Calculating Drive Times and Distances in ArcGIS Pro (VINCI)

June 24, 2025
Access and Community Care Engagement Network Team (ACCENT)

This document presents a tutorial for two methods of using ArcGIS Pro in VINCI to calculate driving time and distance between origins and destinations.

Goal:

Calculate the driving duration or distance from one or more origin locations to the closest facility.

Use Case:

You have the locations of 25 (mostly) rural Utah Veteran home addresses and want to calculate the driving times and distances to the nearest non-VA hospitals.

Notes:

ArcGIS Pro in VINCI is version 3.1.3 (as of March 2024), but this tutorial was developed on 3.4.3—the steps should still align closely.

All use case Veteran home locations are fictitious. There are no real Veteran home locations represented in this document.

This tutorial is more detailed than standard Esri tutorials, with extra tips for VINCI quirks and common pitfalls. This document contains extras. In particular, I've added comments about how VINCI might react differently than ArcGIS Pro installed elsewhere, as well as provide cautions on how to avoid accidentally saving your analysis data to the wrong place within VINCI. I also include extra tips and details to help with some of the common errors I've seen.

VINCI has a limited number of Network Analyst licenses; remember to release the license when finished.

Assumptions:

Software Familiarity:

Assumes basic ArcGIS Pro skills (navigating the interface, adding data, using geodatabases, attribute tables, simple geoprocessing, geocoding, coordinate system basics).

You will be using the ArcGIS GUI (not using Python, Arcade/Avenue, ModelBuilder, et cetera).

If you are unfamiliar with the software, Esri provides some excellent free online courses that will get you started:

ArcGIS Pro Basics (~1hr)

GIS Basics (~2.5hr)

Data prepared:

There's a geodatabase *in your VINCI project folder* (i.e. *.gdb* file type) and you have set this geodatabase to be your default geodatabase in ArcGIS using one of these methods (this ensures all results stay in your project folder):

Project → Options → Current Settings → Default Geodatabase

In Catalog, *right click* on the geodatabase you want for your default and select *Make Default*.

Make sure you have two point layers ready: one for your origin locations (e.g., Veteran home addresses) and one for your destination facilities (e.g., hospitals). These can be stored in your geodatabase (preferred) or as shapefiles.

Appendix B provides *very* brief details on using ArcGIS Pro to connect to CDW.

Analysis:

You will not be using historical traffic flow to inform the solver.

Your analysis will be for driving a car from the origin to a single closest destination, will have no barriers, and will have no time limits.

Desired output:

The process outlined in this document produces specific outputs; I assume one of these is necessary for your project:

Graphical output:

Roadways: Detailed lines from each origin location to the closest destination facility.

Straight lines: Simple, as-the-crow-flies lines from origins to destinations.

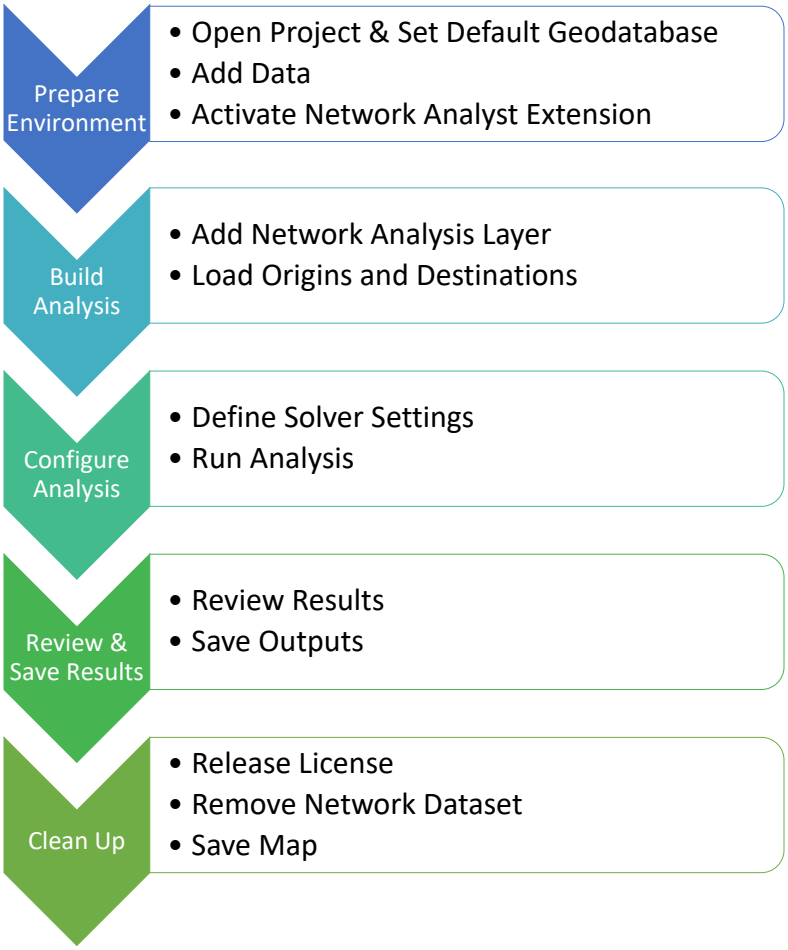
No graphical output.

Numerical:

Detailed distances and times, associated with a graphical output.

A table that details distances and times, not associated with graphical output.

Overview of the steps for calculating drive distance/time between Veteran homes (origins) and VA/non-VA facilities (destinations) using ArcGIS Pro & Network Analyst



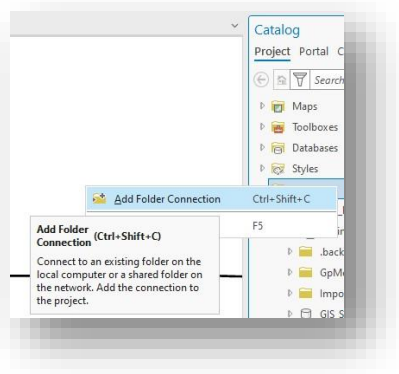
Note: Appendix A is a quick guide to the processes described in this document

Preliminaries (before starting the analysis, prepare your ArcGIS Pro session):

ArcGIS Pro should be running and your map should be open. Find your project geodatabase (you should have created this in your VINCI project folder) and keep in mind where it's located. Ideally, you should select this geodatabase as your default geodatabase.

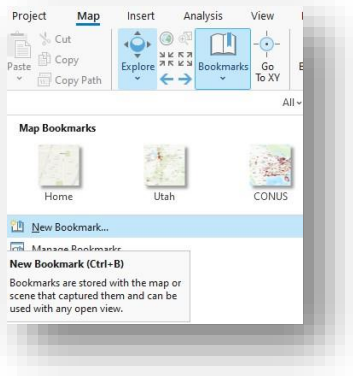
> **Tip:** Confirm your project geodatabase is set as default (if not, set it now as described above in *Assumptions→Data prepared*).

> **Tip:** Add your VINCI project folder (or the folder in your VINCI project space where you keep your GIS work) to the Folders shortcut in your Catalog view. Right-click on Folders and select *Add Folder Connection*.



Tip: Turn off the default base map. Outside of VINCI, ArcGIS Pro usually uses a live internet connection to display a base/background layer. VINCI cannot update the live Esri base map, so it's best to disable it and use local boundary shapefiles if needed. This can speed up performance in VINCI's offline environment.

Tip: (Optional) Create a bookmark for your area of interest (e.g., the state or city you'll be looking at) for easy navigation later (Note that these bookmarks are only for your current project. If you open a different map, the bookmarks will not be there to use.)



Prepare the map for analysis

In this step, you're adding the starting points (origins) and ending points (destinations) to the map, creating/configuring an analysis layer, and giving ArcGIS Pro the road network data it will need to find the fastest/shortest route between origins and destinations. (Again, this tutorial assumes you're familiar with ArcGIS Basics, including geocoding.)

Add the origins and destinations points to your map

In ArcGIS Pro, you can do this using either of these methods:

Dragging each point layer from the Catalog pane onto the map, or

Clicking the Add Data button on the ribbon and browsing to your geodatabase to select the files.

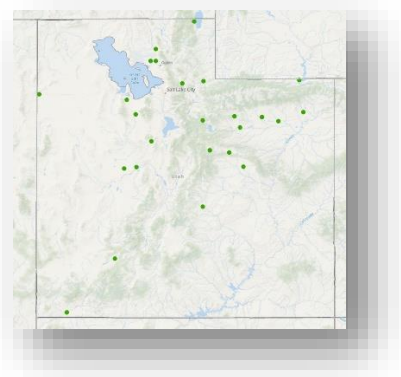
After adding the points, zoom to the layer to verify they appear in the expected locations on the map. This is especially the case of you have created points based on longitude/latitude or X/Y coordinates. The following

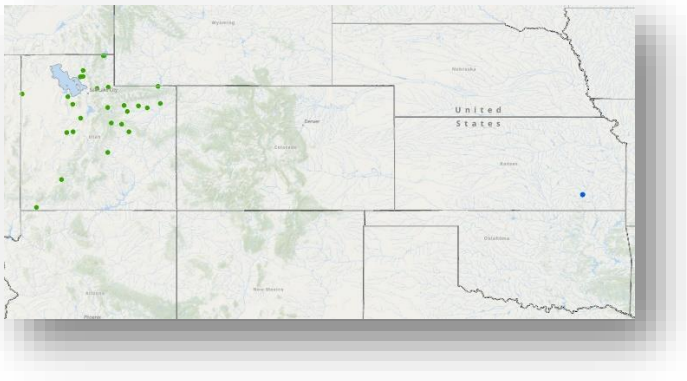
cautions cover three of the most common errors when using longitude/latitude or X/Y coordinates to create points:

Troubleshooting—If your points appear in the wrong place:

Coordinate System Mismatch: Maps have coordinate systems, projections, and datums as does each shapefile; however, a map and shapefile's characteristics do not necessarily align. ArcGIS Pro will attempt, on the fly, to align coordinate systems, projections, and datums, but sometimes it guesses wrong or doesn't realize there's a problem. If something seems off, make sure to fix it before continuing or the drive time measurements you make will likely be incorrect.

Here is an example of what the Utah Veterans home locations (fake addresses) look like when all of these systems align (left, with green points), and one example of what it looks like if they did not align (right, with blue points).

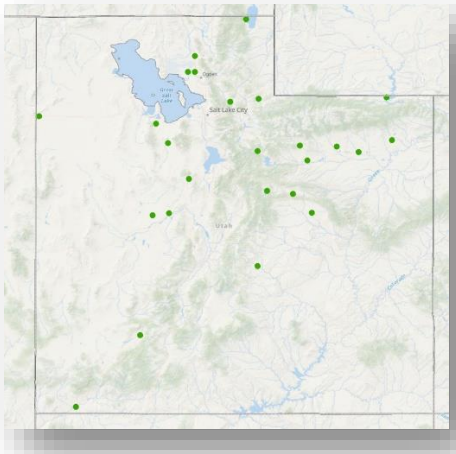


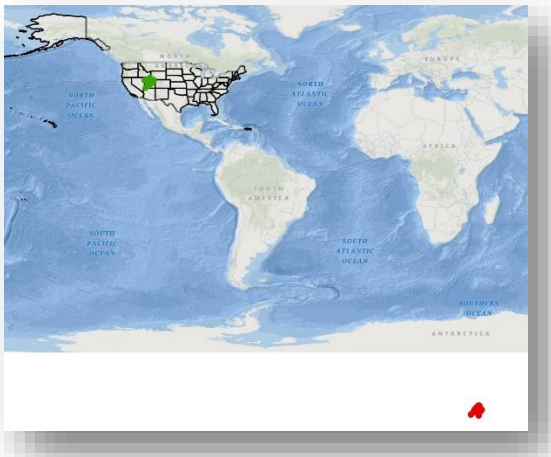


Note that what appears to be the single blue point in Kansas is actually all 25 points, but the mix-up of systems means that the incorrect version was drawn so small that it only covers *18 feet* in Kansas when at the scale of the map with green dots.

