Spider Maps: A Summary of Best Practices and Guide to Design

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ABSTRACT

System transit maps are useful for riders to navigate from station to station, but give little direction about the area within walking distance of stations. Spider Maps include a map that simplifies transfers and walking maps that provide clear direction for riders leaving transit stations. Some transit agencies have implemented Spider Maps at select stations, but there are no clear procedures for their design. The purpose of this research is to provide guidance for transit agencies to create Spider Maps and increase rider understanding of station connections and the surrounding areas. This was accomplished by researching transit agencies that have produced and currently display Spider Maps and both in stations and online. These maps helped determine innovative Spider Map design methodologies. In addition to examining existing Spider Maps, a comprehensive literature review on map design contributed to a guide of effective Spider Map design. Using MARTA in Atlanta as a case study, these effective design methods were used to create a model that automatically generated Spider Maps for each MARTA station. In addition to paper maps, this process yielded an interactive web application for riders to view the MARTA Spider Maps online, to assist in trip planning. This paper summarizes findings and makes recommendations for agencies who wish to pursue and design Spider Maps.
INTRODUCTION

System transit maps are important and useful because they help transit riders navigate from one point in the system to another with all possible routes shown. However, system maps give little direction for areas and destinations within walking distance of train stations and sometimes are too complicated to provide clear directions to transfer between modes if the system includes train and bus routes. Riders may know which train station to alight at, but may be unsure where to go from there, whether they are walking or transferring to a bus. To fill in this gap between stations and a rider's final destination, some agencies have used Spider Maps at train stations and/or online.

Spider Maps are maps specific to each train station. They show one train station in the center and all bus routes that connect to that particular station radiating outward. The shape of many bus routes coming from one origin somewhat resembles a spider, hence the name. Spider Maps have also come to include walking determine where they are and where everything is in relation to the station. Spider Maps provide clear direction for riders leaving train stations and orient riders to their surroundings and transit connections to other modes.

The three main goals of this project are to:

1. Identify best practices in Spider Map design,
2. Create a reproducible model that will automate creation of Spider Maps for transit agencies,
3. Create a reproducible, interactive Spider Map web application that transit agencies can replicate.

Spider Maps add understanding of the connections and surroundings of a station, which can be helpful to riders. Because of these maps provide a benefit to riders, the team will provide the model and web application open source for transit agencies to develop their own Spider Maps.

The team selected the Metropolitan Atlanta Regional Transit Authority (MARTA) in Atlanta as a case study because the bus system is largely a feeder system for the rail system, which translates well for Spider Maps. Using research on effective map designs, recommendations from blogs by transit mapping experts, and existing Spider Maps, the project team created both paper Spider Maps for all MARTA Transit Stations as well as a Spider Map web application. In addition to the maps for MARTA, the recommendations include a guide that other agencies can use to produce effective Spider Maps.

SPIDER MAP OVERVIEW AND BACKGROUND

To best understand Spider Maps, it is important to understand the discussions and relevant research. Spider Maps have been designed both schematically and geographically and have including multiple types of route information. This section gives an overview of relevant literature, popular transit blogs that discuss Spider Maps, and agencies that have Spider Map displays within their systems.

Relevant Research

There is very little scholarly research that has been performed specifically on Spider Maps. To create effective Spider Maps, research on general map design as well as walking area were consulted so that connecting and local areas can be displayed in a way that is easy for riders to understand.
Alasdair Cain, previously of the University of South Florida, performed extensive research on effective map design. He produced a guide entitled *Designing Printed Transit Information Materials*. Cain's document is a guidebook focused on the “design of hand-held, printed materials used to provide transit trip planning information for fixed bus services” (1). Cain addresses the discussion of schematic versus geographic maps. He states that both are acceptable mapping displays but that geographic displays are more flexible in what details can be included beyond the map (1).

A professional who addressed the effectiveness of schematic maps was Zhang Guo whose article *Mind the Map* discussed that while schematic representations of transit systems can effectively make maps easier to understand and more visually pleasing, there are some issues. Guo identified multiple locations in the London Underground Map where train station locations were not appropriately placed and indicate that someone could easily walk between two stations when the distance is actually quite far (2). While schematic maps are acceptable, it is important to provide some type of orientation for riders and adequately represent the travel time between stations. While the MARTA train map is not nearly as complicated as the London Underground, the entire MARTA system, including buses and trains, is extremely complicated.

