RWR 4015

Traffic Simulation for Planning Applications

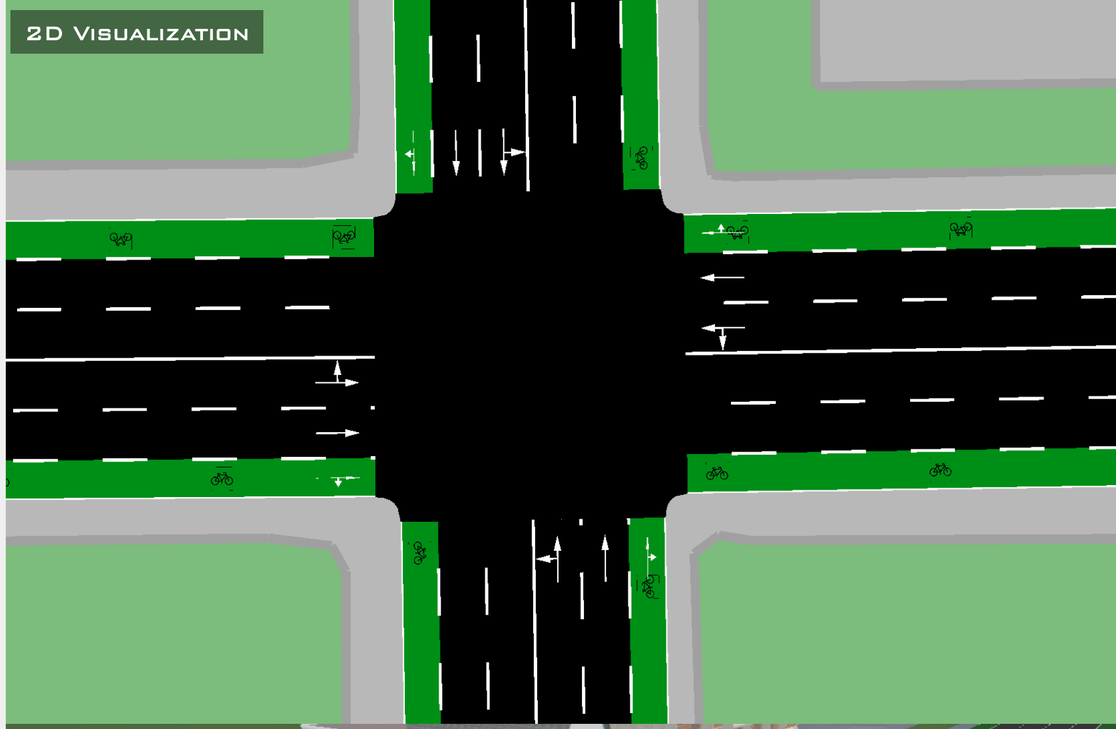
Dr. Ahmad Mohammadi

Week 1 | Lecture:
Introduction to Traffic Simulation

Fall 2026

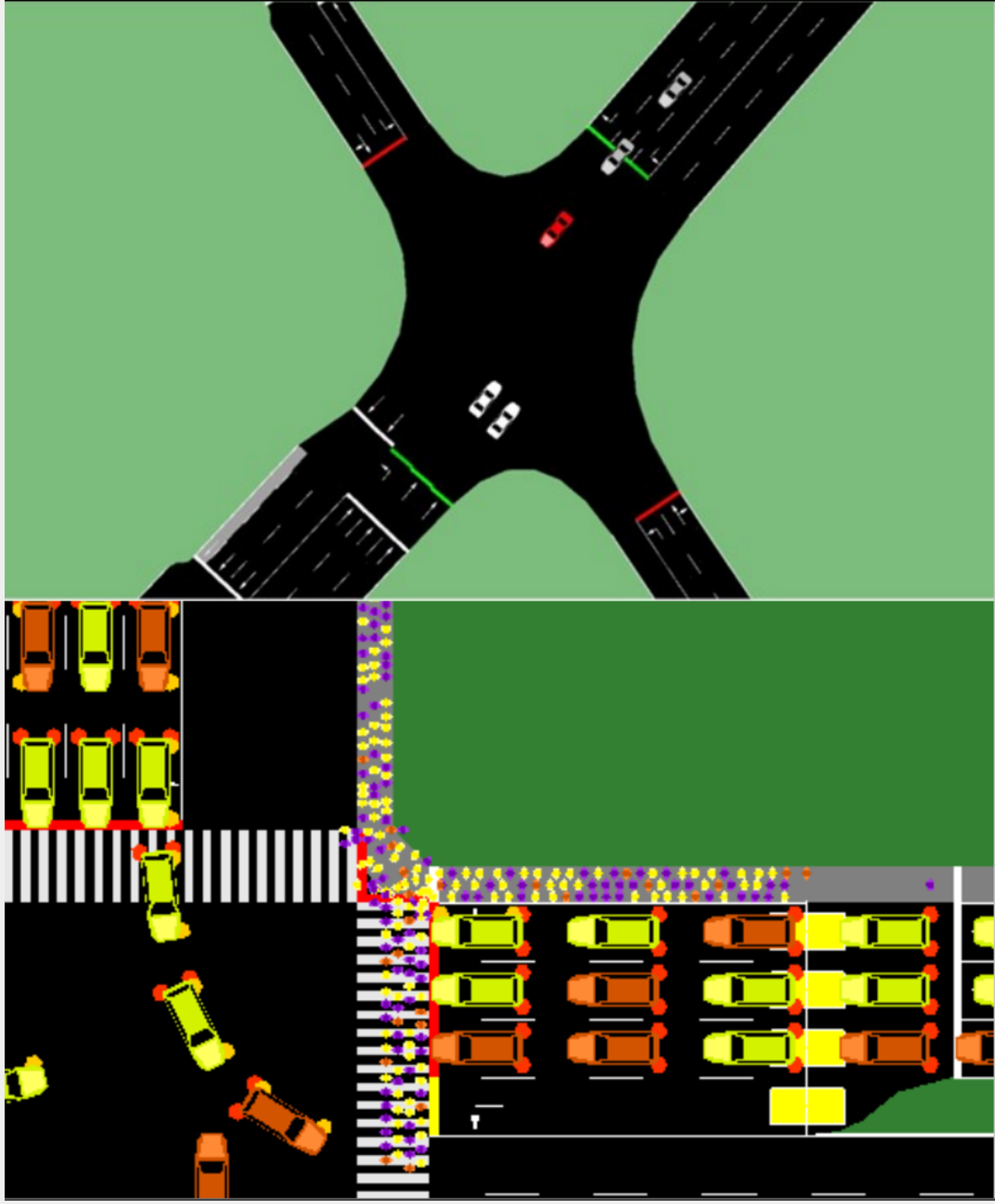
RoadwayVR

roadwayvr.github.io/TrafficSimulationforPlanningApplications



Agenda

- ❑ What is traffic simulation?
- ❑ The purpose of traffic simulation
- ❑ Examples of traffic simulation studies
- ❑ Course description



