



RESEARCH & DEVELOPMENT

RP 2018-12: Demand Response Transportation Planning and Visualization Tools

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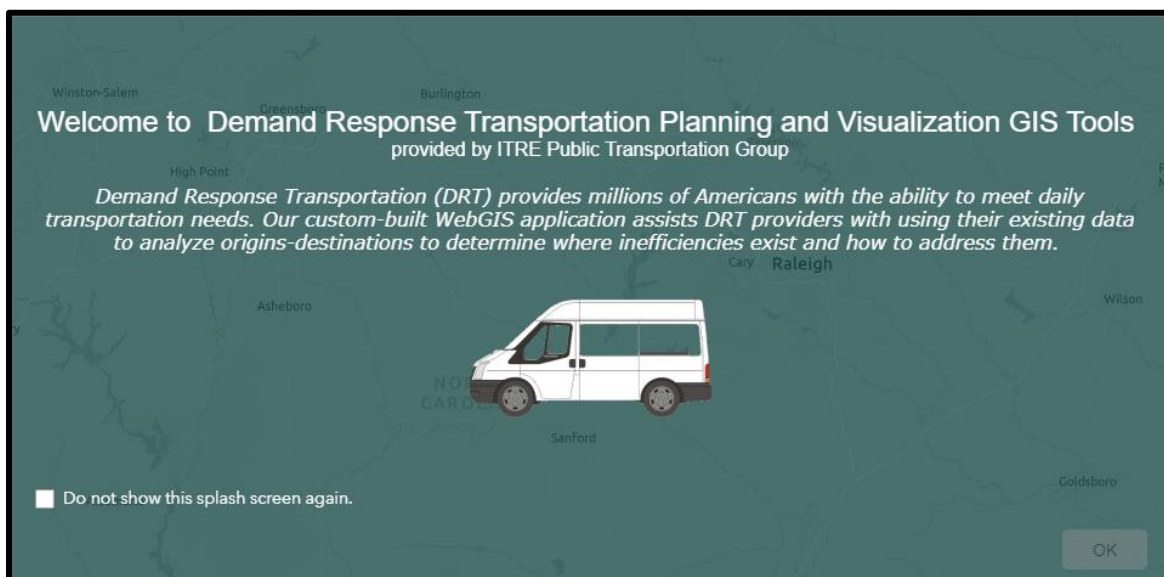
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Splash screen that appears the first time the application is accessed

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16. Abstract Demand Response Transportation (DRT) provide a necessary service to their community. One of the biggest issues facing DRTs is the continued decrease in funding, from Federal to State to the Local level. To continue to meet the needs of their community, DRTs must evolve their service offerings to become more efficient to meet the financial burdens. This does not have to require eliminating service but redefining how they offer service and asking their community to work with them to try and group more trips. To do this, DRT providers need a suite of tools that can find patterns within their historical origin and destination data to support changes to their service patterns that will help to maximize their efficiency. The Demand Response Transportation Planning and Visualization web-mapping application not only provides visualizations of high areas of demand but also highlights patterns of movement across their service area. In addition, this application provides a DRT with a set of tools to help in redesigning service patterns that can simplify the scheduling process, create a more intuitive operating environment, and increase transportation effectiveness to their community.			
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Executive Summary

Demand response transportation (DRT) providers need tools that can harness the ‘big data’ of trip origins and destinations into service plans that allow them to expand service, increase effectiveness, and understand tradeoffs from service design and delivery decisions. Mountain Mobility, for example, is like many other DRT providers in that they have a growing need to provide service to their community and not enough funds to continue to meet this need using traditional DRT service methods. A recent service plan recommends that Mountain Mobility explore alternative service delivery models such as zone-based routes. However, Mountain Mobility does not possess the staff time nor resources for developing service plans on its own. As is the case with most agencies, service planning is contracted to a consulting group that will conduct a one-time analysis. This solution does not allow the agency to quickly respond to changing circumstances or fully evaluate the impacts.

DRT systems are constantly generating trip demand data, but are unable to employ this enormous resource because they lack the tools. What Mountain Mobility and countless other DRT providers need is a toolbox that allows them to import existing data against a backdrop of Census and other data to visualize demand and rapidly explore and evaluate different scheduling scenarios. This is not automated scheduling software that makes sense of unstructured demand. Instead, it is a transportation planning toolbox that seeks to identify patterns in the demand to allow for better service delivery models to be deployed. This application proposed to develop a suite of demand response planning tools that can be quickly and easily employed by DRT providers who wish to develop and evaluate service design scenarios regardless of their technical capacities.

This toolbox consists of many of the tools that are currently employed by transportation planners including origin/destination analysis, frequency analysis, transportation-disadvantaged assessments, and social justice measures. Two components made this proposal essential. First, the transit system will be able to use the tools on its own because the tools will be easy to use and based on existing data that the transit system already generates. Second, the transit system will be able to employ the tools at any time, allowing for rapid responses to changes in the service environment. With these tools, the transit system can analyze service structure at any time.

From a customer standpoint, these tools are essential because stagnant service delivery designs can result in denied service, increased ride times, and increased costs. When transit systems can adapt to the real-time needs of their communities, the number of customers served will increase and the customer experience will be greatly enhanced.

The project is split into three phases. Phase 1 developed a common schema for importing service data. Phase 2 developed tools that can be added to Geographic Information Systems. Phase 3 converted these tools into a high-quality web-based interface. To accomplish these tasks, we have organized a team of experts in the fields of transportation policy, transportation planning, transit operations, user-interface/user-experience, and mobile and web-based applications. When combined with an innovative and motivated public transportation provider, this team has the expertise and industry knowledge to deliver a high-quality product that enhances personal mobility. In addition, new and improved tools will be easy to implement into the toolbox and web interface with future enhancements.

The industry is rapidly changing. DRT systems that are unable to conduct real-time service planning are months or years behind the trends because of the delay in planning. Having quickly accessible planning tools based on currently available data is the only way that demand response providers will be able to adapt and thrive through these changes.

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RP 2018-12: Demand Response Transportation Planning and Visualization Tools

Introduction

This proposal aimed to develop easy-to-use tools that enable demand response professionals to quickly analyze their service and conduct scenario planning based on existing data. The first phase developed a standardized data schema. The second phase developed the tools as a Geographic Information Systems (GIS) toolbox. The third phase transitioned the GIS toolbox to an online platform that can be used by anyone, regardless of his or her knowledge of GIS software. For feedback on testing, design, and implementation, we partnered with Mountain Mobility- a demand response provider based in Buncombe County, NC

Research Need

Many DRT providers suffer from a severe lack of planning. Most DRT providers have one or two management-level positions, often directors or operations managers, who expertly manage the day-to-day operations of the transit system, but have no planning background or other staff resources specifically devoted to transportation planning activities. Once the service demand begins to push against service capacity, it is necessary to implement service planning. The data necessary for service planning is constantly generated by the DRT provider in the form of trip origin and destination data, but the providers do not have the necessary tools to conduct this planning or analyze potential solutions that can help provide proactive measures instead of reactive responses.

DRT is often viewed as a random service whereas it usually follows patterns. However, the patterns are often not identified nor are they shared with the customer. This service is offered ad hoc on a first-come-first-serve basis and the transit system must continuously try to make sense of the daily demand for service. Customers make appointments with no information as to the ability of the transit system to provide service aside from general operating hours. The transit system accepts these appointments whose times may be arbitrarily decided because the customer has no information concerning the transit system's schedule. Or, the transit system may negotiate or deny the service because it feels like it has reached its carrying capacity or exceeded its funding capacity. The transit system then must use software and/or the scheduler's skills to make sense of the routing problem on a day-to-day basis.

Demand response scheduling software does not incorporate service planning tools but is instead solely focused on solving the daily conundrum of how to provide service to the myriad of requests it receives. The result is often inefficient service from the transit system's perspective and circuitous, unreliable, time-consuming service from the customer's perspective.

Demand response service delivery has many patterns that are evident upon analysis, but the analytical tools were not readily available and the analysis was difficult to replicate with new data. Where such patterns have been identified, they are often hidden from the user. If the transit system could identify the patterns and establish service designs around them, the customer could make appointments according to the schedule thereby saving travel time while simultaneously increasing productivity. In addition, when the service patterns are made public, latent demand for the service will be exposed because customers with similar transportation needs will know that service is provided.

Mountain Mobility is a typical DRT provider in North Carolina. A 2016 AECOM Technical Services memorandum states that:

“Mountain Mobility should consider establishing demand response service zones in the future. These zones would assist in managing transit demand and fare revenues. By establishing zones, Mountain Mobility could determine when service is offered in a specific location to match available transit resources.”

What Mountain Mobility and numerous other demand response providers needed was planning and visualization tools that could be used to develop and evaluate service designs.

Research Objectives

The objective of this research was to develop algorithms for counting passenger trips using existing security camera footage and test the accuracy of this technology in counting transit passengers.

Literature Review

A related product designed for the fixed-route environment has recently been developed, named Transit Remix (<https://www.getremix.com/>). Users believe that it streamlines transit planning for urban fixed route systems (1). This research proposal focuses on creating a similar tool but for demand response systems. Transit Remix is a new technology and we found no research on the outcomes related to its use.

The Transit Cooperative Research Program (TCRP) regularly commissions studies and writes reports related to demand response transportation. However, these reports do not include much information about how to plan for demand response services. TCRP Report 101, for instance, addresses the act of planning only by indicating which funds may be used for planning (2). Thus, instead of informing the transit provider how to plan, the report instead implies that planning should be contracted out.

TCPR Report 136 is about improving performance for demand response systems (3). Service design is one of the eight recommendation areas. The report suggests that service design be evaluated regularly and consistently to ensure that it “fits” the needs of the community based on land use development patterns and ridership and use patterns. The report offers no advice on how to assess service design options.

Research Tasks and Methodology

Because the planning and visualization tools were readily available and based on existing data, the tools were agile, responsive, and accessible. Seamless multimodal services were enabled because the service was planned, which means there were comprehensible connection points and times.

The project was divided into three phases. Phase 1 was to develop the data import schema. This schema was based on commonly available data from the majority of demand-response transportation software companies. North Carolina has seven scheduling software packages in use across the state. Companies that are not represented were identified and consulted.

Phase 2 was to develop the GIS tools necessary for planning demand response service. ITRE provided the technical resources to create the tools. Next, the tools were tested by local transit systems. Feedback was used to add to the list of tools and to enhance their functionality.

Once the tools were developed, tested, and improved based on user-feedback, Phase 3 was to convert the tools into a web-based mapping application. Again, local transit systems utilized the tools and provided feedback. The development team used this feedback to improve the product.

Web-Application

Overview

The Demand Response Transportation Planning and Visualization web-mapping application is intended for transportation systems that provide demand response service. The tools available in this application provide a spatial understanding of the historical demand within a given service area. In addition, tools were created to highlight patterns of movement within the service area and ways to increase the efficiency of transporting clients within the service area.

Technical Details

The current application was developed within the Amazon Web Services (AWS) architecture. Prior to selecting Amazon, the project team assessed the viability of Microsoft Azure for this project. In both cases, the project team attended workshops that provided an overview of the capabilities of each product. Although the end product would not have been affected by utilizing Microsoft Azure, the project team found better support for implementing ArcGIS Enterprise within the AWS architecture.

Certain tools required back-end data to run. In several situations, the user is asked to choose an existing service area boundary and in some cases, the back-end data is embedded within the tool script. In all of these cases, back-end data is housed within a PostgreSQL database. In the current version of the web-mapping application, this limits the users to North Carolina Public Transit Systems.

The web-mapping application can currently be accessed at the following URL:

<https://test.transitportal.org/#>.

To gain access to the application and tools therein, please send an email to ptg_support@ncsu.edu.

The following screenshots provide an overview and introduction to the structure of the application.



Figure 1 Splash screen that appears the first time the application is accessed.

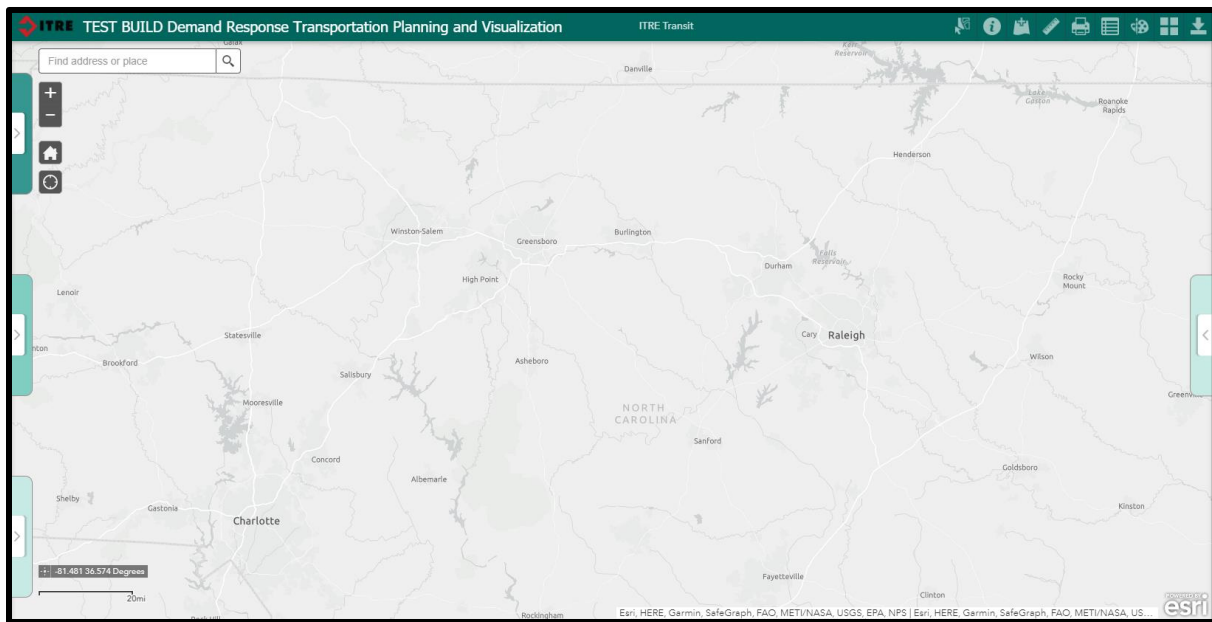


Figure 2 The Demand Response Transportation Planning and Visualization web-mapping application interface.