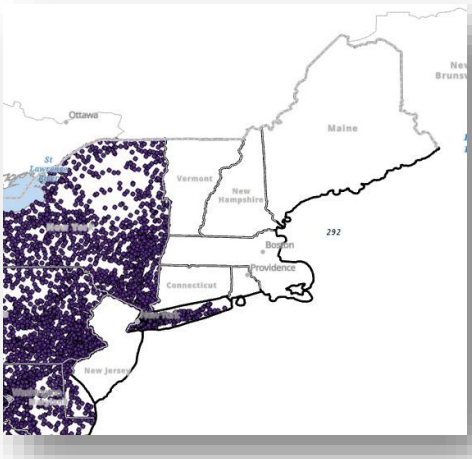
Longitude/Latitude Swapped: Another common error when adding XY data is mixing up the X (longitude) and Y (latitude) fields. If your points seem to be scattered in a line or in a completely wrong region, they might have been interpreted incorrectly (for instance, latitude values used as X). ArcGIS might guess the field names, but it's not foolproof. Double-check your input—longitude should map to X and latitude to Y.

Here (below) is the common way that this error manifests. The green points on the left are how they should appear on your map, and the red points on the right show how they appear with longitude and latitude swap. (It probably goes without saying that trying to find driving distances from Antarctica to non-VA hospitals in and around Utah is an effort guaranteed to fail.)



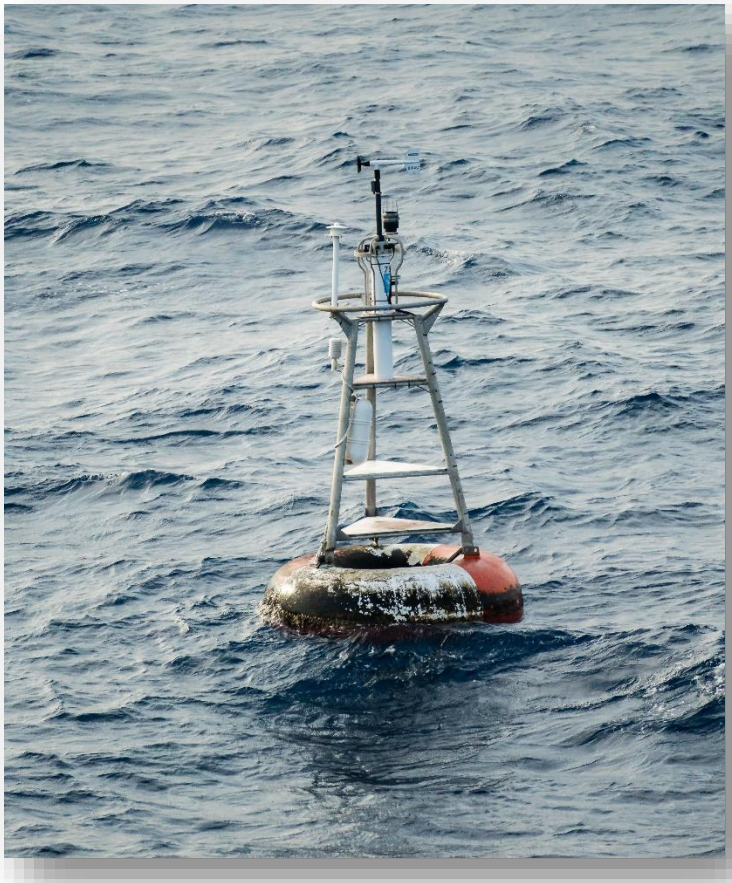


Missing ZIP Code Points (Leading Zeroes): If you're using ZIP Code centroids or any data where codes like *08901* might be read as a number, you could inadvertently drop locations. For example, many New England ZIP codes start with 0, and if those zeros were dropped (e.g., *08901* becoming *8901*), any join or lookup might fail, causing those points not to appear and any driving distances will not include these ZIP Codes. Ensure that any such data joins preserve leading zeros (format fields as text, etc.) so all points load properly.

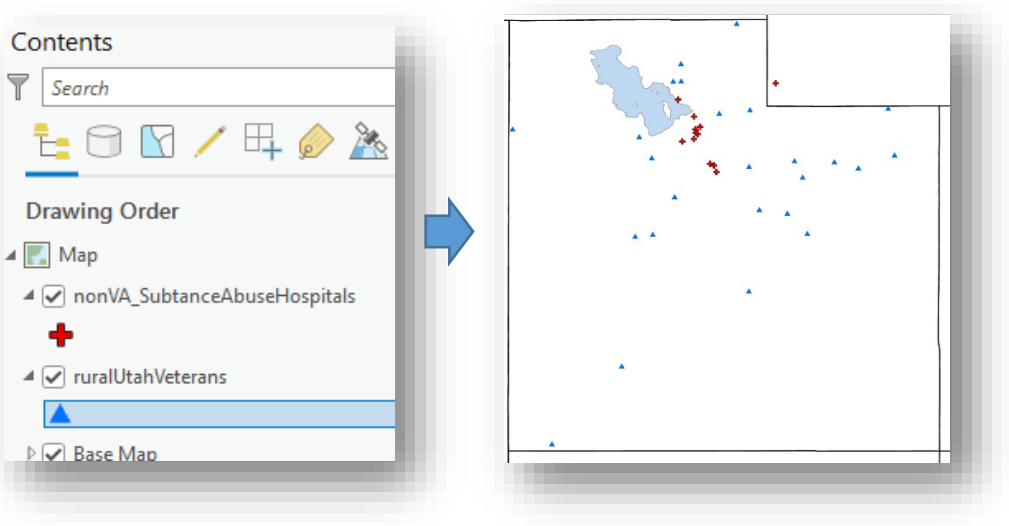


Just for fun—Bolstering your Nerd Card: At some point, you may unexpectedly find one or more of your points in the Gulf of Guinea, about 300 miles off the west coast of Africa. If so, the GIS has read the point's coordinates as Latitude = 0 and Longitude = 0. That location (0,0), is jokingly referred to by GIS nerds as *Null Island*. It goes without saying that the GIS will struggle to find any nearby VA facilities.

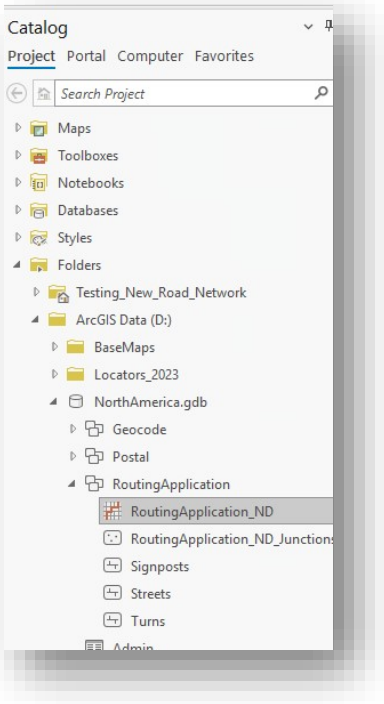
The Buoy at Null Island



Tip: Change the symbols for both your origin and destination points. When you add them, they’ll be small dots and it may be hard to distinguish. In this example, clicking on the point symbol in the Contents window (usually far left) opens the Symbology window (usually far right) where you can change the points to various shapes and colors. For our use case, Veteran homes are blue triangles and non-VA hospitals are red crosses. This step isn’t necessary, but your map will probably be easier to read with these changes.



Add the road network dataset to your map. The road network dataset is in the D Drive in VINCI (drag the road network database to your map or use the *Add Data* button: ArcGIS Data (D:)→ NorthAmerica.gdb→ RoutingApplication_ND→ RoutingApplication_ND). A road network dataset is a specialized form of GIS data that allows "travel" along roads. It is a very large file (more than 25GB) and so you will only want to add the network dataset to your map long enough to conduct the analysis.

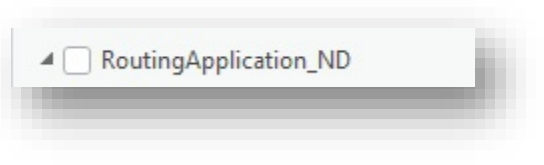


Caution—Minimize Rendering Load: This dataset is huge (covering ~63 million road segments across the US, Canada, and Mexico). The moment you add it, ArcGIS will try to draw all visible roads in your current map view. This can cause ArcGIS to stall or even crash. To that end, here are four suggestions to reduce the risk of a crash and mitigate any problems a crash might cause:

Save your work first. If a crash does occur, you won't lose your map project.

Zoom in to small area (perhaps your local VAMC or even your home neighborhood) before adding the road network dataset. This way, ArcGIS will only attempt to draw roads in that small extent, reducing load.

Immediately turn off the network layer's visibility after adding it. In the Contents pane, uncheck *RoutingApplication_ND*. This prevents the software from drawing millions of roads. You can turn it back on later if needed.



Be patient during drawing. If ArcGIS seems to stall or "hang" while adding the network, let it finish. Don't pan/zoom or click around, as that will restart the drawing process and could increase the crash risk.

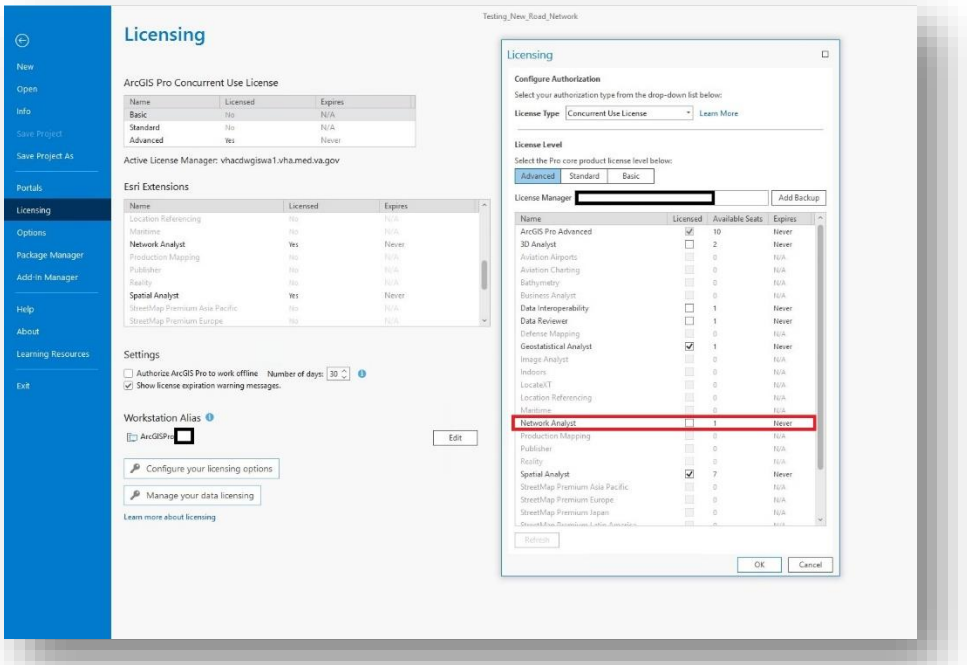
Caution: Do not export or copy the entire road network into your project geodatabase—it's too large: It will probably max out your drive space and then fail, possibly corrupting your geodatabase. It's fine to leave it in your map document, but you should not export or save a copy in your VINCI Project Folder.

