European Bus System of the future

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This document is the first issue of the EBSF Compendium. Until the end of the EBSF project in 2012, it will be yearly completed with a new Compendium of the activities achieved.

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1. Foreword

The main objective of the first year of EBSF project has been the definition of the whole EBSF system, through the activities performed in the Sub-Project 1. This work has produced a significant set of documents detailing the complex aspects of the bus system, combination of vehicle, infrastructure and operation.

This Compendium has been produced with the aim of presenting the main results of this work in a clear way and for an audience larger than the project members. It includes the main outcomes and results of all the activities, analysis, review, meetings, brainstorming, task forces sessions, expert consultation, performed by more than 200 people belonging to the 47 partners of the project. All the concepts included in this Compendium are supported by detailed analysis: the specific EBSF source documents are always indicated in the presentation of these results. Such documents are available for further consultation: please refer to them for more detailed information.

Here below is the list of the source documents for this Compendium.

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And here are the logos of all the EBSF 47 Partners that have contributed to this work:

To each of them goes my personal “Grazie”

Umberto Guida
EBSF Project Director
International Association of Public Transport (UITP)
2. Logic of the project

The whole is more than the sum of its parts

*Aristotle, Metaphysics*

The European Bus System of the Future project, EBSF, is conceived as a driver to increase the attractiveness and raise the image of bus systems in urban and suburban areas, by means of developing new vehicle and infrastructure technologies in combination with operational best practices. The EBSF project does not look at the vehicle in isolation but as one of the elements integrated into the whole bus system; such logic is called "the system approach". This system approach reflects also the system composed by the main bus system stakeholders: the organizing authorities and the municipalities; the operators and the bus manufacturing industry.

The following diagram describes the logic of the EBSF project. It is composed of three phases: the System Definition, the Technology Developments and the Use Cases.

During the EBSF System Definition phase, the requirements of the whole system and the subsystems (vehicle, infrastructure and operations) have been identified to design the architecture of the whole system. Such activities were executed in the frame of the sub-project 1 mainly performed in the first year of the project. They will be deeply described in the following sections.

This first stage in EBSF acts as the baseline of the second phase: the Technological Developments of the key concepts and elements of the global EBSF system for the vehicles and infrastructures, and the relative operational concept and practices. The sub-system design, the development of the equipments of the prototypes and the bus demonstrators’ integration will be covered by the Sub-Projects 2 and 3. These activities, which started in the first year of EBSF, will be mainly executed in the second and third years of project.

In the last phase of the project, the solutions developed will be tested in seven Use Cases (Bremerhaven, Budapest, Gothenburg, Madrid, Rome and Rouen) in real operational scenarios in order to evaluate the added values of the proposed new solutions vis-à-vis the existing status. Performed in the Sub-Project 4, these activities will mainly take place in the last year and half of the project.

Strategic activities, including the dissemination of the results and the initial standardization process of the developed solutions, complement all the phases of EBSF in the view of increasing its visibility and acceptance in the Public Transport domain.

EBSF is a complex project that produces outputs at different levels, as presented in the following figure:

The aim of the following sections is to present the first year project activities; in particular the EBSF System Definition. EBSF partners defined the needs of the major Public Transport stakeholders, and transformed them into system requirements. In order to define a common system applicable to the European Bus System of the Future. The reference architecture has been developed by studying the system requirements.

In addition, initial activities relating to technological developments, draft use cases scenarios and their relative strategies were performed.
3. EBSF System Definition

3.1 General logic

Urban bus services, like Public (and mass) Transport in general, contribute to meeting the mobility needs of citizens. One part of these needs is made up of quantifiable requirements, but another part is based on “perceptions” of the service itself. For this reason, the holistic definition of the EBSF System is the result of the combination of the two approaches illustrated in the following picture:

The “top-down” approach

The “top-down” approach is based on a creative brainstorming involving European Public Transport experts. Since the first ideas rose about this project, some basic public transport topics have been identified to be the roots of the EBSF system definition: vehicles and infrastructures’ accessibility, service performance, safety and security, environmental issues, maintenance, economic and operation issues, urban development and quality of life, etc…

At the earliest stage of EBSF, the experts of the Consortium identified the main factors influencing the evolution of bus systems in Europe. These main factors compose today the six strategic concepts included in the EBSF Vision.

In the EBSF Vision, the project partners provide one common message about ideal bus systems for European cities. All the elements of that define the EBSF system participate directly in the achievement of the mission settled chapter by chapter in the Vision.

The “bottom-up” approach

The “bottom-up” approach is built on consolidated system engineering methodologies.

The atomic system requirements stem directly from the stakeholders’ needs, acting as the basis from which derive a complete and consistent set of requirements for the vehicles, the infrastructures as well as the operations. The elements of the EBSF System Definition are issued of the synthesis of the system engineering process.

3.2 Top-down: The Vision setting the EBSF Mission

The EBSF Vision\(^1\) is the first strategic document of the project. Addressing a broad public, the Vision is the main dissemination tool for spreading the common message of the EBSF Consortium about ideal bus systems for the future in Europe. The Vision is one of the cornerstones of the project, describing its missions.

1. More information in the D4.4.1 “EBSF Vision”, available also as a booklet
The six chapters of the Vision represent the main key factors impacting on the evolution of bus systems: passengers’ needs; social and environmental needs; cities’ needs; political support and legislation; and the need for a strategic research agenda for bus systems.

a. Responding to passengers’ needs
The bus service provision has to take into account the needs of all users. This aspect is fundamental to raising the attractiveness of urban bus services. A new tailored mode of transport in line with needs could put users’ satisfaction levels at least on a par with cars, and therefore encourage people to choose public transport.

b. Responding to social and environmental needs
In order to respond to social needs, bus systems of tomorrow must mirror the evolution in society, taking into account the new mobility trends of European citizens. Ensuring sustainable mobility is also a daily target of European society, which can only be achieved through a smart use of energy resources.

c. Responding to the needs of cities
Cities are the heart of EU sustainable development efforts. A good urban bus system can promote the image of cities and help them to be “greener”. The bus of the future therefore cannot be conceived as a vehicle in isolation, but as an integral part of the city network interconnected to all transport modes; public, private and soft modes and in harmony with urban planning.

d. Promoting political support and relevant legislation
Europe needs a political framework adapted to PT and allowing PT to develop its full potential. Therefore, it is particularly important to coordinate all levels of intervention/decision in the PT domain and to provide PT authorities with the relevant powers.

e. Securing global leadership
Operators seek solutions tailored to the current constraints that they face in trying to reduce operational costs and provide flexible services. To reach a customer-oriented solution while keeping the system affordable for customers and operator, the importance of a correct fare policy and collection has to be emphasized. The objectives are to create a favourable business and regulatory environment/framework for PT.

f. Call for a strategic research agenda for urban bus systems
Making a vision become reality calls for the creation of a strong research agenda for urban bus systems and the identification of the research priorities for the bus system: systems integration and standardization; environmental performance; modularity.
3.3 Bottom-up: Application of System Engineering Process

Bus system as defined in the frame of the EBSF project, i.e. the synergetic superposition of vehicle, infrastructure and operation, can be considered as a “complex system”: the properties of EBSF as a whole greatly differ from the sum of the properties of its parts. This underpins the EBSF project approach of applying modern system engineering methodologies and the relative tools.

