Institution: University of Bristol

Unit of Assessment: 15 - General Engineering

Title of case study: ULTra PRT - personal rapid transport system benefits passengers and the environment

1. Summary of the impact (indicative maximum 100 words)

A new form of personal rapid transit has been developed from research which began at the University of Bristol in 1995 and has since been commercialised by a University spin-out company. The ULTra system is now in operation at Heathrow Airport Terminal 5 and constitutes a world first for the UK. Since opening in 2011, passengers have benefited from a personal, fast, reliable and low cost *driverless* transport system, that has removed the queuing and inefficiencies associated with bus transfers to the terminal. The *Heathrow pods* completed a million miles of fully driverless operation within two years of the system opening and have the highest satisfaction rating of any passenger service at Terminal 5, which itself is rated as the best in the world. The success of the system has led to a plan to extend it to Terminals 2 and 3.

2. Underpinning research (indicative maximum 500 words)

In 1995, with the support of an EPSRC grant, Lowson (UoB 1986-2004) started a research project to identify the optimum form of transport in cities for the 21st century. A *systems* engineering approach was applied to the challenge. During the first grant a detailed requirements analysis was conducted, which demonstrated that the optimum urban transport service would have the following characteristics:

- On-demand availability.
- Non-stop from start to destination.
- Full choice of destinations.
- Environmentally sustainability.
- Low cost.
- Demonstrably high levels of safety and personal security.
- Good integration with other forms of transport.

This specification formed the basis for the design synthesis of an urban transport system. The solution which emerged was called ULTra, short for Urban Light Transport. Much of the detail of this solution was contained in a series of internal University reports, many of which were referred to extensively in the subsequent engineering development. This research was disseminated in a number of presentations and papers, notably [1].

Part of the University's research was to examine existing concepts and identify the limitations that resulted in them not being exploited. The concept of Personal Rapid Transit (PRT), where a point-to-point service is provided, dated back to the late 1950s. Full-scale experiments were undertaken in several countries, including the UK, in the 1960s and 1970s, but no system emerged into practical service. Note that PRT is distinct from Group Rapid Transit, where larger vehicles follow a pre-defined route with multiple stops, which was successfully installed at Morgantown, West Virginia, in 1985. The University's analysis of the proposed PRT systems showed that the key reason for previous failure was inadequate systems. This meant that the three main components – vehicle, structure and control system – had inadequate design integration. Also, the previous designs attempted to mimic existing capabilities of public transport rather than meet the basic requirements listed above.

An agreed standard had emerged for PRT from these older studies, and this standard had been recorded in a number of books. Analysis by the Bristol team showed that this standard design had significant flaws. For example, the accepted design of a PRT control system led to significant requirements for on-line queuing. These flaws were deleterious from the viewpoints of safety, operational flexibility, infrastructure scale/cost and reliability/availability. Several other elements of

the previously accepted approach were also rejected (see, for example, [1]). Key new insights were gained from the research at Bristol, including these requirements for delivering a successful system:

- A separate guideway (away from other forms of transport) to permit safety authorisation of a fully automated system.
- Off-line stations with independent berths allowing an on-demand system with negligible waiting times or queuing.
- The ability to use stored energy because of the frequent opportunities to recharge.

In addition, particular emphasis was put on achieving an effective, low-cost infrastructure, since this represented more than 50% of the total cost. The resulting infrastructure was lighter and cheaper to build than an equivalent foot-bridge.

A major feature of the Bristol design was its high sustainability. This was achieved through the use of lightweight, low-speed vehicles. Again, these ideas were disseminated in a variety of papers and presentations, for example [2, 3].

In 1996/7, following further support from the Rees Jeffreys Road Fund and the DETR seedcorn programme, a series of detailed transport applications were analysed to determine the best approach to meeting practical transport application requirements. Summaries of these were also published in the leading papers noted under the references. This provided a range of practical information on approaches to sizing systems to meet demand. These studies also led to important changes in basic system design (notably the choice of battery power and station layout) which allowed far more flexibility than the older, standard PRT design approach and enabled greater capacity to be delivered from a given system. For example, replacing a power pickup by batteries removed 30% from the cost of the guideway infrastructure as well as offering major improvements in flexible operation [2].