Traffic in Different Cities

2024 Impact Rank (2023 Rank)	Urban Area	Country	2024 Delay per Driver (hours)	2023 Delay per Driver (hours)	Change from 2023	Downtown Speed (mph)
1 (6)	Istanbul	TUR	105	91	15%	15
2 (1)	New York City NY	USA	102	101	1%	13
3 (5)	Chicago IL	USA	102	96	6%	14
4 (2)	Mexico City	MEX	97	96	1%	13
5 (3)	London	GBR	101	99	2%	13
6 (4)	Paris	FRA	97	97	0%	13
7 (10)	Jakarta	IDN	89	65	37%	13
8 (7)	Los Angeles CA	USA	88	89	-1%	22
9 (9)	Cape Town	ZAF	94	83	13%	14
10 (12)	Brisbane	AUS	84	74	14%	21
11 (14)	Bangkok	THA	74	63	17%	16
12 (8)	Boston MA	USA	79	88	-10%	13
13 (13)	Philadelphia PA	USA	77	69	12%	14
14 (11)	Miami FL	USA	74	70	6%	20
15 (16)	Dublin	IRL	81	72	13%	15
16 (15)	Rome	ITA	71	69	3%	15
17 (19)	Houston TX	USA	66	62	6%	17
18 (20)	Brussels	BEL	74	68	9%	12
19 (21)	Atlanta GA	USA	65	61	7%	18
20 (28)	Warsaw	POL	70	61	15%	17
21 (22)	Melbourne	AUS	65	62	5%	18
22 (18)	Washington DC	USA	62	63	-2%	12
23 (27)	Seattle WA	USA	63	58	9%	18
24 (25)	Milan	ITA	64	60	7%	18
25 (17)	Toronto ON	CAN	61	63	-3%	13

https://ftnnews.com/wp-content/uploads/2025/01/INRIX_2024_Global_Traffic_Scorecard.pdf

What is Traffic Simulation?

- A computer-based model that imitates how traffic moves and interacts on a road network over time, allowing “what-if” testing of changes (signals, lanes, demand) without affecting real traffic.

Watch the Video

https://youtu.be/CQV4e2ZA8h0

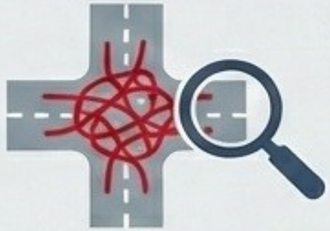
Why Traffic Simulation?

WHY TRAFFIC SIMULATION?

01 UNDERSTAND SYSTEM PERFORMANCE

Analyze current & future network performance, including potential improvements.

02 MODEL COMPLEX CONGESTION



Analyze complex systems under congested conditions where analytical methods fail.

03 CAPTURE DETAILED INTERACTIONS

Evaluate interactions like queue spillback, weaving, and merging behaviors.

04 VISUALIZATION FOR COMMUNICATION

Use animated flows for public outreach and stakeholder presentations.

05 CONSIDER ALL MODES

Assess impacts on general traffic, transit, and pedestrians for multimodal effects.

06 SUPPORT PLANNING & INVESTMENT

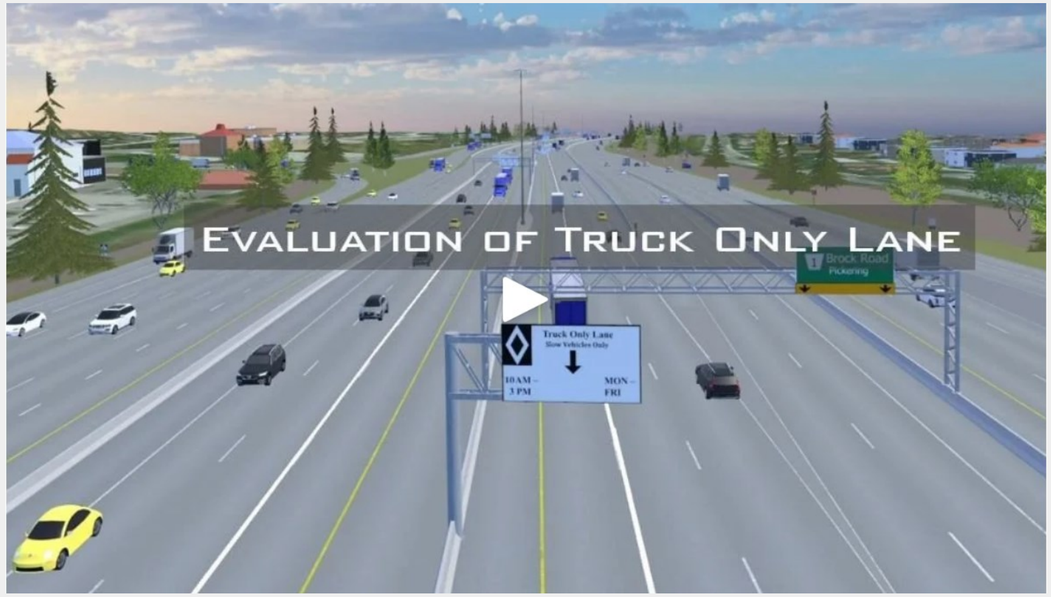
Inform decisions on signals, freeway operations, ITS strategies, and more.

Purpose of Traffic Simulation

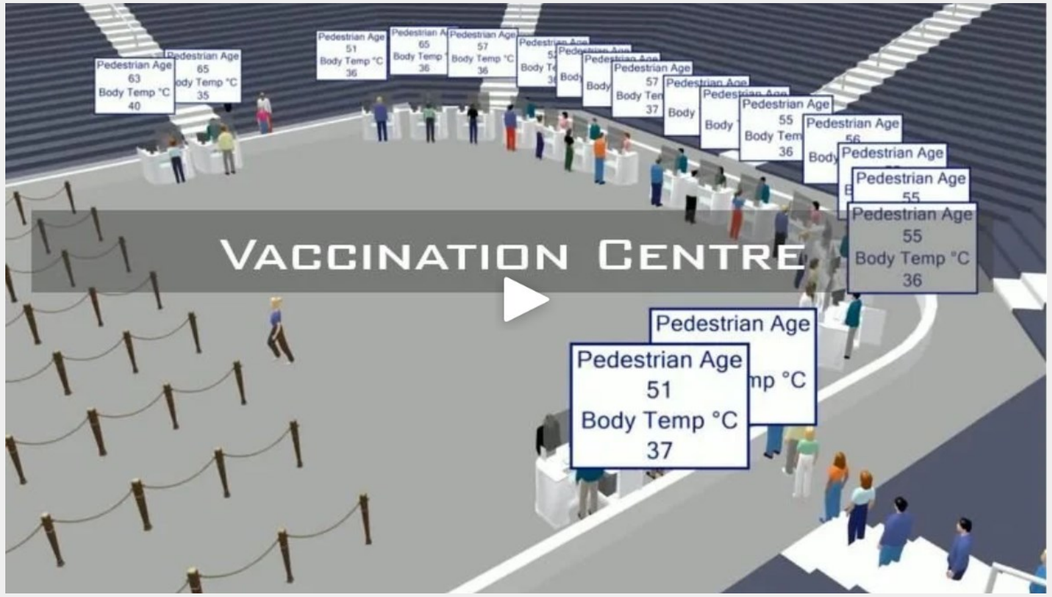
Traffic simulation helps us to:

