



TENNESSEE
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Campus-Like Emergency Modeling Evaluation: Overview of Two Approaches VISSIM vs. FLEET

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- This study is being sponsored by Department of Homeland Security (DHS)
- Dr. Deo Chimba is the principal investigator, and I am one of the students supported by this project.

Introduction

Natural and manmade emergency events

- Campus shootings
- Hurricanes
- Chemical leakages
- Terrorist attacks

Need for efficient strategies and management to evacuate all affected population in a limited time frame.

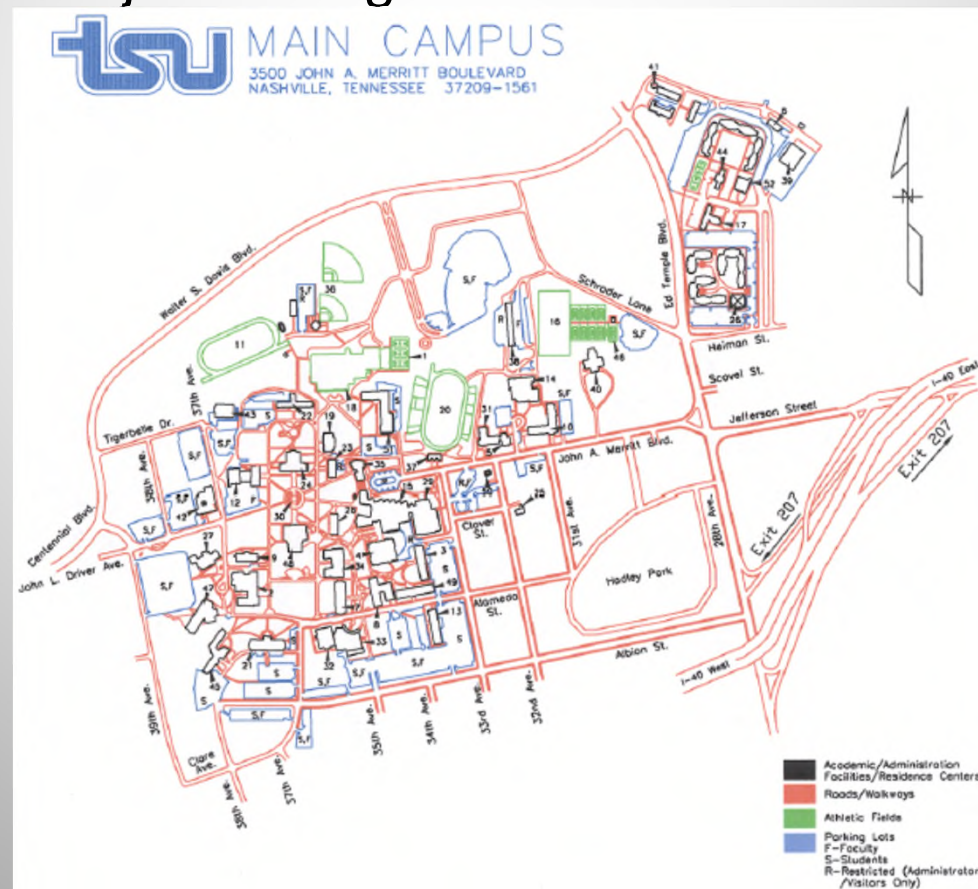
- Pedestrians
- Vehicles
- Busses- Transit

Introduction

- This study focuses on the response including smooth evacuation during disasters at campuses, case study Tennessee State University.
- VISSIM simulation was used
- FLEET simulation was used
- Different evacuation strategies and scenarios were simulated under varied evacuation time, parking lot locations and utilization levels and intersections surrounding the campus

Introduction

- TSU covers 903 acres area with a student plus staff and faculty body of more than 10,000 persons
 - 6 major parking lots
 - A lot of on-street parking
 - 7580 parking spaces
 - considered as a major traffic generator within Metro Nashville area.





Introduction

Four arterials surrounding the campus considered as major evacuation routes in case of emergence events including

- Walter S. Davis Blvd
- Heiman St.
- John Merritt Blvd
- Albion St.
- Interstate 40 (I-40) is the closest freeway that serves the TSU campus



Evacuation Considerations

- Evacuation with private vehicles
- Pedestrian Evacuation
- Evacuation with MTA or Public/Campus busses (Transit)

Realistic combination of evacuation main scenarios

- Combined vehicle and pedestrian evacuation
- Combined vehicle, pedestrian and, Transit



EVACUATION STRATEGIES

EVACUATION STRATEGIES

- What are the level in which the parking lots are utilized
- Will the evacuation be primarily through the signalized intersections or non-signalized or both
- Routing of the evacuation
- Is the use of reversed lanes possible?

GOAL

- A central goal was to transform critical intersections into uninterrupted flow facilities, meaning trying to achieve less delay as possible.
- An uninterrupted flow facility does not require vehicles to come to a full stop; however that was not possible in this case as the locations of parking lots caused traffic to cross at certain points



FOR FLEET

EVACUATION STRATEGIES

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THE USE OF VISSIM FOR EVACUATION SIMULATION

TRAFFIC ASSIGNMENT

- Two route assignments in VISSIM were considered
 - Routing Decision (RD)
 - Dynamic Assignment (DA)