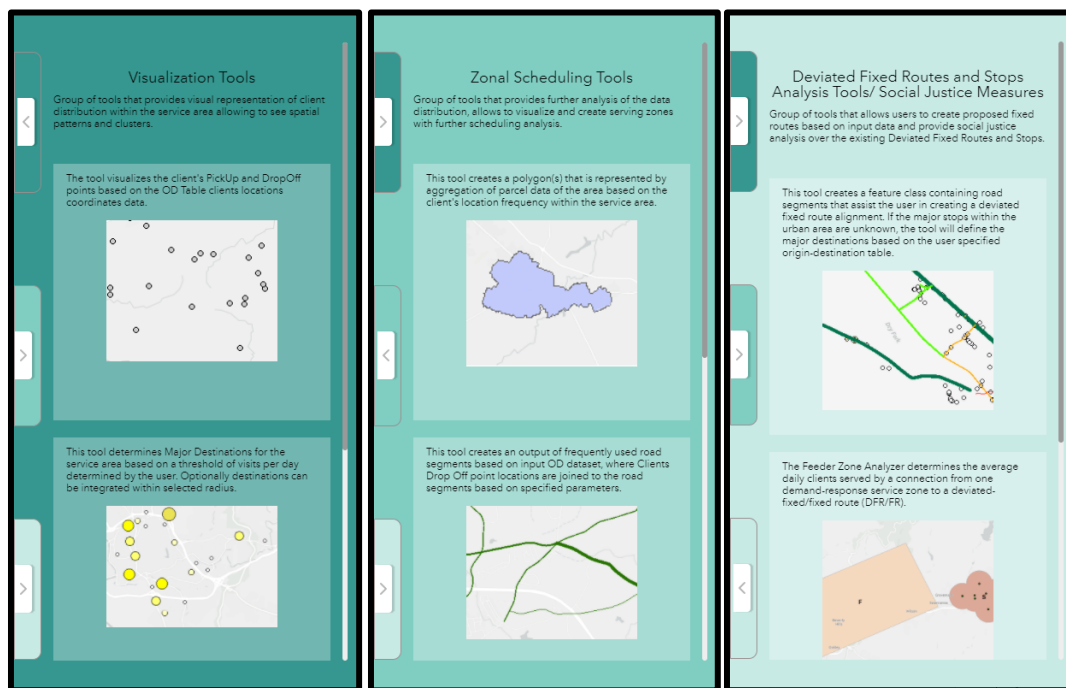


Figure 3 Three sets of planning and visualization tools. These can be accessed from the left-hand side of the application.

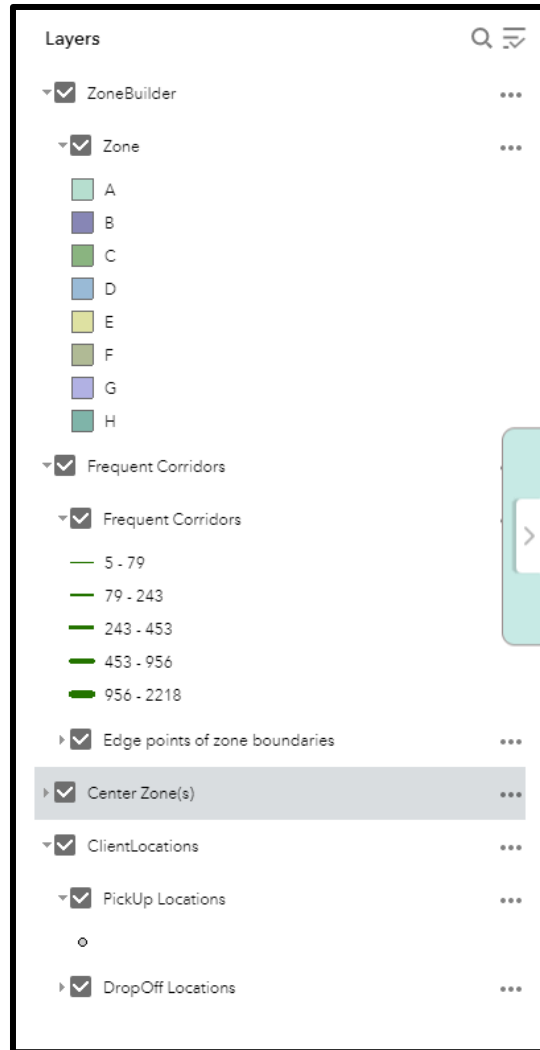


Figure 4 The legend shows the symbology for each of the layers displayed on the map. The Legend can be found on the right-hand side of the application.



Figure 5 The Utility Tools toolbar contains a set of tools that can be used in support of the planning and visualization tools. The Utility Tools toolbar can be found in the upper right corner of the application.

The tools available in the Demand Response Transportation Planning and Visualization Tools web-application are categorized into 3 groups:

1. Visualization Tools – This group of tools provides a visual representation of client pickups and drop-offs. Subsequently, the tools can provide insight into spatial patterns and clusters of a transit system's travel demands within the service area.
2. Structured Scheduling Tools – This group of tools goes beyond just a visual representation of the data by providing a deeper analysis of the historical demands within the service area. Through this analysis, a transit system can create a set of zone boundaries and develop a structured

scheduling methodology to simplify the scheduling process and improve transportation inefficiencies.

3. Deviated Fixed Routes and Stops Analysis / Social Justice Measures Tools – This group of tools can assist a transit system in understanding where a deviated fixed route can have the greatest impact on not only existing ridership but also the community as a whole using Census-based residential data. Included in this category are tools that provide social justice measures within the service area, ensuring equity of service across the service area.
4. Utility Tools – This group of tools is used for basic utilities such as adding existing shapefiles to the map interface, saving the current session, and other miscellaneous tools.

The following is a description of each of the tools contained within the Demand Response Transportation Planning and Visualization Tools web-application. Within the description of each tool, the following is provided: 1.) An introduction to the tool providing a quick overview of the inputs, outputs, and a screenshot of the final result from running the tool; 2.) An explanation of each input parameter with a screenshot of the user interface; 3.) A description of the output from running the tool, along with screenshots showing the legend and how to download the output layers.

Each tool requires the use of a tabular file containing x- & y-coordinates of the client's pickup and drop off locations with additional attribute data. The input table must be in a .csv file format and match the required schema. See the Appendix for the OD Table and other table schemas.

Visualization Tools

1. Client Origin and Destination Visualization

The Client Origin and Destination Visualization tool takes the latitude and longitude of each client's pickup and dropoff locations and displays them on the map.

The screenshot below is output from running the tool on sample client origins and destinations, providing a quick visualization of the existing demand within a transit system's service area. *Note: the result of running this tool does not show the spatial relationship between specific client origin and associated destination.*

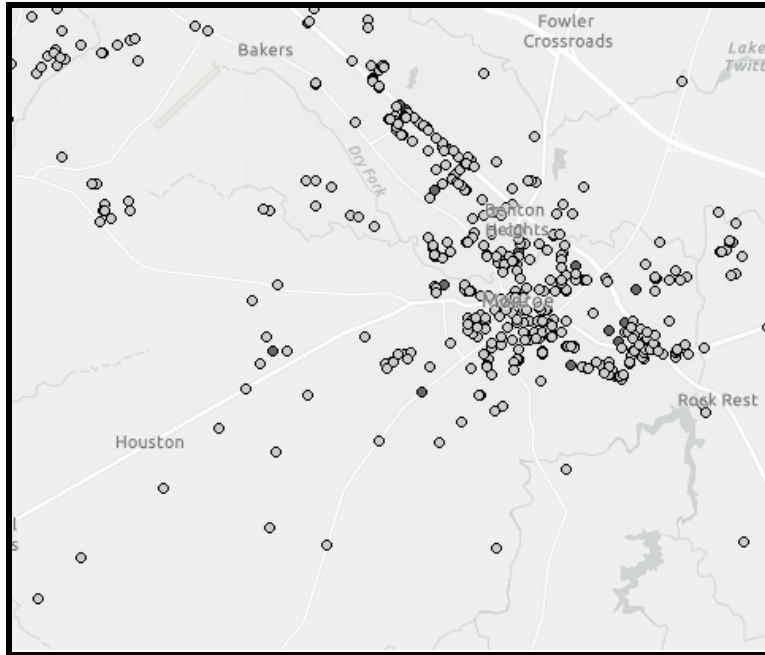


Figure 6 Visualization of client's origins and destinations.

Input Parameters:

OD Table: The Client Origin and Destination Visualization tool requires one parameter, a user-specified origin and destination table in .csv format matching the required schema. The screenshot below shows the user interface of the tool.

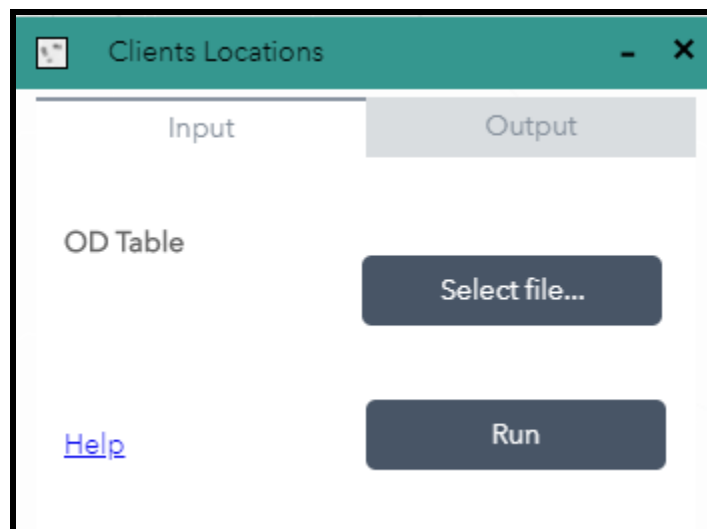


Figure 7 Tool interface of the Client Origins and Destinations Visualization tool.

Tool Output:

After running the tool, two feature layers are displayed in the map window: client pickup and client drop off locations. The screenshot below shows the legend containing the two layers that have been added to the map. Each layer will be displayed with a default color differentiating them.

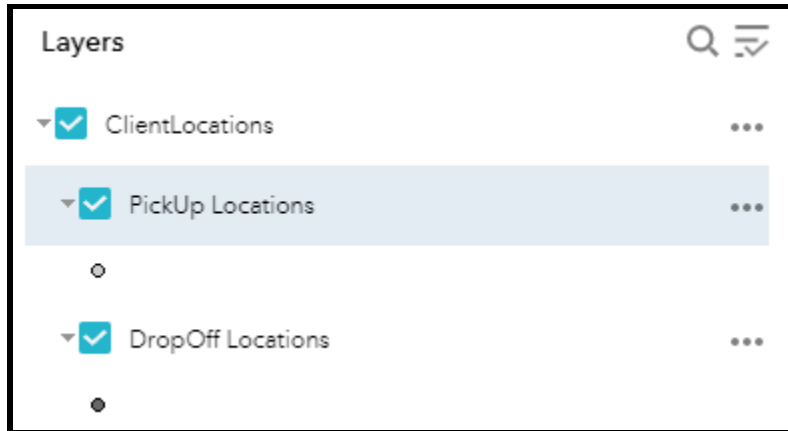


Figure 8 Feature layer legend showing the two feature layers created. Each will be displayed separately and differentiated by color.

These two feature layers are also made available for download in a zip file named *ClientLocations.zip*. The screenshots below show the steps to download the feature layers from the application, and where the zip file will be saved.

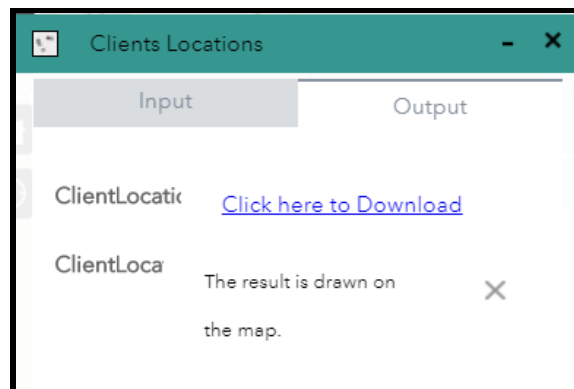


Figure 9 Screenshot showing the link to download the files created by running the tool.

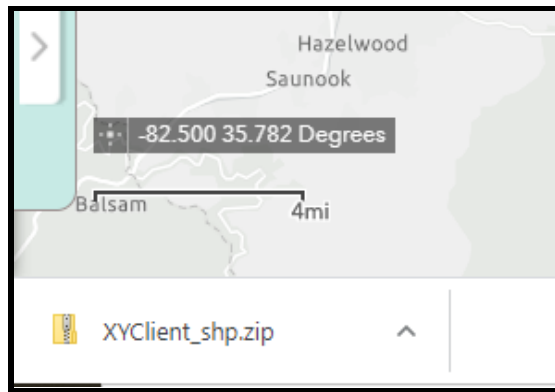


Figure 10 Screenshot showing the saved zip file containing the feature layers at the bottom of the browser window.

2. Major Destinations

The Major Destinations tool analyzes the historical demand of client dropoff locations and displays on the map those locations that were determined to be major destinations within the service area. Dropoff locations are labeled major destinations based on a user-defined minimum threshold of visits per day. This tool includes an option for destinations within a user-specified radius to be grouped.

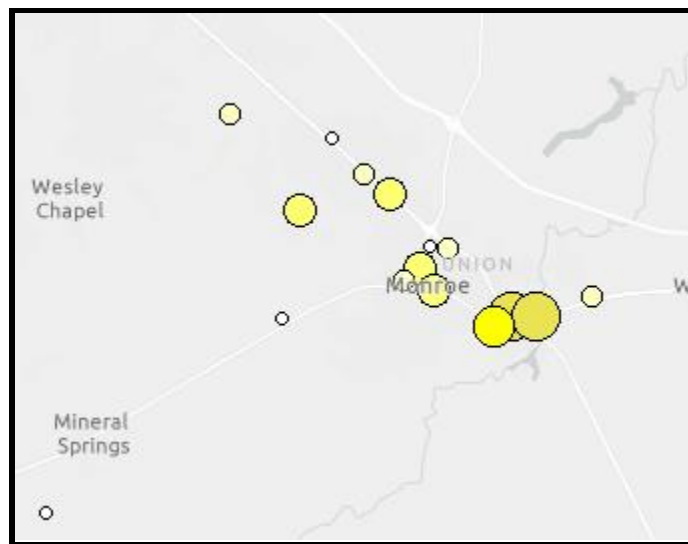


Figure 11 Sample output from the Major Destinations tool. Destinations with greater visits per day are represented by larger circles.

Input Parameters:

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Include Residential Destinations?: Specify whether or not to include residential destinations in the output.

Please enter the minimum # of visits per day to be considered as a major destination: Specify the minimum number of visits per day for a destination to be considered as a major destination.

Would you like to group destinations or keep them separate? The user can group destinations into a single location by checking this box. Upon checking this box, the next parameter will become enabled allowing the user to define the distance threshold. *Note: if this option is selected, the actual location of the point will be an approximation of the points grouped and may not represent an actual destination.*

Please specify the distance and units to group destinations together: If the previous parameter is checked allowing for destinations to be grouped, this parameter will become enabled. In this parameter, the user can define a distance threshold within which destinations will be grouped into a single location.

Include Saturdays: The default setting is to include Saturday trips.

- **Checked:** *Saturday trips will be included in the ridership analysis to determine the location of major destinations.*
- **Unchecked:** *Saturday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Include Sundays: The default setting is to include Sunday trips.

- **Checked:** *Sunday trips will be included in the ridership analysis to determine the location of major destinations.*
- **Unchecked:** *Sunday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Major Destinations

OD Table Select file...

Include Residential destinations? ☐

Please enter the minimum # of visits per day to be considered as a major destination

Would you like to group destinations together or keep them separate? ☐

Please specify the distance and units to group destinations together. Feet

Include Saturdays ☒

Include Sundays ☒

[Help](#) Run

Figure 12 User interface of the Major Destinations tool showing all of the parameters used in determining major destinations.

