The Cartographic Journal Vol. 45 No. 2 pp. 117–128 Use and Users Special Issue 2008

REFEREED PAPER

Conveying Geospatial Public Transport Information on the World-Wide Web: a Review of the United Kingdom Sources

Robin Scrimgeour[1] *and David Forrest*[2]

[1] HarperCollinsPublishers, Westerhill Road, Bishopbriggs, Glasgow G64 2QT, UK. [2]Department of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, UK
Email: robin.scrimgeour@harpercollins.co.uk

The Geospatial Public Transport Information available for the United Kingdom on the World-Wide Web is evaluated. Searches for relevant websites were made at different geographical scales; the breadth of content covered and level of technology used was assessed for each site found. Public Transport Maps on each website were rated according to eleven aspects of cartographic design and Web functionality. It was found that interactivity (represented by the use of higher technology) was greater for websites giving Public Transport Information for larger areas; however, the majority of information was communicated through text or static maps. The use of colour and symbology was generally found to be good in Public Transport Web maps, but marginalia was often insufficient and hardcopy printing sometimes inadequate, limiting the usability of the maps. A number of guidelines for good practice in the production of Public Transport Web maps are suggested, stressing the importance of clarity and legibility, plus some comments on website functionality.

Keywords: Geospatial Public Transport Information, World-Wide Web, Internet mapping, Content Technology Matrix, Web functionality

INTRODUCTION

Geospatial Public Transport Information, or GPTI, takes a variety of forms: it can be expressed as a set of written (or spoken) instructions; it can take the form of tabular data (a timetable); it can be visualised in map form; or it can be a combination of these methods.

Public and private bodies provide this information for members of the general public who may wish to make a journey on public transport or otherwise ascertain service information. Historically, GPTI has been produced in the printed format but advances in technology have seen the use of other media such as electronic display boards, touch-screen terminals, home computers linked to the World-Wide Web, and portable devices such as mobile telephones. Access to information is greater than ever and GPTI is becoming increasingly interactive in its nature.

Public Transport Information (PTI) may include details of vehicles or associated infrastructure like roads or station facilities; this study is solely concerned with information on public transport journeys, i.e. information that has a geospatial component. For the purposes of the study, ‘public transport’ includes regular timetabled travel by bus; train; tram, trolley bus, or light rail; subway, metro or underground; boat or ferry; and aeroplane. On-request bus journeys or those by taxi or minicab are not included; neither are special tourist services.

There are some good existing guidelines about the presentation of PTI on the Web (ILT, 1999; ITS, 2002; Kenyon *et al*., 2001) but little mention is made in these of cartographic design. Mooney and Winstanley (2001) looked at schematic representations in GPTI and the need for public transport maps to be rotatable if they are to fulfil their potential, while Lyons (2001 and 2002) looks at how the presentation of travel information can influence users’ choices. An overview of Internet-based public transport journey planning is provided by Mooney and Winstanley (2003) and a survey of the geospatial content of public transport websites worldwide was recently undertaken by Morrison (2007).

This paper highlights some of the issues of using Web maps to illustrate public transport information, emerging from a survey undertaken in the summer of 2006 (Scrimgeour, 2006).

A METHODOLOGY FOR EVALUATION OF GEOSPATIAL PUBLIC TRANSPORT INFORMATION

Geographical areas of the UK were chosen randomly and PTI websites found using an Internet search engine. The geospatial properties of each website were recorded – the breadth of content and technology used – and PTI Web

DOI: 10.1179/174327708X305111

maps were evaluated on the basis of cartographic design and Web functionality.

Breadth of GPTI content

Information on PTI websites is provided for different public transport services, divided into four categories based on the operator (public transport service provider) and mode of public transport:

- C1 One operator of one mode of public transport, e.g. Arriva bus
- C2 One operator of more than one mode of public transport, e.g. First bus and First train
- C3 All operators of one mode of public transport, e.g. buses
- C4 All operators of all modes of public transport, i.e. information provided for all public transport services in an area

Technology used to communicate GPTI

Various methods are used to present GPTI on the Web, categorised by the increasing level of interactivity they offer the user:

- T1 Textual information
- T2 Static maps
- T3 Interactive maps
- T4 Advanced maps
- T5 Journey planners
- T6 Customised maps

Textual information ranges from route descriptions to lists (e.g. of all the stations on a train line) and timetables. The most sophisticated type of textual information would be real-time service updates (but not supporting user interaction).

Static maps may have been produced specifically for the Web, or simply be scanned images of paper maps. The user is unable to change the map's design or extent, however, zooming and panning within a fixed location and design may be possible for PDF files, which are included under this classification. Interactive maps may have the facility to zoom in and out (changing the scale and design) or pan the view (changing the location) beyond the image initially shown. Clicking or hovering the mouse over a particular point may reveal a hyperlink to further information such as a timetable or a more detailed map. More advanced maps may include animation, sound, or have the facility to show and hide different layers of information.

In journey planners, a database is queried through user inputs to provide an itinerary for travel by public transport, giving details of recommended services and times. The initial output is usually textual but may include a link to an existing map in the database. Customised maps may be produced as output from a journey planner, being automatically created on demand to user specifications. They may be used where the number of possible outputs is too large for a website to store pre-designed maps for each.

Sampling of geographical areas

The population chosen for sampling was the United Kingdom, studied at four geographical levels: National, Regional, County and Local Authority. A random number generator (Random.org, 2002) was used to choose the 31 areas to be studied (listed in Table 1), from a complete list of current administrative divisions in the UK (National Statistics Online, 2005).

Searching for Public Transport Information websites

A meta search engine, Dogpile (2006), was used in order to reduce the time required for data collection. This compiles results from popular Internet search engines including Google, Yahoo! Search, MSN Search and Ask.com. The default settings were accepted and Advanced Web Searches (UK sites only) were performed by entering a search string for the area name plus either the exact phrase 'public transport' or words associated with its various modes: bus, train, tram, rail, subway, metro, underground, tube, ferry, boat, plane, air. The number of hits (search results) followed – twenty or forty depending on the type of search – reflects the tendency of a user to give up and pursue alternative avenues if the relevant information is not found on the first page or two of results returned by the search engine.

Properties of GPTI websites

For each website found to contain GPTI, the following properties were recorded:

- Breadth of GPTI content (classified C1–C4, see above)
- Highest level of technology used (classified T1–T6, see above)

Generally, only current information about 'getting around' the area was studied, although for Shetland and the Scilly

Table 1. List of areas for which GPTI was searched

Ref.	Area name	Scale
1	Cambridge	Local Authority
2	Broadland	Local Authority
3	Ipswich	Local Authority
4	Northampton	Local Authority
5	Newark and Sherwood	Local Authority
6	Camden	Local Authority
7	Barking and Dagenham	Local Authority
8	Castle Morpeth	Local Authority
9	West Lancashire	Local Authority
10	Ards	Local Authority
11	Moyle	Local Authority
12	Banbridge	Local Authority
13	Shetland Islands	Local Authority
14	Eastbourne	Local Authority
15	Swale	Local Authority
16	Bracknell Forest UA	Local Authority
17	Wokingham UA	Local Authority
18	Brighton and Hove UA	Local Authority
19	Isles of Scilly	Local Authority
20	Cheltenham	Local Authority
21	Swansea	Local Authority
22	North Warwickshire	Local Authority
23	Leicestershire	County
24	Nottinghamshire	County
25	Cumbria	County
26	Oxfordshire	County
27	North Yorkshire	County
28	London	Regional
29	Scotland	Regional
30	Wales	Regional
31	United Kingdom	National

Isles some ‘getting to’ information was included due to their isolated locations. Websites simply giving directions to one place were not studied; neither were those simply containing a list of hyperlinks to relevant information but no GPTI themselves. However, such links were followed to one degree (i.e. one further click away from the search results page) and the resulting website studied if applicable – reflecting the habits of a Web user trying to find GPTI.