GOAL

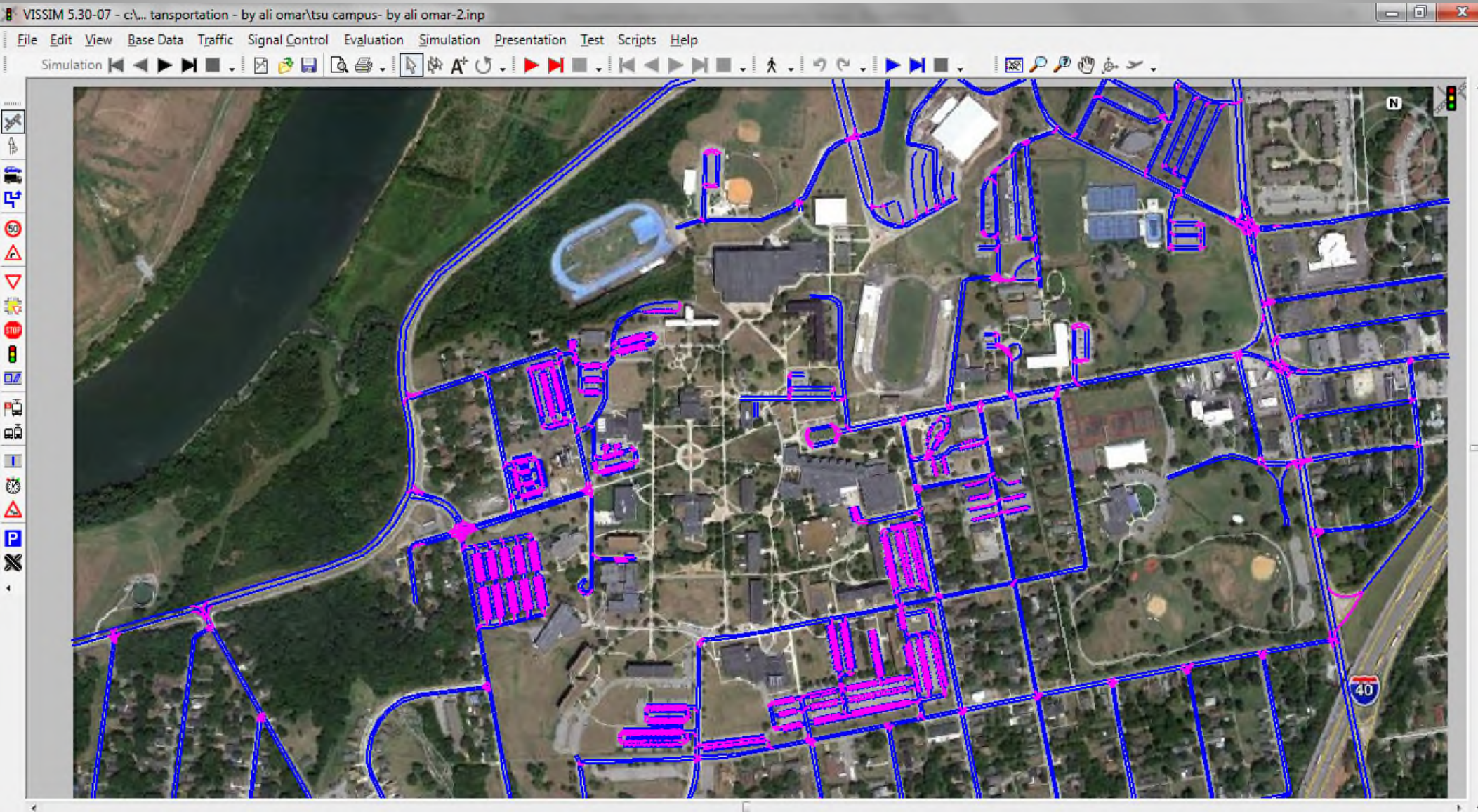
- The decision is based on the distance between each parking lot to the intersection of choice.
- The routes with the shortest distance are chosen because during evacuation, the main goal is to evacuate all the traffic within the shortest time possible



SIMULATION CONDITIONS

- Data gathering was an important component of the study as detailed roadway network and traffic information are needed for VISSIM simulation model to be coded.
- The types of information needed to build the simulation model included:
 - Roadway network geometry information
 - Location of traffic control devices, such as traffic signals, stop signs, yields signs etc.
 - Signal timing plans and phasing
 - Traffic information, such as vehicle composition and hourly volume
 - Information for origin-destination (O-D) demand, such as the parking lot capacity

Simulation and Analysis with VISSIM



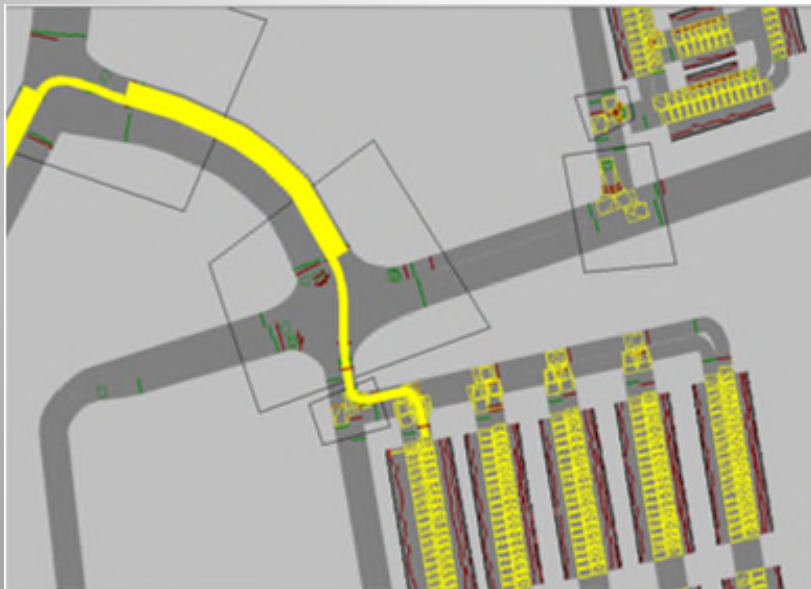


Simulation and Analysis with VISSIM

- Evacuation under different parking lot capacities:
 - Parking lots 100% full (all 7580 parking spaces utilized)
 - Parking lots 50% full (only 3790 parking spaces utilized) and terrorist attacks)
- Evacuation considering signalized and non signalized intersections:
 - Traffic will evacuate through signalized intersections only
 - Traffic will evacuate through both signalized and not signalized intersections

