Deliverable 2.4

PTV Vissim extension – new features and improvements

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Author: Peter Sukennik, PTV Group

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Document Control Page

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Creator	Peter Sukennik
Editor	Charlotte Fléchon
Reviewer/s	Charlotte Fléchon Bernard Gyergyay Syrus Gomari
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Deadline for approval	

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1 Introduction

This document describes new automated vehicle (AV) related features and improvements specifically in PTV Vissim software developed within the CoEXist project.

1.1 PTV Vissim version

All parameters or features mentioned below are available since PTV Vissim 11 release version (planned release date: end of September 2018). Most of the API (application programming interface) improvements are available in PTV Vissim 10 version already. For consortium partners & CoEXist purposes, a development version is available since May 2018. A beta version, available for all users with a valid Vissim 10 license, will be released at the beginning of August 2018.

1.2 Knowledge transfer

For an explanation of all new functionalities and AV-related how-to, a webinar was held on June 21, 2018. The slides of the webinar are in appendix A of this document. An AV-related PTV Vissim guide will be prepared in October 2018 (D2.5). An updated PTV Vissim manual will be available (most of it) until beta release (August 2018), a full update will be available with the release version of PTV Vissim 11 (end of September 2018).

1.3 Driving logics

How to use individual features in combination with the driving logics[1] used within the CoEXist project is described in deliverable D2.3. This document describes what was developed and for what purpose.

1.4 Cooperation & communication functions of AVs

Some implications of simple cooperation & communication functions of AVs might be simulated by using new features and appropriate settings in PTV Vissim. For modelling of complex cooperation & communication functions additional actions might be necessary – using one of the available interfaces (COM, drivermodel.dll or drivingsimulator.dll) to mimic complex communication and cooperation strategies.

2 API improvements

PTV Vissim offers three APIs. Two of them, described below, have been improved significantly. APIs can be used for:

- Simulating vehicles with own algorithms within PTV Vissim

[1] See D1.4 and its appendix A

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- Connecting & exchanging information with an external simulator (e.g. a sensor simulator)
- Simulating communication & cooperation strategies or any other feature which is not directly available in the GUI of PTV Vissim

API are widely used by car manufacturers and researchers who are developing their own control algorithms. The use of API requires programming skills.

The full description of both mentioned PTV Vissim interfaces can be found in the documents delivered within PTV Vissim installation (see Appendix 1 and 2 of D2.2 “PTV Vissim API - Driver Model Interface.pdf“ and “PTV Vissim API - Driving Simulator.pdf Interface”).

2.1 Drivermodel.dll

The External Driver Model DLL Interface of Vissim provides the option to replace the internal driving behaviour by a fully user-defined behaviour for some or all vehicles in a simulation run. The user-defined algorithm must be implemented in a DLL written in C/C++ which contains specific functions (as specified below). During a simulation run, Vissim calls the DLL code for each affected vehicle in each simulation time step to determine the behaviour of the vehicle. Vissim passes the current state of the vehicle and its surroundings to the DLL and the DLL computes the acceleration / deceleration of the vehicle and the lateral behaviour (mainly for lane changes) and passes the updated state of the vehicle back to Vissim.

The external driver model can be activated for each vehicle type separately in the dialog box “Vehicle Type” by checking the checkbox "Use external driver model” on the tab page “External Driver Model" and selecting a driver model DLL file and optionally a parameter file to be used. If this option is checked, the driving behaviour of all vehicles of this vehicle type will be calculated by the selected DLL. A subdirectory DriverModelData\ must exist in the directory of vissim.exe in order to avoid a warning message when Vissim is started.

