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EXPLOITATION PLAN

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1 Executive summary

This exploitation plan gives an overview of the main results of the CityMobil project and a draft idea on how consortium partners intend to use these project results in on-going and future activities and in their further R&D and product marketing strategies.

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2 List of exploitable results

N	Result	SP/WP	Reference
1	PRT Simulation tools	SP2	ATS ltd
2	Business Case tool	SP2	TRG
3	Certification Guidelines	SP1	TNO
4	City Application Manual	SP2	TML
5	Personal Rapid Transit - Applicability	SP1	ATS ltd
6	Personal Rapid Transit – Evaluation	SP1	ATS ltd
7	Personal Rapid Transit – Heathrow demonst.	SP1	ATS ltd
8	Advanced City Car	SP3	CRF
9	Dual Mode vehicles	SP3	CRF
10	Alternative Patronage Estimator	SP2	TML

3 Exploitation plan

In the following paragraphs the exploitable results are analysed in detail. At the end there is a table showing the different stakeholders that could be interested. The coloured boxes will indicate the stakeholders that could be interested by the specific result.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.1 PRT Simulation tool

3.1.1 Short description

Personal Rapid Transit (PRT) is an innovative new form of public transport in which small, automatic vehicles travel on a special network of guideways. Passengers board a vehicle at an access point and travel to any chosen destination directly, without stopping on the way. Because empty vehicles are generally already waiting at stations when passengers arrive, PRT services offer little or no waiting, and a much faster journey over urban distances than can be achieved by conventional public transport, and indeed faster than many urban journeys by car.

The ATS/Citymobil software enables users to examine a wide range of potential PRT applications, either by looking at the dynamic operation of provided case studies, or by constructing an actual network using any configuration of guideways within an area of the user's own choosing up to 5km square. It enables the user to:

- examine the working of case study networks provided
- build and edit a network of guideways, stations and depots against a map of the area selected: the software provides warnings if the constructed network is not operable for PRT, and suggests remedies
- determine the level of demand at each station and construct an origin-destination matrix accordingly
- run the simulation, either in real time or much faster than real time, with vehicles in the stations or moving between them indicated as empty or carrying passengers
- see how the individual vehicles are controlled to wait at stations until passengers arrive and then directed to the requested destination station, and how empty vehicles are called to stations where passengers have arrived when no vehicle is waiting
- see how many passengers are waiting at each station, and how many vehicles are at each station, waiting empty, unloading or loading passengers
- see the mean waiting time at each station and overall, and the number of vehicles required

The specification of the PRT network is that of ATS Ltd's ULTra system of 4-seater battery electric vehicles (see http://www.ultraprt.com/). **The ULTra system is now operating at London's Heathrow Airport, and is the first operating PRT system in the world.**

It requires no prior knowledge of PRT to use the simulation to examine how PRT might work in a specified location, though it is not to be expected that the inexperienced user will be able to design a network of high efficiency, or one which will work near the limits of network capacity. Nevertheless, the user can very quickly design and build PRT networks which work adequately, and the process confers a high degree of understanding of the PRT concept, and the ways in which it can offer a much superior service to conventional public transport. In addition to its educational value, it offers good entertainment value.

The simulation package can be downloaded from the CityMobil website or from
https://atsltd.sharefile.com/d/s350ff7eaab84f478
and will operate on any reasonably modern PC.

3.1.2 Contact person/organisation

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3.1.3 Target Audience

The Heathrow PRT system is the first publicly operating PRT system in the world. People and authorities interested in the possibility of applying PRT in their own areas can visit Heathrow and see how it operates, but they can also use the CityMobil simulation tool to gain a better understanding of what might be possible in their own specific circumstances. This helps exploit the technology not only of ULTra, but of PRT generally, since although other PRT developers will provide systems with different specifications from ULTra the simulation will help in showing how any form of PRT could provide a public transport service in the modelled area.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.2 Business Case tool

3.2.1 Short description

A business case is the basis for the economic justification of any new scheme. It takes into account all the factors that need to be considered, and presents them in a way that is easy to understand. It also facilitates a comparison of alternatives in order to assess value for money. An alternative may be a ‘do nothing’ or ‘business as usual’ scenario, or it may be an alternative transportation system. Either way, the results of a business case are needed to show the funding partners if their investment will be worthwhile.

