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Demand responsive transport: towards the emergence of a new market segment

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Abstract

This paper focuses on recent British experience with telematics-based Demand Responsive Transport (DRT) services in rural areas. In recent years, the ability of DRT concepts to provide efficient, viable transport services has been greatly enhanced by the use of transport telematics as demonstrated in a variety of environments across Europe. The success of British local authorities in winning substantial funding under the Rural and Urban Bus Challenge programmes for the implementation of DRT has resulted in widespread interest in flexible forms of transport. It is thus timely to evaluate the impact of this substantial investment. Drawing on the experience of a number of UK schemes, the paper assesses the reasons for the new-found success of what is becoming a relatively well-accepted mode by concentrating on a variety of factors including: service characteristics (particularly route flexibility, flexibility of booking method and pre-booking regime), emerging markets and the overall contribution of DRT to increased social inclusion and intermodality. Impediments to the development of DRT services are highlighted. The paper also discusses current research into the next generation of DRT services and concludes by identifying some key issues for policy-makers concerned with the future implementation of DRT services.

Keywords: Demand responsiveness; Demand Responsive Transport; Telematics; Rural; Agency

1. Introduction

This paper focuses on recent British experience with telematics-based Demand Responsive Transport (DRT) services in rural areas. The paper begins with a brief introduction to DRT within the context of public transport provision. This is followed by discussion of telematics-based DRT systems which are organised via Travel Dispatch Centres (TDCs) using booking and reservation systems which have the capacity to dynamically assign passengers to vehicles and to optimise the routes taking account of the status and location of the fleet. An introduction to examples of telematics-based DRT is provided, drawing on early experience of the implementation of DRT services in West Sussex, Surrey, Gloucestershire, Lincolnshire, Wiltshire and Northumberland. The paper moves on to consider key issues regarding the next generation of DRT services, and concludes by identifying matters of importance to policy-makers concerned with their implementation.

2. The demand responsiveness of public transport

In most economically developed countries, statutory authorities are charged with ensuring that adequate transport is provided for members of the general public to reach their desired destinations—whether for work, health or leisure purposes—leading to consultation with a wide variety of agencies in order to fulfil these legal and social obligations. Commonly accepted definitions

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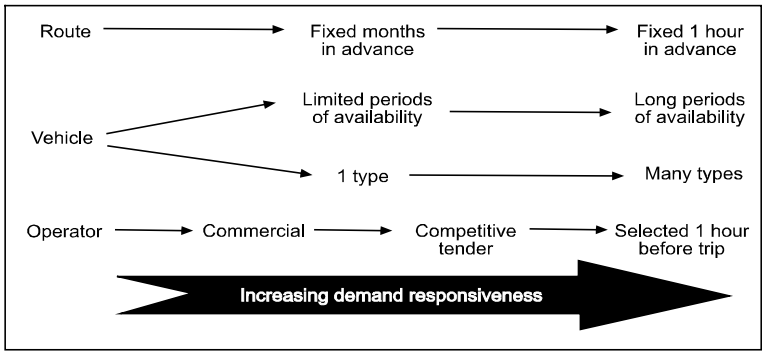


Fig. 1. The Demand responsiveness of public transport.

of public transport normally include commercially operated and supported registered bus, rail, ferry and air services, but should also include individual and shared ride taxis and private hire, community transport group hire, community group owned vehicles, Patient Transport Services (PTS), education and social services transport provision, participation in a car club and even paying another person in kind or cash for a lift.

Ideally, public transport would be as convenient as private transport, suggesting that 'all public transport should be demand responsive'. The term Demand Responsive Transport has been increasingly applied in the last 10 years to a niche market that replaces and feeds into conventional transport where demand is low and often spread over a large area. A typical working definition of DRT is 'an intermediate form of public transport, somewhere between a regular service route that uses small low floor buses and variably routed, highly personalised transport services offered by taxis'. Services are routed according to the needs of the customers, generally only stopping where passengers request collection or dropping off (Mageean et al., 2003).

One public transport service type extreme occurs with a registered, commercially run 'fixed' route service: it is demand responsive because the operator's historical knowledge of customer demand influences the route taken and the type of vehicle used. Since the objective is to maximise profit, the route and vehicle are adjusted to match demand as closely as possible given the resources available. The operator is fixed for that particular service, given the registration requirements, and because the operator wishes to retain a competitive advantage by not sharing with any other provider. [1]

Close to the other extreme, a registered, subsidised 'flexibly' routed service is much more demand responsive because a system is in place which allows the route to be altered on each service journey, and the exact route to be taken is finalised very close to the actual time of operation. In the UK such services are almost always allocated to operators through competitive tendering. Although, as with the fixed route service, the operator is fixed and the vehicle used is selected according to historical knowledge of customer demand, a service that is regarded as flexibly routed is finalised very close to the actual time of operation, i.e. it is a DRT service.

Fig. 1 shows that public transport can be described according to three variables, each in terms of increasing demand responsiveness. The closer to the time of travel that the route is determined, the more responsive it is. A vehicle available for longer periods is more responsive, whilst a greater choice of vehicle specification is also more likely to include a vehicle that satisfies capacity and accessibility requirements. If the transport provider is determined solely on a commercial basis, the cost of providing the service is less likely to be responsive to customer requirements than a transport provider selected a short time prior to travel. As demand declines within an area—such as rural and peri-urban areas—network efficiency is best achieved by delaying the decision about the route, the vehicle and transport provider as close as possible to the time of travel and by offering the same service to as many passengers as possible, rather than having a standalone network for each client group, e.g. social services and patient transport users.

3. The contribution of telematics-based DRT services

3.1. Characteristics of telematics-based DRT services

DRT services are now accepted by many rural and urban communities as a lifeline to reduce social exclusion (Department of the Environment, Transport and the Regions (DETR, 2000a)). Historically, DRT evolved from door-to-door dial-a-ride services provided by statutory authorities and community groups for restricted usage (usually the disabled and elderly). The scheduling

[1] In the UK bus services that can be used by members of the general public have to be registered with the Traffic Commissioner 56 days prior to operation. Less notice is possible for variations of existing registrations.

of such dial-a-ride services offered the client some flexibility in the route, but the decision had to be taken days in advance of travel as the schedule was developed entirely manually (or more recently by using spreadsheets), thus hampering its ability to handle widely dispersed trip patterns at short notice. The potential to broaden the application of DRT to registered public transport services arose with the development of transport telematics, which enables the scheduling of a greater number of journeys closer to the time of travel whilst also taking account of advanced and repeat reservations. Telematics-based DRT services have the scope to bring public transport closer to the flexibility and convenience of private transport, whilst retaining the fare levels associated with fixed route registered services rather than the more flexible—but costly—private hire and taxis.

