UCR | College of Engineering- Center for Environmental Research & Technology

Eco-Friendly Applications in Connected and Automated Vehicle Technology

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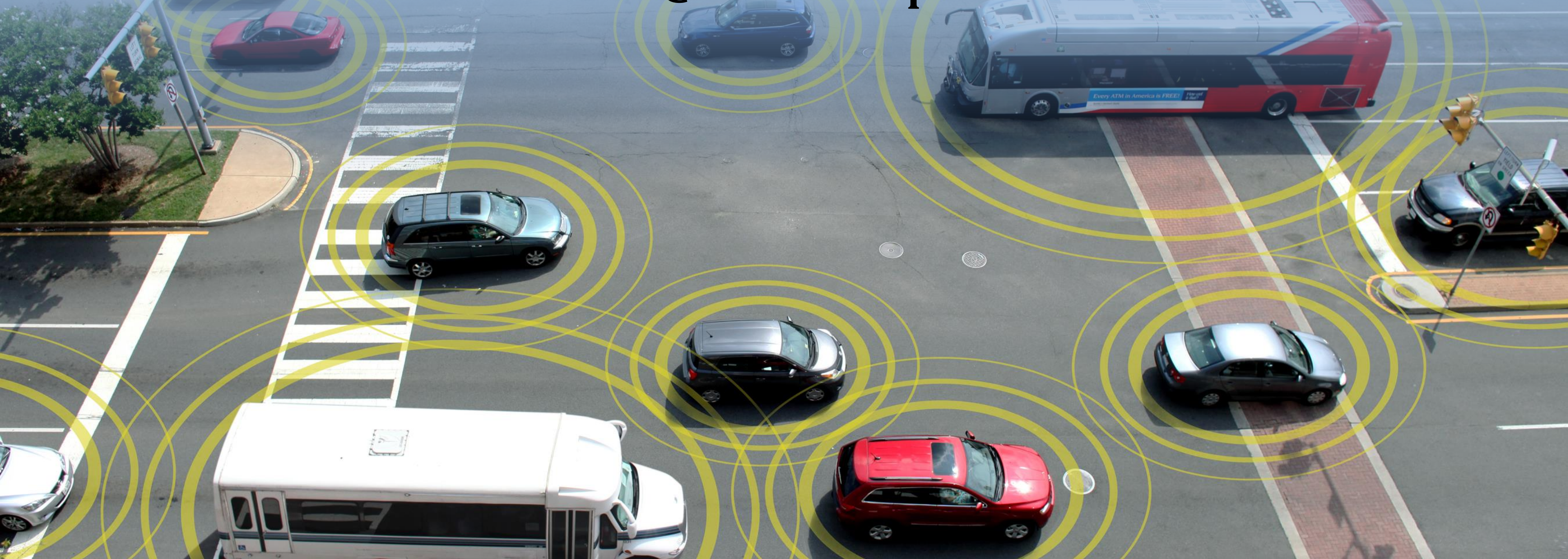
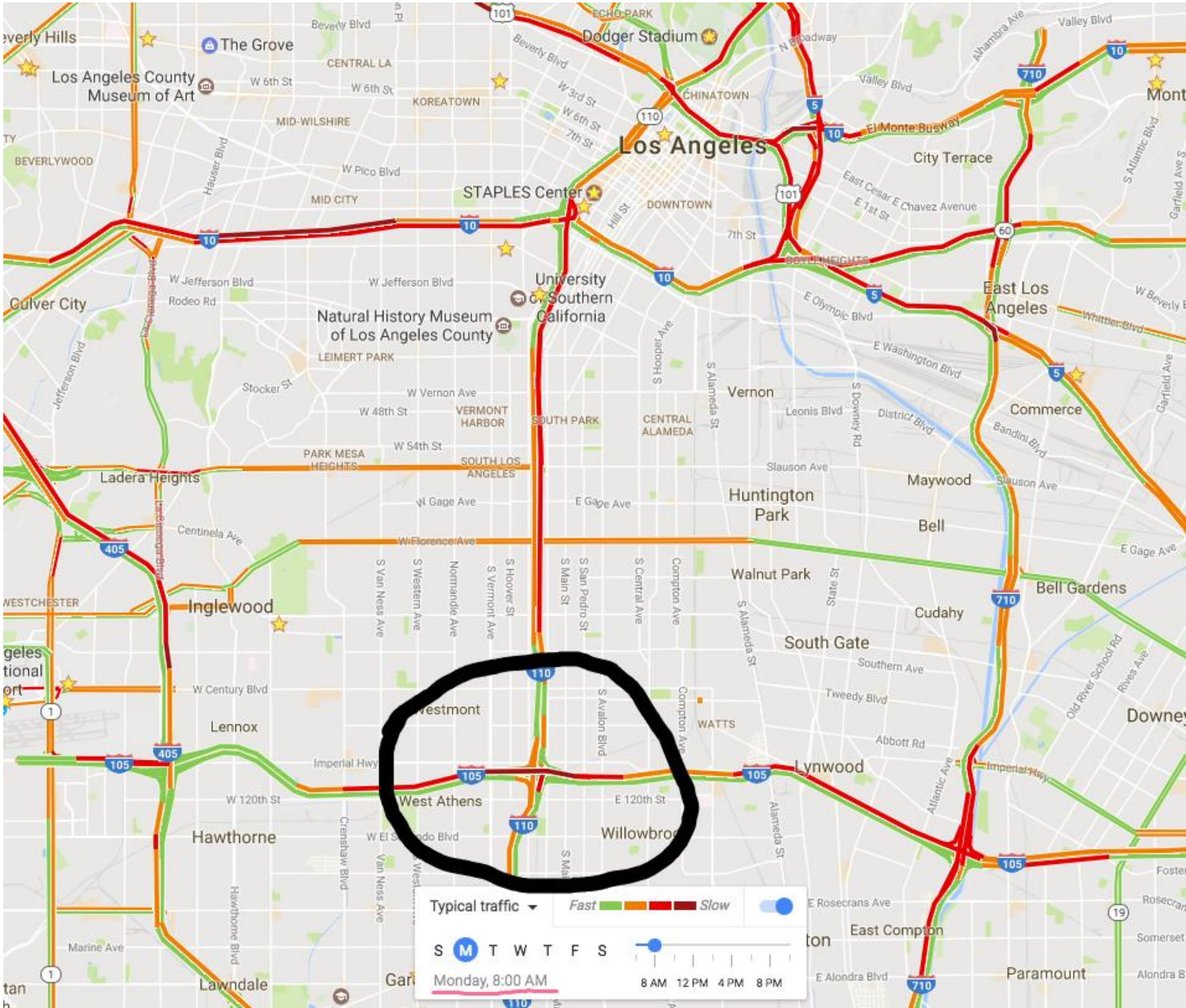


105/110 freeway interchange

(Source: Google Map)



105/110 freeway interchange

(Source: Google Map)

Wasted Fuel and Wasted Time

- In 2016, Los Angeles tops the global ranking with 104 hour/commuter spent in traffic congestion
- In 2014, 3.1 billion gallons of energy were wasted worldwide due to traffic congestion
- In 2013, fuel waste and time lost in traffic congestion cost $124 billion in the U.S.

