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Final Group Project - Optimal Route Finding

Jason Biesinger

Levi Burr

Tyson Terry

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Tyson Terry
Jason Biesinger
Levi Burr

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Background

Emergency response teams are always preparing rescue plans and protocols so they may respond quickly to various incidents. Fire trucks and ambulances need to arrive at the scene of the incident rapidly to mitigate injury, and avoid more damage to property in the case of a fire (Kolesar et al. 1973). Holidays are times of high incidence, and officials always plan for potential risks that surround large events.

The network analysis toolbox can be used to find and map out the quickest route from a variety of locations. The network analysis toolset in ArcMap makes it possible for us to enter in several potential starting points, make the shortest route connecting points, define travel restrictions (example: no U-turns, no tight turns, etc..), and add obstacles. These tools give us the ability to create routes in anticipation of potential incidents. These tools are also useful in analyzing traffic flows and use of multiple transportation options (Beuth et. al 2001, Lee et. al 2013)

Problem Statement

Every year on Independence day, Provo hosts its "Grand Parade" as part of the Freedom Festival. Many people attend this event as it marches down University Avenue near BYU campus. The parade route is closed to traffic the morning of the parade, and crowds build along the parade route to spectate. Emergency responders know the parade route, and create a shapefile that defines the road closures that correspond to the parade event. In this exercise, you will be using the network analysis tool to determine the best route for firemen to arrive at fire on BYU campus.

The Maeser building on BYU campus is very old, and important to the community. In this scenario, the maeser building catches on fire, and the local authorities are contacted. Map out the quickest route for firemen to respond to a fire at the Maeser building. Make points to represent the fire stations, a point to represent the fire (Maeser Building), and a shapefile to represent the parade route. Use your created points with the network analysis tools to determine the quickest route on a normal day with no obstacles, and the quickest route the morning of the parade.

Data

The following data will be needed for this project. You will need to download the transportation network, and create several shapefiles for this project.

- https://gis.utah.gov/data/transportation/street-network-analysis/ Utah Transportation Network: This is the transportation network for the entire state of Utah. Click the "download Street Network Analysis" button and then click the link UtahRoadsNetworkAnalysis.zip
- User created point shapefile of Provo Fire Stations: (the coordinates can be found on google maps)
- User created polyline shapefile of Provo 4th of July Parade Route (from the crossroads of University Ave. and University Parkway, going south along University Ave. to Center Street, in Provo)
- User created point shapefile of location of fire (Karl G. Maeser Building)

ModelBuilder Tools
- Make Closest Facility Layer: makes a closest facility network analysis layer and sets its analysis properties.
- Add Locations: adds network analysis objects to a network analysis layer.
- Solve: solves the network analysis layer problem.

