



Faculty of the
Built Environment



Centre for
Transport &
Society



The Variable Price and Attribute Transport System

**Stage 1 Report:
Understanding the Market for Flexible Shared
Transport**

Commissioned and
grant-supported by:

**Tech
4all**

Tech 4all

Tech4all is a charity devoted to reducing poverty, in particular through the use of technology. It runs a very successful Voicemail for the Homeless scheme (together with the leading homeless charity St Mungo's), used by 700 people in 2006. Tech4all has sponsored this research in order to investigate whether modern technology could create a radical improvement in the availability of high-quality transport services for disadvantaged groups, at low or zero incremental cost to the taxpayer, and in a way which fostered integration of disadvantaged and better-off users."

The Project Team

Dr Graham Parkhurst (Project Leader)
Email: graham.parkhurst@uwe.ac.uk
Tel: +44 (0) 117 32 82133

Dr Marcus Enoch
Email: m.p.enoch@lboro.ac.uk
Tel: +44 (0) 1509 223408

Mr Danny Myers
Email: danny.myers@uwe.ac.uk
Tel: +44 (0) 117 32 83031

Dr Stephen Ison
Email: s.g.ison@lboro.ac.uk
Tel: +44 (0) 1509 222605

Faculty of the Built Environment
University of the West of England
Frenchay Campus
Coldharbour Lane
Bristol BS16 1QY
Fax: +44 (0) 117 32 83002

Department of Civil and Building Engineering
Loughborough University
Loughborough
Leicestershire
LE11 3TU
Fax: +44 (0) 1509 223981

Published online by the University of the West of England, Bristol
May 2007

<http://www.transport.uwe.ac.uk>

Contents

1. Introduction	3
1.1 Structure of the Stage 1 Report	4
1.2 Context	4
1.3 Key Characteristics of the Flexible Transport System	6
2 The Attribute Approach to Consumer Behaviour Theory	9
2.1 The Attribute Approach	9
2.2 A reduction in taxi fares	11
3 State of Knowledge with Respect to Demand Functions	15
3.1 Empirical Measures of Demand	15
3.2 Difficulties of Interpretation	20
4 Towards a Specification for VPATS	21
4.1 Nature of VPATS flexibility	21
4.2 Characterisation of Existing Flexible Modal Offers	22
4.3 Consideration of near-market systems	27
5 Conclusions	29
References	30

1. Introduction

Tech4all is a charity committed to the alleviation of poverty through the application of technology. Tech4all has commissioned this study to examine whether the further application of technology to the transport market could broaden the range of services available and increase overall utility.

The broad aims of the present study are:

1. to conduct a re-analysis of the demand and supply of road public transport services, to test the hypothesis that higher-technology, more flexible approaches to transport provision would better meet the needs of the travelling public, including the travel poor;
2. to consider the operational feasibility of any alternative transport systems, particularly in terms of resource costs; and
3. to consider feasibility more generally, including any specific implications for the travel poor.

Given resource constraints, the work is conducted through a desktop feasibility study, although informed where possible by real world knowledge of transport economics and transport systems. The study is primarily focussed on the needs of urban travellers, although may well have relevance for rural travel markets.

A key feature of the approach to the study is that the appraisal is made in terms of the analysis of 'attributes' and 'bundles'; attributes include all the qualities that combine to comprise the overall utility offered by a trip, including practical, objective factors such as journey time, reliability, and price, and more subjective, perceptual, quality-of-life variables, such as in-vehicle comfort and pleasantness of staff. The whole range of possible attributes can be combined and recombined into different bundles. Some possible bundles are in fact represented by existing transport modes. In principle, new bundles may attract sufficient demand so as to complement, or to some extent replace, traditional bus and taxi services. As the possible new mode is conceived as being flexible in its mode of operation (as well as being flexible in time and space), and because price is expected to be a significant variable, it is given the working name '*The Variable Price and Attribute Transport System*' (VPATS).

VPATS differs from existing, operating Demand Response Transport (DRT) services in that the same vehicle (or pool of vehicles) is used to offer a range of service attribute bundles, with demand for the bundles of varying service quality being discriminated by the price mechanism. Hence, demand for specific bundles is expected to reflect willingness to pay, but the offer of a wide range of bundles within the same operating structure can attract a wide range of travellers to the one system. As a result, economies of scale can lead to higher overall service quality for lower levels of subsidy demand.

The study will be reported through three staged documents, relating to the number points above. The present report concerns Stage 1, and considers evidence on demand, the extent to which existing transport services meet those needs, and the nature of a possible alternative. Stage 2 will focus on supply issues, conducting a feasibility analysis of implementation scenarios in the city of Bristol, with the new system variously coexisting with and replacing the established transport systems.

Stage 3 will examine the practical barriers to implementation and practical barriers to advantaging the travel poor through implementation.

1.1 Structure of the Stage 1 Report

The remainder of Section 1 summarises the social and political context of the transport market.

Section 2 considers the concepts of attributes and bundles through the characteristics approach, which has not commonly been applied to understanding how people respond to travel opportunities. In essence the application of this approach considers transport modes and modal variants as classes of goods which provide utility to travellers according to their attributes, but are purchased as an ensemble. Hence, demand functions need to consider the bundles in different combinations, rather than in isolation (Estrin & Laidler, 1995).

Turning from this conceptual approach, the relationships between demand and supply have traditionally been explored empirically in the transport field through the estimation of demand elasticities and cross-elasticities, and on the specification of demand functions. The state of current knowledge is summarised in Section 3, where an attempt is made to disaggregate the relevant variables. The evidence is more developed with respect to price; less so with respect to the other attributes.

Notwithstanding the limitations of empirical data availability, it is necessary to devise appropriate scenarios to form the basis of Stage 2 and 3 of the feasibility study by re-bundling the relevant attributes. The chosen route to constructing these scenarios is to consider, to a greater or lesser extent, variations on real-world bundles, as represented by established modes and others which have been theoretically constructed, but not necessarily trialled in the field. This analysis is found in Section 4.

1.2 Context

Ongoing suburbanisation, rising car ownership, and the associated dispersal in travel and land use patterns, taken together point to a growing share of the population in both developed and developing countries becoming harder to provide for with conventional bus services. At the same time, some bus networks are actually contracting in time and space, whilst fares are rising due to worsening revenue/cost ratios or greater demand for profit by private sector operators.

Throughout the developed world, flexible public transport services are being seen as a solution to the problems of limited access of the travelling public to conventional road-based public transport networks, increasing costs of providing conventional bus services and the needs of particular traveller groups¹.

Urban residents are worthy of particular consideration here, in part due to the recent focus of concern about transport poverty in rural areas. In practice, the situation is complex, with poverty arguably being of a greater magnitude in urban areas, but

¹For example of schemes in the UK, Belgium, Finland, Italy, France and Switzerland see the website of the pan-European FAMS project: <http://www.famsweb.com/>.

possibly more hidden in rural areas². In any case, like rural areas, not all parts of towns and cities are served by effective bus networks all of the time. Traditional public transport is arguably failing this section of society, in terms of both quality and price. The needs of this group are not always adequately represented in evaluation procedures which are applied at the aggregate level of the whole society.

Further, a high quality public transport system, at an acceptable price, is a cornerstone of government policy more generally (Department of the Environment, Transport and the Regions, 1998). Here, greater 'transport integration' is sought; essentially the implementation of measures that will lead to the replacement of some car journeys, or parts of journeys, with other modes, in order to encourage 'sustainable mobility'. The latter concept can be defined as a transport system which meets both current and future societal needs for social equity, economic development and environmental protection (Feitelson, 2002). This concept is operationalised in the UK through the Government's *New Approach to Appraisal*, which requires transport plans, policies and programmes to be assessed against the five overarching objectives: environment, economy, accessibility, safety and integration (Department for Transport, 2003). However, more than one commentator has noted the risk that social equity considerations are subsumed where they conflict with economic or environmental objectives (e.g., Green & Wegener, 1997; Baeten, 2000).

A particular focus of the analysis is the needs of the travel poor. Kenyon, Lyons & Rafferty (2002) have argued that travel poverty is a particularly important form of exclusion, in that it leads to secondary exclusion from opportunity. The Social Exclusion Unit (2003) investigation into the role of travel poverty in exclusion from social and economic opportunity has indicated that:

- access to transport is a barrier to work for 40 percent of jobseekers,
- 16 percent of people without cars have difficulty accessing supermarkets,
- 18 percent of those without access to a car find that mobility constraints limit social interaction with friends and family,
- 1.4 million people each year do not take advantage of medical services due to the deterrent effect of poor transport links, and
- transport costs are a barrier to half of 16 to 18 year-olds staying in education.

The transport market is often characterised by the problems of excess supply, rather than insufficient supply, particularly at peak hours in urban areas. In any case, simply increasing supply would do nothing, *per se*, to assist the travel poor. Hence, any new services should directly serve any needs that are not currently met, and should, in principle, be accompanied by a reduction in demand and supply of the established modes, in order to ensure that the total level of mobility is not significantly increased.