(Source: La La Land)

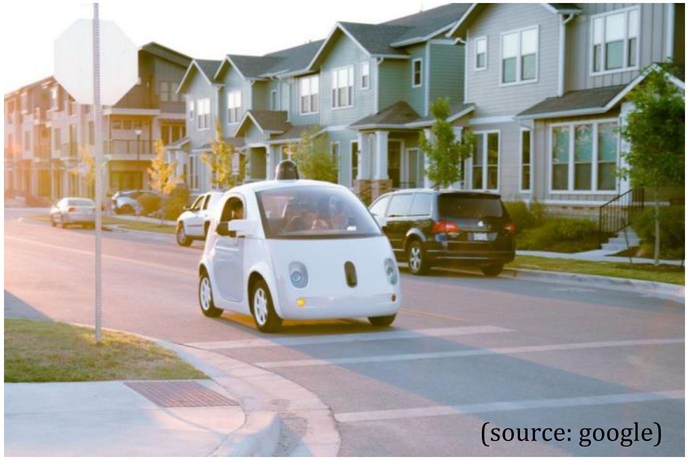
Automated Vehicle Technology

- Definition of automated vehicles

At least some aspects of a safety-critical control function (e.g. , steering, acceleration, or braking) occur without direct driver input

- Sensing techniques

Radar, Lidar, GPS, odometry, computer vision, etc.



(source: google)

(source: google)

- **Level of automation by SAE**

- Level 0: No Automation
- Level 1: Driver Assistance
- Level 2: Partial Automation
- Level 3: Conditional Automation
- Level 4: High Automation
- Level 5: Full Automation

Connected Vehicle Technology

- Definition of connected vehicles

Vehicles that are equipped with Internet access, and usually also with a wireless local area network

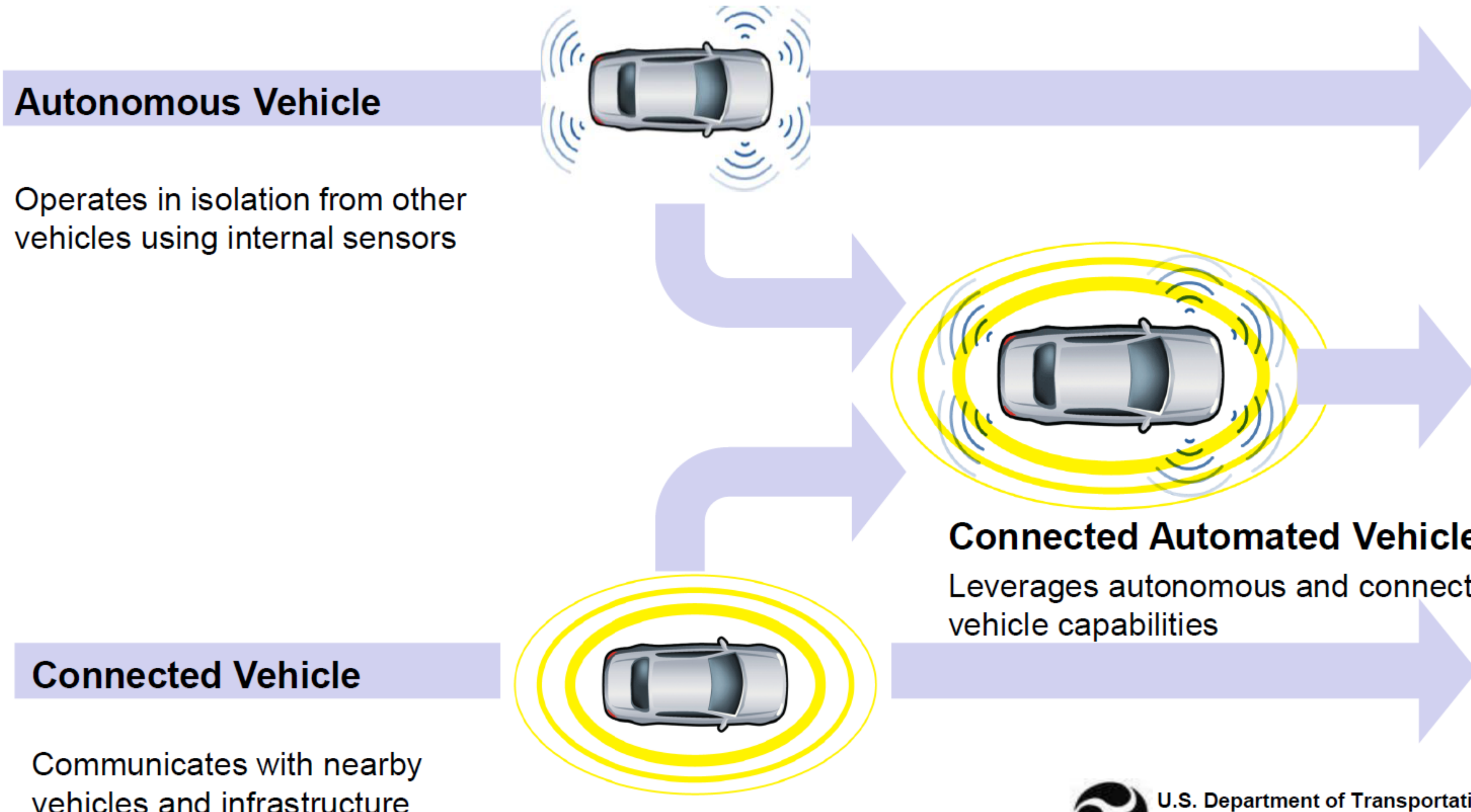
- Communication flow

- Based primarily on dedicated short-range communications (DSRC)
- Between vehicles (V2V)
- Between vehicles and infrastructure (V2I/I2V)

(source: connectedvehicle.org)

(source: USDOT)