The following improvements have been implemented:

- External driver model DLLs may be used now in multithreaded simulation runs if all DLLs confirm that they support multithreading (unless there is only one externally controlled vehicle or all externally controlled vehicles are on the same link, the DLL needs to be programmed accordingly, of course).
- If the DLL requests it, Vissim sends the data of all nearby vehicles that the ego vehicle sees according to the current driving behaviour (min./max. look ahead and look back distances, number of observed vehicles) instead of at most 2 for each upstream and downstream per lane.
- User-defined vehicle attribute values can be passed to the DLL and can be modified by the DLL.
- World coordinates of the front end and rear end of nearby vehicles are passed from Vissim to the DriverModel.DLL as well.
- The polyline of the current lane of the ego vehicle (along its route/path, within the visibility distance) is passed to the DLL as well.

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2.2 Drivingsimulator.dll

The PTV Vissim add-on module "Driving Simulator Interface" (see Figure 1) allows to connect Vissim to a driving (cycling, walking) simulator (DS). That DS can either be a simulator hardware used by a human or a piece of software representing the algorithms of a CAV (or multiple CAVs).

Vissim provides the surrounding traffic (vehicles, bicycles, pedestrians) to be visualized in the DS, and the DS passes back the current position and orientation of the simulator vehicle(s) (bicycle(s) / pedestrian(s)). The vehicles and pedestrians in the Vissim network react to this simulator data as to all other vehicles and pedestrians in the microscopic simulation model. In addition, Vissim passes traffic signal states to the DS for visualization, and the DS can set detectors in Vissim explicitly in order to affect the signalization.

The DS does not need to know the Vissim data model where the network is modeled from links, connectors, areas, ramps and obstacles. The DS needs to have its own world model (for simulation and visualization). As all vehicle and pedestrian positions are exchanged in cartesian world coordinates (x/y/z), the DS must be able to provide/use such coordinates, and the coordinates of the networks on both sides (Vissim / DS) must match precisely.

The following improvements have been implemented:

- Automatic interpolation of Vissim vehicle/pedestrian world coordinates, orientations and speeds between Vissim time steps if the simulator informs Vissim about a higher frame rate than the Vissim simulation resolution in the call of VISSIM_Connect().
- Optionally, simulator pedestrians can be passed to Vissim now. The pedestrian type for those needs to be selected in the network settings on the new tab page "Driving simulator". The checkbox for activation of the driving simulator interface and the selection box for the vehicle type for simulator vehicles have been moved there as well.
- The maximum number of objects of each type to be exchanged between the simulator and Vissim can be set by the simulator in the call of VISSIM_Connect().
- The simulator can pass a maximum visibility radius to Vissim in the call of VISSIM_Connect(). Vissim vehicles and pedestrians will be passed to the simulator only if they are inside of this radius from the center of the front end of a simulator vehicle or pedestrian.

3 New features

3.1 Enforce absolute braking distance

Idea: the vehicle can stop safely anytime (without a crash), even if the leading vehicle stops instantly ("turns into brick wall"). This ensures that the brick wall stop distance is always kept.

It has implications for:

- Following behaviour
- Lane change behaviour

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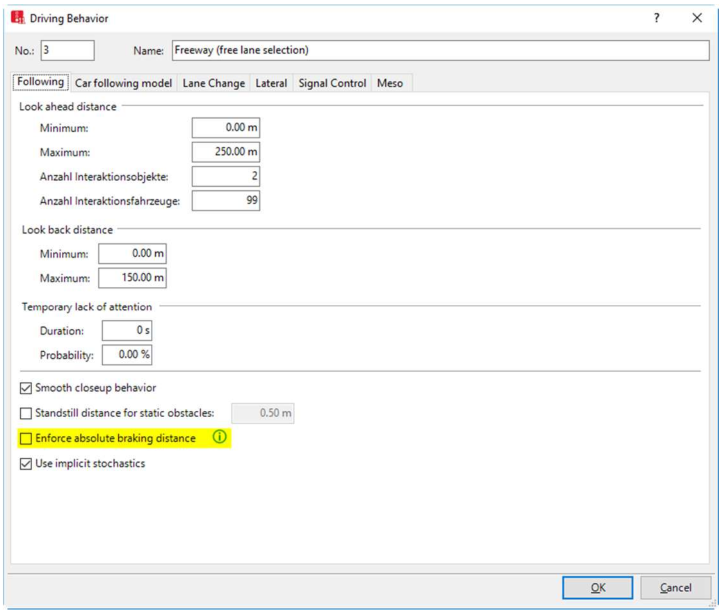
- Gap acceptance at intersections (conflict areas only)



