall, etc.



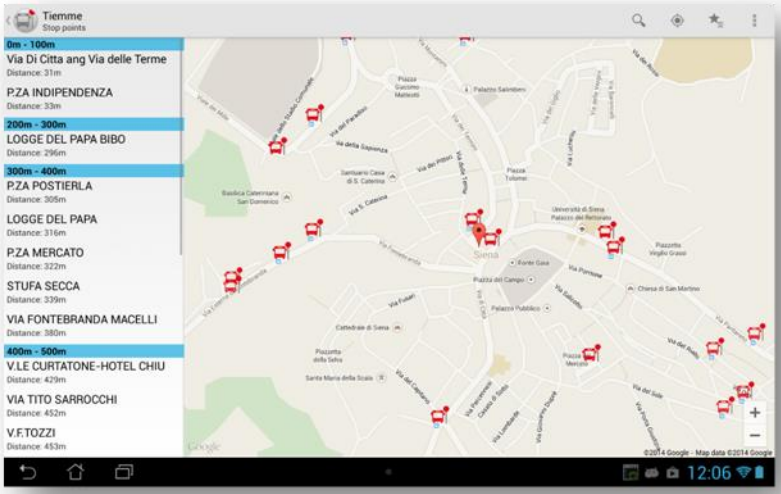


Figure 6.1:Different channels to provide user information

6.1 ARCHITECTURE AND MAIN COMPONENTS

Table 6.1 below identifies the main technological options available on the market for the provision of PT info, the main features to be considered in user needs analysis and some key suggestions.

Technological features	*Available options*	*Suggestions*
Panels typology	1) Panel to be installed at bus stops 2) Panel to be installed at terminal 3) Panel to be installed under the stop shelter	Panel to be installed under the shelter require minor installation work and they have less impacts in the urban environment.
Display feature	1) TFT/LED 2) One–side/two-sides	
Display dimensions	To be defined based on the number of lines which transit at the bus stops. Typically: 1) Panel to be installed at bus stops (4 lines) 2) Panel to be installed at terminal (8-16 lines) 3) Panel to be installed under the stop shelter (no more than 2 lines)	When the number of lines is high, the info should be visualized in different pages and the rotation effect could be confusing for the users. Panels in shelters cannot be installed at bus stops served by a high number of lines.
Environment for installation	1) Indoor 2) Outdoor	Outdoor panels must comply with specific requirements for visibility, operational features and protection (i.e. at least ingress Protection IP67)
Power supply	1) Electrical power 2) Solar cells + rechargeable battery	Solar panels require minor installation work as the cabling to power supply is eliminated. Solar panels can be installed also in locations far from public power supply but the location needs to be sunny (to avoid shadow effect at certain/major hours)
Internal equipment	WiFi module (optional)	WiFi module restarts the real-time arrival info when the bus is detected at short distance. In this case the info “vehicle on transit” is displayed. This device can help to minimize the effect to the users when the real time prediction and the effective transit of bus are slightly not aligned.

Table 6.1: Technical options for info-panels

Figure 6.2 provides examples of the different typologies of panels mentioned in the previous table (a LED panel installed in bus stop shelter (Florence), a LED panel installed at bus stop in Hamburg and a solar panel installed at bus stop in Siena.

Figure 6.2: Example of technical solutions for PT info-panels

6.2 MAIN INFORMATION AND FUNCTIONALITIES

Usually the information typology to be provided can be summarized as the following one:

- Real time information on the arrival times of vehicles at the bus stops;
- Scheduled time information on the arrival times of vehicles at the bus stops;
- Real time information on the irregular conditions of the service (trips cancellation, lines diversions, etc.) and events on the network;
- Static information (lines routing, planned timetable, lines directions, fares, strikes, etc.);
- General information and advise (phone number of the call centre, tourist information, etc.);
- Commercial advertisement

In this context, the main functionalities are the following:

- Visualization of real time info;
- Visualization of scheduled time info;
- Visualization of public advise, events, etc.;
- Management of info visualization based on both the following scenarios:
    - On events (when a command is sent to the panel);
    - Based on scheduling;

- Management of commands to disable the visualization of real time info (for a specific line/group of lines/all the lines, for a specific bus stop/a group of bus stops/all the bus stops);
- Management of commands for the shutdown and restart of the panel;
- Diagnostics (related to the single matrix or the minimum area/components of the screen).

6.3 KEY CHOICES FOR THE DESIGN

For each of the main functionalities indicated in above section 6.2, Table 6.2 highlights the key choices to be considered in the user needs analysis and design phase.

Functionality	Suggestions to be considered	Notes
Visualization of real time info	The real time info can be provided in terms of actual waiting time (i.e. “in 5 minutes”) or indicating the last bus stops where upcoming vehicles have been localized (current position of the vehicles)	Indication using waiting time require a good algorithm for real time prediction but it is understandable by all (regular users but also tourists). Indication of bus position does not require a good algorithm for real time prediction but it is clear only for regular users
	The visualization must be differentiated between real-time arrival time and scheduled time	Users can easily understand if the time is real or planned For example real time info can be indicated as actual waiting time (“in 5 minutes”) and scheduled arrival times as hh:mm.
Visualization of scheduled time info	Panels must visualized scheduled time when vehicle is on service but not localized or if the on-board system is not working	
Command to disable the transmission of real time information from AVM to panels	AVM must allow to disable in any moment the transmission real time information from AVM to panels.	Relevant for system launch and when AVM is not working.

Table 6.2: Key choices for provision of info on panels

7 AVM SYSTEM

The information provided by the PT information system are generated by an AVM (Automatic Vehicle Monitoring) system. AVM is sometime, especially in Mediterranean area, indicated as SAE (Système d'Aide à l'Exploitation) or as AVL (Automated Vehicle Location) specially in the US and American countries.

The provision of PT real-time info is one of the most critical functionality of PT information system. It requires an efficient and reliable AVM system and duly responsive to cope with all the different operation conditions of PT services and a full-level management of the system itself.

If the objective of Public Authorities/PT Operator is the provision of reliable information system, for example, a bus installed with an “out of service” on-board unit should not be used for operating the service.

Furthermore it must be considered that on-road info can be tested/managed for some lines (disabling the provision of real time info according to the functionality indicated in section 6.2): this procedure (strongly recommended) will allow the verification of reliability of info provided for a bus line and the tuning of the AVM system’s performances, operational procedures, required data (i.e. precision of bus stops localization, precision of the description of line routing, etc.). This approach will guarantee a smooth introduction/testing phase of the AVM system to be articulated on consecutive steps. Moving from on-road panels to web/SMS/APP it is easily understandable that these info channels are even more critical as it is not possible to limit the provision of info to certain bus stops/service areas/lines (this could be hardly accepted by the users). When the info-channels are SMS/web/APP the AVM system must be highly performing and duly operated (on all the PT network) when information services are launched.

AVM system is not explicitly mentioned as the object of any CIVITAS DESTINATIONS measure but it is included in these as it is the “data provision” system for PT information services which are widely adopted, on the contrary, by CIVITAS DESTINATIONS sites (as single demo measure or as part of the data to be integrated into multimodal APPs, infomobility portals, etc.).

The AVM system main components are highlighted in Figure 7.1.

