APPENDIX 5: THE TREATMENT OF FLEXIBLY ROUTED TRANSPORT SERVICES IN ACCESSION

Introduction

1. The purpose of this document is to provide information for the contractor undertaking the development of the accessibility planning software tool, as well as providing general information for those interested in the manner in which demand responsive and flexibly routed transport services in general are to be handled within the accessibility planning software tool.

2. The software tool specification contains a number of mandatory requirements for the accessibility planning software tool to enable users to undertake multi-modal accessibility assessments by any combination of the following modes of transport:

   i. cycle

   ii. all forms of public transport (bus, train, metro, tram) (in addition to the use of scheduled public transport services, the accessibility planning software tool must be capable of being applied to demand responsive and flexible routed and timed services, school and social service transport and other forms of service-specific transport)

   iii. walk

   iv. car

3. The routing algorithm incorporated within the software tool must facilitate multi-modal journeys by a selection of any combination/permutation of the four transport modes highlighted above. The routing algorithm must allow for the use of both a segmented and a full public transport timetable. In particular the routing algorithm must be capable of facilitating multi-criteria based shortest path routing incorporating turning restrictions and penalties. In addition the algorithm must be capable of identifying time dependent shortest paths using a continuous clock time used in conjunction with a full public transport timetable.

Lincolnshire County Councils Demand Responsive Service

4. In order to inform how demand responsive services should be treated the following section provides an outline of how the Lincolnshire County Council (LCC) demand responsive service currently operates.

5. LCC demand responsive service services take two forms:

   a) A semi-fixed route where there is a defined start and finish to the service with time built into the schedule for variations off the route in response to pre-booked requests.

   b) A fully flexible routing with all journeys pre-booked; this operates within 6 or 7 miles of an interchange hub and has been described as many origins to one

destination (though there may be several set down points at the destination), and the reverse.

6. The procedure of booking usage of LCC demand responsive service is that an individual makes a telephone booking. If the journey can be made within the prescribed timescales, i.e. the bus must be at the interchange point before the connecting bus arrives and stay until it departs (about a 45 minute window), the LCC booking software allocates the passenger. The passenger is advised that the bus will pick them up within a 10 minute window. A message is sent to the driver 30 minutes in advance of the person being picked up. The process takes longer if a wheelchair user has booked the service and an allowance is built into the schedule.

7. Some additional information on how the LCC demand responsive service operates is provided below:

   a) The overall journey time on the bus will vary depending on the order of pick up and the distance from the destination. This could a maximum of 45 minutes but could be as little as 5 minutes. The LCC demand responsive service booking software calculates the estimated travel time using a algorithm based on type of road and vehicle speed.

   b) The typical wait time for those who have pre-booked usage of the demand responsive service is of the order of 10 minutes.

   c) The only scheduled pick up/drop off point of the demand responsive service would be at the destination. Most users will have pre-booked but the driver will accept passengers who turn up but only after checking with the control centre.

   d) The destination of the journey is set at the time of booking. Passengers can be set down at other locations in the vicinity of the main destination at the driver's discretion.

   e) LCC demand responsive service employs a zonal fare scheme for travel solely on the demand responsive service but passengers can book a through fare to any other place within the network within the corridor. Fares do not vary by time of day but can potentially do so. The main ticket types that LCC's demand responsive service encompasses are single, return and concessionary.

Proposed Treatment of Flexibly Routed Transport Services

8. Within the software tool it is anticipated that users, like for all transport modes, will wish to evaluate the benefits of existing flexibly routed services, as well as using the software tool to both develop new and modify existing flexibly routed services.

9. The question now is if we assume that users of flexibly routed service have pre-booked the service and incur a start wait time for instance of 10 minutes (t_d),

which can be uniquely defined within the software for each demand responsive service and person type (e.g. wheel chair user), the question is how do we incorporate the flexibly routed component within the software tool.

10. Following comments received in response to the previous draft of this note it was generally accepted that the proposed treatment of semi-fixed demand responsive services was too complex and consequently will only be incorporated within the software tool if the contractor feels that it can be coded relatively easily. However if this is the case the development of the software tool should be undertaken in such a manner as not to preclude the incorporation of semi-fixed demand responsive transport at some point in the future. It will thus be treated as a desirable component. A fully flexible demand responsive service will be incorporated as a mandatory component within the software tool. The remainder of this note outlines how such a fully flexible transport service is to be incorporated within the software tool with the final sections outlining the desirable methodology which can be used to model semi-fixed demand responsive services.

Bi-Directional Fully Flexibly Routed Services (Mandatory)

11. Fully flexible bi-directional demand responsive services are invariably area based services, which operate within a defined catchment area, location or region. As such it is proposed that users of the software tool will define interactively within the software tools map window, the boundary of the region within which the bi-directional flexibly routed services are available for use by the local community. It is worth noting that the following general mode of operation of a bi-directional flexibly routed service applies not only to demand responsive services, but also to other flexibly routed area based services e.g. pupil transport, special needs transport, patient transport, social service transport, community/voluntary transport, private taxi etc.

