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CityMobil

Towards advanced transport for the urban environment

Analyses tool for Business Cases

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History.

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- for test and evaluation by partners.

VF1.1 update to correct some minor errors DJ 3/2/09

- Used for:
    - the MARS modelling exercise reported in CityMobil deliverable D2.4.2 ‘Application of the BCT’;
    - cost /benefit studies of:
        - a pilot system of PRT in Uppsala;
        - a pilot system of PRT in Daventry;
        - the CityMobil demonstration of HTB in Castelleon.

VF2.1 final update, in the light of experience DJ 16/6/11

- corrects some minor errors;
- explains alternative definitions of BCR;
- Introduces WS17 ‘DCF’ as the means to allow for:
    - A build period;
    - A vehicle and infrastructure replacement/refurbishment programme;
    - The effects of growth in demand on numbers of vehicles and other facilities required.
- Includes an update of system costs on WS 12 ‘Cost (G)’ and the representative costs of the CityMobil systems: PRT, CTS/GRT, HTB,

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1. Introduction.

Deliverable D2.4.1 from the CityMobil project describes the development of a tool for assessing the business case for new automated transport systems. The tool itself is provided in the form of an Excel Spreadsheet. This document provides the User Guidelines to accompany the tool.

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.

The business case tool described here 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 of both 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 methodology basically provides for a comparison of a new ie CityMobil system with a conventional alternative eg 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. The TOAST requires the user to exercise his/her 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 figures, and facilitates an assessment of value for money.

This document provides an overview of the methodology used by the tool in section 2. It then provides some useful notes for the user in section 3 before going on to describe the use of the tool itself in section 4.

2. Methodology

The spreadsheet tool comprises a number of interlinked spreadsheets. If these are used in sequence, they take the user through a structured set of questions that are designed to elicit the information and data needed to build up the transport and business cases for two alternative schemes, one based on a CityMobil system (eg Personal Rapid Transit (PRT) or Cybernetic Transport System (CTS)), the other a conventional alternative, such as a bus or tram scheme.

2.1 The questions

The questions that the user is asked to answer provide:

Statements of the Problem(s) to be solved. For example:

- Meet a forecast increase in demand
- Relieve congestion
- Encourage mode shift and reduce car use
- Encourage regeneration development
- Relieve air quality problems
- Improve accessibility

These are designed to establish clear and succinct statements of the problem(s) that the new system is intended to solve.

Statement(s) of relevant Policy objectives, which could include, for example:

- Public acceptance
- Quality and level of service
- Transport patterns
- Social Impacts
- Environmental impacts
- Financial Impacts
- Economic considerations
- Legal impacts
- Technological success

These are designed to establish that there is a direct linkage between the problems identified and the local and national policies.

An appreciation of the Context, which could include, for example statements on:

- Fit of the new scheme with existing/ planned demand management measures
- Likely impacts during construction
- System image and public acceptability
- Extent to which other existing PT modes will lose passengers
- Technology risk
- Legal and institutional issues

These are designed to confirm that user understands the context in which the new scheme is to be built and any difficulties that may need to be overcome.

An appreciation of the Physical opportunities and Constraints, such as:

- Segregation of system (i.e. is it necessary, and if so how and where to provide?)
- Built environment (e.g. impacts on structures, historic centre)
- Physical constraints (e.g. gradients, curves, need for land take)
- Constructability (e.g. disruption, costs)
- Severance (e.g. effects on the movements of people)

These are designed to establish that the user has a full appreciation of any constraints that will affect implementation of the scheme.

An understanding of the Scheme and Operational factors, including:

- Scheme characteristics
- Numbers and passenger carrying capacity of vehicles
- Number of stations/stops

Operating headway
Average Journey time and reliability
Fare level
Forecast demand
Revenue = f (fare, demand)
Other income (developer funds, parking or RUC schemes, subsidies etc).

These are required in order to determine the numbers of passengers carried, the attractiveness of the system in terms of average journey and waiting times etc, and the income from fares and other sources.

An analysis of the Benefits (both quantifiable and non-quantifiable) including:

User time savings
Saved operating costs of cars given up, and increased efficiency for traffic
Saved accidents
Time savings of non-users from reduced congestion and delays
Saved pollutants
Jobs generated
System reliability
System punctuality
System attractiveness
Sustainability impacts
Any other intangible benefits and disbenefits (eg revenues lost on existing services)

These are required if a full socio-economic analysis is required that takes account of social costs and benefits as well as cash flows.

An appreciation of the Capital cost, including:

Land take and utilities diversion
Vehicles, and vehicle replacement costs
Civils and trackwork
Stations and stops
Electrical power
Communications and signalling
Depot/ control centre
Highway works
Traffic management
Design and management

An appreciation of the Operating costs, including:

Fuel
Fixed costs (tax, insurance)
Salaries (drivers and system operators)
Maintenance (vehicles, Infrastructure)
Security
Depreciation

2.2. Benefit-cost ratio

During the process of the user inputting information and data in response to the questions, certain calculations are performed, so that at the end all the parameters that can be quantified can be combined in the Calculation of the benefit cost ratio (BCR) for a scheme, and given by:

BCR = (PVB - PVC) / PVC

where:

PVB = Present Value of Benefits
PVC = Present Value of Costs

Two BCR figures are provided: a **business benefit-cost ratio** made up from actual cash flows ie costs, revenues and other income; and a **total benefit-cost ratio** that includes the cash flows and also those benefits to society, such as travel time savings, if they are available (eg from a separate transportation modelling exercise) and are input to the spreadsheet by the user.

