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Towards advanced transport for the urban environment

Identification of the Key Parameters affecting Passenger and Operator Satisfaction with the Heathrow Pilot PRT Scheme, and the Key Benefits Anticipated

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Executive Summary

The CityMobil project includes three demonstrations of advanced transport systems. The first of these is a pilot installation of Personal Rapid Transport (PRT) at the new Terminal 5 of London's Heathrow Airport. The airport owner's purpose in building the Pilot System, which provides a shuttle loop between a business car park and the Terminal, is to prove the concept of PRT. If the demonstration provides a good and reliable quality of service, passenger satisfaction, and acceptable capital and operating costs, it is the owner's intention to expand the system into a comprehensive network serving the whole north side of the airport and, via the access tunnel, Terminals 1, 2 and 3 in the Central Terminal Area.

This Report builds on the recommended Framework for Evaluation of the CityMobil Demonstrations proposed in Deliverable 5.1.1, to identify the main indicators to be used in the ex post evaluation of the Heathrow PRT Demonstration. The Pilot system is not intended to be economically justified in its own right, and so the ex post evaluation will focus on the technical operation of the system, passenger satisfaction, and the costs. Nevertheless, additional data relevant to a wider socio-economic assessment will also be collected, to inform the financial and economic justification for expanding the Pilot system, and for applications elsewhere.

The key parameters for the evaluation are listed in Table 1 of the Report. This lists the indicators which are considered to be relevant, either directly or indirectly, to an ex post evaluation. Each category of indicators is then briefly discussed.

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1 Introduction

1.1 Background

The CityMobil Project aims to achieve more effective urban transport by developing advanced concepts for autonomous and automated road-based vehicles for passengers and goods. The city of tomorrow is in need of integrated traffic solutions that provide good mobility in an efficient, non-polluting, safe and economic manner.

The CityMobil Project will build on the results of recent European and national projects to validate and demonstrate the capabilities of new mobility solutions in different European cities. In five horizontal sub-projects the issues that still prevent full-scale implementation of innovative automated transport systems will be investigated and solutions will be developed. At three sites: Heathrow Airport in the UK, Castellón in Spain, and Rome, large-scale demonstrators will be set up to supply proof of concept of innovative transport systems integrated into the urban environment.

The first of the large-scale demonstrators is a pilot installation of Personal Rapid Transport (PRT) at the new Terminal 5 of London's Heathrow Airport. The primary aim of the pilot is to demonstrate and evaluate the concept of PRT. Once it is shown to work successfully the intention is to expand the pilot system into a wide network serving the whole Northside of the airport, and Terminals 1, 2 and 3 via the access tunnel into the Central Terminal Area. Thus it is not intended that the Pilot Scheme will of itself be economically justified, but it is intended to be the start of a fully-operational PRT system. After the Pilot phase, the system will continue to serve passengers travelling between the business car park and Terminal 5. The design of the Pilot system must, therefore, be as detailed and functional as the larger network.

Developing the technology of the CityMobil demonstrations, and showing that they work, is not enough. For the Projects to be useful it is essential to evaluate their operations in a way which enables the likely performance and benefits of similar applications elsewhere to be assessed and predicted. Evaluation is an important part of the whole Project, and is addressed separately in Sub Project SP5. Each demonstration and showcase will be assessed, adopting and developing further the techniques drawn from those developed in previous Framework Projects, such as CONVERGE, MAESTRO and HEATCO, and in the work of Sub Project SP5.

1.2 This Report

This Report identifies the key parameters and factors appropriate to evaluating the Heathrow Demonstration.

2 The Heathrow Pilot PRT Scheme

The Heathrow Airport Pilot PRT Scheme has been commissioned and financed by the owner BAA (originally the British Airports Authority), now owned by the Ferrovial Group. This follows an extended period of analysis of alternatives to provide the key landside transport needs of the airport. BAA concluded that all existing forms of public transport were unsuited to meeting their key requirement, on the grounds of cost or inflexibility or both. BAA have concluded that the only transport solution which can meet their future needs is a PRT network.