12. Within the software tool users will define area based bi-directional flexibly routed services on the basis of the following, by:

    a) Defining with the mouse the demarcation of the region within which fully bi-directional flexible routed services are available. The mouse is to be used to define the vertices of the polygon in sequential order.

    b) Defining with the mouse the top left-hand corner and the bottom right-hand corner of the region within which bi-directional fully flexible routed services are available.

    c) Importing or opening the demarcation boundaries of the bi-directional fully flexible routed services in ESRI Shape, MapInfo Tab, Mif/Mid formats together with associated data regarding the manner of operation of the flexibly routed service, e.g. service type, wait time, speed of travel, cost of travel etc.

13. For a) and b) above the user will be able to define the general characteristics of the bi-directional flexibly routed service in question, by specifying a) a service type;

b) an average wait time; c) average speed of travel or speed of travel based upon a proportion of corresponding highway speed; d) a cost of travel, expressed as either a fixed fare or as a cost per kilometre travelled.

14. In the case of c) the user will be able to modify any of the corresponding variables associated with each defined region.

15. Having defined the region(s) of operation of the bi-directional flexibly routed service the software tool would, (assuming the bi-directional flexibly routed transport mode in question had previously been selected by the user for incorporation with an accessibility assignment), proceed to identify all origin, destination and public transport access points located within the confines of the boundaries of the bi-directional flexibly routed service demarcation. These selected points essentially define the locations from which it is possible for an individual to board or alight from the bi-directional flexibly routed service.

16. From this stage onwards the bi-directional flexibly routed service in a modelling respect is treated as a private vehicle, where it is possible to use any route which satisfies the general routing criteria in question e.g. minimum time, distance, cost, generalised cost.

17. The typical or average wait time of the users of the bi-directional flexibly routed service (t_d) at each origin point under consideration (10 minutes in the above LCC DRT case study) is added to the boarding time (t_b), which in turn is added to the onboard passenger journey time (t_j) (i.e. the travel time associated with shortest path from the origin point in question to the relevant destination point). For all origin points located within the demarcated region the following function will apply:

$$t_t = t_d + t_b + t_j \qquad (1)$$

18. Where:

- t_t - Total journey time using flexibly routed service
- t_d - Wait time of the user of the flexibly routed service (which is user defined at the assignment stage)
- t_b - Boarding time (the time it takes for the individual to physically board the vehicle, which is a function of the individual/person type in question and is user defined at the assignment stage)
- t_j - Onboard journey time along the flexible route between the origin and destination (calculated dynamically during the assignment stage)

19. This process is repeated for each origin point located within the demarcation of the flexible routed service after which it will be possible to produce journey time, cost or generalised cost contours.

20. It is important to note that for a uni-modal assignment involving just one flexibly routed transport mode (e.g. DRT) it will not be possible for an individual to reach

a destination located outside of the demarcation region associated with the flexibly routed service in question. In order to access a destination location situated outside of the demarcated region then:

a) The individual will either have to interchange with another flexibly routed service, for which the demarcation regions associated with both flexibly routed services intersect (possibly at an appropriate access point or intermediate destination).

b) The demarcation region of the flexibly routed service will have to be extended to encompass the destination in question.

c) The uni-modal assignment will have to be changed to a multi-modal assignment in which it is possible for the individual to interchange with for instance a traditional scheduled public transport service at an appropriate access point located both within the demarcation region associated with the flexibly routed service and served by the traditional scheduled public transport service.

Directionally Based Flexibly Routed Transport Services (Mandatory)

21. There are a number of local authorities that have or are shortly to introduce directionally based flexibly routed transport services where it is only possible to use the flexibly routed service in a specific direction of travel (e.g. from region o to region d). GMPTE have a number of demand responsive services which operate such a manner and it is proposed that software tool must support this form of flexibly routed transport.

22. In practice such services possess an origin demarcation region within which it is possible for individuals to access the service and a destination demarcation region where users of the flexibly routed service can alight. It is not possible for users to alight at regions outside the defined destination alighting area

23. Within the software tool users will define area based directional flexibly routed services on the basis of the following, by:

    a) Defining with the mouse the demarcation of the **origin** region within which it is possible for users to board the directionally based flexible routed services. The mouse is to be used to define the vertices of the polygon in sequential order. Defining with the mouse the demarcation of the **destination** region within which it is possible for users to alight from the directionally based flexible routed services. As before the mouse is to be used to define the vertices of the polygon in sequential order.

    b) Defining with the mouse the top left-hand corner and the bottom right-hand corner of the **origin** region within which it is possible for users to board the directionally based flexible routed services. Defining with the mouse the top left-hand corner and the bottom right-hand corner of the **destination** region within which it is possible for users to alight from the directionally based flexible routed services.

c) Importing or opening the **origin** and **destination** demarcation boundaries of directionally based flexibly routed services in ESRI Shape, MapInfo Tab, Mif/Mid formats together with associated data regarding the manner of operation of the flexibly routed service, e.g. service type, wait time, speed of travel, cost of travel, directionality etc.

