# Automated Vehicle Monitoring and Human-Vehicle Communication

FORUM MobiliT.AI

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CIRRELT

# Outline

The Safety of Automated Vehicles

Human-Vehicle Communication

Conclusion

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# Why Automating Road Vehicles?

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- 1.35 million people die each year on the world's roads
- millions more are severely injured
- 54 % of those dying on the world's roads are vulnerable road users

(Road Traffic Injuries, World Health Organization)

# Why Automating Road Vehicles?

$\approx$ 95 % of accidents involve human factors

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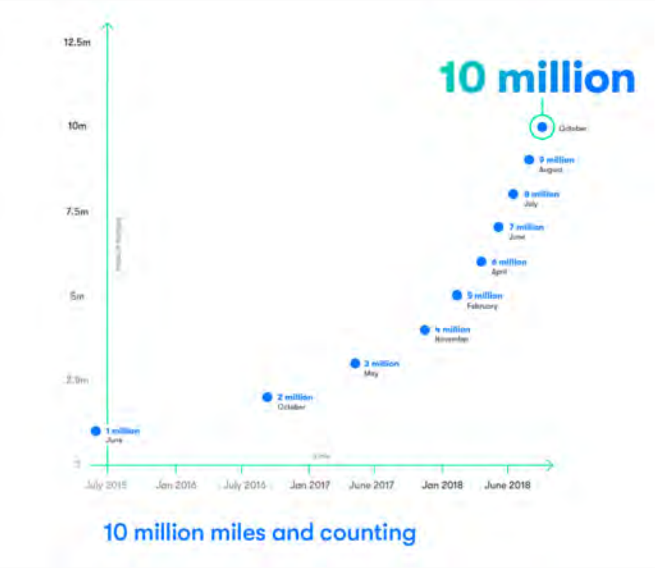

# How To Prove Automated Vehicles (AVs) are Safer than Humans?

Waymo engineers build virtual scenarios that allow our self-driving vehicles to drive up to 8 million simulated miles each day.

**Simulation: How the Virtual World Helps Our Cars Learn Advanced Real-World Driving Skills**

Waymo's simulator can replay the real-world miles we have driven with each new software version, but also can build completely new realistic virtual scenarios for our software to be tested against. Each day, as many as 25,000 virtual Waymo self-driving vehicles drive up to eight million miles in simulation, refining old skills and testing out new maneuvers that help them navigate the real world safely.

For example: at the corner of South Longmore Street and West Southern Avenue in Mesa, Arizona, there's a flashing yellow arrow for left turns. This type of intersection can be tricky for humans and self-driving vehicles alike — drivers must move into a five-lane intersection and then find a gap in oncoming traffic. A left turn made too early may pose a hazard for oncoming traffic; a turn made too late may frustrate drivers behind.

Simulation lets us turn a single real-world encounter like this into thousands of opportunities to practice and master a skill.

5 billion self-driven miles simulated → regression testing

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This is also an advantage as software can be instantaneously updated in the whole fleet to fix issues

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This is insufficient. A person being licensed has extensive experience and knowledge, e.g. about the physics of the world.

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Yes, monitoring will be needed: defects will occur, vehicles are constantly updated and might be tampered with, by their owners or hackers

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Why is this important if we have only driverless vehicles on the road?

Because there will be pedestrians and we want to encourage active modes of transportation (walking, cycling)

# Information and Communications in Current Road Traffic

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- Vehicles: movement, vehicle lights (turning, braking)
- Users: movement, gestures, gaze

# Principles of Traffic Control Devices

*"To be effective, a traffic control device should meet five basic requirements:*

1. *Fulfill a need;*
2. *Command attention;*
3. *Convey a clear, simple meaning;*
4. *Command respect from road users; and*
5. *Give adequate time for proper response."*

*"Uniformity of the meaning of traffic control devices is vital to their effectiveness"*

*"Uniformity of devices simplifies the task of the road user because it aids in recognition and understanding, thereby reducing perception/reaction time." (MUTCD)*

**Connected Vehicles**

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When is this going to happen and more importantly, is that a viable future?