Evaluation of maps on GPTI websites

Up to three maps illustrating PTI on each website were studied by the first author. The following properties were recorded:

- Mode of transport represented
- Geographic representation (analogue, schematic or hybrid)
- Style used (classic or ‘French’)
- Evaluation of eleven design and usability elements, rated from 1 (very poor or non-existent) to 5 (excellent)

Only maps showing route information were studied. Those simply showing the location of one public transport node (e.g. a railway station or bus stop) were not included. The study of more than one map of a very similar design on the same website was avoided.

Geographic representation refers to how closely the map resembles reality. An analogue map relates the correct distances and angles on the ground, while a schematic map is an abstraction of reality, emphasising the connectivity of a network. The classification of hybrid geographic representation was used where distance and/or direction were only slightly stylised or simplified.

The *style* of a map relates to a classification devised by Morrison (1996) for the representation of bus routes. In the classic style, service numbers are shown alongside the streets followed by the route, while the ‘French style’ uses a separate line and colour for each route. No style type was attributed to maps showing a single route, or ones that did not identify individual services.

The cartographic design and usability of Web maps used to communicate GPTI is evaluated on eleven aspects, based previous map and website evaluation studies and the authors’ experience:

- *Colour and contrast:* effectiveness of the chosen palette in communicating information;
- *Symbology*: the design and use of symbols, including lines, to portray information through the map;
- *Annotation:* including size or legibility of text;
- *Name placement:* including cropping or overlapping;
- *Marginalia:* the incorporation of elements such as legend, scale bar and title;
- *Size of map window:* referring to the degree of enlargement or panning required to view the whole image clearly on an 800 by 600 pixel display;
- *Hard copy output:* the quality and legibility of a printout of the map from a standard colour inkjet desktop printer, as may be used at home; also includes use of ink and ease of printing;
- *Legibility for users with visual impairment:* size of map detail or facility for user to enlarge image;
- *Requirement for additional software:* as an indicator for accessibility;
- *Time taken to download on a standard home broadband connection:* large file sizes may result in user aborting download, especially if using a dial-up modem;
- *Overall fitness for purpose:* effectiveness and relevance of information presented.

The assessment of these elements was intended to be as objective as possible, using predefined rating criteria. Some could be quite rigorously defined, such as download times – these were recorded over the course of a Sunday evening, when it was hoped connection speeds would be relatively even. However, some elements, such as fitness for purpose, were harder to quantify and their evaluation was inevitably more subjective.

GEOSPATIAL PROPERTIES OF PUBLIC TRANSPORT INFORMATION WEBSITES

Values relating to the content and level of technology used by GPTI websites were summarised in the form of Content Technology Matrices (CTMs), after those used by de Róiste (2006) and Arleth and Campagna (2005) in studies of the use of GI in public participation. Three matrices were produced for different scales (Regional and National were classed together due to the relatively small number of websites for each) and visualised in the form of interpolated surface diagrams (Figures 1–3), with values converted to percentages of the total number of websites in each CTM.

Figure 1 shows that Local Authority PTI websites have a generally low level of interactivity, with none of those studied having journey planning facilities. Most of those found only hold information on one mode of public transport, while over a third only provide textual information. Figure 2 reveals that County PTI websites are often more interactive than those for Local Authorities, with over 20% incorporating a journey planner or producing customised maps. As with websites at the Local Authority scale, the most common method of technology used was static maps. From Figure 3 the relatively high use of more interactive technology at the Regional and National scale can be seen, in particular relating to information provided for all operators. The only customised maps found were for all operators of *all* modes, for instance comprehensive travel planning sites such as Transport for London (URL 1) and Transport Direct (URL 2).

The main trend shown by Figures 1 to 3 is of increasing interactivity as the geographical coverage of the website expands. The combined results of all scales are summarised by Figure 4, showing the percentage of each type of content provided on GPTI websites, and the proportion of websites using each level of technology to communicate GPTI. The majority of GPTI websites provide information for only one operator of one mode of transport (C1). By far the most common level of technology used was static maps (T2). It was sometimes hard to determine if customised maps were actually created on demand or simply retrieved from a large collection of pre-designed possible outputs.

In comparing the availability of GPTI at a variety of levels, it is worth noting that this may not be provided at all levels in a given area. For instance, some County councils devolve responsibility for this to Local Authorities, and vice

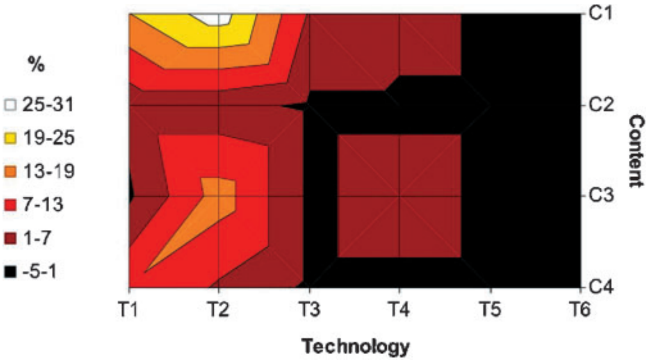

Figure 1. CTM surface for Local Authority PTI websites

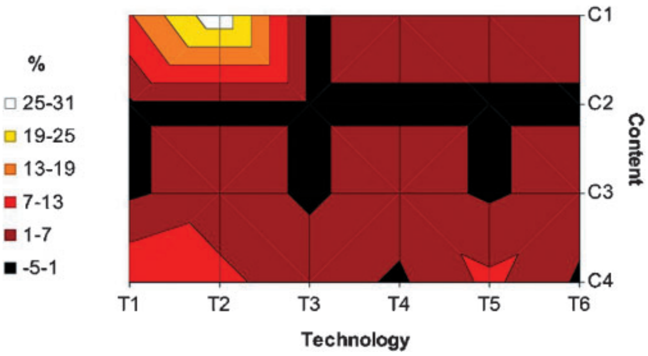

Figure 2. CTM surface for County PTI websites

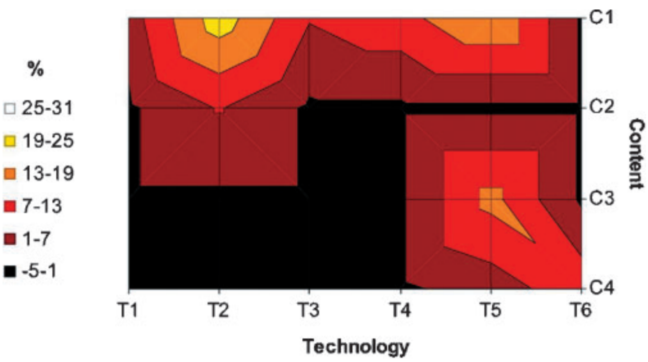

Figure 3. CTM surface for Regional and National PTI websites

versa. Alternatively, operators running services over a wide area may not provide specific information for each Local Authority. The operation of public transport itself also varies from area to area. Where local authority services dominate there may be few or no other providers, compared with an area where there is competition amongst a number of private companies. These operators will usually present details on their own websites, while a local authority may additionally choose to collate all PTI for use by their citizens (e.g. Cumbria County Council, URL 3).

