EUROPEAN COMMISSION
DG RESEARCH

SIXTH FRAMEWORK PROGRAMME

THEMATIC PRIORITY 1.6

SUSTAINABLE DEVELOPMENT, GLOBAL CHANGE & ECOSYSTEMS

INTEGRATED PROJECT – CONTRACT N. 031315

EXPERIENCE WITH THE CITYMOBIL BUSINESS CASE TOOL

Deliverable no.	D2.4.3
Dissemination level	
Work Package	WP 2.4: Business Cases
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Status (F: final, D: draft)	Final, 08/11/11
File Name	D2.4.3-PU-Experience with the CityMobil Business Case Tool vF.doc
Project Start Date and Duration	01 May 2006 - 30 April 2011

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Executive Summary

The CityMobil BCT (Business Case Tool) is the product of CityMobil WP2.4 on Business Cases. The tool itself comprises an Excel Spreadsheet and accompanying User Guidelines which are available separately from the project.

A business case is the basis for the economic justification of any new scheme. The CityMobil Business Case Tool (BCT) has been developed and is designed to provide a quick and simple means for assessing the economic case for a new transportation system. It is based on the results of a literature review from which a list of the relevant factors has been determined together with a preferred methodology for taking them into account. The BCT is a spreadsheet comprising a number of interlinked worksheets. 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, for example, a PRT (personal raid transit) versus a conventional bus scheme. The structure and use of these worksheets is fully described in the User Guidelines document.

This report describes the experiences gained within the CityMobil project of using the BCT to evaluate a range of new transportation systems and the consequences for the final version of the BCT. The experiences include the assessment of proposed schemes in the cities of Daventry (UK), Uppsala (S), Tyne and Wear (UK), Madrid (E), Trondheim (NO), Vienna (A) and the three CityMobil demonstrators in Castellon (E), Rome (I) and Heathrow airport (UK). The results are presented and discussed.

A complete print out of the Spreadsheet for Daventry is included at Annex A.

1. Introduction

The CityMobil BCT (Business Case Tool) is the product of CityMobil WP2.4 on Business Cases (Ref 1). The tool itself comprises an Excel Spreadsheet and accompanying User Guidelines which are available separately from the project.

A business case is the basis for the economic justification of any new scheme. The CityMobil Business Case Tool (BCT) has been developed and is designed to provide a quick and simple means for assessing the economic case for a new transportation system. It is based on the results of a literature review from which a list of the relevant factors has been determined together with a preferred methodology for taking them into account. The BCT is a spreadsheet comprising a number of interlinked worksheets. 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, for example, a PRT versus a conventional bus scheme. The structure and use of these worksheets is described fully in the User Guidelines document.

The development of the BCT involved testing the prototype tool on a known case of a proposed pilot scheme of Personal Rapid Transit (PRT) in the city of Daventry (UK). Subsequently, a first release version of the tool was made available on the project web site for the CityMobil Reference Group of cities and other partners in the project who might be interested to assess local plans for themselves.

This first release version was first used within CityMobil project itself to assess the business cases for the cities and schemes analysed using the MARS model in CityMobil WP2.3 (Ref 2). This involved assessing four different systems in each of 4 cities.

The cities are: Gateshead (UK), Vienna (A), Trondheim (NO) and Madrid (E)

The schemes are:

- Personal Rapid Transit (PRT)
- Inner City Cybernetic Transport System (IC CTS)
- Cybernetic Transport System Feeder (CTS Feeder)
- Hi-Tech Buses (HTB)

A second use of the first release of the BCT was by partner WSP who used it to evaluate a proposed scheme of PRT in the city of Uppsala (S).

A final release of the BCT (spreadsheet and user guidelines, versions vF2.1) accompanies this report and has been used to re-assess the proposed pilot scheme of PRT in Daventry and the three CityMobil demonstrators ie HTB in Castellon (E), CTS in Rome (I) and PRT at Heathrow airport (UK).

The results are presented and discussed below.

2. The BCT

The BCT includes a methodology 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) to help facilitate a comparison.

The BCT produces a discounted cash flow analysis for a time period and discount rate specified by the user, and calculates Present Values (PV) of capital costs, operational costs and benefits. The outputs include a Business BCR (benefit cost ratio) made up of cash flows only, and a Total BCR that includes social benefits where they are known.

The Benefit Cost Ratio BCR = (PV Benefits-PV Costs)/PV Costs

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.

A pilot scheme of PRT has been previously proposed for Daventry and evaluated in the Daventry Pilot PRT System Study (DPPSS) report, 2008 (Ref 3). This included estimates for the costs and socio-economic benefits, and a discounted cash flow analysis for 2 schemes: a PRT scheme compared with a High Quality Bus (HQB) alternative.

The costs and benefits estimated in the DPPSS report were used to check and confirm the performance of the Business Case Tool during the development process.

The results obtained for Daventry using the final version of the spreadsheet are reported in section 5 below. A complete print out of the spreadsheet is provided for illustrative purposes in Annex A.

3. MARS modelling exercise

The first application of the first release of the BCT was to assess the business cases for the cities and schemes analysed using the MARS model in CityMobil WP2.3. The results are reported in Ref 2. In this exercise the BCT was applied to the MARS model outputs for 4 proposed schemes in each of 4 cities.

The cities are: Gateshead (UK), Vienna (A), Trondheim (NO) and Madrid (E)

The schemes are:

- Personal Rapid Transit (PRT)
- Inner City Cybernetic Transport System (IC CTS)
- Cybernetic Transport System Feeder (CTS Feeder)
- Hi-Tech Buses (HTB)

In order to accommodate the particular requirements of the exercise, and to facilitate cross-site comparisons, the BCT was adapted and applied in a specialised way.

Indicative costs were estimated for each of the systems. In each case, the MARS model results provided the length of the route, the number of stations/stops, the average fare, the

peak and off-peak demand figures (passengers/hour) for a 16 hour/day operating period, and the growth in demand over a 25 year period. Assuming maximum waiting times of 180 and 300 seconds for the PRT and CTS schemes respectively, the numbers of vehicles needed was calculated automatically by the spreadsheet, but figures had to be provided separately for the number of buses needed in the HTB schemes.