1. Design and compare alternatives (lanes, geometry, signal plans) before real-world changes
2. Understand traffic dynamics (queues, spillback, bottlenecks, merging/weaving) over time
3. Assess new strategies and technologies (ITS, transit priority, CAV concepts, work zones) safely
4. Optimize operations (signal timing, coordination, ramp metering, lane management) to improve performance

I. Design and Compare Alternatives?



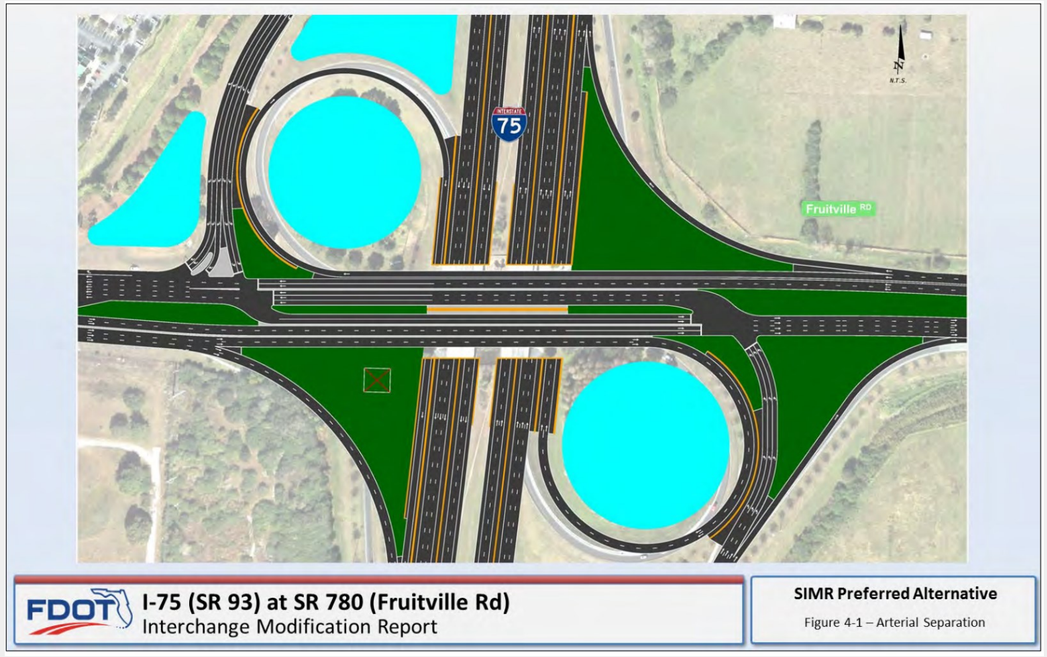
https://www.youtube.com/watch?v=rEOmc2tJ9WY

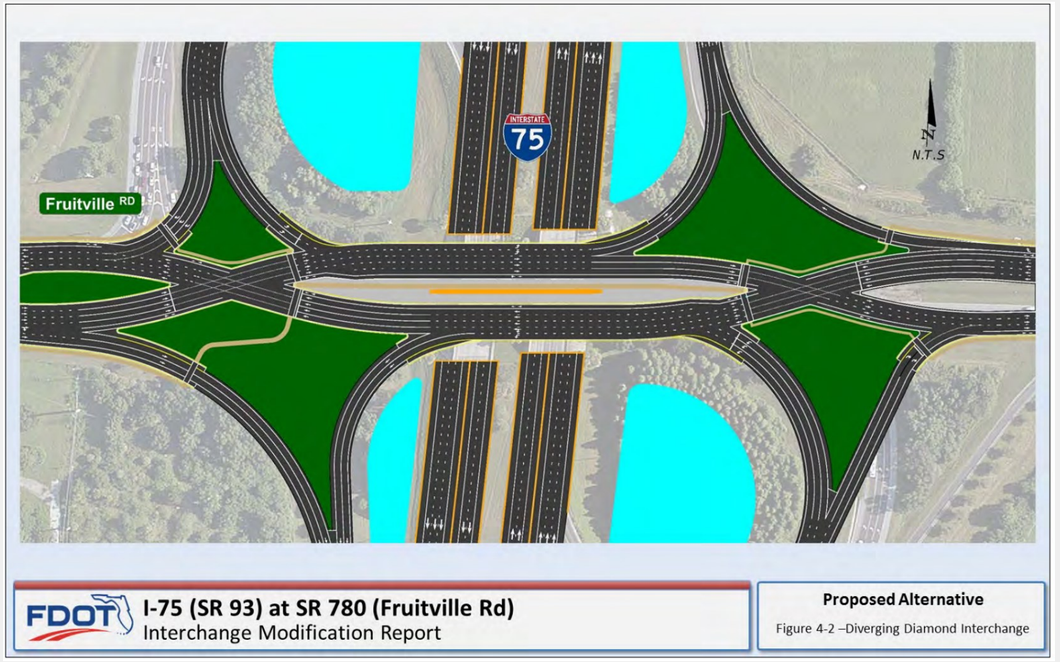


https://www.youtube.com/watch?v=Z5ep9H5cPZE

I. Design and Compare Alternatives?

- ❑ **Which design layout is the best for less congestion in now and 20 years later?**





https://www.swflroads.com/project-files/112/I-75%20at%20Fruitville%20Rd.%20Interchange%20-%20Final%20Interchange%20Modification%20Report.pdf