In EBSF, this methodology has been concretely applied in the Sub-Project 1: more than 500 users needs have been collected from all stakeholders of the bus system (regular and non-regular users, operators, authorities, industries, etc…) and then translated into precise, unambiguous statements with targets to be met by the bus system as a whole. Each system requirement has been written, justified and the relative trade-offs and links identified. In addition, they have been clustered into basic functional requirements to provide a overview of the system features and to facilitate the handling.

The system requirements were then divided up and translated into the requirements to be included in each sub-system (vehicle, infrastructure and operation).

The overall bus system architecture was finally drawn up in order to describe all subsystems (vehicle, infrastructure and operation) and their interfaces in respect of the functionalities necessary to comply with the requirements.

The result is a complete, consistent and coherent set of system and sub-system requirements (and the corresponding architecture).

2. More information in the D1.3.1 “EBSF System Requirements”
Systems engineering

Systems engineering (also known as Systems design engineering) is an interdisciplinary field of engineering that focuses on how complex engineering projects should be designed and managed.

In engineering a requirement is a singular documented need of what a particular product or service should be or should do. Those requirements, both system and sub-system, are characterized by well defined properties formulated according to a well-described style-manual.

According to the European Space Agency (ESA) Engineering Standards ECSS-10a, a requirement is:

- Singular and identifiable; addressing one and only one thing and associated with an identifier (document, paragraph number, etc...).
- Complete: it is fully stated with no missing information (self explaining).
- Consistent: it does not contradict any other requirement and is fully consistent with all applicable documentation.
- Unambiguous: the requirement is concisely stated. It expresses objective facts, not subjective opinions.
- Justified: the rationale behind each requirement has to be expressed.
- Traceable: the backward traceability is the process to trace back the source of each requirement to the requirement from which it derives (user needs) and the forward traceability is the process to establish that the requirement is implemented at the appropriate phase of the design.

3.4 EBSF pillars: User Needs and KPIs

Assessing the needs and requirements of the various stakeholders towards the bus system and identifying the Key Performance Indicators for the whole system play a key role in the definition of the European Bus System of the Future.

User Needs

The analysis of user needs analysis started with extensive information collection and harmonization of the existing documents, data, studies, researches, surveys at local, national and European levels. Then, by means of interviews, questionnaires sent to external parties, working session and focus groups, missing information and gaps were identified. The final results have been validated by the EBSF consortium, and assessed externally via the consultation of the EBSF User Group.

Needs were investigated in order to determine, from the different bus-transport stakeholders’ point of view, the functionalities required by the new system, and also to analyze the performance scenarios to be tested.

The categories of stakeholders investigated are the public transport users (regular users, passengers with special needs, and occasional users), the public transport operator, public and transport authorities, other road-users (as potential new users) and the industry.

3. More information in D1.1.1 “EBSF User Needs Collection”
4. The EBSF User Group has been set in the frame of the EBSF project in order to follow the project and to assess some of its major results. The User Group is composed of Public Authorities, European networks and Public Transport Operators (Istanbul, City of Malmö, HVV Hamburg Public Transportation, EUROCITIES, POLIS, Tisso, STIB, Arriva, TMB Barcelona, TPG Genève, BGV Berlin, TFL London, Wiener Linien, DPP Praha, ATC Terni, CTM Cagliari, HVV Hamburg Public Transportation, Hamburger Hochbahn, Keolis, Carris).
a. The public transport users

The regular users: public transport users are concerned not only by the conditions on board the bus but also by the ease of the entire trip (from its planning to its conclusion in a door-to-door logic). They are particularly responsive to all the investigation areas impacting on the service quality, in particular:

- Personal security (at the station/stop and on the bus)
- Certainty of the travel (being on the right bus, travelling to the right destination/direction, having the right ticket)
- Rapidity
- Reliability of the service
- Frequency
- Continuity of the service (temporal and physical)
- Comfort and cleanness (at the station/stop and on the bus)
- Customer care and welcoming environment/staff
- Real time information
- Affordability of the fare system

Passengers with special needs (elderly, people with temporary or permanent disability, children, students...): every need valid for the regular users is also valid for people with special needs. In addition, passengers with special needs have certain expectations regarding accessibility and information. Overall, the specific collected needs require the application of a user-oriented and system approach to accessibility impacting on both the conditions on board and off board the vehicle. Special attention has to be paid to the general friendliness of the bus system and to the removal of any type of physical and psychological barrier.

Occasional users: in addition to the results on the regular users, that generally remain valid also for these stakeholders, the occasional users are particularly sensitive to all the issues related to the access to the public transport network and then to the bus service, highlighting the need for a user-friendly approach able to fulfill also the expectations of the less-experienced, regardless travel time or destination. Service performance is the main factor influencing the choice of public transport users: punctuality, intermodality and accessibility are the key performance domains to be improved to enhance modal shift.

b. The public transport operator

The management: it takes care of all aspects impacting on the service quality and on the solidity of the performed business; particularly crucial are:

- Improved PT image
- Passenger-oriented vehicle design and technologies
- Flexibility to travel demand (peak and off peak hours)
- Improved commercial speed
- Safety and security of passengers, staff and assets
- Attractive, optimized and standardized workplace for drivers
- Ergonomics
- Efficient fleet management and vehicle use
- Reliability of the vehicle
- Low operating costs
- Optimised maintenance activities

Attention shall be paid to the staff, their working environment and their role towards passengers. Strong support is also requested to policy makers and authorities to adequately foster public transport through integrated planning and supportive measures.

The drivers: key areas of investigation for drivers are safety and security, service performance, comfort, cleanness and perceived quality and passenger information and relational and behavioural issues. Overall drivers prove to be increasingly aware of their role towards passengers and express a pro-active approach to customer-care and service quality.

The maintenance personnel: the monitored areas of investigation for these stakeholders are safety and security and maintenance.

- Safety and hazard free maintenance activities
- Optimization of maintenance activities (planning and execution)

These actors insisted on the great potential and margin for improving the efficiency and the effectiveness of maintenance activities, which impact on both the reliability of the service and the operating costs.
c. The public transport authorities

The needs expressed by the authorities in relation to the bus system are related in particular to the following items:

- Reduction of congestion
- Improved city image and quality of life
- Social cohesion
- Support to city development
- Space optimization
- Safety and security for citizens
- Environmental care
- Return on investments

The bus system is viewed in terms of both its mobility and social functions: it is intended as a driver to city growth and image, to be developed assuring maximum environmental protection and return on investments. The bus system is also seen as crucial in ensuring access to urban activities for all and, therefore, it is considered an urban facilitator.

d. The other road-users

This analysis identifies the reasons for occasional users and other road-users for changing their mobility habits and turning to public transport. The expectations put forward by the regular users of the bus system generally coincide with the main factors that might motivate the other road-users to shift to public transport (e.g. better comfort and cleanliness or service performance). In addition, these stakeholders stress the concept of intermodality and see the bus system as a tool to seamless mobility. In particular, cyclists’ associations consulted identified the need for the bus system to implement full integration with cycling.

e. The industry

The industry has been especially consulted about the effects on its activities' sensibility to the bus market evolution. The primary need of the industry is to sell its products. To this end, the industry has obviously to respond to the requisites from organizing authorities and operators previously reported. The industry expresses its needs towards the bus system in terms of economic issues, underlining in particular the need to control production costs, carefully manage innovation and develop products that are saleable in wider markets.

