An approach to study the interaction between evacuation and land use & transportation structures

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Disasters or Shocks

Tasmania flooding: 6 Jun 2016[1]

Equador Earthquake 16 April 2016[3]

Paris attacks: 14 Nov 2015[5]

Indian Ocean Tsunami in 2004[2]

Hurricane Katrina 2005[4]

American Airline 587: 12 NOV 2001[6]

1 : ABC NET News; 2: Daily news; 3: New York Post; 4: Black Post ; 5: Mirror UK; 6: Fox News

Urban Resilience

"Urban Resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to **survive**, adapt, and grow no matter what kinds of chronic stresses and **acute shocks** they experience." - Rockefeller Foundation

from www.100resilientcities.org

Transit Oriented Developments

- The neighborhood is designed for non-motorized transportation modes (cycling and walking), with adequate facilities and **attractive street conditions**.
- Streets have **good connectivity** and **traffic calming** features to check traffic speed.
- Within each neighborhood, there is a **mixed-use development** that includes shops, schools and other public services.
- Parking management is aimed to **reduce** the amount of **land** devoted to the **parking**, and take advantage of the parking cost savings associated with reduced automobile use.
- **Transit stops and stations** that are convenient, comfortable and secure, with features such as comfortable waiting areas, refreshments, and magazine shops, washrooms, etc.

Hypothesis

"Transit oriented developments if faced with a shock, perform better than car dependent city structure."

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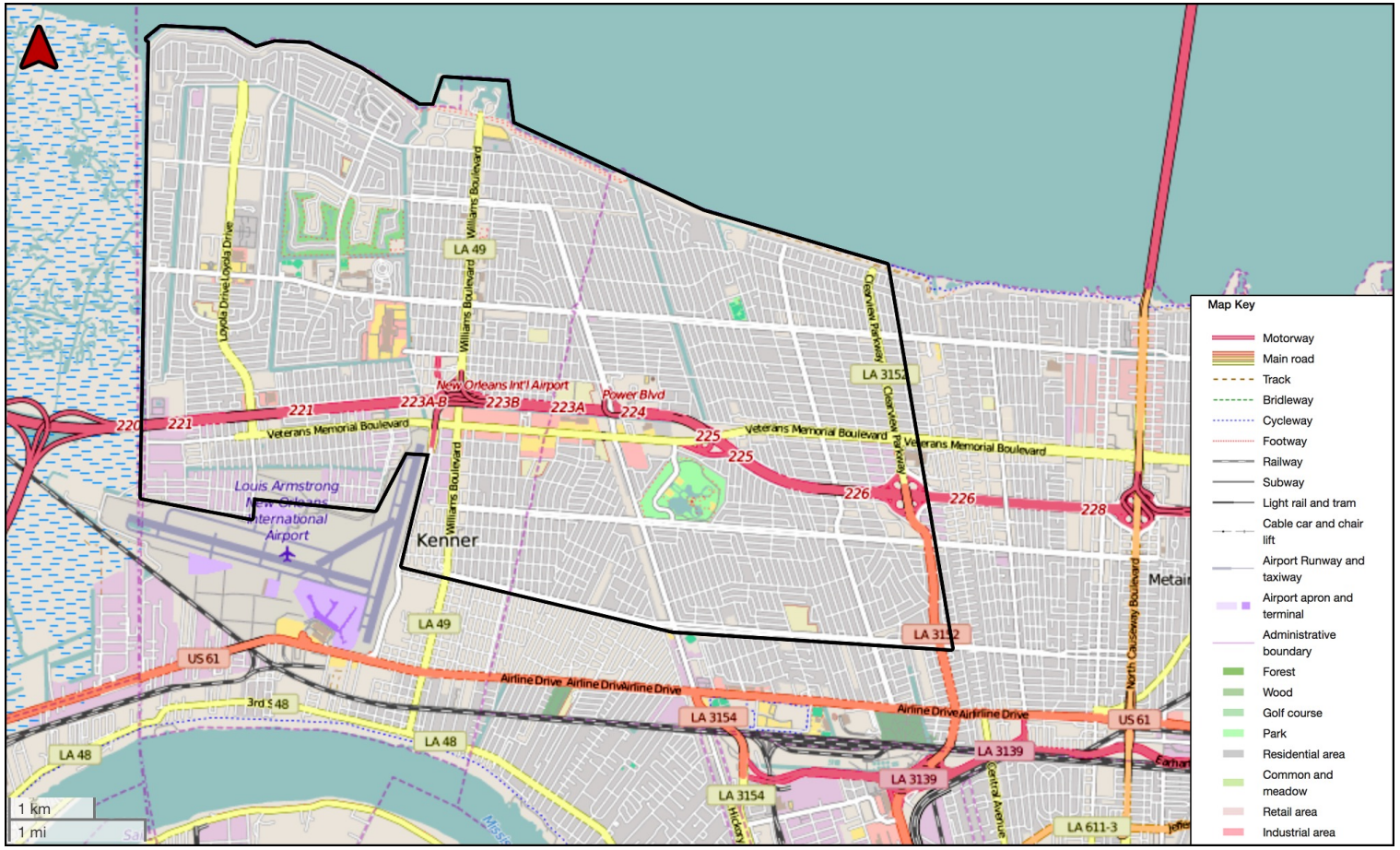
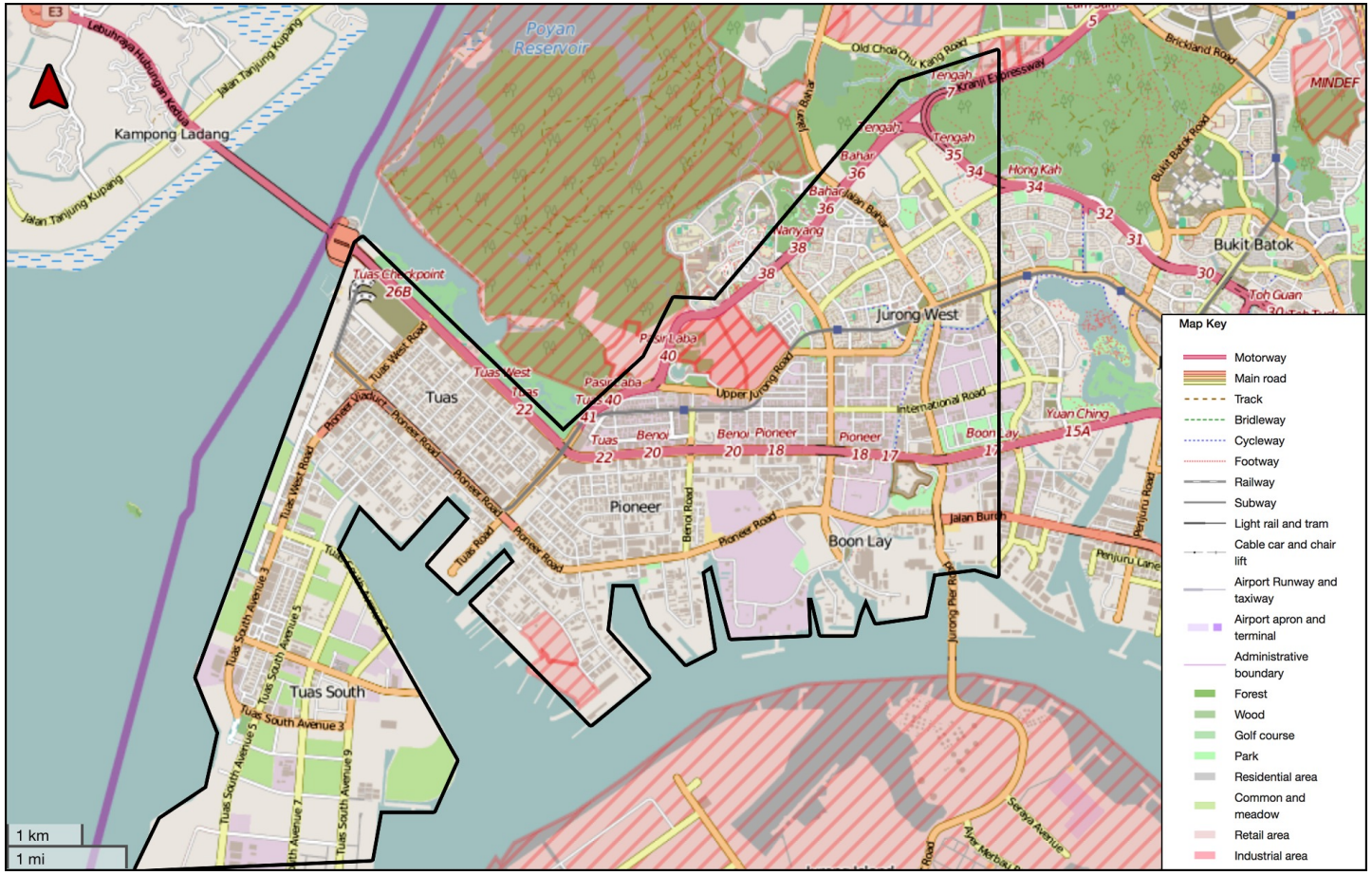
Study area – Louisiana