A variety of comparative analyses between PRT and conventional public transport were also undertaken, e.g. [3-6]. These showed that the new approach would offer major benefits in trip time to the user over conventional types of transport. Traditional public transport involves collecting passengers together to travel on prescribed corridor routes. This inevitably involves both waiting and stopping during the journey. This form of transport is rejected in favour of the car in all developed countries – for example, in the UK 85% of trips are by car and only 15% by traditional public transport (in the US the former figure rises to 97%). In contrast, the system which emerged from the University's research requires neither waiting nor stopping. This is a radical change and, as is normally the case with disruptive approaches, is only partly accepted by the transport research community. The evidence from actual passengers is that this new approach is strongly welcomed – see section 4.

3. References to the research (indicative maximum of six references)

[1] *M.V. Lowson, 1999. *Personal Public Transport*. Proceedings of the Institution of Civil Engineers, Transport 135, 139-151, dx.doi.org/doi:10.1680/itran.1999.31806.
[2] M.V. Lowson, 2002. *Sustainable Personal Transport*. Proceedings of the Institution of Civil Engineers Municipal Engineer 151(1), 73-82, dx.doi.org/doi:10.1680/muen.2002.151.1.73.
[3] *M.V. Lowson, 2003. *A New Approach To Effective And Sustainable Urban Transport*. Transportation Research Record, Journal of the Transportation Research Board 1838, 42-49, dx.doi.org/doi:10.3141/1595-01.
[4] M.V. Lowson, 2003. *Service Effectiveness of PRT vs Collective – Corridor Transport*. Journal of Advanced Transportation 37(3), 231-341, dx.doi.org/doi:10.1002/atr.5670370301.
[5] M.V. Lowson, 2004. *Idealised models for public transport systems*. International Journal of Transport Management 2(3-4), 135-147, dx.doi.org/10.1016/j.ijtm.2005.05.001.
[6] *M.V. Lowson, 2005. *PRT for Airport Applications*. Transportation Research Record, Journal of the Transportation Research Board 1930, 99-106, dx.doi.org/doi:10.3141/1930-12.

* References that best indicate the quality of the underpinning research.

Grants include:

- 1996-98 Grant from Rees Jeffreys Road Fund, approximately £40,000 pa

- 1996-7 Seedcorn Grant from DETR to Professor M.V. Lowson, approximately £50,000

4. Details of the impact (indicative maximum 750 words)

Following the research conducted at Bristol, the University spin-out company Advanced Transport Systems Ltd was set up in 1995. This company (now called Ultra global PRT) designed and, since it opened in 2011, runs the world's first fully operational PRT system at Heathrow Terminal 5.

The papers and conference presentations relating to this work inspired a worldwide interest in potential applications of the system and led to Advanced Transport Systems Ltd winning the DETR Innovative Transport competition (contract value £2.7M) in 2000, ahead of 15 other entrants, including some major international companies. This allowed a complete prototype system, including vehicles, infrastructure and controls, to be designed, built and tested over the period 2000-2003. In addition, a grant from NESTA supported the commercial development of the ideas.

Heathrow pods

Testing of this system, several elements of which were supported by further University of Bristol research under EC and other contracts, gave highly satisfactory results. Transport decisions for cities have very long timescales. It was found that the ideas could provide immediate benefit in airports [6]. This led to a decision by BAA to install ULTra at Heathrow Airport to meet its transport connectivity demands. *[text removed for publication]* [a]. The *Heathrow pods*, the first fully operational PRT system, opened to the public in April 2011.

The Heathrow pods have received an extraordinarily positive response from passengers and have attracted intense media interest around the world. In 2011, John Holland Kaye, Commercial Director at BAA, stated:
"We've been listening carefully to our passengers as part of our plan to make every journey better at Heathrow. Passenger feedback has been amazing and positive Twitter comments abound. We love watching people's reactions when they see the pods for the first time and then again when they step off just five minutes later at their destination.
"The Heathrow pods offer a personal, comfortable and reliable ride that is free of emissions. That's why our excitement for this pioneering British technology is being shared by town planners, architects, other airports, business parks, campuses, retail and residential destinations from the US, Europe, India, Mexico and the UK, who believe that this system could revolutionise transport in urban environments" [b].