Currently, DRT services are established by selecting an operator—usually by competitive tender—to provide a specific service. Vehicle selection is usually undertaken at this stage, either by the statutory authority or the operator identifying vehicles based on projected patronage and user accessibility requirements. If several vehicles are available, the choice may be made on the day of the service journey. Finally, the route is the most flexible variable, being determined in many telematics-based systems only 1 h before the service journey.

Engels et al. (2004) proposed a number of service typologies and scenarios for DRT, starting from a fully predefined route and timetable—the fixed service option noted above—to a fully flexible service for which stops are determined in a period just before operation or even during the course of the service journey. Between these extremes, a semi-fixed route may be operated, in which some stop points are obligatory whilst others requiring deviation from the core route are not. Additional dimensions include the geographical coverage of the service—either as a corridor or area service—and the proximity of the passenger to the pick up and drop off points, which could be the door step (a non-predefined stop point) or a short walk to or from predefined stop points (Mageean and Nelson, 2001). Furthermore, services can be integrated with different transport modes, by providing feeder services to fixed bus routes and the rail network, or they can remain free-standing. The use of telematics-based technologies permits rapid calculation of routes according to the typology defined for each service.

The main components of a telematics-based DRT system are: (i) the Travel Dispatch Centre; (ii) devices for users to access the DRT system; (iii) on-board units; and (iv) the communications network. Telematics-based DRT systems are organised via TDCs using booking and reservation systems which assign passengers to vehicles and optimise the routes. Automated Vehicle Locationing (AVL) systems provide real-time information on the status and location of the fleet for the route optimising software. Early European examples of standalone telematics-based DRT services include the EC-funded SAMPLUS (System for Advanced Management of public transport operations PLUS) demonstrations in Belgium, Finland, Italy and Sweden (Mageean and Nelson, 2003).

3.2. Rural DRT services—recent British experience

Recent experience of DRT in the UK warrants special attention due to the widespread and rapid introduction of applications in diverse rural areas (see also Jones, 2002). There is also considerable interest within the UK in urban and peri-urban applications. Following its success in securing substantial funding from central government, the Passenger Transport Executive Group (PTEG) implements DRT services at a variety of sites across the seven Passenger Transport Executives (for further details see Mageean et al., 2003). [2]

The most widely used TDC support software package in the UK is *MobiRouter*, which was developed during the SAMPLUS project and is distributed by Mobisoft (UK) Ltd. (Duffell, 2002). [3] The applications highlighted below all employ the *MobiRuter* software and this assists the like-for-like comparison that has been undertaken. In this section of the paper examples are discussed from West Sussex, Surrey, Gloucestershire, Lincolnshire, Wiltshire and Northumberland. [4] These schemes have received funding from the Rural Bus Challenge (RBC)—an additional funding stream made available by the national government for England and Wales—following the government's decision to support the development of demand responsive transport solutions (DETR, 2000b). It is thus timely to evaluate the impact of this substantial government investment.

3.2.1. West Sussex: "DoRiS"

DoRiS was the first DRT service in the UK to use *MobiRouter* following a successful joint bid to the RBC by Sussex and Surrey County Councils, utilising the experience gained as a 'follower' site in the SAMPLUS project. The £446,000 award enabled the establishment of services for 2 years in West Sussex and Waverley (Surrey). Initially the project was managed by both councils, with day-to-day operations overseen

[2] The seven PTEs are: Centro (West Midlands), Greater Manchester, Merseytravel, Nexus (Tyne and Wear), South Yorkshire, Strathclyde and West Yorkshire. They are responsible for public transport planning within their boundaries.

[3] The Canadian company Trapeze is increasingly active in the UK market.

[4] Other high-profile examples of DRT services in the UK include those in Highland, Hampshire and Worcestershire. Those in Angus are considered later in the paper.

by West Sussex County Council and the TDC was located in council offices at Midhurst.

DoRiS commenced operation in West Sussex on 21st July 2000 with eight services in the rural area of Midhurst—Petersfield—Haslemere. These new services were designed to feed in to existing fixed line services. The routes were semi-fixed with non-predefined stop points available on non-fixed sections. There are no passenger eligibility restrictions and the vehicles are owned by the council. The routes have been refined in response to patronage trends during the early period of the project (for example, the Friday and Saturday evening service takes account of public house and restaurant opening times, and buses run until midnight). Services are operated from Monday to Saturday, but none run every day in an attempt to match the demand throughout the area. From September 2002 *DoRiS* has also operated a fully flexible service with the objective of stimulating patronage.

Overall, patronage has grown from around 100 to 240 passengers per month (autumn 2001) and, following service changes, to around 1500 passengers per month (spring 2003). The initial slow growth may be attributed in part to the lack of 'bus culture' in this area of high car ownership. Most patronage is drawn from the young and elderly, although the service is open to all. More recently the focus of the services has moved from Haslemere and Petersfield to Midhurst and Petworth.

3.2.2. Surrey: "DoRiS"

In Surrey, the County Council has experience of working with West Sussex in the development of the *DoRiS* DRT scheme. The service itself is virtual and flexible, operating between Monday and Saturday throughout the single zone of South Waverley. Originally there were three separate travel zones but take-up was poor due to travel restrictions (only disabled passengers are eligible to use the service). The accessible vehicle is council owned.

The objective has been to explore new ways of service delivery with an emphasis on combating rural isolation. Particular frustrations have been the inability to qualify for the Bus Service Operators' Grant (BSOG)—which refunds around 80% of the duty paid on fuel—on the non-fixed part of the routes and the lack of patronage base after 18 months of operation. As in West Sussex, low patronage has been attributed to the relative inexperience of the local population with any form of public transport, coupled with a reluctance to use the telephone booking facility and problems with mail drops for publicity purposes. A new initiative in Surrey, known as Waverley Transport Solutions, has established a community transport service (with its own dispatch centre) with RBC and Local Transport Plan funding. The Waverley project combines group transport, contract work and DRT and operates under a Section 19 permit, unlike *DoRiS* which is a registered public service. [5] Patronage has subsequently increased to a maximum of 400 passengers per week.

3.2.3. Gloucester: '*Village Link*'

The *Village Link* project resulted from RBC funding in 1999 for a service to operate for 2 years. The project co-ordinator is the consultancy firm Halcrow, whilst Gloucester County Council is responsible for day-to-day management. Gloucester Ambulance Trust withdrew its offer to provide the TDC due, amongst other things, to union restrictions regarding the hours of working. This led to the decision to use *MobiRouter* and the switching of the TDC to a commercial call centre in Gloucester. The service, for which there are no user restrictions, is operated with council owned vehicles.

