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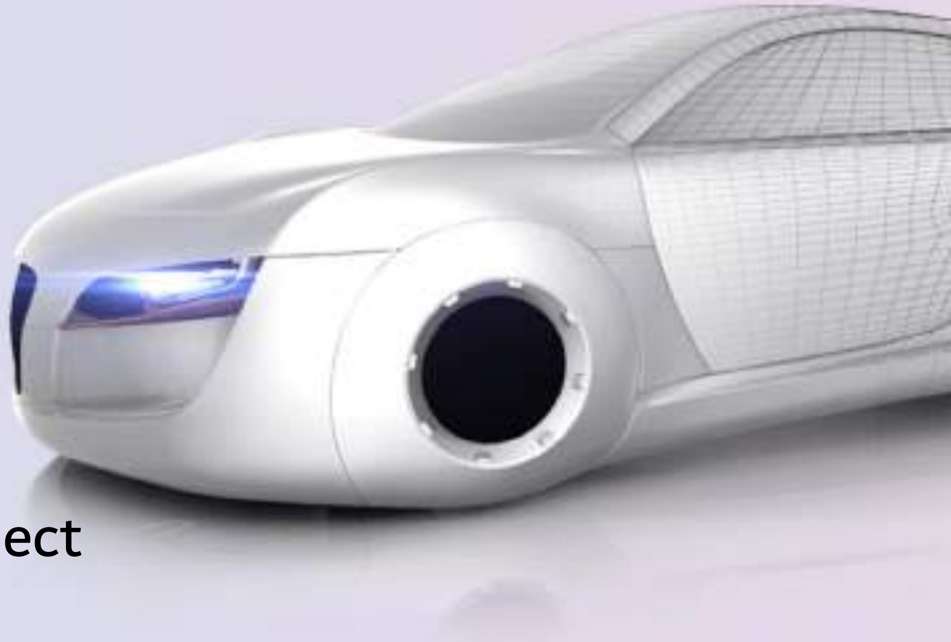
Testing and Validating Autonomous Vehicles using PTV Vissim Traffic Simulator with a Case Study in Dubai



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Manager Microscopic Simulation, Transport Modeller, Project Management & Services

PTV Group

Experience
and expertise.

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40 Years

2,500 Cities

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PTV Vissim
product introduction

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What is PTV Vissim?

Multimodal microscopic traffic flow simulation

→ Individual entities

→ Cars, trucks, busses, bikes, pedestrians

- Traffic flow model which moves each participant according to sophisticated movement model
- Full traffic control model (traffic signals, VMS, etc.)

Traffic Simulation

- Multimodal
- Test before implementation / real world tests
- Evaluate impact on
  - Throughput
  - Traffic flow
  - Safety
- Optimize Signals

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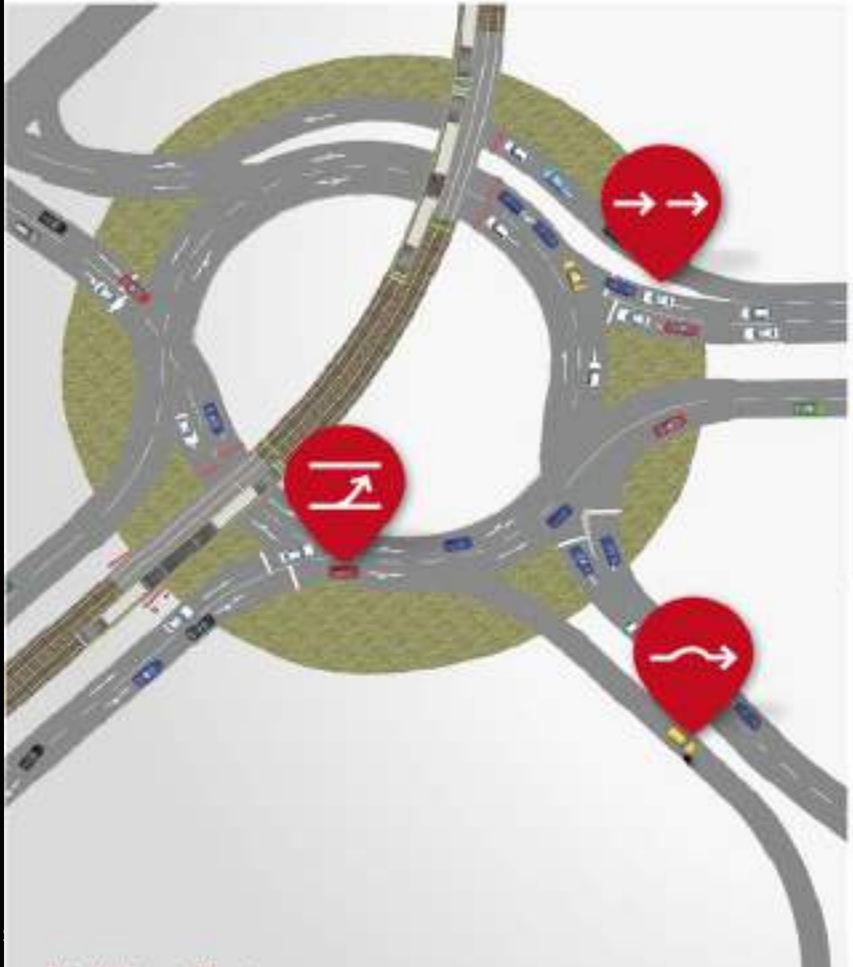
SIMULATING DRIVING BEHAVIOUR

The modelling of driving behaviour is the core of traffic simulation. Vehicle movement models are a key element in being able to replay dynamics in a realistic manner.
A distinction is made between three models:



FOLLOWING MODEL

The psycho-physical car-following model by Prof. Rainer Wiedemann was developed at the Karlsruhe Institute of Technology in 1974 and 1999. It describes the movement of traffic on a single lane. The model is implemented in the PTV Vissim simulation software and can be adjusted by the user via parameters in line with local conditions.

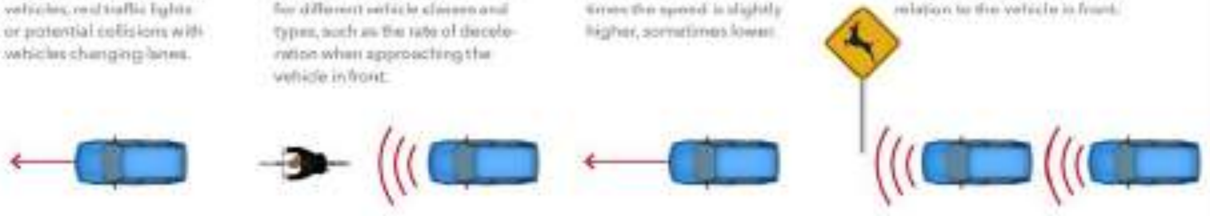
The vehicle following model describes 4 states:

1. FREE DRIVING
The driver proceeds at his or her desired speed provided there are no obstacles in front of him or her. Such obstacles may include, for example, slow moving vehicles, red traffic lights or potential collisions with vehicles changing lanes.