Example Model
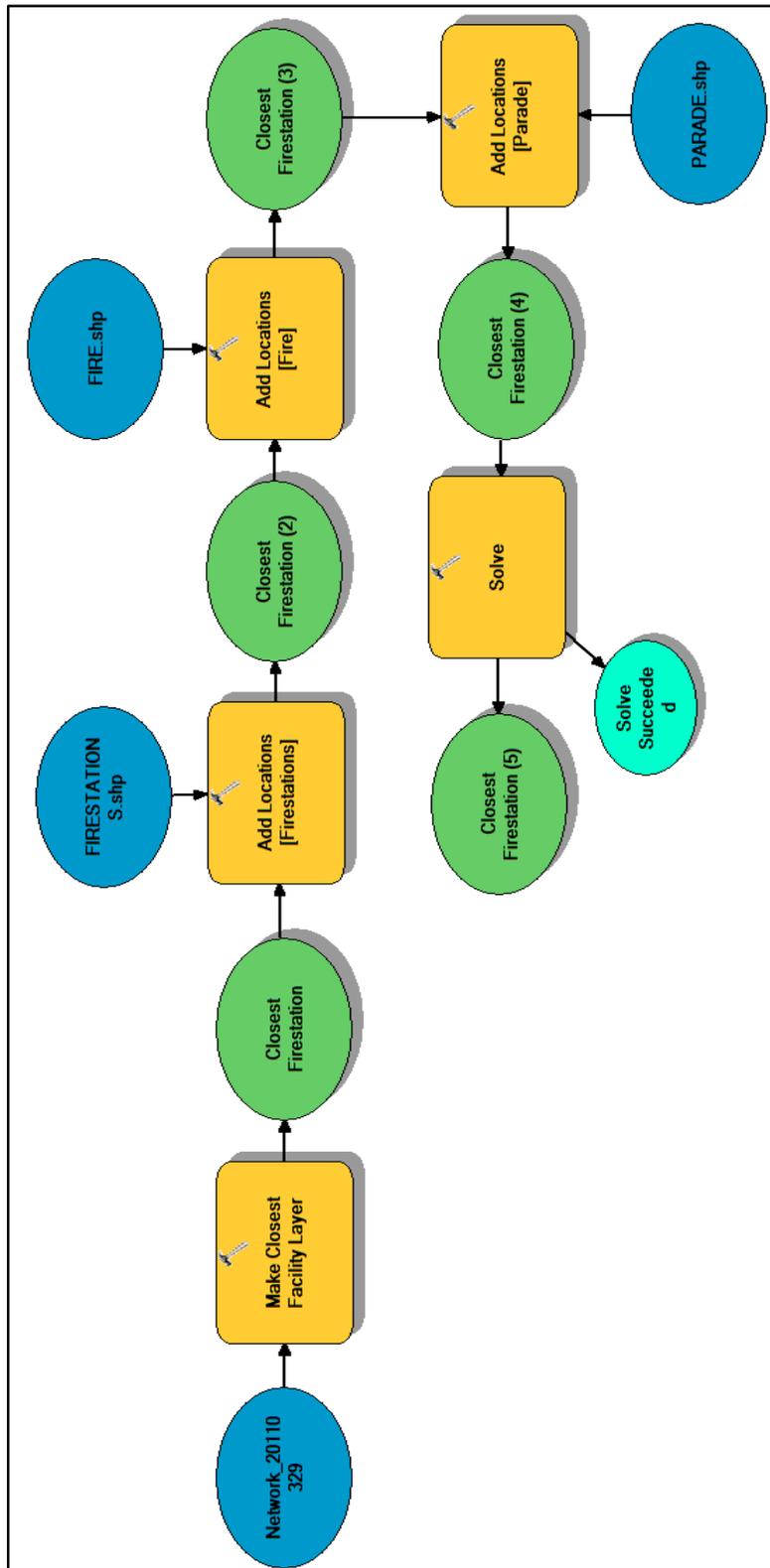
Step by Step Solution

For an advanced GIS student, the information up to this point is all you need to complete the assignment and create an output map from the results. Feel free to try conducting the analysis using only the information provided above. If you need specific steps, follow the instructions.

Step 1

To use network analysis you'll need to turn on the extension for network analysis and activate the "Network Analyst" ribbon in ArcMap. Go to Customize, Toolbars, and check on the Network Analyst toolbar. Once you have the toolbar, open the Network Analyst Window, which will be displayed on the left side of the screen.

Figure 1

Before starting your model, create a point shapefile that represents a fire. Remember to use the "NAD 1983 Zone 12N" projection when creating your shapefile. Locate the Maeser building on BYU campus and a point shapefile "fire".

You should also create another point shapefile that represents the locations of the five fire stations within Provo. Remember to use the "NAD 1983 Zone 12N" projection when creating your shapefile. You will need to search online for the locations of the five fire stations that are located within Provo, UT, and then place them on your map.

And lastly, before starting the model you will need to create a polyline shapefile which will represent a parade. Remember to use the "NAD 1983 Zone 12N" projection when creating your shapefile. The parade will extend from the crossroads of University Ave. and University Parkway, and go south along University Ave. to Center Street, in Provo. In this analysis, we are taking into consideration that there is road blockage from University parkway to Center St. for safety concerns. Therefore, the whole parade will be drawn from the crossroads of University Ave. and University Parkway, down to Center Street.