As mentioned, Spider Maps sometimes include destinations within walking distance of a station. To address this, walking area map research was also consulted. A study performed in China provides a process to decide which signs should be placed at which locations of a train station. While this study is directed at large, multi-level, train stations with multiple possible transfers, some of the recommendations can be applied to Spider Maps. The Spider Maps tend to include both walking area map and the regional Spider Map of bus routes. The research by Zhang, Chen, and Jiang stated that this type of information should be provided near the entry and on the top level of train stations (3).

In addition to the location of signs, acceptable walking area for accessing transit is important. According to the *Transit Capacity and Quality of Service Manual*, 0.5 miles is an acceptable walking distance for rail transit and can sometimes be expanded up to a mile for more rapid service (4).

**Blogs Discussing Spider Maps**

The three main blogs consulted for this project were *Greater Greater Washington*, *The Global Urbanist*, and *Human Transit*. The blog *Greater Greater Washington* is dedicated to the Greater Washington D.C. Area and is written by activists and volunteers looking to improve the walkability and vitality of the region (5). The *Global Urbanist* is a blog created by alumni of the London School of Economics and Political Science about improving urban areas around the globe (6). Finally, *Human Transit* is written and maintained by Jarrett Walker, a professional transportation analyst. Posts in all of these blogs have specifically referenced Spider Maps, debated their effectiveness, and discussed the need for transit agencies to use them.

The Spider Maps most widely discussed in these blogs are produced by Transport for London (TfL) at train stations and the one that the Washington Metropolitan Area Transit Authority (WMATA) has created for Dupont Circle Metro Station bus connections.

While London is famous for its schematic Underground Map, it has also installed schematic Spider Maps at major transit nodes within its system. These maps are schematic and not to scale, (Figure 1), but gives
transit riders an idea of where they can get via buses from those nodes. In addition to London, Washington D.C. has recently implemented Spider Maps at certain locations within the WMATA system. Because of this, many transit bloggers have discussed and compared those two.

In, Greater Greater Washington, Michael Perkins breaks down the London Spider Maps and discusses useful features specific to these maps including the walking map to all connecting bus stops, schematic bus route map, and a timetable for each route. Perkins also describes what he sees as challenges to implementation of schematic maps, including selecting which local bus stops to label and whether or not to include routes with low frequency and/or dynamic schedules (5). Buses have many more stops than trains, but typically only stop if requested. To label stops in a schematic map, popular ones would have to be selected based on attributes such as proximity to a popular destination, neighborhood, or some combination. It would also have to be clear that simply because a stop is labeled does not mean the bus will stop there without a request.

Another Greater Greater Washington Spider Map blog written by a previous London resident was entitled H Street Bus 'Spider Map' Can Demystify Bus Service. In this post he discussed how the schematic Spider Maps helped him navigate complicated London bus systems. To him, the buses around Dupont Circle were also confusing and the installation of the Spider Maps helped him navigate them as well. Of a similar opinion that Spider Maps could be useful if altered, David Alpert stated that integrating these maps into the system would be helpful if they added attractions and walking circles for fifteen minutes (6).

In The Global Urbanist, Kerwin Datu argues that Spider Maps are not helpful because they do not give the customer a complete picture of the bus network. He states that they do not account for transferring from bus to bus, and they often cut off adjacent routes by not including bus routes within the walkable area and only those connecting directly to a station. Datu also believes that destinations should be added to give users a better sense of location and possible destinations (7).

Finally Jarrett Walker in Human Transit makes a case for frequency and that maps should not give the impression that all bus routes provide the same level of service. There are a lot of posts in Walker's blog that reference the importance of maps that are easy to understand. One of his problems with the London Spider Maps is that by being schematic and representing each route equally with thickness and line type, riders may assume the same level of service and/or frequency in all bus routes, or even that they are comparable to the frequent trains in London because they look similar to the London Underground Map (8). In his opinion, this must be addressed for generally effective maps.

Walker also states that Spider Maps are useful in conjunction with system maps. They promote the one-seat bus rides from each train station, but neglect to show what connections can be made along these bus routes (8).