2. APPROACHING
The driver recognises that there is a slow moving vehicle in front of him or her and brakes within the desired gap. In PTV Vissim, it is possible to define different driver and vehicle characteristics for different vehicle classes and types, such as the rate of deceleration when approaching the vehicle in front.

3. FOLLOWING
The driver tries to maintain his or her distance from the vehicle in front when following it. However, the distance between the two vehicles oscillates – sometimes the speed is slightly higher, sometimes lower.

4. BRAKING
If a vehicle reduces its speed downstream, then the vehicle behind must also brake. For each vehicle, Vissim checks in each simulation time step the distance and the differences in speed in relation to the vehicle in front.



LANE CHANGING

There are two different types of lane changing:

1. FREE LANE CHANGING
Free lane changing takes place when overtaking slow moving vehicles, i.e. when an individual's desired speed is higher than the person in front. Attention must be paid to ensure that vehicles in the other lane are not unduly affected by this.

2. NECESSARY LANE CHANGING
This occurs if the driver needs to change lane, e.g. in order to follow a route. The closer the driver gets to the decision making point, the more aggressively the driver behaves and is prepared to accept the hindrances posed by other drivers. Other vehicles also co-operate in order to allow the driver to change lanes.

LATERAL BEHAVIOUR WITHIN A LANE

NON-LANE BASED BEHAVIOUR
The choice of position within a lane is always important if vehicles are able to overtake each other within a particular lane and are able to be side-by-side. This is the case on cycle paths or on regular streets in certain regions, for example.

http://vision-traffic.ptvgroup.com

Traffic Engineering

Capacity analysis

- Proof that performance (traffic flow) is ensured

Testing of signal controllers

- Ensure quality of signal controllers of traffic responding signals

Visualization

- Demonstrate new infrastructure solution to non-engineers, e.g. decision makers

Traffic is very stochastic: Not interested at single scenarios / situations → all possible scenarios

Monte Carlo simulations with different situations
e.g. driver characteristics, varying demand (AM/PM peak), weather conditions, etc.

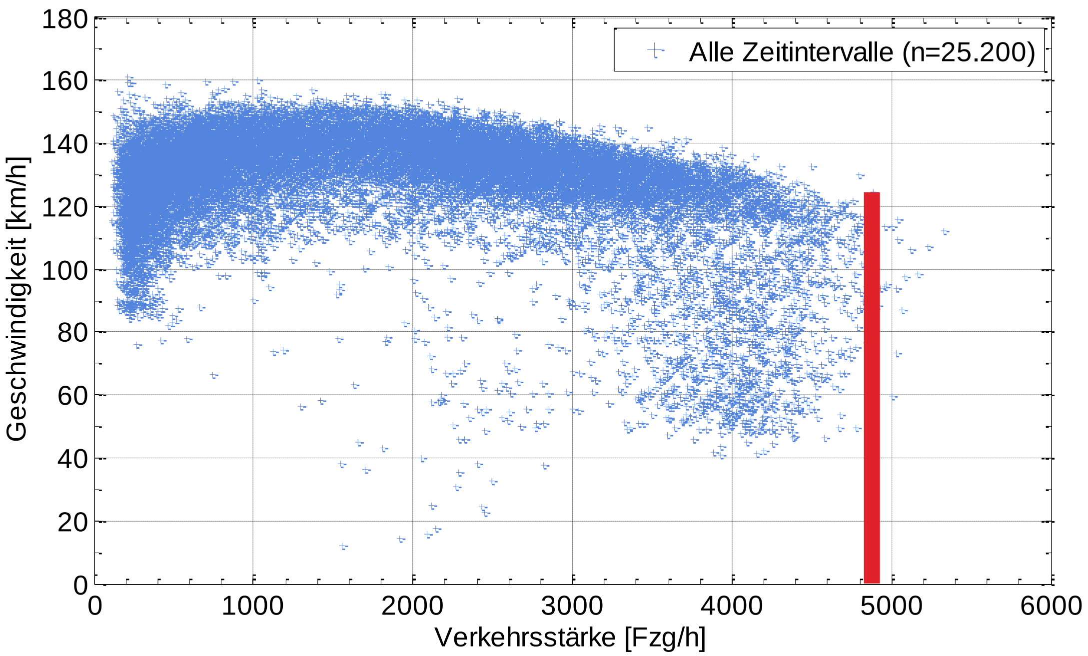
Requirements

Traffic engineer

- Important: Road capacity
- Sacrificing: individual behavior, e.g. acceleration

Automotive, change in priorities

- Important: realistic individual behavior
- Not-important: road capacity



Introduction CoEXist

CoEXist is a European project (May 2017 – April 2020) which aims at preparing the **transition phase during which automated and conventional vehicles will co-exist on cities' roads**.

The **mission of CoEXist** is to systematically **increase the capacity of road authorities** and other urban mobility stakeholders **to get ready for the transition** towards a shared road network with an increasing number of automated vehicles, using the same road network as conventional vehicles.

CoEXist aims at enabling mobility stakeholders to get "AV-ready" (Automated Vehicles-ready). To achieve its objective, **CoEXist develops a specific framework and both microscopic and macroscopic traffic models that take the introduction of automated vehicles into account.**

The tools developed in the framework of CoEXist are tested by road authorities in the **four project cities**: Helmond (NL), Milton Keynes (UK), Gothenburg (SE) and Stuttgart (DE) in order to assess the **"AV-readiness" of their local-designed use cases**.

https://www.h2020-coexist.eu

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POLIS
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Demand Modelling

