AVDTA: Dynamic Traffic Assignment

Michael W. Levin

July 25, 2016

Table of Contents

Chapter 1

Introduction

Distribution

AVDTA is a research software for studying DTA and mesoscopic simulation models of autonomous vehicle technologies. AVDTA is not available for commercial use. AVDTA may not be used without the permission of the author, Michael W. Levin.

Support

The author may be contacted at michaellevin@utexas.edu.

Chapter 2

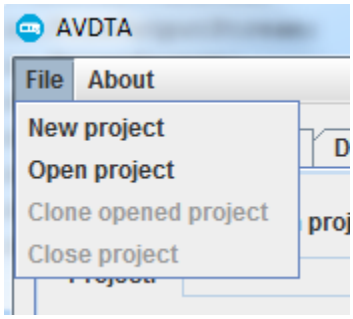
Project structure

2.1 Introduction

AVDTA is organized around *projects*. A project is best thought of as a specific scenario under study. For instance, a project might represent a certain demand scenario or network configuration for a city network or subnetwork. The AVDTA GUI contains methods to modify project options, such as link types or intersection controls. Data files can also be copied to and from Excel for easy modification.

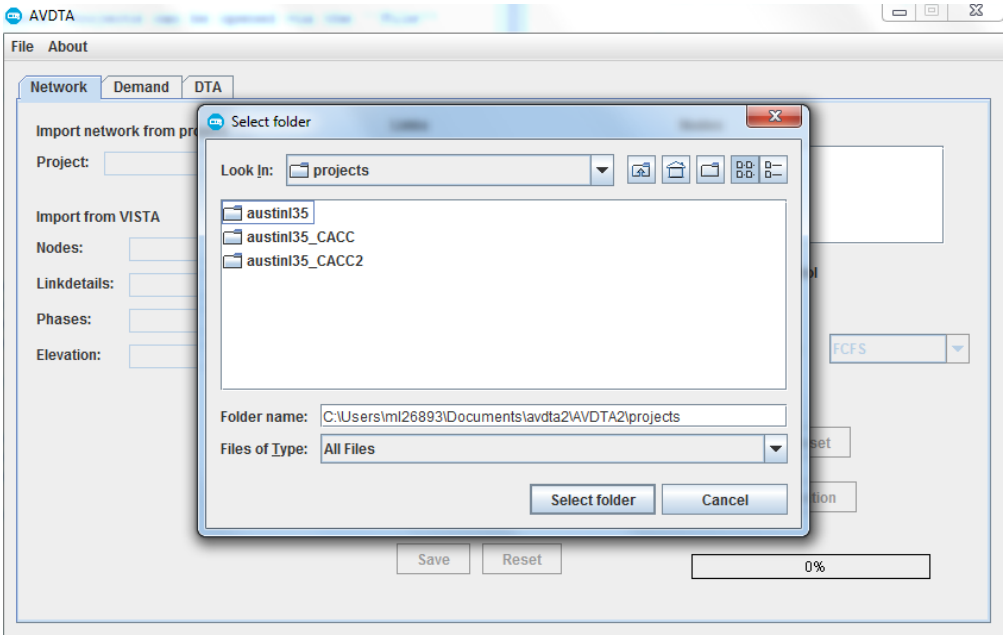
2.2 GUI

The AVDTA GUI is designed to interact with projects. Each instance of AVDTA can have a single project open at a time. Projects can be created and opened via the "File" menu.