The initial service comprised two circular DRT routes and one bookable (optional) peak period fixed route in the Southern Vale of Gloucester; all three services operated from Monday to Saturday, were bookable door-to-door and provided replacements for poorly used fixed line services. The services started in April 2001 but were heavily revised in July 2002. Two demand responsive services (one linear and one fully flexible) now concentrate services on areas of high demand, and a third, peak time feeder, service to Gloucester has also been introduced. The previous evening service has been discontinued due to lack of patronage.

3.2.4. Lincolnshire: 'CallConnect'

In Lincolnshire, the fourth most sparsely populated English county, the County Council has been developing a strong interurban bus network with feeder rural services. A mixture of funding from the Rural Bus Grant, the Countryside Agency, the European Commission and the RBC has contributed to the overall development of fixed and responsive services in the area which have addressed the need for improved quality and convenience of interchange through an emphasis on 'connections management'. Specific RBC funding was used to implement the software for the DRT services. Lincolnshire County Council is responsible for project and day-to-day management, with the TDC based in Lincoln City Council offices. Vehicles are either leased by the County Council or owned by the operator.

The DRT services commenced in March 2001, using a diary system for booking. *MobiRouter* became operational in July 2001. Six routes in the Horncastle, Spilsby and Wragby area were initially bookable DRT services.

[5] A Section 19 permit is issued by the Department for Transport enabling non-commercial (i.e. no profit) provision of bus services to specific groups of people; in some circumstances they can be registered services.

Two of these are known as *CallConnect Plus* services, which are flexible routes that only operate on demand using eight-seat vehicles and require a minimum of 2 h advanced booking. The four *CallConnect* services are semi-fixed, using 16-seat vehicles. The services are bookable as door-to-door and also pick up/drop off at known meeting places such as telephone boxes. All services operate Monday to Saturday and there are no passenger restrictions. As with the Vale of Gloucester, these are replacements for conventional services although the DRT services greatly improve accessibility by serving a more diffuse area and providing a basic hourly Monday to Saturday timetable in place of very limited fixed routes. *CallConnect* services interchange with trunk services, branded as *InterConnect*, between Lincoln and Skegness.

The response from users has been encouraging, with success attributed to the extended period of operation, strong branding and community-oriented nature of the service. Monthly patronage on DRT services is around 25% greater than the former fixed route network carried over the same area. The importance of involving user groups in the development of services has been demonstrated. The County Council has been considering other opportunities for integrating the operations of social services transport and health trusts, but subsidy per passenger journey is around £5 for *CallConnect Plus*—emphasising the need (now realised) for DRT to become eligible for BSOG.

The *InterConnect* and *CallConnect (Plus)* concept has been expanded to several trunk routes: Lincoln-Boston (feeders at Coningsby), Spalding-King's Lynn (Long Sutton and Holbeach areas), Lincoln-Grimsby (Market Rasen and Caistor areas) and, in 2004, Mablethorpe-Boston.

3.2.5. Wiltshire: 'Wiggly Bus'

Wiltshire County Council, Kennet District Council and the then DETR provided funding for 3 years from 1999 on the *Wiggly Bus* project, including the purchase of the vehicles. The Metropolitan Transport Research Unit was the project co-ordinator. The *Wiggly Bus* services are booked alongside the Gloucester *Village Link* services at the TDC in Gloucester. The dispatching for the *Wiggly Bus* project was initially undertaken by the Wiltshire Ambulance Service, but this posed a variety of problems leading to the transfer of the booking system to *MobiRouter* in September 2001.

The services link outlying areas with conventional services. Three circular core routes in the Devizes, Pewsey, Woodborough and Cadley area operate hourly with diversions on demand. One service was re-routed in spring 2001 as a result of user requests. The services use predefined stop points. In addition, the bookable (optional) fixed route *Wiggly Bus Express* service between Pewsey and Devizes connects with most of the DRT services. All services operate from Monday to Saturday. There are no user restrictions, and a travel club offering discounted travel is available.

In autumn 2002 patronage was around 3000 passengers per month although, prior to the reorganisation of the TDC, it was 3500. The higher level of patronage had been regained by spring 2003 (approximately 3800 passengers per month) following service changes and the introduction of an additional vehicle. Further growth in patronage is expected. An average subsidy payment of around £5 per passenger journey was experienced in the third year of operation and, although high, such a figure is not unknown in the context of the conventional bus service operation and is cheaper than a taxi alternative. The *Wiggly Bus* concept was extended to Calne in April 2003 and to the Mere area in south-west Wiltshire in 2004.

3.2.6. Northumberland: 'Phone and Go'

The *Phone and Go* project has established DRT services in two contrasting rural areas of Northumberland, Allen Valleys and Lower Coquet. *Phone and Go* received £750,000 of RBC funding over the 3 years between April 2001 and March 2004. The project co-ordinator is Northumberland County Council, whilst the University of Newcastle upon Tyne's Transport Operations Research Group (TORG) hosts the TDC and is responsible for day-to-day management.

In both *Phone and Go* areas, the DRT services supplement existing fixed route services and there are no passenger restriction criteria. Passengers can travel door-to-door (non-predefined stop points) and to predefined stop points such as interchanges and schools. The TDC is open 12 h a day Monday to Friday and eight hours on Saturday in order to monitor passenger-TDC contact patterns and to maximise the time available for passengers to contact the TDC. A further element of best practice implementation was sought when specifying attractive, accessibly user-friendly vehicles. At both sites, feedback from users has been extremely positive, particularly the personalised nature of the service offered by TDC staff.

The Allen Valleys lie in the sparsely populated uplands of south-west Northumberland. The DRT service feeds from small outlying settlements in the West Allen valley into the small town of Allendale where connections can be made to Hexham, with onward rail and bus services to Newcastle and Carlisle. *Phone and Go* also connects the West Allen and lower East Allen valleys with bus and rail at Haydon Bridge. The service became operational in September 2002, with journeys operating between 07:15 and 17:30 Monday to Saturday. Regular passengers include education contract schoolchildren. A disappointing peak of only 100 passengers per week necessitated an extension of the service hours and operational area to Haydon Bridge throughout the day from May 2003.

