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Executive Summary

The global 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.

For this aim, four different technologies will be tested and evaluated in the project:

- Personal Rapid Transit (PRT): a transport system featuring small fully automatic vehicles on dedicated tracks for the transport of people.
- CyberCars (CC): fully automated vehicles which are allowed to operate on any road infrastructure, although at low speed if there is a possibility for them to encounter fixed or moving obstacles.
- High Tech Buses (HTB): buses on rubber wheels, running for part of their route on guideways, and operating more like trams than like traditional buses.
- Dual-mode vehicles (DMV): advanced city vehicles with a cybercar capability. This means that the vehicles can be driven either manually (with driving assistance) or in full automatic mode in specific areas or conditions. This is particularly interesting for car-sharing operation to move the empty vehicles when and where needed. The vehicles can move fully autonomously on a dedicated lane (as a cybercar) or can be moved in a platoon with a single driver.

The demonstration, the showcases and the case studies involved in the CityMobil project have to provide a data collection for the evaluation of their feasibility and performances. In such way it is possible to evaluate the results, linked to the introduction of the new technologies proposed in the project, in terms of advantages for the users and improvement of new transport scenarios. Three different evaluation phases are required for each site: initial evaluation, ex-ante evaluation, and ex-post evaluation.

Work Package 5.3 aims at evaluating the overall contribution to the sustainable urban development brought by advanced transport systems when implemented at a city-wide scale, that is how these help achieving long-term social, environmental and economic objectives.

To this end, a number of European cities were selected as case studies (named modelling studies) for modelling work carried out by the CityMobil SP2 working group, with the purpose of reproducing the behaviour and the performances of these technologies over the entire urban area and not just at a single isolated site. The purpose of the work outlined in this document is to study the scenarios depicted with that modelling, in order to facilitate the interpretation of those results in terms of benefits and sustainability achievements. The further and final step of this process will be to integrate the experience gained from the on-going demonstrations with the broader full-scale analysis performed in this work, and finally produce an overall evaluation of the automated system applications (WP 5.4).

This deliverable is the first part of a whole deliverable which will be done once the case studies analysis will be completed, the results obtained will be cross-compared and the overall evaluation of the case studies will be possible.

The deliverable is organised in eight main sections, including the introduction (first section) in which the main objectives of the case studies evaluation are reported.

The second section briefly describes the technologies adopted and analysed for the case studies: Personal Rapid Transit, Cybercars, High Tech Buses and Dual Mode Vehicles.

In the third section a brief description of the five case studies chosen for the analyses is reported. They are: Trondheim, Gateshead, Vienna, Madrid and Uppsala. All of them will test

schemes for all the four technologies, with the exception of Uppsala, where only a PRT system will be tested.

In the fourth section the division of the indicators to be used for the case studies and the ways in which they will be obtained are reported. Starting from the set of 64 indicators defined in the evaluation framework, they are subdivided in those to be measured within the city modelling activities, those produced outside the models but derived elsewhere from the project (for example from SP3, SP4 and WP5.2) and quantified for the single case studies, and those not assessed at all.

The fifth section reports the main evaluation resources: the MARS modelling and the Business Case analysis. MARS is a strategic land-use transport interaction model, built and run in the WP2.3 of the CityMobil project, which models different scenarios for each of the four cities testing all the technologies (Trondheim, Gateshead, Vienna and Madrid) and provides social, environmental and economic impacts for them. The Business Case analysis is a tool, developed within the WP2.4 of the CityMobil project, for the investigation of the business cases for the new advanced transport systems through simulations, which produces outputs in terms of performance parameters, operating characteristics, economic analysis and a qualitative assessment of other system benefits.

Both MARS and the Business Case analysis represent the input for the Multi Criteria Analysis (MCA).

The Multi Criteria Analysis is the tool used to evaluate the scenarios for the Advanced Transport Systems (ATS) in CityMobil (in such case the scenarios for the different Advanced Transport Systems tested in the different case studies) through the analysis of the results of land-use transport interaction models.

A brief description of the Multi Criteria Analysis used for the case studies is reported in the sixth section. A weighted summation method has been chosen for this Multi Criteria Analysis, and its three steps are reported and described: 1) Evaluation matrix assembled with the indicator results for each scenario according to the modelling results and score calculation, 2) Aggregation of the scores to a commensurate utility value for each scenario, 3) Sensitivity analysis in order to test the stability of results under the variation of valuing and weighting functions.

The seventh section briefly reports other two evaluation resources which will contribute to the ex-ante evaluation: the VOLTair methodology and the City Councils consultations.

The VOLTair methodology is made for transport planning and integration, to be applied within WP2.3 of the CityMobil project downstream of the MARS models to produce a full set of detailed recommendations to each city, give guidance for the integration of the selected applications scenarios, define strategies for the assessed cities, with the final aim of complementing the assessments obtained through the strategic modelling.

Concerning the City Councils consultations, the outcome of the models and the overall conclusions will be submitted to the responsible city councils agencies, asking to comment and to possibly find out weak points and clarifications of model results based on their higher local involvement. The cities will be asked to express their opinion on the different scenarios ratings and rankings obtained by the CityMobil analysis for their municipality.

In the eighth section, the last one, the tool which will be used inside WP5.3 to prepare the generalization of the results which will be formalized in the following WP5.4 is presented: the Passenger Application Matrix. The purpose of this tool is to move the focus from the researcher perspective to the decision maker's one, typically more practical, trying to think in terms of what system is best to be implemented in order to improve the mobility in a certain specific situation. In this matrix the case studies, the demonstrations and the showcases are grouped according to the type of areas linked by the single scheme. Being the possible type of areas, the same (rows and columns), the matrix results to be a two-dimension symmetrical

one. The information for each OD pair, expressed in terms of the available indicator values, can be considered as the third dimension.

The matrix reported in the present deliverable is the first release of it: during the workpackage, it will be filled with the demonstrations, showcases and case studies results obtained during the project, in order to provide a complete tool to the WP5.4.

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Evaluation report of the A ex-ante study

1 Introduction - Main objectives of the city-studies evaluation

Work Package 5.3 aims at evaluating the overall contribution to the sustainable urban development brought by advanced transport systems when implemented at a city-wide scale that is how these help achieving long-term social, environmental and economic objectives.

To this end, a number of European cities were selected as case studies for modeling work carried out by the CityMobil SP2 working group, with the purpose of reproducing the behavior and the performances of these technologies over the entire urban area and not just at a single isolated site. The purpose of the work outlined in this document is to study the scenarios depicted with that modeling, in order to facilitate the interpretation of those results in terms of benefits and sustainability achievements. The further and final step of this process will be to integrate the experience gained from the on-going demonstrations with the broader full-scale analysis performed in this work, and finally produce an overall evaluation of the automated system applications (WP 5.4).

The cities chosen to undergo this evaluation are those belonging to the Reference Group (Gateshead - UK, Trondheim - Norway, Vienna - Austria, Madrid - Spain, Uppsala - Finland). They are considered to be representative of the European cities as for variation in size, geography, economy and existing transport systems.

The selected city scenarios which will be modelled, thus forming the basis for the evaluation, are based on previous work undertaken in SP2, where a consistent combination between possible contexts (high/medium growth), technologies (or passenger application scenarios) and complementary measures was established. The schemes will be applied over a total of 30 years, with 2005 as the base year.

With the aim to draw a complete picture of the impacts brought by the implementation of the new modes of transport, the modeling work was designed as to produce the results in terms of an extensive set of indicators, as specified in the evaluation framework (see Deliverable D5.1.1, Marsden et al., 2007). A subset of these indicators has been selected to feed a Multi-Criteria Analysis (MCA) tool which is the core of the city-studies. It will provide a comparable appraisal of the modeling outcome and facilitate the real understanding of the advantages brought by the implementation of such systems although the whole indicators group is involved in the sustainability assessment work. The classes of impacts represented by this subset are the social, environmental and economic ones. The SP2 performance results will be transformed into scores according to linear valuation functions and weighted according to the local weights obtained for the single city case studies (see D5.1.2, Gühnemann & Kimble, 2008). For comparability between the cities these will be expressed in relative achievements compared to a base situation.