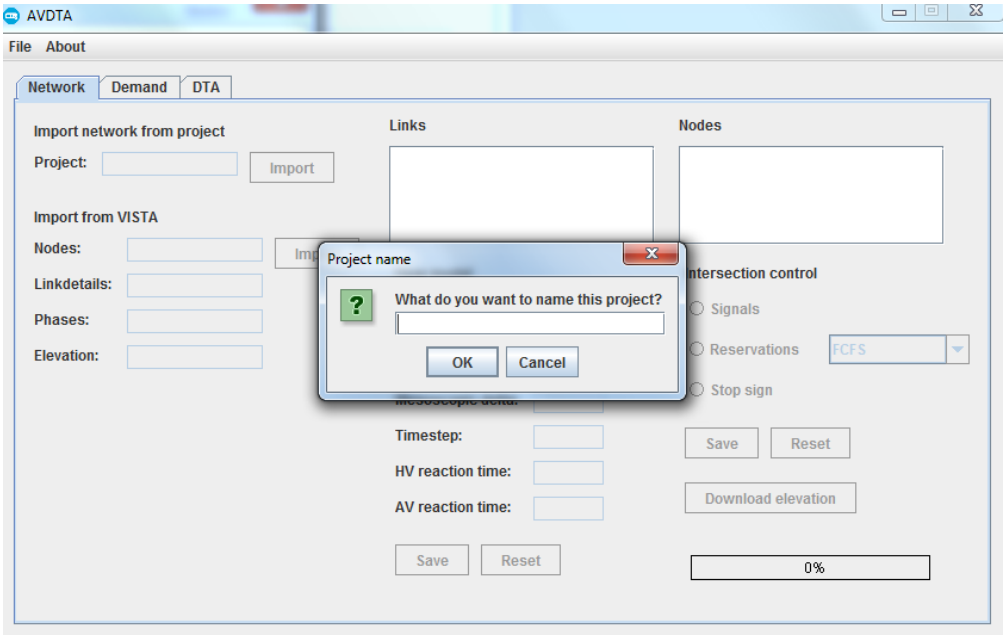


2.2.1 New project

To create a new project, you will first be asked to select the root folder. By default, this folder is `avdta/projects`, but it may be changed.

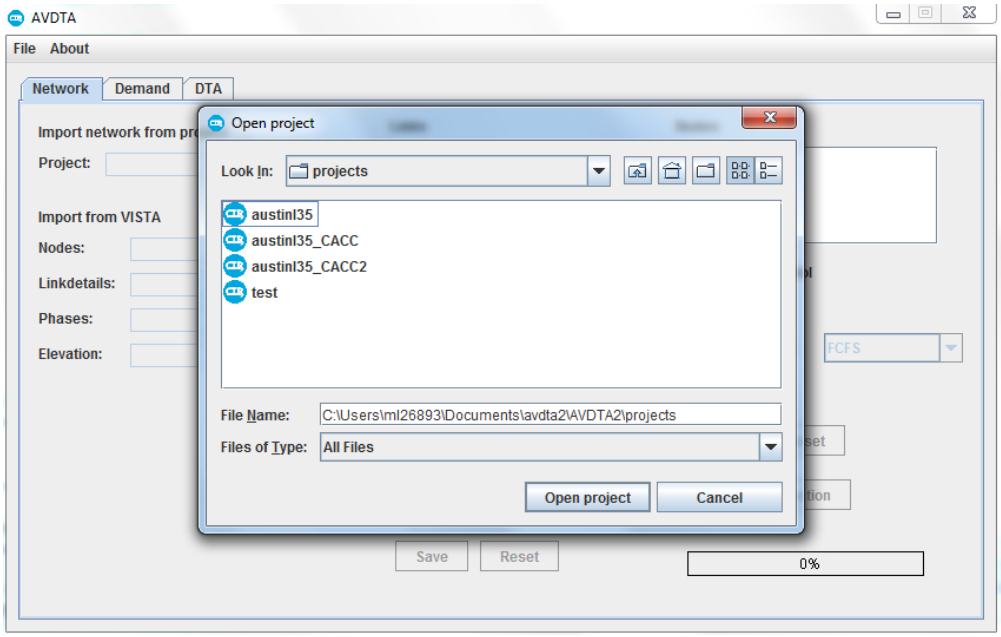


You will then be asked to enter the name of the new project. A project folder with the entered name will be created in the selected root folder.



2.2.2 Open project

AVDTA project folders are shown with a special icon. Select a project folder and click "open project" to open it.



