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Towards advanced transport for the urban environment

Comparison of the ULTra PRT system with the existing bus service from the passenger and operator viewpoints

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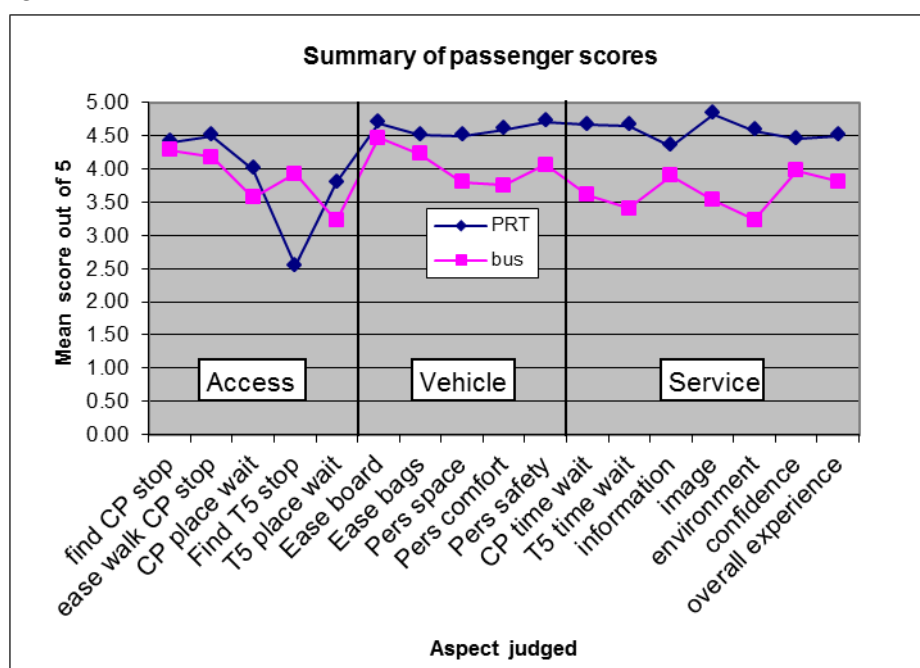
Executive Summary

The CityMobil project includes three demonstrations of advanced transport systems. One is a pilot installation of **Personal Rapid Transport (PRT) at the new Terminal 5 of London's Heathrow Airport**. This small system provides a shuttle service between a business car park and the Terminal. BAA's purpose in building it was to **prove the concept of PRT** as a means of transporting passengers around Heathrow. If the demonstration provides a good and reliable quality of service, high passenger satisfaction, and acceptable capital and operating costs, BAA will consider whether to extend the network.

Central to the **CityMobil** project is a comprehensive evaluation of the demonstrators, and for the Heathrow system an extrapolation of the results to **a general assessment of the use of PRT in a variety of applications**. In order to do this, it is necessary to judge the benefits and costs of PRT in comparison with alternative transport systems. At present, Heathrow Airport relies on bus services to transport passengers between the various car parks and the Terminal buildings, and also to link the different Terminals, car hire centres, hotels, staff workplaces, and various other centres of activity. In a fully-developed PRT network, many of these bus services could be replaced by PRT. Terminal 5 at Heathrow has been operating since spring 2008. Until the PRT service between the T5 Business Car Park and Terminal 5 began operation in April 2011 the car park was served by a transfer bus service. In this Report passenger attitudes to PRT are compared with passengers' views of the previous bus service. **Deliverable 1.2.5.1** discusses the wider application of PRT.

Surveys: The transfer bus passengers from the Business Car Park to Terminal 5 were surveyed in March 2009, and 304 completed returns were collected. PRT passengers were surveyed in May 2011, and 314 returns were collected. Both questionnaires asked exactly the same questions. Passengers were asked to score 17 aspects of the services on a 5-point scale, with 1= very poor to 5 = excellent.

Results from comparison of PRT and bus scores: On all except one aspect PRT outscored the bus service by substantial and statistically-significant margins, as the figure below shows.



Here the PRT scores have been adjusted downwards slightly to allow for the effect of better weather during the PRT survey than the bus survey: a consistent effect of weather was seen in both surveys.

The PRT service gains a very low mark for “ease of finding the T5 station”. This was because at the time of the survey direction signs to the station had not yet been fixed in the Arrivals Hall (they were in place shortly afterwards), and passengers were annoyed at having to ask. The out-of-the-way location of the station, in the short-term multi-storey car park, underscores the fact that this system is a pilot. In a wider and fully-integrated system stations could be brought within Terminal buildings, since PRT is quiet and emissions-free. Indeed, this limited pilot cannot demonstrate other wider benefits of PRT, since a larger network would allow passengers to go anywhere on the network without intermediate stops or interchange, whereas this system is only a shuttle between two areas.

On all other aspects PRT scored much better than bus, even on those aspects such as walking to the car park station where in fact the distance is slightly longer than for bus. The first five aspects in the chart above are aspects of access to the service, and are not intrinsic to PRT itself. **For the 12 aspects of the PRT vehicle and the service PRT provides, the mean score was 4.58 ± 0.04 , compared with 3.82 ± 0.05 for the transfer buses** (weather adjusted). The gap in scores between PRT and bus are highly statistically significant. As would be expected the highest score was for the **image** of the PRT service, at 4.83 ± 0.03 , but it is extremely encouraging that the second highest score was for “**personal safety**”, at 4.71 ± 0.03 compared with 4.06 ± 0.05 for bus. This is for a totally new mode of transport, without a driver, and on track which is elevated by several metres over most of its length. PRT also scored highly, at 4.57 ± 0.04 compared with 3.23 ± 0.06 for bus, for being “**environmentally friendly**”. Especially high scores were also given for the very low waiting times, whether in the car park or at T5, as well they might with average waiting times of less than a third of a minute.

Twitter: That passengers thought highly of PRT was also emphasised by the large number of spontaneous and enthusiastic remarks posted on “Twitter”. These are available at <http://twitter.com/#!/ULTraPRT/>.

Questions specific to PRT: Two additional questions were added at the end of the PRT survey, so as not to influence the marking of the previous questions. Passengers who had experienced both transfer bus and PRT were asked which they preferred: 95% preferred PRT to bus, 5% were indifferent, and none preferred bus to PRT. Passengers were also asked how much they would be prepared to pay for an urban PRT service, but their responses were clearly constrained by concern that enthusiasm here might lead to higher charges in the car park, since 28 said less than for bus, even though no-one preferred bus to PRT. Of the rest, 45% said the same as for bus, 40% said more than for bus but not so much as for a taxi, 7% said the same as for a taxi, and 8% were enthusiastic enough to offer more than for a taxi. Ultimately people are likely to be willing to pay what the service is worth to them in time and convenience, which is more than for bus but probably less than for a taxi.

Views of the Owner and Operator:

Views on the service were sought from the owner, BAA, and from the developer and operator, ULTra PRT Ltd.

BAA consider reliability the prime requirement for a transport system, and opted for PRT because airport roads were at capacity and PRT could not only provide passenger capacity

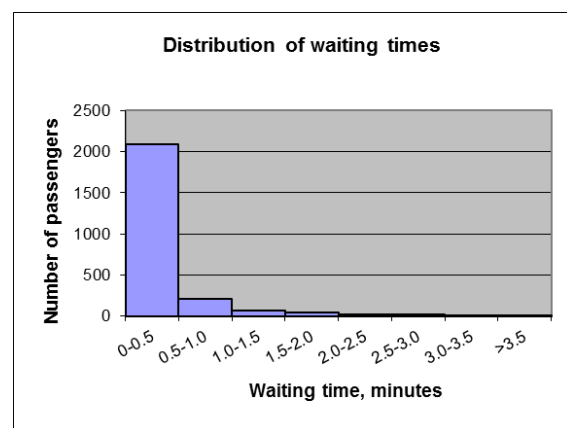
without taking up road-space, but it could make maximum use of space through the tunnel into the Central Terminal Area. At no time, during construction or operation, has it interfered with the day-to-day operation of the airport. The high level of on-demand service, with little waiting, is a big attraction, as is the ability to take the service directly into buildings. Early feedback from passengers has been overwhelmingly positive, and there has been an increase in the numbers of flyers using the T5 Business Car Park. The T5 system is small, as befits a first trial, but it has negotiated successfully a wide range of airport topography, and demonstrated that it could be installed in any airport. BAA has insisted on an extended commissioning system to ensure high reliability from the start of public operations. BAA are pleased with ULTra’s operation, but they will be constantly looking for ways to improve it.

ULTra PRT Ltd note that the main difference from operating conventional public transport is the lack of a schedule, and direct interaction with passengers from central control. It is essential to understand how the system will respond in each situation, such as meeting the needs of passengers at busy and quiet times of the day, and ensuring vehicles are in place and ready to go when needed. The most critical aspects for good performance of the system are vehicle management and service recovery in case of any faults on the system. In making the system reliable, the most problematic aspects have been the operation of the bay and vehicle doors, a difficulty fairly common in other public transport. It is important to learn from passengers: for example, there were some complaints from passengers hitting their heads on the top of the vehicle door-frame, so a message was added to the alighting instruction. ULTra PRT has been under development from 1995, but it has taken a long time to achieve the first installation because clients have to invest huge amounts of money, time, resources, faith and their reputation on something that has no proven track record, and most potential clients are risk adverse.

Operating characteristics of PRT:

Waiting time: In the survey passengers marked the waiting time very highly for PRT. This marking was consistently good at both T5 and the car park, at 4.66 ± 0.04 for both (weather adjusted), compared with 3.41 ± 0.07 and 3.61 ± 0.07 respectively for bus. The high score for PRT reflects the very low average wait time, at 19 seconds, with a standard deviation of 30 seconds. Waiting times were estimated from the measured time from the passenger pressing the touch-screen to call the vehicle to the time the vehicle moved off, and then subtracting 15 seconds to allow for the passenger to board the vehicle and doors to close. In fact, 70% of passengers took 30 seconds or less from call to first movement. For most of them the vehicle would have been in the station when they arrived, but some would have taken longer than normal to press the “doors close” and “start” buttons: almost all the passengers were using the system for the first time, and would not be familiar with the start sequence.

Some passengers did have to wait for a vehicle to be directed to their berth, however. Only 6% had to wait for more than a minute, and during the three days of the survey the longest wait was 5.8 minutes. The Figure shows the distribution of waiting times.



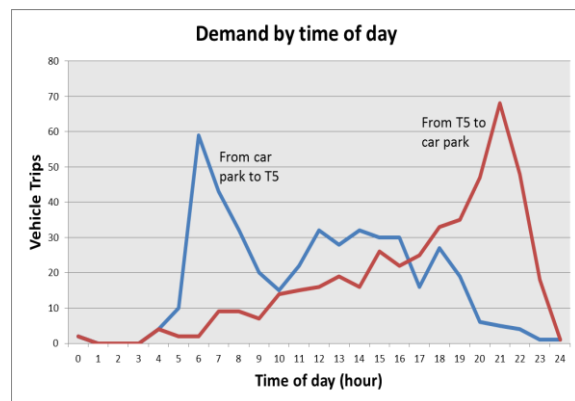
Other delays: As with other transport systems, there can also be delays in transit. Normally, with the PRT system these arise because a vehicle does not have an empty station berth to run into, and has to wait while either a loaded vehicle leaves or an empty vehicle occupying a berth is “pushed” out to run to another station or onto a stand. The mean additional delay during the survey days was 24 seconds beyond the programmed uninterrupted run times.

Run times:

from car park station A to T5	5m 10s	from station B to T5	4m 55s
from T5 to station A	4m 41s	from T5 to station B	4m 58s

Daily statistics: Demand is quite peaky, as the Figure shows. This necessitates quite a lot of empty vehicles running back to the car park stations in the morning peak, and to T5 in the evening peak.

loaded vehicle	trips per day:	817
passenger	trips per day:	1,062
passenger-km	per day:	1,592
Loaded vehicle-km	per day	1,179
Empty vehicle-km	per day	1,057



Service reliability: All stations were available (to request journeys to and from T5) for 99.7% of the time over the time of the survey. On a few other days there have been longer delays, and this has reduced the overall reliability slightly to 98.7% over the period of full-day operation from May 7th to June 12th. However, operation is still on a learning curve, and delays will become rarer.

Acceptance by disabled people: The Heathrow vehicles have level and easy access for wheelchairs. The prototype vehicles were audited for accessibility by disabled people generally and found to be superior to conventional public transport.

Energy requirements: Primary energy use by the vehicles (ie energy input to the electricity generating station which charges the PRT’s batteries) has been measured at 0.31MJ per loaded veh-km, excluding power for heating or air conditioning. This equates to 1.1MJ per passenger-km. This is substantially more than the 0.55MJ per passenger-km estimated for the prototype ULTra vehicles. In part, this is because the prototype estimate referred to a slightly higher occupancy and a more efficient management of empty vehicles than is possible with this limited network. These are the conditions which would apply to a wider network serving the airport, and under these wider network assumptions the energy use per passenger-km would be reduced to 0.91MJ. The difference between this and the prototype vehicle estimates arises because the Heathrow vehicles are larger and heavier than the prototype vehicles, but this is still only about three quarters of average energy use by rail or bus public transport.

Emissions: The vehicles are non-emitting on site, and could if required be taken into buildings to run close to check-in desks and passenger arrivals. They are also very quiet, with full-speed noise levels at 2.5m from the guideway less than 50dBA (L_{eq}). Carbon dioxide emissions at the power station are important globally, but PRT emits only about half the CO₂ per passenger-km emitted by the previous transfer buses.