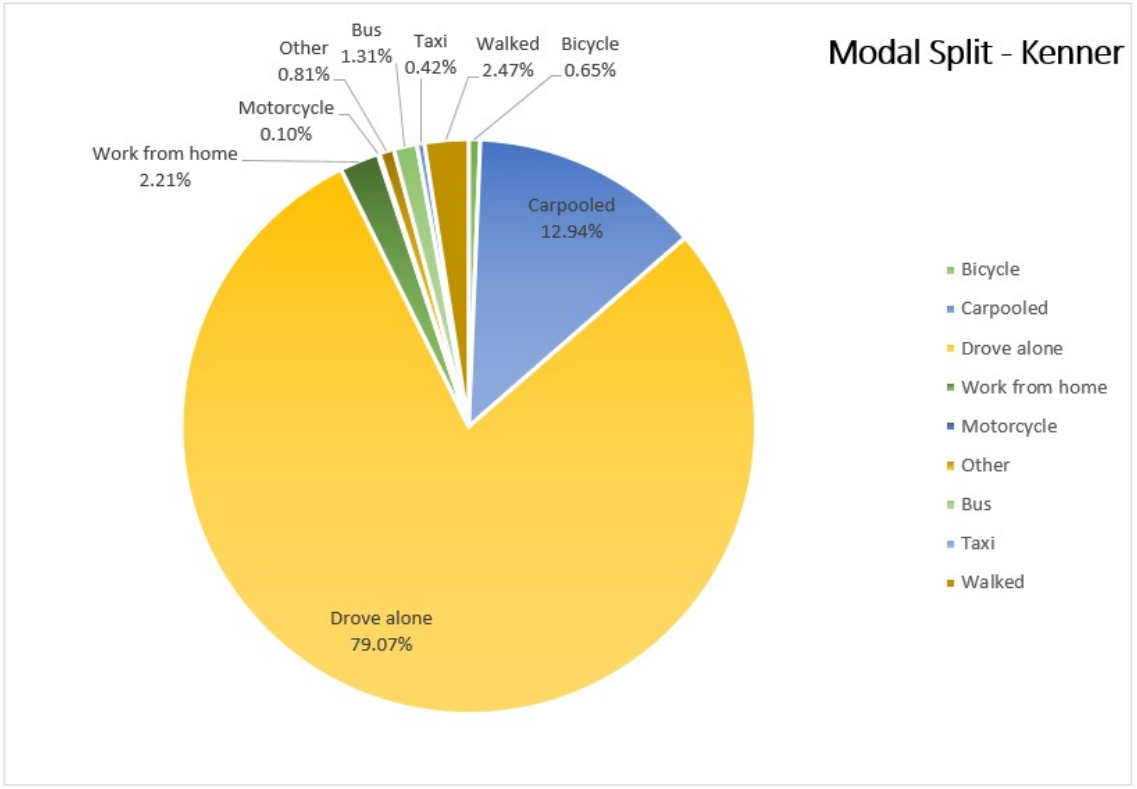
Source: Openstreetmap, 2016

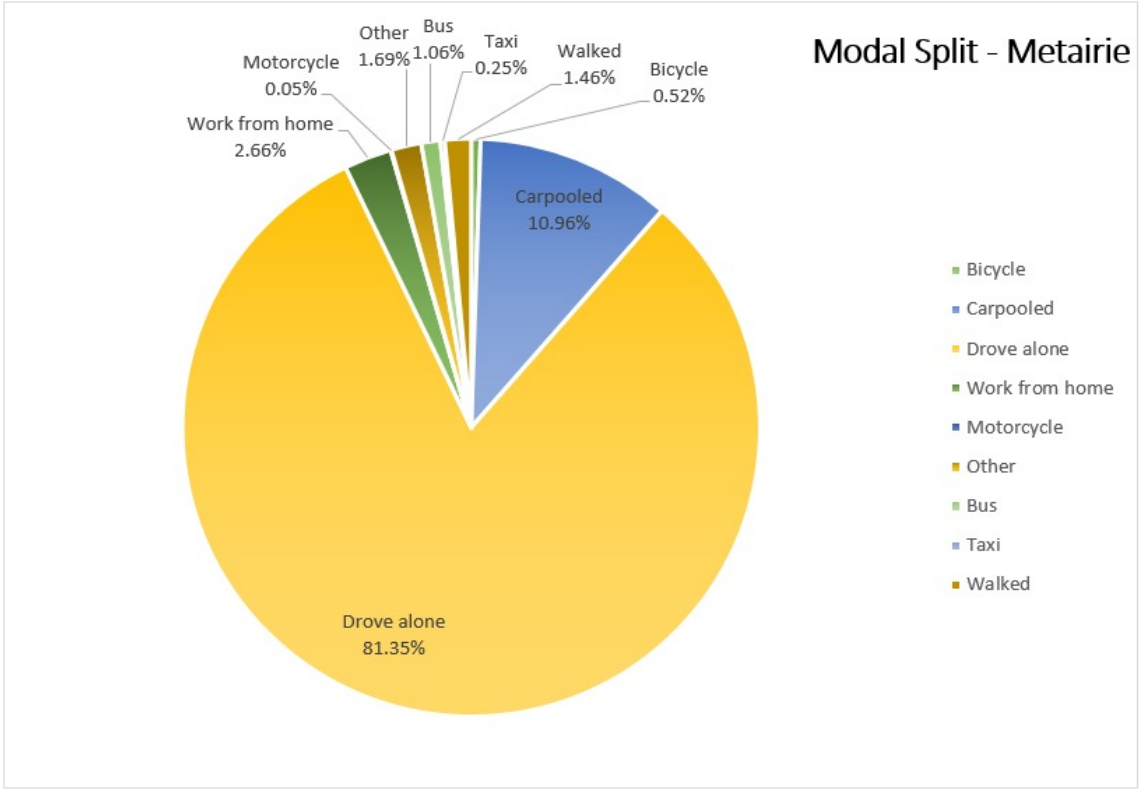
Study Area – Singapore



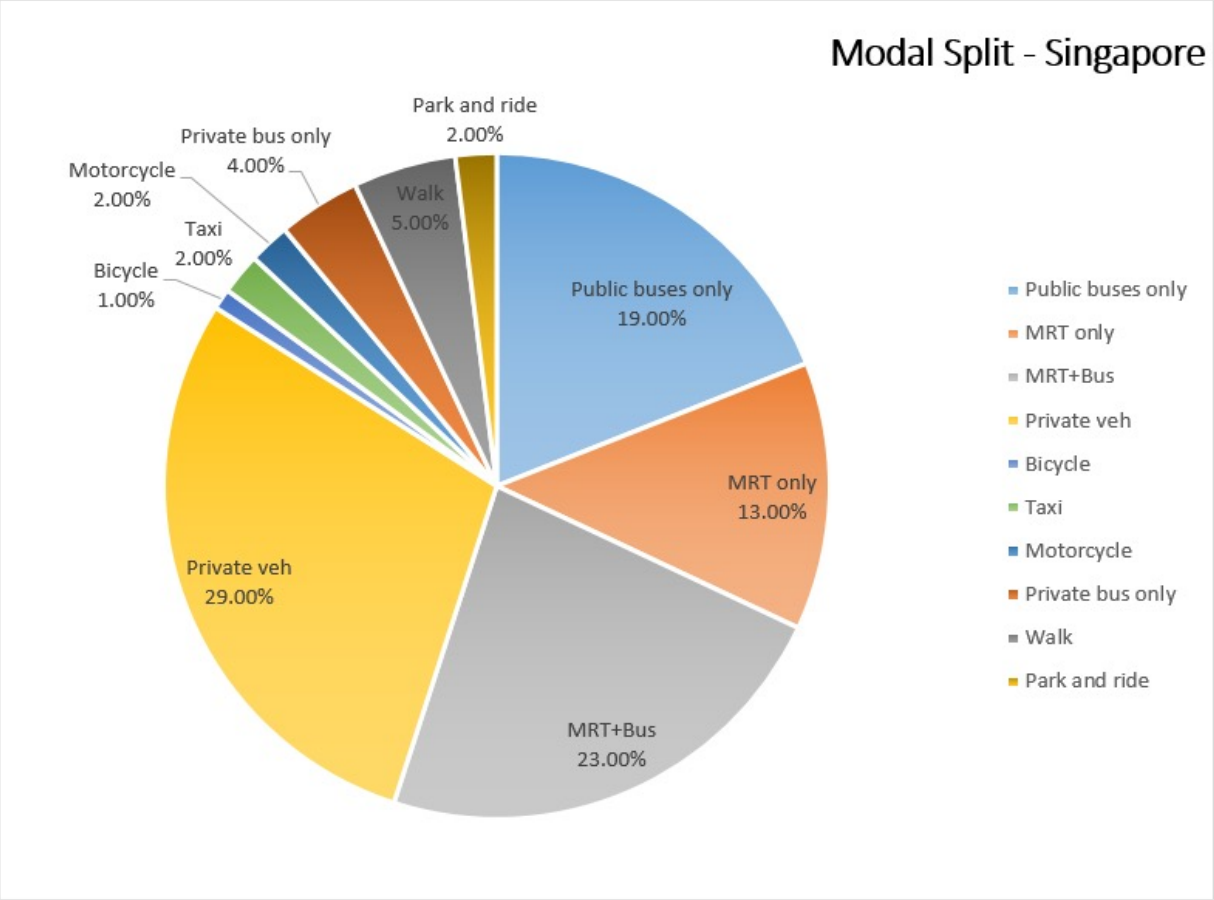
Source: Openstreetmap, 2016

Modal Share – Louisiana

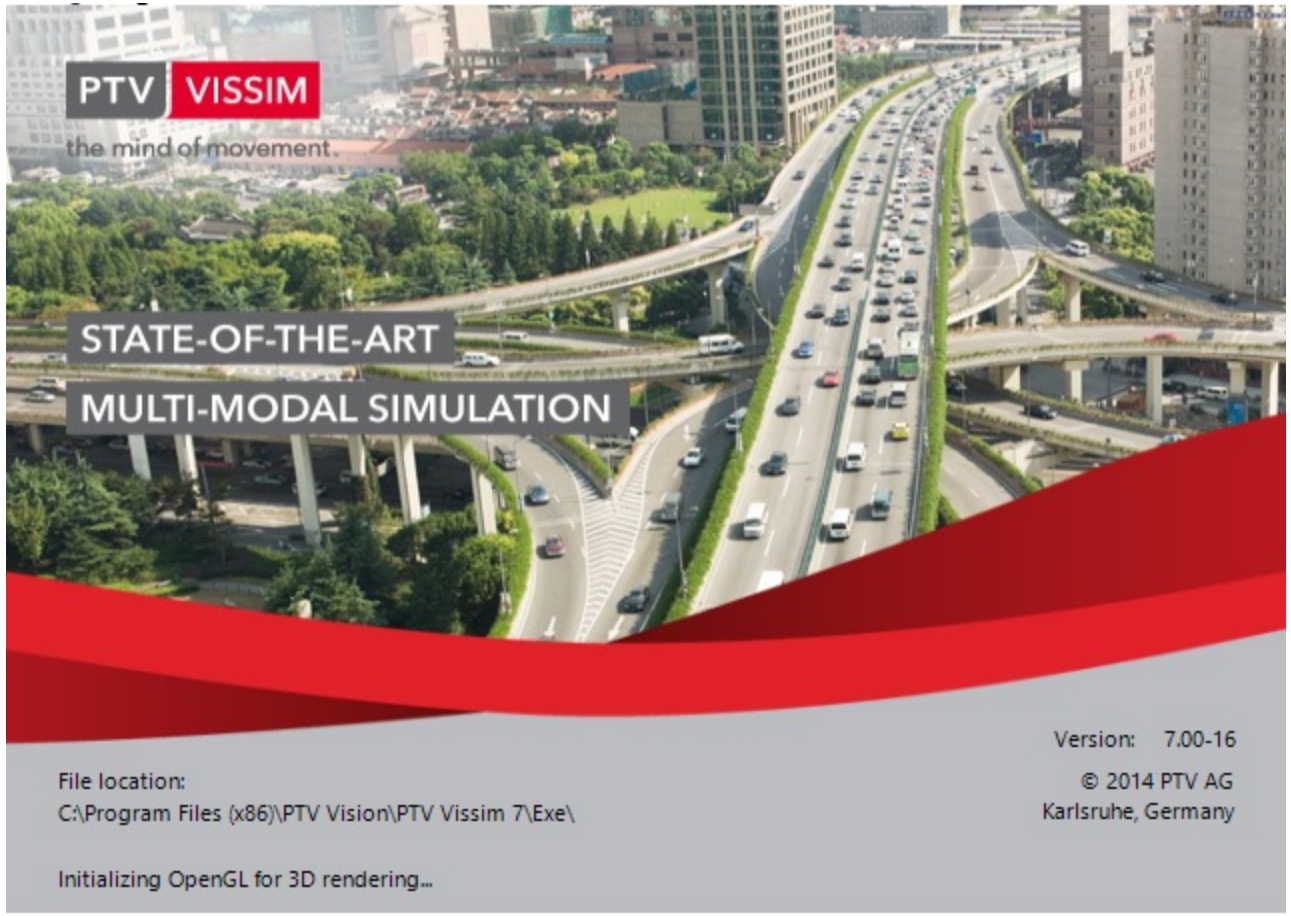




Modal Share – Singapore

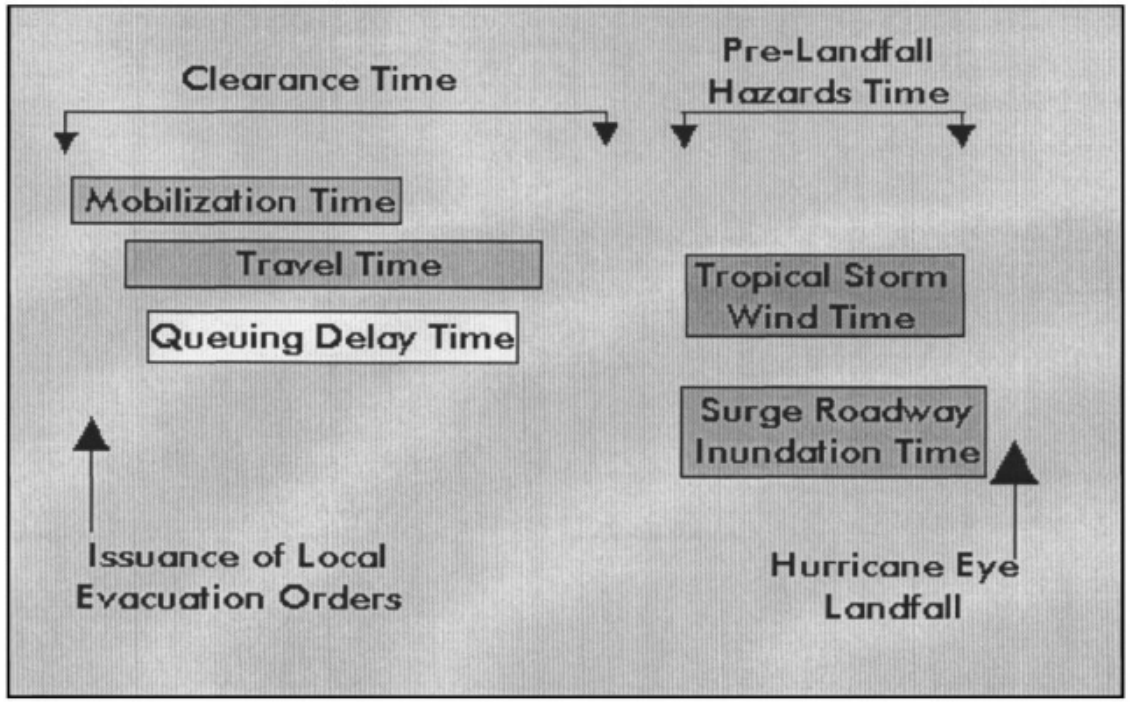


Software Used



Defined Shock – Hurricane

- Hurricane Information System
- Evacuation Areas
- Evacuation Time
- Voluntary Evacuation
- Recommended Evacuation
- **Mandatory** Evacuation.



Limitations and Assumptions

- Network Size : max. 10 km in length
- Signal Controllers : max. 10
- Bus trip definition is not possible
- Same transport infrastructure and supply*.
- All vehicles from different zones started at the same time[1].
- Shortest path to the highway.
- At intersections, 5% of cars do not follow the direct evacuation path.
- At intersections, all buses follow the direct evacuation path.
- Warm-up time of 600 seconds.
- Simulation runs with random seed values**.
- Evacuation by buses and cars only.

1: (Lindell, Lu, and Prater 2005); * : all major roads connecting to highways are model exactly as in real world.; **:Scenario 1 and 3- at least 3 (3-4 hours) , Scenario 2- at least 2 (more than nine hours)

Case Studies

- Hurricane Floyd - Florida
  - High coastal development
  - Brenda Gonnella : returned home after 9 hours
  - Isolated evacuation, communication system failed, unpredicted evacuation
  - Shadow evacuation
  - 25% of total households took more than one vehicle; 31% of three or four person household took two or more cars;
  - 21% of two person household took two cars

Hurricane Katrina and Rita

- 200,000 to 300,000 persons had no vehicle
- Only 500 transit buses, drivers not available
- Poor conditions at shelters*.
- 10 to 20 miles in 9 hours
- Unplanned lane reversal orders
- No refueling vehicle, emergency vehicles from other regions, ambulances

*: led to longer evacuation distance than required

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Scenario Definition

Scenario	1	2	3
Percentage evacuation	61%[1]	100%	100%
Vehicle Input Time	9 hours	12 hours	12 hours
	25.4% (9 am to 12pm) 22.6% (12pm to 3pm)	Same proportions	Same proportions
Evacuating Population – Louisiana	68,008	111489	111489
Evacuating Population – Singapore	109,226	179059	
			Modal Share of Louisiana = Singapore

1: Hurricane Floyd (Dow and Cutter 2002)

VISSIM Results

- Data collection: to count cars and buses traveling to the desired destination, and to know when the last vehicle left the network
- Queue length: to see how long is the queue due to congestion
- Vehicle travel time: to measure the average travel time of the vehicles
- Network performance parameters: average delay time and average speed of the vehicles were collected to analyze the performance of the network.