Note that other definitions of BCR are possible, and PVB/PVC (=1 + the value as defined above) is commonly used. The definition used here uses the net benefit ie (PVB-PVC) and so gives a positive result if the benefits exceed the costs, and a negative result if the costs exceed the benefits.

All values are present values, i.e. measured over the lifetime of the project (say for example, 20 years) and then discounted (using an appropriate discount factor eg 6%) to the present day. This shows the extent to which a scheme is likely to cover its operating costs.

2.3 TOAST and Value for Money

An assessment of value for money (VfM) must then be made, and is greatly assisted by the TOAST (Technology Options Appraisal Summary Table) methodology provided. This allows the user to use his/her professional judgement to rate (and also to weight, if desired) the various benefits, intangibles, impacts and risks of the alternative schemes.

Factors taken into account in the TOAST include:

- user time savings
- system reliability
- system punctuality
- image/attractiveness
- improved mobility
- saved vehicle operating costs
- accident savings
- saved pollutants
- jobs generated
- non-user benefits
- other system benefits
- compliance with objectives
- barriers and risks to implementation

The spreadsheet then uses the rate and weight figures given for each factor to calculate a ranking figure. The different rankings for the two alternative schemes 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 BCR figures, and facilitates an assessment of value for money.

2.4 Outcome

The results are finally summarised in a summary table which shows the key features of the alternative systems including the types, numbers and carrying capacities of the vehicles needed, the length of the route, if a special guideway is required, the number of stations/stops, the average vehicle speeds and passengers waiting times, business and total BCR values and the TOAST ranking.

Decisions should then be possible for the funding partners from a consideration of the cash flows revealed by the Business BCR analysis, plus any additional funding needed, and of any subsidy required.

For the business case to be decided there is, in principle at least, no need for a comparison of alternative schemes, or for a full appreciation of the background, i.e. policy and context, and social benefits. In practice however, it is thought highly unlikely that a (local) government partner in particular would, or could commit to funding a particular scheme without the larger view and justification provided by these additional details and the Total BCR figure.

3. Notes on usage

First, make a copy, save it under a new name, and work with that ! The spreadsheet that accompanies these guidelines is provided in ‘read only’ form so that the user cannot accidentally change any of the embedded formulae in the original. Keep the original so you can start over again if necessary.

Application: the spreadsheet can be used with any transportation scheme, but contains some special facilities that make it especially useful for assessing CTS and PRT systems.

CTS (Cybernetic Transport Systems, sometimes also called **Group Rapid Transit** or **GRT)** are a ‘collective transport’ system. They use minibus sized vehicles, with a carrying capacity of up to about 20 persons to transport people around a route, and stop as required to pick up and put down passengers at stops along the way.

PRT (Personal Rapid Transit) is an ‘individual transport’ system. It uses smaller vehicles, typically with 4 or 5 seats to transport people around a route, but it goes directly to the required destination without stopping at any intermediate stations.

Conventional public transport systems (buses, trains, trams, metros etc) are mostly collective transport systems. Taxis are individual transport systems.

The spreadsheet tool itself 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 facilities to go further and 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 simplified 'simulations' of PRT and CTS systems so that the user can very simply specify a system in terms of the maximum time a user must wait for a vehicle to arrive. The number and speed of vehicles required for the operation, the average waiting time and a range of other parameters are then calculated automatically. 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.

And finally: a caution. The tool will produce a business and a transport case, but it is not a transportation model. It does not provide a mechanism for estimating likely passenger demand, Nor does it provide a mechanism for estimating the quantifiable benefits such as user time savings or reductions in accidents and vehicle operating costs. Guidance on these topics is provided separately in the CityMobil City Application Manual (Ref 20).

4. The Spreadsheet Tool

The spreadsheet tool comprises a number of interlinked worksheets as shown in Fig 4.1. When these are used in sequence, they take the user through a structured set of questions that are designed to elicit the information and data needed to build up the business cases for two alternative schemes. In the 'Anytown' example used for illustrative purposes in this document, one (the CityMobil or CMS) system) is based

on a CityMobil Personal Rapid Transit (PRT) system, and the conventional alternative (CAS system) is a shuttle bus scheme.

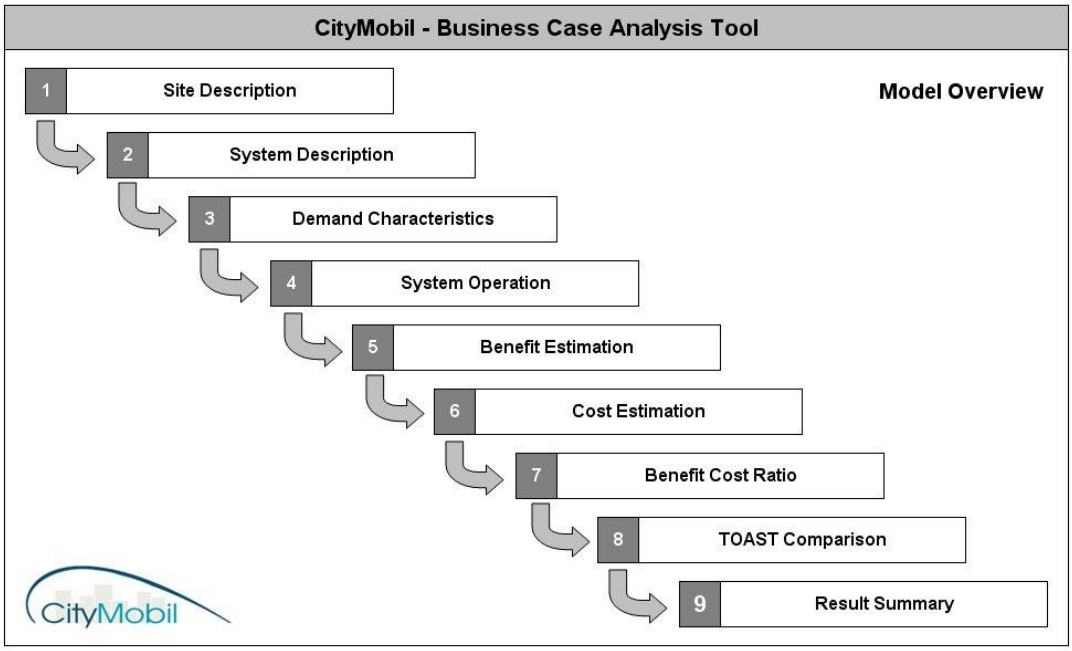

Fig 4.1.WS1 'Over'. Overview

The series of worksheets is as follows:

WS1 'Over': provides an overview of the process and the worksheets involved;
WS2 'Key': provides a key to the responses (eg textual or data) the user is required to provide as input to the worksheets;
WS3 'Site': requests contextual information that describes the problems to be solved, the relevant policy objectives, and the physical restraints;
WS4 'Site (G): provides guidance advice for the user to complete WS3;
WS5 'Sys': requests information about the proposed CityMobil system and the Conventional Alternative System to be considered;
WS6 'Sys(G)': provides guidance advice to the user to complete WS5;
WS7 'Dem(CMS)': requests information about the likely demand to use the CityMobil System;
WS8 'Dem(CAS)': requests information about the likely demand to use the conventional alternative system;
WS9 'Op': requests information about the CityMobil system, either a PRT or a CTS, and the conventional alternative to be considered.;
WS10 'Ben': requests information about proposed passenger fares, subsidies and other sources of revenue, and also the discount period and rate to be used in order to produce a discounted cash flow analysis.;
WS11 'Cost': requests information about system capital and operating costs;
WS12 'Cost(G)': provides guidance advice to the user on the range of costs of different systems;
WS13 'BCR': brings forward the data and calculations from previous worksheets to compute the business and total benefit-cost ratios (BCR);
WS14 'TOAST': provides the methodology for rating and weighting the various benefits, intangibles, impacts and risks of the alternative schemes;
WS15 'TOAST(G)': provides guidance for the use of the TOAST methodology;
WS16 'Sum': provides a summary of the results.

WS17 ‘DCF’: provides a tabulated example of a discounted cash flow over a period of 30 years.

5. The Worksheets

Several of the worksheets provide information or guidance for the user. Those which actively contribute to the business case are shown above in bold. All the worksheets are presented below in sequence.

5.1 WS1 ‘Over’ (Overview): provides an overview of the process and the worksheets involved, and is shown in Fig 4.1 above.

5.2 WS2 ‘Key’: shown in Fig 5.2 provides a key to the responses (eg textual or data) the user is required to provide as input to the later worksheets. It shows the type and source of the data to be entered or to be displayed in the worksheets, together with an indication if any guidance is available.

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Key

Type of information			Data Source			User Guidance		
Description	:	Answer in free text	**?**	:	User input	**G**	:	Guidance available
From list	:	Choose from list	**=**	:	Calculated	**-**	:	No guidance
7-point-scale	:	Rate on scale	⇨	:	Previous value	**n/a**	:	Not applicable
Yes/ No	:	Answer Yes/ No	**Cells for model input and output**					
#	:	Number of items					:	User input
[Unit]	:	Unit for value					:	Model Output

Fig.5.2 WS2 ‘Key’

For each data entry or display cell 3 characteristics are given, *type of information*, *data source*, and *user guidance*. *Types of information* include a description, choosing an item from a given list *, rating on a 7-point-scale, yes/no, number of items, and specific units. *Data sources* are either user input, calculation by the model, or a value previously entered/ calculated. U*ser guidance* indicates whether or not guidance is available, or if it is not applicable. As an aid to the user, cells for user input are coloured green, and cells for model output are dark grey.

** Tip: where ‘choose from list’ is indicated, click on the cell to reveal a down arrow, click on this to reveal the list, then click on your selection from the list.*

5.3 WS3 'Site' (Site description): requests contextual information that describes the problems to be solved, the relevant policy objectives, the context and the physical restraints. These are designed to establish clear and succinct statements of the problem(s) that the new system is intended to solve, to show the links with relevant local and national policies, and to confirm that the user understands the context in which the new scheme is to be built and any difficulties ie barriers and risks, that may need to be overcome.