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Comparison of the ULTra PRT system with the existing bus service from the passenger and operator viewpoints

1 Introduction

The objective of the CityMobil project is to achieve a more effective organisation of urban transport, resulting in a more rational use of motorised traffic with less congestion and pollution, safer driving, a higher quality of living and an enhanced integration with spatial development. Its focus is on automated vehicles, whether operating on general-purpose roads or in segregated systems. Amongst a wide range of sub-projects, it contains three large-scale demonstrations: a Personal Rapid Transit (PRT) system at Heathrow Airport in the UK, an automatically-guided bus system at Castellón in Spain, and a low-speed cybercar shuttle in the car park of an Exhibition Centre in Rome. These demonstrators are intended to supply proof of concept of innovative transport systems integrated into the urban environment.

The pilot installation of PRT serves a Business Car Park and links it to the new Terminal 5 of London's Heathrow Airport. The airport's owners, BAA, constructed the system to prove the concept. It opened to public use in April 2011. Once PRT is shown to work successfully, BAA will consider whether to extend the network. The pilot system is essentially a shuttle system, and cannot fully demonstrate the advantages of PRT as a network where passengers can travel directly from any point to any other point on the network, without intermediate stops, and with little or no waiting. Nevertheless it demonstrates the technical operation and reliability of the system, and its suitability for wider application. Thus it is not intended that the Pilot Scheme will of itself be economically justified, but it is intended to be the forerunner of a wider 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. Experience of the construction and operation of this Pilot provides a basis for judging the merits of future applications of PRT.

Evaluation is an important part of the whole CityMobil Project, and is addressed separately in Sub Project SP5. For the Heathrow Demonstrator, the PRT system will be judged against the alternative conventional transport, in this case a transfer bus service. At present, Heathrow's other car parks are served by buses, as are inter-Terminal connections, car hire, hotels, staff workplaces, and a range of other activity centres. The evaluation needs to assess the suitability of PRT for this wide range of tasks. It has been done here, and in Deliverable 1.2.5.1 which addresses the wider application of PRT, in a way which is consistent with the recommendations of SP5.

In **Section 2** this Report describes the shuttle bus system, and **Section 3** describes the passenger surveys which were made for the transfer buses in March 2009, and for the PRT system in May 2011. The results of each survey are discussed in detail in Deliverables 1.2.4.1, for the buses, and Deliverable 1.2.4.2, for PRT. This Report compares the results of the two surveys in **Section 4**, to see how passengers view the two modes of transport. **Section 5** considers the views of the PRT system's owner and operator.

Section 6 summarises the PRT operating statistics for the period covered by the survey. **Annexes** contain the passenger questionnaires, graphs of the distribution of passenger scores for the various aspects of the service, a selection of “Twitter” comments, and a Table of operational indicators as recommended in SP5, and in the earlier Deliverable 1.2.3.1.

2 The Heathrow Pilot PRT Scheme

The Heathrow Airport Pilot PRT Scheme was commissioned and financed by the airport owner BAA, now part of the Ferrovial Group, following an extended period of analysis of alternatives to provide the key landside passenger 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, and decided to construct the world’s first fully-operational PRT system on a pilot basis, with the intention of extending it to the whole northside of the airport if it were successful.

The scheme carries passengers arriving at the Business Car Park to the new Terminal 5 Building, which opened in March 2008. It has 3.8 kms of dedicated guideway, collecting passengers from two two-berth stations in the car park, transporting them along an elevated dual-guideway mainline section which skirts the perimeter of the airport, and terminating in a four-berth station on the third floor of the multi-storey short-term car park alongside the Terminal 5 Building, as shown in Figure 2.1, which also shows the route of the transfer buses which preceded the PRT system.

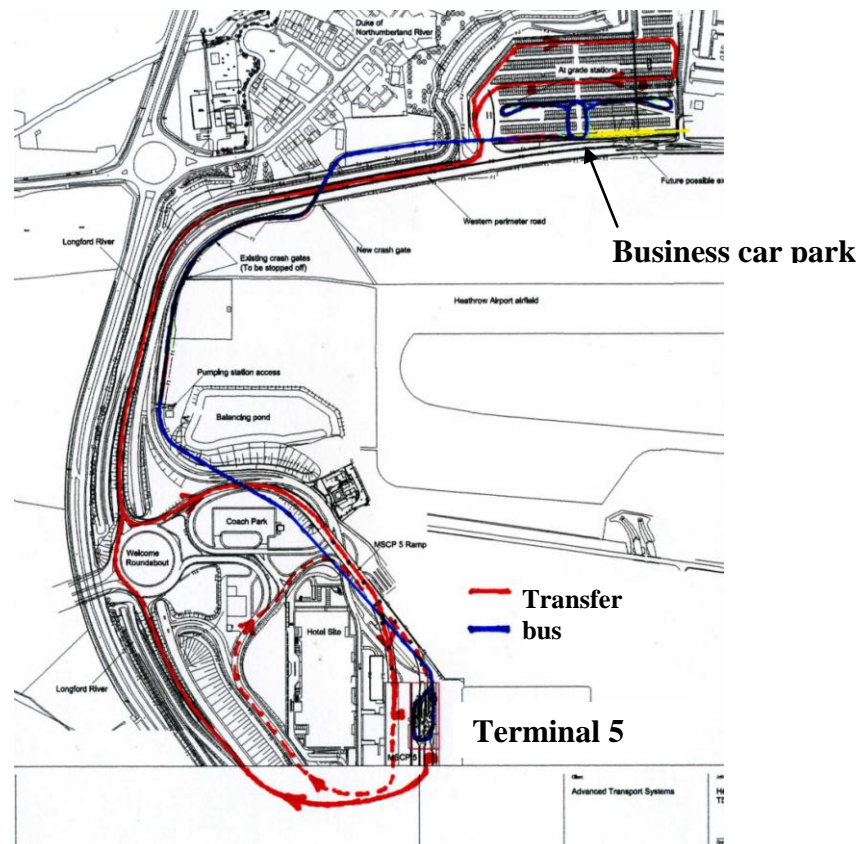


Figure 2.1. Routes of the Bus and PRT services between the Business Car Park and Terminal 5

The system is served by 21 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. **It is important to understand that, because the PRT system is a pilot to demonstrate proof of concept, some aspects of its location are unavoidably sub-optimal. Had the system been designed as an integral element of the airport the Terminal 5 stations would have been installed closer to the Terminal building itself, either within the building (the PRT vehicles are battery electric and produce no exhaust emissions and very little noise) or placed along the exterior wall of the building. For the pilot scheme, which was constructed after Terminal 5 opened, the easiest place to locate the PRT station without disrupting the operation of the Terminal building was on the second floor of the multi-storey car park, at a level intermediate between the Departure and Arrival levels. Thus passengers have to use lifts or escalators, cross a bridge and walk along one side of the multi-storey car park. In this after-fit access to and from PRT is substantially worse than to or from the buses.**

The route taken by PRT parallels that used by the previous transfer buses but only takes about 5 minutes, compared with a typical 5-10 minutes for the bus (which has to stop at two stops and then negotiate several busy roads). In addition, the return bus journey detours around the multi-storey car park, adding a further minute to that journey, and bus passengers had a mean waiting time of 5.2 minutes, compared with only 0.3 minutes for PRT.

By bus, the typical time (with no congestion) from the car park to the Departures level of Terminal 5 was 4.9 minutes. The return journey, from the Arrivals level, took 6 minutes since it involved a detour around the short-term multistorey car park. Except in the small hours of the morning, the bus services were provided by two midi-buses operating on a nominally eight to ten minute frequency, but they were not scheduled and in normal operation they could provide a service which was more typically seven or eight minutes. There were occasional hiatuses in the service, however, when one bus was unavailable for short periods, and on such occasions intervals could become as high as twenty minutes or more. The mean interval between buses as obtained from the barrier lift timings was 8.9 ± 1.2 minutes, corresponding to a mean waiting time of 5.2 minutes for randomly (Poisson) arriving passengers.

Personal Rapid Transit has an average journey time of 5 minutes from T5 to Business car park, and just under 5 minutes return. The service normally provides a vehicle waiting in each station, and except at times when larger groups of passengers arrive at the same time, and a vehicle has to be called up, there is no waiting. The average waiting time for the PRT service during the passenger survey was 0.3 minutes, and only 6% of passengers waited more than one minute.

Figure 2.2 shows the transfer bus, while Figures 2.3 to 2.7 show aspects of the PRT service in operation.



Figure 2.2 The transfer bus



Figure 2.3 Car park station A and depot



Figure 2.4 Touch screen at car park station



Figure 2.5 Vehicles in transit



Figure 2.6 Terminal 5 station



Figure 2.7 Inside the vehicle

3 The surveys

The **survey of the transit bus passengers** was carried out between March 13-26th 2009. Survey supervisors met passengers boarding the buses at Terminal 5 and asked if they would complete a questionnaire while en route to the Business Car Park. The supervisors were able to travel on the bus and offer assistance if needed, and collected the completed questionnaires as passengers alighted. The questionnaire was of the tick-box type, covering in 24 questions a range of aspects of the journey and car park, and of the passenger's own details. For most aspects of the journey the passenger was asked to rate the experience on a scale of 1 to 5, with 1 corresponding to "extremely poor" and 5 to "excellent". The survey collected 304 completed returns. This sample size was estimated to provide a standard deviation on the mean score of better than ± 0.1 .

The **survey of PRT passengers** was carried out between May 18 to 20th 2011. In this case supervisors could not travel with passengers in the small vehicles, and so they met passengers at the Terminal 5 station, introduced the reasons for the survey, and asked passengers to complete the questionnaire during the journey to the car park, where completed forms were collected. Supervisors could provide assistance if required at both ends of the journey. The questionnaire was exactly the same as for the transfer bus passengers, except that two questions were added at the end. These asked for the passengers' views on the relative performance of bus and PRT, and about their willingness to pay for an urban PRT service in their own town. The questions were answered at the end of the form in order not to influence answers to the same questions asked of the bus passengers. The survey collected 314 completed returns.

Both questionnaires are appended at Annexe A.

4 Comparison of Passenger Scores for the PRT and Transfer Bus Services

4.1 The respondents

The survey asked the purpose of the passenger's journey, the gender, and how many times the passenger had used the T5 Business Car park in the past year. There were minor differences between the Transfer Bus and PRT samples:

gender: 12% of PRT passengers were female, compared with 15% of bus passengers. Differences between male and female passengers were examined, and for bus passengers they were on the margin of statistical significance in relation to comfort within the vehicle, waiting times, and overall experience, but in each case women gave a higher score than men so had there been fewer women in the bus survey the bus scores would have been very slightly lower.

journey purpose: 98% of the PRT passengers were travelling on business, compared with 96% of the transfer bus passengers. For bus the non-business passengers tended to rate

aspects of the bus service slightly lower than business passengers, while non-business PRT passengers tended to rate it slightly more highly, but the numbers of non-business passengers are far too small either to affect the overall averages or to support evidence of different perceptions between business and non-business passengers.

frequency of use: 38% of bus passengers had used the T5 car park only once or twice in the past year, compared with 41% of PRT passengers. 20% of bus passengers had used the car park more than 15 times, compared with 25% of PRT passengers, but in fact the car park had been open rather less than a year when the bus survey was made, so these proportions are very comparable.

weather: passengers were also asked to rate the weather at the time of their trip on a five-point scale, and the weather during the bus survey was significantly worse, with an average score of 3.61, than during the PRT survey, when the mean score was 4.14. It seems that weather has an effect on passengers' perceptions not only in relation to activities such as walking or waiting, where weather can make the activity more or less comfortable, but in relation to perceptions overall, where good weather makes passengers feel better about everything. This is discussed in Section 4.7, where adjustments are made to the scoring to allow for this effect.

4.2 Access to the transport services

A number of the questions were directed at access to the bus or PRT services at each end of the route. These aspects are not fundamentally aspects of the transport mode itself, but they are important to the passengers' perceptions of the service overall, and in some aspects the nature of the mode constrains the access.

The Business Car Park

The T5 Business Car Park is an open-air car park situated next to the airport perimeter road. Prior to the PRT system, transfer buses entered through an automatic barrier from the perimeter road, and made a loop around the car park using two of the corridors between the parking spaces. There were two standard glass-enclosed bus shelters on one of the main east-west corridors, evident to passengers by flags above the roofs of the shelters. Passengers parked and walked to the nearest bus stop, though the bus drivers were often willing to pick people up, and especially to drop people off, as they passed. This was convenient to the passengers involved, but added a small delay to any passengers on board.



Figure 4.1 PRT Station “A”

PRT must necessarily place its stations on the perimeter of the car park, since the guideways are segregated, unless it is decided to use an elevated guideway above the car park, which entails additional cost. At Heathrow, the two stations are situated in the two corners of the car park alongside the perimeter road. The two stations are intended by BAA to make a statement, and as Figure 4.1 shows their architecture is iconic.

The survey asked passengers to score three aspects of the **car park**:

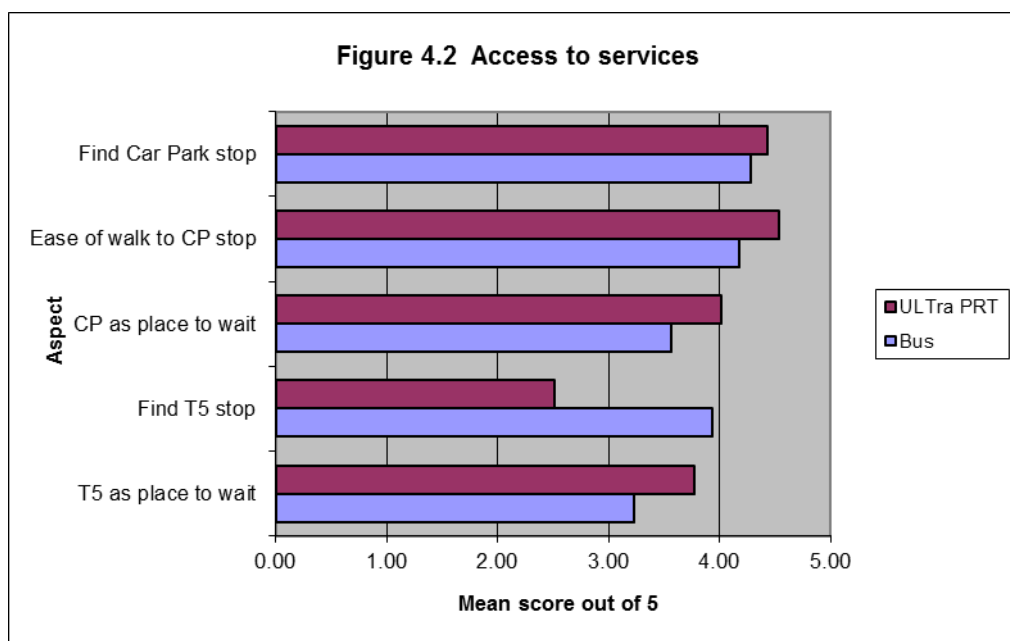
“Ease of finding the PRT station in this Car Park?”
“Ease of walking to the station from your car?”
“The station in this Car Park as a place to wait?”