Vissim Model – Louisiana

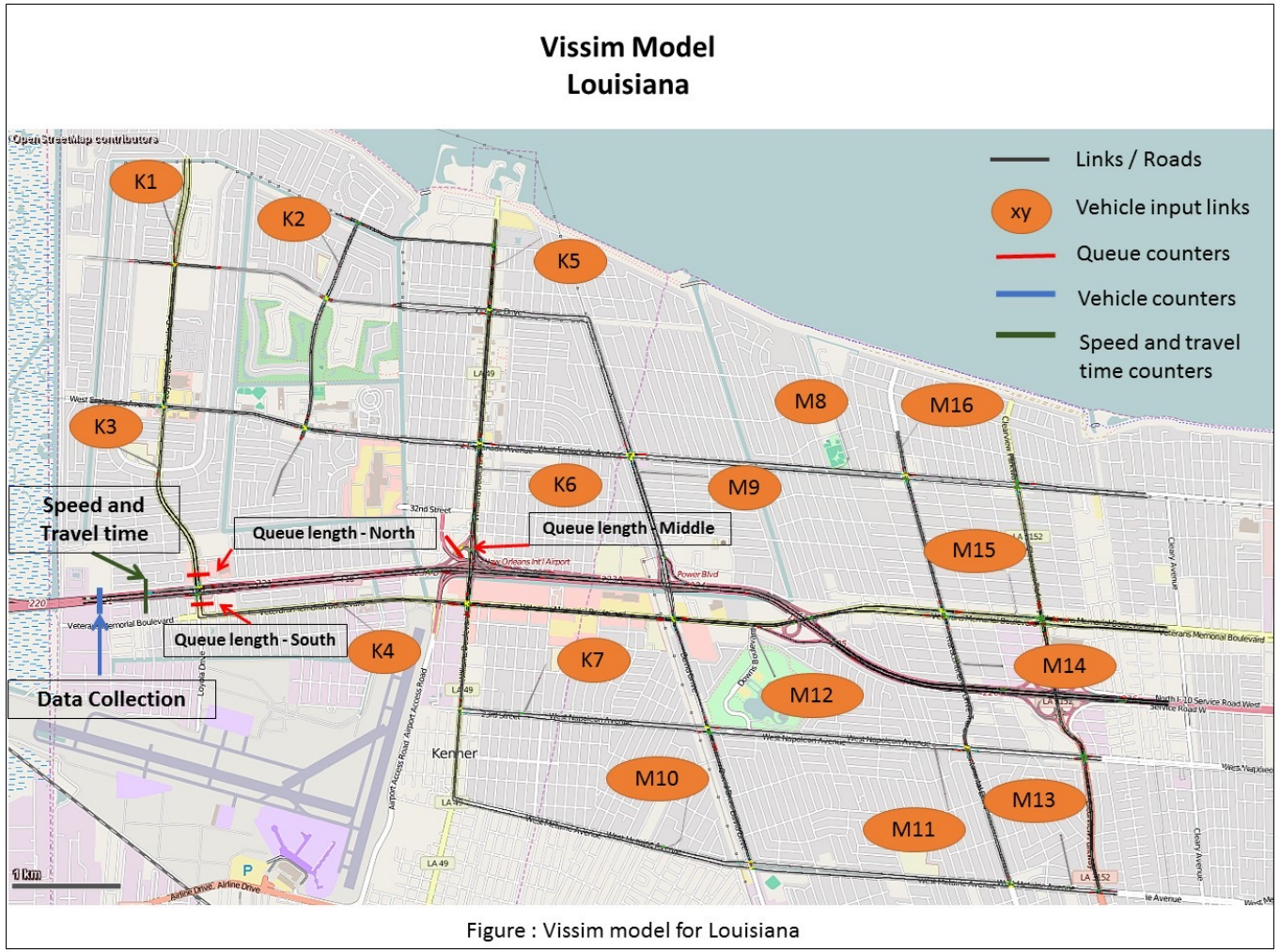


Figure : Vissim model for Louisiana

Vissim Model – Singapore

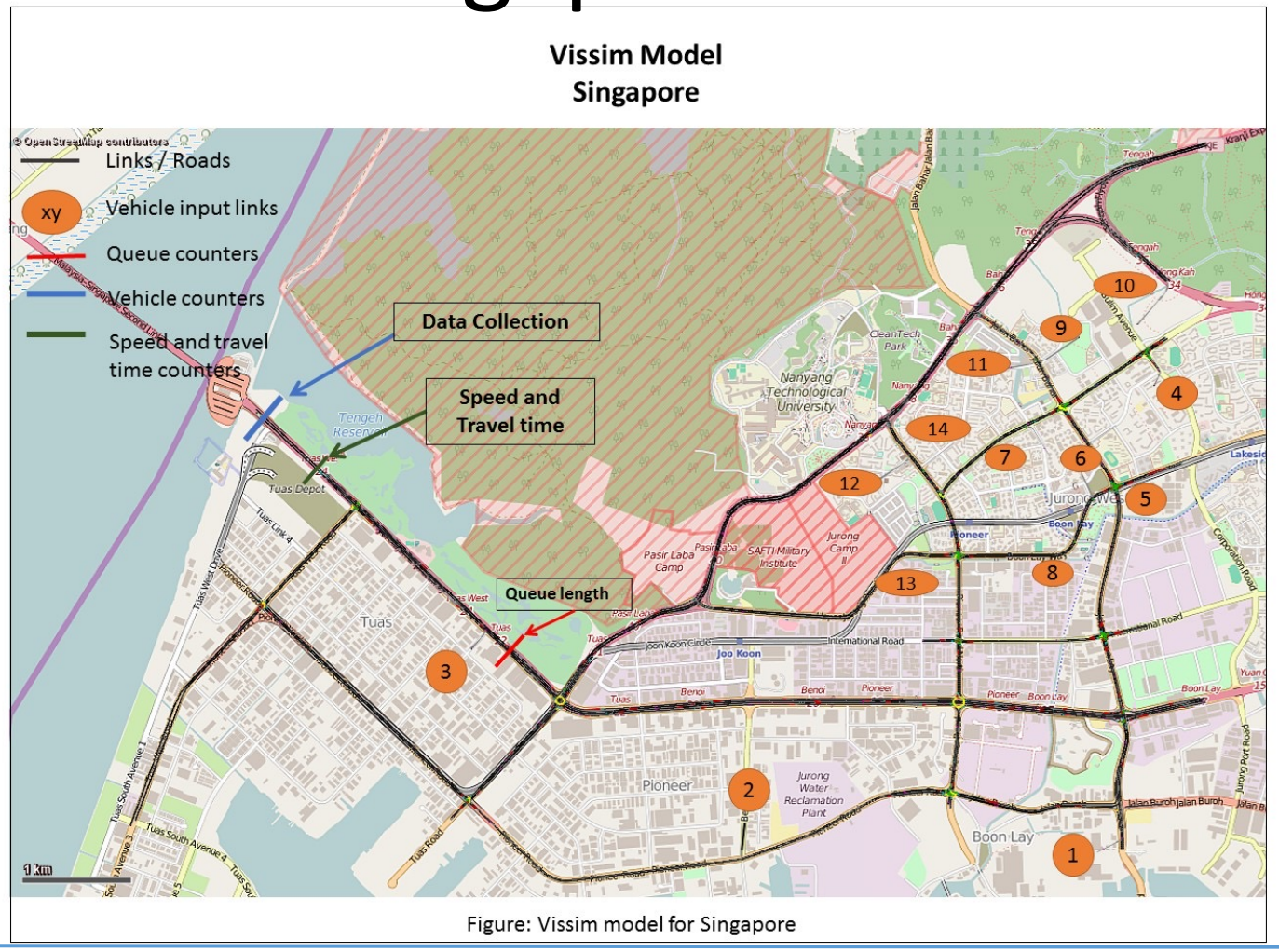
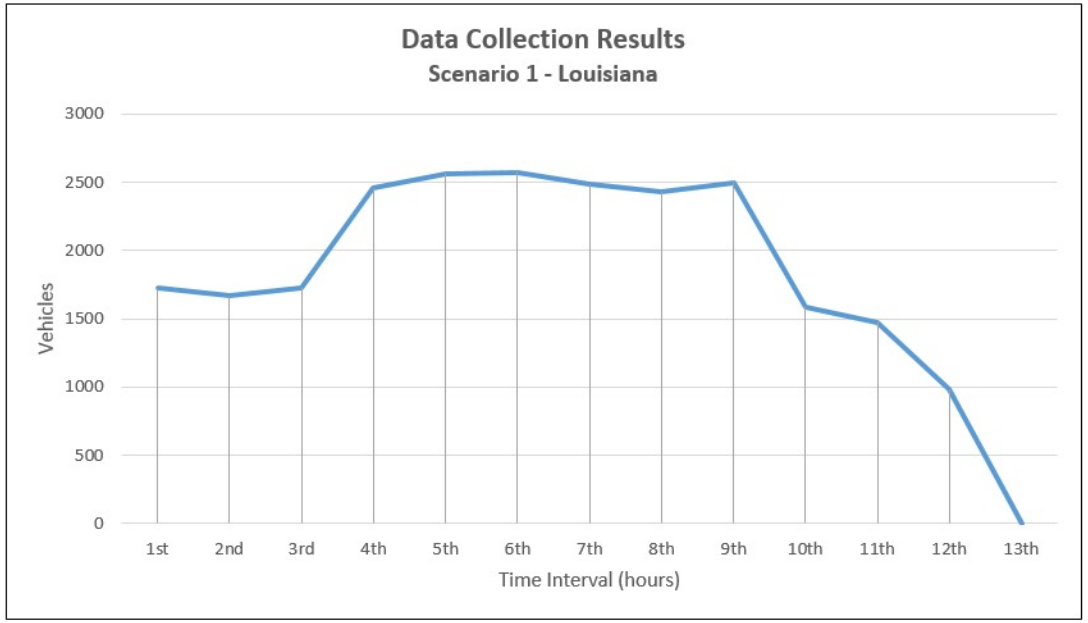
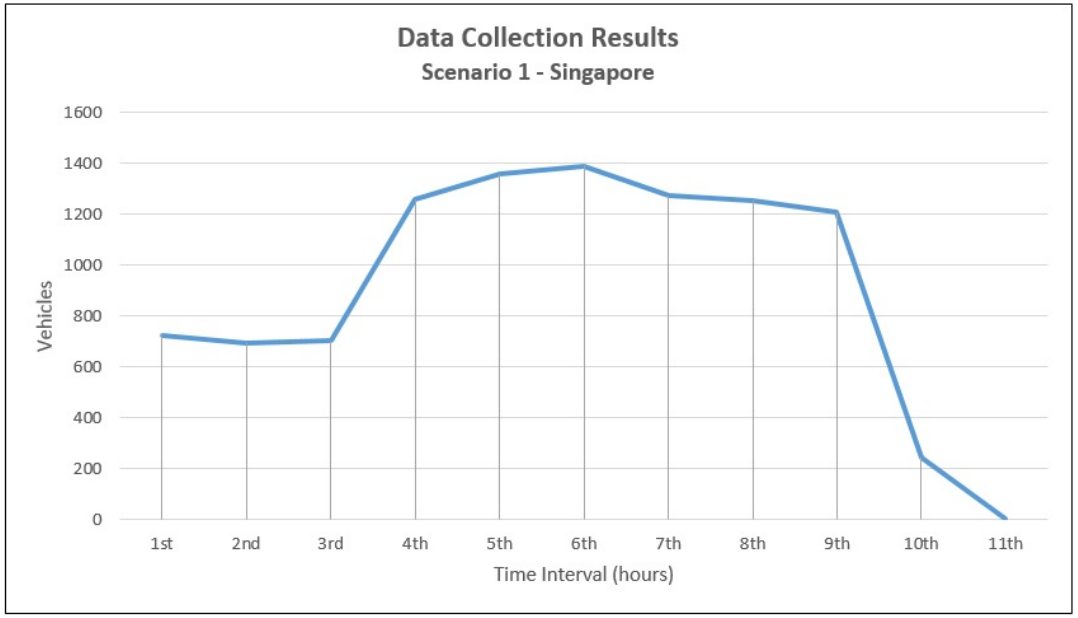


Figure: Vissim model for Singapore

1: Boon Lay; 3: Tuas; 2:Pioneer; 4-5: Boon Lay Place; 6-7: Jurong Central West; 8: Kian Tech; 9-10: Wenga; 10-14: Yunnan

Scenario – 1 Results





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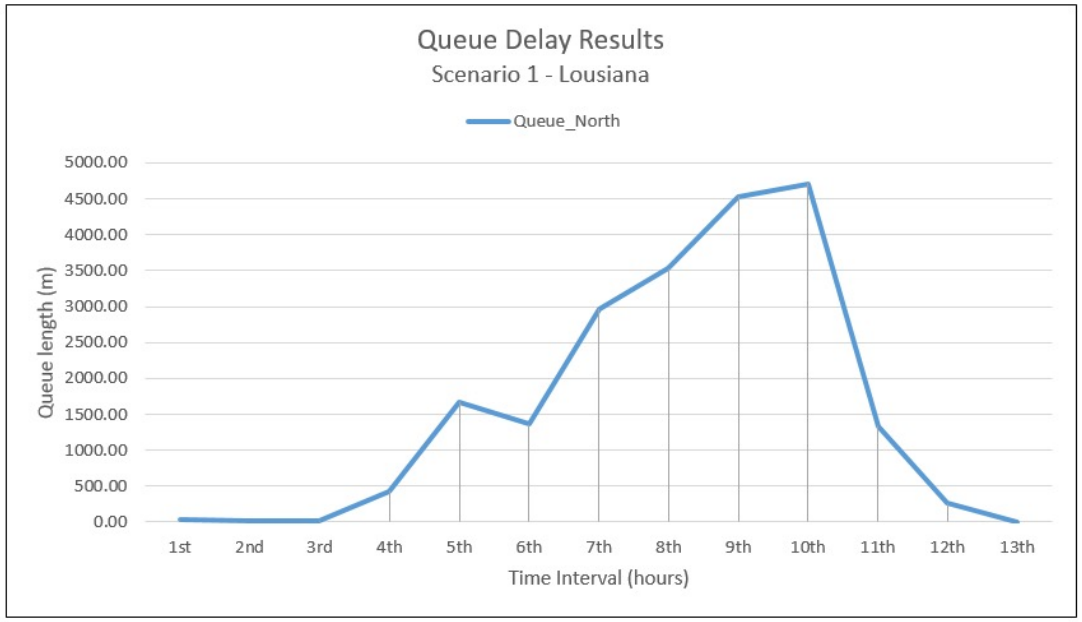