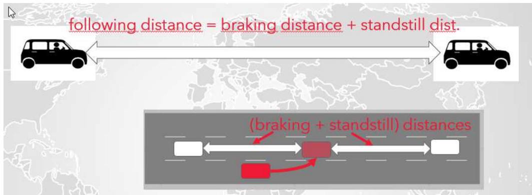


Figure 1 Enforce absolute braking distance dialog (left) and an illustration (right)

3.2 Use implicit stochastics

Idea: the stochastic imperfection of human driving is replaced by deterministic machines & computers. If this attribute is false, a deterministic instead of a stochastically distributed value is used. Affected are the values that:

- cannot be influenced by user e.g. via an adjustable distribution
- are expected to be unaffected by human perception in AVs.

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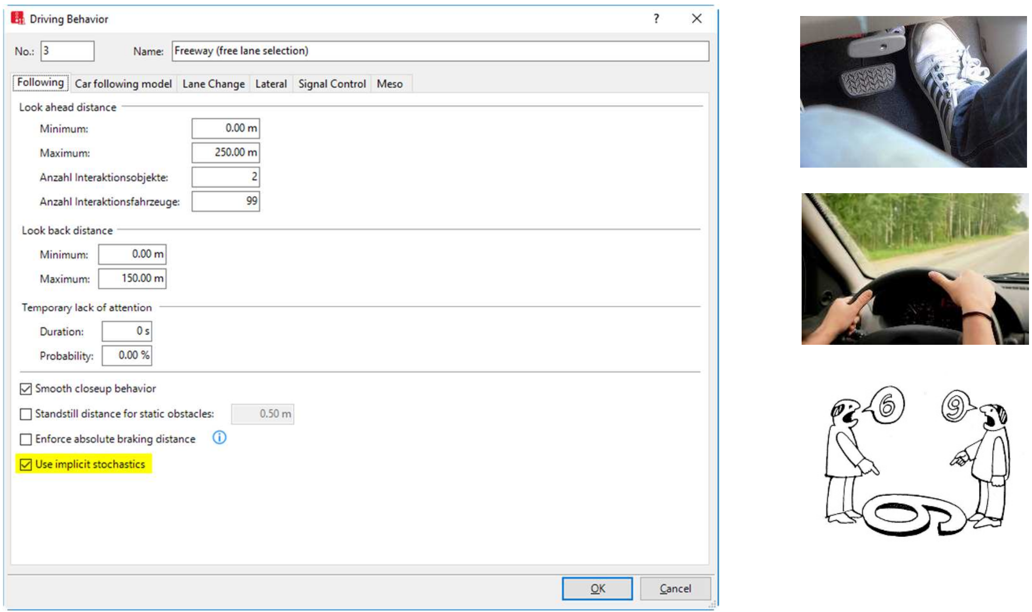

Figure 2 Use implicit stochastics dialog (left) and illustrations (right)

3.3 Class dependent safety distance in following behaviour

Idea: the headway to the followed vehicle depends on the followed vehicle class.

This allows to set different following distances to conventional vehicles, automated vehicles, connected and automated vehicles, cyclists etc.

