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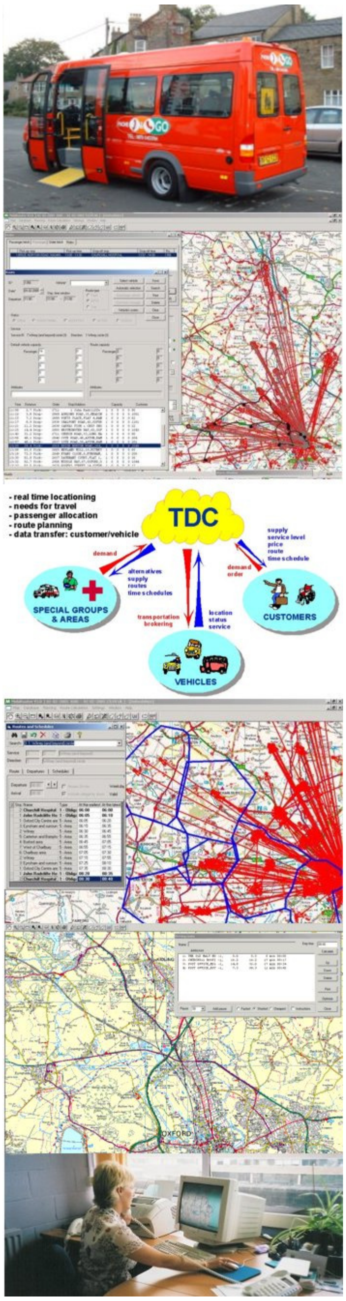

TRANSPORT AND ACCESS TO HEALTH CARE: THE POTENTIAL OF NEW INFORMATION TECHNOLOGY

Final Report

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EXECUTIVE SUMMARY

The objectives of this research are to:

1. Map the existing transport facilities supported by public agencies and the voluntary sector to the Oxford Radcliffe Hospitals and selected GP surgeries;
2. Map the transport services needed to enable people to access health care facilities;
3. Compare the existing provision with transport needs and establish revised models for the provision of transport to improve access.

In achieving these objectives, the research specifically seeks to address the following:

1. Study the potential for on-line communication and scheduling of travel and access to hospital;
2. Develop a demand responsive transport plan for a hospital trust;
3. Determine the impact of implementing such a plan on both the hospital and those who experience difficulty accessing it.

This work focuses on the potential for demand responsive transport (DRT) solutions to facilitate easier access. DRT services provide transport "on demand" from passengers using fleets of vehicles scheduled to pick up and drop off people in accordance with their needs. DRT is an intermediate form of transport, somewhere between bus and taxi and covers a wide range of transport services ranging from less formal community transport through to area-wide service networks. In recent years, the ability of DRT concepts to provide efficient, viable transport services has been greatly enhanced by the use of transport telematics software and hardware.

There appears to be relatively little written about the links between transport and health care access. Recent policy review by the Government and bodies such as the National Health Service (NHS), Audit Commission and Social Exclusion Unit have started to refer to the concept of hospital and general practitioner (GP) access in relation to transport issues. In Section 2, this report summarises the evidence collated and analysed in the literature review (Rajé *et al*, 2003a), grouped into key themes of policy and practice:

- The need for new perspectives on transport and health;
- Missed appointments and transport;
- Transport as a determinant of health;
- Non-emergency patient transport – the need for action;
- The emergence of the demand responsive transport option;
- The expansion of demand responsive transport schemes;
- Telematics and demand responsive transport;
- Demand responsive transport, health and social inclusion; and
- The role of the community in designing appropriate access solutions.

Section 3 summarises the findings of a two-pronged approach to developing an overview of current health care and transport provision in Oxfordshire (Rajé *et al*, 2003b). It provides information obtained from secondary sources on public transport services and health care facilities in a number of geographical locations in the county and also provides the findings of primary research carried out to ascertain in greater detail how people access the John Radcliffe and Churchill Hospitals in Oxford as well as general practitioner services in West Oxfordshire District, Cherwell District and the City of Oxford.

The empirical research was designed to fill what appears to be a gap in available data which was underlined in the literature review process: although there is a large body of literature available on transport and health, it is mainly focused on the health impacts of transport such as emissions and accidents. Separate questionnaires were used for the hospital and GP elements of the survey. The hospital questionnaires sought information on non-staff travel and the GP questionnaires on patient travel. A total of 1366 questionnaires were distributed, of which 221 hospital questionnaires and 144 GP questionnaires were returned and analysed.

From this it appears that journeys to the hospitals at Headington can be quite complex, requiring interchanges in public transport, coordination with other family members and friends and the use of taxis. Nearly all areas have some form of community transport service available but there are often restrictions on these services and some people are unsure about their eligibility for such services. There is also an apparent need for information about available transport services to hospitals. As may be expected, travel to GP facilities appears to pose rather less difficulties than travel to hospital. Other key results were:

- The most frequent problems described by respondents in travelling to hospital were parking problems, difficult/impossible to get there/back by public transport, traffic congestion and having to rely on someone else to take them.
- Most people (almost half) reported driving to and from hospital and the median travel time in either direction was 30 minutes.
- The hospital survey indicates that the greatest number of arrivals appear to have been between 0900 and 1100. Times of departure from hospital appear to peak between 1100 and 1300.
- The median total cost for a round trip to hospital was £5.00, although costs varied between £0.40 and £31.00.
- Most patients drove to their GPs while just over a quarter walked.
- Visits to/from the GP appear to have involved a median travel time of about 10 minutes.
- The average total travel time to and from a GP surgery was 20 minutes and total cost was estimated at £2.00.

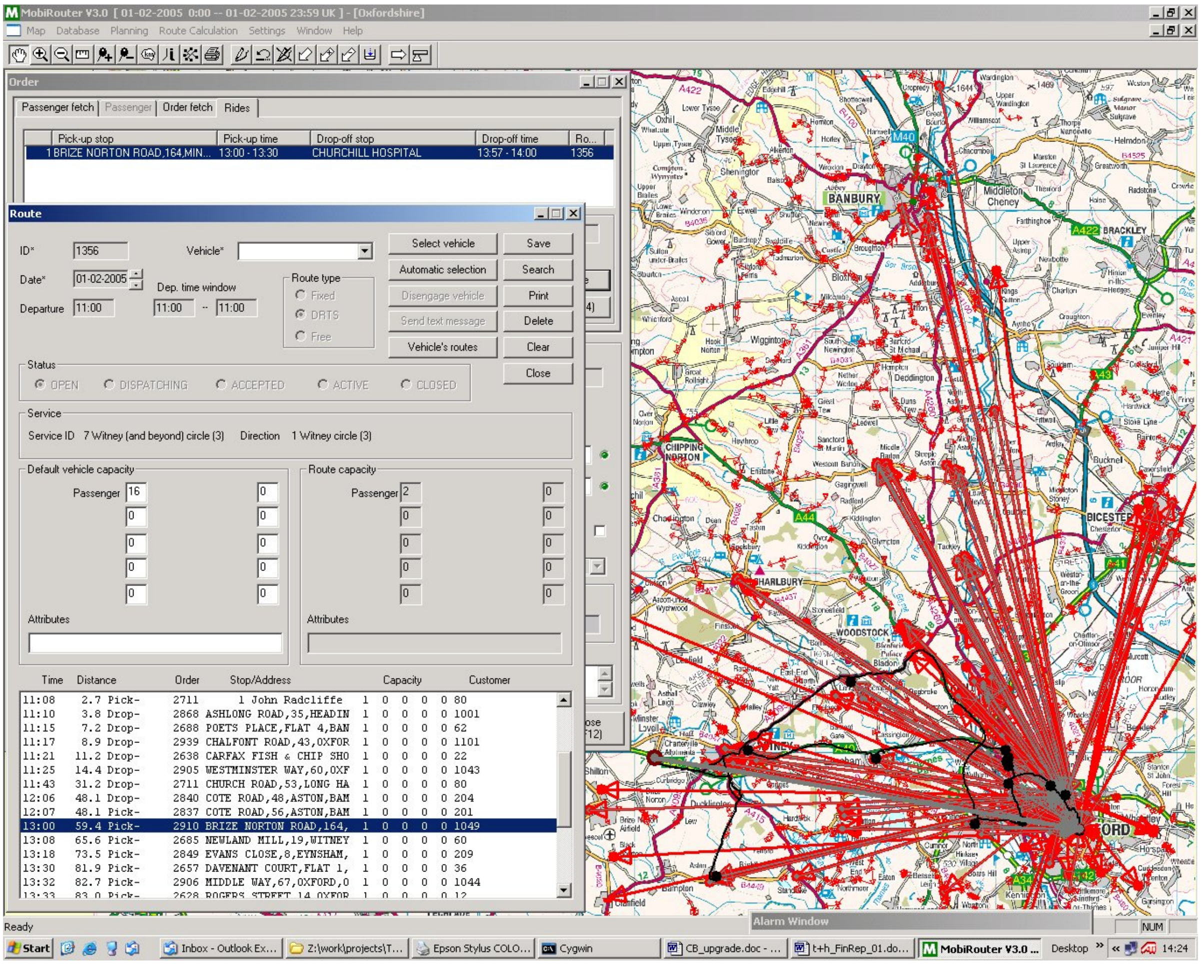
The main and solely new part of this report is presented in Section 4. This specifically addresses study objective number 3 by comparing the existing provision with transport needs and establishing a revised model for the provision of transport to improve access. The *Mobirouter* DRT software package was used to develop this model employing a range of flexible demand responsive transport services. These services are viewed as being both supplementary and an alternative to existing service provision such as taxi, bus, ambulance patient transport services and private motoring. The software tool allows for testing a range of service definitions and scenarios on a ‘what if’ basis (see Figure 1 for an example vehicle route assigned by the software). The model represents a first step towards an alternative health care transport plan for Oxfordshire.

The main results of the modelling exercise are:

- Overall, about 40% of the hospital orders were assigned to a service route within a 20-minute time window for this initial setup. Note the same ‘success rate’ applies to the GP surgery services developed separately from the hospital ones.
- For non-car drivers and/or the elderly, the DRT service routes have significant accessibility benefits. This is particularly true where access to public transport is poor.
- The £5 per average single DRT trip compares favourably to complex public transport journeys, some car journeys (incl. parking charges) and most taxi trips.
- The picture is not entirely clear when assessing DRT journey time savings compared to actual journey times reported by the hospital patients/visitors, with a wide range of time

savings and increases for individual passengers. Savings can be significant when compared to journeys involving existing public transport, intra- or inter-modal transfers, walking and waiting. Again, the picture is similar for trips to/from GP surgeries.
- The improved reliability of transport to hospital is likely to show significant benefits of lowering number of missed appointments. However, this could not be verified in this work.

Figure 1: Screenshot of the *Mobirouter* DRT system software, showing an example vehicle route with passenger pick-ups and drop-offs along the way



- The 215 completed surveys amount to 10.8% of the daily hospital patronage with destinations in the study area of 2,000 (SDG, 2001). This is slightly more than the share of respondents without access to a car (8.8%) and substantially less than respondents' 'expression of interest' for DRT (27.4%).
- Given the uncertainty in estimating potential demand for DRT, three demand scenarios were tested in terms of financial viability: a CENTRAL market share for DRT of 5%, and LOW and HIGH market shares of 2.5% and 7.5%. In light of the empirical evidence of this study and other sources (e.g. Grosso et al, 2002; Jones, 2002; Rajé et al, 2003a; Brand, 2003), this range of demand figures appears to be a reasonable for the purpose of this demonstration. The financial feasibility analysis provides a range of net present values for the three market shares. According to this analysis, the 'breakeven demand' for zero profit/loss is about 34 passengers per vehicle per day (or 6% of total demand) based on an average passenger charge of £5.
- The model has the potential to introduce greater equity of transport access.

The average charge per passenger was chosen here somewhere between bus and taxi charges. It lies well in the range of charges observed for existing DRT schemes in the UK. If replacing subsidised services such as community transport or non-emergency Patient Transport Services, a subsidy for DRT could significantly lower this charge to levels comparable to, for example, parking charges that are most 'visible' to the patient/visitor. Furthermore, the above demand figures are for hospital users only. It may be beneficial to combine demand and service supply with GP surgery demand. This might be tested in future work.

The demand figures employed are well within the usage figures reported by CfIT (2002), ranging from 10 to 51 passengers per vehicle per day for flexible DRT services with similar service frequencies and daily coverage. However, more detailed demand forecasting work will be required to substantiate the case for DRT services for health care services in the area.

Given the demonstrative nature of the model, there was insufficient time for the level of iteration necessary to make the services truly efficient. Further iterations would be required to make this a more efficient setup, with higher 'FLEX success rates' expected. Real world applications have shown that timings have to be fine tuned on a regular basis, reflecting weekly and seasonal differences in demand patterns. Indeed, this flexible approach can be seen as one of the strengths of DRT services and is most suitable to transport to health care provision.

Further work is required to test the feasibility of closely linking any DRT services with existing public transport provision (as feeder services) and major private transport interchanges (e.g. P&R). This would demonstrate a truly integrated transport provision, not only for transport to health care but supplementary to other forms of transport such as taxi, community transport, bus, rail etc.

Last but not least, the authors believe that modern DRT services have an important role to play in areas of poor provision, which in turn could contribute to the NHS' founding principle of providing access to care to all on the basis of need.

1 INTRODUCTION

1.1 Objectives

This report has been prepared by the Transport Studies Unit (TSU), University of Oxford, in association with the Transport Research Institute (TRI), Napier University, the Oxford Radcliffe Hospital Trust and Jeff Duffell, an external IT consultant. It reports on the findings of a study on Transport and Access to Health Care: The Potential of New Information Technology for the Department for Transport – New Horizons Programme.

This research is specifically aimed at mapping the existing transport facilities supported by public agencies and the voluntary sector and mapping the transport services needed to enable people to access health care facilities in order to compare the existing provision with transport needs and develop a revised model for the provision of transport to improve access.

In achieving these objectives, the research specifically seeks to address the following:

1. Study the potential for on-line communication and scheduling of travel and access to hospital
2. Develop a demand responsive transport plan for a hospital trust
3. Determine the impact of implementing such a plan on both the hospital and those who experience difficulty accessing it.

1.2 Setting the Scene

While there are other solutions to health care access problems such as the development of telemedicine and e-health, this work concentrates on the potential for demand responsive transport (DRT) solutions to facilitate easier access. DRT services provide transport "on demand" from passengers using fleets of vehicles scheduled to pick up and drop off people in accordance with their needs (Grosso *et al*, 2002). DRT is an intermediate form of transport, somewhere between bus and taxi and covers a wide range of transport services ranging from less formal community transport through to area-wide service networks. In recent years, the ability of DRT concepts to provide efficient, viable transport services has been greatly enhanced by the use of transport telematics software and hardware and its successful demonstration in a variety of environments in EC-funded R&D projects such as SAMPO, SAMPLUS and INVETE and currently in the FAMS and EMIRES projects (Nelson and Mageean, 1999; Grosso et al, 2002).

In the UK the Government in its Ten Year Plan for Transport has pledged to remove or (at least) relax constraints on the development of flexibly-routed bus services and to promote a greater role for community-based services. Recently-published research argues that flexible public transport services, provided by local authorities and bus operators in partnerships with employers, stores and leisure centres would help break down social exclusion (DETR, 2000a; DETR, 2000b). The recent successes of local authorities in winning substantial funding under the Rural (and indeed Urban) Bus Challenge programmes for the implementation of DRT confirms this new interest in flexible forms of transport (Jones, 2002; Grosso *et al*, 2002).

For many there is a call for a transport solution that is reliable, involves no interchange, precludes the need to rely on friends/relatives and provides door-to-door travel. Efficient and effective demand responsive transport can meet these needs, at a cost per trip somewhere in between taxi and public transport (Rajé *et al*, 2003a; Grosso *et al*, 2002).

1.3 This Report

Following this introductory Section, Section 2 of this report gives an overview of what has been written about transport and access to health care by briefly summarising the literature in the field. This is mainly based on the more detailed literature review carried out earlier in the project (Rajé *et al*, 2003a). Section 3 presents a summary of the results of profiling transport and health care in the study area. Again, this is based on work reported on in more detail earlier in the project (Rajé *et al*, 2003b). However, it has strong links with the current work and is therefore summarised here.

Section 4 represents the main part of this report, providing the results of the development of an alternative demand responsive transport plan built on telematics-based DRT service provision and on-line communications. This also includes a brief excursion into current DRT software provision and use, based on work reported earlier (Brand, 2003). Conclusions and an outlook are given in Section 5.

2 TRANSPORT AND ACCESS TO HEALTH CARE: SUMMARY OF THE EVIDENCE

2.1 Introduction

The literature review (Rajé *et al*, 2003a) found that there appears to be relatively little written about the links between transport and health care access. Recent policy review by the Government and bodies such as the National Health Service (NHS), Audit Commission and Social Exclusion Unit have started to refer to the concept of hospital and general practitioner (GP) access in relation to transport issues. This Section summarises the evidence collated and analysed in the literature review, grouped into key themes of policy and practice:

- The need for new perspectives on transport and health;
- Missed appointments and transport;
- Transport as a determinant of health;
- Non-emergency patient transport – the need for action;
- The emergence of the demand responsive transport option;
- The expansion of demand responsive transport schemes;
- Telematics and demand responsive transport;
- Demand responsive transport, health and social inclusion; and
- The role of the community in designing appropriate access solutions.

2.2 The need for new perspectives on transport and health

A key barrier to improved health and well-being is access to health services. The Audit Commission (2001a) states that 'Patients' expectations about both the availability and the quality of the transport needed to allow them to access health services are likely to rise.' The public's concerns about the NHS are wide-ranging but include 'better transport and access to services, better community care, and more joined up services' (NHS, 2000).

It is widely acknowledged that current provision of health care transport is inefficient and poor transport connections negatively affect health quality. Issues of accessibility in the health care literature have been found to cover a range of concepts such as waiting lists and physical access (Martin *et al*, 2002). Indeed, even the term access can be nebulous and has been described as both geographic and sociological in nature (Wakeman, 1999).