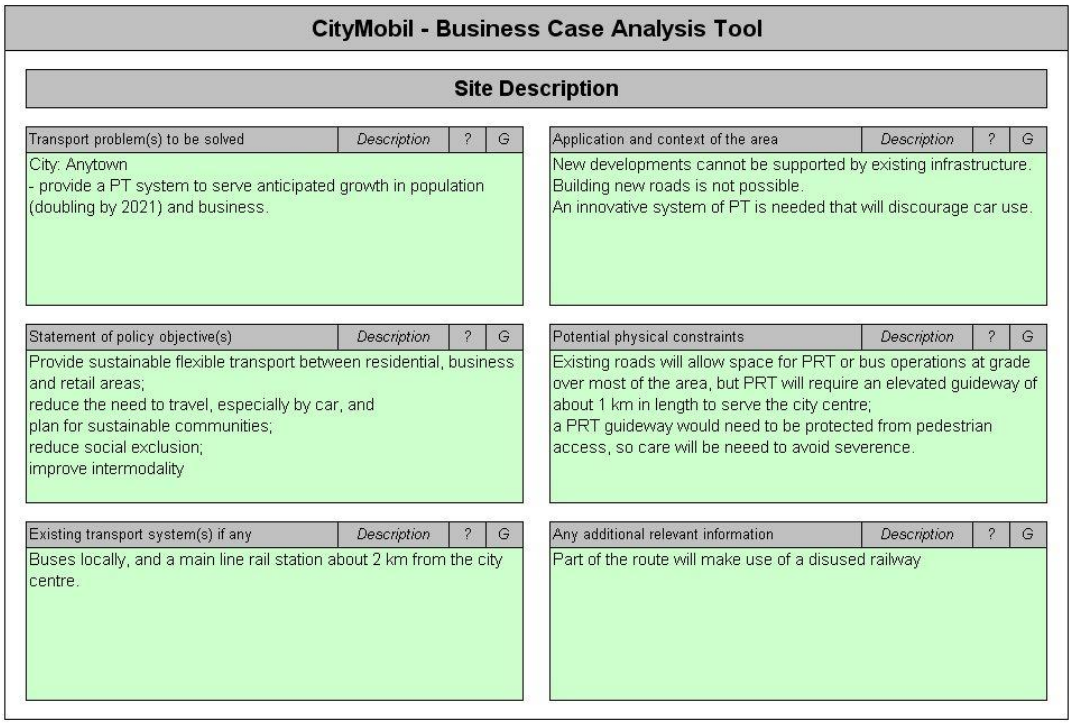

Fig 5.3. WS3 'Site'. Site description.

The example of a PRT in 'Anytown' is shown in Fig 5.3. Contextual issues relating to the construction and implementation of the dedicated guideway and automatic vehicles could have included:

Likely impacts during construction
Built environment (e.g. impacts on structures, historic centre)
Physical constraints (e.g. gradients, curves, need for land take)
Severance (e.g. effects on the movements of people)
System image and public acceptability
Extent to which other existing PT modes will lose passengers
Technology risk
Legal and institutional issues regarding the operation of automatic vehicles

Tip: while typing text in a box, use Alt+Return to move to a new line.

5.4 WS4 'Site (G): provides guidance advice and examples to help the user complete WS3

5.5 WS5 'Sys' (System description): requests information about the proposed CityMobil (in the example, a PRT) system and the Conventional Alternative System (in the example a shuttle bus) scheme to be compared.

Remember: where 'choose from list' is indicated, click on the cell to reveal a down arrow, click on this to reveal the list, then click on your selection from the list.

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System Description				CityMobil System (CMS)	Conventional Alternative System (CAS)
Transport mode/ vehicle	*From list*	?	G	PRT	Bus
Type of guideway	*From list*	?	G	Separate Lane/Guideway	Existing Road
Length of guideway	*[m]*	?	-	4780.0	5000.0
Number of stations/stops	#	?	-	5	10
Depot(s) required	*Yes/ No*	?	-	Yes	Yes
Other facilities	*Description*	?	-	5 stations, 1 control centre, power	10 stops
Compliance with policy objectives	*7-point-scale*	?	G	6	3
Identification of risks/ barriers	*Description*	?	G	Technical/Operational	Societal/Acceptability
Severity of risk/ barriers	*7-point-scale*	?	G	1	7
Minimise risks/ barriers	*Description*	?	G	risks assessed and are managable	n/a
Additional Information	*Description*	?	-		

Fig 5.5 WS5 'Sys'. System information

The information to be entered by the user is shown in Fig 5.5, and includes details of the length of the guideway (ie route or line), facilities needed; and ratings estimated by the user, that reflect (on a 7 point scale) an assessment of risks / barriers (1 = high risk), and the extent to which the schemes comply with policy objectives (1 = low compliance).

5.6 WS6 'Sys(G)': provides guidance advice to help the user complete WS5

5.7 WS7 'Dem(CMS)' (Demand data for the CtyMobil system) requests information about the likely demand to use the CityMobil System.

As shown in Fig 5.7, data can be input in passengers per hour for a system with up to 10 stops in three 10 x 10 matrices, one each for the morning, evening and off-peak periods. Alternatively, aggregate figures for each period can be entered into each of the matrices, or a single aggregate figure into only one of them, to represent a typical day.

In all cases, the user must specify the duration of each matrix to make up a typical days demand, and also the number of days of operation in a year. The total demand is then calculated and shown as the 'base tear demand' at top right in Fig 5.7.

If demand figures are not available, guidance for estimating them is provided in the CityMobil 'Cities Application Manual' (Ref 20).

Base Year Demand Characteristics* (PRT)

Days of operation per year	{Days/year}	?	-	365
Annual growth in demand	{%}	?	-	0.0
Base year demand	{Pass/year}	=	n/a	7105581

AM Peak Hour Trips [Pass/hr]

Duration of demand					{hr}		?	-	1.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	90	0	0	730						820
2	90	0	70	370	10						540
3	0	270	0	0	290						560
4	0	190	0	0	10						200
5	180	0	50	70	0						300
6											0
7											0
8											0
9											0
10											0
Sum	270	550	120	440	1040	0	0	0	0	0	2420

PM Peak Hour Trips [Pass/hr]

Duration of demand					{hr}		?	-	1.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	90	0	0	180						270
2	90	0	270	190	0						550
3	0	70	0	0	50						120
4	0	370	0	0	70						440
5	730	10	290	10	0						1040
6											0
7											0
8											0
9											0
10											0
Sum	820	540	560	200	300	0	0	0	0	0	2420

Off-peak trips (mean per hour) [Pass/hr]

Duration of demand					{hr}		?	-	17.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	30	0	0	170						200
2	30	0	60	100	0						190
3	0	60	0	0	60						120
4	0	100	0	0	10						110
5	170	0	60	10	0						240
6											0
7											0
8											0
9											0
10											0
Sum	200	190	120	110	240	0	0	0	0	0	860

Fig 5.7. WS7 'Dem(CMS)'. Demand data for the CtyMobil system

Caution: if peak hour figures are not provided, it is not possible to calculate the total number of vehicles required to cope with the peak demand.