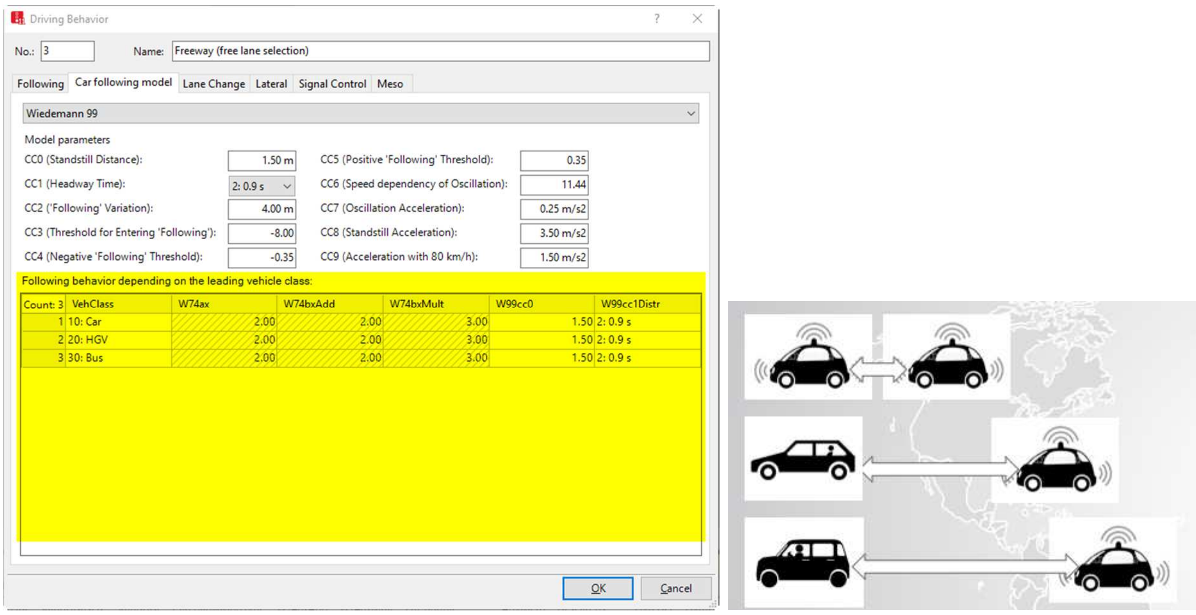

Figure 3 Vehicle class dependency in the dialog (left) and an illustration (right)

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3.4 Number of interaction objects & vehicles

Idea: automated vehicles can see the signals ahead, but only one (or two…) vehicle in front of itself because the sensors cannot see through the leading vehicle.

