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Using Simulation to Assess and Reduce Conflicts between Drivers and Bicyclists

A SAFER-SIM Collaborative Project with UI, UMass, and UCF

Do Protected Bicycle Intersections Reduce Right-Hook Crashes?

A collaboration between

the University of Iowa and the University of Massachusetts, Amherst

Presented by

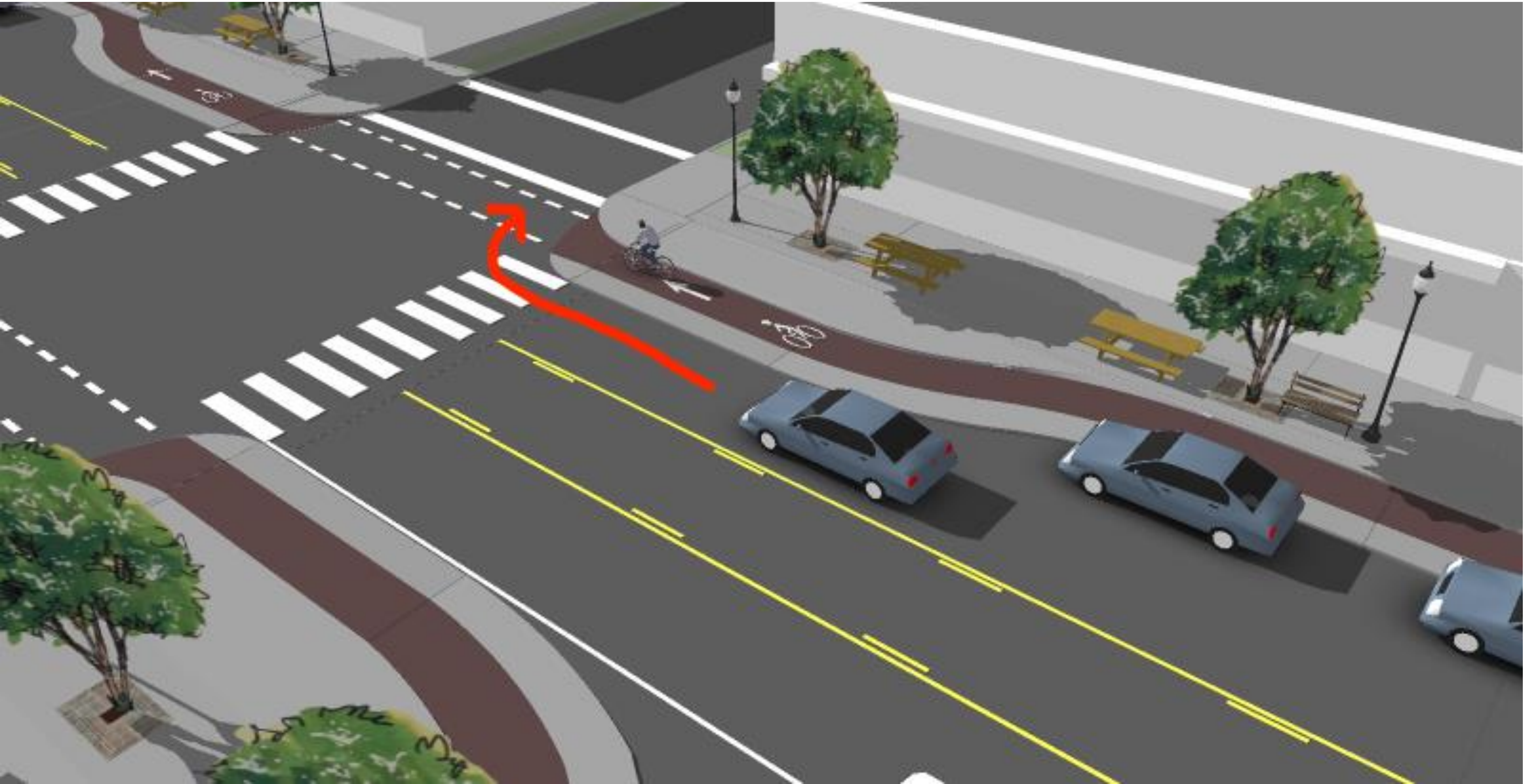
Elizabeth O’Neal

The University of Iowa

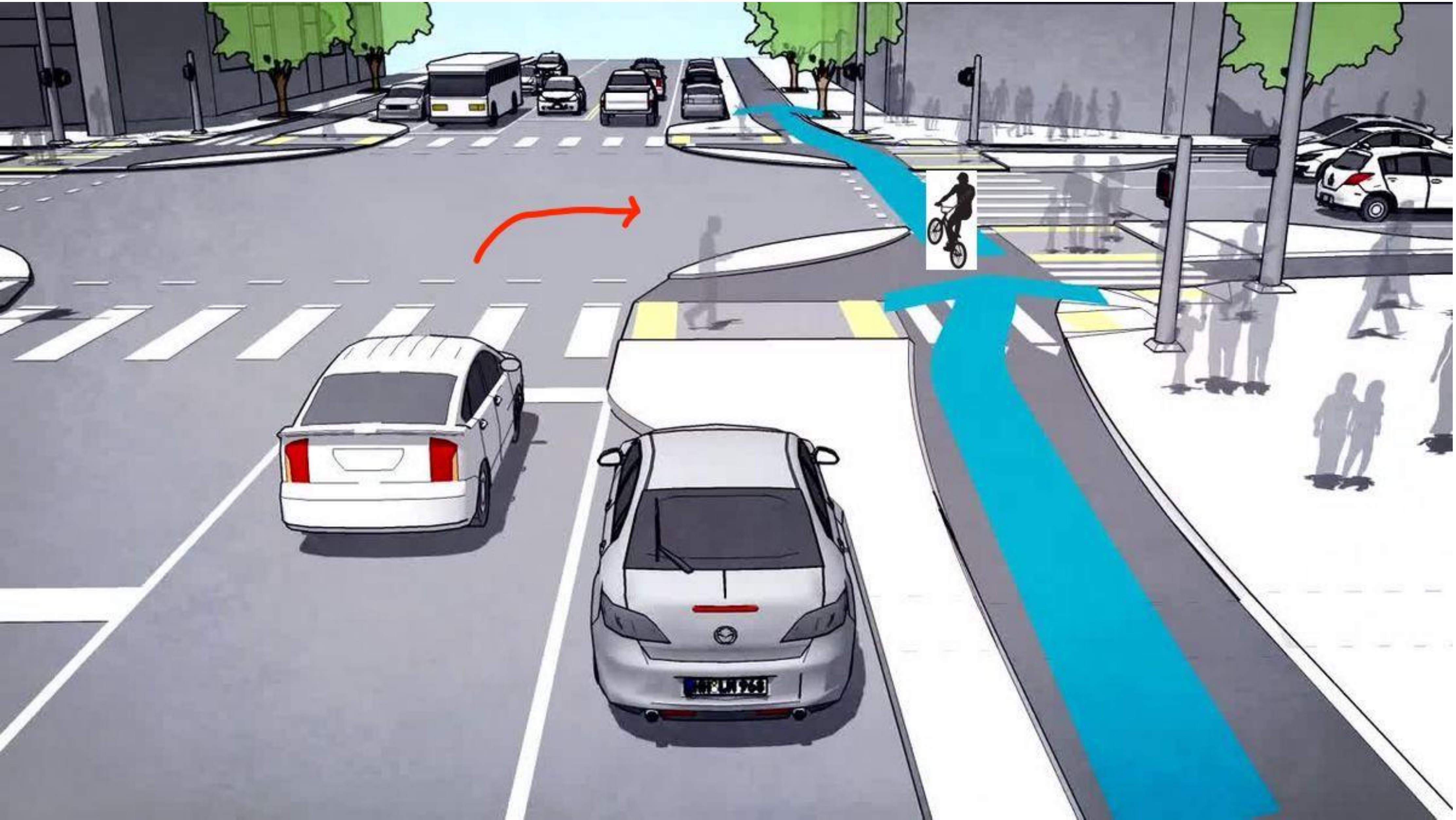
The Problem

- Separated bicycle lanes are increasing in popularity in the U.S
- Documented benefits include safer cycling and increased ridership
- Concerns about potential conflicts between bicyclists and vehicles when they come back together at an intersection
  - After a period of separation, drivers may be less likely to anticipate and scan for the presence of bicycles
  - One specific risk is right-hook crashes

Right-Hook Turn without Protected Bicycle Intersection



Right-Hook Turn with Protected Bicycle Intersection



How might protected bicycle intersections reduce right-hook turn conflicts?

