CITYMOBIL, ADVANCED ROAD TRANSPORT FOR THE URBAN ENVIRONMENT. FINAL RESULTS

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ABSTRACT

CityMobil is an Integrated Project in the 6th Framework Programme of the European Union. The project addresses the topic "Advanced Road transport for the Urban Environment." The project started in May 2006 and will run until December 2011. The project is carried out by a group of 29 partners led by TNO, the Netherlands Organisation for Applied Scientific Research. The goal of this research project is to make significant steps forward towards realisation of automated traffic solutions for the city of tomorrow. The total project budget is roughly 40 million Euros, of which 11 million is funded by the EU.

The paper describes the final results of the project. In addition to the large number of detailed conclusions and learning points presented in this paper and in the CityMobil deliverables some general conclusions can be drawn: The process of setting up a full-scale implementation of an advanced transport system is a very difficult and time consuming one. There are many barriers of various natures to overcome. Contrary to the believe of many of the project partners at the time the project started, most of these barriers are not of a technological nature. Barriers relating to legal, administrative financial and political issues and safety, security and privacy appear to be more important and need to be addressed urgently. Although further technological developments are indeed required, the present state of the art allows implementations of automated transport systems under certain well-defined conditions.

GENERAL

The city of tomorrow is in need of integrated traffic solutions that provide the required mobility solutions in an efficient, safe and economic matter. The CityMobil project continues the work that was done in the 5th Framework Programs City of Tomorrow and Cultural Heritage, and combines the outcome of the Netmobil (1) and LUTR (2) clusters. The CityMobil project depends on two main pillars: a research and a demonstration part. In the research part a number of technological and other issues that are still in the way of large-scale implementation of automated transport systems are identified and addressed. In the demonstration part the lessons learned in CityMobil and a number of earlier projects (1), (2), are used to set up large-scale demonstrations of automated transport systems in 3 European cities and a number of smaller demonstrations, showcases and practice related city-studies. The large-scale demonstrations are not of a temporary nature, but are intended to be among the first implementations of permanent automated transport systems.

There are five work packages in CityMobil. The demonstrations are included in WP1, the research activities in WP's 2, 3 and 4. WP 5 is an evaluation work package, in which the results of the various activities will be evaluated. One of the important focal points in WP 5 is the contribution of the various CityMobil results to sustainability.
Sub-project 1: Demonstrations
Sub-project 2: Future scenarios
Sub-project 3: Technological issues
Sub-project 4: Operational issues
Sub-project 5: Evaluation

RESULTS

This paper describes the results of the project. These results mainly consist of a large number of detailed reports on a variety of issues, reports on the large scale city implementations and the other demonstration activities and the large scale implementations themselves. The preliminary results were presented during the ITS World Conference in Busan in 2010.

BARRIERS

One of the main goals of the R&D part of the project is to identify barriers that still are in the way of the large scale implementation of automated transport systems in urban areas. These barriers can be of a technological nature, but in practice other barriers appear to be much more important. Where significant barriers were identified in some cases tools were developed to help removing the barriers and in other cases guidelines and strategies were developed to address the barriers in the future. An overview of the most striking results is given in this paper. For more detailed results most of the CityMobil deliverables can be found on the CityMobil website (3).

Legal barriers

One of the most important barriers is of a legal nature. The Vienna Convention on Road Traffic is an international treaty on Road Traffic Law between the contracting parties (over 60 countries worldwide). According to Art. 8 No. 5 of the Vienna Convention on Road Traffic "Every driver shall at all times be able to control his vehicle" and Art. 13 states more clearly that "Every driver of a vehicle shall under all circumstances have his vehicle under control". These articles assume there is a driver present and therefore effectively bar the use of vehicles without drivers on public roads in the contracting countries. When a driver is still present in the vehicle and only certain driving functions have been automated, the legal issues are much alike those of driver assistance systems that have already been introduced today: This might be considered the case for advanced high-tech buses that offer full automation of steering. If the driver can take control of the vehicle and override the automated function at any time the legal requirements are met. In order to allow automated vehicles without a driver to use public roads the relevant articles in the Vienna Convention will have to be changed.