Tool Output:

After running the tool, a single feature layer will be displayed on the map showing the major destinations based on the parameters chosen by the user. Figure 13 shows the legend of the Major Destinations layer that was added to the map. The default symbology classifies points by the number of visits per day where larger circles represent a higher number of visits per day.

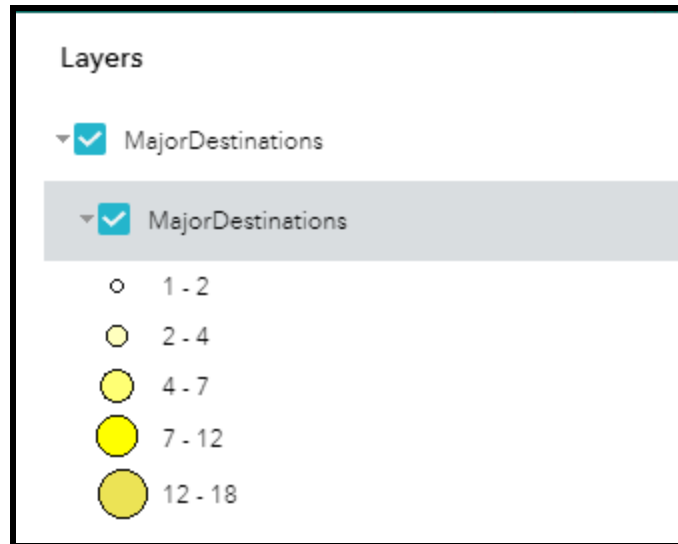


Figure 13 Legend of the major destinations feature layer where larger circles represent a higher number of visits per day.

The feature layer is also made available as a download in a zip file named **MajorDestinations.zip**. Depending on the parameters chosen by the user, the shapefile contained in the zip file will be named one of the following:

- A. Output includes residential and non-residential destinations and the destinations are grouped:
Major DestinationsOfAll_DropOffs_Integrated
- B. Output includes residential and non-residential destinations and the destinations are not grouped:
MajorDestinationsOfAll_DropOffs
- C. Output includes only non-residential destinations and the destinations are grouped:
MajorDestinationsOfNonResidential_DropOffs_Integrated
- D. Output includes only non-residential destinations and the destinations are not grouped:
MajorDestinationsOfNonResidential_DropOffs

3. Origin-Destination Spider Net

The Origin-Destination Spider Net tool helps to visualize the relationship between a customer's pickup and associated dropoff. This tool helps the user quickly visualize common areas of interest as well as patterns of movement within the service area.

Figure 14 shows a sample output from running the Origin-Destination Spider Net tool. Thicker lines represent a higher number of trips per day between the origin and associated destination.

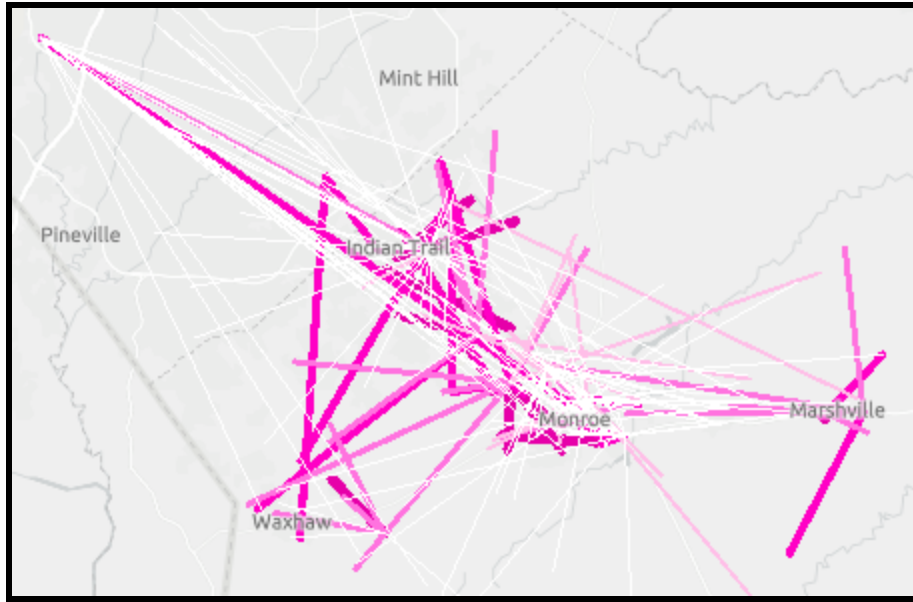


Figure 14 Sample output from running the Origin-Destination Spider Net tool.

Input Parameters:

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Filter by Major Destinations: Specify whether to visualize the connections between all origins and their associated destinations or only those origins that are connected to major destinations.

- **Checked:** Visualization results will show only the origins that connect to a major destination. If this option is selected, the user will specify the layer that contains the major destinations in the next parameter. Typically, the feature layer selected is an output from the Major Destinations tool. However, the user can upload their own major destinations feature layer and use that instead.
- **Unchecked:** Visualization results will show the connections between every origin and its associated destination.

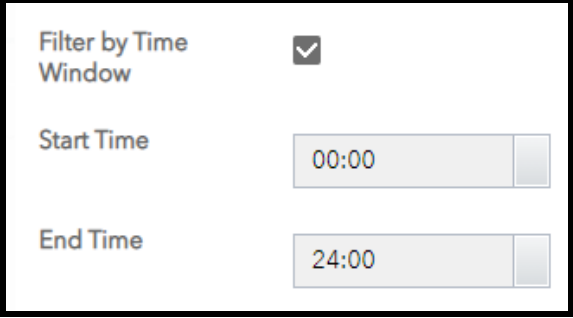
Major Destinations: Specify the feature layer that contains the major destinations to be used in creating the spider net visualization.

Filter by Time: Specify whether to filter the origins and destinations within a user-specified time window.

- **Checked:** Include only those origins and associated destinations within the time window specified below. This is the default setting.
- **Unchecked:** Include all origins and associated destinations. The option to choose the start and end time parameters will be disabled.

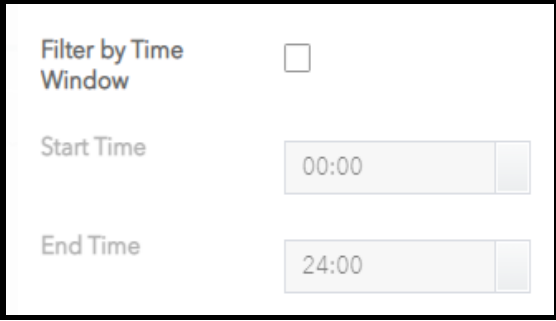
Start Time: Specify the start time of the window to be used to filter the origins and associated destinations.

End Time: Specify the end time of the window to be used to filter the origins and associated destinations.



A screenshot of a user interface for a time filter. It features a section titled "Filter by Time Window" with a checked checkbox. Below this, there are two time input fields: "Start Time" set to "00:00" and "End Time" set to "24:00". Each input field consists of a text box and a small square button to its right.

Figure 15 Screenshot of the time filter window enabled.



A screenshot of the same user interface as Figure 15, but with the "Filter by Time Window" checkbox unchecked. The "Start Time" and "End Time" fields remain at "00:00" and "24:00" respectively.

Figure 16: Screenshot of the time filter window disabled

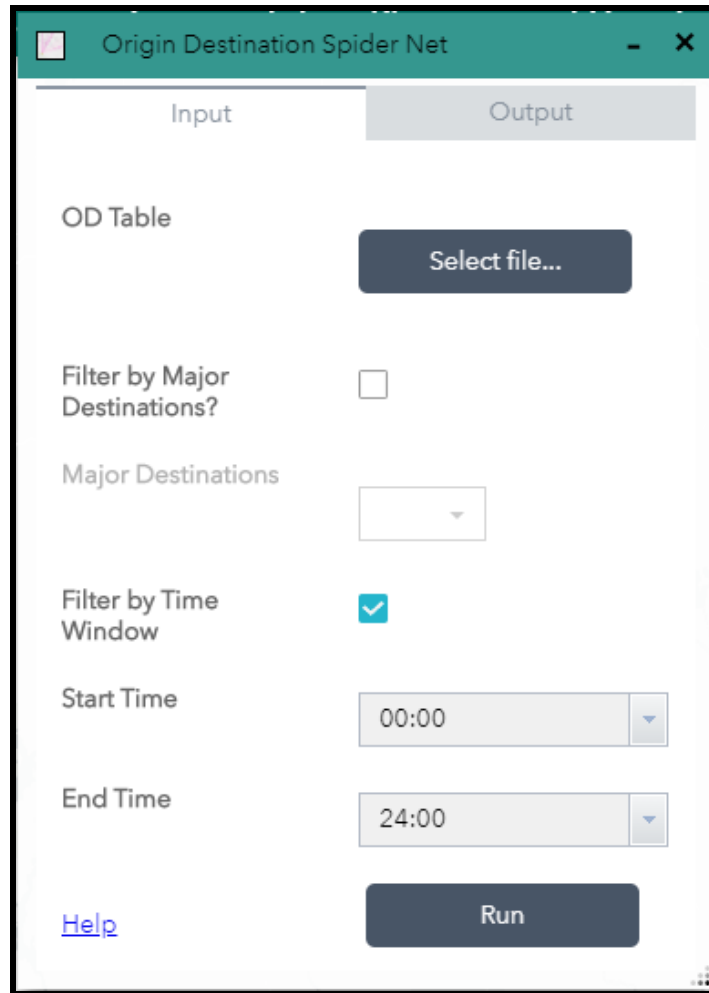


Figure 17 Screenshot of the user-defined parameters used to create the origin-destination spider net layer.

Tool Output:

After running the tool, a single feature layer will be displayed on the map and will be named *OD_Lines*. Figure 18 shows the legend of the *OD_Lines* layer that was added to the map interface. The default symbology classifies lines by the number of visits per day between an origin and associated destination. Thicker lines represent a higher number of connections.

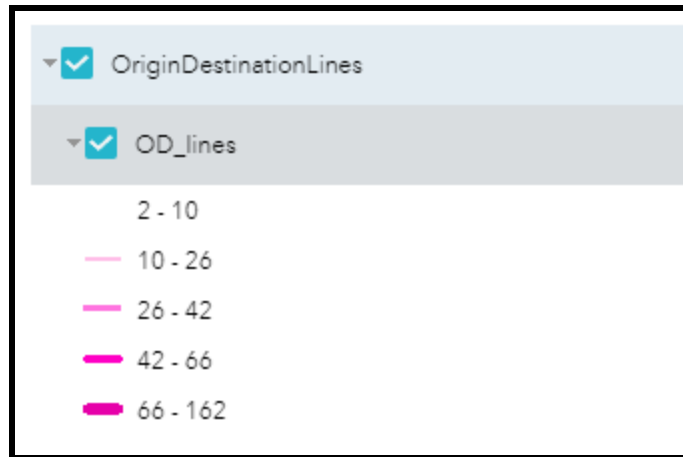


Figure 178 Legend of the OD_Lines layer where thicker lines represent a higher number of connections.

The layer is also made available as a download in a zip file named **OriginDestinationLines.zip**. The name of the shapefile contained within the zip file is **ODLines_lyr.shp**.

Structured Scheduling Tools

The structured scheduling suite of tools aims to assist the transit system in increasing the efficiency of the service while decreasing the effort required to schedule trips on a daily basis. Although some of these tools can be run as standalone tools, if the user is interested in developing a structured scheduling operating environment, it is recommended the tools be run in order as the output from earlier tools are used as input(s) into later tools.

1. Center Zone(s)

The Center Zone(s) tool creates one or more polygons whose boundary generalizes an urban core within a transit system's service area. Center zones are created by aggregating parcels together based on the user's inputs. The result of running this tool is to create a zone that contains a large majority of the client destination requests in the service area. This will ultimately help in reducing the effort required in scheduling trips on a daily basis. The output from running this tool can be used as an input into the remaining tools in this suite: Frequent Corridors, Zone Builder, and Scheduling Generator.

The screenshot below shows a sample output from running the Center Zone(s) tool. In this scenario, two center zones were created due to the nature of this service area's demand characteristics.

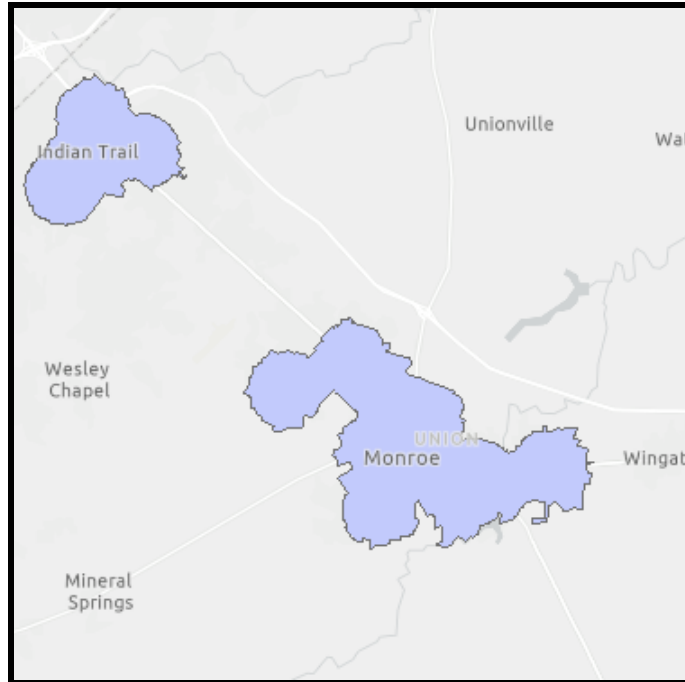


Figure 18 Result from running the Center Zone(s) tool.

Input Parameters:

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Service Area: Specify the service area of interest. In the current application, service areas are based on North Carolina transit system boundaries.

Frequency Threshold: Specify a frequency threshold based on the minimum number of visits per day. Note: only parcels that meet or exceed the frequency threshold will be used in the model. However, the center zone will contain parcels that do not meet this threshold through an aggregation process that is required to fill in gaps in the resulting boundary.

Select Parcels within Radius: Specify the radial distance around each client destination. All parcels within this distance will be selected as the base group used for further aggregation.

