CITY AUTOMATED TRANSPORT SYSTEM (CATS): THE LEGACY OF AN INNOVATIVE EUROPEAN PROJECT

Derek Christie, Philippe Vollichard, Sonia Lavadinho, Stéphanie Vincent-Geslin, Michaël Thémans, Michel Bierlaire, Vincent Kaufmann
Ecole polytechnique fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland
Anne Koymans, Raphaël Gindrat
BestMile, EPFL Innovation Park, 1015 Lausanne, Switzerland
Thierry Chanard, Susana Limao
GEA Architects-Urbanists, 1003 Lausanne, Switzerland
Erik Bessmann, Isaline Chaumier, Philippe Dupuy
IFSTTAR, 69675 Bron, France
Fabienne Janin, Stéphane Laporte
Europe Recherche Transport, c/o IFSTTAR, 69675 Bron, France
Céline Oppenhauser, Delphine Krieger, Ronan Golias, Géraldine Lecocq
Communauté urbaine de Strasbourg, 67076 Strasbourg, France
Jean-Marc Lasgouttes, Arnaud de La Fortelle, Thomas Liennard, Sami Mahari,
Inria, Roquencourt, 78153 Le Chesnay, France
Shlomo Bekhor, Leonid Tartakovsky, Milena Mirkis
Technion, Technion City, 32000 Haïfa, Israel
Adriano Alessandrini, Daniele Stam
Università degli Studi La Sapienza, 00184 Roma, Italy
Annarita Granata
Agenzia Regionale per la Mobilità della Regione Lazio, Roma, Italy
Milena Perpelea
Primaria Municipiului, Ploiesti, Romania
Jean-François Argence, Virginie Machado, Marie-José Navarre
Lohr Industrie, Hangenbieten, 67838 Tanneries, France
Pierre Lefèvre, Frédéric Lenti
Induct, 78290 Croissy sur Seine, France

ABSTRACT

CATS is a collaborative European project promoting driverless vehicles that ended in December 2014. This contribution explains how the project evolved, including the handling of unexpected events and concentrating on lessons learned. The constructor and vehicle had to be changed for economic reasons in the middle of the project timeline. A second constructor went bankrupt, although access to his vehicles could be secured. For security and legal reasons, part of the final demonstration was relocated at short notice to the EPFL campus in Lausanne, Switzerland, where around 1600 people were transported during 16 days of vehicle operation. Reactions to the driverless vehicle concept were overwhelmingly positive. Implications for the acceptability of driverless vehicles in Europe and elsewhere are discussed.

1. INTRODUCTION

According to several authors, a transport system including self-service automated cars may produce a number of positive impacts in urban areas. Since most cars are used only during short periods and remain unused for most of the day, in a city with shared automated cars the total number of vehicles would be lower, therefore considerable urban space now used for parking would be gained (Alessandrini et al. 2015). Autonomous vehicles may also bring about savings linked to vehicle safety, congestion and travel behaviour, in the range of $2000 to $4000 per vehicle and per year according to a recent US-based evaluation (Fagnant and Kockelman 2015). At a practical level, such systems could become cost-effective and efficient by minimizing travel time paths, combining requests for trips and optimizing the location of parking and recharging stations (Awasthi et al. 2011).

CATS (City Automated Transport System) is a European FP7 project which lasted 5 years (2010-2014) and whose objective was the development and experimentation of an urban transport service based on a new generation of driverless vehicles. The aim of the new service was to fill the gap between public mass transit and private individual vehicles, achieving a more efficient mobility profile in cities through a balanced use of small clean vehicles and mass transit options. This new transport system would be inclusive in the sense of being adapted to the needs of groups such as people with reduced mobility, young passengers and tourists.

The initial plan was for the CATS project to promote the use of a single type of vehicle for two uses: individual and collective transport. This new service was based on two operating principles: the self-service concept where small and clean urban vehicles are offered on a short term rental basis and the flexible shuttle service where a variable length of vehicles convoy, driven by a professional driver, operates at fixed hours along a line on a permanent basis or on a case by case basis. Both these principles were integrated in a single service, composed of vehicles and stations, called Cristal.

