ESPRIT project is now launched!

Today, transportation both to and from city-centres and within suburban areas, is unsatisfactory in terms of congestion, environmental and societal aspects. To answer identified needs, the Easily diStributed Personal Rapld Transit (ESPRIT) project aims to develop a purpose-built, light weight L category electric vehicle that can be stacked together to gain space. Thanks to pioneering coupling systems, up to 8 ESPRIT vehicles can be nested together in a road train, 7 being towed, for an efficient redistribution of fleets and a smartly-balanced and cost efficient transport system. Within the project, 2 user scenarios are foreseen: a one-way carsharing system within city centres and a last kilometre personal mobility system to existing public transport infrastructures in suburban areas. A preliminary test and demonstration of three prototype vehicles will take place in 3 different geographical pilot sites (Glasgow, Lyon and L’Hospitalet de Llobregat near Barcelona). The ESPRIT concept will be achieved through state-of-the-art developments of diverse technology components.

To prove the ESPRIT concept, the project will also work on modelling and simulation tools to predict, once ESPRIT vehicles are deployed, the economic, social and environmental benefits as well as key operating strategies. It is anticipated that this concept will encourage citizens to use conventional public transport and carsharing solutions rather than their private vehicles leading to seamless intermodal transport, reduced congestion and significant reduction of noise and air pollution. To reach relevant stakeholders, the ESPRIT project will not only rely on its technical expertise but also on the knowledge and network of its end user community represented by several partners as well as the ESPRIT Advisory Board which includes carsharing organisations, public authorities and transport operators, who will participate in workshops and dissemination events.

As the key to the ESPRIT transport system is the ability to redistribute 8 vehicles at a time by a single operator, the project expects to demonstrate through simulation that it is possible to achieve a continuous 90% availability rate of vehicles across all stations (in last kilometre and one-way carsharing mode) using less manpower compared to current systems which have 50% of empty stations several times a day.

This ambition can be translated into the following technical objectives:

- **Objective #1:** Produce the ESPRIT operation and business model estimation tool to be able to accurately predict the economic viability of deploying the ESPRIT transport system in a variety of different urban/suburban configurations. It will also predict the public transport modal share induced by the system. This activity will be supported by studies to analyse citizens’ lifestyle criteria and their specific requirements for last kilometre and one-way carsharing services. It will also state if a 90% availability rate for vehicles is achieved, thanks to the newly possible redistribution strategies.

- **Objective #2:** Develop the necessary technological components to equip the vehicle, which answer the following technical challenges, namely:
  - A **Guiding and Coupling System** to allow the vehicles to be linked electro-mechanically together and perform the coupling action in a semi-automatic way. It will be particularly critical in terms of security and operating safety of the system. It will be responsible for the physical integrity of the road train but also for the transfer of electrical signals and power supply.
  - A **Powertrain and Steering Control System** linked to the steering, propulsion and braking equipment, enabling the road train to work safely in forward and reverse gear. In particular, it will prevent lateral oscillations (sway) and toppling, jack knifing and trajectory drift of the road train. The Kinematic and Dynamic Behaviour Management System (KDBMS) will also include a braking energy recovery function to maximise the energy efficiency.
  - A **Charging and Electricity Storage System** able to charge a complete road train using a single charging station.
  - An **Auxiliary Management System** to control some specific auxiliaries impacted by the dual single and road train configuration (position in the road train): the lights, mirrors, windscreen wipers, windscreen defrosting system and Heating Ventilation and Air Conditioning (HVAC).
  - Vehicle and Road train architecture which includes:
    - Development of attractive, high-tech design bodywork combined with robust external and internal finishes. The focus will be on sustainability whilst making the vehicle
appearance appealing for ESPRIT users. Design criteria similar to buses and trains will be used, to ensure minimal wear and tear from daily public use, reducing maintenance and damage claims, reducing insurance costs and delays in customer handovers.

- **Fit for purpose Heating Ventilation and Air Conditioning (HVAC) system.** As journey times are expected to be on average no more than 10 minutes, the HVAC system will be conservative to ensure reduced energy consumption and weight saving.

- **Objective #3:** Manufacture 3 fully functional demonstrator ESPRIT vehicles to perform a complete functional validation of all sub-systems, including road testing, and be able to physically present the ESPRIT transport system to end users (citizens, operators, decision makers, government authorities). 3 additional representative weighted chassis will be used to test the road train functionality of a road train of 6 vehicles.

- **Objective #4:** Produce recommendations for development of regulations and standards enabling the use of ESPRIT vehicles driven like road trains by an operator. In parallel, the perspective of allowing the general public to also drive the ESPRIT vehicle in a road train configuration limited to two vehicles will be evaluated.