Building on Martin *et al*'s (2002) conception that there are large variations in access to transportation between those adjacent to, and those remote from, nodes in the transportation network, the current study looks at the ways in which demand responsive transport can bring people from areas that are remote from the mainstream transportation network towards those who are adjacent to the network to provide a service that makes efficient use of the existing network and allows access to health care that is at once timely and tailored for individual needs.

Martin *et al* (2002) go on to describe some of the complexities associated with travel to hospital such as the reliance on lifts, use of voluntary car schemes and public transport. Where public transport is poor, the authors suggest that difficulties associated with travel to hospital are compounded by the absence of any voluntary scheme.

Turning to health care provision itself, some believe that health care provision in general and GP services in particular are scarce in rural areas. This points to the dependence of rural residents on travel over relatively long distances in order to access health care. Transport must then be an even more important facilitator of health service access. Furthermore, the Rural Development Commission (1995) found that 'consultation rates for rural GP's tend to be lower than for those in urban practices, even where the village has a surgery, and lowest of all in the more remote villages'. Interestingly, the authors also report that when a branch surgery is added 'increases in attendance have been achieved without any major impact on the numbers attending the main practice (Fearn *et al*, 1984 and Bentham and Haynes, 1992), though significantly most of these gains have been from the elderly, those suffering from long-standing illnesses and, particularly, households without a car'. This indicates that for households without a car, access to health care must be subject to suppression when there is no conveniently located GP facility.

In addition, there is evidence from research on social variation in use of an out of hours patient transport service (O'Donnell et al, 1999) that indicates that equity of access to out of hours primary care is a major issue, 'particularly in areas of socio-economic deprivation where demand is high but access to transport is poor'.

2.3 Missed appointments and transport

It has been suggested that 20 per cent of adults experience some difficulty getting to their hospital while less than 6 per cent experience difficulty in accessing services such as the chemist or GP (Rushton, 2002).

A recent study to examine the problems faced by outpatients travelling to the Royal United Hospital Bath showed that 48% of respondents said that they come to hospital by car because it is the quickest way to travel and 18% said that there was no alternative means of travel (Bath and NE Somerset Council, 2002). Interestingly, however, 42% said they would consider using public transport if improvements were made. This study also found that the most seriously affected by these transport difficulties are people who do not own a car, people who live in remote rural areas, people who are elderly and people who are disabled or whose physical condition makes travel difficult. A report on barriers to access to essential services in Northern Ireland (Independent Research Solutions, 2001) states that healthcare was reported most frequently as causing difficulties and was exacerbated where long distances and limited availability of transport made it difficult to time visits to coincide with surgery hours.

According to the Department of Health, 5.2 million hospital outpatient appointments are missed in one year (MORI, 2002) resulting in a cost of £250 million a year (BBC, 1999). The Social Exclusion Unit states that over a 12-month period, 1.4 million people miss, turn down or choose not to seek medical help because of transport problems.[1] The Department of Health's activity summary for 2001-02 reports that, at the Oxford Radcliffe Hospitals NHS Trust, from April to Sept 2001 there were 207,966 outpatient attendances and 22,100 appointments for which people did not arrive. Of the 10% of outpatients who did not attend, it would be interesting to determine how many attributed this to transport or access difficulties. Hamilton and Gourlay's (2002) investigation into whether there is a link between missed hospital appointments and transport indicates that although health professionals consider that patient apathy is the main cause of missed appointments, 'transport rather than apathy was a significant factor'. In addition, transport related factors, such as travelling with children, were also cited as a reason for failing to attend appointments. These findings imply that provision of an efficient transport solution could result in considerable cost savings to the NHS.

Against this background, the crisis in the health care service is highlighted even further in a news release by the Oxfordshire Health Authority (1999) which urged patients not to use

[1] http://www.socialexclusionunit.gov.uk/publications/reports/html/transportfinal/chapter1.html

hospital transport unnecessarily, suggesting that they 'find alternative means where possible to get to their routine appointments, perhaps using public transport or enlisting the help of relatives and friends'. This press release was issued during a holiday period, a time when an effective new technology-based demand responsive transport system could have helped satisfy the surge in demand for transport, particularly since volunteer availability is usually greater during vacation time when people's travel patterns tend to differ considerably from their norm.

The Social Exclusion Unit states that 'three areas affect people's ability to get to healthcare services: access to mainstream and specialist transport, financial support for people on low incomes and the location of healthcare facilities'.[2] In this light the importance of transport away from the health care facility must not be overlooked. The Audit Commission (2001b) suggests that prompt transport for discharged patients 'helps to ensure that people leave hospital as soon as they are fit to do so, reducing bed blocking.'

It must also be noted that, where transport is provided, there are new initiatives in place to prevent intentional missing of appointments and consequent unnecessary trips being made by the patient transport provider. The Audit Commission (2001a) provides further details about efforts to save 'wasted trips' involving clerical officers telephoning patients the day before their appointment to find out whether they intend to attend. The Audit Commission reports that 'this has both increased hospital attendance and reduced the incidence of non-emergency Patient Transport Services (PTS) crews arriving to pick up a patient who is not planning to travel'.

2.4 Transport as a determinant of health

The Department of Health and Neighbourhood Renewal Unit (DH, 2002) in a joint report identify transport as one of the determinants of health. The report also states 'When people think about health, they tend to think about illness and access to specific NHS facilities, such as the local doctor's surgery or the nearest hospital', thereby underlining the importance of access to health care facilities.

2.5 Non-emergency patient transport – the need for action

In its guide for managers on improving PTS, the Audit Commission (2001a) recognizes that 'poor access to health services because of a lack of, or infrequent, public transport, or high transport costs, is a major factor in social exclusion and rural isolation. Free non-emergency PTS helps to overcome this problem.'

Following a clinical governance review, Mersey Regional Ambulance Trust NHS Trust reported (Commission for Health Improvement, 2002) that 'many patients are frustrated by cancellations and long delays in the patient transport service'.

People experiencing the long delays in the patient transport service described above are likely to be dependent on a variety of transport services as they endeavour to participate in key social activities not just accessing health care. This dependence on multiple providers leads to difficulties described by the Audit Commission (2001a) related to the arrangements that may have to be made with each service by an individual (e.g. social services transport to go to a day-centre, Dial-a-Ride to go shopping and non-emergency patient transport to attend hospital). The Audit Commission sees this as particularly problematic for elderly or frail people, those with learning or literacy difficulties, or those whose first language is not English. For many people, applying for help is complex and may be a significant barrier to obtaining support. This indicates a need for lessening the burden of trip-planning for these

[2] http://www.socialexclusionunit.gov.uk/publications/reports/html/transportfinal/chapter11.html

vulnerable transport users – a flexible DRT service can be the path towards easier access for such people.

2.6 The emergence of the demand responsive transport option

DRT options have recently emerged as an important policy option in the context of policy concern with congestion and the constraining of car based mobility. Given that travel to health care facilities is particularly difficult for those who do not have access to a car (Rushton, 2002), 'small scale, on-demand public transport services could be the social and economic answer' (Schwartz, 2000).

New information technology can readily collect together information on persons with low mobility wishing to make similar journeys, provide a booking system or intelligent reservation system which permits the pick up and drop off at home and organize this in a way which is cost effective at the community level (Grieco and Hine, 2002). The authors suggest that buses routing around the needs of low mobility passengers is an existing capability of the new information age.

2.7 The expansion of demand responsive transport schemes

In its study of European best practice in the delivery of integrated transport, the Commission for Integrated Transport (CfIT, 2001) states that demand responsive transport schemes are becoming more common in the UK but are still basic in comparison to services provide abroad. CfIT suggests that 'Although front-end costs are much higher than low-tech systems, introducing similar technology in the UK could help optimise resources in the long term by lowering subsidy costs per passenger'.

One of the areas where examples of more flexible transport schemes can be found is in Scandinavia. A concept called *FlexRoute* was developed in Gothenburg. It is described as an intermediate form between shared-ride taxi and traditional service routes for the mobility impaired (Ståhl, 1999). In Finland, demand responsive services are provided by low floor minibuses, taxis and service taxis (specially equipped for mobility impaired people). Lindstrom (1999) indicates that the appropriate vehicle is chosen according to the needs of the customers and the number of customers that have booked a trip.

It may be argued that for certain journeys demand responsive transport would be an appropriate solution, given the need to increase the route pattern and frequency of buses and the perceived high cost of taxis. This type of service could involve vehicles operating between a fixed pair of points but with flexible routes so that passengers can be delivered to their doors to overcome the problems of carrying heavy goods and fears about personal safety, and helping to reduce the impact of bad weather.

2.8 Telematics and demand responsive transport

In the health sphere, the use of new information technology (IT) is becoming increasingly widespread. Through investment in modernizing IT, the NHS has set out a number of goals including electronic booking of appointments for patient treatment by 2005 and connection of all GP practices to NHSnet, giving patients improved diagnosis, information and referral (NHS, 2000).

In the transport sector, telematic developments create opportunities for 'smart' or 'intelligent' demand responsive transport schemes which can reduce the length of booking window required. There are several software solutions available which have been explored during the research for suitability for application to improving hospital access. Some of these are briefly described below:

- There is on-going work in Australia to develop technology that can meet the needs of scheduling new forms of public transport such as demand responsive transport (see CSIRO, 2000).
- Other transportation software tools are available such as *tod* (Transport Optimized on Demand) which is intended for persons who are poorly served by traditional transportation services. The goal of the application is to never have empty vehicles in circulation and to use the vehicle best suited to transportation needs in order to satisfy customer demand. By pooling users together in the same vehicle, customized transportation moves more people, more quickly and at a lesser cost.
- Mobisoft (UK) Ltd. produce MobiRouter which is a software package which allows real-time scheduling and despatch of vehicles.

The software review (Brand, 2003) contains further information on these and other (overseas) schemes. This includes the following DRT applications in the UK, covering a wide range of geographical locations:

- *Wiggly Bus*, Vale of Pewsey, Wiltshire
- *CallConnect*, Lincolnshire
- *U Call*, West Newcastle and Airport, Tyne and Wear
- *Phone and Go*, Northumberland
- *Click and Go*, Northumberland
- *Cango*, Andover, Hampshire
- *Village Link*, Southern Vale of Gloucester
- *Local Link*, Wythenshawe, Manchester
- *Meltham's Minibus*, West Yorkshire
- *Hampole and Skelbrooke Taxibus*, Doncaster, South Yorkshire
- *DoRiS*, West Sussex and South Waverley, Surrey
- *InterConnect*, Lincolnshire
- *FAMS* EU project, Angus
- *Corlink*, Cornwall
- *EMIRES* EU project, Highlands
- Flintshire

Horn (2002) describes fleet scheduling and dispatch in the context of demand responsive passenger services. He states that 'Responsiveness to demand…requires effective communication between prospective travellers and a scheduling centre, and between the centre and the drivers of the various vehicles'. Schwartz (2000) has explored 'the role of demand responsive public transport as a tool for providing an equitable and cost effective transport service to supplement mass transit and reduce transport disadvantage'. The current research focuses on the application of new technology to demand responsive transport to lessen transport disadvantage even more than conventional demand responsive services have done until now.

2.9 Demand responsive transport, health and social inclusion

The Audit Commission (2001a) recognises the links between health, social inclusion and transport when it states that 'Inability to access health services is one example of social exclusion. Some people cannot afford private transport. People who use wheelchairs need to travel in vehicles that can carry their chairs; these tend to be larger and costlier than the average private car, increasing affordability barriers. Alternatively, people may not use private transport because no one in the household knows how to drive. Illness or disability may prevent younger people from learning to drive; many older people may never have learnt to do so. While increasing proportions of elderly people have driving licences, many still do not, particularly women. Elderly women, most of whom live alone, are therefore less likely than elderly men to have access to a car. Other people may no longer be able to drive'.

In light of the indicated links between transport, health and social inclusion, the Audit Commission's (2001a) report goes on to describe a number of schemes other than the Hospital Travel Costs Scheme[3] which try to address the accessibility and financial barriers to travel. Of particular relevance to the current study are the Dial-a-Ride and ring and ride, Taxicard and Voluntary sector community bus schemes and voluntary car schemes. The potential for linking such schemes into a flexible demand responsive transport service is greatly heightened through the availability of software that allows efficient management of vehicles from a number of fleets.

2.10 The role of the community in designing appropriate access solutions

In order for any transport service to be designed appropriately for its users, it is clear that the evolution of such a scheme must take account of the needs expressed by the potential users in the community. The Audit Commission (2001a) refers to patient-centred service provision stating that 'In the transport context, this means that patients should be asked regularly whether current standards and arrangements are meeting their needs and, if they are not, to identify what improvements are needed'.

It is apparent then that the development of a truly flexible demand responsive transport service must take account of issues such as the minimum time prior to travel that people say they would prefer to be able to book the service (time window, latest drop-off), the nature of trips (in terms of length, number of stops etc) that they would find acceptable and the length of time they would be willing to wait for transport home after an appointment (time window, earliest pick-up). Arguably a service that grows out of its users' expressed needs is much more likely to provide them with a transport solution that they find easy to use.

[3] More information on Hospital Travel Costs Scheme is available in Rajé *et al* (2003), Appendix 1.

3 CURRENT TRANSPORT AND HEALTH CARE PROFILES IN THE STUDY AREA

3.1 Introduction

This Section summarises the findings of the second phase of the project, which aimed at mapping the existing transport facilities supported by public agencies and the voluntary sector to compare the existing provision with transport needs.

The main output of this research exercise, the Report on Transport and Health Profiles (Rajé *et al*, 2003b), describes the findings of a two-pronged approach to developing an overview of current health care and transport provision in Oxfordshire. It provides information obtained from secondary sources on public transport services and health care facilities in a number of geographical locations in the county and also provides the findings of primary research carried out to ascertain in greater detail how people access the John Radcliffe and Churchill Hospitals in Oxford as well as general practitioner services in West Oxfordshire District, Cherwell District and the City of Oxford.

3.2 Mapping Existing Transport Facilities

Transport and health care profiles were drawn up for 12 locations in the Oxford Radcliffe Hospitals NHS Trust catchment area. Nine of these locations were outside of the city of Oxford boundary – 4 in West Oxfordshire and 5 in Cherwell. In addition, profiles of 3 residential areas of the city were also put together. Figure 2 shows the location of the two hospitals on a map of Oxford while Figure 3 gives an overview of the research area, indicating the district council boundaries.

Figure 2: Map of Oxford showing location of hospitals (in ovals)

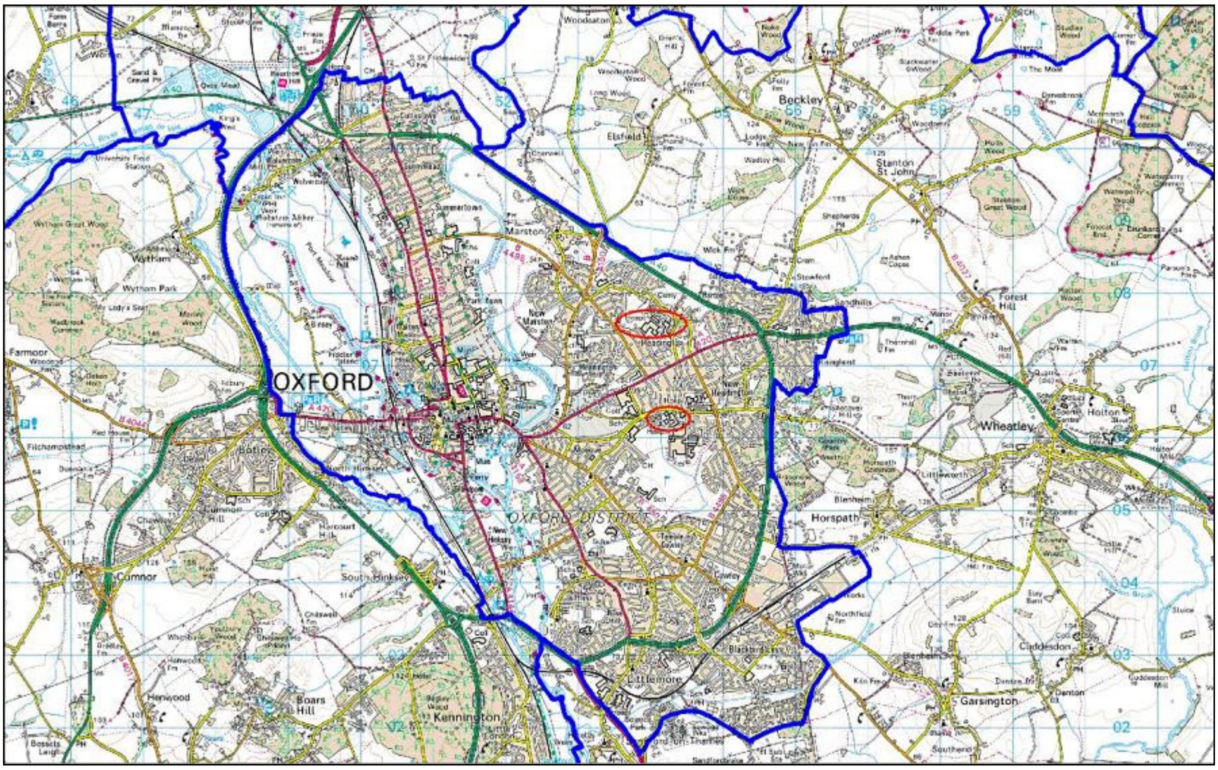
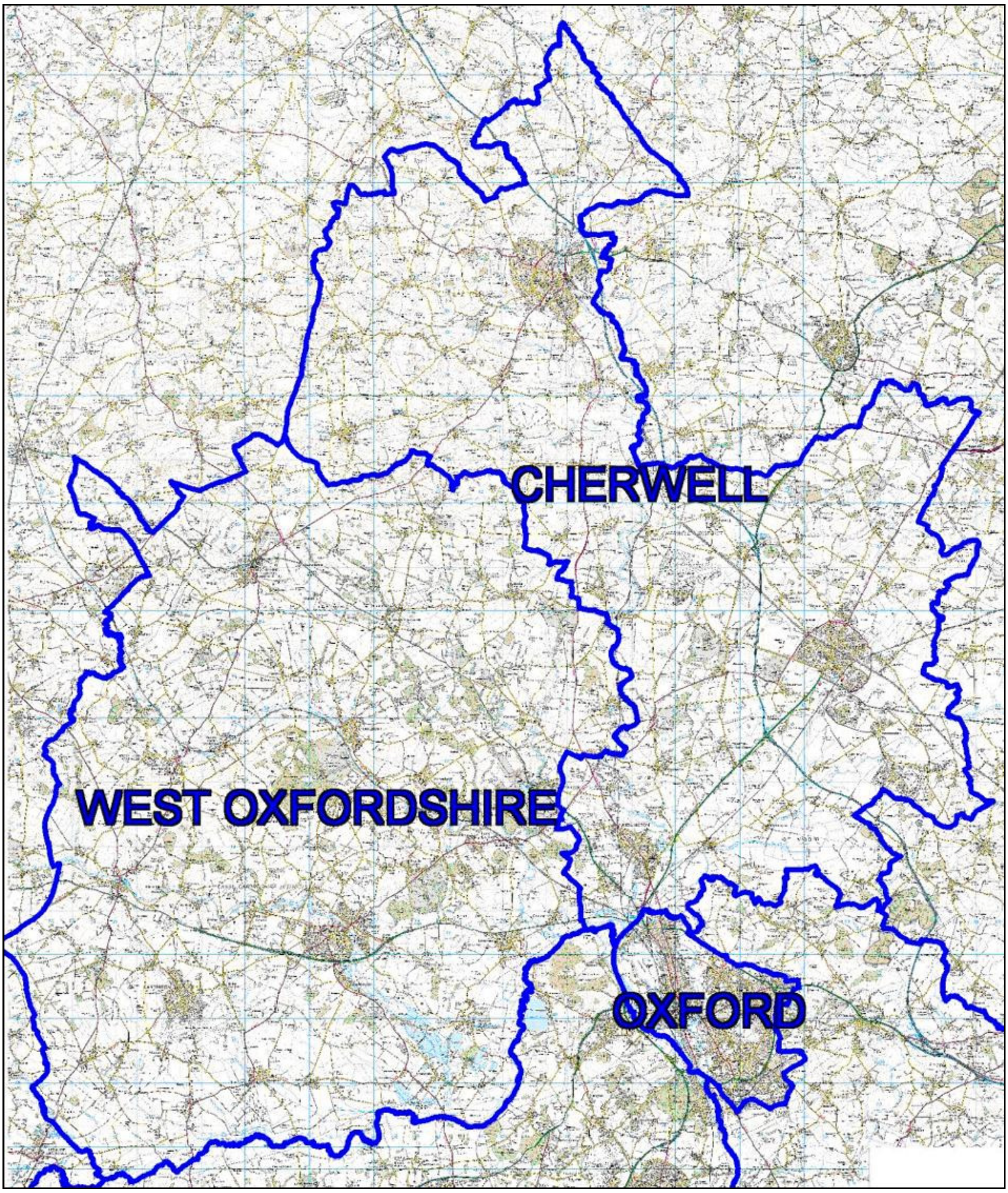