5.8 WS8 'Dem(CAS)' (Demand data for the Conventional Alternative System) requests similar information about the likely demand to use the conventional alternative system;

The worksheet is similar to that shown in Fig 5.7, but may involve different numbers of station/stops and different demand figures as shown in Fig 5.8.

Base Year Demand Characteristics* (Bus)

Days of operation per year	{Days/year}	?	-	365
Annual growth in demand	{%}	?	-	0.0
Base year Demand	{Pass/year}	=	n/a	3554131

AM Peak Hour Trips [Pass/hr]

Duration of demand					{hr}		?	-	1.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	45	0	0	365						410
2	45	0	35	185	5						270
3	0	135	0	0	145						280
4	0	95	0	0	5						100
5	90	0	25	35	0						150
6											0
7											0
8											0
9											0
10											0
Sum	135	275	60	220	520	0	0	0	0	0	1210

PM Peak Hour Trips [Pass/hr]

Duration of demand					{hr}		?	-	1.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	45	0	0	90						135
2	45	0	135	95	0						275
3	0	35	0	0	25						60
4	0	185	0	0	35						220
5	365	5	145	5	0						520
6											0
7											0
8											0
9											0
10											0
Sum	410	270	280	100	150	0	0	0	0	0	1210

Off-peak trips (mean per hour) [Pass/hr]

Duration of demand					{hr}		?	-	17.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	0	15	0	0	85						100
2	15	0	30	50	0						95
3	0	30	0	0	30						60
4	0	50	0	0	5						55
5	85	0	30	5	0						120
6											0
7											0
8											0
9											0
10											0
Sum	100	95	60	55	120	0	0	0	0	0	430

Fig 5.8. WS8 'Dem(CAS)'. Demand data for the Conventional Alternative System

Again, aggregate figures can be entered to represent a typical day.

Note that in the example shown there are 10 stops, but since they occur in pairs (one either side of the road) a 5x5 matrix is sufficient to describe the demand.

5.9 WS9 'Op' (Operational characteristics) requests information about the CityMobil system, either a PRT or a CTS, and the conventional alternative to be considered. For the PRT and CTS systems the user is required only to specify the maximum waiting time which must be selected from 60, 180 or 300 seconds.

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System Operation*				CityMobil System	Conventional Alternative System
Transport mode/ vehicle	From list	⇨	n/a	PRT	Bus
Max desired waiting time *	*[sec]*	?	-	60	60
Average vehicle speed	*[kph]*	=	-	27.40	25.00
Average trip time	*[min]*	=	-	3.66	12.00
Average waiting time	*[min]*	=	-	0.33	5.00
Number of vehicles	#	=	-	135	10.0
Vehicle.km / hour	*[veh*km/hr]*	=	-	2140	
Trip production / hour	*[pax*km/hr]*	=	-	1501	
Average vehicle spacing	*[m]*	=	-	35.4	

*) For the CityMobil system, specify only the maximum desired waiting time, select from list: 60, 180 or 300 secs;

Fig 5.9. WS9 'Ops'. Operational characteristics

Algorithms are 'built in' so that the other characteristics, including the average waiting time and the number of vehicles needed, are then calculated automatically. The demand figures from the previous worksheets are used to determine the maximum numbers of vehicles needed to serve the peak hours.

Note: in the case of CTS, which is a collective transport system (ie it will stop to pick up more passengers at stops en-route) the algorithms calculate the typical passenger loading resulting from the demand at the different stops. In the case of PRT, which is an individual transport system (ie goes directly to the destination without stopping at any intermediate stations), the algorithms assume the typical passenger loading is 2. In practice, the actual figure will vary with the application and could range from perhaps 1.5 in a city network application with many stations in off peak hours, to 4 in an airport shuttle at peak times where people with common destinations can easily identify one another and agree to share a ride.

If the actual number is higher (or lower) than 2, then the number of PRT vehicles needed to satisfy the demand will be lower (or higher) in proportion. If required, the number of vehicles can be changed manually on the cost sheet (WS11) as appropriate.

Caution: if only aggregate demand figures have been provided, the number of vehicles calculated will be an average and may not be sufficient to cope with the peak demand.

5.10 WS10 'Ben' (Benefits) requests information about proposed passenger fares, subsidies and other sources of revenue, and also the discount period and rate to be used in order to produce a discounted cash flow analysis. It also provides an opportunity to include any quantifiable social benefits that are known, such as savings in user time, accidents, vehicle operating costs etc.