Add the Network Analyst extension license:

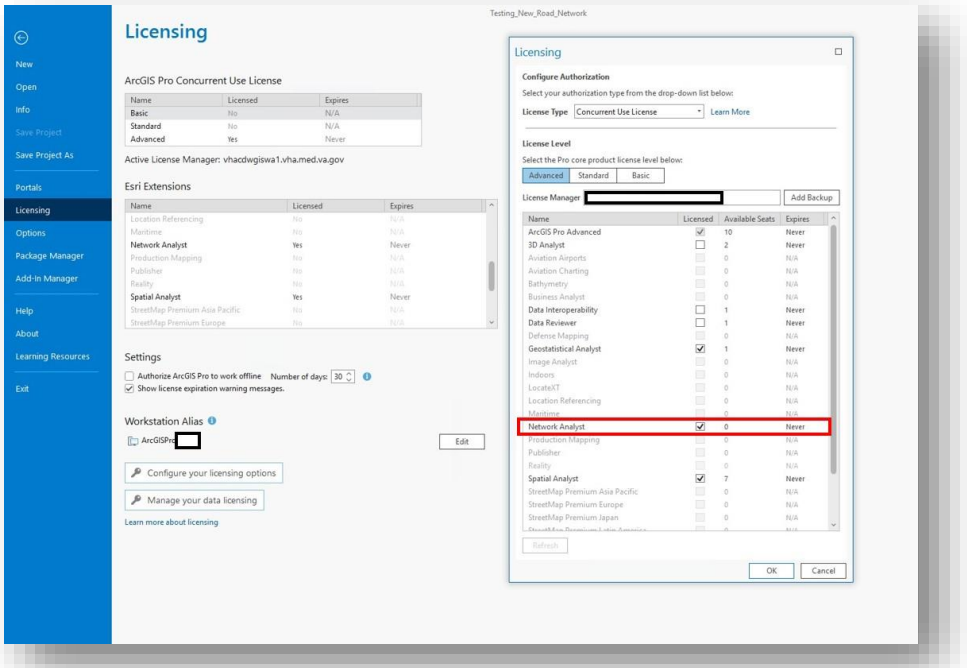
Running the Closest Facility or OD Matrix analysis requires a Network Analyst extension license. VINCI has a limited number of licenses.

To add the Network Analyst extension license, navigate to *Project→ Licensing*, and then click the button titled *Configure your licensing options*. If there's an empty box next to Network Analyst in the *Licensed* column and a 1 or higher number in the *Available Seats* column, you can "check out" a license by clicking in that box. You should see the number of available seats decrease by one. If the *Available Seats* column for Network Analyst shows a 0, you'll need to wait for a license to become available.

This screen snip shows there is one available license. To add the extension, you would check the empty box in the Licensed column.



The license should show you are licensed for the Network Analyst extension.



Step 1 Summary: At this point, the following four items should be complete:

Your *origin points* layer visible on the map.

Your *destination points* layer visible on the map.

The RoutingApplication_ND network dataset added (with its layer present, even if visibility is off).

The Network Analyst extension enabled (license checked out).

Prepare the analysis layer: In this step, you create a special analysis layer (either an OD Cost Matrix or Closest Facility layer) which will compute the routes. You'll then load your origin/destination data into this layer.

Network Analyst offers two methods for calculating route travel time and/or distance. Here is a description of both methods:

Closest Facility method: This method finds closest facility to each origin point and provides options for a graphical output as lines connecting origins and destinations. These lines can illustrate the route "driven" between origin and destination, can provide a simple, straight line between the two (even though "closeness" was determined using roads), or you can choose not to output any lines (which is essentially the same as the OD Cost Matrix).

OD Cost Matrix method: This *much* faster method generates numbers without the option for graphical output. It might be the better option if you're trying to calculate distances for tens of thousands of origins and destinations, especially if you have no need to illustrate the roads connecting origins and destinations.

Analysis Layer Type	Output	When to Use
Closest Facility	Option for detailed driving routes (along roads), straight lines, *or* no lines. Time/distance results for each origin–closest destination pair.	Use when you need to *visualize actual routes* on the map, or if you need multiple closest locations per origin. Best for smaller datasets due to heavier processing.
Origin-Destination (OD) Cost Matrix	Option for straight lines *or* no lines (no detailed road routes). Time/distance results for each origin–destination pair (or for each origin–nearest destination).	Use when you have many points or only need the distance/time values. It's faster and uses less memory, but it won't draw the actual driving path (straight lines option can be represented).

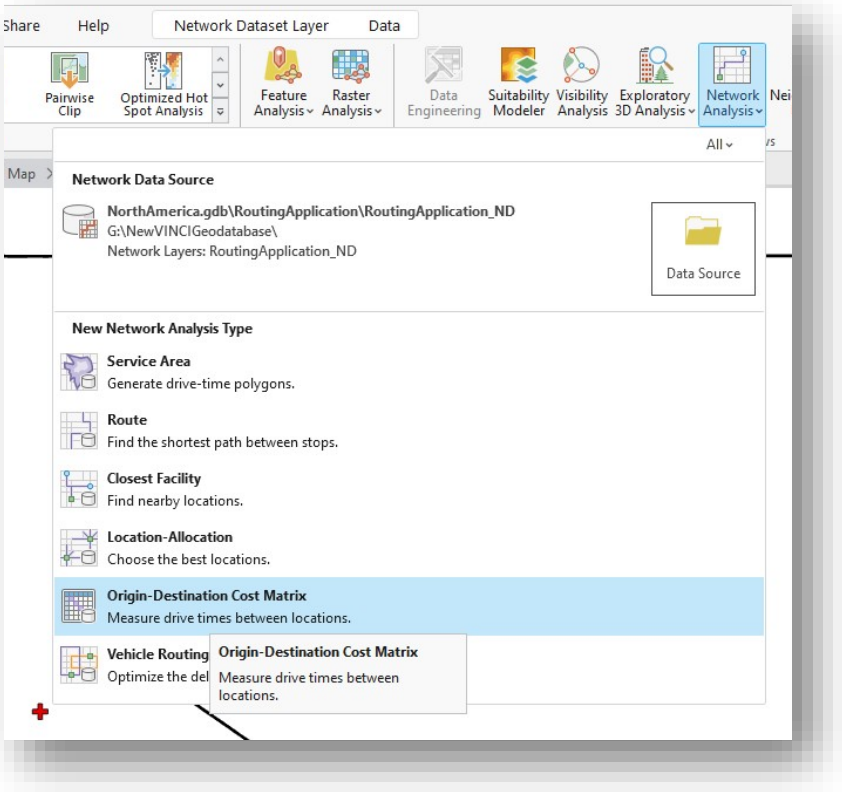
Just for fun—Bolstering your nerd card: Dijkstra's algorithm has proven to be one of the most successful route solving algorithms, consistently performing well against several challenges designed to confuse it. Here's Esri's description of how they created a, *multiple-origin, multiple-destination algorithm based on Dijkstra's algorithm*:

"The classic Dijkstra's algorithm solves the single-source, shortest-path problem on a weighted graph. To find a shortest path from a starting location, s, to a destination location, d, Dijkstra's algorithm maintains a set of junctions, S, whose final shortest path from s has already been computed. The algorithm repeatedly finds a junction in the set of junctions that has the minimum shortest-path estimate, adds it to the set of junctions S, and updates the shortest-path estimates of all neighbors of this junction that are not in S. The algorithm continues until the destination junction is added to S."

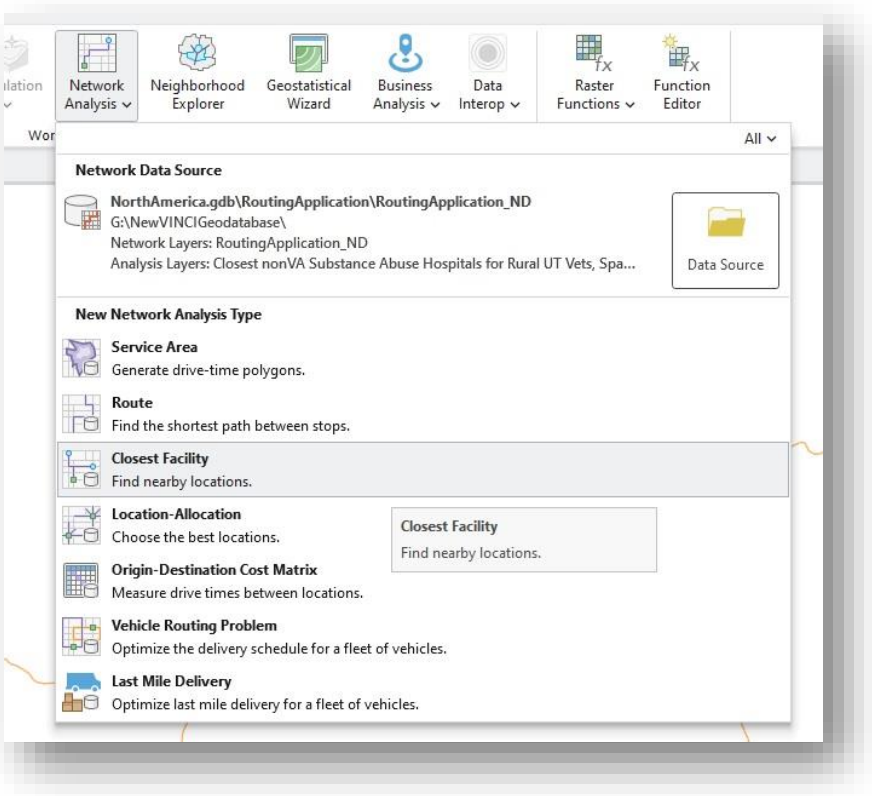
https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/algorithms-used-by-network-analyst.htm

Add an analysis layer to your map: Add the analysis layer. This will be either the OD Cost Matrix layer or the Closest Facility layer. Navigate to *Analysis→Network Analysis→Origin-Destination Cost Matrix* or to *Analysis→Network Analysis→Origin-Destination Cost Matrix* or *Closest Facility*. Note that if you were not able to activate a Network Analyst extension license that the Network Analysis button may be greyed-out (not usable). If that's the case, you may need to verify you have activated a Network Analyst license.

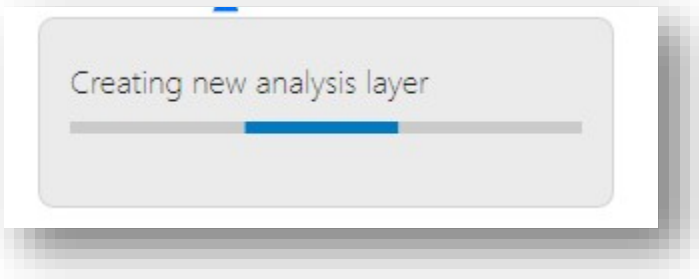
Adding the OD Cost Matrix Analysis Layer



Adding the Closest Facility Analysis Layer



ArcGIS Pro will show the Creating New Analysis Layer window while it prepares the analysis layer. This may take a few minutes. It's wise to let ArcGIS Pro finish preparing the layer before interacting with the software.