Figure 3: Overview of research area, indicating the district council boundaries



Under license from Ordnance Survey (via digimap), 2003

The sources of information included public transport timetables, community transport information and the NHS databases of GP and hospital services (Rajé *et al*, 2003b).

An example of the current transport service profile for Bladon village is given in Table 1. The village was chosen because it is relatively near to an urban area but without direct public transport to Oxford city (and the hospitals)[4]. Note for access to the John Radcliffe Hospital a patient/visitor would need to:

[4] Note the relatively good availability of community transport services.

1. Get a bus to Woodstock (or walk to the main road);
2. Get another bus to Oxford City Centre;
3. Walk to another bus stop (up to 10 minutes);
4. Get a bus to the hospital.

Table 1: Example of the current transport service profile for Bladon village

GP Services	Hospitals*	Public Transport Services to JR/Churchill	Community Transport Services
Available at Woodstock (3 km). The Surgery Park Lane, OX20 1UB Opening times: Mon 0830-1130 1330-1830 Tue 0830-1300 Wed 0830-1130 1630-1830 Thu 0830-1300 1600-1830 Fri 0830-1300 1600-1830 Sat 0830-1230 This GP practice operates from more than one site, so opening times may vary. PCT: North East Oxfordshire No. of GPs: 5 Available at Long Hanborough (3.4 km) 56 Churchill Way Long Hanborough OX29 8JL Opening times: Mon 0830-1300 1400-1830 Tue 0830-1300 1400-1700 Wed 0830-1300 1400-1830 Thu 0830-1300 1400-1830 Fri 0830-1300 1400-1800 Sat 0900-1000 PCT: South West Oxfordshire No. of GPs: 8	Nearest: Witney Community 11.5km John Radcliffe: 13.1 km Churchill: 14.4km	No direct bus services found. There is a direct bus service from Woodstock to Oxford City Centre. 1133 1135 RH Transport No. 242 Bladon Woodstock 1140 1155 RH Transport 203 Woodstock Kidlington 1207 1232 Oxford Bus Co. No. 2A Kidlington to Oxford George St 1251 1315 Stagecoach No. 10 Oxford Rail Station to JR Saturday service resembles weekdays. No Sunday services.	1.Cherwell District Dial-A-Ride – Kidlington Area Bookings taken Mon –Fri 0900-1100. Wheelchair accessible. Seating capacity: 1-16 2.Hanborough Community Care Group – Care Scheme Long Hanborough surgery catchment. Seating capacity: 1-4 3. Ring-A-Ride – West Oxfordshire Book up to 7 days in advance 0930-1230. Anywhere within West Oxfordshire District. Passengers limited to 2 journeys per 7-day period. Wheelchair accessible. Seating capacity: 1-16 4. Villager Community Bus Services Timetabled. North Gloucestershire and West Oxfordshire. Covers 61 villages. Low step for disabled users. Seating capacity: 1-16 5.Witney Volunteer Link-Up Car Scheme Open Mon-Fri 0900-1300, answerphone other times Seating capacity: 1-4 6.Kidlington Lynx – Route 1 Timetabled community bus operating on route: Kidlington, Yarnton, Cassington, Church and Long Hanborough, Bladon, Woodstock. Driven by volunteers and vehicle available for hire. Wheelchair accessible. Seating capacity: 1-16

Source: Rajé *et al* (2003b)

Overall, it appears that journeys to the hospitals at Headington can be quite complex for people who live outside of the city of Oxford. Trips from these, more rural locations, can involve a number of changes of not only buses but also bus operators. Other trips involve both train and bus travel.

In addition, for some areas, the outbound trip is via one transit point whereas the return involves another. There is also a need, for nearly every journey, for the passenger to walk to either St. Aldates or the Railway Station in Oxford to catch the bus to the hospital. As this can take up to 15 minutes, it has implications for less able-bodied people and those who are debilitated.

Nearly all areas appear to have some form of community transport service available. Yet there are often restrictions on these services, in terms of times that bookings can be made (people often do not know in advance when they may need to make a crisis journey to hospital), number of journeys that can be made in a 7-day period (an individual may wish to visit a relative in hospital several times over a one-week period) or breadth of geographical coverage of the service (transport may not be available to the hospitals).

3.3 Mapping Transport Needs

Primary data was collected through questionnaires designed to obtain a snapshot of how people currently travel to health care facilities in these geographic areas. The empirical findings, described in more detail in Rajé *et al* (2003b), are based on a two-pronged survey of a) how people travel to the John Radcliffe and Churchill Hospitals in Oxford and b) how people travel to their GP's facilities. Separate questionnaires were used for each of these elements of the survey. The hospital questionnaires sought information on non-staff travel and the GP questionnaires on patient travel. A total of 1366 questionnaires were distributed.

221 hospital questionnaires and 144 GP questionnaires were returned and analysed, with the following headline results:

Hospitals

- The hospital survey indicates that respondents made a median of 2 trips to the John Radcliffe and 1 to the Churchill in the last year.
- 57% of the trips reported on in the survey were to the John Radcliffe and 39% of trips made to both hospitals were for follow-up appointments or treatment.
- Most people (almost half) reported driving to and from hospital and the median travel time in either direction was 30 minutes.
- The hospital survey indicates that the greatest number of arrivals appear to have been between 0900 and 1100.
- Times of departure from hospital appear to peak between 1100 and 1300.
- While the results indicate large variations in length of visit to hospital, the median duration of a visit was one and a half hours.
- The median total cost for a round trip to hospital was £5.00, although costs varied between £0.40 and £31.00.
- The most frequent problems described by respondents in travelling to hospital were parking problems, difficult/impossible to get there/back by public transport, traffic congestion and having to rely on someone else to take them.

GP surgeries

- The average number of trips made to the GP in the last year was 6.
- Most patients drove to their GP's while just over a quarter walked.
- Visits to/from the GP appear to have involved a median travel time of about 10 minutes.
- The average total travel time to and from the GP's was 20 minutes and total cost was estimated at £2.00.
- The average duration of a visit to the GP's was 30 minutes.

'Trip distribution maps' of travel to the hospitals in Oxford and to their GP's facilities are provided in Figure 4 and Figure 5 respectively, showing as-the-crow-flies trip patterns for both ‘to’ and ‘from’ journeys. The hospital trip pattern illustrates that Banbury, Bicester and Witney are the main trip origins and destinations. As expected, the average trip length is significantly higher for journeys to/from hospitals than for trips to/from GP surgeries. People make trips of more than 50km to the hospitals while trips to GP surgeries are often short (<2km) and therefore walkable.

Figure 6 shows a zoomed-in screenshot of the Woodstock-Tackley area to the North-West of Oxford. This graphically shows that Woodstock has a surgery while Tackley (and other villages) has not: residents of Tackley have to travel longer trip distances than, say, residents of Woodstock.

Figure 4: ‘Trip distribution map’ of travel to/from the hospitals in Oxford

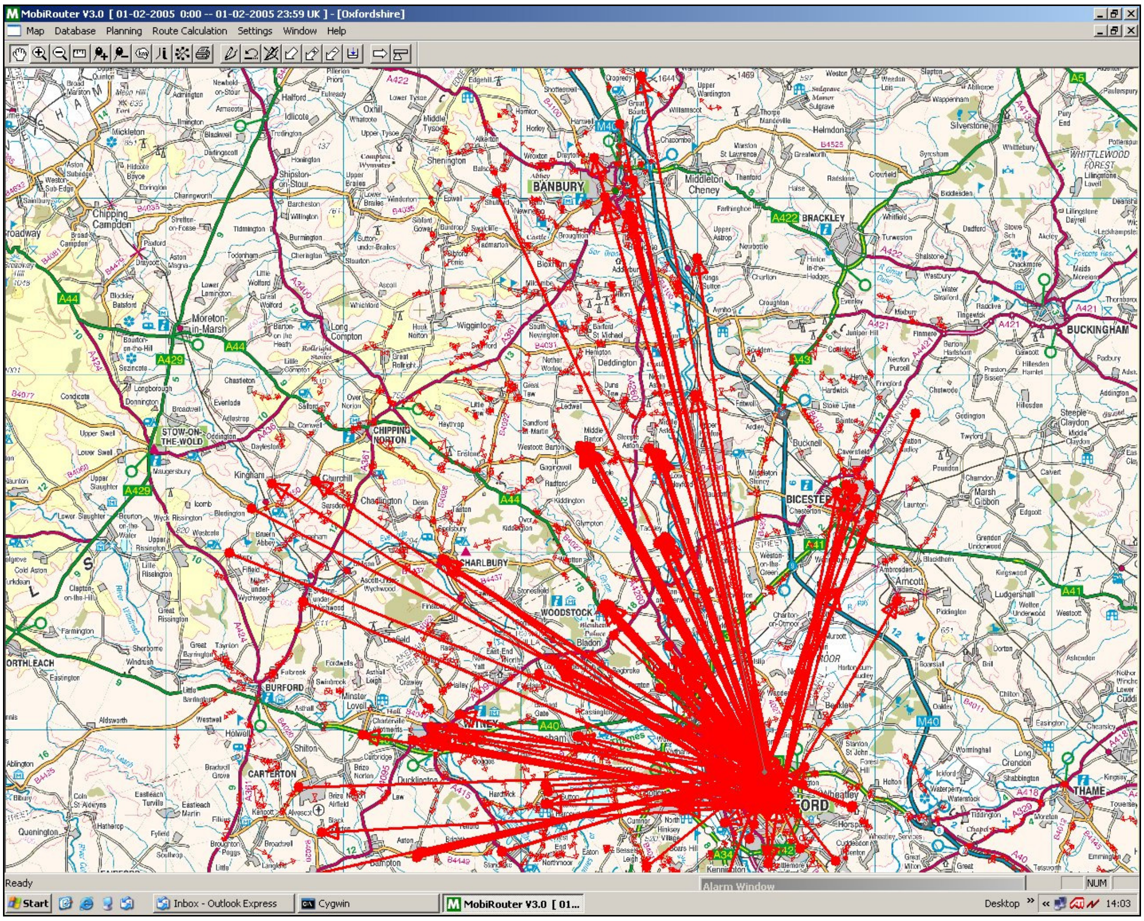


Figure 5: 'Trip distribution map' of travel to/from selected GP surgeries

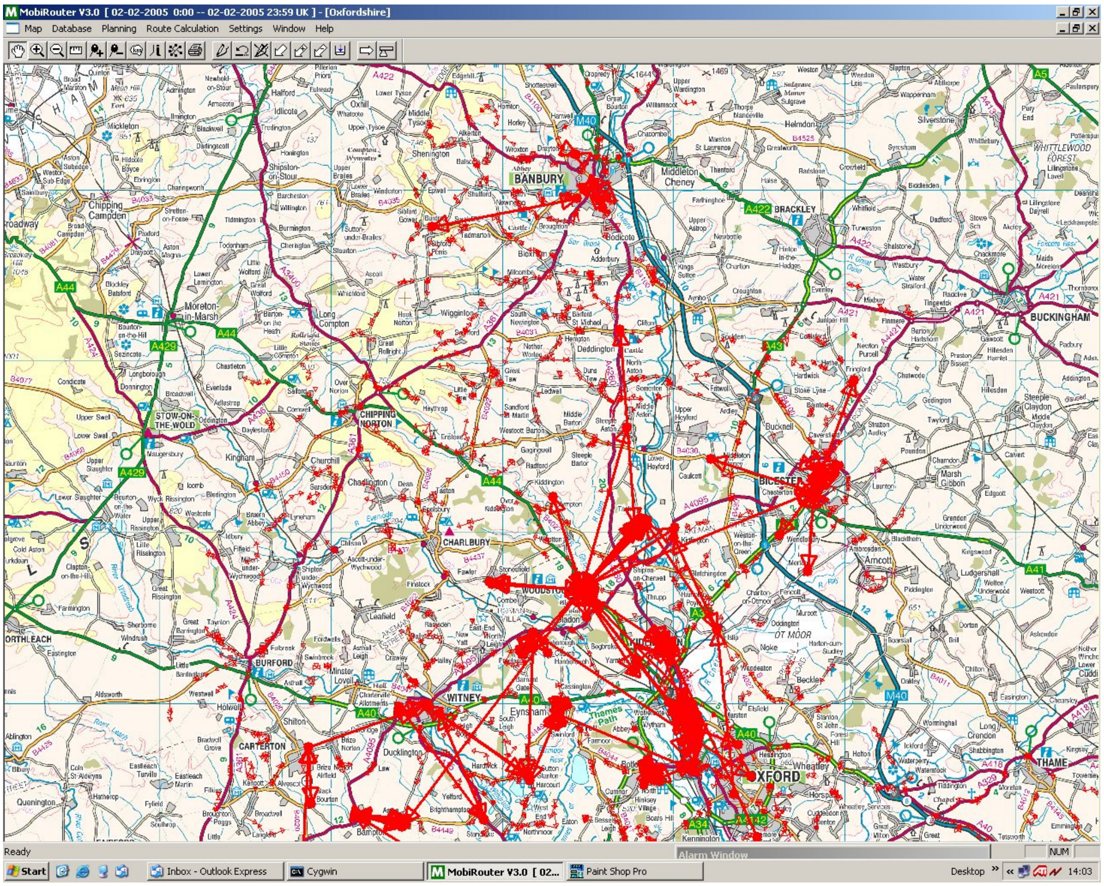
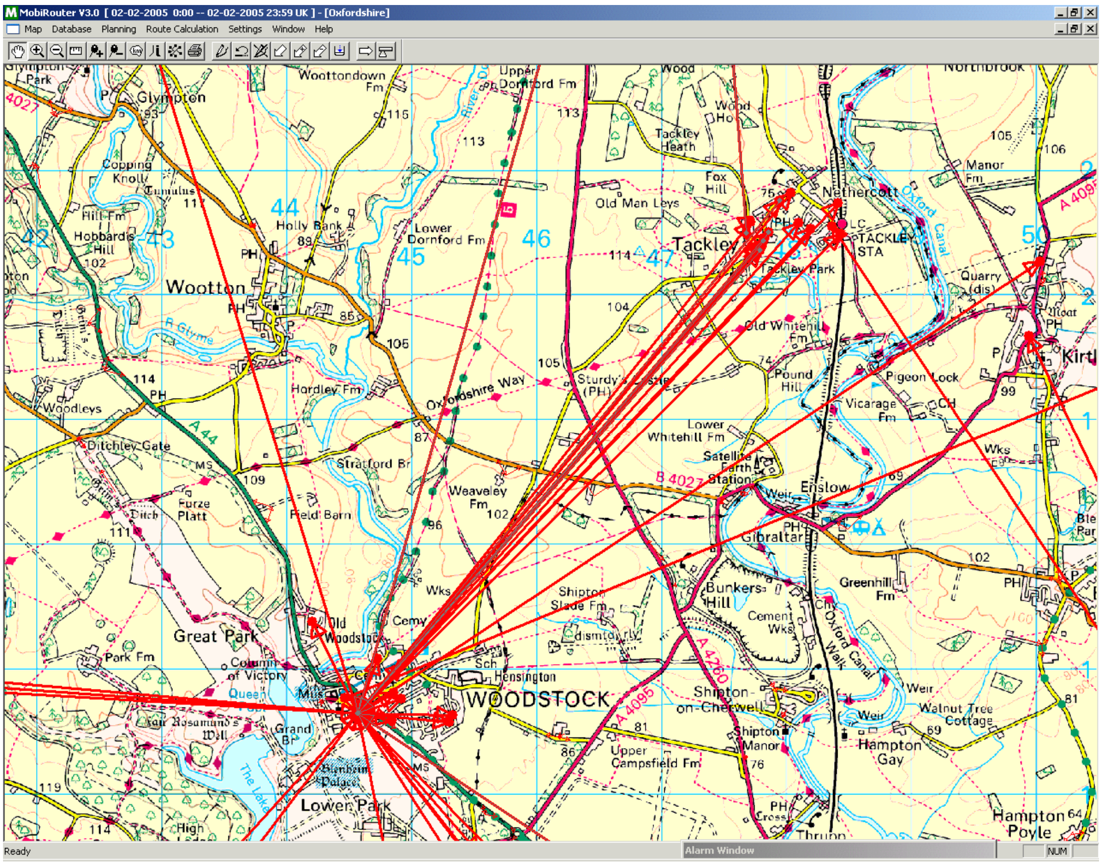