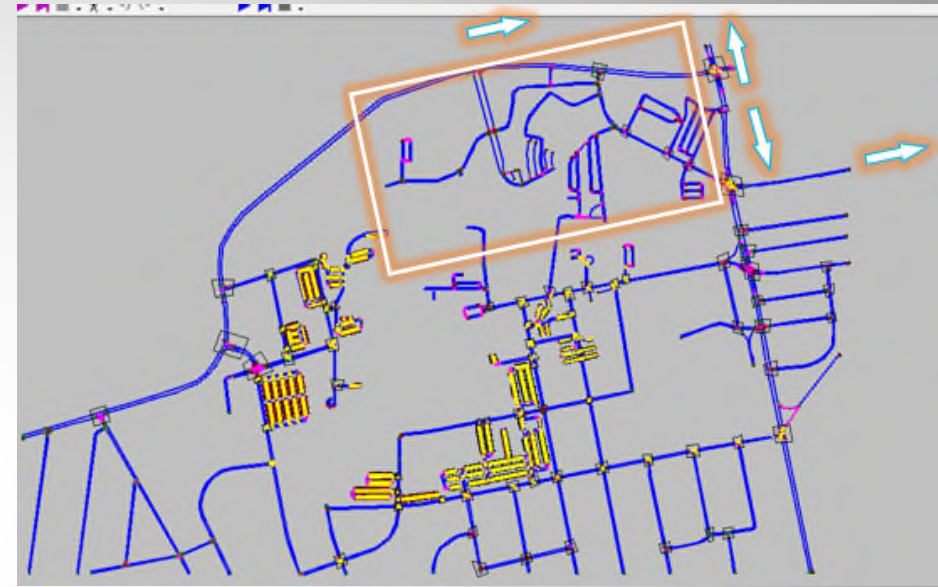
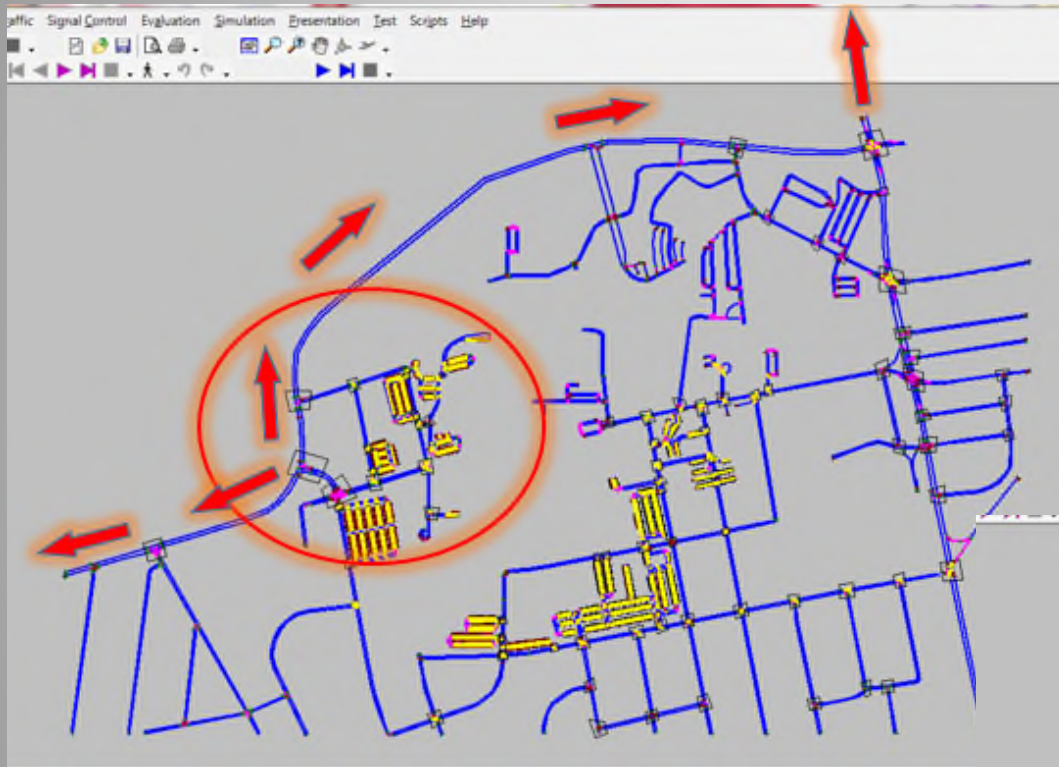
Simulation and Analysis with VISSIM

- **Different Routes for each scenario**
 - Scenario 1: 100% full parking lots – Using only major roads and intersections
 - Scenario 2: 50% full parking lots – Using only major roads and intersections
 - Scenario 3: 50% full parking lots – Using all allowable roads, streets and intersections



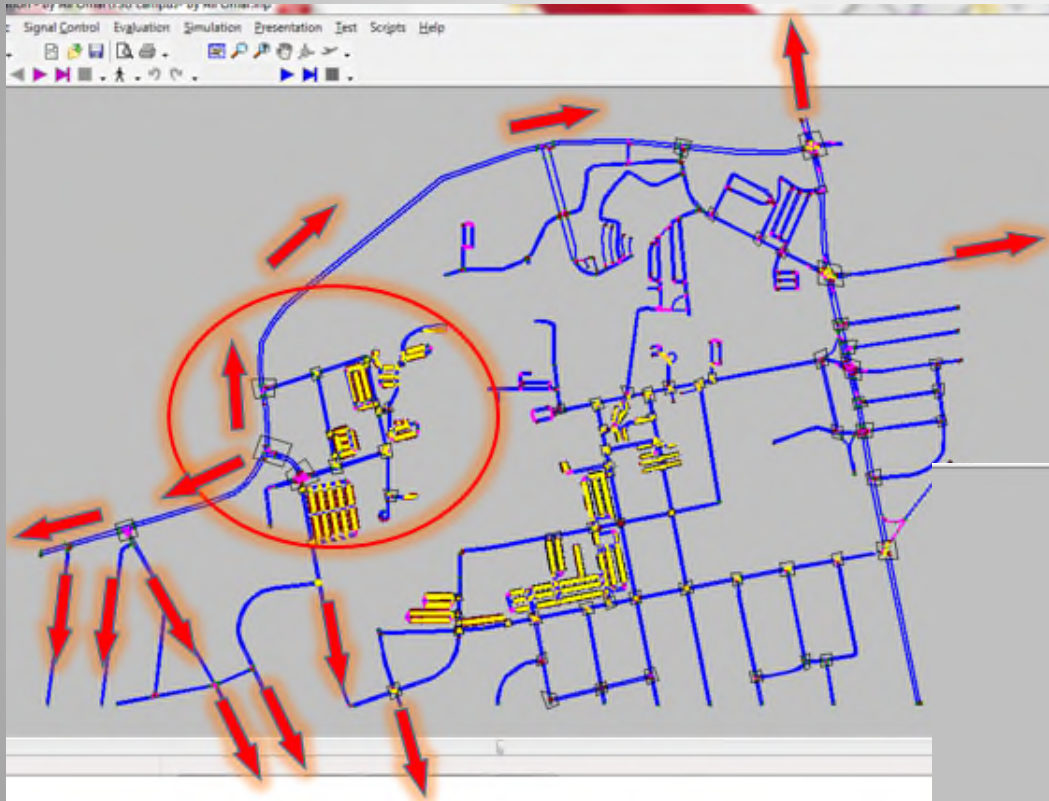
Simulation and Analysis with VISSIM

- Scenario 1: 100% full parking lots – Using only major roads and intersections



Simulation and Analysis with VISSIM

- Scenario 3: 50% full parking lots – Using all allowable roads, streets and intersections





Simulation and Analysis with VISSIM

- Different evacuation timeframes
 - 15 minutes - 900 Second (for events such as campus shooting and terrorist attacks)
 - 30 minutes - 1800 Seconds (for events such as campus shooting and terrorist attacks)
 - 45 minutes - 2700 Seconds (for events such as campus shooting, terrorist attacks and tornadoes)
 - 60 minutes - 3600 Seconds (for events such as campus shooting, terrorist attacks and tornadoes)
 - 80 minutes - 4800 Seconds (for events such as campus shooting, terrorist attacks and tornadoes)



Simulation and Analysis with VISSIM

- Comparing the results

- Scenario 1 -VS- Scenario 2

- Scenario 2 -VS- Scenario 3

- Scenario 1 -VS- Scenario 3

- Comparing the results for the time periods 15 min, 30 min., 45 min, 1 hour, and 1 hour and 20 min.



Simulation and Analysis with VISSIM

- Simulation and Analysis of evacuation with vehicles

■ SIMULATION REPORT

□ Network Performance

- Number of Vehicles Evacuated
- Distance Traveled
- Travel time
- Network delay

□ Delay

- Per intersection
- Per approach
- Per turning movement

□ Level of Service (LOS) (A, B, C, D, E, F)

□ Queue Lengths



Simulation and Analysis with VISSIM

- Simulation and analyze results
 - The simulation results including network and intersection performances were analyzed under different evacuation scenarios in terms of number of vehicles evacuated, distance traveled, delay, speed, number of stops and level of service (LOS)
 - It was found that with the current campus roadway network and intersections, evacuation will be efficient only if the parking lots are 50% utilized but will fail if 100% occupied during the evacuation.