Deliverable D2.4.1 Generic Analysis Tool for Business Cases from the CityMobil project describes a tool that has been developed for assessing the business case for new automated transport systems. The tool itself is provided in the form of an Excel Spreadsheet together with a User Guidelines document. They are stand alone items, available from the project.

The business case tool is based on the results of a literature survey of earlier economic analyses undertaken in association with the development of new automated transport systems, and of previous guidelines developed to assist in the economic and value for money assessments of new transport systems and schemes.

From this literature review a list of criteria and a methodology have been developed for the assessment both of a wider ‘transport case’ that includes details of the background, policy and context, and the social costs and benefits that are needed to enable a local authority partner to assess a scheme, and also for a more focussed ‘business case’ that considers only cash flows and is needed separately to satisfy the funding partners.

The approach adopted basically provides for a comparison of a new i.e. CityMobil system with a conventional alternative e.g. bus scheme through a structured set of questions that are designed to build up the transport and business cases for each system. The process then provides a formal framework for the appraisal of the two schemes in terms of relative costs and benefits, and the use of a TOAST (Technology Options Appraisal Summary Table) methodology that uses professional judgement to rate and weight the various benefits, intangibles, impacts and risks of the alternative schemes, and produces ranking figures that enable the two options to be compared. The use of the TOAST enables a more complete assessment as compared to just relying on a purely economic evaluation using the benefit-cost ratio (BCR) figures, and facilitates an assessment of value for money.

The tool is designed for use at several levels:

At a basic level, it is designed to assess the business case for a new transport system. It does this by collecting information about expected cash flows and calculating a business benefit-cost ratio. It is expected that this result should generally be sufficient for the funding partners.

At a second level it provides the facility to collect additional information that is needed in order to answer the additional questions that can be expected from the (local) government partners. This additional information is designed to reveal details of the background, policy and context of the scheme, and to recognise social costs and benefits where the information can be provided. It also suggests that the scheme should be considered in comparison with a conventional alternative scheme such as a bus, and provides a TOAST methodology for assessing their relative value for money.

At a third level the tool is designed to be useful as a design tool, and two particular features are provided to assist the user:

i) The tool contains ‘simulations’ of PRT and CTS systems so that the user can specify a system in terms of either user needs e.g. required performance characteristics such as average, minimum, and maximum in-vehicle travel times and waiting times; or of system design parameters such as the size of vehicles (passenger carrying capacity) and the number and speed of vehicles required for the operation. The simulations also facilitate testing of a range of ‘what if’ questions so that effects of changing demand, network length or vehicle carrying capacity can be easily answered;

ii) The tool provides guidance on a range of information and parameters taken from real life examples, such as data on the costs of different systems. The tool has been developed to be comprehensive, so that the methodology and lists of criteria encompass a full range of factors that should be taken into account in a scheme evaluation. However, at the same time the tool has been designed for use at a ‘high level’ and can, for example, easily be used in a first pass with incomplete and unrefined data to get an initial and rough idea of a business case.

In addition the tool can be used in an iterative process through varying and refining the values for a number of different input figures in order to assess the effects of these alterations on the overall BCR and TOAST results. This will help to determine the optimal system operating characteristics to be taken forward for a full design.

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3.2.3 Target Audience

The business case tool is targeted mainly at local authorities and potential funding partners, together with their advisors e.g. consultants and academics, who wish to understand and develop the business case for implementing a new public transport scheme, and assessing the value for money.