BAA are financing the system in two ways, by a major contract with ATS to install, integrate and commission the ULTra PRT system, and secondly by making a substantial investment in ATS which pays for the development of a full production system. The CityMobil programme will also make some contribution to the provision of the Pilot scheme.

CityMobil will monitor the performance of the scheme and fund some aspects of PRT beyond the scheme itself, with the aim of achieving an evaluation of the operation of PRT which can then be applied to other potential installations.

The scheme will carry passengers arriving at the Business Car Park to the new Terminal 5 Building , which will open in March 2008,. There will be 3.9 kms of dedicated one-way guideway, collecting passengers from four two-berth stations in the car park, transporting them along an elevated dual-guideway mainline section which skirts the perimeter of the airport and terminates in a four-berth station on the third floor of the multi-storey short-term car park alongside the Terminal Building. The system will be served by 16 small four-seater battery-electric vehicles, controlled automatically. Except where there are sudden large peaks in arrivals, passengers will find a vehicle already waiting to collect them at the stations, and there will be little or no waiting. The scheme is intended as proof of concept. Once it is demonstrated to operate satisfactorily, reliably and safely, BAA intend to expand the network to serve business, public and staff car parks along the entire northern edge of the airport, plus car hire offices and hotels, and link them through a tunnel to Terminals 1, 2 and 3 in the Central Terminal Area.

The ULTra PRT scheme is intended to open six months after the opening of Terminal 5. The intial operation of the car park to Terminal link will by buses. This has particular attractions for the CityMobil programme, since this provides the opportunity of a direct one-to-one comparison of the passenger satisfaction and benefits of the two different modes.

A full description of the Pilot Scheme can be found in CityMobil Deliverable 1.2.2.1 (Bly and Lowson 2007).

3 Principles of Evaluation

Evaluations within the CityMobil Project are to be standardised and integrated so far as possible by the Evaluation Sub Project SP5. This work is not yet complete, but this Report examines and selects the key parameters relevant to an evaluation of the Heathrow demonstration on the basis of SP5's preliminary report D5.1.1 "Evaluation Framework" (Marsden et al, 2006). The recommendations of D5.1.1 are based in turn on evaluation work

done previously in EU Framework Programmes, particularly CONVERGE (Zhang et al,1998), MAESTRO (2000) and HEATCO (2005).

D5.1.1 summarises these recommendations as follows.

CONVERGE provides a general procedure for developing the assessment methodology, suitable for the majority of transport telematics projects, whether R&D, verification or demonstration, with a methodology based around a seven stage process:

- Determination of user needs;
- Classification and description of telematics applications;
- Formulation of assessment objectives;
  - Technical (system performance, reliability)
  - Impact assessment (safety, environment etc.)
  - User acceptance (users' opinions, preferences, willingness to pay)
  - Socio-economic evaluation (benefits and costs)
  - Market assessment (demand and supply)
  - Financial assessment (initial and running costs, rate of return, etc.)
- Pre-assessment of expected impacts;
- Choice of assessment methods;
- Methods available for data analysis; and
- Reporting of results.

MAESTRO builds on CONVERGE, and proposes three main evaluation phases:

- Before the project begins, when users define their specific transport problem and decide whether a Pilot or Demonstration project is the best way to try to solve the problem;
- During the project (the methodology), when users address the issues associated with setting up the project, specifically defining the objectives, site selection, pre-design and initial evaluation, as well as considering the design and ex ante evaluation, and concluding with implementation of the Pilot/Demonstration and ex post evaluation;
- After the project, when users consider how best to use the project results, and whether to proceed to full-scale implementation.

The first stage of the methodology involves the definition of objectives. General transport and sector-specific objectives are first identified to set the context for the definition of the project objectives. The definition of the project objectives is vital: all other parts of the methodology depend on their accurate definition.

The **HEATCO** project analyzed current practice in the European Union (Odgaard et al., 2005) and the state-of-the-art in project appraisal (Bickel et al., 2005a), with a special focus on cost-benefit analysis (CBA), and with the aim of developing a harmonized framework for transport project appraisal in Europe. Figure 1 illustrates the suggested process for CBA.