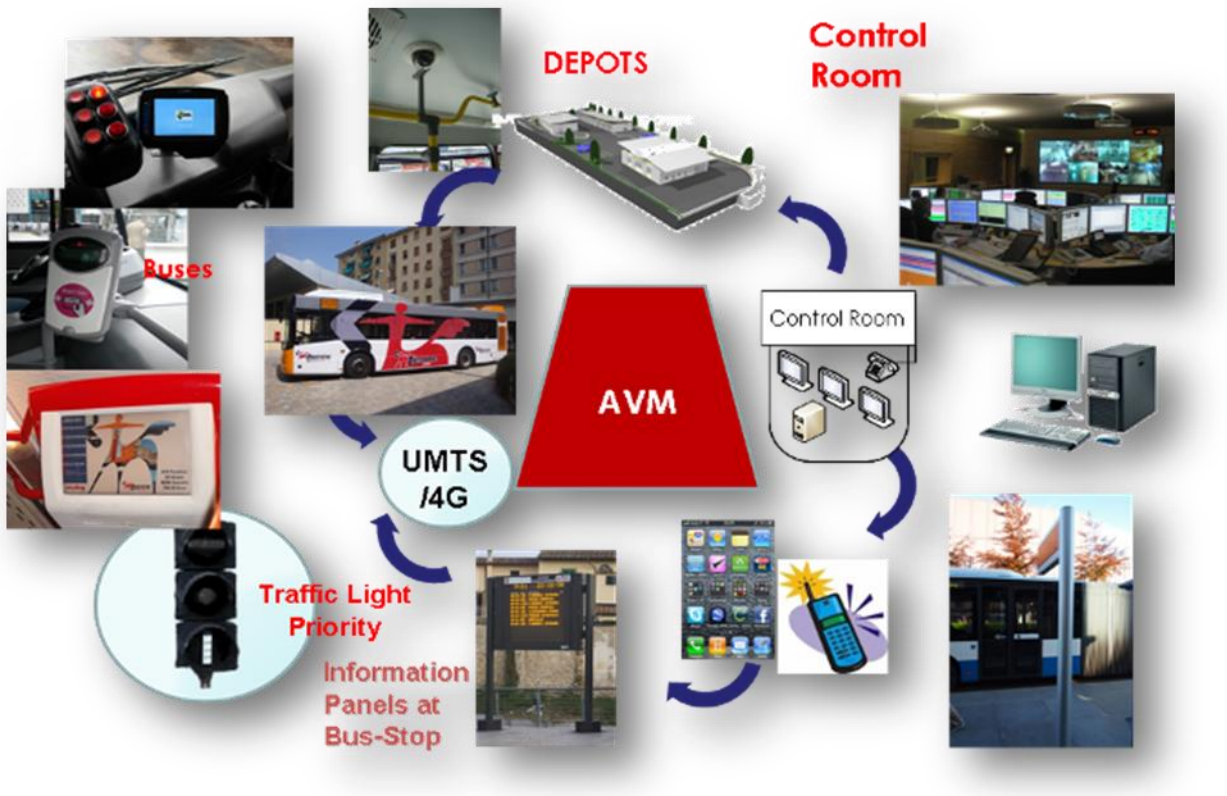


Figure 7.1: Main components of AVM system

AVM has a key role among all the ITS supporting the operation of Public Transport and mobility services, into details:

- AVM is “ancillary” to other systems specially for e-Ticketing, User Information and Traffic Light Priority;
- AVM is fundamental for service contract monitoring allowing the reporting and assessment of PT service performances;
- AVM has a relevant role in any mobility initiative for city: Urban Mobility Governance, Traffic and Network Monitoring, MaaS.

7.1 ARCHITECTURE AND MAIN COMPONENTS

An AVM architecture is shown in Figure 7.2.

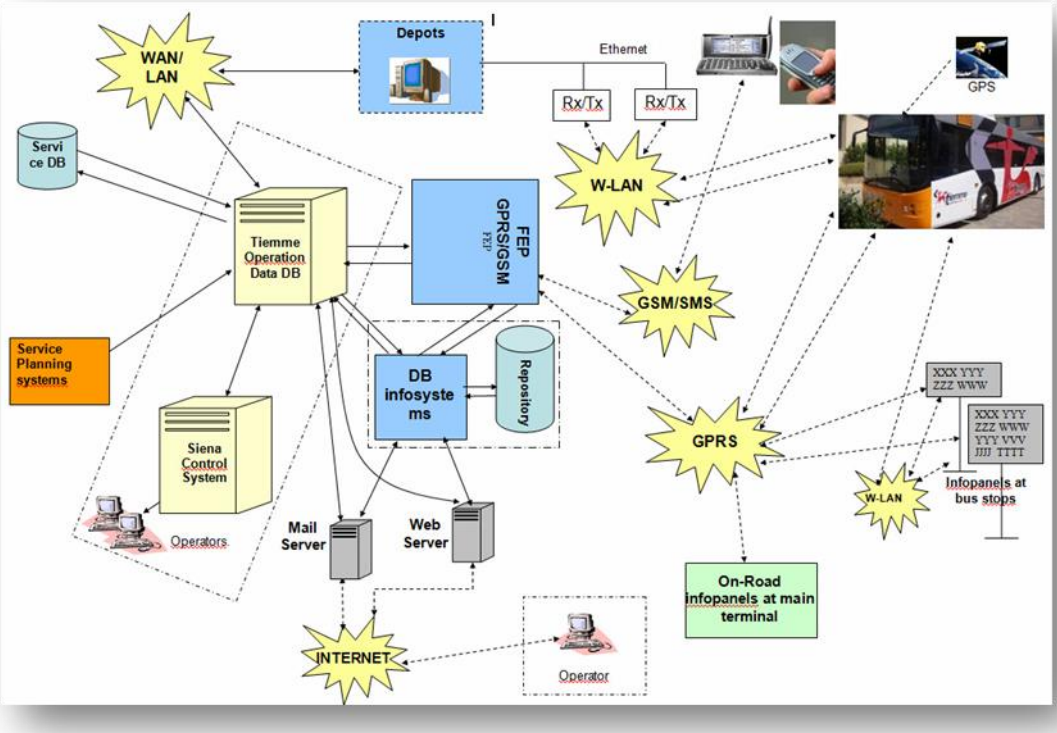


Figure 7.2: A possible AVM architecture

The main components of AVM system are the followings:

- On board terminal;
- Control Centre;
- Communication network:
  - Long-range communication network (UMTS, GPRS, LGTE, private network as TETRA, etc.):
    - Between on-board unit and central system;
    - Between central system and info-panels/web-portal/app;
  - Short range communication network (W-LAN at depots) between central system and on-board unit. It can be used to upload geo-localized data and scheduled service (which is a huge amount of data, several MB in each upload) guaranteeing high reliability and performances (bandwidth, speed). UMTS/GPRS network do not guarantee these performances for huge amount of data;
  - Intranet/Internet (WAN, LAN, MPLS, etc.) for the communication between the central system and the operator workstation (also in a location geographically far from the server farm where the central system is installed).

Figure 7.3: **AVM System control room and onboard devices**

Table 7.1 details the different communication networks involved in the operation of an AVM system.

	On-board unit	*Info-panels*	*Central system*	*Operator workstation*	*Web-portal/APP*
On-board unit			2G/3G/4G Private network WiFi (at depots)		
Info-panels			2G/3G/4G Private network		
Central system	2G/3G/4G Private network WiFi (at depots)	2G/3G/4G Private network		INTERNET/ INTRANET	2G/3G/4G
Operator workstation			INTERNET/ INTRANET		
Web-portal/APP			2G/3G/4G		

Table 7.1: Options for communication networks involved in the operation of an AVM system

7.2 MAIN FUNCTIONALITIES

AVM has a wide range of functionalities which can be grouped as follows:

a) Service monitoring;

b) Service regulation;

c) Reporting and data analytics;

d) Safety for drivers and passengers;

e) User information.

In the Table 7.2 a detail of the functionalities is provided.

7.3 TECHNICAL REQUIREMENTS

It is mandatory that all the equipment is installed on-board (i.e. terminal. PC/unit, etc.) presenting the automotive certification **("E")**.

7.4 KEY ISSUES FOR THE DESIGN PHASE

For each of the abovementioned group of functionalities, Table 7.2 highlights the key issues to be considered in the design phase.

Main AVM functionalities	*Details of AVM functionalities*	*Suggestions to be considered in design phase*	*Notes*
Service monitoring	Vehicle assignment	This function can be assured by various procedures: - Assignment transmitted by the central system on the basis of the planned service; - Assignment done by driver on the on-board terminal; - Assignment done by central system after intervention of the operator.	The choice of most suitable scenario for vehicles assignment depends on the Public Transport Operator organization and operational procedure, in particular it depends on the confidence on drivers work and on the choice to implement a control centre (or not, see "Service Regulation" – "Management of irregular service conditions"). These procedures for vehicle assignment can be combined: in this case a hierarchical priority among them must be defined.
	On-board data collection	The system can adopt one of the following procedures: ▪ "Event-Driven" – this means that the data of bus localization are sent when a specific event occurs (i.e. the bus stops and opens the doors); ▪ Based on pre-defined time interval – this means that the data of bus localization are sent regularly at predefined time interval; ▪ A mix of the abovementioned two procedures. The system could allow to configure the two procedures depending on lines and hours.	The "event-driven" procedure allows to reduce the traffic between the vehicles and the central system even if this scenario is currently less relevant than before as the flat rate offered by Communication operators includes high data volumes and "bundle" function. The configurability of the procedures allows to tune the traffic flow depending the reference context and the service typology: in urban areas where the requirements focus on real-time fleet monitoring and service regulation, "pre-defined time interval" procedure is more suitable: the value of time interval can be shorter for trunk and main axis and longer for suburban/peripheral areas. "Event driven" procedure is more suitable for interurban and rural services when the requirements for real-time fleet monitoring and service regulation are less relevant.
	On-board localization	The presence of the functionality of autonomous on-board localization is recommendable as it is fundamental to get reliable localization data. The autonomous on-board localization includes: ▪ Collection of GPS signal; ▪ Dead reckoning navigation, including odometer;	Accelerometer/gyrometer signal could be avoided

Main AVM functionalities	*Details of AVM functionalities*	*Suggestions to be considered in design phase*	*Notes*

		▪ Map-matching algorithm;
		▪ Algorithm to identify:
		  ▪ Exit/entrance event from/to the depots;
		  ▪ Departure/arrival at terminal and lines CIVITAS DESTINATIONS;
		  ▪ Transits at bus stops;
		  ▪ Bus stops.	