In principle, one type of journey that might be better served by a flexible transport mode is the intra-suburban work journey, for which bus services may be available, but require travel into a central interchange point in order to change between radial

²Analysis by region (Department of Work and Pensions, 2004: Table 3.2 [AHC]) shows Inner London to have the highest proportion of households in the lowest disposable income quintile (after paying housing costs), with Outer London, the Midlands and the North East also having above average rates of poverty. Relatively rural South East, Eastern and South Western England have below-average rates of households living with low disposable incomes.

routes. If travel times are hence prolonged, this might make taking a particular job – perhaps a part-time position fitted in between delivering and collecting children from school – unviable.

Some out-of-town supermarkets are served by conventional bus services, but this sometimes occurs as a result of time-limited agreements as part of the conditions of granting planning permission. The services may serve only limited districts, or be very circuitous, or both. A flexible service could in principle increase the sphere of influence of the supermarket, and also enable individual journeys with a lower 'generalised cost'; an overall notional measure of monetary and non-monetary costs, in which time and fares are usually significant components.

Similar arguments can be rehearsed in respect of journeys for social and health reasons, except that the destinations may be even less accessible than the activity locations associated with employment and grocery purchases. Journeys for health may be occasional, and so knowledge about travel opportunities may be limited; the availability of accurate and sufficient information is regarded as fundamental to the successful use of any transport system, but this is particularly true for public transport, where the traveller has less control over the system.

Finally, ability to pay is a significant cause of all kinds of social inclusion, not just travel poverty. The 'holy grail' of the current research exercise would be to identify a means by which technology could bring the level of travel utility associated with using private cars or taxis to the car-less and poor, ideally with lower fares than currently paid, but without requiring greater subsidy from the state.

1.3 Key Characteristics of the Flexible Transport System

VPATS can be defined as a novel, flexible, technology-intensive approach to providing public transport services within which key characteristics such as responsiveness to demand in time and space, overall journey time, and degree of exclusivity of use of the vehicle can vary according to need and/or ability to pay.

A fair understanding has been developed by the transport community over recent decades about how travellers, or, more correctly, potential consumers of transport services, respond to changes in the characteristics of a mode. The range of explanatory (or independent) variables that could potentially be considered is large. A major review of factors affecting demand for public transport has recently been published (TRL, 2004). Flexible transport services are without doubt a special case of public transport. Hence, the experience of a recent review by Enoch, Potter, Parkhurst, & Smith (2004) has been drawn upon. In light of these reviews, the variables that have been judged most relevant and important for the feasibility study of flexible transport are:

- the fare, P ;
- the immediate availability of the service in space, A_s ;
- the immediate availability of the service in time, A_t ;
- the in-vehicle journey time, T ;
- the reliability of the service, R ;
- degree of exclusivity of use, E ;
- the level of comfort, C ;
- the degree of actual or perceived safety and security, S .

The variable P has special importance, being the medium through which the consumer expresses the value or utility that a transport service offers to him or her, although with some conceptual limitations here, around the difference between willingness and ability to pay.

A_s and A_t are both measures of flexibility: A_s is a measure of physical or route flexibility in space, whilst A_t includes the frequency of the service, and whether advanced notice or booking time must be allowed for. In the case of a journey by private hire taxi, for example, A_s is very high, as it offers a near door-to-door service, whilst A_t is fairly high, but reduced by the need to make a telephone request and wait until a vehicle arrives. A conventional bus service will generally offer low to moderate A_s ; the Transport for London objective is that origins are within 400m of a bus route. However, Tyler (2002) reports a study in Bloomsbury, London which showed real distances as having a mean distance of 528m for walkers, rising to 930 for wheelchair users³. In any case, some potential bus users would not, or could not, travel that distance, and where potential origins are relatively dispersed, distances would naturally rise.

A_t varies greatly between services. Provided the traveller is within reasonable access of a bus stop, some services then operate on what are described by operators as a 'turn-up-and-travel' basis with a 5 to 10-minute frequency. Where private hire vehicles need to be summoned by phone, this service frequency may in fact be superior, although hackney carriage availability in central London will generally be more immediate. At the other extreme, outside of urban areas, some bus services may operate only once a week, and there may be very few private hire vehicles in a rural locality, requiring booking hours or days in advance in order to guarantee departure time. Both the limitations of A_s and A_t are fundamental to the case for VPATS both in urban and rural contexts.

T and R are the familiar concepts of transport analyses of how long the journey lasts when in the passenger transport phase and whether the journey can be completed to the desired destination and in the expected journey time. Theories of travel behaviour generally regard time spent in all conditions A_t (e.g., scheduled waiting time) and time spent in abnormal conditions of R or T (i.e., a delayed journey or absent scheduled service) as being perceived as having higher values than are values of time in R or T travel situations which occur as planned.

E is a particularly important variable for VPATS, as it is expected that E will vary with respect to P as a matter of service policy, in order to allow some degree of cross-subsidy between high-income and low-income users; the assumption being that low income users will be happy to trade high E for low P , with this possibly increasing T

³ Tyler and his colleagues have investigated the implications in practice of the Transport for London guideline that all origins should be within 400 perpendicular metres of a bus route (but not necessarily a stop). The theoretical outcome is that, where demand justifies stops will be 566-800m apart due to street geometry and maximum walk distances up to 566m. In practice walk distances will also reflect detailed street design, which places practical constraints on bus stop positioning and possible walking routes. In the case of central London, the street geometry is more accessible on foot than the ideal grid, so mean distances were somewhat lower.

as a result. High income users, instead, are expected to seek the reverse, prepared to pay a high P in exchange for low E , in order to preserve, *inter alia*, low values of T .

All VPATS services will achieve a basic level of C and S . However, it may be possible to offer enhanced C at a premium rate, through the operation of a varied fleet, in the same way that E , A_s and A_t can be varied with respect to P . S covers both personal security and vehicle safety, although the latter is assumed to be at least at the standard of the public transport industry, which in statistical terms is safer than travel by private car. However, the personal security element will vary according to A_t in particular, to some extent with A_s , and possibly also with respect to E ; the most secure journey arguably being that made door-to-door, without the need to wait in a public place, and with one or more fellow travellers. As some of these attributes would normally have an inverse relationship with the level of P , it might be necessary to provide levels of service in respect of some of these attributes in return for low levels of P , for vulnerable traveller groups.

2 The Attribute Approach to Consumer Behaviour Theory⁴

Conventional consumer demand theory assumes that consumers maximise their satisfaction, subject to an income constraint. In 1966 Kelvin Lancaster developed a new theory of consumer behaviour stating that goods and services have *attributes* that do not yield a well-defined service, and that it is those attributes that yield satisfaction, not the goods/services themselves.

Whilst the Lancaster theory is not without its limitations, most notably in terms of the fact that characteristics can be difficult to identify. Nonetheless, it is still a useful tool with which to analyse the market for the various public transport modes to be found in the urban environment. For a detailed analysis of the attributes approach see Estrin & Laidler (1995), Gravelle & Rees (1992), Griffiths & Wall (2000), and Salvatore (1986).

2.1 The Attribute Approach

The factors appraised as being the attributes (characteristics) yielding satisfaction to users of urban transport provision, including bus, taxi and any demand responsive mode, are those indicated in Section 1.3. In selecting a public transport mode in urban areas, the individual is in fact selecting a bundle of attributes, and the utility function will reflect this:

$$U = G(C1, C2, \dots, Cn).$$

The choice of mode is not, therefore, simply determined by income and price, but also the characteristics of the particular mode. Two assumptions must be made to allow two-dimensional graphical presentation:

1. a particular mode has two characteristics;
2. there is a predetermined expenditure on the service.

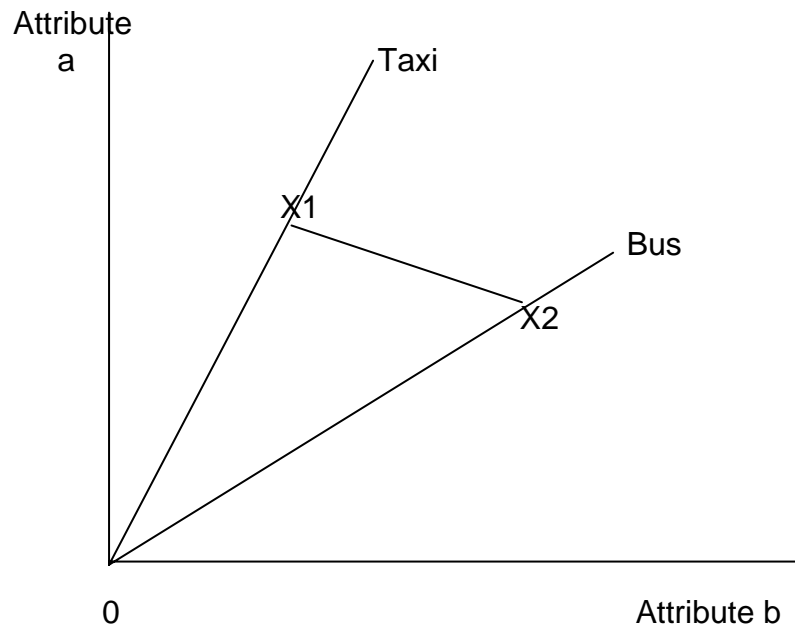
Hence, in Figure 2.1 the two axes refer to two particular attributes, attributes *a* and *b*. The Figure incorporates two modes, for example taxi and bus, each mixing the two attributes in different proportions – the slope of the ray from the origin representing the proportions they each provide in terms of the two attributes. Hence the taxi possesses more of attribute *a* but the bus more of attribute *b*. In terms of consumption these are measured in fixed proportions moving out from the origin along the ray.