Table 1
Summary of DRT Installations: Travel Dispatch Centre

	DoRiS West Sussex	***DoRiS*** Surrey	***Village-Link*** Gloucester	***Wiggly Bus*** Wiltshire	***CallConnect*** Lincolnshire	***Phone&Go*** Northumberland
TDC Operation						
Booking times	Mon–Sat 08:00–16:30		Mon–Sun 24 h		Mon–Fri 09:00–16:00 Sat 10:00–16:00	Mon–Fri 08:00–20:00 Sat 09:00–17:00
First service time	06:00	10:30	07:30	06:55	08:00	06:50
Last service time	18:45 (Mon–Thu) 23:15 (Fri/Sat)	15:00	18:30	22:45 (Wed/Thu/Sat) 18:10 (Mon/Tue/Fri)	18:30	19:40
Refusal rate	5%	Not known	0% for viable journeys	0%	5%	<10%
Booking speed: *Registered users with default journey*	1 min		1 min	Lengthy	0.5 min	2–3 mins
Non-registered users/difficult journey	2–3 mins		2 mins	Very lengthy	2–3 mins	>5 mins
Passenger Registration:						
Compulsory?	No		No	No	No	No
Number	200		300	Not known	>210	300
Customer profile	Older and/or female	Disabled	Mostly disabled and elderly	Mixed many young	Old shopping/ leisure	Mostly school children
Call rate	0845		Local		0845	0870
Number of lines	3		Many		1	2
Customer acceptance	Low acceptance of telephone booking		High		High	–
Booking computers	3 (only 1 manned)		9 take calls, transferring to 2 who make bookings		1	2 (only 1 manned)
TDC Staff						
Number	2 total 1 at any one time		40 total 6–8 day time, 3 night time 1 could handle Glos.	3 could handle Wilts.	1 + other staff cover meals etc.	4 total 1 at any one time
Sole job?	No		No		No	Yes + service evaluation
Training by Software provider	On the job		1 week for 2 dispatchers. They train others in-house.		On the job	1 day for 3 dispatchers1 trained in-house

The Lower Coquet area lies on the more densely populated coastal strip in the east of the county and is bounded on the east coast by the small town of Amble and the large village of Warkworth, whilst Felton village lies to the west of the operational area. The DRT service provides a feeder service at Felton, connecting with an interurban bus service between Newcastle, Alnwick and Edinburgh. Local bus connections to Alnwick, Berwick and Ashington are possible at Amble and Warkworth. Rail connections can be made at Acklington to Newcastle. This service commenced in December 2002. It operates between 06:50 and 19:40 on Monday to Saturday. There is a strong interest in the service from the local communities with passengers travelling to schools and a doctor's surgery. Patronage is steady at 200–250 passengers per week.

3.3. Comparison of TDC, vehicle and service characteristics

This section compares the findings from the six applications referred to above. Tables 1–3 are comparative summaries of the approaches adopted when setting up DRT services with respect to the TDC, vehicles and service. For reasons of commercial confidentiality this discussion does not cover specific software issues.

Table 1 shows wide variations between the installations' TDCs and their staff. Whilst the Gloucester and Wiltshire services can be booked for 24 h a day, seven days a week, the opportunities are more restricted at the other locations where bookings cannot be made outside service operating hours. This situation is compensated for in Northumberland, West Sussex and Wiltshire where requests can be made on-line or by answer phone; the dispatcher confirms the bookings by telephone later.

There is a wide range of usage for the different services, the heaviest demand being for Wiltshire (about 180 calls per day), which was previously reflected in a relatively high refusal rate at the time of booking (10%). The reason(s) for this could be a function of the scheduling software or because demand for the service cannot be met by existing levels of provision, in which case additional investment in vehicles and drivers would be required. In the case of West Sussex the refusal rate (around 5%) is mainly caused by the diversion of the bus to complete a school contract.

At all but one installation the booking time is rapid for registered users (up to 1 min) and acceptable for difficult/new bookings and non-registered passengers (up to 3 min). The reasons for the lengthy booking time in Wiltshire lie in the history of the installation, as already discussed. The reasons for customers' low acceptance of the TDC technology in West Sussex is not clear, but could relate to a lack of clarity in the publicity material, the way in which bookings are handled, or the level of training offered to dispatchers. At all TDCs the staff were involved in more than one job and this demonstrates that the structure of the TDC staffing arrangements is flexible.

Vehicle type (Table 2) has an indirect effect on the success of the DRT service. A poorly specified vehicle will affect the acceptance of the technology and the service by the dispatchers, drivers and customers. Driver training is a critical factor and may need revisiting at some installations. All the installations purchased

Table 2
Summary of DRT Installations: Vehicles and Drivers

	DoRiS West Sussex	***DoRiS*** Surrey	***Village-Link*** Gloucester	***Wiggly Bus*** Wiltshire	***CallConnect*** Lincolnshire	***Phone&Go*** Northumberland
Vehicles						
Type	1 Renault Master + part-time use of Surrey Renault Master1 back up Renault Master	1 Renault Master	2 Renault Master 1 back up Renault Master	3 Renault Master 1 back up Renault Master	2 Renault Master 1 back up Renault Master 5 IVECO	2 Mercedes Sprinter 2 back up LDC
Accessibility	Side steps Tail lift	Side steps Tail lift	Low floor side ramp	Low floor side ramp	Renault: rear inclined ramp + lowering suspensionI VECO: tail lift	Low floor side ramp
Drivers						
Acceptance of technology	Variable	–	Variable		90% acceptance	100% acceptance
On-board Unit (OBU) Training	<1 day		Not known. New drivers trained by those already trained.		10 min in person or by telephone. Relief drivers seldom use OBU	2 h

Table 3
Summary of DRT Installations: Service

	DoRiS West Sussex	***DoRiS*** Surrey	***Village-Link*** Gloucester	***Wiggly Bus*** Wiltshire	***CallConnect*** Lincolnshire	***Phone&Go*** Northumberland
Service						
Type of area	Rural	Rural	Rural	Rural	Rural	Rural
Type of service	5 Fixed + flexible sections. Door-to-door	Virtual flexible	2 Fixed + flexible sections. Door-to-door 1 fixed only	3 Semi-fixed Predefined stop points 1 fixed only (Wiggly Bus Express)	2 Flexible, 4 Semi-fixed Door-to-door & predefined stop points	2 Flexible Door-to-door and predefined stop points
Evening services	Fri/Sat	No	On trial	Wed/Thu/Sat	No	Early evening
Sunday services	No	No	No	No	No	No
User restrictions	None	Disabled	None	None	None	None
Patronage	Max. 390/week	Max. 300–400/week	200/week	955/week	8,830/week (*Call Connect/ CallConnectPlus*)	Allen: max. 100/week Coquet: max. 250/week
Route Registration problems	Yes	No	Yes	–	No	No
Minimum pre-booking period	1 h	No limits	0.5 h	0.25 h	None Wheel chair: previous night	Allen: 2 h Coquet: 1 h
Booking on fixed sections	Advisable	Not applicable	Advisable	Yes on semi-fixed Advisable on fixed	Advisable	Not applicable
Multiple bookings	Up to 1 week in advance	–	Up to 1 week in advance + restrictions	Up to 1 week in advance + restrictions	Up to 1 week in advance + restrictions	Yes
Interchange	Bus and rail	No	Bus and rail	Wiggly Bus Express	Bus	Bus and rail
Through ticketing	Not yet	No	Yes: 1 service	Yes: Wiggly Bus Express	Yes: InterConnect network	Some journeys: discount if interchange proved
Interchange improvement	–	No	Yes	–	Yes	Yes — planned
Operator	ACCORD	Waverley Community Transport	Swanbrook Coaches Ltd.	Hatts Coaches	Translinc/Cavalier Travel/Brylaine Travel	Allen: Tynedale Group Travel Coquet: Northumbria Coaches
Contract length	2 years	2 years	–	–	5 years	Allen: 2 years Coquet: 3 years
Service reliability	Some natural hazards	–	Very good	Poor due to vehicles	Generally good	Good
Plans for expansion	Yes	Yes	–	–	Yes	Yes

accessible vehicles, although their utility will not be fully realised until all vehicles on connecting services also offer this facility.