24. It should be noted that if there is a requirement for users to alight in a particular region not served by the directionally based flexibly routed service then one or more of the following must be employed:

a) A modified directionally based flexibly routed service must be produced in which the destination region boundary is expanded to encompass the desired alighting points or destinations in question.

b) A new directionally based flexibly routed transport service must be developed encompassing the desired alighting points or destinations in question.

c) A fully flexible bi-directional flexibly routed service (outlined in the previous section) section must be introduced serving the origin/destination region in question.

d) Alternatively the user must be able to interchange with traditional scheduled public transport services serving access points/bus stops located within the existing destination demarcation region and which offer a direct transport link (or indirect transport link via interchange) with another scheduled public transport service to the desired destination region.

e) Alternatively the user may need to interchange with another flexibly routed service (whether bi-directional or directional in nature) which through service interchange enables the user to access the desired destination in question. In this instance the boundaries of the destination end of the directionally based service must intersect with the origin boundary of the interconnecting directionally based service or with the general service boundary of the bi-directional service.

25. It is worth noting that if a directionally based service is introduced linking a rural community with a town centre, then there may well be a need to introduce a corresponding directionally based service for the reverse journey, linking the town centre with the a rural community. Please note that a bi-directional service can be considered to be a special example of this in which the origin and destination boundaries are identical for the inbound and outbound journeys. In such cases there is a need to provide functionality within the software tool for the user to be able to do this automatically using the boundary information previously entered but reversing the origin and destination tags/identifiers.

26. The mathematical formulation of the journey time components associated with directionally based flexibly routed services are identical to that presented in equation 1 and in paragraphs 17-19 inclusive.

Semi-Fixed Demand Responsive Services (Desirable)

27. Whilst it is mandatory for the software tool to be able to incorporate fully flexibly routed services, it is also desirable for the software tool to be able to incorporate semi-fixed demand responsive services. However if the consultant feels that it is too complex at the present moment in time to incorporate the following methodology (for semi-fixed demand responsive services) within the software tool then it is essential that the software tool be developed in such a way that it does not preclude the incorporation of semi-fixed demand responsive services (using the following methodology) within the software at some point in the future.

28. The known clock time at the start of the semi-fixed route (t_s) and end of the route (t_e) together with the available flexible routing travel time budget (?t_f) for diversions from and back to the fixed route to pick/drop passengers can be used to operationalise semi-fixed demand responsive services.

29. In this approach it is assumed that the semi-fixed demand responsive service starts from the first stop on the fixed route and deviates from this route at access points, bus stops or user defined locations such as priority junctions, cross roads, roundabouts etc, located along the fixed routing within the highway network. These locations will hereafter be referred to as the deviation point, (refer to figure 1). The software tool identifies the highway nodes/links and associated origin point locations which the demand responsive bus service can be both reach, remain at for a duration of time to collect the passenger or allow the passenger to board (boarding time t_b) and then travel back to the fixed routing of the demand responsive service to the deviation point under consideration. The total distance travelled along the shortest time path could be calculated via (?t_f - t_b) * v where v might be the average speed of travel of the demand responsive service, or alternatively the minimum time tree built from the deviation point in question would have a maximum path length in time units of (0.5?t_f - t_b) assuming inbound and outbound journey times are identical. All the origin points located within reach of this spanning tree have an associated onboard journey time (t_j) plus boarding time (t_b), the total of which varies depending upon the relative location of the origin point in question but in no circumstances exceeds (e.g. 0.5?t_f - t_b).

30. The wait time of the user of the demand responsive service (t_d) at the origin point under consideration (10 minutes in the above LCC case study) is added to the boarding time (t_b), which in turn is added to the onboard passenger journey time (t_k) from the origin point in question to the relevant deviation point, which is then added to the demand responsive service travel time from the deviation point in question to the end of the route (i.e. the total time along the fixed route t_{fr}) to give a total journey time (t_t) in question for the origin point under consideration to the point at which the demand responsive service ends. In essence for all origin points the following function will apply:

$$t_t = t_d + t_b + t_k + t_{fr} \qquad (2)$$

Where:

t_k - Onboard journey time along the flexible route between the origin point and the deviation point.

t_{fr} - Onboard journey time along the fixed route between the deviation point and the end of the route.

31. This process is repeated for each subsequent deviation point located downstream along the fixed routing of the demand responsive service. In so doing it is possible that an origin point may have more than one total journey time associated with it, in which case the minimum journey time is selected.

32. It should be noted that this approach assumes that each demand responsive service only picks up just the one passenger, as the time budget available for the flexible routing is automatically allocated in identifying the single origin point location situated at the end of the spanning tree. Thus the resulting series of origin points reachable within the flexible routing time budget represents the best case example. Origin points located outside of this location cannot be served by the service in question given the fixed routing and the flexible routing time budget. In addition it should be noted that within the region feasibly accessible by the demand responsive service may be located origin points for which if the flexible time budget has already been fully used in collecting a particular passenger will not be accessible to the demand responsive bus journey in question.

Figure1: Example of Semi-Fixed DRT Service