Figure 6: Passenger trips (red or grey) in Woodstock (GP surgery) and Tackley areas



4 TOWARDS AN ALTERNATIVE HEALTH CARE TRANSPORT PLAN

4.1 Introduction

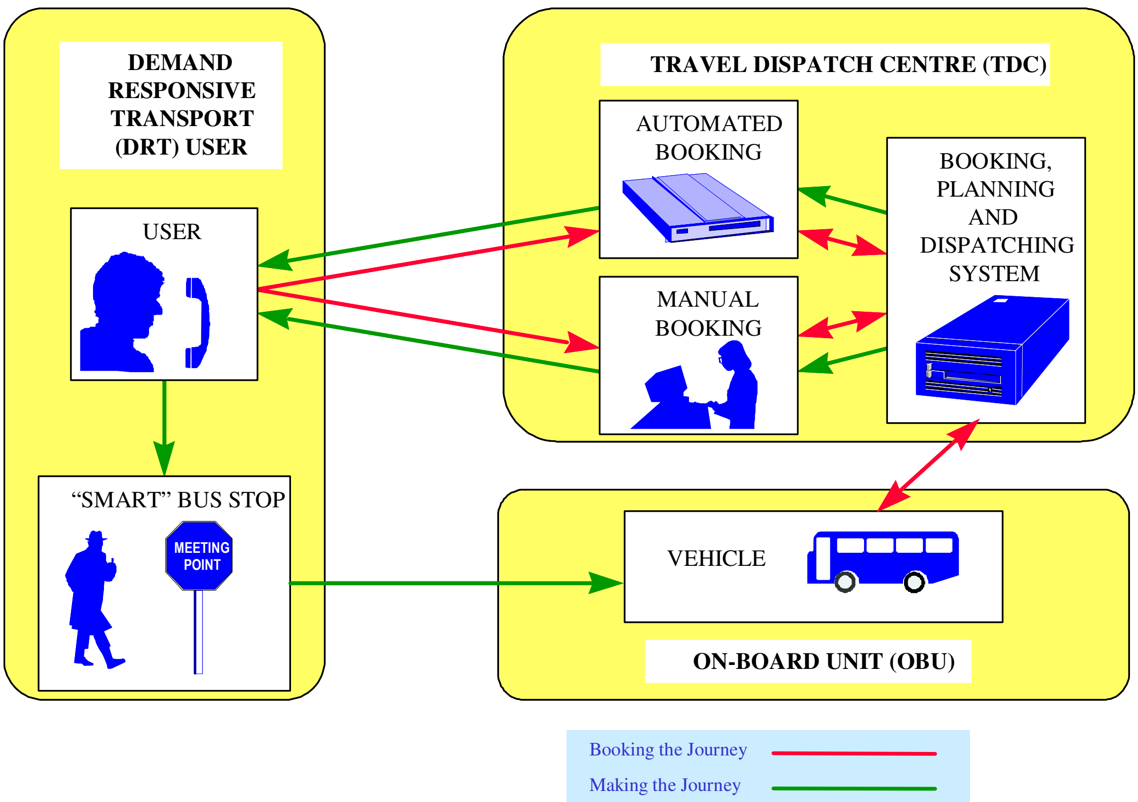
This Section provides the results of the final phase of the project: the development of the revised model for the provision of transport to improve access. The *Mobirouter* DRT software package was used to develop this model employing a range of flexible demand responsive transport services. These services are viewed as being both supplementary and an alternative to existing service provision such as taxi, bus, ambulance patient transport services and private motoring. The software tool allows for testing a range of service definitions and scenarios on a 'what if' basis. The scenario described below represents a first step towards an alternative health care transport plan for Oxfordshire.

Prior to presenting the alternative model and results of the demonstration, a reminder of what underlies telematics-based DRT is given below, taken from the previous Report on Software Review (Brand, 2003).

4.2 Telematics-based Demand Responsive Transport

Telematics-based DRT systems are based upon organisation via Travel Dispatch Centres (TDC) using booking and reservation systems which have the capacity to dynamically assign passengers to vehicles and optimise the routes. Automated Vehicle Locationing (AVL) systems are used to provide real-time information on the status and location of the fleet for the route optimising software. A schematic representation of telematics-based DRT services is shown in Figure 7.

Figure 7: Schematic representation of telematics-based DRT services



Source: Mageean and Nelson (2003)

The TDC booking, planning and dispatching system can be a based on a single PC/server or multiple servers networked together via high-speed Local/Wide Area Network (LAN/WAN) connections. For example, the Northumberland TDC offering *Phone & Go* and *Click & Go* DRT services incorporates the existing *Northumberland Journey Planner* (a fixed routes database) into the new flexible route system (running Mobirouter). The so-called Intelligent Mobility Engine serves as the pivot, with additional external links to the VISUM traffic model database. As described further down below, the setup used in this demonstration uses a single PC workstation without external links to simulate the booking and planning procedures. The workstation acts both as server (i.e. database management, processing power) and client (mainly the user interface).

The TDC software is usually based on digital mapping and address data (for example, Ordnance Survey TrafficMaster© and AddressPoint©). The maps assist with locating addresses and seeing vehicle positions. The address database makes it easy to find addresses or post-codes. Depending on the application, the customer database contains customer details and requirements, which in some cases can be automatically sent to the driver. The TDC operator can define all kinds of demand-responsive services, including fixed, semi flexed, deviating fixed route or free route. In addition, the supply side is covered by a vehicle database consisting of those vehicles that are offering DRT services (e.g. mini-buses, buses and taxis). Vehicle capacity and availability information are key parameters – in some cases service offerings such as wheelchair and bicycle rack can be defined and used to appropriately match users and vehicles.

One of the main design features for the call centre software is to allow quick and efficient order taking and allocation of customers to vehicles with, for example, the facility to pre-register customers and default journeys. DRT software has come a long way since first introduced to assist dial-a-ride operations. Today's powerful hardware and database software environments have changed the scale, complexity and speed of Travel Dispatch Centre operations as seen in a range of case studies and supporting software features in Brand (2003). It is now possible to dynamically assign passengers to vehicles and optimise routes in real time – e.g. while the customer is on the (mobile) phone or on-line using an internet terminal at a hospital.

The Final Report on Transport and Social Exclusion (ODPM, 2003) states that

> *"The use of technology in Gothenburg [the* FlexLine *DRT service] to ensure a rapid demand-responsive service has few parallels in the UK".*

However, as demonstrated in Brand (2003), there are many not few applications of modern telematics-based DRT services currently operating in the UK, many of which are operating *MobiRouter* as the software tool. This was one of the reasons why the project team chose *MobiRouter* for the following model of an alternative health care transport plan.

4.3 The alternative model for transport provision

The setup of the *Mobirouter* model demonstration is presented first, including data sources, service definitions, routes and schedules. This is followed by the results of trying to match passenger trips from the empirical survey (Section 3) to the developed DRT service supply. Last but not least, the model is discussed with regards to its viability and potential improvements.

4.3.1 Setup of the model demonstration

Digital mapping

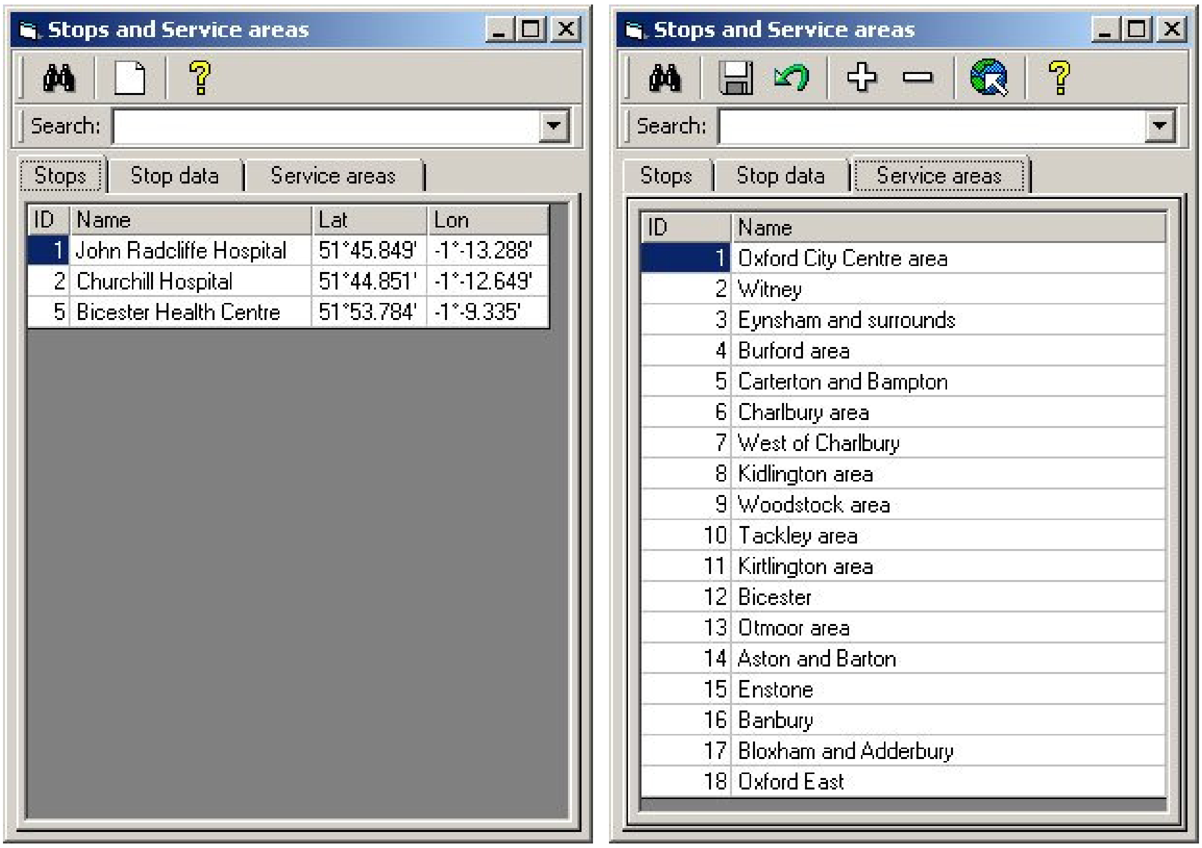
The heart of *Mobirouter* is an Oracle™ database application running in so-called 'client-server mode' – 'client' representing the dispatcher's PC and 'server' a central PC holding the databases needed to run the operation (and likely linked to other databases and applications). This demonstration was developed on a single laptop PC, hence 'server' and 'client' are represented by this one PC.[5]

The databases underlying this setup include digital maps, address data and so-called vector maps (consisting of location *and* direction information). Some of the mapping data were provided by the Department for Transport (New Horizons Programme and Statistics Division), including Ordnance Survey raster maps (1:50,000, 1:10,000) and AddressPoint© location maps of every address in Oxfordshire. The road network vector maps were provided by Mobisoft (UK) Ltd for the purpose of this project. The latter are required to model road traffic and service routes. All in all, the Oxfordshire data fit on 3-4 CD ROMs and use about 3GB of hard disk space.

Defining stops and service areas

An important part of setting up flexible DRT services is the definition of stops and service areas.[6] In this demonstration, the two main stops were chosen to be the hospitals, with an additional stop representing a frequently visited surgery in Bicester (Figure 8).

Figure 8: Stops and service areas defined in the demonstration



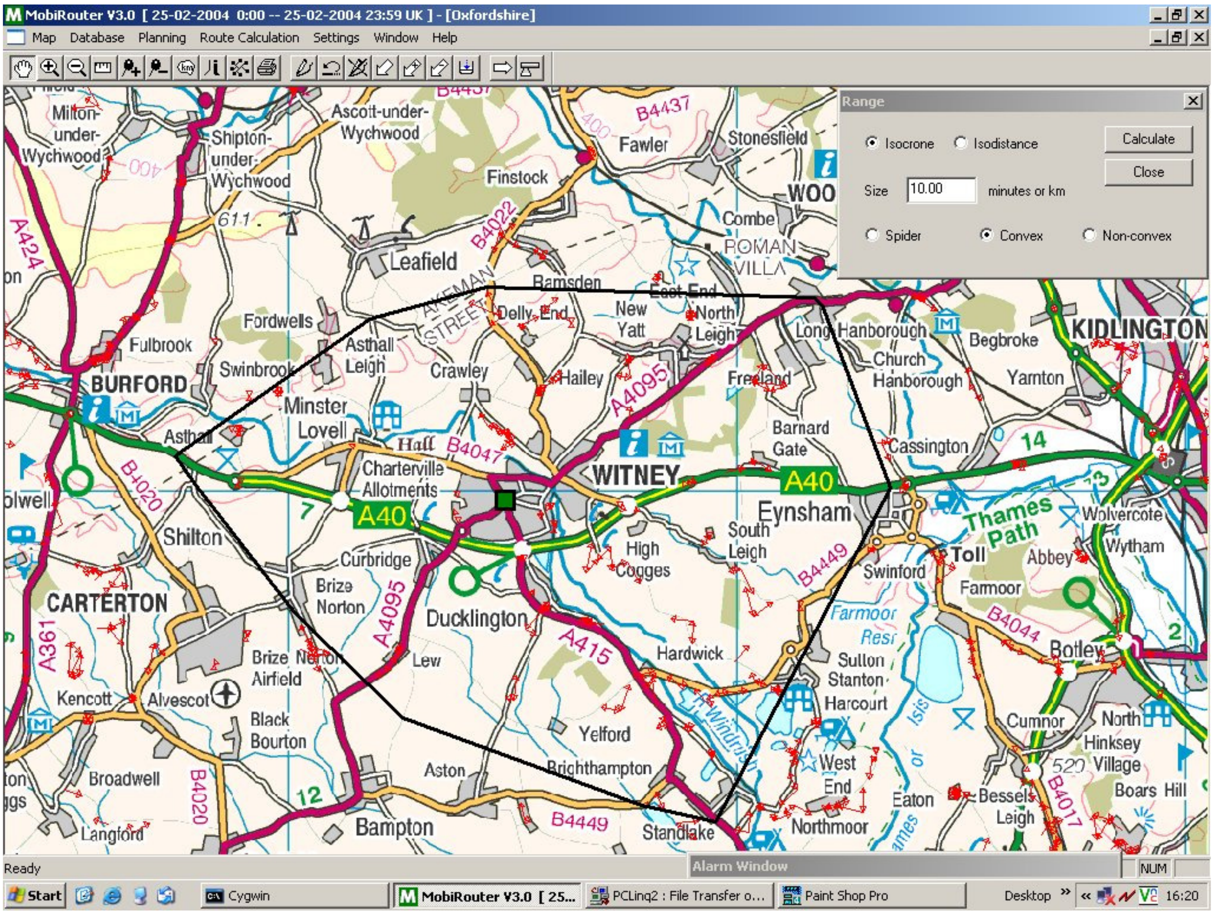
ID	Name	Lat	Lon
1	John Radcliffe Hospital	51°45.849'	-1°-13.288'
2	Churchill Hospital	51°44.851'	-1°-12.649'
5	Bicester Health Centre	51°53.784'	-1°-9.335'

ID	Name
1	Oxford City Centre area
2	Witney
3	Eynsham and surrounds
4	Burford area
5	Carterton and Bampton
6	Charlbury area
7	West of Charlbury
8	Kidlington area
9	Woodstock area
10	Tackley area
11	Kirtlington area
12	Bicester
13	Otmoor area
14	Aston and Barton
15	Enstone
16	Banbury
17	Bloxham and Adderbury
18	Oxford East

[5] In a real world application, the connection between the then separate machines would be an internet-based link (using IP connection).
[6] 'Stops' are obligatory call points for service vehicles. 'Service areas' define an area which vehicles may or may not service. In the latter, service vehicles deviate 'on demand' from the general service direction to pick up and drop off passengers.

Following consultation with the software provider, the service areas were defined as convex polygons. In terms of size and shape, the key criterion was to allow a vehicle to get from one end to the other in about 10 minutes time. The software's 'Range' tool was used to design the convex area shapes as shown in an example in Figure 9. This tool visualises isochrones and isodistances around a central point such as a stop or area centre in three alternative shapes: spider, convex and non-convex. Figure 9 gives the 10-minute isochrones around Witney as a convex polygon shape (in black). Note the shape and size of an area varies according to the variations in geography and speed (or distance and time) of the underlying road network.