- The greater distance between the driver and bicyclist is designed to
  - Create visual angles that make it easier for the driver and rider to see each other
  - Give the driver and rider more time to react before a collision

- Our goal is to systematically test whether protected bike intersections reduce the likelihood of bicycle-vehicle conflicts involving right-hook turns
  - Driver behavior
  - Bicyclist behavior

Study Design

- Conditions
  - Separated bike lane with protected intersections
  - Separated bike lane without protected intersections

- UI bicycling simulator: Study how bicyclists respond to virtual cars making right–hook turns

- UMass driving simulator: Study how drivers respond to virtual bicyclists when making right–hook turns

Thoughts on the Task and Measures

- Task Characteristics
  - We’d like to create bicyclist and driver tasks that are mirror images to the extent possible so that we can make direct comparisons
  - Does the right-hook turn conflict need to be a one-time surprise event, or could it occur multiple times throughout the drive/ride?
  - Need to get the timing right in the scenario so that there is at least one right-hook turn conflict event.

- Measures
  - Categorical measure: Is there a crash?
  - Continuous measures
    - When does the driver/bicyclist begin to slow down?
    - How much does the driver/bicyclist slow down?
    - When does the driver/bicyclist begin to look at the bicyclist/driver?

Thank you!

An Assessment of Traffic Safety between Drivers and Bicyclists based on Roadway Cross-Section Designs and Countermeasures Using Simulation

Mohamed Abdel-Aty

Juneyoung Park

Background

The safety issue between drivers and bicyclists has been recognized as one of the critical traffic safety problems, and there is a desperate need to identify and test roadway countermeasures to improve driver and bicyclist safety.

Research Objective 1

- Conduct comprehensive safety analysis to explore the safety effects of roadway geometric cross-section designs on mixed traffic condition

Research Question 2

- Investigate the effects of different roadway designs and countermeasures using micro-simulation

Preliminary Safety Analysis Results

Developing Crash Modification Functions (CMFs) to Assess Safety Effects of Adding Bike Lanes for Urban Arterials

Evaluated CMFs of adding a bike lane for urban arterials

Calculation method	Crash modification factor (standard error)			
	All crashes (KABCO)	All crashes (KABC)	Bike crashes (KABCO)	Bike crashes (KABC)
Before-After with EB 227 segment: 2003-2005 (before) VS 2010-2012 (after)	0.829(0.029)	0.804(0.039)	0.439(0.083)	-
Cross-Sectional 2010-2012: 227 treated segments VS 517 reference segments	0.680(0.083)	0.726(0.089)	0.422(0.096)	0.398(0.093)

Note: All CMFs are significant at a 95% confidence level

- The safety effects of adding a bike lane are positive (i.e., CMF<1)
- Adding a bike lane is more effective in reducing bike crashes

Following Research Tasks

1. Identification of more applicable treatments
2. Development of SPFs and CMFs
3. Conducting a micro-simulation experiment
4. Analysis of the experiment results

Project Schedule

Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Task 1-1: Review state-of-the-practice															
Task 1-2: Identification of applicable treatments															
Task 2-1: Comprehensive crash analysis															
Task 2-2: Development of SPFs and CMFs															
Task 3-1: Designing microsimulation frame															
Task 3-2: Microsimulation network calibration and validation															
Task 3-3: Build scenarios															
Task 3-4: Microsimulation experiments															
Task 4-1: Conducting statistical analysis															
Task 4-2: Summarizing the results															

Thank you.

Any questions?

An Assessment of Traffic Safety between Drivers and Bicyclists Based on Roadway Cross-Section Designs and Countermeasures Using Simulation

Mohamed Abdel-Aty Juneyoung Park

Multi-modal Distributed Simulation Combining Cars, Bicyclists, and Pedestrians

-- SaferSim Project Kickoff (UI, UW, UMass)

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Yuanyuan Jiang

Ph.D. Candidate

University of Iowa

Hank Virtual Environments Lab

http://psychology.uiowa.edu/hank-virtual-environments-lab

Motivation

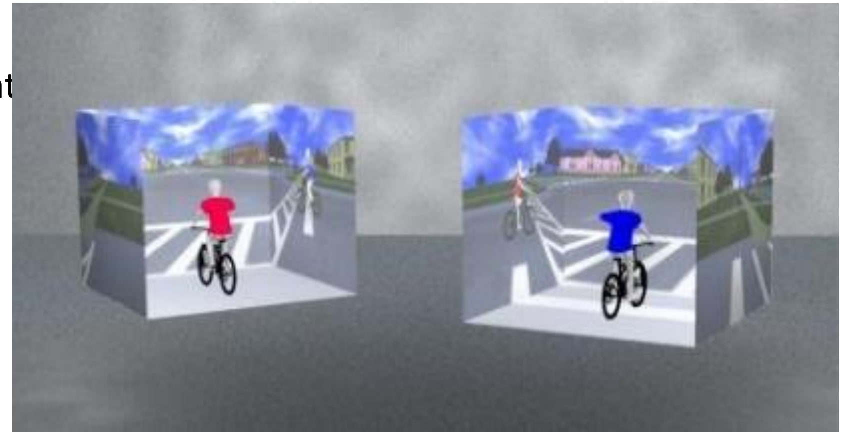
- Driving, bicycling, pedestrian simulators

  Causes of crashes & countermeasures

Interaction between driver, bicycler, pedestrian

- Connected simulators
  - Shared virtual environment
  - Human-to-human interaction across plat

  - Warning, detection systems
  - Mitigating crash risk



Project Aim

- Connecting VE simulator

  UI, UW, UMass

- Potential simulator types

  Pedestrian Simulator

  Bike Simulator

  Driving Simulator

Current Simulators

- UW-Madison
  - Will integrate to Unity-based driving simulator
- UMass
  - Two RTI driving simulators integrated
  - Running experiment: multiple vehicle crashes & mitigation mechanisms

  - Integrating 2 Unity-based driving simulators to 2 RTI simulators
- UI
  - Two large screen simulators (bike or ped)
  - Connected ped VE demo – example in this talk

CAVEs in Hank

Unity Networking

Between multiple Unity

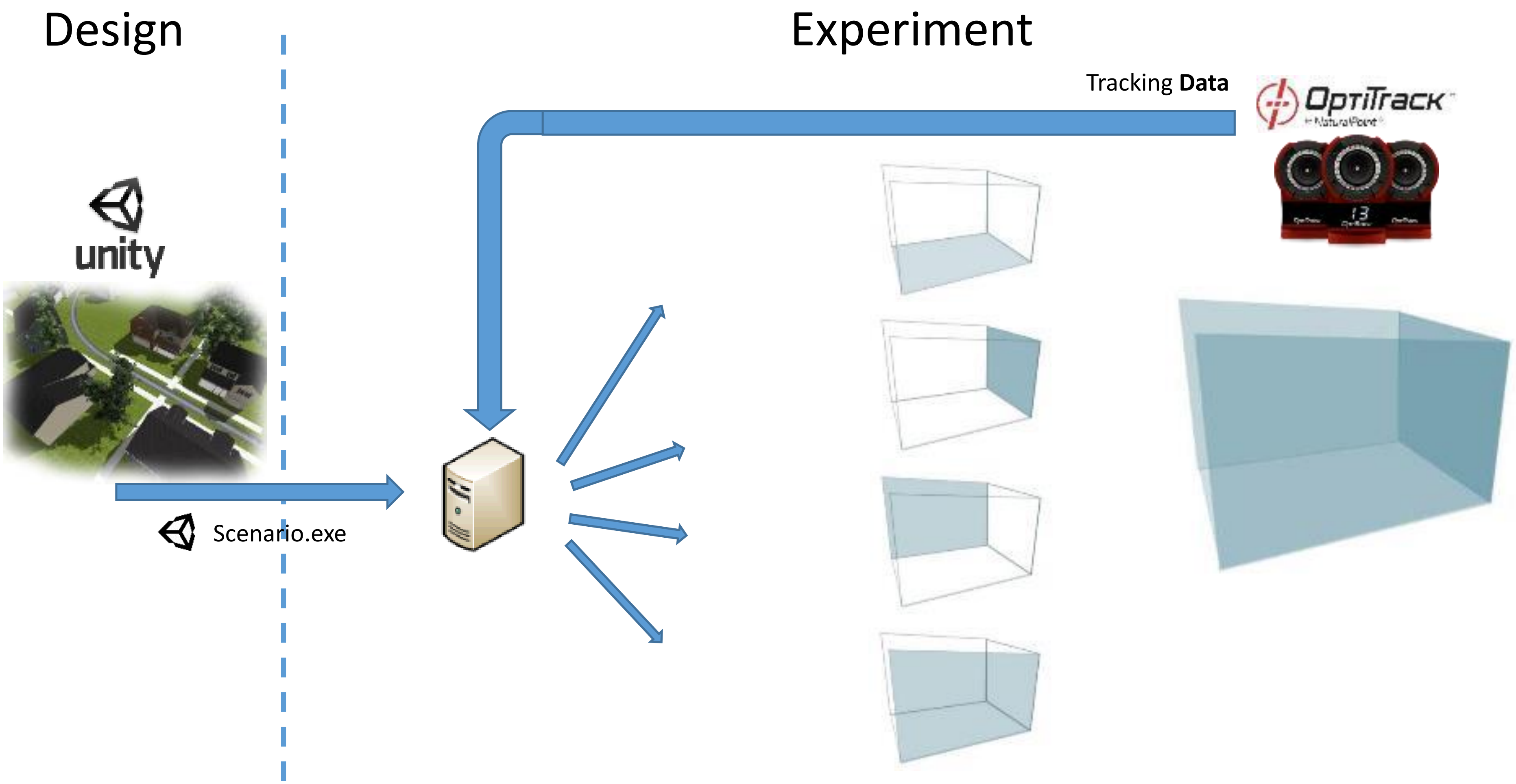
- High-Level API –Convenient *(Prototype working in Hank Lab)*
  - Network object management
  - Automatic network performance & sync management
  - Sync customized control var