The average scores obtained are summarised in the top section of Figure 4.2. In all cases the scores achieved by the PRT system are greater than those for the bus system, and the differences are statistically significant. Annex 2 illustrates the distribution of scores for all questions in the survey, and gives the mean scores and the standard deviation on the means, and the statistical t value on the difference between bus and PRT.

The PRT station is scored as being slightly **easier to find** than the bus stops (4.44 cf 4.28), and given the large and spectacular nature of the PRT stations this is understandable, though neither bus stops nor stations can be hard to find. 18 passengers scored ease of finding the PRT station at 1 or 2 only, and it may be that some passengers found it hard to believe that the station buildings were actually intended for transit.

Curiously, **ease of access** was scored more highly for the PRT stations than for the bus stops (4.54 cf 4.18), despite the fact that, on average, and especially with a full car park, the mean distance to the stations is slightly longer than to the stops, adding perhaps 20 metres. But as we shall see, this higher scoring for PRT extends across all aspects, and is in some part a result of passengers’ overall preference for PRT. The higher scoring for the PRT passengers’ walk is not a result of the **better weather** during the PRT survey. Adjustment for this factor reduces the PRT score from 4.54 to 4.51, compared with the bus score of 4.18, with standard deviations on the mean of ± 0.04 .

The PRT stations were also scored as being better **places to wait** (4.02 cf 3.57), though both stops and stations were considered perfectly acceptable. Given the more substantial nature of the stations it is perhaps surprising that they did not score even higher, but it is also the case that everyone is familiar with a bus stop, and nothing more is required than to get on a bus, whereas PRT passengers were asked to select a destination on a touch-screen by the PRT doors. This is a trivial task here, but in a large PRT network passengers will be asked to select from a list of destinations.



Terminal 5 access

Passengers were asked to score two aspects of access at the Terminal 5 end:

“Ease of finding the PRT station at Terminal 5?”

“The station at Terminal 5 as a place to wait?”

The scores are shown in Figure 2, where it is clear that passengers did not find it easy to reach the station. The arrangements for accessing the bus and PRT were necessarily very different. The bus service dropped car park users on the Departures level of Terminal 5, on the top level of the short-term multi-storey car park. From there, passengers walked across a level bridge into the Terminal building. Returning passengers were picked up on the ground floor of the Terminal building at the Arrivals level of T5, out on the road which runs underneath the multi-storey car park. This is very convenient for passenger access, though the Departures stop is dark and draughty and not pleasant for waiting, and having the stops on different levels adds about a minute to the return bus journey time.

The PRT station at T5 is on the second floor of the multi-storey car park alongside the Terminal building. Reaching it involves taking escalators or lifts from Arrivals or from Departures to this middle floor, crossing a bridge and walking about 50 metres to the station. The station is clean and modern (Figure 4.2b), but the car park roof is low and the station is necessarily tucked away in a side area of the car park. This is not the easiest arrangement for passengers, but it was the easiest location for insertion of the station once Terminal 5 was largely complete. Installing a permanent PRT network into the airport in an integral way will probably see PRT stations constructed inside the terminal buildings, since with zero emissions and little noise the vehicles will be perfectly acceptable close to passengers.



Figure 4.2b The T5 station

Thus the T5 PRT station is not in a very convenient location, but it was also the case that, at the time of the survey, signs indicating where to find the station had not yet been installed. Consequently, many passengers had to ask where it was. The very low score for “finding the station” reflects this, and is substantially lower than the score for the bus stop, which was adequately marked. The mean score of 2.51 ± 0.09 for PRT rates as “poor”, while 3.93 ± 0.06 for bus is at the “satisfactory” level verging on “good”. The direction signs were installed shortly after the survey.

Scoring of the stop and station as a place to wait reflects the very different ambience of the two sites, and the PRT station is clearly regarded as a more acceptable place to wait (3.78 cf 3.23). In practice, most passengers for PRT do not have to wait at all, while the waiting time for bus could be several minutes, so assessment of the location as a place to wait is much more important for bus than for PRT. Even so, the score for the PRT T5 station is lower than for other aspects of PRT and it may be that the dissatisfaction with finding it also influences passenger attitudes towards the station itself.

4.3 The vehicles and service

There were seven questions about the vehicles, which passengers were asked to score out of 5. These were:

Ease of boarding the vehicle?

Ease of storing your baggage once on board?

Amount of personal space in the vehicle?

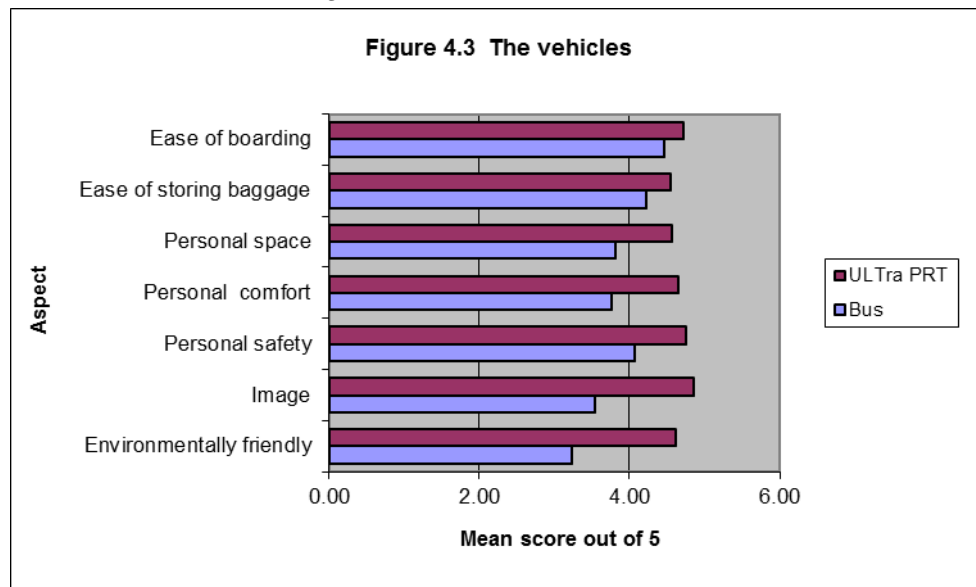
Personal comfort whilst in the vehicle?

Personal safety whilst in the vehicle?

The PRT vehicle (the “pod”) in terms of having a modern image for the airport?

The vehicle for being environmentally friendly?

Figure 4.3 summarises the average scores for bus and PRT.



In all aspects PRT outscored bus, by margins which were extremely statistically significant. The differences were relatively modest for **ease of boarding** (4.71 ± 0.03 cf 4.47 ± 0.04), where bus passengers had to step up into the vehicle while PRT passengers had to bend slightly to board, and **ease of storing baggage** (4.55 ± 0.04 cf 4.22 ± 0.04), where bus passengers had a multi-level rack to take baggage while PRT passengers merely put it on the floor between the seats. For the other aspects the margins were large.

This is especially encouraging in relation to **personal safety** (4.75 ± 0.03 cf 4.06 ± 0.05), since PRT is a mode which passengers had never encountered before, the vehicle had no driver, and much of the guideway was elevated at substantial heights. This marking is second only to that for “image”.

Personal space (4.57 ± 0.04 cf 3.81 ± 0.06) and **personal comfort** (4.64 ± 0.03 cf 3.76 ± 0.05) are also perceived to be good in what is a small vehicle. The arrangement is of course rather similar to a car, and the familiarity perhaps translates across. The maximum gradients used are conservative in order not to make passengers feel uncomfortable, but on the basis of these scores it may be practicable to use higher gradients.

The high mark for **image** (4.85 ± 0.03 cf 3.54 ± 0.06) is expected, although despite its appearance as something out of the future in reality the vehicle itself is based on tried-and-tested automotive engineering, and makes use of relatively cheap automotive components.

PRT also gains very high marks for its **environmental friendliness** (4.62 ± 0.04 cf 3.23 ± 0.06), in spite of most passengers not knowing anything of its power requirements or power source, or net emissions. But passengers can see that it is quiet and clean, and there are no obvious emissions. In particular, it is clearly not powered by an internal combustion engine, and gains credit for this.

4.4 The service generally

Finally, passengers were asked to score aspects of the service

The information about using the system as being easy to understand?

The amount of time you had to wait at the Terminal 5 station?

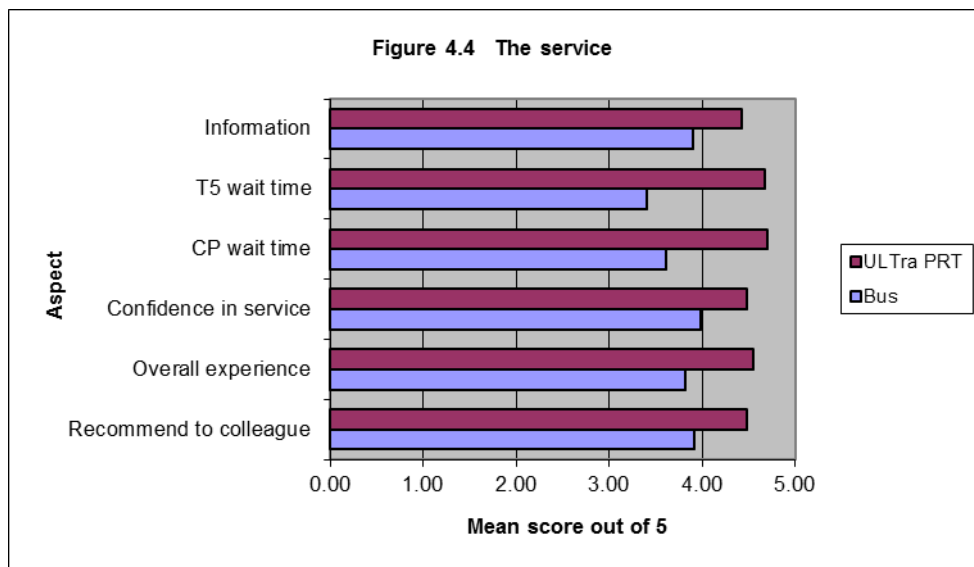
The amount of time you had to wait at the car park station?

Your degree of confidence in the PRT system as a means of travelling between the Car Park and the Terminal?

Your overall experience of the PRT system?

How likely would you be to recommend using this Car Park to a friend or colleague?

Figure 4.4 summarises the scores for PRT and bus. The question about recommending the car park to a friend or colleague was scored out of 10, but scores have been halved here for easy comparison.



Information about the service is clearly more important for PRT than for the transfer bus, since this is a completely new mode to the users. It is encouraging that passengers actually rated information more highly for PRT than for bus (4.42 ± 0.05 cf 3.89 ± 0.05), though this may be because the bus information merely told passengers that buses would run every ten minutes throughout the day, and passengers were unsure exactly when one would come,

whereas most PRT passengers saw that there was a vehicle waiting for them. Of course, calling the vehicle via the touch-pad was very simple since at Terminal 5 there were only two stations to choose from, and only one at the car park. A fully-developed PRT system will have many possible destinations, but nevertheless the system will remain very simple to use.

Waiting time is one of PRT's great strengths, and it is to be expected that it will score much more highly for PRT than for bus (4.68 ± 0.04 cf 3.41 ± 0.07 for T5 and 4.69 ± 0.04 cf 3.61 ± 0.07 for the car park). There is consistency shown here, since the questions for T5 and the car park were separated on the questionnaire but scored almost exactly the same for PRT. The lower score for bus at T5 is also understandable, since buses spent standing time at the car park end. Relatively few PRT passengers had to wait at all, and when a vehicle was not standing in the station it rarely took more than a minute or so to call one up. In this early stage of operation the PRT empty vehicle management has still not been optimised, and this aspect of PRT will become still better. The average waiting time was 19 seconds, as shown in Section 6.1.

Passenger scoring of PRT for **confidence in service** (4.47 ± 0.04 cf 3.98 ± 0.05) is obviously based on their appreciation of the system rather than experience of reliability, since hardly any passengers can have used the service before the survey. Bus scores fairly highly in this respect, and many passengers have used the T5 transfer service, and similar bus services around Heathrow, frequently in the past and can judge their reliability. Even so, the PRT service outscores it simply because passengers are pleased with the service it has given them on this occasion. It is also likely, though, that it gains because like rail systems it has a dedicated track which gives visual promise that a vehicle will appear if it is not already there, while because buses use the common roadway there is not the same psychological implication that a bus is on its way.

The result is very similar for **overall experience**, though PRT scores slightly better and bus slightly worse (4.55 ± 0.04 cf 3.81 ± 0.05). Of course, some of this will be due to the novelty of PRT, whereas buses are familiar and tend to be disparaged. Nevertheless, this summing up of the merits of PRT over bus encompasses the reduction in waiting time, and the privacy and comfort of the vehicles, and comes despite unhappiness with the routeing information at T5. Moreover, this pilot application cannot offer the other main advantage of PRT, that passengers will be transported directly without intermediate stops or interchange, and insulated from road traffic congestion. Thus novelty will play its part in this survey, but there is robust evidence to suggest that PRT will be much more attractive to passengers than bus, and perhaps by extension than other forms of mass transit, in the long term also.