Step 2

Then in ModelBuilder the Make Closest Facility Layer tool is used to make a closest facility network analysis layer and set its analysis properties. The properties should allow for u-turns, which is found under Restrictions in the Make Closest Facility Layer tool.

Figure 2

When choosing the input while using these tools, it's important to choose the input that has the symbol that looks like a recycle sign, as seen below. This way, you're choosing the shapefile that you created, and not the layer that the Network Analyst tool created automatically. It's simpler to use shapefiles to add data for the "incidents" or "facilities" within the network analyst tools.
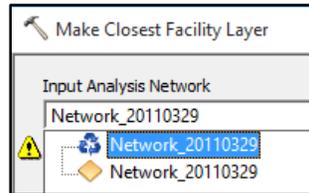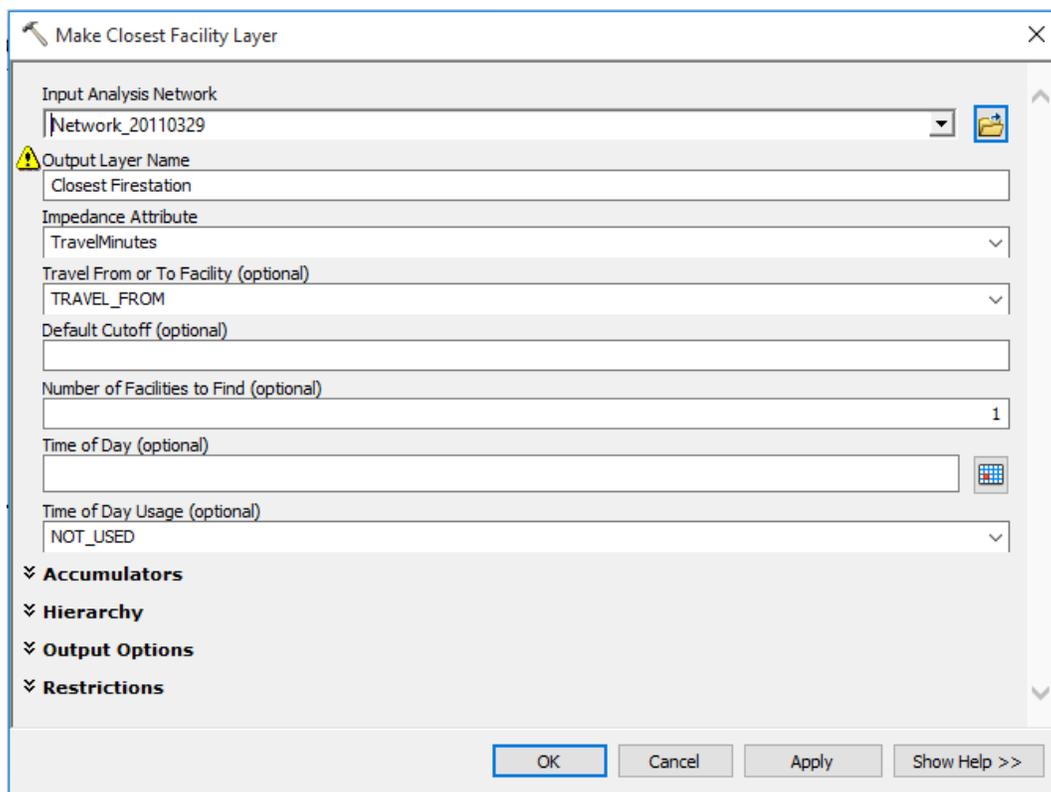
Figure 3

Figure 4

Step 3

The Add Locations tool is used to assign the fire station shapefiles as "facilities" within the network analysis layer. Make sure that the Sub Layer is set to facilities. Under "Field Mappings", leave the Curb Approach to "Either side of vehicle".