CoEXist – WP2: AV-ready microscopic and macroscopic traffic modelling tools

RENAULT

INSTITUT VEDECOM DU VÉHICULE DÉCARBONÉ ET COMMUNICANT ET DE SA MOBILITÉ

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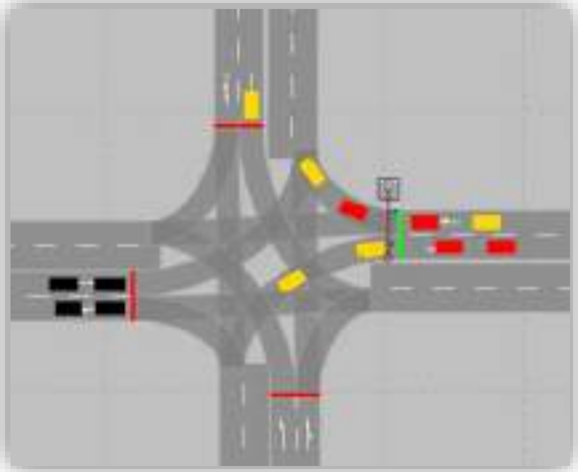
Micro

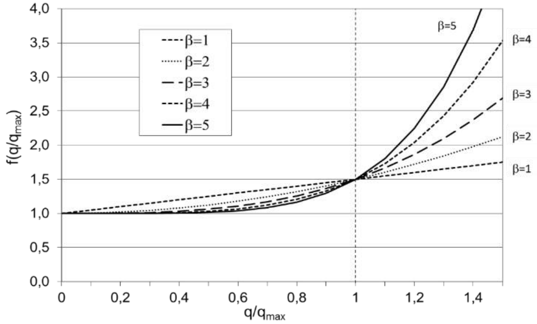
PTV VISSIM



Macro

PTV VISUM

- Capacity
- Volume – Delay Function



Data collection & validation of AV-ready microscopic traffic flow simulator

Collect data of two CAV on the public test site for validation of microscopic modelling tool

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 723201-2
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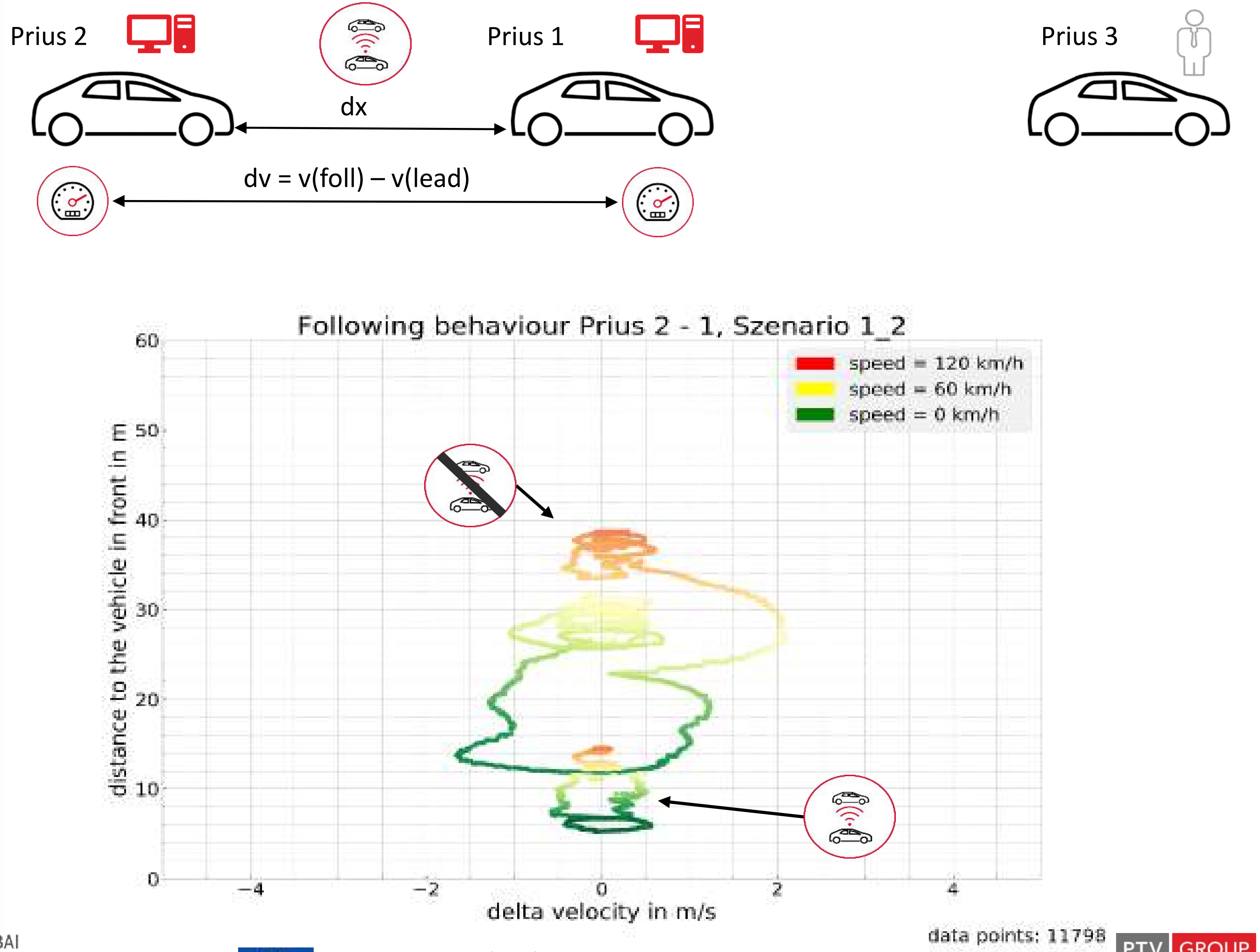
Results