The software will not alert you when it has finished. Instead, you'll have a new group item in your table of contents called OD Cost Matrix or Closest Facility, and it will contain several items. Here is what the added layer looks like in the table of contents (OD Cost Matrix on the left, and Closest Facility on the right), and what the added items mean once you have configured the solver:

Origins/Incidents: These will be your origin or starting points.

Destinations/Facilities: These will be your destination or ending points.

Lines/Routes: Optional. These will represent the connections between origins and destinations. You'll indicate the particular form of line (OD Cost Matrix) or route (Closest Facility) when you configure the analysis a little later.

Point Barriers: Optional, and rarely used. This is primarily designed to stop the solver from using a road on the network. It could, for example, represent a locked gate or a closed street.

Line Barriers: Optional. You could use this to force the solver to work within a certain area. An example of when you might use this would be to limit the road network to a state or other boundary (a VISN, perhaps). You would need the shapefile representing that boundary, and would load it in the solver the same way you add origins and destinations.

Polygon Barriers: Optional. This is the same as for Line Barriers, except the barrier would be a polygon rather than a line.

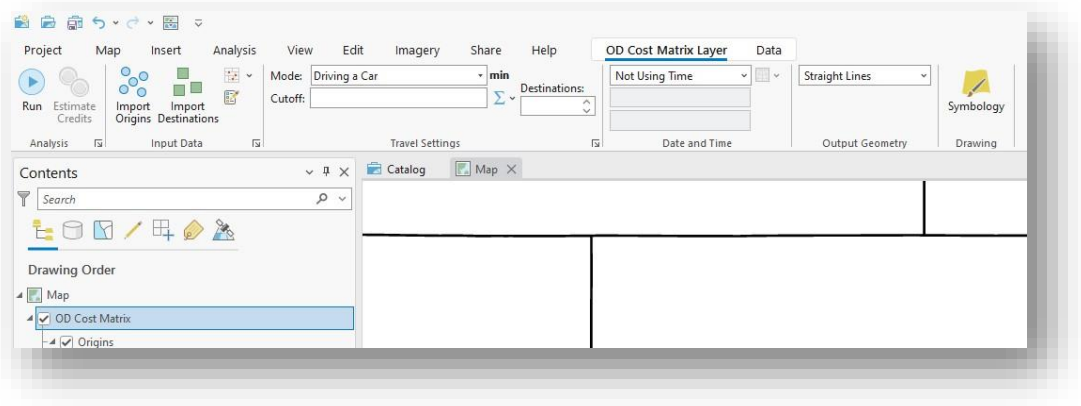
Note: Rather than the straightforward default terms Origins and Destinations in the OD Cost Matrix, you'll notice that the Closest Facility layer uses the default terms Incidents and Facilities. This stems from the historical

use of this tool for finding the closest medical facility to an accident or incident. Hence, *Incidents* are your origins, and *Facilities* are your destinations. If it helps, you can rename these in your table of contents.

Load the origins and destinations into the Analysis Layer

Click on the OD Cost Matrix or Closest Facility in your table of contents. On the ribbon, you should see a new set of tabs appear. They will be called *OD Cost Matrix Layer* or *Closest Facility Layer*, and, separately, *Data*. To the left side, you'll see buttons for *Import Origins* and *Import Destinations*.

Here's what it looks like for the OD Cost Matrix. It'll basically look the same for Closest Facility, except the tab will indicate Closest Facility Layer. For the next few images, we'll just illustrate using the OD Cost Matrix, as the two are similar.

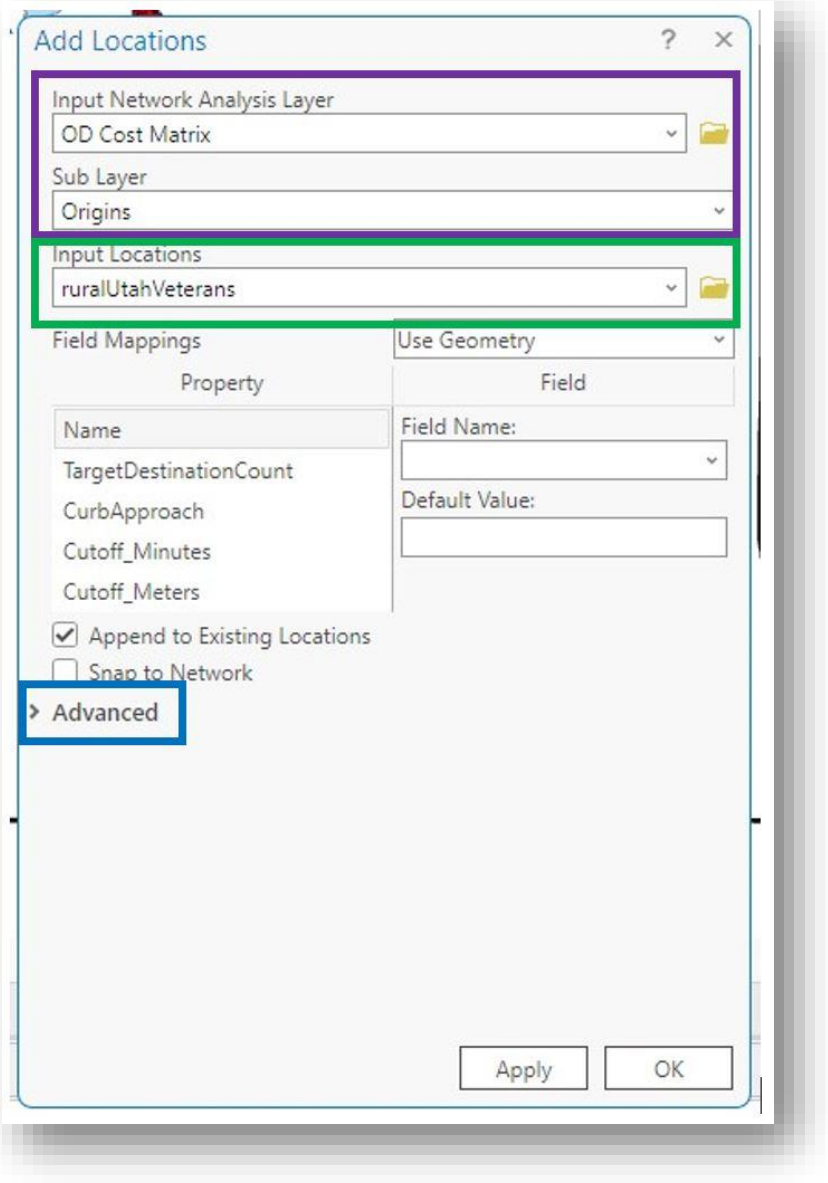


Note: If you cannot find the OD Cost Matrix or Closest Facility tab in the ribbon, click on that layer in the table of contents. ArcGIS Pro hides these when they're not the focus.

Origins: Click on *Import Origins* (OD Cost Matrix) or *Import Incidents* (Closest Facility).

A dialog box titled Add Locations will open. The first two fields (***Input Network Analysis Layer*** **and** ***Sub Layer***) should be populated with *OD Cost Matrix* (or Closest Facility) and *Origins*, respectively. You're going to add your Origins point file to the next box, ***Input Locations***, and you have two options for doing this. First, you can drag your origins point file from your table of contents and drop it into the Input Locations box (probably the easiest method). The second option is to click the dropdown caret in the Input Locations and select your origins points

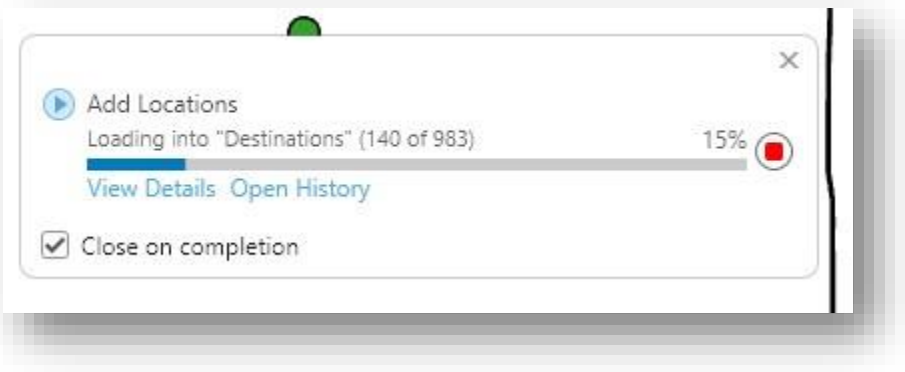
from that dropdown list. When you have finished, the dialogue box should look like this, where the point file for this demonstration is called ruralUtahVeterans:



Leave the other settings (under ***Advanced***) as they are, unless you want to change how the solver interacts with the network. (Going into the ***Advanced*** menu is beyond the scope of this basic tutorial.)

Click *OK*.

A box will open showing progress as it loads the origins. Depending on how many points you're adding, this can take time. If you have thousands of these, it might take a while—maybe a good time to stretch your legs. The key here is to let it finish—don't interrupt the process! And be aware that if *Close on completion* is selected, you'll have no confirmation that the process has completed other than a glance at the History.



When it's done, you'll see your origin points now marked with the special *Origins* symbol (usually a dot-in-square icon by default) on the map. The Contents pane will show that the Origins sublayer has points.

Troubleshooting—If points are missing: If the GIS was unable to associate one or more points with the road network—perhaps the point was too far away from a road—you will see a different symbol over those unlocated points. At this step, you will need to decide whether to reconfigure the point file or the analysis or not worry about those specific origins or destinations. You can make changes to how the solver associates points with roads by increasing the search tolerance in the *Advanced* caret on the Add Locations window. The particulars of these adjustments go beyond the scope of this tutorial. Esri's help pages provides many additional details on associating locations with the road network, including how to adjust the process's parameters.

Troubleshooting—If VINCI closes: If your session of VINCI closes while ArcGIS Pro is open—and possibly running an analysis—it's hard to predict what will greet you when you're back in VINCI.

If you haven't logged out and the session closed within the previous hour or so, it's likely that ArcGIS Pro will still be there and only require you to log in. Usually, in that case everything will be as you left it. Sometimes, if ArcGIS Pro is not listed as still open, opening a second instance of ArcGIS Pro will bring the original instance back to view. If that's the case, you can close the second instance of ArcGIS Pro once the first is once again visible.

If when it opens you don't see the *Add Locations* window still populating places, it might be that the process has finished. Look at your geoprocessing *History* window to see if it complete (it will have a green checkmark next to it if it has finished).

If your locations were still adding when your session closed, you might be greeted with a stalled or whited-out software window. Usually, that means ArcGIS Pro is still loading locations, and the software hasn't given priority to rendering the screen. If that's the case, it's wise not to mess around with it. Log back in every hour or so to check if the analysis has completed.

There are several other scenarios, and it is hard to predict what will greet you. Obviously, if the servers were restarted or if you logged out ArcGIS Pro probably will not have saved your progress.