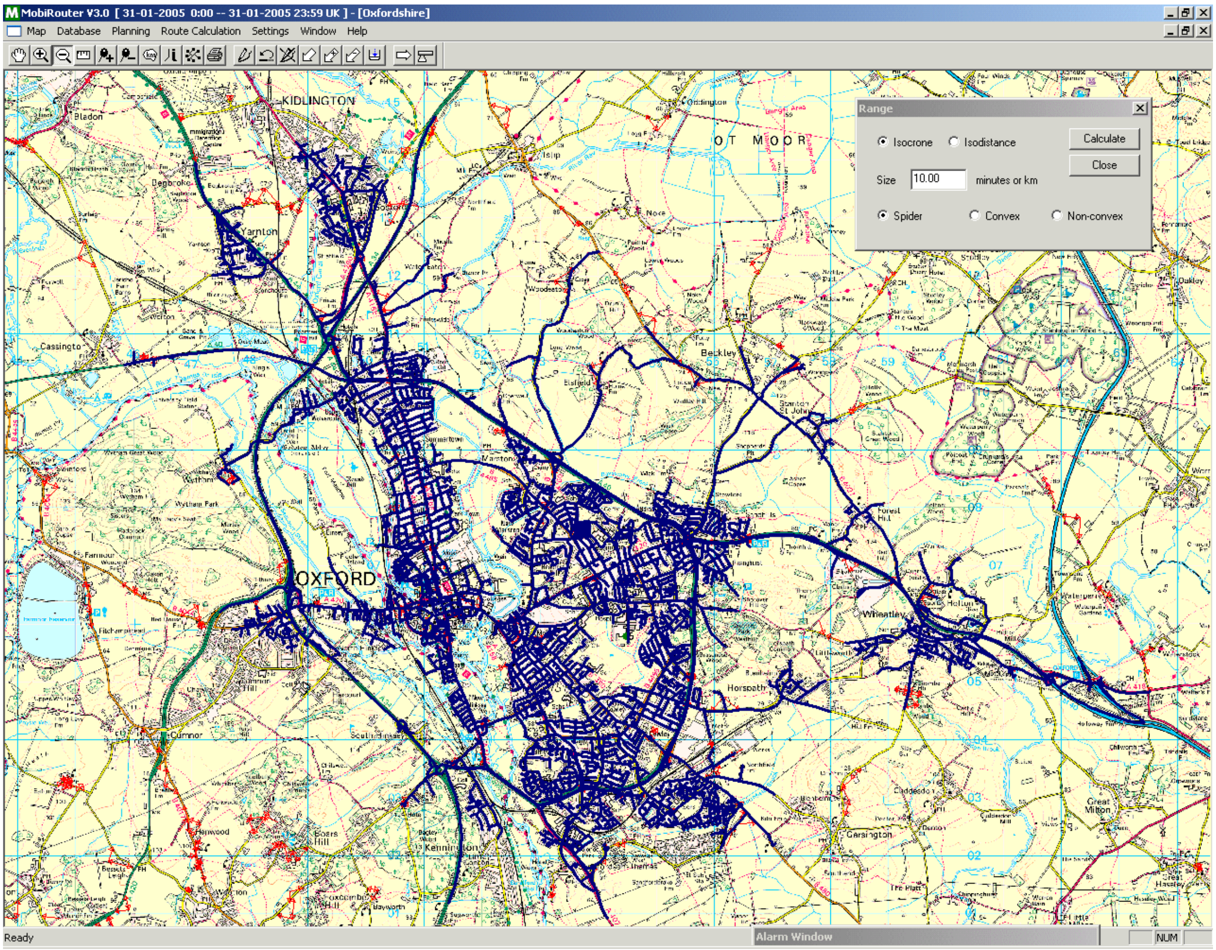
Figure 9: Example of convex-shaped 10-minute isochrones around Witney (in black)



Similarly, Figure 10 shows an example of spider-web shaped 10-minute isochrones (in dark blue) around the Oxford John Radcliffe hospital.

Obviously, the 'reach' of the isochrones depends heavily on the road link speeds set in *Mobirouter*. The demonstration setup utilises 20 different road categories with speeds based on observed averages in non-congested conditions. Motorway and double carriageway speeds range from 65-80km/h; 60-65km/h for major 'A' roads; 40-55km/h for minor/rural 'A/B' roads and 25-40km/h for local urban roads. The important feature is that the user can change the speeds by road category and time of day down to the level of hourly intervals. For example, the speed for 'motorway category 10' is, by default, 80km/h all day; this could be changed to, say, 70km/h for peak times 8-900 and 16-1800. Note junction delays cannot be modelled at present. One way around this would be to lower link speeds for links approaching a particular junction. In future applications, it might be worth varying speeds by time of day to simulate traffic conditions at, for example, peak and off-peak times. The resultant service areas are described in the following section on service definition.

Figure 10: Example of spider-web shaped 10-minute isochrones around the Oxford John Radcliffe hospital (in dark blue)



Service definition: vehicles, routes, departures and schedules

As mentioned in the Section 3, three main hospital trip demand 'corridors' were identified, with origins/destinations in the Banbury, Bicester and Witney areas. 7 services were developed with the aim to match this demand as completely as possible. These services are based around 3 service routes utilising a total of 7 minibuses (at capacity of 16 passengers each). In more detail, the 3 service routes are:

1. Hospitals-Banbury-Hospitals: 3 overlapping service routes, taking 3h to complete the circle; departing at 700, 800, 900, … , 1800h, returning at 1000, 1100…2100h.
2. Bicester Health Centre-Hospitals-Bicester Health Centre: 1 service route, taking 1.5h to complete the circle; departing at 730, 900, 1030, …, 1630, returning at 900, 1030…1800.
3. Hospitals-Witney-Hospitals: three overlapping service routes, taking 3h to complete the circle; departing at 600, 700, 800, …, 1700, returning at 900, 1000, …, 2000.

The 3 service routes are shown graphically in Figure 11, Figure 12 and Figure 13. The 'Routes and Schedules' boxes on the left detail scheduled departure and arrival times at stops as well as deviation time windows for service areas. Note that the *obligatory stops* (in blue) have fixed departure and arrival times, sometimes extended to allow for delays due to traffic conditions (e.g. stop 1 John Radcliffe on the Banbury service route, Figure 11). In contrast, the semi-flexible nature of DRT services allows vehicles to deviate in or not service at all the defined *service areas* (also in blue), with time windows set for pick up or drop off 'at the earliest' and 'at the latest' time possible.

Figure 11: Definition of the Banbury corridor service route and schedules

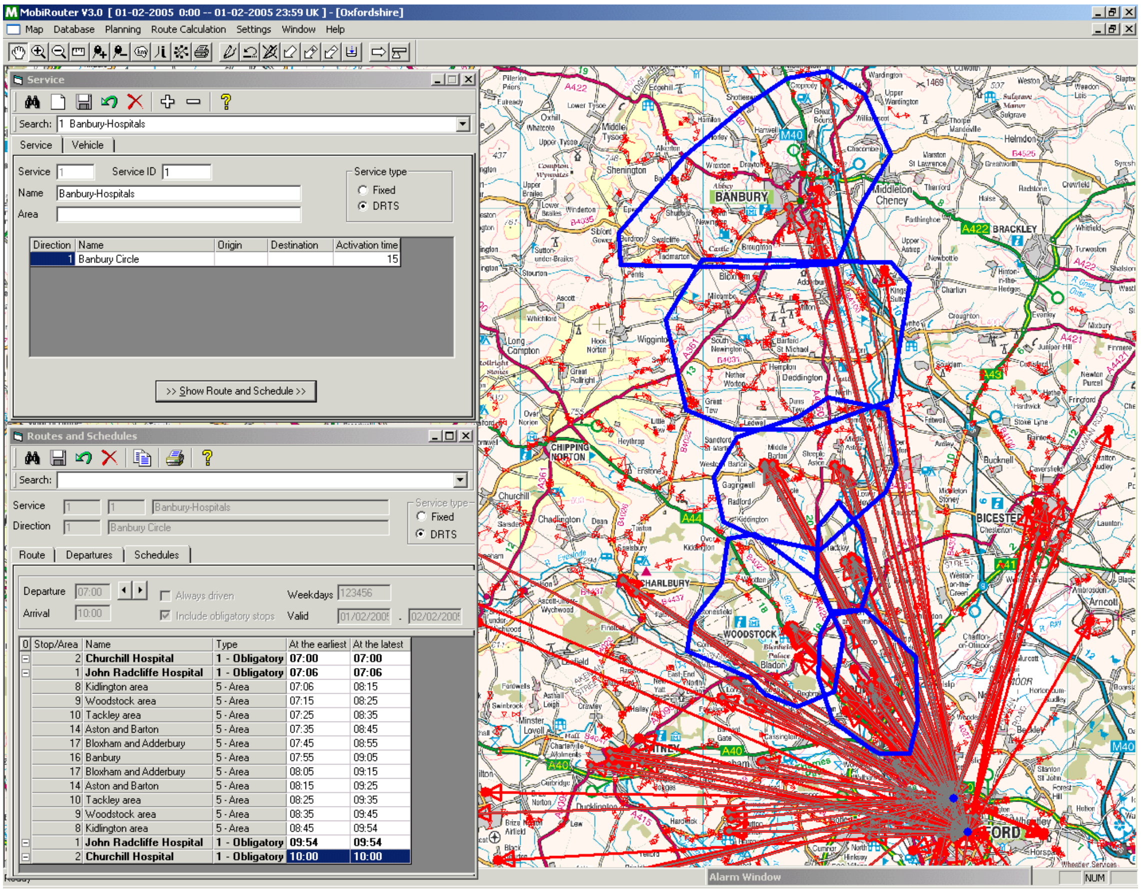


Figure 12: Definition of the Bicester corridor service route and schedules

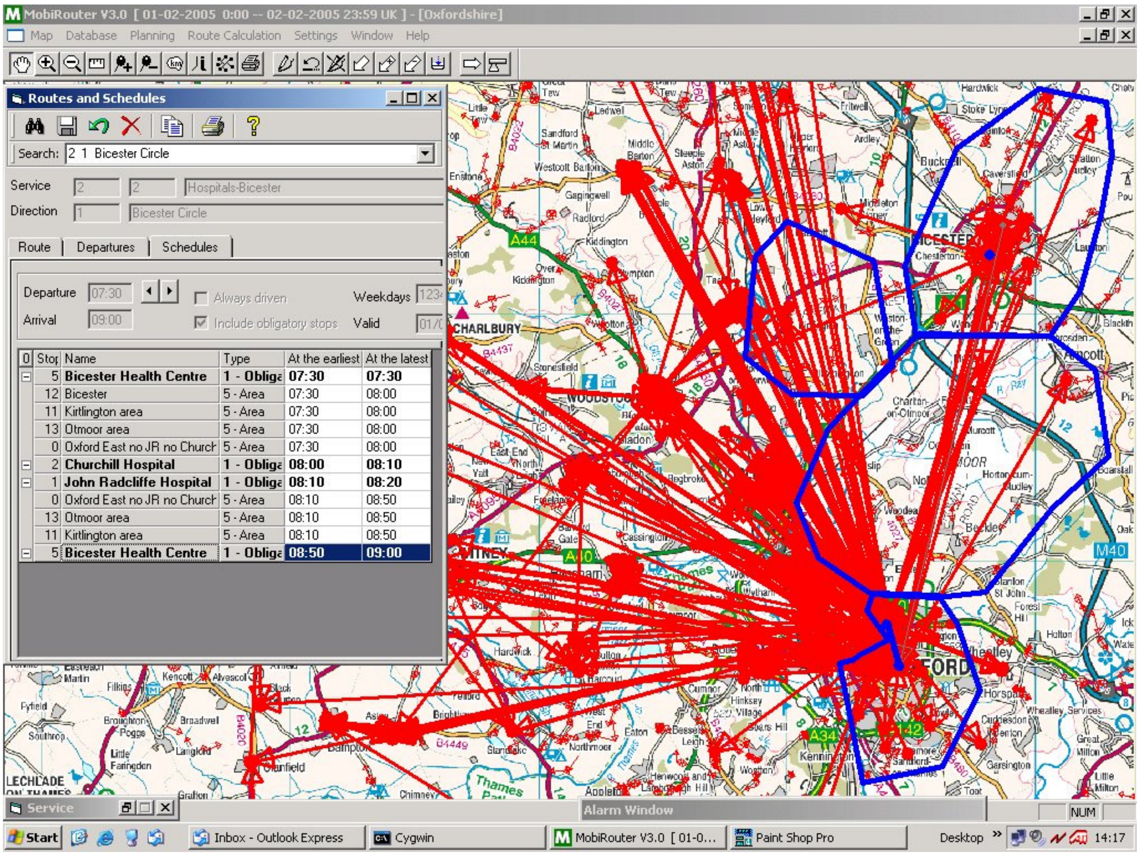
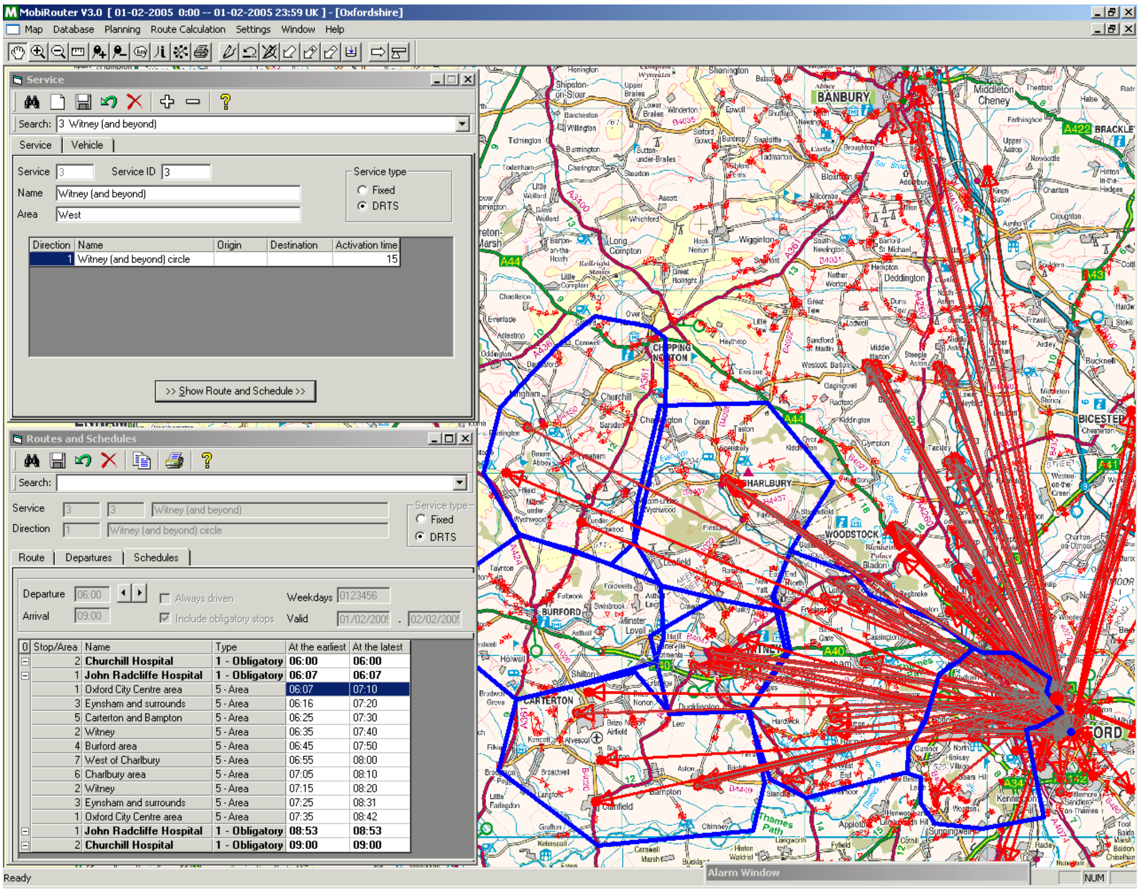


Figure 13: Definition of the Witney corridor service route and schedules



Route departure times and schedules are based on three main assessments:

1. An assessment of likely round trip times using *Mobirouter*'s 'Driving Route' tool (see below for an example);
2. The observed frequency and timings of trip demand data reported in the survey work (Rajé *et al*, 2003b); and
3. Advice given by the external DRT consultant on service route frequency providing a trade-off between costs and successfully matching demand and supply.[7]

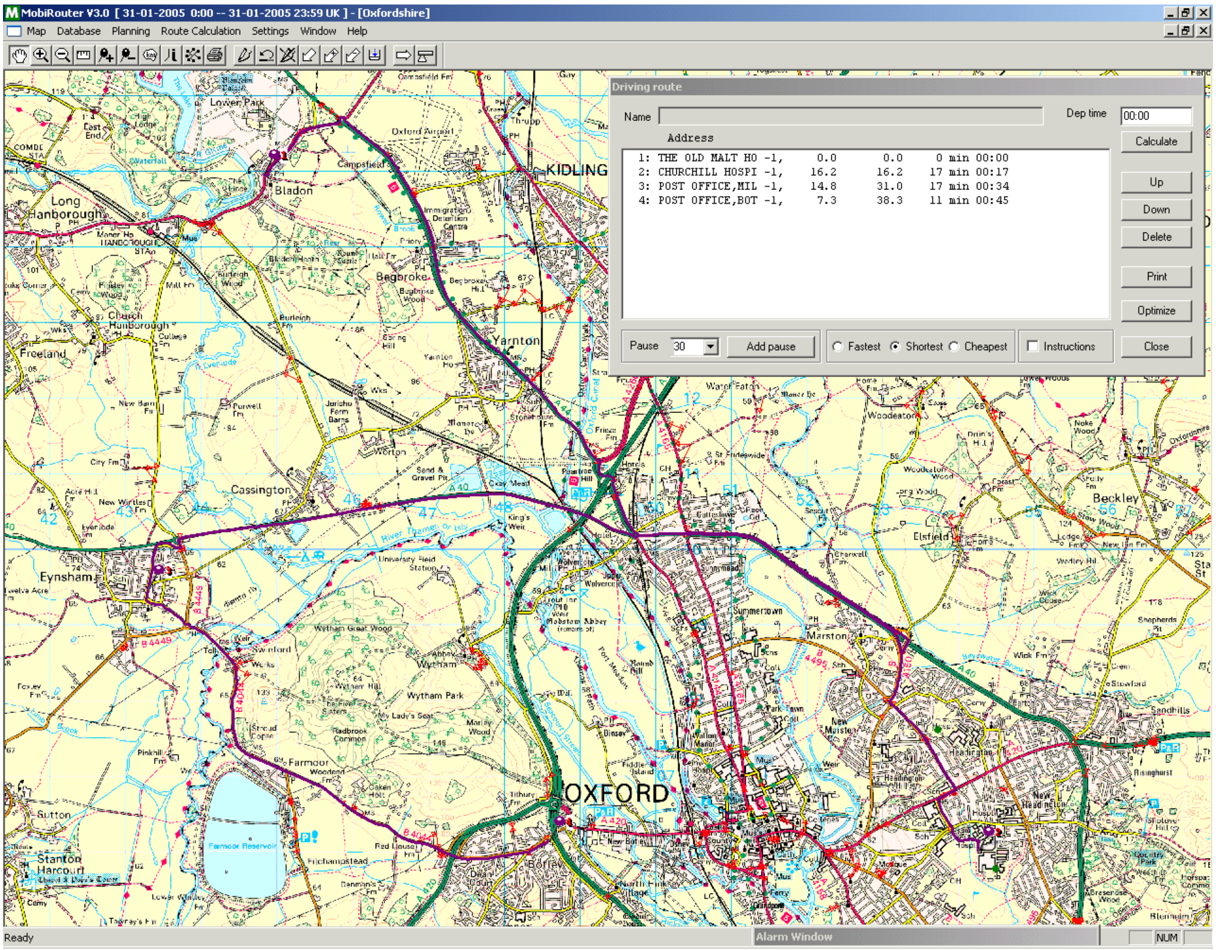
Figure 14 illustrates an example driving route (Bladon-Churchill Hospital → Eynsham Post Office → Botley Post Office, in purple), taking 45min to complete based on default road link speeds.