Service design has a fundamental role in determining the success of DRT. Table 3 shows that wide variations in the service specification demonstrate the flexibility of DRT services. The service types are predominantly semi-fixed. Two sites operate fixed, optionally bookable services as part of the DRT concept. Importantly, sites have been able to alter service patterns, for example to focus on areas of high demand (e.g. in Gloucester) or to stimulate additional patronage (West Sussex).

The overall characteristics of the existing installations are that only one restricts users (Surrey); none operate Sunday services; evening services are limited across and within the sites; through ticketing is limited but considered a desirable objective; service reliability is good, except where vehicle reliability is poor (Wiltshire); and only Surrey (due to the nature of the service) does not offer interchange. Positive steps have been taken to improve the interchange infrastructure at two sites. It was recognised at all sites that the registration of the routes with the Traffic Commissioner requires careful consideration, and has posed limitations in some cases. The requirement for a minimum number of timing points, for example, can constrain the flexibility of the service. All sites experience positive customer feedback but it is difficult to expand the market beyond a loyal core of passengers.

Some factors have a direct impact upon the software. For example, the longer the minimum pre-booking period (2 h at Surrey compared with 15 min for Wiltshire) the easier it is to schedule the vehicle and it is less stressful for dispatchers. West Sussex and Gloucester operate DRT routes with fixed sections and although booking is recommended for the fixed sections, it is not compulsory. Such an approach is workable when passenger numbers are low, but would create load problems if demand substantially increases since a pre-booked passenger boarding later on during a journey could risk losing his or her seat. The availability of seats for ad hoc passengers is checked by the driver, which may lead to issues regarding the drivers' acceptance of the software.

3.4. Issues arising from practical experience

From the findings reported here several important points arise. First, European experience, particularly in the context of the SAMPLUS project whose lessons have now been transferred to the UK, has demonstrated that the integration of DRT services into the network of existing public transport services provides greater transport cohesion. Flexible routing of services allows access throughout an area rather than on specific corridors. There is improved access to local services and, to some extent, to larger centres. Improved mobility allows socially excluded groups to participate more fully in their communities and reduces barriers to equality with other citizens. Improved mobility and access to services helps retain people in areas of declining population and DRT can, to a degree, encourage tourism without cars.

The second key issue is that the potential market for DRT services is defined by raising the awareness of local authorities and operators about the potential for DRT to address many existing transport problems. Experience in Lincolnshire highlights the importance of involving user groups in the development of services; equally, in Surrey the development of DRT appears hampered by a lack of awareness of the service coupled with unfamiliarity with public transport. Driver acceptance should not be underestimated and there have been reported problems in understanding the need to be 'flexible', for example in accommodating both prebooked and non-booked passengers.

Thirdly, a number of institutional, legal and economic barriers must be overcome if DRT is to develop. Institutionally, the potential for conflict between different potential service providers (e.g. bus and taxi) and between DRT and other public transport modes is very real, perhaps more so in urban areas. Questions of ownership and control with respect to the TDC may relate to the degree of regulation governing the public transport market. As a relatively new form of public transport, the juridical status of DRT has been unclear, with applications being hampered by issues of how to register services successfully. The widespread success of statutory authorities in winning substantial funding under the Urban and Rural Bus Challenge programmes for DRT services has contributed to the establishment of many schemes which were ineligible for BSOG on any flexible route sections, leading in some cases to inappropriate DRT service design in order to receive BSOG and increases in the levels of subsidy required for the services. Despite these problems, there is an increasing awareness of the link between flexible public transport services and reduced social exclusion (DETR, 2000a).

In response to these developments, the UK Government pledged to remove or (at least) relax constraints on the development of flexibly routed bus services by clearly specifying the conditions for route registration of commercially operated and supported services, and to promote a greater role for community-based services (DETR, 2000b). Subsequently, the publication of the Rural White Paper (DETR, 2000c) was followed by a Department for Transport (DfT) Consultation Paper, *The Flexible Future*, which put forward new proposals for the registration of flexible transport services (DfT, 2002). These proposals, implemented as of February 2004, permit the registration according to a simple classification of service types: 'many to one'—picking up individual passengers from a location specified by them and taking them to a single, fixed destination; 'one to

many'—the above type in reverse; and 'many to many'—offering maximum flexibility, picking up passengers from various locations on demand and taking them to disparate destinations within a defined operational area.

Crucially, BSOG has been extended to flexibly routed local bus services, although some outstanding issues may deter new DRT registrations. In order to avoid unnecessary DRT registrations in which operators perceive that the rules for time keeping are slacker than in conventional fixed route services, operators are required to compile not only evidence of when it is planned that passengers will be picked up and dropped off—which is easy to extract from the scheduling software—but also the actual pick up and drop off times. Such information is not readily available from the software and places an additional burden on the drivers. With regard to the BSOG claim, this must be supported by full evidence of mileage on flexible route sections, which is also not readily available. These changes and remaining difficulties notwithstanding, it is anticipated that there will be an acceleration in the registration of DRT services.

The fourth key issue is that the viability of DRT services as a self-supporting system has not yet been demonstrated, and in the UK the issue of fares, and the cost of phone calls, subsidy, bus and TDC operation pose challenges. Experience in Lincolnshire and Wiltshire—where fixed line services were replaced—shows that patronage has increased as a result of introducing DRT services. The West Sussex and Northumberland schemes are additional services so DRT patronage is over and above pre-existing levels. Experience from across Europe suggests that for financial and scheduling reasons, DRT services do not aim to be the dominant public transport supplier in a market, but are regarded as a vital supplier of services where conventional solutions are untenable, for example low demand areas, special transport services and where social exclusion is evident. Additionally, European experience shows that DRT is easier to implement in more regulated environments as there is less conflict with other public transport modes. The role of service substitution (i.e. DRT versus fixed route) from the perspective of a tendering authority or commercial operator is not yet known (Mageean and Nelson, 2003).

Fifthly, in terms of technologies for DRT services, the level of telematics support available at the local level is critical. In any situation, major investment can only normally be justified if high patronage can be confidently predicted. Fortunately, the telematics solutions for DRT are highly transferable to rural and urban areas which display varying complexity, route requirements and time/distance criteria. Developments with respect to internet-based pre-trip planning can only help the emergence of DRT.