	Speed detection	The system should identify and collect the vehicle speed when one of the following events are detected:
		  ▪ Approaching bus stop;
		  ▪ When a pre-defined max value of speed is overcame.
			This function can be useful in case of incidents for the management of assurance.

Service regulation	Identification of delay conditions of the vehicle	The system should provide the following functionalities:
		  ▪ To identify and show at central system level (control centre) the current transit time difference at last approached bus stops;
		  ▪ To send automatically the countdown for next departure from terminal/trip origin;
		  ▪ To allow the central system (control centre) to send pre-defined messages to drivers in order to put into practices actions to restore the service regularity.	

	Management of irregular service conditions	The system should allow to manage irregular service conditions on two levels (at central system (control centre) and on-board). The system should allow: ▪ To the drivers: to send pre-defined messages to notify that an irregular condition is occurring;	The system should automatically calculate and register the duration of irregular service conditions (start/end), the km travelled under these conditions and assign them with the info provided manually at central system (control centre) level (description of the irregular event, motivations, actions for restoring the service regularity), These data should be collected to fed automatically the process for the

Main AVM functionalities	*Details of AVM functionalities*	*Suggestions to be considered in design phase*	*Notes*
		▪ At central system (control centre): to send pre-defined messages to the drivers indicating the actions for restoring the service. Two scenarios can be identified: - a control centre is equipped with dedicated workstation used for service control and fleet management. Each workstation is dynamically assigned to certain lines. Operators are full time allocated to the service monitoring and fleet management. The regulation of the service in case of irregular conditions is carried out in real time. This scenario is suitable for large/medium urban areas; - a control centre with dedicated workstation is not equipped. When a predefined event occur (i.e. an irregular service condition of the bus notified by the driver), the AVM central system send a SMS/e-mail notification to the operator. Operators are part time allocated to the service control: they carried out this activity "on-demand" (following the notification of the irregular condition). This scenario is suitable for small urban areas, suburbs and rural areas.	monitoring/assessment of service quality and regularity performances.
Reporting and data analytics	Data gathering on Kms and trips operated	AVM automatically collect data on operated service: - Kms travelled during the trips; - Kms travelled during the service operation but not in the trips (i.e. from depot to departure terminal/stop, etc.); - Kms travelled "out of service" (i.e. to restore the planned headway).	This functionality is required both for the assessment of service performances and for the optimization of service planning and operation.

Main AVM functionalities	*Details of AVM functionalities*	*Suggestions to be considered in design phase*	*Notes*
	Data gathering on real time of departure/arrival/transits	AVM automatically collect data on operated service: - Departure time from depots; - Arrival time to depots; - Travelling time stop by stop.	This functionality is required both for the assessment of service performances and for the optimization of service planning and operation.
	Data gathering on real geo-localized data	AVM automatically collect data on operated service: - Real localization of bus stops - Distance stop by stop.	This functionality is required to have feedbacks from the operation of service to optimize the service planning.
	Reporting of data collected during the service	The data collected during the service are processed to identify: - Trips operated as scheduled; - Trips partially/not operated; - Trips started before the scheduled time; - Transit time at bus stops before scheduled; - Delays at bus stops compared to scheduled time.	This functionality supports the assessment of service performances in terms of regularity.
	Data analytics	Report can be generated by: - Service area; - Line; - Trip; - Stop; - Day/Hours (i.e. weekdays, weekends).	This functionality supports the “business intelligence” and then the data mining for improving the service oriented approach of bus service.
Security	Management of alarms	The system can allow the driver to send an alarm notification to central system (control centre). This message can be forwarded by the central system (control centre) to the Police for prompt intervention.	This functionality can be integrated with on-board videocameras recording.

Table 7.2: Key recommendations for the design of AVM functionalities

Summarizing the previous table the key decisions to be faced in the design phase of the AVM system are the following:

- Definition of the on-board technological solutions to be implemented:
  - "Full AVM" including on-board unit, driver terminal and connections with all the other on-board system and technologies (i.e. validators, on-board info – next stops visualization/announcement, line indicators, vehicles diagnostics, etc.). This option guarantees the full range of AVM functionalities. Investment and operation costs are high. Operational procedure are resources consuming. This scenario is more suitable for metropolitan areas, large urban areas, BRT and main corridors/axis;
  - "Light AVM" which could be implemented also through APP running over tablet/smartphone: it does not provide connections with on-board devices. It guarantees the main functionalities of AVM (in particular the reporting of the data collected during the service and the assessment of service performances) but not the integration with external on-board systems. Investment and operation costs are deeply reduced. Operational procedures are simplified. This scenario is more suitable when the reporting of data collected during the services and the assessment of service performances are the main objective of AVM implementation;
- Identification of the procedures to be adopted for service control:
  - On-line continuous control procedures: they require the installation of a central control room with dedicated workstation and full-time operators. This scenario is more suitable for large/medium urban areas with short headway lines (under 10 minutes);
  - Notifications of events by the system and on-line control procedures managed based on notifications. This scenario is more suitable for medium/small urban areas with longer headway lines (over 15-20 minutes);
  - Mixed procedures - on-line control procedures managed based on notifications on low demand hours and On-line continuous control procedures on peak hours;
- Identification of the procedures to be adopted for the assignment of scheduled service to the vehicles:
  - Download of scheduled services from the AVM central system;
  - Assignment by the driver;
  - Assignment by command sent by AVM central system;
  - Hierarchical levels among the previous procedures (in case of adoption of more of these).

8 E-TICKETING SYSTEM

E-ticketing system involves different technologies for selling/storing the tickets: smart cards, SMS, QR code, etc. In the following, the description focuses on the smart cards as this is the first recommended step a Transport Operator/Authority should consider for evolving from paper to electronic system. E-ticketing systems based on smart cards allow to face all the operational and organization issues and to set the base level of integration with external system (AVM, sw for service planning, database of tariff and tickets structure and description, accounting sw, etc.) which deal horizontally with all the kind of e-ticketing system (despite the support and the technology for tickets implementation and storing).

On a general level, all the different e-ticketing systems abovementioned can be considered as different selling channels encompassed in the same architecture.

8.1 ARCHITECTURE AND MAIN COMPONENTS

Figure 8.1 represents the logic architecture of an interoperable e-ticketing system and its main components.