- Low-Level API – Complex customized network protocol

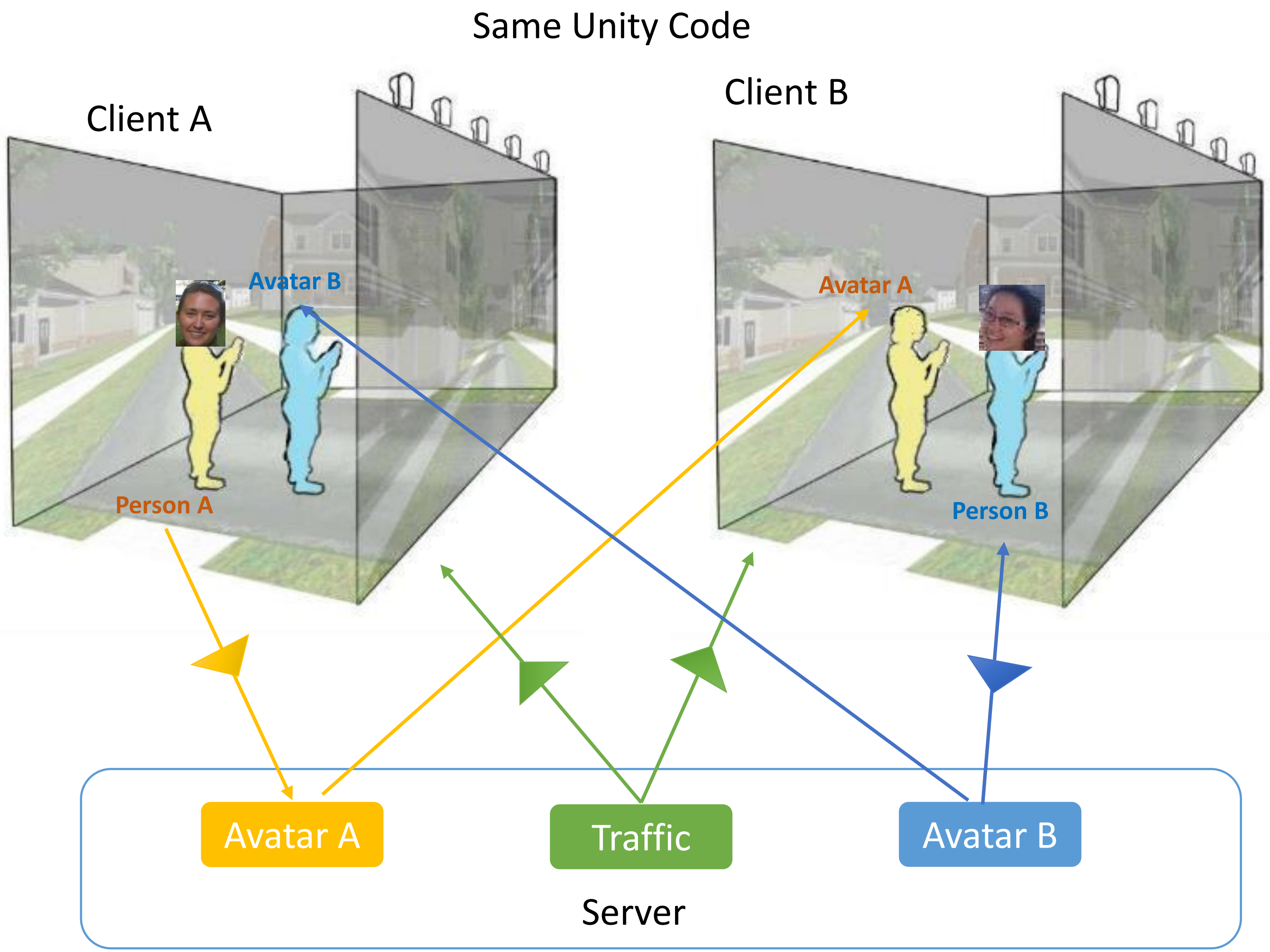
Unity & other program

- C# UDP networking
  - Existing complex traffic server
  - Unity as client & renderer