EVALUATION OF PUBLIC TRANSPORT INFORMATION WEB MAPS

Properties of PTI Web maps

Of the 85 PTI Web maps found, the modes of transport represented were: Bus (50 maps), Train (16), Plane (5),

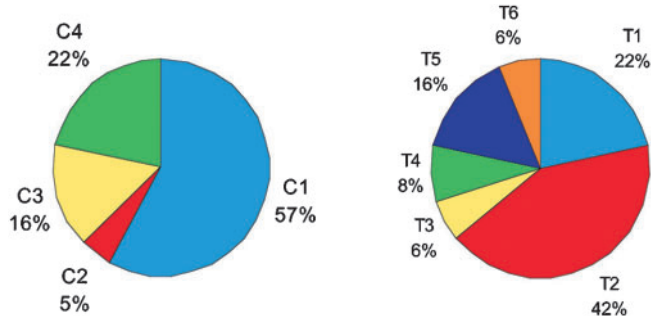

Figure 4. (a) Website GPTI content and (b) technology used to communicate GPTI

Ferry (4), Tram (3) and more than one mode (7). The styles used were: 'French' (28 maps) and classic (13), while neither style was applicable to 44 maps. 48% of maps used an analogue geographical representation, 33% conveyed information schematically and 19% were classed as hybrid.

69% of train maps, but only 28% of bus maps, were schematic. 'French style' maps were split evenly between schematic and analogue/hybrid. The classic style was only found to be used on maps showing bus route information, while 44% of train maps used the 'French style' to communicate GI.

Cartographic design

Colour and contrast

Colour and/or contrast can be used to show distinctions between categories of information on a map, or to emphasise certain items over others. In public transport maps the most important aspect is route information, which includes service numbers, frequency, cost, stop or station names, termini, and the course of travel.

The two distinct styles identified by Morrison (1996) use colour in different ways. The classic style shown in a map for London Buses (Figure 5) uses red for roads served by this operator, green for those used by different operators and grey where no bus services run. Alongside each section of road are bus numbers, which in this case are coloured according to service frequency. In Figure 6, the colour of service numbers reflects the number of days a week a service operates, while roads not served are pushed into the background by being depicted in white. On the map shown in Figure 7, the roads themselves are coloured according to how often they are served (by any bus) while each service number is itself coloured to denote its frequency of operation.

There is much use of the 'French style' in the examples found. Maps such as that in Figure 8 attribute a different colour to each service number. In cases where there are too many services to be shown separately, they may be colour-coded into groups by geographical area served (e.g. Figure 9). In this example, service numbers are shown alongside each part of the route; the map could therefore perhaps be classed as having a hybrid 'French-classic' style.

Where a map shows only a single route, this may be coloured to match its representation on a map of the entire network, or may reflect the livery of the vehicles themselves. This continuity may be useful in establishing an identity for

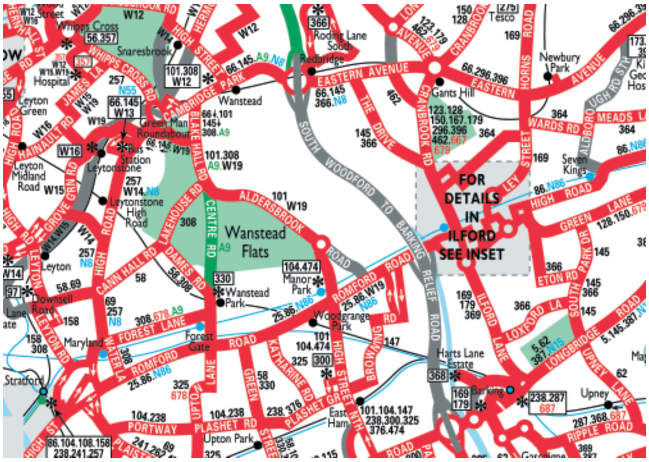

Figure 5. Use of colour in the classic style (URL 4). Extract reproduced with permission of The Greater London Bus Map – www.busmap.org

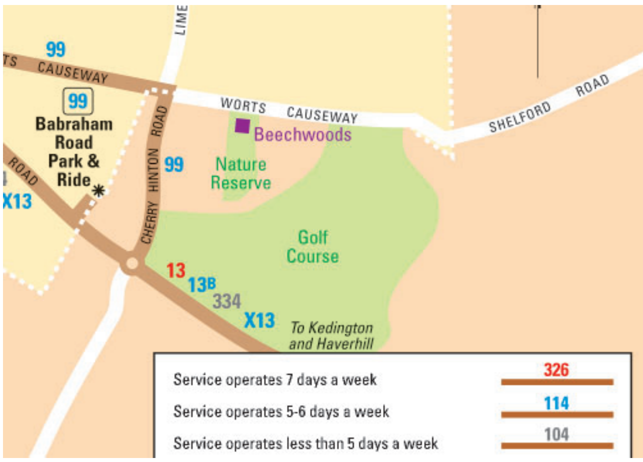

Figure 6. Use of colour in the classic style (URL 5). Extract reproduced with permission of Cambridgeshire County Council

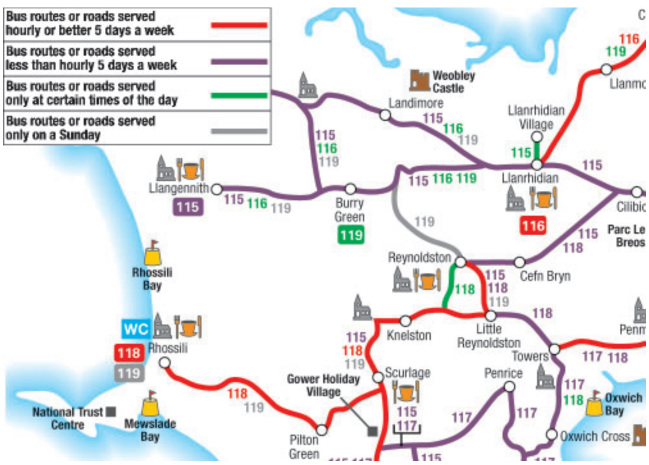

Figure 7. Use of colour in the classic style (URL 6). Extract reproduced with permission of FWT and the City & County of Swansea

the route in the mind of the user. An operator's network map may alternatively use company colours to reinforce their brand.