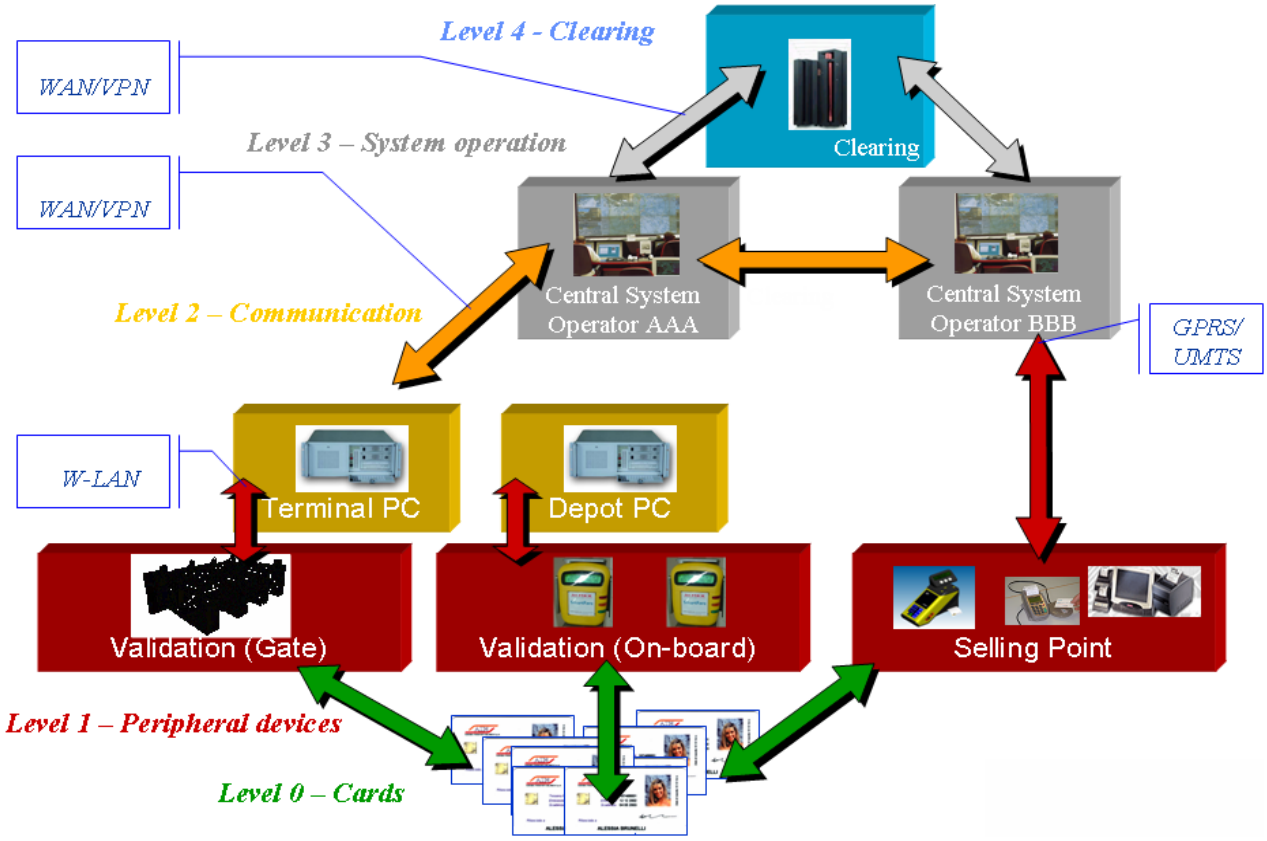


Figure 8.1: Architecture and main components of e-ticketing system

The main components can be detailed as follows:

- Central system (service data, tariff and tickets, data collection, statistics and reporting, system monitoring and management);
- Emission points;
- Selling/Recharge points:
    - Recharge points (POS, etc.);
    - Automatic vending machine;
    - Web selling application (QR code, to be recharged on smart cards, etc.);
    - SMS;
    - On-board selling.
- Validation/access points:
    - On board;
    - At gates;
    - On platforms.
- Communication network (WiFi, GPRS/UMTS);
- Clearing module (for interoperable systems).

8.2 MAIN FUNCTIONALITIES

The main functionalities of a ticketing system are the following:

- Central System:
    - Import and management of data describing fare structure (tariff and tickets), lines, tariff zones, etc. (this could include the integration with AVM or with the sw for service planning);
    - Management of data on registered users;
    - Management of the distribution of tickets and supports;
    - Communication with other devices and sub-systems (i.e. selling network, etc.);
    - Communication with external central system for the management of interoperability;
    - Data collection and reporting;
    - Export to accounting sw.
- Selling network:
    - Smart card personalization and emissions;

    - Tickets selling and renewal (subscriptions);
    - E-purse recharge;
    - Management of payment under different modalities (cash, credit cards, e-purse, etc.);
    - Accounting of cash flow.
- Validators:
    - On-board integration with AVM to:
        - Check the spatial validity of tickets (i.e. tariff zones, different urban services, etc.);
        - Cross-reference validation data with service localization to fed data mining tools;
        - Integrate the monitoring of validators with AVM.
    - Tickets validation;
    - On-board tickets purchasing (i.e. through e-purse);
    - On-board tickets/e-purse recharge (i.e. once the recharge has been carried out and paid on web portal);
    - Data communication with on-board devices, depots and/or central system.

8.3 TECHNICAL REQUIREMENTS

It is mandatory that all the equipment to be installed on-board (validators, on-board selling machine, etc.) has the automotive certification ("E").

8.4 KEY CHOICES FOR THE DESIGN PHASE (SINGLE SYSTEM)

Key choices in the design of the e-ticketing system are the following:

- From the business point of view it must be verified whether the supply of the e-ticketing system and its operation (card distribution, ticket sales, value-loading, clearinghouse management) would be bundled as a concession or PPP (in contrast to under direct contract);
- Review of fare structure to be implemented: reducing the complexity of fare structure could be wise in order to decrease the system complexity and to improve the interactions for users. Table 8.1 can be used as template for the assessment of the complexity level of the fare structure;
- Management of fare structure (tariff, ticket definition): it can be imported by the e-ticketing Central System from external systems or directly configured in the system. This procedure is beneficial if different selling channels are operated (i.e. smart cards, SMS, APP/web): in this case each channel could be developed by a different IT provider. The required integration

between the various selling platforms is guaranteed by the database describing the fare structure which can be shared by all the selling platforms. Furthermore, the “common” database will then guarantee the data flow communication among all the selling platforms and the unique accounting system;

- Definition of typology of tickets support: smart card, chip-on-paper, magnetic, SMS, APP/web, NFC and in particular the kind of support/technology to be used for single trip / daily pass (rechargeable RFID with different support, no rechargeable support as magnetic, etc.). This choice affects investment and operation costs and also the ticket distribution and selling procedures which must be adopted off-station and on-station (see for details Section 8.6);
- Integration with accounting system: the e-ticketing system must be integrated to export data on transactions and money according to the accounting requirements and procedures adopted;
- Integration with AVM system can be managed at three different levels:
    - Central level: e-ticketing Central System can import data on lines and bus stops description from the AVM Central System. This avoid doubling the configuration actions in both the systems separately and facilitate the data maintenance as one data can be modified once and updated in both the systems;
    - Communication level:
        - e-ticketing and AVM can share the same communication network (with separate sub-networks) and separate communication modules. This scenario avoids the duplication of communication infrastructures in the depots but communication modules are duplicated on-board. An alternative scenario is represented by sharing also the on-board communication modules (e-ticketing system can use the AVM on-board communication modules): this last option allows to minimize investment costs allowing a wide range of functionalities (for example: monitoring of validators status by the AVM Control Centre) but it is more critical for operation and it is not “fault tolerant”;
    - On-board level: on board integration aims to achieve a two-fold objective:
        - Verification of the spatial validity of the tickets;
        - Availability of cross-related info including validation time and location.
- Security must be managed by Transport Authority/Operator/third party and outside the code (through security keys). Security must not be in the hands of IT provider.

Ticket typology	*Reference area*	*Spatial Validity*	*Time Validity*	*Profile applicable*
Single trip Going/back Multi trip Daily pass Multi-days pass	Urban area	Flat Zones	Limited	Weekdays Weekends Peak hours Low demand hours Etc.
Single trip Going/back Multi trip Daily pass Multi-days pass	Interurban	Flat Zones Km distance	Limited	Not applicable
Single trip Going/back	Integrated Urban+interurban	Km distance	Limited	Not applicable
Subscription	Urban area	Flat Zones	Limited	Standard School Workers Elderly Etc.
Subscriptions	Interurban	Flat Zones Km distance	Limited	Standard School Workers Elderly Etc.
Subscriptions	Integrated Urban+interurban	Km distance	Limited	Standard School Workers Elderly Etc.

Table 8.1: Example of guided template to be used for mapping the different tickets typologies

8.5 KEY CHOICES FOR THE DESIGN PHASE (INTEROPERABLE SYSTEM)

In case of interoperable system, the design phase must:

- Identify the interoperable tickets;
- Identify the role of the different stakeholders/Authorities/Operators which are involved in a interoperable system;
- Detail the commercial relations/agreements among them;
- Define the clearing procedure and related functionalities (i.e. data access, etc.).

Identification of interoperable tickets

This is the first design step. Usually interoperable tickets are multi-trips, subscriptions or e-purse. The e-purse is the “native” interoperable payment tool and it is largely adopted.

Payment with bank cards is an alternative “native” interoperable payment tool but the difference is that, in case of smart cards and e-purse the design and technological choices are in the hands of the Public Transport Operators or Authority whereas, in case of credit cards, the design and technological choices are in the hands of bank operators. Furthermore, the implementation of certification data algorithm in on-board validation (not connected real-time with a central system) is expensive and then these kind of implementations are not consolidated in the real practice of bus operator outside large and metropolitan areas.

Role of the different stakeholders/Authorities/Operators

The following role can be identified:

- Smart card production;
- Smart card emission;
- Interoperable tickets seller;
- Interoperable tickets renewal responsible;
- Service operator.

In an interoperable e-ticketing system these roles can be assigned to different organizations: this means that smart card can be sold by an organization/entity, the ticket can be sold or renewed by a second one and then it can be used for validation on the vehicles of a third one.

Commercial relations among the stakeholders

The abovementioned example clarifies that the commercial relations among the involved stakeholders must be specified once their role has been assigned. For example: who is the smart card emitter? Who can renew the subscription sold by a ticket seller? Can a seller renew the interoperable ticket sold by another entity or not? In all these cases which is the money flows between the smart card emitter, the ticket seller and the ticket renewal responsible?

Clearing procedure

The clearing procedure can be specified on the basis of the outcomes of the abovementioned actions.

The clearing procedure are usually running on selling and validation data collected by the system but sometime the real data over a time period are balanced by statistical considerations and historic data.