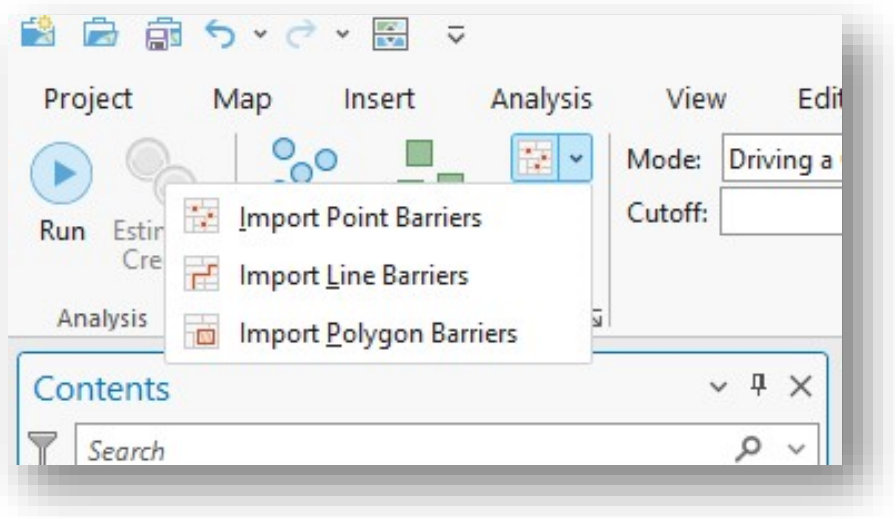
Verify all points loaded correctly by opening the attribute tables for both your origins point file as well as the file for Origins in the OD Cost Matrix layer. If they have the same number of rows, they probably loaded correctly. If there are fewer rows in the OD Cost Matrix layer point file for Origins, something didn't work and you'll need to troubleshoot.

Destinations: Now, it's time to load your destination points.

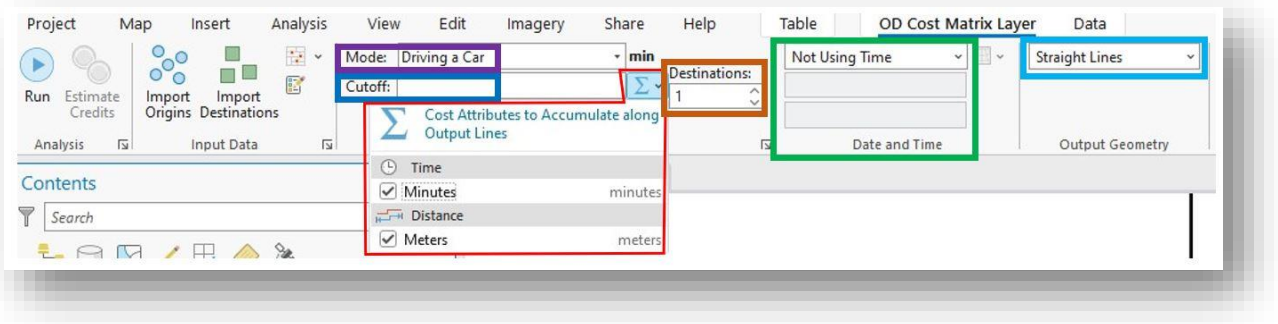
Click on Import Destinations and follow exactly the same procedure for your destination points that you used for your origins.

Your map should now have all its origins and destinations points covered with points from the OD Cost Matrix.

Optional—Barriers: As mentioned, this tutorial does not cover the use of barriers, but if you are going to use them then this is the point when you'd load them. You'll find the Load Barriers options in a dropdown next to the Import Destinations button. If you're not using them, just ignore them for now.



Configure the analysis settings: Now, it's time to tell Network Analyst what you want it to do.



The items you'll want to configure are the following (font color corresponds to highlighted areas in the figure, above):

Mode: Most of the time you'll select *Driving a Car*, but you have options for an emergency vehicle, a bus, a motorcycle, and others. There's even an option for walking.

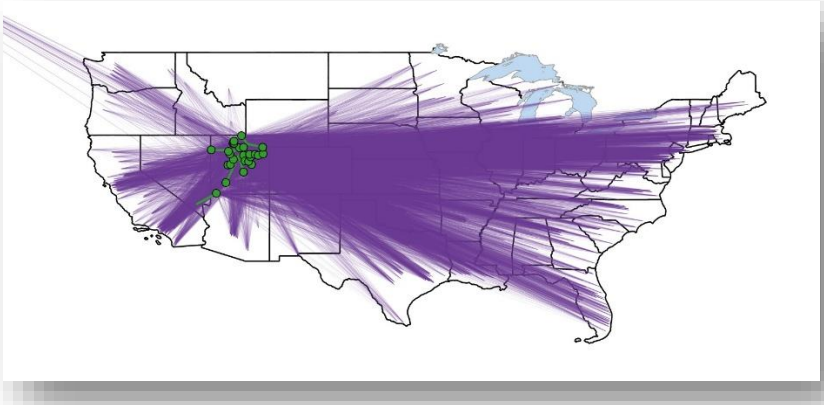
Cutoff: You can select a limit if you'd prefer to cut off the search after some limit has been reached. For example, if you're not interested in finding destinations that require driving beyond a certain amount of time or distance. Maybe for purposes of your analysis, you don't want to search for locations that require more than one hour of driving. If that's the case and impedance is set for minutes, enter 60 for 60 minutes. The searcher will not identify any locations that require more than 60 minutes of drive time.

Cost Accumulation (dropdown with a summation symbol): This is how you tell the solver that you want it to calculate how far and/or how long travel is (the amount traveled is the *cost*). You'll click boxes for time and (if you want) distance. ***If you do not click these, they will not be in your results!***

Destinations: How many destinations or facilities do you want the solver to find for each origin? If you want just the closest destination, make sure there's a 1 in the box. You can find more than one, as well. If you're trying, for example, to find the three closest destinations, you'll want to enter a *3* in that box. In the screenshot, the solver will just look for one destination.

Critical: Do *not* leave the *Destination* box empty. If it is empty, Network Analyst will find *every* possible combination of origin to *every* destination—a Cartesian explosion of results.

Here's what forgetting Destination looks like with just the 25 origins from our use case.



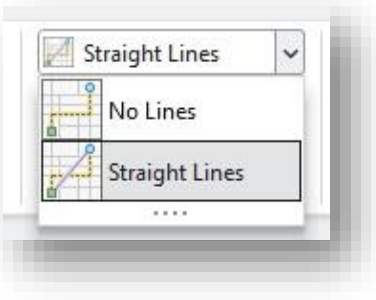
A Note on Performance: Retrieving multiple closest facilities can increase solve time significantly. Finding the 1st closest is fastest; adding a 2nd or 3rd closest may make the solver search a much larger area, slowing things down exponentially.

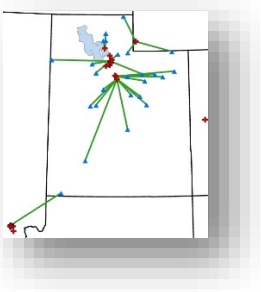
If the Solver Cannot Find a Facility: If the solver cannot find the specified number of facilities, it will simply return null values. So, for example, if you had set the analysis to find the closest three facilities within a 60min drive and there were only two within that limit, Network Analyst will return results for the first two values and null values for the third.

Date and Time: Using specific days/times will incorporate typical traffic delays (e.g., rush hour) into travel time, but that requires more advanced usage and data. For this tutorial, we'll ignore traffic by choosing 'Not Using Time,' which is appropriate for most scenarios.

Output Geometry: This is different depending on whether you're using an OD Cost Matrix or Closest Facility. Regardless of which method you choose and regardless of the output geometry you select (No Lines, Straight Lines, or Along Network), know that the solver is using the road network distances and times for its calculations. (It will *not* be solving using a straight line shortest distance, even if the output is straight lines.)

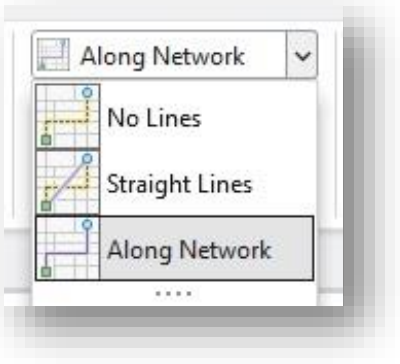
OD Cost Matrix: You can choose Straight Lines or No Lines. Straight lines will generate straight lines between origins and destinations. It adds processing time to the analysis, but it can be very helpful to make sure the analysis ran correctly. Additionally, these lines provide a compelling visual should you want to show what origins and destinations the solver found. Selecting *No Lines* will generate tabular results, but the resulting Lines shapefile will not draw lines.

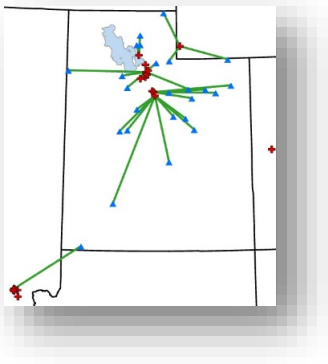


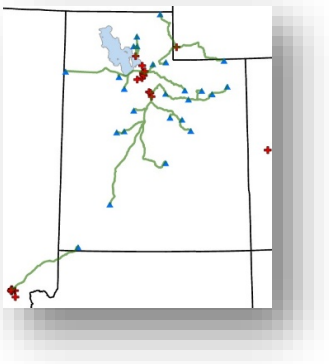


Closest Facility: The Closest Facility solver gives you three options. The first two (No Lines and Straight Lines) are the same that the OD Cost Matrix outputs. The third options is Along Network. This third option outputs lines connecting origins to destinations, but rather than straight lines the connecting lines illustrate the roads driven.

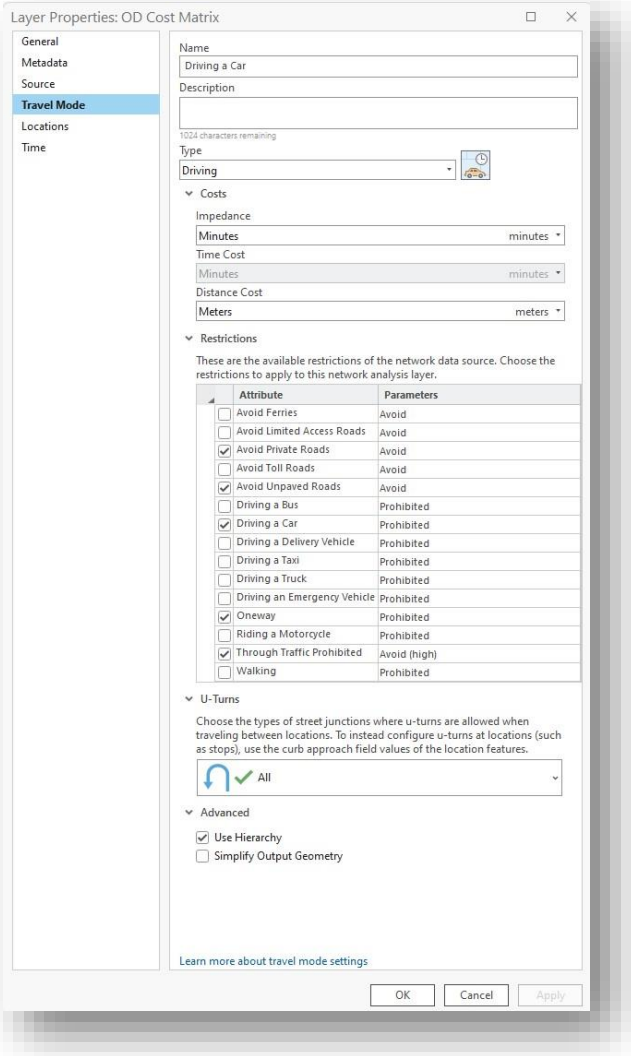
Along Network takes considerably longer to run, draw, and requires a much larger digital footprint in your geodatabase, but the results can be useful for hypothesis generation, including being able to see which roads tend to get used most, and can also be helpful for troubleshooting.