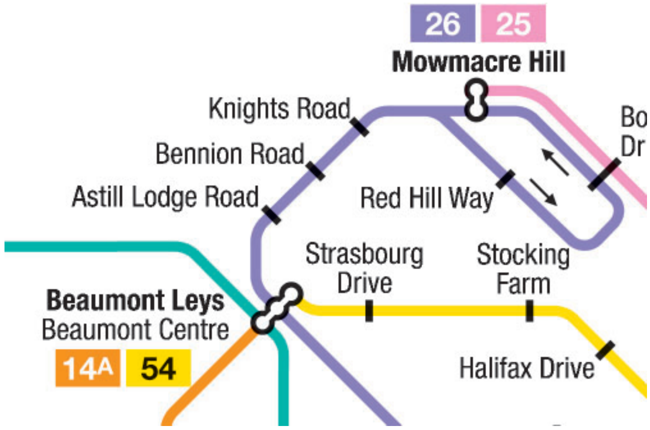

Figure 8. Use of the 'French style' (URL 7). Extract reproduced with permission of FirstGroup plc

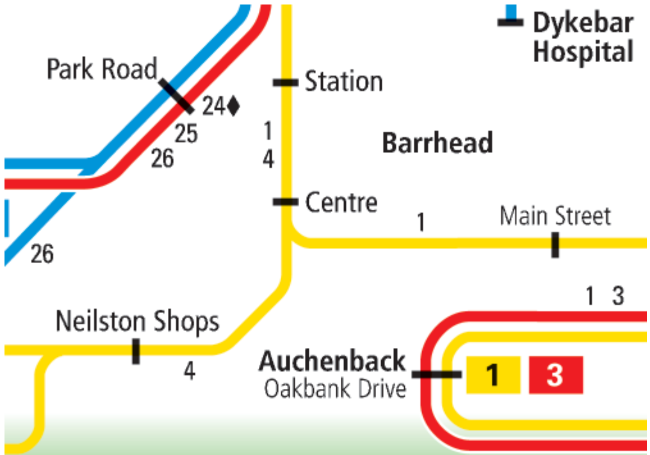

Figure 9. Hybrid 'French–classic style' (URL 8). Extract reproduced with permission, © FWT

Background colours may show less important information such as built-up areas, green space or topography to add texture and context. In the case of Figure 10, however, district extents are shown in a weight of colour out of proportion to their relevance, unnecessarily distracting from route information. The Transport for London 'Tube, DLR, Trams and Train Travelcard zones map' (Figure 11) is a good example of how background information can add another layer of information, using coloured zones to denote fare stages – the pastel colour avoids conflict with bolder shades used for lines of transport.

On the customised maps found, the recommended route was shown brightly, with different modes of transport often being denoted by different colours (see the Transport for London Journey Planner, URL 11). Interactivity offers the opportunity to highlight or dim parts of the map when the mouse is held over certain features.

Only one map (Figure 12) did not employ colour to illustrate GPTI, instead using shades of grey to differentiate between routes. This may have been an artistic decision, using black and white to reinforce the fact these are night services, but otherwise there would be little reason (aesthetically or technically) not to use colour.

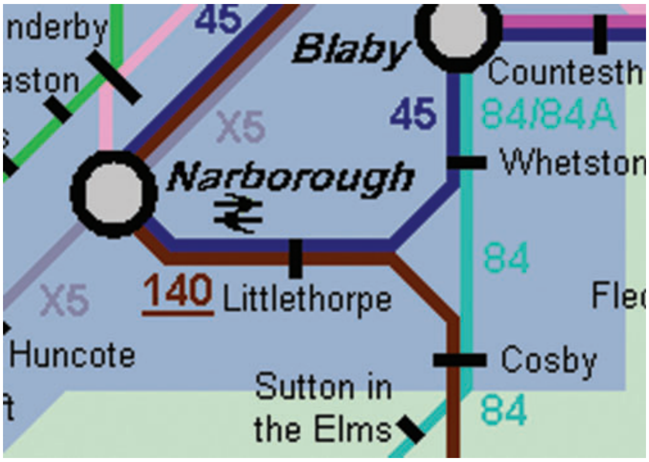

Figure 10. Poor use of background colour (URL 9). Extract reproduced with permission of Leicestershire County Council

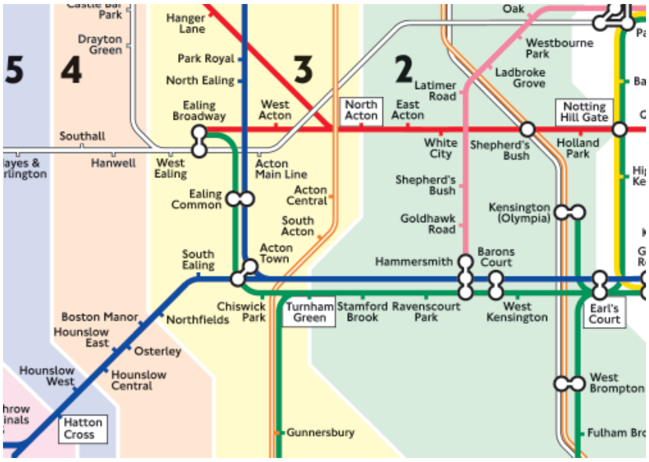

Figure 11. Good use of background colour (URL 10). Extract reproduced with permission, © Transport for London

Symbology

Route lines may be varied in thickness or style to show different properties; this is often done in conjunction with different colours to increase the number of line styles.

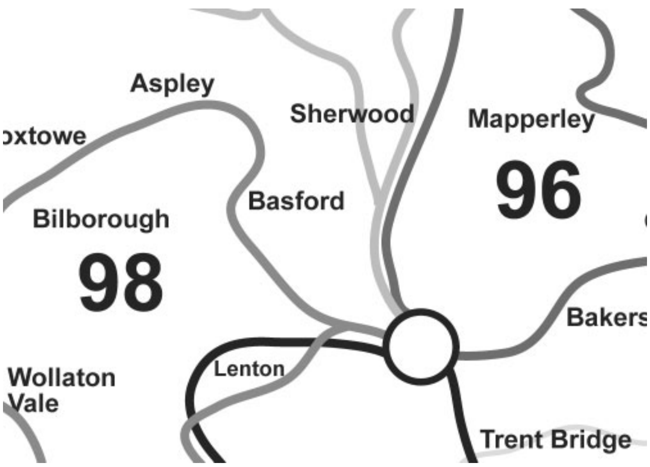

Figure 12. Monochrome map (URL 12). Extract reproduced with permission of Nottingham City Transport

Figure 13. Use of symbology for service variations (URL 14). Extract reproduced with permission of FWT and the City & County of Swansea

Slight variations on a bus route are sometimes shown as dashed lines (URL 13). Routes where services are less frequent may be represented as 'hollow' lines, having a thickness and casing colour the same as regular lines, for example in Figure 13. One other use of line thickness encountered by the author (outside this study) is as a guide to service frequency, where roads carrying more buses are portrayed by a thicker line (Figure 14).

On schematic maps, stops or stations are sometimes shown by small circles within the line (see Figure 15) or more commonly as protrusions from the line (Figure 16), with circles representing interchange points. However, when a non-schematic map (e.g. URL 18) uses these interchange circles at main junctions, the interruption can make it hard to follow the path of a particular route.