Figure 5

Figure 6

Step 4

The Add Location tool is used again, but now to assign the fire shapefile as an "incident" within the network analysis layer. Make sure that the Sub Layer is set to incidents.
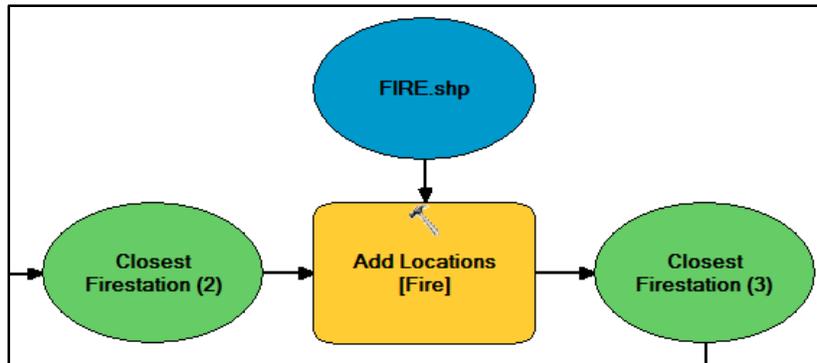

Figure 7

Step 5

Now we'll use the Add Location tool to assign the parade shapefile as a "line barrier" within the network analysis layer. Make sure that the Sub Layer is set to line barriers. Under "Field Mappings", leave the Barrier Type as "Restriction".
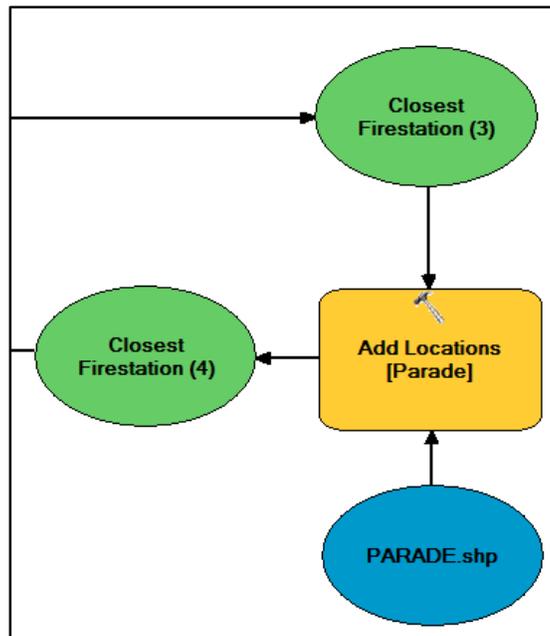

Figure 8

Step 6

The Solve tool solves the network analysis problem based on its network locations and properties. Basically, the Solve tool solves for the quickest route from the closest facility (or fire station) to the incident (or fire, in this case).
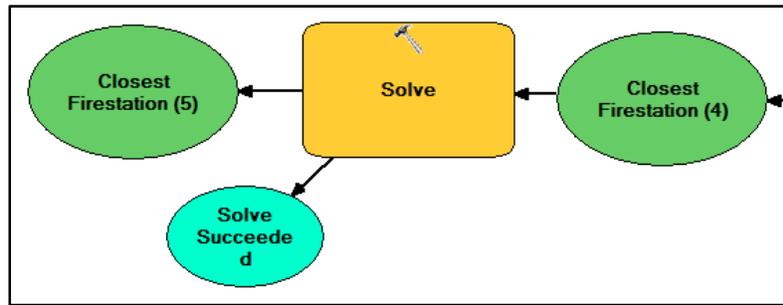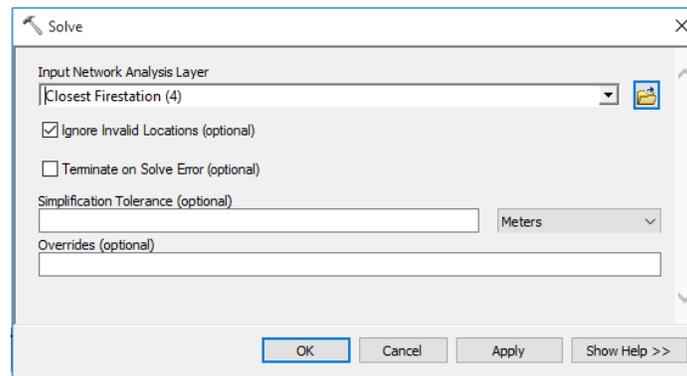
Figure 9

Figure 10

Step 7

Add and activate a new data frame to your view. This is done by clicking the insert tab on the top of the window and selecting "Data Frame." Under this data frame we will be creating a second model and map. Right click the data frame and select activate to begin editing and adding data to this data frame. The map from this data frame will be used in your final layout view to show the quickest route for firefighters without the parade. It can be helpful to name your data frames, so that you can keep them organized. This can be done by right-clicking the data frame and selecting properties. Once the properties window pops up, you can edit the name under the general tab.