With the indicator set ranging widely from technical to social, environmental and financial aspects, the modelling work was organized in two parts: the majority of the indexes will be produced via a strategic land-use transport interaction model (MARS), built and run within WP2.3; on the other hand, the financial-economic indicators will be obtained from the Business Cases study performed within WP 2.4 on a few scenarios as to complete the input set for the Multi Criteria Analysis where possible.

In order to consider and evaluate all the effects connected with the implementation of Advanced Transport Systems, the results obtained from the Multi Criteria Analysis will be integrated, where needed and where possible, with a broader analysis including extra information, coming from the outcome of the VOLTair methodology and from the discussion with city representatives involved. Also the indicators produced by the models but not used

as inputs to the Multi Criteria Analysis will be considered in the formulation of the sustainability results.

Figure 1 reports such links between the ex-ante evaluation of the case studies and the other sub-projects and tools of CityMobil.

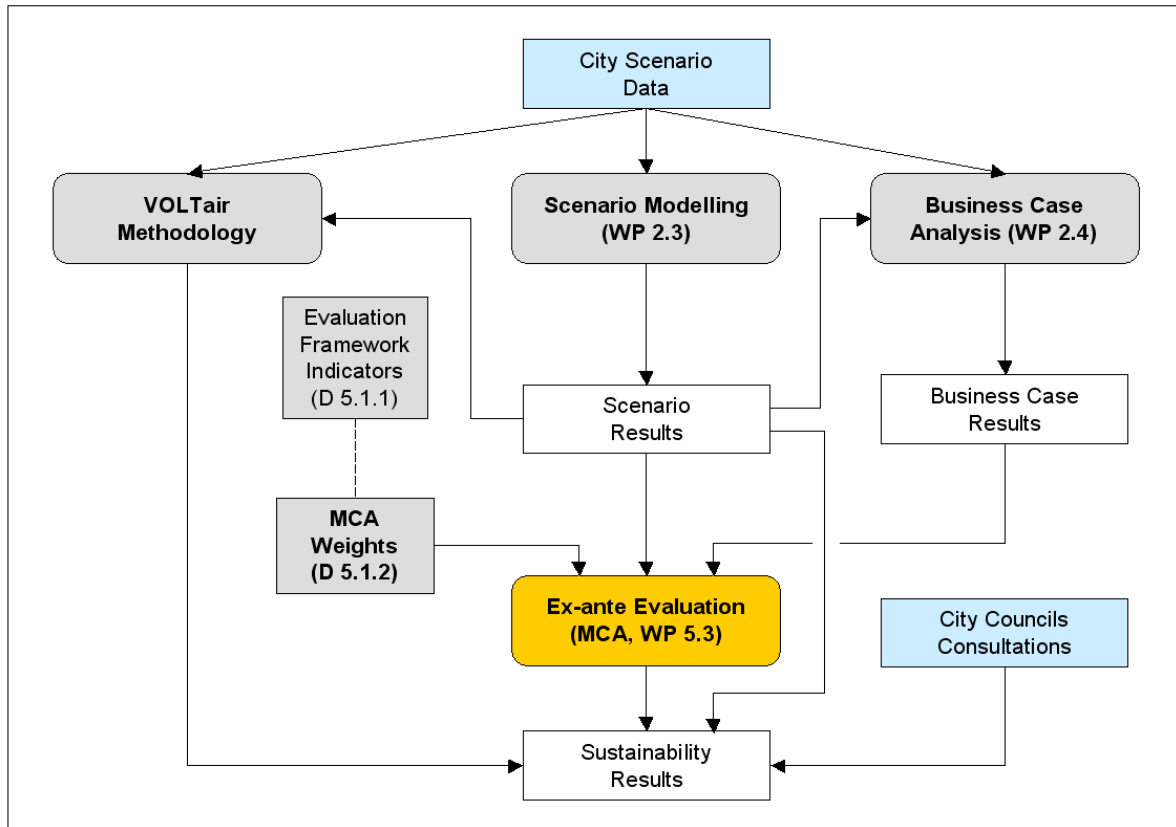


Figure 1 Ex-ante evaluation of city case-studies

Transferability of the results is an important aspect of the evaluation process carried out by this Work Package. The findings for the single city case-studies should effectively be usable for a generic city-wide implementation. An interesting challenge of WP5.3, depending on the available results from the modeling team, may also be to understand which are the trends under different conditions, which cannot be put to use by the demonstrations.

This deliverable, 5.3.1a, represents the first part of the whole evaluation work report. It contains the preliminary definition of the evaluation field and the analysis setup for the data coming from the models and from the field. A second part, 5.3.1.b, containing the actual evaluation based on the results of the Multi Criteria Analysis and all the other inputs, will be produced in the following step. The findings of this quantitative evaluation will be presented and all the aspects raised in the present document will be discussed and developed on the top of the results.

The results reported in 5.3.1b will form the basis for the final conclusions expected from the Citymobil project, which will be formalized in Work Package 5.4: these draw together the findings of the ex-ante evaluations from several different systems and contexts into a series of more generalized findings in order to assess to which extent automation would make urban transport sustainable; establish the next step-stones to achieve a higher transport

sustainability through automation; define a roadmap to urban transport sustainability through the progressive adoption of advanced transport for urban environments.

2 Technologies description

The Advanced Transport System technologies that were submitted to the city wide models are briefly recalled in this paragraph. Among the five technologies examined in the CityMobil project (Personal Rapid Transit, Cybercars, High Tech Buses, Dual-Mode Vehicles, Advanced City Vehicles), four are considered in the MARS models; the Advanced City Vehicles are excluded from the models due to the fact that the advantages brought by these technologies are mostly punctual and would not affect capacity. For the Business Cases modeling, also the Dual Mode Vehicles are excluded since these do not involve public expenditure, and thus no costs can be assumed for the cost-benefit ratio calculations. For what concerns the VOLTair methodology, finally, the same technologies considered in MARS are considered and analyzed.

Personal Rapid Transit (PRT) is a transport system featuring small fully automatic vehicles on dedicated tracks for the transport of people. The PRT is fully automated and the vehicles are small with capacity usually limited to 4 to 6 persons per vehicle. PRT offers an on-demand service, where people are transported directly from the origin station to the destination station without stopping at intermediate stations, without changing vehicles and ideally without waiting time.

Cybercars are small automated vehicles for individual or collective transportation of people or goods. Cybercars offer a fully automated on demand transport system, meaning that under normal operating conditions no human interaction is needed. They can either be fully autonomous, or make use of information from a traffic control centre, information from the infrastructure or information from other road users. Cybercars are small vehicles, either for individual transport (1-4 people) or for transport of small groups (up to 20 people). Cybercars can either use a separated infrastructure or a shared space. In theory there can be interaction with other road users, but the present state of the art limits their use to specific areas such as city centres with little or no interaction with other road users.

High Tech Buses are buses on rubber wheels, running for part of their route on guideways and operating more like trams than like traditional buses. High Tech Buses are vehicles for mass transport (>20 persons) that use an infrastructure which can be either exclusive for the buses or shared with other road users. They can use various types of automated systems, either for guidance or for driver assistance or for other purposes, and always have a driver, who can take over control of the vehicle at any time, allowing the vehicles to use the public road.

Dual-mode vehicles are advanced city vehicles with a cybercar capability. This means that the vehicles can be driven either manually (with driving assistance) or in full automatic mode in specific areas or conditions. This is particularly interesting for car sharing operations to move the empty vehicles when and where needed. The vehicles can move fully autonomously on a dedicated lane (as a cybercar) or can be moved in a platoon with a single driver. They represent the migration path from traditional cars to automatic driving.

3 The sites

This section reports a brief description of the five case-study cities that were chosen for the analysis (Gateshead - United Kingdom, Trondheim - Norway, Vienna - Austria, Madrid – Spain, Uppsala - Finland), including some information about the cities and the schemes for the proposed new Public Transport lines. Dual Mode Vehicles are assumed to be privately

owned and not part of a public transport system and are modeled as being integrated into the existing fleet.

These cities have been selected to represent the types of variation in size, geography, economy and existing transport systems and problems, found in cities across Europe.