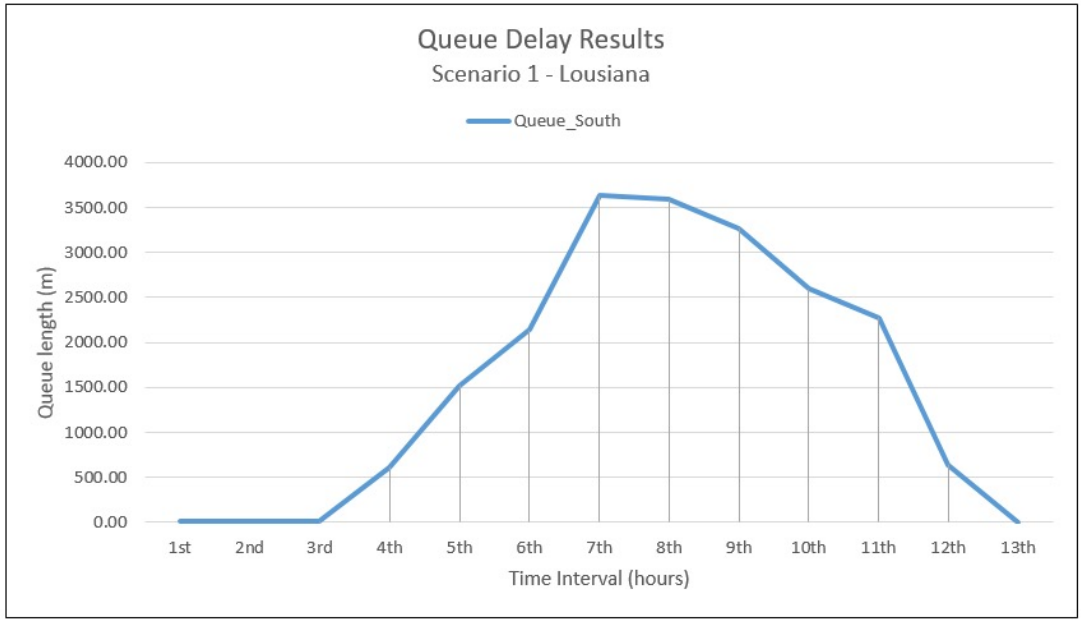

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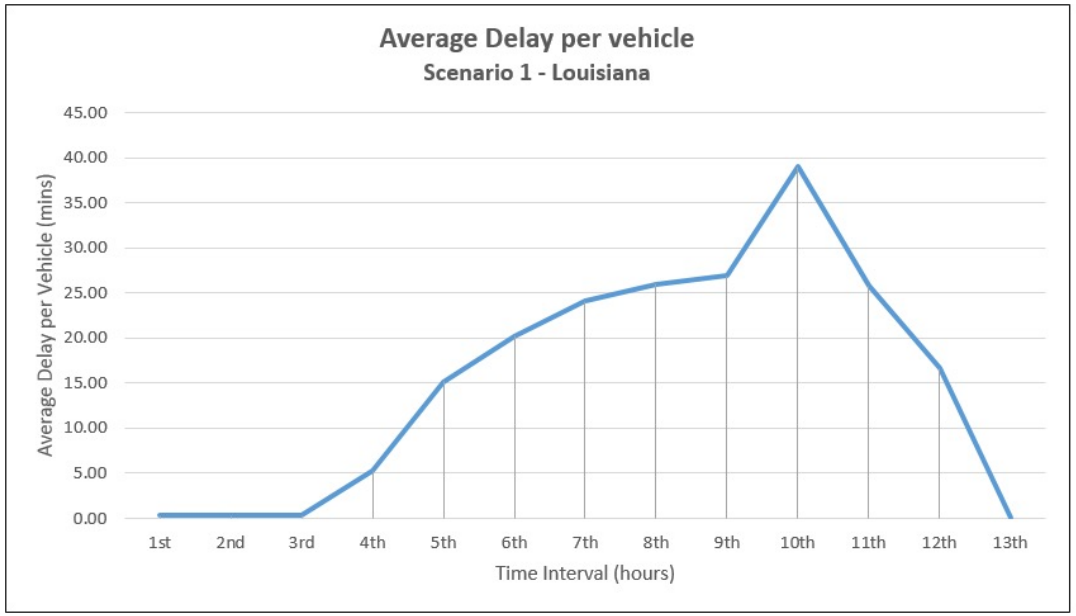

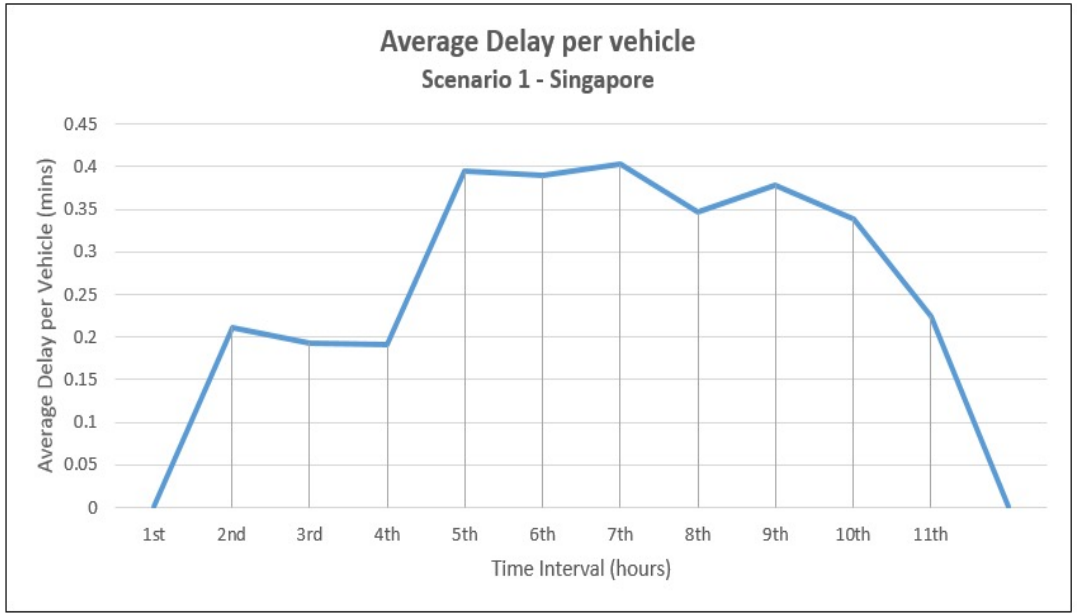

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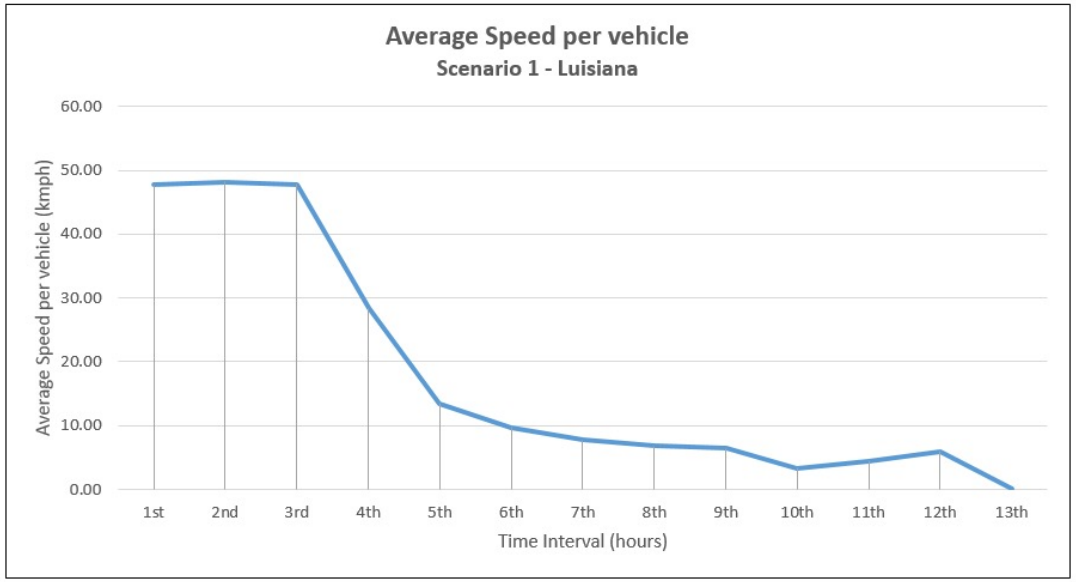

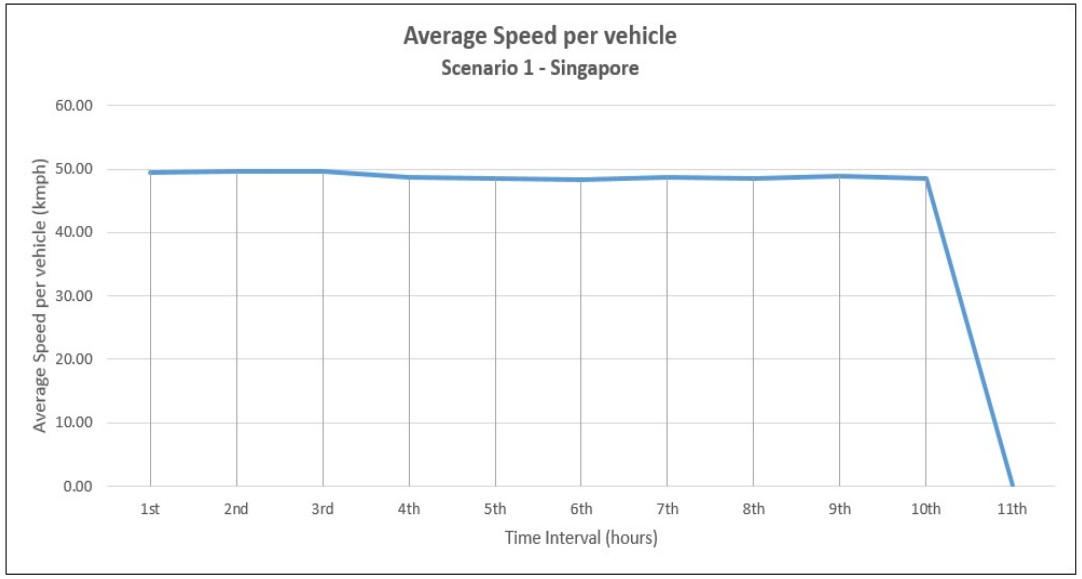

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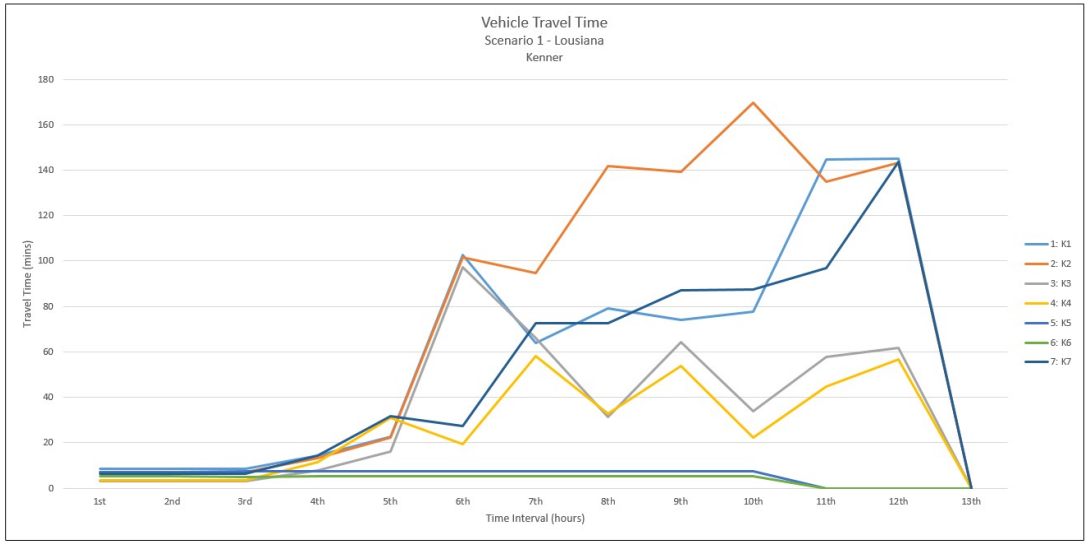
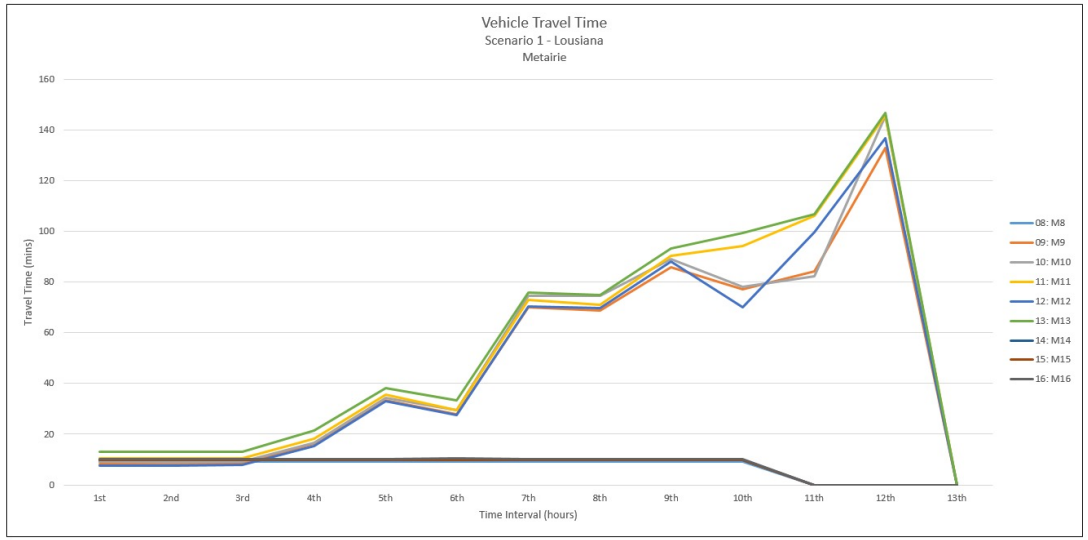
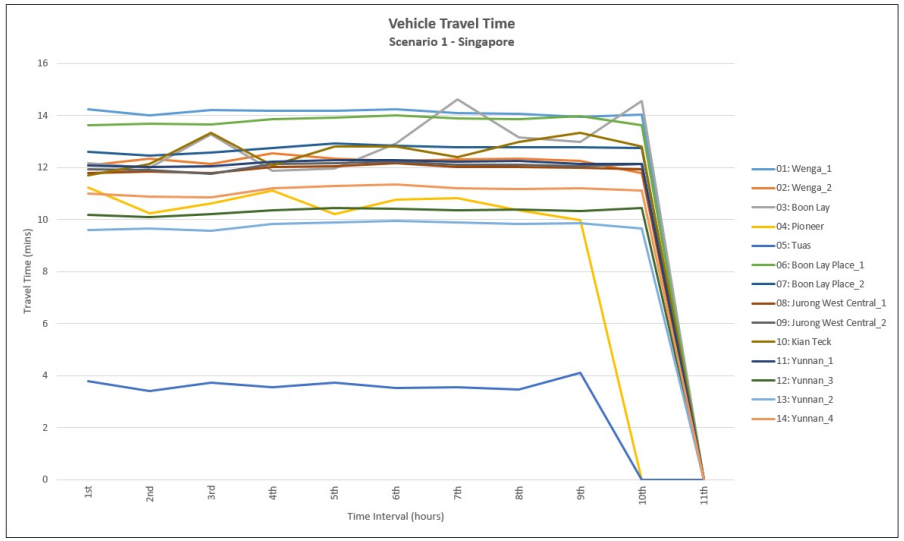
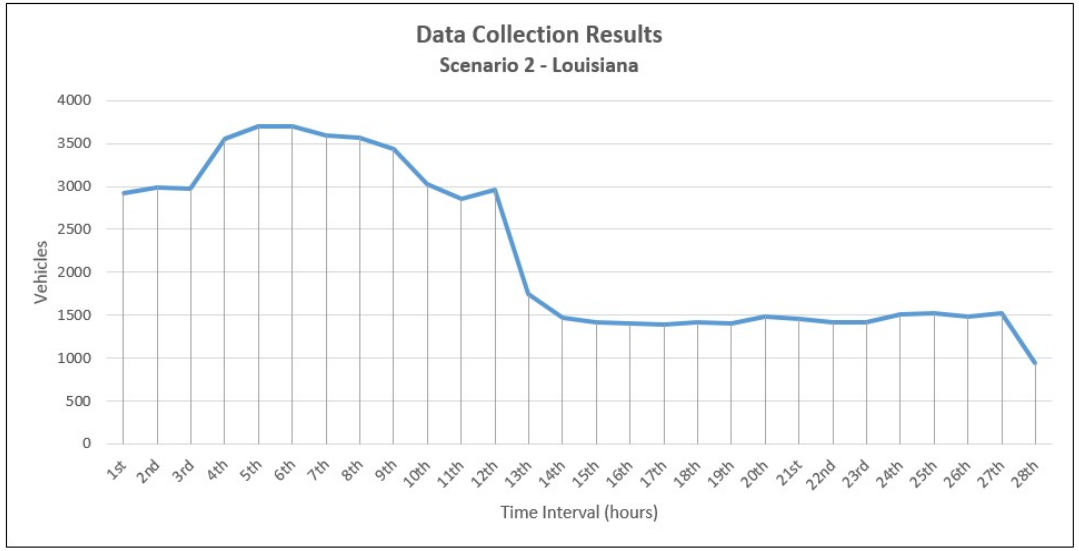






