SAFETY EVALUATION OF THE ADVANCED STOP ASSIST SYSTEM IN THE CONNECTED VEHICLE ENVIRONMENT

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in collaboration with:

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Presentation Agenda

1. Introduction
2. Overview of Connected and Autonomous Vehicles
3. Modeling Connected and Autonomous Vehicles
4. Research Case Study: Safety Evaluation of Stop Assist System
5. Microsimulation Model
6. Results
• Arcadis (2017-Present)


• Florida Atlantic University (2013-2014)

• North Carolina State University (2008-2013)
Modeling CAV

**Macro**
- Travel Demand Modeling
- Shared Mobility Impact
- Macro Level Evaluation

**Meso**
- City Level Analytics
- Impact on Network Assignment
- Speed, Density Analysis

**Micro**
- Detailed CAV Vehicle Replicated
- Virtual Environment to test CAV Performance
- Microscopic Evaluations
Typical Simulation Workflow

1. Input of Network Data
   - Directly from Map Providers such as Bing, Open Street Map.
   - Networks from external software such as CarMarker, PreScan, and ConceptStation

2. Input of Traffic Data
   - **Traffic Composition**
     - Vehicle Types, Visual Models, Public Transportation
     - Full Interaction
   - **Individual Behavior Settings**
     - Acceleration/Deceleration Profiles
     - Speed and Distance Settings
   - **Calibration**
     - Real World Data

3. Application of Scenarios
   - Input Systematic Variation
   - Design of Experiments
# CAV Simulation Aspects

<table>
<thead>
<tr>
<th>INFRASTRUCTURE</th>
<th>VEHICLES</th>
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<tbody>
<tr>
<td>Will the Vehicle communicate with the infrastructure?</td>
<td>What would be the headway to other vehicles in all situations?</td>
</tr>
<tr>
<td>Impact of CAVs on Highway Speed-Flow Relationship?</td>
<td>What is the acceleration and deceleration profile?</td>
</tr>
<tr>
<td>What about intersection saturation flow?</td>
<td>Will the vehicle form a platoon?</td>
</tr>
<tr>
<td>Will dedicated CAV Infrastructure provide a significant benefit?</td>
<td>How to behave if the next vehicle isn’t an CAV?</td>
</tr>
<tr>
<td>How many CAVs create a “tipping point” in the network?</td>
<td>What if the vehicle in front has less deceleration power?</td>
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## Key CAV Simulation Data Input

| Car Following Behavior | ✓ CAV keeps smaller standstill distance  
| ✓ CAV keeps smaller headway |
| Lane Change Behavior   | ✓ CAV reacts on the signal immediately |
| Speed Profiles         | ✓ CAV keeps the desired speed strictly without variation |
| Acceleration Profiles  | ✓ CAV accelerates and decelerates equally without variation |
Psycho-physical Car Following Model (Wiedemann)

Normal Following

CAV Following

- Constant Headway
- Shorter Headway
- Constant Speed
- Constant Acc/Dec
Vissim and CAV Simulation

**How to Model CAV with PTV VISSIM**

**Calibrating Built-In Models**
- Car Following Model
- Lane Change Behavior
- Speed and Acceleration Profiles

**Using PTV Vissim Interfaces**
- Component Object Module
- Event Based Scripts
- Driver Model Library
- Driver Simulator Library

Internally

Externally
### Other External Modifications

<table>
<thead>
<tr>
<th>Event Based Scripts</th>
<th>Driver Behavior DLL</th>
<th>Driving Simulator DLL</th>
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<tbody>
<tr>
<td>• Introduced in Vissim 8</td>
<td>• Replaces “internal” driving model with a user defined one</td>
<td>• Driving in the simulation environment</td>
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<tr>
<td>• Scripts stays active</td>
<td>• Different Vehicle Types</td>
<td>• The driver decided where the vehicle would be in the next time step</td>
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<td>• Reduces the overhead per call</td>
<td>• Specific and Detail Behavior</td>
<td>• Human driver interacting with CAV vehicles</td>
</tr>
<tr>
<td>• Global values retain their value</td>
<td>• Manufacturer Algorithms</td>
<td>• DLL passes info at every single time step</td>
</tr>
<tr>
<td>• Minimizes variable definition</td>
<td>• DLL passes info at every single time step</td>
<td></td>
</tr>
</tbody>
</table>
Sample Case Study

On-board Equipment (OBE)

Dedicated Short Range Communication (DSRC)

Road Side Equipment (RSE)

Signal

Vehicle to Infrastructure (V2I) System
Sample Case Study

- Type
- Status
- Speed
- Acceleration/Deceleration
- Position
- Lane of Movement

Decision
- Pass or Stop?
- Accelerate or Decelerate?
- Advisory Speed

- Signal State
- Signal State Running Time
- Remaining Green Time

- RSE Location
- Stop Bar Location

DSRC Range

Vehicle to Infrastructure (V2I) System

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Microsimulation Model

- **Used Hard Braking** as Safety Surrogate Measure
- **Simulation Calibration**: SHRP2 Naturalistic Driving Study (NDS) through Virginia Polytechnic for Bruce B Downs corridor in Tampa, FL. Calibration is in accord with *FDOT Simulation Guideline*.
- **Signal Timing Data**: **City of Tampa**
- **Market Penetration Rates**: 00%, 20%, 40%, 60%, 80%, 100%
- **Speed Profile**: Average Speed
Results

Speed Profiles for Different Penetration Rates

Safety Benefits for Different Penetration Rates

Paper Link
THANK YOU 😊

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