Because this is a Pilot scheme, a full CBA is less important than an assessment of the performance and acceptability of the technology, and therefore MAESTRO is more relevant to the discussion in this report than HEATCO. Nevertheless, CBA will be central to justifying the expansion of the system, and in evaluation of the Pilot it will be important to measure the various components of a full CBA.

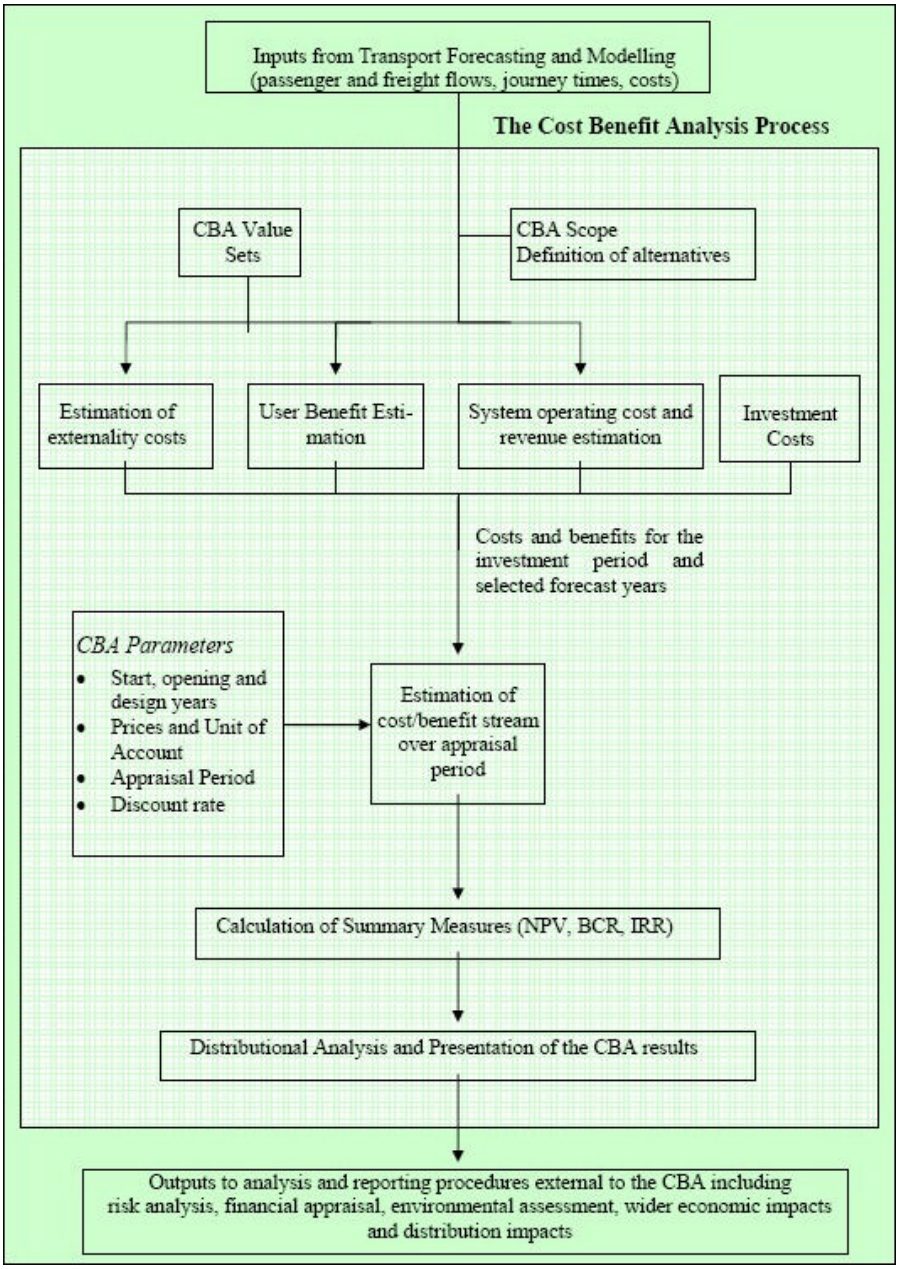

Figure 1 The Cost-Benefit Analysis process for HEATCO (Bickel et al 2005)