Safety and certification

Another main barrier to the introduction of automated transport systems is the absence of a dedicated certification system, to prove to stakeholders that automated systems indeed are safe.

For traditional cars and for many other technical systems procedures and standards exist, that deal with the safety-analysis and with the certification of these systems, but for automated transport systems such standards did not yet exist. Therefore, building upon the work done in earlier projects, certification procedures for automated transport systems were developed in CityMobil. CityMobil deliverable D.2.5.2 describes these procedures (3). Central in the procedures is the FMECA (Failure Modes, Effects and Criticality Analysis), a well-known method for system analysis. Among the reasons to choose this method was the fact that many people in the automotive world already have some experience with it. A detailed set of instructions has been designed around the FMECA core to guarantee a uniform use and acceptable reproducibility of results.

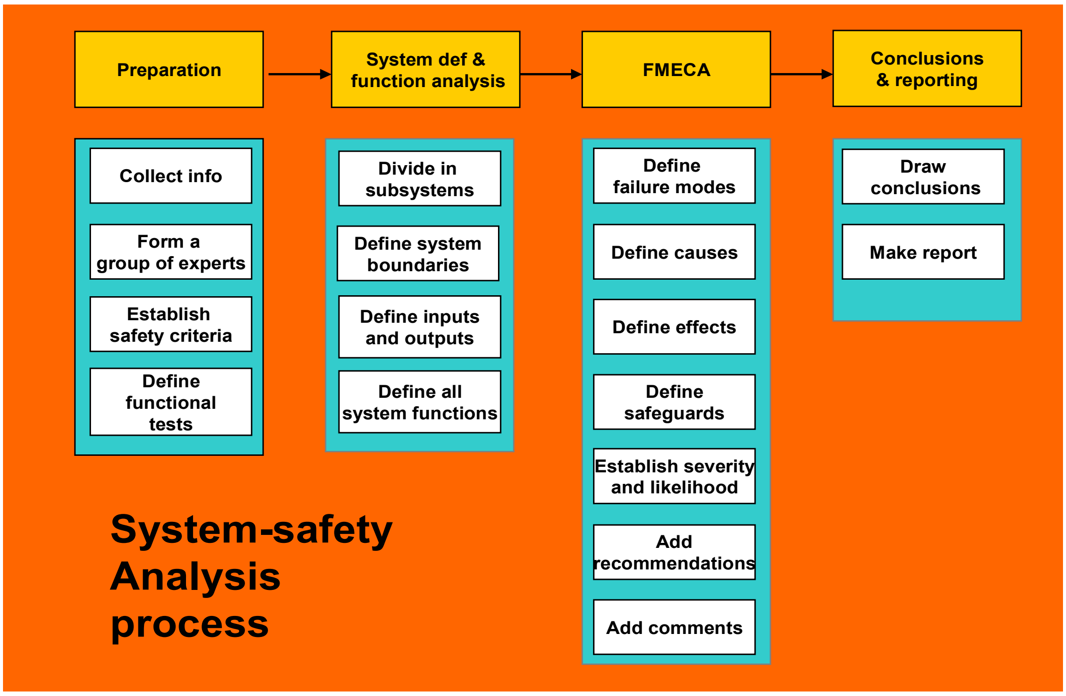

Figure 1. Certification process.

The certification method was evaluated by applying it to the CityMobil Rome demonstrator and the Masdar PRT system in Abu Dhabi. The Italian Ministry of Transport accepted the results as the main basis for its decision to certify the system. The Ministry of transport in Abu Dhabi required an additional analysis before the system was accepted. In both cases a time consuming process of negotiations was necessary. These experiences show the importance of generally accepted procedures, which, by omitting the need for these discussions and extra requirements can speed up implementations significantly.