2.2.3 Clone opened project

If a project is open, the AVDTA GUI enables the option of creating a clone. Follow the instructions in Section 2.2.1 to choose the location and name of the clone. You can also create a copy of a project folder within the file system.

2.3 Files and folders

A project consists of a file folder containing several specific files and subfolders. The project folder, along with many of its files and subfolders, is automatically generated when a new project is created. However, many files will be empty, requiring the import of data from other projects or other sources. Note that removal or modification of these files outside of the AVDTA GUI could result in errors when loading the project. However, adding files or folders will not affect the project.

Projects contain several types of files. Text files (`.txt`) contain project inputs or outputs and are intended to be read or modified. However, if modifying these files, ensure that the format and units are correct. Text files are tab-delimited, and have a header indicating the data in each column. Text files may be copied to and from Excel.

Data files (`.dat`) are used to load the project and are not intended to be opened or modified. Similarly, files with other unknown extensions are not intended to be opened.

2.3.1 Files

2.3.1.1 `project.txt`

The `project.txt` file contains project properties used to load the project within AVDTA. The file consists of two columns: The file consists of two columns:

key	value

name This is the project name that is displayed when AVDTA loads a project. This does not have to correspond to the project folder name.

seed This is the random number generator seed. If two projects have matching seeds, actions involving random numbers performed in the same order should have identical outputs.

type This denotes the project type.

2.3.1.2 `options.txt`

The `options.txt` file contains project parameters that define the loading and simulation of the project. The file consists of two columns:

key	value

Keys are case insensitive. Values are a string that could represent multiple data types, such as integers, floating-point numbers, or booleans ("true" or "false"). The options file is automatically generated with default values when a project is created.

av-reaction-time This is used to determine the capacity and congested wave speed increase due to autonomous vehicles when using the multiclass CTM [7]. A typical value is 0.5 (s). Note that capacity and congested wave speed are scaled from the values in the `networks/links.txt` file.

hv-reaction-time This is used to determine the baseline capacity and congested wave speed when using the multiclass CTM [7]. A typical value is 1 (s). Note that capacity and congested wave speed are scaled from the values in the `networks/links.txt` file.

dynamic-lane-reversal If set to "true", DLR will be activated on DLR links. DLR is a specific type of CTM link, and the type of links can be set in the `networks/links.txt` file.

hvs-use-reservations If set to "true", HVs will not avoid reservation-controlled intersections in their route choices. Reservations will use the legacy early method for intelligent traffic management [2], adapted to DNL [7] for HVs. Otherwise, HVs will avoid reservations in their route choices, passing through reservations only if no other route is available.

simulation-duration This is the duration of the simulation, in seconds. The duration should be sufficiently longer than the demand departure times interval to allow all vehicles to exit the network.

simulation-mesoscopic-step This is the time step used in simulation. For CTM, a typical value is 6 (s). For LTM, a typical value is 10 (s).

ast-duration This the interval for averaging travel times for calculating shortest paths. A typical value is 900 (s).

2.3.1.3 `dta.dat`

The `dta.dat` file marks the project as a DTA project, and should not be modified.

2.3.1.4 `paths.dat`

The `paths.dat` file contains a list of all known paths in the network. AVDTA does not generate a complete list of paths, but all paths that are created during DTA are saved here. The file is used when loading and saving assignments.

2.3.2 Folders

`network` folder The `network` folder contains all network data files, discussed in Chapter ??.

`results` folder The `results` folder is used to store and organize results files.

`demand` folder The `demand` folder contains all demand data files, discussed in Chapter 4.

`assignments` folder The `assignments` folder stores previous assignments for the project. Each assignment consists of a subfolder, usually named by the time at which the assignment was created. Previous assignments can be loaded through the AVDTA GUI.

Each assignment subfolder contains several files. The `log.txt` file contains a log of the DTA run that created the assignment. It includes results from each iteration of DTA as well as summary statistics for the assignment. The `vehicles.dat` file contains summary statistics in a more readable form for AVDTA, and then a list of vehicles and the path they are assigned to. The path ids correspond to a path in the `paths.dat` file. Do not modify the `vehicles.dat` file.