Concerning the first four cities mentioned (Gateshead, Trondheim, Vienna and Madrid), each of them was modeled within WP2.3 by using the MARS methodology according to the different scenarios contained in the evaluation matrix, in order to estimate the values for the set of indicators established in the evaluation framework (WP5.1). These scenarios include the combination of the four technologies (cybercar – in the two environments “Public Transport feeder” and “Inner city service”, Public Rapid Transit, High Tech Bus, Dual Mode Vehicles); two different grow rates (high growth, medium growth); under the implementation of some complementary measures or not. The schemes were modeled over a total of 30 years, with 2005 as the base year. In all cases the new technologies are introduced in 2010.

The same cities were submitted to the Business Case modeling within WP2.4 by applying the specific tool for the assessment of the Economic and Financial impacts.

Finally, these cities are the object of the VOLTair methodology application, which provides further useful information for the case-studies evaluation.

A consultation with the cities administrations completes the input to the evaluation activities of this work package.

A complete and more exhaustive description of the sites can be found in D2.3.1.

With regards to Uppsala, a PRT system is going to be made and will be analyzed. In this case only one scenario will be provided because it will not be modeled with MARS nor submitted to the business case modeling and to the VOLTair methodology application.

3.1 Trondheim (Norway)

Trondheim is a 150000 inhabitants town, 30000 of which are students. The city hosts the regional public administration, and is also a centre for commerce, though the number of industrial companies is limited. Most offices are located in the city centre. The topography of the city creates challenges for transport, making it difficult to connect the east and west parts of the city.

In 2006 the city closed down the toll ring after 15 years of operation. Public transport in Trondheim is served by a bus system with local and regional routes. There is also a tram line connecting the city centre, Byåsen, to a recreational area on the western side of the city. The map of bus routes also includes the tramline as line 1. The bus system has 42 lines that serve 1100 stops. On average there are 70 000 bus passengers daily. The bus system length is 787km in one direction. The modal share in Trondheim is 57.6% car, 10.8% public transport and 31.6% walking and cycling.

The schemes for **High tech bus** include services on major routes into the city centre, and a route linking the city centre to a key facility. The proposed routes for the high-tech bus schemes will make use of the existing public transport priority network. Currently there are intersections within this network where public transport is given priority over general traffic, either towards the city centre or away from it. Most of the buses towards the city centre will be aided by this priority system at the final stage towards the city centre, meaning a reduced travel time in the peak. The proposed high-tech bus routes will run for 3.3km from the west, 5.3km from the east, and 4.3km from the south. All the routes except for the University loop are main arterials towards the city centre.

As for the **PRT**, the schemes include a city centre network linking key facilities. The 18.5 PRT network includes a west-east line linking the two sides of the river and the city centre to the university campuses, and a north-south line linking the harbor to the city centre.

Two sets of schemes are to be designed for **Cybercar** – a city centre network, and feeder services in suburban zones linking to the existing public transport. The feeder system in the suburban zones will allow the bus routes to be simplified as the buses will not have to take detours to cover the whole area (most users will use the feeder to get to and from the bus stops) and will therefore reach the city centre more quickly.

Integrated ticketing between the bus and the feeder system is foreseen, as well as coordination with their operational times.

3.2 Gateshead - Tyne and Wear (UK)

The Tyne and Wear region comprises five local authority districts – Newcastle-upon-Tyne, Gateshead, Sunderland, North Tyneside and South Tyneside. The urban conurbation of Newcastle and Gateshead will be the focus for the modelling work, with the other areas featuring in the external zones. Newcastle and Gateshead have populations of 259000 and 186000 respectively, of which around 66% and 64% are of working age.

Newcastle and Gateshead are adjacent with Newcastle located in the north of the River Tyne and Gateshead located in the south. The two cities are highly interdependent with intense commuting flows between the urban centres supported by an interconnected transport infrastructure. The majority of this is the Metro underground system, though the lines running from just north of Gateshead town centre to the west and south are heavy rail track mostly used for regional services. The River Tyne acts as a geographical barrier between the two cities; several bridges serve various modes, however they tend to act as bottle necks.

The Tyne and Wear Metro system largely covers the central and eastern areas of Gateshead and Newcastle, but also links to Newcastle Airport located to the northwest of the city centre. The Metro is 74.5km long and has 59 stations.

The modal split in Tyne and Wear is approximately 6.5% rail, 16.7% bus, 64.5% car and 12.3% walking and cycling. On average each household in Tyne and Wear owns 0.78 cars, compared to the English average of 1.11 cars.

Three schemes for the **High tech bus** are planned, covering different zones. The route length range is 14 to 19 km each, with 5 to 7 stops 3 km distant to each other approximately. The first high-tech bus route runs from south-east to north-west along the A1 key route, a dual carriageway that experiences a large amount of congestion around the Metro shopping centre. The scheme includes a dedicated bus lane along both sides of the road. The second proposed high-tech bus route runs from Gateshead town centre, along the northern side of the River Tyne, up to Newcastle Airport. Although it is currently possible to travel by Metro from Gateshead to Newcastle Airport, the communities in the west of Newcastle are not served and the proposed schemes would address this. An additional bus lane would be added to the most congested sections on the route. The third proposed high-tech bus route runs from Rowlands Gill, along the south side of the River Tyne, to Gateshead town centre. This route would also link the Metro Centre and Teams, which is an area with a large amount of industrial activity.

The proposed **PRT** system includes one scheme, linking a number of key facilities, including the Metro Centre, Newcastle and Gateshead centres and the Newcastle Business Park. There is currently no river crossing to the north of the Metro Centre and it is proposed that this would be created for this scheme. The other crossings would make use of existing bridges. It is currently problematic to travel between the north and east of the cities, and this scheme would aim to in part address this.

As for the **Cybercar** system, the inner city scheme is the same as the PRT city centre network to enable direct comparison between the two modes. The three proposed suburban cybercar schemes link to the existing public transport network (the Metro in this case). These schemes were all selected for locations where the existing public transport coverage is fairly sparse.

3.3 Vienna (Austria)

The city of Vienna has a population of 1500000 approximately, and steep increase in population is foreseen for the next decades. The city has a well developed and efficient public transport system consisting of LRT, metro, tramway and bus lines. The density of public transport stops is about 33 stops per km² built up land. Due to the good public transport system Vienna has a high share of public transport.

All the three proposed **High-tech bus** routes run on existing corridors of bus lines: the first one is positioned along the 48A bus line. The second route is running on the same corridor as the existing 57A bus route. The third proposal for a high-tech bus scheme parallels the existing 59A bus line.

For the **PRT** schemes there are two proposals. The first is within a new development on the outskirts of the city, and the second is a city centre network.

The city of Vienna is currently in the process of developing a new high quality mixed use city district on the area of the former airfield "Flugfeld Aspern". The master plan developed by Tovatt Architects & Planners has recently been approved by the city council. The "Flugfeld Aspern" will involve the 23 Viennese administrative districts and will be connected to the Viennese PT system by an extension of the metro line U2 and an extension of the tramway lines 25 and 26. The metro and tramway stations will be linked to several bus lines (the distance between the bus stops on the circular part of the bus lines is about 300 to 500 meters). The circular part of the bus would be replaced by the PRT system, with an average distance between the stops of about 200 meters and a total line length of about 3.5 kilometres.

The second line is planned to serve the city centre, also named Central Business District (CBD). In 2001 the Viennese central business district was home to 17056 residents and 101668 workplaces. More or less the whole district is a protected cultural heritage site and covers about 3 km². The city centre is well connected by public transport: within or very near to its boundaries there are 39 bus stops, 23 tramway stops and 14 metro stations. This gives a density of about 25 public transport stops per km². From nearly every location in the Central Business District it is possible to get to the next PT stop within 3 minutes walking. Within 5-6 minutes walking a metro station can be reached from more or less any point of the CBD.

The proposal for the case study of Vienna includes the following measures:

- make the whole Central Business District car free except on the ring roads "Ringstraße", "Kai" and "frühere 2er Linie" and on the access roads to public garages,
- replace the existing feeder bus lines by a new PRT system.

The suggested PRT system has 49 stops. The total length of the network is about 11 km.