If shown at all on bus-orientated maps, railways are generally represented by thin black lines. The Transport for London network map (Figure 17) presents train lines in white with a black casing, and the Tramlink as a patterned line, to make them distinct from the solid smooth lines of tube routes. The National Rail network map (URL 19) uses

Figure 14. Use of line thickness as a guide to service frequency (URL 15). Extract reproduced with permission of First in Glasgow

Figure 15. Use of symbology for bus stops (URL 16). Extract reproduced with permission, © Transport for London

Figure 16. Use of symbology for bus stops (URL 17). Extract reproduced with permission of Brighton & Hove Bus and Coach Company Ltd

two thicknesses of line: wide for principal routes and narrow for other selected railway lines.

Clicking some interactive maps will activate further detail, for example on some aeroplane maps this will extend

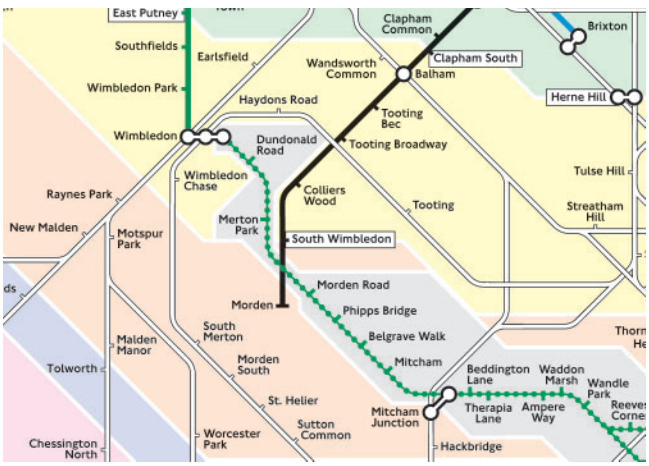

Figure 17. Use of line symbology (URL 10). Extract reproduced with permission, © Transport for London

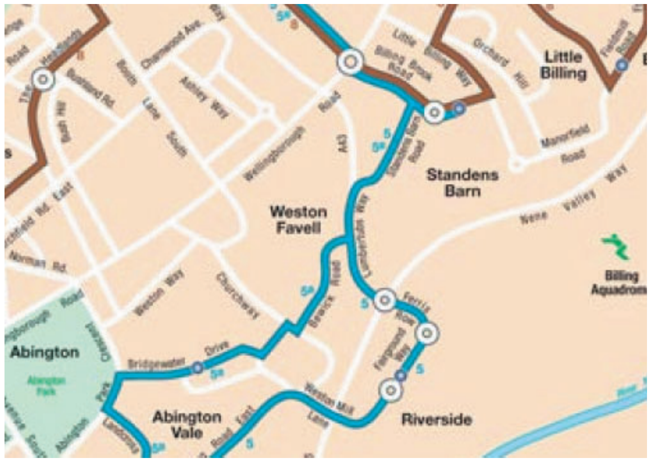

Figure 18. Illegibility of annotation (URL 22). Extract reproduced with permission of FirstGroup plc

Figure 19. Lack of annotation (URL 23). Extract reproduced with permission of trent barton

lines from an airport to the destinations served by each operator. A live rail map (URL 20) has stations indicated by yellow pins and trains by red ones, with each being clickable for further information. On the Ipswich Buses website (URL 21), moving symbols (bus numbers) travel up and down the extent of the route. These are not particularly useful, but as an interesting feature of the website they may help attract users.

A number of additional symbols are sometimes used on PTI maps, for example to represent connections with other modes, or the availability of park and ride schemes or cycle lockers. On some journey planner outputs, numbered dots show where a change in service or mode of travel needs to be made.

Annotation

Many well-annotated maps were found, but several others would have scored higher if the text had been more legible – for example the First bus map in Figure 18; presumably distortion occurred during compression of the image for use on the Internet.

On some maps delivered in Flash or PDF formats, which have a magnification capability, names are sometimes so

Figure 20. Poor name placement (URL 24). Extract reproduced with permission of Citylink

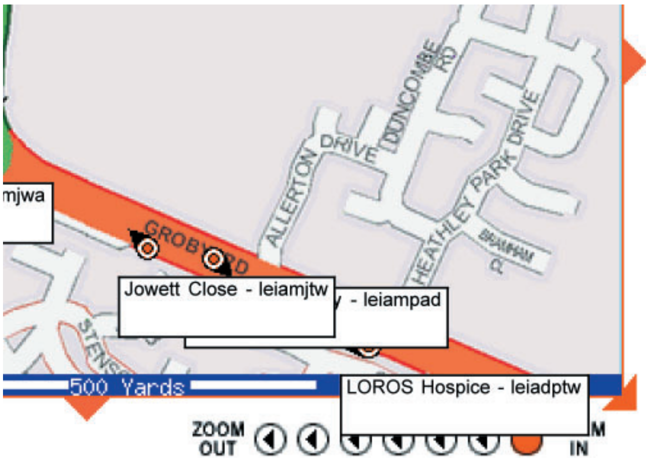

Figure 21. Poor name placement (URL 25). Extract reproduced with permission of Leicester City Council

small as to require zooming in two or three levels to read them – coming at the expense of being able to see the bigger picture.

Single-route bus maps often showed only a limited amount of surrounding information or none at all which might make it hard for a user, especially if they are unfamiliar with the area, to put the route into context. Maps such as Figure 19 show some roads crossing the route but they are mostly unnamed and would not appear to be very useful for orientation purposes.

The annotation of schematic maps was found to be more limited as they were usually simpler and of a smaller-scale, with text often restricted to town or node names.

Name placement

While name placement on the majority of maps was acceptable, some are poorly designed in this respect. This often occurs when text has been superimposed on a generic existing map, obscuring some of the detail underneath. Sometimes there is too much conflict with underlying detail, a lack of clarity regarding where the annotation refers to (Figure 20), or names are cropped by the edge of the map. Customised maps are the worst offenders, some of the software used being seemingly unable to resolve name position conflicts (e.g. Figure 21).

Marginalia

The inclusion and quality of marginalia (including a title, legend and scale bar) was the worst-rated of the eleven design elements. Around a third of maps rated 1 out of 5, mostly because little or no marginalia was present. Certainly, a scale bar would seem to be a necessity on maps with an analogue geographic representation, while an explanation of colours or symbols on some would ease comprehension.

However, it could be argued that the use of full marginalia is not always strictly necessary, particularly for schematic maps to which a scale bar and north arrow would not be applicable. Also, symbology may be quite limited and self-explanatory, negating the need for a legend; in these respects, the rating for some maps may be a little harsh.

Web functionality

Size of map window

Where the size of the map window on a Web page was too small, this meant that much panning was needed or that it was often difficult to see a large enough area; bus and train maps on the websites of the operator First were notably awkward in this respect. Alternatively, if the map was too big, it may have been necessary to scroll the whole page. This was not as important for PDF files, which were easy to zoom and pan.

Hard copy output

Many Web maps are not designed with printing in mind, yet this remains common practice with some users. A common problem is that the map (particularly when in PDF form) is too large to fit on a sheet of A4 paper, so it either needs to be shrunk to fit – often becoming illegible – or be cropped. It is awkward in applications such as Adobe Acrobat to print one page of a PDF over several sheets. Sometimes detail shown on-screen is missing on the hard copy, this being particularly common with Flash maps. In only a few cases was an alternative 'printable' version of a map made available.