Safety distance without connection much higher than in the communication case



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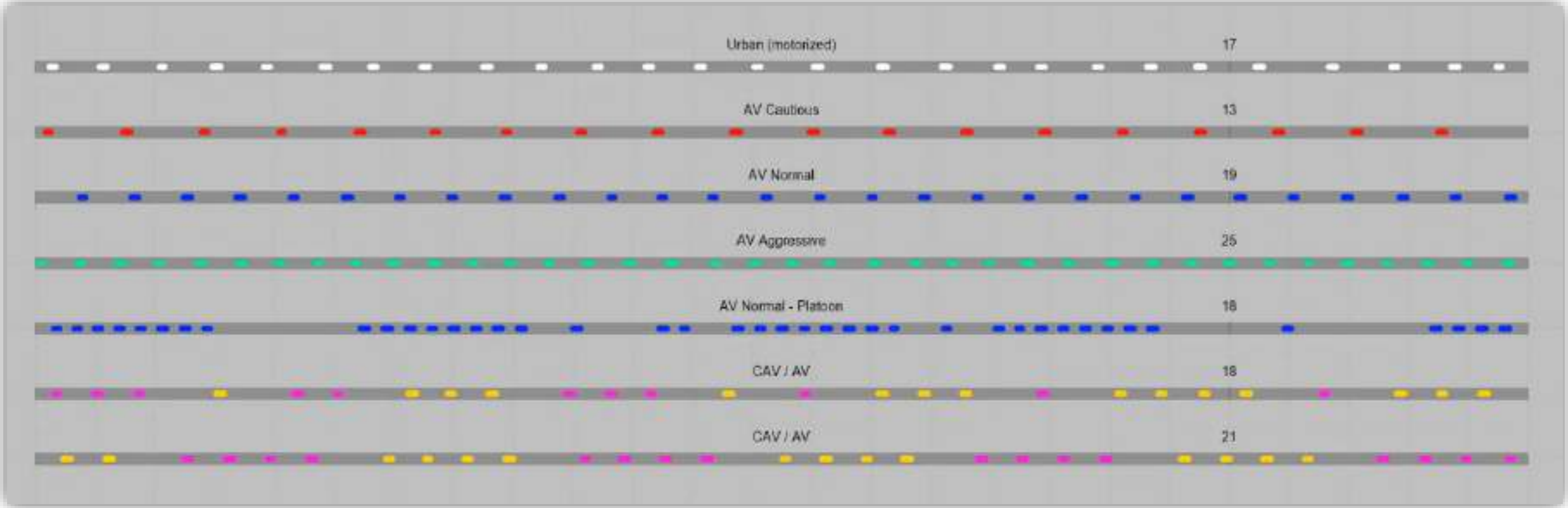
Automated vehicles simulation

Addition of new driving behaviors to replicated connected & automated vehicles.



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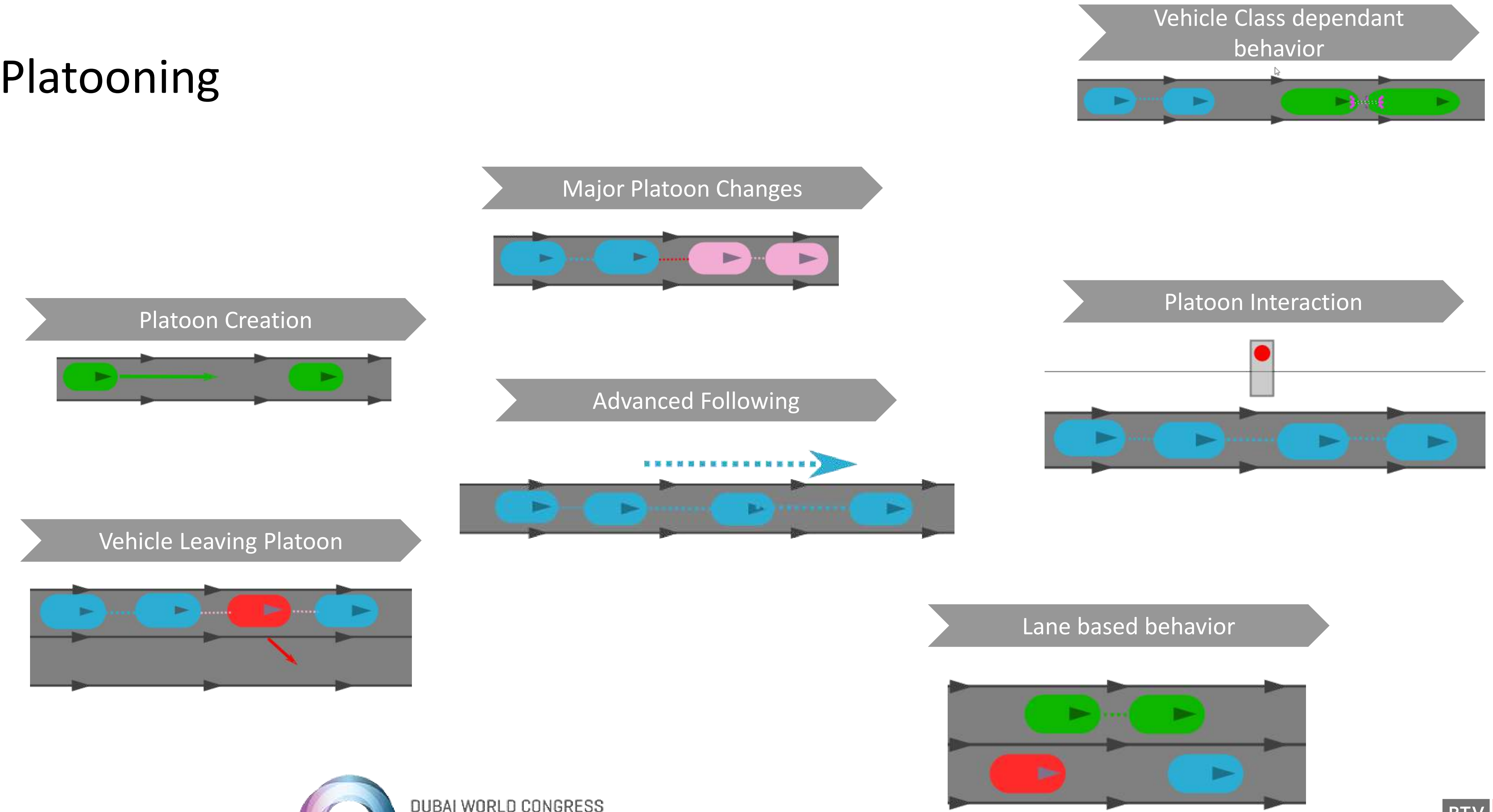
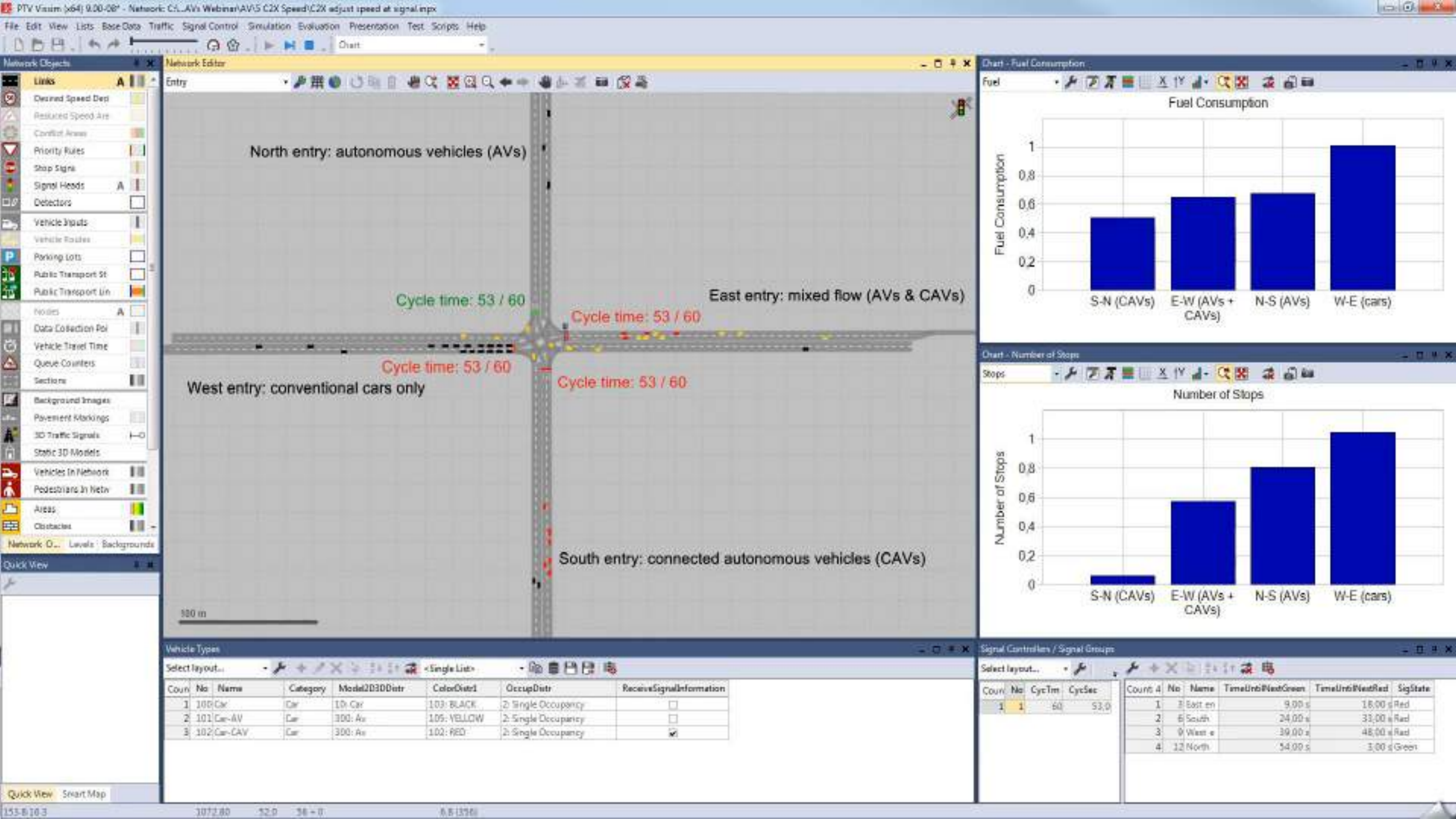
Platooning