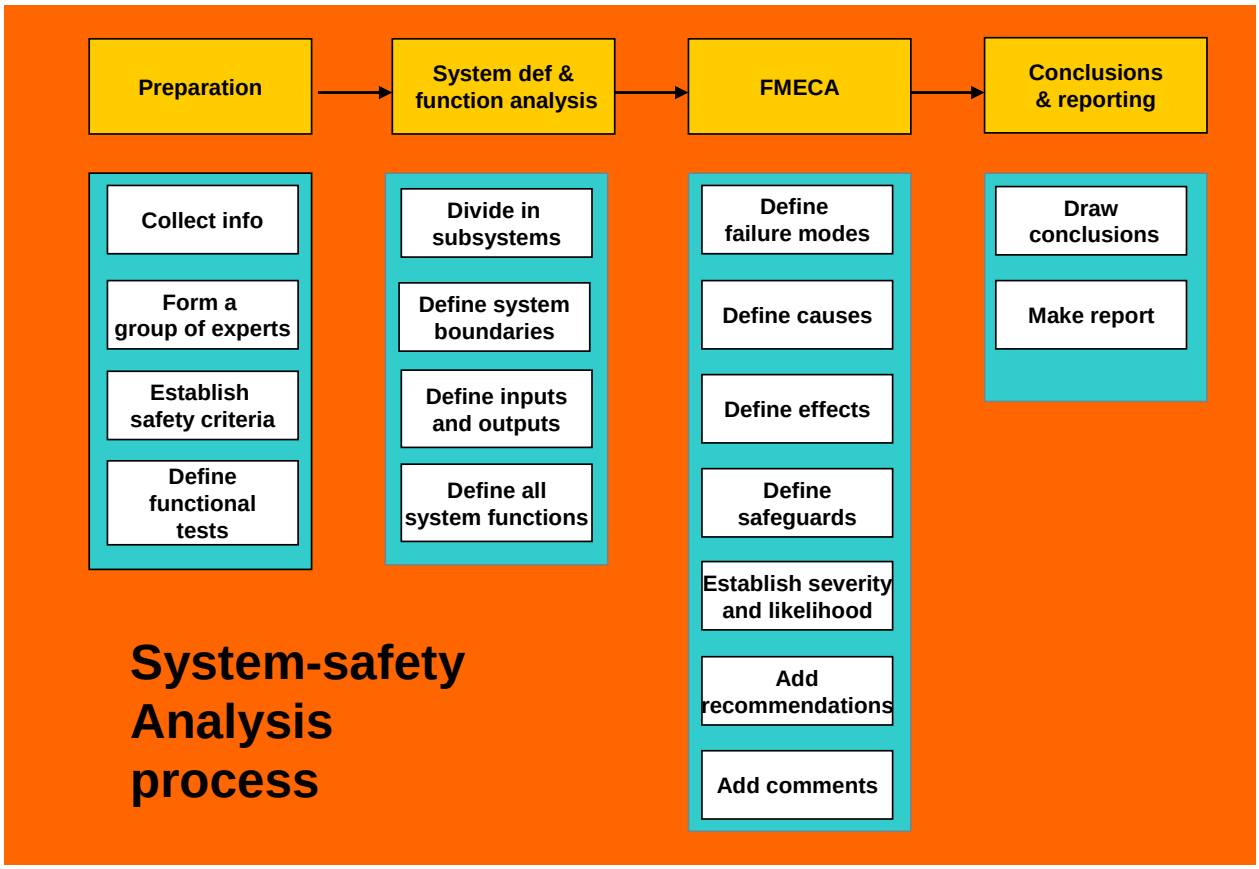
Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.3 Certification Guidelines

3.3.1 Short description

One of the main barriers for the implementation of automated transport systems is the absence of a certification system. Such a system is necessary to prove to authorities and other stakeholders that the transport system meets the applicable safety requirements. Therefore a system safety analysis process was designed that can serve as a certification tool as well as a design tool.

During the development phase several analyses of automated transport systems were carried out, among which the Floriade people mover and the Parkshuttle, that presently operates in Capelle a/d IJssel in the Netherlands. In 2009 a full evaluation was carried out with the people mover for the CityMobil Rome demonstration as a subject. In 2009 and 2010 an analysis of the Masdar PRT system was carried out.



One of the main challenges during these last two analysis processes was the acceptance issue. How to convince the certification authorities that the procedures are indeed suitable for the certification of automated transport systems.

Therefore it is important that certification authorities but also developers and operators of automated transport systems gain experience with the procedures in order for the confidence in the procedures to grow. In the near future it is necessary that a series of analysis is carried out, so that the usefulness and the user-friendliness of the method can be proved to as many stakeholders as possible. A next

step after that will be the introduction of the procedures in formal certification systems like ISO, EEC and ECE.

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3.3.3 Target Audience

The certification guidelines are meant to be used as a tool for certification as well as a design tool. By carrying out a safety analysis in various phases of the design process important improvements can be made in an early stage. This avoids expensive and complicated modifications in later stages of the design process. So the certification guidelines do not only target the certification authorities, but also the vehicle and component developers.

