Marine Corps Marathon
Modeling & Simulating the Expo

Sponsor : Matthew Aylward
Operations Analysis Directorate – Combat Development & Integration

Mumtahina Mahmud
Richard Neary
Nghia Nguyen
Elshaday Yilma

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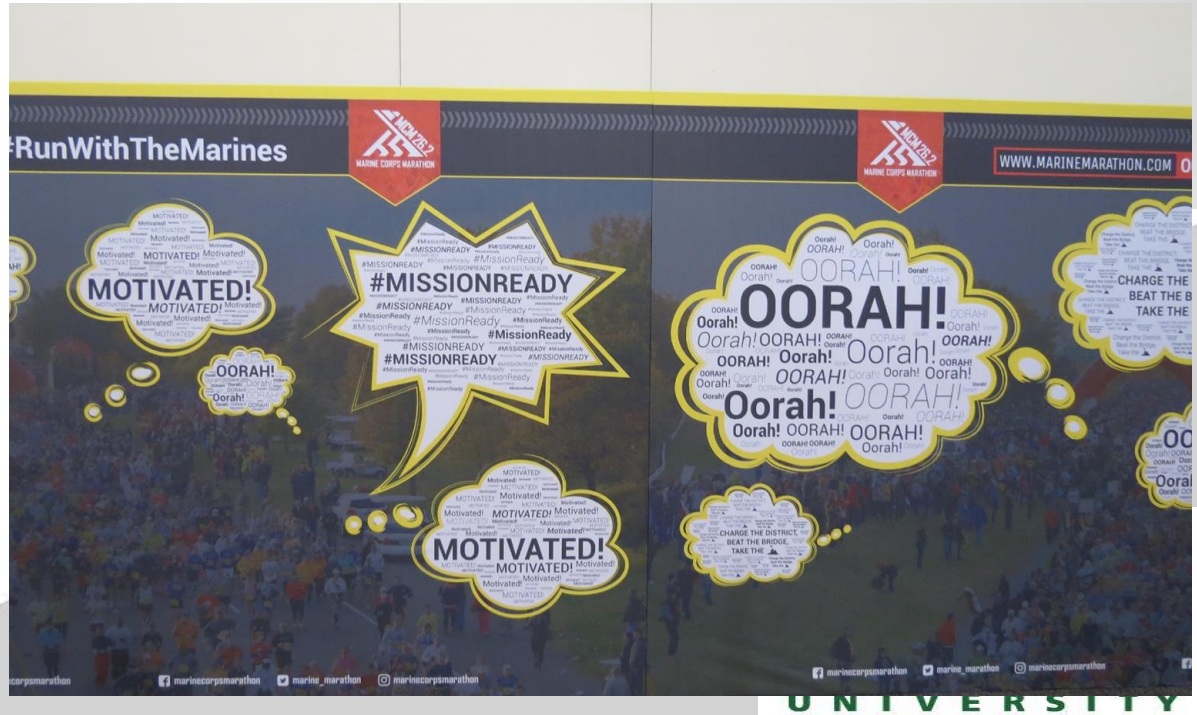
Agenda

- Project Context
- Assumptions
- Methodology
- Model
- Validation
- Scenario Results
- Conclusions
- Further Work

Project Background

- One of the largest US Marathons
- 20,000 runners annually
- Health & Fitness Expo
  - Packet Pickup
  - Goodies
  - Event

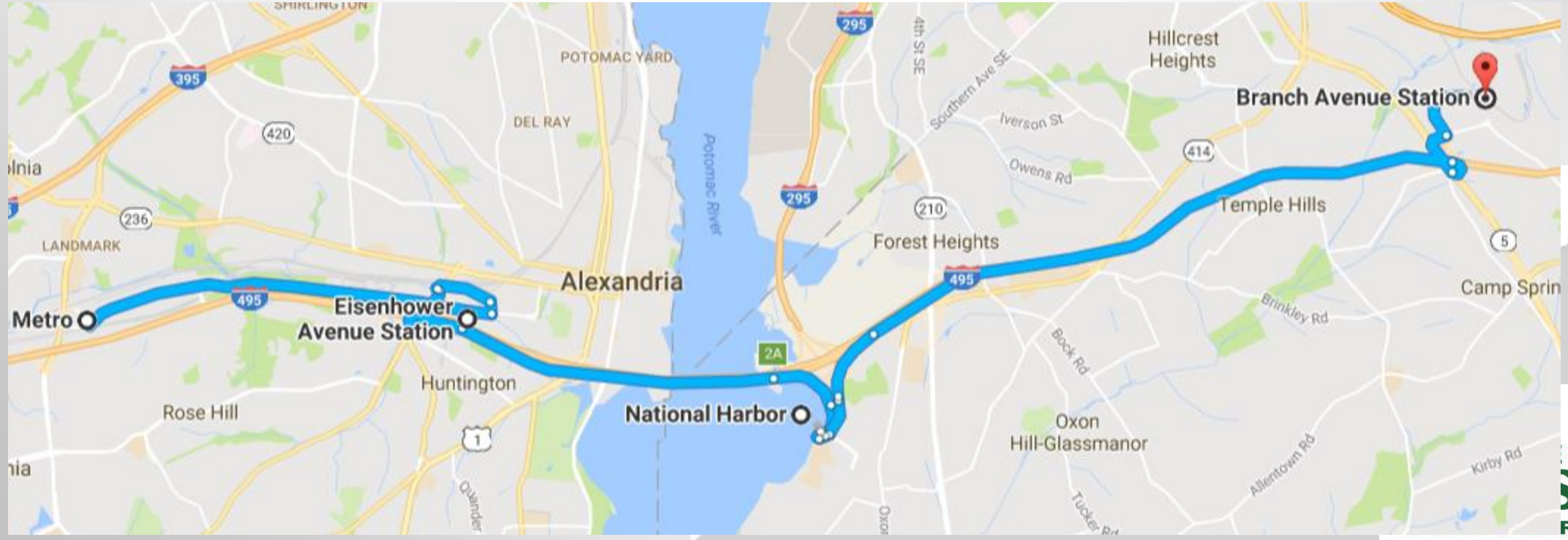


Problem Statement

Given the lack of readily available public transit to the National Harbor, how many buses should the MCMO provide?

Scope

- Assess the new location
- Focus on the three metro stations
  - Eisenhower, Van Dorn, and Branch Avenue
- Focus on the traffic
  - 495E
  - 495S
  - National Harbor Boulevard



Scope - Tasks

- Identify data is required for the model
- Develop a discrete event simulation model
- Generate means of data collection for use by the MCMO
- Execute ‘what-if’ analysis

Literature Review

- Using Traffic Modeling to Explore How Congestion Information Affects Traffic - Smith, Jennifer L (GMU Thesis)

- Median opening/closure techniques for special event traffic control - Metzger, David N (ITE Journal)

- *Exploring Engineering, An Introduction to Engineering and Design* - George Wise, Philip Kosky, Robert T. Balmer, and William D. Keat

Assumptions - General

- The water taxi will not have any meaningful impact on traffic
- Cycling will not have any meaningful impact on traffic
- The parking lot does not begin empty
- Buses can be directed to other stations
- Metro transit and delays are not tracked

Assumptions - General

- Attendees will only enter the system at a few points:
  - Arrival at a Metro pickup stop (need a shuttle)
  - Arrival by car (rideshare/taxi, personal vehicle)
  - Arrival by watertaxi

- A user exits the system upon exit of the Expo

Overall Solution Technology

- Building a simulation that models:
  - Time attendees will spend getting to the National Harbor
  - Time attendees will spend at the National Harbor
  - Traffic attendees will experience getting from access points (metro stop locations) to National Harbor
  - Traffic attendees will experience getting to National Harbor via 495

Simulate

- Turn the model into a simulation
  - Requires data collection
  - Assumptions - already done!
  - Identification of parameters
  - Post Marathon data dump

Data Collection - Emails

- Determine relevant organizations
- Determine other large National Harbor events
- Email the organizations involved
  - No helpful responses were provided
  - Most recent email received 11/30

Data Collection - Scraping

There was some publically available information available for the team to work with

- Metrobus schedule
- Traffic delays (via Google Maps)
- National Harbor available parking
- Watertaxi schedule
- Metro parking
- Metro schedule
- Traffic camera

Data Collection - Survey

1. What day did you attend the Expo at the National Harbor?
2. What time of day did you leave for the National Harbor?
3. How did you travel to the National Harbor on the day of the packet pickup?
4. How long did it take you to arrive at the National Harbor?
5. How long did you spend at the Expo?
6. If you took a shuttle, how packed was it?
7. If you travelled in a group, how many people went with you?
8. Did the transit to the Expo impact your enjoyment of it?
9. How did you enjoy the Expo?