On the basis of its review of previous work on evaluation frameworks, D5.1.1 emphasises the need to establish the following key evaluation elements:

- **Objectives** – a series of key evaluation categories relating to the achievement of sustainability goals and capable of capturing the practical implementation of new technologies;
- **Framework** – a specific interpretation of the evaluation categories developed from the objectives which sets out the key impacts that relate to each category and the more specific indicators that can be used to assess achievement;

- **Assessment methods** – a clear understanding of how the framework should be applied (for example using social cost-benefit, Multi Criteria Assessment or mixed approaches) and to which parts of the CityMobil project
- **Implementation** – the establishment of clear procedures for the ex-ante and ex-post evaluation of the different parts of the project.

It recommends a mixed approach in terms of the evaluation methodologies to be used, but for the SP1 demonstrations it suggests the evaluation should focus on full social CBA, financial assessment, local cost values, plus additional non-weighted tables to deal with issues of public acceptance and distribution / equity.

4 Application to Heathrow

The MAESTRO process described above suggests three well-defined and logical stages to developing new technology, beginning with a definition of the problem and identification of the technical solution, followed by decisions about where best to apply the solution in order to demonstrate its effectiveness. The application should first be assessed prior to construction by an ex ante evaluation, which will set the objectives and targets to be met. After the demonstration, its performance will be measured by an ex post evaluation to determine whether the objectives have been met, and various other relevant measures of performance.

D5.1.1 accepts that any individual evaluation will not cover all of the issues suggested by these general evaluation frameworks, and that it will be sensible to select those approaches, and those indicators, which are relevant to the situation being assessed. In any case, when the general theory of evaluation is applied to an existing situation, it is inevitable that some issues will lie outside the control of the evaluators.

In practice, at some stage the new technology will have to be developed on a commercial basis, and at that point financial constraints are likely to restrict the available options. Achieving a full-scale application of an advanced transport system can be more difficult than developing the technology itself. Consequently, although the various stages of the MAESTRO process will be fulfilled in one way or another, it is rarely the planned and continuous progress which MAESTRO describes.

In the case of ULTra, the first stage of the MAESTRO process began in the mid-1990s with studies at the University of Bristol, led by Professor Martin Lowson, into the best form of urban transport for the 21st century. This work was based on a conventional systems engineering approach, identifying a basic requirements definition and finding a technical response to these requirements. It was concluded that the form of transport already known as PRT was the best solution to the underlying problems of conventional public transport. These were that conventional public transport is inflexible in the way it serves individuals, because it has to collect them together and serve their travel needs collectively, rather than addressing their individual needs as does a private car. PRT offers the potential to compete better with the car than could bus or LRT, because its individual vehicles offer the privacy and comfort of a car, no waiting and non-stop travel between origin and destination. The disappointing history of PRT in the 1970's taught that what was needed to succeed was reduced cost, to be achieved by use of technically simple and reliable components, and a small footprint with minimum visual intrusion, achieved by lightweight vehicles and infrastructure.

Although the system was conceived while Professor Lowson was at Bristol University, development of the prototype system required funding beyond that which is normally available from academic research grants. Development of a working prototype depended on funding from the UK Department of Transport, which also required the sort of ex ante evaluations which the second stage of MAESTRO suggests. These were essentially desk studies of ULTra, applied to an existing city (Cardiff - ATS, 2000), to a transport interchange (Heathrow Airport - ATS, 2002), and to a developing New Town (Corby - ATS, 2003). It was these hypothetical evaluations, plus the existence of the operational prototype vehicles on the Cardiff Test Track, which convinced potential purchasers to take PRT seriously, and the Heathrow study, in particular, which convinced BAA to commission the Pilot Scheme. Thus although ATS identified Heathrow Airport as a suitable place for the application of PRT, the choice of objectives, and of the Pilot site at Terminal 5, was a matter for BAA, not for ATS as the developers of the technology. Indeed, it will always be a problem with new technology that few customers are willing to be first to purchase a costly system. Most need the confidence inspired by a system which can be seen in full and enduring operation. It is pioneering of BAA to adopt the system for Heathrow, but BAA judge that successful development of PRT is essential to the effective future development of Heathrow and other BAA airports.