Merging of Connectivity and Automation

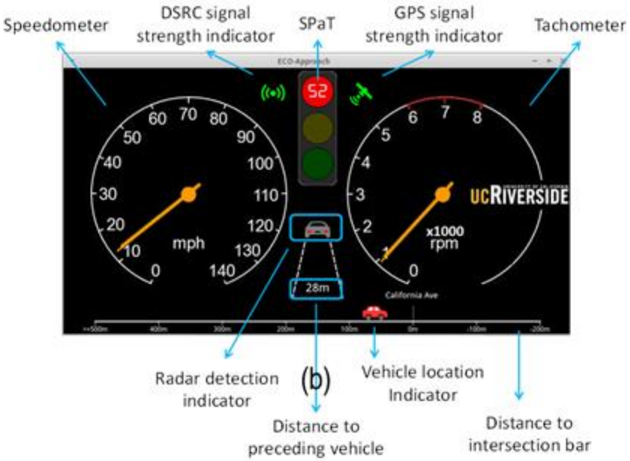


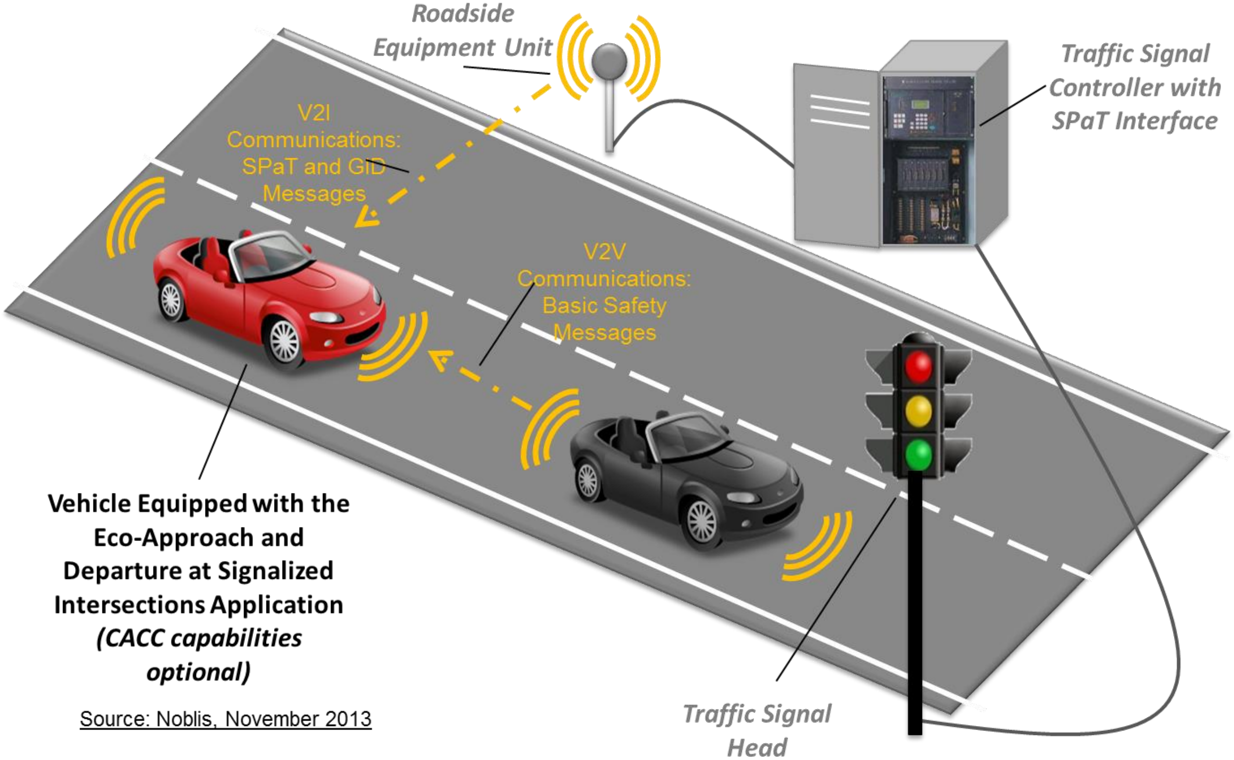
U.S. Department of Transportation
ITS Joint Program Office

Eco-Approach and Departure

Eco-Approach and Departure

- Utilizes traffic signal phase and timing (SPaT) data to provide driver recommendations that encourage “green” approaches to signalized intersections