The user needs collection offered a significant input for the identification of the physical and emotional barriers hampering the use of bus services, from inadequate service performances to difficult access to the network, from poor marketing strategies to scarce attention to the mobility demands of remote zones, to inadequate end-users information.

In general, passengers call for the development of a higher quality standard service taking into account the whole journey from its planning at home to its conclusion. Seamless mobility, and the physical and temporal continuity of the service is also rated as a key need. The collected inputs widely confirm that safety and security are among the primary concerns for the various actors of the bus system, usually positioned just after reliability and frequency in the ranking of the key factors for not using public transport by European citize

This large stakeholders' consultation allowed to stress where strong innovation of the current bus systems would promote the image and the quality of the bus system.

In particular, the following measures were identified:

- Combination of push and pull measures, where “push” measures are those imposed on the traveler with a view to influencing individual travel decisions; while “pull” measures are designed to encourage less use of the car by making alternatives more attractive,
- Improvement of marketing strategies,
- Improvement of passenger-oriented design,
- Decreasing operating costs,
- Flexibility to travel demand,
- Fostering the technical and commercial role of drivers,
- Advanced IT and communication systems,
- Identification of new sources for financing.

Key Performance Indicators

From an extensive literature review, the project Consortium identified, in a second phase, a set of Key Performance Indicators (KPI) suitable to assess the ability of the bus systems to provide and ensure a satisfactory and functional service to the targeted users. Such a set of KPIs is “SMART”: Specific, Measurable, Achievable, Realistic, Timely. The final tool gathering the relevant KPIs is a practical, intuitive and friendly Reduced Matrix of Key Performance Indicators.

5. More information in the D.1.1.2 “EBSF Key Performance Indicators”
In the next project activities, KPI will be selected to measure the validity of the solutions developed in the Sub-Projects 2 and 3 by means of use cases testing the performances of prototypes in real operational conditions in cities. The key performances of the Bus System of the Future will be therefore compared versus the present status.

3.5 EBSF as a whole: the System Requirements

Following the engineering process, the careful analysis of the user needs has produced a large set of system requirements.

The user needs collected are qualitative expressions of missing or necessary features or functions, as reported by users, the operators, the authorities, other road users and industry (from their perception of city users needs). They have been translated into precise, unambiguous statements with quantitative targets (e.g. quality levels) to be met by the bus system as a whole.

Then, the system requirements represent a coherent and consistent list of features that the whole EBSF has to include in order to satisfy the stakeholders’ “wish list”: this resulted in a very wide list covering a large set of topics (although some aspects, like propulsion are excluded as not in the EBSF project scope).

This detailed “wish list” with more than 500 system requirements is the basis for:

- The identification of the main peculiar features that are requested to be included in the EBSF vehicle, in the infrastructure adapted to EBSF, and served by coherent operation.
- The definition of the synthetic elements of the EBSF System Definition, able to represent it in the most complete way.

3.6 The EBSF Sub-systems requirements

The work of the definition of the system requirement specification has arrived at a sufficient level of crystallization to proceed to defining the detailed requirements to be fulfilled by the three subsystems in EBSF: the vehicle, the infrastructure and the operations.

Special focus has been placed on safety requirements, as well as on the requirements that can influence the perception and the accessibility of the bus system.

In the following project phase, these results will serve as the basis for the technological developments performed by industries. This will help to take into account users’ needs in the design of a new generation of bus system.

The EBSF Vehicle

The vehicle requirements represent the basic features of a new generation of urban/suburban buses able to support the manufacturers in the development of their product. It focuses on the following topics: driver’s cabin; passenger’s area (on board journey); internal and external modularity; IT application on board; vehicle guidance functionalities; environment and energy saving; strategic vehicle function and relative sub components (Fire, HVAC); maintenance.

The following identified functional specifications represent huge innovation potential and are considered as crucial to reach strong innovation in the next generation of buses.

a. Driver Cabin

Functional/Operating issues

- The driver console shall respect functional and ergonomic conditions
- The bus shall allow the driver to receive information on the state of the vehicle
- The bus design shall allow drivers access to all controls
- The bus design should enable the driver to give information to passengers
- The bus design shall enable drivers to check that passengers comply with regulations

6. More information in the D1.3.1 “EBSF System Requirements and Architecture”

7. More information in the D1.4.2 “EBSF Vehicle Requirements”
Ergonomic and comfort issues
- The design of the driver’s cabin shall allow the driver to operate in comfort
- The driver’s workplace shall be ergonomic and healthy
- Safety and security issues
- The bus shall give drivers a good view of their surroundings
- The bus should protect the driver from noise pollution
- The bus driver shall be protected from collisions

b. Passenger’s area (on board journey)
Internal layout and internal flow
- The bus shall enable the operator to upgrade the vehicle equipment and fittings
- The bus shall offer comfortable standing for passengers whatever the bus load

Attractive design
- The bus design shall create, maintain and customize a modern image of the bus

Information
- The bus design shall include devices for exchanging information
- Passengers and potential passengers shall be informed about PT and other services

c. Modularity
Inside layout modularity
- The bus shall enable the operator to change the vehicle equipment, fittings and organization

Global geometry modularity
- The bus shall enable the operator to couple/uncouple an additional trailer to adapt significantly its capacity
- The bus shall enable the operator to couple/uncouple other buses to combine several lines on a common segment

Modular conception & building
- The bus shall be designed and built as an assembling of elementary standard modules
- The bus shall allow several parameterizations/programming/configurations

d. IT application on board
Interface between the vehicle and functions/devices on board
- The bus should guarantee a good interface for the driver
- The bus shall constitute the passengers’ internal and external interface

Interface between vehicle and back office/ground structure
- The bus should have an on board IT system to provide an advanced interface with the back office
- System architecture
- System architecture should be integrated
- System architecture should be open
- System architecture should be designed to integrate third parties devices, supporting the proper protocol
- On board IT system should be modular

e. Guidance
Guidance, external interaction and steering strategies
- The bus should allow the driver to control his trajectory
- The bus should be able to climb, start up and remain at a standstill without rolling back on a 14% slope
- The bus should be able to pass bends and cope with canted roads
- The bus should provide the driver with sufficient visibility for drawing alongside the stopping area
- The bus should allow the driver to view and control the area swept by the rear overhang when at the platform, pulling out and in bends
- The bus should prevent the driver from colliding with roadway infrastructures
- The bus should not cause injury or disturbance to passengers waiting at stops
- The bus should limit injuries to pedestrians, cyclists, or boarding/alighting passengers in the event of a collision
- The bus should not allow any person to hang on the bus or be snagged by any part of it

Assisted guidance system
- The bus shall help the driver follow a single, exact and repeatable trajectory every time
- The bus shall help the driver to follow a driving profile
- The bus should help the driver coupling trailers or other buses
- Stop approaching system
- The bus shall help the driver to perform precise, regular and repeatable docking
f. Environment, energy saving
Fuel consumption
• The bus shall meet the network performance requirements
Leakage
• Fluids used shall be eco-friendly and hazard free
Leakage control
• Buses shall retain fluid leakage

1. Strategic Sub Components- Fire, HVAC
Fire protection
• All materials on board shall be flame-resistant

b. Maintenance
Maintainability
• All the compartments containing technical equipments shall ensure excellent accessibility
• Bus design should limit the number of builder-specific parts and admit generic spares
• Bus design should maximize the possible for breakdown repair or should allow a small journey to be made in breakdown service mode
• The bus shall be able to interact with ground stations
• The operator should be able to parameterize the bus.