Chapter 3

Traffic network

3.1 Introduction

A *network* in AVDTA defines the

3.2 Nodes

3.3 Links

Each line in the links file corresponds to a link in the network. The links file has columns

id	type	source	dest	length	ffspd	w	capacity	num_lanes

id The id of the link. Each link must have an unique, positive id, but the ids do not have to be consecutive.

type This determines the flow model used for the link. The possible types are

Flow model	type	description
CTM	100	Multiclass CTM [7]
	102	CTM with DLR [6]
	103	CTM with shared transit lane
LTM	200	Standard LTM [9, 10]
	205	LTM with CACC
Centroid connector	1000	Link between a centroid and a node

Standard CTM is achieved through type 100 with HVs.

source The id of the source node.

dest The id of the destination node.

length The length of the link, in feet.

ffspd The free flow speed of the link, in miles per hour. Note that the free flow travel time is rounded up to the nearest time step.

w The congested wave speed of the link, in miles per hour. For LTM links, the free flow speed, capacity, and congested wave speed must be consistent as the fundamental diagram is over-determined. This is not an issue with CTM because CTM accepts a trapezoidal fundamental diagram. A typical value is half of the free flow speed.

capacity The capacity *per lane* for the link, in vehicles per hour.

num_lanes The number of lanes on the link. This affects the total capacity as well as intersection dynamics.

Note that for centroid connectors, the free flow travel time does not depend on the length and free flow speed, but is a constant 1 time step. Also, centroid connectors are not restricted by wavespeed or capacity limitations.

With CTM, the minimum number of cells per link is 2.

Chapter 4

Demand

4.1 Introduction

The demand specifies personal vehicle trips in terms of origins, destinations, and departure times. This chapter discusses the organization of the demand inputs to DTA. All related data files are contained within the `demand` subfolder of a project. The demand is specified through four files. The `static_od.txt` file is a static (time-invariant) trip table that is representative of the static data available to many planning organizations. The `dynamic_od.txt` file is a dynamic trip table that specifies the number of trips per *assignment interval* (AST). The `demand_profile.txt` file specifies the weight, start time, and duration of each AST. The `demand.txt` file contains a list of discrete vehicles, each with a specific origin, destination, and departure time. The `dynamic_od.txt` file can be generated from the `static_od.txt` and the `demand_profile.txt` files. The `demand.txt` file can be generated from the `dynamic_od.txt` file and the `demand_profile.txt` file.

Vehicle types (i.e. HV, AV, etc.) are specified in the `static_od.txt`, `dynamic_od.txt`, and `demand.txt` files. The AVDTA GUI includes methods to generate the `dynamic_od.txt` and `demand.txt` files given appropriate inputs.

4.2 Files

4.2.1 `static_od.txt`

The `static_od.txt` file is a time-invariant trip table. Each line indicates the number of trips of some type between some origin and destination. The columns are

id	type	origin	destination	demand

id An unique id for the trip table entry. Ids do not have to be consecutive, but must be unique and positive.

type The type indicates the type of vehicle, including the driver, engine, and vehicle behavior. The options for types are indicated below:

Category	type	description
Driver	10	HV
	20	AV
Engine	1	ICV
	2	BEV
Behavior	100	personal vehicle (UE routing)
	500	transit (fixed route)

A valid type is the sum of a driver type, an engine type, and a vehicle behavior. Typical types are 111 for HVs and 121 for AVs.

origin, destination These are ids of origin and destination zones in the network (see Section 3.2).

demand A floating point number indicating the number of trips of the specified type from the origin to the destination. Duplicate entries (in terms of type, origin, and destination) are accepted.

4.2.2 `dynamic_od.txt`

The `dynamic_od.txt` file is like the `static_od.txt` file, but with the addition of an AST. Each line The columns are

id	type	origin	destination	ast	demand

ast This is the id of an AST from the `demand_profile.txt` file (Section 4.2.3).