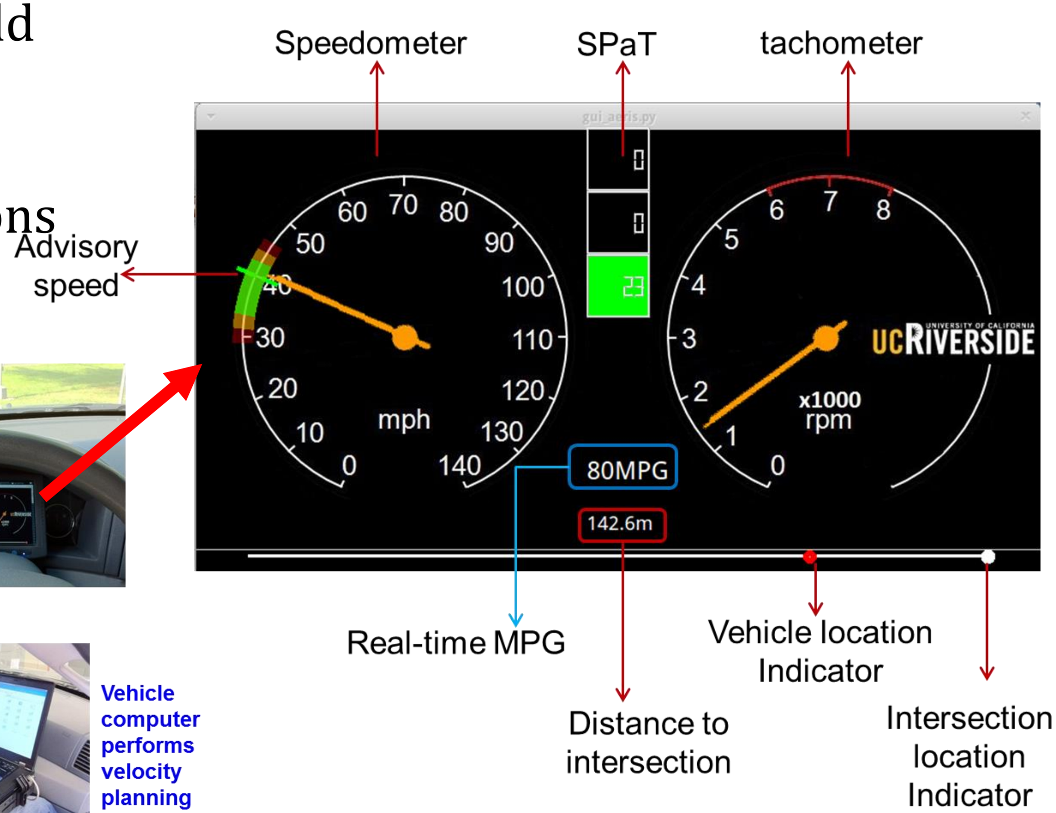


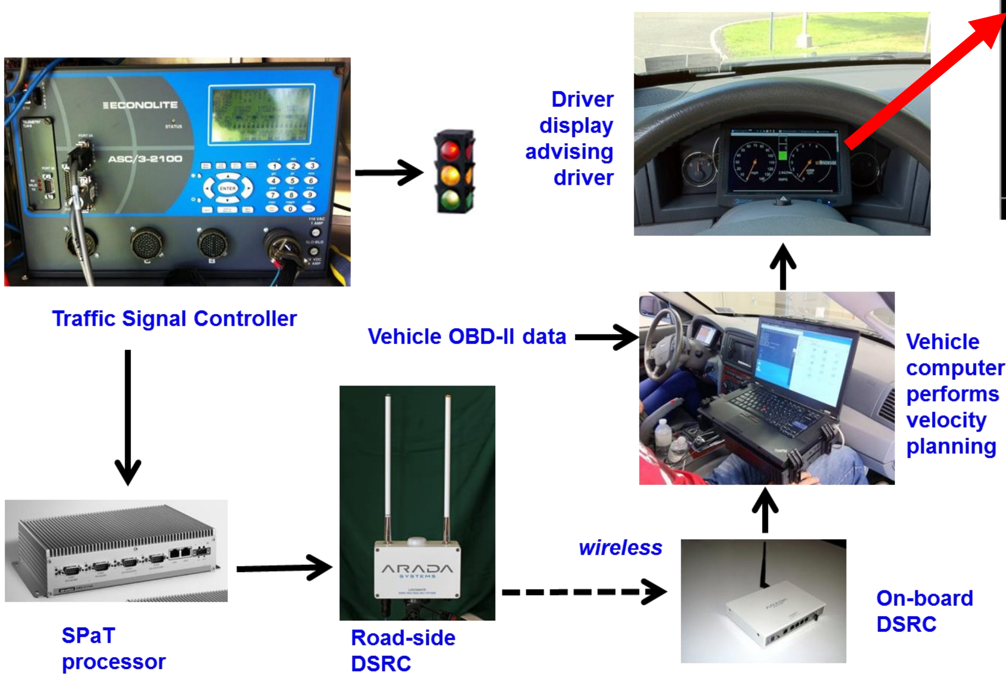
Source: Noblis, November 2013

More benefits for fixed time control

AERIS Connected Vehicle Research

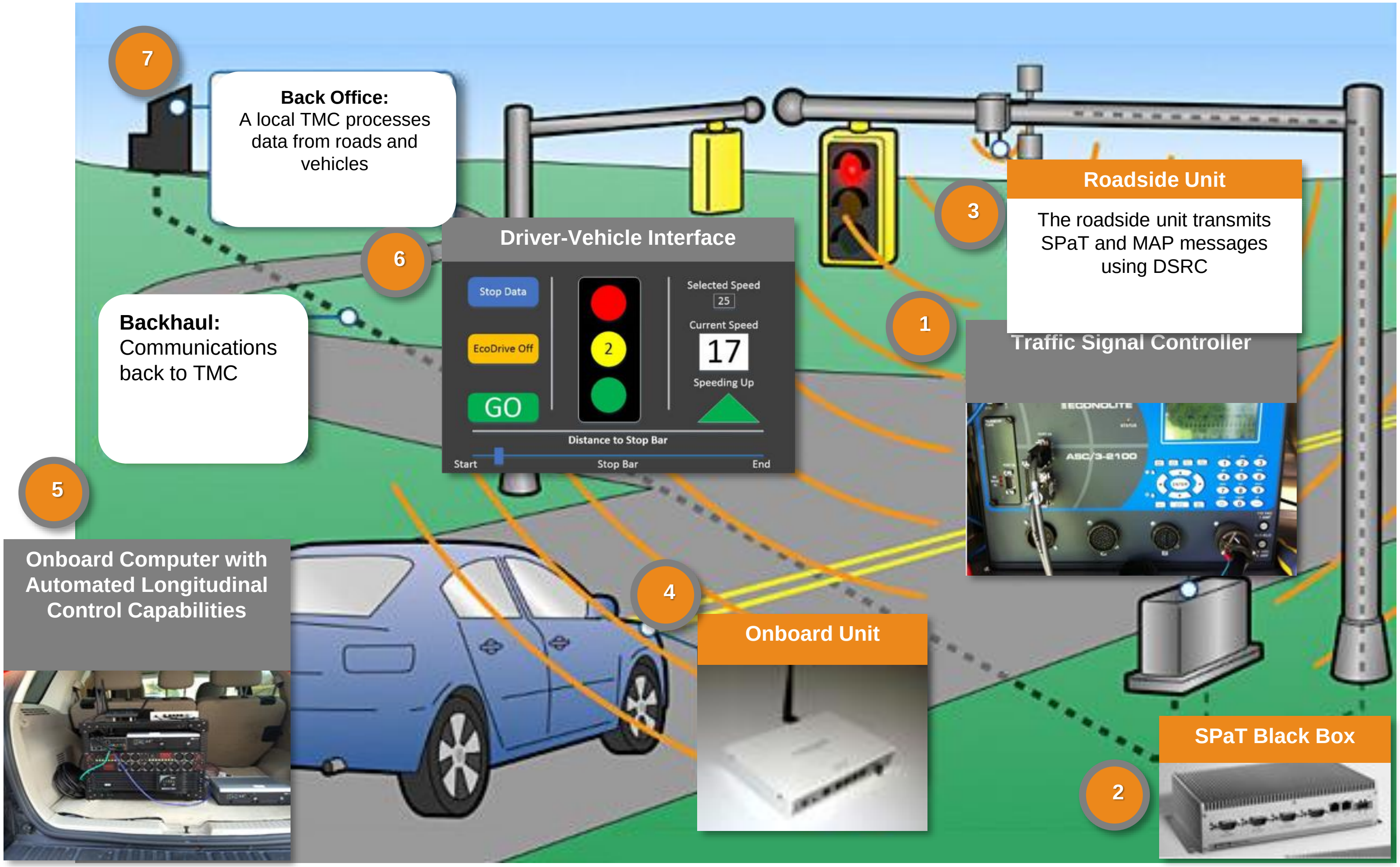
- Developed, modeled, and field tested Connected Vehicle applications targeting at reducing energy and emissions