The EBSF Infrastructure

The Infrastructure Requirements are the specifications of the functional requirements of the infrastructures that will serve EBSF in urban and suburban areas. The description of specific infrastructure requirements covers different topics like design, intermodality and accessibility, safety level and perceived security for staff, users and non users.

The work focuses on different areas: running-way, busway and lanes, running-way geometric characteristics, crossings, stops, accessibility to stops, interface stop-bus, interchanges with other modes, depots and workshops, interface bus-city.

Whilst some of these requirements are well known today, and mentioned as a reminder for state-of-art solutions, many others are strongly innovative compared to current bus systems. This is particularly true concerning busways and lanes, crossings, interface stop-bus and the interchange with other modes requirements.

The identified innovative functional requirements are:

a. Running-way
• The running-way should guarantee safe bus driving whatever the weather conditions and time of day;
• It should be organised so as to give priority to bus traffic over background traffic;
• Buses should be able to negotiate speed reducing constructions and other obstacles on the running-way.

b. Busway and lane
• A reserved space for bus traffic should be provided;
• Busways and lanes shall be sufficiently strong to support the bus weight and its safe circulation

c. Crossings
• Priority systems for the bus should be implemented;
• At crossings, bus circulation and turning should be facilitated.

8. More information in D1.5.1 “EBSF Infrastructure Requirements”
**d. Bus stops**
- Safety and security of passengers should be guaranteed at all times;
- Every stop should provide sufficient and adapted information for all users;
- The stop should have dynamic information, especially real-time information on waiting time and service disruptions;
- Stops should be adapted in line with demand and bus needs (number of buses, type, frequency), operational organization and stop maintenance needs.

**Accessibility to stops**
- The bus stop shall be accessible to all.

**f. Interface stop-bus**
- Boarding and alighting the bus should be easy and secure;
- The driver should be able to know the points where the doors have to be positioned.

**g. Interchanges with other modes**
- Transport terminals and interchange stations should allow passengers to change mode in a shorter time;
- The information on the interchange shall be sufficient, accessible for all and organised to improve the passenger flow;
- The walking environment (paths) and the waiting areas at the interchange shall be pleasant, safe and accessible for all.

**b. Depots and workshops**
- The depots and workshops should be environmentally friendly;
- The equipments in the depots and workshops should be able to interact with the bus.

**i. Interface bus-city**
- The bus system should be integrated into the city planning and its infrastructures to contribute to a more sustainable city.

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**EBSF Operations Requirements**

The operations requirements are the main features of the EBSF bus operation system. They are classified according to the operational phase of the service: preparation for service; entering into service; running service; failures during the service; maintenance; depot management.

Even if some of these requirements are well known today, they could be significantly improved by the use of the latest IT solutions and new technologies or by the use of solutions applied in industry. But most of the requirements have a large innovation potential, especially the requirements linked to information providing, integration of different transport means, as well as fare integration, communication between bus and ground station, or maintenance. The most innovative are:

**a. Preparation for service**
- Network should be planned to minimize lines changes;
- Traffic generators shall be sufficiently served;
- The network shall be designed together with the other PT modes;
- Travel time shall be as reliable as possible;
- The bus lanes should be used in addition only by the emergency services (police, ambulances, fire-fighters) in case of emergencies;
- Fare collection system should be considered when designing the bus service/network;
- The bus service needs shall be taken into account in the city planning and in the definition of the city master plan;
- The operator shall provide pre-trip information as planning, maps, stops, schedules, etc.;
- The operator should be able to develop a simple and convenient system of selling of tickets in the bus, at stops, by retailers, with internet, by mobile phone, etc.;
- The bus service should be organised as complementary and connected to other public transport modes (tram, train, metro, etc…);
- The bus service should be organised as complementary and connected to alternative modes of transport (car-sharing, park and ride, bike-sharing, taxi, etc…);
- Connections shall be easy and fast;
- The information concerning all modes of transportation necessary to make a single journey shall be easily accessible in one single request;

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9. More information in D1.6.2 “EBSF Operation Requirements”
• Fares should be integrated with other public transport systems and also with other services (parking, bike rental, etc…);
• The operator should have a management tool for collecting data and improving the driving style;
• Drivers shall be trained regularly.

b. Entering in service
• Bus preparation to service should be quick and easy;
• The operator shall have the possibility to set up the on-board bus subsystems according to settings defined by the manufacturer;
• The on-board equipment shall be set up before starting the service.

c. Service (operation)
• The operating centre shall be able to locate and communicate with the vehicle and the driver;
• The driver shall have a silent instant security alert for emergencies;
• In case of emergency and accidents the operator shall be able to collect and send images from inside and outside the bus;
• The driver should be able to know if he is delayed or ahead of schedule;
• The driver should be able to check the time between the previous/following bus;
• Staff shall be able to fast adapt the service to the load/demand (internal/external modularity);
• The operator shall be able to take actions against cars which hamper the circulation of the buses;
• The staff shall be able to act on bus parameters according to settings defined by the manufacturer, for easy transfer of the bus from one route to another;
• The driver shall be forbidden to sell tickets or talk during the driving process;
• The operator shall be able to check the quality of the driving of drivers;
• Organization shall allow the capacity to be adapted to the load (internal and external modularity);
• The operator should use visual and audio announcements in the bus;
• Tools using new technologies shall be “user friendly” for all (drivers, staff, and different types of customers: elderly, disabled…);
• The passengers shall be provided with information during the regular trip;
• The passengers shall be provided with reliable and on time information about disruptions on the bus system and also on modes in connected systems: inside the bus, at stops or hubs, and everywhere on demand;
• All passengers must be able to know where the bus is located on a line or on the network (at a stop, in the bus…);
• The information supports must be easy to update;
• The organization shall insure the exchange of information between staffs of different operators (or modes);
• The passengers shall be provided with information about connections with other modes;
• It shall be possible to transfer vehicles in case of total disruption on another mode/to another operator/to another line to take over from the disrupted service.