The question as to whether passengers would **recommend the car park** to friends and colleagues was originally included at BAA's request, since BAA wished to monitor the popularity of the car park for comparison with their internal quality of service studies. However, the comparison between PRT and bus in this question is very telling, with PRT scoring 8.95 ± 0.10 against 7.84 ± 0.33 for bus. This response cannot be directly interpreted in terms of likely demand for the car park, of course, but it does indicate that PRT could substantially increase demand and revenues from car parks, and this can be judged in relation to the costs involved. Thus it is not simply a question of PRT raising the image of the airport, but also of it attracting greater revenues. Indeed, BAA credits PRT with increasing demand for the Business car park (Section 5).

4.5 Passenger views of the PRT service in the digital age

The passenger surveys have been very successful in measuring passenger attitudes to both PRT and bus. Shortly after the service began public operation, however, unsolicited views from passengers began appearing on the “Twitter” website. These are uncontrolled and self-selected, of course, but they provide a very positive underpinning to the findings of the survey. Annex 3 contains a collection of these, but typical examples are:

“The pod transport system at T5 Heathrow is really impressive, bit like a flashback to the 60's vision of the future.”

“Space age pod transfer in Heathrow T5 parking is awesome!!”

“Off to Zurich for [#FIFA](#) debacle. Journey starts in my own personal pod at [#Heathrow](#). Makes the airport fun again.”

"Landed and used the very cool [#heathrowpod](#) between the terminal and car park (@ Terminal 5 w/ 12 others) [pic]:... and they're even better to use - quicker, easier and greener than the buses to/from the car park"

"On personal Heathrow Pod - parking to T5. Awesome sci-fi system."

4.6 Passenger Comparison of PRT and bus, and Willingness to Pay

In the PRT passengers survey two additional questions were asked at the end of the questionnaire. The first question was:

If you have previously used the Transfer Bus system at Heathrow, how do you rate the PRT system against the bus transfer?

Passengers were asked to tick one of four boxes, and the result was:

<i>PRT better than bus</i>	259
<i>Bus better than PRT</i>	0
<i>Neither better nor worse</i>	16
<i>Haven't used the bus</i>	14

Thus no-one thought the bus was better than PRT, though 16 passengers were not concerned whether transport was by PRT or bus.

The second question concerned passengers' willingness to pay for PRT (WTP). This is a difficult question to phrase in order to obtain unbiased results, since passengers will be concerned that they are to be asked to pay extra for the service, and will tend to undervalue the service. Because of this, the question referred to the hypothetical situation of an urban PRT service in their home town:

Suppose a PRT system were available in your home town and could take you from home into the town centre. What is the most you would you be prepared to pay to use it?

<i>Not as much as the bus fare</i>	28
<i>Much the same as the bus fare</i>	118
<i>More than bus, but less than taxi</i>	104
<i>Much the same as a taxi</i>	19
<i>More than a taxi</i>	21

Passenger concern that this question might be a basis for charging for the car park PRT service is evident in the fact that 28 passengers said they were not prepared to pay as much as for bus, even though none of these passengers thought bus better than PRT, and most

thought PRT better than bus. It seems likely that many of the passengers saying they were only willing to pay much the same as bus were actually willing to pay more but unwilling to say so in this context.

Logically, if passengers prefer PRT to bus, and it is quicker than bus, they will be willing to pay more than for bus. It is unlikely that they will be willing to pay as much as for a taxi, or more than a taxi, despite the returns above, since PRT requires a walk access while taxi can pick passengers up from home, though often after a substantial wait. Indeed, in the European EDICT project (EDICT 2004), most passengers riding on the ULtra prototype PRT system at the Test Track in Cardiff said that they would, on average, be willing to pay more for bus but less than for a taxi. Ultimately people are likely to be willing to pay what the service is worth to them in time and convenience, which is more than for bus but probably less than for a taxi.

4.7 Summary of passenger survey comparison

Table 1 summarises the average scores given in the PRT and transfer bus passenger surveys for each aspect, the standard deviations on the means, the differences between the scores for PRT and bus, and the “t” values on these differences. The distributions of the scores are discreet and non-normal, so interpretation of the “t” values is not the same as for a normal distribution, but the values are so large that it is clear that every difference between the mean scores for PRT and bus is highly statistically significant.

Table 1 Summary of survey scores

Question	BUS		PRT		comparison of two samples	
	Avge	SD mean	Avge	SD mean	diff between averages	"t"
Frequency of use	4.04	0.644	6.82	0.536	2.78	3.3
Find Car Park stop	4.28	0.045	4.44	0.054	0.15	2.2
Ease of walk to CP stop	4.18	0.042	4.54	0.037	0.36	6.3
CP as place to wait	3.57	0.054	4.02	0.053	0.45	6.0
CP wait time	3.61	0.066	4.69	0.035	1.09	14.7
Find T5 stop	3.93	0.057	2.51	0.086	-1.42	-13.8
T5 as place to wait	3.23	0.060	3.78	0.060	0.55	6.5
T5 wait time	3.41	0.068	4.68	0.042	1.27	15.8
Ease of boarding	4.47	0.039	4.71	0.032	0.25	4.9
Ease of storing baggage	4.22	0.044	4.55	0.039	0.32	5.5
Personal space	3.81	0.057	4.57	0.039	0.76	11.1
Personal comfort	3.76	0.050	4.64	0.034	0.89	14.7
Personal safety	4.06	0.048	4.75	0.027	0.69	12.5
Information	3.89	0.046	4.42	0.046	0.53	8.1
Image	3.54	0.056	4.85	0.026	1.31	21.2
Environmentally friendly	3.23	0.055	4.62	0.042	1.39	20.2
Confidence in service	3.98	0.049	4.47	0.043	0.49	7.5
Overall experience	3.81	0.048	4.55	0.036	0.74	12.3
Recommend to colleague	7.84	0.328	8.95	0.101	1.11	3.2
PRT better than bus?			1.26	0.045		
Willingness to pay			2.61	0.059	=more than bus/less than taxi	

4.8 Effect of weather

It was noted in Section 4.1 that the weather was, on average, better during the PRT passenger survey than during the bus passenger survey. In both surveys, examination of the correlation between the weather score and the scores for the various aspects of the service showed that better weather encouraged higher scores. The effect is small, but it biases the results in favour of PRT. By taking the variation of the scoring with the marking for the weather, for each aspect individually, and applying it to the PRT scores according to the mean difference on the weather scores of 4.14 for PRT and 3.61 for bus, the PRT averages are depressed, and the gap between PRT and bus is reduced. These adjustments are summarised in Table 2, where it can be seen that the adjustments are minor and all of the differences between PRT and bus remain very statistically significant. The averages across the 12 aspects of vehicle and service (including the wait times), as distinct from access, are 4.58 ± 0.04 for PRT compared with 3.82 ± 0.05 for bus.

Table 2 Adjusted scores for PRT because of better weather

	Original PRT score	weather adjustment	adjusted PRT score	Original bus score	diff between PRT and bus	adjusted t value
find CP stop	4.44	-0.04	4.40	4.28	0.12	1.65
ease of walk CP stop	4.54	-0.03	4.50	4.18	0.32	5.74
CP as place wait	4.02	-0.02	4.00	3.57	0.43	5.69
CP wait time	4.69	-0.03	4.66	3.61	1.05	14.27
Find T5 stop	2.51	0.02	2.54	3.93	-1.39	-13.53
T5 as place wait	3.78	0.01	3.79	3.23	0.57	6.65
T5 wait time	4.68	-0.02	4.66	3.41	1.25	15.60
Ease of boarding	4.71	-0.02	4.69	4.47	0.22	4.42
Ease of baggage	4.55	-0.04	4.51	4.22	0.28	4.83
Personal space	4.57	-0.07	4.49	3.81	0.69	10.08
Personal comfort	4.64	-0.04	4.60	3.76	0.84	14.00
Personal safety	4.75	-0.04	4.71	4.06	0.64	11.67
information	4.42	-0.08	4.34	3.89	0.45	6.91
image	4.84	-0.02	4.83	3.54	1.29	20.94
environment	4.62	-0.04	4.57	3.23	1.35	19.57
confidence	4.47	-0.02	4.45	3.98	0.47	7.21
overall experience	4.55	-0.06	4.50	3.81	0.68	11.41
recommendation	8.95	-0.11	8.84	7.84	1.00	2.88

5 Views from the Owner and Operator

Views were sought from BAA as the owner of the PRT system, and from ULTra PRT Ltd as the operator. Written replies were requested to a number of questions, and the replies are given in full below:

5.1 Views from BAA as Owner

(views provided on behalf of BAA by Max Vialou-Clark, Retail Services Director)

1. **What do you require from a passenger transport system to serve the airport?**

Reliability – it's also what our passengers expect, above everything else. It needs to be easy to use, available and a work-horse that can do what it's supposed to do, day after day.

2. **This is the first public PRT system in the world. Being the first to commit to a wholly new technology always involves a high degree of risk. Why was BAA prepared to take this on?**

The perimeter roads at Heathrow carry a vast number of vehicles – over 50,000 – through the tunnel to the Central Terminal Area each day, and 100,000 on the perimeter roads, including lorries, buses, coaches, minibuses, taxis and cars. This leads to traffic jams and pollution. In 2003 BAA undertook research into alternate methods of moving passengers around the airport and came to the conclusion that it needed to look beyond the usual options, as we were simply running out of road space and didn't have the capacity for a light rail system.

A PRT system was chosen as the way forward and in 2005 Ultra PRT was awarded the design and development contract for the Heathrow pod. It was a bold and exciting decision for BAA, and an acknowledgement that we needed to improve our environmental credentials.

3. **What does PRT offer the airport which conventional public transport cannot?**

The PRT system has been installed without using any land or taking out any road space. At no time, either during construction or operations, has it impacted in any way on airline operations or the building of T5. It can be put directly into a building, alongside a building or around a building (as demonstrated at T5). Because it's an on-demand service, passengers turn up to a waiting pod, programme their destination and head off – on a journey that takes 5 minutes. No more waiting for a bus. In theory, passengers should arrive at their check-in 10-15 minutes earlier than if they had taken a bus, which is good news for passengers and the airline.

4. **Many airports have made large investments in apparently technologically new transport systems – monorails, linear motors, automated people movers. In general, do you think this type of investment provides an adequate return to the airports? In particular, do you think that PRT will?**

All of these systems, when they work well, lead to a greater level of customer satisfaction – as airport research shows. It doesn't matter which airport, or where it is, passengers don't want a long hike from check-in to boarding, yet because of the operational space requirements of most airports this is often unavoidable, hence the

need for the various transport systems mentioned. Indeed, for many passengers, monorails and people movers are actually seen as an exciting part of using an airport.

Early feedback from passengers using the pods has been overwhelmingly positive, and we've seen an increase in the numbers of flyers using the T5 Business Car Park.

Return on investment (ROI) is always an interesting topic – some base it on cost per km to build/maintain/operate – others on cost per passenger. We've put the PRT in an area where the other systems you mention were not an option, so this sort of price comparison doesn't really work.

5. *The T5 system is very limited, acting as a short shuttle from car park to Terminal. Where do you see such a system connecting to in future?*

The Heathrow pod guideway goes through a car park, over two very busy roads, airport water systems, taxi ranks, airside alongside planes being loaded and unloaded and into the T5 car park. For a 1.9km route it covers most of the obstacles to be found in any airport location.

In theory, that means that any airport could implement the system, whether one already in operation or under construction – likewise in a city, workplace or campus environment. It can connect to other transport networks or to locations (internal or external), that's its benefit. The Heathrow pod service has just started passenger service, so over the next 12 months we'll be monitoring its performance and passenger feedback. It's for the BAA Board to decide what happens next.

6. *It's been quite a long haul from initial interest to a working system. What from BAA's point of view have been the most difficult aspects?*

An airport is never going to be an easy place to install any new transport system due to competing demands on space, safety issues, airline operator needs and customer expectations and all of these have had to be factored in along the way. Add this to the fact that we were creating an ambitious new system. While we took some elements of the project from existing technology (ie the pod car chassis) there were many others, such as the computer technology, that had to be specifically created, tested, changed, tested, tweaked – this takes time.

7. *You used a very long commissioning period. Why was that?*

This is a brand new and bespoke system. We wanted to make sure that the system met the needs of our users, both in terms of ease of use, comfort, reliability as well as being efficient and cost effective for us to operate and manage.

It's easy for those who've not undertaken such an untried project to criticise the length of time taken or the meticulous level of testing that we've insisted on, but we'd be foolish not to do so. So much rides on this. This is a big investment for BAA (£30m) – as a customer we are right to demand that ULTra delivers reliability day in day out and is able to demonstrate and prove that the system is robust enough to cope with the needs and demands of our business customers.

Yes, we've demanded changes - to operating systems, IT systems, design, customer care – it's what any sensible company does when it's creating something radical. Look at the key companies out there in the IT, automotive or electronics markets. Wouldn't you find it bizarre if they brought a product to market without extensive research, testing, customer feedback, or changes made? This takes time and sometimes timelines slip – but for a reason. That reason is the need to build in reliability.

8. Are you satisfied with the system's performance? In what ways do you think it could be improved?

A lot has been achieved in the last year and performance has improved dramatically. However, with a transport system there is no place for complacency. Any delays impact on customers and their opinions of the service. There will always be a need to continually look at ways of improving the service, from reliability through to how passengers are handled by the control room if they have a question, suffer a delay, leave an item on board.