Data Collection - Survey

10. How did the Expo compare to previous years?
11. What was your favorite booth?
12. Did you have any suggestions for next year's Expo?

http://www.surveygizmo.com/s3/3129453/New-Survey

While the MCMO didn't directly distribute the survey we put together, they generated and distributed a survey containing the majority of our questions.

http://2016mcmrunner.questionpro.com/

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Data Collection – On Site

Two members of the team went to the Expo to collect data in person. This included:

- Observing incoming buses
- Observing the level of crowds
- Interviewing the vendors
- Interviewing attendees

Transportation Options

- Good level of communication
  - ➢ Alter transportation options to the last week!
- Initial belief was that there would be more parking
- A shuttle company will transport attendees to and from three metro stops
- A promotion with both Uber and the Potomac Riverboat Company was made to make it easier for runners
- A week before the Expo, the MCMO worked with WMATA to include Metrobus access to the National Harbor on the NH1 & NH2 routes

Tools

- The team used ExtendSim version 9.2 to simulate the Marine Corps Marathon Expo traffic.
  - This captures metrics for each entity throughout the system lifecycle
  - Exports the data to an internal database
  - Animation allows the user to verify entity flow
  - The MCMO is familiar with the tool

- Microsoft Excel was used to store parameters and analyze the data with VBA
- SurveyGizmo was used to host the survey

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Modeling Assumptions

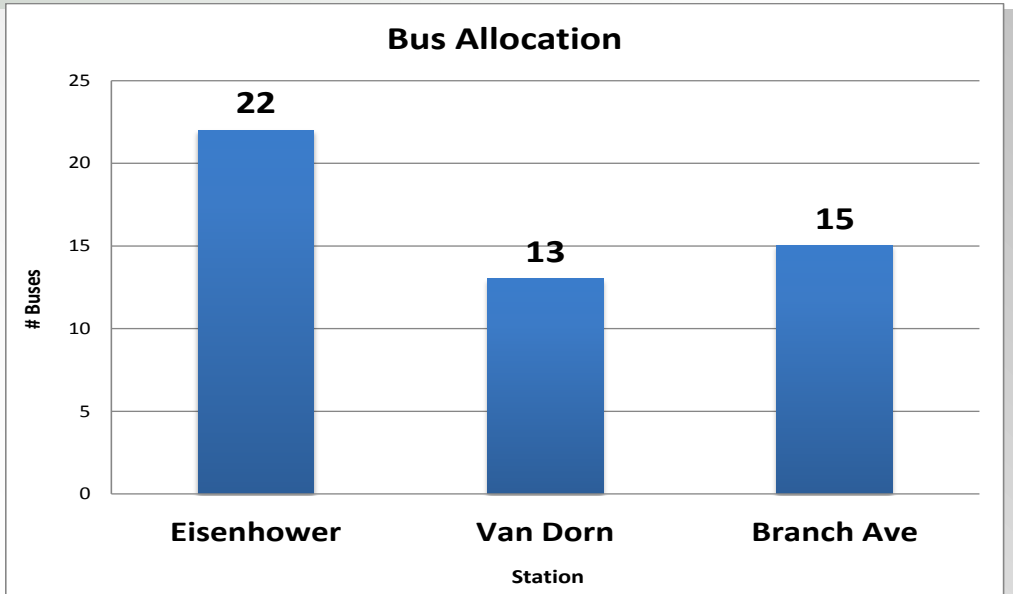
- Gaylord parking availability for the MCMO event will be 650
- Attendees will spend 40 minutes on average at the event, with variation as a triangular distribution (25, 40, 90)
- Runners and accompanying guests will use the same means of transportation throughout
- Shuttle bus riders distribution:
  - Eisenhower – 44%
  - Van Dorn – 26%
  - Branch Ave – 30%

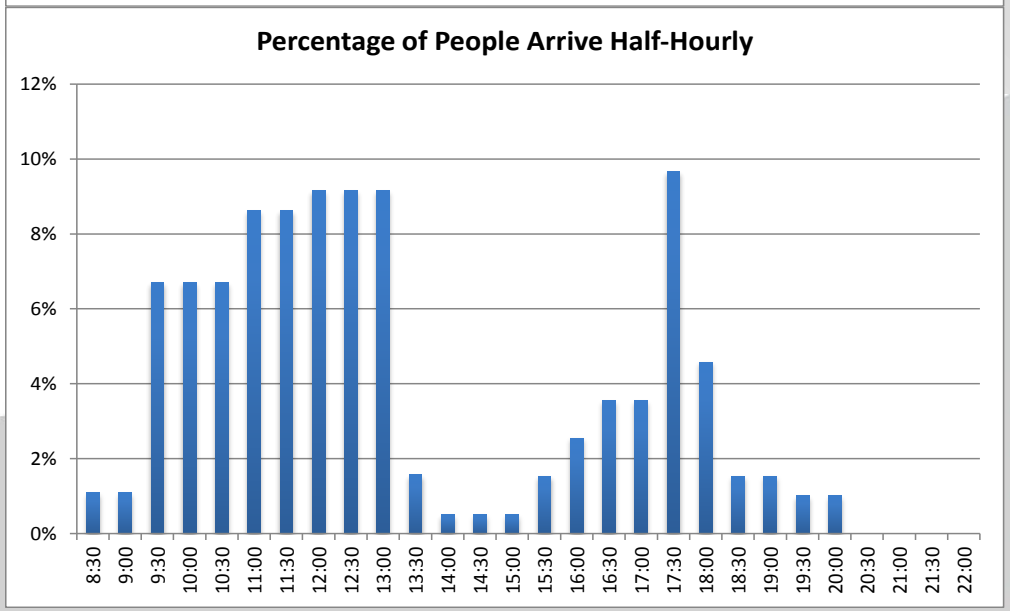
Model Inputs

- Number of Shuttle Buses at
  - Eisenhower station = 22
  - Van Dorn station = 13
  - Branch Ave = 15
- Bus capacity = 55
- Available parking space at National Harbor = 650
- Number of runners ~ 20K
- Percentage of Half-hourly arrival of runners
- Bus departure time ~ 10 minutes

Weekday Service: Inter-arrival Time (minutes)					
Line	5:00AM - 9:30AM	9:30AM - 3:00PM	PM Rush 15-1900	Evening 19-2130	Late Night 2130-2400
Branch Ave	6	12	6	12	20
Eisenhower	6	12	6	12	20
Van Dorn	12	12	12	12	20