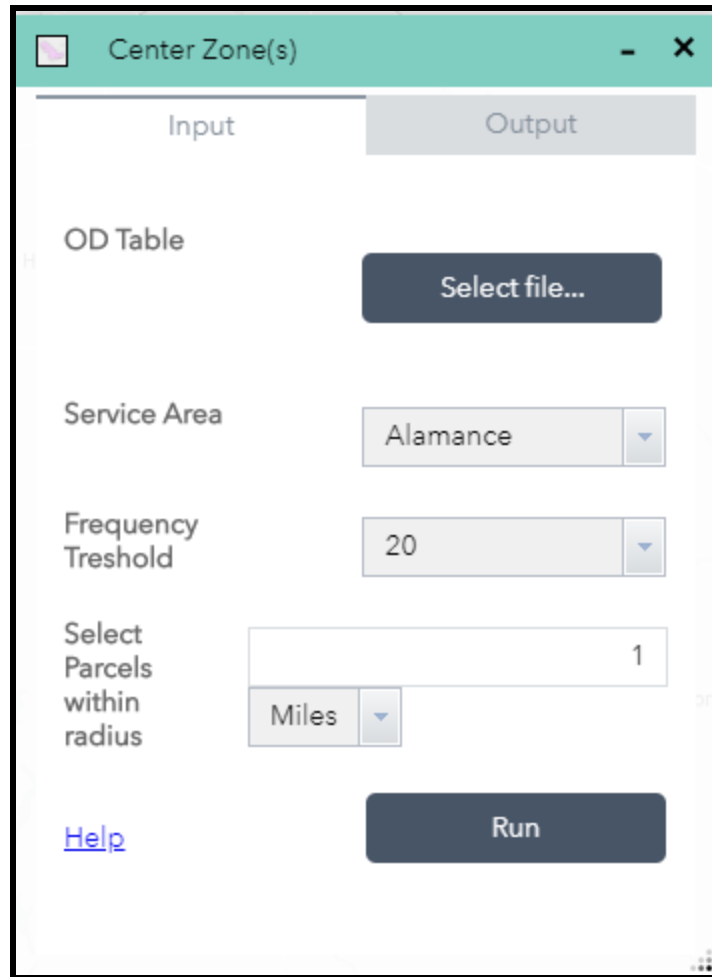


Figure 19 Screenshot of the parameters used in creating the center zone(s).

Tool Output:

After running the tool, a single feature layer will be displayed on the map showing the center zone(s) that were created. The screenshot below shows the legend of the Center Zone(s) layer that was added to the map.

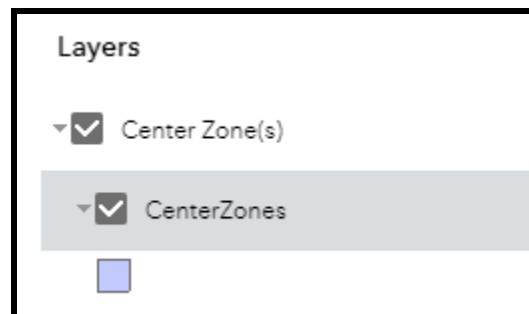


Figure 20 Legend of the Center Zone(s) layer with default symbology.

The layer is also made available as a download in a zip file named **CenterZone.zip**. The name of the shapefile contained within the zip file is *CenterZonesNAD_onlybig_lyr.shp*

2. Frequent Corridors

The Frequent Corridors tool creates a feature layer of frequently used road segments based on input from the user. The results highlight likely corridors of travel within the service area where thicker lines represent a higher number of clients within the user-specified distance threshold of the road. The roads that extend from the outer parts of the service area to the center zone will become the spine of the zones created when running the Zone Builder tool. The underlying road network dataset was obtained from the North Carolina Department of Transportation and can be found at this [link](#).

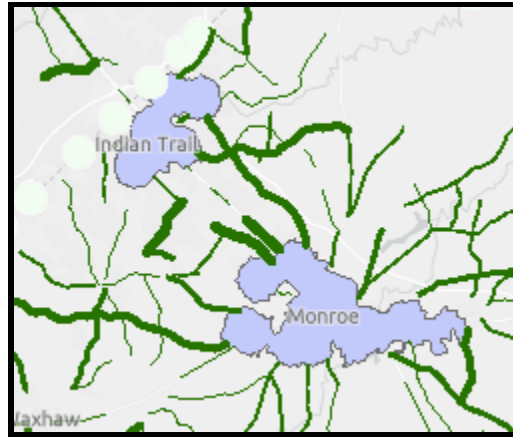


Figure 21 A set of roads that were determined to be frequent corridors based on user-specified parameters. Thicker lines represent a higher number of clients within the user-defined distance threshold.

Input Parameters:

Service Area: Specify the service area of interest. This tool allows the user to select multiple service areas for better representation of the input data.

Center Zone(s): Specify the Center Zone layer to be used in the tool. The tool excludes roads within the central zone from the final result. Typically, the center zone would be created in the previous step. However, the user can upload their own Center Zone layer if preferred. A third option is for the user to draw a center zone boundary directly on the map interface using the tools available.

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Client to Road Threshold: Specify the minimum distance threshold between the client and the nearest road.

Minimum Client Threshold: Specify the minimum number of clients within the road threshold above that is required for a road to be identified as a frequent corridor.

Figure 22 Parameters used in creating the frequent corridors for a service area.

Tool Output:

After running the tool, two feature layers will be added to the map. The first feature layer contains the set of roads that were determined to be frequent corridors. The second feature layer contains a set of points along the boundary of the service area. These points are needed to run the next tool in the suite, the Zone Builder tool.

Figure 23 shows the legend of the Frequent Corridors layer that was added to the map interface. The default symbology classifies lines by the number of clients where thicker lines represent a higher number of clients within the distance threshold.

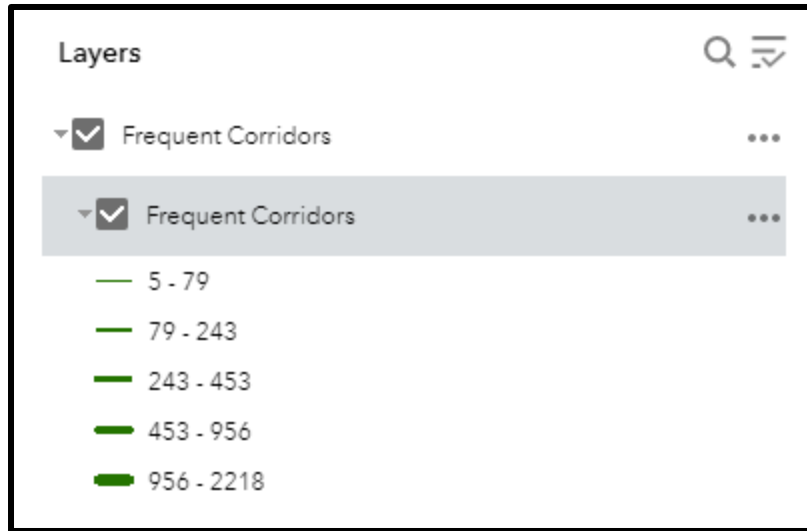


Figure 23 The Frequent Corridors layer legend where the thickness of the line represents the relative number of customers within the user-defined distance.

Both feature layers are made available as a download in a zip file named FrequentCorridors.zip. Only the Frequent Corridors feature layer is contained within the zip file and is named FrequentCorridors.shp.

3. Zone Builder

The Zone Builder tool splits a service area into zones using the three feature layers created by the previous two tools: center zone, frequent corridors, and edge points. To calculate the boundaries of the zones, the tool utilizes least-cost-path analysis to find the shortest distance between the centroid of the center zone and each of the points in the edge point feature layer. Before the calculation can be made, the input feature layers are converted into raster datasets. These raster datasets are then combined to create a single raster dataset using the formula and weights defined below. The tool also requires several feature layers that are maintained in-house. These feature layers are Interstates, Major Roads (US and NC Highways), Minor Roads, Hydrography, and Railroads.

Least Cost Path Formula

$$W_1 * Boundary + W_2 * Interstates + W_3 * Hydrography + W_4 * Railroads + W_5 * Major Roads + W_6 * Minor Roads + W_7 * Frequent Corridors$$

Where the weights are defined as follows:

$$W_1: 30, W_2: -10, W_3: -10, W_4: -10, W_5: 40, W_6: 40, W_7: 2,000$$

The weights are defined in a way to ensure the boundaries of the zones are more likely to fall along Interstates, Hydrography, and/or Railroads. These are typically geographic features that have limited access across them and hence could be prohibitive to transit vehicles. On the other side, frequent corridors

have an extremely high weight. This will ensure they are not a boundary of a zone (recall earlier that frequent corridors would become the spine of the zone) as they provide easy access to and from minor roads. The frequent corridors will also be used as the path of travel from the rural areas of the service area into the center zone.

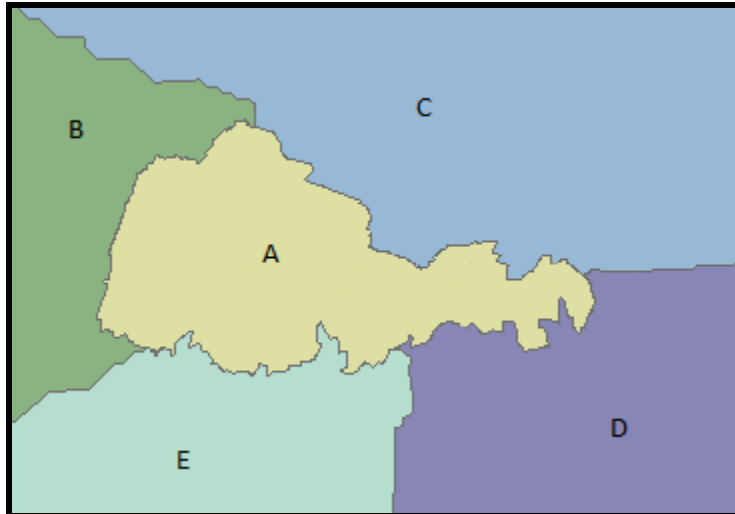


Figure 24 A snapshot of zone boundaries within a service area. In this scenario, there is one center zone and four outer zones.

Input Parameters:

Service Area: Specify the service area of interest. Currently, this is a dropdown list of transit system boundaries in North Carolina.

Frequent Corridors: Specify the feature layer that contains the frequent corridors within your service area. Typically, this would have been created earlier, but the user can upload their own set of frequent corridors if desired.

Boundary Points: Specify the feature layer that contains the edge points. This feature layer was created when the Frequent Corridors tool was run. If a local copy of a Frequent Corridors feature layer was used, it is recommended to run that tool to obtain this feature layer. It is not recommended to upload a local version.

Center Zone(s): Specify the feature layer that contains the center zone(s). This feature layer could be created from the Center Zone(s) tool or created locally and uploaded.

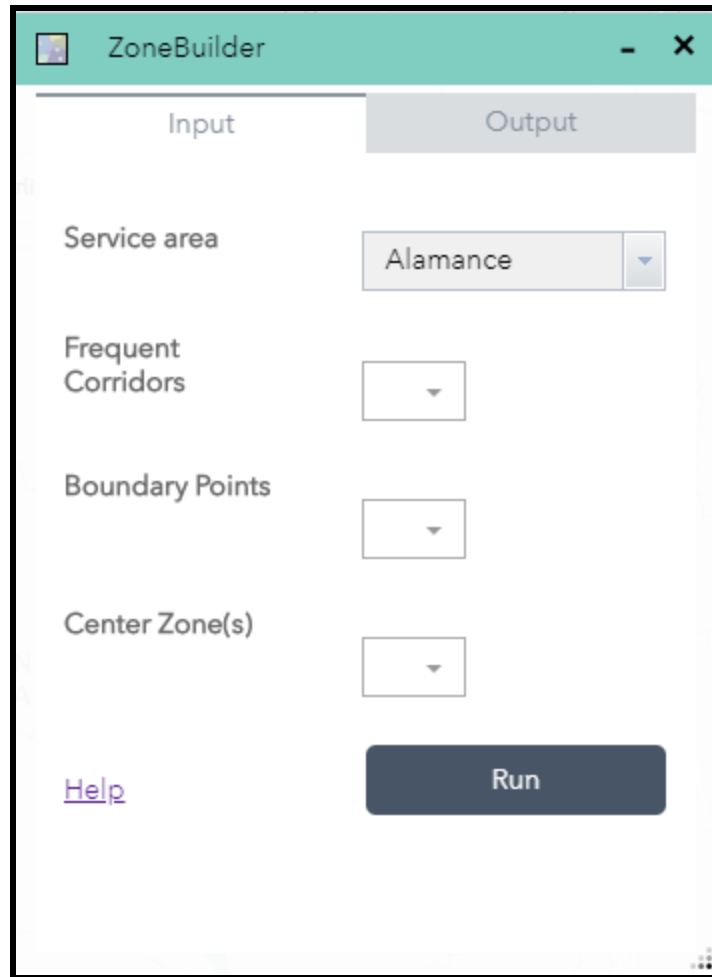


Figure 25 Parameters used to create the Zone Boundary feature layer that covers the service area.

Tool Output:

After running the tool, a single feature layer will be created and added to the map interface. Figure 26 shows the legend of the Zone Boundary layer that was created. The default symbology will ensure each zone is shaded with a different color.



Figure 26 The Zone Boundary layer legend using a default classification scheme that applies a different color to each zone in the feature layer.

The feature layer is made available as a download in a zip file named Zones.zip. The name of the shapefile contained in the zip file is named finalzones_lyr.shp.

4. Scheduling Generator

The Scheduling Generator tool is used to assist a transit system in determining the times of the day service should be provided to and from each zone. Looking at the historical demand within each zone, the instances when the number of trips exceeds the minimum threshold will determine the times when the zones are served. This tool aims to help the transit system group trips more efficiently by asking the clients to schedule appointments based on the time(s) the zone will be served. The minimum thresholds are defined as 0.6 trips per hour between an outer zone and the center zone and 0.4 trips per hour that begin and end within the center zone.

Input Parameters:

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Center Zone(s): Specify the name of the center zone(s). If multiple center zones are to be used in the analysis, make sure to separate them by a semicolon.

Zone Boundary: Specify the feature layer that contains the zone boundaries. This feature layer can be created using the Zone Builder tool or a local copy can be uploaded to the web application.

Include Saturdays: The default setting is to include Saturday trips.

- *Checked: Saturday trips will be included in the ridership analysis to determine the location of major destinations.*
- *Unchecked: Saturday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Include Sundays: The default setting is to include Sunday trips.

- **Checked:** *Sunday trips will be included in the ridership analysis to determine the location of major destinations.*
- **Unchecked:** *Sunday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Speed Limit: Specify the average speed a vehicle will travel throughout an average service day. The speed limit units are miles/hour (mph) and the default speed is 45 mph.

Boarding Time: Specify the average time (in minutes) required to travel to a customer's pickup location and assist the customer onto the vehicle. This time is used when carrying customers to and from an outer zone. For center zone boarding times, see the **Boarding Time in Center Zone** parameter below. The default boarding time is 10 minutes.

Alighting Time: Specify the average time (in minutes) required to travel to a customer's drop off location once in the center zone or another outer zone and to assist the customer exiting the vehicle. The alighting time should take into consideration whether multiple customers have the same drop off request location. The default alighting time is 7 minutes.

Boarding Time in Center Zone: Specify the average boarding time for clients served entirely in the center zone. This should include the time to travel to the client's pickup location. The default value is 5 minutes.

Alighting Time in Center Zone: Specify the average alighting time for clients served entirely in the center zone. This should include the time to travel to the client's dropoff location. The default value is 5 minutes.

Cost per Mile: Specify the estimated cost of service per mile. The default value is \$1.50/mile.