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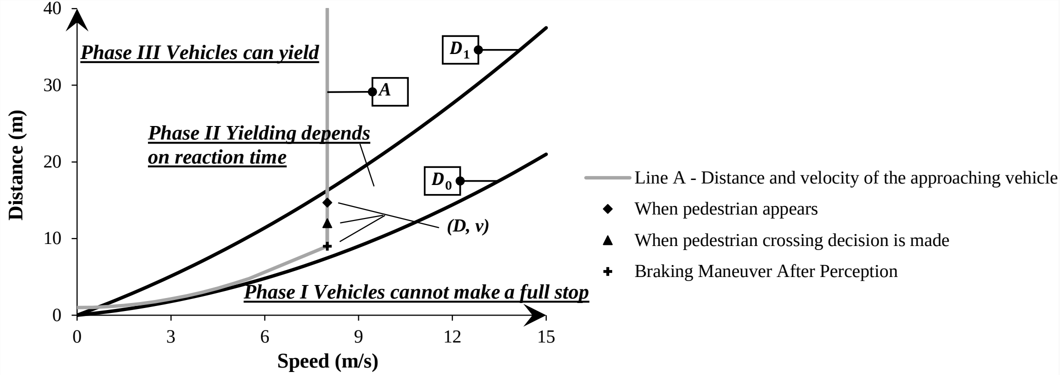
We need to study the interactions of AVs with pedestrians and cyclists

- using direct traffic observations, e.g. video data, computer vision, behaviour and safety indicators

# Methods: Distance-Velocity Framework

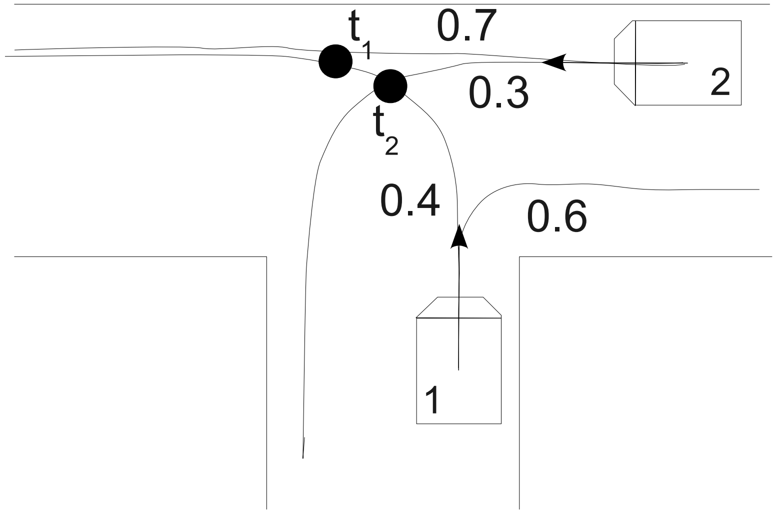


# Methods: Distance-Velocity Framework


*a) Camera locations and installations on the aerial map*


*b) Trajectories of the same vehicle through multiple cameras (displayed on the video frames after the correction for lens*

## Methods: Surrogate Measures of Safety



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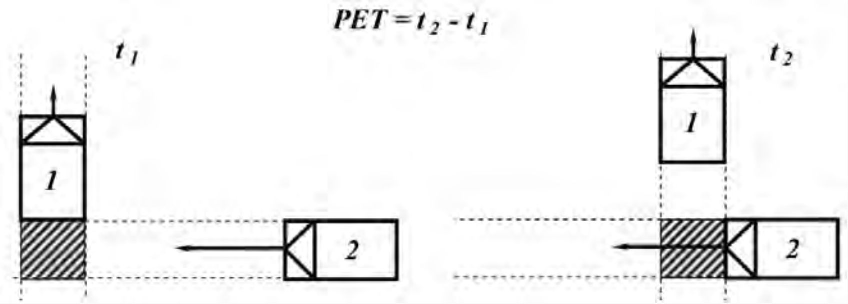
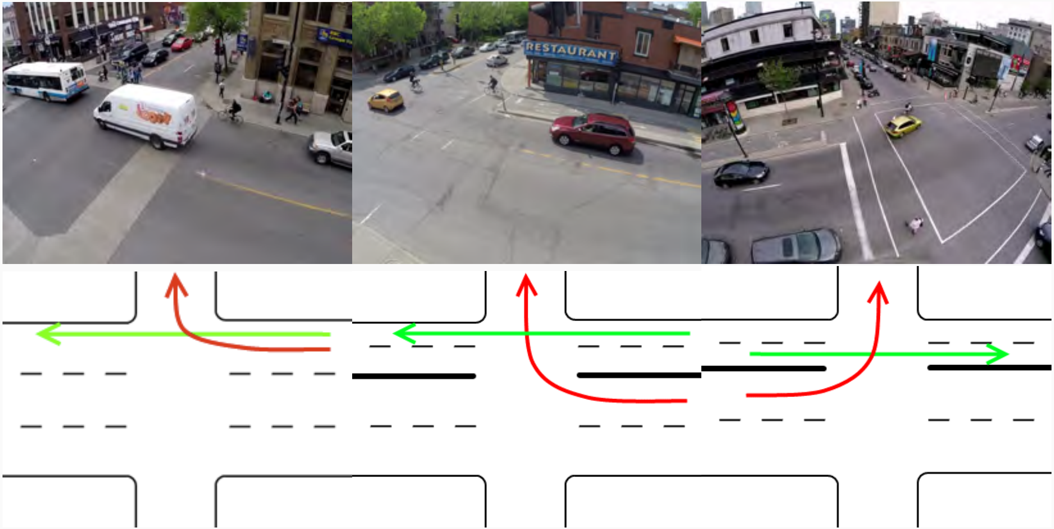