Functionalities related to the clearing are the following ones:

- Management of access profile: on the basis of the role of the involved stakeholders some data could be accessible for all the organization but other should be restricted;
- Verification of the congruency of data between each clearing session and the following (data certification).

8.6 STANDARDS FOR SMART CARDS

The following technologies and standards are available for smart cards:

- Contact (ISO 7816);
- Contactless (ISO 14443 type A/B);
- Hybrid card (contact in recharge mode and contactless for payment);
- Chip on paper (single use or rechargeable).

In the last year the cost of contactless PVC smart card is decreased up to 1.5 Euro so the difference between them and the rechargeable chip on paper is reduced.

The type of contactless smart card which are mostly used over Europe are the following ones:

- Calypso (the standard more used over Europe and, in particular, in Italy) provided by different manufactures: ASK, Watchdata, Overtour, etc.;
- MIFare Ultralight provided by NPX manifacturers;
- CTS;
- DESFIRE.

Market standard for data formatting is EN 1545.

The following Table 8.2 details the possible relations between ticket typology, support and applicable standards.

Ticket typology	*Support*	*Applicable standard*
Single trip/Daily ticket	SMS/QR code	
	Chip-on-paper	ISO 14443 type A (MiFare Classic, Ultralight, etc.)
	Smart card (E-purse)	ISO 14443 type A/B (DESFire, TimeCos, Calypso, etc.)
Going/back Multi-trips ticket	QR code	
	Chip-on-paper	ISO 14443 type A (MiFare Classic, Ultralight, etc.)
	Smart card	
Subscriptions	QR code	
	Smart card	ISO 14443 type A (MiFare Classic, Ultralight, etc.)

Table 8.2: Possible relation between tickets typology, support and applicable standards

9 VEHICLE (CAR) SHARING

In order to provide the recommendations for the design of the system for the management of vehicle sharing, the car sharing system is considered as a relevant example because:

- The principles for the design of the systems are mostly the same for all the kind of shared vehicles (i.e. car, bike, van, etc.);
- The car sharing is the most complex system for the operational procedures in particular for the procedure of pick up and the release of the car and for the monitoring of car status (in particular if electrical cars are used to operate the service).

The design of car sharing system will be drawn based (and linked to) the definition of service rules.

Service rules can be defined before the design of the system for the management of the service.

In particular the service scheme must be specified considering the two main available options:

- "One way" service scheme: the user must pick and release the car at pre-defined points (i.e. parking areas);
- "Free floating" service scheme: the user can pick and release the car anywhere within the served area. This is the most critical service scheme to be operated.

9.1 ARCHITECTURE AND MAIN COMPONENTS

The architecture of car sharing system (see Figure 9.1) consists of the following elements:

- Central system including:
  a. Module for data exchange with external system;
  b. Web portal/APP including:
     - (user restricted area) for the management of registration and bookings;
     - (service Operator restricted area) for the management of back office functionalities;
  c. Module for fleet localization and monitoring;
  d. Module for data communication;
  e. Module for business intelligence and reporting;
- On-board devices including:
  a. Terminal;
  b. On-board unit (GPS, GPRS/UMTS module, etc.).

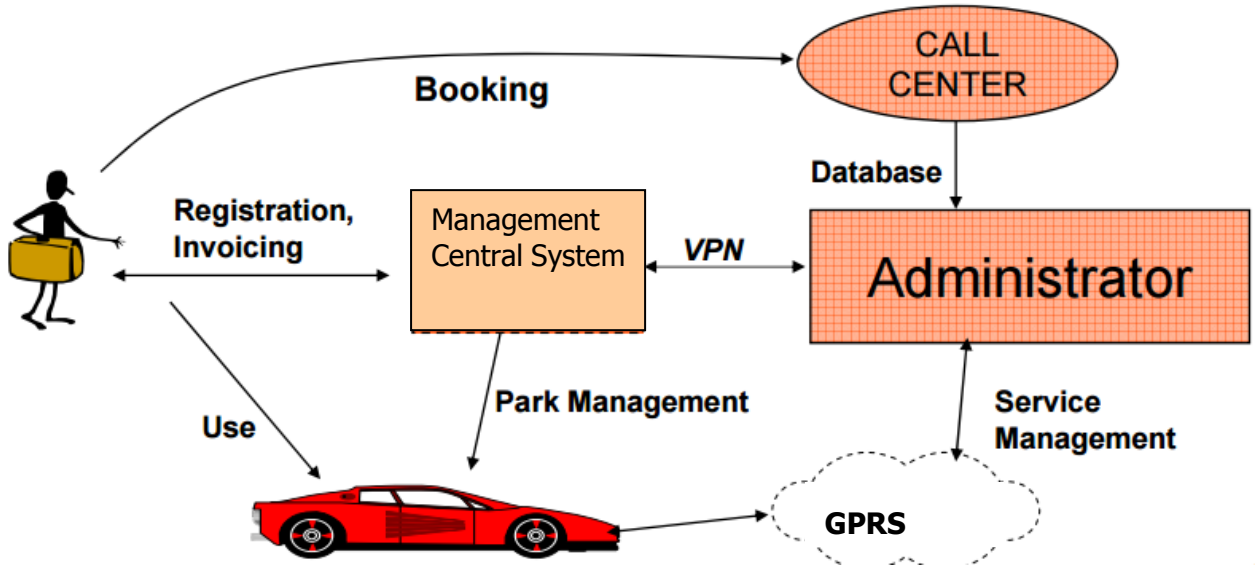


Figure 9.1: Simplified architecture for a car sharing system

9.2 MAIN FUNCTIONALITIES

The main functionalities of the car sharing system are the following:

- Integration with external system (in case of use of interoperable smart card i.e. a city card at least to be used for the service registration);
- Service registration which can be carried out by:
  a. Internet;
  b. APP.
- Car booking which can be carried out by:
  a. Internet;
  b. APP;
  c. Call center.

The booking modalities must be also selected on the basis of the time interval which is required between the booking acceptance and the allowed car pick up. This is valid both for “one-way” and for “free-floating” service schemes.

- Management of pick up and release operations which can be carried out by:
  a. APP;
  b. Smart card (restricted for the car sharing service or interoperable).
- Driver-assistance functionalities (to be displayed on on-board terminal) which can include:
  a. Localization of the car on the map;

b. Navigation mode;

c. Info related to the car reservation and use:

i. Elapsed time from the start of the current trip;

ii. Travelled km from the start of the current trip;

iii. Battery remaining recharge (only in case of electrical car);

iv. Notification in case the distance between the current position of the car and the area covered by the service is longer than the battery remaining recharge.

- Data communication between central systems and vehicles;
- Fleet monitoring including:

a. Cars localization;

b. Visualization of the cars on the map differentiating their status (booked and in use, booked for future reservation, available for booking).

- Back office functionalities for service management (accessible only for the service Operator) including:

a. Reports on payments and invoices;

b. Reports on trips.

9.3 KEY CHOICES FOR THE DESIGN PHASE

In the following the key choices for the design of car sharing system are listed:

- The first relevant option deals with the possibility to join one of the various circuits (as ICS, Car2Go, SharedGo, etc.) coordinated by national association of operators or big player companies (as ENEL in Italy) or contracting the system outside this available circuits. This is a technical choice but it depends also on commercial and contractual issues;
- As already mentioned at the beginning of this section, a second “high-level” choice is to specify the service rules before to select the system. A direct link between the service rules (registration, booking, service scheme, car use, payment, penalties, management of irregular cases, etc.) and the system functions can be created as indicated in the figure 9.2. The system must be selected based on the service specifications and the specific requirements for its management and operation. It is not mandatory to purchase the “full” technological system indicated in section 9.1 (including also on-board terminal) as the service can be managed at a certain level also “manually”, in particular if the dimensions in terms of covered area and vehicles is limited.