Additional configurations: You may right-click on the OD Cost Matrix or Closest Facility layers and select properties for additional options, such as driving rules you want to use or not use as contained in Travel Mode. We suggest leaving them at their default settings, as they're set up for how most of us assume traffic works. Here's what is in the OD Cost Matrix, with the Closest Facility layer featuring the same options.



A Note on Restrictions: Under Travel Mode settings, you'll see various *Restrictions* (like avoiding tolls, one-way streets, etc.) that you can turn on or off. We recommend leaving these at their defaults for now—they're pre-

configured to reflect normal driving rules. For additional details on restrictions, please see *Appendix C: A brief note on the Restrictions configuration in Network Analyst solvers*.

Caution: At this point, you should save your work. The next step (solving) sometimes crashes ArcGIS Pro, so it's good to preserve things as they are right before runtime. Remember, though, that you have checked out one of the Network Analyst extension licenses and that you won't want to keep that forever locked in your saved map document.

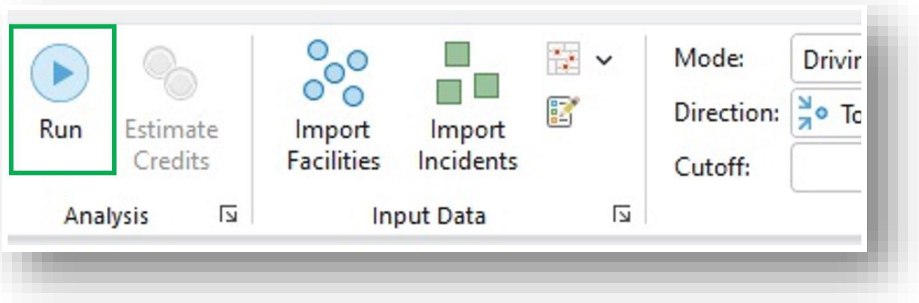
Run the analysis and verify the results make sense:

You're ready to run your analysis.

But *Before* you Hit Run: When ArcGIS Pro finishes the analysis, it will re-draw *the entire map*, including origins, destinations, *all* lines/routes between origins and destinations (if you've selected that option), and anything else you have on the map. The software sometimes hangs when trying to draw the lines for the first time. At a minimum, consider turning off the lines/routes layer before beginning. The analysis will still compute correctly, but ArcGIS Pro won't try to draw thousands of lines immediately upon completion—which can sometimes cause a lag or crash. You might also consider turning off all other unnecessary map items while the solver works on a solution.

Click *Run*.

The Run button for the analysis is at the far left Analysis cluster in the tab for OD Cost Matrix or Closest Facility. It looks like a blue arrow or *play* icon.

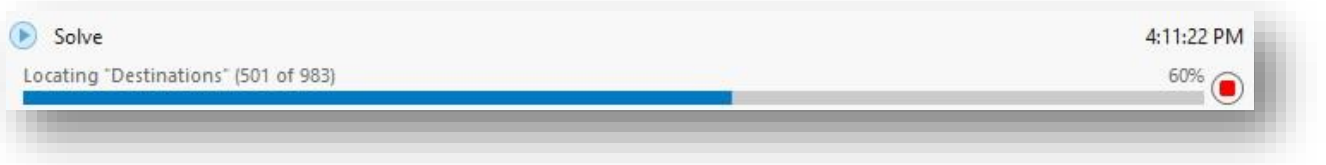


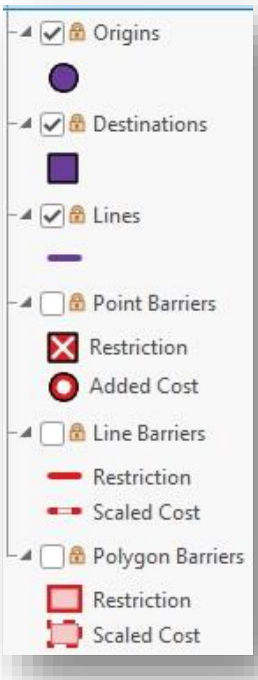
Depending on how many origins and destinations and how many destinations to find, this can be almost instantaneous or may take many hours.

Patience is Paramount: Resist the urge to tinker with the software while the analysis is running, especially if the software becomes non-responsive—you can't make it run faster, and you risk causing the software to crash. It is

not uncommon for the software window to "white out" and stop responding. This doesn't mean it's crashed … just give it more time.

As the analysis runs, ArcGIS Pro will provide a couple of clues that the solver is working on the analysis. The standard geoprocessing loading bar shows how far along the analysis has progressed, and in addition the OD Cost Matrix or Closest Facility layer will display a padlock next to each item.





When the solver finishes: When the solver finishes, it will usually display a window letting you know the process has completed, but on occasion the solver just finishes without any indication it has finished. The padlocks will disappear from the items in the OD Cost Matrix Layer or Closest Facility Layer. If you have opted to include some form of lines between origins and destinations, ArcGIS Pro will draw those along with a complete refresh of everything on the map.

Save Your Project Immediately: When the solver has finished, save your map file. This is a temporary step, but it should preserve the results in case ArcGIS Pro hangs or crashes … which it does on occasion at this step. You can temporarily save the map file with the included OD Cost Matrix/Closest Facility layers, but the resulting file is large and should be saved to your geodatabase in your project database (next step).

The Analysis Layer Results are Temporary: When the solver finishes its work, your results are *not* yet permanently saved. The OD Cost Matrix or Closest Facility layer is a temporary item that lives in your map file rather than on the geodatabase in your VINCI drive space. (If ArcGIS Pro closes or crashes before you save the results, you will likely lose your work.)

How to View Your Results

This depends on what solver you're using, but the most important thing to know is that your time and distance calculations are in the line file, (called *Lines* or *Routes*).

Caution: If you opted not to have the solver draw lines (Output Geometry = No Lines), you will still have a lines file. This bears repeating—*Do not delete the Lines/Routes shapefile!* It contains the results of your analysis. If you delete it, you'll have deleted the results of your analysis.

Note: Using your results tables and producing good maps goes beyond the scope of this tutorial. There are many online tutorials, but here are a few items to get you started:

If you want to export a high-quality map, you'll want to configure it as much as possible before going to *Insert→New Layout*, where you'll be able to add items from the map to this layout. It's also here that you'll add items such as a legend, scale bar, and North arrow.

To use your data tables, you can join and export them from your table of contents as well as from your geodatabase. This next section will point to the linking variables.

If you are a fan of Excel, you can use the *Table to Excel* conversion tool by typing "Excel" into the *Command Search* window at the top center of ArcGIS Pro. Just be sure, as in all other cases, that when you save the Excel table that you're making sure it's going to save in your project folder.

Note: If you selected more than one facility to find, the number of rows should be approximately the number of your origins times the number of facilities you asked the solver to find. This is not a hard rule, however, as the solver will often not find some solutions.

For example, if you started with 10 origins and asked for the three closest facilities, you should expect just around 30 lines in your table. There should never be more than your origins times the number of facilities requested, and you should not be drastically below that number, either. You shouldn't be surprised if there are only 25 lines, but if there were 35 or 12, something probably went wrong with the solve.

Interpreting and Using the Tabular Results

This Lines shapefile Table is from our use case. Recall that we had started with 25 Veterans living in rural Utah, and we were trying to find the closest non-VA hospitals. If you open the Lines or Routes attributes table, you should see something similar to this:

	ObjectID *	Shape *	Name	OriginID	DestinationID	DestinationRank	Total_Minutes	Total_Meters	Shape_Length
1	1	Polyline	Location 1 - Location 5...	1	501	1	116.137272	199475.385393	<Null>
2	2	Polyline	Location 2 - Location 7...	2	741	1	175.148839	287333.091697	<Null>
3	3	Polyline	Location 3 - Location 7...	3	741	1	152.76127	230955.945632	<Null>
4	4	Polyline	Location 4 - Location 7...	4	737	1	111.426194	195166.834377	<Null>

ObjectID: Index number to the in-map object. This number is simply a row index for the line object. It does not represent origin (Veteran's home) or a destination. You may effectively ignore this unless you have a more sophisticated analysis planned for after your Network Analyst analysis.

Shape: This will always say *Polyline.*

Name: This spells out the name of the link by describing (first) the row number in the Origins pointfile and (second) the row number in the Destinations file. In the example, the first link is named "Location 1 – Location 501" and this means the closest destination to the first Origin point in the Origins pointfile was the 501st point int the Destinations pointfile. (The next two variables separate the locations for linking back to the Origins and Destinations pointfiles.)

OriginID/IncidentID: This variable exists as a linking variable. OriginID gives the row number of the Origin point in the Origins pointfile. For example, Origin 1 is the point in the first row. Origin 5 would be the point in the 5th row. The same holds for the IncidentID in a Closest Facility analysis.

Note: The ObjectID in your origins/incidents point file also links to this variable.

DestinationID/FacilityID: This variable exists as a linking variable. OriginID gives the row number of the Origin point in the Origins pointfile. For example, Origin 501 is the point in the 501st row. Origin 741 would be the point in the 741st row. The same holds for the FacilityID in a Closest Facility analysis.

Note: The ObjectID in your destinations/facilities point file also links to this variable.

DestinationRank: If you selected more than one destination per origin (maybe the three closest facilities, for example), this will help you determine which is the 1st closest, 2nd closest, 3rd closest, et cetera. If you only selected one destination, the value of this variable will always be 1.

Total_Minutes: This is how many minutes driving time it would take to travel from the origin to the destination.

Total_Meters: This is how many meters driving distance it would take to travel from the origin to the destination.

Shape_Length: If you opted for the solver to create straight lines for you, this will simply give a non-NULL value that describes the vector size of the line object. If you opted for no lines to be drawn, the results will always be <*Null*>. No need to worry about this.

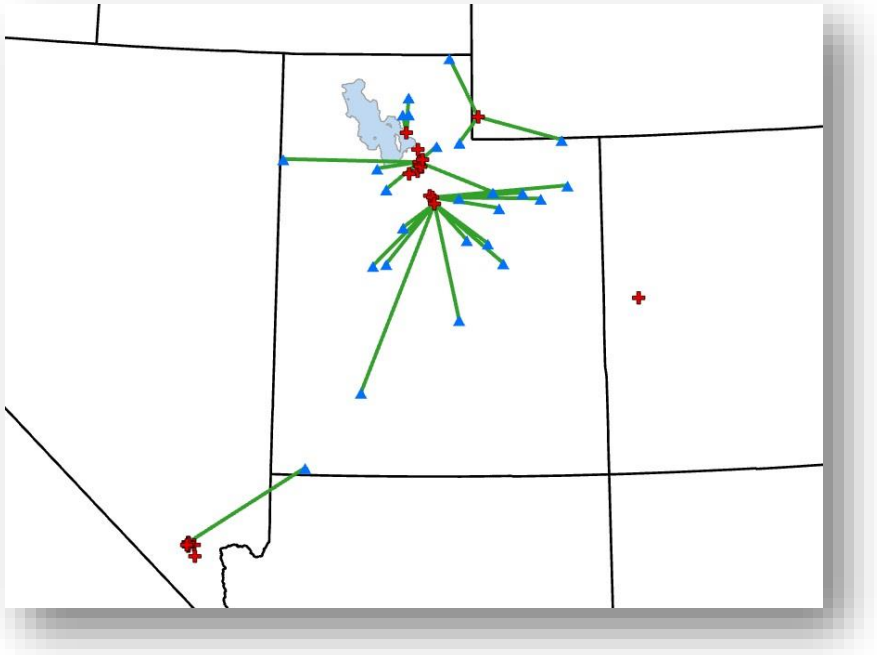
You can explore the results of your analysis both by opening the results table for the Lines shapefile and by examining the resulting lines between origins and destinations on the map.