Particular considerations were as follows:

- scheme benefits were made up from fare revenues only.
- costs of systems were in 2008 prices
- costs and benefits were computed using a discounted cash flow analysis performed over a 30 year period starting in 2009, using a 3% discount rate.
- scheme build was assumed to take place in 2009
- scheme operations and fare collection started in 2010
- schemes operated for 365 days a year
- no land costs were incurred
- no infrastructure replacement costs would be incurred
- PRT and CTS vehicles would be refurbished at 1/3 their original cost after 10 and 20 years; HTBs (which expect to do a much higher mileage) would be refurbished at 1/3 cost after 5 years and replaced after 10 years.
- Residual values were zero at the end of the 30 years.

Note in particular that the method as applied here produces a Business Case in terms of cash flows made up from revenues and costs only. No real socio-economic benefits, such as valuations of time savings by users or of saved accidents and pollutants, were included. These would normally be included in a full socio-economic assessment, and the additional benefits used to support the case for subsidising Public Transport schemes.

A summary of the results obtained is shown in the Table 3.1 below.

Table 3.1. Results of BCR analysis of MARS modelled cities

BCR Analysis	Summary of Results															
	Gateshead				**Vienna**				**Trondheim**				**Madrid (1)**			
	PRT	IC CTS	CTSFeede	HTB	PRT	IC CTS	CTSFeede	HTB	PRT	IC CTS	CTSFeede	HTB	PRT	IC CTS	CTSFeede	HTB
						(2)(4)		(4)	(4)		(2)		(3)			(4)
Route length (km)	20.7	20.7	22.8	50.9	11	11	110	34	18.5	ntr	22.8	25	42	42	90	143
no. stops	56	30	36	18	49	49	500	108	34		36	20	84	84	140	60
peak demand (pph)	5580	2188	2655	3273	744	283	2465	609	580		115	3091	27427	26882	17772	115782
off peak demand (pph)	3776	905	860	931	485	480	2262	984	1624		2	2445	11278	10718	3686	94492
annual demand (Mppy)	24.7	7.2	7.6	8.9	3.2	2.5	13.5	5.2	8		0.18	15.2	95.3	92.1	47.2	591
growth in demand (%pa)	0.11	0.31	0.7	0.2	0.02	0.02	0.1	0.04	0.8		0.7	0.44	-0.72	-0.71	1.19	-0.56
no. vehicles	406	36	43	30	55	5	40	73	43		2	35	1960	450	287	1800
av. veh speed (kph)	30.7	14.4	14.4	30	30.8	14.1	14.1	26	30.8		14	29	30.4	16.2	14.7	40.6
av trip time in pk (mins)	5.8	5.9	5.9	38.37	4.8	5.9	5.9	15	5.8		5.9	21.11	5.8	5.9	5.9	24.4
av waiting time in pk (mins)	1.4	3.1	3.1	4.81	1.4	3.1	3.1	0.6	1.4		3.1	4.07	1.4	3.1	3.1	5
av veh spacing (m)	51	575	530		200	2200	2750		430		11400	1450	21.4	93.3	313.6	
fare (€)	2.21	2.21	2.2	3.15	0.3	0.3	0.3	0.3	2.53		2.53	2.53	0.6	0.6	0.7	0.75
capital costs (€M)	123	29.3	34.6	453	47.7	9.8	94.6	381	75.4		17.2	255	351	190	195	3622
base year op costs (€M)	6.9	2.9	3.3	9.9	2.3	1.4	6.4	20.4	2.7		1.8	9.9	25.8	22.8	17	481
PV cost (€M)	263	88	102	652	95	37.5	224	792	130		53.6	455	872	649	539	13329
base year benefits €M)	54.6	15.8	16.8	27.9	0.96	0.75	4.05	1.56	20.1		0.45	38.5	57.2	55.2	33.1	443
PV benefit (€M)	1062	316	354	549	18.5	14.5	78.8	30.1	429		9.4	783	1001	968	743	7813
Business BCR	**3.04**	**2.58**	**2.48**	**-0.16**	**-0.81**	**-0.61**	**-0.65**	**-0.96**	**2.3**		**-0.82**	**0.72**	**0.15**	**0.49**	**0.38**	**-0.41**
Fare for breakeven (€) (7)				3.75	1.6	0.78	0.85	7.9			14.5					1.27
BCR Sensitivity analysis:																
-20% demand, + 20% cost	2	1.67	1.6	-0.4	-0.86	-0.74	-0.75	-0.97	1.24		-0.88	0.28	-0.11	0.25	0.08	-0.52
+20% demand, -20% cost	4.51	3.85	3.66	0.19	-0.72	-0.42	-0.5	-0.95	3.83		-0.74	1.33	0.51	0.83	0.81	-0.25
BCR special cases																
Special for Vienna (5)								-0.96								
Special for Madrid (6)																-0.39
track costs as HTB	2.04	0.32	0.32		-0.87	-0.88	-0.92		1.06		-0.96		-0.04	0.01	-0.38	

Notes		
	(1)	peaks last for 5 hrs in Madrid, 4 hrs in other cities, all have operating perods of 16 hrs /day
	(2)	vehicle numbers probably too low for scheme to be viable
	(3)	vehicle spacing of 21.4m at 30.4kph = 2.5 secs headway - is not viable
	(4)	peak hour demand < off-peak !
	(5)	35% of required HTB guideway already exists, capital costs are reduced accordingly
	(6)	initial need for 473 buses only, remainder purchased under old bus renewal programme in yrs 5 and 10
	(7)	approx. fare required for BCR = 0 ie PV Benefits = PV Costs

A more detailed account of the application of methodology is given in Refs 4 and 5.