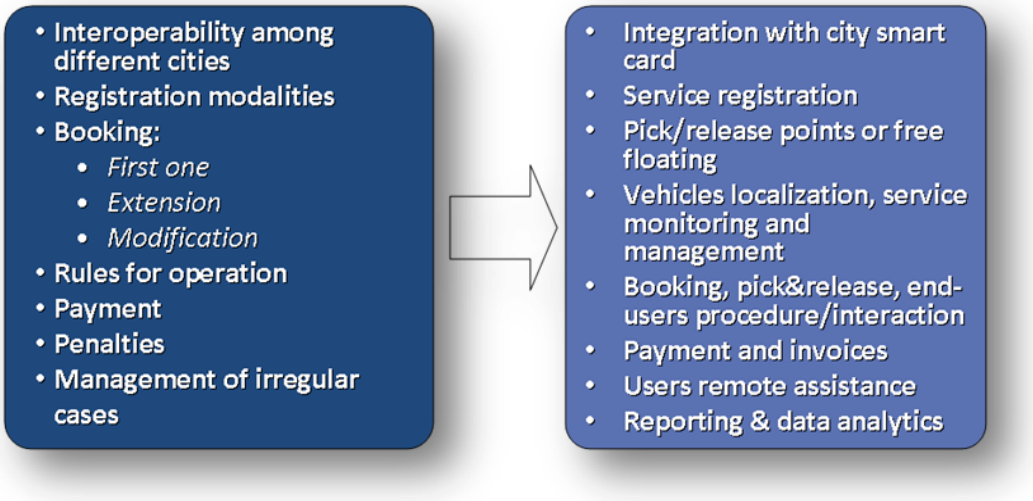


Figure 9.2: Direct link between service rules and systems functionalities

In any case Operators/Authorities committed to launch a car sharing service must be aware that this kind of service are resources consuming. Even if the managing system can be targeted to local specific requirements, not providing all the components and functionalities indicated in section 9.1 and 9.2: the allocation of resources is still demanding (i.e. to manage the real-time assistance for users, management of irregular cases and maintenance of the vehicles):

- Another recommendation is to specify into details the operational procedure for the pickup and release of the car with the objective to simplify the user interactions. Indeed, a lot of irregular cases are caused by incorrect release procedures, for example: the car is released outside the covered area, the car is released outside a parking area, theGPRS/UMTS connection is unstable at pick up and release point. The system should allow for the release of the car only after the following conditions are met:
  - The car is localized in an area suitable for parking (to be defined);
  - The car is inside the area covered by the service;
  - The car is under GPS and GPRS/UMTS coverage;

- Finally, the introduction of the car sharing service should be supported by a change in the mobility and traffic regulation (i.e. incentives for accessing restricted areas, parking payment, etc.). These incentives make car sharing competitive compared to the use of private car contributing to the increase of service users;

- For the integration of car sharing with interoperable smart card the most suitable solutions are based on web services.

10 PARKING MANAGEMENT SYSTEM

Parking Management System can be related to off-street/on-street parking. This section focuses on on-street parking management as this kind of system is strictly involved in the CIVITAS DESTINATIONS sites. The most innovative functionalities of on-street parking are the detection and monitoring of occupancy of available lots: this is a key function for the aggregation of data from different sources into a common data layer platform (section 4), the provision of infomobility services on APP/infomobility portal (section 5) and the centralized management of mobility over the network (section 11). A number of solutions are available for occupancy sensors and different architectural schemes can be designed taking into account the targets of the occupancy monitoring (infomobility and/or control of payment abuse and/or optimization/planning of tariffs and lots allocation over areas for revenue increase). Usually this kind of function can be “native” in the system or added as integration of systems (parkmeters – Parking Management System) already under operation (see section 10.1).

10.1 ARCHITECTURE AND MAIN COMPONENTS

The main components of an on-street parking management system are:

- Central system;
- Parkmeters;
- Sensors for detecting occupancy;
- Data collector of sensors signals.

Three architectural options are available:

- On-street parking sensors are directly connected to the parkmeters being these the collector of data coming from the sensors (Treviso case, Figure 10.1);
- On-street sensors are connected to data collector devices, parkmeters and system for the monitoring of lots occupancy are independent and cross-related info between payment status and occupancy not available (La Spezia case, Figure 10.2);
- On-street sensors are connected to data collector devices, parkmeters and system for the monitoring of lots occupancy are independent but cross-related info between payment status and occupancy are matched by the integration central system (Arezzo case, Figure 10.3).

Figure 10.1: Architecture of Parking Management System operated in Treviso

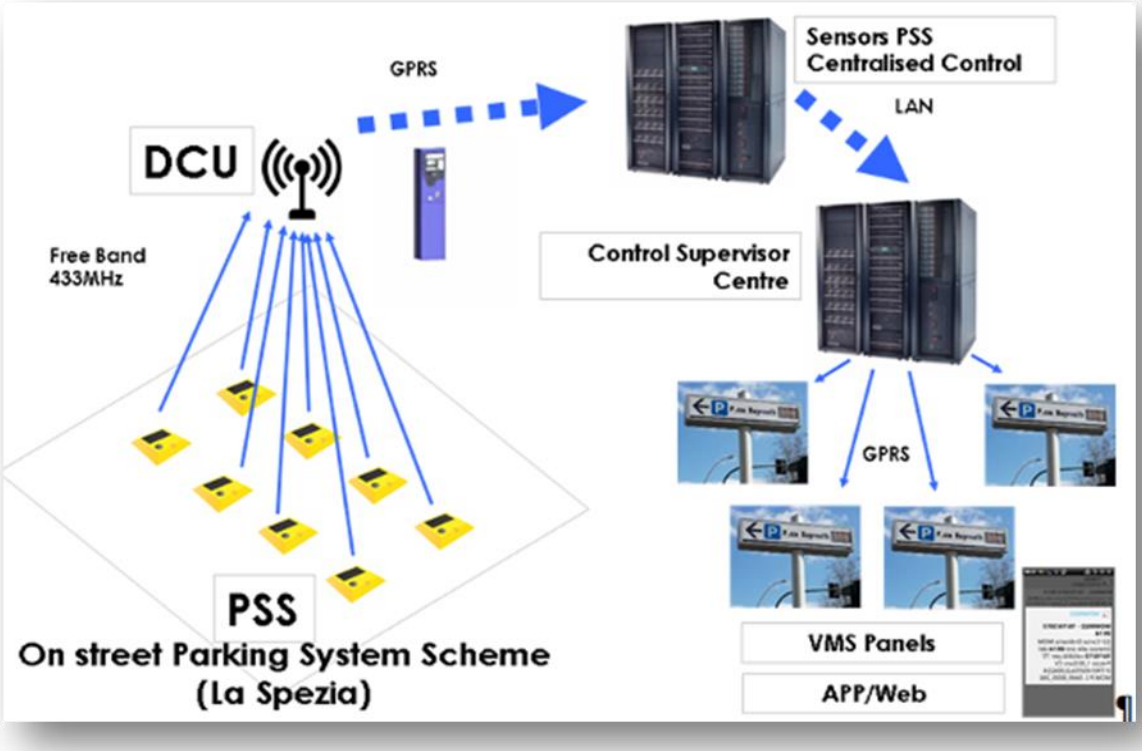


Figure 10.2: Architecture of Parking Management System operated in La Spezia

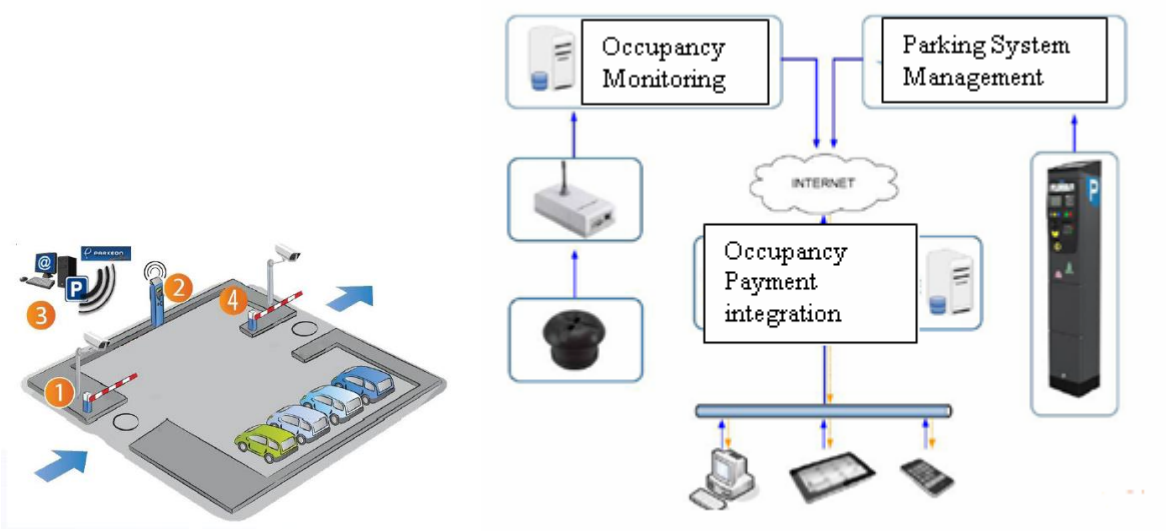


Figure 10.3: Architecture of Parking Management System operated in Arezzo

10.2 MAIN FUNCTIONALITIES

The main functionalities of the system are:

- Devices status monitoring (parkmeters, occupancy sensors, communication network, etc.);
- Pre-alarm and alarm signals generation and management;
- Transactions/payment data collection;
- Occupancy level collection;
- Variable message sign devices management ;
- Reporting and statistics on the collected data.