Vehicle Class dependant behavior
Major Platoon Changes
Platoon Creation
Platoon Interaction
Advanced Following
Vehicle Leaving Platoon
Lane based behavior


PTV Vissim (x64) 9.00-08* - Network: C:\...AVs Webinar\AV\5 C2X Speed\C2X adjust speed at signal.inpx
File Edit View Lists Base Data Traffic Signal Control Simulation Evaluation Presentation Test Scripts Help
Network Objects
Links
Desired Speed Deci
Reduced Speed Are
Conflict Areas
Priority Rules
Stop Signs
Signal Heads
Detectors
Vehicle Inputs
Vehicle Routes
Parking Lots
Public Transport St
Public Transport Lin
Nodes
Data Collection Poi
Vehicle Travel Time
Queue Counters
Sections
Background Images
Pavement Markings
3D Traffic Signals
Static 3D Models
Vehicles In Network
Pedestrians In Netw
Areas
Obstacles
Network O... Levels Backgrounds
Quick View
Quick View Smart Map
Network Editor
North entry: autonomous vehicles (AVs)
Cycle time: 53 / 60
East entry: mixed flow (AVs & CAVs)
Cycle time: 53 / 60
Cycle time: 53 / 60
Cycle time: 53 / 60
West entry: conventional cars only
South entry: connected autonomous vehicles (CAVs)
100 m
Chart - Fuel Consumption
Fuel Consumption
Fuel Consumption
1
0,8
0,6
0,4
0,2
0
S-N (CAVs)
E-W (AVs + CAVs)
N-S (AVs)
W-E (cars)
Chart - Number of Stops
Number of Stops
Number of Stops
1
0,8
0,6
0,4
0,2
0
S-N (CAVs)
E-W (AVs + CAVs)
N-S (AVs)
W-E (cars)
Vehicle Types
Count No Name Category Model2D3DDistr ColorDistr1 OccupDistr ReceiveSignalInformation
1 100 Car Car 10: Car 103: BLACK 2: Single Occupancy
2 101 Car-AV Car 300: Av 105: YELLOW 2: Single Occupancy
3 102 Car-CAV Car 300: Av 102: RED 2: Single Occupancy
Signal Controllers / Signal Groups
Count No CycTm CycSec
1 1 60 53,0
Count: 4 No Name TimeUntilNextGreen TimeUntilNextRed SigState
1 3 East en 9,00 s 18,00 s Red
2 6 South 24,00 s 33,00 s Red
3 9 West e 39,00 s 48,00 s Red
4 12 North 54,00 s 3,00 s Green

CoEXist – WP4:
Demonstration of CoEXist tools in road authorities

Microscopic

Macroscopic

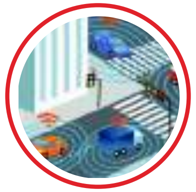
Why co-simulation?