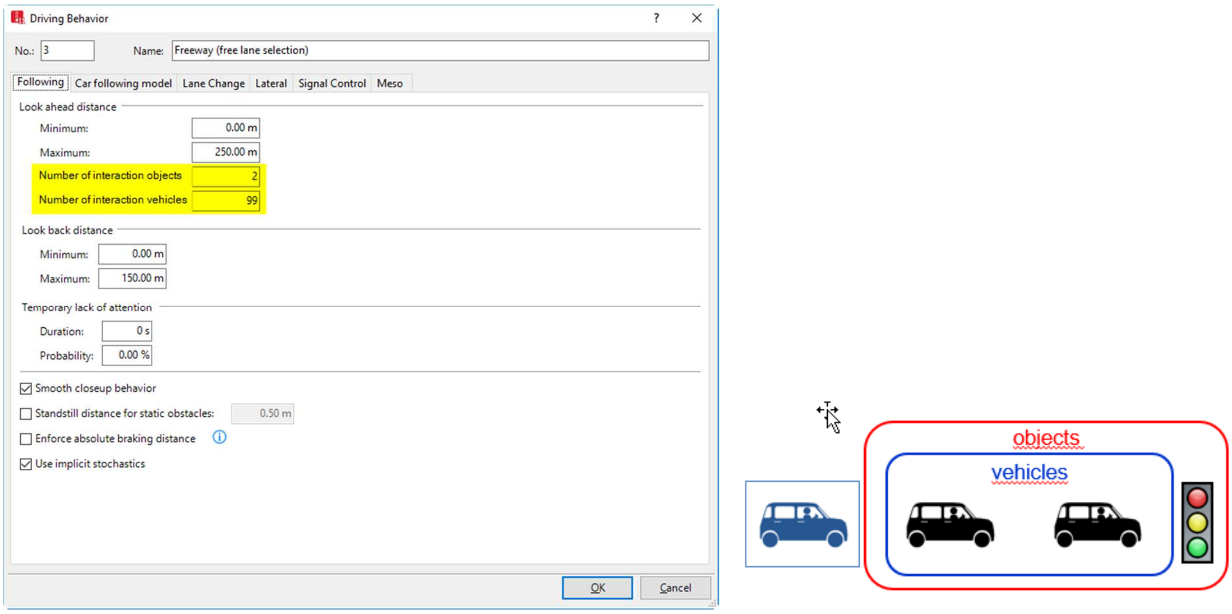

Figure 4 Number of interaction objects & vehicles in the dialog (left) and an illustration (right)

3.5 OpenDrive import

OPEN DRIVE = open file format for the logical description of road networks. It was developed and is being maintained by a team of simulation professionals with large support from the simulation industry. Its first public appearance was on January 31, 2006.

This feature allows to read opendrive database and create a network in PTV Vissim.

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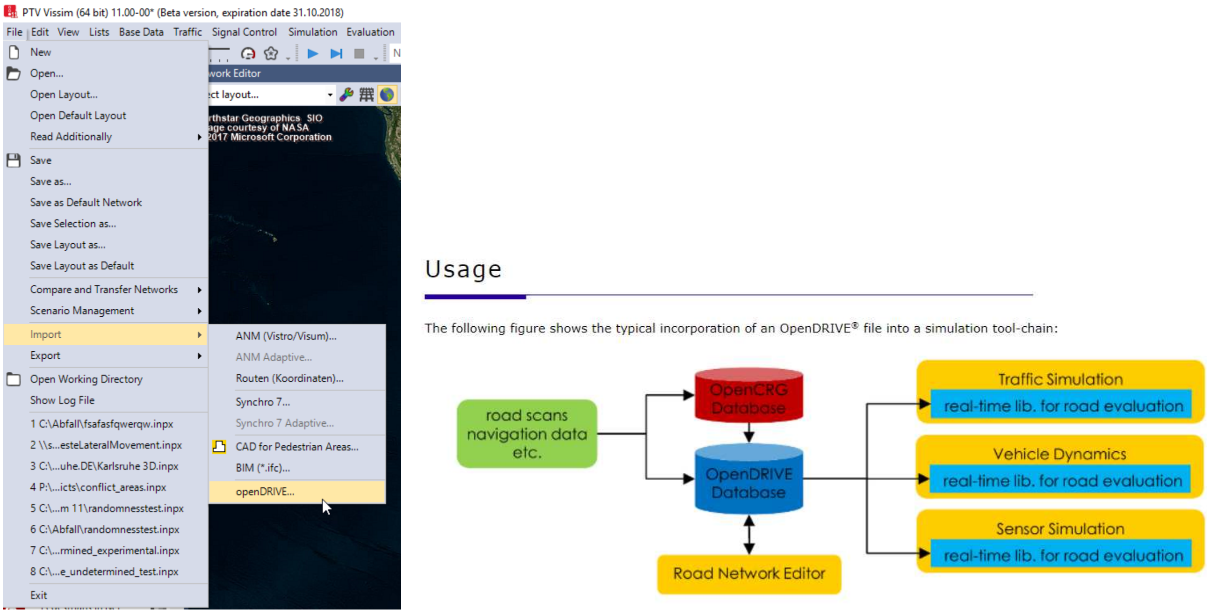

Figure 5 OpenDrive import in the menu and the typical usage of open drive (source: http://www.opendrive.org/)

3.6 Consider vehicles in dynamic potential

This feature improves the interaction between vehicles and pedestrians in crossing conflicts (e.g. on shared space areas). The pedestrians are able to find and use gaps between standing or slowly moving vehicles dynamically, so their behaviour is more intelligent and closer to the real behaviour.