The remainder of the columns are the same as in the `static_od.txt` file (Section 4.2.1). The ids in `dynamic_od.txt` do not need to correspond to the ids in `static_od.txt`. The `dynamic_od.txt` file can be generated within AVDTA from the `static_od.txt` and `demand_profile.txt` files. The distribution of flow over ASTs is determined by the weights in the `demand_profile.txt` file.

4.2.3 `demand_profile.txt`

The `demand_profile.txt` file specifies the ASTs. Each line is an individual AST. The columns are

id	weight	start	duration

id The id must be positive and unique, but does not need to be consecutive.

weight This is the proportion of total flow departing within this AST. Proportions will be scaled to sum to 1 if necessary.

start This is the starting time of the AST, measured in seconds from the beginning of the simulation period.

duration This is the duration of the AST. A typical value is 900 (s).

4.2.4 `demand.txt`

Each line in the `demand.txt` file is an individual vehicle trip. The columns are

id	type	origin	dest	dtime	vot

id The unique vehicle id. Ids must be positive and unique but do not have to be consecutive.

type The vehicle type (see Section 4.2.1 for a list of types).

origin, dest The ids of the origin and destination zones for the vehicle (see Section 3.2).

dtime The departure time of the vehicle, measured in seconds from the start of the simulation period.

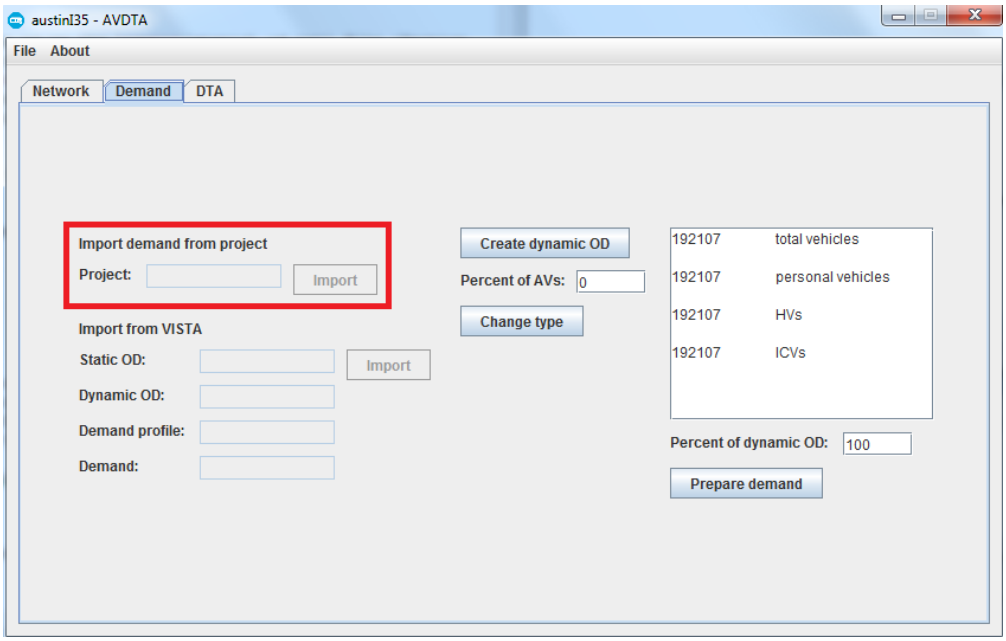
vot The value of time of the vehicle. This is used in certain control policies, such as auctions for reservations. Values of time must be non-negative.