Challenges

- Inclusion of unexpected or non-connected objects
- Scenario completeness
- Self organization of vehicles
- Unrealistic/Unachievable scenario

Solutions

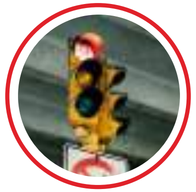
Vehicle sensing (object detection)



Vehicle communication (other vehicle or pedestrian’s intent)

Running different scenarios taking into account intentions

Real-world physics

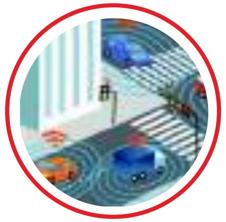


Results analysis and visualization

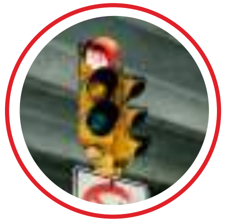
Vehicle dispatching

Solutions

Vehicular Communication



Results analysis

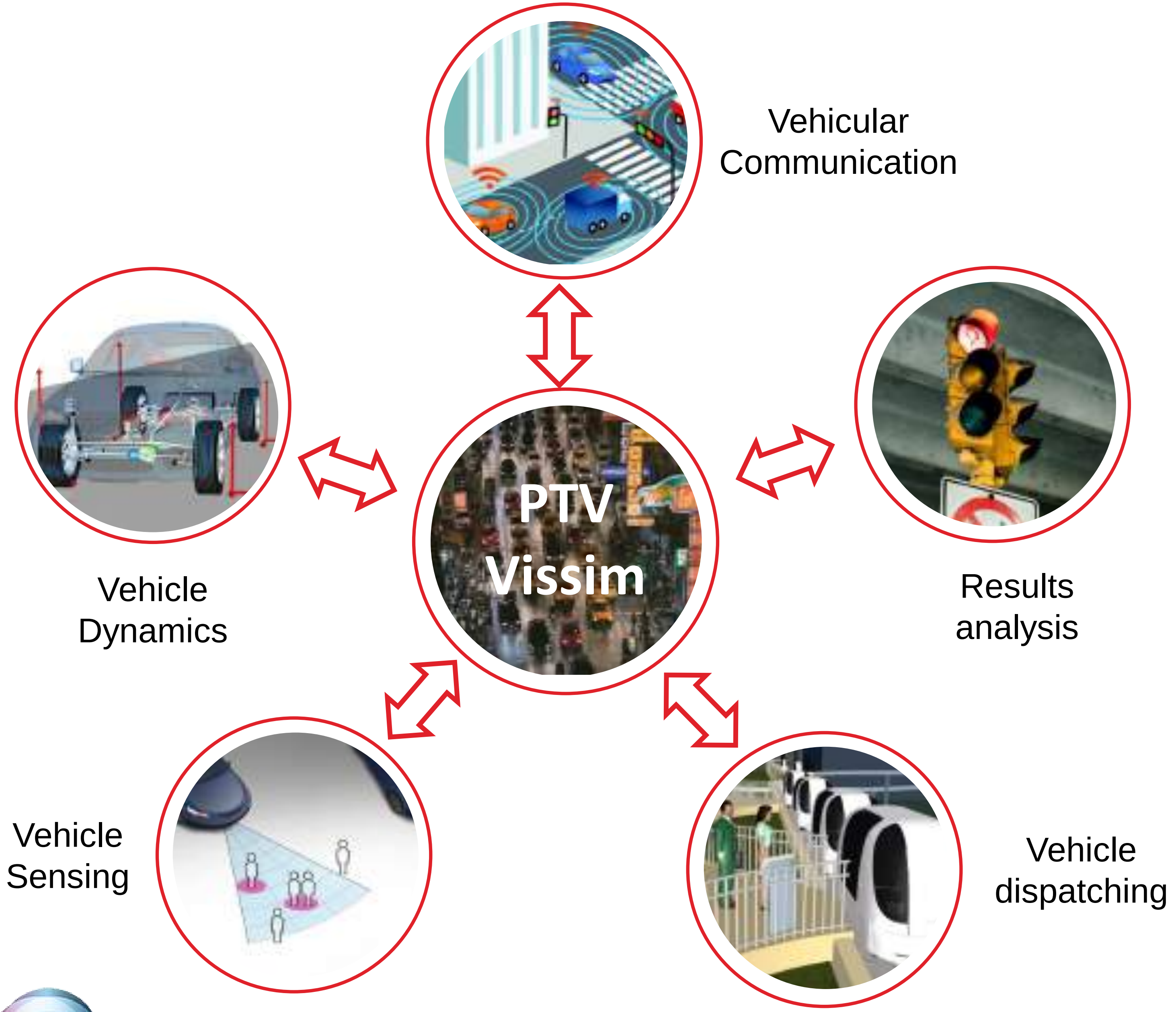


Vehicle Dynamics

Vehicle dispatching

Traffic Simulation

Vehicle Sensing



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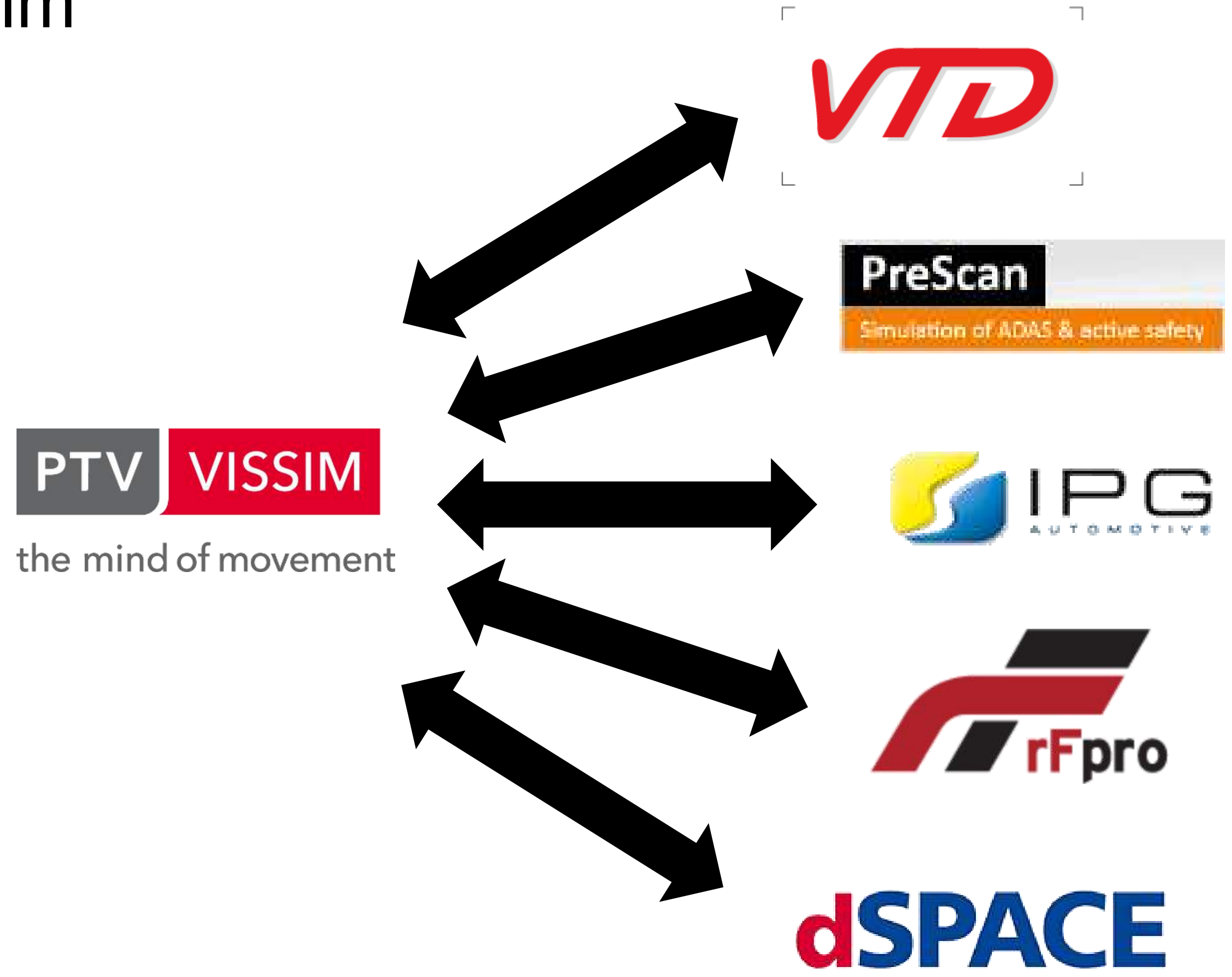
Simulation package PTV Vissim