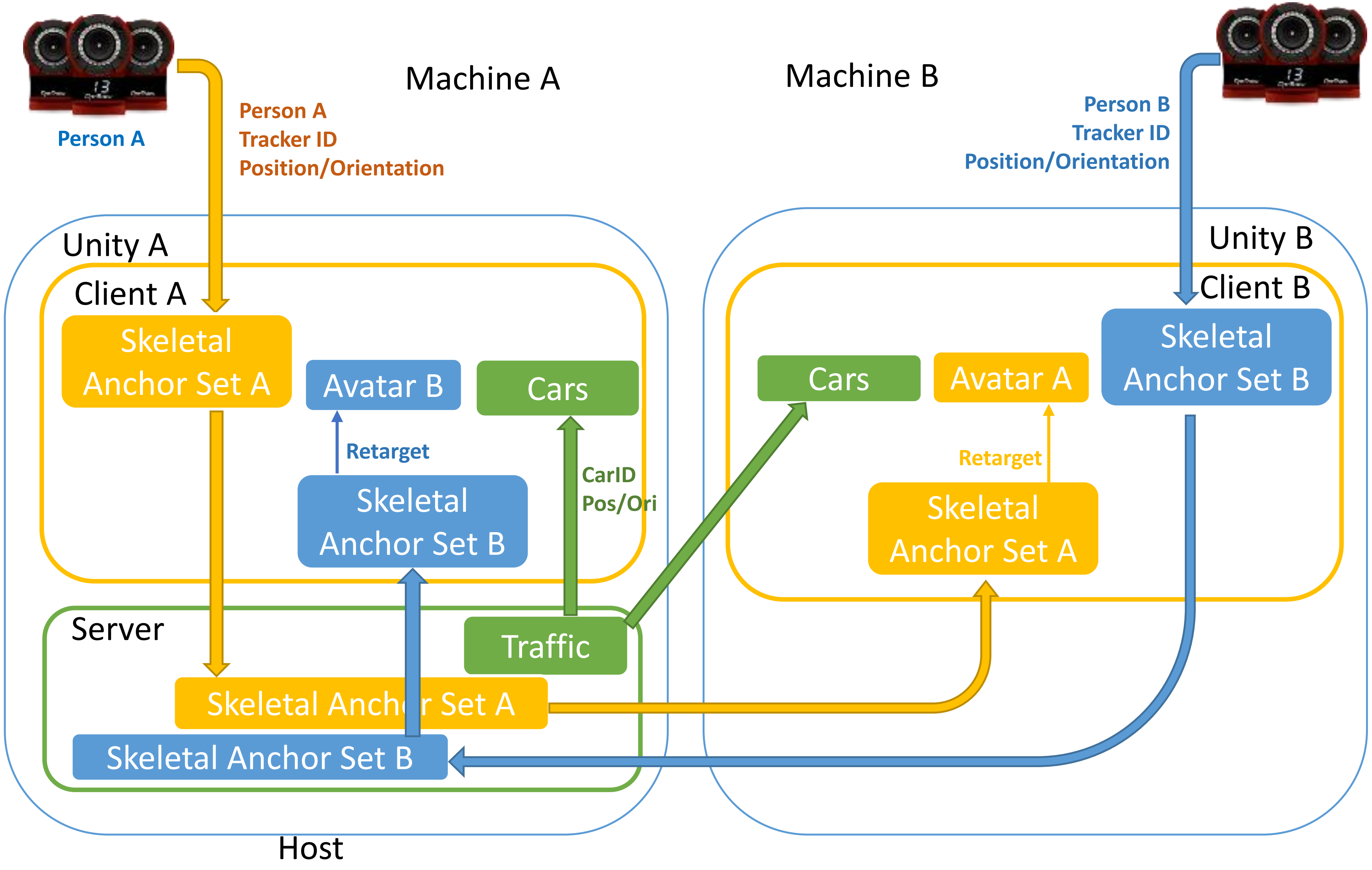
Pedestrian Simulator



Connected Pedestrian Simulator



Connected Pedestrian Simulator



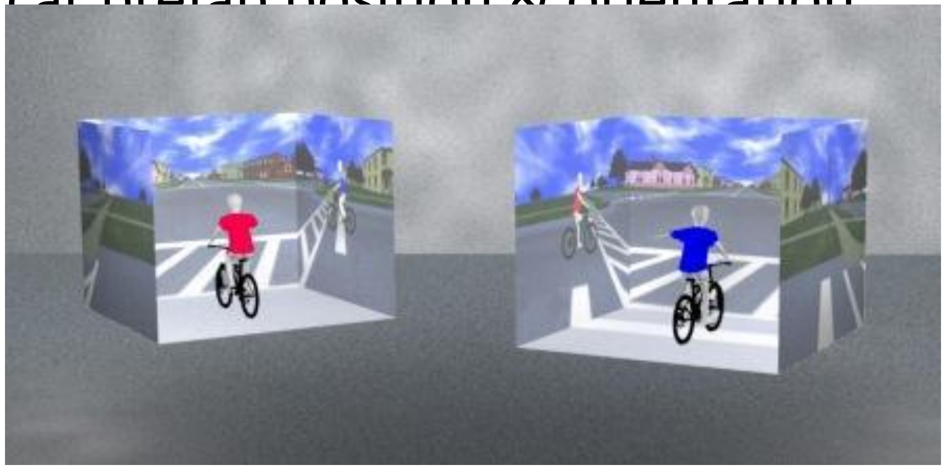
Unity Networking -- Challenges

- Steep learning curve
  - C#
  - General Unity
  - Networking APIs (c# advanced concepts, eg. delegates)
- Learning Resources
  - Unity manual
  - Youtube Unity tutorial
- Remote Collaboration
  - Network protocol establishing
  - Remote testing and debugging
  - Large size Unity project version control & sharing
- Remote Network Speed & Machine Delays
  - Minimal network traffic
  - Loop time testing & local compensation mechanism
- Remote Experiment Running Protocol

Connected VE Types -- Similarities

- Server controlled traffic objects

- Client controlled player objects
  - Pedestrian -> skeletal tracker prefab tree (pos/ori for each tracker)
  - Bike -> bike prefab position & orientation
  - Car -> car prefab position & orientation



Connected VE Types -- Challenges

Same VE types

Pedestrian <-> Pedestrian

Bike <-> Bike

- Reduced marker tracking system
- Player object tree serialization

Different VE types

Pedestrian <-> Bike

Pedestrian <-> Driving

Bike <-> Driving

- One code base for both types of VE (camera, control logic)
- Ped relocation & re-encounter
- Mix in agents for surprising factor

Unity Networking -- HLAPI

Drag drop + c# coding

Built in **Network Manager**

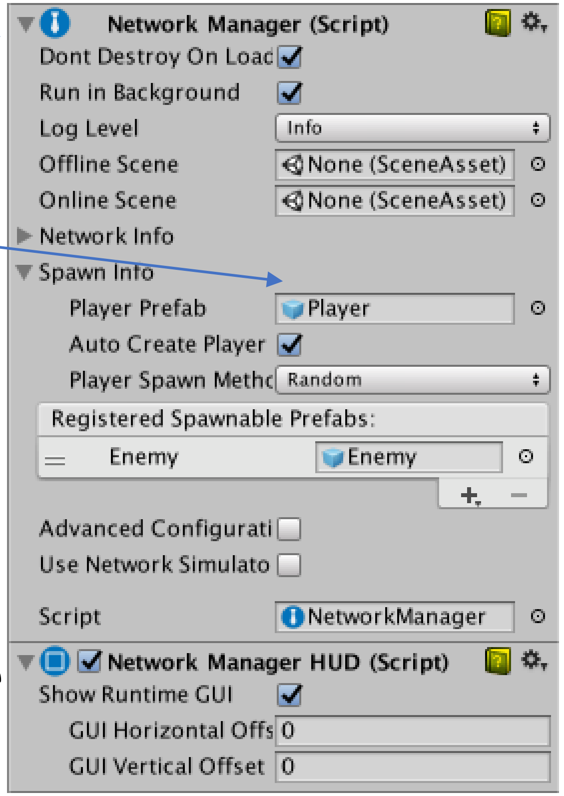
Prefab = model tree + script

Spawn prefab = create moving obj

-- Server:

Spawn car generator prefab

Auto sync to all clients



Player object = prefab spawned by clie

-- Clients:

Spawn avatar skeletal tracker set

Auto sync to server, then to other clients

NetworkServer.AddPlayerForConnection(conn, player, playerControllerId);

Thank You

Hank Virtual Environments Lab

http://psychology.uiowa.edu/hank-virtual-environments-lab

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Enhancing School Zone and School Bus Safety

Presenter: Moatz Saad

Mohamed Abdel-Aty Jaeyoung Lee

Background

- Traffic crashes which involving school-age children are a serious concern, as there has been an increase in the number of school-age pedestrians and cyclists injured and killed throughout the years.

Research Question 1

- What is the best countermeasure to maximize drivers' speed limit compliance rate in school zones?

Research Question 2

- What are the optimal roadway environments to increase traffic safety in school zones?

Research Question 3

- What are the better school bus designs to improve driving behavior?

Research Objectives

Objective 1

Analyzing driving behavior for the reduced speed limit in school zones and countermeasures

Objective 2

Investigating the impacts of geometric design of roadways and the number of driveways on safety in school zones

Objective 3

Exploring driver's reaction to the various designs of school buses and stop signs

Objective 1:

Driving behavior for the reduced speed limit in school zones

- In a school zone, most of the states set a lowered speed at specific time periods to protect children from severe crashes. However, drivers often do not comply with these speed limits.

- Flashing beacons and dynamic speed display can increase the speed compliance (Simpson, 2008; Lee et al., 2006)

Objective 1:

Driving behavior for the reduced speed limit in school zones

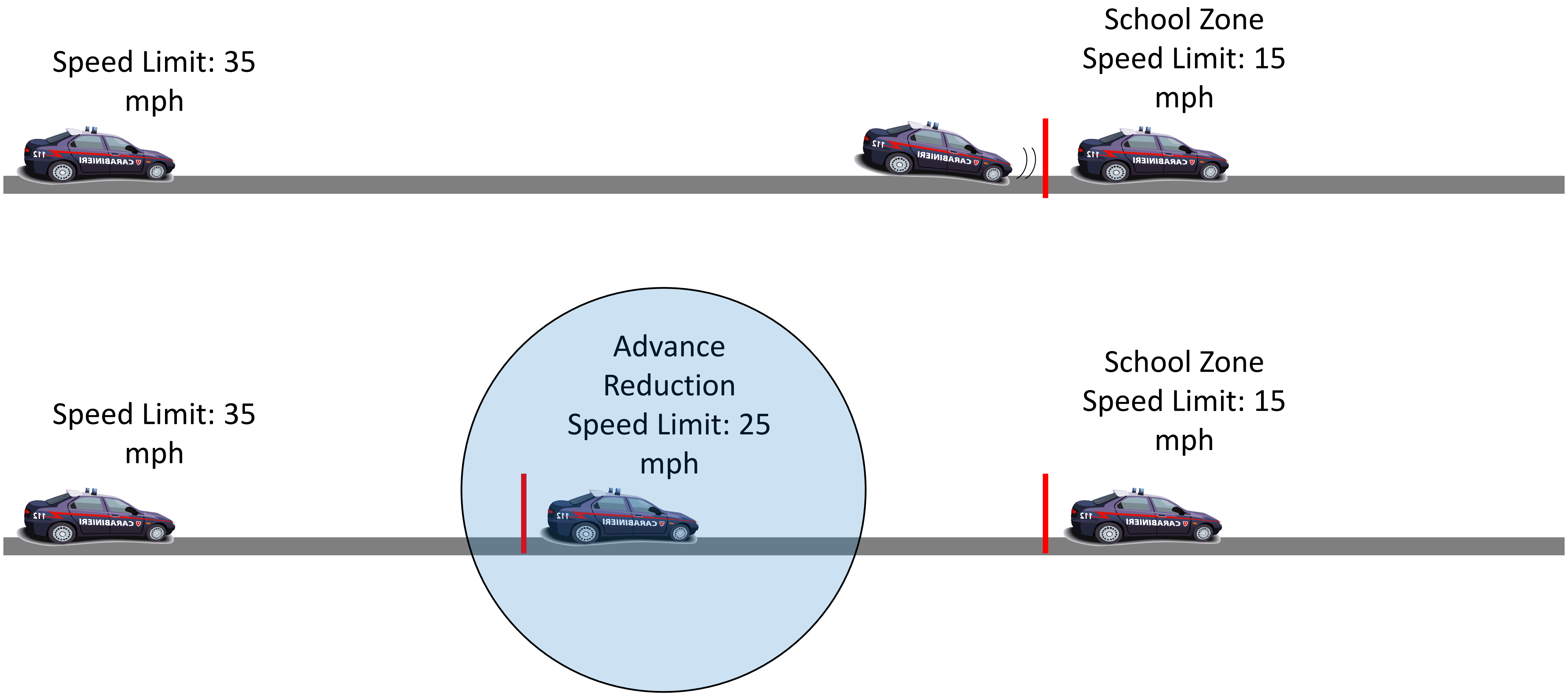
1. Driving simulator experiment

- Investigate countermeasures for school zones that can increase the number of drivers complying with the speed limits (e.g., flashing beacons, pavement marking, two-step speed reduction).

2. Microsimulation experiment

- Some school zones require drivers suddenly reduce their speed (e.g., 35 mph to 15 mph) → may cause a conflict with following vehicles and rear-end crash.
- An additional speed limit between the regular and school zone section (two-step speed reduction).
- Quantify several measures (e.g., TTC, conflict frequency, etc.)

Two-step Speed Reduction



Objective 2:

Investigating the effects of geometric design of roadways and driveways on safety at school zones

- Using microsimulation, we will examine how improved roadway environments (e.g., increasing shoulder widths, minimizing the number of driveways, etc.) affect traffic safety at school zones.

- Actual crash data will be also explored and compared with the microsimulation results.

Objective 3:

Exploring driver's reaction to the various designs of school buses and stop signs

- Drivers must stop upon approaching any school bus that displays its flashing red lights and has its stop sign extended. Some drivers may react more quickly whereas other drivers may take more time to stop for a school bus.

▹Using driving simulator, we will investigate how vehicle type, school bus design (color, the length of extended stop bar arm, stop sign size, etc.), and personal characteristics (e.g., age, gender, driving experience, etc.) impact driving behavior (e.g., reaction time, deceleration rate, TTC, etc.)

Project Schedule (Phase I)

Months	1	2	3	4	5	6	7	8	9	10	11	12
Task 1-1: Literature review												
Task 1-2: Data collection and processing												
Task 1-3: Evaluation of the impacts of geometric designs and speed reduction on safety												
Task 1-4: Construction of network in school zones												
Task 1-5: Microsimulation frame calibration and validation												
Task 1-6: Preparation of simulation model												
Task 1-7: Testing scenarios and summarizing the results												

Project Schedule (Phase II)

Months	13	14	15	16	17	18	19	20	21	22	23	24
Task 2-1: Experimental design for driving simulator test												
Task 2-2: Building scenarios												
Task 2-3: Recruiting subjects and conducting the experiments												
Task 2-4: Statistical analysis of the results												

Thank you.
Any questions?

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Enhancing School Zone and School Bus Safety

Presenter: Moatz Saad
Mohamed Abdel-Aty Jaeyoung Lee

Using Driver State Detection in Automated Driving

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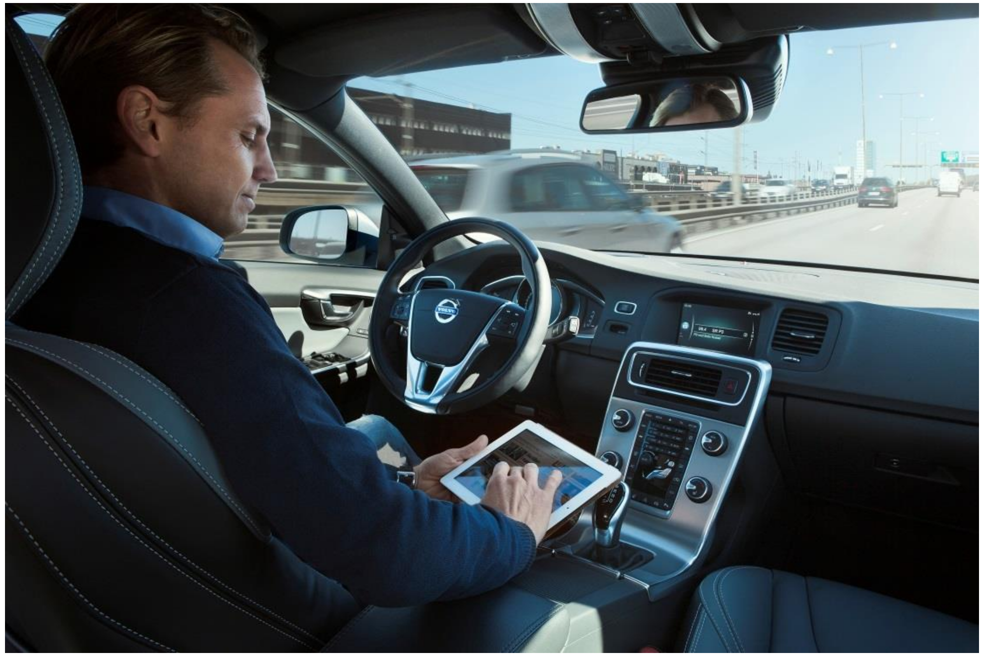
Timothy Brown

University of Iowa

Defining readiness in vehicle automation

Level	Name	Narrative definition	DDT: Sustained lateral and longitudinal vehicle motion control	DDT: OEDR	DDT fallback	ODD
Driver performs part or all of the *DDT*						
0	No Driving Automation	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems.*	*Driver*	*Driver*	*Driver*	n/a
1	Driver Assistance	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT.*	*Driver* and *System*	*Driver*	*Driver*	Limited
2	Partial Driving Automation	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system.*	***System***	*Driver*	*Driver*	Limited
ADS ("*System*") performs the entire *DDT* (while engaged)						
3	Conditional Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
4	High Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene.*	*System*	*System*	***System***	Limited
5	Full Driving Automation	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene.*	*System*	*System*	*System*	**Unlimited**



Transfers of control can become safety critical events for automated vehicles

	Expected	Unexpected
Lower to Higher	Button press	Collision avoidance
Higher to Lower	Grab wheel	Automation failure

Driver Monitoring

<u>Question</u>: Can it be used to categorize situational awareness

<u>Question</u>: Can it be used to modify the timing of a takeover request?

Takeover Time from Automation

drowsy distracted

default

vigilant

Takeover


5604883
E:NA
0 0 0
A:0.00 B: 0
V: 65 S: -2
6/ 1/16 14:30:43
SAFERSIMAV_MAIN1
003MA_SSAVM1_2BRNA01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Takeover situations

Event	More Capable	Less Capable	Notes
#1 Work zone	No TOR	TOR with 10-second warning	Warning occurs about 15 seconds ahead of the work zone. Traffic in left lane.
#2 Missing lane lines	No TOR	TOR with 10-second warning	Warning occurs when lane lines are lost.
#3 Sharp curve	No TOR	TOR with 10-second warning	Elevated ramp with walls.
#4 Slow lead vehicle	TOR with 10-second warning	TOR with 5-second warning	Lead vehicle driving at 25 mph with hazards on. Traffic in left lane.
#5 Exit highway	TOR with 30-second warning	TOR with 30-second warning	Always the last event of the drive. No difference between A and B.