1.1. Origin and timeline of the project

The CATS project was set up in 2009 to answer FP7 call number SST.2008.3.1.1 entitled “New mobility concepts for passengers ensuring accessibility for all”. The winning consortium brought together eleven partners in five countries (France, Israel, Italy, Romania and Switzerland), including transportation systems manufacturers, research institutes, services providers and end users. The project began on 1st January 2010 and its initial objective was to promote the Cristal system, designed and operated by the French company Lohr Industrie.

The initial phases of the CATS project included a mobility needs analysis on three cities (Strasbourg, France, Ploiesti, Romania and Formello, Italy), after which Strasbourg was selected as the most suitable for a public demonstration. Further research identified the Illkirch Innovation Park, which combines University buildings, laboratories and other businesses as the best location within Strasbourg.

Detailed impact analyses on the environment – including CO_2 emissions – were carried out, as well as an evaluation of the acceptance and market uptake of the Cristal system, whose infrastructure and operating principles were redesigned in accordance with city and citizen needs (data not shown). A discrete events model was created in order to simulate the functioning of the Cristal system (Mahari and de La Fortelle, 2011).

Due to economic difficulties facing the car industry at that time, Lohr Industrie abandoned the production of the Cristal prototype in 2013 and partially withdrew from the CATS consortium. In order to pursue the objectives of the project, a second innovative transport system was identified by the consortium: an innovative driverless vehicle, with a capacity of about 10 people, developed by French manufacturer Induct and called Navia. The Navia system was chosen for its similarities with the Cristal system in terms of capacity and certain operation principles; however the vehicles were not able to link up with each other to circulate as a convoy.

The entrance of Induct Technology into the CATS consortium in late 2013 enabled the completion of the first phase of the demonstration in the first months of 2014, whereby three Navia vehicles navigated successfully through the Illkirch Innovation Park for several months, but without taking any passengers for legal reasons. Thereafter, following a period of receivership, the Induct Company was declared bankrupt in May 2014. The assets of the company were acquired by a new owner who was interested in the CATS project and who incidentally renamed the vehicles Navya.

The road tests in Strasbourg highlighted the difficulties of integrating automatic vehicles on the public domain without significant flanking measures to reduce the speed of other traffic. Significant horizontal and vertical signposting would have been needed, with physical safeguards and speed controls at key locations on the route. The road tests led to substantial progress in the approval process of autonomous vehicles on the public domain in France. Following a meeting with several French ministries, the Urban Community of Strasbourg received the first national authorization to operate a fleet of autonomous vehicles on the public domain. Nevertheless, for security and legal reasons it was decided to carry out the second phase of the demonstration, open to the public, on a more protected site.

In order to achieve the project objectives, the following solutions were found: on the one hand, the buyer of the Induct assets agreed to lease the vehicles for the CATS project until the end of the demonstration; on the other hand, the demonstration site was transferred to the EPFL campus in Lausanne (Switzerland).

1.2. Legal and administrative aspects

Following its purchase of a Navia/Navya shuttle in November 2012, the EPFL had already contacted the Swiss competent authorities to request permission to operate automated vehicles on its campus. Due to the private status of the campus, the proposed free access to the shuttles and the demonstration character of the project, the Federal Office of Transport and the Federal Office of Roads both decided not to ask for a certification procedure and delegated the task to the authorities of Canton Vaud. A meeting with the canton in March 2013 had enabled initial clarification of the certification process, in partnership with the canton's police authority.

After a site visit in early July 2014, the authorization for the CATS demonstration was delivered jointly by the transport office of Canton Vaud, the cantonal police and the cantonal office for vehicle approval and testing (Service des automobiles et de la navigation). The conditions were a maximum speed of 12 kilometres per hour, a maximum of 9 persons per vehicle (8 passengers + 1 operator), and an adequate insurance coverage.

Once permission to operate the vehicles had been obtained, the demonstration was implemented by three local partners: the EPFL Vice-Presidency for Planning and Logistics (VPPL), which contributed one vehicle, Navya which provided three vehicles on a rental basis and was available for heavy maintenance if needed, and BestMile, an EPFL start-up company that ensured day-to-day vehicle management and maintenance, data collection, as well as team management.