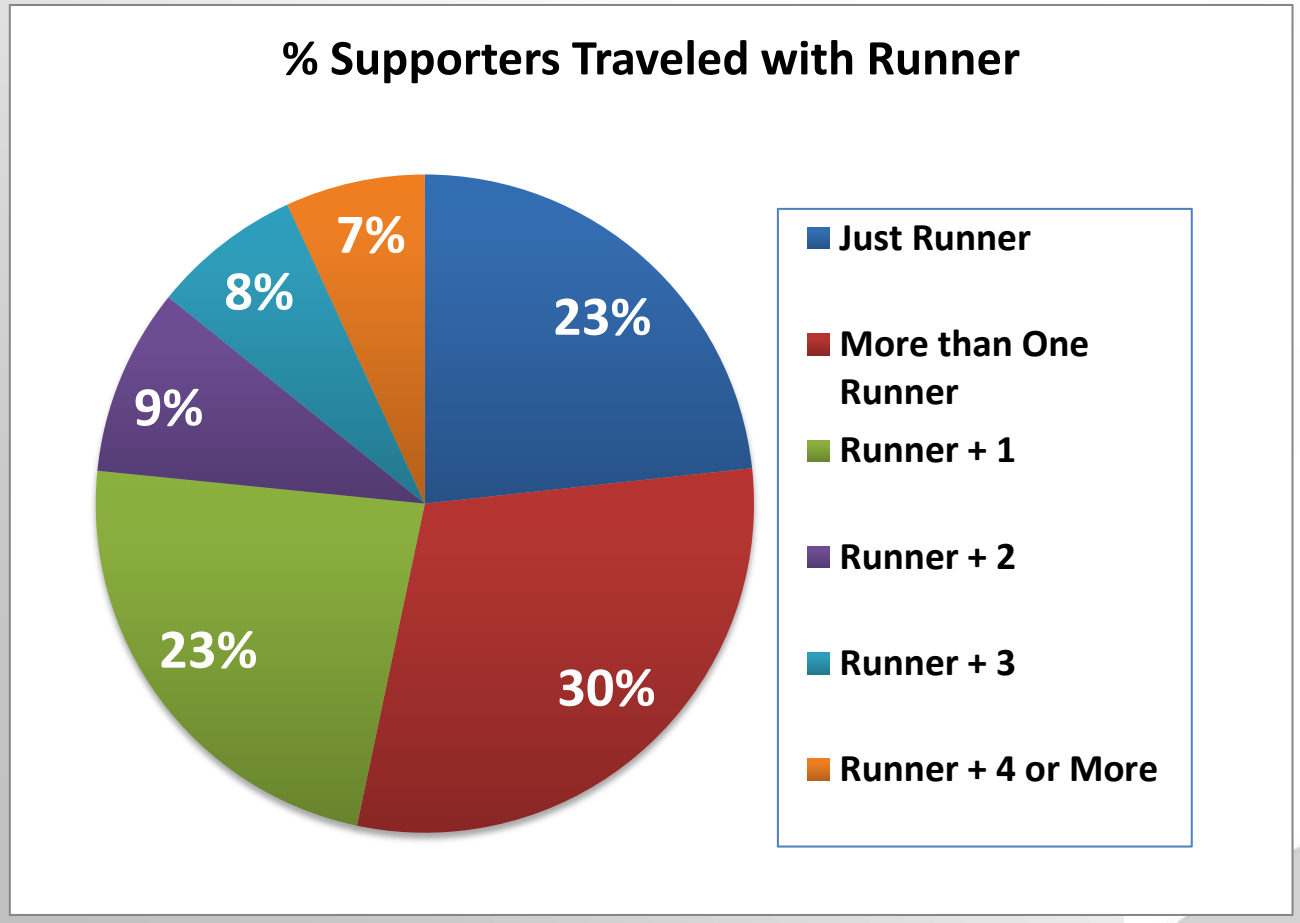
Weekend Service: Inter-arrival Time (minutes)					
Line	5:00AM - 9:30AM	9:30AM - 3:00PM	PM Rush 15-1900	Evening 19-2130	Late Night 2130-2400
Branch Ave	12	12	12	12	20
Eisenhower	12	12	12	12	20
Van Dorn	12	12	12	12	20