Overall. the BCT performed much as expected, and any variations due to known and accountable factors appeared to be encompassed by a simple sensitivity analysis involving a worst case scenario made up from assuming a 20% reduction in demand and a 20% increase in costs.

For best results, the exercise showed that modifications were required to the BCT, in particular:
- to take account of a build period;
- to allow for a vehicles, and perhaps an infrastructure refurbishment / replacement programme;
- to recognise the effects of a growth in demand on the growth in numbers of vehicles required.

These changes have been implemented in the final version of the BCT.

Note: In answer to a question from the EC annual review of CityMobil in July 2010: *"Can the results of D.2.4.2 be confirmed by persons in charge of Gateshead, Vienna, Trondheim and Madrid?* Copies of emails were provided that showed the modellers were indeed consulted with regard to the findings, invited to comment and asked to provide some missing information. Following that the author had some dialogue with representatives from Madrid and WP2.3 on a handful of issues that were all resolved satisfactorily. But no comments were received from anyone else although all the missing information requested was eventually made available.

4. Uppsala

The first release version of the BCT (spreadsheet and guidelines) was also used by partner WSP to evaluate a proposed scheme of PRT in Uppsala as reported in Ref 6.

Key parameters were:

- Length of single way track: 9.4 km
- Maximum waiting time: 180 seconds
- Number of PRT vehicles: 130
- Number of stops: 18
- Demand 2,754,840 passengers per year
- Fare €0.67

The key assumptions were substantially as described above in Section 3 except that the discounted cash flow period was set to 30 years and the discount rate to 0.04%. The discount rate was clearly meant to have been 4%. When this change is made the results are as shown in Table 4.1.

Table 4.1 Uppsala Results

CityMobil - Business Case Analysis Tool					
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	67,818,807	19,327,103
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	341,703,579	48,792,712
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	116,865,960	26,403,036
Business BCR Value*	-	=	*n/a*	-0.419687247	-0.267996961
Total BCR Values**	-	=	*n/a*	1.923893149	0.847996255

The spreadsheet was then reworked using the representative costs for PRT systems. The spreadsheet calculated that 82 vehicles would be sufficient, but for purposes of comparing the system costs the number of vehicles was forced to 130 as used by WSP. The results are shown in Table 4.2.

It is evident that the results obtained using the two different cost models are similar.

Note that the costs for Conventional Alternative System shown in Table 4.1 were identified as incomplete and were set to zero for the recalculation shown in Table 4.2. This is the reason for the #DIV/0! cells shown there.

Table 4.2. Uppsala results using representative system costs

CityMobil - Business Case Analysis Tool					
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	68,634,282.30	19,548,281.10
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	342,007,152.74	48,958,818.06
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	117,939,492.42	0.00
Business BCR Value*	-	=	*n/a*	-0.418055132	#DIV/0!
Total BCR Values**	-	=	*n/a*	1.899852676	#DIV/0!

The author commented on these results in an email to Goran Tegner of WSP dated 19/5/09 saying:

> *Thank you for sending me the Uppsala business case. I have looked through this and make the following observations:*
>
> *1. there are no costs included for the buses. This will mean the BCR for that scheme is very optimistic !*
>
> *2. you appear to have forced the number of PRT vehicles needed to 130. The number calculated by the spreadsheet is 82.*
>
> *3. you have included subsidies in the calculation of the BCRs. While the spreadsheet allows for this, it should perhaps be made clear that a subsidy would normally only be needed to make up the revenues so that they cover the costs.*
>
> 5. *For interest, I have recalculated the costs of the PRT scheme using generic figures I have derived from other sources and used as part of the analysis of the CityMobil modelling exercise on the cities of Gateshead, Trondheim, Vienna and Madrid. Using these figures produces BCRs of -0.09 for the business case and 3.48 for the total (ie transport) case (which compare with your figures of -0.04 and 3.84 respectively) ie they are reasonably close. If I exclude the subsidy, the BCRs are reduced to -0.42 and 3.16.* (Author's note: the BCR figures here were calculated using a discount rate of 0.04% before it was corrected to 4%)

Note: In answer to a question from the EC's annual review of CityMobil in July 2010:

Was this model applied to the project of PRT system at Bolanderna in Uppsala? If not, could it be possible to run such this case and compare the results with the figures described in "D.1.5.6.2-PU-PRT Uppsala Bolanderna-FINAL Draft"?

Copies of emails were provided to show the author had indeed seen the results from an earlier draft of the Uppsala results, and commented on the findings. In particular, he had re-run the model using the Uppsala data with the same generic costs for PRT as applied to the Gateshead, Vienna, Madrid and Trondheim cases above and found very similar cost benefit figures. This confirms we were using very similar cost figures and also validates the model to the extent that feeding the social benefits they had determined separately into the model produces similar results from a discounted cash flow analysis using the same rate and over the same period.

Uppsala also took the opportunity to complete the TOAST section of the spreadsheet, as shown in Table 4.3. At the time, no clear guidance was provided for this. Subsequently it was determined that benefits which had been valued and included in the benefits worksheet should not be included in the TOAST since this would effectively lead to double counting. When the ratings for these (namely: savings in time, operational costs, accidents, pollution and benefits from attractiveness) are set to zero, the Overall TOAST ratings for the PRT and alternative bus schemes reduce to 2.63 and 1.31 respectively.