4.3 GUI

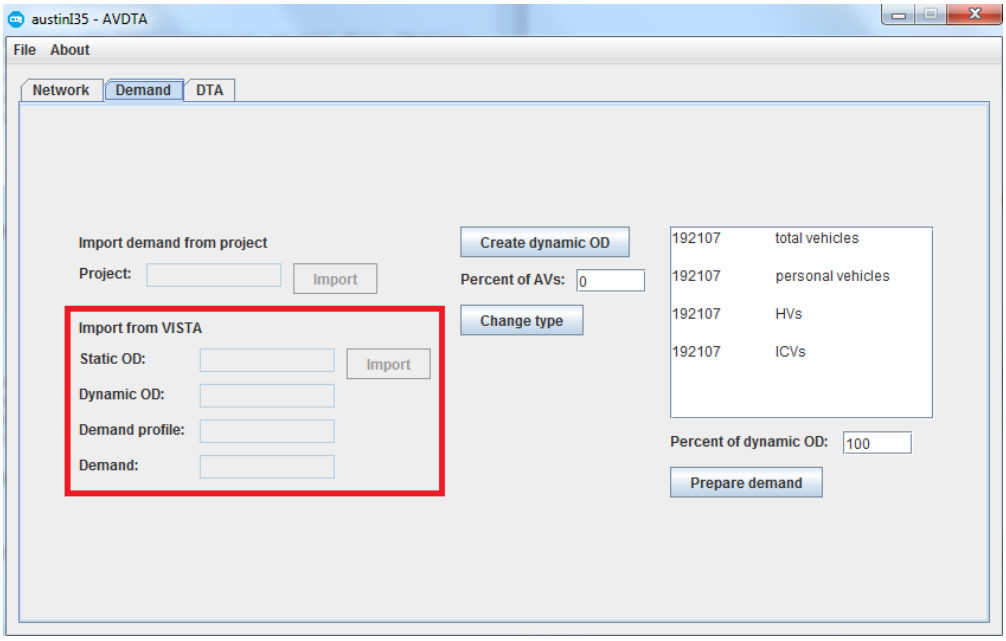
This section describes how to interact with the demand through the AVDTA GUI. The "demand" tab contains all demand interactions.

4.3.1 Import demand

The left hand side contains options to import demand from other sources. The first option is to import the demand from another DTA project. This will copy all demand files from the specified project, overwriting any demand files in the current project. Click on the text field to select the project.

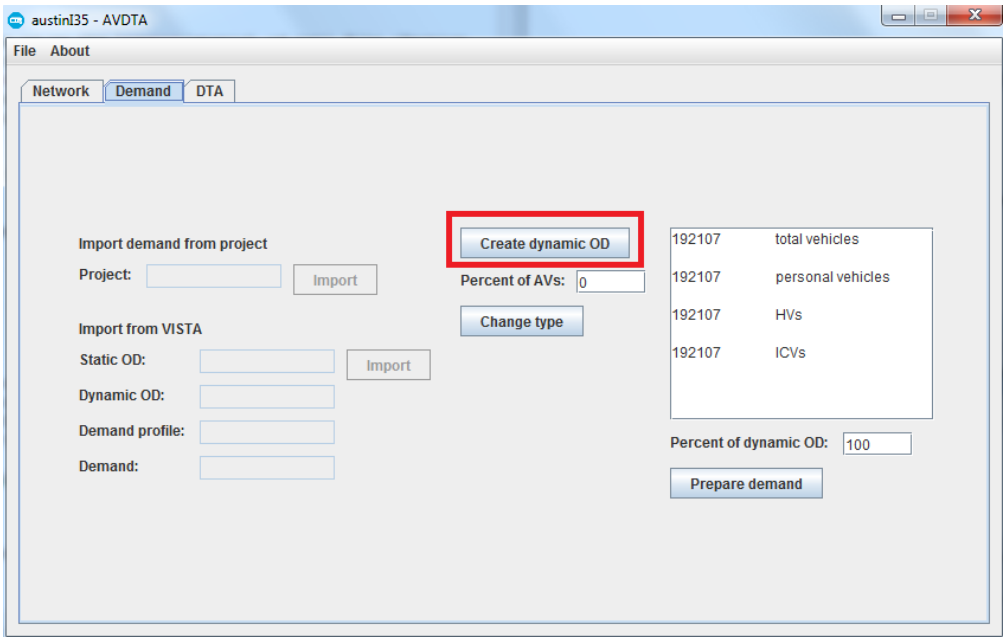


The second option is to import demand from VISTA. This requires the `static_od`, `dynamic_od`, `demand_profile`, and `demand` tables from the VISTA database. Copy them into text files, and select the text files by clicking on the text fields. Note that the file format of AVDTA is not the same as the file format of VISTA, so using the GUI to import demand is recommended.