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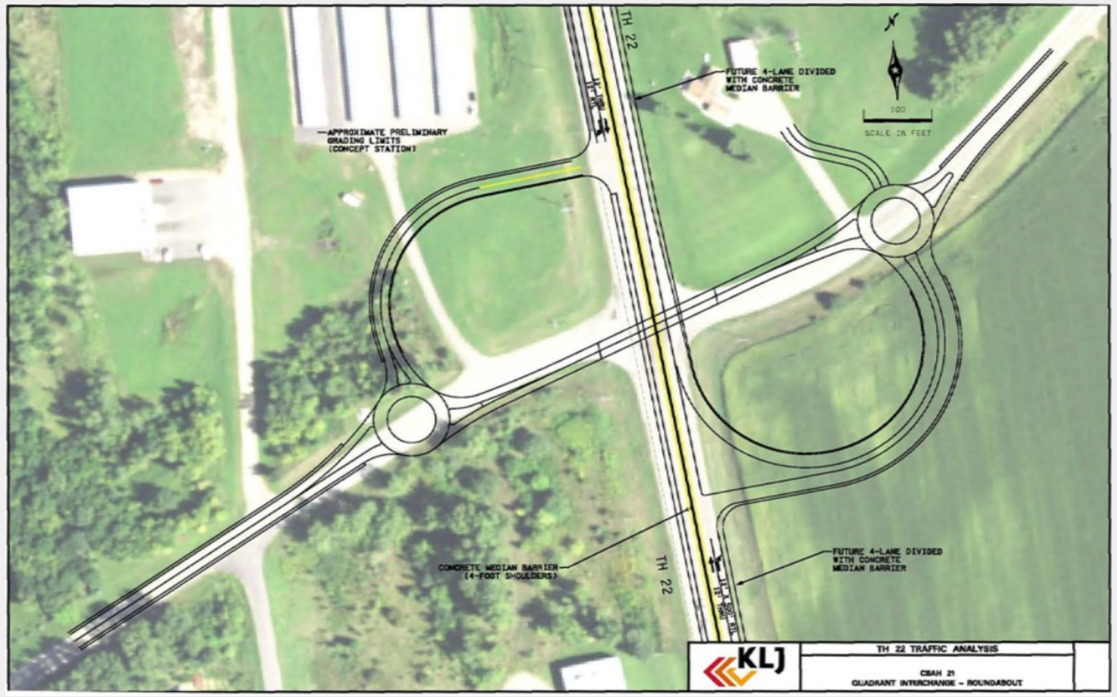
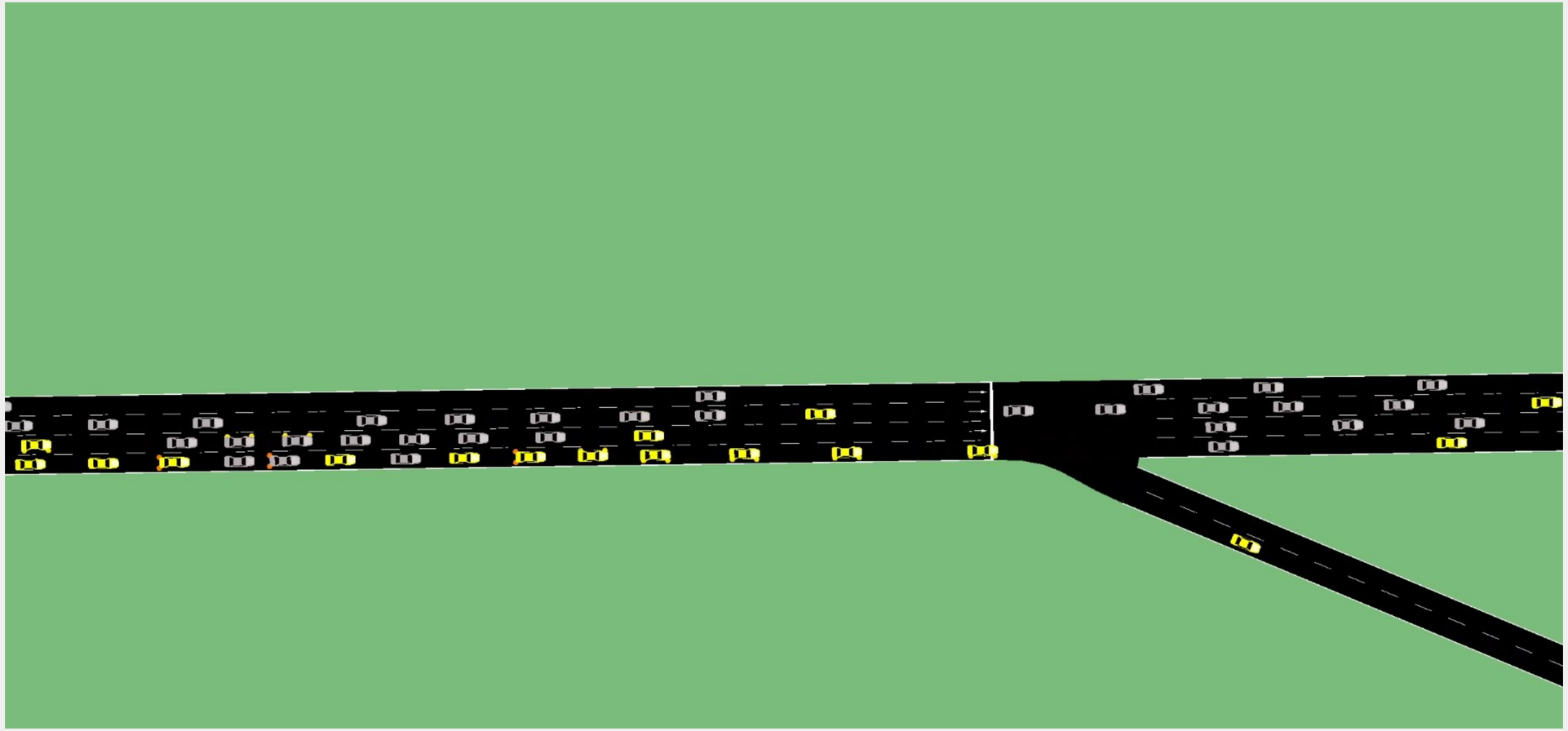


https://kljeng.com/featured-projects/th-22-st-peter-east-mankato-mn-corridor-study#:~:text=The%20study%20broke%20from%20traffic,evaluated%20options%20for%20passing%20lanes