For example, passenger-testing highlighted the fact that customers found the roof level quite low when exiting and were worried that they might hit their heads. We responded to this by changing the messaging on the in-car communications system, so that it warned passengers to mind their heads when exiting. It's all part of being willing to test, make changes and test again, so that it meets the needs of users.

9. How do you rate the PRT service compared with the previous transfer bus service?

The bus worked well, was cost effective and passengers were used to it.

But, it wasn't on demand, which meant passengers could be standing in the car park waiting in all weathers. You were forced to wait for other passengers to load/unload their luggage before you set off or disembarked. The bus did a tour of the car park, stopping at two bus stops before departing on its way to T5. On wet or busy days you could be held up by other road users. The PRT overcomes all of these obstacles, giving passengers an on-demand, programmable, fast and comfortable service.

10. What opportunity do you think there is to bring PRT inside airport buildings?

In theory, this is exactly what a pod system is designed to do – go into and through a building, whether at an airport, office complex or other transport location.

11. Do you think it could be useful airside as well?

This is not part of our programme. In principle it could be applied to baggage transfer, passenger transfer or staff moving – although we haven't got plans to use a PRT system in these instances at Heathrow – but other airports might want to pursue the idea.

5.2 Views from ULTra PRT Ltd, the operator

(views provided on behalf of ULTra PRT Ltd by Fraser Brown, Managing Director)

1. How does operating PRT differ from operating conventional public transport?

The main differences are:

- Managing a system that doesn't have a schedule or timetable, but that does have specific demand requirements, both from the client and passengers.
- Direct interaction with the passenger has to be via the control room, as there are no dedicated station staff or vehicle operators.
- Multi-skilling of staff to undertake control room and engineering duties rather than specialising in one particular area.

2. What are the most difficult aspects of automation to get right, or the most crucial aspects for good performance?

Operationally the most difficult areas are the understanding of the system and how it will respond in each situation, such as meeting the needs of passengers at busy and quiet times of the day. An on-demand service must do just that, so we need to ensure vehicles are in place and ready to go when needed. The most critical aspects for good performance of the system are vehicle management and service recovery in case of any faults on the system.

3. What aspects of the equipment give you the most trouble?

The bay and vehicle doors have required a number of slight adjustments in recent months, due to the (necessarily) tight tolerances involved and the associated fine-tuning that is required to ensure consistent & reliable operation, especially for items such as this which directly affect the passenger experience. This is no different to any other transport system.

4. Have you had passenger complaints? About what?

On passenger trials and start-up of the system we had two areas where passengers raised concerns:

- We had some passengers who complained of bumping their heads on exit from the vehicles. We have added an extra audio announcement now and this has significantly reduced the problem.
- The direction signing from Arrivals at Terminal 5 required updating, but this has now been done and these complaints have all but disappeared.

5. How would you organise passenger revenue if this were a revenue-generating system?

I believe the best way would be a smart card system similar to the “oyster card” system [*in London - an electronic purse*].

6. When did you first start developing PRT?

The ULTra project started in 1995.

7. Why has it taken so long to achieve the first working public system?

This was a world first and the time taken is not dissimilar to other complex system developments such as aircraft. There were some changes to the basic requirement such as precise location and communications frequency. Our customer rightly put the company under considerable pressure to provide a system which was highly reliable and which would provide the passengers with an outstanding level of service.

8. What are the most difficult problems in getting innovation accepted?

You're asking clients to invest huge amounts of money, time, resources, faith and their reputation on something that has no proven track record. Most clients or potential clients are risk adverse. To move on and to make new innovations work, we need to keep pushing them to challenge their thinking and boundaries.

9. What lessons have you learned for other automated transport systems in CityMobil?

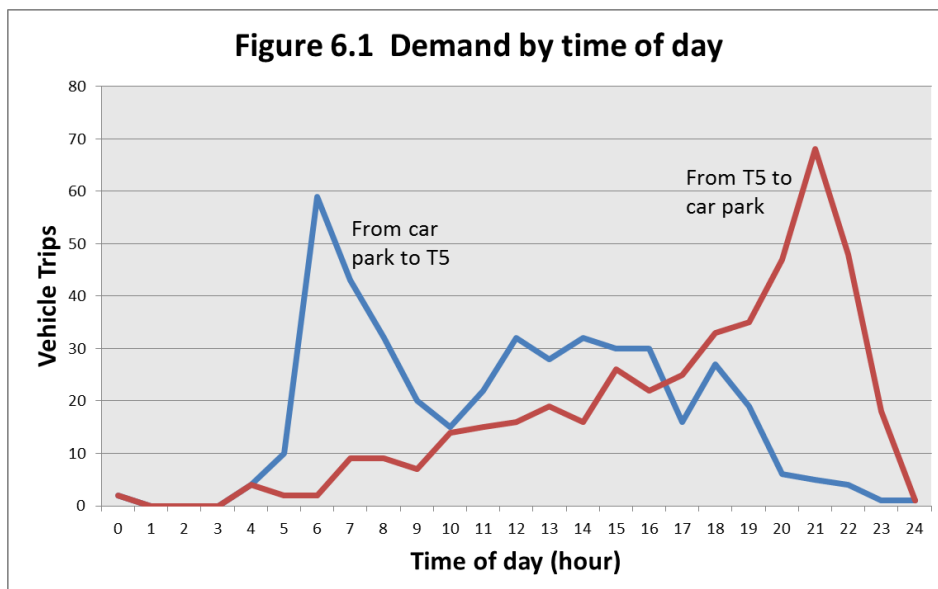
A key skill is to be able to effectively respond to client and passenger feedback – it is important to see and design a system by putting yourself in the place of customers, as well as looking at the problem as an engineer, to ensure it continues to meet with their expectations (e.g. being intuitive, responsive, straight forward and easy to use). It is important to embrace the feedback you get from clients and passenger testing, and make every effort to find a way to address their concerns.

6 Operating data

Because PRT is automatically controlled in every aspect, it readily generates very detailed operating data. This makes monitoring and assessment of its performance very easy. As far as is sensible the operating data discussed in this Section refers to the three days of the passenger survey, though where relevant reference will be made to the longer period of operation, including the pre-public operation where the system carried airport staff and visitors on a regular basis. Generally, though, the survey period was typical of the system's daily operation.

6.1 Demand pattern

There is considerable tidal flow between the T5 Business Car Park and the Terminal, as Figure 6.1 shows. Outbound trips from the car park peak between 6am and 7am, while inbound trips peak between 10pm and 11pm. At the peaks some passengers have to wait for a vehicle since the station bays cannot be refilled quickly enough.

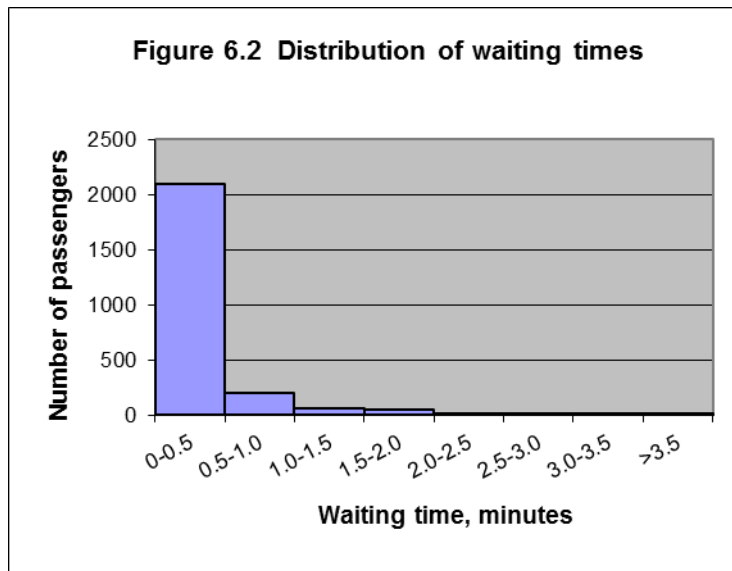


6.2 Waiting times

The data collection system does not measure passenger waiting times from the time the passenger presses the touch screen to call a vehicle to the time when station and vehicle doors open to allow entry. Instead it logs the time of the request and the time at which the vehicle moves from the bay with the passenger aboard. Since it takes on average 15 seconds to load the vehicle, from door open to the passenger pressing the "go" button, waiting times in this report have been measured by subtracting 15 seconds from the call-to-first-move time. Figure 6.2 summarises the distribution of waiting times.

It can be seen that the great majority of passengers wait between 15 and 30 seconds, and very few wait more than one minute. The average waiting time is 19 seconds, with a standard deviation of 30 seconds. 70% of passengers took 30 seconds or less from call to first movement. For most of them the vehicle would have been in the station when they arrived, but some would have taken longer than normal to press the "doors close" and "start"

buttons: almost all the passengers were using the system for the first time, and would not be familiar with the start sequence.



The longest recorded waiting time during the three days of the service was almost 6 minutes, when there was difficulty meeting a very concentrated rush in the evening peak at Terminal 5. There were 14 trips with waiting times over 3 minutes, 48 over 2 minutes, and 154 over 1 minute, but this latter represents only 6% of the total trips. For the most part these seem to be relatively isolated incidents, with only a very few trips with longer waiting times clustering together, and as better empty vehicle handling algorithms are developed it seems likely that these longer waits can become even less frequent.

6.3 Run times

If there is no obstacle to a vehicle moving directly from origin station to destination the run time is tightly defined, as:

5 minutes 10 seconds from Station A to T5

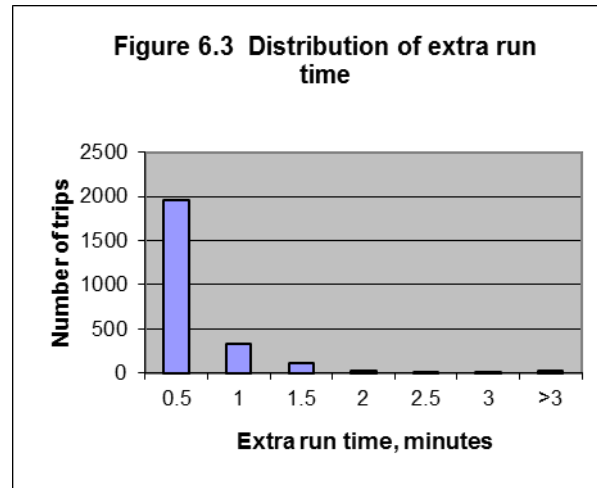
4 minutes and 55 seconds from Station B to T5

4 minutes and 51 seconds from T5 to Station A

4 minutes 58 seconds from T5 to Station B.

However, there are often small delays en route as the control system adjusts the vehicle speed, and occasionally longer delays as a vehicle is made to wait while a berth is cleared for it to enter. These additions to the minimum run times are logged by the system, and their distribution is shown in Figure 6.3.

For the great majority of passengers the extra time is measured in a few seconds: for 60% of passengers the delay is 15 seconds or less. For a few, however, the delay can extend to minutes to wait for a vehicle to clear its berth, sometimes because passengers take a long time to press the "go" button. There was also one occasion during the survey when at the peak of morning demand five vehicles were held up waiting on the guideway at Terminal 5 for almost 20 minutes while the guideway was cleared of a disabled vehicle. This increased the overall standard deviation on the run time to 57 seconds on a mean of 5 minutes 19 seconds, but as control procedures are improved by experience such long delays should be eliminated.



6.4 Reliability

As noted above in relation to waiting times and run times, for the vast majority of passengers the system performance is remarkably good, but for a very few passengers where serious problems arise in clearing berths for vehicles there have been unacceptably long delays. As noted above there was one incident during the survey when a problem with a vehicle caused very long delays to five vehicles. A failure of the system is defined when any of the three stations is not available to request a journey to or from. **For the three days of the survey reliability was 99.7%**, and the same level of reliability was obtained during four months of Simulated Revenue Service, prior to full public operation, over those periods when the system was operating. Reliability of the system needs to be measured over a much longer period than that of the survey. On a few other days there have been longer delays, and this has reduced the overall reliability slightly to 98.7% over the period of full-day operation from May 7th to June 12th. However, operation is still on a learning curve, and delays will become rarer.

6.5 Passengers carried

The daily average of loaded vehicle trips is 817 per day. With an average occupancy of 1.3 passengers per vehicle this equates to 1062 passengers per day. The average journey length is 1.44km, so the system carries an average of 1,529 passenger-kms per day. The average occupancy is boosted over the mean car occupancy at entry to the car park, which is around 1.1, by a few passengers opting voluntarily to share a vehicle, especially at peak times. This use is very similar to passengers sharing a lift: there is no suggestion in the information that passengers should share, but passengers see no reason why they shouldn't.

The vehicles covered 1,179 kms per day carrying passengers, and 1,057 kms empty. Thus empty vehicle-kms amount to 90% of loaded vehicle-kms. Much of this is unavoidable given the high tidal flow, but it is also the case that improved empty vehicle management should be able to reduce empty vehicle travel very substantially.

Trials have been undertaken to estimate the system capacity with a fleet of 18 vehicles. A maximum of 164 vehicle trips per hour was achieved. At the occupancy of 1.3 this equates to a maximum passenger flow of 213 passengers per hour, though this could be increased with more sharing, since this flow carries 656 seats per hour. The fleet now has a total of 21 vehicles, and this will increase the capacity slightly less than pro rata. Obviously, with a larger fleet and more station bays (and possibly some additional guideway links to cope) higher capacity can be achieved. With a proper network design the ultimate capacity of an

ULTra network depends upon the minimum acceptable headway between vehicles. Initially, it is sensible to proceed cautiously with a conservative headway of 6 seconds, but as development proceeds it is expected that headways will be reduced.