- **Objective #5:** Produce a detailed roadmap for the first series of ESPRIT fleet deployment (with approx. 300 vehicles per fleet) in 3 European cities (Glasgow, Lyon and L’Hospitalet de Llobregat, near Barcelona). This roadmap will cover industrialisation, further progressive deployment and exploitation issues as well as necessary regulatory issues.

The development work that will be performed to answer these objectives and challenges must above all guarantee public confidence in the ESPRIT transport system by showing that the vehicle is safe, easy to drive and use and has the required driving range under real conditions to meet users travel needs both in urban and suburban conditions. Additionally, the expected cost for the user must be seen as affordable for the service that will be provided. As such, ESPRIT will perform a needs analysis of potential users and stakeholders in the 3 pilot sites. This will steer the design of a safe and accessible vehicle, charging and redistribution system.

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Modelling activities within ESPRIT

One of the key objectives of the ESPRIT project is to demonstrate through a suite of modelling tools, the economic viability of deploying the ESPRIT transport system in a variety of different urban/suburban configurations. These modelling tools are outlined below:

Figure 1 shows the interaction of the different models making up the overall modelling tool. The individual elements are described below.

Demand and Revenue Model

For ESPRIT, carsharing and other innovative urban mobility concepts, the changes proposed to the users’ lifestyle are very significant (e.g. by deterring second car ownership). The state-of-the-art transport models for predicting demand and revenue are no longer appropriate. It is necessary to develop a new paradigm called a ‘Lifestyle’ component. ESPRIT will have a better service quality than other one-way carsharing systems. But the level of expectation will have a cost (that of redistributing the ESPRIT vehicles) and so the model will need to reflect the correct compromise between redistribution and demand. The more redistribution, the more demand but the more operating costs, and vice versa.

It is well known that as the speed of public transport alternatives increases, the demand for private cars decreases. Similarly with other variables, the main driver of the demand (and consequently the revenue) is the level of service variables which include: in-vehicle travel time, walking time, waiting time, interchange, travel time reliability, car availability versus reliability of the bus / metro etc., quality of service, perception of the different modes of transport and so on. For example if ESPRIT vehicles can be displayed on a Google map on a cell phone application and possibly reserved in real time through the application: the user is assured of getting their ESPRIT vehicle. These variables are taken from the operations model and entered into the demand and revenue model as decisions people make about their travel. Expected impacts could be:

- Improving public transport accessibility and facilitating mode choice – e.g. choose ESPRIT to bring a local bus or rail interchange point into range for a journey that might otherwise be taken by private car or taxi.
- Small changes in choice of travel time: e.g. the reduction in the uncertainty in door to door travel time due to difficulty in parking allows the user to choose to travel later.
- Mode of transport: e.g. ESPRIT versus an alternative such as their own car
- Short term destination choice: e.g. travelling via ESPRIT to a more attractive shopping centre
Choice of time of travel: e.g. because a more reliable ESPRIT service allows one to travel at a more convenient time
Combination of activities: e.g. because one can go shopping on the way back from work with ESPRIT carrying the shopping bags.
Escort choice: e.g. for escorting children to school
Leisure choice: e.g. a new hobby may become possible as travel constraints are lifted.
Longer term choices: e.g. workplace or school because new travel options are available.
Choice of car ownership: avoid buying a second car to use the savings elsewhere.
Work status: e.g. because the second adult can now find a part time job
Impact of the internet, smartphones, company car policies, travel plans, etc.

The demand for ESPRIT is not only likely to come from people changing their route, mode, destination which are already covered by state-of-the-art demand and revenue model, but also the more important longer-term changes to their lifestyle. A decade ago, the conventional approach to predicting demand and revenue would have been a four stage transport model comprising trip generation, distribution, mode split and assignment. This was superseded by activity-based models which deal with the activities people undertake to go in their daily lives – travel being what was needed to go from one activity to the next. However, we only have to view the ‘peak car’ effect in almost all European countries (whereby traffic levels are generally declining or at least not increasing at the rate forecast with these models) to realise that this current paradigm for predicting travel demand and revenue simply does not work anymore. The demand and revenue model will have a conventional state-of-the-art model to which will be added an innovative lifestyle component which will include:

- Measurement of quality-of-life, happiness and ‘well-being’;
- A model of the changes people make to their lifestyles at certain change-points in their life where transport is part of their decision;
- System reliability and quality (by including the probability of a vehicle being available when it is needed, the time to wait for a vehicle, the need to eventually share a vehicle when not enough vehicles are present).

The fundamental theory underlying transport models is the economic theory of discrete choice which uses a utility function for each alternative to derive the probability of choosing each alternative and hence the decisions people make. In the case of travel choice, the utility function comprises the utility of travel which usually includes variables about the travel alternative (such as travel time, distance, fare, etc.). ESPRIT proposes to model lifestyles within this utility theory by including two additional terms (over and above the utility of travel) to cover the utility of the activity and the utility of the lifestyle improvement each being functions of independent variables. The variables associated with the activity and the lifestyle improvements would be found using the standard market research techniques of qualitative market research to understand the variables and market segmentation; stated and revealed preference to measure their perceived value and hence estimate the utility functions; and quantitative market research to measure the market sizes of decisions people have already made.