d. Failures during the service
• The driver shall have an instant alert device for emergencies
• In the case of break-down of a bus system staff should be able to know what is happening without asking the driver
• The driver should be able to know about the status of different bus systems
• Vehicle manoeuvres in breakdown situations shall not endanger other road users
• It should be possible to deal with a break-down remotely
• It should be possible to prevent a critical fault by a bi-directional communication between remote assistance and bus
• Passengers shall be informed about the break-down and the alternative for continuing the trip

e. Maintenance
• The maintenance procedures shall be hazard-free for employees
• The bus should run without failures, following the maintenance procedures, due to a permanently managed and monitored maintenance process
• The on-board computers shall be able to communicate with the ground station to monitor the mechanical conditions of the bus, the communication protocol shall be standardized
• Working area should be designed to improve the speed of diagnosis and repair time
• All the maintenance operation done for each vehicle shall be recorded in a comprehensive database containing structured information about previous maintenance operations and data from bus diagnosis system
European Bus System of the Future

f. Depot management

- The vehicular flow in depot shall have the appropriate space and organisation for the movement of vehicles and necessary maintenance operation
- The telematic components on the bus should be standardised in order to allow fast and easy communication with the ground station
- The operating data from the on-board computers shall be downloaded at the entrance to the depot
- The service data for the next day (timetable, routes, advertising, head up display etc.) shall be uploaded on the on-board computers
- The bus emissions data record from the on-board computer should be transmitted to the back office
- The utility devices (washing machines, fuel station, vacuum cleaner, oil refuelling system, etc) should automatically identify the bus, monitor the operation and communicate with the back office
- The operator shall recycle the water from washing station

3.7 System definition elements

As stated in Chapter 2, the main scope of the first year of EBSF has been to perform the EBSF System Definition. Figure 3 clearly shows that the EBSF system is defined through the following elements:

- the EBSF Basic Functions,
- the main associated trade-offs,
- the core KPIs,
- the axes for innovations of the bus-system solutions
- the EBSF reference architecture.

EBSF Basic Functions

The basic set of functions, represented by the Basic Functional Requirements can be seen as the first level of functional architecture of EBSF.

These functions express the main topics of EBSF and identify various elements inherent to every public transport experience.

The EBSF Basic Functions represent closely the system requirements which have been clustered into them. Such complete, consistent and limited number of functions/clusters eases an overall reading and access to the system requirements.

Figure 6 - Clusterisation of System Requirement into Basic Functional Requirement

It should be noted that not all of the identified EBSF Basic Functions are further developed in the project. They are part of the EBSF global system definition and their analysis is left to future projects and activities (see also section 5.2).
The 17 EBSF Basic Functions are the following

1. Make an efficient use of urban space: in an urban environment, public and transport authorities need to efficiently use the public space and then take it into due consideration when they make decisions about urban development planning.

2. Improve the attractiveness of the bus service as a means to achieving modal shift without adding constraints to people: the different aspects which improve the attractiveness of the bus service must be enhanced to encourage users to shift to public transport without suffering constraints.

3. Contribute to improving the image of the city: a service which is integrated into the city-environment and that gives to people the possibility to reach their destinations without obstacles enables the city to focus on its living and working-functions.

4. Provide to the different categories of users high quality services integrated into their operational environment: combine a set of complementary services for different sizes of cities and transport organisation concepts. Passengers with different needs, goals, experiences and expectations must find a common interest in the system.

5. Efficiently interact with soft modes of transport: interaction with soft modes requires coordination and planning, as well as more operational aspects on transport devices, interchanges, information, etc.…

6. Offer to decision makers, different options for Bus System Solutions¹⁰ implementation: for this reason, EBSF has to include tools to assess its quality parameters in order to provide the European decision makers with the most appropriate information to make the right implementation choices, to identify the best solutions, to pursue optimization in investments, etc.…

7. Implement fare pricing policy and efficient fare collection: to reach a customer-oriented solution and keep the system affordable for customers and operator, EBSF emphasizes the importance of a clear, correct and, when appropriate, integrated fare policy and collection.

8. Improve passenger comfort and ease flow: a better mode of transport than private transport modes in terms of travel time and perceived comfort.

9. Implement safety and security management tools and processes: EBSF foresees the use of the most modern practices and tools for safety and security management and requires every evolution related to bus transport to be subject to safety and security assessments.

10. Provide timely and complete information to the passenger during the entire trip, from the planning stage to efficient door-to-door navigation: the PT-user requests complete (i.e. relative to all the means composing the urban mobility scenario), permanent, available and updated information to move from A to B and remain informed about possible changes all along the trip.

11. Improve users’ accessibility to the EBSF elements: the complex structure of EBSF including fares, network-choices, safety-solutions, etc.…, has to be easy to understand and accessible for all kinds of users.

12. Improve environmental performance of the bus service: in every step of its life cycle, the EBSF elements need to consider environmental performance at the highest level, to mark the difference with private transport. Environmental management tools and processes shall become common practice.

13. Facilitate and promote the smart use of existing and alternative energy resources: the smart use of the resources (maximal performance per energy-use) and research and development of alternative and cleaner energy sources are key points for EBSF and public transport in general, in order to maintain its characteristic of an environmentally-friendly transport mode.

14. Maximize the use of open technical and operational standards, existing or new: EBSF considers that the strong use of shared technical standards (current and future) and shared operation practices is an important element to reduce costs in maintenance, promote job satisfaction in operations and enhance product-recognition for public transport users.

15. Be modular and flexible enough to adapt to each specific operational and environmental condition: modularity at all levels shall be taken into account to balance the highest level of standardization required by the operator and industry and the individualization of the service provided according to users' preference to have environmental benefits.

16. Allow a reduction of the operational costs: EBSF encourages cost-controlling and the development/introduction of technologies and practices for operational cost reduction/control, including maintenance costs, with an impact on the subsidizing government or the customers.

17. Be capable of evolving according to upcoming needs or advantageous new technologies: EBSF will be capable of identifying and assessing the most promising future technologies (IT and engines etc) and upcoming needs (social, economic and environmental) by offering a platform for the definition, development and testing of such new solutions.

¹⁰. Within EBSF, the term Bus System Solution is used to indicate a certain combination of Vehicle, Infrastructure and Operations, and their interaction. Its definition includes the relative interfaces associated to a certain type of perceived bus service (for example BHLS, BHLS LITE, classic lines, local lines).
Trade offs

In EBSF, the identification of conflicting requirements creates the need to resolve trade-offs between the different possible solutions and alternatives. Stakeholders’ expectations and conflicting requirements at system level are detected and recorded all along the process. Making trade-offs is essential to find the optimal way to solve conflicting and contradicting requirements when moving from the conceptual level to the level of solutions. This applies to all the stakeholders, including city authorities, and encourages making trade-offs before making system choices.

A short list of the main potential conflicts has been identified at the system level and linked to the Basic Functional Requirements. They identify the choices to be taken while implementing the different functionalities. Potential conflicts have been classified by category of stakeholders keeping in mind that the identification of the suitable solution requires the endorsement or the involvement of the impacted stakeholders, including the responsible local authorities.

The identified trade-offs impact mostly on the authorities’ operators’ and manufacturers’ policies.

Below is the list of the 16 potential conflicts at system level and trade-offs needing to be resolved:

1. Public bus operator vs. private bus operator
2. Public money vs. private interests
3. Political approach: long term vs short term policies; Public Transport vs. car incentives
4. Authorities’ behaviour towards standardisation: rolling stock cost vs. “uniqueness”; innovation vs. proven technology.
5. Creating dedicated and protected bus lanes: public transport attractiveness vs. optimized use of urban space
6. Prioritize solutions for young users vs. old users
7. Attractive vs. affordable system
8. Pricing policy: pay- for-service consciousness vs. promoting modal shift
9. High frequency vs. low cost
10. Maxi capacity vs. maxi seating
11. Average commercial speed (dwell time and accessibility) vs. anti-fraud fight
12. Dedicated lanes reserved to buses or shared with other users (electric cars, taxis, bicycles…): average commercial speed vs. smooth integration and acceptance by other users
13. Additional customers for peak hours: added revenue vs. added cost (when the network reaches saturation point)
14. Drivers’ protection and concentration vs. passenger contact
15. Search for improved environmental impact vs. rolling stock cost and operating cost
16. Manufacturers’ behaviour towards standardisation: cost reduction vs. “market protection” (feeling of competitive edge through customised solutions)

Lines of innovation

As well as identifying the sub-system requirements, it is important to identify the aspects driving innovation in the development of the relative solutions at the system level. Thus, through the analysis of the system requirements, a group of experts identified for each Basic Function a set of key concepts strictly related to innovation. When necessary, such concepts have been linked to a corresponding trade-off from the list in the section above.