It is worth pointing out at this stage that the geographical characteristics and timings of the service routes and schedules are a first attempt to provide an efficient demand responsive transport service for access to the hospitals. This is appropriate for a demonstration of the utilised DRT system and software. Further iterations would be required to make this a more efficient setup. Real world applications (e.g. Gloucestershire, Northumberland) have shown that timings have to be fine tuned on a regular basis, reflecting weekly and seasonal differences in demand patterns. Indeed, this flexible approach can be seen as one of the strengths of DRT services. In this case, it is most suitable for transport provision to health

[7] Without resource constraints, a service frequency of the maximum time window for bookings is desirable, e.g. a vehicle scheduled to depart every 20min (given a 20min time window for bookings). However, this is most likely not to be commercially feasible unless trip demand is relatively high (e.g. for combined patient, visitor *and staff* DRT services).

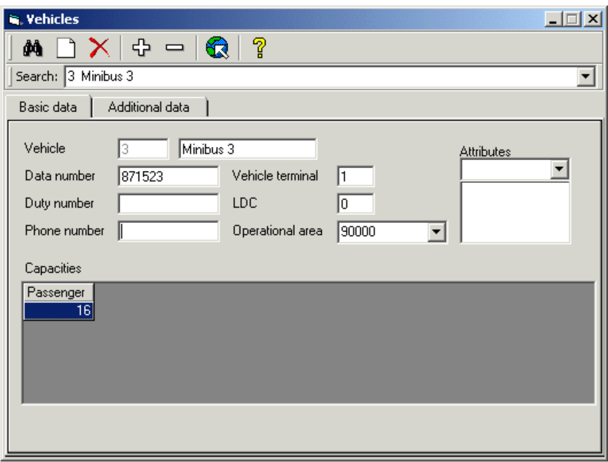
care services where weekly changes in appointment schedules cause variations in trip patterns to and from the hospitals.

Figure 14: Example vehicle driving route utilising the *Mobirouter* 'Driving Route' tool



The above services utilise a number of vehicles, which can be defined in a simple dialog box as shown in Figure 15. In this case, 7 identical minibuses were defined with a capacity of 16 passengers each. Note the system allows for special conditions to be taken into account, e.g. wheelchair access. In addition, vehicle operating costs can be set in the dialog box (under the 'Additional data' tab), allowing the operator to assess likely DRT service operating costs.

Figure 15: Vehicles dialog box showing 'Minibus 3' with a capacity of 16 passengers



4.3.2 Demonstration results – hospitals

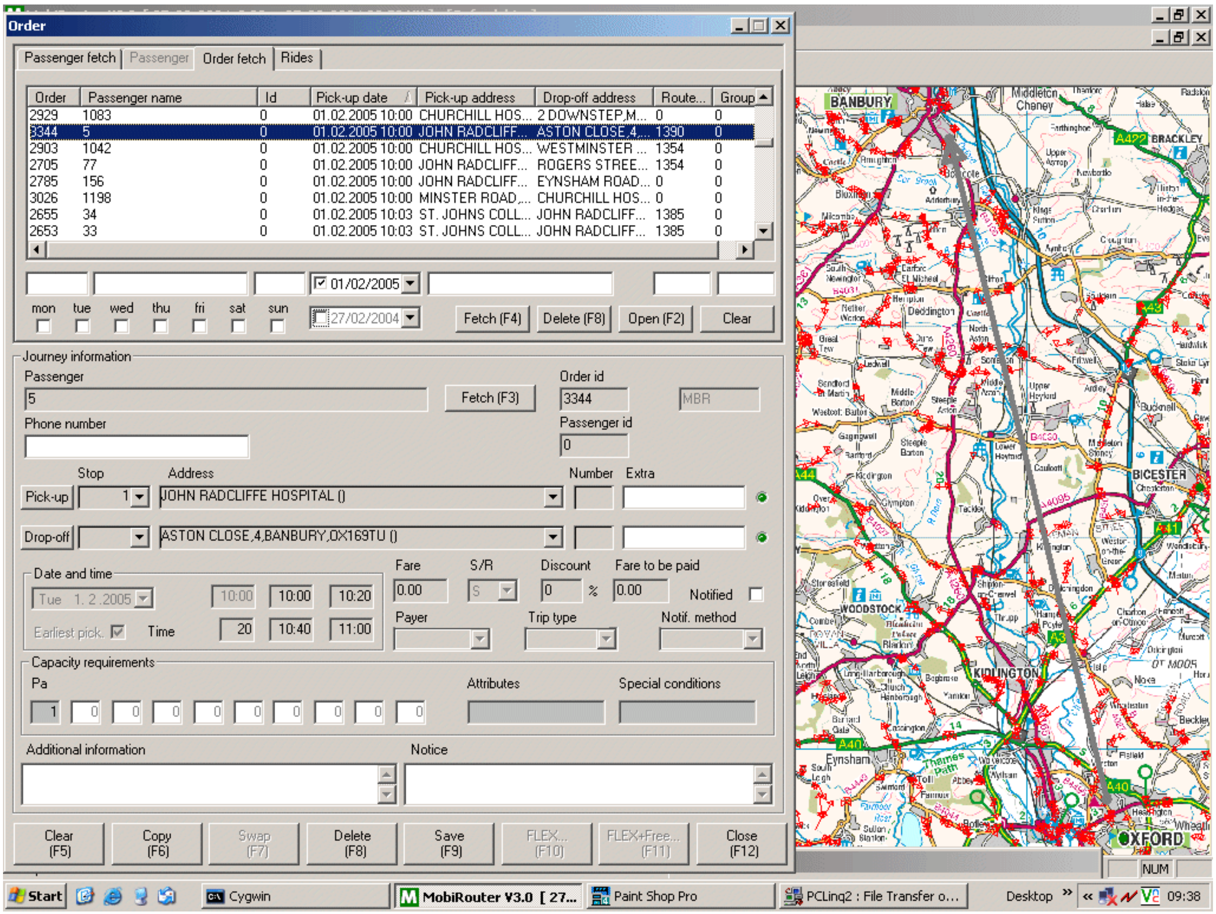
Once the model system was set up, the actual demonstration was performed, providing an insight into how successful the defined DRT services may be in improving accessibility to the hospitals. This involved 'taking' passenger orders and assigning the passengers to, if possible, an available vehicle on an evolving but not yet dispatched vehicle route. The following sections aim to clarify this process.

Passenger orders

For hospital trips, the 221 return passenger orders obtained in the survey work (Rajé *et al*, 2003b, see also Section 3) were entered into the *Mobirouter* 'Orders' database for a chosen future date, the 1st of February 2005. Note a return trip has to be entered as 2 single trips, making the total number of orders 442. The data needed for taking fresh orders is outlined in a screenshot in Figure 16. This includes:

- Origin and destination postcodes and first lines of address (unless either of them are predefined stops such as the hospitals where the stop identifier is sufficient);
- Earliest pick-up or latest drop-off times;
- The desired time window (the default was 20min);
- Any special requirements such as wheelchair access.

Figure 16: Passenger order form showing example booking details (order No. 3344) and a grey arrow on the map representing the order



The example order (Figure 16) shows a trip from the John Radcliffe Hospital in Oxford to an address in Banbury, represented by a grey arrow. The passenger left the hospital at 1000 hours, hence requested an 'earliest pick-up' time of 1000 hours. The time window for the booking was 20 minutes, making the 'latest pick-up' time at 1020 hours. At this stage, the system further calculates the likely arrival time window based on road link speeds (direct trip, no deviation), in this case between 1040 and 1100 hours. This helps the dispatcher to convey to the passenger (on the phone/mobile/online) the likely arrival time before confirming the booking.[8]

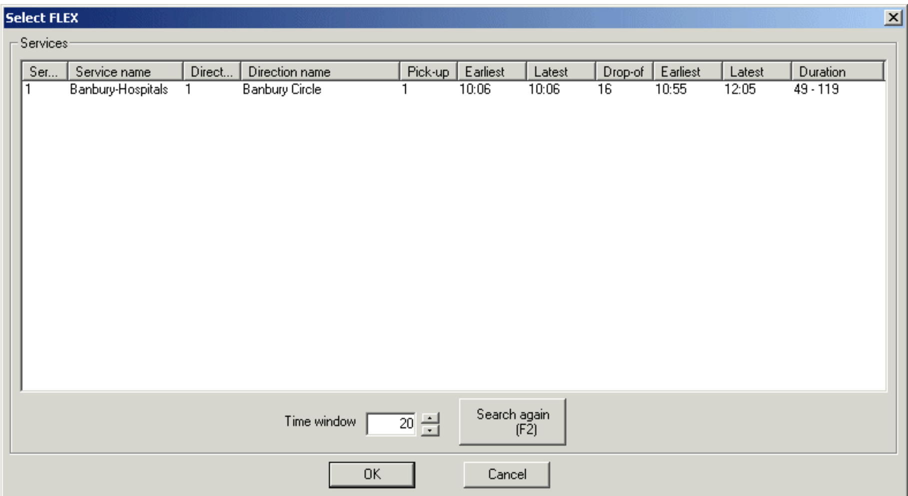
The choice of a single date for all collected orders raised the question how representative the total figure of 221 return trips and the trip pattern are compared to the likely demand for DRT services on a given day. This important point is discussed in the following Sections. *For the purpose of this demonstration it was assumed that the total demand figure and trip pattern represent a typical day in the near future.*

FLEXing orders to vehicle routes

Once an order is 'taken', the dispatcher uses the *Mobirouter* FLEX tool to try and get the passenger assigned to an open vehicle route only defined by obligatory stops and *optional* service areas. In this demonstration without real online communication to the passenger or the vehicle, this is simply done by clicking the FLEX button (or F10 key) in the 'Orders' dialog box (Figure 16). Three things can then happen:

1. *Mobirouter* opens a new dialog box, implying that a number of possible routes that match the given criteria were found (Figure 17). This may be followed by:
    a. *successfully* choosing a suitable vehicle route by clicking OK, in which case the order has been assigned to a vehicle route. The Select FLEX form disappears and the order form now shows the vehicle ride of that order.
    b. an *unsuccessful* assignment due to timetable, route direction or vehicle capacity constraints, in which case the dispatcher can go back to the passenger, change the trip criteria and repeat the process until a *successful* assignment is achieved.
2. *Mobirouter* cannot find a close enough match to predefined DRT services, indicating a mismatch of key selection criteria such as the time of day of the order not being near enough to the offered service times. No new dialog box appears.

Figure 17: 'Select FLEX' dialog box, showing a possible service route



Note in a real world application, this happens while the prospective passenger is on the telephone/mobile or online via an internet terminal (e.g. in a hospital). If (1.b) or (2.) occur, there is therefore the possibility to consult the passenger and change some of the booking criteria such as the booking time window and try to FLEX again. If this doesn't work, the order can't be taken. The point to make is that the speed and convenience of online

[8] Note no fares or costs were modelled in the *Mobirouter* part of the demonstration.

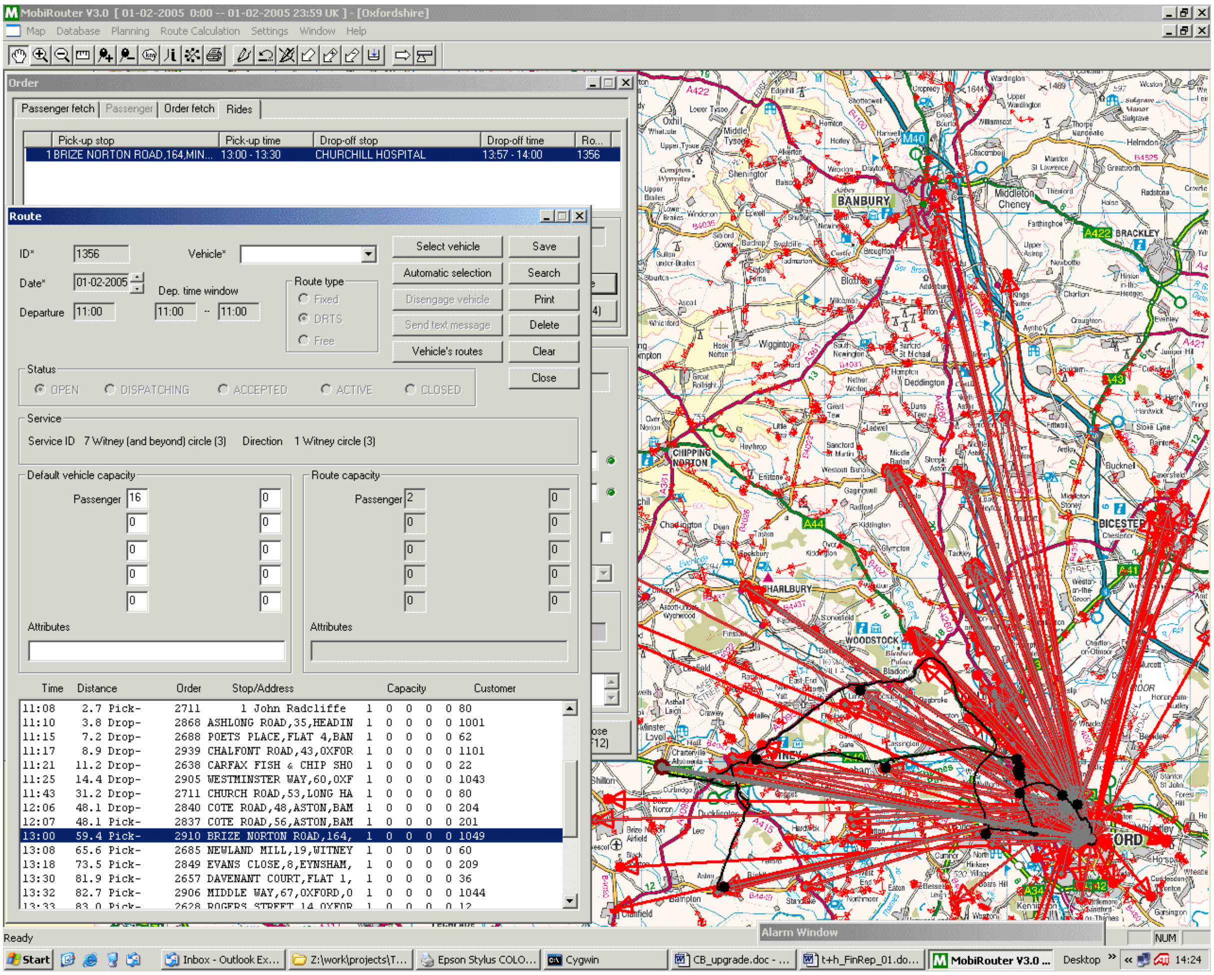
communications allow for a flexible approach to taking orders that is likely to increase ridership and hence service efficiency.

For the purpose of this demonstration, the orders were put in order of time of day, starting with the first order at around 0200 hours and so on. Given that the first service starts at 0600 hours, that first order was unsuccessfully assigned to a service route. However, a significant number of orders were successfully assigned during peak hours, i.e. 0900-1200 hours and 1300-1600 hours, depending on the hospital.

Overall, about 40% of the hospital orders were assigned to a service route within a 20-minute time window for this initial setup.

To illustrate the 'FLEXed' vehicle routes, two examples are described below. The first example is shown in Figure 18 for one of the 3 Witney services.[9] This clearly shows passenger pick-ups and drop-offs along the way. It also shows that the vehicle does not serve all service areas defined for this service. For example, the vehicle does not go far beyond Witney on this route.[10] This demonstrates the semi-flexible nature of DRT: a mix of obligatory and optional stops and service areas.