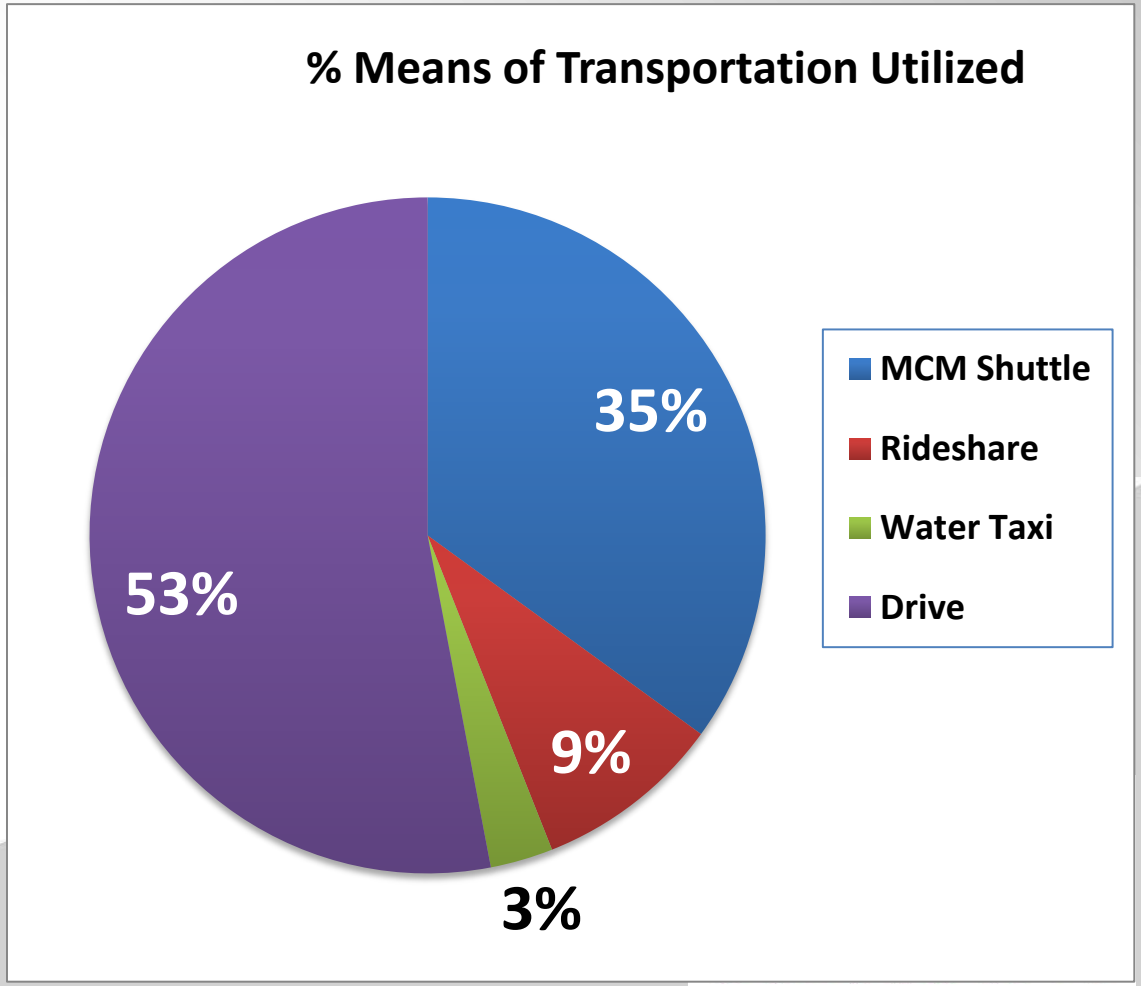


Model Inputs

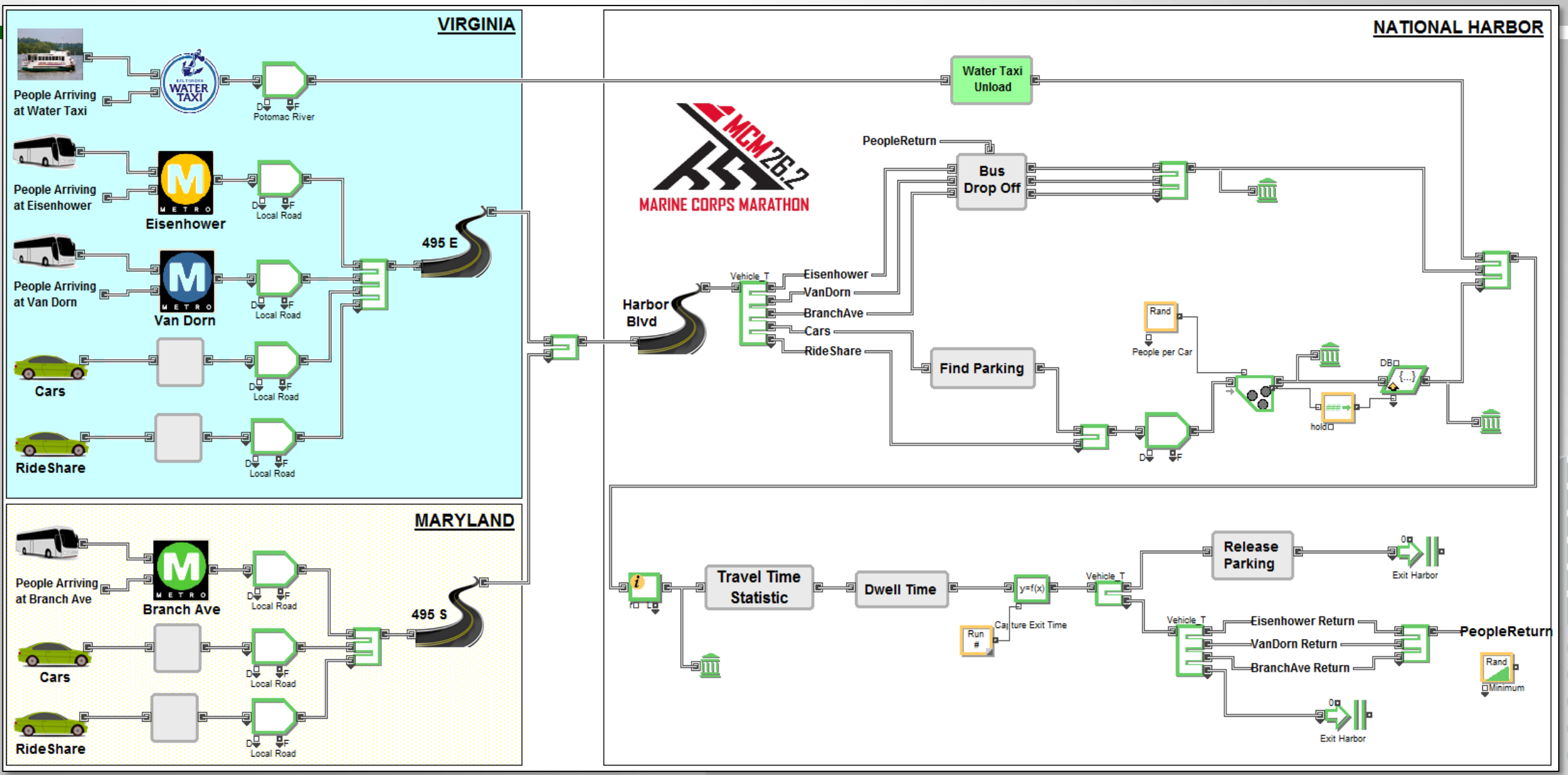
- Percentage of supporters



- Percentage of runners using different means of transportation

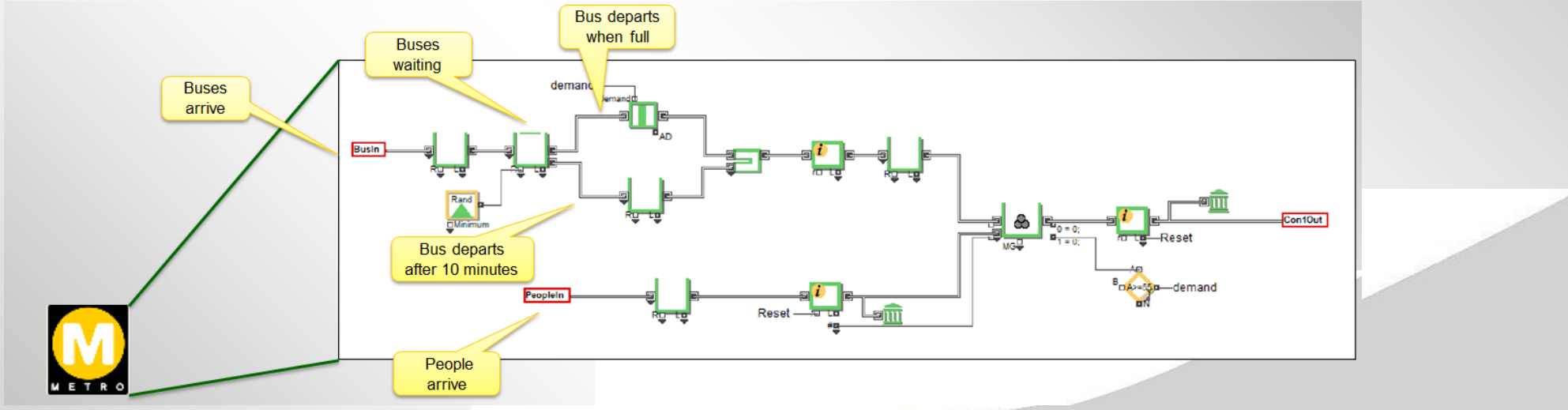


Model Topology



Main Logic Implemented

- People and vehicle inter-arrival time
  - ➢ Derived from available data
- Bus departure condition
  - ➢ Every 10 minutes or when full (55 people)



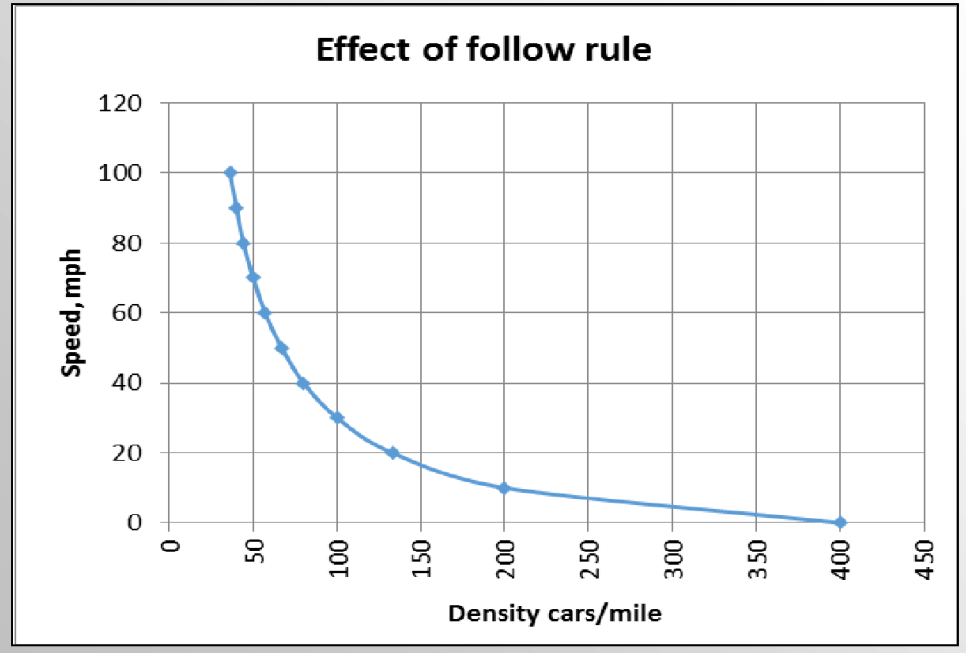
- Traffic delay – details in next 3 slides