PTV Vissim provides traffic in the simulation tool chain and a link to:

- Sensor simulation like PreScan, …
- Vehicle dynamics like CarMaker, VTD…
- Visualization with rFpro, …



DrivingSimulator.DLL Interface

Applications

- External vehicle control
  - Human-in-the-loop (HITL) → Driving simulator
  - Software / Hardware-in-the-loop (SIL / HIL)

- Positions in world coordinates are exchanged, the external vehicle can be moved completely freely inside the network.
- Existing example for Unity

Unity

AR windshield

- prognosed trajectory
- greenband for signals
- route in automated mode

Example: Co-Simulation Vissim + CarMaker

Case Study: City Walk, Dubai

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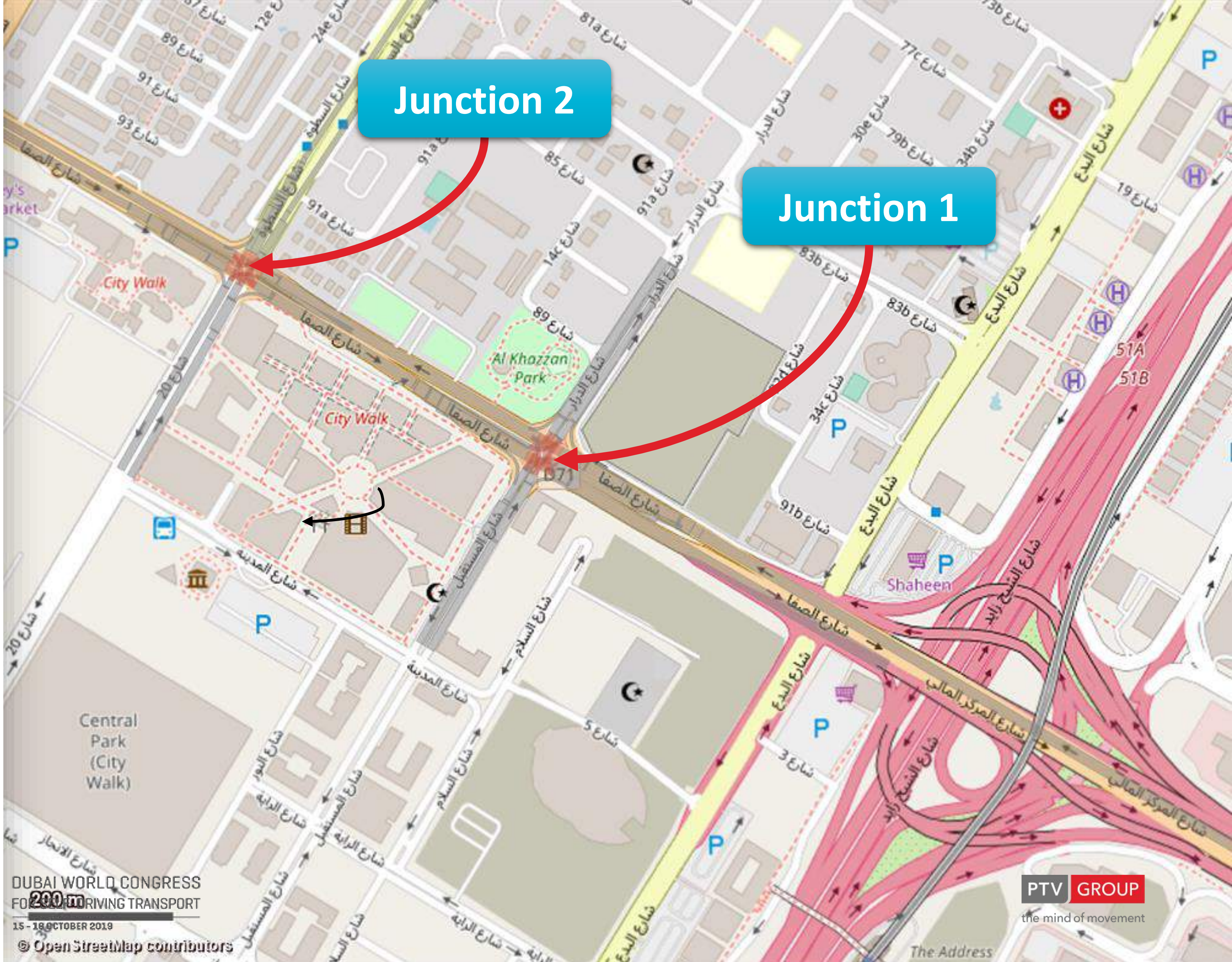
Study Location

Intersection of Al Safa Street with Al Mustaqbal Street in City Walk, Dubai.



Simulation Results

It is expected that increasing AVs fleet will manage to decrease the delay in the model. In the first case study scenario, the average network delay in the base model (0% AVs) is 57 seconds. The number goes down as the AVs percentage goes up.