10.3 KEY CHOICES FOR THE DESIGN

In this section key choices for the design of on-street monitoring system are highlighted:

- Selection of the most suitable sensors models in terms of detection technology, communication solution (to a data collector or directly to the central system in remote cloud) and installation modalities (the sensors installed out of the pave facilitate the maintenance but decrease safety, sensors installed into the pave impact less on urban environment);
- Definition of appropriate mitigation strategies/procedures taking into account that any of the available solutions for sensors guarantees a 100% reliability. The measured accuracy is around 85-90% due to operational problems (see Figure 10.4) such as cars parked outside the lots, sensors covered by boxes, papers, etc. Mitigation actions are: to plan and to provide an information campaign to the users to sensitize them how avoiding abuse in the parking and to design the lots layout properly in order to make easy to park into them;

- Assessment of latency time generated by the Parking Management System between the sensor detection and the storage of related occupancy status in the central system/DB. This is a key feature in order to guarantee an acceptable “real-time” data refresh for infomobility applications (see section 4.3) and supervision of traffic/network (see section 11).

Figure 10.4: Examples of operational conditions affecting reliability of occupancy detection

11 TOWARDS THE INTEGRATION: MOBILITY GOVERNANCE AND SMART CITIES

In Table 3.1 it can be realized that various ITS planned in CIVITAS DESTINATIONS sites for managing/supporting the demonstration of local mobility measures cannot be considered separately but they are often interrelated each other as:

- The same ITS provides functionalities for more measures;
- ITS supporting different measures are integrated in the same system.

This leads to include in this deliverable some guidelines for the design of ITS for integrated mobility governance and smart cities.

In the last years the requirements of Public Administrations and Mobility Stakeholders (Operators and Authorities) for a full integration of ITS systems/services and related technological solutions under a common umbrella (i.e. a common architecture, an integrated Supervision or Control Centre) has become more and more significant. This requirement arises from the needs for a more effective operation of technological systems for mobility and transport management in order to:

- Provide "added value" services for public transport users, travellers, citizens (i.e.: infomobility services, integrated payment systems, etc.) or stakeholders (monitoring of traffic flows and resources on the network, etc.);
- Improve the coordination capability of Public Administration in terms of monitoring procedure, decisions/planning, "real time" interventions aiming to achieve a definitive city governance;
- Minimize the costs and resources for the management, operation and maintenance of the systems, avoiding the growth of "doubled" costs.

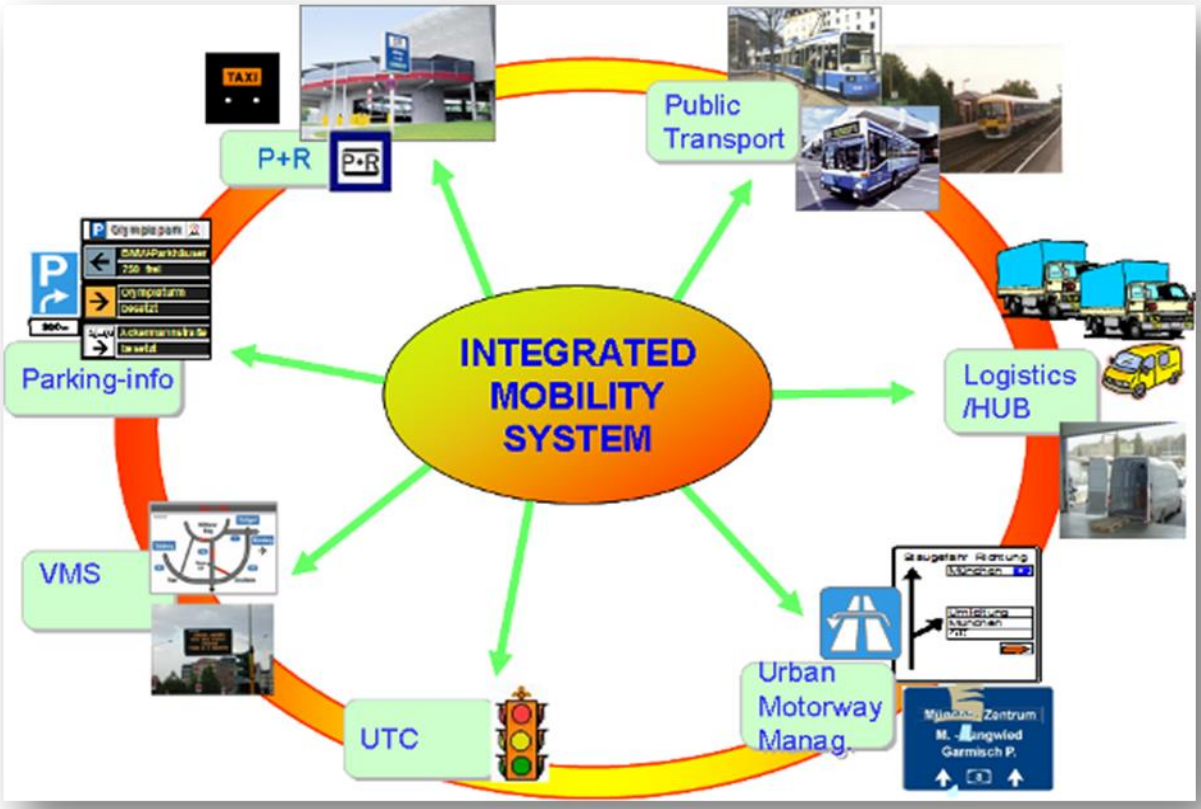


Figure 11.1: The concept of integrated mobility for urban mobility governance

Even if significant results have been achieved at standardization level both for data communication and web publishing (refer to section 4.4) and for Hw/Sw architecture for system integration (refer to initiatives as CONVERGE, FRAME, etc. at EU level, ARTIST and TTS initiative at National (Italian)

level, etc.), the achievement of a full integrated technological platform/architecture supporting all ITS systems operating in the urban area is not the “normal” state-of-art. Different experiences of the integration of legacy ITS systems aiming at implementing a common Supervision and Control Centre have taken place in Europe and in Italy. A more advanced level of integration has been reached for specific IT sector/services (in the following these examples will be indicated as cases of “partial integration”).

A first example of “partial” integration is the provision of “real time” infomobility services based on the integration of flow information from different services (detailed in section 4).

A second example is provided by Shared Mobility Coordination Agency (Figure 11.2) able to manage intermediate/flexible transport systems and shared services under a cooperative model and coordinate different mobility policies.

The Shared Mobility Coordination Agency carries out the following actions:

- Integration of data produced/related to different transport services;
- Management of an integrated mobility offer (coordinating also different Operators, fleets, etc.) enhancing resources optimization;
- Management and operation of common payment tools and clearing among Operators;
- Provision of real time information and user feedbacks management;
- Integrated design and operation of Conventional PT service and flexible/shared services;
- Certification of data collected during the operation and assessment of service performances.

The Shared Mobility Coordination Agency is the operational and technological “kernel” on which MaaS (Mobility-as-a-Service) offer can be built (see Figure 11.2).

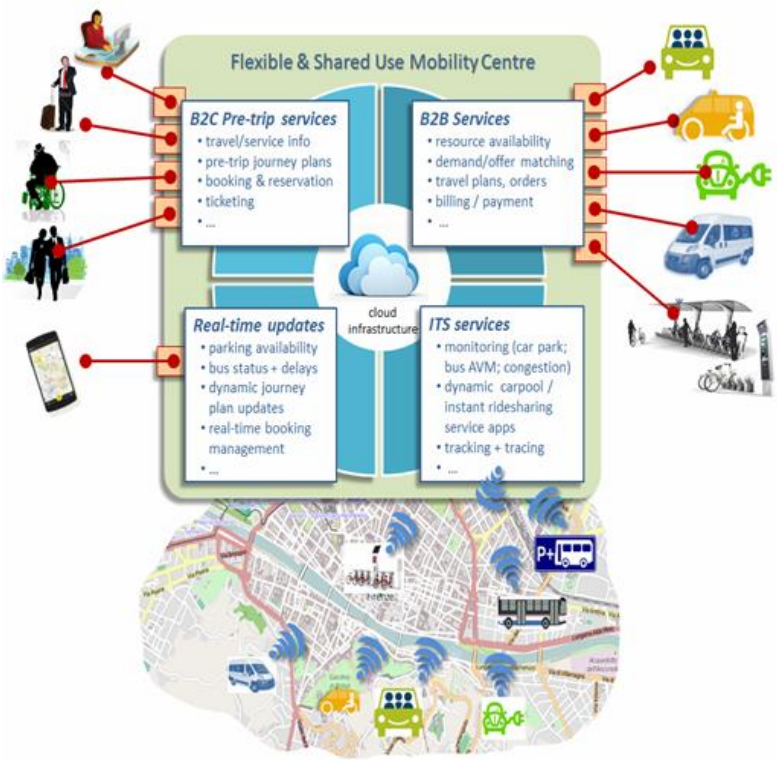


Figure 11.2: The Shared Mobility Coordination Agency as kernel of MaaS offer

A last example consists in the implementation of Coordination and Supervision Mobility centre (COSM) briefly described in the following.