Along each ray there is a price, which must be paid in order to acquire the two attributes. With a particular predetermined expenditure on the service, the individual is able to buy certain amounts of the two services. This could be X1 and X2 in Figure 2.1, the taxi being the more expensive of the two services.

⁴ It is important to state that examples of this approach have tended to focus on goods rather than the service sector. See for example Griffiths and Wall (2000), Salvatore (1986) and Estrin and Laidler (1995). This approach can be seen as schematic.

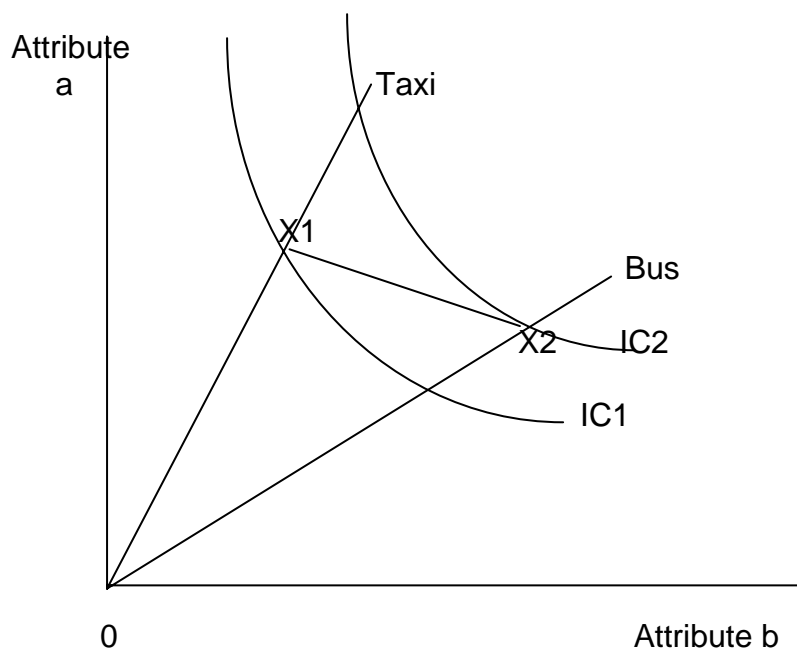
Given the prices of the two modes of transport, the consumer is faced with a discontinuous budget line. This can be seen as X_1X_2 in Figure 2.1. Area OX_1X_2 represents the feasible region, and the budget line X_1X_2 can also be termed the characteristics possibility frontier. The gradient represents the relative prices of the two characteristics/attributes.

Figure 2.1: The attributes approach



The indifference curves⁵ IC1 and IC2 in Figure 2.2 indicate the preference bundles of the characteristics, rather than preference bundles of goods (as in the traditional indifference curve analysis). If the consumer is restricted to buying only one of the two services, then given the situation in Figure 2.2 the bus alone will be used since it affords the consumer a higher level of satisfaction, being on indifference curve IC2 (point X2).

Figure 2.2: Maximising satisfaction



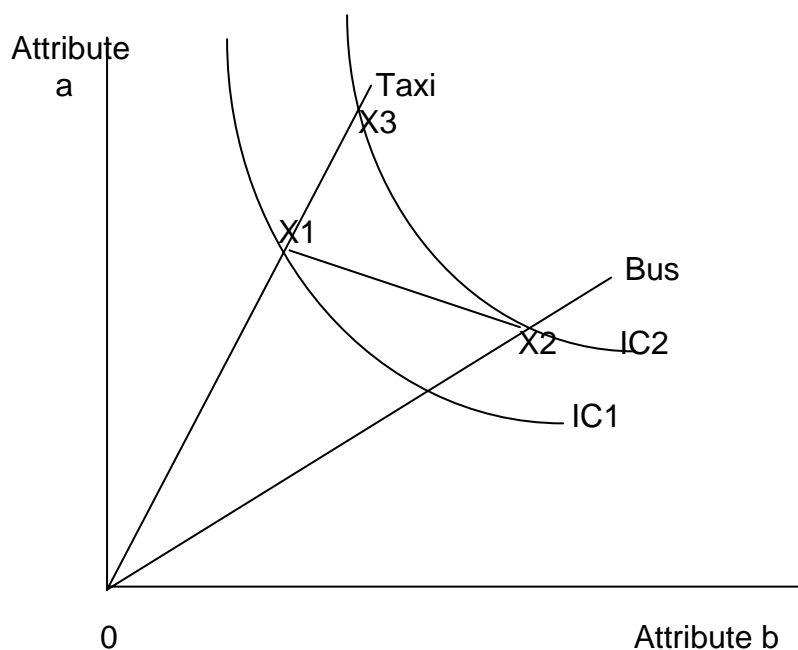
2.2 A reduction in taxi fares

A fall in the price of one of the two modes can be analysed by use of Figure 2.3. Traditional consumer demand theory states that as the price of a good falls more of that product will be bought, assuming *ceteris paribus*. This is not necessarily the case however. In terms of Lancaster's theory a fall in taxi fares will mean that it is possible to move further along the taxi ray in Figure 2.3. However unless it gets to a point beyond X3 there will be no effect on the individual consumer behaviour. This means therefore that there is an element of mode loyalty in terms of individual choice, since price is only one of the factors⁶.

⁵ An indifference curve reveals all the combinations of two products between which the consumer is indifferent; in other words combinations which yield the same level of satisfaction.

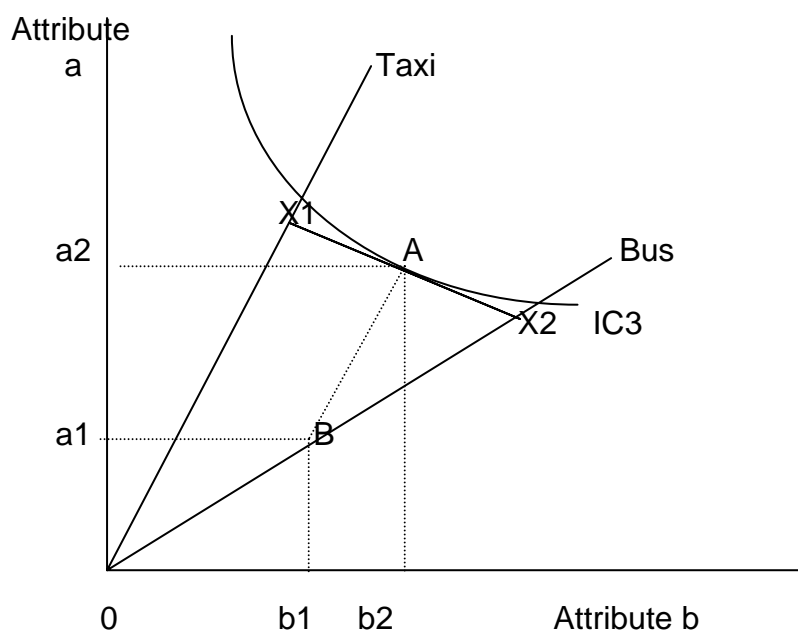
⁶ In terms of the theory the idea of a smooth downward sloping demand curve is undermined, at the individual level. Conventional demand theory has difficulty dealing with product differentiation and brand loyalty. It treats products as homogeneous.

Figure 2.3: A fall in taxi fares



So far the consumer has been unable to obtain any mix of attributes other than those made available by consuming one or other of the two modes. In other words it has been assumed that only one mode is used. It is, however, possible to obtain a combination of the attributes by using both the taxi and bus for different journeys. This can be illustrated by the use of Figure 2.4.

Figure 2.4: Utilising two modes



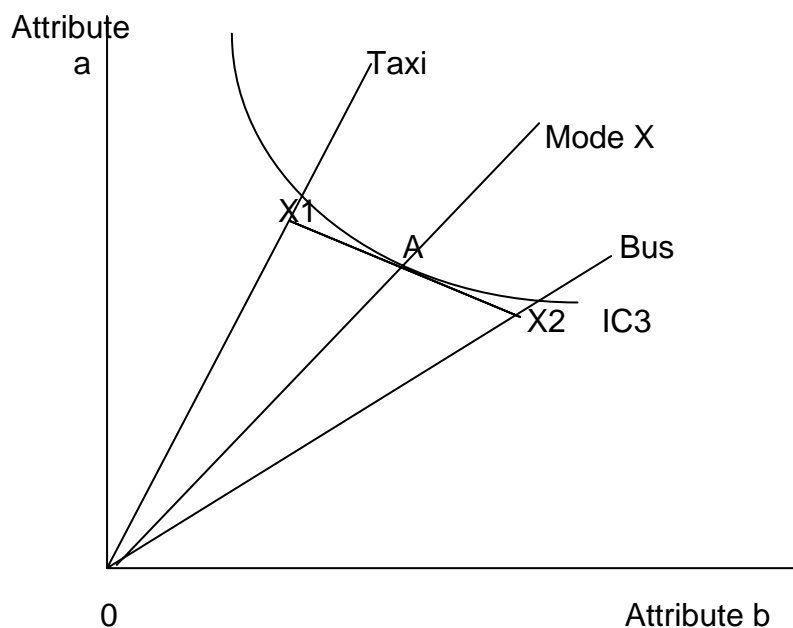
By utilising different modes for different journeys the individual can achieve point A which represents more satisfaction than would be obtained if only one mode were chosen. Point A could be achieved by purchasing:

- OB bus provision (giving a1 of attribute a and b1 of attribute b)
- BA taxi provision (giving a1a2 of attribute a and b1b2 of attribute b).