The city centre **Cybercar** network will mirror the proposed city centre PRT network to enable comparison between the modes.

3.4 Madrid (Spain)

Madrid currently has 6 million inhabitants, in an area of some 8030 km². Its population is distributed unevenly among the city and the outskirts.

The main problems related to traffic and air pollution are concentrated in the central city and its suburbs with high density of populations and activities.

Regarding mobility patterns, nearly 15 mill trips are made every working day in Madrid Region. One third of them are no-mechanized trips. The rest, 54.7 % are made on Public Transport, and rest on private vehicles. This means that 11 mill trips are motorised trips every working day.

Public Transport maintains a high modal share mainly on those trips linked to the Central Business District or the Inner City of Madrid. But those regarding relation between the outer parts of the region are mainly dominated by car.

Private transport is predominant in metropolitan trips. Also, motorcycles and taxis are the lowest demand, metro and urban bus are predominant in Madrid City and suburban bus and rail in metropolitan and regional trips.

Current Public Transport scheme is mainly a radial scheme. There is a high density of public transport supply on the City, and good connections between the suburbs and the City Centre (radial Scheme). On remarkable issue is the current display of Metro Network that has been enlarged last year to new areas in the outskirts of the city, and also, incorporating some LRT systems on its network (more than 300 km).

The three public transport technologies have been modelled with the following schemes.

High-tech bus: this system is modelled as an enhancement of the existing bus system. It is assumed that new High-tech bus services will substitute existing services through the defined corridors. Thus, trips made on High-tech bus are included on those made by bus.

PRT: it is assumed that PRT systems will be used as a sole mode for those inner trips made on the area where the system is implemented or as a access or egress mean connected with the rail services. PRT system is operationally suitable for the inner city of Madrid as it is an area where car is being restricted more and more, and its street design does not permit to supply with a good surface transport system based on standard buses. If infrastructure scheme is not a limitation, a PRT system is propound to be included on the city centre linking main key facilities and public transport hubs as an extension of the current system.

Cybercar: in the inner city scheme this system has been modelled as an extension of the rail existing system. The same scheme as PRT is propound in order to compare same geographical schemes of transport systems. In the public transport feeder scheme the cybercar is modelled as an enlargement of existing rail system. Four different schemes have been planned: the first in District Number 18 – Villa de Vallecas, the second in the corridor of the highway A3 in the south-east of the city, the third in the Municipality of Boadilla del Monte and the fourth in the Municipalities of San Sebastian de los Reyes and Alcobendas.

3.5 Uppsala (Finland)

Uppsala is the capital of Uppsala County and the fourth largest city of Sweden with about 128,000 inhabitants.

A PRT system is going to made in the Bolaenderna District, with the aim to reduce use of private cars and to enhance the use of the public transport in such area. Such system will also improve the service provided through the buses, which will be substituted by PRT.

The network proposed is 9.4 km long and single-track, with 16 stops and 130 circulating 4-place vehicles.

4 Indicators

A set of 64 Indicators was defined in the evaluation framework (D5.1.1, Marsden et al., 2007) in order to help interpreting in a quantitative way the behaviour and the benefits of the several systems and scenarios implemented or modelled in the CityMobil project. These indicators are hierarchically grouped into 30 Impact Categories and, at an upper level, in 9 Evaluation Categories. The complete list of these indicators and categories is reported in D5.1.1, including also the work packages of the project where they can be measured for the various implementations or models.

Such a structure ensures that the whole evaluation process covers all the aspects characterizing the Advanced Transport System technologies; however it is useful, for the

purposes of WP5.3, to specify the indicators that are measured within the city modelling activities (MARS and Business Cases analysis), those that are produced outside the models but can be derived elsewhere from the project and quantified for the single city-cases, and those that cannot be assessed at all, as reported in Figure 2.

As described in detail in D5.1.2 (Gühnemann & Kimble, 2008), a reduced list of nine indicators was selected among the complete list to feed the Multi Criteria Analysis and thus measure the outcome for the main sustainability criteria (social, environmental, economic). This group is represented in blue in the figure. MARS will produce the values for the indicators belonging to this reduced group, except those related to the economic and financial aspects, for which the Business Case tool will be used (SP2.4). The main outcome used from the Business Case tool will be Benefit Cost Ratios (BCR). The result of the Multi Criteria Analysis will be utility scores and a ranking of alternatives in the medium growth scenario for the two CTS (Cybernetic Transport Systems, based on the use of Cybercars), PRT and High Tech Bus schemes for each of the four cities.

As for the remaining indicators produced by the models but not used in the Multi Criteria Analysis, these will be considered downstream the Multi Criteria Analysis together with the ones produced outside the models. This last group of indicators include those that may be quantified, or at least traced, for the different city-studies scenarios, by considering the results of other subprojects of CityMobil, mainly SP3, (“Technological Issues”), and SP4 (“Operational Issues”). The results from these parts of the project can be reflected, with the proper assumptions, to the corresponding city-studies application scenarios. In most cases the quantification of the indicators may not be available, being these works not precisely dealt in terms of the evaluation categories and indicators. Therefore in the evaluation activity it will be needed to transpose this considerable amount of information into the appropriate indicators in order to exploit it to the best.

In particular, as for SP3, four indicators can be derived from WP3.2 “Human Factors” (Ease of Use, Perceived Comfort, Accident Levels”, “Driver Workload”); in this work package four separate different experiments and explorations that focused on several human factors research questions for highly automated vehicles were conducted. Seven indicators are then treated in the work of WP3.3 “Obstacle Detection and Avoidance” (Incidents”, Control System and Apparatus”, “Control System Maintenance”, “Response Time”, “Accuracy”, “Data Updating Delay”, “Failure Rate”); here the sensors used in the cybercars and advanced city vehicles are analyzed and matched with the requirements of the application scenarios. Six indicators, finally, can be derived from WP3.4 “Cooperative Vehicles and Navigation” (“Effective System Capacity”, “Incidents”, “Response Time”, “Accuracy”, “Data Updating Delay”, “Failure Rate”), where a similar work is performed for the navigation and communication systems of cybercars, automated buses and advanced city vehicles.

As for SP4, five indicators can be assessed from WP4.3 (“User Willingness to Pay”, “Availability”, “Comprehensibility”, “User Satisfaction”, “Perceived Level of Privacy”), twelve from 4.4 (mainly from the System Performance and Environment evaluation categories) and one from 4.5, about the integration with other systems. When the same indicator is dealt in two or more work packages, all of these inputs shall be considered for the evaluation assessment.

Another source for some of the indicators produced outside the models is in Work Package 5.2, where a deep analysis on the user acceptance for two demonstrators (Rome, Castellon) and one showcase (Daventry) was performed. In this investigation some important aspects emerged through some indicators belonging to the Acceptance, Quality of Service, Transport Patterns and Social Impacts evaluation categories, (ease of use, willingness to pay, perception of usefulness, comfort, safety, reliability, accessibility for mobility impaired users and others). In that work (reported in D.5.2.1a), the ex-ante user acceptance analysis was carried out for the two demonstrators (cybercar system in Rome, Advanced City Bus in Castellon), and the ex-post for the showcase (cybercars in Daventry) through dedicated

surveys based on questionnaires or discussions within selected focus groups of involved actors. Based on the different types of collected information, the results for each indicator were quantified, both in terms of performance, providing the average evaluation by the users, and in terms of weights, giving an indication on the importance assigned by the potential users to the various aspects of the system. As for the results from SP3 and SP4, also these results can be reflected, with the proper assumptions, onto the city-studies application scenarios corresponding to the three implementation sites.

All these extra considerations will contribute to a broad and global estimation of the Advanced Transport System implementation contribution to the sustainable development of the specific cities and, as a second step, of their adoption in general.