2. THE PUBLIC DEMONSTRATION AT EPFL CAMPUS

The setting up of the campus demonstration took place on 7-9 July 2014 and the demonstration was open to the public between 10 and 31 July after receiving authorization from the competent Swiss authorities on 9 July.

2.1. The vehicles

The demonstration was carried out using the electric Navya shuttle, where an on-board computer continually generates a precise 3D map of its surroundings as well as monitoring and controlling the vehicle's position and behaviour. This is enabled by a GPS system, stereoscopic optical cameras and 4 Lidar (light radar) sensors. Each sensor has a range of 200 metres and is able to cover the entire environment 25 times per second. Acceleration and speed are analysed according to three axes: forwards-backwards, laterally and vertically (descent-ascent). The vehicle is able to detect any obstacle (pedestrian, cyclist or car) to adapt its speed accordingly and stop if necessary. Each vehicle can carry up to 10 people (legally limited to 9 in this demonstration project), has an approved maximum speed of 20 km/h and requires no specific infrastructure such as rails or contact lines.

EPFL rented the vehicles for the duration of the demonstration to the manufacturer (Navya). The shuttle previously purchased by EPFL also participated in the demonstration, as a back-up if one of the three main vehicles failed. It was soon found that, instead of using the fourth shuttle as a replacement vehicle, it was used as a reservoir for technical components, thus allowing the other three shuttles to run. A laser, the on-board screen and other pieces were replaced on the main shuttles thanks to the fourth shuttle, allowing the demonstration to keep running every day without having to wait for the manufacturer to intervene on-site.

2.2. Exploitation scheme

The vehicles were operated by BestMile (a spin-off company based at EPFL campus) from 10 to 31 July 2014, on weekdays from 7:30 to 18:00. This represents a total of 168 operating hours over 16 days. This period of the year is part of the summer break during which most students are on vacation. Although less people were available on campus, potential users were also less likely to be students. Furthermore, if the demonstration had taken place during a semester, demand might have exceeded the capacity of the system.

The demonstration was operated daily according to the following scheme. A student was present aboard each shuttle to explain how the vehicle worked, answer questions, distribute and help complete questionnaires, manage vehicle crossings and engage the emergency brake if necessary. A more senior person, the operator, was located midway on the shuttles route to manage the students, supervise the vehicles, intervene quickly in case of incident or failure, and list any encountered incidents. The students and the operator communicated with each other using walkie-talkies. The operator leased an electric car for the duration of the demonstration in order to store the necessary equipment for maintenance and to be able to intervene quickly in case of incidents.

2.3. The demonstration route

The CATS demonstration route was defined on the basis of a territorial study carried in the framework of the CityMobil2 European project in 2013. This study intended to identify the needs for mobility not yet answered within the campus and the integration constraints for automated vehicles. The study was conducted in order to prepare a 6-month demonstration of automated vehicles for CityMobil2, to start in November 2014. It was thus well adapted for the CATS demonstration and had the advantage of being readily available. For practical reasons, the route selected for CATS was shorter than the route defined for CityMobil2, not serving the Metro station. This choice was dictated by short-term feasibility criteria. The CATS demonstration on campus had to be organized in less than a week and the inclusion of all the sections needed to perform the entire link was not feasible in the available time.

In some sections, the pathway width did not allow two vehicles to pass each other. To manage these sections, two crossover points were defined. The students on board communicated with walkie-talkies to find out if the sections were free or if they had to wait at the crossing point. The students resorted to regularly announcing their position to each other. Given a little practice, this effectively minimized waiting times.

Signposts and banners were installed along the route to inform users of the presence of autonomous vehicles. During the night, the vehicles were brought into a protected parking lot on campus, where each vehicle could be connected to the mains (15A) and where spaces had been reserved. Barriers were used to protect the vehicles and prevent other cars from entrenching. The parking lot was also used as a maintenance centre when needed.