Based on these blog discussions, effective Spider Maps address frequency issues, show popular destinations, and include bus routes that are within walking distance of stations but do not directly connect.
Agencies with Spider Maps

In addition to TfL and WMATA, the Massachusetts Bay Transportation Authority (MBTA) and Los Angeles Metro have also produced Spider Maps.

Transport for London (TfL)

One of the TfL transit nodes with a schematic Spider Map is Liverpool Street, shown in Figure 1. The schematic design of the Spider Maps makes the maps visually appealing; however there are some potential issues for riders unfamiliar with the maps and area. To those unfamiliar users, the city layout and labeled stops, there are no points of reference or indication of where the stops actually are with regards to street names or popular locations.

A helpful attribute is the area map around the station showing exactly where to connect to each bus. Additionally, included on the right side of the map display is a chart of bus information called the “Route Finder”, which lists all routes connecting to that station as well as where to board them. Buses are divided into “Day” and “Night” buses, but there is no information about which hours are considered “Day” or “Night”.

Figure 1: London Underground Liverpool Street Station Bus Spider Map
The existing Spider Map that the team found to be the most informative and useful map was the Dupont Circle Spider Map created by WMATA, Figure 2. This Spider Map includes a timetable with headway information, a bus stop location map, a walking area map, and a regional map showing all possible locations accessible by transit from Dupont Circle.

The headway timetable information makes the map more useful to riders hoping and shows accessibility by bus from Dupont Circle. The headway information provides riders with their expected waiting time and comfort in knowing that if a connection is missed, it is clear how much time until the next bus arrives. When the headways are low and the bus route is frequent, patrons do not need to consult a schedule. This is imperative to include in maps if users are to have an accurate understanding of level of service.

The whole Dupont Circle image contains a smaller map with a radius of 0.25 miles around the train station in the upper right hand corner of the display indicating where riders can catch each bus route. This is important because the buses stop at multiple street corners and not bus bays. To the left of this smaller
map is a walking area map that shows nearby attractions and connections to train stations nearby. One important critique is that the walking area map does not clearly point out where the Dupont Circle Station is on the map to show the rider where they are.

The regional map, on the other hand, clearly shows Dupont Circle with a “You Are Here” bubble that informs riders of their location. This geographic map is helpful because it includes roads for reference and clearly highlights bus routes stopping at Dupont Circle. Highlighting these connecting bus routes makes it clear to riders which locations are accessible with a one seat ride. Displaying the bus routes on an actual street map provides riders with a better spatial perspective of their transportation options. Geographic features like lakes and interstates are shown as well, also adding to the clarity of the regional map. It is important to note that the city of Washington DC is easy to represent geographically because the streets are almost all at ninety and forty-five degree angles, which resembles a schematic map.

Dupont Circle WMATA map also contains a "How to Use This Map" box in the corner which provides instructions for wayfinding and understanding the Spider Map. Contained in this box are instructions on how to read and interpret the maps and headway tables.

Massachusetts Bay Transportation Authority (MBTA)

In Boston, the MBTA has Spider Maps available at some train stations, with one example shown in Figure 3. The MBTA Spider Maps include two separate maps at different scales; a regional map with connecting bus stops and a walking distance map. The walking area map shows a street map of the area within a half-mile radius from the train station as well as connecting bus routes, parks, and bodies of water. However, there are few labels of specific locations and these labels are limited to government buildings such as courthouses or schools.

Figure 3: MBTA Spider and Area Maps at Forest Hills Station (Photo Courtesy of Christopher Silviera)
The regional MBTA map shows the full length of each bus route originating from the station. This map is geographic and displays streets in grey and highlights the bus routes from the station in bold colors as well as other train stations in region. For each bus route from the station, a table lists frequency for all service types, such as peak, day, night, and weekends. The headways in Figure 2 range from ten to forty minutes.

**Los Angeles Metro**

Los Angeles Metro has one schematic Spider Map displayed at Union Station, Figure 4. This Spider Map has a schematic layout with interstates shown as location references. The Los Angeles Metro Spider Map does not include a map of the surrounding walking distance, but does include a map of the station buildings and where various routes meet to make connections and transfers easily identifiable. There is no frequency or schedule data included in this map.