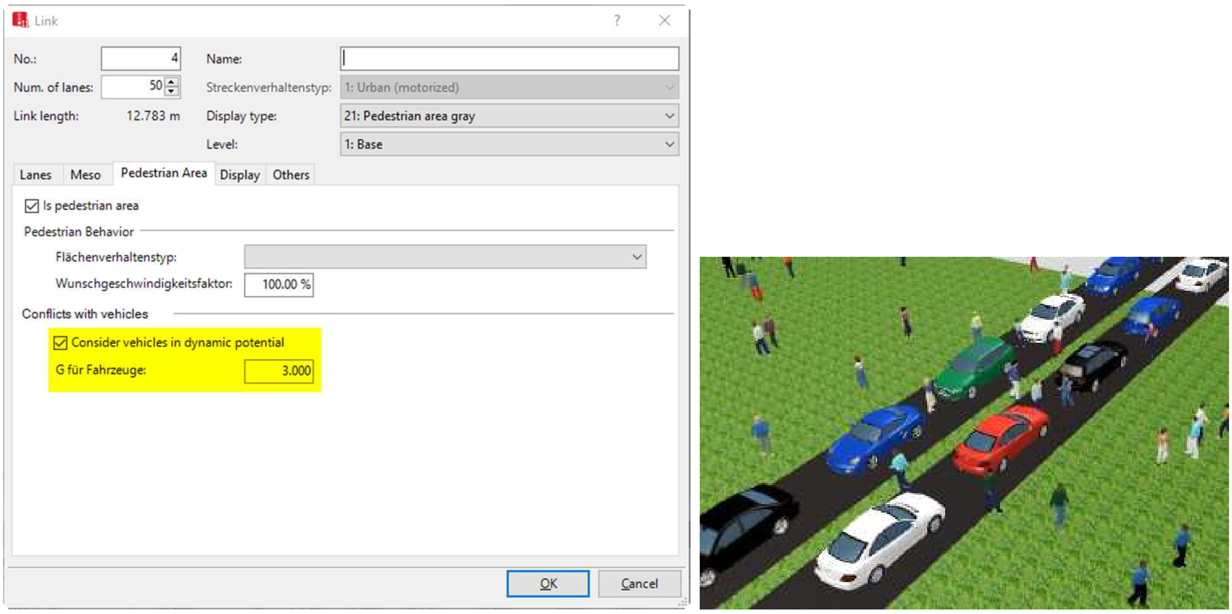

Figure 6 Consider vehicles in dynamic potential in the dialog (left) and an illustration (right)

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3.7 Zero passengers

Idea: Simply to allow “empty trips” for future autonomous vehicles (SAE automation level 4 & 5).