Traffic Logic – 'Follow Rule'

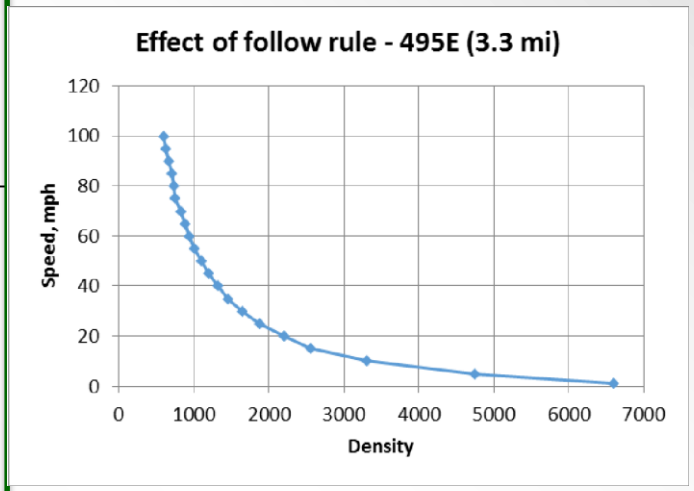
- **Question:** How long does it take to drive from point A to point B?
- **Parameters of interest:** Number of vehicles at different hours on Friday & Saturday, Road maximum capacity, Number of cars at any point in time during the MCM event
- **Roads of interest:** 495E, 495S, and National Harbor Blvd

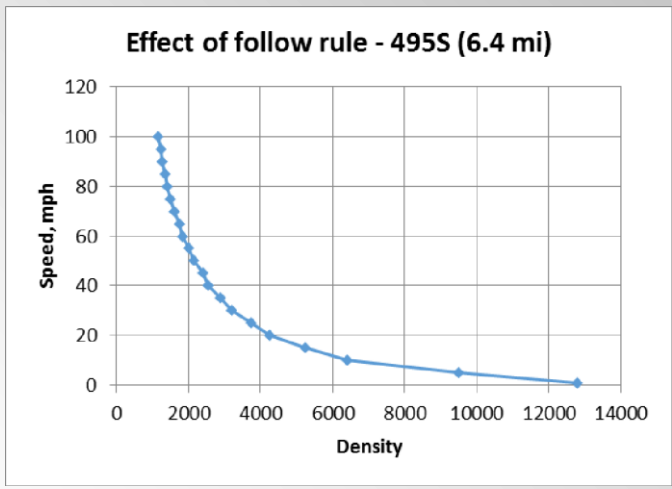
"Exploring Engineering, 2nd Edition, Chapter 13, Kinematics Engineer"

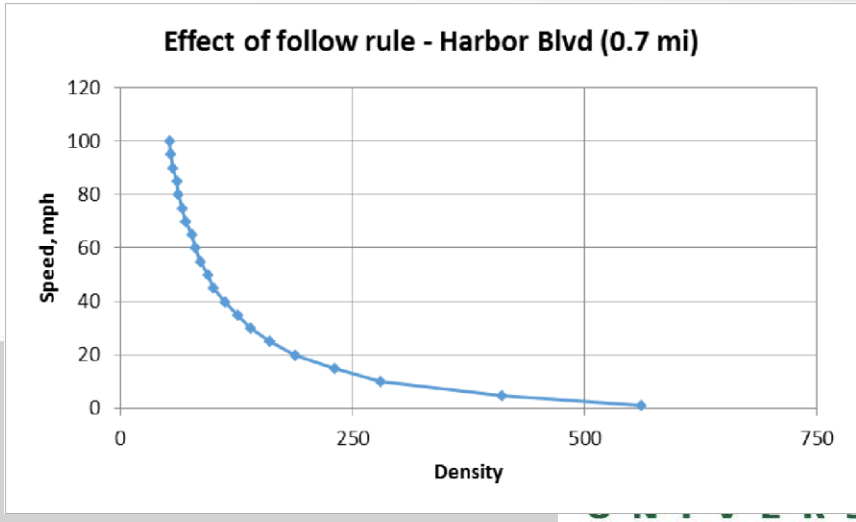
- Follow Rule: Number of car lengths between cars = speed (mph) / 10 (mph)



