Annex I: description of EBSF_2 thematic priorities

Energy management strategy and auxiliaries

Today auxiliaries account for 15% to 25% of the total energy budget of an internal combustion engine (ICE) bus, but they can rise up to 50% in the case of electric propulsion with no excess heat energy to exploit. Thus, requirements for energy management for different propulsion technologies can vary, and so do the optimal solutions. Energy management strategies to be exploited within EBSF_2 are based on both real-time and anticipation of the near future operating profile. This predictive component is based on schedule, the vehicle’s en-route position, street geometry and topography, and enables more adaptive and higher-level system control than traditional real-time but algorithm-based control. Solutions for new buses, especially electric buses, are considered very promising but many solutions can be adapted also for retrofitting of buses already in operation. It is therefore important to keep the additional hardware cost as low as possible.

Heating, ventilation and air conditioning (HVAC) are an important area for improvement in both ICE and battery-powered buses due to their high power needs. A combination of measures can increase the efficiency of air conditioning units as well as reduce heat loss via the interior and exterior design of buses. Effective circulation of air could also help maintain a comfortable temperature inside the bus with less energy input. Fresh air is required to control moisture/condensation on window surfaces which is imperative especially during snowy winter conditions. Solutions related to the bus stop events, such as controlled door openings for less heat exchange or a totally indoors bus stop, offer a major step-up from today's technology level. Improved HVAC systems that can use 20 to 30% less energy will be tested in different climate conditions.

Green driver assistance systems

Decreasing the use of energy in transportation is a key goal. The project demonstrates innovative ecodriving support systems adapted to the specific context of PT as well as different types of buses (diesel, gas hybrid, electric) and compliant with IT standards. The demonstrations allow a comparison and evaluation of different approaches to the development of underlying models. They also aim to increase passenger comfort thanks to characteristics of eco-driving - calmer and smoother operation.

A large number of driver assistance systems, including eco-driving systems, already exist for cars and trucks. However they do not take into account the public transport specifics where the driver needs to keep to a set schedule and starts/stops frequently. “After-market” eco-driving systems designed generically for vehicle fleets provide limited access to data other than vehicle accelerations and braking. Thus, they neither take into account several factors which influence energy consumption, nor differences between the driver’s need for feedback
in e.g. diesel compared to electric buses. Moreover, in eco-driving, like in other driver assistance systems, the efficiency of the feedback relies on the information transmitted to the driver but also on the design of the human machine interface (HMI). Present interfaces typically include displays showing the driver’s eco-driving performance in terms of basic feedback which may suffice for the experienced driver but not for the less experienced. At the same time too much information will be difficult to perceive and may even distract the driver. EBSF_2 will develop insights into this aspect, focusing on hybrid and electric vehicles, by exploring eco-driving support systems adapted to a public transport context as well as information channels, required contents and appropriate choice of modality to inform drivers as well as enhance drivers’ learning.

**Vehicle design (Capacity, Accessibility, Modularity)**

Short dwell times at bus stops and resulting high commercial speeds are necessary prerequisites for an efficient bus operation. EBSF_2 deals with new vehicle designs and optimised interfaces between vehicle and platform in order to improve the accessibility into buses as well as the internal passenger flow for both hybrid and fully electric buses. The electric Bus Passenger Simulation Tool (eBPST) is used to assess design proposals at early design stages, taking into account passengers’ behaviour. In addition, a modular bus concept demonstrates the possibilities to combine different bus segments in bus depots in order to adapt the capacity to the actual demand, which result in more efficient bus operation, especially in terms of energy and maintenance cost.

Applying new design options for the exterior and interior layout of buses may contribute to efficiency improvements by optimising accessibility and internal passenger flow, reducing dwell time at bus stops and, consequently, improving commercial speed of the vehicles and hence overall productivity. EBSF_2 activities concerning the layout of buses are a clear step beyond state-of-the-art solutions. The proposed solutions will capitalise on the EBSF project by extending a vehicle interior layout simulator to also consider the interaction between bus and platform, the design opportunity provided by electric propulsion and accessibility for all requirements, including mobility impaired passengers. Selected designers of public transport systems from the UITP Platform for Design will develop entirely new concepts for electric bus design.

**IT Standard introduction in existing fleets**

EBSF_2 will demonstrate the efficient introduction of IT standards (EN13149, SIRI, NeTEx) in an existing bus operational scenario based on results from the EBSF and 3iBS projects. The main innovation is to pass from vertical / proprietary solutions to fully interoperable ones both on board and back-office. It will permit to avoid IT supplier dependency for IT systems and to open up for competition. The introduction of these IT standards will take into account the co-existence of current IT systems to offer full interoperability. For public transport operators and
authorities, the efficient introduction of such a standard IT architecture will offer a faster, easier and cost-effective interoperability of public transport systems at a regional level.

**Intelligent garage and predictive maintenance**

Currently the maintenance of buses is managed using basic procedures. Applying standard IT architectures for collecting maintenance data in addition to the use of innovative systems based for instance on augmented reality and vehicle automation for intelligent garage can contribute to achieve a relevant saving (at least 10%) of the maintenance costs considering cost categories such as warehouse, labour, diagnostic vehicle immobilisation etc. **The EBSF_2 tests on intelligent garage will focus on the definition of new algorithms for predictive maintenance, the use of innovative tools for bus depot and offers a new way to manage bus fleets with new maintenance procedures.**

**Interface between the bus and urban infrastructures**

It is proven that transforming bus terminals in urban places (rather than anonymous non-places) contributes to the creation of cities with a good quality of life. Passengers’ experiences of bus stops and terminals could determine their perception and acceptance of the whole public transport system. **The innovations that will be developed and tested in EBSF_2 are expected to improve the passengers’ satisfaction, remove accessibility constraints for all, ease the flow of passengers and hereby optimise dwell time.** The research will address also new processes for proposing and discussing design of urban public transport infrastructure with relevant stakeholders.

The implementation of electric buses (clean, high tech appearance, low noise, zero emissions) provides a challenging and appealing opportunity to design concepts and new functionalities for bus stops as well as address interactions between passengers, vehicles and urban infrastructures. One of the innovation potentials identified in EBSF_2 is **the indoor stop for electric buses implemented in Gothenburg**, to address the users’ perception and interplay between vehicle and infrastructure, such as the charging facilities, safety and technological issues.