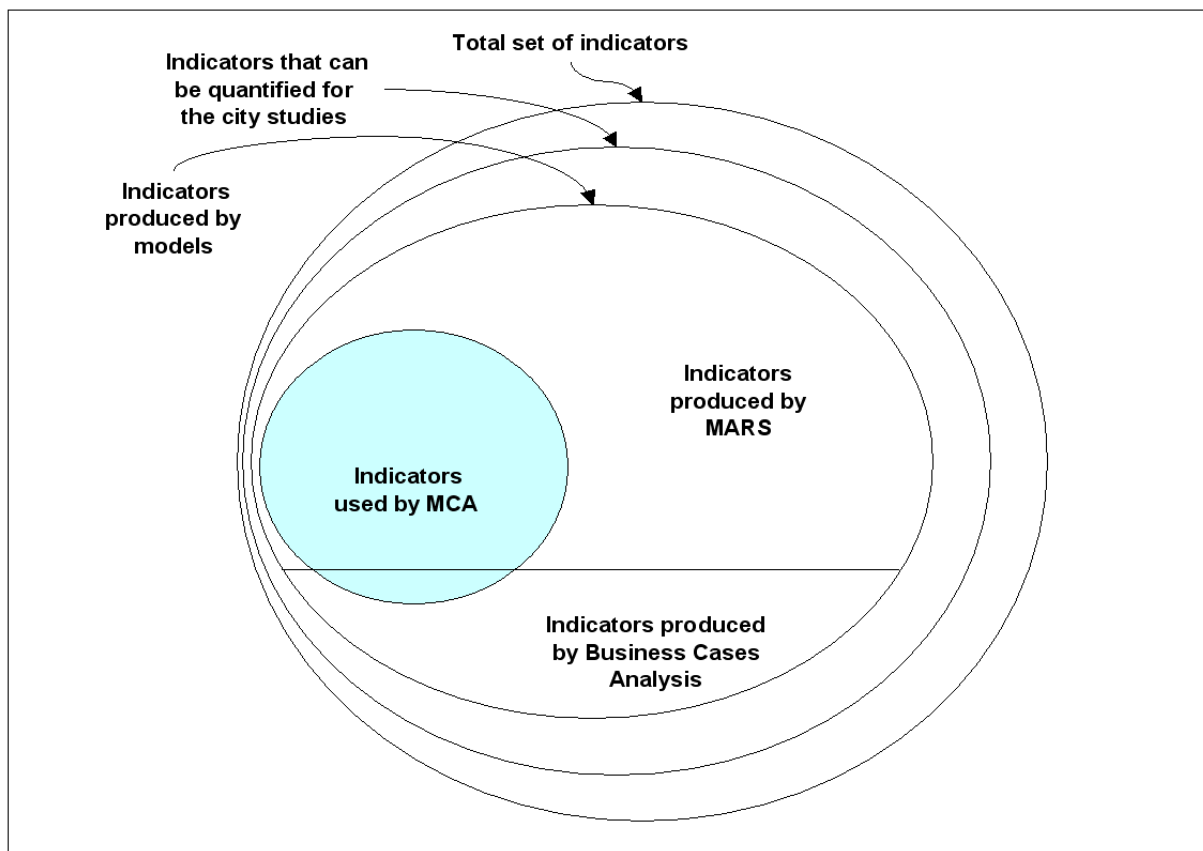


Figure 2 A representation of the evaluation indicators according to how they are produced and used by the Multi Criteria Analysis

5 Main evaluation resources: the inputs to Multi Criteria Analysis

5.1 MARS modelling

A major part of the strategic modelling of the new technologies transport schemes in the four case study cities of Trondheim, Gateshead, Vienna and Madrid will be undertaken using MARS. MARS is a dynamic Land Use and Transport Interactive modelling tool including a transport model simulating the travel behaviour of the people related to their housing and workplace location, a housing development model, a housing location choice model, a workplace development model, a workplace location choice model and a fuel consumption

and emission model (Pfaffenbichler et al., 2008). Since MARS does not currently represent new technologies specifically, a series of micro-simulation models and a stated preferences survey are also being used to determine values of specific parameters which can be included in MARS.

A group of 22 scenarios is modelled for each of the four cities considered, making use of the MARS modelling tool, as indicated in the evaluation matrix reported below in Table 1 (taken from D2.3.1). The schemes will be modelled over a total of 30 years, with 2005 as the base year. In all cases the new technologies are introduced in 2010.

Table 1 Scenarios to be tested in MARS (from D2.3.1)

Context Scenarios	Medium growth		High growth	
Do nothing	MW0	M0	HW0	H0
Passenger application scenarios	With complementary measures	Without complementary measures	With complementary measures	Without complementary measures
Cybercar (inner city)	MW1	M1	HW1	H1
Cybercar (pub. transp. feeder)	MW2	M2	HW2	H2
PRT	MW3	M3	HW3	H3
High tech bus	MW4	M4	HW4	H4
DMV (city wide)	MW5	M5	HW5	H5

The selected scenarios are combinations of different technologies (passenger application scenarios), growths (context scenarios) and option for adoption or not of complementary measures.

As for the Context Scenarios, a medium and high growth context scenario will be modeled. These will involve medium and high growth assumptions about two parameters, population and fuel prices. Among the context scenarios, a 'do-nothing' option will be developed consisting of the continuation of current approaches to system development and levels of expenditure.

The different passenger application scenarios consist of the single technologies applied with certain assumptions about performance characteristics, such as peak waiting time, average vehicle speed, vehicle capacity, fare structure, headway, possible use of segregated ways, and so on. Dual Mode Vehicles, differently from the other technologies, are modeled as being integrated into the existing fleet and are assumed to be privately owned and not part of a public transport system.

As for the complementary measures contemplated in the scenarios, the packages will include two interventions: a fare reduction on rail and bus of 20% over the last 25 years of the modeling period, and a road pricing cordon, with an entering fee of €5 during the peak and €2 during the off peak. Both measures will be assumed to be implemented from 2010 onwards.

The MARS models will report separately on the area wide impacts (e.g. across all the MARS model zones) and, for the schemes that are more localized and just included in several zones, on the more immediate local impacts. The analysis will concentrate on the most likely tests among those indicated in the evaluation matrix, to avoid an excessively complex and demanding work. Also, to simplify the analysis, and to understand the most relevant patterns,

the reporting of results will concentrate on some years among those foreseen for the entire modeling period.

Eight of the nine indicators used in the Multi Criteria Analysis will be produced by the MARS model. These are listed in the following Table 2. Due to modelling constraints, some of the Multi Criteria Analysis indicators had to be slightly altered compared to the survey carried out for eliciting weights for the Multi Criteria Analysis indicators.

Table 2 Indicators used in the Multi Criteria Analysis

Criterion	Indicator	Indicator Information (D5.3.1 survey)	Operationalisation
Social			
Improving Mobility	Accessibility of key services [%]	Percent of population able to access key locations in set time increment	MARS: number of workplaces which you can reach from a zone weighted by generalised costs
Improving Equity	Low income zones non-car accessibility [%]	Accessibility to key locations based only on the population living in low income zones of city and non-car use.	MARS, see above for non-car use and low income
Improving Safety	Number of accidents	The number of accidents per year	MARS, directly
Environmental			
Reducing Energy Consumption & Climate Impacts	Annual CO ₂ emissions	Total annual emissions due to transport activities (direct and indirect)	MARS, well to wheel
Reducing Local Air Pollution	Annual NO _x + PM10 emissions	Total annual emissions due to transport activities (direct and indirect)	MARS, pump to wheel; unweighted addition of NO _x and PM10 emissions
Reducing Land Take	Change in area classified as urban	The amount of land being converted from Greenfield or agricultural land to urban due to direct (infrastructure construction) and indirect effects.	MARS, change in built-up area
Economic			
Reducing Congestion	Average delay in person hours	Journey times lost due to congestion during peak hours	MARS, trip time peak; aggregate of all modes
Reducing Transport Costs	Financial result	Financial benefit-cost ratio including investment, maintenance, operation and revenues	Business Case Tool, BCR
Improving City Economy	Economic vitality index of target zones	Change of number of households and service employments in target zone (e.g. city centre)	MARS, sum of the number of households and workplaces

5.2 Business Case analysis

For the assessment of the Economic and Financial impacts, a tool has been developed within WP2.4. This methodology allows to investigate the business cases for new automated transport systems; the analysis encompasses a full range of factors for the scheme evaluation and produces outputs in terms of performance parameters, operating characteristics, economic analysis and a qualitative assessment of other system benefits. Where benefits can be quantified, they are included in the calculation of a Benefit Cost Ratio (BCR).

