THE DESIGN AND APPLICATIONS OF THE STOP-SPECIFIC BUS MAP

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Abstract

In the United Kingdom, there has been a significant increase in car usage mirrored by a significant decrease in Public Transport usage since the 1970s: today, over 85% of all passenger kilometres travelled in the United Kingdom are by car. This over-reliance on the car has given rise to serious levels of congestion and its associated socio-economic and environmental effects. With the passing of the Transport Act in 2000, there have been many Government-led initiatives to reverse this imbalance by reducing the reliance on the car whilst improving and promoting Public Transport (and other modes) as an attractive and viable alternative.

There are many potential factors that can influence the modal choice of the traveller, one of these being the level and quality of information that is made available to the public about the Public Transport services on offer in an area. However, the main focus of information provision has primarily been on timetabling i.e. **when** a service is due, especially with the recent developments in the provision of real-time departure information, as opposed to providing mapping i.e. to **where** a service is actually travelling.

When planning a bus journey, a typical network map (one showing the routes of all bus services within an area) provides travellers with a large amount of information, most of which is not relevant to the journey they are intending to make. The main objective of this research was to investigate the potential of the Stop-Specific Bus Map (SSBM) concept, as originally proposed by Dr. Alastair Morrison. SSBMs are designed to simplify existing network map information by only showing onward portions of routes

of the bus services which call at an individual bus stop. Previous sections of the calling services are omitted, as it is not possible to travel to these destinations from the stop. The same omission condition applies to those services passing by, but not calling at the stop, including those services calling at other bus stops in the vicinity of the stop in question.

The main feature of a SSBM is that it explicitly tells the passenger where they can travel to using **only the services calling at that particular stop**. This is especially beneficial where there are a number of possible services that can be used to reach the desired destination, as the passenger may not be aware of all the possibilities. A further objective of this research was to ascertain whether this new kind of mapping can actually simplify the planning process involved when travelling by bus, making it easier for the passenger to understand which services go where. It is hoped that by increasing the level of understanding about where bus services operate, and not just those services an individual is familiar with, there is potential for encouraging people to make journeys by bus which may have previously been made using the car, with the added socio-economic and environmental benefits this modal shift could bring.

It is important to note that SSBMs are not intended to completely replace existing network mapping, but to complement them instead. As each SSBM is designed to only be displayed and used at the relevant stop, a unique map would be required for each bus stop, and so only one copy of each map would be produced. If SSBMs were to become a feature at every bus stop, an automated system will be essential to make the overall process efficient and economically viable. However, the purpose of this research was to identify how easy it would be to develop SSBMs on a *manual* basis, and then to test their effectiveness compared to existing forms of bus information (timetables and maps) for journey planning.

A cartographic design flowline was developed using route data captured in ArcGIS which was exported to CorelDraw for the final cartographic editing and production. User tests were then conducted at a range of bus stops in Cambridge, Edinburgh, Glasgow and York. The results of the user testing show significant potential for the SSBM concept, as the maps assisted users in finding a greater proportion of correct answers and faster response times compared to the existing forms of Public Transport Information. Users also felt more confident when using the SSBMs and as a result, said they would consider increasing their frequency of bus use in the future. It is hoped that the results of this study will add weight to the argument for the development of a system to automatically generate SSBMs.

1. Introduction

Since the 1970s, car use and car dependence have significantly increased whilst Public Transport patronage has significantly decreased. An over-reliance upon our cars has given rise to greater congestion on our roads with associated socio-economic and environmental impacts, such as poorer health conditions due to higher pollution levels, or a downturn in working efficiency due to extended traffic delays. It was recognised in the late 1990s that a shift in public attitudes towards how we travel was necessary in order to prevent the road network from reaching total saturation. Transport legislation in the 21st Century has placed a greater emphasis upon investing in the national Public Transport networks to encourage greater use of these modes and reduce reliance upon the car. A range of incentives have since been introduced to encourage people to make more journeys by Public Transport but one question has been generally overlooked:

> Do people refrain from travelling by Public Transport because they have limited knowledge of the services available?
>
> (Lodden, 2002, p.24)

Naturally, maps are the best form of information for those wanting to identify *where* services go and are essential when planning a journey. However, many existing maps show an entire network and whilst such maps can be useful for providing an overview of the services which exist in an area, they provide the user with a substantial amount of information that could be considered redundant when planning a specific journey. To provide users with a ‘legible’ bus system (Bartram, 1984) it is important to present users with information that is relevant to each stage of the ‘Journey Chain’ (Caiafa and Tyler, 2002). Today, we see examples of mapping which attempt to meet these requirements by representing individual components of the whole network, either for a local area (for example, ‘SpiderMaps’ produced by Transport for London), an individual route (often to accompany a corresponding timetable booklet) or even an individual bus stop – the Stop-Specific Bus Map (SSBM).

2. Existing Design Guidelines

> Nearly any reasonably executed map can be read with some degree of success but cartographers should not settle for that. As designers of functional products one of our chief goals should be to make them work as efficiently as possible, a task which requires that extra bit of effort, care, and concern for the user
>
> (Delucia, 1979, p.179)

Delucia’s statement highlights one of the main challenges of cartographic design: designing a map that is functional, yet aesthetically pleasing, is by no means a simple task. There have been many attempts to produce design guidelines for Public Transport information; some have specific sections on the design of network maps (DfT, 1996; Higgins and Koppa, 1999; Denmark, 2000; Cain *et al*, 2008). Avelar and Hurni (2006) and Avelar (2008) have investigated the specific design issues surrounding *schematic* Public Transport maps which, as argued by Morrison (1996a), are not usually suited for the representation of bus networks in relation to a user’s cognitive map.

For the production of SSBMs, Morrison (unpublished) has developed a general specification to be implemented in any software program which has graphical capabilities and programmable functions. This specification has been used to guide the *manual* production of the SSBMs, along with the findings and recommendations from the above design guidelines where appropriate.

3. Design Flowline

SSBMs exist in a number of cities (London, Edinburgh and Dundee) but are of a highly schematic nature. It was felt that to align the information on the SSBMs with users' cognitive maps of the surrounding area and of the bus network, it was important to design SSBMs that were geographically true. An outline of each task in the design flowline is given below.

Task 1. Define Map Dimensions and Background Attributes

An A4 map layout was created in CorelDraw9 (CD9) with a title frame of 19.5 × 3.0 cm and a map frame of 19.5 × 24.75 cm, although this amount of space may not be available within bus stop display cases. Morrison (1996a) discusses the various possibilities for selecting a suitable background colour with the default being a light grey. However, a very pale yellow (CMYK: 0/0/7/0) was used instead as this gave the subtle impression of a background whilst allowing greys to be used for the roads and railways.

Task 2. Data Compilation

The required shapefiles were compiled in a single Layout View of ArcMap 9.2 (AM9.2), with the orientation set according to the general direction of travel of the bus services after calling at the stop (portrait for North-South, landscape for East-West). The data frame used to define the extent of the data to be exported was set to 19.0 × 24.0 cm (or 24.0 × 19.0 cm, depending on orientation), slightly smaller than the map frame used in the overall map layout, to allow for some flexibility when importing and positioning the data into the map frame in CD9.

Task 3. Define Extent of Data to be Exported

Depending on the number of calling services and the geographic extent of their forward-portions, there is the potential for any long distance services to extend far beyond the service area of the majority of services. One solution would be to adopt a scale factor that progressively reduces the scale as the distance from the bus stop increases, as applied to 'Octobus' maps (Morrison, 1996b).

However, the alternative solution proposed in Morrison's specification required any sections of route which extended far beyond the general service area to be truncated at an appropriate point, where a note in the margin names the eventual terminus point. This solution was implemented by visually inspecting the geographic extent of all services and then rescaling and repositioning the map within the data frame to cut off the outlying sections of a few routes.