Sixthly, regarding the contribution of DRT to intermodality, the nature of both the market environment and the service pattern adopted are clearly important. Semi-fixed routes with fixed intermediate stop points are easier for both the customer to understand and the system to schedule with connections, as such routes usually depart from fixed end-points at specified times. Vehicle design also affects intermodality. Whilst the majority of DRT vehicles provide low floor access and wheelchair devices, this is still not true of connecting conventional services.

Finally, other findings from this sample of UK installations suggest that the following specific factors are likely to contribute to the overall success of a DRT operation:

- TDC hours of opening should be as long as possible.
- Booking time will not be minimised if there is a large proportion of users whose contact details are not registered.
- Service characteristics—such as whether to implement compulsory booking on fixed sections and the length of the pre-booking period—need careful consideration.
- The clarification and simplification of route registration and BSOG claims with the Traffic Commissioner should be considered.
- The fare structure should be simple to understand and apply.
- There are clear benefits to be derived from through ticketing, interchange and improved interchange infrastructure.
- Marketing the service is critical to its success, particularly as passenger acceptance is generally good.
- Temporary (i.e. when the service first comes into operation) or permanent support for passengers, particularly the disabled and elderly, promotes confidence in the DRT service.
- Strategic service changes may stimulate additional patronage.
- External factors influence the success of a service, for example black holes in the communications network lengthen the pre-booking period. This is partially alleviated by ensuring the vehicle is more frequently in good reception areas.

4. Towards the next generation of flexibly routed services

4.1. The case for brokered public transport services

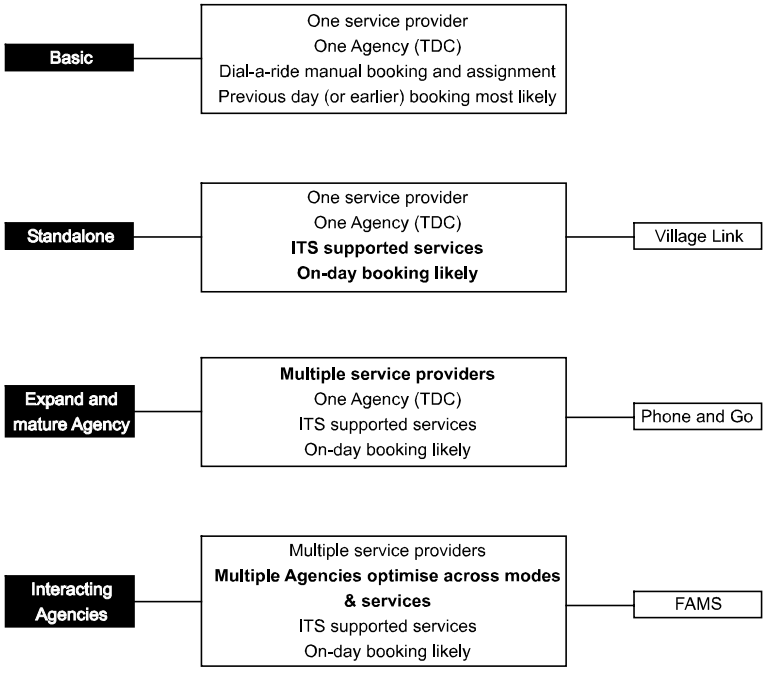
The schemes discussed above represent the current provision of flexibly routed public transport services. Each registered service is delivered by a single operator as a dedicated standalone transport scheme which may connect operationally with rail and fixed route bus services, but has no integration with the other types of pub-

lic transport services available in the same area in terms of operation or resource allocation. The operator is selected by competitive tender mostly using monies from central government funding (such as the RBC), rather than establishing itself commercially or in co-operation with other transport providers. In addition, the choice of vehicle is restricted to that supplied by the statutory authority or the chosen operator.

As already noted, the route offered will be more efficient if there is a choice of operator and vehicle close to the time of service journey operation. Realistically, this can best be achieved by the pooling of resources from all suppliers of public transport, whether operating registered or non-registered services. In order to 'broker' such public transport services, the degree of responsiveness needs to be high and it is here that telematics offers considerable potential to combine routes, vehicles and operators efficiently. The potential for the application of highly demand responsive and brokered services in rural areas is high since, as noted by Gray (2001), there is a tendency to overlook the diversity of the rural transport 'experience'.

The desirability of brokerage across the full spectrum of public transport services is reinforced by the findings from the above schemes. DRT schemes are not self-supporting, and most TDCs using telematics-based systems could easily cope with more services and a much higher call rate, which would reduce marginal costs of the TDC. Furthermore, if additional non-registered services—such as Social Services and Education contracts—are combined with registered services, operational costs will be reduced. The combination of resources would also enable more appropriate vehicle choice, giving enhanced intermodality and improved service integration. By expanding the DRT profile in this way, a larger proportion of the population is aware of the services, thereby increasing the potential passenger pool.

The application of advanced technologies to DRT in order to achieve this multi-modal integration has been considered in detail by Ambrosino et al. (2004). Recently concluded EC-funded research in the FAMS (Flexible Agency for collective deMand responsive Services) project has developed the next generation of DRT services which offer a package of value-added services through the collaboration of multiple service providers (see Finn and Ambrosino, 2002). FAMS, a 2 year Trial Project starting in March 2002, was initiated under the EU Research and Technological Development Programme for Information Society Technologies (IST). It followed the successful SAMPO (System for Advanced Management of Public transport Operations) and SAMPLUS projects, which tested and demonstrated standalone DRT applications (Mageean and Nelson, 2003). FAMS trials have taken place—and are continuing after the project has finished—in Florence, Italy and Angus, UK, showing how telematics-based brokerage can work. In essence, an Agency is an advanced TDC which manages the entire process of public transport service provision—from the booking of the users to the service/



Key: bold text = additional characteristics of successive layers of the model.

Fig. 2. A Layered approach to developing the provision of DRT services.

journey planning, monitoring and operational control—as if there is a single operator with a single fleet and a single booking system, optimising the resources involved and providing an effective response to the mobility needs of the user.

The FAMS project identified five layers that portray an increase in the level of complexity in the provision of DRT services (Fig. 2). The basic layer caters for one network with one service provider at one Agency; booking and assignment is made manually at least one day prior to travel. The standalone layer introduces ITS support, enabling on-day, non-manual booking and assignment. The expanded and mature Agency (third and fourth layers) is more advanced as it manages the routes operated by more than one service provider, i.e. it utilises vehicles from several geographically overlapping networks, combining them into a more efficient aggregated network. FAMS was placed at the third layer. The fifth layer of interacting Agencies would enable the optimisation of modes and services between several Agencies, allowing access to an even greater range of vehicles and more opportunities for passengers to travel where and when it is most convenient for them in a larger geographical network.