![Figure 4: Las Angeles Metro Union Station Spider Map](image-url)
The inclusion of interstates as reference improves the ability for users to identify locations of destinations when compared with the transit station. The regions noted on the map are very clearly labeled, adding to the ability of passengers to easily read and understand the relative areas accessible by bus.

One thing that is different about the Las Angeles Metro Spider Map is the use of colors. Instead of having each route represented by a different color, each mode has its own color. The colors represent the type of bus service (local, express, rapid). The legend for bus type colors and bus route labels is located in the upper right corner of the map. This type of coloring allows riders to know what level of service to expect.

Another feature of the Los Angeles Metro Spider Map is the use of the destination table at the bottom, which lists multiple destinations accessible from Union Station and shows which route to take to reach that particular destination. This wayfinding tool could be very helpful to riders without a trip planner who need to reach a specific destination.

Analyzing current Spider Maps helped identify effective design aspects. The most effective parts of existing Spider Maps were including frequency in the display, including popular destinations within walking distance, including a guide for how to use the map, and including maps at multiple scales to clearly orient transit riders.

**SPIDER MAP CREATION**

The Spider Maps created for MARTA took into account effective map design and acceptable walking distance we well as the most efficient pieces identified in existing Spider Maps. Everything discussed in the previous section contributed to the creation of an ArcGIS model and web application that can be used by any agency to create both paper and online Spider Maps.

The map and website models created for this project are based on this research and the information that was most effectively displayed in the Spider Maps found in London, Boston, Washington D.C., and Los Angeles.

For each station, the Spider Map display includes a Regional Spider Map and a Walking Area Map. These two maps are important to have for two types of train riders; the ones connecting to bus routes and the ones leaving the train station for a final destination near the station.

MARTA does not have uniform walking area maps at their stations. At the Five Points Transit Station, there is a walking area map to show connections to all of the bus routes in close proximity. Some stations have a walking area map outside the station, but these are put in place by either the city or a Business Improvement District.

In addition to having two maps at different scales, the MARTA Spider Maps include bus route information. The regional Spider Maps show all routes that come within a ten minute walkshed. This addresses the concern brought up by Datu of neglecting to show other bus routes in close proximity to the station.

For the MARTA maps, the team selected geographic over schematic representation. The team wanted to display both maps in the same way and geographic was the best representation for the Walking Area Map.
to that there would be no skewing of the distances. Geographic displays were also selected to give bus riders a more precise understanding of which roads the bus routes travel along and allow flexibility for MARTA to add more information to the maps. These local bus routes have stops almost every block so it is more important to understand the exact route instead of a general direction of travel.

As a reference for riders who leave the train station on foot, a fifteen minute walkshed is included in the Walking Area map. The Boston walking area map shows a half mile radius, but walking time may be easier for pedestrians to judge. These walking area maps will display a fifteen minute walkshed based on the network. Some MARTA stations are near highways, freight rail lines, or other locations that are close but cannot be accessed on foot. Therefore, these walksheds are not perfect circles around the stations, but based on the walkable network. Additionally, a 0.75 mile radius is shown to provide references for walkers. In addition to the maps, headway information is included. With this information, riders can quickly understand all possible destinations and have a general idea of how long they will have to wait for their bus.

While ten minutes or less is the headway when riders do not have to consult a schedule, both the MBTA and WMATA include routes with headways up to 40 minutes displayed in their frequency tables. Even though this is a large headway and not a desirable waiting time, it provides riders with an estimation. For MARTA, this can be supplemented by full timetable scheduling information that is already provided at all stations where there are bus connections. If there is a headway greater than ten minutes, riders can consult the provided timetable, but if the headway is short, they can simply wait for the bus at the appropriate location.

MARTA bus headways, similar to other agencies, change during different service periods. For MARTA, these periods are “Peak”, “Base”, “Night”, “Saturday” or “Sunday/Holiday”. The frequency table includes the service period as well as the hours that service begins and ends for each route so that riders can plan for a return trip if necessary.

Finally, one thing that stood out in the Dupont Circle Map by WMATA Metro Bus was the “How to use this information” box. The team found this useful for wayfinding and understanding these maps, so instructions are provided for riders using these maps for the first time. All of these characteristics have been incorporated in the GIS model to create Spider Maps for MARTA.