Public Authority (Certification)	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.4 City Application Manual

3.4.1 Short description

The aim of the ‘Future scenarios’ work of CityMobil was to investigate how automated road transport systems fit into the expected scenarios for advanced urban transport in the future, and in particular how they will contribute to sustainability. A number of tools for cities and operators were developed to analyse transport requirements and potential impacts. These include a series of context scenarios over the period to 2050, a set of passenger and freight application scenarios which indicate the contexts within which different technologies are most likely to be effective, a tool for predicting patronage for new technologies, a business model for assessing the financial viability of technology projects, a sketch planning model for assessing the overall impact of these technologies in cities, and guidance on how to overcome the key barriers to implementation. The City Application Manual is designed to help cities make good use of these tools, and to provide general guidance on the approach which cities might adopt in deciding whether to consider new technologies and how best to apply them. References are provided for those who need more detailed information. Each chapter provides a short description of a particular stage in the policy formulation process, the relevant tools from CityMobil, and examples of their use.

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3.4.3 Target Audience

The text is aimed at policy makers and their advisers.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.5 Personal Rapid Transit - Applicability

3.5.1 Short description

The Heathrow demonstration has achieved three very important milestones:

- It has shown that PRT can work reliably as intended
- Passengers clearly prefer PRT to buses
- The capital and operating costs of constructing PRT on a routine basis have been placed on a stronger footing

Once the practicality of PRT is fully demonstrated, BAA, Heathrow Airport's owners, intend to expand the network to cover the north side of the airport, serving terminals, car parks, car hire centres, staff locations and, perhaps, hotels.

However, the limited Terminal 5 PRT network cannot demonstrate the full strengths of PRT, since at present it connects just two locations. The expanded network will enable passengers to travel from any station on the network to any other, with little or no waiting, non-stop at 40kph, and with the personal comfort of the automobile. It is obvious that PRT can provide an ideal core transport system for an airport. **Deliverable 1.2.5.1** discusses the applicability of PRT to a range of other situations, including, importantly, urban public transport. It is immensely flexible against changes in airport layout, the image is futuristic and high-tech, and the need for elevated segregated guideway presents few problems in the cluttered surrounds of an airport. Moreover, the zero- emissions and low noise mean that the system can be taken into airport buildings.

The Deliverable discusses four detailed desk studies of ULTra applied to Heathrow, Cardiff, Corby and Bath, plus relevant case studies from Sweden and elsewhere. In all cases, and using realistic costing, the savings in passenger travel times strongly justify the cost of the system. Indeed, the Corby study compares PRT with a detailed study of LRT and finds that PRT offers much better value for money, and can probably pay off its capital investment at 6%pa, whereas LRT covers little of its capital costs. The need for segregated guideway means that much of the network has to be elevated, which is a limitation in urban areas because of visual intrusion, but the lightweight nature of PRT means that the infrastructure can be very slim, and the case studies have found adequate acceptable routes through existing development.

The Deliverable discusses the environments and applications where PRT would be appropriate, the practicality of constructing the guideways, especially elevated guideway, the likely costs (specific to ULTra), safety and security, environmental aspects and emissions, the rational process of deciding whether to install a PRT system, and the future of PRT.

Now that the practicality of PRT has been demonstrated, and the service can be tried, airports, commercial campuses and similar new developments are likely to be eager to develop new networks. However, it will be much more difficult for a public authority to take the first adopter risk for a PRT public transport network. To show that it is practical, and to demonstrate PRT's advantages, there will need to be wider governmental, or inter-governmental, support for the first applications.

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3.5.3 Target Audience

The discussion here will be of interest to all owners of campus-style developments, and to local authorities and, hopefully, higher levels of government. It provides essential reading for all potential adopters of PRT, and should encourage wider exploitation of PRT.

ULTra PRT Ltd will extract and use the CityMobil findings to assist the case for applying PRT, and to help adopters to understand and formulate the business and socio-economic cases for the necessary investment. Other PRT developers will doubtless do likewise.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.6 Personal Rapid Transit - Evaluation

3.6.1 Short description

Before the PRT system linking Terminal 5 with its business car park began to operate, car park users were transferred to the terminal by bus. Comparable surveys have been applied to passengers using the transfer bus (**Deliverable 1.2.4.1**) and to riders of the PRT system (**Deliverable 1.2.4.2**). Passengers were asked to rate various aspects of the service on a five-point scale. **Deliverable 1.2.4.3** compares the survey results for PRT against those for bus, and gives a range of other performance indicators for the PRT service based on the operating data. Passengers showed a clear preference for PRT over bus. Ratings were statistically significantly higher for PRT in relation to:

- personal space
- personal comfort
- personal safety
- waiting time
- image
- environmentally friendly
- confidence in the service
- the overall experience.