4.2. Telematics-based brokerage in the UK

The FAMS trial site in the Angus Region was new to DRT services and applications. It covers the rural Angus glens to the north of Alyth, Kirriemuir and Brechin, where public transport has been neglected for many years. The pilot sought to maximise the use of existing public transport resources in the area to produce flexible, integrated services and a sustainable means of delivering transport provision utilising new technologies. The FAMS Agency in Angus, operated by the Angus Transport Forum (ATF), an independent entity, is shown in Fig. 3. The technological capabilities in Angus enable individual flexibly routed services to be booked, scheduled and dispatched close to the time of travel. This required the co-operation of service providers by sharing information about the availability of vehicles and the costs to be charged to the users.

In the Glens of Clova, Isla and Esk, semi-fixed routes were registered in order to convert dead mileage on education contracts to live mileage, making it available to the general public. One transport provider is dedicated to each service, having won a competitive tender. Vehicle availability is usually limited to one specific vehicle per service. Outside peak times the same vehicles are available as private hire for individuals booking door-to-door journeys.

ATF established a Travel Club identifying interest in over 90 activities. This information is used to plan regular and special events. Door-to-door services are offered where no commercial services operate. If part of the route can be undertaken by a fixed route service, a door-to-service link is provided. DRT services for regular and special events are organised on a private hire basis. Individuals and groups can select the operator based on price and vehicle availability, data being compared manually from a database by the TDC.

Group hire is available to organisations with Minibus Driver Awareness Scheme (MiDAS) accredited drivers. ATF owns some of the vehicle fleet and this is supplemented by community education, community transport,

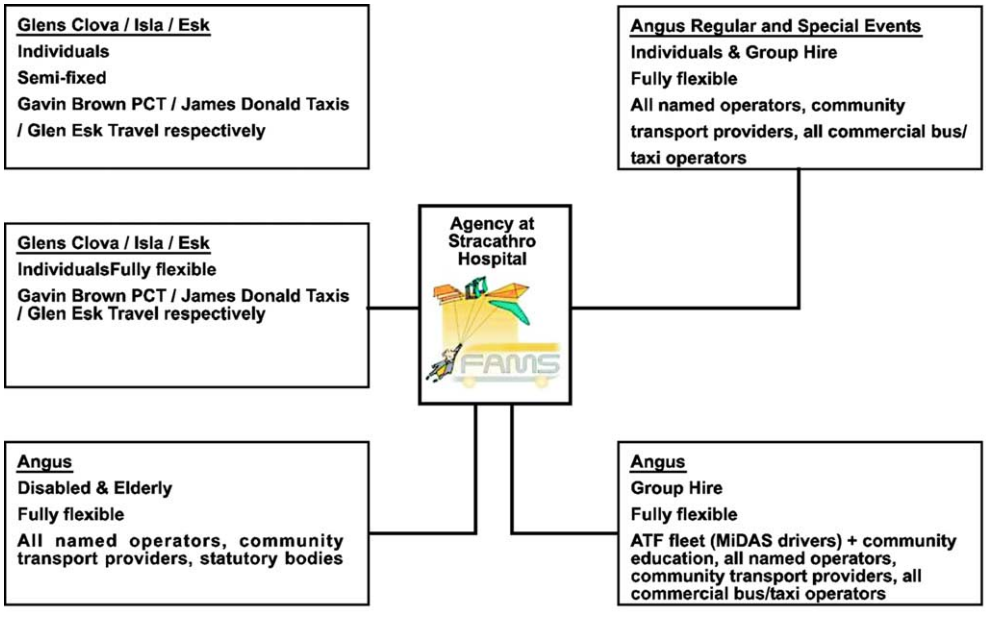


Fig. 3. Brokerage of public transport services in Angus.

and commercial bus/taxi vehicles. Once hired the route is determined by the group.

Proposed disabled and elderly services in Angus will reduce the time currently taken to reach the hospital in Dundee using PTS or by several changes of fixed route bus. The solution is to feed customers into hubs and then transfer to a PTS vehicle travelling directly to the hospital. The feeder operator and the vehicle will be selected from a pool of transport providers according to the price and vehicle availability, the list of transport providers again being compared manually from a database.

In contrast to Angus (which began with the Agency), the development of brokerage in Northumberland has been an incremental process in direct response to issues occurring as opportunities to introduce new DRT services or combine them with Education and Social Services contracts have arisen (Fig. 4). Northumberland brokerage lies in the third layer identified in FAMS (Fig. 2).

Although there are no passenger restriction criteria—all except one *Phone and Go* service is registered—some services are effectively restricted due to brokerage between statutory providers, e.g. the carriage of education contract school children in the Allen Valleys and social services clients in the Lower Coquet. In addition, committed users of the Lower Coquet service, such as non-education contract scholars are booked ahead for each school term. The Shilbottle Taxibus service has a pool of operators, the selection being based upon availability and accessibility (unlike in Angus the passenger cannot choose the operator) with manual vehicle selection by the dispatcher from a spreadsheet. The schedule is sent by fax to the appropriate operator and therefore the scheduling system is not required to select a vehicle in real-time. The Alnwick town service is a switch between the operator and the TDC taking the bookings. The Rural West of Kingston Park community transport service operates under a Section 19 permit.

4.3. Key outcomes of telematics-based brokerage

There has not been an attempt to embrace all aspects of brokerage on all services. Instead, a realistic approach has been implemented with each service being considered in relation to the most appropriate form of brokerage for the opportunity that is presented. In some cases this may be acquiring Education or Social Services contracts, whilst in others a defined group of operators provide a varied vehicle pool with variable fare structures from which to select.

The greatest technological barrier has been the poor overall mobile phone network. Different areas are covered better by different networks, making it difficult to select a single network for the whole area. In practice it is not possible to communicate with vehicles in the glens, meaning on-day bookings cannot be taken: some advantages of the automated scheduling system, the installation of on-board units and the potential to broker vehicles effectively close to the time of travel are thus negated.