Table 4.3. Uppsala TOAST

CityMobil - Business Case Analysis Tool

Transport Options Appraisal Summary Table (TOAST)						CityMobil System	Conventional Transport System
System Benefits	System reliability	Rating	*7-point-scale*	*?*	-	6	2
		Weighting	*Percentage*	*?*	-	0.05	0.05
	System punctuality	Rating	*7-point-scale*	*?*	-	6	2
		Weighting	*Percentage*	*?*	-	0.05	0.05
	Image / attractiveness	Rating	*7-point-scale*	*?*	-	5	3
		Weighting	*Percentage*	*?*	-	0.02	0.02
	Improved mobility	Rating	*7-point-scale*	*?*	-	6	5
		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*	*?*	-	7	4
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Reduced sustainability impacts	Rating	*7-point-scale*	*?*	-	6	3
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Saved pollution	Rating	*7-point-scale*	*?*	-	6	3
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Jobs generated	Rating	*7-point-scale*	*?*	-	3	6
		Weighting	*Percentage*	*?*	-	0.02	0.02
	Saved operating costs	Rating	*7-point-scale*	*?*	-	6	3
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Non-user benefits	Rating	*7-point-scale*	*?*	-	5	4
		Weighting	*Percentage*	*?*	-	0.03	0.03
	Improved city economy	Rating	*7-point-scale*	*?*	-	4	4
		Weighting	*Percentage*	*?*	-	0.03	0.03
	Compliance with policy objectives	Rating	*7-point-scale*	*?*	-	7	2
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Identification of risks/ barriers	Rating	*7-point-scale*	*?*	-	1	0
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Overall rating	Rating	*7-point-scale*	*?*	*n/a*	5.53	2.82

6. Daventry

Following experience with the BCT as described above, a final version (v2.1) of both the Spreadsheet and User Guidelines was produced for release in July 2011.

This version has been used to re-assess the proposed scheme of PRT for Daventry described in the DPPSS (Ref 3).

Generic costs, as developed for the work described in Section 3 above were used to assess the PRT. The original figures provided in the DPPSS report were used to assess the costs of the High Quality (HQ) Bus scheme evaluated as a conventional alternative system. The passenger demands assumed in the DPPSS were used to assess the revenues for purposes of calculating the Business BCRs for the two systems. Valuations of the social benefits calculated in the DPPSS were input as benefits and enabled estimates to be made of the Total BCRs for the two systems.

Key parameters were:

• Scheme:	PRT	HQ Bus
• Length of single way track (km)	4.881	5.0
• Maximum waiting times (secs)	60	-
• Number of vehicles	20	10
• Number of stops	5	25
• Demand (passengers per year)	1,214,720	362,080
• Fare (€)	1.20	1.20

Key assumptions were:

- values in € at 2008 prices (Note: 2008 prices as measured by the RPI are 23% higher than 2002 prices used in the DPPSS, and when £1 = 1.5€ approx);
- 60 year discounted cash flow period;
- discount rate of 3.25% (error <1% cf the DPPSS which used 3.5% for the first 30 years then 3% for next 30 years);
- build and test starts in 2008 and takes 4 years, PRT electrical infrastructure replaced after 30 years over a 2 year period;
- vehicles purchased in years 3 & 4, refurbished at 1/3 cost after 15 years and replaced after 30 years, all over 2 year periods;
- operations and passenger carrying starts in year 5 ie no operations costs or revenues in years 1 through 4;
- no land costs are incurred, no other infrastructure replacement costs are incurred;
- residual values are zero at the end of the project;
- annual growth in demand = 0;
- Buses cost as per the DPPSS 2002 figures in £, x 1.5 for Euro x 1.23 for 2008, and assuming the same build period and refurbishment/replacement program as for PRT.

The BCR results obtained are shown in Table 5.1

Table 5.1. BCR results for Daventry

CityMobil - Business Case Analysis Tool					
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	33,980,967	10,128,942
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	214,024,997	131,758,387
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	72,720,200	76,591,512
Business BCR Value*	-	=	*n/a*	-0.53271626	-0.867753725
Total BCR Values**	-	=	*n/a*	1.943129932	0.720274008

A comparison of these results with the figures given in the DPPSS is shown in Table 5.2. For the purposes of the comparison the DPPSS figures have been multiplied by 1.23 to account for the increase in RPI (ie costs) between 2002 and 2008, and by 1.5 the rate prevailing at the time for converting from £ to €. The fare however has been kept at the £0.8 level originally proposed, equivalent to €1.2 in 2008 prices.

Table 5.2. Comparison of BCT and DPPSS results.

PRT scheme results estimated by:	BCT	DPPSS
PV total benefit (M€)	214	197
PV total revenues (M€)	34.0	-
PV total costs (M€)	72.7	72.0
Business BCR	-0.53	-
Total BCR	1.94	1.74
Fare (€)	1.20	1.20
Fare for breakeven (€)	2.5	

HQB scheme results estimated by:	BCT	DPPSS
PV total benefit (M€)	132	128
PV total revenues (M€)	10.1	-
PV total costs (M€)	76.6	74
Business BCR	-0.87	-
Total BCR	0.72	0.73
Fare (€)	1.20	1.20
Fare for breakeven (€)	9.1	

The results show fair agreement in the estimates for present values (PV) of the costs and benefits, and in the Total BCR figures. Note in particular that subsidies equivalent to an increase in fare from €1 to about €2.5 would be needed for the fare revenues to cover the cost of the PRT system, and an increase from €1 to about €9 to cover the cost of the HQ Bus system.

The results of a TOAST (technology options appraisal summary table) exercise to compare the two systems is shown in Table 5.3.

Table 5.3. TOAST

CityMobil - Business Case Analysis Tool

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*	*?*	-	0	0
		Weighting	*Percentage*	*?*	-	0.15	0.15
	Saved accidents	Rating	*7-point-scale*	*?*	-	0	0
		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*	*?*	-	0	0
		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*	*?*	-	0	0
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Non-user benefits	Rating	*7-point-scale*	*?*	-	0	0
		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	6
		Weighting	*Percentage*	*?*	-	0.10	0.10
	Overall rating	Rating	*7-point-scale*	*?*	*n/a*	2.49	1.80

Note that ratings are set to zero in the table for benefits that have been valued and already included as money benefits on the benefits worksheet. For Daventry, they include valuations of savings in users time, accidents, pollution, vehicle operating costs, and non-user benefits.

The overall summary of results is shown in Table 5.5.

Inspection of these results shows a comparison of the alternative schemes in terms of a range of parameters, including the length of route and number of vehicles, and shows that PRT beats the HQ Bus alternative in terms of both the Business and Total BCRs, and the TOAST score. It can be concluded that PRT should provide the better option in terms of value for money.