Legibility for users with visual impairment

Evaluation of this element fell mostly into one of either extreme. More than a third of maps studied were not enlargeable, including all those in the GIF or JPEG format, while 53% (mostly PDF maps) achieved the highest rating by offering increased resolution when they were enlarged. Many of the Flash maps studied scored poorly in this case, as the facility to zoom (through the right mouse click) might not be apparent to users unfamiliar with this software.

It should be noted that users with poor eyesight might already have altered their VDU settings to enlarge everything, so for them some maps may still be legible. However, in some computing environments, such as on a public library terminal, it may not be possible to customise settings.

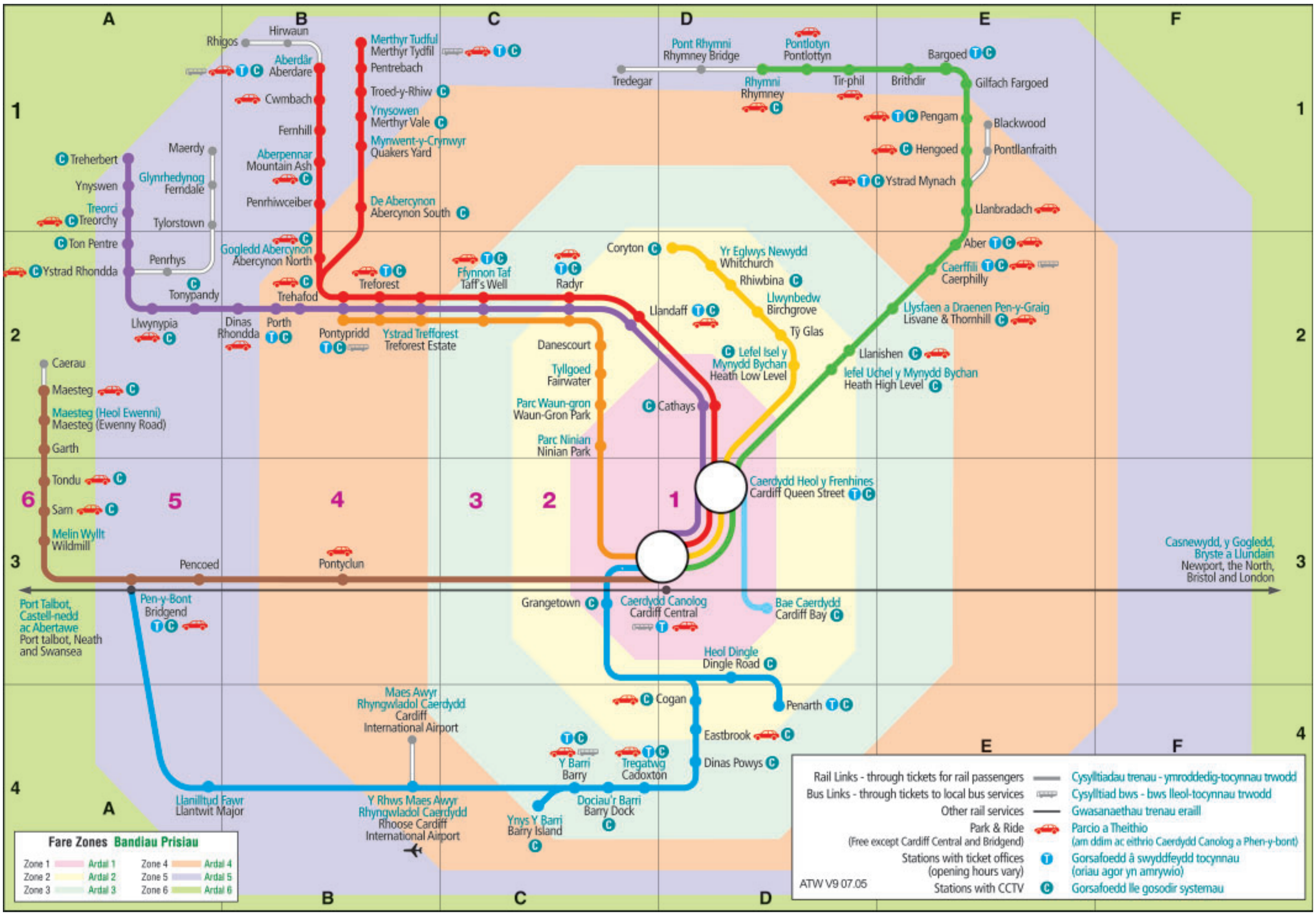

Figure 22. Excellent fitness for purpose (URL 26). Extract reproduced with permission of Arriva Trains Wales

Requirement for additional software

Some users may be using a dial-up Internet connection, an outdated operating system which will not allow them to run certain software, or public terminals (e.g. in libraries) where software downloads are not permitted, making some maps inaccessible.

Over a third of maps were found to need no software additional to that of a standard browser to run, these being in the JPEG, GIF or PNG format. Those requiring commonly used, free software such as Adobe Acrobat (for PDFs) accounted for a further 45%, making the vast majority of maps easy to access for most users. 15%, however, used more advanced plug-ins such as Flash which, although still free and readily available, may not be compatible with some older computers.

Time taken to download on a standard home broadband connection

Download time was <10 s for 85% of the maps, half of these becoming viewable within only 3 s of requesting. However, a small number (all PDFs) were found to take more than 30 s to download; on a dial-up modem these may take such a long time that the user may give up and continue searching elsewhere.

It was noted that PDF files containing raster information were slower to load than those which were primarily vector-based, such as simple schematic maps. Sometimes maps were hidden within larger documents, the file size of which may discourage downloading.

Overall fitness for purpose

The best maps in this category were those which provided a good deal of insight, showing other information such as service frequency in addition to route plans. Figure 22 is a good example as it shows the extent of fare zones, without distracting from the main focus of the map – the transport network.

Overall Web map design scores

Of the top ten maps, nine were created in the 'French style' and they were split evenly between schematic and analogue geographic representations. Six of the top ten were created by cartographers of FWT, a company who specialise in public transport information publicity. However, some well-designed maps were let down by being poorly presented in small windows and with low resolution.

The best overall score, 48 out of a possible 55, was achieved by four maps: two for Transport for London (see Figures 11/17 and 15), one for First bus in Leicestershire (see Figure 8) and one for Arriva bus in Glasgow (see Figure 9).

GUIDELINES FOR GOOD PRACTICE

Both good and bad practices on PTI websites were observed during the course of this study. It is evident that the needs and access conditions of the user are not always given sufficient attention. Some guidelines for the effective presentation of public transport maps on the Web are offered below.

Cartographic design

Colour should always be used, to maximise both the amount of information held and the clarity of its communication. Contrast between colours may need to be greater on Web maps than on printed products as such differences are harder to discern on screen. Background and secondary detail should be muted in colour so it does not conflict with route information, which should be presented in bright, bold colours. On interactive maps, this may be brightened when selected. Where no information is shown in the background, it should be white for maximum clarity and to minimise users' printing costs, or a printable version offered with a white or pale background.