Step 8

Create a second model by copying the first model and pasting it into a newly created model under the same toolbox. In this new model, all you want to do is delete out the "Add Locations" tool that represents the parade (which repeats steps 2-5).
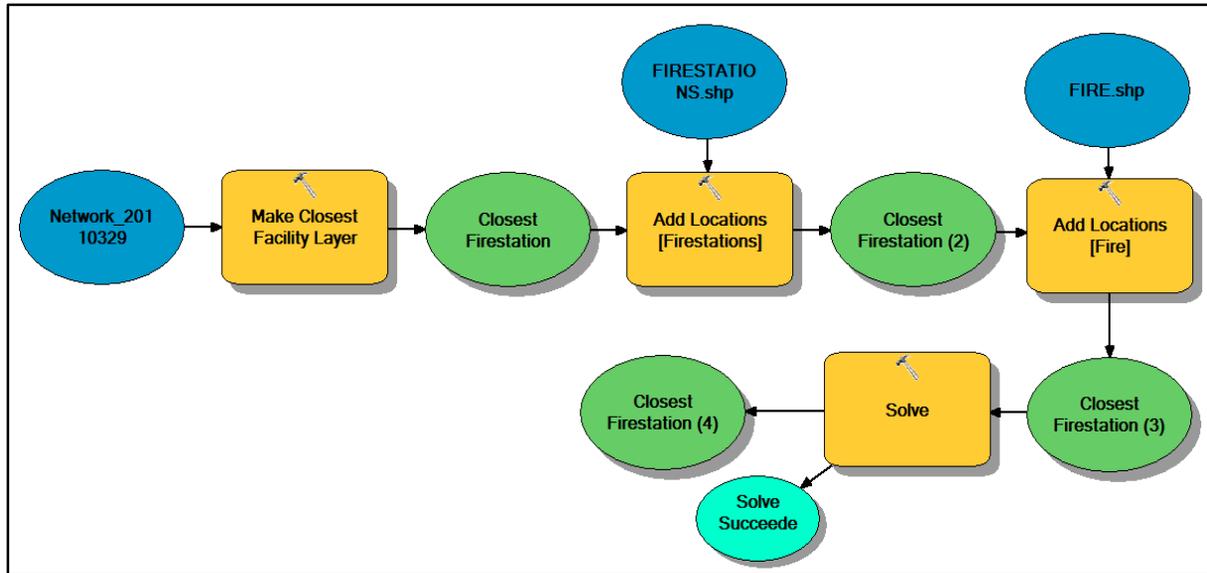
Figure 11

Step 9

Now you'll want to run this second model while your second data frame is activated. This will calculate the quickest route. This is initially to repeat step 6, but now with the second model and second data frame.

Step 10

Add both data frames to Layout. After creating a layout template, you will need to add the data from your second data frame to the map. This is done by activating your second data frame, and then dragging the basemap under that data frame onto the layout display. You will likely have to resize and zoom to make your map match your desired specifications. Get the zoom extent of both the maps to match, so the extent indicator map can show the extent of both maps.