The students aboard the vehicles were responsible for distributing questionnaires to users and helping them respond. The students were occasionally helped by other project participants during periods of heavy attendance of the demonstration. Two versions of the questionnaire, in French and in English, were available.

3. RESULTS

The evaluation focused on the second half of the demonstration period: 21-31 July. Altogether 800 people were transported during 8 days of evaluation. In total, the vehicles travelled for 16 days, with a full week without any rain between 14 and 18 July. According to a linear approximation, we can estimate that a total of around 1600 people were transported during the second demonstration phase in Lausanne. Some 181 questionnaires were completed by users during the two weeks of assessment.

Most users were male (66 %). This is only slightly more unbalanced than the gender split on campus, where only 27% of students and 31 % of personnel are female. Around 70% of the respondents were aged 20-50 years. Moreover, none of the respondents were less than 10 years old although many families with young children were observed using the Navya shuttles. The children evidently did not respond to the questionnaire as such, but it is thought that some may have participated in the assessment via their parents. Only one-third of the respondents were students (see Figure 1). The timing of the demonstration during the summer holidays no doubt enabled a more diverse set of users to discover the shuttles than would have been the case during term time.

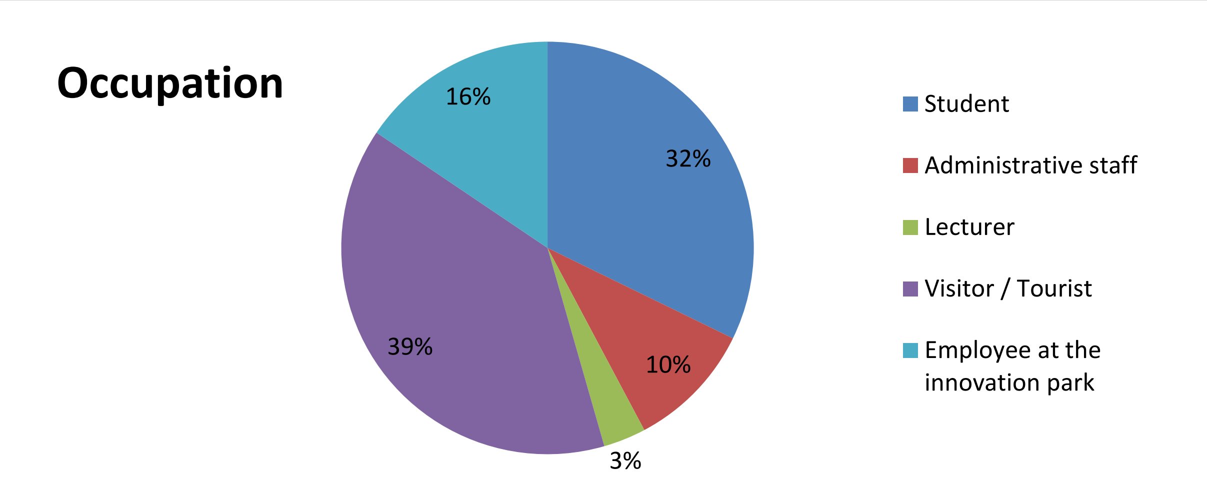

Figure 1. Occupation

The transport modes used to reach campus are varied, although a majority of the respondents use either the car or the so-called Metro (in fact, a light-rail transit system). At a general level, motorized individual transport and public transport are used in similar proportions (both around 40 %). As for human-powered mobility, pedestrians (12 %) are closely followed by cyclists (8 %).

Attitudes and potential problems with the Navya shuttle were investigated by asking respondents: On a scale of 1 (totally disagree) to 5 (totally agree), do you agree with the following statements? The results for eight statements can be seen in Table 1 and Table 2.

	“Agree or totally agree”
The vehicle is aesthetic	81%
The vehicle is futuristic	77%
The vehicle is functional	80%
The vehicle is user-friendly	92%

Table 1. Attitudes towards the Navya shuttle.