Table 5.5. Overall summary of results

CityMobil - Business Case Analysis Tool

Result Summary				CityMobil System	Conventional Transport System
Transport mode/ vehicle	*From list*	⇨	*n/a*	PRT	Bus
Number of vehicles	#	⇨	*n/a*	20	10
Type of guideway	*From list*	⇨	*n/a*	Separate Lane/Guideway	Existing Road
Length of guideway	*[m]*	⇨	*n/a*	4,881	5,000
Number of stations/stops	#	⇨	*n/a*	5	25
Average vehicle speed	*[km/hr]*	⇨	*n/a*	27.7	10.0
Average trip times	*[min]*	⇨	*n/a*	3.7	15.0
Average waiting times	*[min]*	⇨	*n/a*	0.3	5.0
Vehicle.kms / hour	*[veh*km/hr]*	⇨	*n/a*	310.2	
Trip production / hour	*[pax*km/hr]*	⇨	*n/a*	204.4	
Average vehicle spacing	*[m]*	⇨	*n/a*	244.1	
Business BCR Value	-	⇨	*n/a*	-0.53	-0.87
Total BCR value	-	⇨	*n/a*	1.94	0.72
TOAST rating	*7-point-scale*	⇨	*n/a*	2.49	1.80

The full spreadsheet for Daventry is shown in Annex A.

7. CityMobil demonstrations

The BCT has been applied to the CityMobil demonstrations of HTB in the city of Castellon, PRT at Heathrow Airport and CTS (or GRT) at the Rome Exhibition Centre. The intention at the outset of the project was to assess the economic justification for these schemes after they were in and fully operational. However, in practice this has only been possible for the HTB scheme in Castellon. This scheme uses commercially available technology and was designed to provide a viable public transport service. It has been operating for some time and the patronage is known. It has been fully assessed using the BCT to show its financial viability.

The CTS system in Rome did not complete in time to be assessed. While other systems of CTS exist, they are mainly at theme parks. The Rome implementation was innovative, especially in that it had to win safety approval from the Italian government authorities before it could proceed. This had serious consequences for the costs. The scheme was therefore very much a pilot, and as such was mainly designed to test the technology and user acceptance issues. It was not intended to be financially viable. An assessment of the scheme using the BCT has nevertheless been undertaken, using the representative costs for a CTS systems described above. However, the results should not be interpreted as a Benefit Cost assessment, but rather as a means to show the level of subsidy required to support the pilot implementation.

Similarly, the PRT system at Heathrow is a pilot and the first implementation of its kind. It is in and operating, but for a number of reasons, not least due to the need to change the frequency of the telemetry systems so as not to interfere with other systems on the airport coupled with a change in ownership of BAA in the planning stage, it has cost much more than the first estimates. Further, it was never intended to be financially viable: rather it was intended to confirm the technology and user acceptance issues before being extended to cover a more extensive network that could indeed expect to be economically viable. An assessment of the scheme using the BCT has nevertheless been undertaken, using the representative costs for a PRT described above. However, the results should not be interpreted as a Benefit Cost assessment, but rather as a means to show the level of subsidy required to support the pilot implementation.

6.1 Castellon

A full ex-post evaluation of the Castellon demonstration has been undertaken in CityMobil (Ref 7). This used a period of 20 years, a 2% discount rate and assumed inflation rate of 2.3% to estimate the PVs of the costs and benefits using the Conventional Alternative System area of the BCT spreadsheet to assess the economic justification. The results are shown in Table 6.1.1.

Note that there are no results to report in the CityMobil System area of the spreadsheet.

Table 6.1.1. Ex-post analysis of Castellon demonstration

CityMobil - Business Case Analysis Tool						
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**	
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	0	10,413,491	
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	0	44,269,752	
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	#VALUE!	31,857,139	
Business BCR Value*	-	=	*n/a*	#VALUE!	-0.67311907	
Total BCR Values**	-	=	*n/a*	#VALUE!	0.389633645	

The key parameters are:

- Length of single way track: 4 km
- Number of GRT vehicles: 3
- Number of stops: 5
- Demand 558,450 passengers per year

Valuations of a fare of €0.52 plus benefits from savings in sustainability impacts (ie energy), accidents and pollution/emissions were included to give a Total BCR of 0.39. The business BCR of -0.67 suggests that a subsidy equivalent to an increase in fare of about €2 would be needed to cover the costs of the system from the fare box.

When the representative costs for HTB are used, the results are as shown in Table 6.1.2.

Note that there are no results to report in the CityMobil System area of the spreadsheet.

Table 6.1.2. Castellon demonstration using representative costs for HTB

CityMobil - Business Case Analysis Tool

Benefit Cost Ratio				CityMobil System	Conventional Alternative System
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	0	10,413,491
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	0	44,269,752
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	#VALUE!	58,388,260
Business BCR Value*	-	=	*n/a*	#VALUE!	-0.821650942
Total BCR Values**	-	=	*n/a*	#VALUE!	-0.241803884

Using representative costs the costs of individual buses are nearly 60% cheaper, but the costs of infrastructure are nearly 70% higher than the actual costs incurred, and the overall BCR results are much worse. The reason, which was anticipated, is that for a small network (in this case with a length 4km and only 3 buses) the particular system of trolley buses and optical guidance works out cheaper than a typical BRT system using guided buses that are guided using raised kerbs. The Business BCR of -0.82 suggests that a subsidy equivalent to an increase in fare of more than €4 would be needed to cover the costs, compared with the €2 previously. This shows the importance of getting good estimates of the costs in the first place.

7.2 Rome

The results of an assessment of the Rome demonstration using representative figures for CTS/GRT are shown in Table 6.2.1. Passenger demand figures were as estimated in the ex-ante evaluation report (Ref 8).

Note that there are no results to report in the Conventional Alternative System area of the spreadsheet.

Table 6.2.1 Rome demonstration using representative costs for CTS.