On the map: If you have temporarily saved your map file, you should be able to draw your routes to see if they make sense. There's rarely a hang or problem if you've generated straight lines, but if you have detailed (non-straight) routes as the output you'll need to be patient as the map draws these.

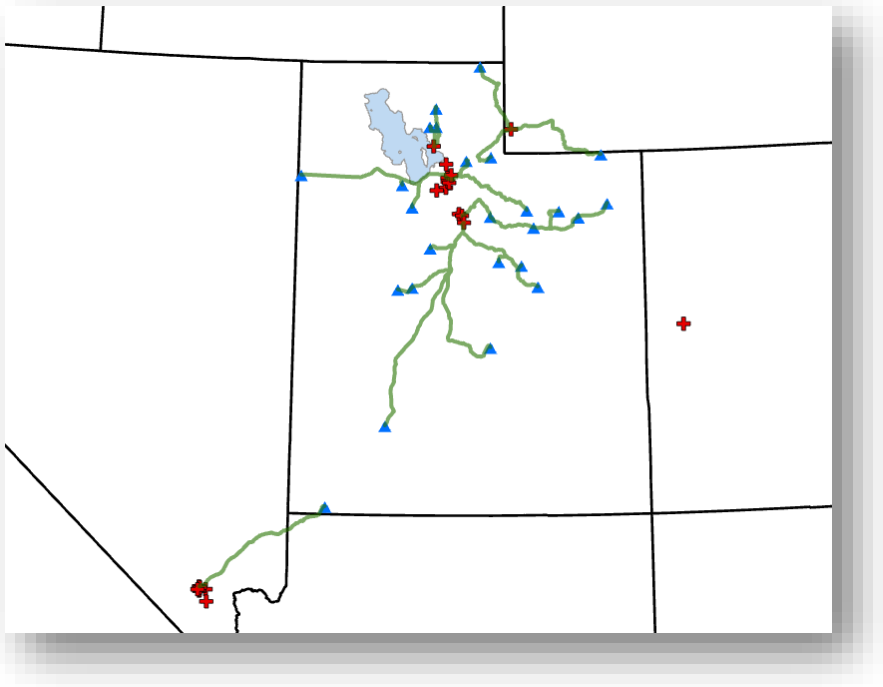
Both OD Cost Matrix and Closest Facility lines are fairly intuitive, and generally have a hub/spoke look to them.

In any case, make sure the routes make sense. You are unlikely to see a very large percentage of lines crossing and as a general rule most of the origins should appear to travel to the closest (*as the crow flies*) facility … but, again, there are exceptions, especially in locations that have rivers, shorelines, and mountains where an origin and destination might be *as the crow flies* close, but the drive might actually require mountain driving or a long diversion to a bridge. If something looks off, it's worth investigating. Zoom in to see what's going on. It's worth exploring and scrutinizing unexpected findings, as sometimes these tell an otherwise hidden story.

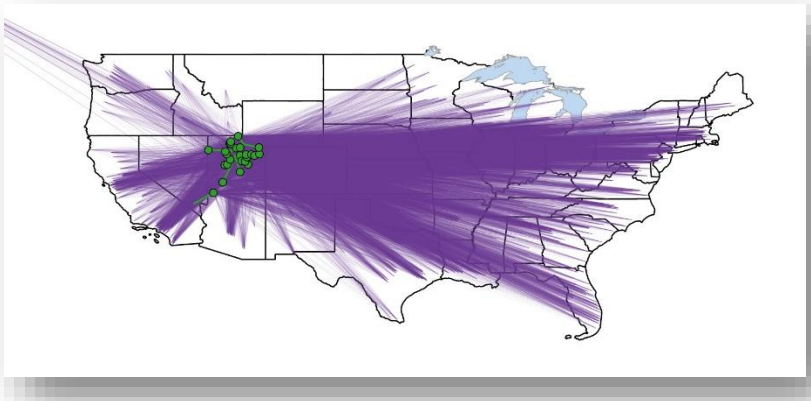
Here are our use case results using straight lines from the OD Cost Matrix with a Straight Lines graphical output.



And here are those same use case results using the detailed line output with Closest Facility with an Along Network graphical output (note that Closest Facility's Straight Lines output would likely be identical to the Straight Lines output from the OD Cost Matrix):



Tip: If the number of results is almost astronomically larger than expected, it is likely you left the destinations box empty when configuring the analysis. Here is what our relatively small 25 origins look like when the destinations box is set to empty, resulting in nearly 25,000 lines:



As a table:

Make sure the number of lines you are expecting is approximately what is in the Lines/Routes file. It's very common for the solver not to find a small percentage of the routes, but unless you told the solver to find more than one destination/facility, the number of lines should be about the same as the number of origins/incidents.

You can right-click on a table and use the Summarize feature to run some quick descriptive statistics

Save the results.

Save the results to your geodatabase.

Decide what you want to save.

You have a few options. You can save the origins/incidents, destinations/facilities, and lines/routes shapefiles separately, or you can link them in a variety of ways before saving the results to your geodatabase. If you used any boundaries, you might opt to save these as well.

I advise preserving these separately as it gives you future options. Technically, you should not need to save the origins/incidents and destinations/facilities points, as these should match the point files you loaded, but I find that occasionally these help me troubleshoot later should something strange come up.

Caution: Double check your files saved to the geodatabase correctly. After saving the results to your geodatabase, drag the items back to your map to ensure you have saved the items correctly. If they fail to draw or the map won't accept them, something may have gone wrong with the saving process.

Consider deleting the OD Cost Matrix or Closest Facility layers: The OD Cost Matrix and Closest Facility items that the solver left in your map are large and temporary items, and they'll make your map file huge. (This is especially the case if you have a large number of origins/incidents.) If you're *absolutely certain* you have saved the items correctly in the geodatabase, you should consider deleting the OD Cost Matrix or Closest Facility. It's not required, however.

Tip: If you're spooked by the idea of deleting the layers, you can always also export these as Excel/csv files. If you do this, be sure that in each case you specify your project folder as the destination. It will likely not export to your project folder by default.

Save your map file.

Release the Network Analyst extension license.

Reverse the process you used to check out the Network Analyst extension license. Ensure it's free.

Remove the road network dataset.

Drop the road network dataset from your map. Sometimes, this can also make your map file size absolutely huge.

Save your map file again.

Appendices

Appendix A: Quick Guide

Quick Guide: Calculating Distances and Drive Times in ArcGIS Pro

Prepare the Environment

1. **Open Project & Set Default Geodatabase**
   -Default geodatabase in VINCI project folder
   -Add project folder to Catalog

2. **Add Data**
   -Origin Points: Veteran home locations
   -Destination Points: VA/non-VA facility locations
   -Road Network Dataset: D:/ArcGISData/NorthAmerica.gdb/RoutingApplication_ND
   (Caution: Zoom in first to avoid crashes)

3. **Activate Network Analyst Extension**
   -Project → Licensing → Enable Network Analyst

Build Analysis

4. **Add Network Analysis Layer**
   -Choose Closest Facility (visual routes) or OD Cost Matrix (faster/tabular)

5. **Load Origins and Destinations**
   -Use Import Origins and Import Destinations
   -Check placement and projections

Configure Analysis

6. **Define Solver Settings**
   - Travel Mode: Driving a Car
   -Cutoff (Optional): e.g., 60 minutes
   -Accumulate Attributes: Check Time and Distance
   -Number of Facilities: Set to 1
   -Output Geometry: Along Network / Straight Lines / No Lines

7. **Run Analysis**
   -Click Run (avoid interacting until complete)

Review & Save Results

8. **Review Results**
   -Check Lines/Routes table for drive times/distances
   -Visually verify routes if needed

9. **Save Outputs**
   -Export Lines/Routes to geodatabase
   -Validate by re-adding to map

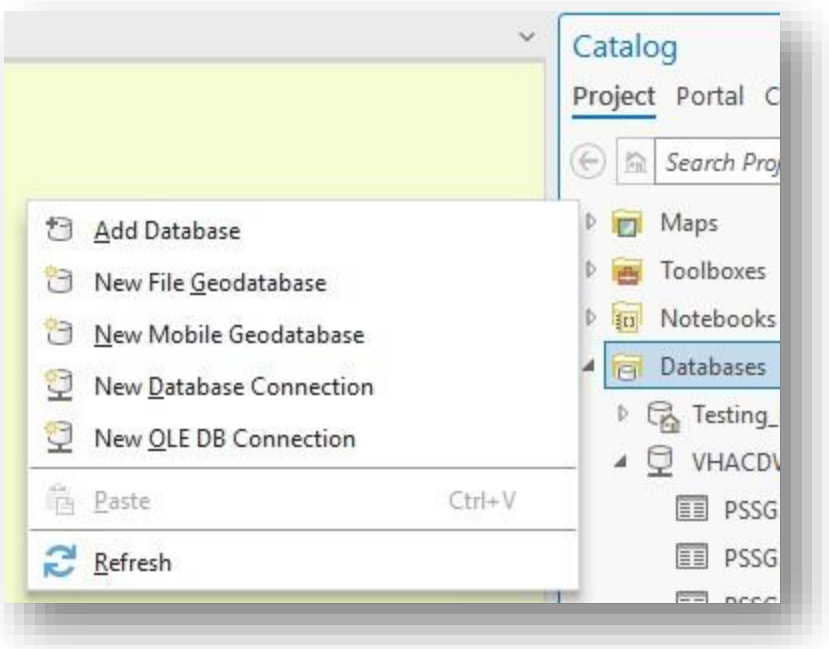
Clean Up

10. **Release License**:
   -Project → Licensing → Uncheck Network Analyst
11. **Remove Network Dataset**
   -Remove RoutingApplication_ND
12. **Save Map**
   -Save map and close project