	“Disagree or strongly disagree”
The vehicle is slow	27%
The absence of driver is a problem	78%
The absence of seating is a problem	60%
The absence of window panes is a problem	52%

Table 2. Potential problems with the transport system

Figure 2. Navya demonstration on EPFL campus in July 2014. Picture showing one of the two crossing points. (© Alain Herzog, EPFL)

Regarding frequency, 61% of respondents said that the proposed frequency (one trip every 7-10 minutes) was sufficient. However, when asked specifically about waiting times only 21% of respondents said they were willing to wait more than 6 minutes for such a service on a daily basis (see Figure 3).

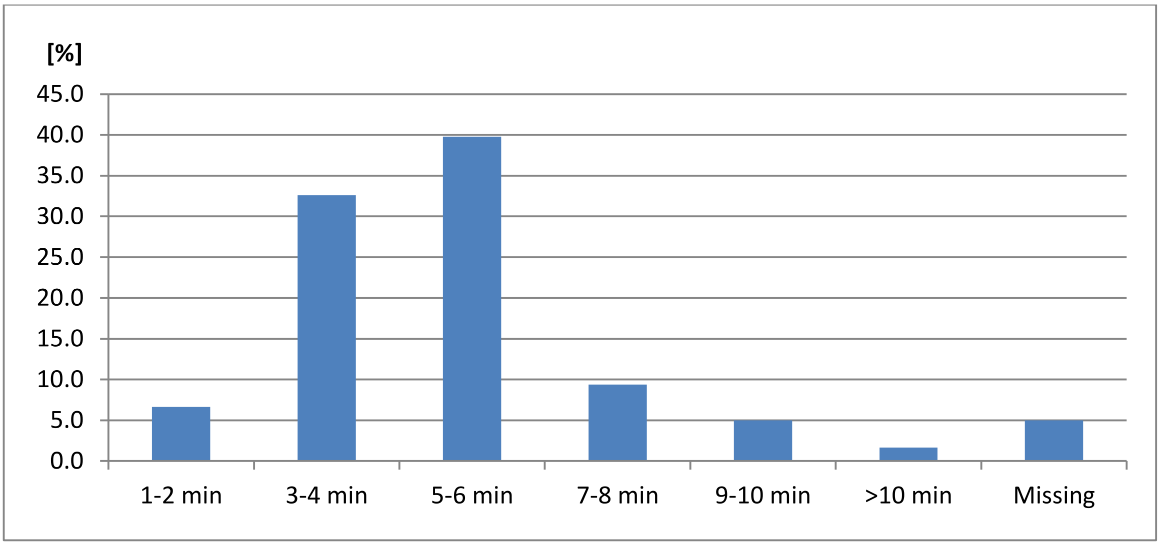

Figure 3. How long would you be willing to wait for such a vehicle?