Existing on-board vehicle technology limits the potential to broker vehicles, which is particularly restrictive for the FAMS concept in Angus. Whilst portable Personal Digital Assistants (PDAs) (referred to as handheld computers) can now provide a solution, total or partial conversion to a Global Positioning System (GPS) is a costly process, and these units have the disadvantage of being less robust, less secure and less easy to read. Indeed, the installation of on-board units was not

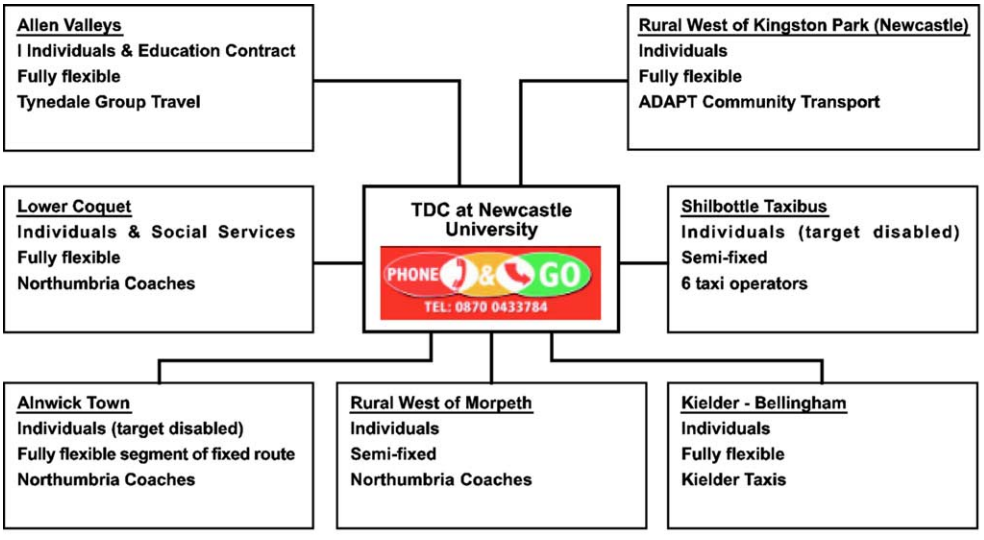


Fig. 4. Brokerage of public transport services in Northumberland.

considered economically justifiable for some services, leading to an increase in the prebooking period and consequent disutility to the customer.

Each mode of public transport has different regulations that affect how responsive it can be. Concessionary fares, for example, are not available to some modes, and given a choice—as exists with regard to some Angus services—a passenger may select a cheaper if less convenient mode. Bus deregulation does not encourage cooperation between transport providers, nor does it promote through ticketing, which ultimately discourages the use of public transport (see Preston, 2003). Furthermore, operators are suspicious about giving information to the FAMS Agency database, and they prefer the status quo of subsidised services which guarantees an income, whereas participation in full brokerage does not—although the opportunities for greater income do exist. Implementation of a disabled and elderly service has been delayed due to ongoing discussion with PTS concerning working practices. All these issues are indicative of the range of problems that face the implementation of brokered services.

The Angus brokerage has successfully provided vehicles for regular events such as after school activities, a Cinema Club, Disabled Ramblers and street football. Special events are very successful but intermittent, e.g. a Hill Walking Festival. Group hire is used by a wide range of customers. The revenue derived from Education contracts in the Allen Valleys (Northumberland) has supported a low patronage service—whereas the Coquet service has higher patronage, the revenue is almost entirely derived from normal public transport fares, giving a lower total revenue. However, from the general public's viewpoint, the brokering limits the opportunities to travel, unless they make identical journeys to the brokered passengers. A successful solution for very low demand services is to use an operator pool to provide appropriate vehicles at less cost than if a single operator was paid a retainer fee in order to be available on demand.

It is interesting to note that not all authorities appear to be pursuing the single Agency concept. In Wiltshire, for example, the Bradenstoke taxibus services are booked via a different entity to the *Wiggly Bus* services.

5. Conclusions

Findings from recent national and international research make it possible to identify a number of important questions likely to influence the future development of DRT services in the UK. There are (at least) four principal areas requiring substantial attention. Firstly, in terms of *legal and regulatory* issues it remains to be seen what the impact will be of the new regulations recently introduced by Department for Transport (following *The Flexible Future*) to revise the registration of DRT services and to permit BSOG claims for DRT services. In order to develop the Flexible Agency concept, regulatory barriers need to be reassessed regarding the co-operation between transport providers, leading to parity concerning the prices that can be offered to customers.

Secondly, *technological* issues include identifying the most appropriate scheduling system. At present, the choice is largely between manual and software scheduling, but internet booking requests can now be made in the Hampshire *Cango* DRT services and in Belgium full booking can be made via the internet or a telephone Interactive Voice Response System. Such scenarios enable savings on staff costs at TDCs. As with the scheduling system, simple communication with the driver may be acceptable, e.g. previous day faxes, if it is considered that passengers do not greatly benefit from on-day booking. This may continue to be the only reasonable solution where communications networks remain poor—a particular hazard of rural areas. The DRT vehicle itself must be well designed and well engineered, but compromises may be required to suit passenger needs and road restrictions. For example, low floor buses appeal to passengers, but are prone to grounding on uneven rural roads and on traffic calming installations. The use of taxis and multi-person vehicles for DRT services may improve service provision in areas of very low demand.

Thirdly, guidance on the most appropriate *service and system design* is lacking. For this, the objectives of the service must be clear and placed in the context of external constraints, such as political, legal, geographical and communication restrictions. It is only then that the most efficient route design for the predicted demand levels can be considered.

Fourthly, of particular interest is the *sustainability of DRT services*. Current solutions include the use of a larger service area compared to fixed routes and more frequent travel opportunities compared to fixed routes. Indirect savings vis á vis conventional services are widely reported, but a subsidy of around £4–5 per passenger journey may be required. The case studies of Angus and Northumberland suggest that whilst in its infancy, the feasibility of fully integrating services and pooling vehicles from all public transport sectors through brokerage at a single Agency will be an important step towards achieving sustainable DRT services whilst concurrently providing a more efficient public transport network. Starting from the single DRT services application, there is a considerable opportunity to evolve towards the concept of an Agency for Flexible Mobility Services by scaling up current technologies and DRT models.

The provision of such brokerage for all public transport services requires the development of telematics systems that can broker rapidly between transport providers according to potentially complex criteria. To date, the carriage of education contract and Social Services passengers and the scheduling of many services from a single TDC are being used to reduce marginal costs. In order to expand upon these approaches, it will be necessary to address the issue of cross-boundary services in terms of where they are scheduled from and how costs and revenues are allocated; conventions for brokering registered and non-registered services will need to be established; and finally the acceptability of such solutions to passengers will have to be ascertained. For example, suspicions about the objectives and longevity of new services need to be alleviated and the services offered must be clearly understood, as well as financially and physically accessible and relevant to user requirements.

These last few points serve as a reminder that public transport services must be responsive to customer needs. For most public transport journeys the responsiveness does not have to be very high, and such trips are satisfied by fixed route services. However, as demand becomes increasingly marginal in terms of service accessibility, frequency, vehicle accessibility and acceptable fares, the three key elements of demand responsiveness of public transport—route, vehicle and operator—require more flexible transport solutions, which, it is envisaged, in the future will encompass all modes of public transport, being administered through a network of Agencies.

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