Finally, if a mode of transport can be offered which combines the attributes in the proportions signified by point A, (such as Mode X in Figure 2.5), and offered at a price that enables the consumer to reach a point above and to the right of A that individual will switch to that mode, since they will be better off.

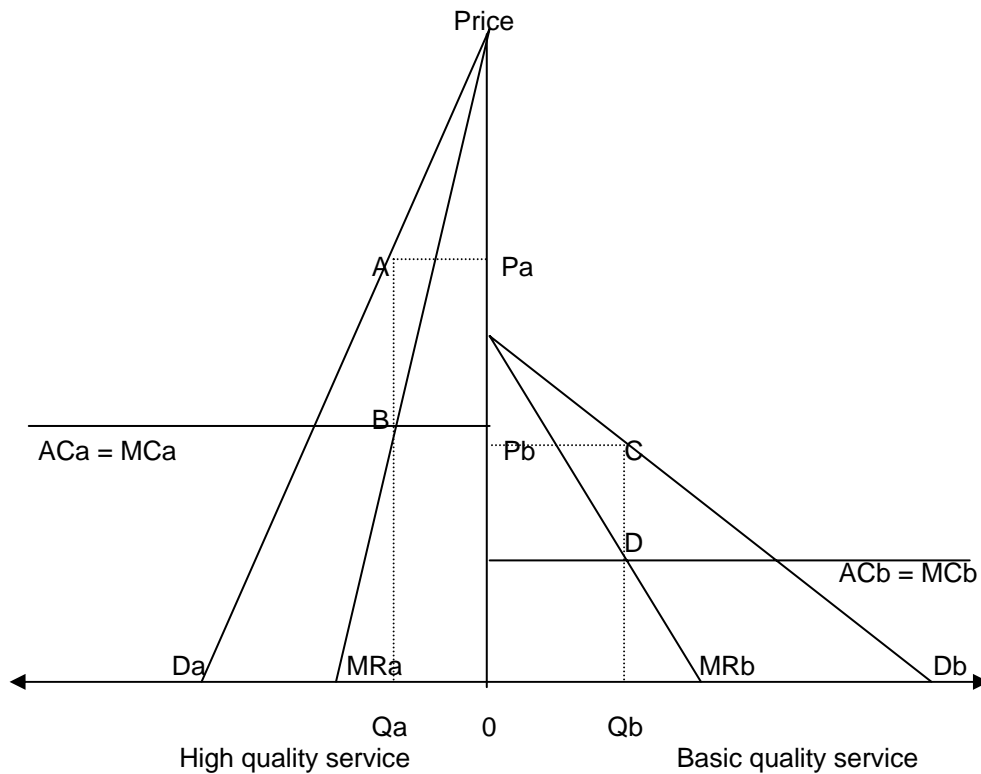
If there are enough consumers with such tastes and it is technically feasible then there is a strong incentive for the service to be provided.

Figure 2.5: New mode introduced into the market



An additional key aspect of VPAT is the pricing differential and this can be outlined by use of Figure 2.6. The Figure refers to the new VPATS with two levels of service, namely a basic level of service (in terms of say comfort and safety as illustrated in section 1.6) and a high quality service (such as enhanced comfort) which would be provided at a premium rate. This would clearly require a varied VPAT fleet. The total level of service provided by the VPAT is $Q_a + Q_b$ and this is provided to the various user groups.

Figure 2.6: VPAT pricing differentials



The Figure illustrates two groups of consumers, namely high quality users and basic users. Each consumer group faces different demand curves. For the high quality user demand is relatively inelastic, represented by D_a , whereas for the basic user (which could be the socially excluded) then demand is relatively elastic, represented by D_b . With demand of D_a and D_b there are associated marginal revenue curves of MR_a and MR_b respectively. If the assumption is made that the VPATS is a profit maximiser⁷ and that costs are constant for the provision of both services then they will charge a price of P_a for the high quality service and P_b for the basic quality service. As seen in the Figure the cost of providing the higher quality service ($AC_a = MC_a$) is higher than the cost of providing the basic quality ($AC_b = MC_b$). Whilst this is the case the mark-up for the higher quality service AB is greater than for the basic service CD .

If an assumption of social enterprise is introduced then it is possible that the basic quality service could be provided at a lower price than P_b . If it is provided below cost then this could be cross-subsidised from the profit earned from the high quality service.

It is important to remember that the analysis in this section has been demand-led, revealing the potential gains to the consumer from unbundling the various attributes obtained from consuming urban transport provision. The potential gains to the supplier, namely higher load factors and lower unit costs, if this could be achieved, will be discussed in greater detail in Stage 2 of the Report.

⁷ This assumption has been made for ease of analysis. In terms of providing a service for social reasons then clearly this assumption can be relaxed.

3 State of Knowledge with Respect to Demand Functions

A wide range of factors influence the demand for any transport system, and this will be at least as true for a flexible system such as VPATS. The wider range of other variables which is not considered directly by the present evaluation, but nonetheless affect demand, such as the cost of car use, number of people without paid employment, the ease of access to and egress from a vehicle, are referred to as contextual variables and are denoted together by the letter, n .

Drawing on the notation in Section 1.3, the demand function for the present feasibility study can thus be formalised as:

$$Q_{rt} = f(P, A_s, A_t, T, R, C, E, S, n\dots)$$

In short the quantity demanded of responsive transport (Q_{rt}) is a function (f) of all the variables inside the bracket. A key objective of Stage 1 of the present study is to reach a justified and informed approach to weighting the relative importance of the attributes which influence demand of a responsive passenger transport system.

3.1 Empirical Measures of Demand

The typical measure used to identify the responsiveness of consumer demand to each of the external variables in the transport mode offer is *elasticity*⁸. The set of explanatory variables that are considered is stated above. Obviously the ability to investigate these issues empirically is highly dependent on the data available – which in the case of elasticity may be derived from actual data or stated preference questionnaire techniques. In the present report we refer to data from a broad range of existing studies to infer the nature of demand for responsive transport systems.

Transport economists worldwide have extensively studied cases of elasticity, the recent TRL (2004) report *The Demand for Public Transport* is supported by a bibliography of approximately 500 publications. Wardman and Shires (2003) *Review of Fare Elasticities in Great Britain* lists 104 studies conducted since 1968. For our purposes, however, it is important that the work cited informs our understanding of demand responsive transport systems in an urban area such as London or Bristol. The following presentation is focused towards that end.

There have been numerous studies of bus **fare (price) elasticity** worldwide and more than 30 in the UK alone. The figures are in a similar region and a frequently used rule of thumb is that each 3% fare increase reduces passenger demand by 1%.

⁸ This can be defined as follows:

$$\text{The elasticity of demand} = \frac{\text{The proportional change in demand}}{\text{The proportional change in the given explanatory variable}}$$

Mathematically it may be expressed in several ways. For example, to calculate elasticity at a particular point, on the demand curve, as an average moving between two points on the demand curve, or using a logarithmic scale to facilitate extrapolation based on point or arc elasticity. (For more on the mathematical background see TRL 2004 or Griffiths and Wall (2000).

However, although these findings refer to the direct effects of price on demand, they are associated with the increased level of car ownership over time in a complex way.

There is firm evidence to suggest that fare elasticities increase with time elapsed after the fare alters, with a distinction made between **short-run** and **long-run** values. For example, a comprehensive study of fares in Great Britain based on official government data from 1970 to 1996 suggested that bus fare elasticity for full fare paying passengers in the short-run is in the region of -0.2 to -0.3 and in the long-run -0.7 to -0.9 (Dargay and Hanly, 1999). In other words, the long-run elasticity can be as much as three times higher than the short-term equivalents⁹.

This seems quite logical, as individuals will not be able to make all the changes they would like to their travel habits immediately. In the first instance (up to one year) much will depend on habit and necessity. In the long run, which Dargay and Hanly (1999) argue can take up to seven years, people have time to adjust to all circumstantial changes. These could include: changes to employment and family situations, revised modal offers, the acquisition of more private cars, concessionary ticketing and so on. Use of VPATS, then, as with all modes, can be expected to develop over time as travellers re-evaluate their options.

Car ownership in practice is sought for a range of reasons, including the limitations of public or shared transport. Once obtained, car ownership has made modal shift away from public modes more possible; hence the level of observed long-run elasticity of bus use with respect to fare. Once a car has been bought the owner may become 'captive' to the vehicle. However, car ownership and use is also price sensitive and affected by cross-elasticity effects.