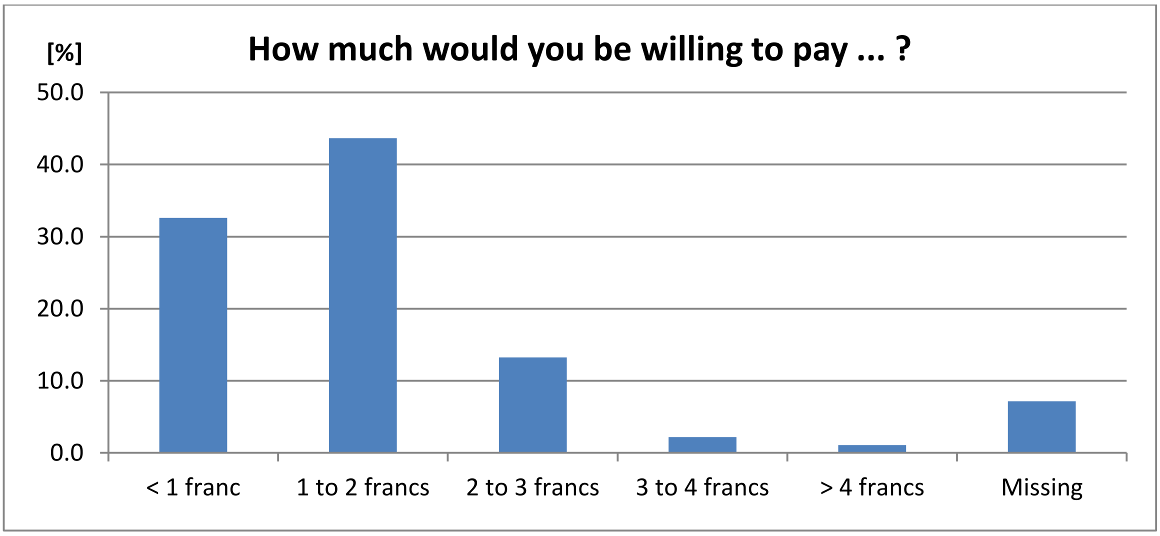

Figure 4. How much would you be willing to pay to board such a vehicle?

To the question “How much would you be willing to pay to board such a vehicle”, 76% of respondents said less than 2 CHF (approximately 1.20 Euro or 1.20 US$ at that time). A full-fare public transit ticket for one hour costs 3.50 CHF in

Lausanne, or 1.90 CHF for a short trip (maximum 3 stops) which is similar to the average price quoted in this survey.

Comfort was rated on a five-point scale, ranging from 1: not comfortable at all to 5: extremely comfortable. Some 76% of respondents found the lumbar support cushion to be comfortable or very comfortable. Direct observation yielded evidence that the proposed support system is ideal for people of average height. While taller people can prop themselves up against the side cushions, smaller people found it more difficult to find a comfortable position.

Regarding the quality of the ride, only 14% of respondents found it excellent. Progressively during the demonstration, the ground on which the vehicles were travelling deteriorated due to bad weather and repeated passage of the vehicles on the same trajectory. Holes were formed in some of the stabilized soil, causing jerkiness.

Another important element of comfort is speed management on slopes. When vehicles accelerated or slowed down (experienced as stop-and-start by users, although the vehicle did not actually stop) on slopes, this reduced the experience of smooth running of the system.

Ease of use was rated very highly. Up to 92% of respondents found it easy or very easy to get into the vehicle, although disabled people and those with reduced mobility had little access to the system since no ramp was made available. Likewise, 91% of respondents felt safe or very safe inside the vehicle and 72% felt safe walking around the vehicle (a further 14% had no opinion for this item since they did not walk around the vehicle).

The size and the speed of the vehicle were considered well adapted to the EPFL campus environment. For both size and speed, around 82% of respondents agreed that the integration was a success. The size of the vehicle is an important element in ensuring the integration of autonomous vehicles in their environment. This is true from the point of view of people's perceptions (it forms an important part of acceptance), but also regarding practical constraints. Indeed, vehicles must be neither too large, in order to be able to use urban roads and manoeuvre through parking lots, nor too tall, so they can pass beneath arches.

Some 58% of respondents find Navya to be an innovative or highly innovative vehicle. Around 39% of respondents said they were willing to use autonomous vehicles regularly in the future. Only 5% of respondents are reluctant to do so. When asked why they boarded the vehicle, a large majority said it was out of curiosity or to test the vehicle, and only a small minority to their destination, in effect using the shuttle as a public transport service.

Additional comments

Respondents found the vehicle user-friendly, futuristic, functional and aesthetic (despite the bad weather which accompanied much of the demonstration phase). The operating speed of the vehicle was divisive: half of the respondents said it was too slow, while the other half saw no problem with the speed. The absence of a driver was not perceived as a problem by 78% of respondents. This important result may be correlated with the type of person likely to be found on the EPFL campus at any time including the summer holidays: often people interested in technology and innovation. The absence of true seating and the lack of window panes were experienced as a problem by some users.

Open comments from users included suggestions to extend the service in various directions (especially towards the Metro station and towards the neighbouring University of Lausanne campus). Other spontaneous comments included: “Very friendly and impressive idea”, “Wonderful innovation, keep your research going!”, “(is this) the place for an after-work drink?” or “You should think of adding music during the ride.” We interpreted these data and comments as a sign that Navya, while being taken seriously as a technological innovation and transport system, is also viewed as being fun.