GIS model creation

To create a process that would automate Spider Map creation for MARTA and would be easily reproducible by other agencies, the team used ArcGIS 10.0 model builder and Python Editor. Using these development tools, the team created a new ArcToolbox with four models and two python scripts. Together, this toolbox can automate the creation of the maps and the headway information for all MARTA Transit Stations with one model run. The steps in the new toolbox are as follows:

1. Define walking distance
2. Generate walk shed based on road network
3. Select and Output bus routes within walk distance to rail stations
4. Output rail stations
5. Output layouts for each rail stations
6. Output maps

The first step defines the area shown in the Walking Area map. This was done by using a straight line walking distance buffer for each MARTA Transit Station. This line shows up as a circle around the station giving riders an idea of distance around the station (4). The inputs for this tool are the train station shapefile, the desired radius, and an output path. Steps one through four are designed to have the same interface as any standard ArcGIS tool.

The second step generates the walkshed based on the road network for each station. The inputs for this step are the train station shapefile and the road network with travel time cost defined in minutes. Users can define the network walking distance for riders leaving the station on foot. In the example, fifteen minutes was used, but this can easily be changed. As the extent of Spider Map was defined in step one, the walking distance defined in this step should be smaller than that so that the entire walkshed will be entirely contained in the Walking Area Map.

Once the walkshed is defined, all bus routes that go through the walkshed are selected in step three. It is important to include all bus routes within the walkshed because there are some MARTA bus routes that come close to a station, but do not directly connect. For example, Route 110 comes within a block of the Midtown MARTA Transit Station, but does not pull into the bus bays there. By including these bus routes as well, Datu's issue with connections to other buses can be addressed within the area surrounding the stations. The bus routes selected in this step will show up in the both Regional Spider Map and the Walking Area Map. Finally, at the end of this step, the program outputs an attribute table of the selected bus for each station in the format of dbf file, so that they can be further edited by users in MS Excel.

Step four outputs a new layer for each train station that includes only the bus routes selected for that particular train station and the calculated walkshed associated with it. The input for this step is a shapefile of the train stations. The layer created for each station is what is displayed in the Regional Spider Map. For both all shapefile inputs, general transit feed specifications (GTFS) could be used because these .txt files contain latitude and longitude values for all stations and stops. The model would simply have to be altered slightly to geocode latitude and longitude inputs instead of shapefiles.

Steps five and six are python scripts and will be made publicly available through the Georgia Institute of Technology website for transit agencies to access. Step five inserts all of the previously generated layers into the layout template. This template includes the location and size of the Regional Spider Map, Walking Area Map, and instructions for reading and using the information provided. Users may change the location of each component as they desire. After the layout output process, the only manual work required is inserting the table output in step three into the remaining space. Unfortunately, ESRI does not provide any python language that automates this process. But in the near future, when their “Arcpy” language is further developed, this will have the capability to be automated. The final script creates one .pdf document where each page is a Spider Map for a particular MARTA Transit Station.

Results and Model Outputs

Based on the discussion of existing maps and the information displays that the group found the most useful and effective, the Spider Map seen in Figure 5 was produced using the ArcGIS model. Figure 5 shows the Midtown MARTA Transit Station as an example and incorporates the Regional Spider Map,
the Walking Area Map, as well as route headway information, and directions on how to use the map. The Walking Area Map includes a fifteen-minute walkshed and allows the potential to add tourist attractions, government buildings, and other important destinations that surround each train station. The scale of the Regional Spider Map is based on the furthest reaching bus route and the scale of the Walking Area Map is based on the fifteen-minute walkshed. The scale of the Walking Area Map for each MARTA Transit Station is the same, but the walkshed varies station to station depending on the street network. The background for these maps is Open Street Maps and the maps will be automatically updated each time the model is rerun.

A screenshot from the Spider Map website for the MARTA Midtown Transit Station can be seen in Figure 6. The same shapefiles included in the paper Spider Maps are included in the website as well as locations. Only the bus routes within the walk distance to the rail station were selected and displayed.
The shapefile was uploaded to a Google fusion table. The color and the width of the bus routes were defined based on the bus frequency information, which corresponds to the weekday peak hour bus frequency.