The main subsystems of a traffic and mobility control and supervision centre can be the following ones:

- Integration platform for the different IT systems installed in urban areas;
- Web portal for the infomobility services;
- Infomobility services provided by using different media channels (media broadcasting, etc.).

The reference logic architecture of COSM is described in Figure 11.3.

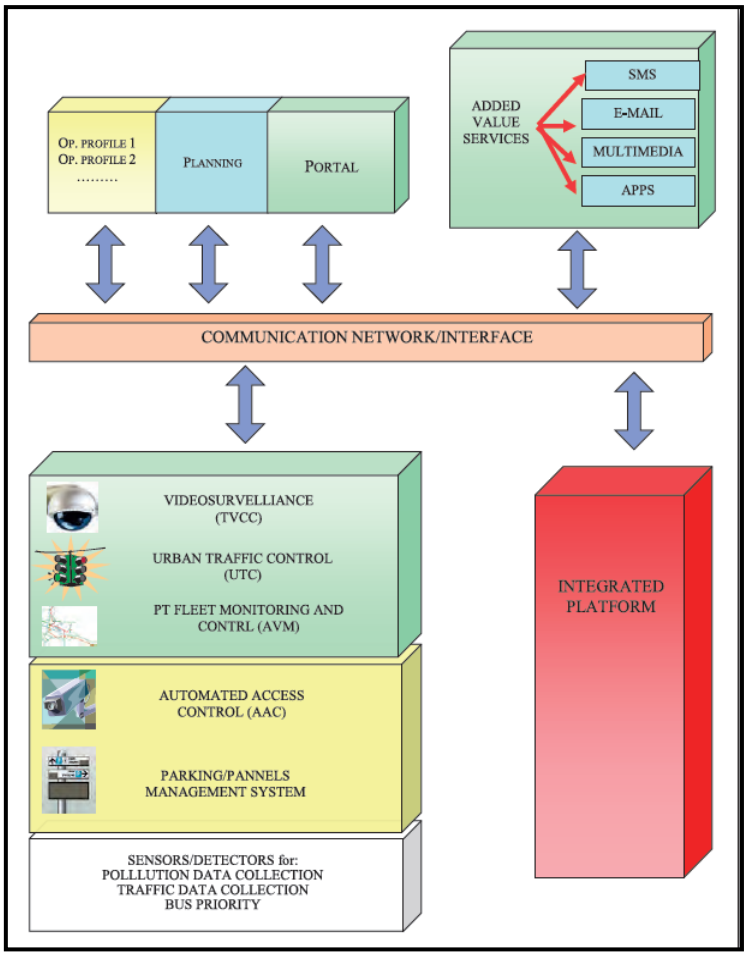


Figure 11.3: Logic architecture of COSM

The architecture should be modular and extensible with respect to the number of workstations, modules and ITS systems to be connected/interfaced. The architecture should be based on a multi-tier structure allowing a separation of these levels:

- Tools and logics of data storage and management;
- Software procedures for data collection and elaboration, tools for data formatting and transmission to external systems;
- Tools and logic for data presentation at the operator work station;
- Management of communication with the other external systems.

The main functions of a Supervisor and Control center could be synthesized as follows:

- Configuration, management and updating of road and transport network and cartographic base;
- Interface and integration with the existing systems for continuous data and information collection and association of the information with the reference network;

- Analysis of network conditions with respect to the different mobility processes (traffic flows, parking situation, accesses to limited traffic zone, etc.);
- Definition of the control strategies more suitable for the management of mobility network and resources (traffic lights coordination, bus priority, parking area coordination, etc.);
- Support of the Control Centre operators for the network state assessment and for the coordination of measures and interventions;
- Management of the control interventions operated by the Control Centre on the single subsystems;
- Management of historical database and of the communications among the supervisor and the connected systems (UTC, VMS, PMS, LTZ, etc.);
- Updated and detailed presentation to the operator of the overall information related to the network, including traffic conditions (flows, parking occupancy rate, accesses to LTZ, etc.), demand and main traffic flows estimation, technological state of the systems, current and foreseen events, etc.;
- Elaboration of the collected data, reporting management and statistical series;
- Management of information interfaces and interaction with the platform by the external actors (Urban policy, transport company, etc.);
- Management of the system policy access;
- Management and distribution of user information by different media channels (web portal, sms, etc);
- Exchange of information with the planning level (interfaces towards the assignment models, etc.).

This approach will guarantee the highest transparency and integration of the technical and functional specifications of the Supervisor Centre with respect to the systems to be connected in the future and with respect to data import and export with external systems.

12 ITS IS NOT A MAGIC SOLUTION

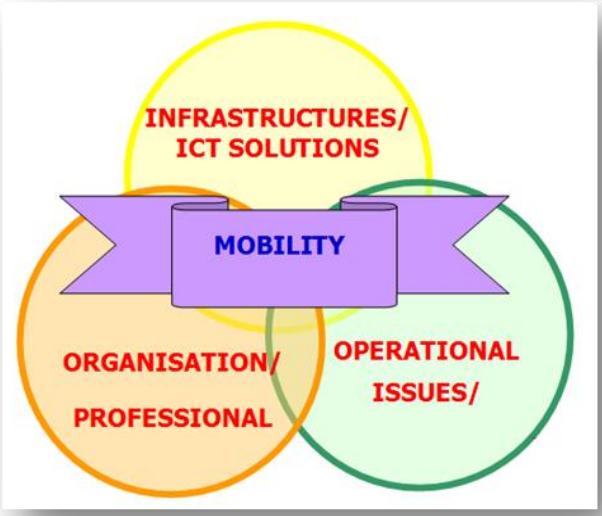


Figure 12.1: Interactions among ICT solutions and organisational/operational issues

In general, the potential of ITS systems' impacts is often overestimated by the providers and by the Contracting Bodies themselves (Public Administrations, Transport Companies, Mobility Agencies, etc.); indeed these systems are commonly supposed to be easily implemented and managed and also able to generate high cost savings and efficiency increasing. But this is not the complete story as the management of any technological systems/devices requires the definition of an appropriate operational procedure and the management of a suitable organizational structure. The implementation, sign off and operation of the system must be evaluated taking into account the framework context from different point of view (statutory level, regulation/legal issues, current state-of-art of IT systems, etc.). This is the only way guaranteeing the achievement of the objectives/benefits planned in the feasibility phase (this is a very critical phase where a wide range of issues/aspects must be taken into account in order to set the objective and benefits/costs ratio properly).

Organizational issues (regulation and coordination level: identification of the actors involved, organizational model, etc.) and management/operating aspects (identification of the professional resources and their responsibility, definition of the operational procedures, etc.) are factors to be evaluated during all the lifecycle of the system (feasibility analysis, functional design and definition of technological requirements, implementation, start up, operation).

The above mentioned issues became more critical when we skip the analysis from the implementation of a single or stand-alone system to the integration of a range of different systems into an overall Mobility and Transport Services Management System as it is largely analyzed in the previous section.

13 CONCLUSIONS

This deliverable provides guidelines to the CIVITAS DESTINATIONS sites (Site Managers and Measure Leaders) for the design of a “core” group of ITS (common data layer platform, infomobility APP, PT users information on info-panels, Fleet Monitoring System, e-ticketing, management system of sharing services, Parking Management System). The deliverable provides reference scheme for architecture and it identifies common functionalities for each of the identified ITS. In any case the indications on common architecture and functionalities must be considered with a string note of caution: the deliverable highlights how different architectural options and key functionalities are deeply dependent on system’s targets, identified needs, local background (in terms of legacy system the ITS must be connected/integrated) and context. Furthermore, the technological systems supporting mobility services and transport operation are strictly related to the operational procedures the Operator (or Managing Entities) wish to adopt. The main functionalities could be similar or roughly speaking the same but defining how these functionalities are able to support the required operational use cases (specifically identified at local level for the specific system implementation) makes the difference between system failure and success. This is the reason why similar systems in terms or architecture and functionalities are successful in one context (with certain operational procedures and resources organization/allocation) but not in others (as the targets/needs are different or the required operational procedures have not been put into practice). The guidelines underline for each ITS when the impacts of operational procedures and organizational structure/resources must be primarily addressed in the ITS design and they provide suggestions how to face them. Standards are indicated where appropriate (aggregation of data into a common data layer, smart cards, etc.).