The screenshot shows the 'SchedulingGenerator' application window. It has two tabs: 'Input' (active) and 'Output'. The 'Input' tab contains the following fields and controls:

- OD Table:** A button labeled 'Select file...'.
- Center Zone Name(s) - If multiple, separate with a semicolon (;):** A text input field containing the letter 'A'.
- Zones Feature Class:** A dropdown menu with a downward arrow.
- Include Saturday:** A checked checkbox.
- Include Sunday:** A checked checkbox.
- Speed Limit:** A text input field containing '45'.
- Boarding Time:** A text input field containing '10'.
- Alighting Time:** A text input field containing '7'.
- Boarding Time in Center Zone:** A text input field containing '5'.
- Alighting Time in Center Zone:** A text input field containing '5'.
- Cost per Mile:** A text input field containing '1.50'.
- Buttons:** A blue 'Help' link and a dark blue 'Run' button.

Figure 27 Parameters used to create a structured schedule.

Tool Output:

The output from running this tool is a downloadable Excel Workbook that contains 13 tabs. The data populating each of these worksheets are based on historical service requests. The data are also based on the average unlinked passenger trips (UPT) per operating day. This does not guarantee the number of trips every day as there may be some days with higher levels of service than others. An explanation of the data contained in each of the 13 tabs is explained below.

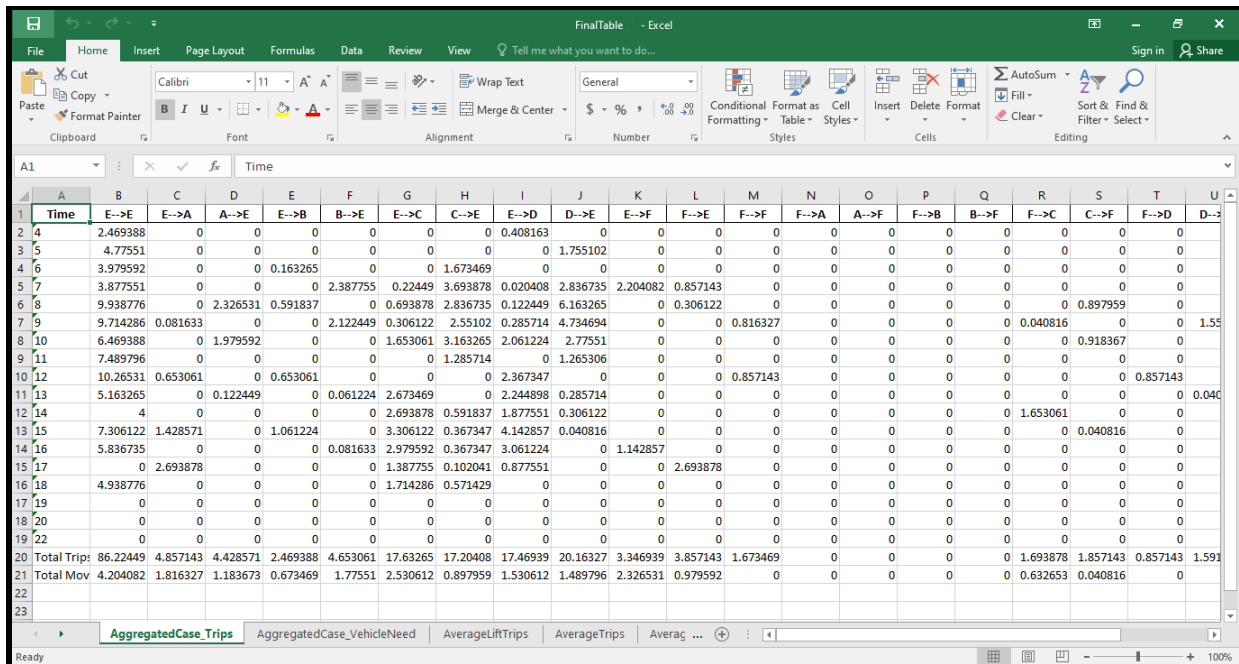


Figure 28 Sample output from running the Scheduling Generator tool. The output is one Excel Workbook containing 13 tabs.

AverageTripsSweeper

The output on this worksheet is the first step in the process of determining when to serve each zone combination. Across the top row are zone-to-zone relationships. The first column contains each hour of the service day. The numbers reported in the worksheet are the average number of UPT for each hour of the day and each zone-to-zone combination. In this case, the zone-to-zone combinations represent service strictly between outer zones. The bottom row sums up the average trips per day for each zone-to-zone combination. The last column sums up the average trips per hour across all zone-to-zone combinations.

AverageTrips

The data on this worksheet is similar to the data reported on the AverageTripsSweeper worksheet except the data are strictly related to service within the center zone and between the center zone and an outer zone. The bottom row of this worksheet shows the average trips per day for each zone-to-zone combination. There are two summary columns at the end of the worksheet: 1. Sum of the average trips for each hour across all zone-to-zone combinations related to the center zone; 2. Sum of the average trips for each hour across all outer zone-to-zone combinations (taken from the AverageTripsSweeper worksheet). Based on this data, a minimum threshold will be used to determine the actual times to serve each zone-to-zone combination (see AggregatedCase_Trips).

AverageLiftTrips

It is important to know whether there are enough wheelchair stations on a vehicle to handle the number of clients who require the use of a lift within a specified hour. The data in this worksheet is similar to the data in the AverageTrips worksheet except it displays the average number of UPT that require the use of a lift vehicle.

AggregatedCase_Trips

Once the average number of UPT for each service hour and zone-to-zone combination is determined, the actual times to serve these zones are pared down. To do this, a minimum average UPT threshold is used

to determine when to serve each zone-to-zone combination. By default, an average of 0.6 trips per hour is used for the cutoff for all trips within the center zone and those between the center zone and an outer zone. If the average trips per hour are less than 0.6 trips per hour, the trip is removed from the schedule. In some cases, trips may be merged with either the previous hour, if the trip is before 12pm, or in the next hour if the trip is after 12pm. If none of the average trips exceed the threshold in the hour before or after, the trip is moved to a sweeper trip (see the MovedTrips explanation below). The resulting data in this worksheet show each instance in which a zone-to-zone combination will be served and the average UPT in the corresponding hour/zone-to-zone combination. Two additional rows show the total number of trips in each zone-to-zone combination as well as the total number of trips moved to a sweeper run. Additional columns show the Total Scheduled Trips, Total Sweeper Trips, Total Trips, and Total Moved Trips for each service hour. The final result of the output in this worksheet is the times each zone-to-zone combination will be served, i.e. the Structured Schedule.

StatisticsSummaryTable

Before determining how many vehicles are required to serve each of the hour/zone-to-zone combinations defined in the AggregatedCase_Trips worksheet, the maximum number of customers served per run needs to be calculated. This worksheet provides the following summary information for each zone-to-zone combination.

- **Zone Distance:** The distance between the centroid of each pair of zones. For trips within the center zone, the distance is calculated by finding the maximum distance across the center zone, divided by 2
- **Travel Time:** The time, in minutes, to travel directly between the centroids of two zones. The travel time between pickups or dropoffs is defined below
- **Available Time:** By default, it is assumed the headway between two zones including travel time, pickups, and drop off is 60 minutes. The available time is calculated by subtracting the Travel Time from 60.
- **Pickup Time per Stop:** This parameter is defined by the user before running the tool. A default time of 10 minutes is displayed when the tool is opened. This time includes the amount of time for the client to get on the vehicle and into their seat plus travel time to the next pickup
- **Drop Off Time per Stop:** This parameter is defined by the user before running the tool. A default time of 7 minutes is displayed when the tool is opened. This time includes the amount of time it takes for the client to exit the vehicle, plus travel time to the next drop off.
- **Maximum Customers Served per Run:** This parameter is calculated by dividing the Available Time by the sum of the Pickup Timer per Stop + Drop Off Time per Stop and rounding down.
- **Time Left:** The amount of time left after picking up and dropping off all clients within an hour headway. This metric can be used to determine if a smaller Pickup or Drop Off Time per Stop could be used to reduce this number so most of the hour is used.
- **Miles per Run:** This metric estimates the total miles a vehicle will travel during one run. This includes the mileage between the centroid of two zones plus the estimated mileage of picking up the maximum number of passengers as stated above.

AggregatedCase_VehicleNeed

Once the output from the AggregatedCase_Trips worksheet is finalized, the next step is to determine the number of vehicles needed to provide service to each zone-to-zone combination for each hour that meets the minimum UPT threshold. The results from the StatisticsSummaryTable show the maximum allowed passengers for each zone-to-zone combination. So, the aggregated trips are divided by the maximum allowed passengers to determine the total number of vehicles needed for each hour and zone-to-zone combination. The summary information included in this worksheet are as follows:

- **Row Summary**

- Run Frequency: Totals up the total number of runs in a day for each zone-to-zone combination
- Total Miles: An estimate of the total miles traveled in a day for each zone-to-zone combination based on the Miles per Run calculated in the StatisticsSummaryTable.
- Column Summary
 - The total number of scheduled runs for each hour across all zone-to-zone combinations.
 - The total number of sweeper runs for each hour across all zone-to-zone combinations.
 - The sum of scheduled and sweeper runs for each hour across all zone-to-zone combinations.
 - This data metric will highlight the peak hour usage and quickly determine whether or not the vehicle need has exceeded the fleet size of the transit system.
 - To reduce the total number of vehicles required, the boarding and alighting times can be reduced. This would be related to the Time Left in the StatisticsSummaryTable. If that number is close to the time needed for an additional pickup, reducing the boarding and alighting times may allow for an additional passenger on the vehicle, and in turn may reduce the number of vehicles required during the peak hour service.

BaseCase_Trips

To determine whether the new structured schedule improves upon the existing service, it is necessary to create a table showing when and how many trips are being served between each zone-to-zone combination in the hour they were actually served. The data in this table is the same as in the AggregatedCase_Trips table but no trips have been moved.

BaseCase_VehicleNeed

The data in this table is calculated in the same way as the data in the AggregatedCase_VehicleNeed table except the trip data comes from the BaseCase_Trips table. Once this table is created, a quick comparison of the summary statistics can be made with those in the AggregatedCase_VehicleNeed table to see if there is any improvement in total miles and number of runs.

ComparisonTable

The data in this table compares the number of Runs, Cost, and Cost per Trip between the existing service and the proposed service using the structured scheduling model. The existing service is tagged with the proposed origin to and from destination zones. The runs are estimated by taking the total number of trips between two zones and dividing by the number of operating days and 3 (-a conservative estimate of the number of passengers that can ride in a vehicle within an hour headway between two zones). The data is broken down for each zone-to-zone combination that revolving around the center zone. The second to last column totals up all of these runs, total cost, and cost per trip. The data for sweeper trips are cumulated into the final column in the table.

CurrentRideTime

Based on historical origin/destination data, the ride time is calculated for each trip by subtracting the pickup time from the dropoff time. These are then summed up for each hour and zone-to-zone combination. The time reported is in minutes.

- Row Summary
 - The total ride time, in minutes, in a day for each zone-to-zone combination
- Column Summary
 - The total ride time, in minutes, for each hour across all zone-to-zone combinations

NewRideTime

Using the proposed zone boundaries, the new ride time is estimated based on the number of passengers, the travel time, and the pickup time for each hour and zone-to-zone combination.

MovedTrips

After determining the average trips between two zones, the next step is to aggregate trips together across service hours. This is usually done when two consecutive hours exceed the minimum threshold to be included in the service. In this scenario, the trips from one hour are moved to another. This allows for the transit system to increase its efficiency by grouping trips together, but also ensuring all trips are still provided.

OD Table

Initial Origin-Destination dataset that includes new columns:

HourBlock - the hour in which passengers board or alight from the Feeder Zone

FromToZone - the origin DFR/FR or Feeder Zone to the destination DFR/FR or Feeder Zone in the format "A_to_B"

Deviated Fixed Route and Stop Analysis / Social Justice Measures Tools

1. Deviated Fixed Route Proposal

The Deviated Fixed Route Proposal tool creates a feature class containing road segments that can assist a transit system in creating a deviated fixed route in the urban core of their service area. This tool is not intended to create the route, but highlight those roads that warrant consideration to be included in the route.

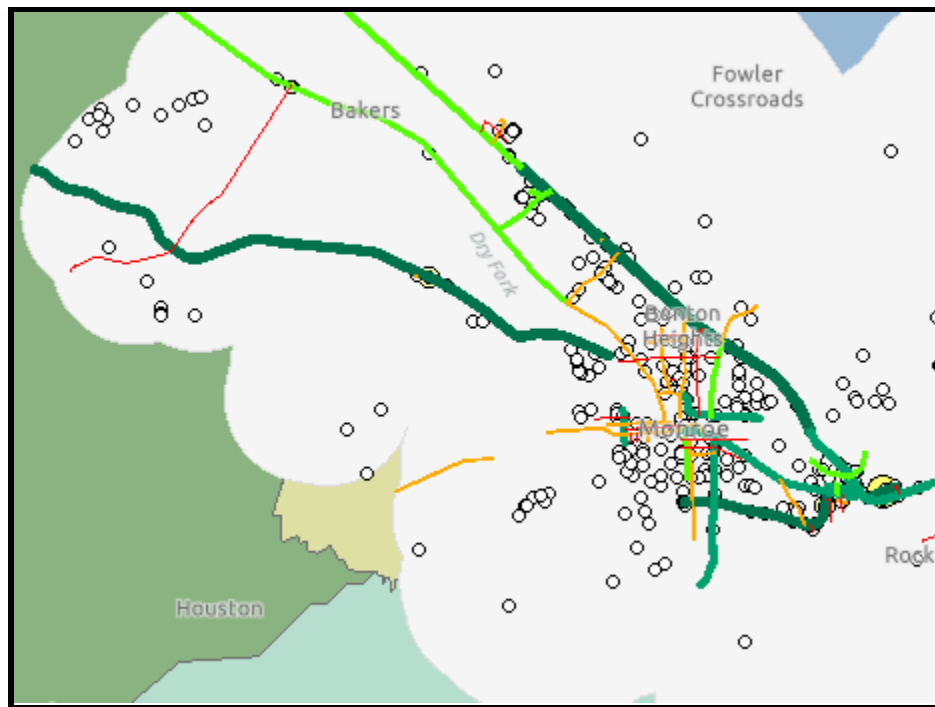


Figure 29 Sample output from the Deviated Fixed Route Proposal tool.

Input Parameters:

City: Specify the name of the city under consideration for a deviated fixed route. This parameter is a dropdown box that contains all of the municipalities within North Carolina.

Do you want to use custom boundaries?: If the user would prefer to use custom boundaries, select this option. Once this option is selected, the next parameter will become enabled.

Custom Boundaries: If the previous parameter is selected, this parameter will become enabled. There are two custom boundary choices the user can use. First, a custom boundary feature class can be uploaded to the application through the Add Data widget. Second, a custom boundary can be drawn on the application using the Draw widget.

Do you know the major stops?: If this option is selected, the next parameter will become enabled allowing the user to upload a feature class of known major destinations. Otherwise, the tool will create a Major Destinations feature layer as part of the process.

Major Destinations: If the previous parameter is selected, this parameter will become enabled and the user will select the appropriate feature layer. If this option is disabled, the Major Destinations feature layer will be created by this tool.

OD Table: User-specified origin-destination table in .csv format containing client information matching the required schema.