This provides a double axe to the analysis, identifying the direction of the innovation together with the key aspects to resolve (identified by the trade-offs): the lines of innovation derived from the system requirements and, therefore from the basic functional requirements.
<table>
<thead>
<tr>
<th>Basic Function</th>
<th>Relative lines of innovation</th>
<th>Trade-offs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creation of strong structural links between urban planning and transport planning (creation of a new dedicated bus-lane and service quality).</td>
<td>3 – 5</td>
</tr>
<tr>
<td>2</td>
<td>Optimization or redesign of the PT (bus) network to define the service offer in line with existing and potential demand.</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Integration of the bus system into the global structure of cities (city insertion, façade to façade treatment) in the urban environment.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Harmonised adoption of complementary bus system solutions tailored to specific user needs and interacting with other PT elements.</td>
<td>6 – 7</td>
</tr>
<tr>
<td>5</td>
<td>Facilitation of the use of soft modes complementary to bus systems (by providing safe and easy access to the bus system, improving information exchange, creating parking space inside and outside the bus, allowing the use of the dedicated bus lanes by cyclists).</td>
<td>3 – 10 – 12</td>
</tr>
<tr>
<td>6</td>
<td>Definition of a wide variety of bus subsystems (bus system solutions) allowing cities to make an optimised and flexible combination according to their needs.</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Development of solutions for easy access to ticketing and to ticket validation, with as low an impact on dwell time and speed as possible. Make pricing policy easy to understand for the users.</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>Give high importance to passenger comfort and flow in the design of all the system elements: bus, stations and connection hubs, but also in the design of the entire network, and the way in which information is provided to passengers.</td>
<td>9 – 10</td>
</tr>
<tr>
<td>9</td>
<td>Push for wider implementation of safety management systems and security management systems, developed on defined and agreed baselines (tools and processes).</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Development and use of information and communication enabling technologies, driven by providing added value. Provision of relevant, complete, coherent and frequently updated information (avoiding the spread of useless information).</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Consistency between the designs of the different system elements. Favour user friendly and user-oriented technology, standardised throughout the European space.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Push for wider implementation of environmental management systems (tools and processes). Promote tools to evaluate environmental impact of system choices.</td>
<td>15</td>
</tr>
<tr>
<td>13</td>
<td>Develop evaluation and promotion tools for existing and alternative energy use, in connection with “clean procurement” directive.</td>
<td>15</td>
</tr>
<tr>
<td>14</td>
<td>Promote standardisation of solutions, to realise economies of scale. Priority for standardisation of rolling stock elements and information systems (Driver working space, IT systems...). Develop guidelines and recommendations for operational practices.</td>
<td>4 – 16</td>
</tr>
<tr>
<td>15</td>
<td>Technological development of elements’ modularity (vehicle modularity, bus stop modularity …). Service flexibility in line with users’ expectations.</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>Development and promotion of new efficient maintenance strategies and systems. Development of dedicated tools to assess system and network changes versus costs (operational and investments).</td>
<td>9 – 10 – 11 – 15</td>
</tr>
<tr>
<td>17</td>
<td>Develop a system platform for assessing new technologies in operational environment (in terms of benefits, cost, risks …).</td>
<td>4</td>
</tr>
</tbody>
</table>
EBSF Core KPIs

The identification of the EBSF Basic Functions makes giving a global description of the whole EBSF system quite manageable in terms of strategy setting. Most of the identified trade-offs enable to understand where the main barriers to the implementation of these functions are, and support the strategic decisions that need to be taken in the implementation of the system.

In order to complete the support to such strategic decision process, it is necessary to identify a reduced set of Key Performance Indicators allowing the strategic evaluation of EBSF.

The objective is to define a small set of single, specific but fundamental KPI, the so-called “Core KPI”. The work has just started during the first year: an initial list has been proposed and discussed with the EBSF User Group members. It will be consolidated during the second year of the project.

The EBSF “reference” architecture describes the system scheme, its components (Vehicle, Infrastructure, Operations), the functional interfaces (both internal between the different Bus System Solutions or external with the “outside world”), as a part of the global urban mobility scenario: the other public transport systems (metro services, light rail services etc), soft transport modes (walking and cycling), and the private transport modes (shared-cycling, shared-taxi etc).

The EBSF reference architecture has been designed taking into account the following principles, to:

- cater for the different existing bus system solutions; maximize the reuse of the “good” concepts existing today, but also include new potentially identified bus system solutions;
- take the operational surrounding for granted, as “re-building our cities is not an option” in most parts of Europe; the historical environment of the European city does not always leave the capability to re-design the city for bus service purposes;
- include both external interfaces with the outside world and internal interfaces with the other public and private transport modes. The respective internal interfaces can be associated to the “bus system” management functions, while the external interfaces with the “urban mobility” management functions.

Figure 7 - combination of 3 factors VIO and interaction; embedded in a bus service

The EBSF reference architecture also includes the set of functions properly describing the coordination of the different bus system solutions between themselves and their integration into the city bus network as part of the urban global mobility scenario. These management functions are not necessarily attributed directly to one single component of the architecture. Such functions derive from the global system thinking, and govern the interactions between the different components, or between the bus system and the external world. In the external world different material and non-material aspects are considered: policy (eg. PDU), planning, laws/regulations, and technology.

Centralizing or sharing out the allocation of these management functions to different entities or “products” depends on the planned service model, (as the status of the operator can be private or public), but also on different countries’ models of allocation: eg. the Scandinavian model, German model, Southern European model. The same goes for special cases e.g. maintenance subcontracting to an industry or a third party or outsourcing of the “planning” function from an historical operator to a mobility agency.

Targeting the same performance level for all the bus lines of a bus network would be an illusion, but the improvement of performance levels in several domains constitutes a fair ground for lines of innovation.

A variety of bus system solutions (BSS) exist today, created to answer existing priority needs coming from specific user categories or behaviours. In a city network, those bus service segments coexist together. The EBSF system architecture is composed as a “solution of solutions”: it includes these BSS as grids and interfaces between the three EBSF sub-systems (see figure below). Four BSS have been taken into consideration in the EBSF system definition: BHLS, BHLS Lite, Classic Lines and Local Lines. As the definition of such solutions is not always identical in the technical literature, a “reference” definition has been made for EBSF.

11. BHLS: Bus with High Level of Service
12. See D1.3.1 “EBSF System Definition”, Annex-2
Innovation of Bus System Solutions

As stated, existing good-practices and bus system solutions were taken into consideration in the design of the EBSF reference architecture. This has been performed through different steps.