II. Understand Traffic Dynamic?



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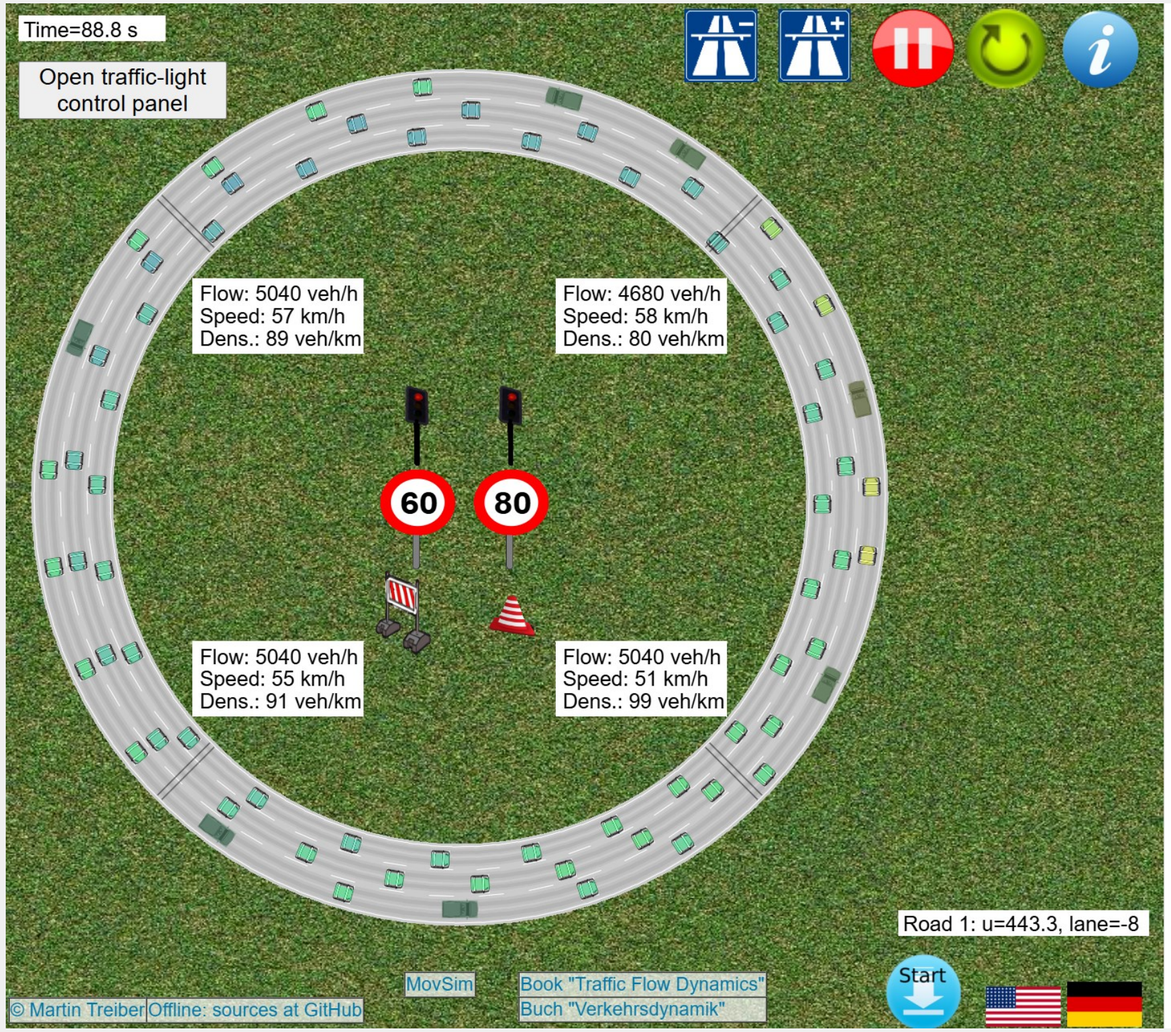
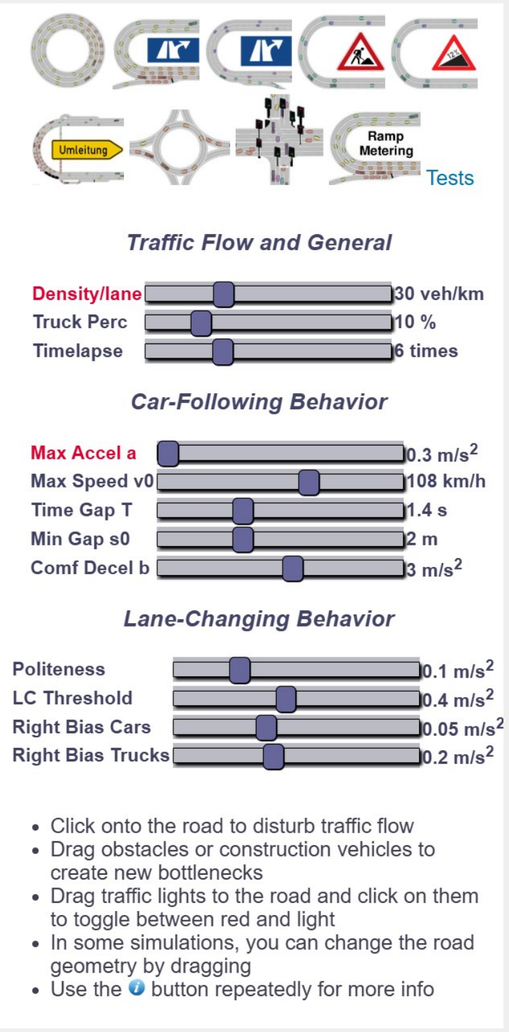
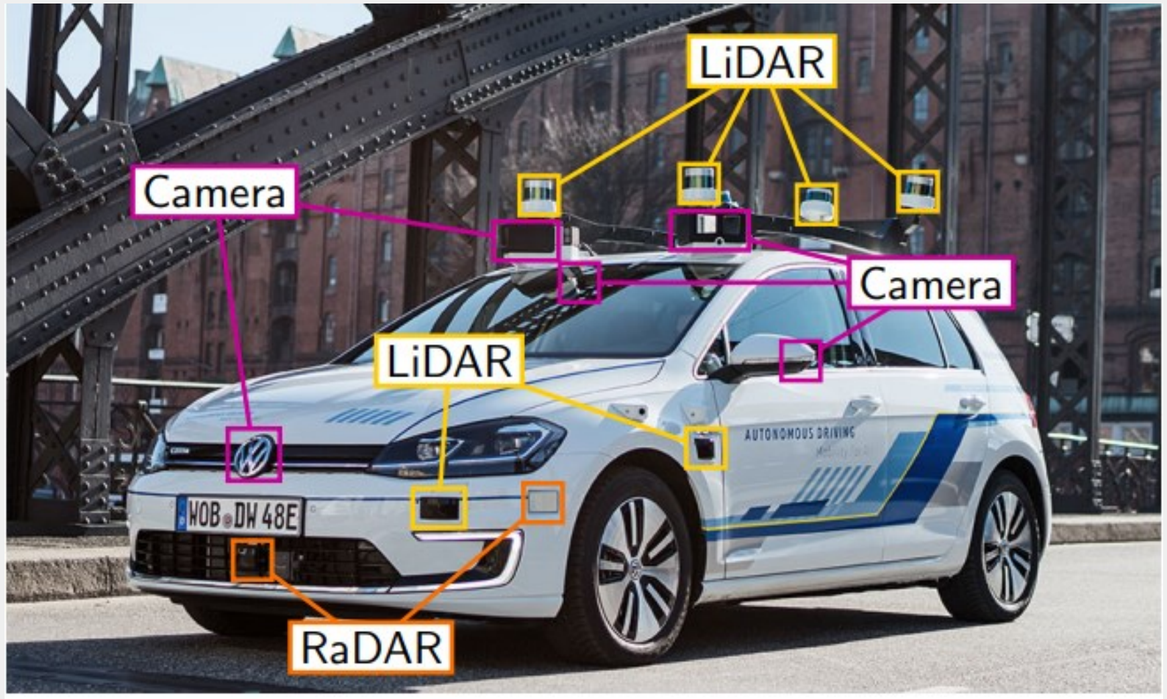