The main requirement of an evaluation is to determine whether the system has met the objectives of its owner. It is important, therefore, to understand the purpose of the Pilot.

5 Objectives of the Demonstration

BAA intend the Pilot to demonstrate the concept of PRT, with the intention, once it has been shown to operate successfully, to extend the network across the north side of the airport and into the Central Terminal Area. Success will be determined by showing that the system:

- offers a better quality of service than the alternative shuttle buses
- operates reliably
- operates safely and securely
- is environmentally desirable, in terms of minimum emissions of pollutants, greenhouse gases and noise: BAA attach great importance to the issue of reduced emissions from the airport's
- is preferred by passengers to the alternative bus system
- operates at the predicted operating cost
- can be extended at the projected infrastructure costs
- is flexible in the way it can be extended and causes minimum disruption during construction
- provides an exciting and technically advanced image for the airport

It is also the case that ATS has a great deal invested in the Pilot, since it will prove the practical success of PRT, and is a showcase for the ULTra system. ATS' objectives coincide very largely with those of BAA, though there will be technical lessons to be learned from the Pilot which will apply to PRT in an urban situation as well, in addition to the rather specialised environment of an airport.

The system is NOT intended to be justifiable on its own in either financial or socio-economic terms. According to the various ex ante desk evaluations, it can be strongly justified when the network is extended across the airport. The original ATS study considered in detail a 7.6km network which linked two business car parks and a staff car park through the access tunnel to the Central Terminal Area and Terminals 1, 2 and 3, comparing the PRT system with the existing shuttle bus services. Although the existing shuttle bus systems have low capital costs, their operating costs are estimated to exceed the ULTra operating costs, providing a Net Present Saving on operating costs over 30 years at a 6% discount rate of £12.5M (€19M). The PRT system provides both business passengers and staff with a much higher level of service, cutting in-vehicle times by an average of 4.4 minutes, walking times by 1.3 minutes and waiting times by 2.7 minutes. These passenger benefits have a 30-year Present Value of £88M (€132M), providing a total Net Present Value of £73M (€110M) after covering the discounted capital costs. Environmentally, the system will reduce the local air burden by 2.9 tonnes of carbon monoxide, 0.9 tonnes of hydrocarbons, 12.9 tonnes of oxides of nitrogen, and 1.7 tonnes of particulates. Although the absence of carbon dioxide emissions at the vehicle is compensated to some extent by emissions at the power station, there is a net saving of 311 tonnes of CO_2 per year.

BAA have made their own assessments of the PRT system, including the Pilot Network on its own. They are clear that the financial justification for using PRT is not as a simple shuttle between the business car park and Terminal 5, but from the large net benefits of the extended system. Thus, it is of obvious interest to both CityMobil and BAA to include within the evaluation measurements of those factors which will be relevant to evaluation of this wider network.

6 Key Parameters affecting Passenger and Operator Satisfaction and Benefits

Most of BAA's objectives as listed above can be translated into key parameters which can be measured quantitatively and judged to be satisfactory or otherwise. These incorporate aspects of passenger satisfaction too, since making Heathrow attractive to passengers is a pervading requirement for commercial success. The question of whether PRT offers a better quality of service than the alternative shuttle buses is a matter of comparing walking distance to the station, waiting times and ride times, plus general passenger perceptions about the service. Matters of reliability, safety, environmental emissions and cost can be measured quantitatively and judged accordingly. Flexibility and disruption of construction will be judged from the experience of installing the system. The last issue, of the image conferred on the airport, is one for the airport owner's own judgement.

Table 1 is taken from the summary Table 3 of D5.1.1, retaining only the column relevant to the demonstrations in SP1. Ticks in the fourth column mark those indicators suggested for inclusion by D5.1.1. Double ticks show those indicators regarded as "core indicators" in Table 4 of D5.1.1. In the fifth column crosses and hatches mark those indicators selected for evaluation of the Heathrow Demonstration: crosses mark those indicators relevant to BAA's objectives in constructing the Pilot system, while hatches mark indicators which, while not directly relevant to BAA's immediate intentions, are relevant to evaluation of the extended network which will need to be justified both financially and socio-economically. Here Table 1 is broken into four sections in order that the indicators in each can be discussed below the section.