First, for each bus system solution, user requirements differ in terms of impact on mission, cost and schedule. Then, the user requirements can be assessed versus each specific bus system solution in order to:

• rate for each of the user requirements how it is fulfilled today, in which operational environment (large, small, medium city…) and in which operational phase (bus-stop, maintenance…);
• highlight if it is a priority need for the solutions in terms of contributing to the achievement of the solution target users;
• if it is a potential area of innovation (that needs strong improvements).

This provides the understanding of how the current bus system solutions answer the identified needs and requirements of the EBSF users and stakeholders.

By assessing the corresponding system requirement (as derived from the user requirements) vs. the bus system solution, it was then possible to highlight the system requirements having both the highest priority and the highest level of innovation for each bus system solution. Thus, the main directions in which such solutions have to evolve as part of the whole EBSF could be identified.

**Main system requirements for the evolution of BHLS as part of EBSF**

- enable punctuality of the service in line with the published schedule
- enable accessibility for all in all zones (buses and stations, connections)
- enable the collection and analysis of mobility demand data
- offer specific services to passengers or the public
- allow a concept of priority for PT
- efficient contingency management in order to minimise delays occurring
- enable customer care in all aspects (comfort, access to information, access to fares, etc)
- contribute to a more sustainable city
- enable a high level of reliability according to the applicable reference documentation and/or standard of it
- allow assessment and management of the economic efficiency of the system components
- guarantee complete and permanent travel information outside the vehicle - (right bus, right destination, right stop and right ticket)
- guarantee complete and permanent travel information inside the vehicle (right bus, right destination, right stop and right ticket)
Main system requirements for the evolution of BHLS-Lite as part of EBSF

- guarantee improved commercial speed on the entire PT-trip
- allow seamless travel and mobility
- be part of urban lifestyle and consequently create a strong brand
- enable a service safe for pedestrians or road-users
- enable capacity to be adapted to demand
- enable additional services and allow easy access to and knowledge about these services
- enable service for all regular, occasional and special-needs users
- guarantee easy access to basic information, like routes, timetables, travel time, schedules
- guarantee maintained service in case of disruption or service breakdown
- enable use of modern technologies to collect and to predict demand, to optimize route and frequency
- maintain attractiveness all along the life cycle to avoid the perception of obsolescence

Main system requirements for the evolution of Classic-Line as part of EBSF

- foster social behaviour that respects public transport
- enable assessment at system level of the real benefits versus costs of vehicles
- be conceived as a driver for attractiveness
- enable an optimized vehicular flow
- allow the same level of perceived security independently of the real operational environment
- allow the necessary flexibility to adapt to all levels of policy vision regarding the social status impact on Public Transport
- be part of urban lifestyle and consequently create a strong brand
- enable a high level of reliability according to the applicable reference documentation and/or standard of it
- enable customer-care in passenger information
- enable optimal seating capacity for specific needs
- guarantee accurate real time information, mainly but not only in case of service disruption, to avoid trip uncertainty
- guarantee the easy access to ticketing services at selected bus stations or on board

Main system requirements for the evolution of Local-Line as part of EBSF

- allow accurate information about connections to ease the use of the PT-system
- enable use of modern technologies to collect and predict demand, to optimize the route and the frequency
- enable passengers to safely board and alight the vehicle
- allow comfortable standing and seating for passengers
- enable the physical protection of passengers, staff and surrounding people in case of accident and attack
- allow the standardization of modular parts in order to decrease costs
- enable the improvement of the transport offer in poorly served areas
- enable the level of modularity required by the specific level of service
- enable the lowest LCC (life cycle cost)
- allow an optimization of timetables and connections / transfers
- allow information on fares / tickets / passes to be easy to find and understand
- foster social behaviour that respects PT
- The use of the EBSF and its elements shall be easy to understand
As part of the same analysis, the following table shows how the EBSF Basic Functions, which stand for the mission of the EBSF system, represent the priorities for the evolution of the Bus System Solution as part of the EBSF system.

<table>
<thead>
<tr>
<th>High priority</th>
<th>BHLS</th>
<th>BHLS LITE</th>
<th>CLASSIC BUS LINES</th>
<th>LOCAL BUS LINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium priority</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low or no priority</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Make an efficient use of urban space</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>2 Improve the attractiveness of the bus service as a means to achieving modal shift without adding constraints to people.</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>3 Contribute to improving the city image</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>4 Provide the different categories of users with high quality services integrated into their operational environment</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>5 Efficiently interact with soft modes of transport</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>6 Offer, decision makers different options for the Bus System Solutions implementation</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>7 Implement fare pricing policy and efficient fare collection</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>8 Improve passenger comfort and flow</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>9 Implement Safety and Security Management tools and processes</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High priority</th>
<th>BHLS</th>
<th>BHLS LITE</th>
<th>CLASSIC BUS LINES</th>
<th>LOCAL BUS LINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium priority</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low or no priority</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Provide timely and complete information to the passenger during the entire trip, from the planning to the efficient door-to-door navigation</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>11 Improve accessibility of users to the EBSF elements</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>12 Improve environmental performance of the bus service</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>13 Facilitate and promote the smart use of existing and alternative energy resources</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>14 Maximize the use of open technical and operational standards, existing or new</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>15 Be modular and flexible enough to adapt itself to each specific operational and environmental condition</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>16 Allow reduction of the operational costs</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
<tr>
<td>17 Be capable to evolve according to new upcoming needs or advantageous technologies</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
<td>✈</td>
</tr>
</tbody>
</table>

Figure 9 - EBSF Basic Functions and their correspondence with the Bus System Solutions
3.8 EBSF System database

An ad hoc web tool has been designed, developed and populated to ensure the traceability between requirements at each level of the system breakdown structure. This enables to determine if all initial requirements have been completely addressed, and if all lower levels of requirements can be traced to a valid source.

The tool allows to identify the interdependencies among all the elements of the EBSF System from the collection of the user needs (UN) and KPI to the definition of sub-system (VR, IR, OR) and system requirements (SR) and the relative clusterisation into Basic Functions.

The architecture is then described in the tool by three levels of breakdown (Functional analysis FBS, Product breakdown PBS and Interfaces), that is the basis for the allocation of the functional requirements.

![EBSF Database structure](image)

Figure 10 - EBSF Database structure

4. Other project activities

During the first year of the project some preliminary activities of the other Sub-Projects have been performed. The results of such tasks will be consolidated during the next year, and will be the core of the next EBSF Compendium.

SP2- Vehicle Implementation of the European Bus System, Development and Implementation

To prepare the technical development of the prototypes and bus demonstrators that will be executed in the next project period, partners started to work on some of the technical specifications of the vehicle elements.

From the on-board passenger flow simulation tool partners extracted information about the present and future distribution of passengers’ age and gender in many European cities like Bremerhaven, Gothenburg and Rome.

Concerning the driver’s workplace in urban buses, researches and analysis covered in particular the subject of the driver’s tasks, the current European driver work places with relevant input from other projects, European standards, regulations and recommendations, trends and innovations in this domain. Functional specifications for the future European driver workplace have been drafted, with the view on: definition of the construction point; seat; pedals; steering wheel; visibility; actuating elements; ticketing; control and information elements; position of control, information and actuating elements; heating/air conditioning; interior noise; driver security and safety.