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Benefit Estimation						CityMobil System	Conventional Alternative System
Discount Period		{year}	?	-	30.0		
Discount Rate		{%}	?	-	6.00		
System Revenue	Base year fare per passenger		{EUR/Pass}	?	-	2.0	2.0
	Base year demand		{Pass/year}	⇨	n/a	7105581	3554131
	Base Year Revenue		{EUR/year}	=	n/a	14211161.27	7108261.27
	Base Year Subsidies		{EUR/year}	?	-	0.00	0.00
	Base Year Other System Revenue		{EUR/year}	?	-	0.00	0.00
	Base Year Total System Revenue		{EUR/year}	=	n/a	14211161.27	7108261.27
	System Revenue Annual Growth Rate		{%}	?	-	0.00	0.00
	Present Value of total System Revenue (PVSR)		{EUR}	=	n/a	207351089.52	103714657.18
Social Benefits *	Base Year User time savings		{EUR/year}	?	-	0.00	0.00
	Base Year System reliability		{EUR/year}	?	-	0.00	0.00
	Base Year System punctuality		{EUR/year}	?	-	0.00	0.00
	Base Year Image/ attractiveness		{EUR/year}	?	-	0.00	0.00
	Base Year Sustainability impacts		{EUR/year}	?	-	0.00	0.00
	Base Year Saved operating costs		{EUR/year}	?	-	0.00	0.00
	Base Year Accident savings		{EUR/year}	?	-	0.00	0.00
	Base Year Saved pollutants		{EUR/year}	?	-	0.00	0.00
	Base Year Jobs generated		{EUR/year}	?	-	0.00	0.00
	Base Year Non-user benefits		{EUR/year}	?	-	0.00	0.00
	Base Year Other system benefits		{EUR/year}	?	-	0.00	0.00
	Base Year Total System Benefits		{EUR/year}	=	n/a	0.00	0.00
	System Benefits Annual Growth		{%}	=	-	0.00	0.00
	Present Value of total Social Benefits (PVSB)		{EUR}	=	n/a	0.00	0.00
Present Value of total Benefits (PVB=PVSR+PVSB)			{EUR}	=	n/a	207351089.52	103714657.18

Fig 5.10. WS10 'Ben'. Benefit information

The social benefits are required if a full economic analysis is needed that takes account of socio-economic costs and benefits. They would normally be available from the application of a conventional transportation planning model in a fuller feasibility study and appraisal.

However, If they are not available, they can nevertheless be taken into account in the TOAST methodology described later.

Note that WS15 'TOAST(G)' (see below) gives examples of social benefit valuations including:
- user time savings: values of travel time savings range typically from 6.93€/hr in the Czech Republic to 9.58 €/hr in Belgium;
- saved accidents: values of saved fatal accidents range typically from €488,000 in the Czech Republic to about €1,400,000 in Finland;

These values are taken from CityMobil Deliverable document D5.1.1 Annexes 'Evaluation Indicators and CBA' (Ref 19) which also gives details of discount rates used and the valuations attributed by some countries to climate impacts from CO2, exhaust emissions (tonnes of CO, NOx and PPM) and noise..

5.11 WS11 'Cost' (Costs) requests information about system capital and operating costs;

Costs include both the capital costs, incurred initially to implement the system, and the operating costs incurred subsequently to keep it running.

Cost Estimation						CityMobil System	Conventional Transport System
Discount Period	[year]	⇨	n/a		30.0		
Discount Rate	[%]	⇨	n/a		6.00		
Capital Costs	Cost of guideway per metre		[EUR/m]	?	G	2133.90	600.00
	Length of guideway		[m]	⇨	n/a	4780.00	5000.00
	Total cost of guideway		[EUR]	=	n/a	10200042.00	3000000.00
	Cost per vehicle		[EUR/vehicle]	?	G	78000.00	225000.00
	Number of vehicles		#	⇨	n/a	135	10
	Total cost of vehicles		[EUR]	=	n/a	10530000.00	2250000.00
	Cost per stop		[EUR/stop]	?	G	270000.00	60000.00
	Number of stops		#	⇨	n/a	5	10
	Total cost of stops		[EUR]	=	n/a	1350000.00	600000.00
	Cost of depot(s)		[EUR]	?	G	1260000.00	1500000.00
	Cost of other facilities		[EUR]	?	-	5250000.00	
	Other capital costs		[EUR]	?	-	960000.00	
	Total Capital Cost		[EUR]	=	n/a	29550042.00	7350000.00
Operating Costs	Base year Operating Cost per Metre		[EUR/m]	?	G	533.47	429.00
	Length of guideway		[m]	⇨	n/a	4780.00	5000.00
	Staff costs		[EUR/year]	?	-	0.00	0.00
	Energy costs					0.00	0.00
	Maintenance costs					0.00	0.00
	Other operating costs					0.00	10000.00
	Base Year Total Operating Costs		[EUR/year]	=	-	2549986.60	2155000.00
	Operating Costs Annual Growth Rate		[%]	?	-	0.00	0.00
	Present Value of total Operating Cost (PVOC)		[EUR]	=	n/a	37206143.09	31443003.8
Present Value of total Cost (PVC=Capital Cost+PVOC)			[EUR/year]	=	n/a	66756185.09	38793003.80

Fig 5.11. WS11 'Cost'. Cost data

The worksheet enables the user to summarise the costs as shown in Fig 5.11. A full appreciation of the Capital costs should include:

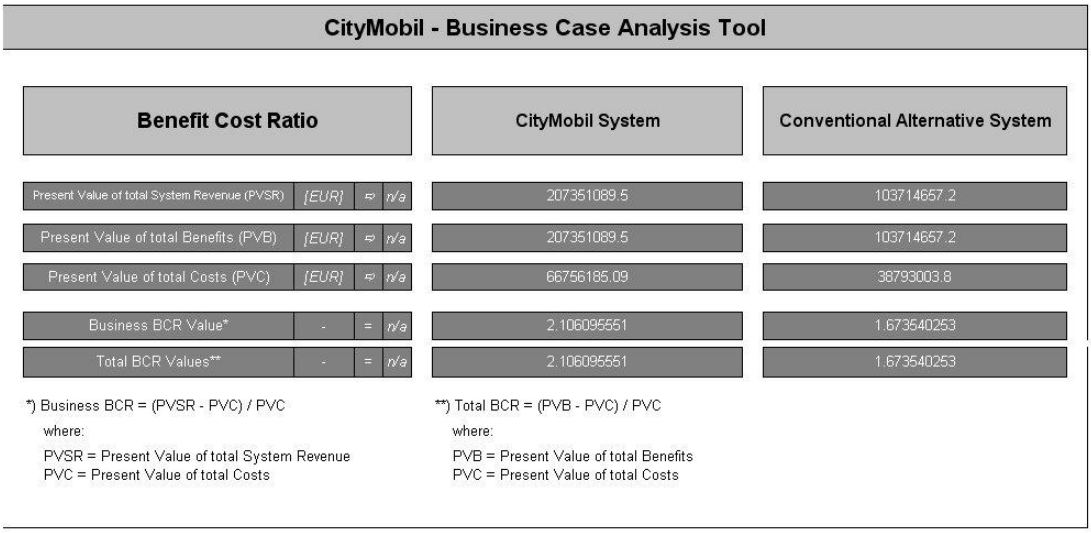
- Land take and utilities diversion
- Vehicles, and any subsequent vehicle replacements
- Civils and trackwork
- Stations and stops
- Electrical power
- Communications and signalling
- Depot(s) / control centre
- Highway works
- Traffic management
- Design and management