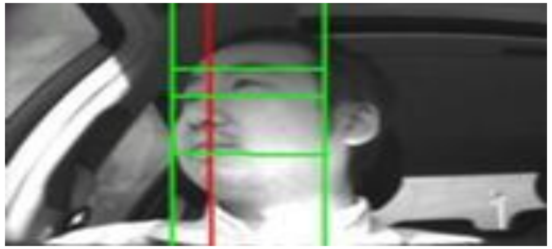
*Examples from prior SaferSim study at the NADS

- 5-minute acclimation to driving simulator
- 15-minute trust building period with automation
- Driving in automated mode with takeover requests
  - Planned takeover
  - Unexpected hazard event(s)
    - Failure without takeover request

Readiness during takeover

- Identify SA ground truth measure
- Classify readiness using ground truth
- Relationship of driver monitoring to SA ground truth
- Machine learning techniques to predict using DMS data
- Determine whether takeover requests could have come earlier

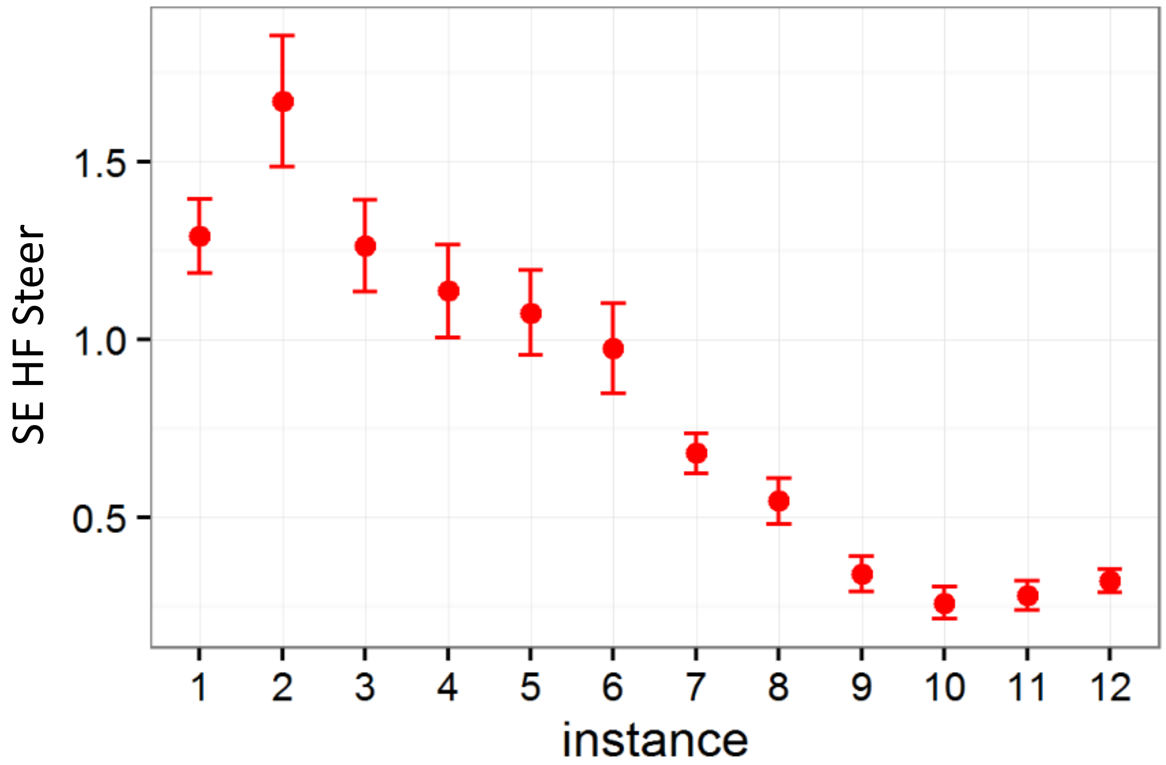
- Latent hazard detection
- Eyes on forward road
- Freeze-probe technique



How does driver state influence takeover and acceptance?

- Takeover Quality
  - Takeover time
  - Driver errors
  - Stabilization in steering and lane
  - Eye gaze and head behavior

- Subjective trust and acceptance
- Subjective workload



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The Impact of Connected Vehicle Market Penetration and Connectivity Levels on Traffic Safety in Connected Vehicles Transition Period

Mohamed Abdel-Aty

Yina Wu (Presenter)

Background

- The development of information and communication technologies have facilitated connected vehicle (CV) technologies, in which vehicles communicate with other vehicles (V2V), roadway infrastructures (V2I), and pedestrians (V2P) in real-time.

Level 0

- no connection

Level 1

- vehicles connects of infrastructures

Level 2

- vehicles connect to vehicles

Level 3

- vehicles connect to vehicles and infrastructures

Research Objectives

Objective 1

Proposing strategies to help CV to avoid crash in fog conditions

Objective 2

Using V2V and V2I information to predict the traffic parameters of conventional vehicles

Objective 3

Recommending the optimal CV technology and active traffic management strategies under a CV environment in fog conditions

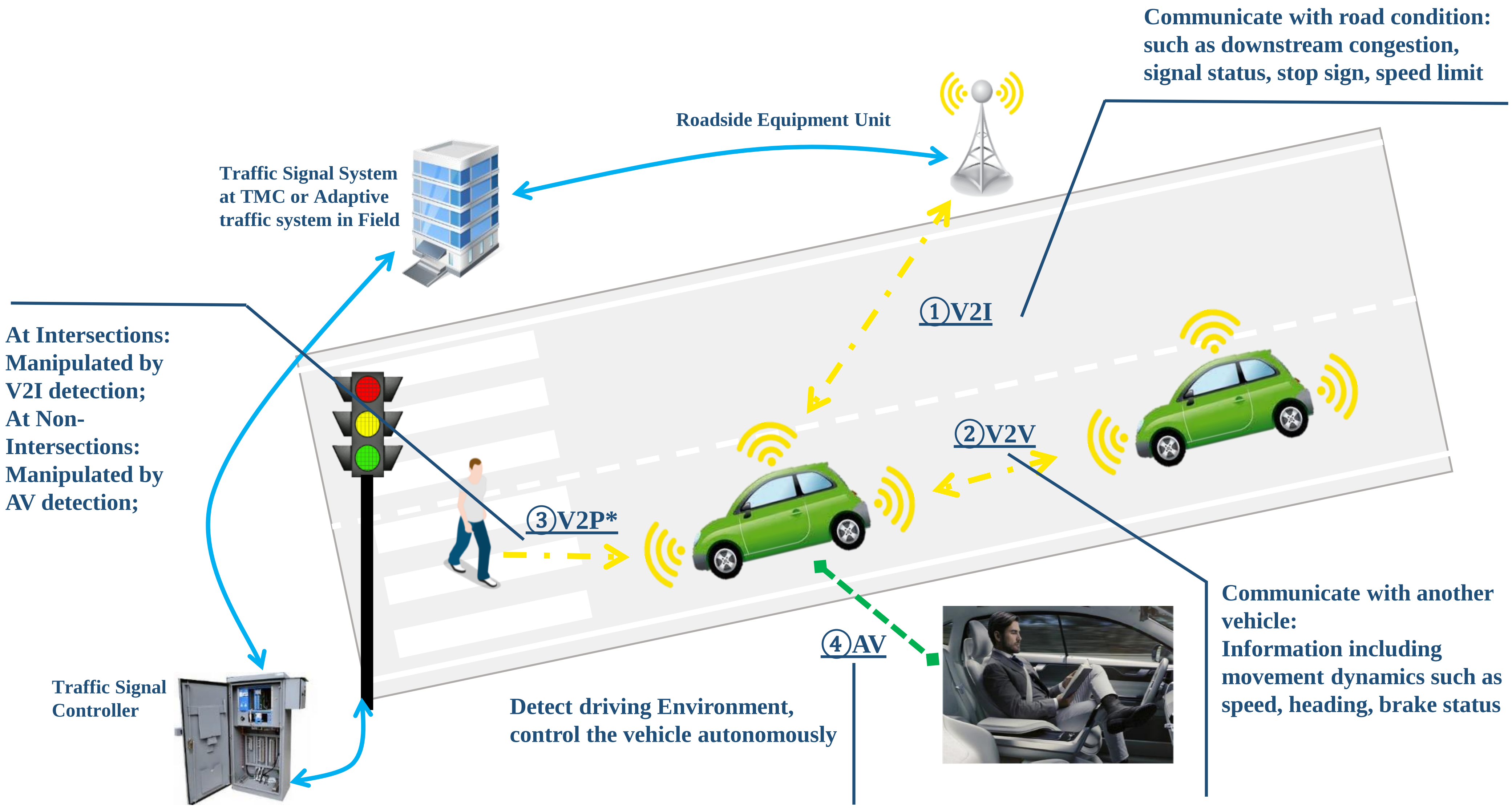
Objective 4

Building car-following models for CV platoons

Objective 5

Recommending the number of CV platoon managed-lanes under different penetration rates

What is CAV Technology?