4. DISCUSSION

The CATS project as a whole can be considered a success, despite significant pitfalls and challenges throughout the project timeline. The most successful element is that, despite one change of vehicle and two changes of industrial partner, it proved possible to organise a large-scale public demonstration involving several vehicles and over 1500 participants.

As a confirmation that the acceptance of the project was not only a Swiss phenomenon, it should be mentioned that the CATS project also included a public showcase demonstration in Ploiesti, Romania, which took place in October 2014. Many school classes attended the two-day event and although there was no formal evaluation, municipal authorities considered the event to have been a great success. Although the initial project only included an exhibition, the city of Ploiesti decided to organize a larger event with vehicles supplied by Inria and thus allowing visitors to test them on a secure route in a pedestrian area in the city centre. These results confirm other studies suggesting that urban users in Europe are generally receptive to the idea of using automated road transport systems (Payre, Cestac and Delhomme 2014; Alessandrini et al. 2014).

The main challenges encountered during the demonstration were around vehicle hardware. The vehicles used during the demonstration were prototypes and were therefore slightly different versions of the same vehicle. These vehicles regularly encountered hardware problems during the demonstration: loosening of screws, loss of lasers alignment, problems of fuses, soldering requirements at short notice. In addition, the vehicles occasionally faced software problems such as location loss which could be solved thanks to the prompt intervention of the operator and the experience gained progressively by the students inside the vehicles. The intervention of the manufacturer was required only once during the entire demonstration.

Another challenge was that the demonstration route had several sections whose width did not allow the crossing of vehicles. Operators on board therefore had to anticipate crossings so that they did not occur on one-way sections. This involved some “exploitation stops” of the shuttles to wait for the oncoming vehicle to releases the one-way section. With experience, operators increasingly succeeded in anticipating and avoiding such unexpected stops. Finally, in some places, the repeated passage of the vehicles for four weeks partially damaged the soil on which the vehicles were traveling.

At the administrative and legal levels, it is clear from the CATS experience that the federal political structure in Switzerland is an advantage for moving projects forward in a context of innovation which necessarily includes a degree of improvisation and creative thinking. It appears that the Swiss contribution was decisive in helping the project evolve towards success. However, the contributions of the other partners should not be underestimated. For example, the on-road testing of the Navya vehicles in Strasbourg, France, was critically important for moving the project forward.

Likewise, although it may be thought that time was lost while developing the first part of the CATS project with the Cristal vehicle which was finally abandoned, it should be remembered that it is the Cristal concept that inspired the project in the beginning, that led to the constitution of the project consortium and ultimately therefore to the success of the project. The main lesson learned, for the participants in this project, is that innovative transport projects may not advance in a predictable manner. It is sometimes necessary to allow some leeway so that solutions to new problems can be found along the way.

One implication of this finding is that the creators and constructors of innovative vehicles should not be left alone to design and test their products. There is a need for academic support – especially around modelling and monitoring and evaluation – and a strong need for external funding. It follows that European projects such as FP7 and Horizon2020 are the instruments of choice in order to pursue the development of innovative and sustainable mobility solutions in Europe.

This is important in a broader context where a review of 2500 research solicitations in EU Framework Programmes has found that, while socio-technical integration tended to increase between 1998 and 2010, projects integrating socio-ethnical and stakeholders into scientific research actually decreased in time. We therefore suggest that future projects investigating and promoting driverless vehicles continue to address the points of view of the end-users and indeed of potential non-users of these systems.

5. CONCLUSION

The demonstration conducted as part of the CATS project was followed in November 2014 by another demonstration, also in the EPFL campus area, organized in the framework of European project CityMobil2. This demonstration lasting six months involved 6 automated vehicles on a longer and more complex route connecting the campus and the Innovation Park with a metro station. These demonstrations and the continued involvement of EPFL and its partners in European projects show the strong interest in Switzerland for deploying automated transportation systems. In the case of CATS and CityMobil2, it has become clear that Switzerland offers an environment which is favourable to innovative transport systems. Although it is not part of the European Union, Switzerland has shown through its participation in the CATS project that it can help develop and showcase innovative transportation projects which may then be developed further or implemented in other countries.

6. ACKNOWLEDGEMENTS

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