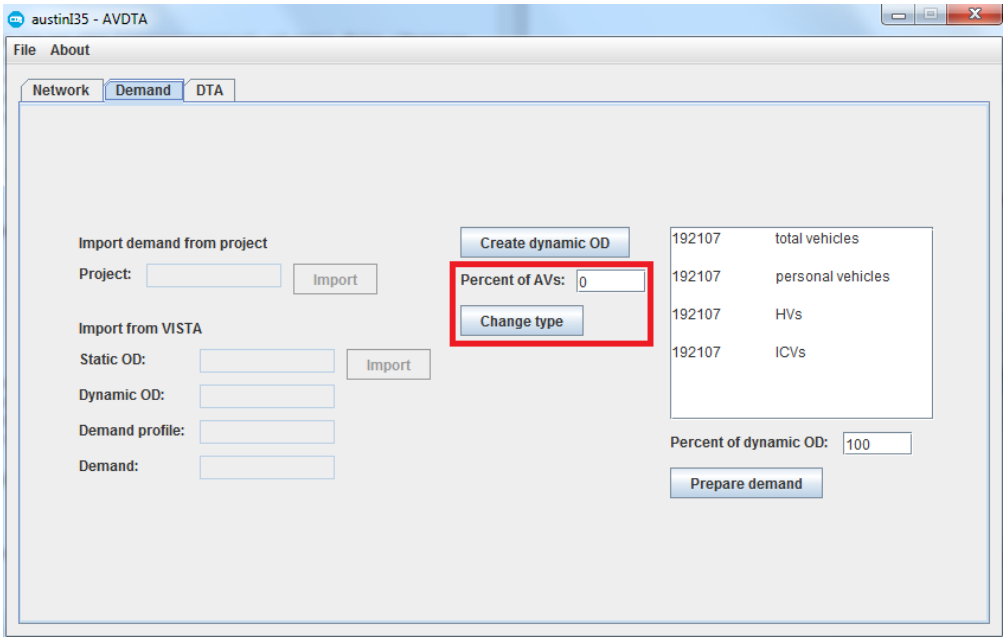


4.3.2 Creating demand

The middle section includes options to change the `dynamic_od.txt` file. The first button will generate the `dynamic_od.txt` file based on the `static_od.txt` and the `demand_profile.txt` files, as discussed in Section 4.2.2.