A full appreciation of the Operating costs should include:

- Fuel
- Fixed costs (tax, insurance)
- Salaries (drivers and system operators)
- Maintenance (vehicles, Infrastructure)
- Security
- Depreciation

5.12 WS12 'Cost(G)': provides guidance advice and help to the user on the components that make up capital and operating costs, and the range of costs of different systems.

5.13 WS13 'BCR' (Benefit Cost Ratio) brings forward the data and calculations from previous worksheets to compute the business and total benefit-cost ratios (BCR);



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Benefit Cost Ratio				CityMobil System	Conventional Alternative System
Present Value of total System Revenue (PVSR)	[EUR]	⇨	n/a	207351089.5	103714657.2
Present Value of total Benefits (PVB)	[EUR]	⇨	n/a	207351089.5	103714657.2
Present Value of total Costs (PVC)	[EUR]	⇨	n/a	66756185.09	38793003.8
Business BCR Value*	-	=	n/a	2.106095551	1.673540253
Total BCR Values**	-	=	n/a	2.106095551	1.673540253

*) Business BCR = (PVSR - PVC) / PVC
where:
PVSR = Present Value of total System Revenue
PVC = Present Value of total Costs

**) Total BCR = (PVB - PVC) / PVC
where:
PVB = Present Value of total Benefits
PVC = Present Value of total Costs

Fig 5.13. WS13 'BCR'. Benefit Cost Ratio

During the process of the user inputting information and data in response to the questions, calculations are performed so that at the end all the parameters that can be quantified can be combined in the Calculation of the benefit cost ratio (BCR) for a scheme, and given by:

BCR = (PVB - PVC) / PVC

where:

PVB = Present Value of Benefits
PVC = Present Value of Costs

Two BCR figures are provided: a **business benefit-cost ratio** made up from actual cash flows ie costs, revenues and other income; and a **total benefit-cost ratio** that includes the cash flows and also those benefits to society, such as travel time savings, if they are available (eg from a separate transportation modelling exercise) and have been input to the spreadsheet by the user.

Note that other definitions of BCR are possible, and PVB/PVC (=1+the value as defined above) is commonly used. The definition used here uses the net benefit ie (PVB-PVC) and so gives a positive result if the benefits exceed the costs, and a negative result if the costs exceed the benefits.

All values are present values, i.e. measured over the lifetime of the project (say for example, 30 years) and then discounted (using an appropriate discount factor eg 6%) to the present day. This shows the extent to which a scheme is likely to cover its operating costs.

5.14 WS14 'TOAST' (Technology Options Appraisal Summary Table) provides the methodology for rating and weighting the various unquantifiable benefits, intangibles, impacts and risks of the alternative schemes.

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Transport Options Appraisal Summary Table (TOAST)						CityMobil System	Conventional Transport System
System Benefits	System reliability	Rating	7-point-scale	?	-	6	4
		Weighting	Percentage	?	-	0.05	0.05
	System punctuality	Rating	7-point-scale	?	-	6	3
		Weighting	Percentage	?	-	0.05	0.05
	Image / attractiveness	Rating	7-point-scale	?	-	6	2
		Weighting	Percentage	?	-	0.02	0.02
	Improved mobility	Rating	7-point-scale	?	-	6	3
		Weighting	Percentage	?	-	0.05	0.05
	User time savings	Rating	7-point-scale	?	-	6	3
		Weighting	Percentage	?	-	0.15	0.15
	Saved accidents	Rating	7-point-scale	?	-	6	2
		Weighting	Percentage	?	-	0.10	0.10
	Reduced sustainability impacts	Rating	7-point-scale	?	-	6	2
		Weighting	Percentage	?	-	0.10	0.10
	Saved pollution	Rating	7-point-scale	?	-	6	4
		Weighting	Percentage	?	-	0.10	0.10
	Jobs generated	Rating	7-point-scale	?	-	1	2
		Weighting	Percentage	?	-	0.02	0.02
	Saved operating costs	Rating	7-point-scale	?	-	6	2
		Weighting	Percentage	?	-	0.10	0.10
	Non-user benefits	Rating	7-point-scale	?	-	6	4
		Weighting	Percentage	?	-	0.03	0.03
	Improved city economy	Rating	7-point-scale	?	-	5	4
		Weighting	Percentage	?	-	0.03	0.03
	Compliance with policy objectives	Rating	7-point-scale	?	-	6	3
		Weighting	Percentage	?	-	0.10	0.10
	Identification of risks/ barriers	Rating	7-point-scale	?	-	1	7
		Weighting	Percentage	?	-	0.10	0.10
	Overall rating	Rating	7-point-scale	?	n/a	5.37	3.27

Fig 5.14. WS14 'TOAST' .Technology Options Appraisal Summary Table

An assessment of value for money (VfM) is greatly assisted by the TOAST (Technology Options Appraisal Summary Table) methodology. This allows the user to use his/her professional judgement to rate (and also to weight, if desired) the various benefits, intangibles, impacts and risks of the alternative schemes.

