DEVELOPING A NEW MOBILITY AS A SERVICE CONCEPT

Valery Cervantes,
CEA, Commissariat à l'énergie atomique et aux énergies alternatives
Peter Davidson, Helen Porter
Peter Davidson Consultancy

1. INTRODUCTION

We developed a new mobility as a service (MaaS) concept from initial research, through finding the funding then using market research to move the product around its potential market to find the optimum system design and market niche. The development of the vehicles and the infrastructure was then iterated between the design considerations and the market requirements until the design was fixed and the first vehicles were built and are now being trialled.

This paper tells the story of how we went about it, research and development methodologies adopted, lessons learnt and initial results of how well it fits into its market, operational requirements and initial results from the testing. We also planned it together with its infrastructure, to fit into the rest of the transport system in 3 demonstration areas in Glasgow, Lyon and Barcelona. We also build a specialist transport model to deal with MaaS and integrate them into the demonstration areas but this is the subject of another ETC paper and won't be covered in this one except to show some of the results. This paper does not cover the deployment which we hope to implement the first of the new services in 2018.

The initial MaaS research showed that there could be much more potential for 1-way car sharing than currently existed provided it could be made to work properly. One of the barriers was that the vehicles ended up where people did not want to travel from, which entails expensive redistribution of the vehicles. This was addressed by coupling the vehicles together so that they could be driven in a train thereby reducing the redistribution costs and possibly allowing users to drive a train rather than single vehicles which could reduce redistribution costs further. There is no precedent for a train of cars to be driven in the roads with potentially unsafe driving conditions such as the train swaying, jacknifing or overturning. This led to important vehicle design issues which affected the system design. The research identified the requirement for electric vehicles and this led to the possibility of charging the complete train and load balancing to optimise the availability of vehicles. Other issues included how many seats should the vehicle have? What voltage/ short high voltage charge for fast charging or slow low-voltage (and cheaper) charging stations, the optimum deployment of charging stations, the use of the internet within the vehicle, advertising to reduce the user cost and many other issues which we resolved. These will be covered in the paper. The research is being undertaken for the ESPRIT Horizon 2020 project.

2. USER AND SYSTEM REQUIREMENTS AND COMMON FUNCTIONAL SPECIFICATION

The objectives of the beginning of the project were to define a list of requirements and common functional specification based on both user feedback and European specifications. Therefore, the following tasks could be defined:

- Engage with (i) European stakeholders, (ii) the range of potential user target groups and (iii) related projects to assess the requirements and define scenarios where ESPRIT vehicles and systems will form an important new mobility market. (These will be tested at the end of the project)
- Undertake a preliminary market appraisal for ESPRIT vehicles and systems; outlining the drivers and barriers that need to be addressed to ensure fast market take-up
- Produce a common European functional specification for the design of ESPRIT category vehicles and systems
- Produce the functional safety level of expectations to ensure the safe design and operation of the ESPRIT vehicle (proof of concept) at both vehicle and road train levels.

2.1. European Assessment of the Potential Market for ESPRIT: defining the scenarios for ESPRIT vehicles and systems and their take-up by different social groups

The objective of this task was to assess user and stakeholder needs to be fed into the ESPRIT functionality and design, as well as define scenarios where ESPRIT vehicles and systems can best form an important part in the mobility market to pave the way for broader roll out. User needs assessment process was managed in the three cities of Glasgow, Lyon and L'Hospitalet. A market research expert was appointed to work almost simultaneously in three countries, to meet the scheduling. The focus groups received a discussion guide (gender balance and users with specific needs and non-specific needs) which were translated into French and Spanish as required. The focus groups and questionnaires were designed to gather information on the separate needs of men and women as well as those with specific mobility needs. This

led to the inclusion in the ESPRIT vehicle of handles to assist entry/exit into vehicles and the ability of a vehicle to carry a pushchair.
Stated Preference games (questionnaire and game designed by PDC) were integrated into Lyon and Hospitalet Focus Groups to provide extra insight into the mobility preferences of users, and data for analysis. There was good take up thanks to extra incentives and translations. A short animation was also played to ensure users got a full grasp of the ESPRIT concept.