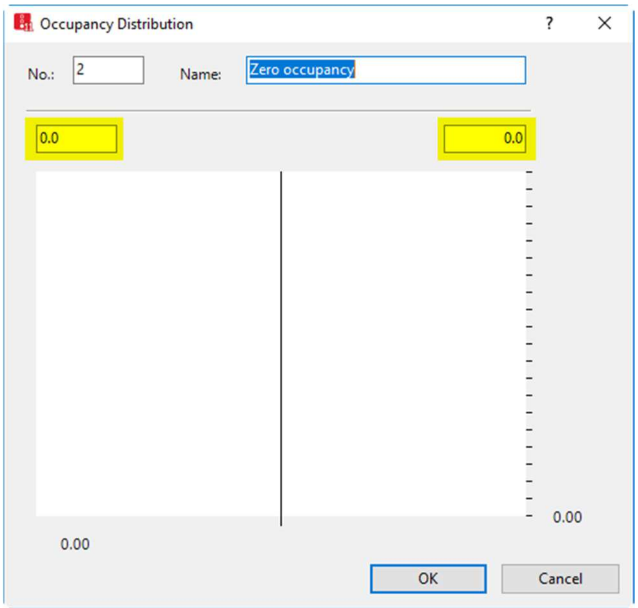
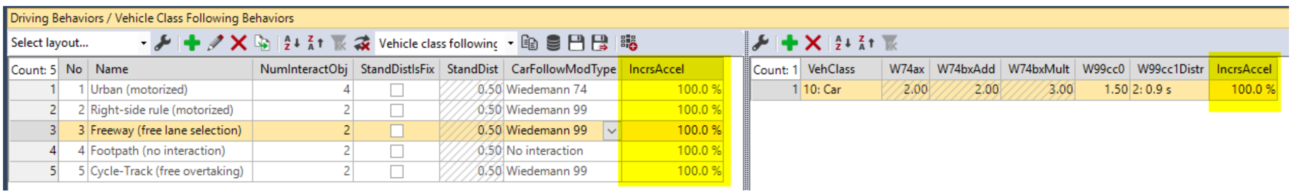


Figure 7 Zero passengers in the dialog

3.8 Increased acceleration in following possible

This new parameter allows to set higher acceleration in following process in order to “stay in touch” when the speed of the leading vehicle increases significantly. The ability to keep close following distance without big losses when leading vehicle accelerates was observed on the test track in Helmond (described in D2.6 Technical report on data collection and validation process). To mimic such behaviour in Vissim, this parameter can be set to value above 100% for specific vehicle class and also in dependency on leading vehicle class.


Driving Behaviors / Vehicle Class Following Behaviors

Count: 5	No	Name	NumInteractObj	StandDistIsFix	StandDist	CarFollowModType	IncrsAccel
1	1	Urban (motorized)	4		0.50	Wiedemann 74	100.0 %
2	2	Right-side rule (motorized)	2		0.50	Wiedemann 99	100.0 %
3	3	Freeway (free lane selection)	2		0.50	Wiedemann 99	100.0 %
4	4	Footpath (no interaction)	2		0.50	No interaction	100.0 %
5	5	Cycle-Track (free overtaking)	2		0.50	Wiedemann 99	100.0 %

Count: 1	VehClass	W74ax	W74bxAdd	W74bxMult	W99cc0	W99cc1Distr	IncrsAccel
1	10: Car	2.00	2.00	3.00	1.50	2: 0.9 s	100.0 %

Figure 8 Increased acceleration in the list & coupled list

3.9 Labels for vehicles

This feature allows to show any vehicle attribute as a vehicle label which is moving with the vehicle during 2D visualisation. This is useful for debugging or analysing the model, showing results etc.

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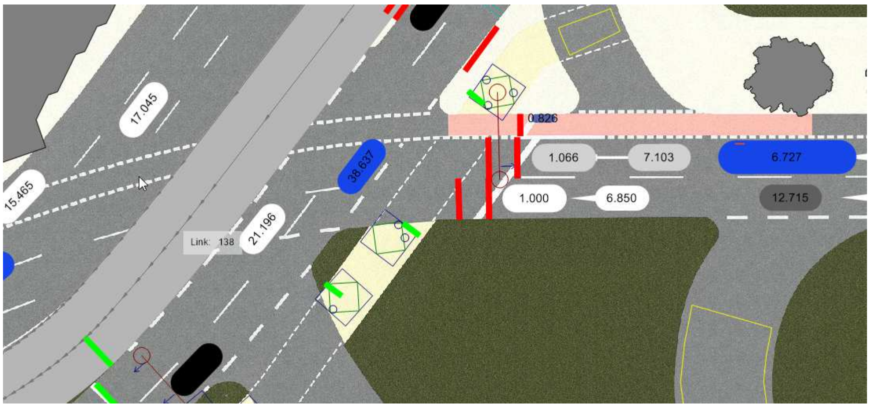

Figure 9 Example of vehicle label showing following distance

4 Future outlook

From many possible ideas, two major issues have been identified as interesting features in relation to automated driving: platooning and simple ITS. Both features are not within the scope of CoEXist. The realisation of the development is dependent also on existence/availability of data and standards allowing reasonable parametrisation of the process. Important criterion is also the flexibility of the feature (e.g.it is not ineffective to develop features covering just a single use case).