https://traffic-simulation.de/ring.html

III. Assess New Strategies and Technologies

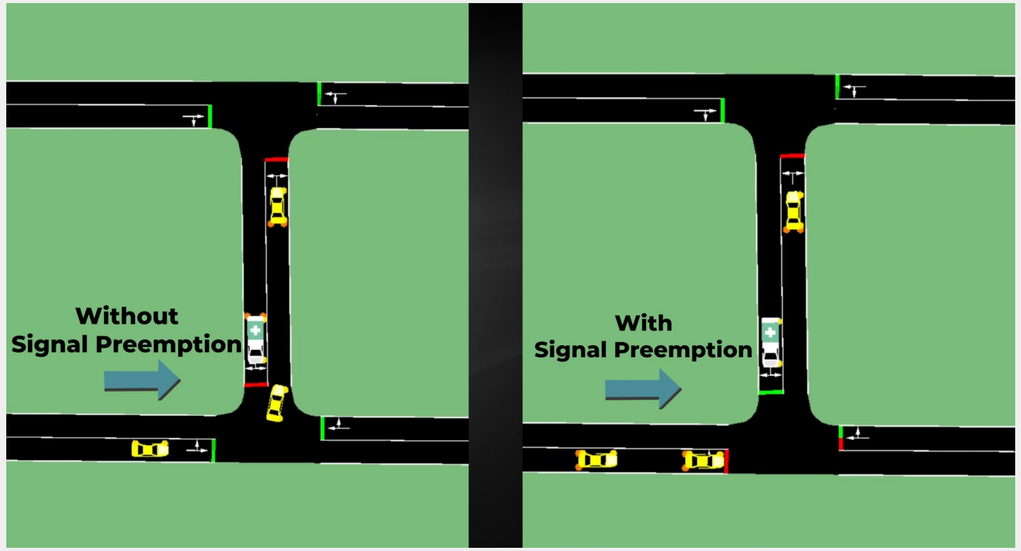
❑ **Autonomous Vehicle (AV) Without Connectivity:** Vehicles rely purely on their onboard sensors (for example, radar, Lidar, camera) and artificial intelligence algorithms to handle tasks like steering, braking/acceleration etc.



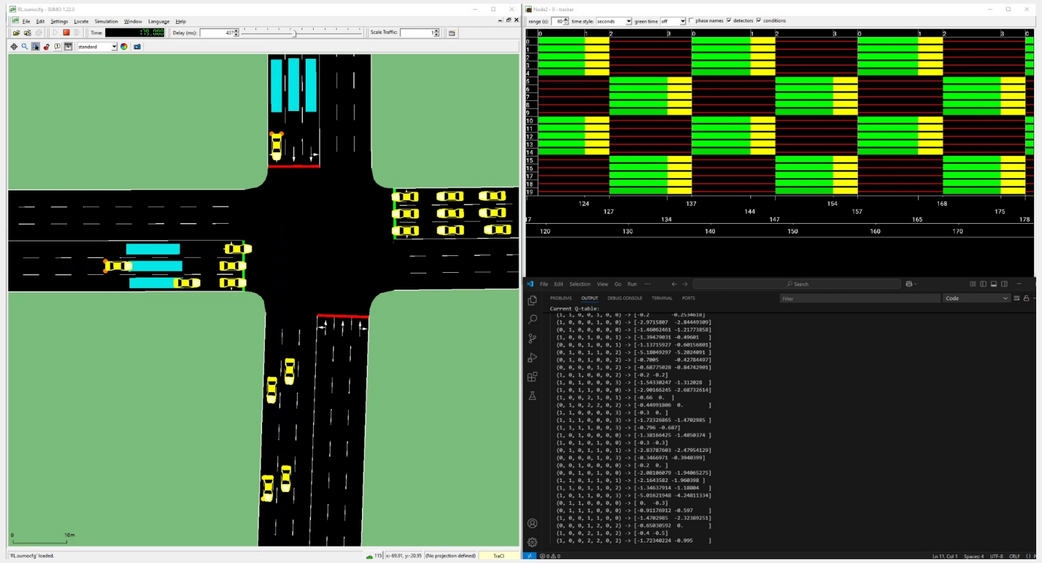
Reference: Bar, A., Lohdefink, J., Kapoor, N., Varghese, S. J., Huger, F., Schlicht, P., & Fingscheidt, T. (2020). The vulnerability of semantic segmentation networks to adversarial attacks in autonomous driving: Enhancing extensive environment sensing. *IEEE Signal Processing Magazine*, *38*(1), 42-52.