6.6 Acceptance by disabled people

This has not been examined specifically during operation of the Heathrow system, but the design of both stations and vehicles has been tailored to the abilities of disabled people. The vehicle is wheelchair accessible, and the prototype vehicles at the Cardiff Test Track were subject to an inspection by a mobility expert during the EDICT project (EDICT 2004). The vehicle and station door system allows adequate room for the largest wheelchairs, which can be backed against the fixed seats for stability, though the ride is very smooth, and acceleration, deceleration and jerk should cause no problem for any kind of disability.

6.7 Energy use and emissions

Electricity use by the vehicles has been measured at 0.308MJ/veh km (0.086kWh) for occupied vehicles, and 0.285MJ/veh km (0.079kWh) for empty vehicles, excluding power for heating or air conditioning, which has not been required in this operating period. Since empty vehicles travelled 90% of the distance travelled by loaded vehicles (ie a tidal flow factor of 0.9) and the average occupancy is 1.3, this equates to 0.434MJ/passenger-km.

This is energy used at the vehicle. For comparison with gasoline-powered vehicles it is necessary to look at the primary energy used as input to the power generating stations in the UK, which have a conversion efficiency of about 40%.

Thus the primary energy used by the system is 1.08MJ/passenger-km.

This is substantially more than the 0.55MJ per passenger-km estimated for the prototype ULTra vehicles. In part, this is because the prototype estimate referred to an average occupancy of 1.4 and empty-vehicle kilometres only 70% of loaded kilometres. These are the conditions which would apply to a wider network serving the airport. Empty vehicle management in the T5 system is constrained by the guideway layout, which does not enable empty vehicles “pushed” from berths to divert back around the stations to stand. This aspect was not a priority in demonstrating the practicality of the system, but would be improved substantially in a wider network, though there will unavoidably be considerable tidal flow.

Under the wider network assumptions the primary energy use per passenger-km would be reduced to 0.91MJ. The difference between this and the prototype vehicle estimates arises because the Heathrow vehicles are larger and heavier, but their energy use is still only about three quarters of average energy use by rail or bus public transport.

The advantage of electrical power lies in the fact that the vehicles emit no emissions on site. Thus they do not contribute to local air pollution at Heathrow. They are also very quiet: specific noise measurements have not been made for the Heathrow system, but measurements at the Cardiff Test Track indicate that, at full speed,

noise levels at 2.5m from the guideway will be less than 50dBA (L_{eq}).

In a busy airport terminal building noise levels can easily reach 70-75dBA, so ULTra vehicles would not be audible in this environment. In the existing Heathrow network PRT vehicle noise is obviously of no concern set against the general external noise of the airport, but the

lack of noise and zero emissions makes PRT ideal for bringing the airport transport system directly into the buildings to maximise passenger convenience.

The vehicles emit no tailpipe emissions, but the power stations which provide the electricity emit both air pollutants and greenhouse gases. However, generating stations are usually in less urban areas, where the regulated air pollutants, carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HC) and particulates (PM₁₀), are of much less concern than in dense urban areas, though NO_x and HCs contribute to acid rain and photochemical smog. Greenhouse emissions, mainly of carbon dioxide (CO₂) have a global effect on climate change, however, no matter where they are emitted.

The UK Department for Transport gives emission factors for buses, updated to 2009, as:

UK Emission rate* (g/km)					
	CO	HC	NO _x	PM ₁₀	CO ₂
<i>bus</i>	1.670	0.369	8.197	0.175	939.39

**Emission rates taken from the UK DfT Road Vehicle Emission Factors 2009 (TRL revision)*

<http://www2.dft.gov.uk/pgr/roads/environment/emissions/emissionfactors.xls>

This refers to all buses as a category, however, and these are mainly large service buses. The transfer buses used at Heathrow are midibuses, with carbon emissions about half those of full-size buses. They have an average occupancy of about 3.5 passengers since they run some 130 round trips per day during the 20 hours of operation (service is on demand during the remainder of the day) and carry 830 passengers in total in both directions. The mean CO₂ emissions per passenger-km are around 134 gms.

The PRT vehicles, by contrast, use 0.434MJ of electrical energy per passenger-km, or 0.121 kWh, and generating 1 kWh of electricity in the UK generates 527 gm of CO₂ (see the carbon calculator at <http://www.carbonindependent.org/>).

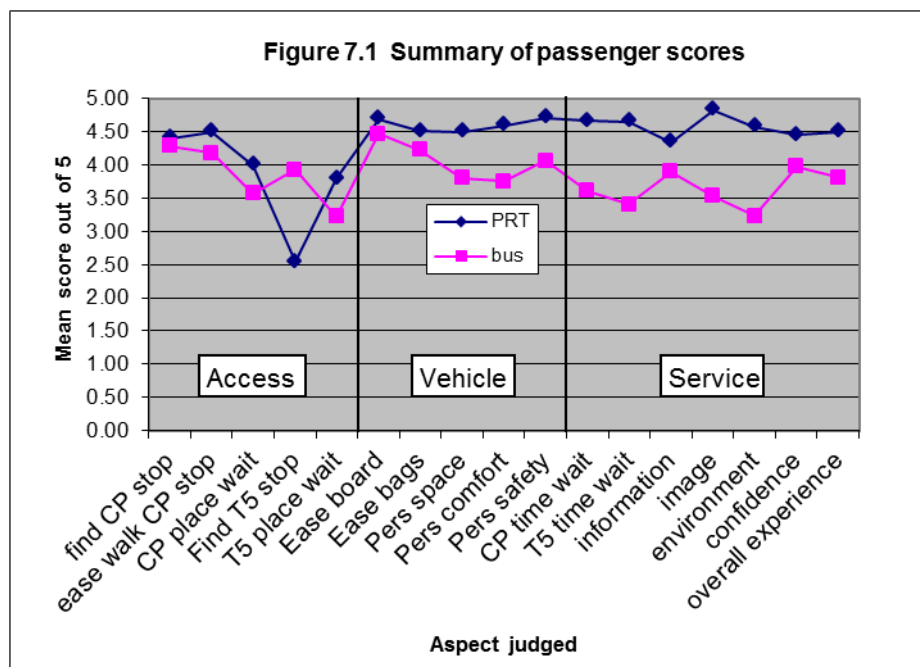
Thus the ULTra vehicles generate 63.5 gm CO₂ per passenger-km, about half that of the transfer buses, and no local air pollutants.

By comparison, the transfer buses would generate approximately 900 gm of CO, 200 gm of HC, 4,750 gm NO_x, and 93 gm of particulates per day within the Heathrow site. Obviously, the greenhouse emissions from PRT depend upon how the electricity is generated, and future emissions will decrease as electricity generation becomes less carbon dependent. Using electricity as the energy source gives flexibility to the type of energy used.

7 In Summary

The PRT service connecting the Business Car Park to Terminal 5 at Heathrow airport opened to the public in April 2011. Prior to the PRT service, transport was provided by a midibus operating on a notional 8-10 minute frequency, though the bus service was often more frequent than this. The in-vehicle journey time between car park and T5 was similar for both modes, but PRT offered little or no waiting, and non-stop travel in a private 4-seater vehicle or “pod”. Passengers were asked to score a range of aspects of the service on a five-point scale, where 5 = “excellent” and 1 = “very poor”. The two surveys were exactly similar for bus and PRT, apart from the addition of two extra questions at the end of the PRT survey. In each case, just over 300 passenger responses were collected.

The average scores are summarised in Figure 7.1. In this comparison, the PRT scores have been adjusted downwards as described in Section 4.8 to allow for the effect of the weather being better on average during the PRT survey than during the bus survey. In both surveys, better weather tended to encourage higher scoring.



**Mean scores for PRT have been adjusted downwards to allow for better weather during PRT survey compared with bus survey*

For all aspects except “ease of finding the T5 station” PRT scores consistently higher than bus, and with a difference which is highly statistically significant. Passengers scored access to the T5 station very lowly, and were obviously irritated with this aspect of their journey. The problem was that at the time of the survey route directions to the PRT station had not been fixed, and the route to the station in the multi-storey short-term car park is not obvious. Most passengers would have had to ask, and perhaps those used to Terminal 5 might have gone to the ground floor location of the transfer bus. Appropriate route signs were fixed shortly after the survey, but in any case access to the service is not intrinsic to PRT itself. For other access characteristics PRT scores more highly than bus, but this appears to be primarily a consequence of passengers being so pleased with the PRT service that they marked the other aspects highly too. Passengers marked ease of access to the car park stations higher than that for bus, even though the distances involved were slightly longer on average. This is

an aspect where PRT may require average longer distances, since the car park stations have necessarily to be on the perimeter of the car park unless elevated guideway is used.

For aspects connected with the vehicles and the service, the mean score was 4.58 ± 0.04 for PRT, and 3.82 ± 0.05 . As might be expected, the highest score was for the image, but it is encouraging that the second highest score was for personal safety, given that the vehicle has no driver and much of the guideway is elevated. The system also scored particularly high marks for being environmentally friendly, and indeed it uses substantially less energy per passenger-km than buses, and emits no pollutants on site, and its greenhouse emissions at the power station are about half those from the transfer buses. Waiting times score highly, as they should, since the mean waiting time was about 20 seconds, and only 6% of passengers had to wait more than a minute.

It is clear from the passenger scores, and from their “Twitter” comments, that the PRT service is greatly appreciated by the Business Car park passengers, and the service owners too are pleased with the results so far.

8 References

EDICT 2004. Evaluation and Demonstration of Innovative City Transport. Fifth Framework Programme Key Action “City of Tomorrow and Cultural Heritage”. Site Assessment Report

Transport Research Laboratory (2010) Report Number PPR361 - Emissions factors 2009: Final summary report. (TRL, Crowthorne UK, also on the UK DfT website)

ANNEX 1 The Transfer Bus and PRT Passenger Questionnaires

T5 BUSINESS CAR PARK – Transfer bus

(March 2009)

Good morning / afternoon / evening. I am conducting a survey on behalf of the airport. We are interviewing users of the Car Park Transfer Bus and would like to ask for your opinions on the service...

[include this occasion, use leading zero]

1 How many times have you used this car park in the last 12 months?

--	--

 1-2

Using a scale of 1 to 5 [SHOWCARD], where 1 is 'Extremely Poor' and 5 is 'Excellent', how would you rate the Transfer Bus in terms of...

[code as '9' if Don't Know]

2 Ease of boarding the vehicle?			3
3 Ease of storing your baggage once on board?			4
4 Amount of personal space in the vehicle?			5
5 Personal comfort whilst in the vehicle?			6
6 Personal safety whilst in the vehicle?			7

Thinking about the transfer journey you have just made between Terminal 5 and this Car Park, how would you rate...

7 Ease of finding the Bus Stop at Terminal 5?			8
8 The Bus Stop at Terminal 5 as a place to wait?			9
9 The amount of time you had to wait at the Bus Stop?			10

Now, thinking back to when you first arrived in this Car Park and transferred over to Terminal 5, how would you rate...

10 Ease of finding the Bus Stop in this Car Park?			11
11 Ease of walking to the Bus Stop from your car?			12
12 The Bus Stop in this Car Park as a place to wait?			13

13 The amount of time you had to wait at the Bus Stop?

 14

14 How would you rate the weather at that time?

 15

Using the same rating scale as before, and thinking about the Transfer Bus in general, how would you rate...

15 The information about using the Transfer Bus as being easy to understand?

 16

16 The Transfer Bus in terms of having a modern image for the airport?

 17

17 The Transfer Bus for being environmentally friendly?

 18

18 Your degree of confidence in the Transfer Bus as a means of travelling between the Car Park and the Terminal?

 19

19 Your overall experience of the Transfer Bus?

 20

On a scale of 0 to 10, where 0 is 'Not at all likely' and 10 is 'Extremely likely', how likely would you be to recommend...[use leading zero]

20 ...using this Car Park to a friend or colleague?

 21-22

21 What was the main reason for your trip today?

 23

- Business 1
- Holiday – Package 2
- Holiday – Independent 3
- Staying at own property 4
- Visiting friends and relatives 5

Other non-business 6

[Thank and close]

Respondent was Male / Female

 24

- Male 1
- Female 2

The PRT Passenger Questionnaire

T5 BUSINESS CAR PARK – PRT PASSENGERS

May 2011



Heathrow has a new transport system to carry passengers between Terminal 5 and the Business Car Park. This Personal Rapid Transit system is the first of its kind in the world, and we are keen to know what passengers think of it. We would be grateful if you could spare a few minutes to tell us. Please fill in this questionnaire and hand in the form at the station where you alight, in the box provided. Thank you for your time.

[include a leading zero if less than 10]

1 How many times have you used this car park in the last 12 months?

		1-
		2

Using a scale of 1 to 5, where **1 is 'Extremely Poor'** and **5 is 'Excellent'**, how would you rate the PRT service in terms of.....

2 Ease of boarding the vehicle?

	3
--	---

3 Ease of storing your baggage once on board?

	4
--	---

4 Amount of personal space in the vehicle?

	5
--	---

5 Personal comfort whilst in the vehicle?

	6
--	---

6 Personal safety whilst in the vehicle?

	7
--	---

Thinking about **the journey from Terminal 5 to the Car Park**, how would you rate.....
(score 1 to 5 again)

7 Ease of finding the PRT station at Terminal 5?

	8
--	---

8 The station at Terminal 5 as a place to wait?

	9
--	---

9 The amount of time you had to wait at the station?

	10
--	----

Now, thinking back to when you first arrived in this Car Park and transferred over to Terminal 5, how would you rate.....
(score 1 to 5 again)

10 Ease of finding the PRT station in this Car Park?

	11
--	----

11 Ease of walking to the station from your car?

	12
--	----

12 The station in this Car Park as a place to wait?

	13
--	----

13 The amount of time you had to wait at the station?

	14
--	----

14 How would you rate the weather at that time?

	15
--	----

Using the same rating scale as before, and thinking about the PRT system in general, how would you rate...