CityMobil - Business Case Analysis Tool						
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**	
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	13,837,974	0	
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	13,837,974	0	
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	13,826,439	0	
Business BCR Value*	-	=	*n/a*	0.00083431	#DIV/0!	
Total BCR Values**	-	=	*n/a*	0.00083431	#DIV/0!	

The key parameters are:

- Length of single way track: 1.6 km
- Max waiting time: 180 seconds
- Number of GRT vehicles: 6
- Number of stops: 12
- Demand 4,944,800 passengers per year

The key assumptions are:

- Discounted cash flow period: 30 years
- Discount rate: 3%
- 2008 values and prices
- Build and system test starts in 2008 and takes 2 years
- Operations and passenger carrying starts in year 3
- No revenues or operations costs occur in years 1 and 2
- All vehicles are refurbished at 1/3 original cost in years 12 and 22
- No land costs are incurred, no infrastructure replacement costs are incurred
- Residual values are zero at the end of the project
- Growth in demand and inflation are set to zero

No social benefits are included so the Business and Total BCR figures are the same. They are set to zero in the example by choosing a fare of €0.02 which is in effect the subsidy required to support the system. But as discussed above, it was never intended that the system should be economically viable, rather that it should provide a sufficient service to enable confirmation of the technology and user acceptance.

6.3 Heathrow

The results of an assessment of the Heathrow demonstration using representative figures for PRT are shown in Table 6.3.1. Passenger demand figures were as estimated in Ref 9.

Note that there are no results to report in the Conventional Alternative System area of the spreadsheet in Table 6.3.1.

Table 6.3.1 Heathrow demonstration using representative costs for PRT.

CityMobil - Business Case Analysis Tool					
Benefit Cost Ratio				**CityMobil System**	**Conventional Alternative System**
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	40,849,896	0
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	40,849,896	0
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	40,755,041	0
Business BCR Value*	-	=	*n/a*	0.00232744	#DIV/0!
Total BCR Values**	-	=	*n/a*	0.00232744	#DIV/0!

The key parameters are:

- Length of single way track: 3.9 km
- Max waiting time: 60 seconds
- Number of GRT vehicles: 21
- Number of stops: 3
- Demand 387,630 passengers per year

The key assumptions are:

- Discounted cash flow period: 30 years
- Discount rate: 3%
- 2008 values and prices
- Build and system test starts in 2008 and takes 2 years
- Operations and passenger carrying starts in year 3
- No revenues or operations costs occur in years 1 and 2
- All vehicles are refurbished at 1/3 original cost in years 12 and 22
- No land costs are incurred, no infrastructure replacement costs are incurred
- Residual values are zero at the end of the project
- Growth in demand and inflation are set to zero

No social benefits are included so the Business and Total BCR figures are the same. They are set to zero in the example by choosing a fare of €5.80 which is in effect the subsidy required to support the system which is used currently by 1062 passengers per day (Ref 9). But as discussed above, it was never intended that the system should be economically viable, rather that it should provide a sufficient service to enable confirmation of the technology and user acceptance.

8. Discussion

The BCT spreadsheet can be used with any transportation scheme, but contains some special facilities that make it especially useful for assessing CTS/GRT 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 (Note: for this calculation to work properly the peak hourly demand must be specified on the 'Dem(CMS)' worksheet). 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 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 10).

9. Conclusions

The BCT appears to work reasonably well and should provide a useful tool for helping a city assess the business case for proceeding with a new transport system. The BCT has been applied in a number of situations, and rigorous checks and tests have been conducted to try and pick up and correct any errors. As a result of experience and feedback some enhancements and improvements have been added. Notably: an extra worksheet has been included that will allow a user to play with the discounted cash flows to simulate the effects of:

- an extended build period;
- a vehicles, and an infrastructure refurbishment / replacement programme;
- the effects of a growth in demand on the growth in numbers of vehicles required.

The results are determined in terms of multipliers that can be applied to appropriate cells in the various worksheets, and so help to refine the results.

The BCT provides an easy method for estimating the economic case for a new transport system and for answering 'what if' questions. To assist in this process, guidance is provided on the indicative costs of representative systems, but great care is needed in using these figures which will clearly vary with different systems using different technologies, and with time. In common with most computer software, the axiom 'rubbish in, rubbish out' will also apply to the BCT.

10. References

1. CityMobil deliverable D2.4.1 Generic Analysis Tool for Business Cases.
2. CityMobil deliverable D2.4.2 Application of the BCT.
3. Daventry Pilot PRT scoping study (DPPSS), Daventry District Council, Feb 2008.
4. Muir, Jeffery, May, Tripodi, Shepherd and Vaa (2009), Assessing the contribution and feasibility of a city wide personal rapid transit system, TRB, Washington, Jan 2009.
5. May, Muir, Shepherd, Jeffery and Levine (2012) An assessment of city-wide applications of new automated transport technologies, paper submitted to TRB, Washington, Jan 2012.
6. CityMobil deliverable D1.5.7.1 Report on the Uppsala Boländerna PRT feasibility study
7. CityMobil deliverable D1.4.5.3 Ex-post impact assessment of the Castellon demonstration.
8. CityMobil Deliverable D5.2.1a Field trial A ex-ante evaluation report.
9. CityMobil deliverable D1.2.4.3 Comparison of the ULTra PRT system with the existing bus service from the passenger and operator viewpoints.
10. CityMobil deliverable: City Application Manual (in the press).

11. Annex A. BCT Spreadsheet for Daventry

Showing the main worksheets.

Fig A1. Worksheet 'Site' showing the description of the site.

CityMobil - Business Case Analysis Tool

Site Description

Transport problem(s) to be solved	*Description*	*?*	*G*
Daventry pilot PRT vs a High Quality Bus schemes as proposed by SKM in the DPPSS Provide a PT system to serve anticipated growth in population (doubling by 2021) and business			

Application and context of the area	*Description*	*?*	*G*
New developments cannot be supported by existing infrastructure. Substantial building of new roads is not possible. An innovative system of PT is needed that will discourage car use.			