IV. Optimize Operations

1. Traffic Signal Priority

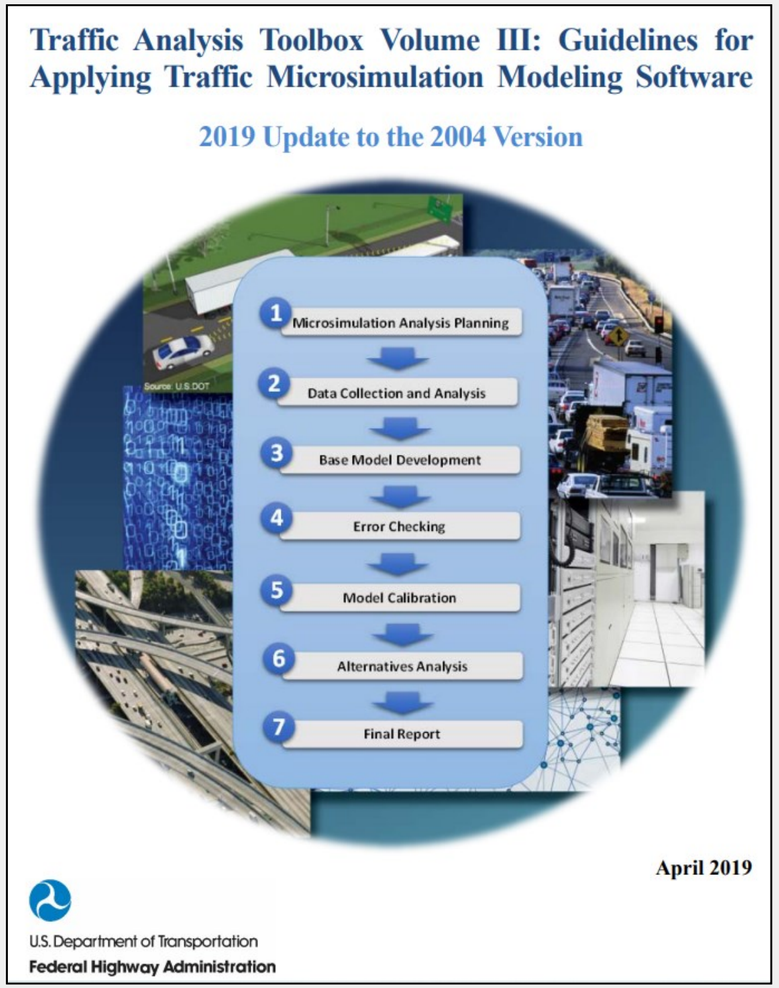


2. Intelligent Traffic Signal



IV. Optimize Operations

Cities Developed Traffic Simulation Guidelines



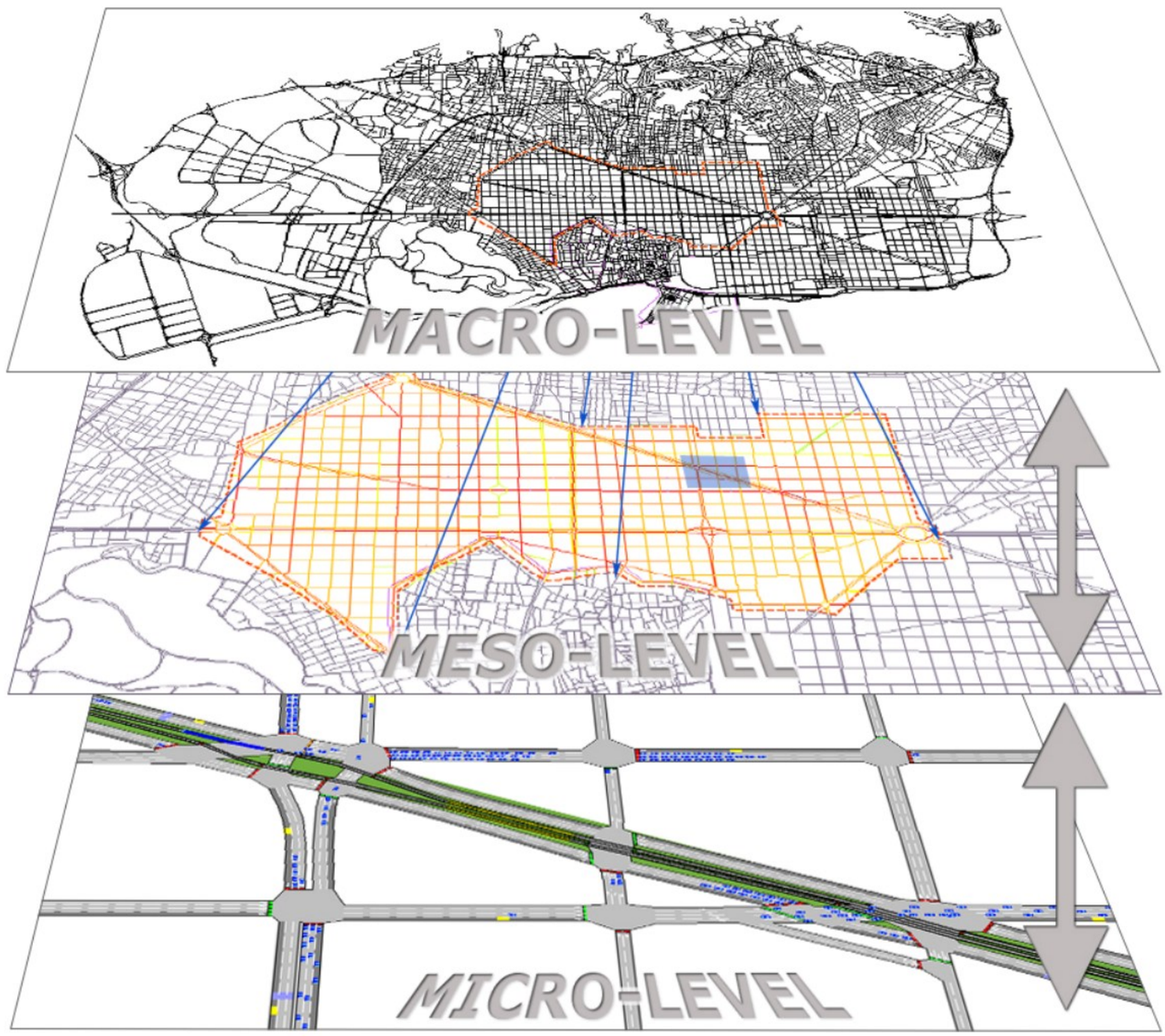
Reference link:
https://ops.fhwa.dot.gov/publications/fhwahop18036/fhwahop18036.pdf

Traffic Modelling

Macroscopic: Traffic as aggregate flow

Mesoscopic: Groups/packets

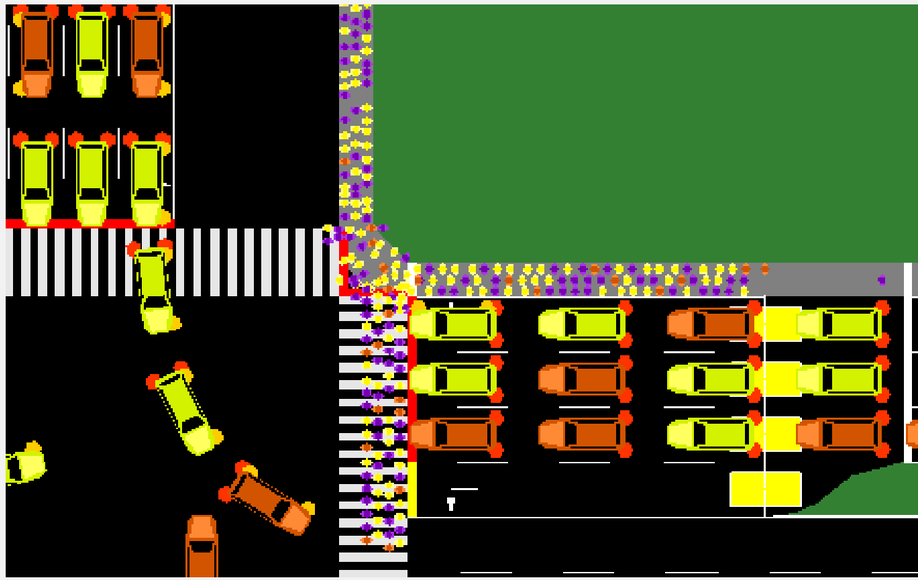
Microscopic: Individual vehicles



Barceló, J., Casas, J., García, D., & Perarnau, J. (2005, May). Methodological notes on combining macro, meso and micro models for transportation analysis. In *Workshop on Modeling and Simulation* (pp. 1-40).