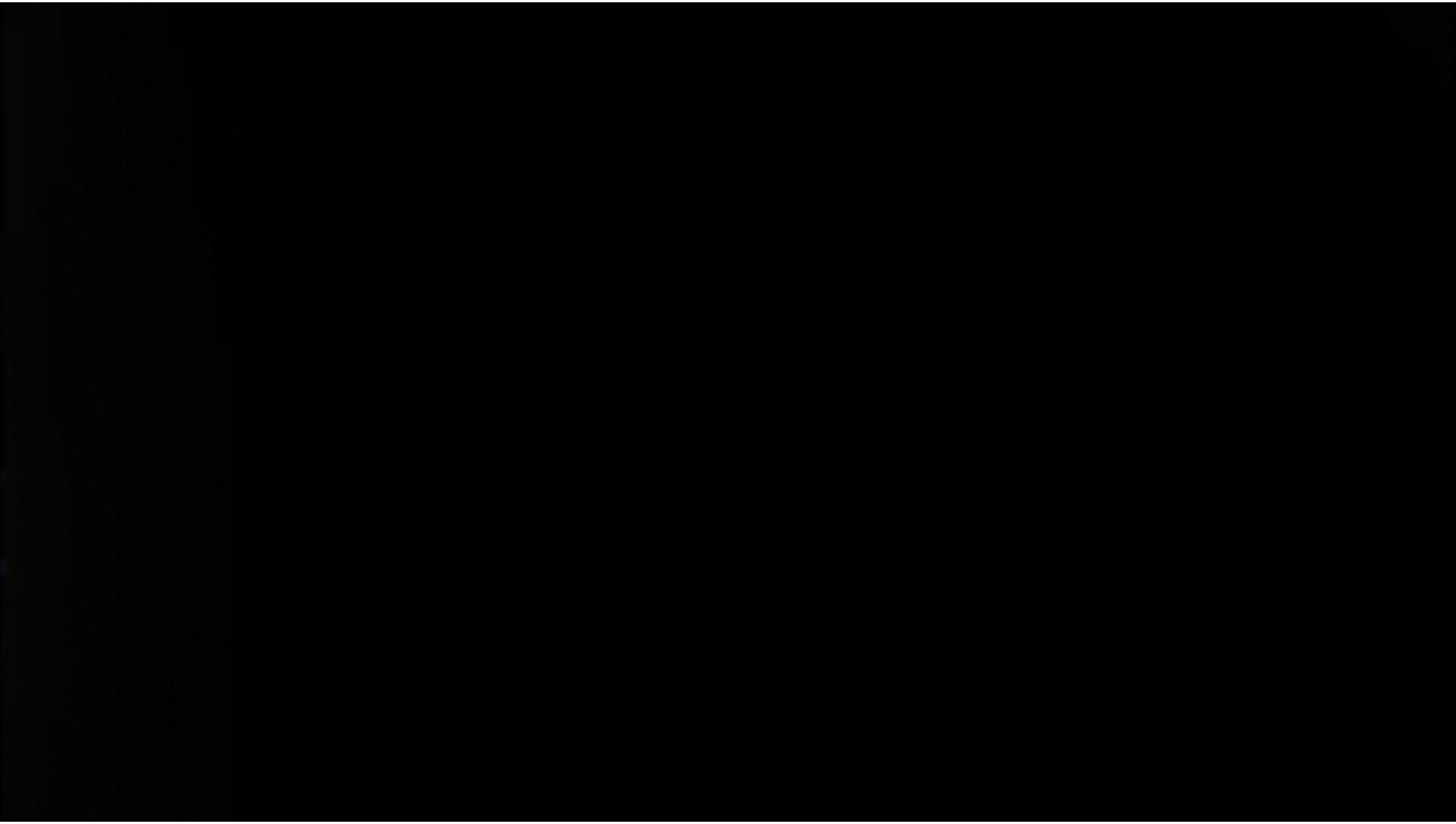




5-20% fuel savings from field experiments

GlidePath I: Partially Automated EAD



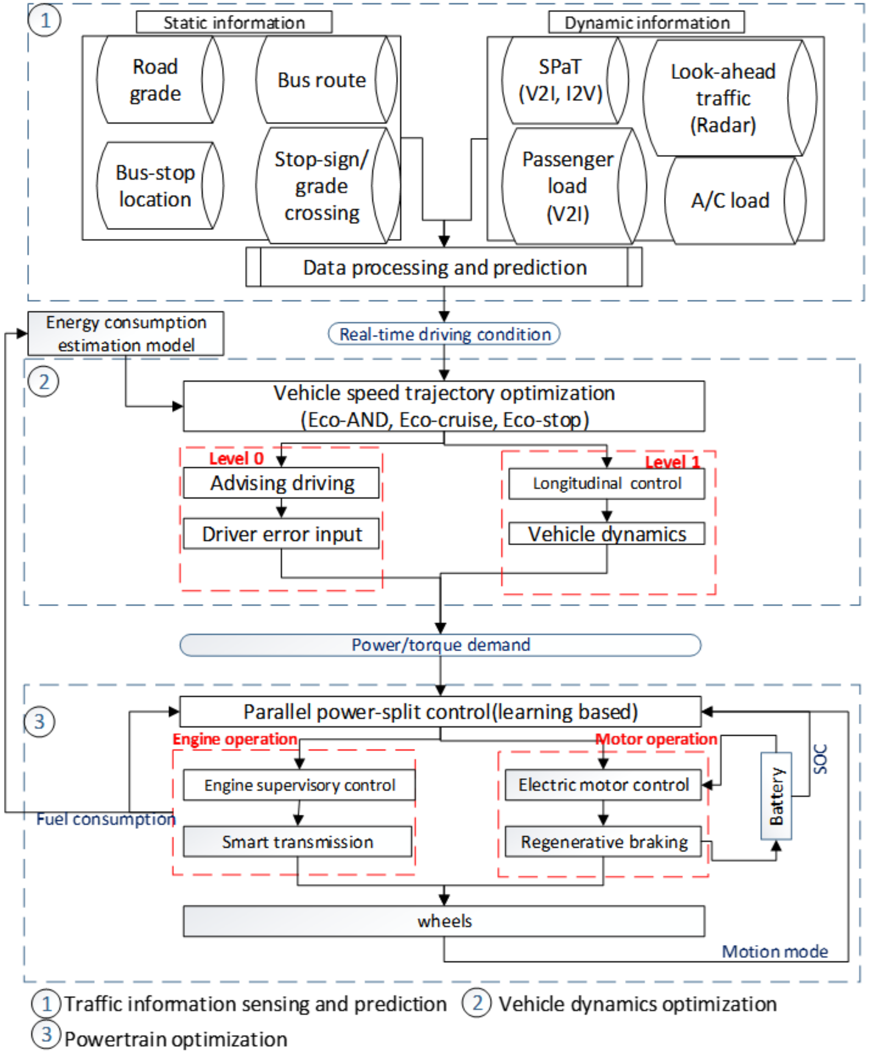


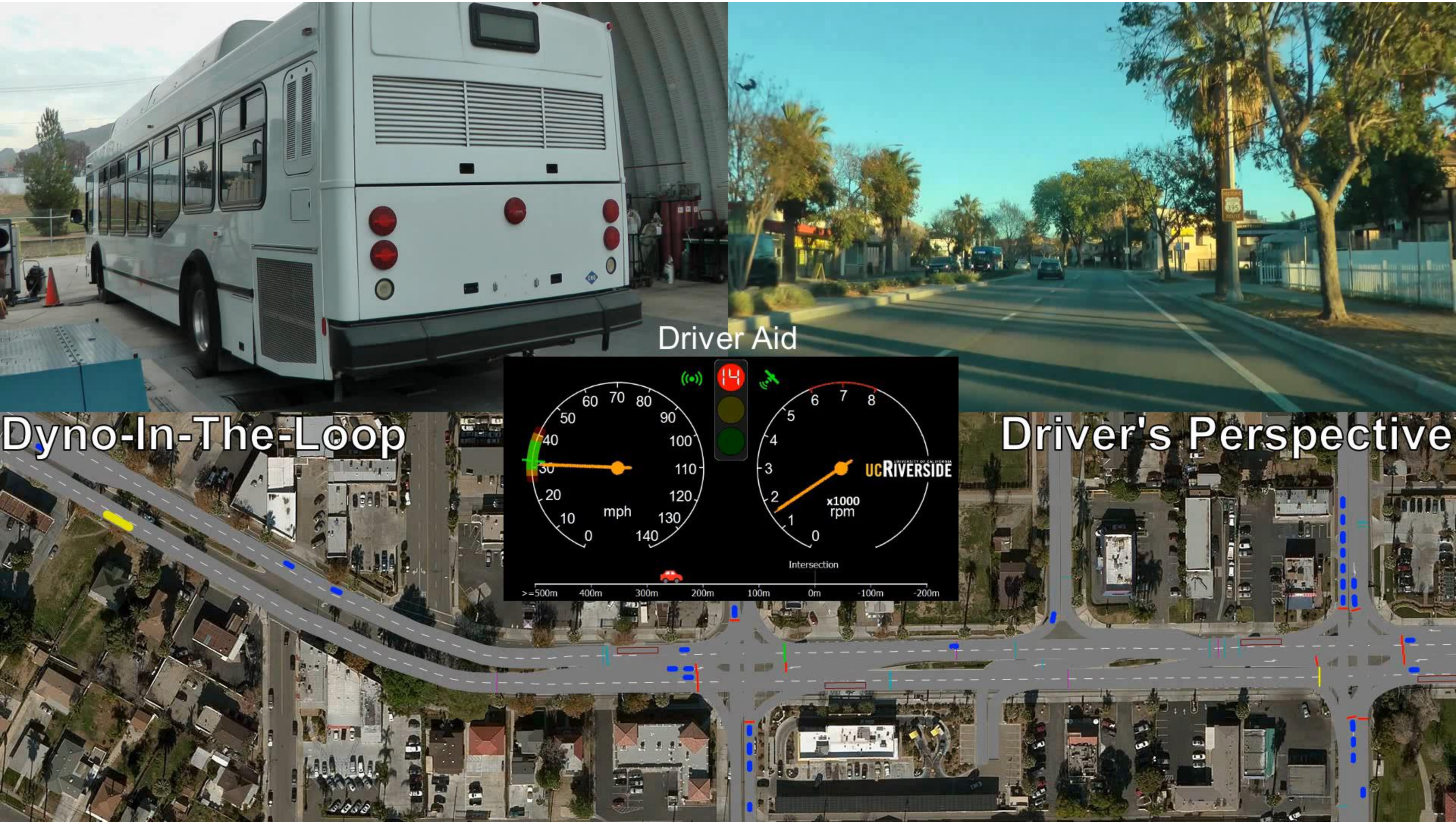
City of Riverside Innovation Corridor

- Six mile section of University Avenue between UC Riverside and downtown Riverside
- All traffic signal controllers are being updated to be compatible with SAE connectivity standards
- UC Riverside is providing the Dedicated Short Range Communication modems in each traffic signal
- Corridor will be used for connected and automated vehicle experiments (ARPA-E hybrid bus, light-duty vehicles, etc.)