- 15 The information about using the system as being easy to understand? 16
- 16 The PRT vehicle (the "pod") in terms of having a modern image for the airport? 17
- 17 The vehicle for being environmentally friendly? 18
- 18 Your degree of confidence in the PRT system as a means of travelling between the Car Park and the Terminal? 19
- 19 Your overall experience of the PRT system? 20

On a **scale of 0 to 10**, where **0 is 'Not at all likely' and 10 is 'Extremely likely'**, how likely would you be to recommend.....

- 20 ...using this Car Park to a friend or colleague? 21-22

- 21 What was the main reason for your trip today? 23

- | | | |
|--------------------------------|---|-------------------------------------|
| Business | 1 | Place appropriate code in box above |
| Holiday – Package | 2 | |
| Holiday – Independent | 3 | |
| Staying at own property | 4 | |
| Visiting friends and relatives | 5 | |
| Other non-business | 6 | |

- 22 If you have previously used the Transfer Bus system at Heathrow, how do you rate the PRT system against the bus transfer? 24

- | | | | |
|--------------------------|---|--------------------------|----------------|
| PRT better than bus | 1 | <input type="checkbox"/> | (tick one box) |
| Bus better than PRT | 2 | <input type="checkbox"/> | |
| Neither better nor worse | 3 | <input type="checkbox"/> | |
| Haven't used the bus | 4 | <input type="checkbox"/> | |

- 23 Suppose a PRT system were available in your home town and could take you from home into the town centre. What is the most you would you be prepared to pay to use it? (tick one box) 25

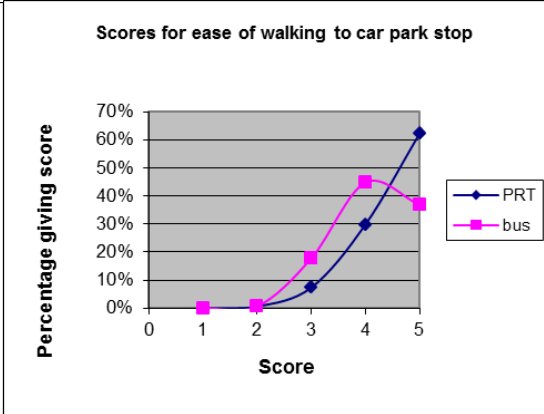
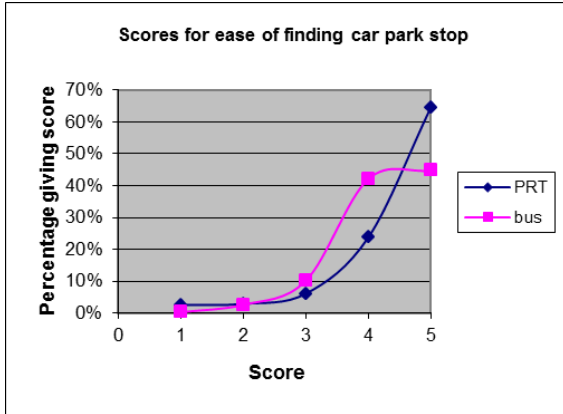
- | | | |
|-----------------------------------|--------------------------|---|
| Not as much as the bus fare | <input type="checkbox"/> | 1 |
| Much the same as the bus fare | <input type="checkbox"/> | 2 |
| More than bus, but less than taxi | <input type="checkbox"/> | 3 |
| Much the same as a taxi | <input type="checkbox"/> | 4 |
| More than a taxi | <input type="checkbox"/> | 5 |

- 24 Are you male or female? please tick male female 26

Thank you for helping us with this survey

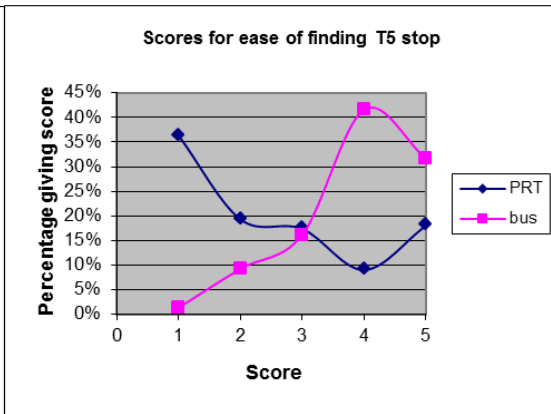
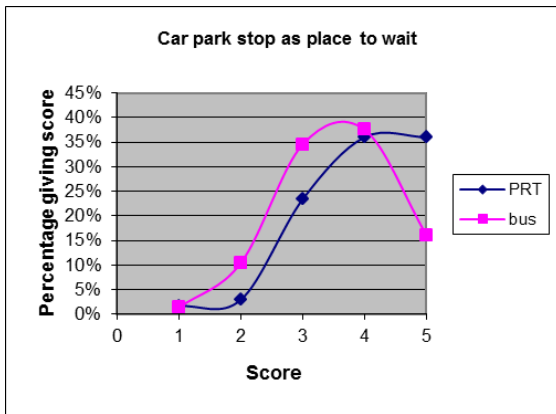
Annex 2 Distribution of scores for each of the questions

Access



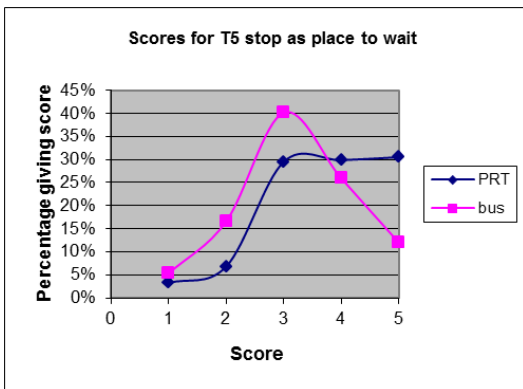
Average score PRT 4.44±0.05
 t=1.65 Bus 4.28±0.06

Average score PRT 4.02±0.05
 t=5.74 Bus 3.57±0.05



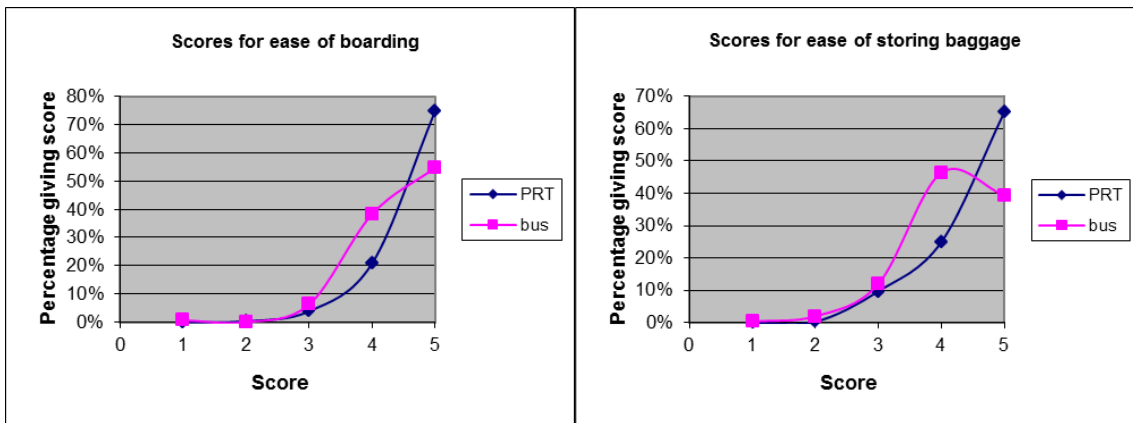
Average score PRT 4.02±0.05
 t=5.69 Bus 3.57±0.05

Average score PRT 2.51±0.09
 t=-13.53 Bus 3.93±0.06



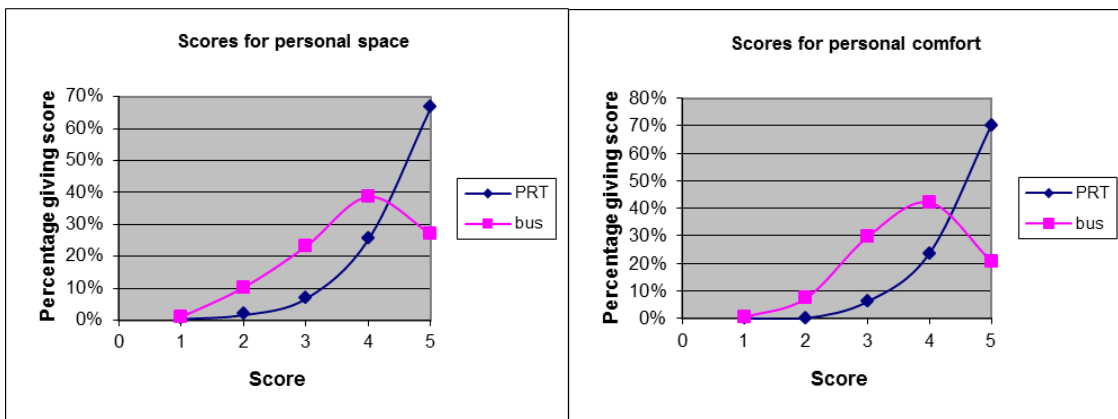
Average score
 PRT 3.78±0.06
 Bus 3.23±0.06
 t=6.65

Vehicles



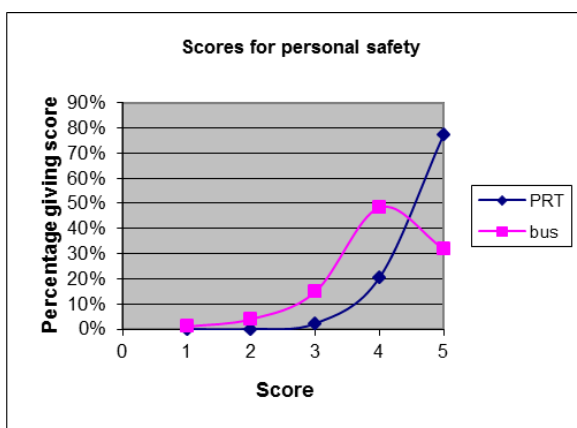
Average score PRT 4.71±0.03
 t=4.42 Bus 4.47±0.04

Average score PRT 4.45±0.04
 t=4.83 Bus 4.22±0.04



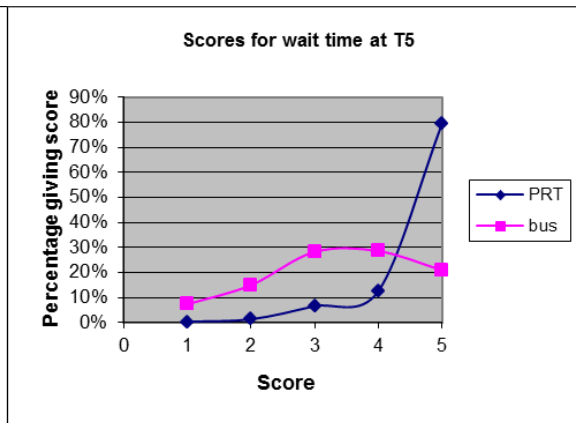
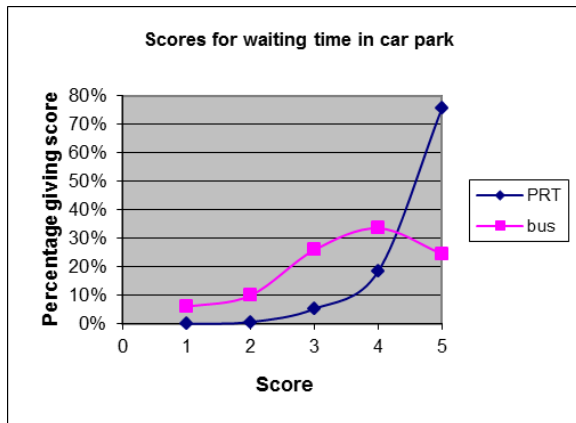
Average score PRT 4.57±0.07
 t=10.08 Bus 3.81±0.06

Average score PRT 4.64±0.06
 t=14.00 Bus 3.76±0.05



Average score PRT 4.75±0.03
 t=11.67 Bus 4.06±0.05

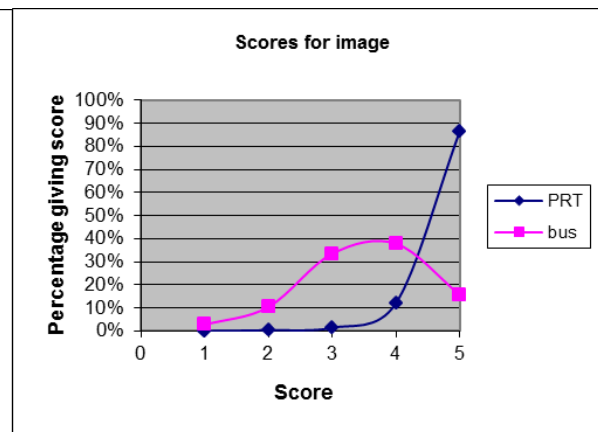
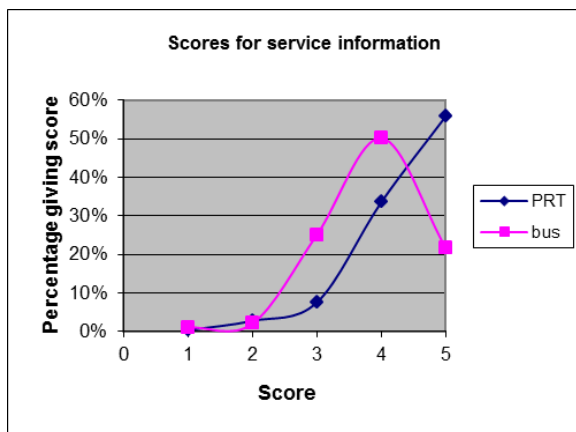
Waiting times