Figure 18: Example vehicle route No. 1356 showing passenger pick-ups and drop-offs along the way (route in black, orders in red or grey)



[9] The vehicle route with number 1356 is shown in black. Orders are shown as red or grey arrows. The 1300 hours pick-up of passenger 1049 is highlighted in the route stop list and also as a bold grey arrow on the map.
[10] It may do so in a real world application if a suitable order came in requesting, say, a drop-off near Burford. Of course, this would have to be requested *before* the vehicle is finally dispatched.

The picture is not entirely clear when assessing DRT journey time savings compared to actual journey times reported by the patients. For example in the case of 'passenger 80', the in-vehicle time from the John Radcliffe hospital back home is 35 minutes (on vehicle route 1356, Figure 18), matching the reported journey time (Rajé *et al*, 2003b). 'Passenger 209' would have spent 22 minutes on the same vehicle route from Eynsham to the John Radcliffe, compared to the reported 15 minutes in a car at off-peak times – the latter clearly a result of good direct access by car from the village to the hospital via the A40 and the ring road. 'Passengers 201' and '204' would have spent 90 and 59 minutes to and from Aston village on DRT, compared to significantly shorter journey times of 30 and 45 minutes reported in the survey. On the more positive side, 85-year old 'passenger 62' would have spent 7 minutes on DRT going from the John Radcliffe to Summertown, 23 minutes less than reported. All in all, there can be journey time savings, however not guaranteed, and it can take longer due to deviation at busy (DRT) times or simply due to the unfortunate service definition. The main point from the analysis though is that accessibility for non-car users and the elderly is greatly enhanced.

The second example (Figure 19) shows one of the 3 Banbury services, indicating passenger pick-ups and drop-offs along the way. In this case, the vehicle does serve all service areas defined for this service.[11]

Figure 19: Example vehicle route No. 1417 showing passenger pick-ups and drop-offs along the way (route in black, no orders shown)

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11 For illustration, the 1657 hours drop-off in Banbury of passenger 177 is highlighted in the route stop list and on the map as a thin dark red arrow.

Again, the picture is not clear cut in terms of journey time savings. However, for non-car drivers or the elderly, the DRT service route to Banbury has significant accessibility benefits.

4.3.3 Demonstration results – GP surgeries

Passenger orders

Similar to hospital orders, the 144 return passenger orders to/from GP surgeries collated in the survey work (Rajé *et al*, 2003b) were entered into the *Mobirouter* 'Orders' database, however for a different future date, the 2nd of February 2005. Again, a return trip has to be entered as 2 single trips, making the total number of GP surgery orders 288. An overview of the orders is shown in Figure 5, while Figure 6 zooms in on the Woodstock-Tackley area. Different dates for hospitals and GP surgeries were chosen because of better separation in the system.

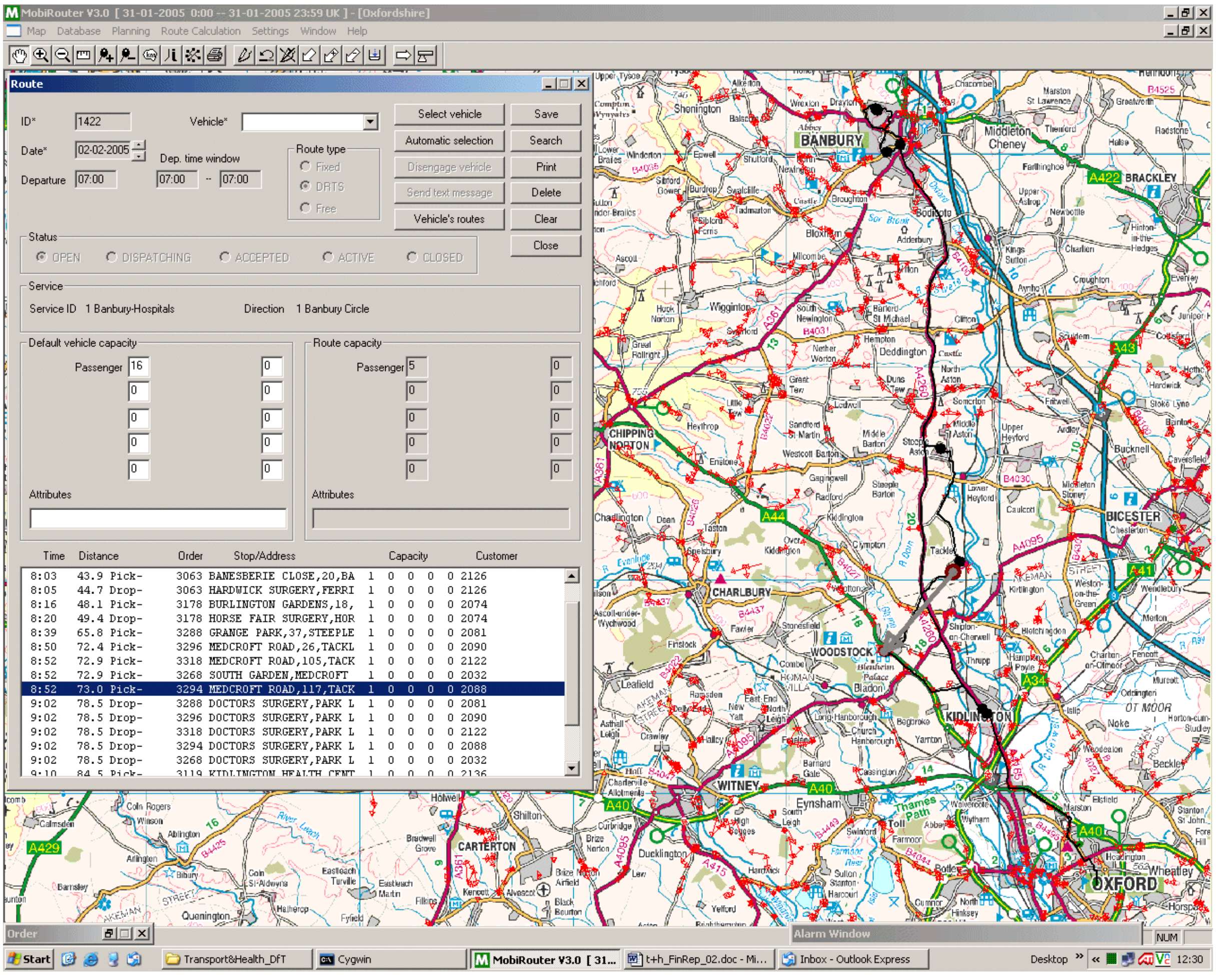
FLEXing orders to vehicle routes

As the focus of this work was on hospitals, the booking of passengers on semi-flexible DRT services is demonstrated here only briefly. The different date for orders means that this part of the demonstration is purely for GP surgery orders. A combined service supply was not tested but could be done in future work. Note the design of the DRT services was with hospital trips in mind (3 radial routes centred on the hospital stops). Therefore, GP surgery services may well require a completely different service pattern in terms of *where* and *when*.

The default time window for surgery bookings was 10 minutes, reflecting shorter trip lengths and times. Again, the bookings were entered in order of time of day. As in this part there are no hospital bookings to "distract" the vehicles from GP surgery bookings, a similar 'FLEX success rate' of about 40% of entered orders was achieved.

To illustrate the 'FLEXed' vehicle routes, an example is described below. In this demonstration, three Banbury services cover the GP surgeries between Oxford and Banbury, including the one in Woodstock. Figure 20 shows passenger pick-ups and drop-offs at home and surgeries (Kidlington, Woodstock, Banbury) along the way. The total route basically represents a series of mainly local pick-ups and drop-offs, in contrast to a somewhat different trip pattern in the hospitals case with longer trip distances.

Figure 20: Example vehicle route No. 1422 showing passenger pick-ups and drop-offs along the way (route in black, no orders shown)



Zooming in on the Woodstock surgery area, the five trips from Tackley to the GP surgery *en route* back from Banbury suggest significant in-vehicle time savings compared to actual journey times reported by the patients. In this selected case, the passenger in-vehicle times from Tackley to Woodstock surgery range between 8 and 12 minutes, compared to a range between 10 and 40 minutes reported for the actual journeys (Rajé *et al*, 2003b).[12] A 10-minute journey time seems to be typical for reported *car* journeys, while the 40 minute end of the range corresponds to a *public transport* trip. Without going into detail, this holds true for other surgeries and/or origins with poor non-car transport accessibility.

It is worth keeping in mind that many trips to/from surgeries are shorter than the Tackley-Woodstock trips, indeed within cycling or even walking distance for the reasonably fit. Therefore, the potential for DRT to offer a viable alternative or addition to the current transport system on surgery trip grounds alone may be limited.

4.4 Potential impacts

The potential benefits of telematics based DRT services have been covered elsewhere (Brand, 2003; Rajé et al, 2003a; Duffell, 2002). The likely impacts of implementing the DRT

[12] Given the door-to-door (taxi-like) service characteristics of DRT services, in-vehicle times and total journey times should not differ much at all, hence the comparison is appropriate and fair.

model presented above on both the hospital and those who experience difficulty accessing it are briefly discussed in this Section. The main potential impacts are:

- Accessibility impacts for non-car drivers;
- Accessibility impacts for the elderly;
- Accessibility impacts for people with disabilities;
- Effects of journey time savings for patients;
- Benefits of lowering number of missed appointments by improving reliability of transport to hospital;
- Journey cost savings.

The main positive effect is the significantly improved accessibility for non-car drivers, the elderly and people with disabilities (although the latter could not be demonstrated). This is particularly true where access to public transport is poor. The hospitals are 2 miles away and up a steep hill from the main public transport hubs in the city centre, with fairly regular buses connecting to the city centre and the railway station. However, from almost anywhere else transfers (e.g. bus Summertown-City Centre .. walk .. bus City Centre-JR) and mode changes (e.g. car to P&R .. bus P&R-City Centre .. walk .. bus City Centre-JR) are required, resulting in poor non-car accessibility for most of the population in the study area.[13] The DRT services modelled here could potentially lessen this 'accessibility gap' by providing direct on-demand service, in particular for pre-registered non-car drivers, the elderly and people with disabilities. The latter potential is highlighted by the fact that of the 21 respondents registered disabled, 15 stated they would find DRT a useful or very useful addition/alternative (Rajé *et al*, 2003b).

The effects on journey times can be profound, as the examples above show, however not always positive especially when compared to direct car journeys.[14] It may be argued that in terms of journey times comparing DRT with car trips is unfair, as the car taking direct non-stop routes should always be quicker than a deviating, multi pick-up and drop-off service, however efficiently it is run on dynamic demand and schedule.[15] So a comparison with public transport, community transport and other non-car modes is more appropriate, at least in service level terms. And here DRT fares particularly well, with likely benefits of lowering the significant number of missed appointments by improving reliability of transport to hospital.

Journey cost savings may be possible, but this depends heavily on how prices are set and the achieved service take-up. This is discussed further in the following Section.

4.5 Demand and cost estimate

This Section seeks to address the crucial question of how representative the data collected above are in terms of a "typical" day of patient and visitor trips to the hospitals. Furthermore, a rough and ready cost estimate is made to give an idea of how much the DRT model may cost.

[13] Note the Oxford Bus Company's X13 Express bus from Abingdon now goes direct to the John Radcliffe via the city centre in 43 minutes. However, Abingdon is outside the study area and is not included here.
[14] In this work, it was not attempted to assess the potential journey time savings for all the 'booked' and FLEXed journeys due to resource constraints.
[15] When car parking charges (min. £2 for 1hr) and the time spent finding a car parking space (5-10min during busy times, i.e. daytime after 10am) are included, the car becomes less attractive. Yet most people with easy access to a car still perceive it as the best and often only viable option.

4.5.1 Demand

Of the 221 hospital journeys entered 215 gave all necessary details suitable for further analysis. Of these 215, 125 were to the John Radcliffe, and 90 to the Churchill hospitals. The survey work revealed that 59 out of 215 respondents (27.4%) would find DRT 'very useful' and 97 would find it 'useful OR very useful' (45.1%) (Rajé *et al*, 2003b). Furthermore, 19 out of 215 (8.8%) did not have access to a car, many of whom have to use more than one mode to get to the hospitals. This will include walking, waiting for public transport, transfer times between modes and perceived transfer penalties[16].

Travel plan survey work done by Steer Davies Gleave (SDG) for the Oxford Radcliffe Hospitals NHS Trust (ORH) in 2001 provides figures for patient and visitor frequencies. The average daily frequency for the John Radcliffe and the Churchill were estimated as 3,000 and 1,060 patients and visitors per day, or 4,060 in total (SDG, 2001). Note this covers all destinations, i.e. more than this study. In fact, SDG (2001) report that 75% of that survey's respondents came from the OX postcode areas.

So how do these figures compare? We have covered 11 out of 17 OX postcode areas, or 65% of all OX postcode areas. Assuming that each OX postcode area covers the same number of residents each, we have covered (75% * 65% =) 49.3% of the SDG study. Therefore, the basis for comparison in this exercise is assumed to be 2,000 patients and visitors per day. The 215 completed responses therefore amount to 10.8% of the estimated daily hospital patronage. This is slightly more than the share of respondents without access to a car (19 out of 215, or 8.8%) and substantially less than respondents' 'expression of interest' for DRT (59 out of 215, or 27.4%).

Given the uncertainty in estimating potential demand for DRT, and following discussion with the IT consultant to the project, we have assumed 3 demand scenarios that reflect the results of the discussion above. The CENTRAL market share for DRT is assumed to be 5% (100 return trips per day), with LOW and HIGH market shares as 2.5% (50 return trips per day) and 7.5% (150 return trips), respectively. In light of what was discussed above and the evidence reported elsewhere (see e.g. Grosso *et al*, 2002; Jones, 2002; Rajé *et al*, 2003a; Brand, 2003), this range of demand figures appears to be a reasonable for the purpose of this demonstration. The implications are discussed further in the following Sections.

4.5.2 Estimated lifetime costs of the demonstrated DRT model

A simple spreadsheet model was developed to assess the feasibility of the model in terms of lifetime costs of the software based DRT services. This was done on the basis of net present value of costs and revenues. A range of demand market shares were chosen to conduct a limited sensitivity analysis, partly based on the data and analysis presented above.

1. LOW demand = 2.5% market share, or (2.5% * 2,000 * 2 =) 100 single trips;
2. CENTRAL demand = 5% market share, or (5% * 2,000 * 2 =) 200 single trips; and
3. HIGH demand = 7.5% market share, or (7.5% * 2,000 * 2 =) 300 single trips.

Assuming the 7 vehicles carry equal loadings on average, the number of passengers per day *per vehicle* can be derived as 14, 29 and 43 (rounded) for the LOW, CENTRAL and HIGH scenarios, respectively. While demand was analysed across this range, other input parameters stayed fixed as shown in Table 2. This includes the average cost per passenger trip of £5. The price per passenger will obviously depend on the pricing structure (flat or staged) and subsidy levels (as in most DRT services).

[16] Such a penalty is often simulated by adding a transfer penalty time/cost to the generalised time/cost of the journey.

The net present values of the investment and revenue over a 25 year period are shown in Table 3. A time series of the cumulative profit/loss is provided in Figure 21. See Appendix A for further details of the spreadsheet model.

Table 2: Parameters underlying the feasibility cost analysis for the DRT model

Description	*Value*
Number of vehicles [1]	7
Number of shifts per day	2
Number of days per year [2]	313
Number of vehicles per dispatcher	10
Number of vehicles per dispatcher with Internet booking	50
Cost of driver	£20,000
Cost of dispatcher	£20,000
Discount rate	3.5%
Scheduling system costs	
MobiRouter software	£50,000
Maintenance & support (p.a.)	£7,500
Internet booking (if applicable)	£20,000
Maintenance & support (p.a.)	£4,000
Dispatch centre and vehicle hardware	£6,000
Years to replacement	5
Dispatch centre staff	1
Vehicle costs	
Capital cost per vehicle	£25000
Years to replacement	6.25
Fuel (diesel) cost per litre (net of BSOG, excl. VAT) [3]	30p
Fuel efficiency (litres/100km) [4]	12
→ Fuel costs per km (pence/km) [4]	3.6
Mileage per vehicle per day (km) [5]	200
Office expenses (p.a.)	£15000
Income related	
Charge per passenger (average across network)	£5

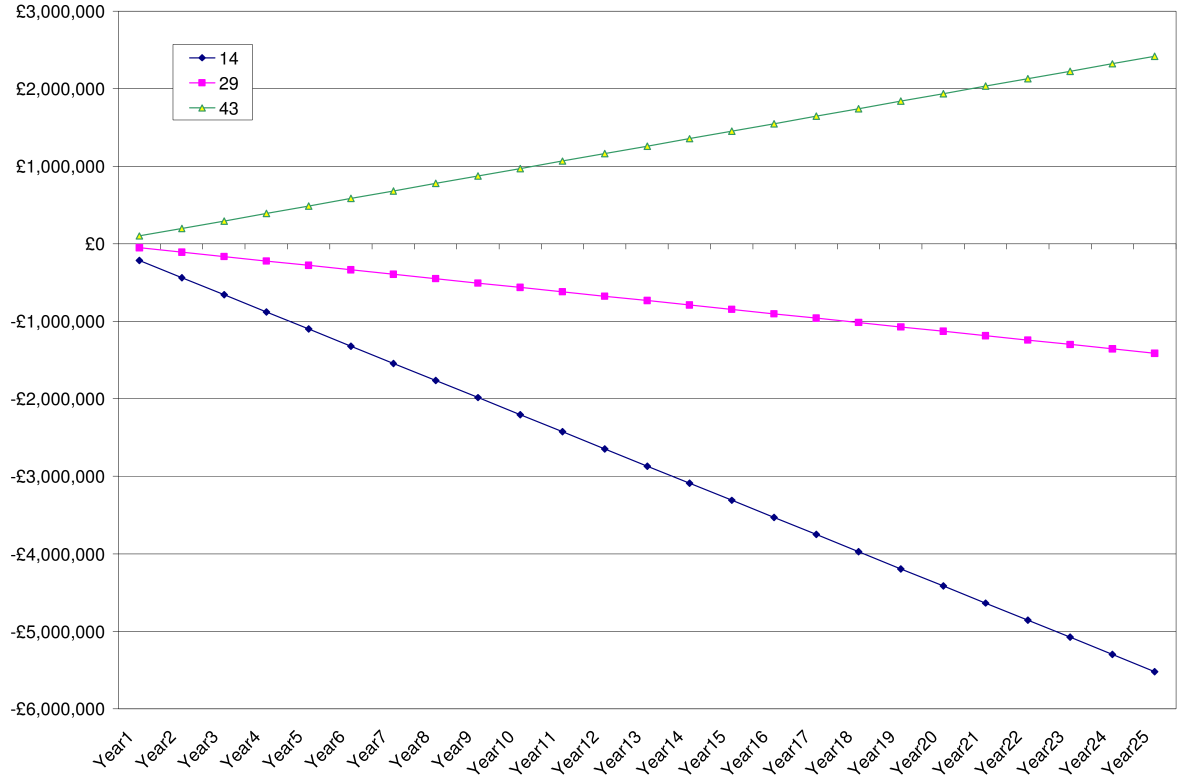
Notes: [1] Equals the number of service routes. [2] Mon-Sat only. [3] Assuming the BSOG (Bus Service Operators Grant) is available for community bus transport, currently at 80% of duty. Fuel price = 21p; pre-VAT duty 47p; pre-VAT duty net of BSOG = 9.4p. [4] Based on combined driving cycle for typical 16-seater minibus. The smaller Ford Transit and VW Transporter consume 8 to 9 l/100km while urban buses consume 25-30l/100km (VCA, 2004; NAEI, 2002). [5] The daily mileage is based on an average of 4 round trips at 50km each.