Statement of policy objective(s)	*Description*	*?*	*G*
Provide sustainable flexible transport between residential, business and retail areas; reduce the need to travel, especially by car, and plan for sustainable communities; reduce social exclusion; improve intermodality			

Potential physical constraints	*Description*	*?*	*G*
Existing roads will allow space for PRT or bus operations at grade over most of the area, but PRT will require an elevated guideway of about 1 km in length to serve the city centre; a PRT guideway would need to be protected from pedestrian access, so care will be neeed to avoid severence.			

Existing transport system(s) if any	*Description*	*?*	*G*
Buses locally, and a main line rail station about 2 km from the city centre.			

Any additional relevant information	*Description*	*?*	*G*
Part of the route will make use of a disused railway			

Fig A2. Worksheet 'Sys' showing the systems investigated.

CityMobil - Business Case Analysis Tool

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]*	?	-	4,881	5,000
Number of stations/stops	#	?	-	5	25
Depot(s) required	*Yes/ No*	?	-	Yes	Yes
Other facilities	*Description*	?	-	5 stations, 1 control centre, power	25 stops, bus priorities etc
Compliance with policy objectives	*7-point-scale*	?	G	6	3
Identification of risks/ barriers	*Description*	?	G	high: technical/operational	low: societal/acceptability
Severity of risk/ barriers	*7-point-scale*	?	G	1	6
Minimise risks/ barriers	*Description*	?	G	risks assessed as manageable	n/a
Additional Information	*Description*	?	-		

Fig A3. Worksheet 'Dem(CMS)' showing the passenger demand estimated for the PRT system.

CityMobil - Business Case Analysis Tool

Base Year Demand Characteristics* (PRT)

Days of operation per year	*[Days/year]*	*?*	-	365
Annual growth in demand	*[%]*	*?*	-	0.00
Base year demand	*[Pass/year]*	=	*n/a*	1,214,720

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	333										333
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	333	0	0	0	0	0	0	0	0	0	333

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	333										333
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	333	0	0	0	0	0	0	0	0	0	333

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

Duration of demand					*[hr]*		*?*	-	22.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	121										121
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	121	0	0	0	0	0	0	0	0	0	121

Fig A4. Worksheet 'Dem(CAS)' showing the passenger demand estimated for the High Quality Bus alternative.

CityMobil - Business Case Analysis Tool

Base Year Demand Characteristics* (Bus)

Days of operation per year	*[Days/year]*	*?*	-	365
Annual growth in demand	*[%]*	*?*	-	0.00
Base year Demand	*[Pass/year]*	=	*n/a*	362,080

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	100										100
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	100	0	0	0	0	0	0	0	0	0	100

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	100										100
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	100	0	0	0	0	0	0	0	0	0	100

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

Duration of demand					*[hr]*		*?*	-	22.0		
OD	1	2	3	4	5	6	7	8	9	10	Sum
1	36										36
2											0
3											0
4											0
5											0
6											0
7											0
8											0
9											0
10											0
Sum	36	0	0	0	0	0	0	0	0	0	36

Fig A5. Worksheet 'Op' showing the operating characteristics.

CityMobil - Business Case Analysis Tool

System Operation*				CityMobil System	Conventional Alternative System
Transport mode/ vehicle	From list	⇨	n/a	PRT	Bus
Max desired waiting time *	*[sec]*	*?*	-	60	n/a
Average vehicle speed	*[kph]*	=	-	27.71	10.00
Average trip time	*[min]*	=	-	3.68	15.00
Average waiting time	*[min]*	=	-	0.33	5.00
Number of vehicles	#	=	-	20	10.0
Vehicle.km / hour	*[veh*km/hr]*	=	-	310	
Trip production / hour	*[pax*km/hr]*	=	-	204	
Average vehicle spacing	*[m]*	=	-	244.1	

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

Fig A6. Worksheet 'Ben' showing the benefit calculations

CityMobil - Business Case Analysis Tool

Benefit Estimation						CityMobil System	Conventional Alternative System
Discount Period	*[year]*	?	-	60.0			
Discount Rate	*[%]*	?	-	3.25			
System Revenue	Base year fare per passenger		*[EUR/Pass]*	?	-	1.20	1.20
	Base year demand		*[Pass/year]*	⇨	*n/a*	1,214,720	362,080
	Base Year Revenue		*[EUR/year]*	=	*n/a*	1,457,664	434,496
	Base Year Subsidies		*[EUR/year]*	?	-	0	0
	Base Year Other System Revenue		*[EUR/year]*	?	-	0	0
	Base Year Total System Revenue		*[EUR/year]*	=	*n/a*	1,457,664	434,496
	System Revenue Annual Growth Rate		*[%]*	?	-	0.00	0.00
	Present Value of total System Revenue (PVSR)		*[EUR]*	=	*n/a*	33,980,967	10,128,942
Social Benefits *	Base Year User time savings		*[EUR/year]*	?	-	0	2,348,982
	Base Year System reliability		*[EUR/year]*	?	-	0	0
	Base Year System punctuality		*[EUR/year]*	?	-	0	0
	Base Year Image/ attractiveness		*[EUR/year]*	?	-	0	0
	Base Year Sustainability impacts		*[EUR/year]*	?	-	0	0
	Base Year Saved operating costs		*[EUR/year]*	?	-	0	17,223
	Base Year Accident savings		*[EUR/year]*	?	-	0	38,643
	Base Year Saved pollutants		*[EUR/year]*	?	-	0	-1,092
	Base Year Jobs generated		*[EUR/year]*	?	-	0	0
	Base Year Non-user benefits		*[EUR/year]*	?	-	0	28,238
	Base Year Other system benefits		*[EUR/year]*	?	-	0	0
	Base Year Total System Benefits		*[EUR/year]*	=	*n/a*	3,600,000	2,431,994
	System Benefits Annual Growth		*[%]*	=	-	0.00	0.00
	Present Value of total Social Benefits (PVSB)		*[EUR]*	=	*n/a*	180,044,030	121,629,445
Present Value of total Benefits (PVB=PVSR+PVSB)			*[EUR]*	=	*n/a*	214,024,997	131,758,387

*) If not possible to monetise leave blank and apply rating on 7-point scale as part of TOAST comparison instead

Values of social benefits are given on TOAST(G). More details can be found in CityMobil Deliverable document D5.1.1 Annexes 'Evaluation Indicators and CBA'

Fig A7. Worksheet 'Cost' showing the cost calculations.