90% of respondents preferred PRT to bus. When asked about willingness to pay, the majority indicated they would pay more than for bus, but less than for taxi. The service has achieved an operating reliability of 99.7%, and an average waiting time of 18 seconds.

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3.6.3 Target Audience

This work provides a quantitative measure of how passengers regard PRT, and gives confidence that a PRT service will be attractive to its passengers. The socio-economic justification depends solely on the extent to which PRT can reduce passengers' travel times, set against the system costs, but these findings indicate that, other things being equal, passengers are likely to regard the benefits of PRT as extending beyond the strictly economic indicators, and that in making a financial or business case passengers would be willing to pay more than the fare for bus, and perhaps more than the fare for other forms of conventional public transport. This strengthens the case for adoption of PRT.

ULTra PRT Ltd will extract and use the CityMobil findings to assist the case for applying PRT, and to help adopters to understand and formulate the business and socio-economic cases for the necessary investment.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.7 Personal Rapid Transit – Heathrow demonstration

3.7.1 Short description

The most important achievement for PRT of CityMobil is the demonstration at Heathrow that PRT works, and its assessment of its performance and passenger acceptability. The Terminal 5 system is entirely funded by BAA, but CityMobil has disseminated information about the concept and made quantitative measurements of its success. This is a world first, and a culmination of a transport concept which has been around for 50 years, but which has only now become technically feasible at an acceptable price. The Heathrow demonstration does not show the full strengths of PRT, since the limited network cannot illustrate how PRT can take passengers seamlessly from anywhere on the network to anywhere else, and it is this that marks the superiority of PRT over conventional public transport. Nevertheless, the achievement is there on the ground for any sceptic to see that the concept is completely practical, and for potential developers to sample its quality.

Deliverable 1.2.2.2 describes the Heathrow system in technical detail. The system uses ULTra, as provided by ULTra PRT Ltd, and other PRT systems currently under development differ in particular aspects, sometimes radically. Even so, this is a valuable showcase for the entire industry, and is likely to encourage other suppliers.

The entire justification for PRT within CityMobil as far as exploitation is concerned is that the information produced and disseminated by the project will inform potential future applications. This will take PRT from being merely a transport concept to an important component of integrated public transport. Such an outcome will become increasingly important in transport policy as traffic congestion worsens and concern grows over the contribution of transport to global warming.

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3.7.3 Target Audience

All the PRT contributions to the Exploitation Plan are aimed at helping PRT to progress to the next stage. The findings contained in the CityMobil project will certainly encourage the uptake of PRT as an ideal transport system for airports and campus-type developments, but a potentially more important, and more difficult, step is to have PRT accepted as an important component of urban public transport systems. This will take more than either a demonstration of its practicality or helpful information about PRT. It will require positive policy action at governmental level.

ULTra PRT Ltd will extract and use the CityMobil findings to assist the case for applying PRT, and to help adopters to understand and formulate the business and socio-economic cases for the necessary investment.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.8 Advanced City Car

3.8.1 Short description

Basic ADAS functions have been developed up to now under the umbrella of the "*Advanced Driver Assistance*" concept, while further developments are still in progress. In particular functions such as assisted parking, lane keeping, stop-and-go automatic driving assistance in traffic congested situations, have been developed with the aim to improve driving safety and comfort.

Advanced City Car are vehicles dedicated to urban trips which are equipped with solutions to increase the safety and comfort of the driver, through the automatisation of some manoeuvres and the provision of support for all driving tasks.

Examples already exist in the market: semiautomatic parking, where the vehicle controls automatically the steering wheel while the driver keeps the control of the vehicle speed, paying attention to avoid collisions.

Fig. 1. Citymobil vehicle during an automatic parking manoeuvre.

In CityMobil this manoeuvre has been extended to full automated parking. Other manoeuvres are possible with the solution developed in CityMobil, like automated Stop&Go and the full automatic driving in a dedicated lane (called e-lane).

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3.8.3 Target Audience

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.9 Dual Mode vehicles

3.9.1 Short description

The Advanced City Vehicles designed for the required application within CityMobil, represent a Dual Mode Vehicle concept, where normal production cars equipped with ADAS allow additional functions with capabilities to offer an automatic mode in specific situations and scenarios like CTS (Cybernetic Transport System).