Table 1: Passenger evaluation categories, impacts, indicators and where indicators can be measured/modelled

Evaluation Category	Impact	Indicator	SP1 Demonstrations	Selected for Heathrow Demonstration Evaluation
eptance	User acceptance	Usefulness	✓	+
		Ease of use	✓	+
		Reliability	✓	+
		User satisfaction for the on demand service	✓	+
		Integration with other systems	✓	NA
	Willingness to pay	User willingness	✓✓	#
		Authorities willingness	✓	
Quality of service	Information	Availability	✓	+
		Comprehensibility	✓	+
	Ticketing	User satisfaction	✓	+
	Cleanliness	Perceived cleanliness	✓	+
	Comfort	Perceived comfort	✓	+
	Privacy	Perceived level of privacy	✓	+
	Perception of safety and security	Perception of safety	✓✓	+
		Fear of attack	✓	+
	Perceived performance	Overall (not in D5.1.1 Table 3, but in Core Indicators Table 4)	✓✓	+

✓ marks the selected indicators in SP5's suggested scheme, and ✓✓ are the core SP5 indicators. For the Heathrow demonstration + marks the most relevant indicators for the Pilot, but # marks those relevant to wider application

Acceptance: For BAA, the main purpose of the Pilot is to ensure that the PRT system will appeal to its passengers, and provide an exciting part of the whole airport experience, as well as demonstrating that it will work technically as it was designed to do. The usefulness of the system is obvious, as an alternative to the shuttle buses currently used to serve other airport car parks, but the user's perceptions of ease of use, reliability, and general satisfaction with the system will be important to the owner. Reliability of service will have its own technical measures directly from the operating data, but the more qualitative passenger perceptions will be measured by interviews of passengers and scaled rankings, in a similar way to the attitude surveys carried out with passengers on the Cardiff Test Track by Travel and Transport Research (TTR, 2003) and reported in EDICT (EDICT, 2004). Passengers' willingness to pay is not directly relevant to the Pilot situation, since the cost of the PRT transport is included in the car park fee, and for this reason may be difficult to measure reliably, but the general willingness to pay provides the operator with an indication of how much revenue might be increased without passengers feeling disadvantaged and is therefore of commercial interest. In the Cardiff study passenger interviews found that people would be willing to pay €3 to €5 for the 2km trip.

Quality of Service: Again, these indicators are largely measures of user perceptions to be investigated by survey and interview, though service availability will be a matter of direct operating data. Although passengers pay no "fare", car park tickets may be used to call the PRT vehicle, and the call and ticket system will be an important part of the technology in general. Where possible, passengers' preferences will be compared with those for the alternative shuttle buses, since there will be an interval between the opening of Terminal 5 and the start of the PRT service, during which shuttle buses will be used.

Table 1 (cont'd): Passenger evaluation categories, impacts, indicators and where indicators can be measured/modelled

Evaluation Category	Impact	Indicator	SP1 Demonstrations	Selected for Heathrow Demonstration Evaluation
Transport patterns	Modal change	Induced mode changes in the other segments of the journey	✓	NA
		System modal share	✓✓	NA
	System use	Total passenger·km travelled	✓	#
		Total N° of trips	✓	#
		Vehicle occupancy	✓	
	System performances	Average Journey time per OD pair	✓	+
		Journey time variability	✓✓	+
		Total delay per/trip	✓✓	+
		Average Waiting time	✓	+
		Waiting time variability	✓	+
		Interchange time	✓	NA
		Effective system capacity	✓	#
Social Impacts	Spatial Accessibility	Change in range of key activities accessible within time thresholds	✓	NA
		Distribution of accessibility changes by social group	✓	NA
	Service Accessibility	Access times for mobility impaired users	✓✓	+
	Safety	Accident levels		+
		Incidents	✓	+
		Driver workload		NA

✓ marks the selected indicators in SP5's suggested scheme, and ✓✓ are the core SP5 indicators. For the Heathrow demonstration + marks the most relevant indicators for the Pilot, but # marks those relevant to wider application

Transport patterns: Modal share is not relevant here, since all car park passengers will use PRT. Similarly, demand is determined by use of the car park, so although data on demand will be collected in order to determine performance indicators which might be applied to the expanded network and other applications it is not directly relevant to the success of the Pilot. Estimates of ultimate system capacity will be important in future applications. However, journey time variability and waiting time are key measures of system performance. It is intended that average waiting times will be less than one minute, and that few passengers will have to wait more than two minutes.