Scenario – 2 Modification



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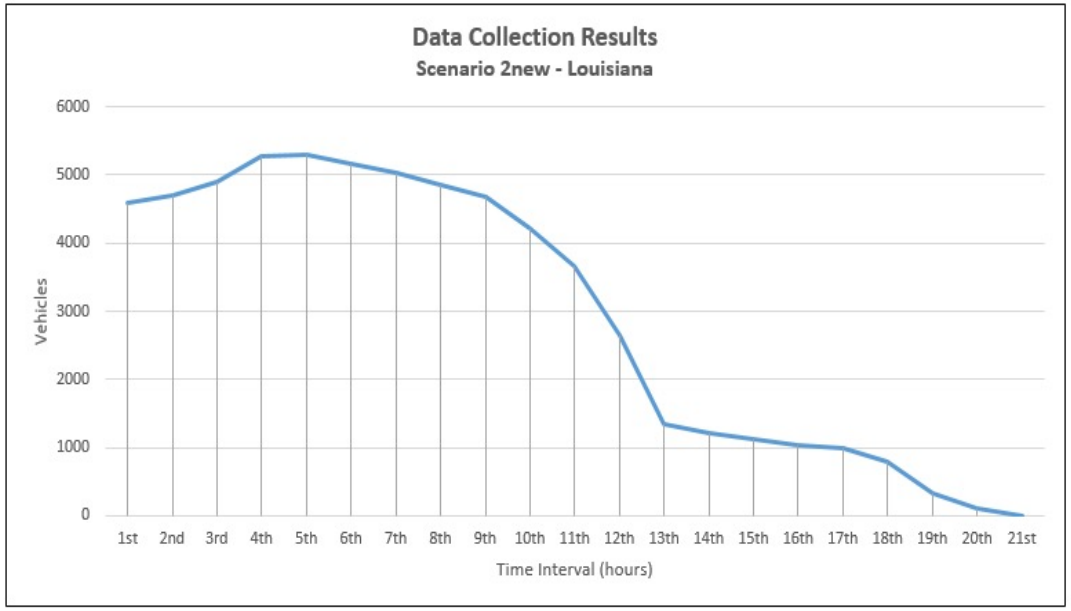

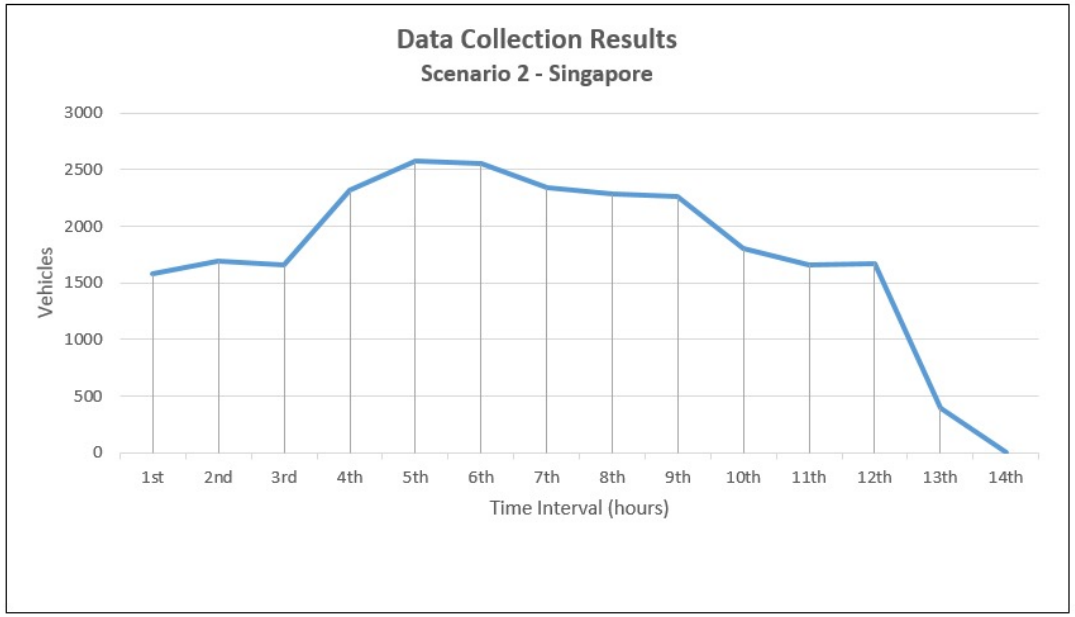

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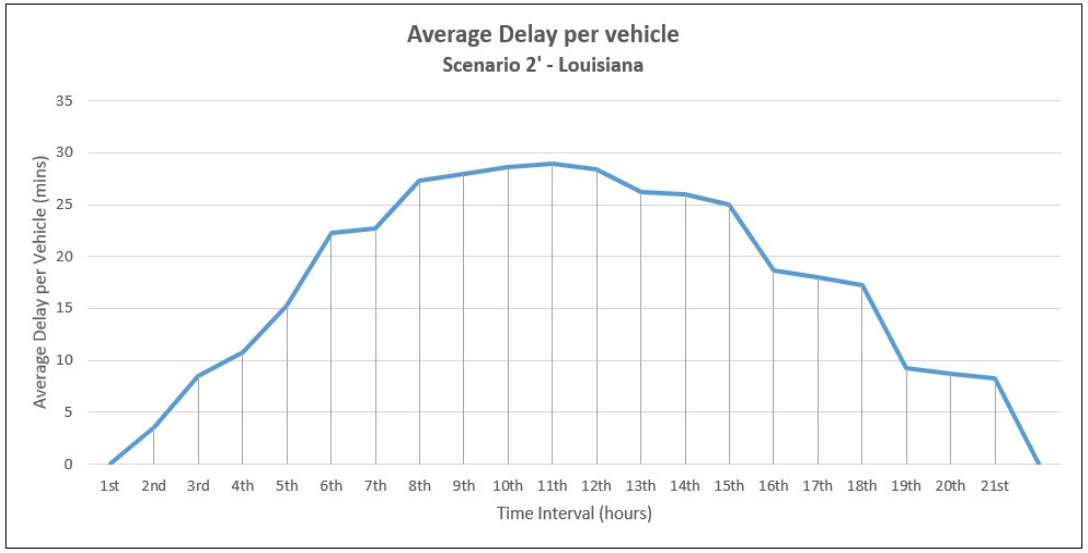

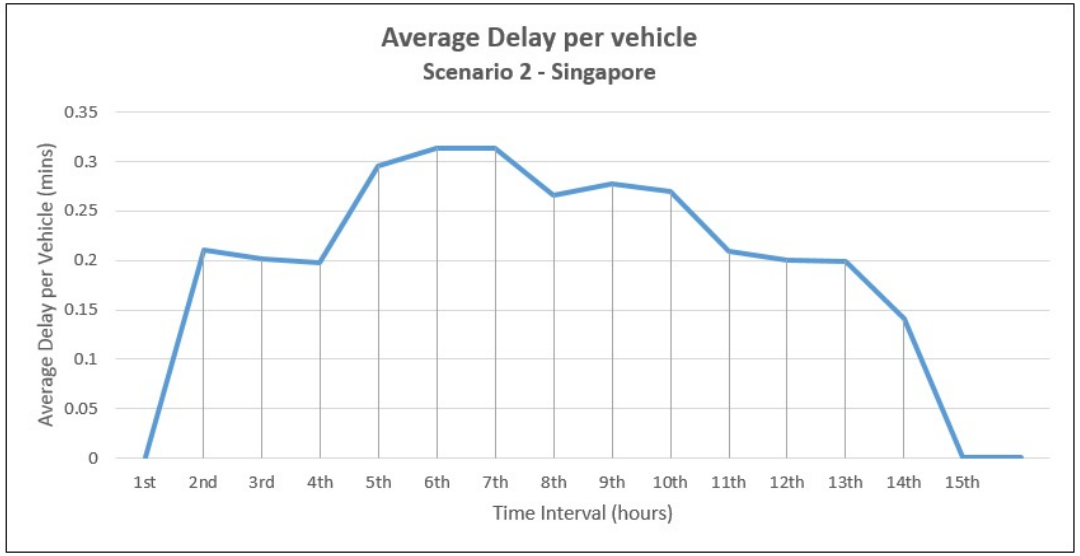

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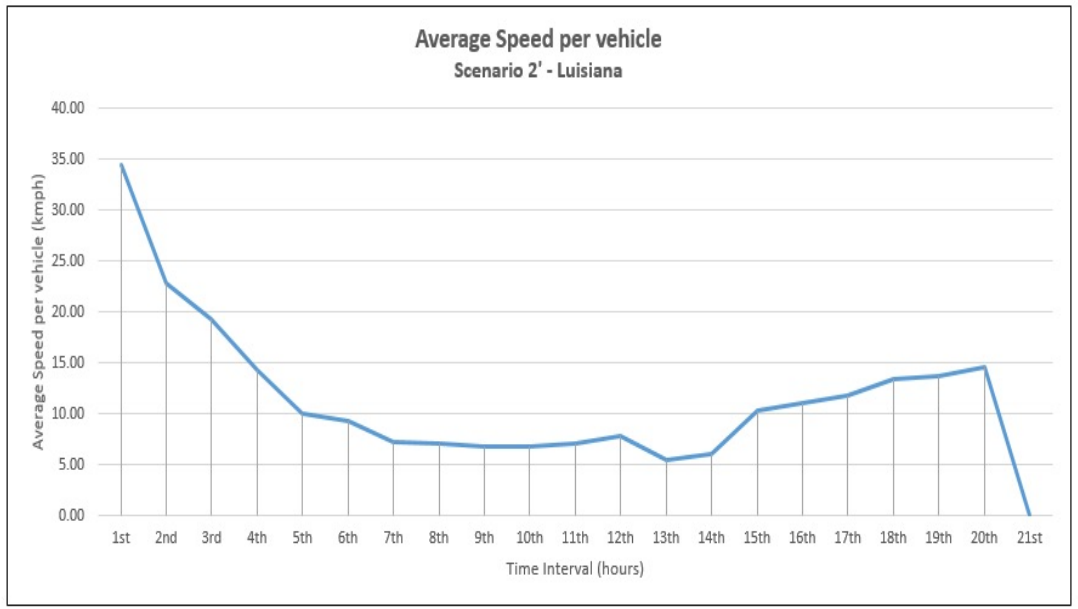