Connected Eco-Bus

- An Innovative Vehicle-Powertrain Eco-Operation System for Efficient Plug-In Hybrid Electric Buses
  - Co-optimization of vehicle dynamics and powertrain control
  - 20% energy consumption reduction target



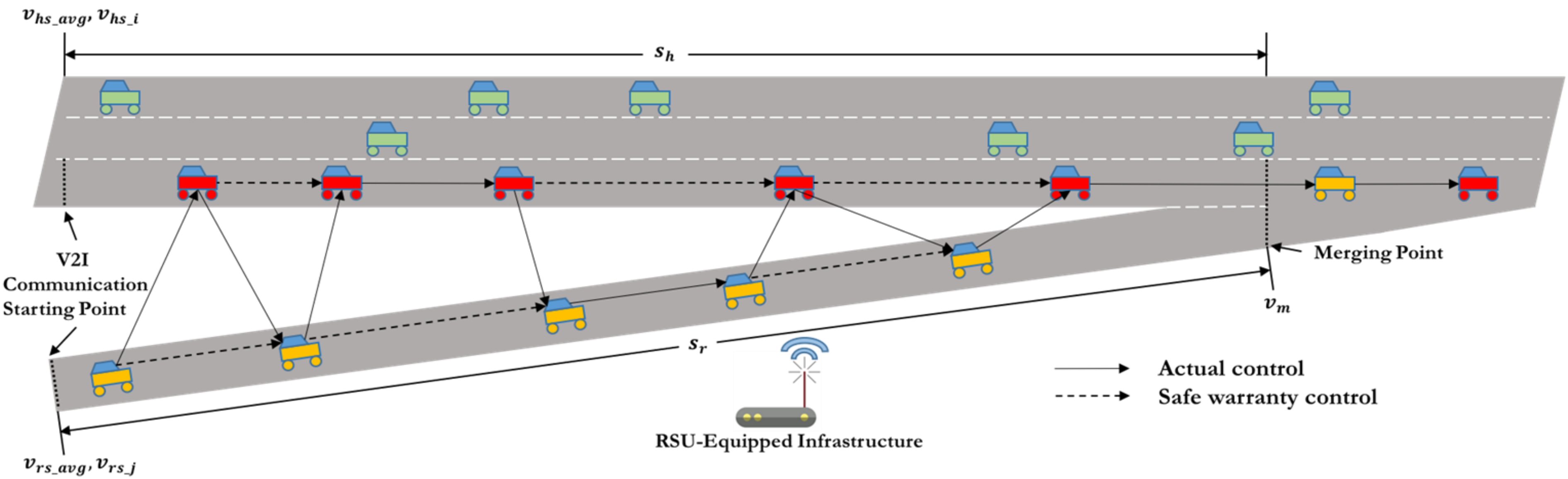

Driver Aid
Dyno-In-The-Loop
Driver's Perspective
60 70 80
50 90
40 100
30 110
20 120
10 mph 130
0 140
14
6 7 8
5
4
3
2
1 0
x1000
rpm
UC RIVERSIDE
Intersection
>=500m 400m 300m 200m 100m 0m -100m -200m

Cooperative Ramp Merging

Cooperative Ramp Merging

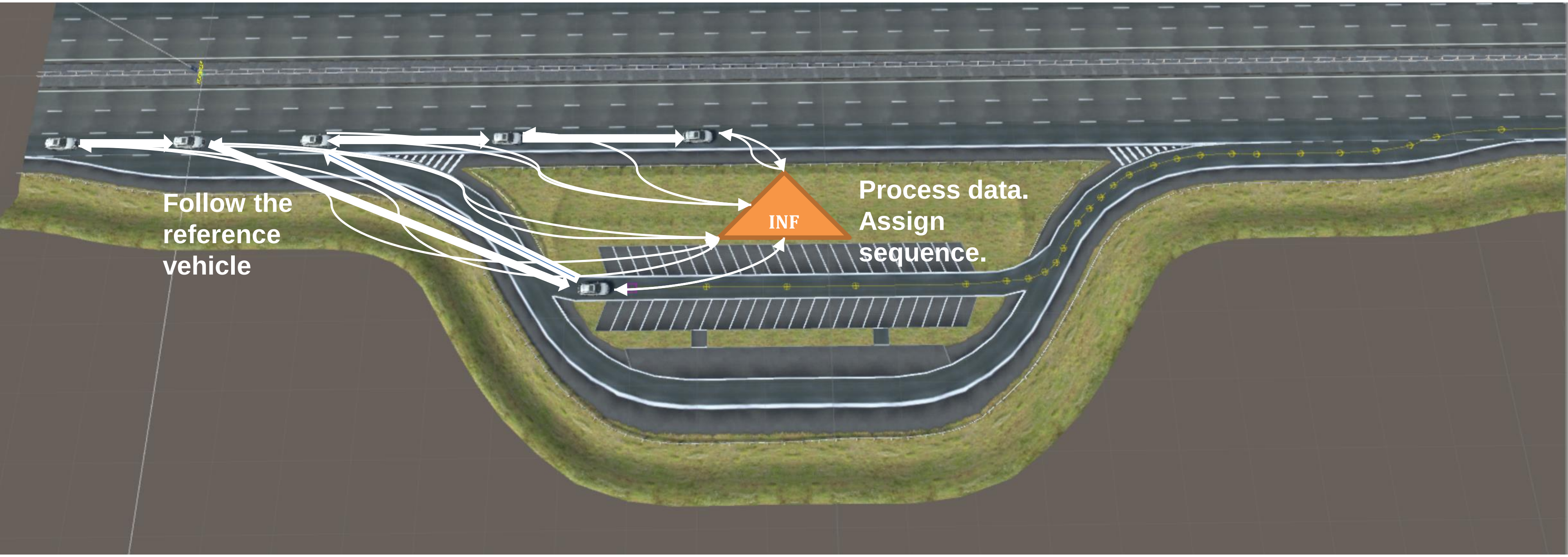
Benefits of *distributed consensus-based cooperative on-ramp merging system*