The simulations contained in the modeling tool are designed so that the system can be specified either in terms of user needs (i.e. required performance characteristics such as

average, minimum, and maximum in-vehicle travel times and waiting times) or in terms 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; moreover, 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; this flexibility allows to tune the model on the desired scenario and also to exploit the experience gained from the ongoing demonstrations and real life as well as evolving situations. 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.

The Benefit Cost Ratios are calculated for single Transport Cases; these are defined according to a number of criteria including also the analysis of feasibility, i.e. the Business Case. A wide set of components is included in the definition of a transport case (see D2.4.1); what is mostly important for the final evaluation purposes of WP5.3 is that the BCR is obtained by considering all the quantifiable parameters describing, on one side, the cash flows envisaged for the scheme, on the other the indirect impacts factors that can be translated into a positive or negative value.

In the following Figure 3, taken from D2.4.1 (Tom Voge, David Jeffery) the Inputs and Outputs of the Business Case Analysis Tool are presented schematically.

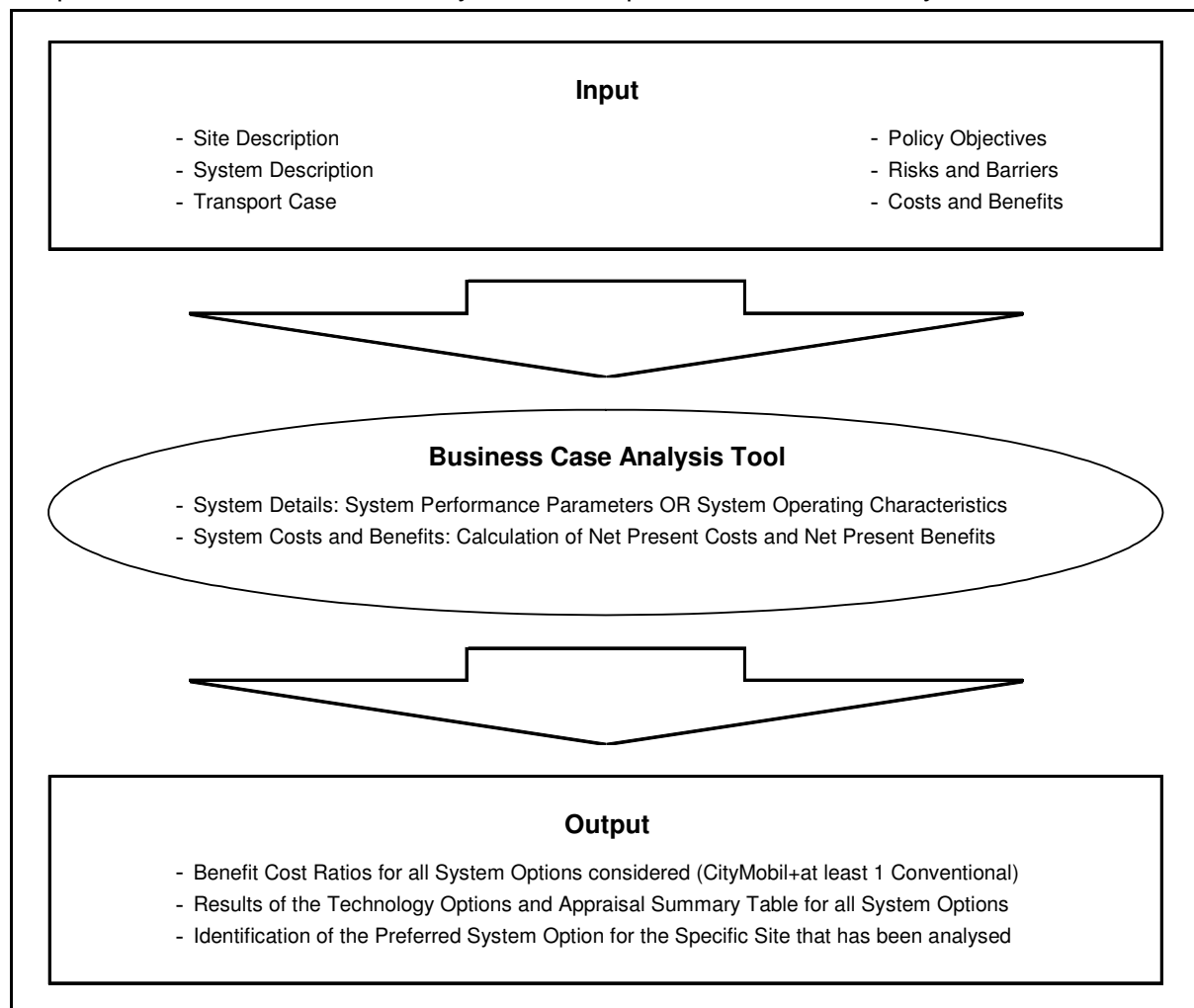


Figure 3 Inputs and Outputs of the Business Case Analysis Tool (from D2.4.1)

For the evaluation assessment performed within the present Work Package it will be needed to take into consideration, once the Business Cases results will be available from WP2.4, the elements that concurred to produce the Benefit Cost Ratio for the different schemes.

Other than this, the coordination with the MARS modeling will be assumed, that is the scenarios simulated with the two models will need to correspond as for the scheme specifications and assumptions, in order to allow a coherent evaluation by the Multi Criteria Analysis and all the further assessments. This will be ensured by the fact that, as depicted in Figure1, a significant amount of information at the basis of the Business Case simulated scenarios will come from the MARS model itself. For possible other common assumptions, a strict cooperation between the two modeling working groups will be needed.

The scenarios to which the modeling tool will be applied and Cost Benefit Ratios calculated are the medium growth scenario for the two CTS tests (Inner City and Public Transport Feeder), the PRT test and the High Tech Bus test for each of the four cities. No ratios will be calculated for the Dual Mode Vehicles test, since these do not involve public expenditure, and thus there is no “cost” involved.

6 Multi Criteria Analysis methodology

The evaluation of scenarios for advanced transport systems in CityMobil will apply a multi-criteria analysis of the results of land-use transport interaction models.

The proper design, implementation and management of public urban transportation demand a careful balancing of many goals, and the search for desirable solutions is made more complex by the interactions between environment, technology, economy and society. One of the main reasons underlying the growing interest in multi criteria analysis for the implementation of new transport systems is the need for an integrated approach to such complex problems. Multi criteria analysis can support the decision making process, allowing the concerns of major actors to be explored, giving trade-offs between conflicting goals, and leading to the evaluation of options from different perspectives.

For this Multi Criteria Analysis, a weighted summation method has been chosen. In the first step, an evaluation matrix with the indicator results for each scenario is assembled based on the modelling results. In the weighted summation method, these performance results are then transformed into commensurate units reflecting the aggregated value (or utility) for each scenario in two steps. Firstly, the indicator results are assigned a score on a harmonized scale using a value function. We will apply linear value functions with scores ranging between 0 (lowest performance = least preferred) and 100 (highest performance = most preferred). Thus, the score for each indicator i is calculated using the following formula:

$$\text{Score}_i = (\text{Result}_i - \text{Worst case}_i) / (\text{Target}_i - \text{Worst case}_i) * 100$$

These target ranges were set for a future time period, in our project the assumed time is 30 years. Due to the model results potentially exceeding this range, scores below 0 (negative below worst case) and above 100 (overachievement of target) are possible, as reported in Figure 4.