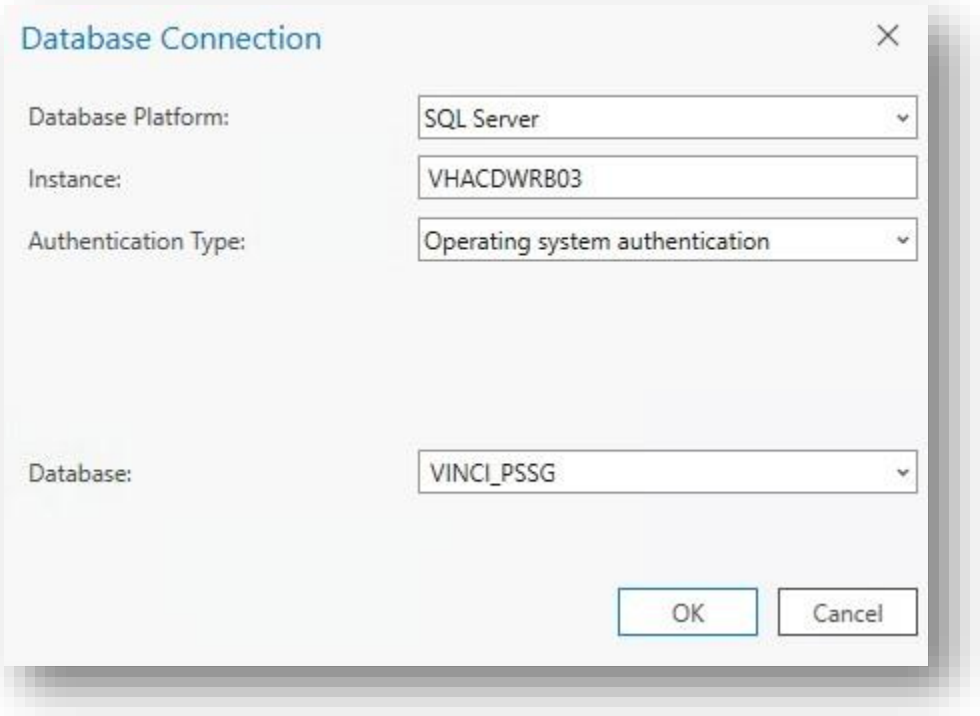
Appendix B: A brief note on using ArcGIS Pro to access data in VINCI

You can use ArcGIS Pro's Database Connection mechanism to tap data in CDW, provided, of course, that you have the correct permissions. The particulars are beyond the scope of this paper, but I'll briefly note that this process involves the following:

From within ArcGIS Pro, right-click on *Databases* in your Catalog and in the window that pops up select *New Database Connection.*

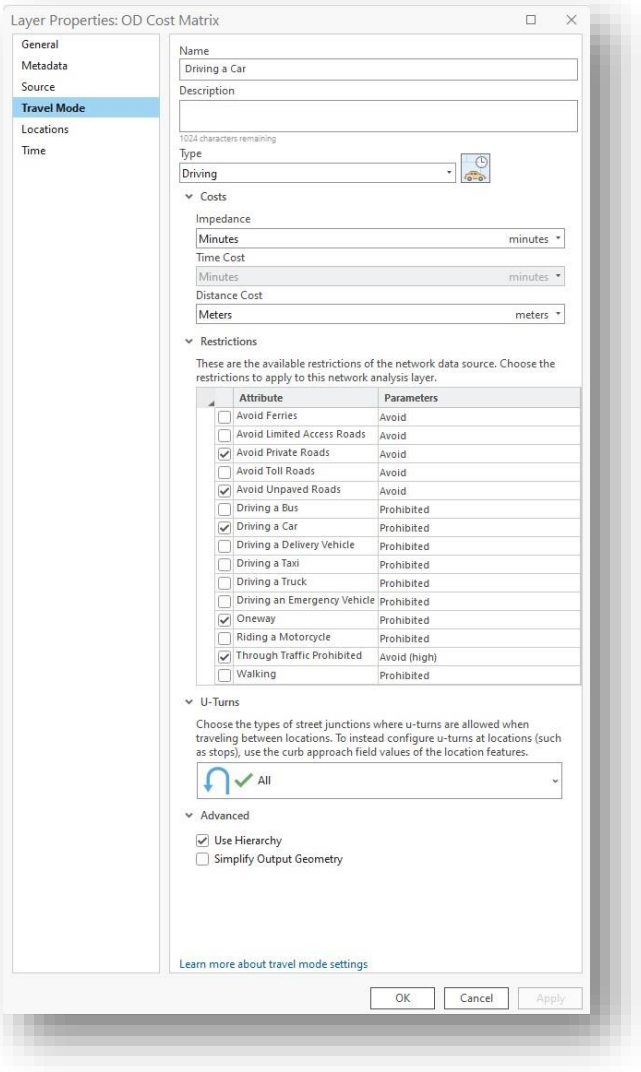


Here's an example connection to VINCI_PSSG on RB03. Note that this example is set up for operations (VINCI_PSSG), but connecting to your ORD project (in the *Database* dropdown) will use the same process.



Appendix C: A brief note on the *Restrictions* configuration in Network Analyst solvers

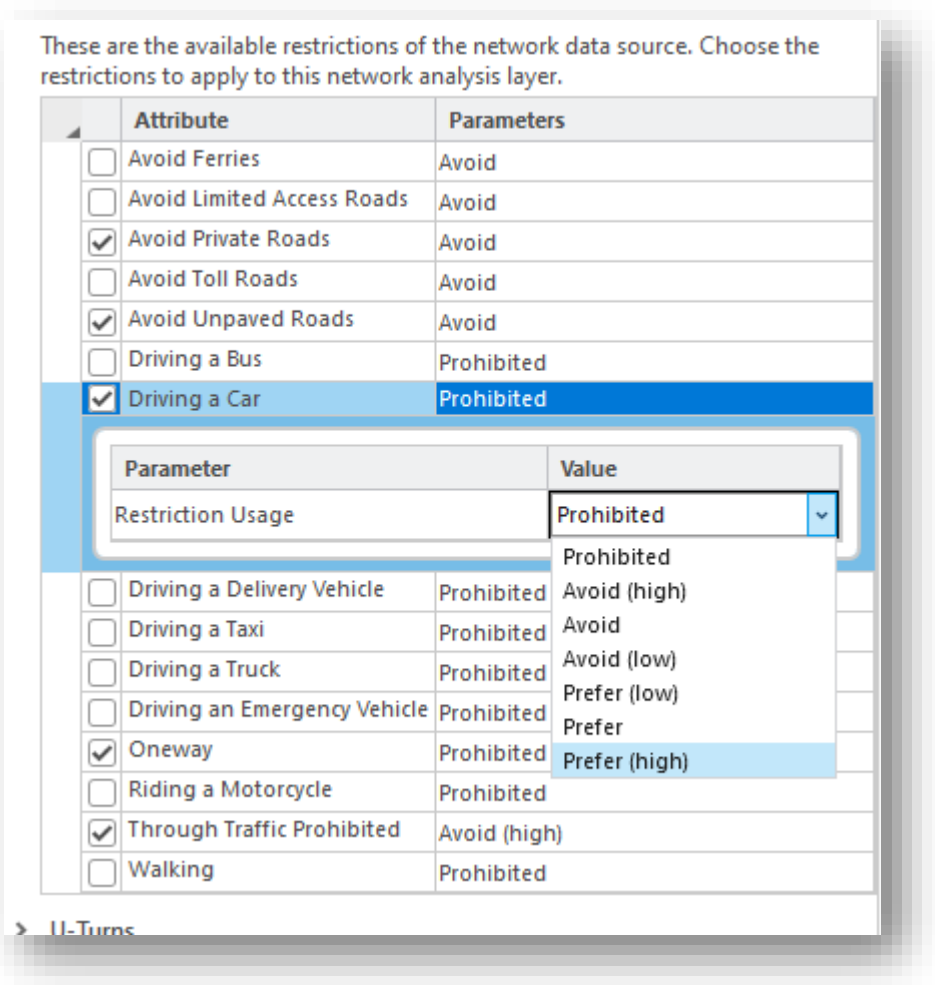
The Restrictions configuration can be confusing. I'll attempt to explain what they do and why you may or may not want to change them. These options are available in both OD Cost Matrix and Closest Facility.



What the restrictions in Travel Modes do: Think of *Restrictions* as *preferences* (which might have been a better thing to call them). Restrictions in the Travel Mode section of the analysis layers allow you to select the "rules of the road" that your solver will follow. Each of the 63M road segments in the road network dataset has a few additional fields, including speed limit, whether it's a toll road, if it's a one-way road, and then there are also several additional restrictions such as *Restrict Cars?*, *Restrict Busses?*,

Restrict Taxis?, *Restrict Emergency Vehicles?*, and so forth. These have values of *Yes* or *No* values for each street segment.

In Network Analyst, restrictions can be defined for network elements (road segments) to control their usage during analysis. You indicate which of these restrictions the analysis should honor, using a checkbox (indicating whether to honor the rule or not). Additionally, conditional restrictions can be set based on parameter values entered at solve time, for example, perhaps indicating that a bus can traverse the road while a car cannot or that vehicles above a certain weight are prohibited. The "Restriction Usage" parameter determines how the restriction is applied, with options to "Prohibit" (completely disallow), "Avoid" (with varying degrees of preference to detour), or "Prefer" (with varying degrees of preference to include) specific network elements in the analysis. This allows for sophisticated routing based on various constraints and preferences.



There are three kinds of restriction:

Prohibit: Completely disallow certain roads (effectively infinite cost).

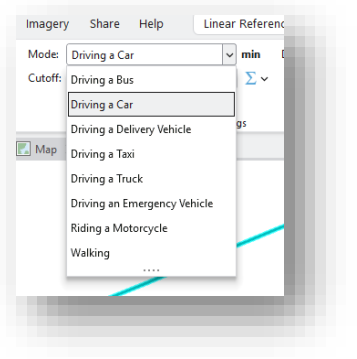
Avoid: Try not to use those roads (adds a penalty cost; can be High/Medium/Low)

Prefer: Try to use those roads (reduces cost; Low/Medium/High effect).

You are able to force the solver to honor any restrictions or allow it to ignore those rules. In addition, you are able to change the parameter from, for example, *Prohibited* to something less restrictive by clicking on the box that's currently marked Prohibited and selecting your preferred option in the dropdown box.

From the solver algorithm's point of view, restrictions modify the impedance (or cost) of traversing each network element. *Prohibit* effectively assigns an infinite impedance, ensuring the segment is never part of the optimal solution. *Avoid (high)* significantly increases the impedance, making the segment highly undesirable and only considered if absolutely necessary or if alternative routes have a much higher overall impedance. A parameter setting of *Avoid (low)* means the segment is less preferable to an otherwise similar segment without that parameter, but it would be preferable to a much more costly solution (say, several miles longer). Conversely, *Prefer (high)* drastically reduces the impedance, effectively making the segment very attractive and likely to be included in the optimal solution unless significantly less costly alternatives exist.

Which restrictions are in place partially depends on the mode of travel you selected when configuring the analysis and on the attributes of that road segment or transport.



Here's a real-world example of road segments in a public park having the following attribute: *Driving a Car: Prohibited* and *Driving an Emergency Vehicle: Avoid (low)*. The pathways in this park are paved and drivable, but they're meant for residents to walk while enjoying the park. If, however, there was a need for an emergency vehicle to drive through, the solver (if configured as *Driving an Emergency Vehicle*) would first attempt to find a route on public roads as the park roads are set to *Avoid (low)*, but if the alternative solution required a long diversion or if it was blocked, the solver would include these park road segments in the solution. In practice, this means an ambulance will stick to public roads unless the only or much shorter path is through the park, in which case it will use the park road (just like real life—generally, *no*, but if it saves a life, *yes*).

Other situations where a configuration might make sense is if you would prefer that the solver use public roads rather than a ferry or a toll road, but to use those if there's no other reasonable alternative. You could, for example, change the parameter to something like *Avoid (high)* for ferries and the solver will look for almost any other solution, but if the solution was impossible or, perhaps, required a 50 mile diversion, it might prefer the ferry.

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