Factors that can be taken into account in the TOAST include:

- System reliability: this relates mainly to journey time
- System punctuality: this relates mainly to waiting time
- Image/attractiveness: an overall perception of a range of factors such as appearance, ease of use, cleanliness, comfort, safety, security, privacy etc
- Improved mobility: this relates mainly to accessibility and usefulness
- User time savings: values of travel time savings range typically from 6.93€/hr in the Czech Republic to 9.58 €/hr in Belgium *
- Saved accidents: values of saved fatal accidents range typically from €488,000 in the Czech Republic to about €1,400,000 in Finland *
- Reduced sustainability impacts: these can include reduced energy consumption and climate impacts (CO2) *
- Saved pollution: can include saved exhaust emissions (CO, NOX, PPM) and noise *
- Jobs generated: can include jobs created to manufacture the systems as well as for operational purposes
- Saved operating costs: can include staff savings enabled by the use of automated vehicles
- Non-user benefits: can include reduced congestion and delays resulting from drivers leaving their cars at home in favour of the new transport system
- Improved city economy: can include reduced requirement for land take

- Compliance with policy objectives: is brought forward automatically from worksheet 'Sys'
- Barriers and risks: is brought forward automatically from worksheet 'Sys'

The spreadsheet then uses the rate and weight figures given for each factor to calculate a ranking figure. The different rankings for the two alternative schemes 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 BCR figures, and facilitates an assessment of value for money.

* CityMobil Deliverable document D5.1.1 Annexes 'Evaluation Indicators and CBA' (Ref 19)

Tip: default weightings are provided for the various factors in the example shown. The user is free to change these if he or she wishes.

Note: the user should not include benefits in the TOAST that are also included on the benefits estimation (Ben) worksheet as they would then be double counted.

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5.15 WS15 'TOAST(G)': provides guidance for the use of the TOAST methodology;

5.16 WS16 'Sum' (Summary of results) presents a summary of the results.

The results are finally summarised in a summary table which shows the key features of the alternative systems including the type and number of the vehicles needed, the length of the route, if a special guideway is required, the number of stations/stops, the average vehicle speeds and passengers waiting times, business and total BCR values and the TOAST ranking.

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Result Summary				CityMobil System	Conventional Transport System
Transport mode/ vehicle	*From list*	⇨	*n/a*	PRT	Bus
Number of vehicles	#	⇨	*n/a*	135	10
Type of guideway	*From list*	⇨	*n/a*	Separate Lane/Guideway	Existing Road
Length of guideway	*[m]*	⇨	*n/a*	4780.0	5000.0
Number of stations/stops	#	⇨	*n/a*	5	10
Average vehicle speeds	*[km/hr]*	⇨	*n/a*	27.4	25.0
Average trip times	*[min]*	⇨	*n/a*	3.7	12.0
Average waiting times	*[min]*	⇨	*n/a*	0.3	5.0
Vehicle.kms / hour	*[veh*km/hr]*	⇨	*n/a*	2140.3	
Trip production / hour	*[pax*km/hr]*	⇨	*n/a*	1501.1	
Average vehicle spacing	*[m]*	⇨	*n/a*	35.4	
Business BCR Value	-	⇨	*n/a*	2.11	1.67
Total BCR value	-	⇨	*n/a*	2.11	1.67
TOAST rating	*7-point-scale*	⇨	*n/a*	4.52	2.15

Fig 4.11. WS15 'Sum'. Summary of results

5.17 WS17 'DCF' (Discounted cash flow) shows a tabulated example of a discounted cash flow analysis. This can be used, as shown in the example, to show the effects of allowing for a vehicle refurbishment programme. This is calculated in terms of a multiplier which can then be applied to the cell containing the present value of vehicle costs in the 'costs' worksheet.

This worksheet therefore allows for more refined application of the business case tool. Examples of factors which could be allowed for in a similar way include:
- the consequences of allowing a build period over which costs can be spread and in which no passengers are carried or revenues collected;
- to allow for a vehicle and infrastructure replacement and/or refurbishment programme;
- to allow for the effects of forecast growth in demand on the numbers of vehicles and other facilities (eg depots, power supplies etc) needed.

6. Conclusion

Based on the results obtained, decisions should then be possible for the funding partners from a consideration of the cash flows revealed by the Business BCR analysis, plus any additional funding needed, and of any subsidy required.

For the business case to be decided there is, in principle at least, no need for a comparison of alternative schemes, or for a full appreciation of the background, i.e. policy and context, and social benefits. In practice however, it is thought highly unlikely that a (local) government partner in particular would, or could commit to funding a particular scheme without the larger view and justification provided by these additional details and the Total BCR figure.

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8. Glossary of abbreviations

BCR	Benefit Cost Ratio
BCT	Business Case Tool
CBA	Cost Benefit Analysis
Civils	Civil engineering works
CTS	Cybernetic Transport System
CVHS	Cooperative Vehicle Highway System

DfT	Department for Transport in the UK
EU	European Union
GRT	Group Rapid Transit
HTB	High Tech. Bus
Mppy	Million passengers per year
O-D	Origin - Destination
Pass	passengers
Pax	passengers
pph	passengers per hour
PRT	Personal Rapid Transit
PV	Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
PVSR	Present Value of total System Revenues
TOAST	Technology Options Appraisal Summary Table
VfM	value for money