Social impacts: The vehicles are designed for easy access by physically impaired and disabled users, and sliding doors and level station access ease wheelchair access. Indeed,

Table 1 (cont'd): Passenger evaluation categories, impacts, indicators and where indicators can be measured/modelled

Evaluation Category	Impact	Indicator	SP1 Demonstrations	Selected for Heathrow Demonstration Evaluation
Environment	Energy	Daily consumption (KWh)	✓	+
		Energy Efficiency (KWh/pkm)	✓✓	+
	Toxic emissions	NO_x	✓✓	+
		PM_{10} and/or $PM_{2.5}$	✓✓	+
		CO	✓✓	+
	Climate Change	CO_2	✓✓	+
	Noise	L_{DEN} and L_{night}	✓	+
	Land take	Loss of green space from construction	✓	
		Total land use change		#
Financial impacts	Start up costs	Track construction and civil works	✓	+
		Vehicle acquisition/construction	✓	+
		Control systems and apparatus	✓	+
	Operating costs	Personnel	✓	+
		Vehicle maintenance	✓	+
		Track and civil infrastructures maintenance	✓	+
		Control system maintenance	✓	+
	Revenues	Operating revenues	✓	NA
	Subsidies	Perceived public subsidies	✓	NA

✓ marks the selected indicators in SP5's suggested scheme, and ✓✓ are the core SP5 indicators. For the Heathrow demonstration + marks the most relevant indicators for the Pilot, but # marks those relevant to wider application

an audit by a disability advisor for the EDICT study found that ULTra was easier to use than conventional forms of public transport (EDICT 2004). Thus assessments by physically impaired passengers will be of particular interest, as will ease of carrying baggage. Safety is of course crucial to assessment of the system. ULTra is designed to have a lower accident incidence than mainline rail. With the low levels of demand for the Pilot it is not expected that there will be any cases of injury to passengers or staff, and instead safety will be assessed by the reporting of every incident which might have potential safety implications, and judgement of how serious, and how frequent, these might be.

Environment: BAA is keen to improve the environment of Heathrow, and although the contribution of the Pilot is obviously small, the environmental effects of a PRT system expanded to form the backbone of the airport's landside passenger transport can be substantial. ULTra vehicles are battery-electric, with zero exhaust emissions. Energy use is exceptionally low. These aspects will be compared with energy use and emissions from the alternative diesel shuttle buses. Local emissions of regulated pollutants are removed entirely, of course, though there will be some compensating emissions at the electricity generating stations which charge ULTra's batteries, and although this is irrelevant to local pollution it is important to account for it in estimating the net saving in greenhouse gas emissions. Noise is also important, because in the expanded system it will be desirable to route the system through some buildings, bringing passengers as near as possible to check-in desks etc. Land take is of interest beyond the Pilot, in that PRT enables reduction of road space, especially within the Central Terminal Area, and releases land for other uses.

Financial: It is in the areas of Financial and Economic assessment where BAA's most important questions will lie. The whole programme of construction and commissioning has been carefully costed, but PRT is an entirely new system and some uncertainty is unavoidable, so the out-turn costs will be crucial to justification of an expanded system, and applications elsewhere. However, the comparison of out-turn costs against predicted costs must be done carefully, for it is inevitable that in commissioning, designing and building a system like this more effort is put into decision-making, detail design and testing, and management than would be the case if PRT were a well-established transport mode. There is unavoidable duplication of management effort between BAA, ATS and the civil engineering contractors, as everyone needs to ensure that the project fulfils their intentions. In estimating the costs of future applications it will be important to strip out these one-off costs of prototyping. Similarly for the auditing of operating costs: the Pilot will provide the learning curve for operating PRT, and initially there will be a much greater staffing requirement to ensure safe and reliable operation, until experience is gained and it becomes clear how best to distribute effort.