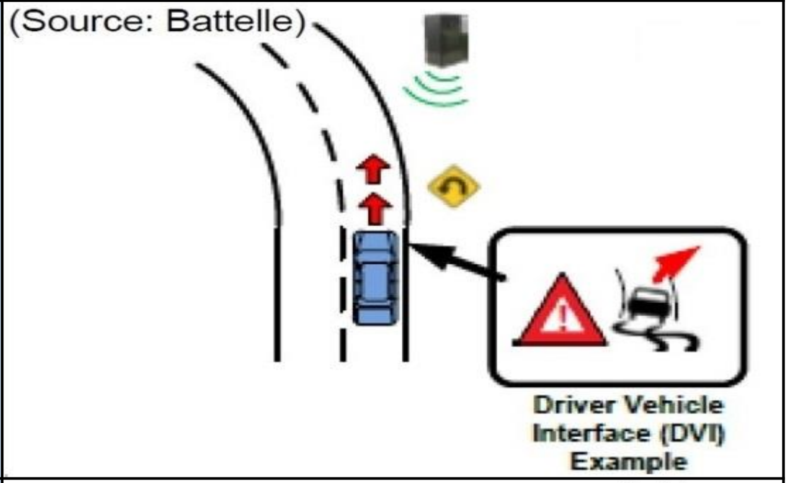
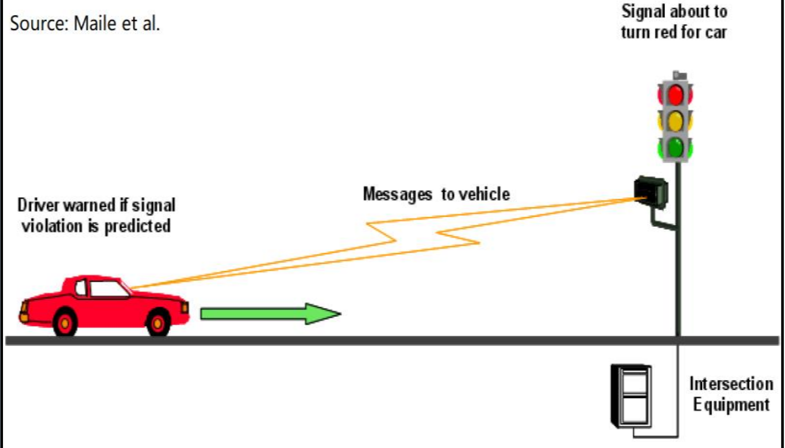


Why CV Technology could be helpful?

① V2I Safety Benefits

Help a driver know Road Conditions like downstream congestion, speed limit on a curve, signal status, stop sign and pedestrian crosswalks, so that the driver could adjust his/her driving speed, awareness or travel route and so on to avoid a potential crash or congestion.

Examples of V2I Technology Warning Pre-crash Scenario

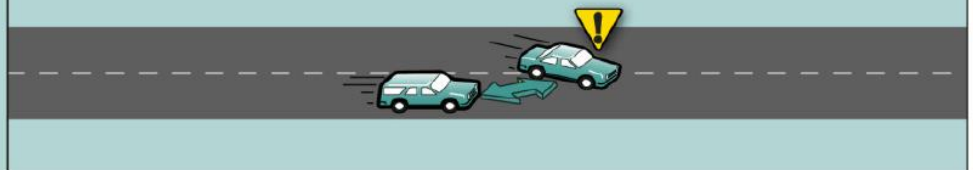
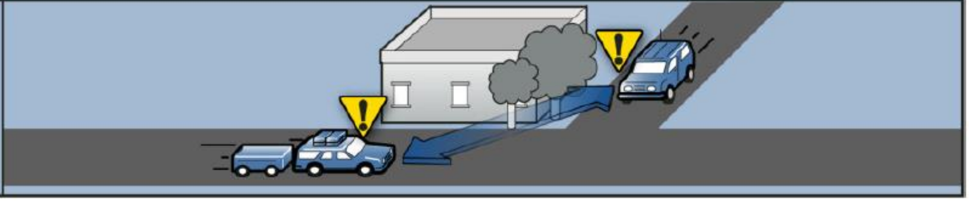
Scenario and Warning Type		Scenario example
Road departure collision scenarios	**Curve speed warning** Approaching a curve or ramp at an unsafe speed or decelerating at insufficient rates to safely maneuver the curve	
Crossing path collision scenarios	**Running red light/stop sign** Violation at an intersection controlled by a stop sign or by traffic signal	

Why CV Technology could be helpful?

② **V2V Safety Benefits**

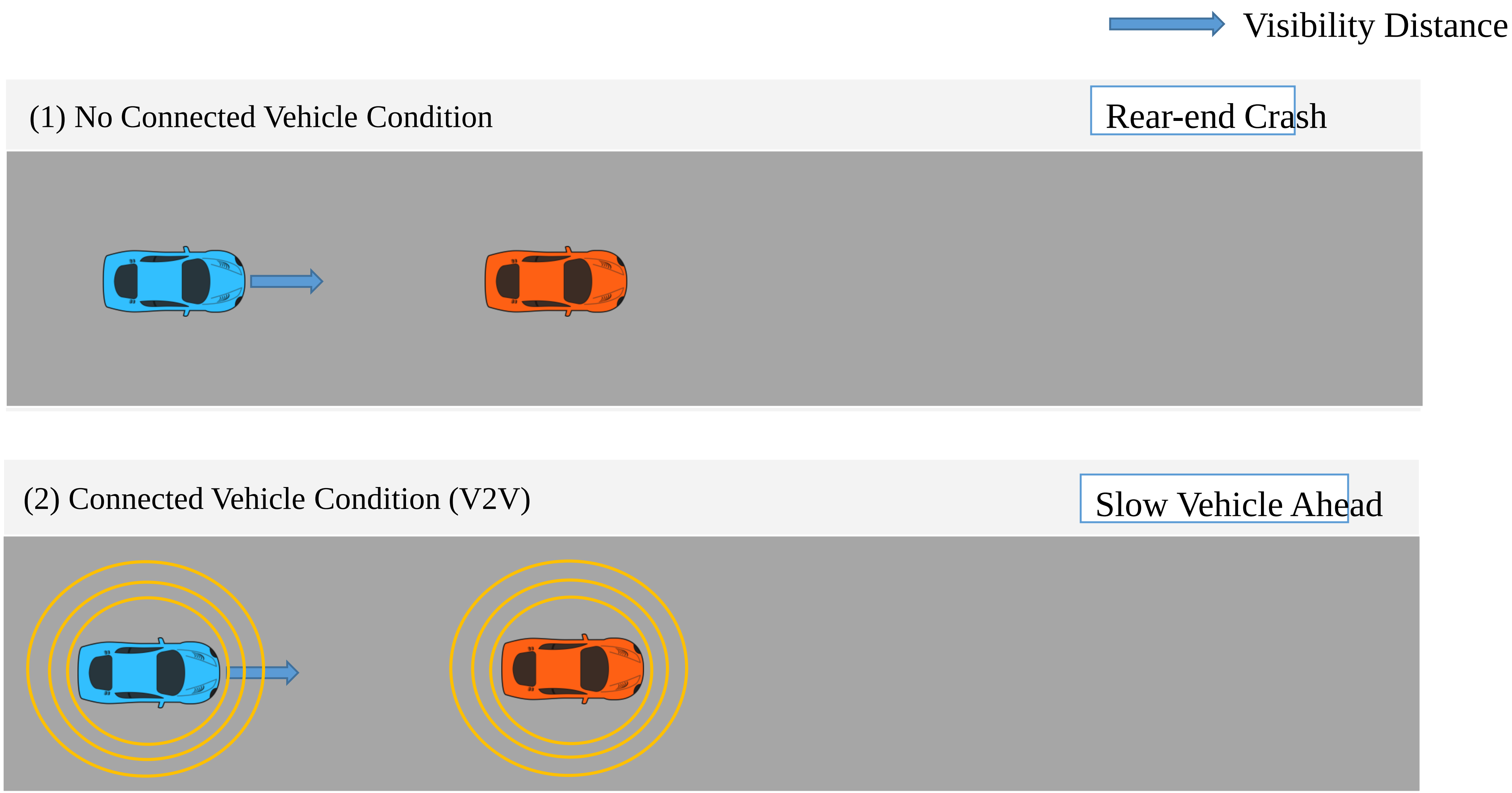
Help a driver know an unobservable presence or an unpredictable movement of another vehicle in pre-crash scenarios, so that an evasive action for the driver could be made in advance.

Examples of V2V Technology Warning Pre-crash Scenario

Scenario and warning type		Scenario example
Rear end collision scenarios	**Forward collision warning** Approaching a vehicle that is decelerating or stopped.	
	Emergency electronic brake light warning Approaching a vehicle stopped in roadway but not visible due to obstructions.	
Lane change scenarios	**Blind spot warning** Beginning lane departure that could encroach on the travel lane of another vehicle traveling in the same direction; can detect vehicles not yet in blind spot.	
	Do not pass warning Encroaching onto the travel lane of another vehicle traveling in opposite direction; can detect moving vehicles not yet in blind spot.	
Intersection scenario	**Blind intersection warning** Encroaching onto the travel lane of another vehicle with whom driver is crossing paths at a blind intersection or an intersection without a traffic signal.	