Average score PRT 4.69±0.03
 t=14.27 Bus 3.61±0.07

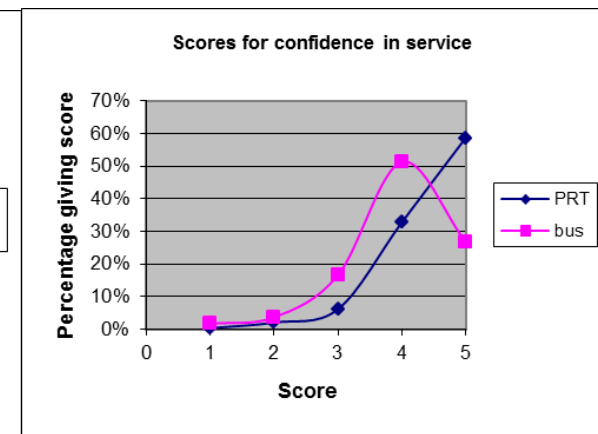
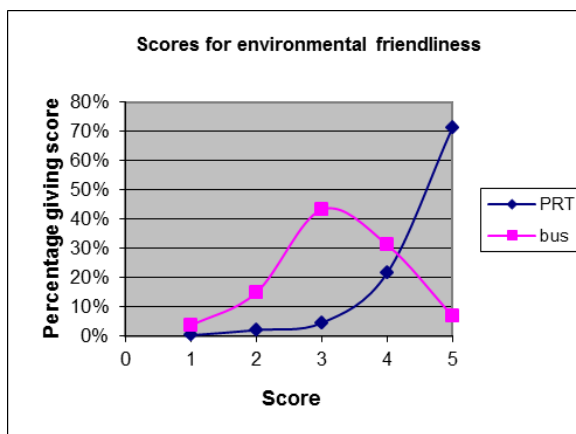
Average score PRT 4.68±0.04
 t=15.60 Bus 3.41±0.07

Service



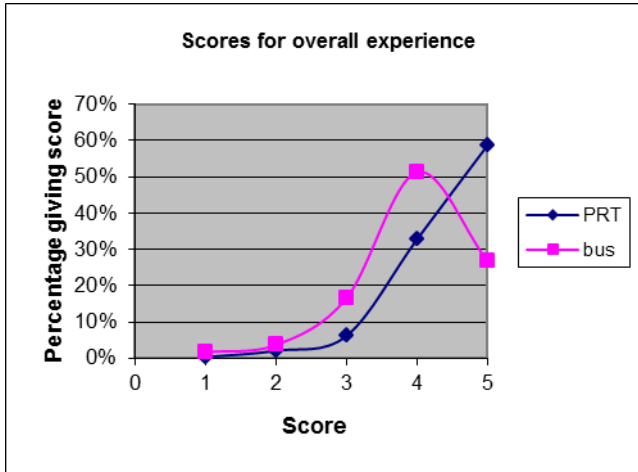
Average score PRT 4.42±0.05
 t=6.91 Bus 3.89±0.05

Average score PRT 4.85±0.03
 t=20.94 Bus 3.54±0.06

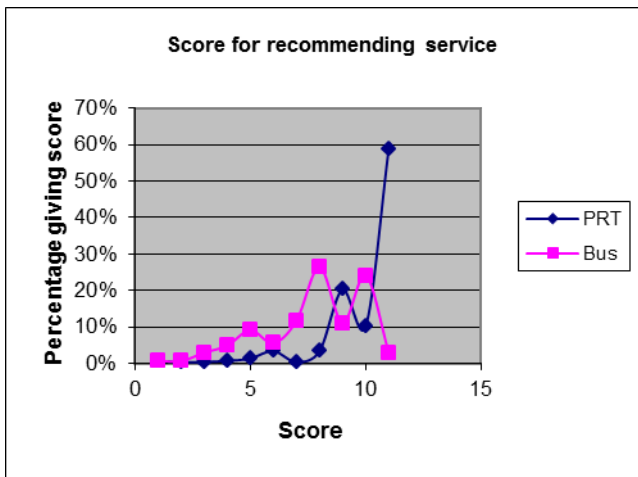


Average score PRT 4.62±0.04
 t=19.57 Bus 3.23±0.06

Average score PRT 4.47±0.04
 t=7.21 Bus 3.98±0.05



Average score PRT 4.55 ± 0.04
 Bus 3.81 ± 0.05
 t=11.41



Average score PRT 8.95 ± 0.10 (out of 10)
 Bus 7.84 ± 0.33
 t=2.88

Annex 3 Passenger views of the PRT service appearing on “Twitter”

The following are all the relevant Tweets between May 25th and June 23rd:

“Futuristic journey to terminal 5. In the Heathrow pod.

Loved the Heathrow Pod. Magic driverless cars!

This is the company behind the Heathrow T5 pods. Very cool indeed and British!. ULTra - Self-Driving Electric Vehicles

On the LHR T5 Pod. Absolutely brilliant

LHR T5 + Pod = aircraft door to front door in 1 hour. Immense.

Traveling in Pod from Business Parking to Terminal 5 ... Brilliant!

Love love love the new pods [@heathrowairport](#) from business parking into T5 - would recommend to anyone!

Heathrow Pod - Definite [#win!!](#)

Planes, trains, automobiles & Heathrow Pod. To/Fr business car park 5 to LHR. Very nice.

Started the day with a little ride in the travel pods at Heathrow. Great fun! BMW International Open in Munich this week. Stay away rain!

I am lovin heathrow t5. Driverless Electric pods to take me from parking 2 departures. Arr parking to ba lounge 30 mins. World class [@ba](#)

Took the pods from car park into the terminal, very back to the future! (@ Terminal 5 w/ 11 others

Pods at [#Heathrow](#) T5 finally running from business car park. Highly entertaining and fast

Good to be back in UK and [#T5](#) pod worked perfectly

This is me in the new pods at terminal 5 from business parking to main airport. Its mini spaceships

Wheels down at Heathrow 22:08, front door 23:18 (incl 45min drive) not bad!!! thanks to IRIS and the Pods arriving at Heathrow was a dream!

Went on the Heathrow T5 pod again today. Missed out on a pod race though!

Finally in business parking pod at heathrow t5 - just wicked

Pod system from terminal 5 business parking is ace its like being in a johnny cab from total recall

Just rode on my first pod at Heathrow T5. It was fun

Good news! The pods at Heathrow work and are awesome!

Lol! Personal transport pod! How very Sci Fi!!! (@ T5 Pod) [pic]

Back on board the Pods at Heathrow. I love these things. Best airport transfer devices ever

T5 pods rock

I'm in my own little electric pod at T5, its quality!

Had my first trip on the Terminal 5 pods at Heathrow

Used heathrow pod, amazing no driver! (@ Terminal 5 w/ 11 others)

Back at Heathrow in the PRT pods - addicting!! [#heathrowpod](#)

Finally got to use the LHR T5 pods this morning. Truly excellent! Now celebrating with a brekkie bubble in the lounge...

[@British_Airways](#) were great today. Love T5 & those pods that take you to and from the terminal

[@HeathrowAirport](#) absolutely love the T5 pods. No need for exorbitant short stay overnight anymore, a real winner.

At LHR t5 - they have personal driverless pods to take you from parking to check in. Fantastic things

The pod train from business parking to t5 is surely the most exciting form of transport I've been on in a long time

the Heathrow Pod - we live in the future! Wider application pls! [10 Jun](#)

New experience - Heathrow Pod to Terminal 5 Apparently worlds 1st [#PRT](#) system

Me and [@John_Slavin](#) using the pod to T5 business parking

The new transport pods at Heathrow T5 are great. It's like being in Blade Runner!

The Heathrow pod service is the greatest mode of transportg known to man!

Pods are running at LHR T5. How cute is that!

The little business car park PODS at Heathrow 5 are SO COOL!!

Driverless pod transport at Heathrow T5, love this

Anybody been on the Heathrow pod? It's a bit like being at Disney! marvellous invention

Space age pod transfer in Heathrow T5 parking is awesome!!

Anyone ridden one of the T5 business park shuttle pods? Fun!

On the new pod system at Heathrow airport. Soooo cool!! [#heathrowpod](#)
Wicked! I'm in a little pod carrying me from the carpark to term 5! no buses here. and its
chatting to me! [#lhr](#) [#nicesurprise](#) [#greatidea](#)

In the heathrow pod from t5 business car park. Exciting stuff. <http://t.co/WGYW8pP>

Journey starts in my own personal pod at [#Heathrow](#). Makes the airport fun again.

The gloom of being sat in London rush hour traffic instantly lifted after a call to go to Zurich -
now in a pod heading into T5 at heathrow

in our pod to terminal 5. NYC here we come!

News 14 TV coverage of ULTra in Raleigh:

More news coverage of possible ULTra system in Raleigh: [ULTraPRT](#) ULTra PRT
ULTra PRT coming to Raleigh, North Carolina

Me on the Heathrow pod, just like being at Alton towers but at an airport

OMG! The Heathrow Pod is amazables!

EU Transport Vision 2050 might boost Personal Rapid Transit (PRT). 50% of Europe's
vehicles to be zero emission by 2030

PRT study by [@cbuchananucubed](#) -- Cutting Car Use in Daventry

All aboard the T5 pod! Geek transportation par excellence!

Heathrow Pod in action... [JeremyHarpham](#) Jeremy Harpham

FAST though!

I am in a pod. A bit like the cab on Total Recall without the mad driver!

[@ULTraPRT](#) great service :-)

Trying the new Heathrow Pod!

EU Transport Vision 2050 might boost Personal Rapid Transit (PRT): Image: ULTra Ltd. The
European Union announced...



On personal Heathrow Pod - parking to T5. Awesome sci-fi system, this is Johnny Cabs fm

Total Just rode the "Heathrow Pod" It's awesome!! Been waiting to ride it since 1st heard about it 2years ago.

In a "pod" from car park to T5 at Heathrow. Cool - never had my own personal train before.

Skyport News -- Terminal 5 Passenger Pods to Launch This Summer:
yes and they're even better to use - quicker, easier and greener than the buses to/from the car park

Landed and used the very cool [#heathrowpod](#) between the terminal and car park (@ Terminal 5 w/ 12 others) [pic

”

Annex 4 Tabular summary of the assessment data

Passenger evaluation categories, impacts, indicators (as given in Deliverable D1.2.3.1 according to schema in D5.5.1)

Evaluation Category	Impact	Indicator	Achieved in Heathrow assessment
Passenger Acceptance	User acceptance	Usefulness	Passenger survey: PRT scores 4.55 vs bus 3.81 for overall experience
		Ease of use	Passenger survey: PRT scores 4.42 vs bus 3.89 for PRT information
		Reliability	See survey results:: PRT scores 4.47 vs bus 3.98 for confidence in service plus operating data: 99.3% reliability
		User satisfaction for the on demand service	As above
	Willingness to pay	User willingness	Passenger survey gives WTP between bus and taxi
		Authorities willingness	see Owner's/Operator's comments
Quality of service	Information	Availability	Passenger survey: PRT scores 4.42 vs bus 3.89 for PRT information
		Comprehensibility	As above
	Comfort	Perceived comfort	Passenger survey: PRT scores 4.64 vs bus 3.76 for comfort
	Privacy	Perceived level of privacy	Passenger survey: PRT scores 4.57 vs bus 3.81 for space
	Cleanliness	Daily cleaning and inspection	Personal examination found vehicles extremely clean. Note that internal CCTV enables controllers to check interiors for rubbish
	Perception of safety and security	Perception of safety	Passenger survey: PRT scores 4.75 vs bus 4.06 for safety
		Fear of attack	Not specific, as above
	Perceived performance	Overall (not in D5.1.1 Table 3, but in Core Indicators Table 4)	Passenger survey: PRT scores 4.55 vs bus 3.81 for overall experience
	System use	Total passenger-km travelled	1529 pass-km per day
		Total N° of trips	1062 passengers per day
		Vehicle occupancy	1.3
	System performances	Average Journey time per OD pair	4m 59s
		Journey time variability	57s SD
		Total delay per/trip	24 seconds average
		Average Waiting time	19 seconds
		Waiting time variability	± 30 seconds
Effective system capacity with 21 vehicles		190 veh trips per hour = 760 seats/hr = 247 passengers/hr at average occupancy	

Evaluation Category	Impact	Indicator	Achieved in Heathrow assessment
		Accidents	NIL since operation began
		Incidents	NIL since public operation began for incidents with potential passenger harm. Very occasional problems where service is not available, but few lasted more than a few minutes, hence:
		Reliability	Service available 99.7% of time during survey, 98.7% over first month of full service (7 th May to 12 th June)
Social impacts	Spatial accessibility	Change in range of key activities accessible within time thresholds	No substantial change over transfer bus in this pilot scheme, but if extended within airport will radically improve access time contours
	Access times for mobility impaired users	Audit of accessibility by mobility impaired	Wheelchair accessible. Mobility audit of prototype reported in EDICT
Environment	Energy	Daily consumption (kWh)	398 kWh
		Energy Efficiency (kWh/pkm)	0.26 kWh/pkm
	Toxic emissions	NO _x	NIL (at vehicle)
		PM ₁₀ and/or PM _{2.5}	NIL (at vehicle)
		CO	NIL (at vehicle)
	Climate Change	CO ₂	substantial net reduction in greenhouse gas emissions
Noise	L _{eq10}	<50dBA at 2.5m	
Financial impacts	Costs		See Deliverable D1.2.5.1: costs of Heathrow system will not be made available by BAA, and the actual costs of a first application under specialised circumstances are not relevant to likely costs of PRT in future applications. The Heathrow exercise has enabled a realistic updating of ULTra PRT Ltd's costing methodology, and although the details are commercially confidential D1.2.5.1 gives equations which enable an adequately accurate costing of proposed systems in outline.
	Revenues	Operating revenues	NA
	Subsidies	Perceived public subsidies	zero
Legal impacts	Impacts on legal and regulatory framework		See operator comments