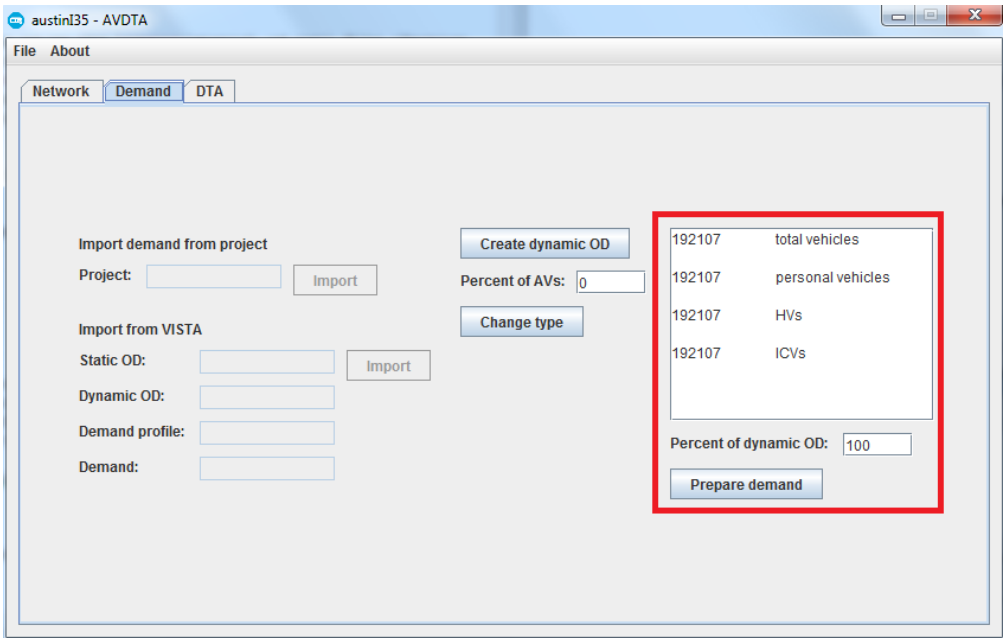


The second option will change the type of vehicles to 111 for HVs or 121 for AVs (see Section 4.2.1 for types) in the `dynamic_od.txt` file based on the specified percent of AVs.



The right hand side describes the individual vehicle trips. The text area lists the total numbers of vehicles, then breaks down the numbers of vehicles by type (driver, engine, and behavior). Click the "prepare demand" button to generate the `demand.txt` file from the `dynamic_od.txt` and `demand_profile.txt` files. You can also scale the percent of demand.

Preparing demand uses a random number generator when the number of trips is not an integer. If d is the number of vehicle trips in `dynamic_od.txt`, prepare demand will create either $\lfloor d \rfloor$ or $\lceil d \rceil$ trips depending on the outcome of the random number generator.



Appendices

Appendix A

Abbreviations

Abbreviation	Definition
AST	assignment interval
AV	autonomous vehicle
BEV	battery-electric vehicle
CV	connected vehicle
CTM	cell transmission model [3, 4]
DLR	dynamic lane reversal [5, 6]
DNL	dynamic network loading [1]
DTA	dynamic traffic assignment [1]
DUE	dynamic user equilibrium [1, 8]
HV	conventional (human-driven) vehicle
GUI	graphical user interface
ICV	internal combustion vehicle
LTM	link transmission model [9, 10]
UE	user equilibrium [8]

References

[1] Chiu, Y.-C., Bottom, J., Mahut, M., Paz, A., Balakrishna, R., Waller, T., and Hicks, J. Dynamic traffic assignment: A primer. *Transportation Research E-Circular*, E-C153 (2011).

[2] Conde Bento, L., Parafita, R., Santos, S., and Nunes, U. Intelligent traffic management at intersections: Legacy mode for vehicles not equipped with v2v and v2i communications. In *Intelligent Transportation Systems-(ITSC), 2013 16th International IEEE Conference on* (2013), IEEE, pp. 726–731.

[3] Daganzo, C. F. The cell transmission model: A dynamic representation of highway traffic consistent with the hydrodynamic theory. *Transportation Research Part B: Methodological 28*, 4 (1994), 269–287.

[4] Daganzo, C. F. The cell transmission model, part ii: network traffic. *Transportation Research Part B: Methodological 29*, 2 (1995), 79–93.

[5] Duell, M., Levin, M. W., Boyles, S. D., and Waller, S. T. On system optimal dynamic lane reversal to improve traffic efficiency for autonomous vehicles. In *Transportation Research Board 95th Annual Meeting* (2016), no. 16-4922.

[6] Levin, M. W., and Boyles, S. D. A cell transmission model for dynamic lane reversal with autonomous vehicles. *Transportation Research Part C: Emerging Technologies 68* (2016), 126–143.

[7] Levin, M. W., and Boyles, S. D. A multiclass cell transmission model for shared human and autonomous vehicle roads. *Transportation Research Part C: Emerging Technologies 62* (2016), 103–116.

[8] Wardrop, J. G. Road paper. some theoretical aspects of road traffic research. In *ICE Proceedings: Engineering Divisions* (1952), vol. 1, Thomas Telford, pp. 325–362.

[9] Yperman, I. The link transmission model for dynamic network loading. *status: published* (2007).

[10] Yperman, I., Logghe, S., and Immers, B. The link transmission model: An efficient implementation of the kinematic wave theory in traffic networks. In *Proceedings of the 10th EWGT Meeting* (2005).