NETWORK PERFORMANCE

TABLE 1 Network Performance Comparisons by Scenario

	Evacuation Time	Vehicles Evacuated	Total				Per Vehicle		
			Travel Time (h)	Distance (mi)	Delay (h)	Avg Speed (mi/h)	Avg Delay (s)	Avg Stops	Avg Stop Delay (s)
Scenario 1 Evacuation with 100% parking lots full and all signalized and unsignalized intersections open	900 (15 min)	2681	461	847	407	1.84	546.63	16	503.32
	1800 (30 min)	3420	815	1853	717	2.27	754.48	23	689.26
	2700 (45 min)	4140	1069	2673	939	2.5	816.3	25	745.75
	3600 (60 min)	4820	1230	3505	1064	2.85	794.99	26	719.97
	4800 (80 min)	5825	1459	4167	1271	2.86	785.45	25	714.89
Scenario 2 Evacuation with 100% parking lots full but only Signalized Intersections Open, Unsignalized closed	900 (15 min)	2671	480	689	431	1.43	580.28	19	532.22
	1800 (30 min)	3401	952	1342	872	1.41	922.67	32	843.9
	2700 (45 min)	4093	1382	1908	1275	1.38	1121.29	40	1024.75
	3600 (60 min)	4734	1763	2413	1634	1.37	1242.73	44	1139.61
	4800 (80 min)	5625	2219	3042	2064	1.37	1321.16	48	1210.49
Scenario 3 Evacuation with 50% parking lots full, only Signalized Intersections Open, Unsignalized closed	900 (15 min)	1704	237	793	190	3.35	401.27	20	344.48
	1800 (30 min)	2385	378	1552	302	4.1	455.27	23	388.64
	2700 (45 min)	3007	483	2255	383	4.67	458.18	22	390.1
	3600 (60 min)	3549	563	2850	443	5.06	437.37	21	372.72
	4800 (80 min)	3790	665	3567	521	5.36	411.1	19	352.13

NETWORK PERFORMANCE

TABLE 1 Network Performance Comparisons by Scenario

	Evacuation Time	Vehicles Evacuated	Total				Per Vehicle		
			Travel Time (h)	Distance (mi)	Delay (h)	Avg Speed (mi/h)	Avg Delay (s)	Avg Stops	Avg Stop Delay (s)
Percentage Decrease (-) or Increase (+) of Scenario 2 over Scenario 1	900 (15 min)	-0.4%	4.3%	-18.7%	5.8%	-22.3%	6.2%	18.8%	5.7%
	1800 (30 min)	-0.6%	16.8%	-27.6%	21.6%	-37.9%	22.3%	39.1%	22.4%
	2700 (45 min)	-1.1%	29.2%	-28.6%	35.8%	-44.8%	37.4%	60.0%	37.4%
	3600 (60 min)	-1.8%	43.3%	-31.1%	53.5%	-51.9%	56.3%	69.2%	58.3%
	4800 (80 min)	-3.4%	52.1%	-27.0%	62.4%	-52.1%	68.2%	92.0%	69.3%
	Average	-1.5%	29.1%	-26.6%	35.8%	-41.8%	38.1%	55.8%	38.6%
Percentage Decrease (-) or Increase (+) of Scenario 3 over Scenario 1	900 (15 min)	-36.4%	-48.6%	-6.4%	-53.3%	82.1%	-26.6%	25.0%	-31.6%
	1800 (30 min)	-30.3%	-53.6%	-16.3%	-57.9%	80.6%	-39.7%	0.0%	-43.6%
	2700 (45 min)	-27.4%	-54.8%	-15.6%	-59.2%	86.8%	-43.9%	-12.0%	-47.7%
	3600 (60 min)	-26.4%	-54.2%	-18.7%	-58.3%	77.5%	-45.0%	-19.2%	-48.2%
	4800 (80 min)	-34.9%	-54.4%	-14.4%	-59.0%	87.4%	-47.7%	-24.0%	-50.7%
	Average	-31.1%	-53.1%	-14.3%	-57.6%	82.9%	-40.6%	-6.0%	-44.4%
Percentage Decrease (-) or Increase (+) of Scenario 2 over Scenario 3	900 (15 min)	-36.2%	-50.7%	15.0%	-55.9%	134.3%	-30.8%	5.3%	-35.3%
	1800 (30 min)	-29.9%	-60.3%	15.6%	-65.4%	190.8%	-50.7%	-28.1%	-53.9%
	2700 (45 min)	-26.5%	-65.0%	18.2%	-70.0%	238.4%	-59.1%	-45.0%	-61.9%
	3600 (60 min)	-25.0%	-68.0%	18.1%	-72.9%	269.3%	-64.8%	-52.3%	-67.3%
	4800 (80 min)	-32.6%	-70.0%	17.3%	-74.7%	291.2%	-68.9%	-60.4%	-70.9%
	Average	-30.1%	-62.8%	16.8%	-67.8%	224.8%	-54.9%	-36.1%	-57.9%

Simulation Result Analysis

- The best evacuation scenario however evacuated all of targeted vehicles but only after 80 minutes of evacuation time.
- Most of the signalized intersections performed at undesired level of service with evacuation targeted at 15 minutes or 30 minutes but improved to LOS D or better for evacuation targeted at 60 minutes to 80 minutes.

SIGNALIZED INTERSECTION PERFORMANCE



TABLE 2 Intersection Delays and Level of Service by Scenario

	Evacuation Time	Simulation Scenario 1		Simulation Scenario 2		Simulation Scenario 3	
		Delay	LOS	Delay	LOS	Delay	LOS
Ed Temple and John Merritt Blvd	900 (15 min)	35	C	42	D	25	C
	1800 (30 min)	31	C	37	D	20	B
	2700 (45 min)	22	C	31	C	16.7	B
	3600 (60 min)	18.4	B	28	C	13	B
	4800 (80 min)	15.4	B	24	C	9.5	A
Schrader Ln and Ed Temple Blvd.	900 (15 min)	80	E	99.7	F	65.7	E
	1800 (30 min)	76.2	E	93	F	62.8	E
	2700 (45 min)	74.3	E	89.4	F	60	E
	3600 (60 min)	72.4	E	83.9	F	58.6	E
	4800 (80 min)	69	E	77.2	E	55	D
Walter S. Davis and Ed Temple	900 (15 min)	64.8	E	106	F	57.8	E
	1800 (30 min)	62.3	E	99	F	52.8	D
	2700 (45 min)	58.8	E	90	F	47.1	D
	3600 (60 min)	57.1	E	80	E	43.5	D
	4800 (80 min)	49	D	72	E	38.3	D
Walter S. Davis and 39 Ave N	900 (15 min)	57.5	E	65.7	E	50.7	D
	1800 (30 min)	52.8	D	62	E	45.4	D
	2700 (45 min)	49	D	59.4	E	39.1	D
	3600 (60 min)	45.1	D	58.1	E	35	C
	4800 (80 min)	44.2	D	54.5	D	31.3	C
Albion St and 28th Ave.	900 (15 min)	84.8	F	106	F	72.6	E
	1800 (30 min)	74.6	E	95.7	F	65.3	E
	2700 (45 min)	70.2	E	91.8	F	54.8	D
	3600 (60 min)	66.4	E	85.1	F	49.3	D
	4800 (80 min)	55	D	77.2	E	44.2	D