Simulation of Urban Mobility (SUMO)

- ❑ SUMO: Traffic Simulation
- ❑ Open Source and Free to Everyone
- ❑ Designed Vehicle Characteristics, Car Following Model, Lane Changing Model
- ❑ Includes Passenger Cars, Trucks, Public Transport, Bicycle, and Train
- ❑ Include Traffic Signal Scheduling



In-class Deliverables

- A total of 5 In-class Deliverables will need to be submitted through course website (submission date is fixed).

- In-class Deliverables is mandatory! If you don’t submit one or more of the design lab report, you will lose 15% (out of 100%)

Course Textbook

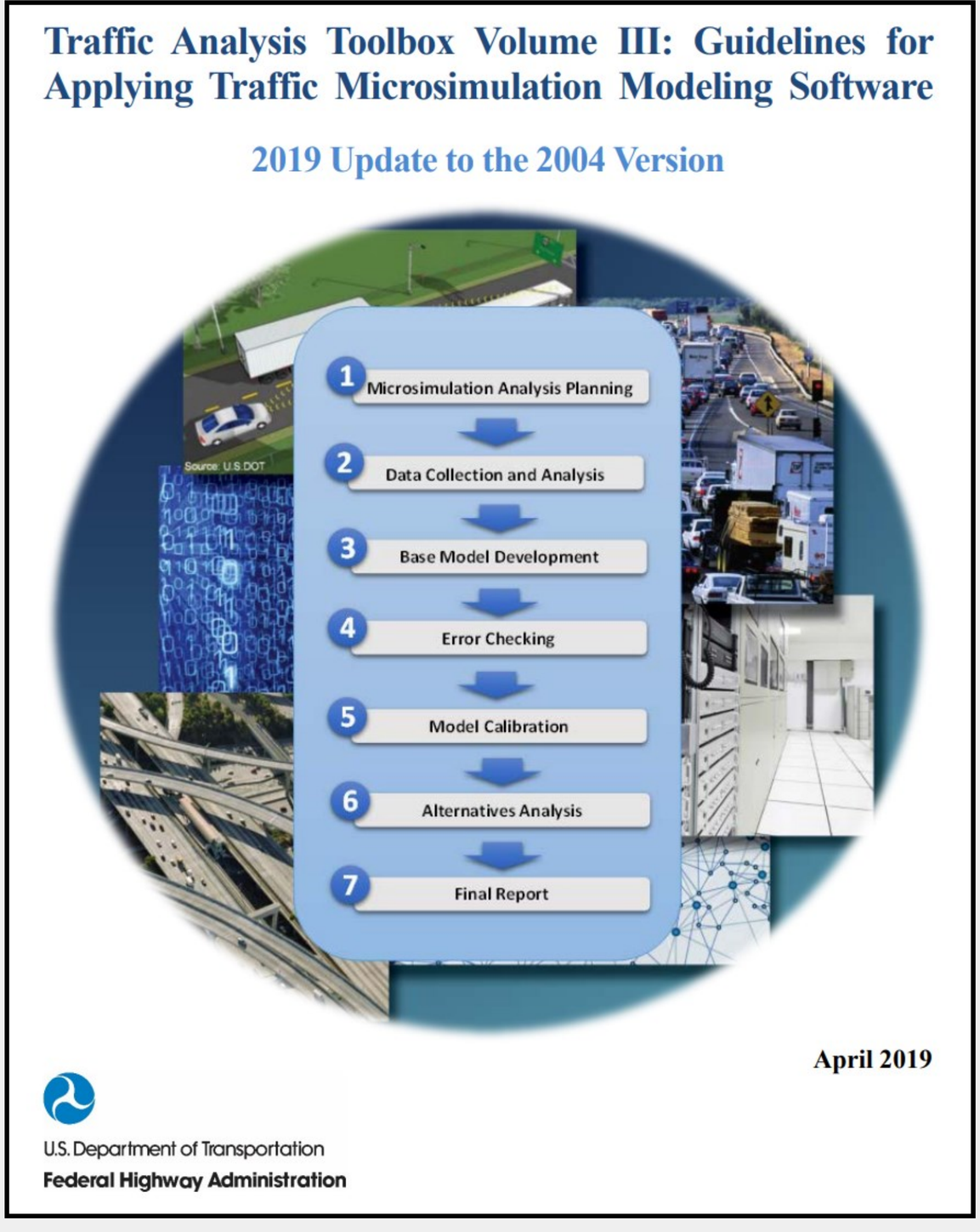
- ❑ **No Designated textbook:**
- ❑ **Lecture notes & other needed materials will be posted on the course website**

Course References:

Wunderlich, K., Vasudevan, M., & Wang, P. (2019). Traffic analysis toolbox... (FHWA-HOP-18-036). FHWA. Access:

PDF:

https://ops.fhwa.dot.gov/publications/fhwahop18036/fhwahop18036.pdf



Overview of Course Syllabus - Course Website

- ❑ All the materials are on the below website

Instructor

- Ahmad Mohammadi
- PhD & Postdoctoral Fellow, Transportation Engineering
- MSc & BSc in Industrial & Systems Engineering
- Creator of Roadway VR Course Hub
- **Email:** AhmadMohammadi1441@gmail.com

Grading Scheme

Activity	Type	Frequency	Weight	What It Evaluates
Class participation	Participation	Weekly	5%	Active engagement, peer learning, professional communication
In-class deliverables	Progressive	Weekly	15%	Technical skills application, immediate feedback on modeling
Transportation news brief presentation	Communication	Once per student	10%	Ability to analyze current events and present to peers
Assignments	Practice	Throughout term	10%	Concept reinforcement, preparation for midterm
Midterm examination (paper-based)	Summative	Week 8	25%	Conceptual understanding, calibration reasoning without software
Design project	Applied Project	Cumulative	35%	End-to-end planning workflow, professional deliverables

Periodic Evaluation

- ❑ Each student needs to present once about a news on transportation problems at the start of class
- ❑ This will be scheduled

Design Project

- Group project (three/four students in a group).
- You will evaluate the contribution of yourself and other group members twice.
- This means that there is a possibility that each student in a group can obtain different scores associated with design lab submissions.

Assignments

- There are three Assignments in overall.
- Submissions are to be delivered on time.
- Grade for a late submission will be deducted 20% per day late. Accommodations may be made on a case by case with valid reasons (illness, etc.).
- Nonetheless, if the solutions are posted online or reviewed in virtual class, late submissions will no longer be accepted.

Exam

- **Exam:**
  - **One Midterm examination**
  - **Midterm Date/Time/Room:**

    October 19th (Tue)/11:30am-01:00pm
  - **The exam will be open notes/references exam.**

Missed Exam

- Students who missed midterm test will require a valid reason and appropriate documentation (such as doctor’s note for illness) to arrange a possible deferred exam.
- Arrangements can be made on a case by case basis
- Further accommodations will be possible through a formal petition to the Faculty