Minimum # of trips per day: If the major destinations are not known, the user will specify the minimum # of trips per day for a client destination to be considered a major destination.

Search radius: Specify the search radius around the major destinations to identify road segments to be considered as part of the proposed deviated fixed route.

Include Saturdays: The default setting is to not include Saturday trips.

- *Checked: Saturday trips will be included in the ridership analysis to determine the location of major destinations.*
- *Unchecked: Saturday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Include Sundays: The default setting is to not include Sunday trips.

- **Checked:** *Sunday trips will be included in the ridership analysis to determine the location of major destinations.*
- **Unchecked:** *Sunday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

DeviatedFixedRoute

Input

Output

City

Elizabeth City

Do you want to use Custom Boundaries?

☒

Custom Boundaries

Areas

Do you Know the Major Stops?

☒

Major Destinations

MajorDe...

ODTable

Select file...

ICPTA_OD_20190301_20190830.csv

Minimum # of Trips per Day

10

Search Radius

1,000

Feet

Include Saturday

☐

Include Sunday

☐

[Help](#)

Run

Figure 30 Parameters used to create route segments to be considered for a fixed route. In this example, the output is based on a custom boundary drawn on the map and major destinations that were created using the tool in this application.

Tool Output:

After running this tool, several layers are created and added to the application interface. The first feature layer contains the set of proposed route segments that meet the criteria defined in the input parameter. The second feature layer contains the client pickups and dropoffs within the buffered service area. The third feature layer contains the major destinations within the buffered service area. The final feature layer contains a polygon layer that is a 1-mile buffer around the service area.

Each of these feature layers are made available as a download in a zip file named **ProposedFixedRoutes.zip**. Within the zip file, the four shapefiles are named: **ClientsDOInUrbanArea.shp**; **MajorDestinations.shp**; **ProposedFixedRoutes.shp**; **ServiceAreaBuffer.shp**.

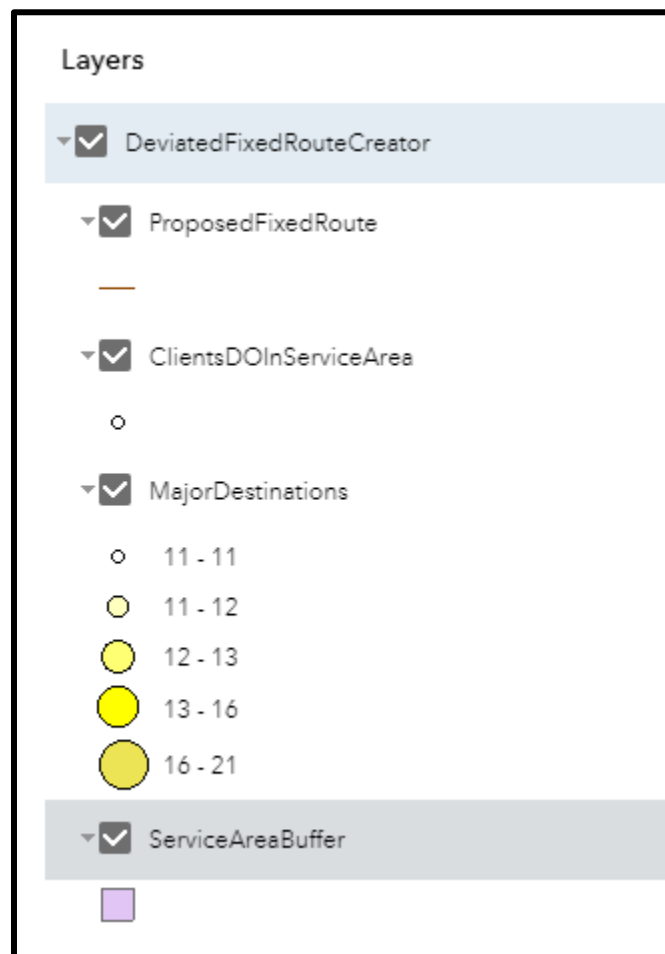


Figure 31 The legend showing the default symbology for each of the feature layers created when running the Deviated Fixed Route Proposal tool.

2. Feeder Zone Analyzer

The Feeder Zone Analyzer tool determines the average daily clients served by a connection from a demand response service zone to a deviated-fixed/fixed route (DFR/FR).

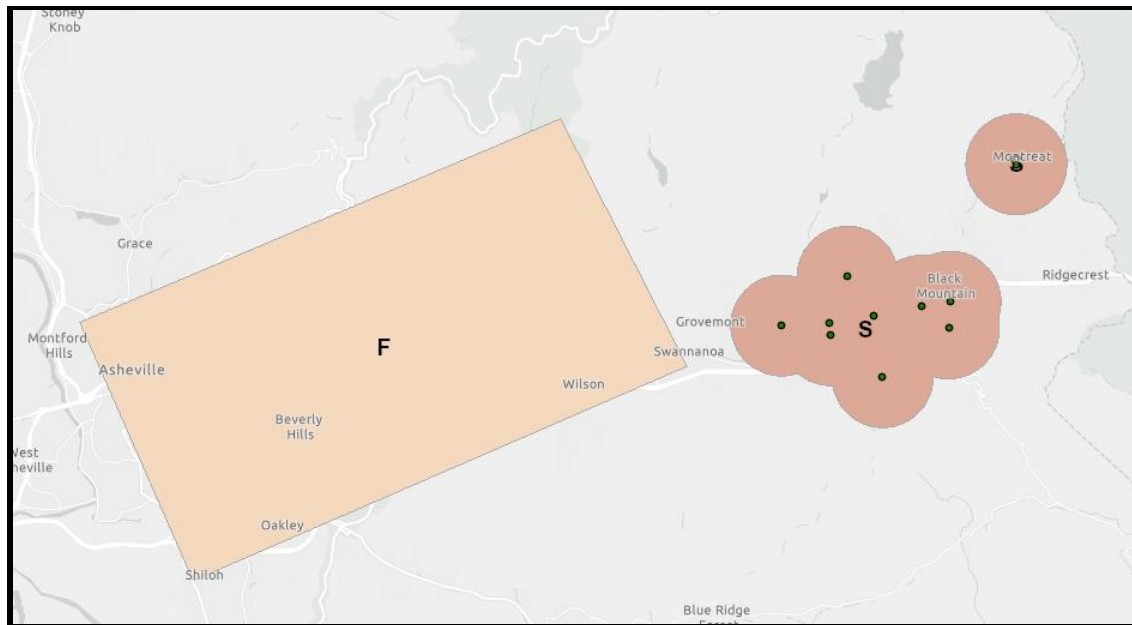


Figure 32 Scenario showing the Feeder Zone, F, and the buffered service area, S, around the deviated fixed route.

Input Parameters:

Input Stops Data: Specify the feature class or layer containing all stops in the user-specified DFR/FR. The columns containing the scheduled stop times must include the word ‘time’. Ideally, the input feature class would follow the schema defined in the Appendix.

Selected Stops: Specify the name or ID of the stop chosen to make the connection from the feeder zone to the DFR/FR.

Deviated Fixed Route: Specify the feature class or layer that delineates the shape of the DFR/FR. If no DFR/FR feature layer is specified, the service area will be based on the stops provided in the Input Stops Data parameter above.

Buffer Distance: Specify the buffer distance around the route defined in the DFR/FR feature layer. If no DFR/FR feature layer is specified, the buffer distance will be applied to the stops provided in the Input Stops Data parameter above.

Feeder Zone: Specify the polygon feature class or layer that represents the zone from which clients will be transferred to or from the DFR/FR.

Include Saturdays: The default setting is to not include Saturday trips.

- *Checked: Saturday trips will be included in the ridership analysis to determine the location of major destinations.*
- *Unchecked: Saturday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Include Sundays: The default setting is to not include Sunday trips.

- **Checked:** *Sunday trips will be included in the ridership analysis to determine the location of major destinations.*
- **Unchecked:** *Sunday trips will NOT be included in the ridership analysis to determine the location of major destinations.*

Travel Time in Feeder Zone (in minutes): Specify the amount of time it takes to travel within a feeder zone to pick up all clients and travel to the transfer stop location on the DFR/FR.

Figure 33 User interface of the Feeder Zone Analyzer tool.

Tool Output:

The output from running this tool is a feature layer that is added to the map with a default symbology differentiating the feeder zone from the service zone. This feature layer is made available as a download in a zip file named **FeederZoneAnalyzer.zip**. In addition, a .csv file named **FeederZoneAverageTrip.csv** is available to download which shows the average trips per day between the feeder zone and the service area.

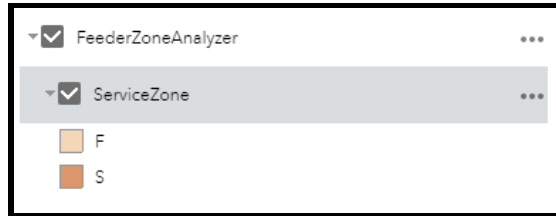


Figure 34 Legend showing the default color scheme assigned to the feeder zone (F) and service area (S).

	A	B	C
1	Time	F-->S	S-->F
2	11:30	0.083333	0.333333
3	14:30	0.166667	0
4	15:30	0.5	0.25
5	7:45	0	0.083333
6	8:30	0	0.833333
7	9:30	0	0.166667
8	No service	3.166667	1.916667

Figure 35 The average trips per day between the feeder zone (F) and the service area (S) by the time of day.

3. Social Justice Measure

The Social Justice Measures tool displays in the web-application a series of feature layers based on data obtained from the most recent American Community Survey 5-year dataset.

- Total Population (Census Block level)
- Elderly Population – 65+ (Census Block Group level)
- Limited English Proficiency Population (Census Block Group level)
- Population Below Poverty Line (Census Block Group level)
- Zero Car Households (Census Block Group level)
- Limited Mobility Population (Census Block Group level)

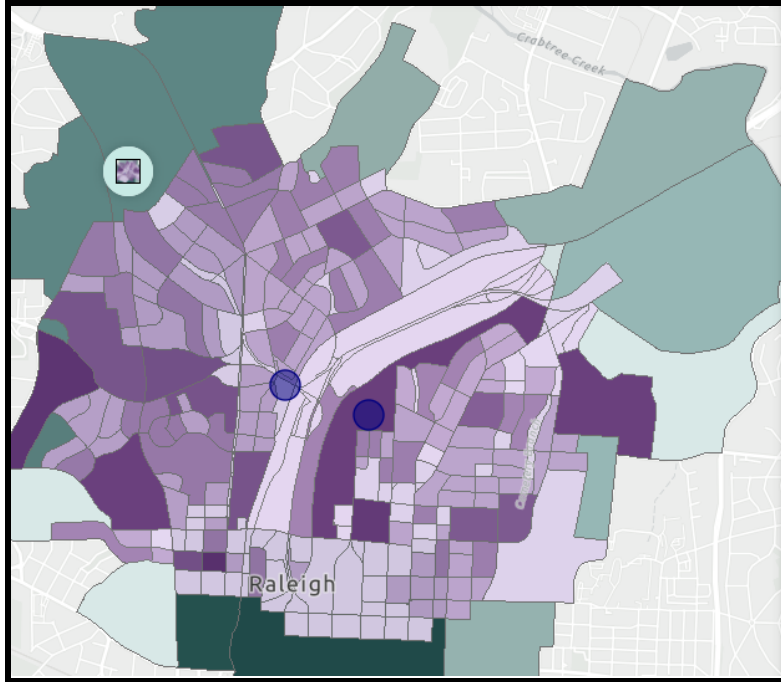


Figure 36 Sample output from running the Social Justice Measures tool. In this example, the two points in blue define the 'area' of interest, and the Census Blocks and Block Groups were selected based on a user-defined radius around the points of interest.

Input Parameters:

Service Area: Specify the service area to be analyzed. This can be any of the outputs generated from a previous tool or the data can be uploaded using the *Add Data Widget* tool. The input feature layer can be a layer of points (stops), polylines (DFR/FR), or polygons (service area).

Would you like to draw your object on the map?; The user can select this option if they would like to draw the object of interest on the map. This can include multiple points, polygons, or polylines. After checking this box, the set of drawing tools will become enabled.

Custom Service Area: Choose one of the drawing tools to create one or more points, polygons, or polylines.

Selection Radius: Define the radius around the user-specified service area to be evaluated.

The image shows a software window titled "Social Justice" with a light blue header bar containing a small icon and window controls. The interface is divided into two tabs: "Input" (active) and "Output".

Under the "Input" tab, there are three main sections:

- Service area:** A dropdown menu with a downward arrow.
- Would you like to draw your object on map?:** A checkbox that is checked.
- Custom Service Area:** A grid of 12 icons for drawing shapes:
 - Row 1: Pin icon, straight line icon.
 - Row 2: Zigzag line icon, curved line icon.
 - Row 3: Arrow pointing up-right, solid triangle icon.
 - Row 4: Solid square icon, solid circle icon.
 - Row 5: Solid oval icon, solid pentagon icon.
 - Row 6: Star icon, red square with a white exclamation mark icon.

At the bottom of the "Input" section, there is a "Selection Radius" section with a text input field containing the number "1" and a unit dropdown menu currently set to "Miles".

At the bottom of the window, there is a blue "Help" link on the left and a large green "Run" button on the right.

Figure 37 User interface of the Social Justice Measures tool. In this example, the user has chosen to draw a customized service area on the map.

Tool Output:

After running the Social Justice Measures tool, seven feature layers will be added to the map interface. Six of the seven layers are symbolized by the attribute matching the feature layer name. This data is summarized from the most recent American Community Survey 5-year data. The Total Population feature layer is comprised of Census Blocks while the rest of the feature layers are comprised of Census Block Groups. The final feature layer added to the map is a copy of the input service area with a single record summing up the data contained within all of the blocks and block groups that intersect the service area. This feature layer is also made available as a download in a .zip file named **SocialJustice.zip**.