2.2. Develop an overall European functional specification for ESPRIT category vehicles and systems

This task produced a common European functionality specification for the design of the lightweight ESPRIT category vehicles and systems, drawing on the recommendations from user needs assessment.
Preliminary specifications were developed by CEA and issued to all partners to review then discussed in detail to strengthen. Following the results of the user needs the ESPRIT Functional Specification was reviewed considering the recommendations made. CEA has also in this period developed and distributed to all partners a number of versions of vehilce design sketches to rate preferences. CEA has been liaising with sister H2020 projects (GV5) to share common learning especially in the area of homologation in different countries, on which much progress has been made in ESPRIT.

2.3. Perform an overall functional safety design

This task produced the functional safety level of expectations to ensure the safe design and operation of the ESPRIT prototype and the future system at both vehicle and road train levels.
A functional analysis was delivered on a concept level followed by a preliminary hazard analysis and risk assessment for identified items. This followed input from most technical partners at parallel sessions at the Paris consortium meeting.
Whilst the task and deliverable are complete, it will be advantageous to feed in the learning from the testing of the safety design in the pilots and hence to review the Functional analysis report at the end of the project.

3. ROAD TRAIN ENERGY STORAGE MANAGEMENT SYSTEM

This technical report is written within the framework of ESPRIT project. It is presenting a part of the results of the tasks on Electric and cooling architecture and Modular battery management system architecture, inter-vehicle balancing and prioritisation algorithm and communication with infrastructure.

The main objectives of the project in terms of charging and balancing are:

- To use only one single point charging station for charging the road train in order to downsize and simplify the infrastructures
- To fast charge the road train vehicle in order to optimize the usage

- To have possibility of exchanging energy between vehicles in order to balance state of charge between vehicles and secure the usage of each vehicle.

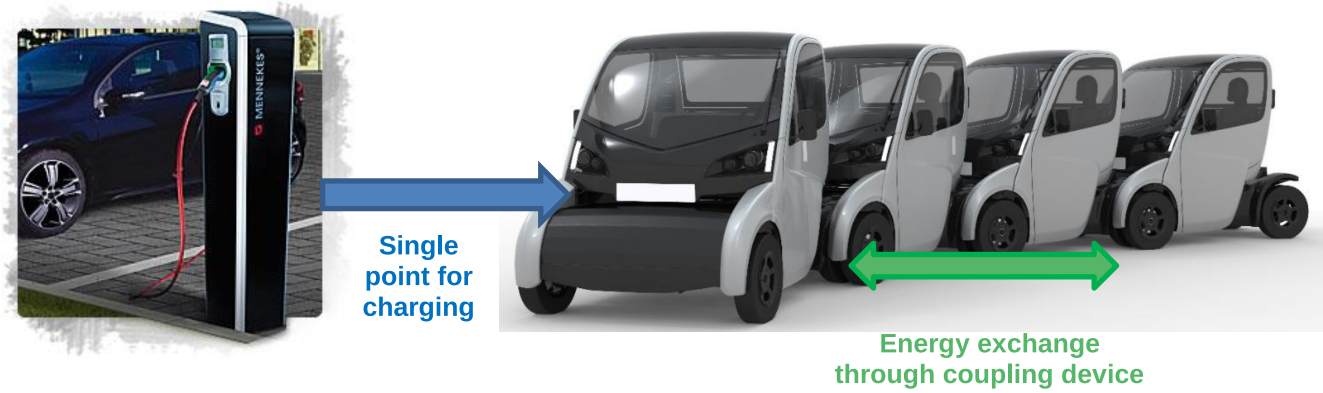

Figure 1 - Balancing and charging concept

The RESMS is the Road Energy Storage Management System. It is composed of different sub-systems which all together are able to full fill the requirements of charging, managing and balancing energy in and between vehicles.