Step 11

Though this is not required on your map output, you will need this information to answer questions in your lab report. You will need to find travel time calculated for both routes. This can be done by right-clicking each created route in the correct data frame and selecting the properties. The routes are selected from the network analysis table of contents and not on the layout view.
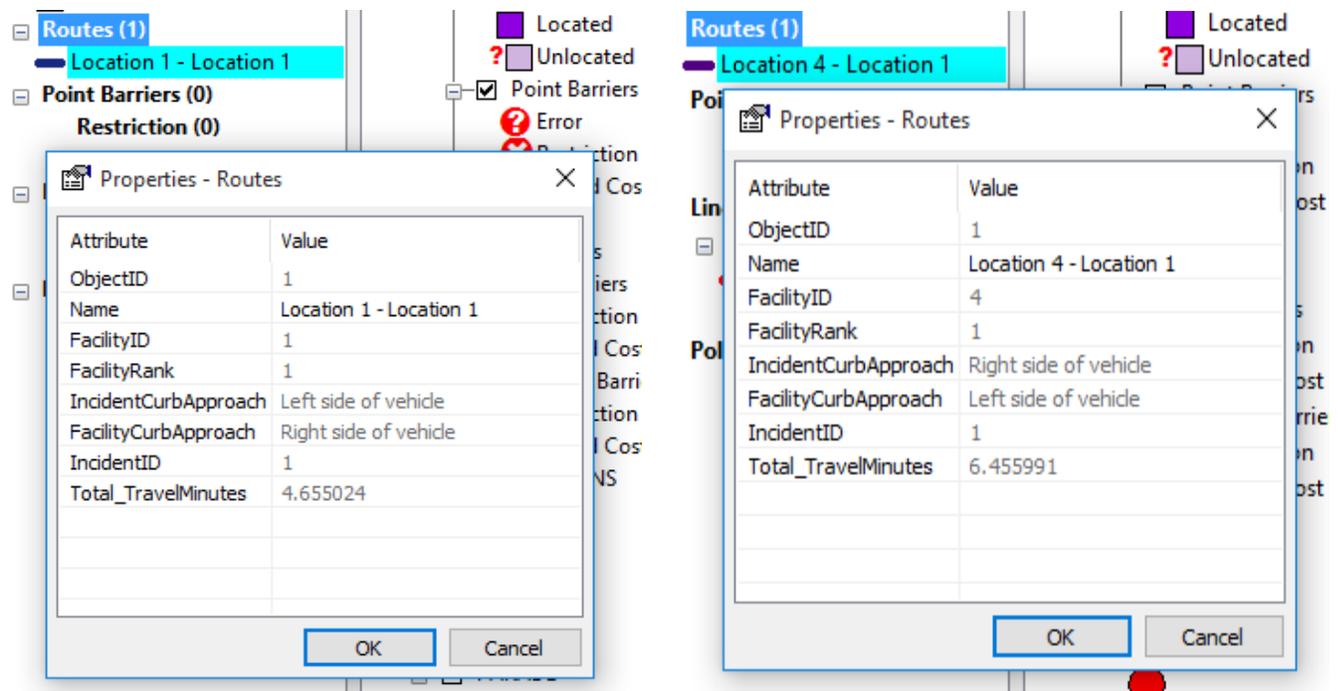
Figure 2

Deliverables

Construct a model within ModelBuilder that creates a makes a closest facility layer from the transportation network, adds a barrier, adds location of fire and fire stations, and solves for the quickest route from the quickest fire station. Two maps should be included in the final output: one map showing the quickest route without the parade, and one map with showing the quickest route with the parade.

Prepare a report that summarizes the data you used, the aspects of your model, and your final output. Your final output should include all aspects listed on the rubric. Make sure to address the questions listed within the rubric.

Questions

How long will it take firefighters to respond to the fire on a regular day, and also on the day of the parade? Are they different? What differences do you notice between the two routes?

Extra Credit

Within the specifications of the "Make Closest Facility Layer" tool, there are specifications that allow analysis at specific times. Run the model at different times of the day, or include other barriers to show other possible routes in different scenarios.

References

Beuthe, M., Jourquin, B., Geerts, J. F., & a Ndjang'Ha, C. K. (2001). Freight transportation demand elasticities: a geographic multimodal transportation network analysis. *Transportation Research Part E: Logistics and Transportation Review*, *37*(4), 253-266.

Kolesar, P., & Blum, E. H. (1973). Square root laws for fire engine response distances. *Management Science*, *19*(12), 1368-1378.