Security

Security is defined for this purpose as "the protection against unfriendly actions of other people". There is a difference in the perception of personal security for passengers of automated public transport systems and traditional transport systems. In traditional transport systems there usually is a driver or other official persons present. The presence of people who are obviously there for professional reasons enhances the feeling of security of users of the system. In automated transport systems there often is no physical presence of official persons. Therefore some measures are advisable in addition to measures that are also taken in traditional systems. CityMobil deliverable D.2.5.3 (3) describes a number of guidelines meant to increase the security and the feeling of security of the passengers. Among the proposed measures are the use of camera systems, monitoring the vehicle and the environment and communication systems allowing passengers to make immediate contact with an official. Freight security and anti terrorism activities are also addressed.

Privacy

Privacy is defined as "the level of protection of personal information". It is clear that there is a sensitive balance between the requirements of privacy and security. More security often means less privacy and more privacy often results in less security. The guidelines for security, described in CityMobil deliverable D.2.5.3 also take into account the privacy issues related to security measures. For instance, for privacy reasons permanent video monitoring of the inside of vehicles is not recommended. Instead an emergency button is proposed that switches on a camera that covers the inside of the vehicle and enables the operator to take action if needed. The camera only operates after a deliberate action from the passenger.

Economical and administrative barriers

Money is one of the main obstacles towards implementing automatic transport systems, especially in the initial phase (when the uncertainty is greatest). There is a great financial risk to be the first city to implement a new system. Later implementations have the advantage to be able to avoid known pitfalls and learn from earlier experiences. Finding funding for an implementation is therefore one of the major barriers. Other financial risks relate to robustness of cost/revenue forecasts and the likelihood of future financial viability. There may be difficulties in constructing robust forecasts for innovative systems. Additionally there may be problems of "credibility" even if it can be demonstrated that forecasts are robust. This may belong partly in the category of political barriers. In order to address the economical barriers a business case tool was developed that can help authorities to assess the financial consequences of the introduction of an advanced transport system. The model is described in CityMobil deliverable D.2.4.1 (3). It was evaluated by applying it to a number of cities involved in the CityMobil project.

Political barriers

There can be many reasons for politicians to either adopt or oppose new initiatives on the field of automated transport systems. Reasons for opposition can include:

- Other priorities for the available funding
- Change of the laws necessary to allow driverless vehicles can be politically sensitive
- Not enough information available to introduce automatic transport systems
- Election periods could intrude with the planning or implementation of new systems
- Hesitations about the feasibility of the new initiative

It is difficult to give general guidelines on how to address political barriers, since they can be of very different natures. However, there are two important instruments for the removal of political barriers that can be used almost everywhere: information and publication. Politicians will be more confident in making decisions if they have reliable and extensive information about the advantages an automated transport system could have in their particular situation. Extensive publicity campaigns have proven to be able to change the hearts and minds of people. The same

instruments can be used to inform political bodies about the necessities to change the laws that are now in the way of the introduction of automated systems.
Many of the political barriers are of a local nature, but in case issues of certification or national laws are in play, careful consideration should be given to the political level on which decisions could be influenced. It seems logical to address certification issues and legal issues on a national or even European level, while economic issues often are better addressed locally.

Technological barriers
There are no more significant technological barriers to the introduction of automated systems that make use of their own separated infrastructure. At the time the CityMobil project finishes there are two PRT (Personal Rapid Transit) systems in operation (Heathrow Airport and Masdar City) and one Cybercar system in Capelle aan de IJssel in the Netherlands. These systems make use of well tested and evaluated technologies. The same conclusion can be drawn for advanced bus systems. Presently there are systems in operation in a number of European cities, among which Castellón in Spain, one of the CityMobil demonstrations.

For systems that make use of public roads and require operation in mixed traffic with other road users the situation is different. In addition to the legal issues mentioned above a wide range of technological and human interaction issues needs to be addressed and solved before large scale introductions are possible. Most significant among these are developments in obstacle detection and avoidance systems and in decision making algorithms. However, as the CityMobil La Rochelle demonstrator shows, implementations of automated systems in mixed traffic are already possible under certain conditions. If speeds are low and interaction with other traffic meets stringent safety requirements automated systems can already contribute to solve urban mobility problems.