Follow Rule can be derived for 495E, 495S, and Harbor Blvd

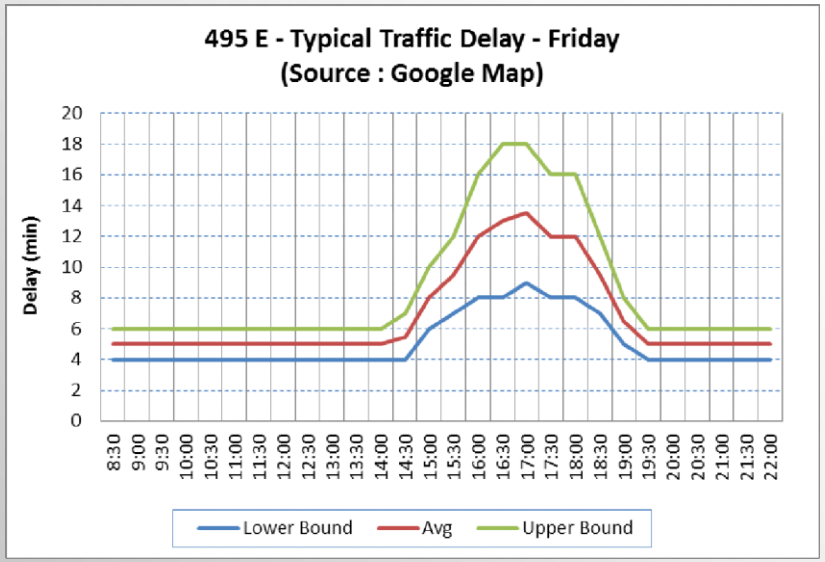


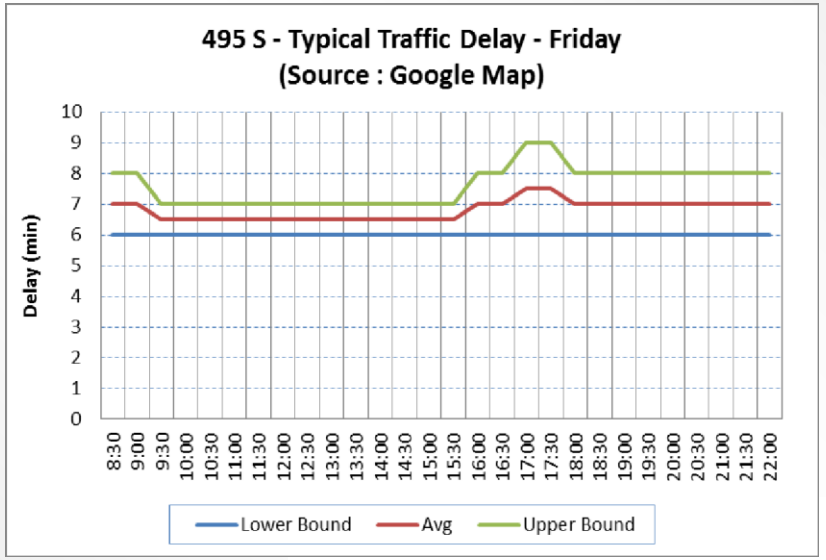


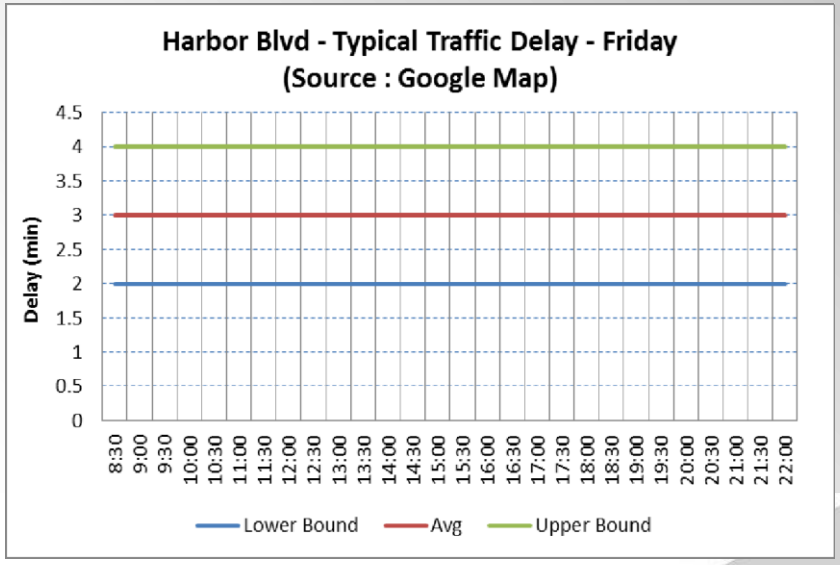


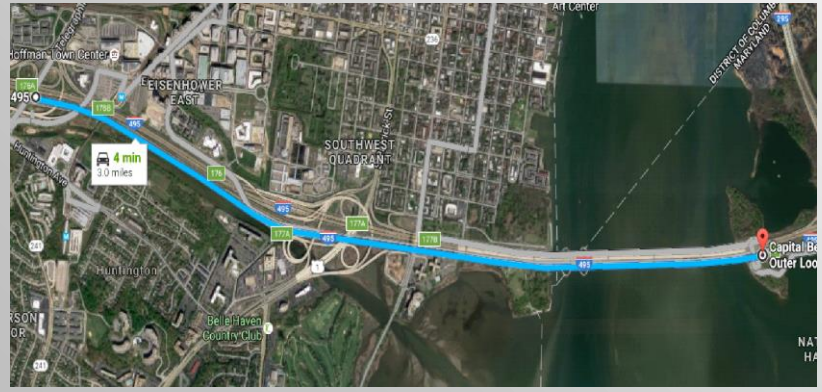
Traffic Logic – Typical Traffic Delay & Density

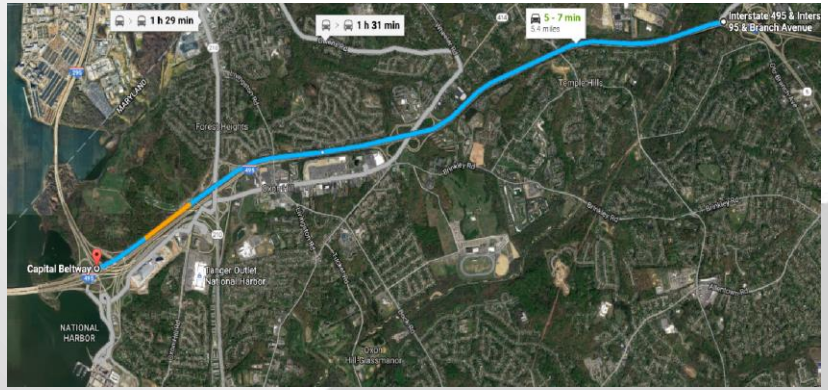
- **Parameters of interest:** Typical road delay on Friday & Saturday → Typical road density
- **Roads of interest:** 495E, 495S, and National Harbor Blvd

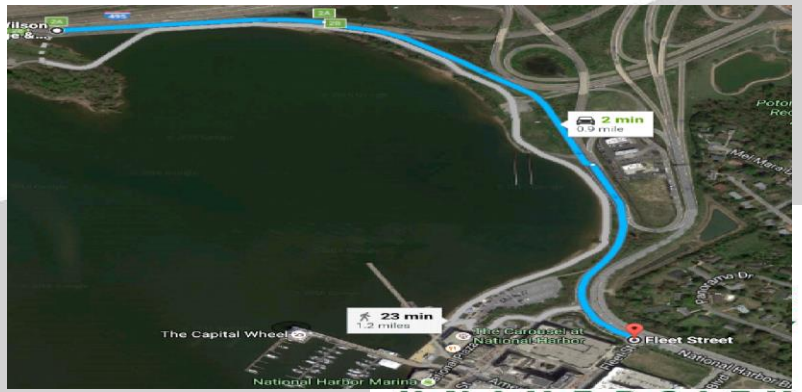










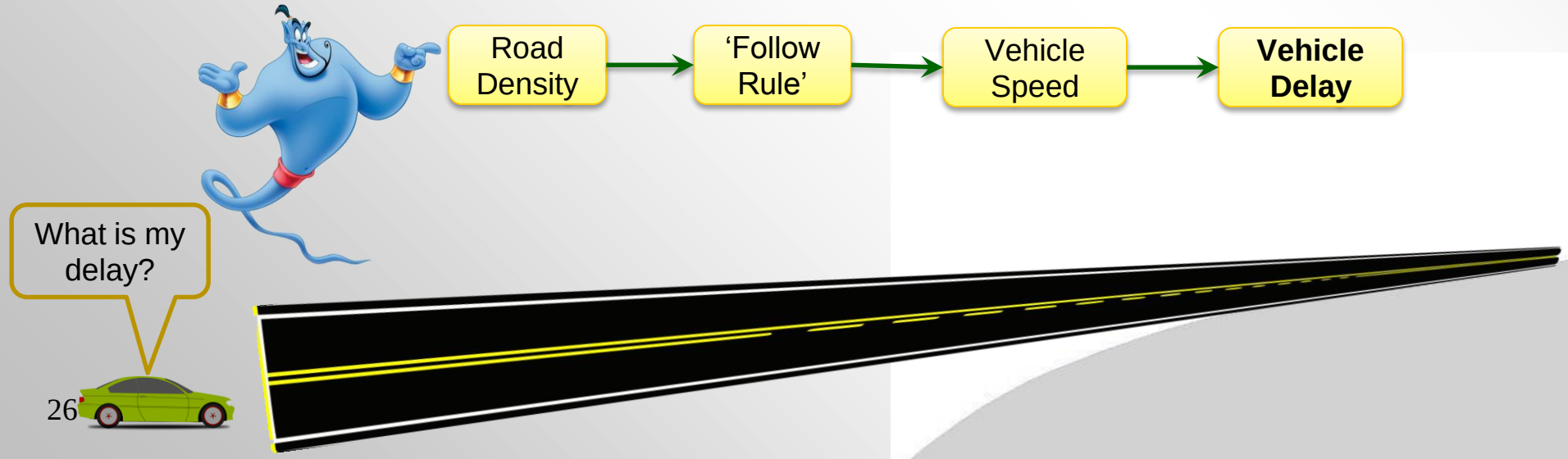


Traffic Logic – Model Algorithm

As a vehicle enters any of the modeled roads, the model will:

- Capture the road density
- Map against the Effect of Follow rule to determine vehicle speed
- Calculate vehicle Delay Time

Every hour, the model will initialize typical traffic on each road.