- Increase merging ***safety*** by applying V2X communications
- Increase traffic ***mobility*** by assigning vehicles into cooperative adaptive cruise control string before merging
- Reduce ***energy*** consumption by avoiding unnecessary speed changes



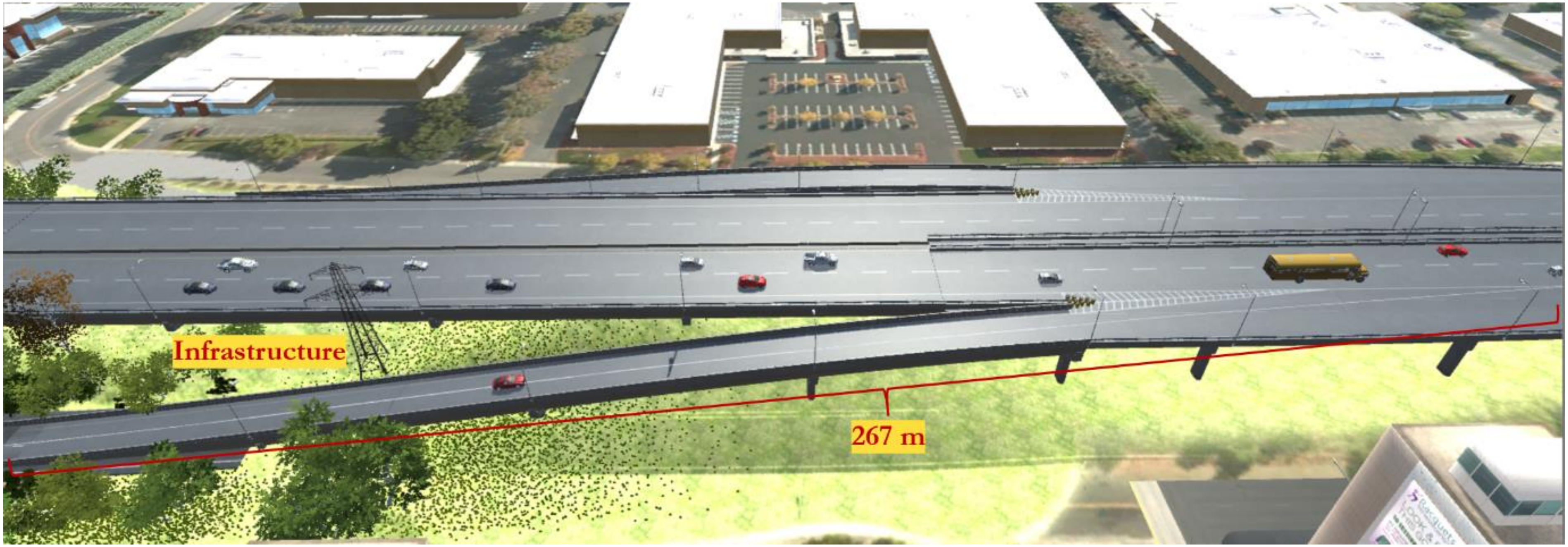
* RSU: Road Side Unit

System Workflow



Simulation Setups

- Mountain View simulation network in game engine Unity3D



Simulation Results

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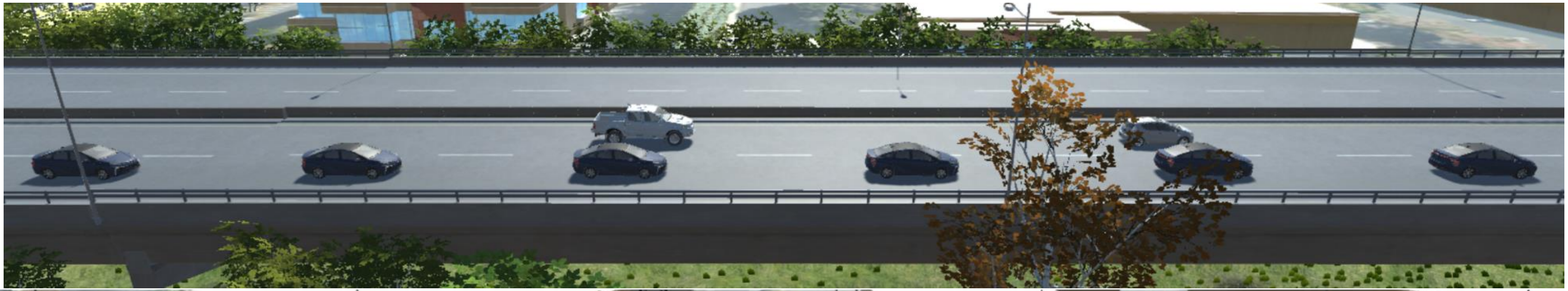
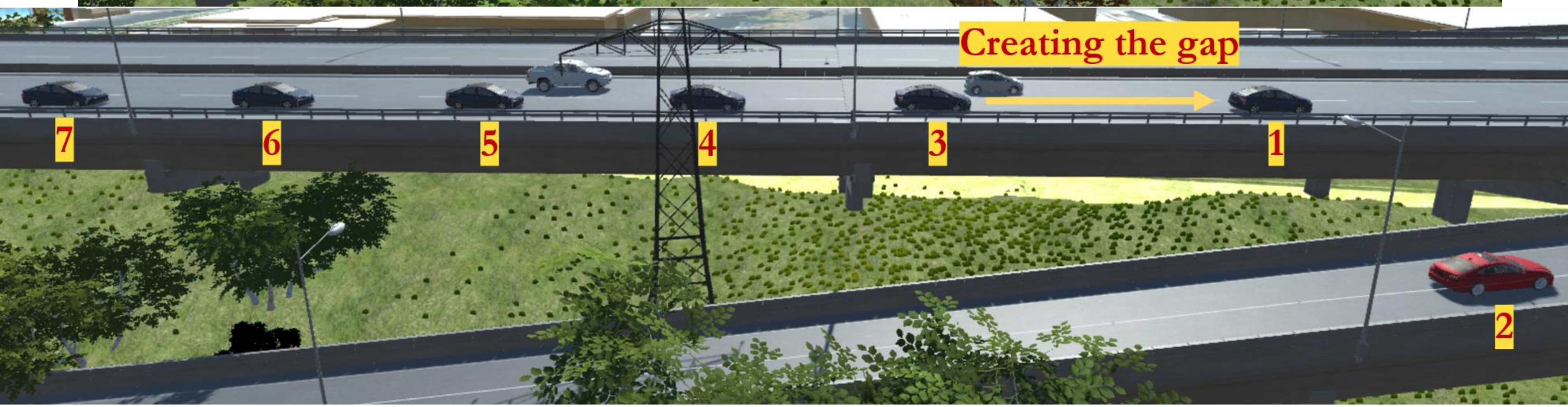
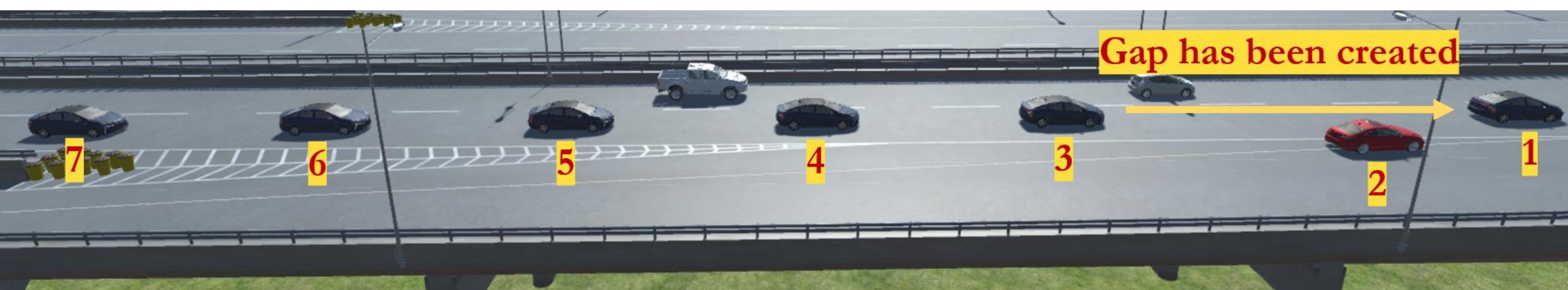