Operational issues
Automated transport systems do not automatically fit into existing urban environments and thus integration issues can present barriers. Transport structures and traffic management systems need to be adjusted and new strategies and new architecture need to be developed. Especially with regard to information flow automated transport systems require new functionalities, especially with regard to safety. Automatic accident notification and emergency shutdown systems are among the additional functionalities required. The need for new architecture and strategies was addressed in CityMobil resulting in a number of deliverables presenting solutions and topics for further study.

Tools for cities
In order to help to remove the barriers a number of tools have been developed that can help city authorities, operators of public transport systems and other stakeholders to make decisions as to whether or not an advanced transport system is a viable solution for their particular city. Among these tools are the certification guidelines and the business case tool described above. The first tool a city might use is the City Application Manual, CityMobil deliverable D.2.2.4 (3) in which all issues are addressed that a city has to deal with in order to be able to make a decision on the implementation of an advanced transport system. In the final version of the City Application Manual the lessons learned during the implementation processes and the results of discussions with many stakeholders have been included.

DEMONSTRATIONS

CityMobil supports three large-scale implementations of automated transport systems in urban areas. The three large-scale implementations represent different environments and different systems in order to cover a wide variety of solutions. The three large scale demonstrations are held at Heathrow Airport (UK), Castellón (ES) and Rome (IT).

Figure 2. Heathrow PRT system.

Heathrow.

The objective is the implementation of a PRT (Personal Rapid Transit) system at Heathrow Airport. Small fully automated electric vehicles, able to carry 4 persons and their luggage bring people from the business car-park area to the new Terminal 5 on the systems own dedicated guideway. The ULTra PRT system was developed by Advanced Transport Systems Ltd. (ATS) and was extensively tested at a test site in Cardiff over the last years. The ULTra system is an on-demand system. Passengers press a button at one of the stations, upon which a vehicle arrives. Upon pressing a destination button the vehicle brings the passengers to their final destination without stopping. Other stations are bypassed, so that no time is lost waiting for other traffic, making the system quick, comfortable and efficient. The first pilot phase is 3.9 km in length, serviced by 21 vehicles. The Heathrow system started operation with members of the public in the spring of 2011 after a long testing period. If the pilot is successful, the system will be extended over Heathrow airport and possibly other airports. An important focal point for the CityMobil project is to evaluate the effectiveness of the ULTra PRT system in this application.

Rome

The new Rome exhibition centre, a huge complex between the city and Fiumicino Airport opened its doors in 2007. The Rome demonstrator is a short distance transport service using medium sized fully automated vehicles, also called cybercars, to transport people from the parking of the new Exhibition Centre to the entrances. The distance between the parking places and the entrance of the buildings can be as much as 700 metres, making a transport system necessary. The traditional bus system that was part of the original plans was abandoned in favour of a driverless transport system.

The Rome demonstrator unintentionally was a demonstration case for the influence non technological barriers can have on the implementation process. In spite of the support of the local partners involved in the project, implementing the Rome demonstrator before the end of the CityMobil project failed. During a period of 6 years a number of events hindered the progress of the project. The slowness of the decision making process, influenced by political changes and financial problems delayed the project and led to a stop of the activities in the spring of 2011. Many lessons were learned during the process and in spite of the fact that the implementation failed there is one other important result. The Italian Ministry of Transport formally agreed to certify the system if it would be realized in accordance with the specifications, making this the first time an automated transport was approved by a European authority.

Castellón

The Castellón demonstrator concerns the implementation of an advanced bus system in the metropolitan area of Castellón, in Valencia province in Spain. Corridors of high quality public transport were created, using advanced buses providing services on a reserved platform. The system started operation in June 2008.

Figure 3. The advanced bus system in Castellón

The Castellón buses are partly automated; the driver is responsible for accelerating, decelerating and braking, while the steering and docking is fully automated. The level platforms in combination with the very accurate docking at an average of 4 cm from the platform edge, allow for an efficient process of entering en exiting of the buses, also for older and disabled people. The automated steering allows the use of lanes that are narrower than is required for manually driven buses. The Castellón buses are trolleybuses, using a reserved platform, with a number of crossings with public roads. The steering is controlled by an optical system, consisting of a camera located above the windscreen, following dotted lines on the road surface. The buses have an additional diesel engine, allowing them to travel on shared infrastructure for short distances. Thus the Castellón advanced bus system is a sustainable, quick and efficient solution. The first phase was operational in June 2008. In this first phase 3 buses connect the University with the Castellón city centre, a distance of about 3 km with 6 stops. In the next phase the buses will cross the city centre towards the coast and later further north to the town of Benicassim, a total distance of about 40 km.