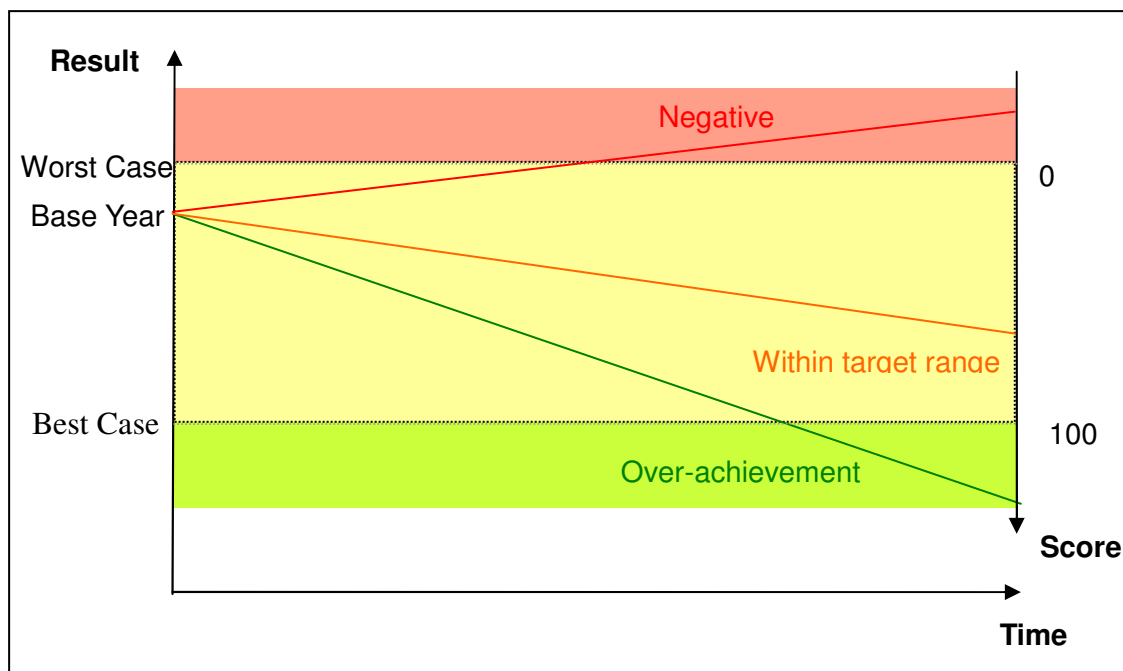


Figure 4 Possible scores for model results

The second step of the weighted summation method is the aggregation of the scores to a commensurate utility value for each scenario. This requires the definition of weights to be attached to the indicator scores. The weights to be used have been determined based on a survey of participants of the CityMobil project and are summarised in the following Table 3. For each city, in addition to the average weights, a local set of weights will be applied to reflect local preferences. At the time of the survey, the Madrid case study was not yet included, hence we will apply only average weights there.

Table 3 Weights for three of the case studies

Group	Weights [%]								
	Mobility	Equity	Safety	Energy	Air Pollution	Land Take	Congestion	Costs	City Economy
Average	14.14	8.91	13.79	13.27	13.63	8.56	11.66	7.01	9.03
Gateshead/UK	15.14	8.18	13.11	14.26	10.93	9.40	12.78	7.99	8.21
Trondheim	19.62	9.23	7.46	13.27	19.50	8.45	10.19	6.21	6.08
Vienna	10.59	10.21	14.72	12.61	15.06	11.84	6.52	7.38	11.07

The outcome of the Multi Criteria Analysis will be a weighted score for each scenario, technology and city. These scores will allow us to rank the alternatives and also identify which indicators contribute most to the results.

In the final step, we will carry out a sensitivity analysis in order to test the stability of results under the variation of valuing and weighting functions. The different viewpoints on the importance of sustainability criteria are explored through the application of the differentiated weights.

7 Other evaluation resources

7.1 VOLTair methodology

As defined in D2.3.1, this methodology for transport planning and integration will be applied within WP2.3 downstream of the MARS models to produce a full set of detailed recommendations to each city, give guidance for the integration of the selected applications scenarios, define strategies for the assessed cities, with the final aim of complementing the assessments obtained through the strategic modelling.

The VOLTair methodology is based on a general "top-down" process of urban transport planning and integration, similar to what is done today concerning conventional modes. Its originality is represented by the power to be highly complementary with the two approaches developed by city planners :

- the functional approach, directly related to transport planning and operating ;
- the societal and environmental approach, including a larger panel of "urban planners", such as urban designers, sociologists, ergonomists, economists, etc.

The term planning relates to the various analyses that have to be made before passing on to the implementation phase and the term integration stresses the fact that an urban transport system has to be integrated in an existing transport network and in a present urban context.

Conceived as a methodological guideline for city decision-makers, the general process of urban transport planning and integration is based on the following "top-down" strategy: "first identify and define on the global city perimeter the needed functions and links to be assured

and then pick the right tool for the right place. Only later is it possible to dimension the best possible transport system in adequacy to the best possible city development scenario".

The five steps of the general process of urban planning and integration are illustrated in Figure 5.

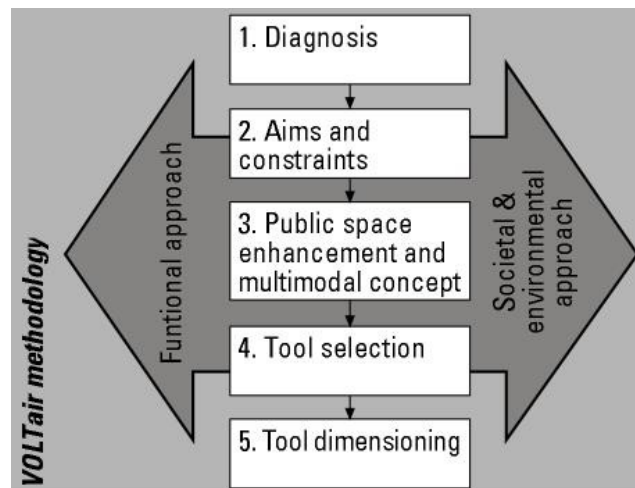


Figure 5 VOLTair methodology steps

These five steps are :

- step 1 Diagnosis of the current urban situation
- step 2 Formulating and identifying the aims and constraints
- step 3 Defining a city specific public space enhancement and multimodal concept
- step 4 Selecting the tool for each new or improved identified functions to be addressed
- step 5 Dimensioning of the tools on a local scale

The aims that are set for the application of the VOLTair methodology are to:

- define strategies for the assessed cities ;
- give guidance for the integration of the selected applications scenarios for each city ;
- elaborate recommendations for city strategies in complement to the assessments through the strategic modelling.

The application of the VOLTair methodology for the CityMobil project will have various links with other of its tasks in order to ensure the consistency with the work in the SP2.

For the purpose of the CityMobil project, the VOLTair methodology is not applied for itself, but spread into two parts in order to take the right inputs and give the appropriate outputs for the global project, as shown in Figure 6.

The first three steps of the methodology are used to elaborate global city strategies, taking into account the specified scenarios. This process is mainly based on the same data as the ones for the strategic modelling and completed by some qualitative inputs provided by the cities.

The integration of the different applications scenarios for each city is based on their definition, given by the WP2.2, their selection for the strategic modelling and completed by the fifth step of the methodology. The inputs from WP2.2 and other tasks of WP2.3 allow to skip the fourth step of the methodology.

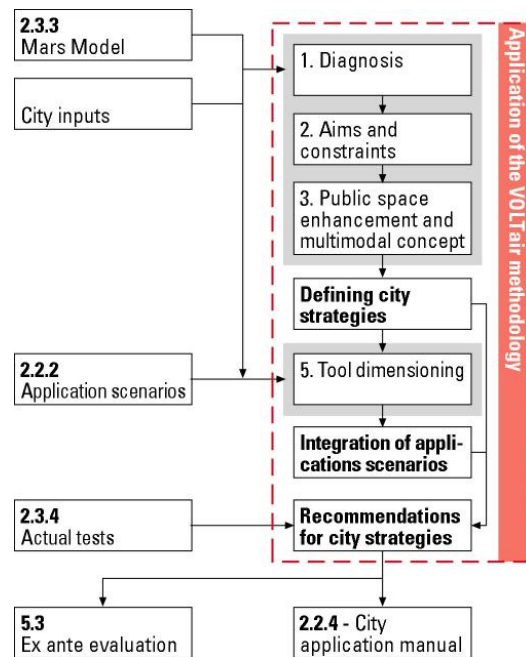


Figure 6 VOLTair methodology and links to the CityMobil sub-projects

Finally, thanks to the previous results and the tests conducted after the strategic modelling, recommendations for city strategies are concluding the application of the VOLTair methodology.