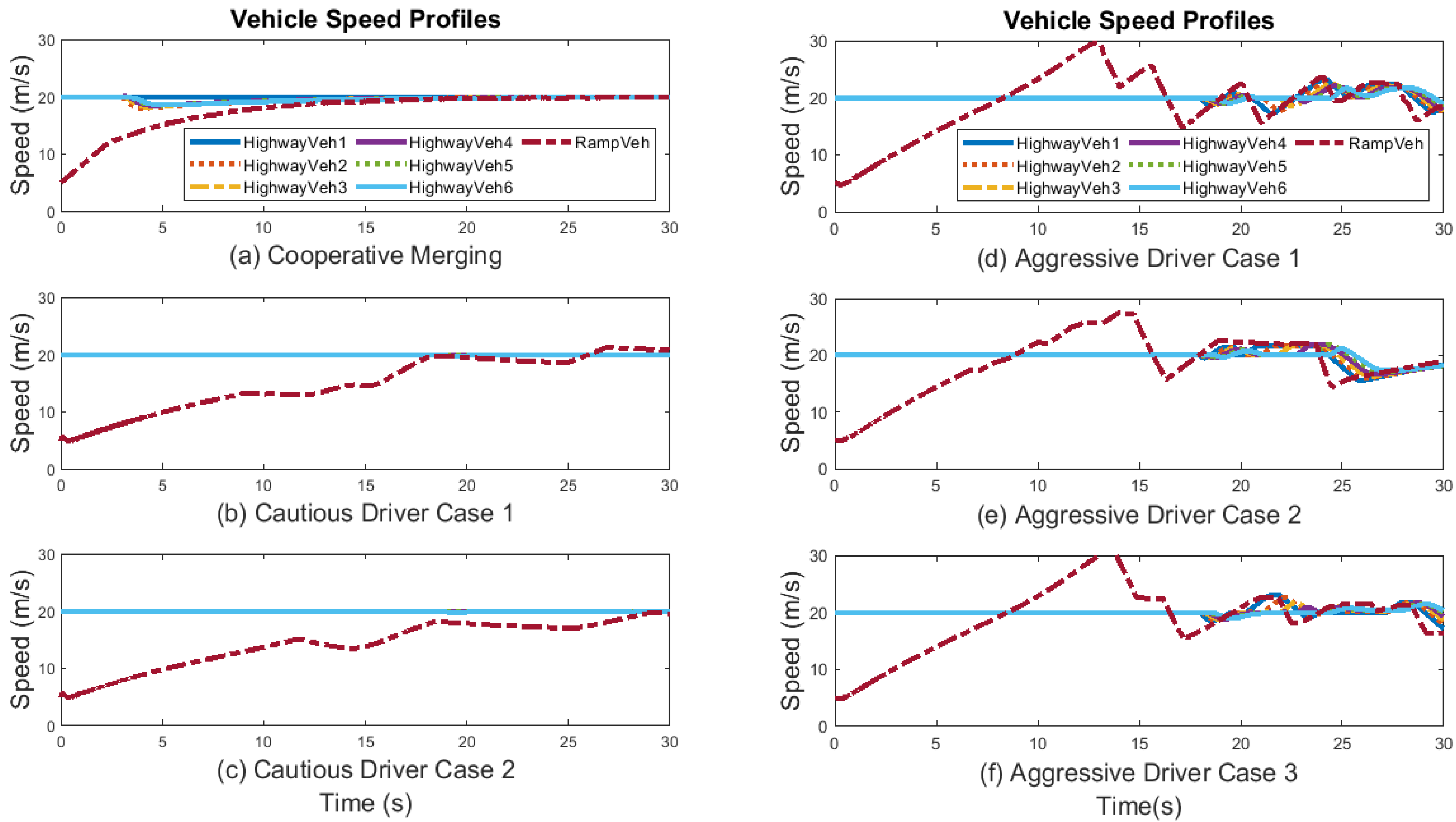






Simulation Results



Simulation Results

	Travel Time	Energy	HC	CO	CO2	NOx
Human-in-the-Loop (baseline)	233.58 s	9930.56 KJ	0.0200 g	2.8192 g	706.5392 g	0.0759 g
Cooperative Merging (proposed)	218.14 s	9153.97 KJ	0.0094 g	1.1737 g	651.287 g	0.0440 g
Reduction Percentage	7.08 %	8.48 %	112.77 %	140.20 %	8.48 %	72.5 %

* hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx)

Savings in travel time, energy and emission

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Thank you! Questions and comments?

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