La Rochelle
In addition to the three large scale implementations 2 smaller scale demonstrations were planned. These were set up as temporary demonstrations where automated systems fulfil a real transport need for a period of 3 – 6 months, resulting in ample information to decide whether or not the system could be implemented in a later stage. One of the demonstrations was planned for Lausanne (SU), but it could not be realized because of a number of largely non technological issues. The other demonstration took place in La Rochelle (FR), in the summer of 2011. Fully automated cybercars provided transport from the harbour ferry to a nearby industrial and living area. Although there are no cars on the trajectory, the cybercars mixed with pedestrians and cyclists using the same infrastructure. The demonstrator started in May 2011 and ran for 2 periods of about 3 months until the end of 2011.

SHOWCASES

The main goal of the showcases was to demonstrate the new mobility concepts offered by automated transport systems and dual mode vehicles (able to be driven manually and fully automatically on a designated infrastructure) to city authorities and other stakeholders. For this purpose a small fleet of 3 cybercars and 2 advanced city vehicles was developed. 5 showcases have been held in the cities of Daventry (UK); La Rochelle (FR); Trondheim (NO); Vantaa (FI) and Orta San Giulio (IT).

Figure 4. Advanced City vehicle in the La Rochelle showcase

CITY STUDIES

At the beginning of the project a Reference Group was formed, consisting of cities that had expressed interest in setting up a demonstration or implementing an advanced transport system. During the first months of the project there has been an intensive information exchange between these cities and the project partners. This resulted in a better understanding of the needs of widely differing cities and provided the project partners with the possibility to select cities for showcases demonstrations and city studies. The cities of Uppsala (SW) and Sophia Antipolis (FR) have been selected for city studies, which address subjects that have not sufficiently been covered elsewhere in the CityMobil project and that are of importance for a wider group of cities. In Uppsala (SW), the city wanted to investigate the advantages of a PRT system for the Bolaenderna district, a spread-out commercial area south of the city centre. In Sophia Antipolis (FR) the possibilities of an advanced transport system for the connection between the city of Antibes and the science park at Sophia Antipolis was investigated. In both cases there is the expectation that the studies will help the cities to make implementation decisions.

EVALUATION

The final question to be answered concerned the advantages of the introduction of new transport systems and the improvement of new transport scenarios. In the first phase of the project an evaluation framework was conceived, capable of capturing the social, environmental, economic, legal and technological impacts of advanced transport systems. The framework was developed to address the different scenarios used in the project, ranging from laboratory and test-track situations through computer modelling to real-world implementations on a large scale. For the evaluation of passenger transport systems a list of 64 indicators was generated, subdivided in 9 evaluation categories: acceptance, quality of service, transport patterns, social impacts, environment, financial impacts, economic, legal impacts and technological success.

The data collected during the implementations, demonstrations, showcases and case studies in the project have been used to fill the cells of a bi-dimensional matrix, called "Passenger Application Matrix". In this matrix results have been grouped according to 10 different transport origins and destinations: city centre, inner suburbs, outer suburbs, suburban centre, major transport nodes (e.g. airport, central station), major parking lots, major educational or service facilities (e.g. university campus, hospital), major shopping facilities, major leisure facilities (e.g. amusement parks) and corridors. The cells of the matrix represent all the possible origin/destination pairs and the main results obtained by the different CityMobil activities have been grouped in the cells. Not all cells have been filled and not all automated transport systems have been evaluated in each cell. The main outcomes are included in CityMobil deliverable D.5.2.4. (3). The general result emerging from the analysed cells is that short trips in low to medium density areas PRT would be the best option, while for longer trips high tech buses seem the best option. Cybercars as dual mode vehicles give the best results as feeders for public transport in low population density areas.

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