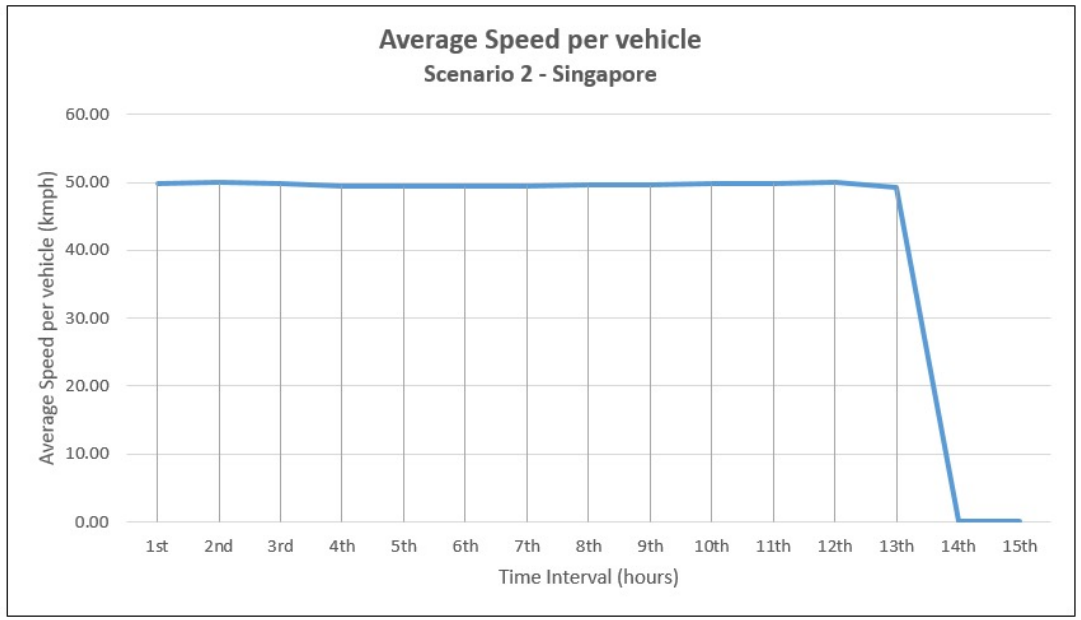

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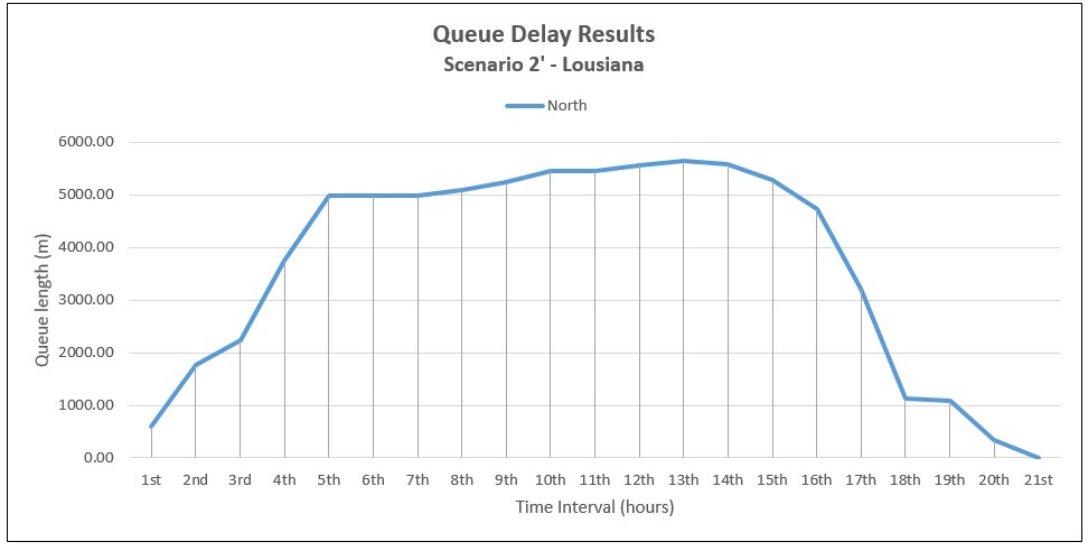

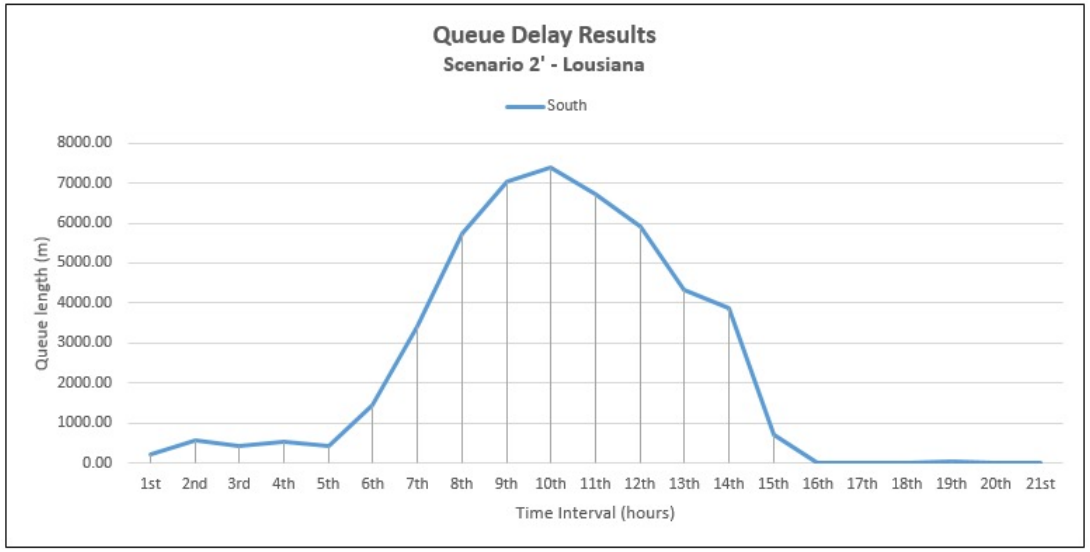

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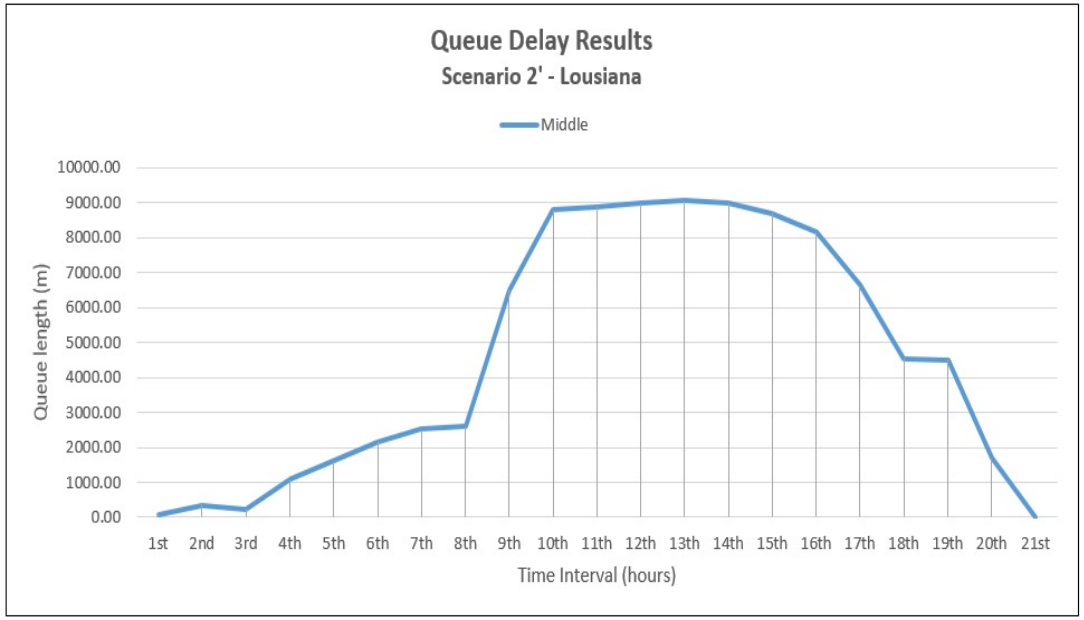

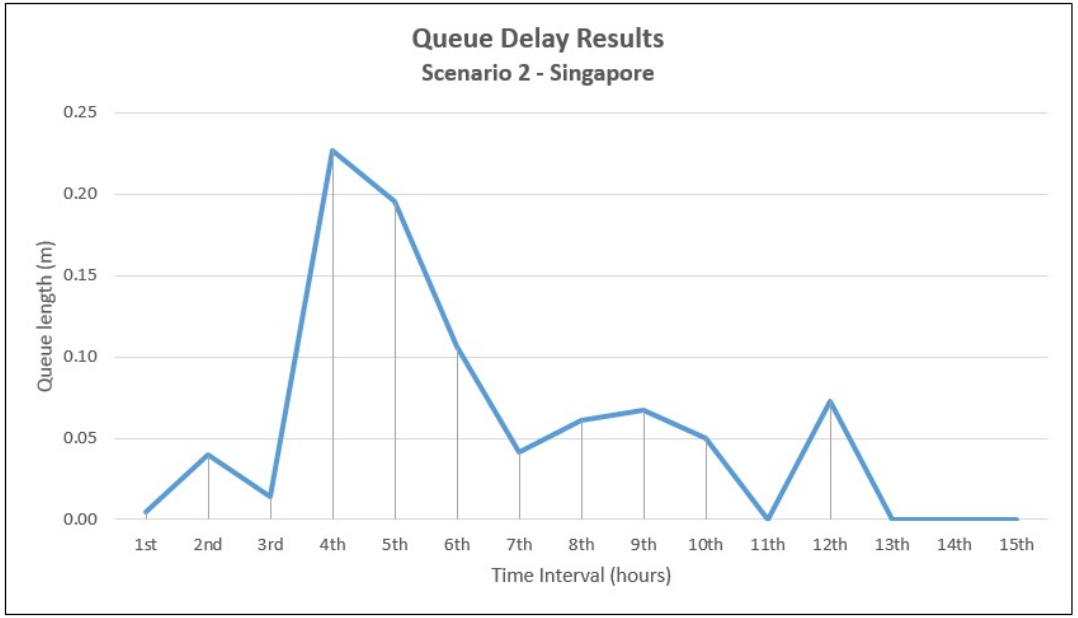

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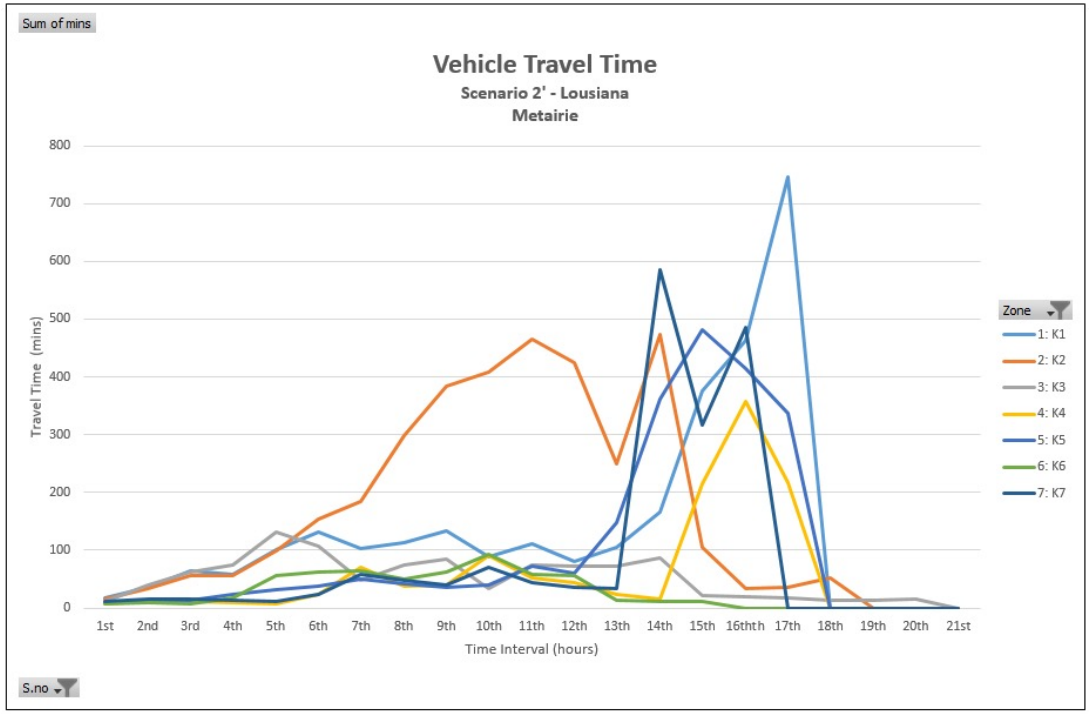