7.2 City Councils consultation

As a further input, a discussion of the results with the respective city authorities will be necessary. The outcome of the models, as well as the Multi Criteria Analysis assessment, and the overall conclusions will be submitted to the responsible city councils agencies, asking to comment and to possibly find out weak points and clarifications of model results based on their higher local involvement. The cities will be asked to express their opinion on the different scenarios ratings and rankings obtained by the Citymobil analysis for their municipality. Their required input will be in terms of:

- a. Financial feasibility
- b. Technical feasibility
- c. Legislative feasibility
- d. Acceptability (to the public and to politicians).

For the last aspect, a link to the mentioned Demonstrators and Showcase User Acceptance investigation will be also recalled (see D5.2.1a). In addition, the authorities will be asked to indicate any barriers to the implementation of the technologies included in the optimal scenarios. These observations could be general in nature or be made in terms of advantages and disadvantages to particular user classes. The city officials will also be invited to suggest alternative strategies which they would wish to have tested, and, in case new model runs will be possible, the opportunity will be taken to discuss the results obtained with the first models.

8 Data analysis and next steps - The Passenger Application Matrix

The scenarios approach is adopted with the aim to look at how possible combinations of technologies, growth rates and complementary measures adoption may influence the key aspects of sustainable urban development: society, environment, economics, as well as safety and reliability of the public transport service. The final objective is to understand whether investing in the adoption of Advanced Transport System systems is worthwhile for the cities and, in case, under which conditions and assumptions.

This global assessment needs to be carried out by considering the highest possible amount of inputs, of which the scenarios simulations are just a part, although considerable.

The analysis of the Multi Criteria Analysis results will be carried out firstly looking at results on a city by city basis. A comparison across cities will follow with the aim to extract further considerations. For each one of the sites, the modeled scenarios will be ranked according their utility value resulting from the Multi Criteria Analysis. The indicators having the highest influence on the utility esteem will be highlighted and investigated.

The perspective will then be enlarged by including the extra-MCA inputs into the qualitative evaluation: mainly the indicators produced by the models and not used by the Multi Criteria Analysis, then the outcome of the consultations with the cities and finally, where possible, the results from the VOLTair methodology.

The examination of the achievements, both from Multi Criteria Analysis and the other input resources, will focus on some specific points:

- a. **Generalization** and **transferability** of the results in space and time. One of the main achievements will be to figure out if and how the results obtained for the single cities will be usable for other cases or for drawing general considerations. In order to do this, a strong understanding will be needed of how the parameters of each scenario and the Advanced Transport System application may interact to produce the impacts on sustainability.
- b. The evaluation process shall be carried out making sure the **potential risks** connected with the implementation of Advanced Transport Systems emerge and are clearly outlined, in relation to the main involved aspects (Financial feasibility, Technical feasibility, Legislative feasibility, Acceptability). Proper mitigation strategies should also be envisaged in order to facilitate the efficient implementation of such systems on a city-wide scale.
- c. Focus to limited evaluation resources on **data gaps**. For scenarios where not all required inputs are available, proper assumptions will need to be made and the subsequent reduced reliability, compared to the standard situation, shall be taken into account when general conclusions, rankings and suggestions are drawn.

The final step of the evaluation process, which will be addressed in the next WP5.4, will be to formalize the generalization of the results coming from the different inputs to the CityMobil technologies appraisal and finally provide a global assessment of the technologies.

In order to set the stage to this process, a dedicated table was built by the evaluation team, named Passenger Application Matrix. The purpose of this tool is to move the focus from the researcher perspective to the decision maker's one, typically more practical, trying to think in terms of what system is best to be implemented in order to improve the mobility in a certain specific situation.

In this matrix the case studies, the demonstrations and the showcases are grouped according to the type of areas linked by the single scheme. Being the possible type of areas

the same (rows and columns), the matrix results to be a two-dimension symmetrical one. The information for each OD pair, expressed in terms of the available indicator values, can be considered as the third dimension.

The use of this general view should be ideally focused on each cell of the matrix, and help evaluate pro and cons of the implementation of the different technologies in each particular environment. Nevertheless a strict “single cell based” analysis will not be always feasible, in particular when the city-study modeling are involved; in fact in the modeled scenarios, due to the different dimensions of the cities, the area types may not be consistent with the categorization of the matrix, or the same area type of cities that are very different in dimension may lead to non proper comparisons; on the other hand, the indicator values resulting from the models may refer to single zones of the modeled area and not to the entire city, and this may avoid the cross comparisons as well. Such cases do not however represent a problem to the matrix filling, because in these cases it will be possible to provide valid results to the decision makers by changing the level of the geographical scale and evaluating the information on a more aggregate geographical level, i.e. grouping more cells.

In Figure 7 the first release of the passenger application matrix is represented.

Such release is based on the results available at the moment from the sites involved in the CityMobil project: during the project the matrix will “evolve” on the basis of the results of the analyses on demonstrations, showcases and case studies, and the final output will be the final passenger application matrix, which will represent the tool to be used by decision makers (i.e. the local authorities) once the introduction of a new Advanced Transport System is required for a site.

The step forward brought by this kind of comparison will consist in having a vision of all the possible evaluation inputs as to enable an analysis of general transport applications and not just on the single city schemes.

In the next deliverable 5.3.1b, the evaluation of the modeled scenarios will be done, together with the identification of the best scenario or each city study, with the exception of Uppsala which will not be modeled with MARS and will provide only one scenario. Once concluded the Multi Criteria Analysis, it will be possible to have a complete ex-ante evaluation of all the case studies and the cross-comparisons between them will be done and reported in the same deliverable. At the same time the passenger application matrix will be “evolved” with such results and with the results provided by demonstrations and showcases in the WP5.2.

Destination→ Origin ↓	City centre	Inner suburbs	Outer suburbs	Suburban centres	Major transport node	Major parking lot	Major service facility	Major shopping facility	Major leisure facility
City centre	ACC (Genoa, La Rochelle) Cybercar (Trondheim, Vienna, Madrid) PRT (Gateshead, Vienna, Madrid, Uppsala) DMV (Madrid, Gateshead, Trondheim, Genoa, La Rochelle) HT-bus (Trondheim, Castellon)								
Inner suburbs	HT-bus (Trondheim, Castellon, Gateshead) ACC PRT (Gateshead, Uppsala) Cybercar (Gateshead)	Cybercar (Madrid, Gateshead, Daventry) ACC (La Rochelle) PRT (Uppsala)							
Outer suburbs	HT-bus (Gateshead, Madrid) ACC	DMV (Madrid, Gateshead, Trondheim) HT-bus (Castellon, Gateshead)	Cybercar (Trondheim, Gateshead, Madrid) PRT (Vienna) DMV						
Suburban centre (within an intermediate distance range)	HT-bus (Gateshead) (ACC)	HT-bus (Gateshead)	HT-bus (Gateshead)	HT-bus PRT Cybercar (Gateshead, Madrid)					
Major transport node (e.g. airport, central station)	ACC (La Rochelle) HT-bus (Gateshead)	HT-bus (Gateshead)	HT-bus (Gateshead)	HT-bus (Gateshead)	PRT (Heathrow) HT-bus (Gateshead)				
Major parking lot	Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)		Cybercar (Rome) PRT	Cybercar (Rome) PRT			
Major educational or service facility (e.g. University campus, hospital)	HT-bus (Castellon) PRT (Trondheim)				Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)		
Major shopping facility	HT-bus (Trondheim) PRT (Gateshead, Madrid)				Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)		Cybercar (Gateshead) PRT (Gateshead)	
Major leisure facility (e.g. amusement parks)	HT-bus (Trondheim, Castellon) PRT (Gateshead, Madrid)				Cybercar (Gateshead) PRT (Gateshead)	Cybercar (Gateshead) PRT (Gateshead)			Cybercar (Gateshead) PRT (Gateshead)
Corridor	DMV HT-bus (Gateshead, Vienna ?)	DMV HT-bus (Gateshead, Vienna ?)	DMV HT-bus (Gateshead) Cybercar (Madrid)	DMV HT-bus (Gateshead)					

Figure 7 First release of the Passenger Application Matrix

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