CityMobil - Business Case Analysis Tool

Cost Estimation					CityMobil System	Conventional Transport System
Discount Period	*[year]*	⇨	*n/a*	60.0		
Discount Rate	*[%]*	⇨	*n/a*	3.25		
Capital Costs	Cost of guideway per metre	*[EUR/m]*	*?*	*G*	3,800.00	600.00
	Length of guideway	*[m]*	⇨	*n/a*	4,881	5,000
	Total cost of guideway	*[EUR]*	=	*n/a*	19,289,712	3,120,000
	Cost per vehicle	*[EUR/vehicle]*	*?*	*G*	75,000.00	225,000.00
	Number of vehicles	*#*	⇨	*n/a*	20	10
	Total cost of vehicles	*[EUR]*	=	*n/a*	1,950,000	3,442,500
	Cost per stop	*[EUR/stop]*	*?*	*G*		84,000
	Number of stops	*#*	⇨	*n/a*	5	25
	Total cost of stops	*[EUR]*	=	*n/a*	0	2,100,000
	Cost of depot(s)	*[EUR]*	*?*	*G*	0	1,500,000
	Cost of other facilities	*[EUR]*	*?*	-	0	0
	Other capital costs	*[EUR]*	*?*	-	0	4,923,971
	Total Capital Cost	*[EUR]*	=	*n/a*	35,257,922	15,086,471
Operating Costs	Base year Operating Cost per Metre	*[EUR/m]*	*?*	*G*	0.00	429
	Length of guideway	*[m]*	⇨	*n/a*	4,881.00	5,000
	Staff costs	*[EUR/year]*	*?*	-	0.00	0
	Energy costs				0.00	0
	Maintenance costs				0.00	0
	Other operating costs				0.00	0
	Base Year Total Operating Costs	*[EUR/year]*	=	-	1,607,000.00	2,145,000
	Operating Costs Annual Growth Rate	*[%]*	*?*	-	0.00	0.00
	Present Value of total Operating Cost (PVOC)	*[EUR]*	=	*n/a*	37,462,278	61,505,041
Present Value of total Cost (PVC=Capital Cost+PVOC)		*[EUR]*	=	*n/a*	72,720,200	76,591,512

Fig A8. Worksheet 'BCR' showing the calculation of BCR values.

CityMobil - Business Case Analysis Tool

Benefit Cost Ratio				CityMobil System	Conventional Alternative System
Present Value of total System Revenue (PVSR)	*[EUR]*	⇨	*n/a*	33,980,967	10,128,942
Present Value of total Benefits (PVB)	*[EUR]*	⇨	*n/a*	214,024,997	131,758,387
Present Value of total Costs (PVC)	*[EUR]*	⇨	*n/a*	72,720,200	76,591,512
Business BCR Value*	-	=	*n/a*	-0.53271626	-0.867753725
Total BCR Values**	-	=	*n/a*	1.943129932	0.720274008

*) 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 A9. Worksheet 'TOAST' showing the calculation of the TOAST values.

CityMobil - Business Case Analysis Tool

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*	?	-	0	0
		Weighting	*Percentage*	?	-	0.15	0.15
	Saved accidents	Rating	*7-point-scale*	?	-	0	0
		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*	?	-	0	0
		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*	?	-	0	0
		Weighting	*Percentage*	?	-	0.10	0.10
	Non-user benefits	Rating	*7-point-scale*	?	-	0	0
		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	6
		Weighting	*Percentage*	?	-	0.10	0.10
	Overall rating	Rating	*7-point-scale*	?	*n/a*	2.49	1.80

Rating on 7-point scale:		
7	LB	Large beneficial
6	MB	Moderate beneficial
5	SB	Slight beneficial
4	N	Neutral
3	SA	Slight adverse
2	MA	Moderate adverse
1	LA	Large adverse

Fig A10. Worksheet 'Sum' showing the summary of results.

CityMobil - Business Case Analysis Tool

Result Summary				CityMobil System	Conventional Transport System
Transport mode/ vehicle	*From list*	⇨	*n/a*	PRT	Bus
Number of vehicles	#	⇨	*n/a*	20	10
Type of guideway	*From list*	⇨	*n/a*	Separate Lane/Guideway	Existing Road
Length of guideway	*[m]*	⇨	*n/a*	4,881	5,000
Number of stations/stops	#	⇨	*n/a*	5	25
Average vehicle speed	*[km/hr]*	⇨	*n/a*	27.7	10.0
Average trip times	*[min]*	⇨	*n/a*	3.7	15.0
Average waiting times	*[min]*	⇨	*n/a*	0.3	5.0
Vehicle.kms / hour	*[veh*km/hr]*	⇨	*n/a*	310.2	
Trip production / hour	*[pax*km/hr]*	⇨	*n/a*	204.4	
Average vehicle spacing	*[m]*	⇨	*n/a*	244.1	
Business BCR Value	-	⇨	*n/a*	-0.53	-0.87
Total BCR value	-	⇨	*n/a*	1.94	0.72
TOAST rating	*7-point-scale*	⇨	*n/a*	2.49	1.80

12. Annex B. Glossary of terms

BCR	Benefit Cost Ratio
BCT	Business Case Tool
CTS	Cybernetic Transport System
DPPSS	Daventry Pilot PRT System Study
GRT	Group Rapid Transit
HQB	High Quality Bus
HTB	High Tech. Bus
IC CTS	Inner City CTS
MARS	a transport model (Refs 4 & 5)
Mppy	Million passengers per year
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