The generic on-board IT architecture based on Internet Protocol together with the technical specifications of this architecture has been described.

Activities about Handling Support Systems started and the functional specifications for a height control system and for a lateral gap bridging system are now under finalization. Such two systems can bring guidance systems to a precision level compatible with the needs to maximize passenger flow and offer direct wheelchair access without the need to deploy any ramps. These functional specifications have been structured towards two additional systems: a new system of height control of the
A first draft version of a predictive and adaptive energy management strategy has been set up, supported by a database describing conventional diesel buses with their auxiliaries, as part of a simulation tool. The necessary input data and the relative availability during normal bus operation is under investigation. An initial strategy has been developed for conventional diesel buses using experiences from hybrid buses.

Furthermore, a study on the air cooling / heating / ventilation / air conditioning system installed on class I buses has been carried out and shows the needs of the public transport companies today.

**SP3- Bus System in the Urban Environment (Infrastructure and Operation), Development and Implementation.**

Within the activities dedicated to the infrastructures and operation of the bus system, the main objectives in the first year were to analyze the conditions to achieve efficient bus systems and the conditions to connect the bus system to other transport modes, including policies and rules adopted in cities.

The description of the different urban contexts has been elaborated, as well as the main traffic and transport policies in Europe that can help make an efficient urban bus service. A proposed typology of the hubs for the European Bus System of the Future was also drafted.

To improve interoperability, EBSF is going to develop a new generic back-office. Three main applications have been studied and described: Advance Vehicle Monitoring system (AVMS), Dynamic Passenger Information (DPI) and Predictive maintenance via remote diagnosis.
5. Exploitation

5.1 EBSF System Definition follow-on

The definition of the EBSF system has been performed during the first year of the EBSF project. In the next years of the project the EBSF System Definition will be refined and extended with additional analysis (on future urban scenarios and related technologies, societal perspectives, energy and environmental aspects), performed with the consultation of experts and the involvement of the EBSF User Group, the UITP Commissions and Committees (for specific aspects) and ad-hoc groups.

The results of this interaction (see figure above), in addition with the outcomes of the project development activities and Use Cases, will contribute to the consolidation of the EBSF System Definition, with the aim to ensure the acceptability of the global system definition in the Public Transport domain beyond the Consortium members.

Furthermore, the results will contribute to developing guidance material for operators, public authorities and suppliers, via a set of recommendations on how to implement attractive and efficient bus systems that meet European requirements. These recommendations will be published in a final guidebook, the final update of the overall EBSF Vision.

5.2 Innovation: the “EBSF tree” concept

EBSF is dedicated to the definition of the European Bus System of the Future. The EBSF integrated approach (focused on the synergies between infrastructures, operations, vehicles) contributes to the design and development of an innovative, high-quality “bus system”.

The analysis performed on system level to highlight the main innovative key concepts gives a good overview of the potential for further Research and Development. For this reason, it is helpful to represent the logic of the EBSF system development, including this project, as a “tree”:

- In the initial phase of the project, the EBSF system’s roots were created by drawing up and analysing the needs and expectations of stakeholders (user needs collection) and by defining the “ideal system” (the EBSF Vision).
- The trunk of the global system is composed of the EBSF system definition, made of its system requirements and the system architecture described in the handy database-based tool. The trunk embraces the main basic functionalities of the EBSF system.
- From the trunk the growing branches are the different EBSF aspects that have to be further analysed, developed or translated and tested in use cases and then sprout other branches. Within the others, branches are also the sub-systems requirements (vehicle, infrastructure and operations) that generate new branches of specifications, potential solutions, trade-off analysis and trials …

“Modularity” can be considered to better illustrate the application of this tree concept. From the analysis of the stakeholders’ needs, one of the specific basic functions of the EBSF definition has been identified as relating to the modularity of the system components. Thus, requirements about modularity have been defined at EBSF system and then at sub-system level. This composes the trunk of the tree concept.
The main goal of the first year of the project has been the definition of the whole EBSF System in order to describe its full potential. Considering the complexity of the system, it is impossible to design in detail all the elements that compose the whole EBSF in the scope of a single project.

Therefore, in the following project activities, a selection of key technologies and solutions (like modularity) are subject to detailed specifications (deriving from specific and deep trade-offs and analysis), development of prototypes and will be further tested in a real operational environment: they represent the bricks for the Sub-Project 2 and 3 work.

For the aspects which are not deeply analysed and developed in this project, EBSF acts as the platform where the consistency of specific solutions designed, when put in the global system will be assessed in the future.

In the research scenario, EBSF represents the backbone from which European bus research activities can grow. Based on the defined requirements, in concordance with the global system design and the common specifications set out in EBSF, new research can grow like branches, developing specific areas or aspects of the whole system, and contributing to add detail to the overall EBSF system.

Last but not least, it must be underlined that the “EBSF tree” with its system requirement and architecture platform, will emerge as the benchmark for testing innovative solutions or analysing the impact of changes on the requirements or behaviour. For example, it could be used to assess the effect of new enabling technologies (like Galileo) on IT applications and guidance solutions; or it could be the basis to analyse new requirements coming from new environmental issues.

With EBSF, the bus “renaissance” will happen in Europe! For four years, the EBSF project will apply a systemic approach, looking at “bus systems” consisting of state-of-the-art vehicles, specific European infrastructures and innovative operations in an integrated way. The bus system resulting from the project will respond to the real needs of all stakeholders that benefit from urban bus services on a daily basis, namely passengers, public authorities and operators.

The lines for innovation emerging from EBSF will indicate, guide and promote a sound future for bus systems in the pan-European space.
EBSF has a public website, addressed to a wide audience:

www.ebsf.eu

The website provides visitors with information about the EBSF project: a general presentation of the project, its main activities and the EBSF Consortium. The EBSF website is regularly updated with articles about urban buses as well as forthcoming events relevant for the public of EBSF and visitors can register to receive the EBSF Newsletter.
EBSF is an initiative of the European Commission under the 7th Framework Programme for R&D. Starting in September 2008; EBSF is a four-year project with an overall budget of 26 million Euros.

For the first time, EBSF brings together the five leading European bus manufacturers and forty-two other partners:

- **European bus manufacturers**: Evobus/Mercedes, Iveco Irisbus, MAN, Scania, Volvo
- **Public Transport operators and national public transport associations**: RATP, ATAC Rome, Veolia, TEC, Bremerhaven Bus, ATV Verona, ATM Milan, RATB, BKV, VDV, ASSTRA, UTP
- **Public authorities**: Västtrafik Gothenburg, Nantes Metropole, BIS Bremerhaven, Consortio Regional de Transportes Madrid
- **The supply industry**: Hübner, Init, Digigroup, Ineo, Pilotfish, Actia, Hogia, Vultron, Tekia
- **Research/consultancy**: D’Appolonia, Berends, CERTU, Chalmers, CEIT, Fraunhofer, Transyt, FIT, Newcastle University, PE International, INRETS, University of Rome 3, University of Rome/DITS, TIS, CRF

The project is coordinated by the International Association of Public Transport (UITP), which represents about 3,100 mobility actors from 90 countries worldwide.

[www.uitp.org](http://www.uitp.org)

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