Currently, around 28% of households do not have a car. On average, non-car owning households make roughly 20% of all their trips by bus (151 trips per year), while, for car owning households the figure is only 3% (33 trips). As a result the bus industry has become ever more reliant on the ever-diminishing number of non-car owning households (House of Commons, 2002). That fewer people are dependent on public transport in the longer term is one explanation for the **asymmetry** observed in behavioural changes: fare elasticity may be higher when fares are increased than when they are decreased. Car ownership may be less likely to be reduced as a result of fare reductions than it is increased as a result of fare increases. Alternatively, the long-term responses may be similar, but operate over different timescales, *e.g.*, car ownership only being abandoned when a particular vehicle reaches the end of its serviceable life or as a result of a critical life event, such as unemployment or retirement (Goodwin *et al.*, 1983). It is this relationship that VPATS seeks to exploit to reduce car dependence by attracting relatively wealthy travellers who use private cars and taxis, but might use VPATS, perhaps on an exclusive-traveller basis.

Price (fare) elasticity values also increase with level of bus fare, one explanation being that the large changes are easier to perceive (TRL, 2004). Another view invokes more conscious judgement; that the greater the proportion of income used in

⁹ Although it can be observed here that both the short and long-run responses can be regarded as inelastic, as they are less than ± 1 .

the transaction the more sensitive people are to price changes. Reference can be made to Dargay and Hanly (1999), who demonstrated a five-fold difference between high fares and low fares (the definition employed referring to £1 as high and 17p as low, at 1995 prices). Elasticity in the long-run ranged from -0.2 for low fares to -1.0 for high fares. Given the importance of the level of fares on elasticity, then this may mean the UK, with relatively high bus fares compared with many other EU member states, may be a particularly attractive market in which to initiate a VPATS service, because the economic constraints under which the conventional UK bus industry is operating suggests it will need to make further fares increases, and the elasticity relationship suggests significant loss of custom as a result¹⁰.

Litman's (2004) summary of elasticity values for various levels of **fare, operating costs, and service**, extracted from numerous studies from the 1960's onwards reveals that service elasticity has the highest value (as much as 1.1)¹¹. This suggests that changes in service quality will cause a more than proportional change in demand. Also comparing **service and fare levels**, but for taxicabs in New York City, Schaller's (1999) empirical work suggested that the elasticity of trip demand with respect to fares was approximately -0.22 compared to an elasticity of availability of service nearer to 1.0. Similar to Litman's findings, this would suggest that the availability of taxi services is somewhere in the region of 4 or 5 times more important than fares!

At the aggregate level, then, this explains why many relatively wealthy travellers would see a taxi as the alternative to a private car, rather than a bus. These travellers would use VPATS essentially as a taxi-substitute; expecting a door-to-door service, and only tolerating non-exclusive use if there was minimal or no effect on the service level they experienced. The suggestion is that a significant premium over bus fares might be charged for journeys on this basis, or conversely a discount relative to taxi fares.

In general, it is notable that more empirical evidence focuses on fares than aspects of service such as availability, booking time, comfort, frequency, and safety, so the empirical evidence concerning these important independent variables for DRT as indicative, rather than confirmatory. However, in respect of wait time, Preston and James' (2000) analysis of bus data from 23 UK towns estimated an average elasticity wait -0.64, with a range from -1.17 for off-peak adult trips to -0.39 for peak time adult trips (Table 3.1).

¹⁰ A further observation which arises from the relatively high level of bus fares in the UK is that this reflects the low level of subsidy provided to UK bus operators compared with those in other states. This means that VPATS will be more likely to offer a competitive service without itself needing high subsidy.

¹¹ Service quality emerges as having a strong positive relationship with demand, in contrast to the generally weaker inverse relationships of demand with respect to price.

Table 3.1 Elasticities with respect to wait time – Bus

Dependent Variable	Time period/destination	Elasticity with respect to wait time
Total trips		-0.64
Adult trips		-0.74
Adult trips	Peak/town centre	-0.65
Adult trips	Off-peak/town centre	-0.85
Adult trips	Peak/other	-0.39
Adult trips	Off-peak/other	-1.17
Total trips	Peak/town centre	-0.64
Total trips	Off-peak/town centre	-0.64
Total trips	Peak/other	-0.50
Total trips	Off-peak/other	-1.05

Source: Preston and James, 2000

Furthermore, certain factors considered in the literature are subsumed into the ‘n’ component of the Q_{rt} function. As such they are factors which inform about the nature of the operating niche(s) that VPATS is likely to serve, even if the VPATS will not be designed to vary specifically in respect of them.

A distinction, for example, is made between behavioural responses in **rural and urban areas**. Dargay and Hanly (2002) used county specific data to make the distinction between metropolitan (urban) counties and Shire (rural) counties shown in Table 3.2.

Table 3.2: Estimated short run & long run bus fare elasticity for English counties

	Metropolitan (urban) areas	Shire (rural) counties
Short run	-0.26	-0.49
Long run	-0.54	-0.66

These estimated elasticity values suggest a comparatively higher level of response in rural areas than urban areas. The logic of explanation here is that travellers in relatively rural areas are more sensitive to changes in bus fares because more people in rural areas can opt to use a car, as there is less road congestion and fewer parking restrictions. It is also likely that the relationship is related to the absolute level of fare and service quality: urban areas generally have far better bus service provision (in terms of the number available) and lower fares, so changes in fare are more acceptable.

However, further evidence is revealed by the fact that the long-run elasticity is twice that of the short-run equivalents in the urban areas. This is likely to result from the relatively greater range of modal choices that exist in these areas compared to a rural setting. For example, anecdotal evidence based on suburban London would suggest that short run responses to bus fare changes are quite dramatic as there is a good public transport infrastructure, including the underground, and there is also the option to use the car, as congestion is not quite the problem that exists in central London (White, 2002). More generally, it is known that where bus patronage does increase in urban contexts, only a minority of new trips switch from car; much of the

net increase in demand comes from walkers, cyclists and existing bus users, who choose to travel more.

Reporting on international data, Pratt *et al.* (2000) confirmed and extended the findings of Dargay & Hanly (1999, 2002) by citing bus fare elasticities from 32 urbanised areas with populations less than 1 million compared to 20 larger urban areas. The elasticity respectively was -0.43 compared to -0.36. As one would expect, the less congested the area the greater the level of response, as walking, driving (and parking) are still possible options.

Overall, the lesson for VPATS would seem to be that it is dangerous to regard urban travellers as ‘captive’ to a particular mode, whether that by bus, car, cycle or walk. This suggests opportunities for VPATS do exist, if attractive attribute bundles can be offered, but confirms that they will experience healthy competition from incumbent modes, assuming their supply is not subject to regulation or other limitation.

The **purpose of the trip** will also have a bearing on the elasticity value. Trips made for work or education purposes will be relatively inelastic compared to those made for leisure and shopping. Indeed various studies carried out from 1978 to 2000 drew a clear distinction between peak and off-peak elasticity; categories which to a large extent can be considered approximate surrogates of journey purpose. The calculations are summarised in Table 3.3.

Table 3.3: UK short-run fare elasticities by time of day

	Bus	Underground	Rail
Peak	-0.26	-0.26	-0.34
Off-Peak	-0.48	-0.42	-0.79

Source: Adapted from TRL (2004: 58).

The off-peak elasticity values are approximately twice the value of the peak-time equivalents, with slightly greater variations for rail, which may reflect the greater benefit of off-peak fare discounts available on this mode, which have traditionally attracted a large number of discretionary trips, giving rise to a significant difference in behavioural responses between dependent and discretionary users of these public transport modes: price changes may have little impact on dependent users going to work or school but discretionary users tend to be more price sensitive. This experience is likely to be of direct relevance to VPATS. Assuming the user costs range somewhere between bus and rail, it is reasonable to suppose that the similar finding that off-peak travellers are around twice as sensitive as peak travellers will hold.

Finally, it can be noted that one approach to considering the simultaneous variation of an observed bundle of attributes is through applying the concept of **generalised cost** (GC), which brings together fare costs, with monetised values for in-vehicle time, walk time, wait time, and may also include other factors, such as degree of comfort offered.

Halcrow Fox *et al.* (1993) reported that GC elasticities vary by journey purpose by bus with a range of -0.4 to -1.7, for underground from -0.4 to -1.85 and for British Rail of between -0.6 and -2.00 (Table 3.4).

Table 3.4 Generalised cost elasticities

Purpose	Mode	Low income	Medium income	High income
Home – work	Bus	-0.40 to -0.50	-0.50 to -0.70	-0.60 to -0.80
	Underground	-0.40 to -0.60	-0.50 to -0.70	-0.70 to -0.90
	BR	-0.60 to -0.70	-0.70 to -0.90	-0.80 to -1/0
Home – other	Bus	-1.30 to -1.50	-1.40 to -1.60	-1.50 to -1.70
	Underground	-1.40 to -1.60	-1.50 to -1.70	-1.65 to -1.85
	BR	-1.30 to -1.50	-1.60 to -1.70	-1.70 to -2.00
Employer’s business	Bus		-0.60 to -0.80	
	Underground		-0.50 to -0.70	
	BR		-1.50 to -2.00	

Source: TRL (2004: Table 7.23, after Halcrow Fox *et al.*, 1993).