Table 3: Results of the financial analysis of the DRT model income and outgoings

Demand scenario	*Demand per vehicle per day*	*Income*	*Outgoings*	***Net Present Value***
LOW	14	1,428,236	-3,482,107	**-2,053,872**
CENTRAL	29	2,958,488	-3,482,107	**-523,619**
HIGH	43	4,386,724	-3,482,107	**904,616**

The results show that for LOW and CENTRAL demand, the system requires some kind of subsidy to be viable. For HIGH demand, the system is profitable. The 'breakeven demand' is at 34.1 passengers per vehicle per day at £5 per passenger trip.

Figure 21: Cumulative profit/loss by demand scenario (14-LOW, 29-CENTRAL, 43-HIGH; positive numbers are profit, negative loss)



4.6 Discussion

The model appears to be beneficial as well as viable based on the assumptions and definitions employed. This Section discusses some of the key issues raised during model development and testing.

The average charge per passenger is somewhat arbitrary and was chosen here somewhere between bus and taxi charges. It lies well in the range of charges observed for existing DRT schemes in the UK (CfIT, 2002; Grosso *et al*, 2002; Brand, 2003). For example, the Commission for Integrated Transport (2002) reports heavy subsidies for flexible rural transport projects, ranging from £4.60 to £17.00 per passenger. If DRT services would replace some or all of the non-emergency PTS, this charge could arguably be lowered by a subsidy from the hospital trust or local authority.

The range of demand market shares for DRT was assumed on the basis of results of the survey work and the most recent travel plan survey work by SDG (2001). The demand figures used are well within the usage figures reported by CfIT (2002), ranging from 10 to 51 passengers per vehicle per day for flexible DRT services with similar service frequencies and daily coverage.

In addition, the demand figures developed in the previous Section are for hospital users only. It may be beneficial to combine demand and service supply with GP surgery demand. Although not thoroughly tested, the data collected suggests that there may well be a synergy between the two datasets (hospital and GP) that would provide more useful levels of demand than just the hospital data set on its own. In that way, it may be possible for services to operate via GP practices en-route to hospital and vice versa, allowing the GP practice to be a hub for some passengers while others are picked up at home (since many people report less difficulty getting to the GP than they do getting to the hospital). The limited demonstration of 'FLEXing' GP surgery trips shed some light on this but it will require further work.

There was probably insufficient time to really make the services efficient. The geographical characteristics and timings of the service routes and schedules are a first attempt to provide an efficient demand responsive transport service for access to the hospitals. This is appropriate for a demonstration of the utilised DRT system and software. Further iterations would be required to make this a more efficient setup. Real world applications (e.g. Gloucestershire, Northumberland) have shown that timings have to be fine tuned on a regular basis, reflecting weekly and seasonal differences in demand patterns. Indeed, this flexible approach can be seen as one of the strengths of DRT services. In this case, it is most suitable for transport provision to health care services where weekly changes in appointment schedules cause variations in trip patterns to and from the hospitals (Grosso *et al*, 2002).

Furthermore, the flexibility of a powerful database system enables 'what ifs' to be tried easily. For example, service routes and schedules can be changed easily to accommodate changes in demand patterns. This could be useful for adapting to changes in clinic times for patients and visitors.

The demonstration suggests that the Graphical Information Systems (GIS) interface gives an excellent mechanism for visualising the requirement. Note that in addition to the visualisation presented above, vehicle positions would show on screen in a real world application with General Packet Radio Service (GPRS) equipment fitted to the vehicle.

A key further step would be to look at feeder services, perhaps to existing fixed route lines or new ones. This could involve developing the DRT services around the main public transport hubs (railway stations, bus terminals and stops on frequent routes) as well as private transport interchanges such as the P&R sites around Oxford City. All this could be modelled in the system presented here.

5 CONCLUSIONS AND OUTLOOK

This research was specifically aimed at mapping the existing transport facilities supported by public agencies and the voluntary sector and mapping the transport services needed to enable people to access health care facilities in order to compare the existing provision with transport needs and develop a revised model for the provision of transport to improve access. In so doing, the research aimed to examine the potential for on-line communication and scheduling of travel and access to hospital and develop a demand responsive transport plan for a hospital trust.

The study has determined the impact of implementing such a plan on both the hospital and those who experience difficulty accessing it. The introduction of the demand responsive option to the hospital travel discourse will also be relevant for staff travel and will, hopefully, be considered as one of the potential solutions to be considered in the traditional Green Travel Plan arena.

Evidence in the public domain

The first phase of the study concluded that there appears to be relatively little written about the links between transport and health care access. Recent policy review by the Government and bodies such as the NHS, Audit Commission and Social Exclusion Unit have started to refer to the concept of hospital and GP access in relation to transport issues. This research has built on these foundations and as a result defined a new model for health care provision that harnesses readily available technology to meet the needs of people who find access to health care services difficult at present.

Existing provision and demand

The second phase of the work concluded that travel to the John Radcliffe and Churchill hospitals is often difficult. For some the difficulties relate to the lack of suitable public transport services, while others report problems with congestion en route and parking at the hospitals themselves. As expected some people from rural locations reported difficulties but the problems described by residents of areas such as North and West Oxford and Bladon in accessing the hospitals by public transport were unanticipated.

The transport and health profiles provided a good indication of the types of trips that local people may face and the questionnaire survey gave empirical evidence to support these findings.

The work highlights that, for many, there is a call for a transport solution that is reliable, involves no interchange, precludes the need to rely on friends/relatives and provides door-to-door travel. Efficient and effective demand responsive transport can meet these needs. In addition, the empirical research reveals a peaked nature to demand. The demonstration of DRT services in the study area suggests that satisfying such demand through demand responsive transport solutions is feasible in both efficiency and cost terms.

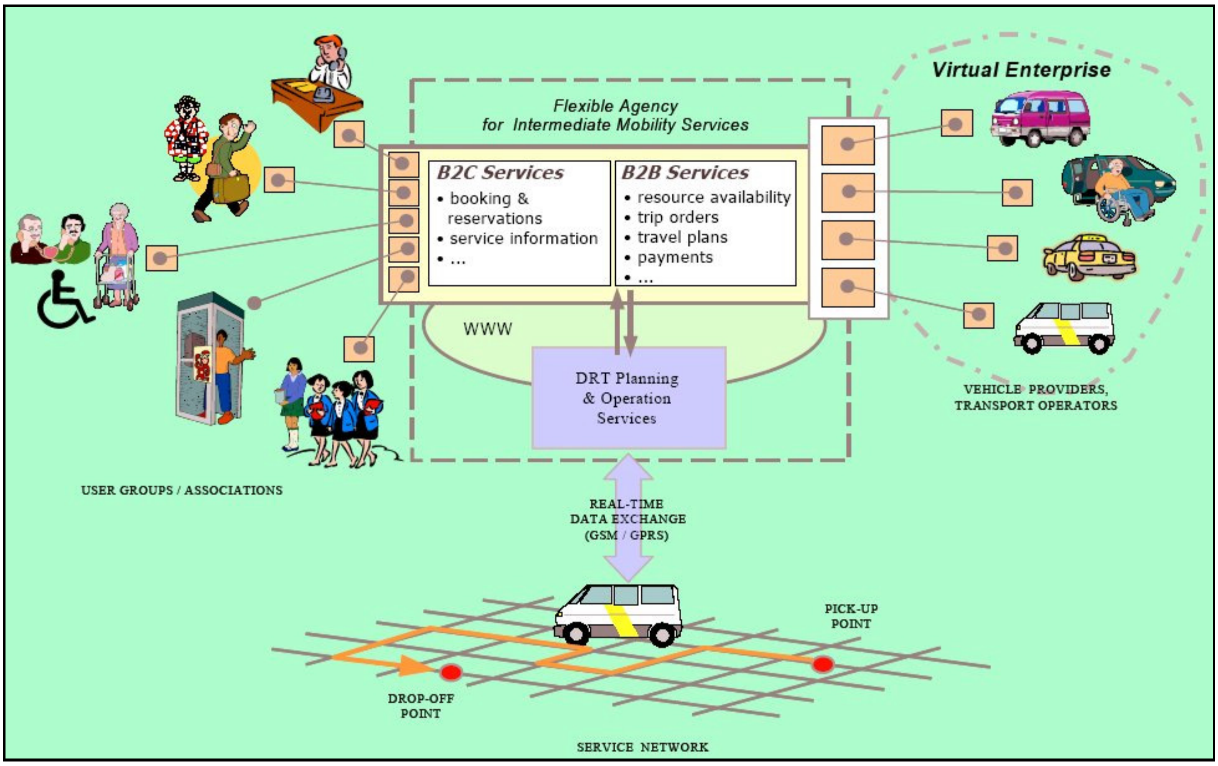
Telematics-based DRT systems

DRT software has come a long way since first introduced to assist dial-a-ride operations. Today's powerful hardware and database software environments have changed the scale, complexity and speed of Travel Dispatch Centre operations as seen in the case studies and supporting software features. It is now possible to dynamically assign passengers to vehicles and optimise routes in real time – e.g. while the customer is on the (mobile) phone or on-line using his/her own PDA or a public internet terminal at a hospital or GP surgery.

The software review showed that in contrast to what was said in the *Final Report on Transport and Social Exclusion* (ODPM, 2003) there are many not few applications of modern telematics based DRT services currently operating in the UK, many of which are operating *MobiRouter* as the software tool.

The current 'movement' in Europe is to start linking DRT much more closely with taxis. The Dispatch Travel Centre could be the centralised transport services hub that starts to pull together many forms of transport (fixed PT, DRT, taxi, P&R bus etc), giving a truly integrated transport system (Duffell, 2002). The FAMS concept developed for the EC (DG INFOSCO), for example, enhances the service provision by developing a 'virtual agency' co-ordinating multiple transport resources (Finn, 2002). This is illustrated in Figure 22.

Figure 22: Overview of the FAMS conceptual framework (Finn, 2002)



Any future vision for transport must recognise the importance of remote communications and hand held devices. This is important for transport operators but even more crucial for the public. Arguably they *will* be using their Personal Digital Assistant (PDA)/Mobile phone (or whatever they get to be called) to book travel. A Travel Dispatch Centre with modern technology is key to this.

'An alternative plan'

While there are other planning solutions to health care access problems such as the development of telemedicine, this work concentrated on the potential for demand responsive transport solutions to facilitate easier access. Hence the 'alternative plan' *is* the DRT model developed here. The Oxfordshire case has shown that the demand for patient and visitor transport to/from hospitals can partly be met by modern DRT services, overall improving the accessibility and efficiency of the transport system.

The assumptions and definitions employed in the DRT model were developed based on current experience of setting up and running a telematics-based DRT system. However, the demonstration setup is only a first attempt to provide an efficient demand responsive transport service for access to the hospitals. Further iterations would be required to make this a more efficient setup, with routes and schedules fine-tuned on a regular basis reflecting weekly and seasonal differences in demand patterns. This flexible approach can be seen as one of the strengths of DRT services, enabling 'what ifs' to be tried easily.

The outcomes of the modelling exercise appear to be beneficial mainly in terms of accessibility improvements. It is also feasible in terms of cost and revenue. However, this depends heavily on demand forecasts and service pricing. The empirical evidence suggests that there is demand; to what extent this materialises in the case of model implementation remains to be seen. Prices depend on how the service would be financed: publicly, privately, or a mix of the two (e.g. PPP, quality contracts). One suggestion is to strip the Ambulance Services of their somewhat costly and inefficient responsibility to provide non-emergency PTS, which could be provided by DRT more efficiently and more cheaply.

More detailed demand forecasting work will be required to make more reliable forecasts and answer questions such as:

- How many car users may switch to DRT?
- How many non-car users are likely to switch from public transport/taxi to DRT?
- How much demand is latent, i.e. how many trips are currently not made due to accessibility problems that DRT could take up?

A stochastic model (e.g. binary logit) or a deterministic model (switch to DRT if its generalised cost is less than that of the existing mode) could be developed in order to determine likely market shares of DRT vs. existing modes. The key issues of such a model are likely to be:

- The value of time at the local level;
- The dispersion parameter of the logit model;
- The interchange penalty (usually 5 minutes on top of the actual time an interchange takes);
- The level of escorting of family members[17].

This study never aimed to perform this type of analysis and forecasting. It would become important, however, if the local authorities and/or hospital trust would take the idea of DRT services in Oxfordshire any further.

Given the demonstrative nature of the model, there was insufficient time for the level of iteration necessary to make the services truly efficient. Further work will be required to test the feasibility of closely linking any DRT services with existing public transport provision (as feeder services) and major private transport interchanges (e.g. P&R). Arguably DRT should not seek to replace efficient existing services such as taxis and bus services, but be supplementary and integrated, especially in areas and at times where existing provision is poor.

It is worth stressing again that the above is *a model* and can be used by other organisations wishing to test out similar ideas. It's not meant to be definitive for the Oxfordshire case.

[17] Where somebody is being driven by a family member then it may very well be the real time cost calculation is the journey of the patient x 2. Reducing the level of escorting is a time saving which demand responsive transport can make but conventional public transport can not provide. The point to point character of the journey substitutes for the escort.

Last but not least, the model has the potential to introduce greater equity of transport access which in turn could contribute to the NHS' founding principle of providing access to care to all on the basis of need (NHS, 2000).

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GLOSSARY

Term	Description
AVL	Automated Vehicle Locationing
CPU	Central Processing Unit
DDR	Double Data Rate memory, a key part of any computer hardware
DRT	Demand Responsive Transport
GIS	Geographical Information Systems
GPRS	General Packet Radio Service
GPS	Geographical Positioning System
IVRS	Interactive Voice Response System
LAN/WAN	Local/Wide Area Network
MB	Megabyte, standard unit of memory and data storage
PDA	Personal Digital Assistant
PTS	(Non-emergency) Patient Transport Services
TDC	Travel Dispatch Centre
VISUM	Name of a traffic network model

APPENDIX A DRT SPREADSHEET MODEL

DRT business case spreadsheet model		
Number of vehicles	7	
Number of shifts per day	2	
Number of passengers per day per vehicle (ave.)	35	
Charge per passenger (ave.)	£5.00	
Number of days per year	313	Mon-Sat only
Number of vehicles per dispatcher	10	
Number of vehicles per dispatcher with Internet booking	50	
Cost per vehicle	£25,000	
Cost of driver	£20,000	
Cost of dispatcher	£20,000	
Fuel cost per km, net of BOSG, no VAT (£)	£0.036	
Time horizon (years)	25	
Mileage per vehicle per day (km)	200	
Discount rate	3.5%	

Demand pe	Income	Outgoings	NPV
14	1,428,236	- 3,482,107	**- 2,053,872**
29	2,958,488	- 3,482,107	**- 523,619**
43	4,386,724	- 3,482,107	**904,616**

(for £5 charge)

Income		0	1	2	3	4	5	6	7	8	9
Item		Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
Income from fares		£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250
	NPV +										
Total income	**£3,570,589**	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250	£383,250

Outgoings											
Scheduling system											
MobiRouter software	50000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Maintenance & support (PA)	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Internet booking	20000	0	800	800	800	800	800	800	800	800	800
Maintenance & support (PA)	4000	0	4000	4000	4000	4000	4000	4000	4000	4000	4000
Dispatch centre and vehicle hardware	6000	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Years to replacement (hardware)	5										
Vehicles											
Capital cost	£175,000	28000	28000	28000	28000	28000	28000	28000	28000	28000	28000
Years to replacement	6.25										
Fuel cost (net of BOSG, no VAT, in £)		15768	15768	15768	15768	15768	15768	15768	15768	15768	15768
Office expenses		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
People costs											
Drivers		£280,000	£280,000	£280,000	£280,000	£280,000	£280,000	£280,000	£280,000	£280,000	£280,000
Dispatch centre staff	1	£20,000	£20,000	£20,000	£20,000	£20,000	£20,000	£20,000	£20,000	£20,000	£20,000
	NPV -										
Total outgoings	**-£3,482,107**	£369,468	£374,268	£374,268	£374,268	£374,268	£374,268	£374,268	£374,268	£374,268	£374,268
	Total NPV										
Total income - outgoings	**£88,482**	£13,782	£8,982	£8,982	£8,982	£8,982	£8,982	£8,982	£8,982	£8,982	£8,982

Note: only the years 1 to 10 are shown for layout reasons; the sheet extends to year 25.