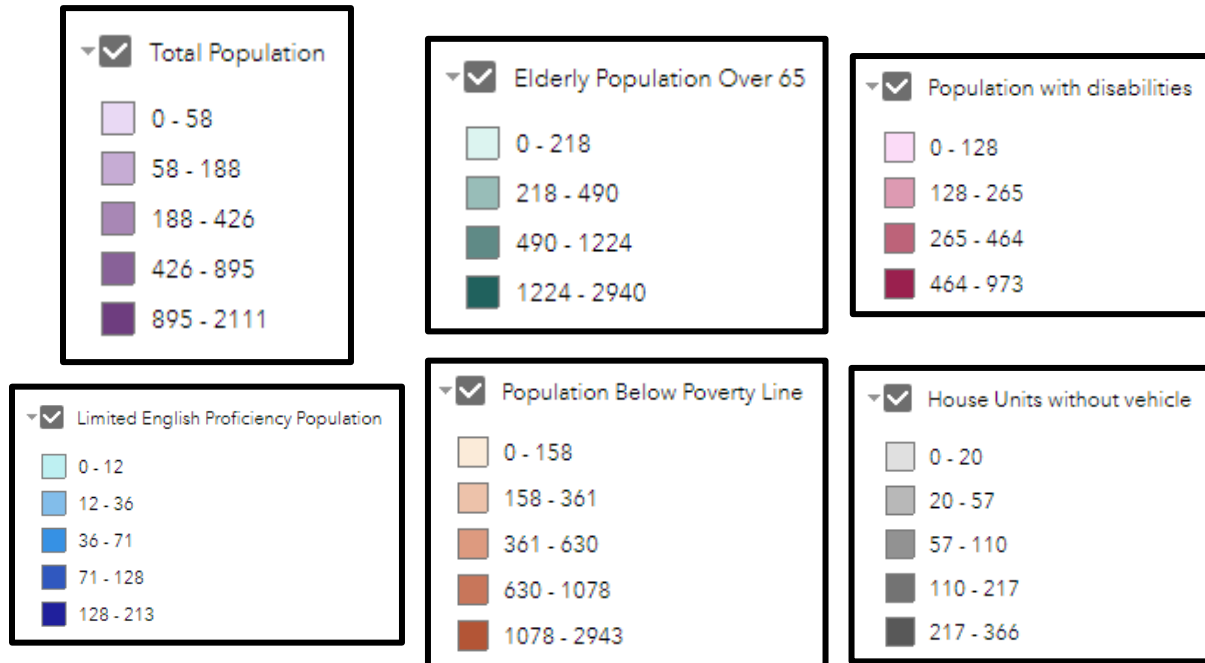


Figure 38 The legend for each of the feature layers, with a default classification, created after running the Social Justice Measures tool. The Total Population feature layer is classified by Census Blocks while the rest of the feature layers are classified by Census Block Groups.

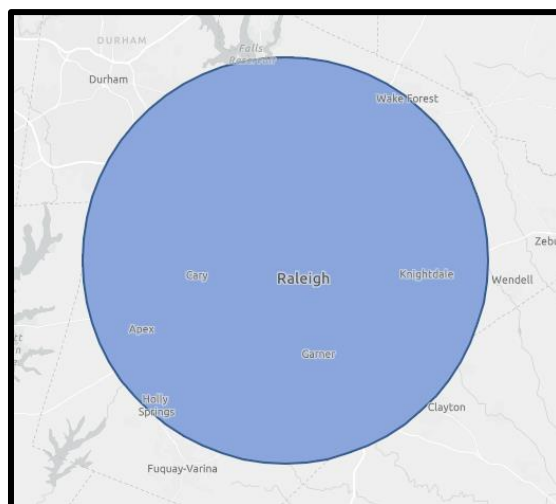


Figure 39 Output feature of the input service area. Attribute data found in Figure 40.

TotalPOP	ElderlyPOP	Disability	LimitedENG	Poverty	ZeroCarHH	BGCount	AREA_acre
1,140,605	124,367	93,745	10,880	181,085	16,542	481	636,051.00

Figure 40 Attribute data in the output feature layer. Each attribute contains the sum of the corresponding Census Blocks or Block Groups that intersect the service area.

Utility Tools



Figure 41 Screenshot of the Utility Tools toolbar. This toolbar is found in the upper right corner of the application window.

1. Add Data

Several of the core visualization and analytical tools allow the user to upload a shapefile of their own. This can be done using the Add Data tool found in the Utility Tools toolbar.



Figure 42 The Add Data tool found in the Utility Tools toolbar.

Three types of files can be added to the web-mapping application. In each case, there is a limit of 1,000 records. The user can either drag and drop the file(s) or browse to the folder containing the file(s) to be uploaded.

1. Shapefile (.shp): To upload a shapefile, it must first be saved to a .zip archive.
2. CSV (.csv): This can be a comma, semi-colon or tab-delimited file. It should contain latitude and longitude information.
3. KML (.kml): Keyhole Markup Language contains geospatial information in XML notation. Can be exported from a Google MyMap

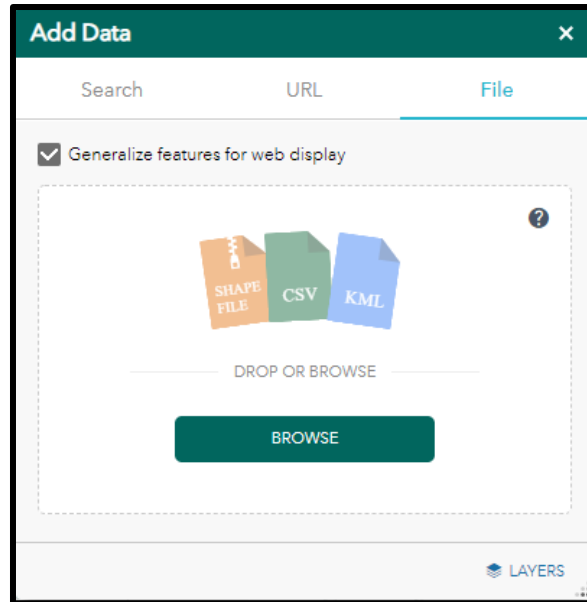


Figure 43 User interface of the Add Data tool. The user can upload a shapefile, CSV, or KML.

2. Change Basemap

The Change Basemap tool allows the user to change the background image displayed on the map interface. Several basemaps are made available which provide different background information, depending on the user's interest and type of tool(s) being run.



Figure 44 The Change Basemap tool found in the Utility Tools toolbar.

After pressing the button to change the basemap, the Basemap Gallery window will open up showing 10 different basemaps to choose from. When the web-mapping application starts, the default basemap is *Light Grey Canvas*.

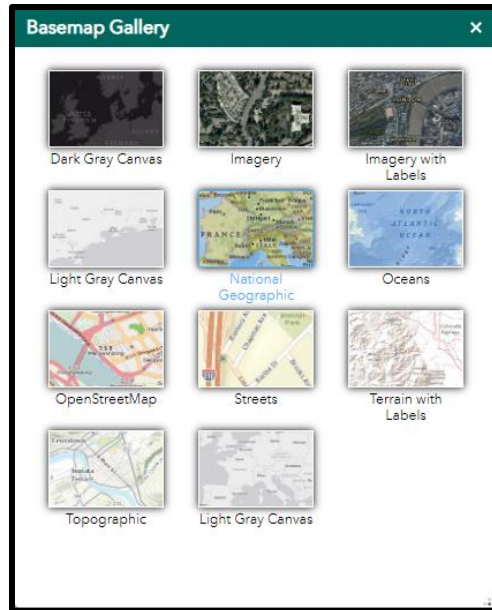


Figure 45 Basemap Gallery showing 10 unique background maps displaying different contextual information.

3. Save Session

The Save Session tool allows the user to save their current progress in the application allowing them to continue at that point instead of having to start over. The Save Session tool can be found in the Utility Tools toolbar in the upper right corner of the screen.



Figure 46 The Save Session tool found in the Utility Tools toolbar.

When the user presses the Save Session button, a SaveSession window opens up on the map interface. In this window, the user will be asked to provide a name for the session. To save the session, the name must be unique and the Save button will remain greyed out until a unique name is provided. The user can then save the session by clicking the hyperlink labeled 'Save to File'. Similarly, if the user would like to load in a previously saved session, they would press the Save Session button and click the hyperlink labeled 'Load from File'.

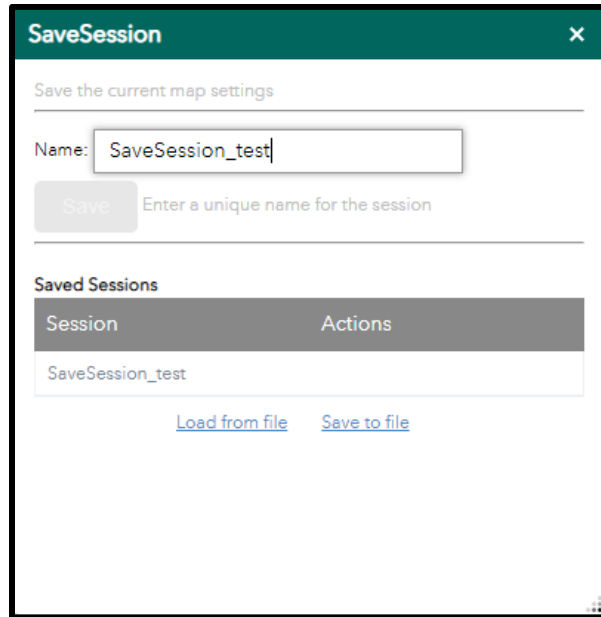


Figure 47 Screenshot of the SaveSession dialog. In this example, there is a previously saved session named 'SaveSession_test'. Therefore, the Save button is currently greyed out because the current name is not unique.

After clicking the 'Save to file' hyperlink, a .json file will be saved to your computer. Generally, the download will show up at the bottom of the application window. It is recommended to create a folder on the desktop of the user's computer and move this file from the download folder to the newly created folder.

To load in a previously saved session, click the hyperlink 'Load from file'. Clicking this hyperlink will open a new window allowing the user to browse to the folder that contains the session to be loaded into the application.

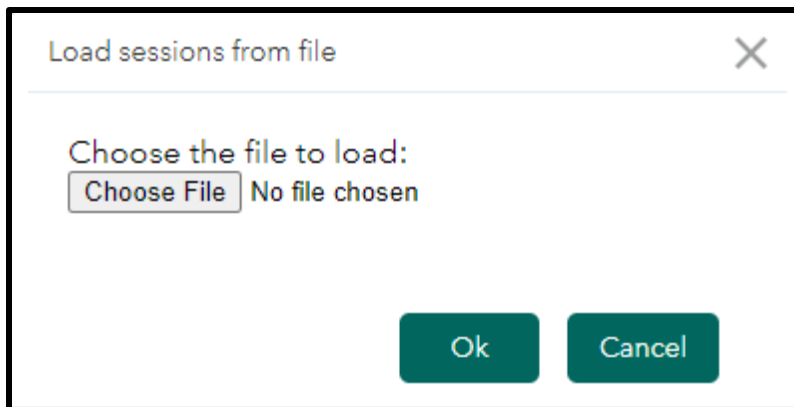


Figure 48 The user interface to load a previously saved session.

Miscellaneous Tools

The remaining tools in the Utility Tools toolbar perform a range of functions. Each of these tools is described below.

1. Select Tool

The user can use this tool to select features from specific layers displayed in the application window.



Figure 49 The Select tool found in the Utility Tools toolbar.

The screenshot below shows the Select tool interface. In the tool interface, there are four layers displayed in the mapping application window (client pickup locations, client drop off locations, center zone, and a drawn rectangle). Only the client pickup layer has been chosen to be a selectable layer. Next to the Select tool interface, the mapping application shows several points that have been selected. A selection was made using the same dimensions as the blue square and the only points shown as selected are the client pickups that are completely contained within the blue square.

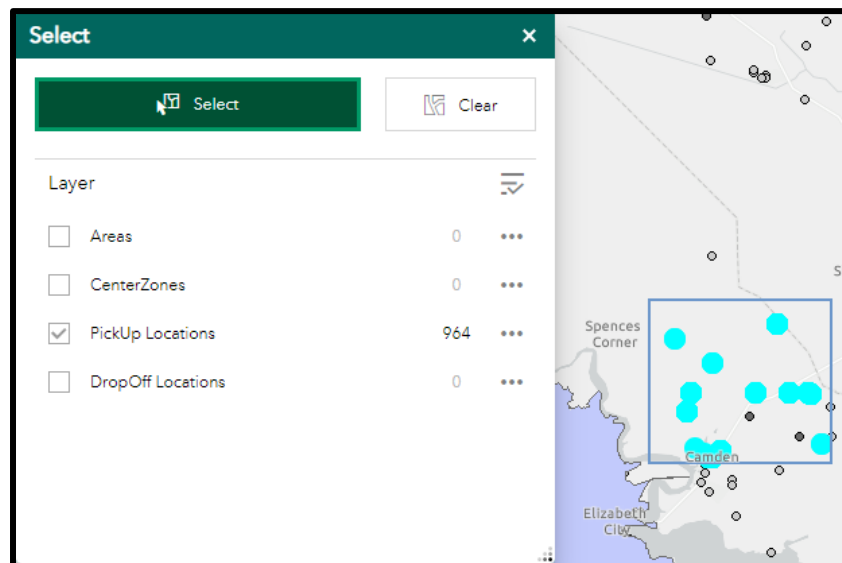


Figure 50 The left side shows the tool interface with one selectable layer. The right-hand side shows selected client pickups in light blue, that were selected by dragging the blue square completely around them.

2. Measurement Tool

The Measurement tool allows for three types of measurement: measure the area of an object; measure the distance between two objects or the length of an object; measure the location of an object. For each case, the user can select the units from the dropdown to the right of the measurement choices.



Figure 51 The Measurement tool found in the Utility Tools toolbar.

To measure the area of an object, open the measurement tool, and select the *Area* measurement option. With the cursor, click and drag the mouse around the area to be measured. At the end of the area, double click to complete the measurement.



Figure 52 The icon used to measure the area of an object within the Measurement tool interface.

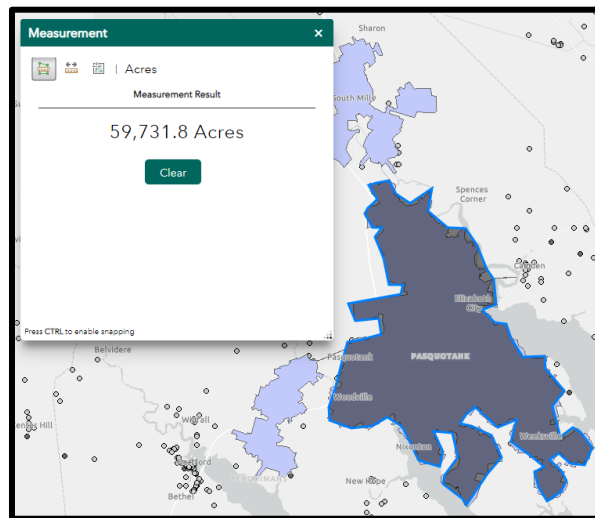


Figure 53 The area of the highlighted polygon is 59,731.8 Acres.

To measure the length of an object or the distance between two objects, open the measurement tool, and select the length measurement option. With the cursor, click the mouse at the start of the measurement, drag to the end of the measurement, and double click the mouse.



Figure 54 The icon used to measure the length of an object or the distance between two objects.

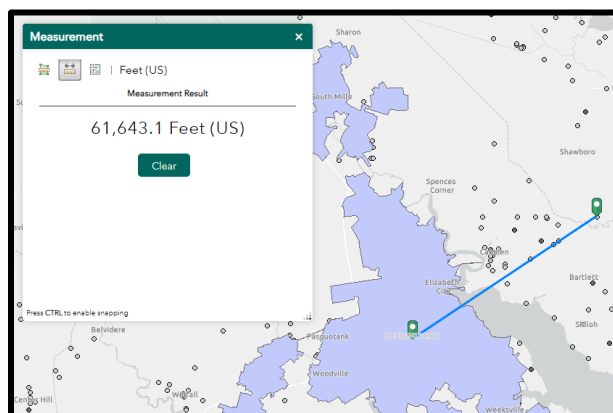


Figure 55 The distance between a pickup and the centroid of the shaded polygon is 61,643.1 feet.

To measure the location of an object, open the measurement tool, and select the location measurement option. With the cursor, select the object of interest.