In addition, the system marks a significant advance in environmentally friendly transport. In a press release of 20 September 2011, BAA reported that the Heathrow pods were expected to eliminate 50,000 bus journeys a year (with over 100,000 passengers using the Pods since the service started five months earlier) and that the pods use 50% less energy to power than a bus [c]. Fraser Brown, Managing Director of Ultra global PRT, said:
"We're very excited about the benefits that the Heathrow pod can offer Heathrow's passengers. Its service is predictable, reduces waiting time and offers reduced journey times; it's also an environmentally sustainable form of transport that ensures reduced emissions.
"There's an enormous sense of pride for all the staff who were involved in turning this science fiction dream into a reality at Heathrow and demonstrating the best of British innovation" [c].
More recently, following two years of full passenger operations the pods had completed 1,007,000 miles of fully driverless operations [a]. The system is already demonstrating extremely high reliability. Availability at 99.5% is higher than all of the long-standing traditional forms of transport operating at Heathrow [a]. The *Heathrow pod* has the highest satisfaction rating of any passenger service at Terminal 5, which itself is rated as the best in the world (Skytrax world airport awards 2012 [d]). The success of the system has led to Heathrow announcing its plan to extend it to Terminals 2 and 3 [e].

In December 2012, the Rt Hon Alan Duncan MP, Minister of State for International Development, said after riding a pod at Terminal 5, that *"…this is British engineering, design and execution at its best. This is a revolutionary, environmentally friendly transport system that's easy and cost effective to install, pollution free and extremely fun to use. It highlights the UK's and Ultra global's ability in designing a world first and world beating new form of transport, moving large numbers of travellers, to exactly where and when they want to go. This is exactly the sort of innovative system that I'll be promoting on my forthcoming Far East Trade Mission*" [f].

Ultra global PRT has worldwide interest in applications of the system. It has been selected for a major urban transport project in Amritsar, India, to convey pilgrims to the Sikh Golden Temple. The system is designed to take 35% of the daily visitors (or 100,000 passengers) to the Golden Temple from bus and railway stations along a 4.8-mile elevated guideway [g].

Other evidence of the success of the research includes numerous awards won by the company. These include:

- The Worship Company of Carmen's Viva Award for Transport Innovation (2009). Previous winners include the Channel Tunnel, Toyota Prius and McLaren Mercedes [h].
- London Transport Awards, 2012, winner of Most Innovative Transport Project [i].
- Global AirRail Awards, 2012, winner of Innovation of the Year [j].

In addition, in 2009 the pod was selected by the Science Museum as the equivalent of Stephenson's Rocket for the 21st century and in 2011 the ULTra prototype vehicle was taken by the Science Museum for the UK national collection, to be retained "forever" for examination by students, historians and interested parties [k].

The success of the ULTra system directly relates to the careful systems engineering research done during the early stages of the project, summarised in the published papers shown in section 2. The company continues to work with the University, supporting three researchers in recent years.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[a] Managing Director, Ultra global PRT.
[b] Quote from the Commercial Director, BAA, in the Ultra global PRT press release *ULTra at London Heathrow Airport,* September 2011.
[c] BAA press release *Heathrow pods transport passengers to the future,* September 2011.
[d] World airports awards 2012 article *Terminal 5, London Heathrow Airport named the world's Best Airport terminal by airline customers,* downloaded from www.worldairportawards.com
[e] Ultra global PRT website article *Heathrow announces plans for an additional Personal Rapid Transit (PRT) system,* February 2013.
[f] Quote from Rt Hon Alan Duncan MP in the Ultra global PRT press release *Heathrow pod's latest Rt Hon fan,* December 2011.
[g] Ultra global PRT website article *World's first and largest urban PRT system is announced*, December 2011.
[h] The Carmen's Award: The full listing of Awards, downloaded from http://www.thecarmen.co.uk/
[i] Ultra global PRT website article *Heathrow pod recognised at London Transport Awards,* March 2012.
[j] Ultra global PRT website article *Ultra Global PRT's Innovation Skills Awarded Yet Again,* May 2012.
[k] Ultra global PRT website article *Ultra Prototype to be taken into the UK National Transport Collection,* October 2011.