Colour coordination of individual and network Web maps (and vehicle livery if possible) should be encouraged to establish a route's identity in the mind of the user. Where the choice is made to use a company colour scheme in PTI maps, this should not be at the expense of map clarity or usability. On classic style maps, road colour can be used to indicate service frequency (e.g. red = regular; green = less regular; grey = no service). This may also be reflected in the service numbers running alongside transport routes.

As with colour, symbols must be made bolder and more distinct for Web than paper maps. Resolution is much lower on screen so small differences between symbols may not easily be perceived. The use of different line styles such as dashed, dotted or hollow lines can show additional information like route variations or different operators. Line thickness can be used hierarchically to represent variables such as service frequency or to distinguish between modes of transport – railways on multi-modal maps are conventionally shown as thinner black lines. Casing all routes on a map should generally be avoided, as this can lessen the contrast between different coloured lines.

Lines on schematic diagrams should flow smoothly and follow an established set of possible orientations, such as: horizontal, vertical and 45°. Interactive or animated maps may wish to make use of extending lines to indicate direction of travel, or moving symbols for real-time displays to show a vehicle's location on the network. Such features must enhance the information communicated, not distract from it.

Annotation of PTI maps should be sufficient for users to establish the route of a public transport service to their satisfaction. For bus journeys, this is particularly important as the traveller needs to know where to alight – the inclusion of several road names and/or landmarks may help in orientation. This level of detail is not always possible on schematic maps, which are often too simplified to successfully convey bus route information.

Regardless of the degree of annotation used, text on maps must be clearly legible. If no zooming facility is available, font size must be large enough to read clearly; if there *is* to be a zoom function, legibility should still be achievable within two magnifications, to safeguard against user resistance. If map files are compressed or manipulated before going online, checks should be made to ensure that image resolution has not been decreased to the extent of text becoming distorted.

Standard cartographic practice should be followed for the placement of names, with particular attention paid to avoiding ambiguity. The functionality of custom-mapping programs should be sufficiently advanced to satisfactorily resolve name position conflicts.

All non-schematic maps should be accompanied by a scale bar, particularly at larger scales where there is little supporting information to guide the user. It should be made clear to users that schematic maps are not to scale. North arrows are less essential unless the data has been rotated; users will generally assume 'up' equals 'North'. On-map titles are preferable so that these may be retained when only the map is saved or printed. Legends should be comprehensive as not all users may be familiar with symbolic conventions and should print with the map.

Web functionality

The map window should ideally be as large as possible while still fitting on a standard 800 by 600 pixel display. The need for excessive scrolling should be avoided.

Where a map will not print legibly on one sheet of A4 paper, without cropping, an alternative printing option should be made available. This may split the image over several sheets, if it is very detailed, and/or link to a simplified map that can be printed clearly in its entirety on one sheet. If an animated or Flash map has been used, a version of this suitable for printing should be offered. In any case, the inclusion of a 'Print Map' button, customised to only print relevant details in a suitable format, would be ideal. Marginalia should be included in the output, while large blocks of solid colour should be avoided as the resulting increased print costs and potential distortion of the paper may discourage use of the information.

Maps should either be very clear with detail large enough for users with visual impairment, or an option should be provided to view the image at a larger scale. PDF files will have a zooming function already available, but larger versions of GIF and JPEG maps may need to be produced, at a suitable resolution. Where maps can be magnified, this function should be clearly shown by an obvious symbol or instructions next to the map window.

Any additional software required to view maps should be free and easily downloadable, for which instructions should always be given. File formats should be restricted to those most commonly used, e.g. JPEG, GIF, PNG, PDF (used by Adobe Acrobat) and SWF (used by Adobe Flash). If advanced software such as Flash is required, there should be a simpler map provided for computers which may not support this.

Map file size should be kept to a reasonable level in order that download times do not exceed 10 s for broadband or 30 s for a dial-up connection. If file size cannot be reduced, a simpler and quicker to load alternative map should be made available. In no circumstances, however, should attempts to minimise file size cause the image to become illegible; changes in font size or the degree of contrast in the map could help maintain clarity. If maps are included as part of a large PDF document, they should also be accessible individually, so that they are quicker to download. PDFs should keep raster information to a minimum, as this greatly increases file size.

Overall fitness for purpose

When adding maps, PTI website designers should keep in mind their aims and market audience – i.e. to present clear, up-to-date, useful information to users, or potential users, of their public transport services. Maps must be easy to use and in a format accessible to all. User testing should be employed as part of any major redesign and a facility made available for customers to submit feedback on an ongoing basis. Local knowledge could be incorporated where applicable, so that the information best fits the needs of users.

FURTHER RESEARCH AND THE FUTURE

The methodology established in this project could be applied elsewhere – to survey GPTI for other countries or across Europe, for example, or to make a further UK study in the future, to establish any changes in the provision of GPTI and any improvement in the quality of PTI Web maps. An exhaustive search could be made of the GPTI available on the Web for a particular area, to assess whether or not it was sufficient. A survey of the requirements of people who use public transport maps on the Web could be conducted, and websites tested on such users, with feedback incorporated into map design.

As technology advances, the format of GPTI will surely develop. More information will become available on mobile devices and less use be made of printed versions. Faster connections, greater memory capacity and better software will continue to increase interactivity. The challenge for the producers of GPTI is to continue to provide information in a relevant manner, up to the level of their customers' expectations and requirements. Newer elements such as animation and sound may become integral parts of future map use – and cartographers should be involved to ensure this information is visualised effectively.

CONCLUSIONS

The primary purpose of public transport websites and Web maps is to provide information to users of public transport. These users cover the whole socio-economic spectrum so it is imperative that access to information is not denied or unfairly impaired as a result of differing technical conditions. Web map creators should keep in mind the purpose of each map, ensuring this is communicated clearly, while website developers should ensure that they are presented in a user-friendly manner. Unless this is done the user will be unable to make effective use of the information.

BIOGRAPHICAL NOTES

Robin Scrimgeour graduated with a BSc degree in Geography with French from the University of St Andrews in 1999. In 2006, he completed a postgraduate course at the University of Glasgow – obtaining the MSc degree in Geo-information Technology & Cartography. This paper is a summary of research carried out for his MSc thesis. Since 2006, Robin has worked as a cartographer for HarperCollinsPublishers in Glasgow. His professional interests include public transport maps and the application of cartography in modern technology, in particular web map design.