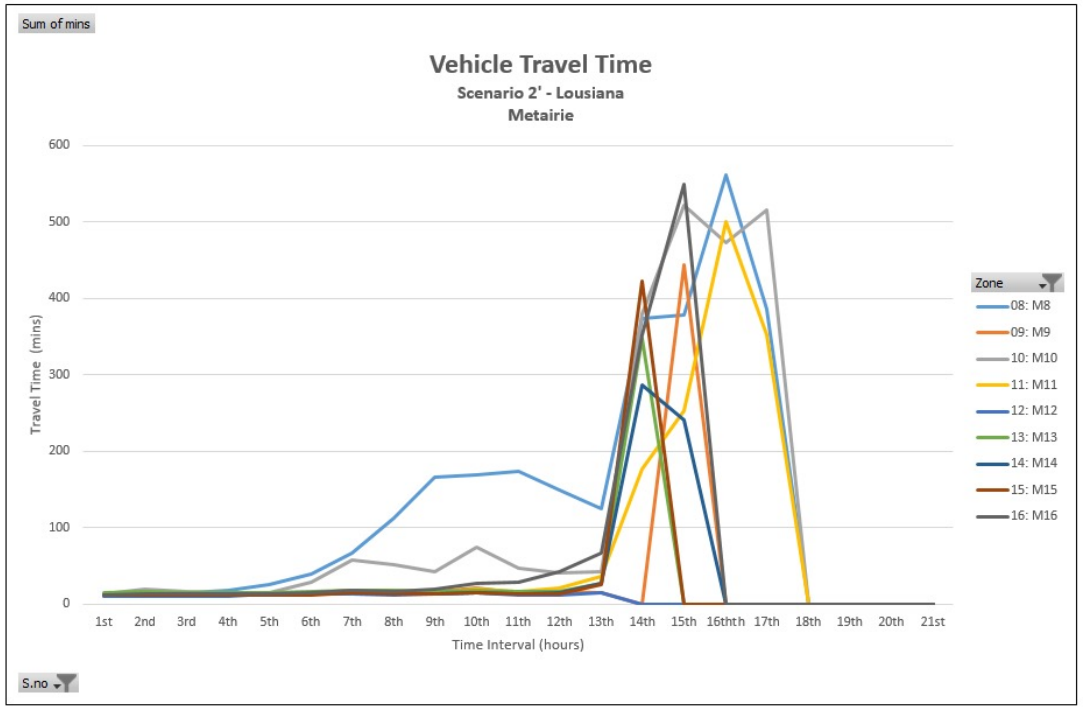

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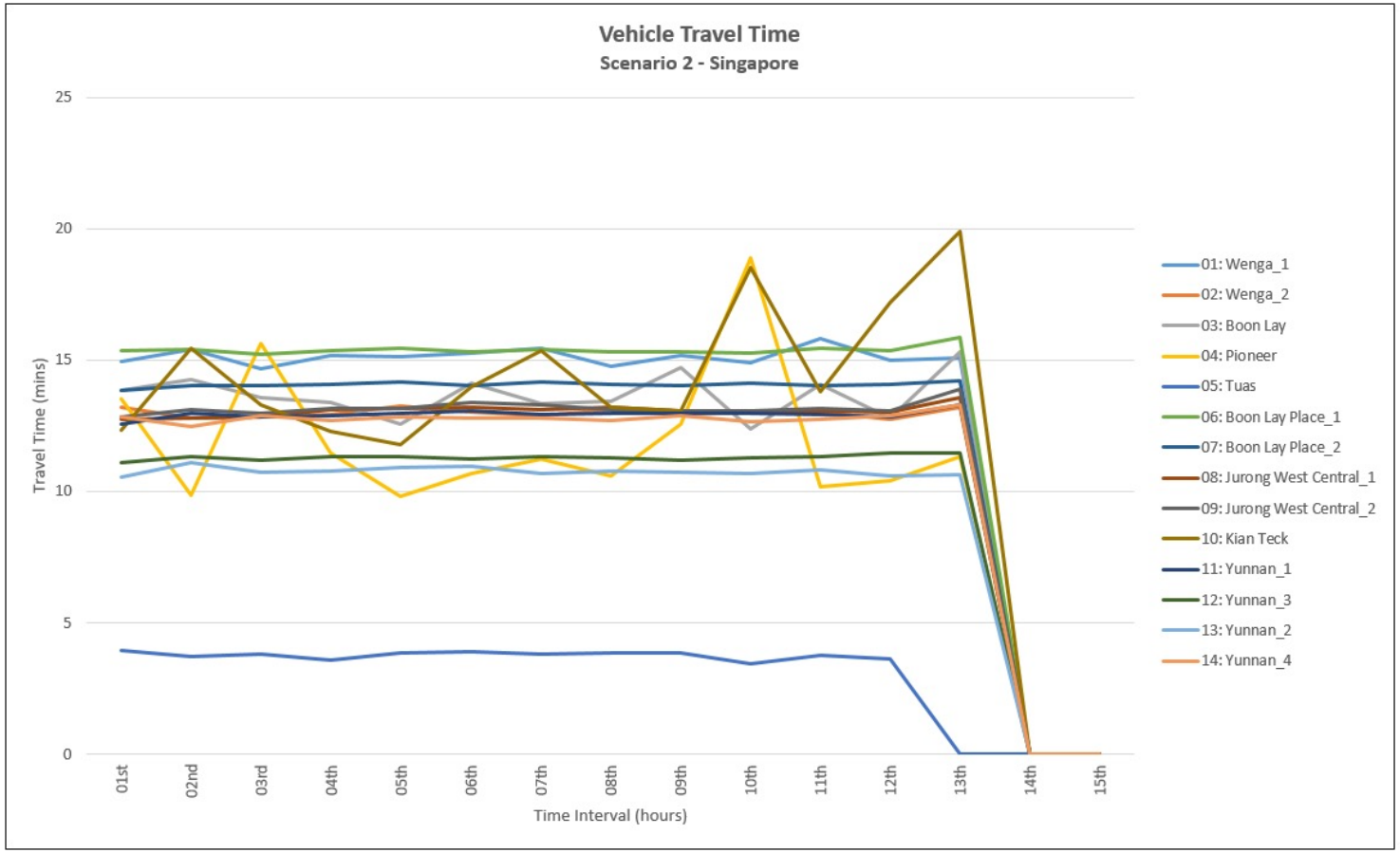

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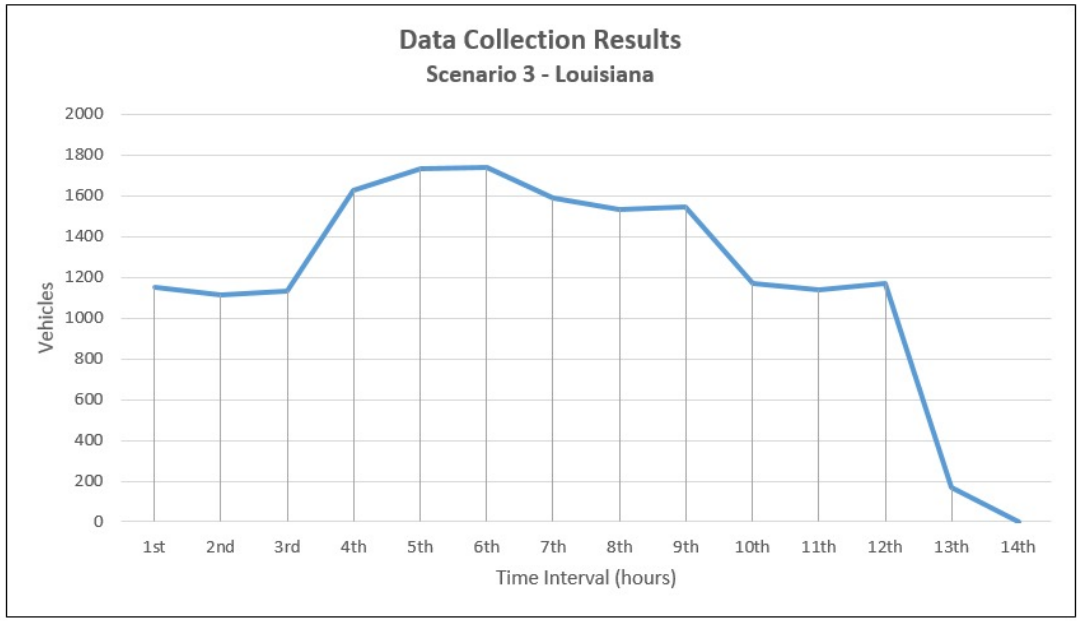

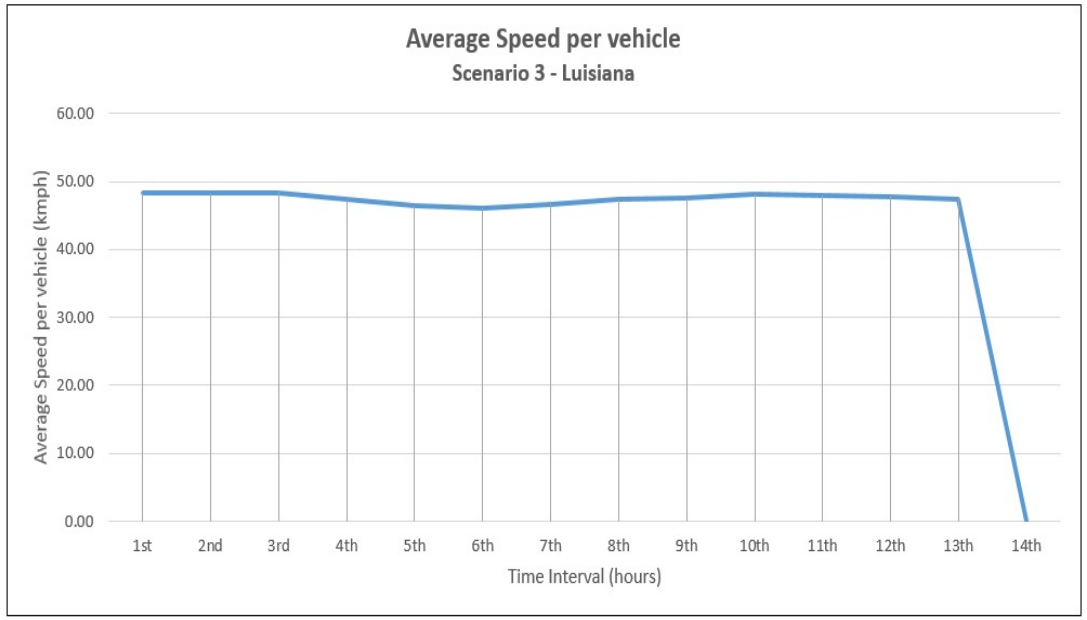

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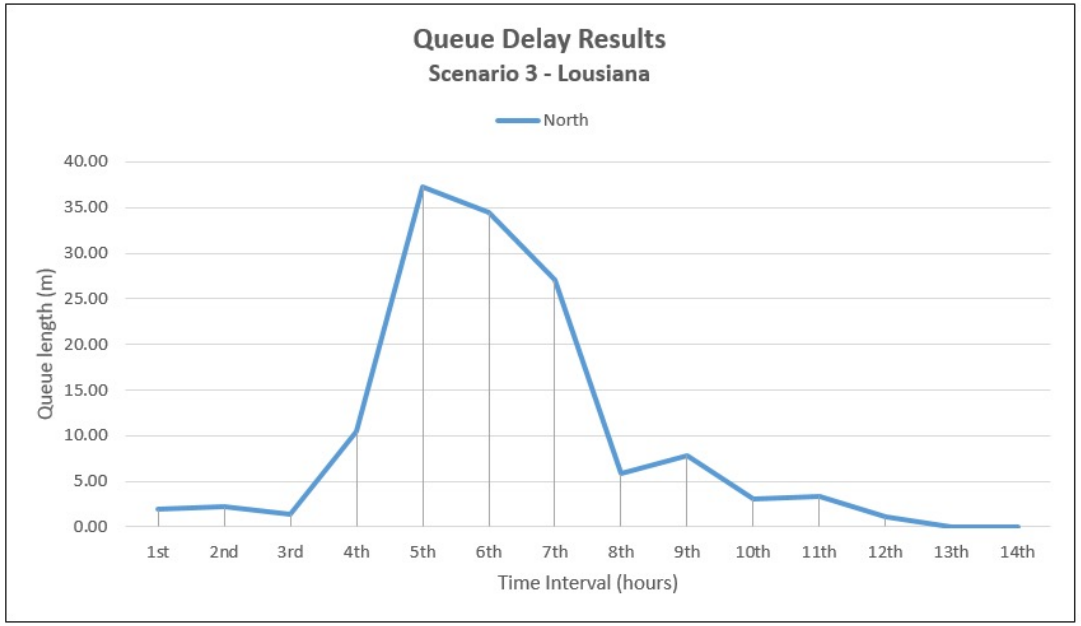