Basic ADAS functions have been developed up to now under the umbrella of the "*Advanced Driver Assistance*" concept, while further developments are still in progress. In particular functions such as assisted parking, lane keeping, stop-and-go automatic driving assistance in traffic congested situations, have been developed with the aim to improve driving safety and comfort.

A typical DMV vehicle has the following main features.

Vehicle propulsion is electric or hybrid, since low emission is a strong requirement for vehicles that will operate mainly or exclusively in urban scenarios; furthermore electric motors are generally considered well suited to perform low speed manoeuvres.

Actuators for vehicle control are derived from the production ones, with some adaptation to extend their functionalities in such a way to include the operation modes required for automatic driving. This can help the introduction of some of the new functions, by shortening the development time and by involving component suppliers in the process at a very early stage.

The localization system does not necessarily rely on GPS. In spite of the fact that Differential GPS is a very common and easy way to precisely locate vehicles and to perform automatic guidance and driving without any additional infrastructure, in urban areas, especially in the narrow streets of inner cities it is very usual for its performance to drastically diminish. Therefore, a localization method based on low cost markings has been adopted, on the basis of on-board image processing technologies, which are well experimented in research on ADAS and are becoming very popular in the automotive industry.

Fig. 2 - Example of DMV on a dedicated lane

Obstacle detection uses laser sensor. A one-layer beam sensor is used, although new multi-layer sensors will soon be available as prototypes, with higher performance, which allow a better sensing of the surroundings, but at a very high (actual) cost. Nonetheless, the choice made is considered adequate for demonstration purposes; furthermore, it must not be considered definitive, since other technologies are under investigation (e.g. short range radar, stereo cameras).

A future exploitation (production) of DMV vehicle based on standard vehicles seems clearly possible from the Citymobil results; however, since the volume will be probably limited

(hundreds or thousands of vehicles) this business will be covered better by specialised SME and not by the automotive industries.

On the other side a different regulatory systems is needed in order to enable the market introduction of this type of vehicle. Driverless transport is today possible only on fully segregated dedicated lane (where it is almost impossible to enter).

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3.9.3 Target Audience

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

3.10 Alternative Patronage Estimator

3.10.1 Short description

Sub-project SP2 ‘Future scenarios’ has the aim of investigating how automated road transport systems fit into the expected scenarios for advanced urban transport in the future. A number of tools for cities and operators were developed to analyse transport requirements and potential impacts.

The Alternative Patronage Estimator is a tool that predicts patronage for new technologies. It is a model for travel demand prediction. The objective of this model is to be able make quick rough estimates of travel demand for a particular public transport service. This tool allows for a first analysis and quick comparison of several schemes for a new automated public transport service. It is particularly useful in the design process of a new system.

The alternative patronage estimator is a simplified version of the more classical four-step approach. It focuses on the use of one particular public transport system, without estimating demand for other modes. The tool is a GIS-based application that predicts the use of an automated public transport system. The demand for the system is calculated based on socio-economic data (number of inhabitants, jobs, schools, etc) in the GIS-map of your region and the properties of the service.

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3.10.3 Target Audience

The tool is aimed at policy makers and their advisers.

Public Authority	***Traffic management***	***Public Transport***	***End Users***
Vehicle Manufacturers	***Suppliers***	***Technology providers***	***Research***

4 Conclusions

The main objective of the CityMobil project is to achieve a more effective organisation of urban transport, resulting in a more rational use of motorised traffic with less congestion and pollution, safer driving, a higher quality of living and an enhanced integration with spatial development.

In order to achieve this goal, three sub-objectives have to be reached:

1. The development of advanced concepts for advanced road vehicles for passengers and goods transport.
2. The introduction of new tools for managing urban transport.
3. The take away of the barriers, which are in the way of large-scale introduction of automated systems.

In order to achieve these objectives 5 subprojects have been defined and developed throughout the CityMobil. The first one of these sub-projects (SP1) is especially dedicated to test, validate and demonstrate the advanced concepts and tools developed in the project in a number of different European cities under different circumstances. For this purpose three large-scale demonstrators have been set up, where implementations of real and innovative systems will be executed. These three big demonstrations will be performed in Heathrow airport, Rome and Castellón.

This deliverable shows the main results of the CityMobil project and those offering the greatest exploitation potential in the future.