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
Simulating CAVs Using Vissim

Simulation of AVs:
Depiction of movement of all levels of automated cars.

Impact of AVs:
Evaluation of autonomous driving and its effects on the entire traffic flow.

Multimodality:
Simulation of all modes of transport and their interaction in a single software.

Vehicle behavior models:
Realistic representation of movement of all road users through proven behaviour models.

Simulate your city:
Ability to simulate local conditions for cities around the world

Traffic scenario testing:
Application of standard and customised scenarios, e.g. "City center at rush hour", "Urban motorways with on/off-ramps" etc.

Evaluation of scenarios:
Monitoring of weather conditions such as rain, fog or snow.

System integration:
Integration of PTV Vissim with other standard development software.
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>
</tr>
</thead>
<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
  - CAV reacts on the signal immediately
  - CAV keeps the desired speed strictly without variation
  - CAV accelerates and decelerates equally without variation

- **Lane Change Behavior**

- **Speed Profiles**

- **Acceleration Profiles**
Psycho-physical Car Following Model (Wiedemann)

Normal Following

- Constant Headway
- Shorter Headway
- Constant Speed
- Constant Acc/Dec

CAV Following

- Constant Headway
- Shorter Headway
- Constant Speed
- Constant Acc/Dec

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Training PTV Vissim - Basic Course
Vissim and CAV Simulation

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

HOW TO MODEL CAV WITH PTV VISSIM

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>
</tr>
</thead>
<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>
</tr>
<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>
</tr>
<tr>
<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>• DLL passes info at every single time step</td>
</tr>
</tbody>
</table>
Sample Case Study

Dedicated Short Range Communication (DSRC)

On-board Equipment (OBE)

Road Side Equipment (RSE)

Signal

Vehicle to Infrastructure (V2I) System
Sample Case Study

Vehicle to Infrastructure (V2I) System

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

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

- RSE Location
- Stop Bar Location

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

DSRC Range
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

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THANK YOU 😊

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