Task 4. Transfer of Data between GIS and Graphics Software

When the final data extent was defined, the remaining data was exported in Adobe Illustrator (.ai) format and then imported into CD9, as there was no option for directly exporting from AM9.2 to CD9 (.cdr) files. Using the .ai file format meant that all the individual data layers were preserved, both during the export and the subsequent import into CD9.

Task 5. Alignment of Data in Map Frame

With the data in CD9, it was aligned and rotated to fit within the map frame so that the general directionality of the services ran up the map, following the 'forward-up equivalence' of Levine (1982). If a rotation was required, the degree of rotation was noted to allow for the correct orientation of a North arrow in due course.

Task 6. Grouping of Services

One of the key aspects of the SSBM concept is the use of groups of services to simplify the amount of information presented to the user. Morrison's specification outlines a detailed algorithm for assigning individual services to groups based upon their 'similarity' scores which is akin to a cluster analysis.

For this study, it was felt that this algorithm was too complex to be applied on a manual basis, and so the grouping was achieved by sketching out the approximate route of each service, noting the eventual terminus and sections of common route (Figure 1). From this, it was possible to develop a list of potential groups primarily based upon the proportions of common route, but also upon the general direction and eventual terminus of each service.

Task 7. Parallel Lines for Adjacent Service Groups

One complication identified in Morrison's specification is the production of multiple parallel curved lines, particularly where adjacent lines turn through angles between 90^o and 180^o. CD9 includes an offsetting tool which allows line segments to be shifted by a specified distance along both the *x*- and *y*-axis, but it quickly transpired that this was a very inefficient, time-consuming process.

Upon investigating and experimenting with additional tools available, it was discovered that the Contour tool could be applied to assist with the generation of very satisfactory multiple parallel lines, including along sections of common route with sharp bends and even complete loops (Figures 1 and 2). Although some post-Contour editing was required to assign different portions of the final parallel lines to the corresponding service group, this technique proved to be much more efficient than offsetting, once fully mastered.

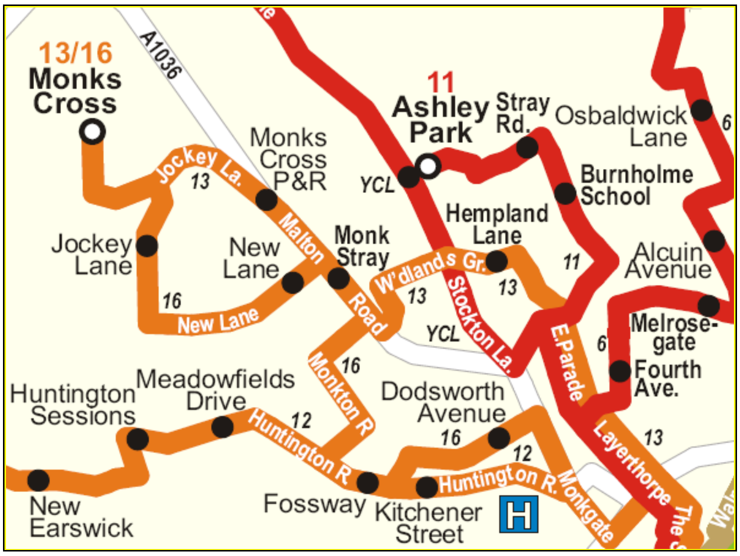

Figure 1 – Extract from a SSBM from York showing the grouping of five services into two service groups (Red – services 6 & 11; Orange – services 12, 13 & 16).

Figure 2 – Extract from a SSBM from Glasgow showing the edited parallel line output from the Contour Tool in CorelDraw9 and the assignment of colours to maximise the contrast between each service group.

Task 8. Assign Colour for each Service Group

The careful use of colour is essential for a successful SSBM. The specification identifies that nine is the maximum number of individual colours that can clearly be distinguished from each other when printed as thin lines (as often found on Public Transport maps), a notion supported by Higgins and Koppa (1999). In Public Transport systems, individual services are sometimes assigned a specific colour and Morrison's specification identifies that where a colour is associated with a specific service, it should be considered in the overall decision process. This then raises the problem of assigning a specific colour to a service group which contains two or more individual services, each having its own associated colour. One possible solution that was implemented was assigning each group with the colour of the service that can be considered as the dominant service of that particular group, defined as the service with the greatest proportion of common route with all other services in the group. Where it was not possible to define a dominant service, colours were assigned to maximise the contrast between each group as defined in Morrison's specification (Figure 2).