PUBLIC TRANSPORT INFORMATION WEBSITES: URLs CITED

URL 1: Transport for London, <http://www.tfl.gov.uk> (last accessed 31/01/2008)

URL 2: Transport Direct, <http://www.transportdirect.info> (last accessed 31/01/2008)

URL 3: Cumbria County Council: Map of Bus Services, <http://www.cumbria.gov.uk/roads-transport/publictransport/busserv/busservmap.asp> (last accessed 31/01/2008)

URL 4: The Greater London Bus Map, <http://www.busmap.org/downloads/No29Page%202.pdf> (last accessed 27/01/2008)

URL 5: Cambridgeshire County Council: Cambridge Passenger Transport, <http://www.cambridgeshire.gov.uk/NR/rdonlyres/B0CCCADF-EFC9-4EE3-A5FE-BAFD-9471093A/0/CambridgeCity.pdf> (last accessed 27/01/2008)

URL 6: City & County of Swansea: Bus Services in Gower, p.2 of <http://www.swansea.gov.uk/media/pdf/2/h/Gower_Bus_Srvcs_TT_Bklt.pdf> (last accessed 27/01/2008)

URL 7: First Traveller – Bus: Leicester Network Diagram, <http://www.firstgroup.com/ukbus/eastmidlands/leicester/map/LeicesterNetwork.pdf> (last accessed 27/01/2008)

URL 8: Arriva: Glasgow Bus Network Map, <http://www.arrivabus.co.uk/__80256E280053B5B6.nsf/vWeb/flDNOS65CHAS/$File/ASW%20Ntwrk%20Dgm.pdf> (last accessed 27/01/2008)

URL 9: Leicestershire County Council: Map showing bus routes in Leicestershire, <http://www.leicestershire.gov.uk/bus_map_04.gif> (last accessed 27/01/2008)

URL 10: Transport for London: Tube, DLR, Trams and Train Travelcard zones map, <http://www.tfl.gov.uk/assets/downloads/Tube-DLR-Trams-and-Train-Travelcard-zones-Map.pdf> (last accessed 31/01/2008)

URL 11: Transport for London: Journey Planner, <http://www.tfl.gov.uk/journeyplanner> (last accessed 2006, design since revised)

URL 12: Nottingham City Transport: NightRider services, <http://www.nctx.co.uk/Timetables/July%202005%20StickMaps/NightRider.pdf> (last accessed 27/01/2008)

URL 13: Eastbourne Buses: Route 3 Map, <http://www.eastbournebuses.co.uk/pdf/route3map.pdf> (last accessed 2006; no longer available online)

URL 14: City & County of Swansea: Bus Services in Lliw, p.2 of <http://www.swansea.gov.uk/media/pdf/6/o/North_Swansea_Cvr.pdf> (last accessed 27/01/2008)

URL 15: First Group – UK bus: Greater Glasgow Network Map, <http://www.firstgroup.com/ukbus/scotland/swscot/map/mapmate8sideA.pdf> (last accessed 2006, this design no longer available online)

URL 16: Transport for London: Buses from South Croydon, <http://www.tfl.gov.uk/tfl/gettingaround/maps/buses/pdf/southcroydon-10301.pdf> (last accessed 31/01/2008)

URL 17: Brighton & Hove Bus and Coach Company: Metro Bus Routes, <http://www.buses.co.uk/metro/metromap.pdf> (last accessed 2006; no longer available online)

URL 18: Eastbourne Buses: Local Services, <http://www.eastbournebuses.co.uk/pdf/ebmap.pdf> (last accessed 2006, revised version at <http://www.eastbournebuses.co.uk/pdf/ebmap0907.pdf>)

URL 19: National Rail Enquiries: National Rail Map (schematic), <http://www.nationalrail.co.uk/system/galleries/download/print_maps/NationalRailSchematicMap.pdf> (last accessed 27/01/2008)

URL 20: Live train map for Glasgow Central, <http://www.traintimes.org.uk/map/> (last accessed 27/1/2008)

URL 21: Ipswich Buses: Interactive Detail Map: Service 7, via <http://www.ipswichbuses.co.uk/mapdetail.html> (last accessed 27/01/2008)

URL 22: First Traveller – Bus: Northampton Network Diagram, <http://www.firstgroup.com/ukbus/eastmidlands/northampton/map/mapindex.php> (last accessed 2006, this version no longer available online)

URL 23: Trent Barton Bus Services: Rainbow 2 route map, <http://www.trentbarton.co.uk/timetables/maps/images/r2route.gif> (last accessed 27/01/2008)

URL 24: Citylink bus and coach travel: Network Map, <http://www.citylink.co.uk/images/maps/map-2004.gif> (last accessed 27/01/2008)

URL 25: Star Trak: Find a Bus Stop for Route 27, <http://www.star-trak.co.uk/controller/clickPanZoomAction?route=27&height=300&width=500&xmin=453356&xmax=456645&ymin=305014&ymax=306987&scale=10000&routeMapImage.x=410&routeMapImage.y=68> (last accessed 27/01/2008)

URL 26: Arriva Trains Wales: Zonal Map, via <http://www.arrivatrainswales.co.uk/Route_Map.aspx> (last accessed 27/01/2008)

REFERENCES

Arleth, M. and Campagna, M. (2005) 'Accessibility of GI for Public Participation: a Danish–Italian comparative study'. **Proceedings of the 8th AGILE Conference on GIS**, Estoril, Portugal, May 2005.

de Róiste, M. (2006) 'Evaluating, Classifying and Comparing GI Applications in Irish Planning Authorities'. **Proceedings of the GIS Research UK 14th Annual Conference**, Nottingham, April 2006. pp. 280–284.

Dogpile (2006) Dogpile Web Search Home Page, http://www.dogpile.co.uk (dated 2006, last accessed 29/6/06)

ILT – The Institute of Logistics and Transport (1999) Netting More Passengers: The fundamentals of travel information on the Web. Proceedings of the workshop organised by the Chartered Institute of Transport, May 1999, http://www.trg.soton.ac.uk/news-features/ilt-web/report.pdf (last accessed 20/02/06)

ITS – Intelligent Transportation Systems, US Department of Transportation (2002) Usability Guidelines for Transit Web Sites, http://www.its.dot.gov/transit_dev/guidelines/main.asp (last accessed 20/02/06)

Kenyon, S., Lyons, G. and Austin, J. (2001). **Public Transport Information Websites: How to Get It Right. A Best Practice Guide.** London: The Institute of Logistics and Transport (http://www.trg.soton.ac.uk/bpg/).

Lyons, G. (2001) 'Towards integrated traveller information.' **Transport Reviews**, 21(2). 217–235.

Lyons, G. (2002) 'Internet: investigating new technology's evolving role, nature and effects on transport.' **Transport Policy**, 9(4), 335–346.

Mooney, P. and Winstanley, A. (2001) 'Cognitive Issues for Human Readers: Internet-based Transport maps.' **GIM International**, 15(8), 13–15.

Mooney, P. and Winstanley, A. (2003) 'Mapping and Internet Based Public Transport Journey Planning and Information Systems.' In: Peterson, M. (ed) **Maps and the Internet.** Amsterdam: Elsevier.

Morrison, A. (1996) 'Public Transport maps in Western European cities'. **Cartographic Journal**, 33. 93–110.

Morrison, A. (2007) 'The geospatial content of public transport websites for 60 localities worldwide', **Journal of Maps**, 2007, 1–19.

National Statistics Online (2005) Local authority key statistics: population and vital statistics, http://www.statistics.gov.uk/downloads/theme_population/regional_snapshot/LA_KeyStats_population.xls (dated 5/5/05, last accessed 22/6/06)

Random.org (2002) Random sequence generator, http://www.random.org/sform.html (dated Jan 2002, last accessed 28/6/06).

Scrimgeour, R. (2006) Conveying Geospatial Public Transport Information on the World-Wide Web. Unpublished MSc thesis, University of Glasgow.