# Turning Vehicle Interactions with Cycle Tracks



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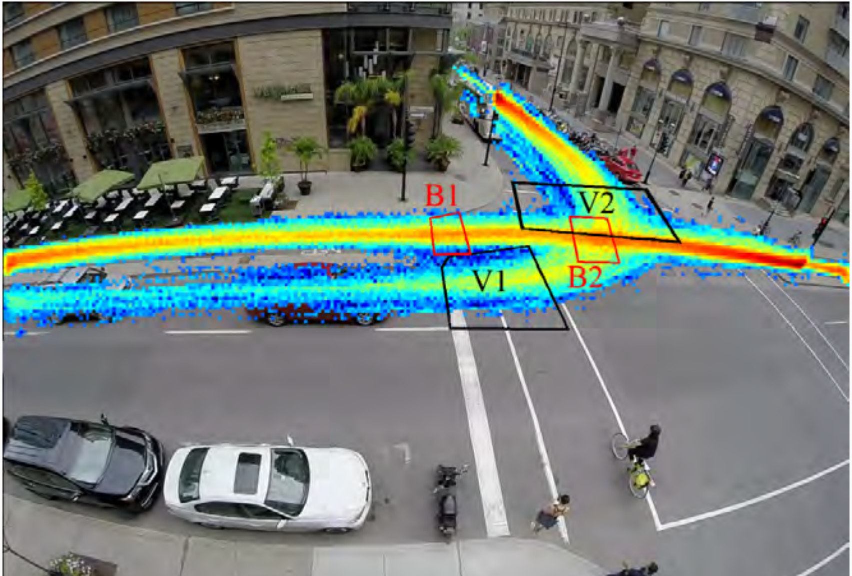

# Turning Vehicle Interactions with Cycle Tracks

| | Model I. Cycle track on the right vs. no cycle track | | | Model II. Cycle track on the left vs. no cycle track | | | Model III. Cycle track on the right vs. cycle track on the left | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Sig. | Coef. | Std. Err. | Sig. | Coef. | Std. Err. | Sig. |
| Cycle Track on Right | 0.395 | 0.181 | 0.03 | - | - | - | - | - | - |
| Cycle Track on Left | - | - | - | Not Significant | | | -0.513 | 0.131 | 0.00 |
| Bicycle Flow for 5s before to 5s after | Not Significant | | | 0.088 | 0.038 | 0.02 | 0.066 | 0.034 | 0.05 |
| Turning-Vehicle Flow for 5s before to 5s after | -2.771 | 0.132 | 0.00 | -3.265 | 0.090 | 0.00 | -3.131 | 0.080 | 0.00 |
| Number of Lanes on the Main Road | -0.151 | 0.078 | 0.05 | Not Significant | | | Not Significant | | |
| Number of Lanes on the Turning Road | Not Significant | | | 0.324 | 0.146 | 0.03 | 0.457 | 0.178 | 0.01 |
| Cut-off 1 | -6.599 | 0.353 | 0.00 | -7.372 | 0.301 | 0.00 | -7.621 | 0.323 | 0.00 |
| Cut-off 2 | -4.233 | 0.273 | 0.00 | -3.807 | 0.223 | 0.00 | -4.125 | 0.265 | 0.00 |
| Cut-off 3 | -3.150 | 0.256 | 0.00 | -2.102 | 0.211 | 0.00 | -2.479 | 0.258 | 0.00 |
| Number of Observations | 2880 | | | 4803 | | | 6567 | | |
| Log likelihood | -804 | | | -1876 | | | -2330 | | |

# Study of Low-Speed Automated Shuttle in Candiac (Summer 2019)

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- Human factors are tricky and cannot be “technologized away”
- Human-vehicle communications must be standardized
- AV interactions in traffic must be monitored independently

# Questions?