“Google Places API” was added to the website, so that users can select places of interest to display in the Walking Area Map. The default setting shows bus stops around the rail station. However, users can select other types of locations such as lodgings, restaurants, schools, and many other location types. Once a type is selected, a list of the relevant places will be displayed, and their locations will pop up in the Walking Area Map. The types of places that could be displayed include any of the dozens of categories that Google Places uses, such as coffee shops, shopping, and many more. From there, users can click on the name of a place and Google walking or transit directions will pop up. It is important to note that one major limitation of “Google Places API” is that it can only return the top 20 places for the type of destination the user selects. However, the defined walking area is rather small, such number of research result is acceptable. Nevertheless, if users want to implement this application for comparatively large areas, the result may not be satisfactory.

The same route search available on Google Maps is also available for users who know their specific destination information. Once users input an address, the transit route between the current rail station and that destination will pop up. Transit is the default travel mode, but other travel modes are also available in case the rider is planning on walking or biking from the station to his/her final destination.

The bus routes are displayed geographically to match the printed ones. However, one of the limitations of the Google fusion table visualization is that it is difficult to tell where multiple bus routes overlap and
how many overlap in a given segment. To allow users to see exactly where each route is located, the team added an interactive function between the frequency table and the maps. By clicking on the desired route number in the frequency table, the corresponding bus route is highlighted in the maps.

An advantage of the website is that it needs very little maintenance. The background maps will automatically be updated by Google maps. The only data that require attention are the bus routes and frequency information. If any of these data change, the maps will need to be updated, which only requires updating the information in the Google fusion table. One possible solution to this is to change the model to incorporate GTFS inputs instead of schedules associated with shapefiles. Using GTFS, the maps would update every time the GTFS feed was updated.

CONCLUSIONS AND DESIGN GUIDELINES

Spider Maps are useful to train riders who do not know their way around their destination station or which buses they can connect. Based on the literature review and Spider Maps that are currently posted, there are a few key pieces of information that should be clearly communicated to make the Spider Maps effective.

**Regional Spider Map and Walking Area Maps** should both be included. They are useful for different types of riders, those connecting to a bus and those walking to their final destination. By providing both maps, riders connecting or walking will be able to find their way and by using the two together, the rider is oriented on both a regional and local scale. Providing the Walking Area Map could also benefit riders connecting to buses if the bus connection is not directly at the train station, such as at the Five Points MARTA Transit Station.

**Frequency and Headway** are important to include. They give an estimation of waiting time and if a rider needs a specific departure time, they can consult a more detailed timetable. The team found that color-coding was an effective way to quickly display whether a bus route had a short or long headway. Regardless, riders can also use headway information to gage whether their return time is flexible or needs to be planned around the transit schedule.

**Instructions** for reading the map are helpful and may give the riders a little more confidence than a normal map legend. For this project, the team created simple steps for riders to follow if they are unsure of the information provided and how to use it. However, only one other agency provided a guide like this, so it is a part of Spider Map design that is an open subject area and could be considered for further research.

**Points of Reference** in the maps are additional features that can provide guidance and orient riders when they are about to exit the train station. These maps use Open Street Maps as the background layer, so some locations are labeled, such as Piedmont Park and the Georgia Institute of Technology. However, the models have the potential to add tourist attractions, government buildings, or any other destinations within the walking area. This will make walking to those destinations clear and could promote certain locations using the map.

Deciding which destination types should be included in the Walking Area Map is another area of research that could further Spider Map development. In some places, it may be obvious which locations to
include, but in an urban area where destinations are concentrated, prioritizing what should be included
would provide further guidance on the design and display of these maps.

The combination of the paper map and the web application is useful to riders because they can improve
the overall trip experience from planning to arrival. There are many riders who plan their trips ahead of
time and use station maps simply to guide them along and increase their transit-riding confidence. Riders
with access to the internet could access the online application and plan their trip before they leave, then
use the Spider Maps at the station to confirm their trip and improve their confidence in taking transit.

These maps and web application were developed to further Spider Map design and implementation and
are easily reproducible at MARTA and other interested transit agencies. They provide another way to
convey transit information easily and effectively to riders and highlight all possible destinations that some
riders may not have been aware of before their implementation.

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