VISSIM SIMULATION CONCLUSION

- Efficient evacuation can only be achieved when the parking lots are 50%.
- Evacuating for shorter length of time, e.g., for 15 minutes will only evacuate 2681 as the best-case scenario for the campus estimated 7580 parking spaces.
- For 80 minutes evacuation, the maximum number of vehicles that can be evacuated is 5825 only.
- Evacuation has to proceed beyond 80 minutes based on the current available transportation infrastructure for whole population (number of parking lots :7580).
- Complete evacuation within very short period of time, complete evacuation cannot be achieved.

POSSIBLE IMPROVEMENTS

- Open some of the connections currently closed which prevent direct access of traffic from one parking lot to use certain intersection within the campus.
- If during the evacuation the drivers will have a well-connected links enabling them to access different intersections from the campus, then traffic will be well distributed which eventually will lead to improved evacuation measures of effectiveness.



Fast Local Emergency Evacuation Times



FLEET

OPEN FLEET



Goal

- To determine the successor failure of an evacuation based off the current road network.
- The most successful evacuation can be analyzed and the parameters that determined its success can be analyzed.
- Parameters of Fleet Software include:
 - Location Selection
 - Population Selection
 - Road Type
 - Evacuation Times

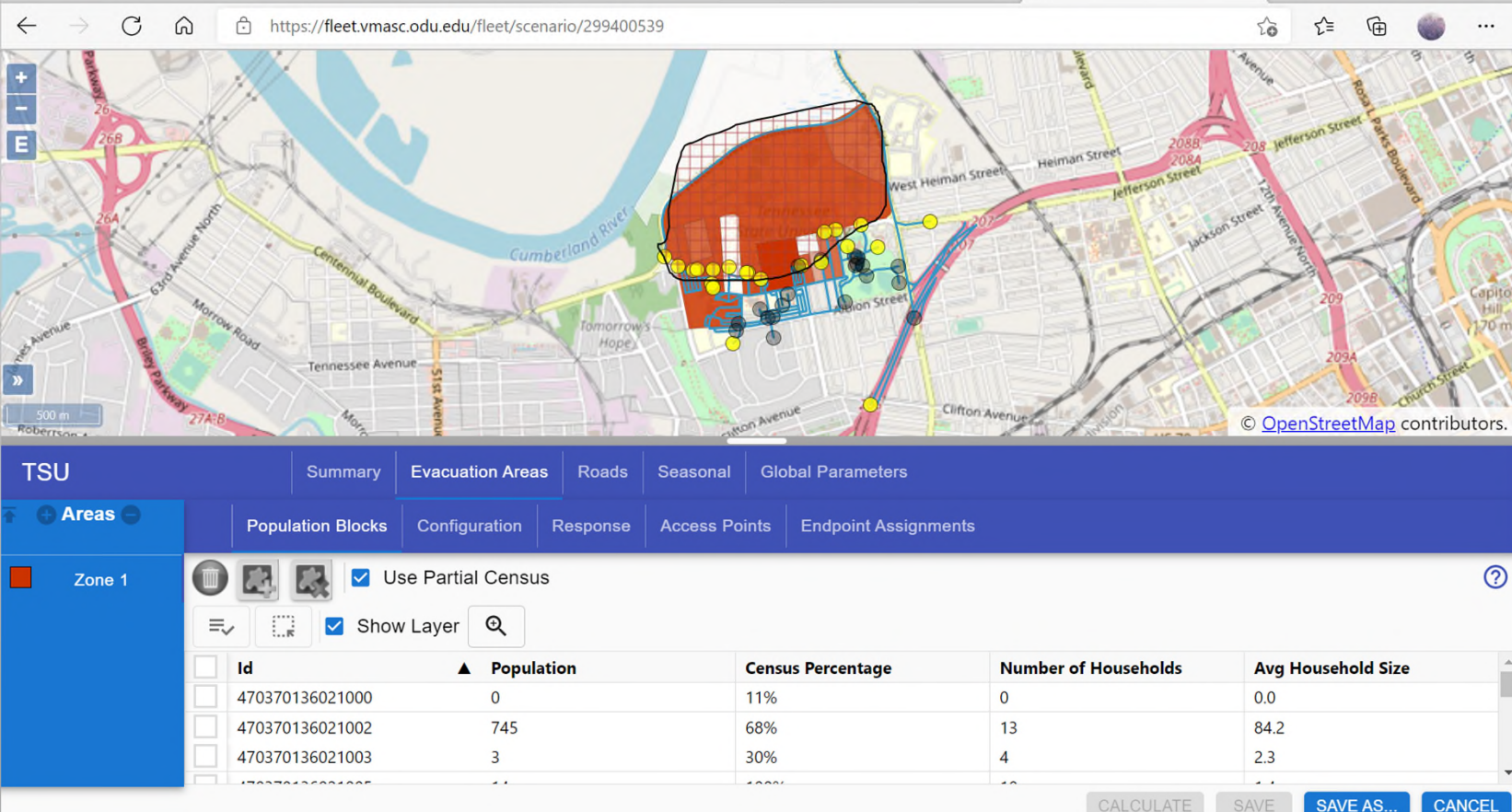


Simulation Conditions

- The software is built with conditions and allows the use to manipulate and combine various traffic conditions to create a model.
- The included conditions are:
 - Roadway network: arterial, major highway, major roads
 - Location of a particular area and the census information provided for that area
 - Population adjustment
 - Adjustable Vehicle Composition
 - Population Concentration based on census data