Note that in an airport there are both special benefits and special costs in the application of a transport, or indeed any other, system. It will be important in the analysis as far as possible to identify areas where either the cost or the benefit is different in an airport application to that which would apply elsewhere.

Table 1 (cont'd): Passenger evaluation categories, impacts, indicators and where indicators can be measured/modelled

Evaluation Category	Impact	Indicator	SP1 Demonstrations	Selected for Heathrow Demonstration Evaluation
Economic	Temporary job provided by installation and demonstration	Jobs provided at the demonstration site	✓	
		Jobs increase induced at the manufacturers	✓	
	Long terms effects on jobs	Local effects on employment		
		Non local effects on employment		
	Vitality	Footfall within defined area	✓	
		Vitality index		
	Efficiency	Net Present Value	✓	#
		Internal Rate of Return	✓	#
Legal impacts	Impacts on legal and regulatory framework	Induced regulation procedure changes	✓	#
Technological success	Performance	Response time	✓	+
		Accuracy	✓	+
		Data updating delay	✓	
	Reliability	Failure rate	✓	+

✓ marks the selected indicators in SP5's suggested scheme, and ✓✓ are the core SP5 indicators. For the Heathrow demonstration + marks the most relevant indicators for the Pilot, but # marks those relevant to w ider application

Economic: It has been noted above that the purpose of the Pilot system is to prove the concept of PRT, and to provide a firm measure of its performance, reliability and costs. The Pilot system cannot be economically justified in its own right. Consequently a full socio-economic evaluation is not appropriate. Nevertheless, it is useful to identify the main components of such an evaluation, because they can provide a more refined ex ante justification for an extended system and for other applications. The effects on employment are not very relevant here, though general staffing levels will feed into the cost estimates. Passenger benefits will be estimated, and Net Present Value and Internal Rate of Return, and other measures of economic efficiency, calculated. The airport is a commercial operation, and will use different discount rates and measures from those appropriate to a public investment, but although measures of passenger benefit do not accrue directly to the commercial return, they provide an indication of how much passengers would be willing to pay for the improved quality of service.

Legal impacts: There are various legal and planning implications which have already been addressed for the Pilot system. These provide experience in developing new applications of PRT, and will be reported.

Technological success: These are all measures of the technical performance of the system judged against its design criteria. They will be extracted from the daily logs of service operation, together with various other measures of system performance. Their main use is likely to be to explain the reasons for problems in operation, since the overall measure of system performance will lie in the mean and variation in passenger waiting times and journey times.

The ex post evaluation must, however, be flexible in response to experience of actually operating the system. Some measures may gain importance, some may lose it, and new measures may be added. Similarly, the recommendations for evaluation flowing from SP5 may change as the Sub Project proceeds. For the present, the above provides a logical and comprehensive framework for the process, and will be used as the basis for data collection when the system is in operation from late 2008 throughout 2009.

7 Summary

This Report builds on the recommended Framework for Evaluation of the CityMobil Demonstrations proposed in Deliverable 5.1.1, to identify the main indicators to be used in the ex post evaluation of the Heathrow Personal Rapid Transport Demonstration. BAA's purpose in building the Pilot System, which provides a shuttle loop between a business car park and the new Terminal 5, is to prove the concept of PRT. If the demonstration provides a good and reliable quality of service, passenger satisfaction, and acceptable capital and operating costs, it is BAA's intention to expand the system into a comprehensive network serving the whole north side of the airport and, via the access tunnel, Terminals 1, 2 and 3 in the Central Terminal Area. The Pilot system is not intended to be economically justified in its own right, and so the ex post evaluation will focus on the technical operation of the system, passenger satisfaction, and the costs, but additional data relevant to a wider socio-economic assessment will also be collected to inform the financial and economic justification for expanding the Pilot system, and for applications elsewhere. Table 1 of the Report lists the indicators which are considered to be relevant, either directly or indirectly, to an ex post evaluation, and discusses their definition and use.

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