3.2 Difficulties of Interpretation

Price changes indicate the factors that directly affect consumer demand; in other words, prices reflect users perceived marginal costs. These can include both monetary and non-monetary costs to arrive at a generalised cost schedule. However, it is commonly accepted that elasticity measurements are a very broad-brush indicator. At an aggregate level they may be used to indicate response levels but in judging specific individual behaviour there may be problems. No single elasticity value will apply in all situations. The above analysis suggests that in general terms, quality of service: availability, safety, reliability, number of modal alternatives, booking time required etc. are important aspects of demand, but relative to price these variables have been less studied in the transport literature relating to elasticity, because of difficulties of measurement.

Second, the analysis has been based on data dating back to 1968 and beyond. In the last 40 years real incomes have increased significantly, and essential transport costs are a smaller proportion of disposable income for many households. Not only is it likely that short-term behavioural responses to changes in public transport service attributes have changed somewhat over time, but the growth in car ownership has increased the number of people able to make long-term changes.

4 Towards a Specification for VPATS

This final main section considers the nature of VPATS flexibility, and the extent to which VPATS-type systems already exist. In the final subsection two prototype high-technology flexible transport systems are appraised as possible models for Polybus.

4.1 Nature of VPATS flexibility

The concept of VPATS is that it will not only be flexible in terms of space and time, but also in the mode of operation that it employs for serving different markets. Potentially, then it has very complex behavioural interactions and raises a wider number of regulatory considerations. Although practical constraints will be addressed in detail later in the study, it is appropriate to consider those constraints that will affect demand, rather than, say, legal status, in Stage 1.

Conventional bus services, and most flexible bus services, have some kind of schedule, whilst taxis and private modes generally do not. In the latter case the complete freedom from schedule is generally welcomed, whilst in the case of public, shared modes, conversely, the lack of schedule may be unsettling; responsible for user-uncertainty amongst those used to having a schedule.

In operational terms a lack of schedule also makes the provision of services across multiple origins, destinations and users complicated, especially if real-time requests are allowed: the potential service vehicle is subject to all the constraints of the passengers currently on board, plus those of all the passengers who are to be subsequently picked up.

Fixed-route services involve scheduled arrivals at given points along a pre-defined corridor. Where provided by conventional bus services, the route is usually associated with a fixed timetable, although flexible-schedule services, such as often occur in developing countries, tend to operate with a fixed route but no schedule; a fill-up-and-go basis. Route-deviation or semi-flexible services extend fixed-route services by permitting a certain amount of deviation from the fixed route. This deviation can be measured in time or by distance, and may be subject to other constraints. For example, a vehicle may be required to deviate from its route and yet pass through all its checkpoints, making it 'late' on the section of route beyond the deviation. Flexible routing is a further extension of route-deviation, in which the vehicle goes wherever required, as with taxis. As with flexible scheduling, the complications and constraints for a shared public transport service are significant, and it does not usually operate in this manner.

Vehicle type is important: first, because the size of vehicle is normally related to the likely levels of demand, and second, because it is influenced by cost. In the UK, each type of operation requires a different type of operating licence issued by entirely separate agencies. Meanwhile some Public Service Vehicles¹² are able to claim several types of subsidy, rebates and exemptions not available to Private Hire

¹² Classically the vehicle operating a conventional bus service, but with some limits to that definition at the margin.

Vehicles or Hackney Carriages¹³. Drivers, too, need different licences depending on which particular vehicles they drive. Fares are only eligible for a zero VAT rating if the vehicle used has nine or more passenger seats.

A one-to-one service operates strictly between two points, although with the potential for access and egress at intermediate points. A one-to-many service delivers passengers from multiple origins to a single destination or vice versa. A many-to-many service transports passengers between any two reasonably accessible points in the service region. The many-to-many service *in extremis* is a door-to-door flexible public transport service offering near-taxi levels of service. In low-density suburban areas these have tended to be very expensive. Running ‘checkpoint’ services along heavily trafficked routes increases the likelihood of filling vehicles but decreases the proportion of the metropolitan area that is covered by the service.

The following subsections consider and evaluate the experience from the most common types of flexible public transport service operating worldwide today.

4.2 Characterisation of Existing Flexible Modal Offers

Existing flexible transport services, such that might inform development of, or even directly contribute to, a VPATS system can be characterised by market niche. Table 4.1 describes a typology for demand-responsive transport (DRT) services. Notably, many examples are drawn from developing countries, where they tend to operate on a low-technology basis, often without temporal scheduling.

Table 4.1: Market classification of flexible transport systems

Additional capacity/part substitution types			Substitutes capacity
Interchange DRT (DRT provides a link to conventional PT)	Complementary types (additional but separate)	Destination-specific DRT	Substitute DRT (DRT replaces conventional PT and/or specialist capacity)
	Network DRT (DRT may replace conventional PT in certain place/times or co-exist)		
Public Policy Driven Examples: Corlink, Cornwall, InterConnect, Lincolnshire, Village Link, Gloucestershire, Dengie Villagelink, Essex, Dial-a-Ride, Siilinjarvi. Proxi Bus, Aix-en-Provence	Public Policy Driven Examples: Regiotaxi KAN, Arnhem-Nijmegen, Wigglybus, Wiltshire Cango, Hampshire RUF-BUS, Wunstorf, Flexi Project and Fare Car, Devon, The Belbus midibus, Flanders, Personalbus, Florence	Public Policy Driven Examples: Deeside Shuttle, Flintshire King County Vanpool, Washington State, Vipre Vanpools, Netherlands, Travelink Maxi-Taxis, Telford, JAUNT, Charlottesville.	Public Policy Driven Examples: Lovedean Carshre, Hampshire Taxibus, Rimouski, Wisconsin Shared Taxi, Gaberlunzie Bus, East Lothian, TaxiTub, Douai, Community Shuttle, Vancouver.
Commercially Driven Examples: Treintaxi, The Netherlands, Bicester Taxibus, Oxfordshire.	Commercially Driven Examples: Taxi-train, Mauritius, Public Light Bus, Hong Kong Yellow Taxibus, Fife Black Taxibus, Belfast.	Commercially Driven Examples: Vodafone Shuttle, Oxfordshire Super Shuttle, Los Angeles.	Commercially Driven Examples: Black Taxibus, Belfast (1969) Taxi Collectifs, Reunion.

Source: adapted from Enoch *et al.* (2004).

¹³ The key distinction between PHVs and HCs being that the former must be booked in advance of the journey, whilst the latter can be hailed at the time of demand, on the street or from a rank.

As indicated in the table, Enoch et al. (2004) identify four function-based composite case types. In principle, each of these can have public policy-supported or commercial applications, although particular combinations of function and objective will be more or less likely. The classification by function begins with a consideration of whether the DRT systems provide additional capacity to a public transport system or substitute existing public transport capacity:-

- Interchange DRT provides additional capacity in order to provide feeder links to conventional public transport, e.g., serving a rail station or conventional bus route.
- Rather than feeding into other public transport services, Network DRT provides new public transport capacity to serve new markets or expand an existing market by providing additional services, or by replacing uneconomic services in a particular place or at certain times. Typically, this substitution happens at times of the day or week when demand for conventional public transport is low or dispersed, so making it hard to offer an attractive service. Night services are an obvious example, when issues like personal security can also come into play. However there are also *places* where DRT may be more appropriate, such as inter-suburban trips.
- Destination-specific DRT has been developed to serve particular destinations such as airports or employment locations, often providing services that would not be economically feasible or sufficiently attractive if provided by conventional public transport.
- Substitute DRT occurs where a system totally (or substantially) replaces conventional public transport services. This represents a reinvention of public transport. In the UK this appears to be an essentially rural public transport option, but there are some overseas urban examples where DRT has entirely replaced conventional buses. With long-term changes towards more dispersed settlements, well suited to travel by car, that have travel demands fragmented physically and in time, there may be locations in the UK where total replacement of buses by DRT could well be appropriate. In some cases, the substitute service in fact replaces a specialist flexible service, such as dial-a-ride for mobility impaired travellers, thus bringing them into a general public service.

Alternatively, the types of DRT can be characterised in operational terms (Table 4.3).

Table 4.2: Operational Categorisation of flexible transport systems

Characteristic	Alternatives
Scheduling type	Fixed-schedule Demand-responsive Unscheduled
Route type	Fixed-route Route-deviation Flexible-route
Vehicle type	Minicab Taxi Minibus Midibus
Origin and destination relationship	One-to-one One-to-many Many-to-one Many-to-many
Origin and destination service	Door-to-door Checkpoint ¹⁴

Source: adapted from Enoch *et al.* (2004).

In theory, it is possible to form a DRT service from any combination of the above categories. In practice, some types are well established.

Dial-a-ride services target specific market niches, supporting the travel needs of vulnerable travellers with difficulty walking more than short distances and who often need to use walking aids or wheelchairs. Typically the services must be booked hours, or even days, in advance, for a particular travel-time window. The service is fully door-to-door, with entry and egress assistance, but is likely to be shared with other people making journeys to the same or other destinations and the length of possible trips will be somewhat limited. Specially adapted, relatively expensive vehicles are specified. Local authorities are required to offer dial-a-ride-type services as part of their social service responsibilities, and in recognition of the fact that conventional public transport will never be fully accessible to all potential travellers.