Lee, S. H., Choi, J. Y., Yoo, S. H., & Oh, Y. G. (2013). Evaluating spatial centrality for integrated tourism management in rural areas using GIS and network analysis. *Tourism Management*, *34*, 14-24.

Example Map

Finding Nearest Firestation with Network Analyst
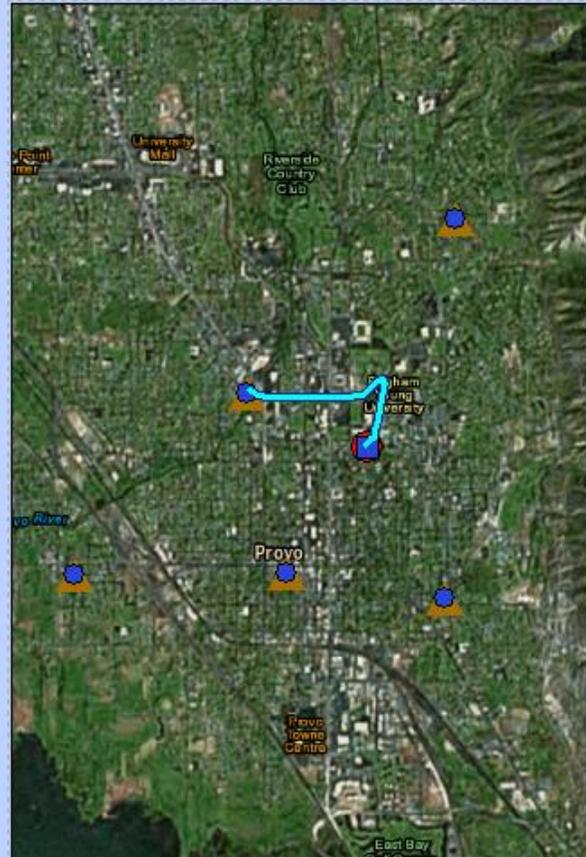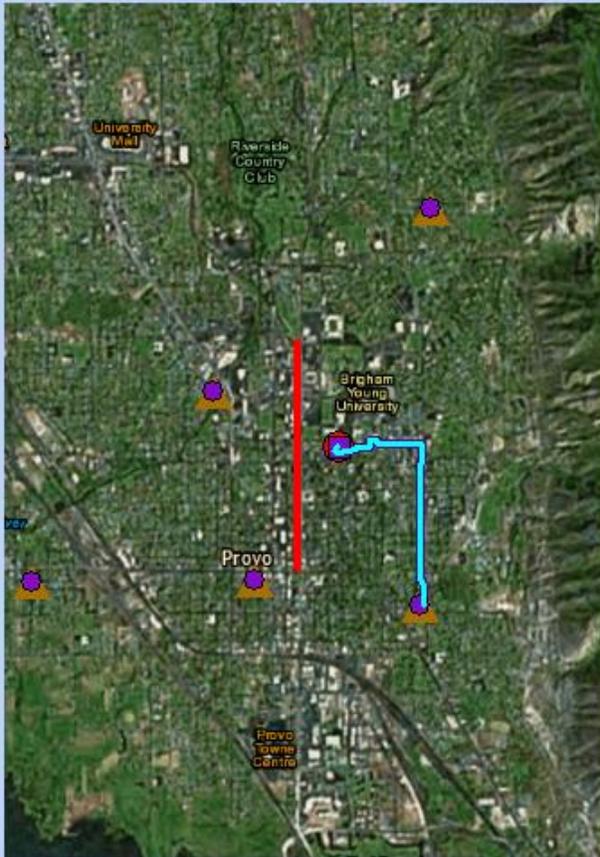
Miles
0 0.4 0.8   1.6   2.4   3.2

Miles
0 0.375 0.75   1.5   2.25   3

Name
Date
Projection

N
W   E
S

Service Layer Credits: Esri, HERE, DeLorme,
MapmyIndia, © OpenStreetMap contributors,
and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar
Geographics, CNES/AirbusDS, USDA,
USGS, AeroGRID, IGN, and the GIS User

Legend

▲ FIRE STATIONS

● FIRE

Miles
0 5 10   20   30   40