How to Simulation Software Works

Select and Evacuation Area: Red Area

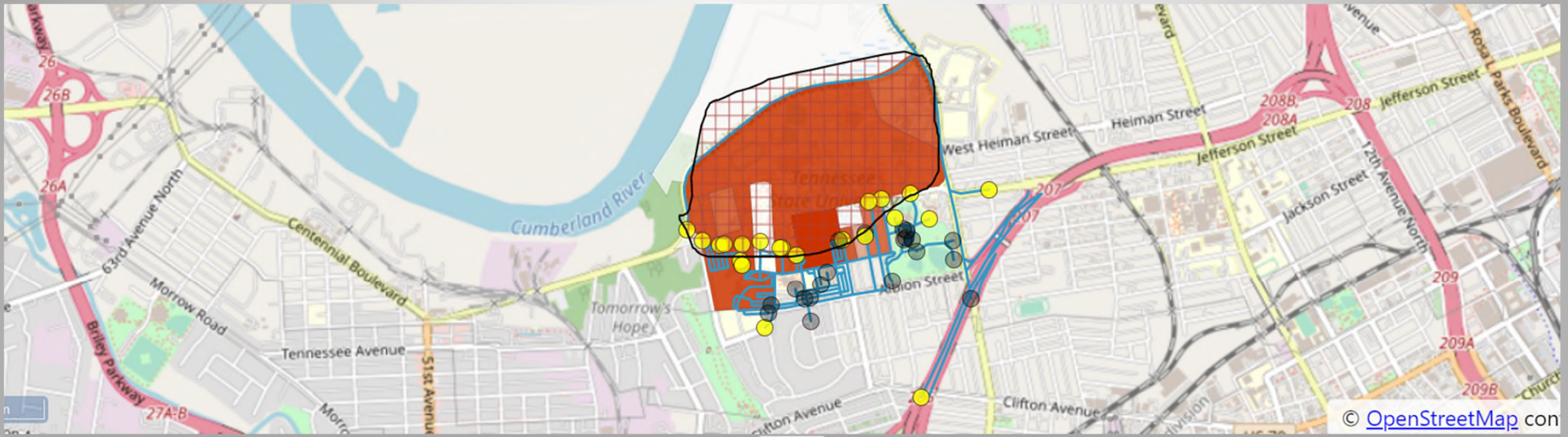


The screenshot shows a web browser window displaying a simulation software interface. The browser address bar shows the URL: <https://fleet.vmasc.edu/fleet/scenario/299400539>. The map displays a city area with the Cumberland River and various streets. A red shaded area, representing an evacuation zone, is highlighted on the map. Below the map, the software interface includes a navigation menu with tabs for 'Summary', 'Evacuation Areas', 'Roads', 'Seasonal', and 'Global Parameters'. The 'Evacuation Areas' tab is active, showing a list of 'Population Blocks' for 'Zone 1'. The interface also includes a search bar, a 'Show Layer' checkbox, and a table of data for the selected zone.

Id	Population	Census Percentage	Number of Households	Avg Household Size
470370136021000	0	11%	0	0.0
470370136021002	745	68%	13	84.2
470370136021003	3	30%	4	2.3
470370136021005	11	100%	10	1.1

At the bottom of the interface, there are buttons for 'CALCULATE', 'SAVE', 'SAVE AS...', and 'CANCEL'.

Choose evacuation end points:
Yellow dotted areas are the end points.



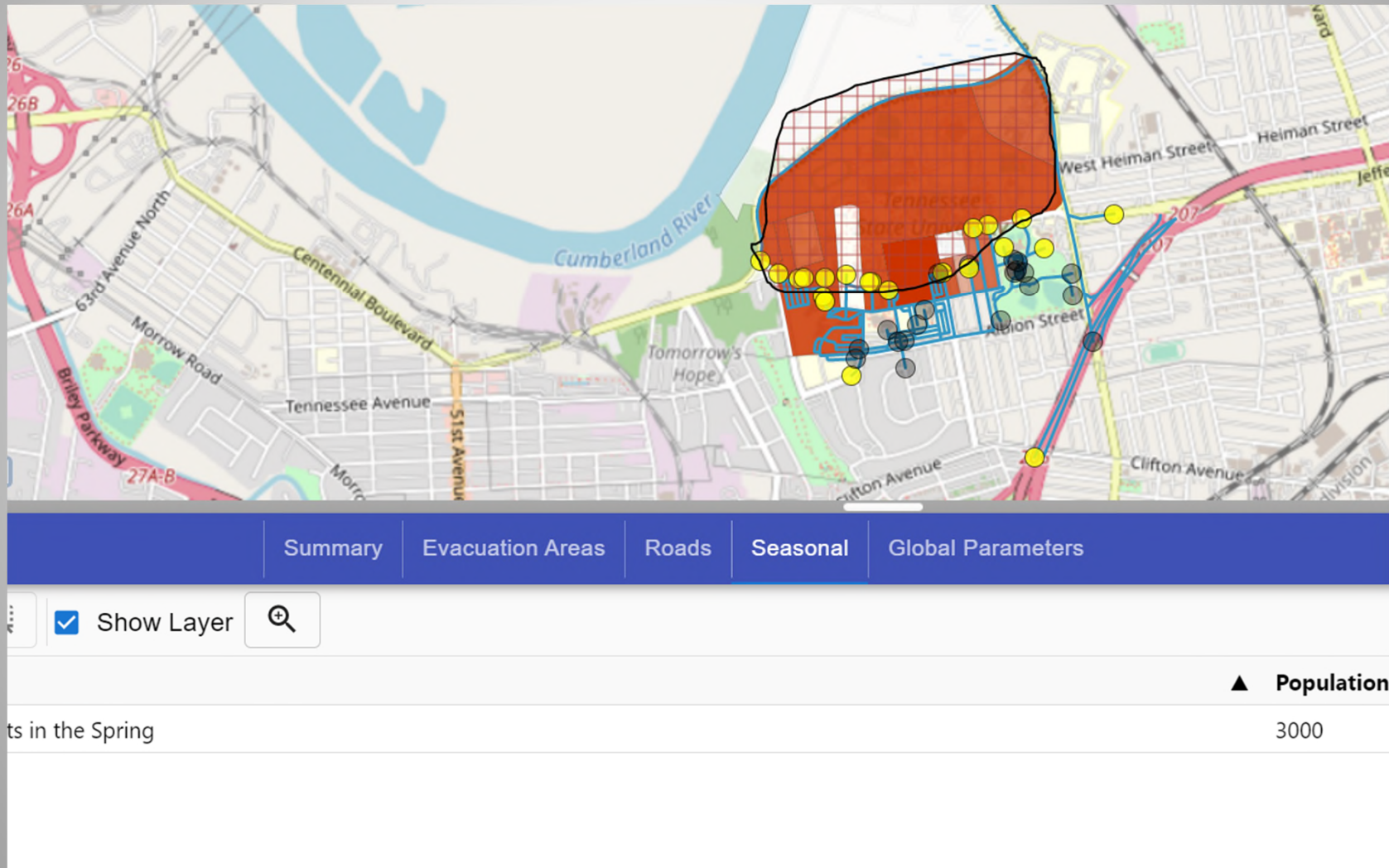
Summary | Evacuation Areas | **Roads** | Seasonal | Global Parameters