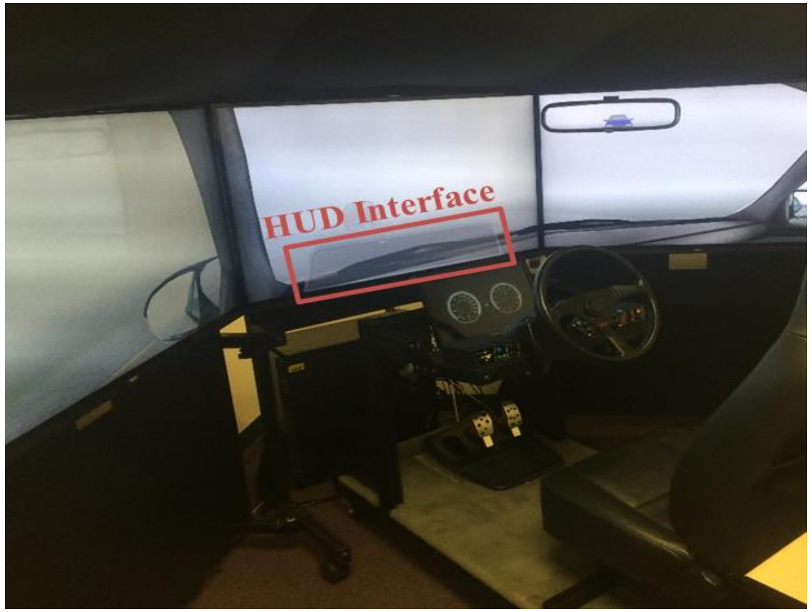
Source: GAO analysis of Crash Avoidance Metrics Partnership information.

Why CV Technology could be helpful during fog?



CV in simulation

Driving simulator	VISSIM



Forward Collision Warning (FCW)

Microsimulation, such as VISSIM, can be used to model connected vehicle behavior in reduced visibility conditions, which is controlled by VISSIM driver model through API .

Project Schedule (Phase I)

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Task I-1: Review CV, fog-related traffic studies, managed-lanes, and platoon																				
Task I-2: Conduct a driving simulator experiment for fog conditions																				
Task I-3: Develop car-following models of CV platoon vehicles																				

Project Schedule (Phase I)

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Task I-4: Conduct a microsimulation experiment for CV platoon managed-lanes																				
Task I-5: Analysis of the results and recommendations																				
Task I-6: Final report																				

Thank you.

Any questions?

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The Impact of Connected Vehicle Market Penetration and Connectivity Levels on Traffic Safety in Connected Vehicles Transition Period

Mohamed Abdel-Aty Yina Wu

Traffic Control Devices and Augmented Reality

University of Massachusetts Amherst

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Traffic Control Devices (TCD's)

Importance

- Driver-to-infrastructure Interactions (D2I)
- Vehicle-to-infrastructure interactions (V2I)

https://goo.gl/images/G2Yk98

Issues with current TCD’s

- Operations cost millions of dollars/year nationwide
- non-conformation (or non-perception)
- Localization

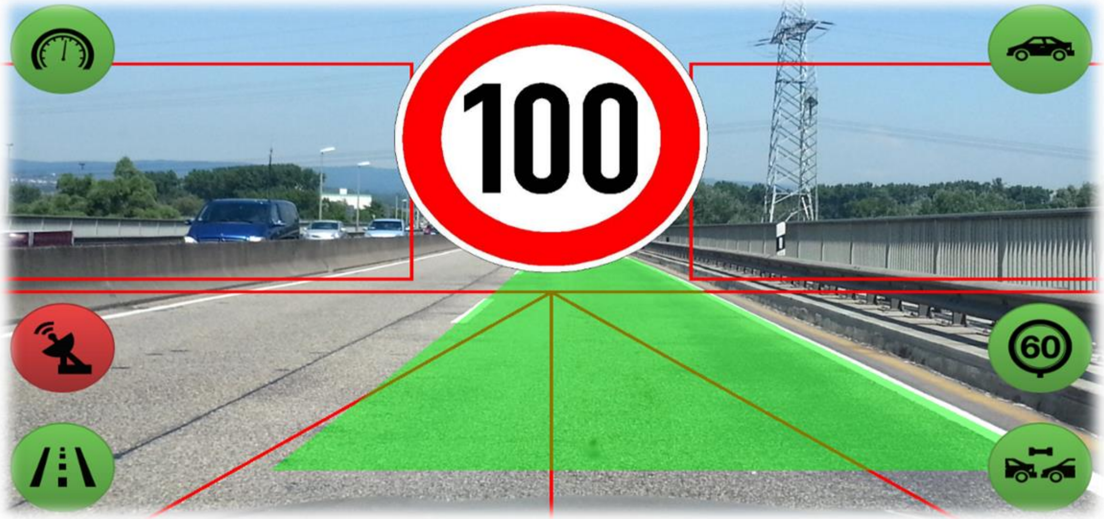
Need for a mechanism that is

- Low cost ✓
- User centric ✓
- Robust ✓

Alternative Mechanism

Augmented reality (AR)

- Flexibility
- Control



https://goo.gl/images/qLowXF

The question is…

"How such safety-critical traffic control information (and what specific information) can be delivered effectively to the driver using AR without causing any form of distraction or engagement-related problems."

Methodologies

Variables

- head/eye movements
- vehicle handling measures
- task-engagement behaviors
- physiological parameters

Contributions

The results help

- Investigate safety benefits of using AR to deliver traffic control messages
- Ascertain the feasibility of eventually replacing physical TCD’s with AR signs.

- Thank You!

UMass Amherst

The Commonwealth's Flagship Campus

Augmented Reality for Safer Pedestrian-Vehicle Interactions

October 4, 2017

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Wisconsin Traffic Operations and Safety Laboratory
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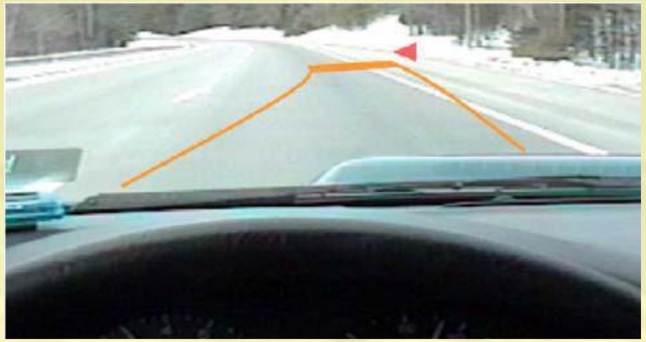
University of Wisconsin-Madison
THE UNIVERSITY of WISCONSIN MADISON

Project Motivation

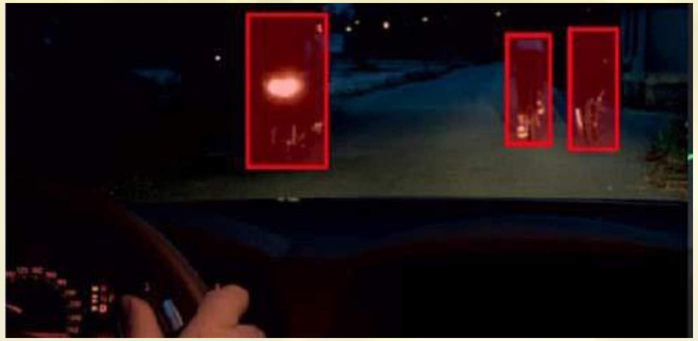
Advancements in AR technologies



Braking distance indicators

Vehicle detection

Lane markings



Pedestrian detection

Project Focus

Safer pedestrian-vehicle interaction

Project Objectives

- Create a streamlined platform for testing AR concepts
- Workforce development component
  - Acquire the skills to create in-vehicle warning systems
  - Understand the design process
- Educational component
  - Build a framework for testing in the simulator

Driving Simulator

Tasks Ahead

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- Continue literature review
  - Identify most promising types of AR designs for enhancing vehicle-pedestrian interactions
- Build scenario for testing designs
  - Flexible platform that allows continuous design iteration by students without the need for significant changes.
- Conduct testing
  - Focus on the identification of best procedures for a streamlined process that ca repeated in the future.

Augmented Reality for Safer Pedestrian-Vehicle Interactions

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SAFER SIM
SAFETY RESEARCH USING SIMULATION
UNIVERSITY TRANSPORTATION CENTER

WISCONSIN TOPS

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