Figure 56 The icon used to measure the location of an object.

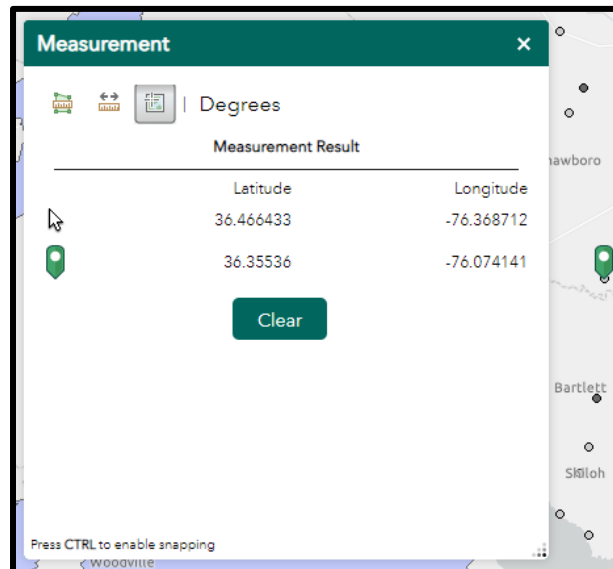


Figure 57 The location of the selected object is 36.35536° Lat and -76.074141° Lon. The measurement tool also displays the coordinates of the cursor as it moves throughout the map interface.

Next Steps

1. Rollout

The next phase of this project is to transfer the application from the testing portal to its permanent web address. For the time being, the application will only be turned on when an access request is made. Once we have started providing training and regular access is requested, the application will be turned on full time.

2. Training

It is recommended interested users attend a workshop providing an overview of the DRT application. The workshop will provide an in-depth overview of the application and all of the tools available within the application. Prior to conducting the workshops, a manual will need to be created that can be used in conjunction with the workshop. The tool overviews contained within this report will form the basis of the manual. Exercises will be created for each tool using real-world data and scenarios to ensure a complete understanding of each tools' capabilities and to familiarize the user with the application interface. Ideally,

these workshops would be in-person which provide a better learning experience. However, under the current operating environment, these will be required to be taught through an online environment.

3. Maintenance Updates

Throughout the life of the application, regular licensing updates will be required. These are typically done on an annual basis as ESRI rolls out new licensing. In addition to regular licensing updates, it will be necessary to create a regular backup schedule to ensure the integrity of the application should there be a catastrophic failure of the server.

Appendix

Contained within this appendix are the data schemas for the Origin-Destination (OD) table and other layers where the OD table utilizes their primary key. The OD table schema is based on GTFS Flex which contains elements common to major scheduling software packages.

1. ER Diagram

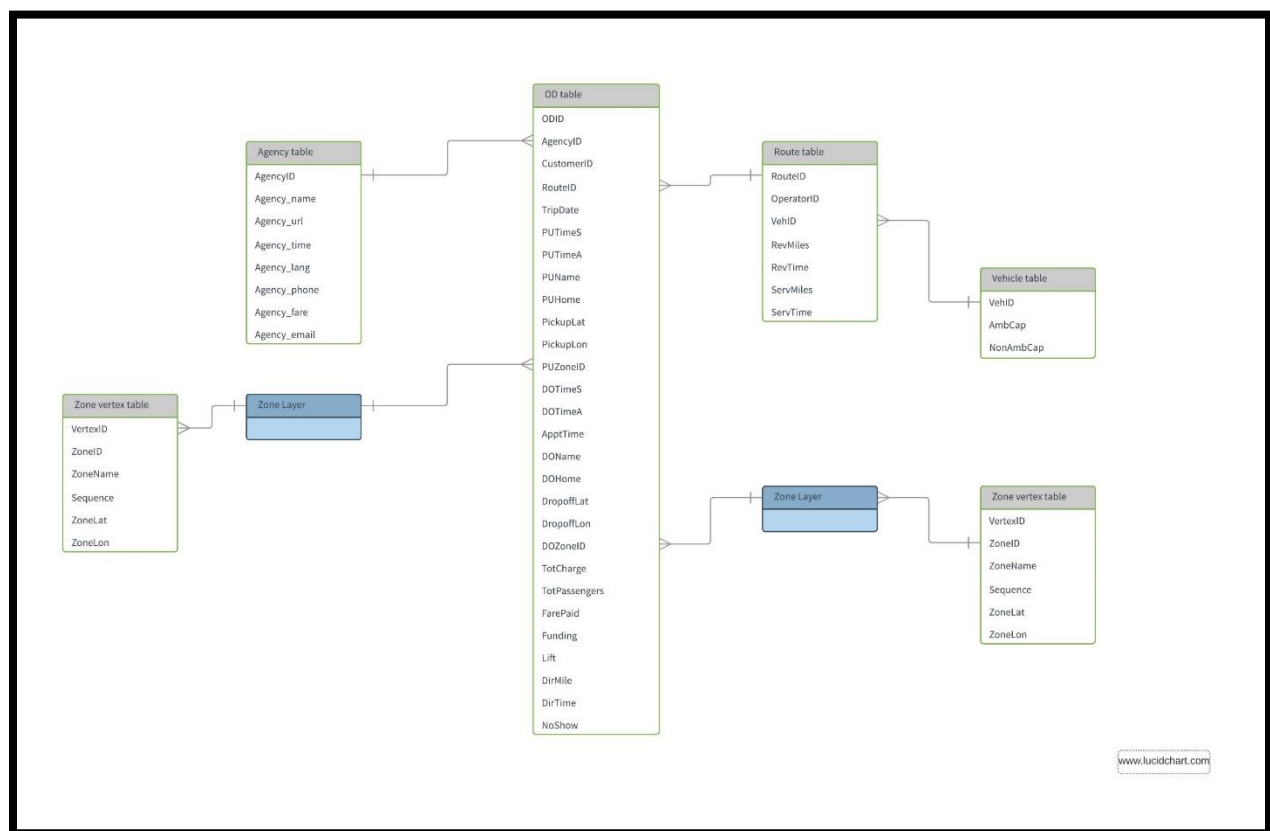


Figure 58 ER diagram showing the relationship between the OD table and other tables used in the GTFS data schema.

2. Agency Table Schema*

Field Name	Data Type	Field Size	Field Name Description	Details
AgencyID	Long Integer		Agency ID	The agency_id field is an ID that uniquely identifies a transit agency. The agency_id is dataset unique.
Agency_name	Text	255	Agency Name	The agency_name field contains the full name of the transit agency.
Agency_url	Text	255	Agency Url	The agency_url field contains the URL of the transit agency. The value must be a fully qualified URL that includes http:// or https://, and any special characters in the URL must be correctly escaped. See http://www.w3.org/Addressing/URL/4_URI_Recommendations.html for a description of how to create fully qualified URL values.
Agency_time	Text	50	Agency Timezone	The agency_timezone field contains the timezone where the transit agency is located. Timezone names never contain the space character but may contain an underscore. Please refer to http://en.wikipedia.org/wiki/List_of_tz_zones for a list of valid values. If multiple agencies are specified in the feed, each must have the same agency_timezone.
Agency_lang	Text	50	Agency Language	The agency_lang field contains a two-letter ISO 639-1 code for the primary language used by this transit agency. The language code is case-insensitive (both en and EN are accepted). This setting defines capitalization rules and other language-specific settings for all text contained in this transit agency's feed. Please refer to http://www.loc.gov/standards/iso639-2/php/code_list.php for a list of valid values.
Agency_phone	Text	50	Agency Phone	The agency_phone field contains a single voice telephone number for the specified agency. This field is a string value that presents the telephone number as typical for the agency's service area. It can and should contain punctuation marks to group the digits of the number. Dialable text (for example, TriMet's "503-238-RIDE") is permitted, but the field must not contain any other descriptive text.
Agency_fare	Text	255	Agency Fare Url	The agency_fare_url specifies the URL of a web page that allows a rider to purchase tickets or other fare instruments for that agency online. The value must be a fully qualified URL that includes http:// or https://, and any special characters in the URL must be correctly escaped. See http://www.w3.org/Addressing/URL/4_URI_Recommendations.html for a description of how to create fully qualified URL values.
Agency_email	Text	50	Agency Email	Contains a single valid email address actively monitored by the agency's customer service department. This email address will be considered a direct contact point where transit riders can reach a customer service representative at the agency.

*This table was built with the GTFS standard (<https://developers.google.com/transit/gtfs/reference/#agencytxt>)

3. Origin-Destination Table Schema

Field Name	Data Type	Field Size	Field Name Description	Details
ODID	Long Integer		Origin Destination ID	Contains an ID that identifies a trip. The tripID is dataset unique

AgencyID	Long Integer		Agency ID	Uniquely identifies a transit agency. This value is referenced from the Agency table.
CustomerID	Long Integer		Customer ID	Uniquely identifies a customer.
RouteID	Long Integer		Route ID	Contains an ID that uniquely identifies a route. This value is referenced from the Route table
TripDate	Date/Time		Trip Date	Contains the date of the trip. The field must be in the format of mm/dd/yyyy
PUTimeS	Date/Time		Scheduled Pick-up Time	Contains the time when the customer is scheduled to be picked up at the pick-up location. The field must be in the format of hh:mm:ss, for example: 14:50:30
PUTimeA	Date/Time		Actual Pick-up Time	Contains the time when the customer was actually picked up at the pick-up location. The field must be in the format of hh:mm:ss: 14:50:30
PUHome	Text	255	Pick-up Name	Contains the name of the pick-up location where the customer scheduled. If it is where the customer lives, enter "Home", otherwise, enter the actual name of the place.
PUType	Integer		Pick-up Location Type	Identifies whether the pick-up location is the customer's home. The field can have the following values: 0: Indicates that pick-up location is not the customer's home 1: Indicates that pick-up location is the customer's home
PickupLat	Double		Pick-up Latitude	Contains the latitude of the pick-up location. The field value must be a valid WGS84 latitude.
PickupLon	Double		Pick-up Longitude	Contains the longitude of the pick-up location. The field value must be a valid WGS84 longitude.
PUZoneID	Text		Pick-up Zone ID	Contains an ID that uniquely identifies the zone of the pick-up location. The field must be one to two characters, either a single letter, double letters or combination of one letter and one number. Examples: AA, A1, A. This value is referenced from the Zone vertex table.
DOTimeS	Date/Time		Scheduled Drop-off Time	Contains the time when the customer is scheduled to be dropped off at the drop-off location. The field must be in the format of hh:mm:ss, for example: 14:50:30
DOTimeA	Date/Time		Actual Drop-off Time	Contains the time when the customer was actually dropped off at the drop-off location. The field must be in the format of hh:mm:ss, for example: 14:50:30
ApptTime	Date/Time		Appointment Time	Contains the time when the customer met the doctor?
DOHome	Text	255	Drop-off Name	Contains the name of the drop-off location where the customer scheduled. If it is where the customer lives, enter "Home", otherwise, enter the actual name of the place.
DOType	Integer		Drop-off Location Type	Identifies whether the drop-off location is the customer's home. The field can have the following values: 0: Indicates that drop-off location is not the customer's home 1: Indicates that drop-off location is the customer's home
DropoffLat	Double		Drop-off Latitude	Contains the latitude of the drop-off location. The field value must be a valid WGS84 latitude.
DropoffLon	Double		Drop-off Longitude	Contains the longitude of the drop-off location. The field value must be a valid WGS84 longitude.
DOZoneID	Text		Drop-off Zone ID	Contains an ID that uniquely identifies the zone of the dropoff location. The field must be one to two characters: Either a single letter, double letter, or combination of one letter and one number. Examples: AA, A1, A. This value is referenced from the Zone vertex table.

TotPassenger	Integer		Total passengers of the trips	Contains the number of total passengers for the trips, including the client(s), children, and any other accompanies.
TotCharge	Currency		Total Charge	Contains the total cost of the trip
FarePaid	Currency		Fare Paid	Contains the fare paid by the passenger
Funding	Text		Funding Source/Agency	Contains the funding source or sponsoring agency of the trips
Lift	Integer		Lift/Ramp Required	Identifies whether a trip needed a lift-equipped vehicle. The field can have the following values: 0: Indicates that the trip did not need a lift-equipped vehicle 1: Indicates that the trip needed a lift equipped-vehicle
DirMile	Double		Estimated Direct Mileage	Contains the straight distance between pick-up location and drop-off location. The unit must be in miles.
DirTime	Double		Estimated Direct Ride Time	Contains the time between pick-up location and drop-off location. The unit must be in decimal time.
NoShow	Integer		NoShow	Identifies whether the customer failed to board the vehicle within five minutes after it arrives within the pick-up window. The field can have the following values: 0: Indicates that the customer board the vehicle 1: Indicates that the customer didn't board the vehicle

Fields in purple are the primary keys of linked tables.

4. Route Table Schema

Field Name	Data Type	Field Size	Field Name Description	Details
RouteID	Long Integer		Route ID	Contains an ID that uniquely identifies a route.
OperatorID	Long Integer		Operator ID	Contains an ID that uniquely identifies a driver.
VehID	Long Integer		Vehicle ID	Contains an ID that uniquely identifies a vehicle. This value is referenced from the Vehicle table.
RevMiles	Long Integer		Revenue Miles	Specifies the miles from the first pickup to the last dropoff. The unit must be in miles.
RevTime	Double		Revenue Time	Specifies the time duration from the first pickup to the last dropoff. The unit must be in decimal time (hours). For example, 2.5 hours
ServMiles	Long Integer		Service Miles	Specifies the revenue miles plus deadhead miles. The units must be in miles.
ServTime	Double		Service Time	Specifies the revenue time plus the deadhead time. The unit must be in decimal time (hours). For example, 2.5 hours

The field in purple is the primary key of the table.

5. Vehicle Table Schema

Field Name	Data Type	Field Size	Field Name Description	Details
VehID	Long Integer		Vehicle ID	Contains an ID that uniquely identifies a vehicle.
AmbCap	Integer		Ambulatory Capacity	Specifies the number of ambulatory passengers that a vehicle can carry.
NonAmbCap	Integer		NonAmbulatory Capacity	Specifies the number of wheelchair passengers that a vehicle can carry.

6. Zone Vertex Table Schema

Field Name	Data Type	Field Size	Field Name Description	Details
VertexID	Long Integer		Zone Vertex ID	Contains an ID that uniquely identifies the x&Y coordinates of each vertex within a zone boundary.
ZoneID	Text		Zone ID	Contains an ID that uniquely identifies a zone. The field must be one to two characters: Either a single letter, double letter, or combination of one letter and one number. Examples: AA, A1, A.
ZoneName	Text	50	Zone Name	Contains the name of a zone.
Sequence	Long Integer		Sequence	The sequence field associates the latitude and longitude of a single angular point with its sequence order of the zone's polygon. The values for sequence must be non-negative integers and must increase sequentially between each point in the polygon.
ZoneLat	Double		Zone Latitude	Contains the latitude of a single angular point of the zone's polygon. The field value must be a valid WGS84 latitude.
ZoneLon	Double		Zone Longitude	Contains the longitude of a single angular point of the zone's polygon. The field value must be a valid WGS84 longitude.

The field in purple is the primary key of the table.