Selected Roads | **Evacuation End Points** | Modified Roads | Additional Roads

Show Layer Show Unselected End Points

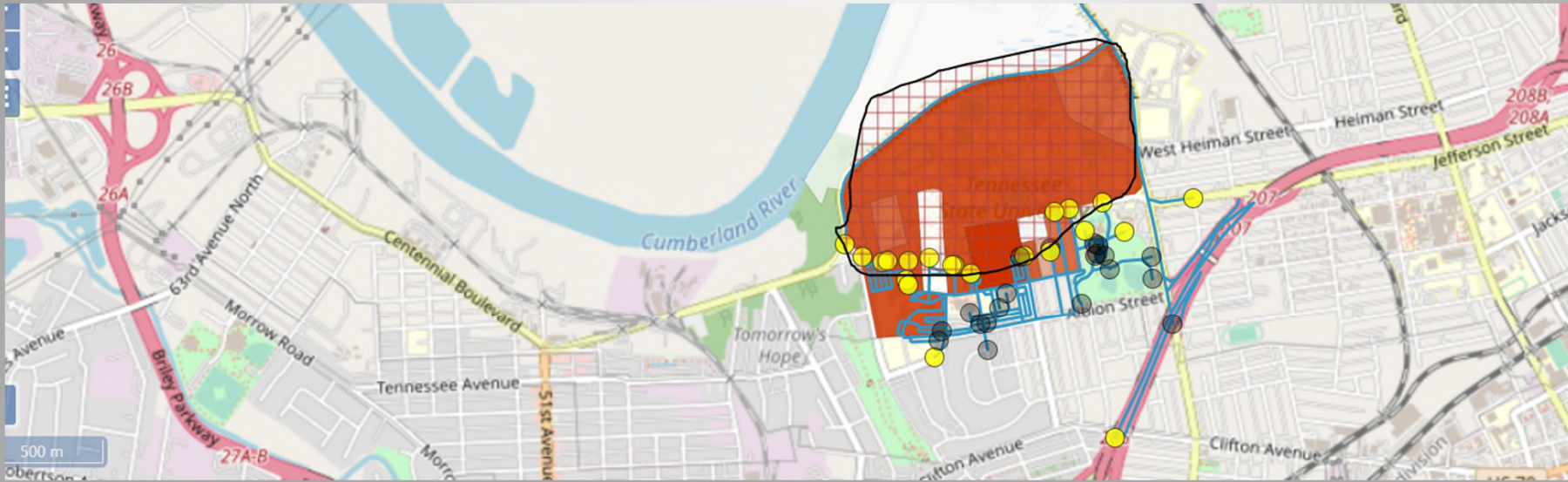
Name	Active	Weight
JEFFERSON ST	<input checked="" type="checkbox"/>	100
10	<input checked="" type="checkbox"/>	100
TEMPLE BLVD	<input checked="" type="checkbox"/>	100
WALTER G. DAVIS BLVD	<input checked="" type="checkbox"/>	100

Enter Seasonal Populations



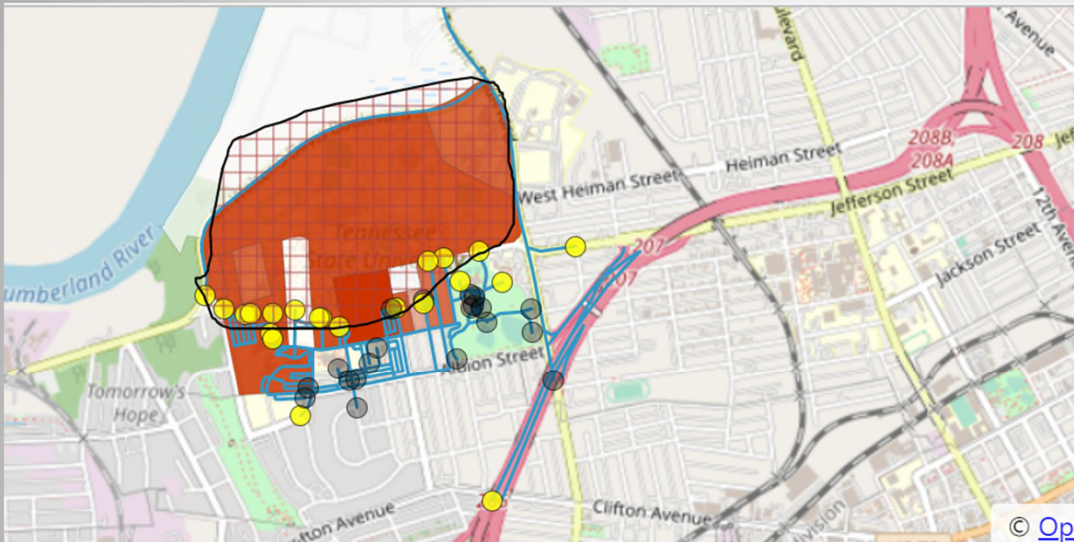
Adjust Configurations:

- Population
- Road Types
- Traffic Flow



TSU		Summary	Evacuation Areas	Roads	Seasonal	Global Parameters
+ Areas -		Population Blocks	Configuration	Response	Access Points	Endpoint Assignments
Zone 1	Label:	Zone 1			Color:	
	Population Change (%):	0			Total Population:	
	People Per Vehicle:	2.5			Total Vehicles:	
	Vehicle Towing (%):	0			Total Vehicles Towing:	
	% of Population Evacuating:	100			Total Population Evacuating:	
	% Using Private Vehicles:	70			Population Using Private Vehicles:	

Run the evacuation and look at the results:



Summary	Roads	Evacuation End Points	Intersections	Population Blocks	Graph
<u>Current Hour</u>			<u>Evacuation Summary</u>		
Hour:	0:00		Total Hours:	8:10	
Total Vehicles Evacuated:	0		Total Vehicles:	2,902	
Total Population Evacuated:	0		Total Population:	7,254	
Remaining Vehicles:	2,902		Seasonal Vehicles:	2,585	
Remaining Population:	7,254		Seasonal Population:	6,464	
Percent Evacuated:	0%				
<u>Simulation Parameters</u>					
Background Traffic: Low, Seasonal Population: Used					

Comparison to VISSIM

VISSIM evaluates the what is created in the system and evaluates the behaviors specific to the scenario created.