4. VEHICLE AND ROAD TRAIN CRASH SAFE AND LIGHTWEIGHT ARCHITECTURE

The technical objectives are here both to design and deliver 3 complete prototypes of the ESPRIT vehicles and 3 additional partially representative connectable chassis and to ensure that the prototypes demonstrate the following key features: road train configuration, sufficiently crash resistant to offer a safe cabin for the passengers, lightweight to be energy efficient. The following reports on the current progress halfway of the project.

4.1. General physical architecture layout, steering and articulation layout, articulated chassis design and component implementation.

The first architecture work was to define volume and weight allowed to the different functionalities of the vehicle. The most critical area was the stacked axles. The total width of the vehicle is limited to 1.5m by L7e regulation, which also limit the weight to 450kg without the battery pack.
L7e regulation is not very strict about length, but we plan to have ten vehicles road train with total length inferior to 18.75m, which is the maximal length allowed for an articulated urban bus. This limit the wheelbase of a single vehicle to 1.812m.
The current design allows sufficient gap between the front and rear axle of two coupled vehicles.

4.2. Body including driver cabin design

The external bodywork of the vehicle was firstly design to be available on the mock-up. It was a big challenge because of the stacking capability of the vehicle. The rear depends on the front and respectively to avoid collision between two stacked vehicles.

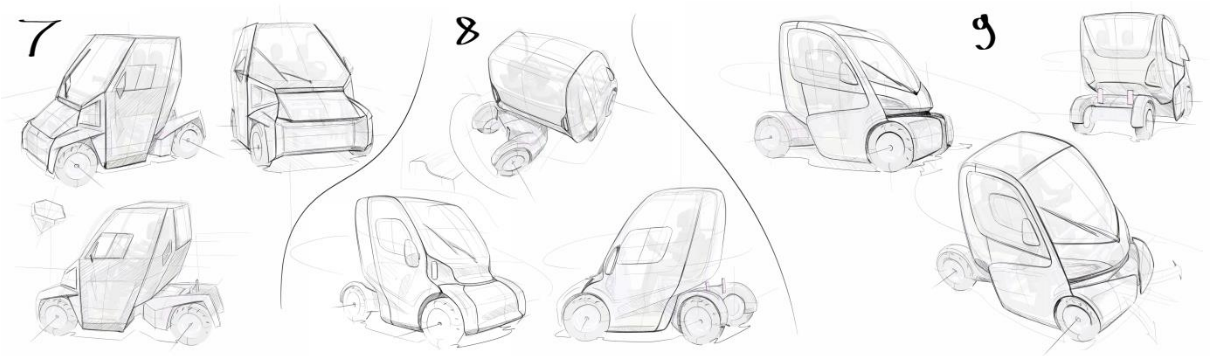

Figure 2 Example of designs submitted to consortium vote

After submitting many designs to the consortium vote, the selected design has been upgraded to 3D representation.
This was not a typical designing work and a lot of iterations have been needed between the design team and the engineering team with no-collision check at each step.

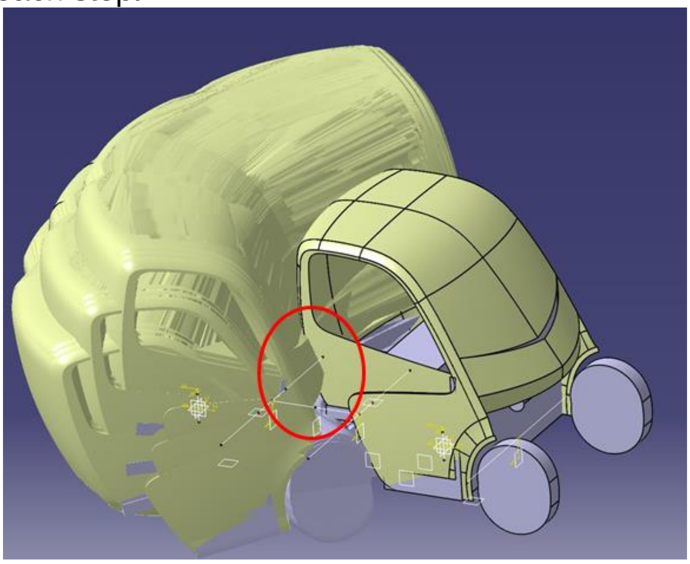

Figure 3 Example of failed collision check

The collision check considers the following degrees of freedom:

- pitch between two coupled vehicles
- roll between two coupled vehicles

The final design shown below is compatible with these two degrees of freedom; it also allows a 37° rotation angle of the rear chassis relative to the front chassis needed to perform a half-turn between two 7m separated walkways.

Figure 4 Final design, front view

Figure 5 Final design, rear view

4.3. Prototyping

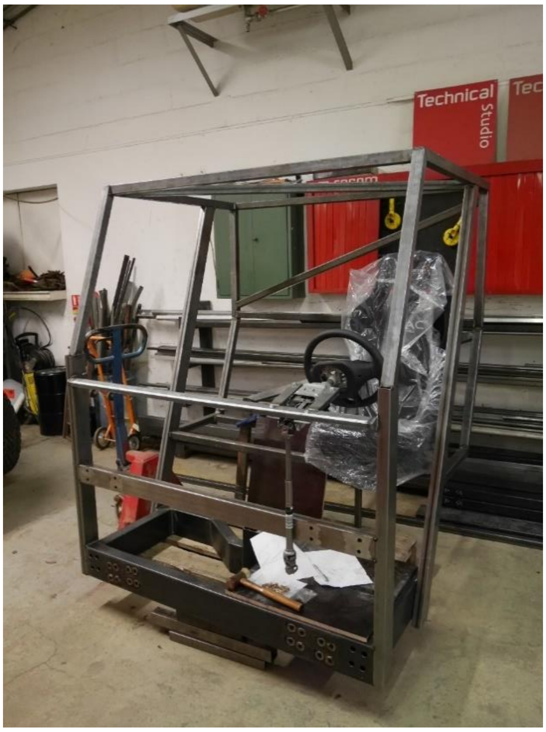

Figure 6 Front chassis, ¾ front view

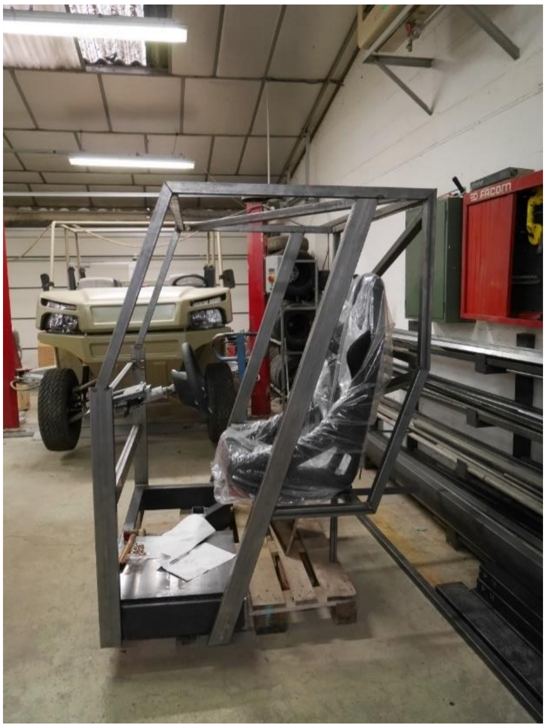

Figure 7 Front chassis, side view

This first chassis has been manufactured at T-STUDIO and has been sent to Continental in January for the brake implementation and tuning.

5. CONCLUSION

This paper addressed many aspects of the development of the ESPRIT concept from the definition of the initial requirements to the testing. A video of the first results on road can be found on http://www.esprit-transport-system.eu/ . The modelling of the transport model is also an important part of the ESPRIT project which has been developed in another paper.

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