Simulation Results

- Metrics captured by the model:
  - Attendees arrival time
  - Road density – 495E, 495S, Harbor Blvd
  - Number of people riding on each bus
  - People travel time – including delay on 495E, 495S, and National Harbor Blvd
  - People dwell time

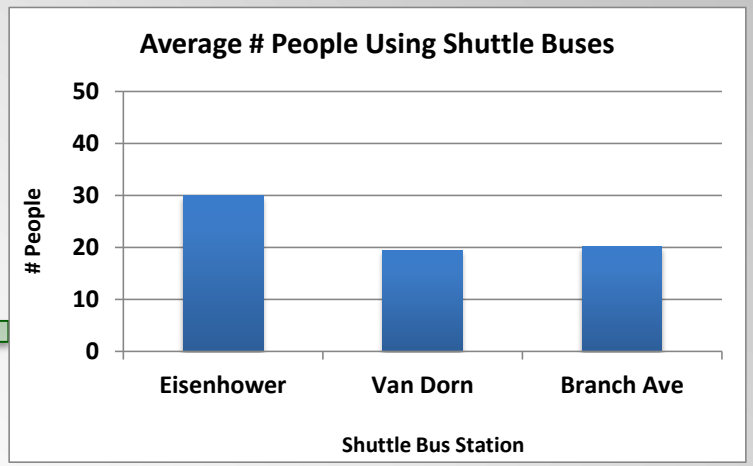
- People travel time and Shuttle bus data are analyzed

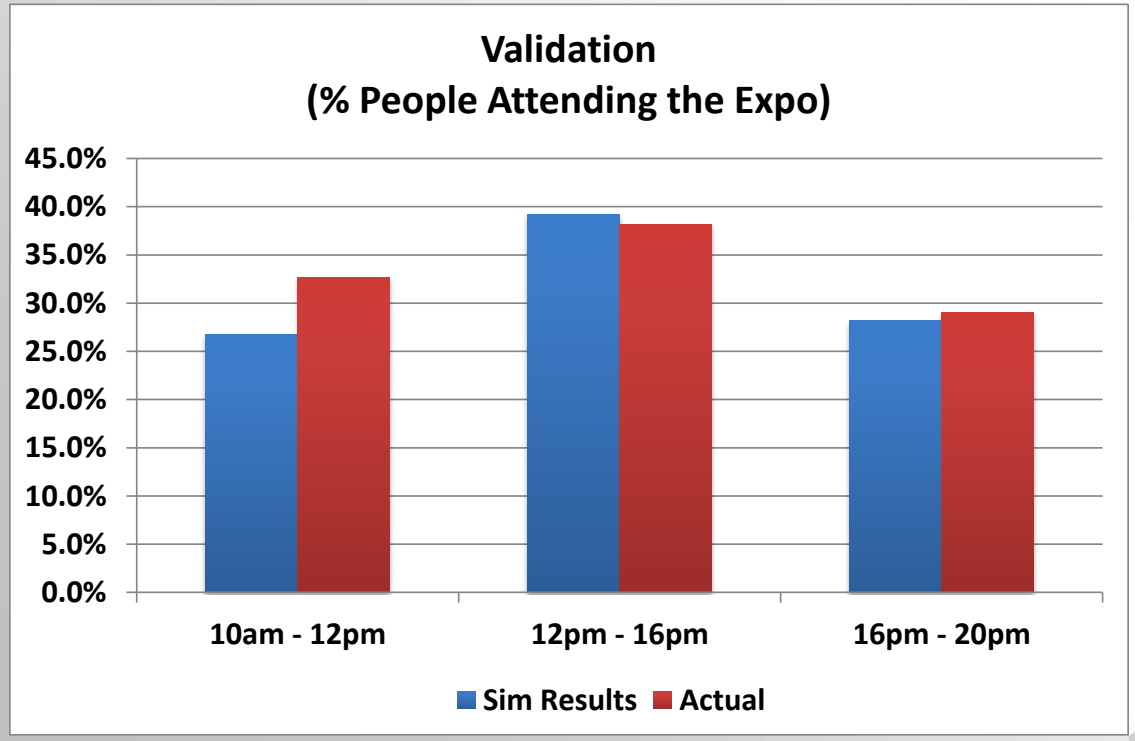
	People Travel Time			
Transportation	**Mean**	**Standard Dev**	**Confident Interval**	**Relative Error**
Car	39.21	3.47	0.99	0.03
Eisenhower	45.73	6.15	1.75	0.04
Van Dorn	45.85	5.52	1.57	0.03
Branch Ave	41.79	3.56	1.1	0.02
Water Taxi	98.71	1.74	0.49	0.01
Ride Share	40.51	5.1	1.45	0.04
Overall	41.85	4.15	1.18	0.03

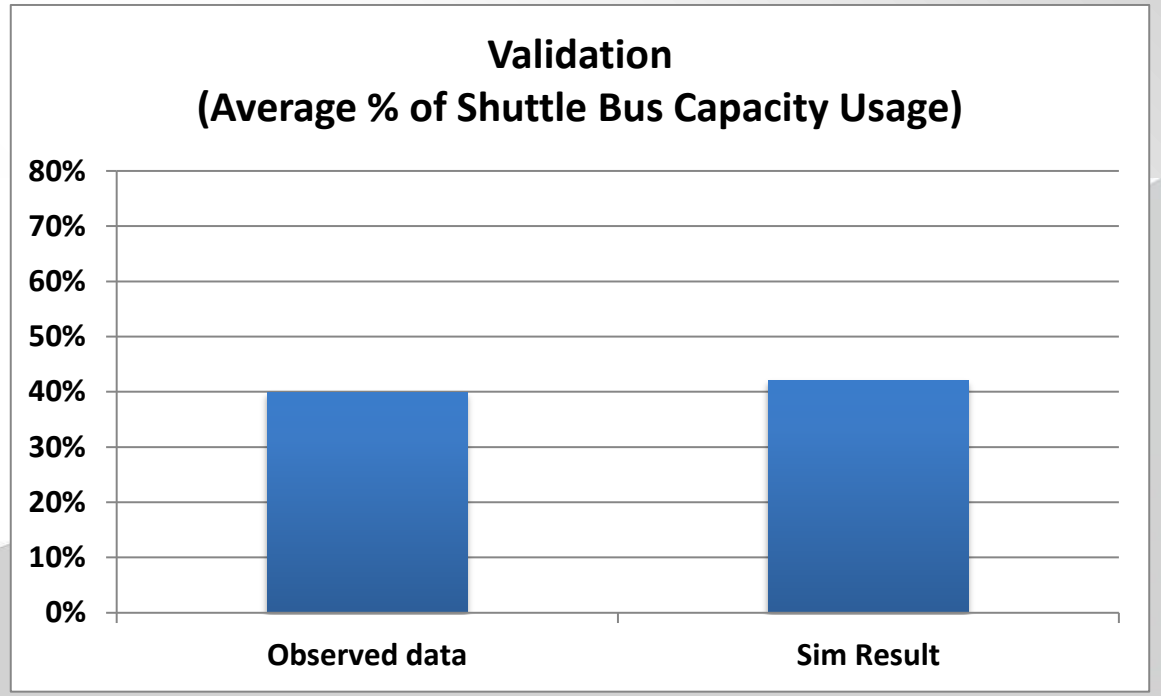
Baseline of People travel time utilize different means of transportation based on 50 iterations & 95% CI

Validation

- The data is not available for full validation
- Able to validate the following (based on limited data):
  - Percent of people attending the expo
  - Average percentage of shuttle bus capacity usage