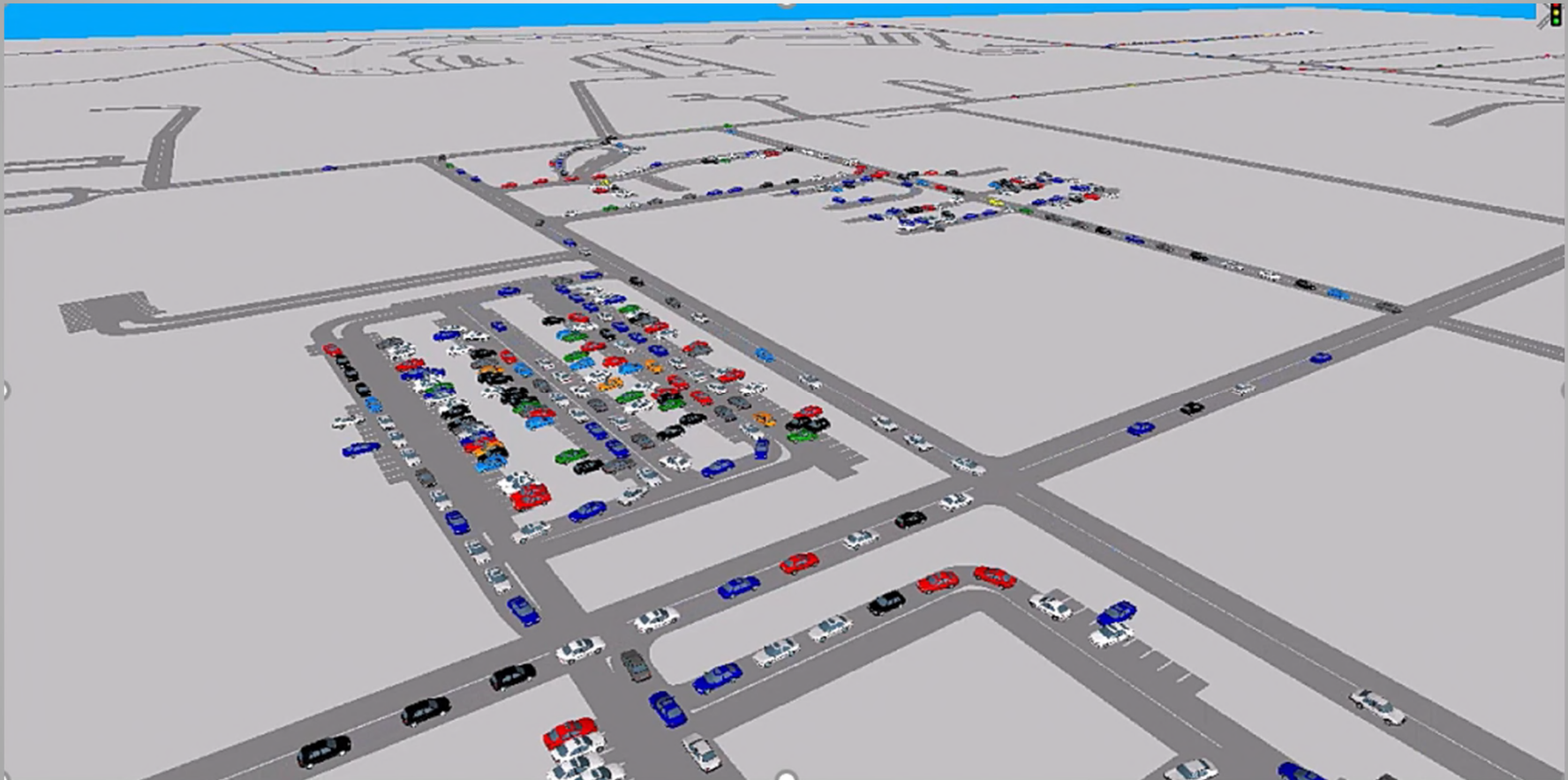
FLEET: has national population, and traffic averages within the program. The only modifications need to be made are traffic related behaviors specific to a certain area.

Both systems model evacuation times.

FUTURE STUDY

- Transit and pedestrian evacuation on top of automobiles from the parking lots.
- It is expected that the evacuation logistics will be complex but eventually network and the intersections will perform much better as number of vehicles to be evacuated will be less because some people will opt to use transit or run instead of driving.
- Working on the FLEET evacuation times and better understanding the program created by Old Dominion.

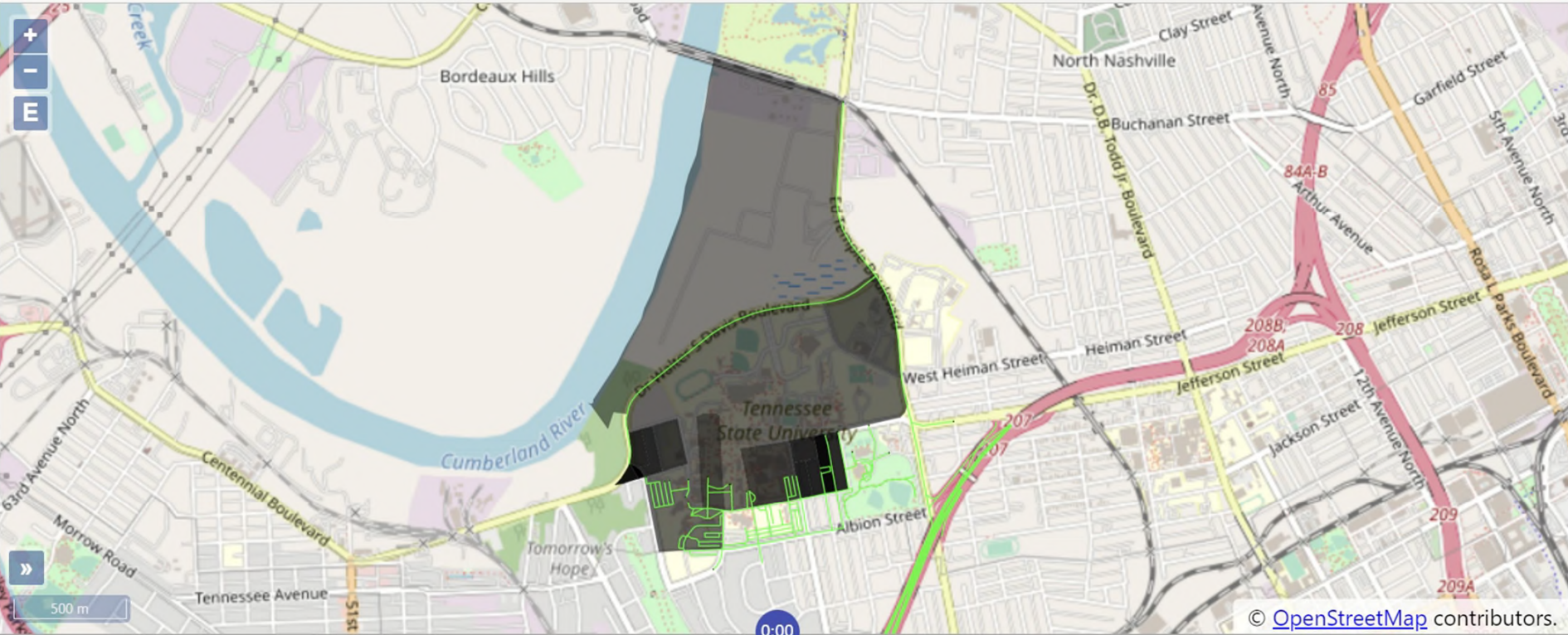
Video Simulation: VISSIM



Video Simulation: FLEET

Simulation Results - FLEET

https://fleet.vmasc.odu.edu/fleet/scenario/301617578/run/301618196



© OpenStreetMap contributors.

Speed Density Throughput

Animate 0:00

Hour

Summary Roads Evacuation End Points Intersections Population Blocks Graph

Total Vehicles Evacuated: 0

EDIT SCENARIO VIEW SCENARIO CLOSE



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Thank you!