Validation of Advanced Vehicle Systems

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What’s TRC?

**Transportation Research Center Inc.**

**The Largest Independent Vehicle Test Facility and Proving Grounds in North America**

- **4,500 acres** – about 1/3 the size of Manhattan
- **7.5 mile high speed track** – 3 times size of Indy oval; banking 4 times steeper
- **50 acre Vehicle Dynamics Area** – 38 football fields, including end zones
- **Home of the only federal vehicle research and test lab for NHTSA**

- Over **1,000 customers** – the most of any U.S. proving grounds
- **450+ employees**
- **24/7 operation**
- **359 days a year**

Non-profit that has contributed over **$54 million** to automotive research
A SMART Ecosystem for Connected & Automated Vehicles

TRC SMART CENTER  SMART MOBILITY CORRIDOR
Vehicle Changes in 100 Years

Terminology

- **ADAS**
  - Advanced Driver Assistance Systems
- **AV**
  - Automated Vehicles
- **ADS**
  - Automated Driving System
- **CV**
  - Connected Vehicle (4G or DSRC)
- **CAV**
  - Connected Automated Vehicle
Advanced Driver Assistance Systems

- Systems which only control the subject in a very limited number of cases and only for brief periods of time.
- Collision Warning, Collision Avoidance
Levels of Automation

• Most of industry is converging around the Society of Automotive Engineers (SAE) levels of automation
  – NHTSA began using these level in the Federal Automated Vehicles Policy (September 2016)

• Level of automation largely is concerned with how the driver interacts with the system, and the distribution of responsibilities.
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Level 2 Comparison

2017 Tesla Model S
- Enhanced Autopilot
- Full Self-Driving Capability
MSRP $78,500

https://www.tesla.com/models/design

2017 Honda Civic
- Honda Sensing
MSRP $20,540

https://automobiles.honda.com/civic-sedan#build-price-app
Level 2 Comparison

2017 Tesla Model S
- Advanced Cruise Control
- Lane Centering
- Automatic Lane Change
- Automatically Exits the Freeway
- Automated Parking with or without driver in the vehicle.

2017 Honda Civic
- Advanced Cruise Control (ACC)
- Lane Centering

This comparison only considers control of certain degrees of freedom, ignoring types of actions and control authority.
Connected Vehicles

- Vehicles utilizing radio hardware to share data with other vehicle and elements of the infrastructure.
Connected Automated Vehicles

- Vehicles utilizing a combination of automation algorithms and data available from connectivity to implement coordinated driving maneuvers.
  - Cooperative Adaptive Cruise Control/ Platooning

http://woodwardcom.com/portfolio-items/cooperative-adaptive-cruise-control-fact-sheet/
In testing driving automation systems, we create environments to understand how a vehicle will respond to various situations.
Where in the World?

Scenarios
How do you define a scenario?

Scenario = Environment + Traffic

- Environment – The roadway and all other static objects in the defined space (pavement and furniture)
- Traffic – Dynamic objects in the environment
  – Other vehicles, pedestrians, animals, bouncing sports balls, anything else you can imagine...
Central Question

What features are desired for testing Highly Automated Vehicles (HAVs)?
Central Question - Revised

What features are necessary for testing Highly Automated Vehicles (HAVs)?
Stakeholder Survey

• In order to answer this question TRC conducted a large user survey
  ▪ Participants from government and industry

• Questions were asked based on what test scenarios were desired
  ▪ Resulted in a very large amount of data

• This information was initially reduced by identifying the course features necessary for each test scenario
Features Necessary
Main Environments with Features

- Suburban
- Highway
- Intersection
- ITS
- Urban
- Temporary Courses
- Environmental
- Parking Lot
- Rural
- Tunnel
- Other Road Users
- Highway
- Suburban
- Intersection
- ITS
- Urban
- Temporary Courses
- Environmental
- Parking Lot
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- Other Road Users
- Highway
- Suburban
- Intersection
- ITS
- Urban
- Temporary Courses
- Environmental
- Parking Lot
- Rural
- Tunnel
Main Environments

- tunnel
- highway
- intersection
- ITS
- suburban
- environmental
- temporary courses
- urban
- rural
- parking lot
- other road users
Ohio’s Transportation Research Center (TRC) is getting a new 540-acre facility specifically for testing and researching smart mobility solutions.
Location at TRC
Facility Detail

Urban Network
The Urban Network consists of a diverse set of roadways and intersections including a circular vehicle dynamics area for simulation of roundabouts and oblique intersection scenarios. The Urban area is suitable for lower speed testing of a variety of environments.

High Speed Intersection
The high speed intersection is six lanes wide in each direction with the North-South leg covering 1.2 miles. At the center is a flexible signalized intersection with multiple traffic detection systems and an advanced traffic control architecture. The intersection is suitable for high speed testing of passenger and commercial vehicles.

Control Building
A 10,000sqft Control Building provides centralized control and coordination of testing, vehicle preparation and calibration, and office space for TRC’s Applied Research Group.
Current State
Current State
Testing System Infrastructure

- State-of-the-art traffic control system (TCS)
- Mobile Traffic Signals
- DSRC V2X coverage over the complete facility with compatible OBUs
- Fixed view and movable cameras for test coordination and data collection.
- Fiber Network with connection points at most intersections
- Wi-Fi available for most of facility
Mobile Test Systems and Data Acquisition

*Final systems are being selected but the following is expected.

- Large low-profile robotic platforms
  - Carries compatible vehicle surrogates
- Small low-profile robotic platforms
  - Carries pedestrian, child pedestrian, bicycle, moped, and deer surrogates
- High precision DGPS systems with integrated range technology (2cm precision)
- Robotic controllers for testing of systems with driver controls.
- Data acquisition systems with CAN synchronized video for collection of all vehicle network traffic and external variables.
How We Test
Can we really test everything?

Impact of Advanced Vehicles

- **Safety**
  - *95%* of all collisions could be prevented
    - Based on data from NHTSA’s National Motor Vehicle Crash Causation Survey
- **Economy**
  - *$242 billion* spent in 2010 on motor vehicle accidents
- **Efficiency**
  - Reduce the *6.9 billion* hours spent in traffic
- **Mobility**
  - Bring mobility options to the *millions* that currently have none

STAY CONNECTED

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