Without Platooning

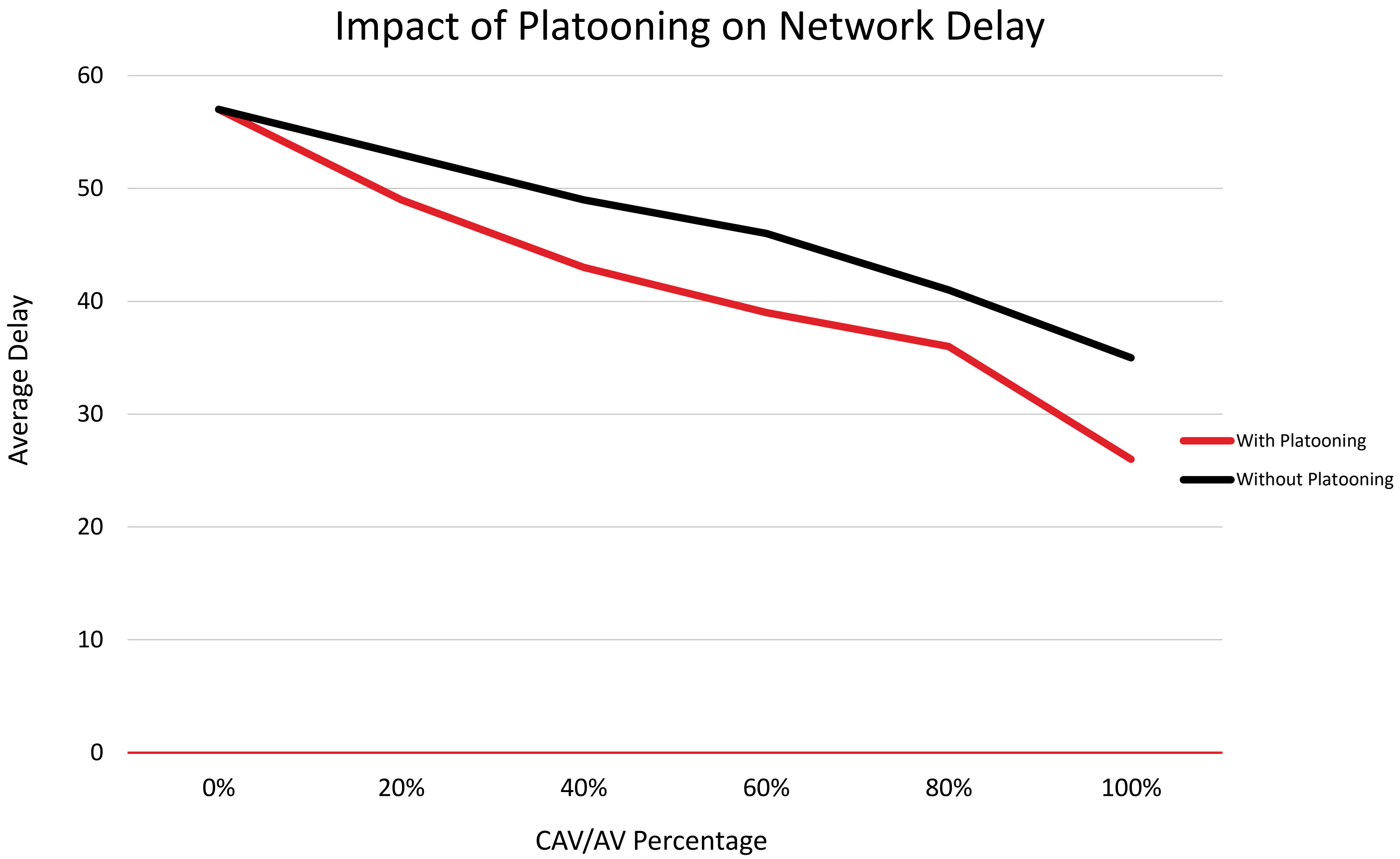
AV Percentage	Base model Average Delay [s]	AV Average Delay [s]	Network Difference
0%	57	57	0%
20%	57	53	-7%
40%	57	49	-16%
60%	57	46	-20%
80%	57	41	-28%
100%	57	35	-39%

Simulation Results

When platooning is active, the simulation results shows better results for the overall network average delay.

	With Platooning		
AV Percentage	**Base model Average Delay [s]**	**AV Average Delay [s]**	**Network Difference**
0%	57	57	0%
20%		49	-15%
40%		43	-25%
60%		39	-32%
80%		36	-37%
100%		26	-55%

Simulation Results



Platooning Parameters

Platooning in Vissim has different parameters to be set by the user depending on his or her preference. In this scenario, the following parameters were using to model a suitable platooning:

- **Maximum number of platoon vehicles;** 5 vehicles
- **Maximum platoon approach distance;** 50 m
- **Maximum platoon desired speed;** 70 km/hr
- **Platooning follow-up gap time;** 0.1
- **Platooning minimum headway;** 0.5

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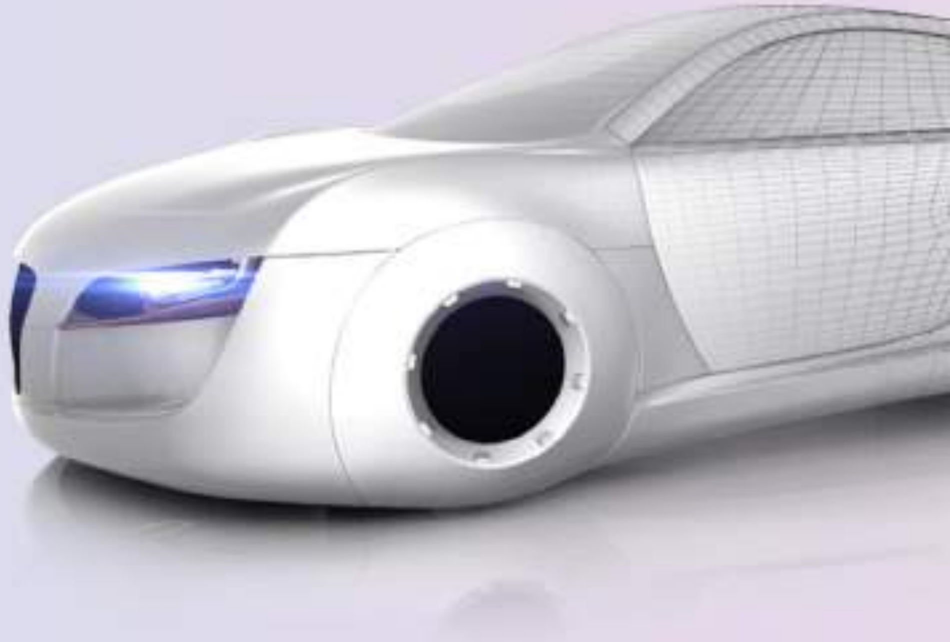
Questions?



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