Figure 2 below illustrates how the lifestyle component of the demand and revenue model interacts with the transport model.
Traffic Visualiser

A traffic visualisation model will micro-simulate the traffic on the road system graphically so as to visually demonstrate the implementation of the ESPRIT concept for the three use case areas. It will take as inputs travel demand, from the lifestyle travel behavioural model, and the vehicle operations, from the operations model. Its outputs will link back to back to the lifestyle and operations models. Outputs will typically be level of service variables, for example travel time, distance, cost or congested travel time.

The ESPRIT Operations Optimisation Model

One of the critical issues of a vehicle sharing system that offers one-way-trips is the imbalance of supply and demand. Vehicles tend to accumulate in areas of lower individual mobility demand where no one wants to use them while they are needed in zones of higher demand for mobility. Thus, to make the carsharing system work, the spatial distribution of vehicles has to be adjusted using a relocation strategy that redistributes vehicles to places where they have the best chance of being used. The state-of-the-art in relocation strategies comprise either user-based relocation strategies, which rely on economic incentives to encourage the customers to deviate from their actual destination or operator-based strategies, where the operator moves the vehicles on a car transporter. Vehicle redistribution can be done once (e.g., at night when the demand is lower) or as continuous process or something in-between. The main disadvantage of operator-based relocation is the high cost of the car transporter, fuel and additional staff. ESPRIT overcomes this by stacking its vehicles to form a road train driven by a single operator. The unique feature of the ESPRIT vehicle will provide unprecedented system flexibility with a new class of relocation strategy to considerably-reduce operational costs thereby reducing the tariff, increasing demand and revenue and hence to the success of the ESPRIT system.

ESPRIT will advance the state-of-the-art of relocation algorithms by developing optimisation models of the ESPRIT operations that can work on a microscopic individual vehicle level. The Operations Model will take into account the most important operational aspects and the underlying mobility patterns of the ESPRIT vehicles including the distribution of durations parked, the spread of trip lengths and the extent to which
the users would relocate the vehicles themselves – perhaps with a financial incentive. Multi-objective optimisation will consider the trade-offs between minimum sized workforce, minimum trip lengths (e.g. to save battery), minimum relocation times and the balance between the availability of vehicles and demand for them. It will also consider the demand pattern, parking slot availability, travel time, tariff and predict the optimum future spatial vehicle distribution. Another critical operational problem for a carsharing system using electric vehicles is how to deploy a recharging infrastructure that can meet travel range constraints imposed by drivers’ typical travel activities with a reasonable infrastructure investment. The state-of-the-art is that most one-way carsharing systems install a charging point in each one of their reserved parking spots or in popular locations where people want mostly to pick up or drop off vehicles. However, this approach is highly inefficient since most of the time the charging stations are not utilized because no vehicle is parked. On the contrary, a whole stack of ESPRIT vehicles can be charged concurrently when parked. Thus a single charging station can serve multiple parked vehicles, and this caters for a significant reduction of the required number of charging stations, with a consequent reduction of deployment and maintenance costs, as well as a lower strain on the power grid. It is intended to advance the state-of-the-art on the charging infrastructure planning, by taking advantage of the ESPRIT Operations Model to establish where to locate the charging points, how many and which is the best balance between fast and slow charging points that minimizes the probability of missed trips subject to a budget constraint and a power resource constraint. It will optimally distribute the available power resources to the set of vehicles connected to the same charging stations taking into account the distribution of parking times and trip lengths. The state-of-the-art will therefore be advanced in this project by taking it a stage further to optimise vehicle redistribution and electricity charging points for the ESPRIT system.

**Business Case Model**

This model will predict profit and cash flow including consumers’ surplus cost-benefit analysis. The model will receive the predicted demand and revenue and operating costs and predict the operating profit and cash flow for one year of operating ESPRIT under present-day conditions. It will allow ‘what-if’ scenarios to be run so as to explore the effect of different operating conditions, behavioural responses, tariff’s etc., so as to find the optimum.

**Review Model**

Initial forecasts using an existing model, based on consolidated costs with simple mode choice to provide initial forecasts for the Lyon demonstration area, allowing both behavioural responses and the development of the business case to be assessed. It will permit the testing of the influence of for example cost, time, speed, fares, value of time, on modal choice, operating costs and revenues. Operation and analysis of this more systemic approach to modelling will allow key behaviours to be understood and insight used in the preparation of the full Business Case Model as well as to define the operational requirements of the ESPRIT vehicles early in the project duration.