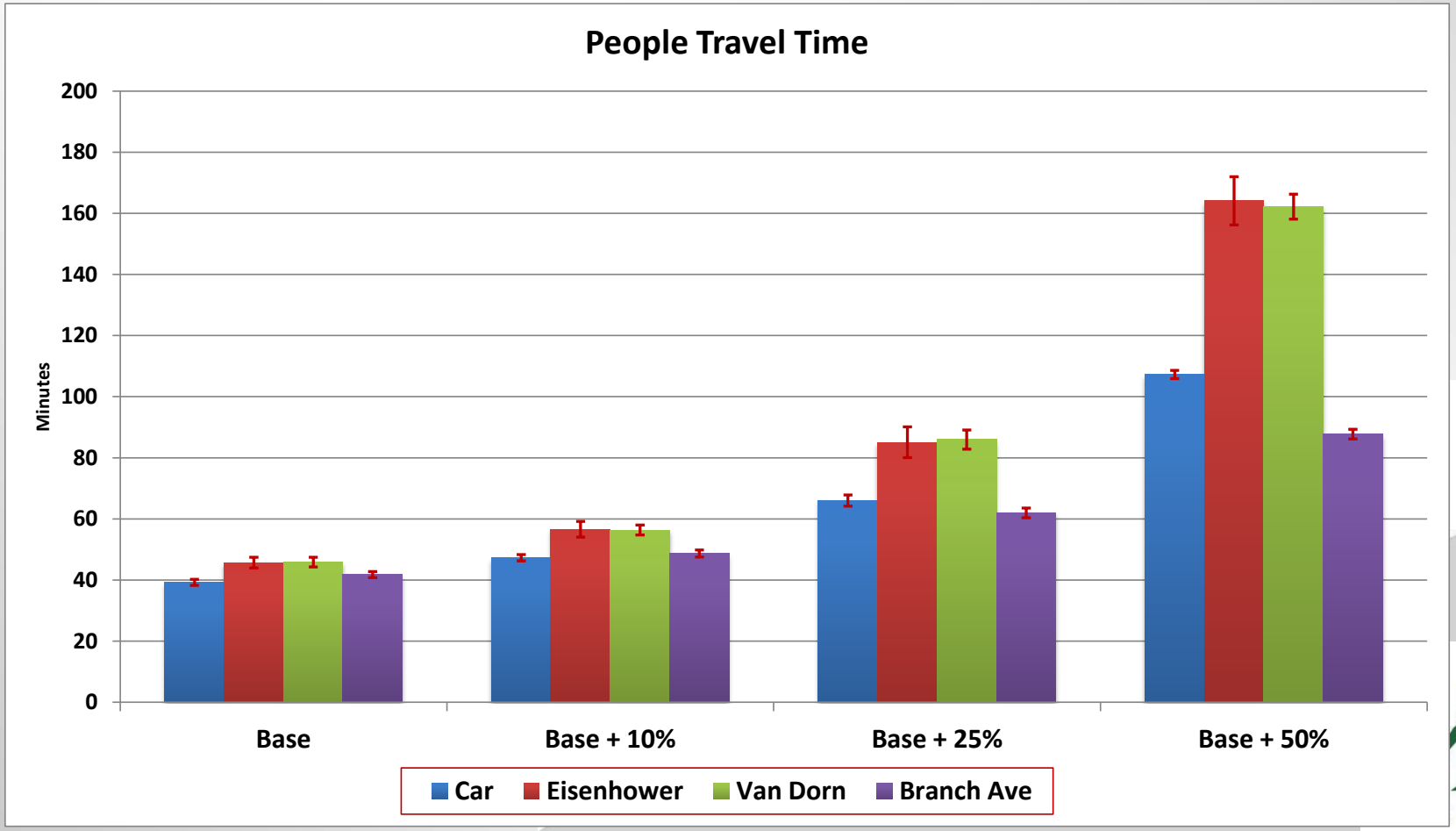






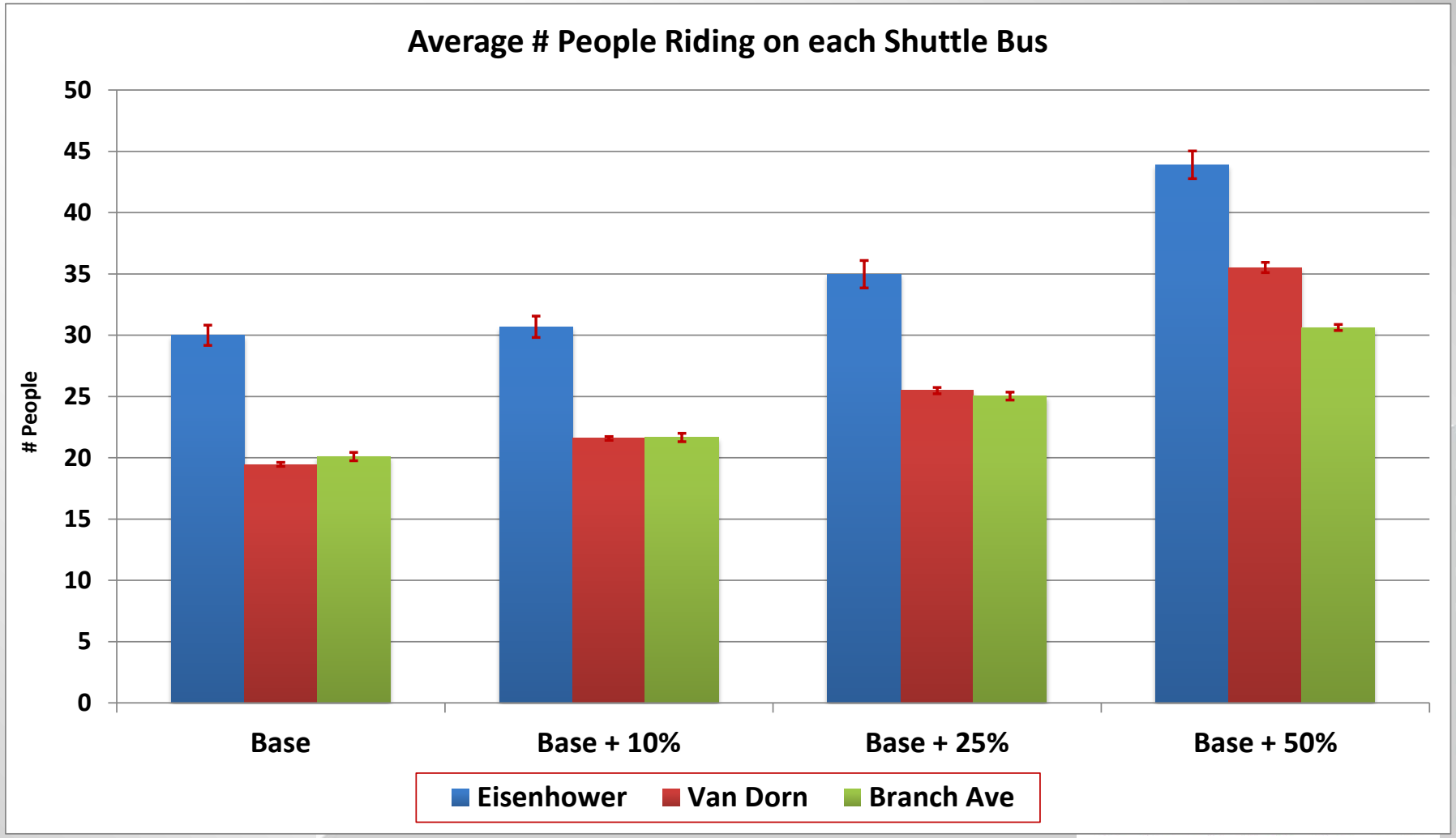
What-if Analysis – People Travel Time

- Increase number of people by 10%, 25%, and 50%
- At 50% increase, travel time increases significantly at Eisenhower and Van Dorn



What-if Analysis – People Riding Buses

- Eisenhower shuttle bus appears to have the highest usage



VB Script

- Calculate the average of each half hour period
- Calculate the average travel time for each vehicle type
- Calculate standard deviation
- Find number of scenarios required to run

Conclusion

- Number of shuttle buses provided by MCMO can support up to 50% increase of attendees assuming the percentage of people using shuttle buses stay the same
- Travel time increases exponentially with the number of attendees
- At 50% expected attendee increase, the travel time begins to reach the maximum travel time (3 hours) allowed by the MCMO

Future Work - Validation, What-If & MGM

Once the MCMO releases the data, the model can be further validated to give us an idea of the accuracy of the model.

Post Validation:

- The MGM Casino can be added into the model
- "What If" scenarios can be run to show the impact of different attendee behavior
- If a vehicular accident occurs, it will fall into two categories:
  - A short delay (delay)
  - A large delay (shutdown)
- Arrival by shuttle bus (NH1, NH2)

Questions?