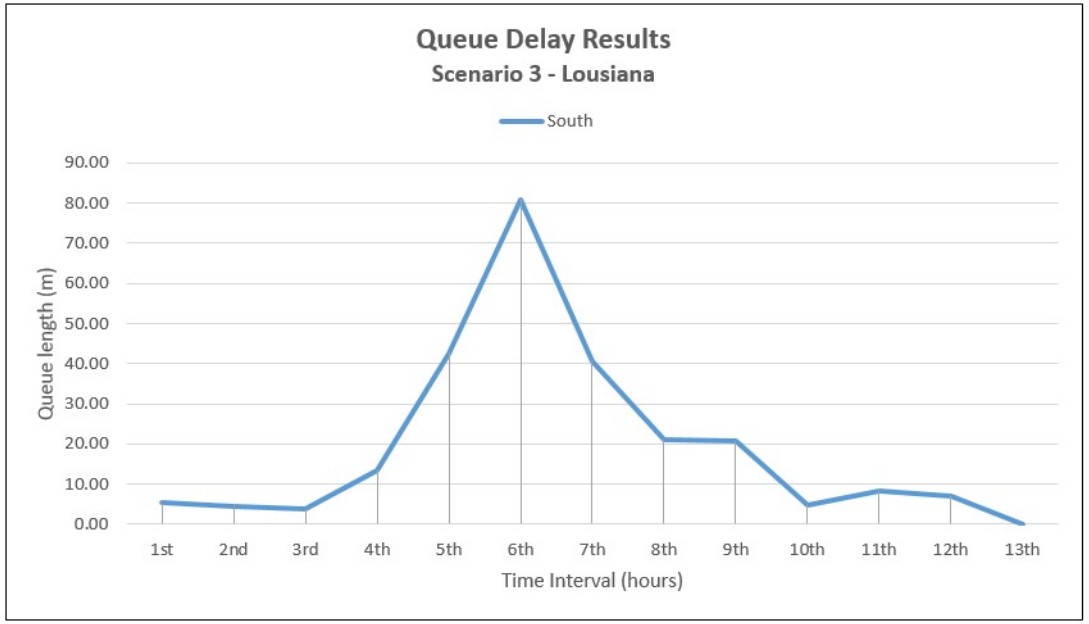

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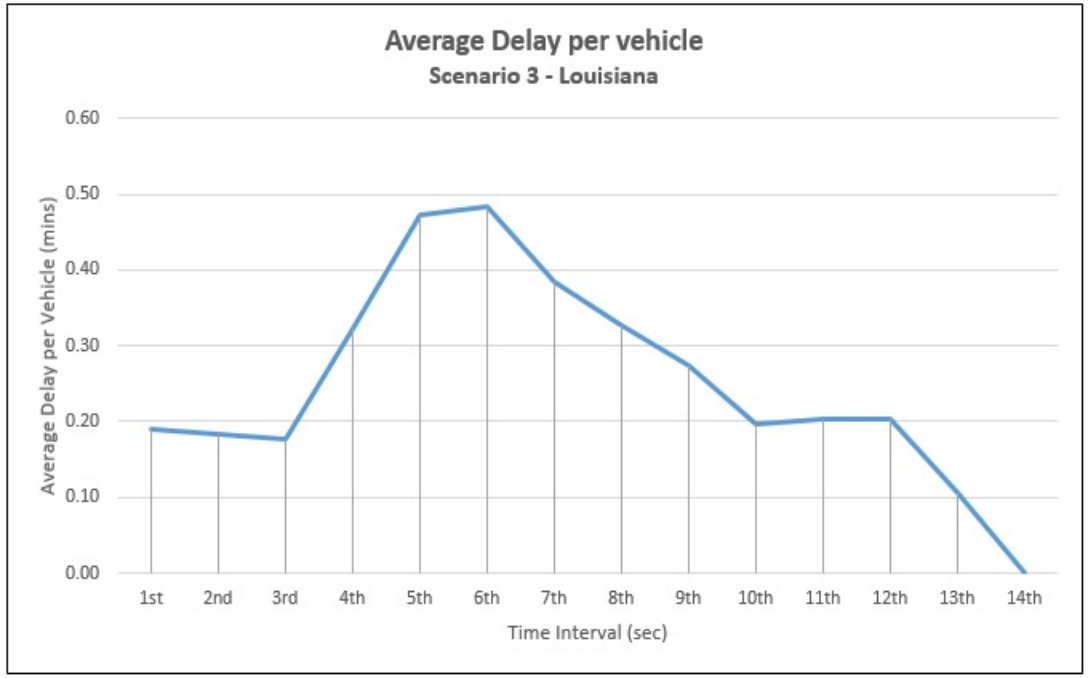
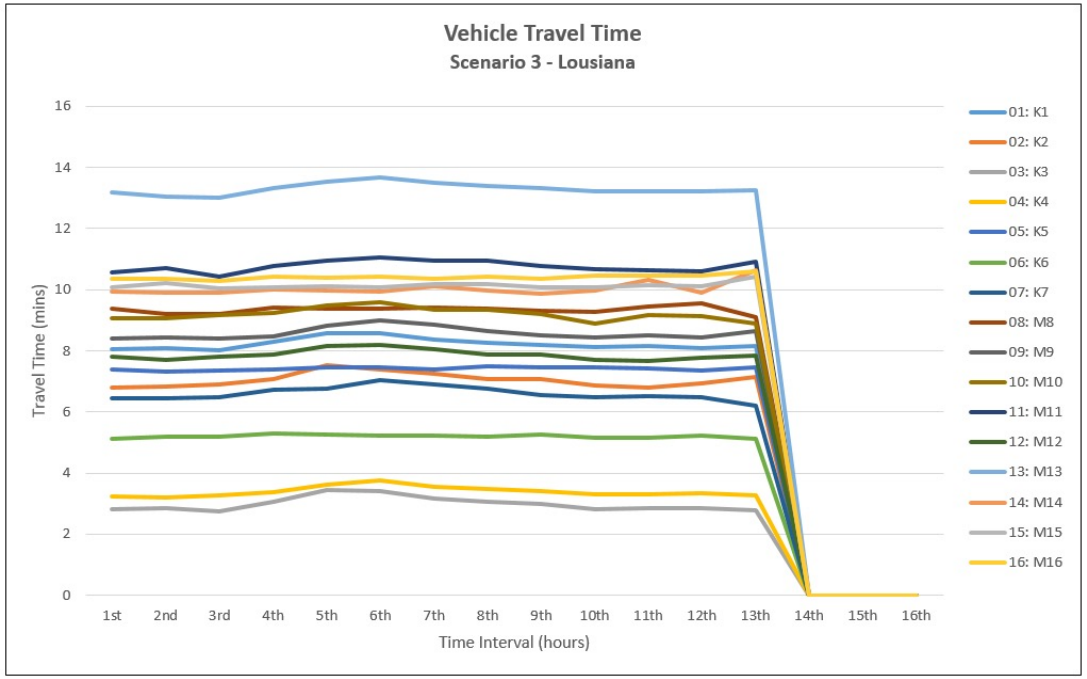
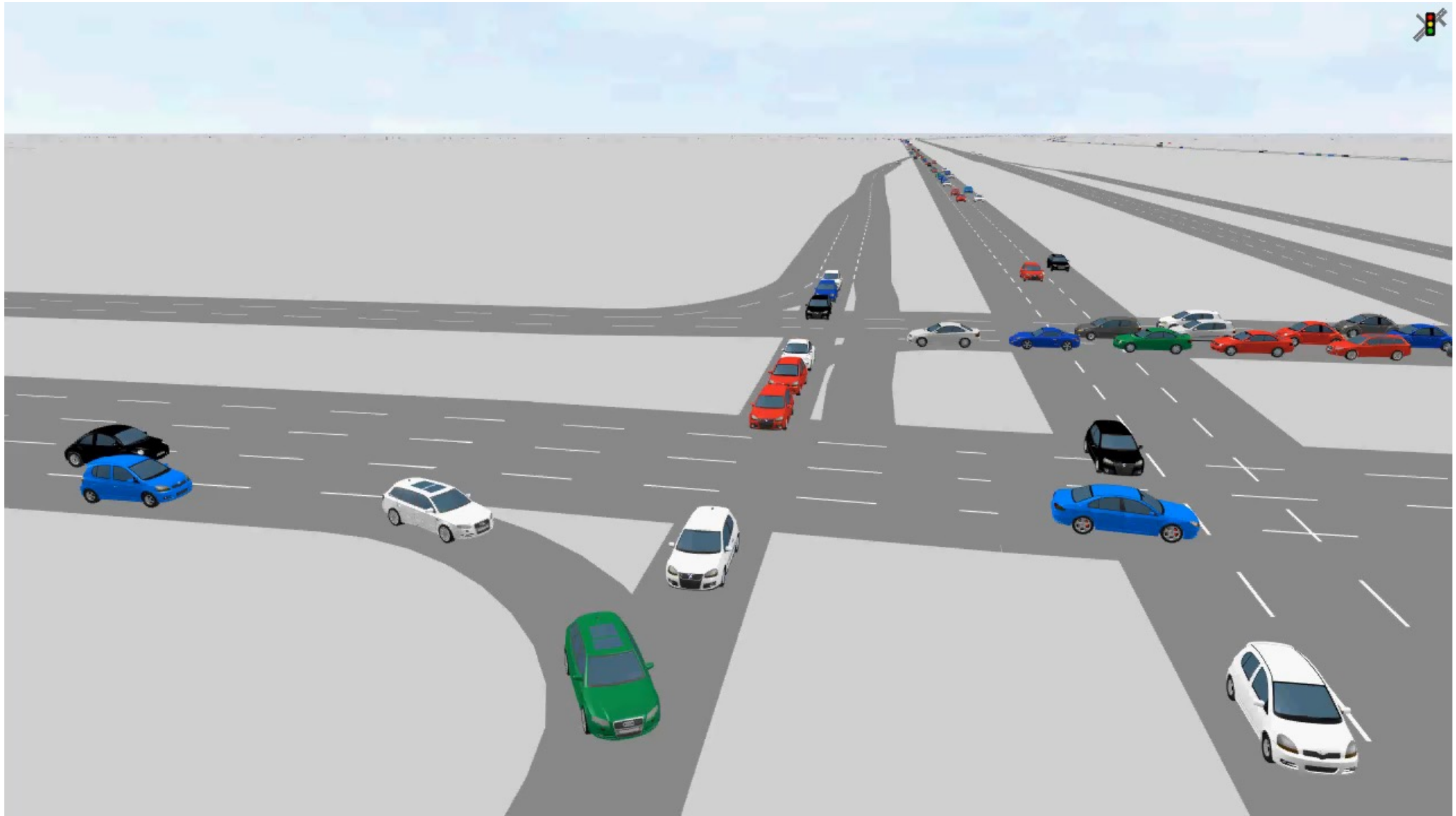
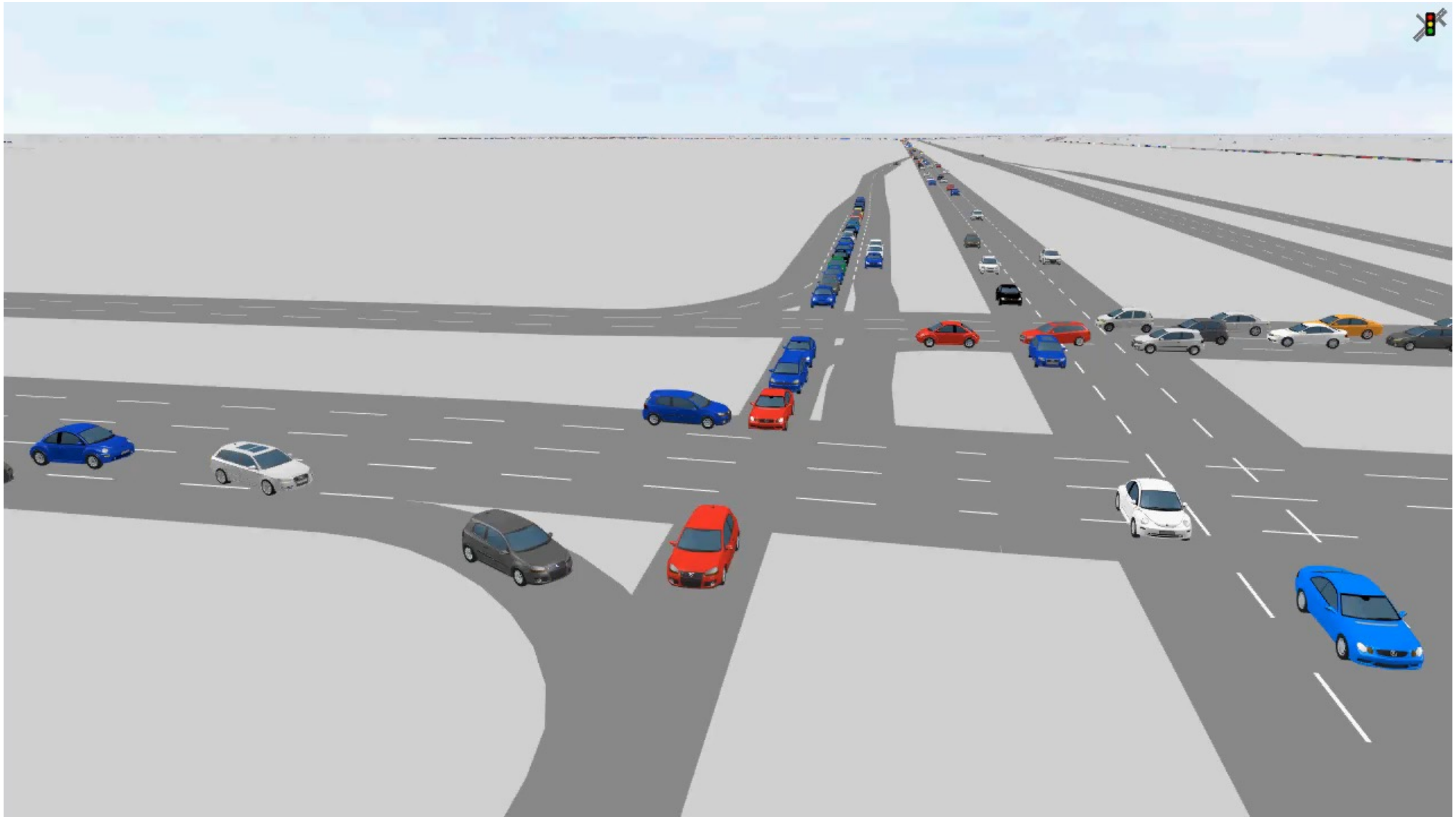




Louisiana – Scenario 2’ – 20 mins



Louisiana – Scenario 2’ – 6th hour



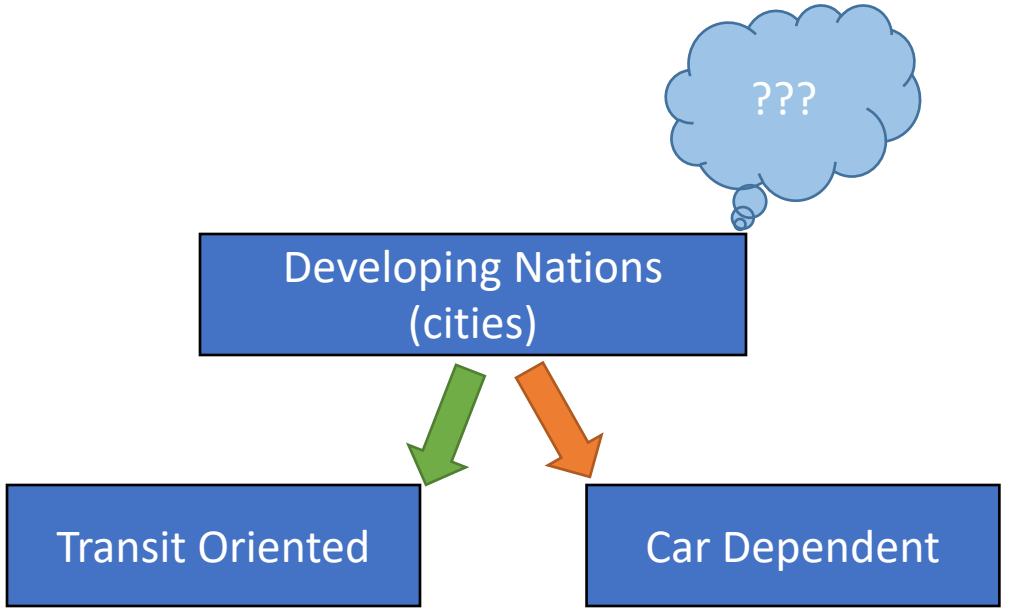
Contents

Conclusion

“Transit oriented developments if faced with a shock, perform better than car dependent developments.”

Recommendations

- TOD offers faster and smoother response to emergency situations.
- Transport Planners have bigger role to play. Mathematical tools can help.
- Importance of good governance.



Future Works

- Lane reversal
- Lane prioritization for HOVs
- Modeling train network
- More research on finding relationship between TOD and Social Capital[1]
  - 1995 Chicago Heat waves[2]
  - Superstorm Sandy[3]

"Areas or cities with transit oriented development if experienced with a shock, perform better than they were expected to."

HOV: High Occupancy Vehicles; 1: (Kamruzzaman et al. 2014); 2: (Klinenberg 2015).; 3: (Coleman 2013) ;
1: Four dimensions of social capital: local social interaction, sense of community, informal social control, and social cohesion (Kamruzzaman et al. 2014).

Thank you

Dhanyawaad

Vielen Dank

Any questions?