Task 9. Define the Road Network to be Shown

The specification identifies three possible types of road:

1. Bus road – followed by at least one bus service on the current SSBM

2. Non-bus road – does not have any bus services
3. Non-bus road (current map) – a road which does have bus services, none of which operate from the particular stop in question.

The distinction between road categories 2 and 3 would be useful if numerous SSBMs were being made from the same network data, but was not made for these maps because each was designed separately. All 'bus roads' were of course shown, whilst 'non-bus roads' included most of the A and B roads which intersect the bus roads plus some minor roads that provide useful links between different bus roads. In addition to these, well-known A and B roads and motorways that are not close to the bus routes were included for orientation purposes.

Task 10. Selecting Bus Stops and Other Point Features

Point symbols were placed on the SSBMs to depict and distinguish service termini, bus stops (Figure 3) and other important locations *en route* which would assist users when following the route of each service on the SSBM. The inclusion of termini was mandatory and took highest priority of all point features. For the remaining point features, Morrison's specification gives priority to places which are well-known and easy to define, such as named road junctions and public buildings. However to allow the information presented on a SSBM to be easily related to the corresponding timetables, it was decided that the highest priority for placing *en route* point symbols would go to timing point bus stops, followed by additional key places along each route.

Figure 3 – Extract from a SSBM from Glasgow showing point symbols used to represent both service termini and bus stops, and their compatibility.

The key to the overall process was obtaining a suitable balance between the aesthetic quality of the SSBM and the amount of information provided. It was important not to overload the SSBMs with too many bus stops as this could potentially increase the overall search time required, but providing little information would clearly not be of great help to the user.

Task 11. Text Features and Final Touches

Perhaps the most important attribute to consider here is the type size, as the use of small type sizes is one of the most common complaints relating to information design amongst Public Transport users (Cain *et al*, 2008), but space on a map face is limited and this usually has an impact on the type size that can be used. The majority of guidelines for printed information (including maps) recommend a minimum type size of 10 point, but Cain does concede that it is often not possible to fit 10 point lettering into the limited space available on maps, and proposes a minimum type size of 8 point.

Where possible, the general rule of not going below the minimum 8 point type size was adhered to, but there were some situations where this simply was not practical or feasible. Placement of the text on the map face followed the standard cartographic procedures, such as relative positioning, avoiding conflict between features and not printing text over lines unless absolutely unavoidable.

With all the text correctly positioned, the final stage of the cartographic editing was the addition of the legend features, other information such as a 'You Are Here' arrow (Figure 2), the date of printing and a North Arrow, which was rotated if necessary, based upon the rotation applied to the initial data when first imported into CD9.

4. Conclusions

This research has demonstrated that SSBMs can successfully be designed on a manual basis using the flowline outlined above. Maps were developed for a variety of bus stops, each having different characteristics, for four towns within the UK. The time taken to produce some of the more complex SSBMs has highlighted just how important the development of an automated system could be, specific actions where automation would be particularly beneficial include assigning each service to a particular group based on their attributes, creating parallel lines for different service groups running along lengthy and/or sinuous sections of common route, and the placement of names and other text features along lines.

With regard to the testing of the SSBMs, every effort was made to ensure that a balanced, representative sample of the population was involved in the tests. To fully understand and quantify the true benefits of the SSBMs, it would be worthwhile to display SSBMs at as many bus stops as possible and monitor their impacts over a longer period of time. Nevertheless, the results were encouraging and clearly show the potential of the SSBM concept. Compared to existing forms of information (network maps and timetables) respondents were able to find a greater proportion of correct answers for a given journey planning task, in a much shorter period of time. These findings provide some motivation for the further development of the SSBM concept.

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