In terms of modal attributes, safety, comfort and proximity are all high value attributes, as they are carefully targeted for specific needs. Fares are typically controlled or fully subsidised. However, limited resources may mean that the service is unreliable and request times need to be long in advance - with long 'arrival windows'. This is related to the special needs nature of the service; not only will travel not be exclusive, but long access and egress times to and from the vehicle may affect journey times. The services are generally offered at a low price to the consumer, for the special reasons of social justice. Overall, the utility provided by this mode is likely to be high for its specific user group, but would not be acceptable to travellers with a wider range of choices.

Arguably, the inclusion of such services within VPATS (with some similarities with proposals to incorporate them in DRT services), could further enhance utility by providing a more immediate, predictable service. Although inclusion in mainstream

¹⁴ 'Checkpoint' services occur whereby the vehicle might stop at a pub or post office, or at the end of a street, rather than provide a door-to-door service.

services is generally to be welcomed, there is not a complete consensus of opinion as to whether the most impaired travellers can in practice be successfully, comfortably carried on public services, including from the perspective of that special needs group themselves. It is likely that specialist provision might need to remain for at least some travellers.

Semi-flexible bus services, such as the Wigglybus in Wiltshire, operate on a fixed route basis, but deviate (or 'wobble') when pre-booked to do so or when a deviation is requested by passengers already on board. Semi-flexible services tend to operate as closely as possible to a fixed timetable. Fares in the UK context are typically regulated through the tendered services procedure and subsidised. The vehicle is no more exclusive than a conventional bus. Request procedures vary, but typically require telephone arrangement or walking to a stop. The journey time is unlikely to be superior to conventional bus; indeed the deviations from route may add to journey time. Deviations do, however, make the service more proximate. Reliability and information provision is dependent on operator quality, but can meet or exceed conventional bus. Comfort and safety are similar to conventional bus, although security may be somewhat better due to greater proximity.

Flexible buses offer only modestly greater utility to the typical traveller than conventional services, as the only real advantage is greater spatial accessibility (although this may be very important for particular users). Fares are often relatively high to the consumer (despite them being subsidised), although this is a matter of subsidy policy; Personalbus in Florence offers flexing off route for a modest fare premium on a low cost to consumer basic fare. This can be seen as the simplest possible VPATS system - varying only the route flexibility attribute within the bundle for a higher price. In general the examples addressed in the present section are less sophisticated than VPATS, as the bundle remains constant with respect to a particular service and given price.

The operating characteristics also mean that accessibility in time and in-vehicle time are likely to be higher than conventional bus, whilst there may sometimes be consumer concerns about reliability, as the operating basis is less definite, although this can be offset with appropriate information.

Jitneys operate along a fixed route, usually a major street, and sometimes have regular stopping places. There is no regular schedule and passengers share the vehicle. There is a fixed fare which is low (Black, 1995). Jitneys were commonplace in the USA during the early 20th Century and are still found in cities such as Atlantic City and San Diego (where they are legal) and New York and Miami (where they are not).

Schemes roughly following the Jitney model include the Black Taxibuses in Belfast, the Taxi Train in Mauritius, and the Dolmus services found throughout Turkey. Indeed, the principal main-market (rather than niche-market) applications of the Jitney concept are in developing economies, or in poorly developed sub-economies of industrialised states. The main rationales are low operating costs for the producer, delivering low fares for the consumer.

The service tends towards high occupancy and therefore low comfort, with frequent stopping, which affects journey time. The unpredictable nature of demand within time means that reliability and information about arrival time is poor. The services are not flexible in space, so there is no proximity advantage over conventional bus, whilst the request procedure is as likely to be 'turn up and wait' as 'turn up and go'. Some of the services are associated with a poor safety record, but this is in part associated with weaker regulation in developing economies, rather than an intrinsic shortcoming. Overall, however, the basic model is likely to offer poor utility in the UK context, suggesting poor suitability. This underlines the fact that the concepts of utility and ability to pay are somewhat in conflict: consumers in developing countries surely desire higher specification services and would demand them if they could pay for them. Most consumers in the UK would demand higher specification services, and jitneys would only emerge where there were spatially concentrated pockets of demand.

Airport shuttles are a typical form of one-to-many operation. Passengers 'turn-up-and-go' from the airport and the shuttle is then routed to drop them off as efficiently as possible. Once empty, the shuttle is then directed to collect pre-booked passengers going to the airport in a many-to-one pattern. Such services have developed as airports attract large volumes of people who either do not have access to a car, or would prefer to avoid car use due to very expensive, limited parking opportunities (perhaps requiring shuttle bus access in any case to the terminals). At the same time, the journeys to and from the airport may begin and end in population centres that are not large enough to justify conventional public transport services to the airport. Airport shuttles are common across the United States, and there are also examples in Singapore and New Zealand. A slightly different scheme operates at Charles de Gaulle Airport in Paris. Here, the timetable is fixed but the service still deviates to collect people and drop others off. This service is targeted more at airport employees than travellers, although it is available to everyone. Similar shuttle services also operate to employment sites (e.g., the Deeside Shuttle in Flintshire North Wales), and to rail or bus interchanges (e.g., the Dutch *Treintaxi* system¹⁵).

The airport shuttle is a relatively high specification flexible mode, typically making use of 'luxury' minibuses with a high level of comfort. Fares are also relatively high by public transport standards, but accepted due to the constraints on parking at the interchange. Exclusivity is also intermediate; although there will be a number of other passengers sharing the vehicle, there will be a 'people like me' factor. Journey times will be longer than by car or taxi, but appropriate scheduling of the flexible operation and proximity to the destination will make the times competitive with bus. The request procedure can be intermediate, where it operates on a fill up and go basis from the interchange, but like a shared taxi from the other origin-destination point. Reliability will be a key feature of the service, due to the importance of flight/train departure times for journeys to the interchange, and by virtue of there being a central dispatching point for the return trips. Similarly, security will be high due to the combination of proximity and the central dispatching point. The utility afforded by this mode to the users typically approaches that of a taxi. This derives from the combination of intermediate exclusivity, accessibility in time, and in-vehicle time, with

¹⁵ See <http://www.treintaxi.nl/>. The London Paddington railway station taxi-sharing scheme has some similarities with this scheme on a smaller scale.

a similarly level of accessibility in space as a private car or taxi, but at a lower fare than for a taxi.

4.3 Consideration of near-market systems

Two similar concepts for flexible urban public transport which have undergone substantial development work are *Polybus*¹⁶, where development work has included limited on-road trials of the technology, and *Intelligent Grouping Transportation* (IGT)¹⁶. Both systems are focused around the aims of providing a door-to-door, on-demand public transport service that will rival car use, although require some level of shared use. However, in other respects, their inventors believe they may even be able to exceed the standards set by private car travel.

The Polybus¹⁷ concept has been under development for a number of years, and has adopted higher-technology solutions as they have become available. The system is conceived as being door-to-door, although mobile telephone bookings from the street could be accepted. It is also envisaged that it would operate as a delivery system for small consignments.

Polybus is not a low-cost system but has favourable user-costs with respect to taxi fares. Initial field trials suggest it can provide a similar level of taxi-type service for a lower level of resource than a taxi fleet. It uses the GPS system to enable door-to-door service which, compared with taxi, has a favourable availability in time (in terms of time expired from request to travel commencing) and which will rival private car when the car cannot be left precisely at the origin and/or destination. In-vehicle time will be higher than for private car and taxi under some circumstances, due to sharing, but the technology maximises the compatibility of journeys, and not all journeys will be shared. In order to optimise operating efficiency and level of service, the field trials suggest an average of between 1 and 2 travellers will use a Polybus at a given time. Reliability will tend to be at least as high as for a car, given the known location of all vehicles in the system, and the possibility to provide replacements quickly. Safety can be expected to be high due to the door-to-door journey, known vehicle location and the prospect of limited sharing.

IGT combines the use of mobile-phone location technology to provide the electronic equivalent of 'hailing' from the street; triangulation between mobile phone masts gives reasonably accurate positioning information of the caller, enabling the nearest available vehicle to be alerted.

The system is also intended to run in two possible modes, including simultaneously; these are taxibus and car pool. Other configurations, including self-drive public transport services may be developed, the latter giving the driver free use of a vehicle provided he or she follows the routing instructions and collects other travellers as necessary. In this respect, it can be regarded as particularly close to the VPATS concept.

¹⁶ Promoted by G A Olmi. (<http://www.taxibus.org.uk/>).

¹⁷ Promoted by O Ephraim of Chelmsford.

IGT is described as a readily scaleable system, but is described in places as much larger in scale than are the Polybus networks, with economies of scale being derived from covering a larger market area and using larger vehicles. A larger incidence of related journey matching means that users can expect to share with 6-8 other travellers, but nonetheless the promoters argue that individual delay will be minimal. Notably, IGT is also regarded as viable with loadings of less than 2. Scale is also behind the aspiration to radically reduce the number of private cars in circulation.

One clear specification difference between the two systems is that IGT includes the requirement to interchange between vehicles to complete some journeys, which is not a requirement of private car use, whilst Polybus does not.

The documentation of neither system explicitly addresses the issue of variable price, or the needs of the travel poor, although IGT does incorporate the feature of private car users contributing their cars to the system to operate the car-pooling feature, in exchange for a money payment, or credit towards use of the taxibus mode.

These concepts may offer some insights about how VPATS might be implemented in practice, and will be given further consideration in Stage 2.

5 Conclusions

The attribute approach describes in theoretical terms the basis on which individuals choose different transport modes for different travel circumstances. They do so because different journey exigencies imply different values are placed on particular aspects of the overall transport service or 'good'. Hence, different transport modes offering broadly comparable services but with subtle 'selling points' have much in common with the concept of brand; where a cheaper brand may provide a basic option, but others offer greater utility, e.g., in terms of luxury or a particular image.

Given the inflexible operating mode of most transport modes, however, consumers choose between modes to achieve different attribute bundles. In the case of VPATS, it is expected that the mode will remain the same, but consumers will select 'brands' from within the overall flexible package, in different proportions. It is hypothesised that this will increase operating efficiency and retain any cross-subsidies within the particular operating context. Indeed, the economies of scale that may be possible with a VPATS system which attracts a wide range of travellers - in terms of journey purpose and disposable income - may be able to reduce or eliminate the need for general subsidy at all, with subsidies only required for providing for specialist transport requirements, such as needed by the mobility impaired.

In general terms, income elasticity is usually positive, the clearest exemplar of this being the rise in car ownership and use which has accompanied economic growth. Arguably, as private car use increases and approaches saturation point and / or is limited by congestion and parking charges it is likely that the income effect on bus patronage will show a positive relationship again; at the present time a debate in the literature is emerging which questions whether the demand for bus journeys continues to be an inferior good in so far as patronage decreases as income increases (Hanly and Dargay, 2002). This positive income effect is assumed to be even more marked for taxis and flexible alternatives where they offer 'money rich – time poor' solutions.

Although evidence suggests that reducing fares would attract some motorists, this would not be an efficient way to build patronage amongst a group that is relatively price-insensitive. As consumers' real incomes increase, they become increasingly willing to pay more to avoid discomforts and/or reduce travelling time. Arguably, a more efficient way to attract motorists would be to enhance the levels of service quality (such as speed, frequency and comfort) for a given level of fare. Overall, given that the majority of travellers do have a car available for a large share of their journeys, it is concluded for the present study that the literature review indicates elasticities with respect to quality to be more important than those relating to price.

The analysis has drawn attention to the properties that need to be considered in appraising demand for specific market niches: such as the purpose of the journey, the characteristics of the section of the population which is targeted and whether the effects are short or long term.

In the developing world and some specific market niches in developed countries, existing flexible services tend to be low specification, low cost services appealing to relatively poor travellers making routine journeys. In most established developed

country niches the services are medium-to-high specification and appeal to relatively wealthy travellers, using them for specific high-value journeys, or to travellers of more modest means who use them on a more routine basis, but in one way or another receive state subsidy to bridge the affordability gap.

Taken together with the earlier conclusion points, this experience demonstrates that, in order to appeal across the transport market within an industrialised state, VPATS needs to be efficient, accessible and marketed effectively - for example, making use of an easily-remembered phone number (where applicable) - and using clean, smart vehicles with polite, friendly staff. Indeed one of the few examples of DRT in London is based on black Hackney cabs, at peak times, which offer shared journeys from Paddington Station to central London.

Elsewhere, considering shuttles to specific major traffic generators, such as airports, there is real-world evidence that higher-income travellers who are generally regarded as 'money rich, time poor' are prepared to trade attributes such as exclusivity for the benefits of immediate availability of a vehicle with spare capacity, with the fare reflecting the perceived value of this 'between bus and taxi' bundle. Further, some operations already incorporate a fare-premium for optional flexing away from an otherwise fixed routing (albeit at a low absolute cost to the traveller). Although there are specific contexts to such observed behaviours - would the businessperson behave differently if expected to travel with 'people not like him/her'? - and would a flex premium be viable if provision costs were fully allocated to the traveller? - but it is concluded that the study has identified tentative support that there are at least some market niches and sectors for which the central 'flexible geometry' principle of VPATS is worth further investigation.

What remains elusive, however, and is a convincing answer to the question about whether there is a significant income effect within the positive elasticity relationship between service quality and price, so that, at least above a certain income threshold, the willingness to pay for higher quality is a more important influence on demand than the more general finding that demand has a negative relationship with respect to price.

This issue is beyond the scope of the present study, but sufficient potential is seen in the concept to progress the research to Stages 2 and 3. To this end, although no existing transport system or prototype system exactly meets the design specification of VPATS, feasibility work on near-market flexible transport systems does provide a useful indicative model for appraising the potential for VPATS in Stage 2, which will be examined in the case-study context of the city of Bristol.

References

- Baeten, G., (2000). The Tragedy of the Highway: Empowerment, Disempowerment and the Politics of Sustainability Discourses and Practices. *European Planning Studies*, **8** (1), 69-86.
- Dargay, J., Hanly, M., (1999). *Bus Fare Elasticities*. ESRC Transport Studies Unit, UCL: London.

- Dargay, J., Hanly, M., (2002). The demand for local bus services in England. *Journal of Transport Economics and Policy*, 36 (1), 73-91.
- Department for the Environment, Transport and the Regions, (1998). *A New Deal for Transport: Better for Everyone*. White Paper on Integrated Transport Policy. The Stationary Office, London.
- Department for Transport, (2003). *Introduction to Transport Analysis*. Integrated Transport Economics and Appraisal Division, Department for Transport, London.
- Department of Work and Pensions, (2004). *Households Below Average Income 2002/03*. TSO, London.
- Enoch, M., Potter, S., Parkhurst, G., Smith, M., (2004). *INTERMODE: Innovations in Demand Responsive Transport*. Report to Department for Transport and Greater Manchester Passenger Transport Executive. DfT, London.
- Estrin, S., Laidler, D., (1995). *Introduction to Microeconomics*. Harvester Wheatsheaf, Hemel Hempstead.
- Feitelson, E., (2002). Introducing environmental equity dimensions into the sustainable transport discourse: issue and pitfalls. *Transportation Research D*, 7, 99-118.
- Goodwin, P.B., Bailey, J.M., Brisbourne, R.H, Clarke, M.I., Donnison, J.R., Render, T.E., Whiteley, G.K., (1983). *Subsidised Public Transport and the Demand for Travel: The South Yorkshire Example*. Oxford Studies in Transport. Gower, Aldershot.
- Gravelle, H., Rees, R., (1992). *Microeconomics* (Second Edition). Longman, Harlow.
- Greene, D. L., Wegener, M., (1997). Sustainable transport. *Journal of Transport Geography*, 5 (3), 177-190.
- Griffiths, A., Wall, S., (2000). *Intermediate Microeconomics Theory and Applications* (Second Edition). Financial Times/Prentice Hall, Harlow.
- Halcrow Fox, Accent Marketing Research, University of Leeds, (1993). London Congestion Charging: Review and Specification of Model Elasticities. Report to Department of Transport.
- House of Commons (2002). *The Bus Industry*. Seventeenth Report of 2001-02 Session of Select Committee on Transport, Local Government and the Regions (HC828). The Stationery Office, London.
- Kenyon, S., Lyons, G., Rafferty, J., (2002). Transport and social exclusion: investigating the possibility of promoting inclusion through virtual mobility. *Journal of Transport Geography*, 10 (3) 207-219.
- Lancaster, K., (1966). A new approach to consumer theory. *Journal of Political Economy*, 74, 132-157.
- Litman, T., (2004). Transit price elasticities and cross elasticities. *Journal of Public Transportation* (forthcoming).
- Pratt, R.H., Texas Transportation Institute, Cambridge Systematics, SG Associates, McCollom Management Consulting, (2000). *Traveler Response to Transportation System Changes: Interim Handbook*. TCRP Web Document 12, National Academy of Science. www4.nationalacademies.org/trb/crp.nsf/all+projects//tcrp+b-12
- Preston, J., James, T., (2000). *Analysis of Demand for Bus Services* (Final Report). Transport Studies Unit, University of Oxford.
- Salvatore, D., (1986). *Microeconomics Theory and Applications*. Macmillan.
- Schaller, B., (1999). Elasticities for taxicab fares and service availability. *Transportation*, 26, 283-297.

- Social Exclusion Unit, (2003). *Making the Connections*. The Stationary Office, London.
- TRL Ltd, (2004). *The Demand for Public Transport: a Practical Guide*. TRL, Crowthorne, Report 593.
- Tyler, N., (2002). *Accessibility and the Bus System: from Concepts to Practice*. Thomas Telford, London.
- Wardman, M., Shires, J., (2003). *Review of Fare Elasticities in Great Britain*. Working Paper 573, Institute for Transport Studies, University of Leeds.
- White, P., (2002). *Public Transport: Its Planning, Management and Operation* (4th Edition). Spon: London.