4.1 Platooning

Now (5/2018), complex platooning can be simulated using APIs only. Platooning functionality configurable through PTV Vissim GUI might be developed in the future. Outputs of the MAVEN[2] project (EU project running parallel) might help (and will be considered).

4.2 Simple ITS

Application of ITS (intelligent transport systems) can be simulated using VAP module (vehicle actuated programming) or COM interface. For the future, PTV is considering a simplification of the process and to offer a direct way through GUI.

5 Appendix: PTV Vissim autonomous vehicles new features and how to

[2] http://www.maven-its.eu/

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PTV GROUP

the mind of movement

Welcome to the Webinar

PTV VISSIM: AUTONOMOUS VEHICLES NEW FEATURES AND HOW-TO

Presenter:

Peter Sukennik

PTV Vissim Product Management
PTV Group, Karlsruhe
peter.sukennik@ptvgroup.com

PTV GROUP
the mind of movement

OVERVIEW

1. Explicit vs. implicit stochastics
2. New features related to AV
3. Driving behavior parameters for AV
4. How to deal with cooperation & communication

PTV GROUP

Presenter:

Peter Sukennik

PTV Vissim Product Management
PTV Group, Karlsruhe

Answering your questions:

Lukas Kautzsch

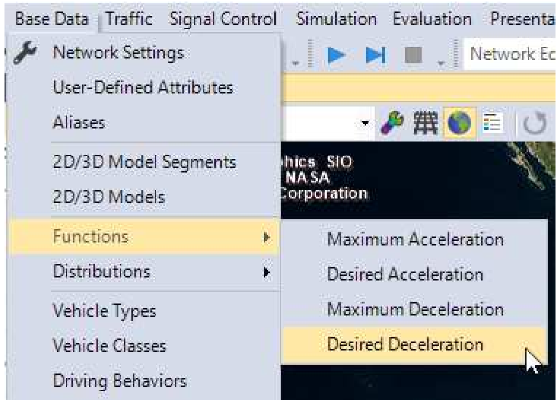
PTV Vissim Product Management
PTV Group, Karlsruhe

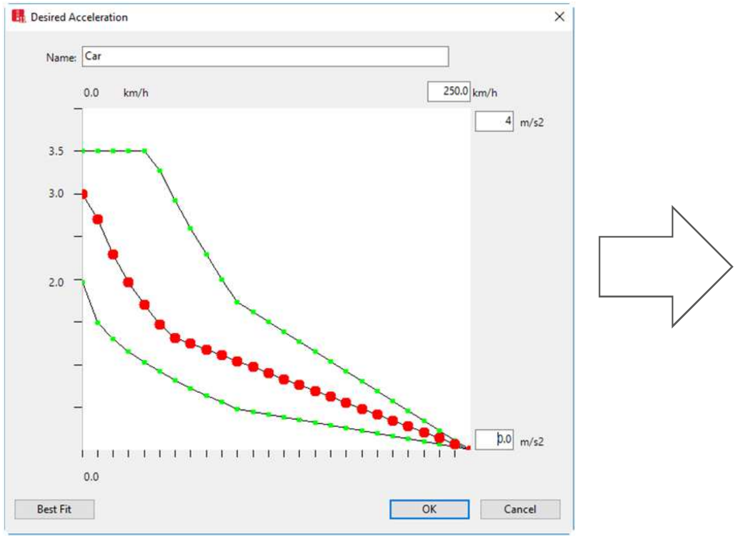
EXPLICIT STOCHASTICS

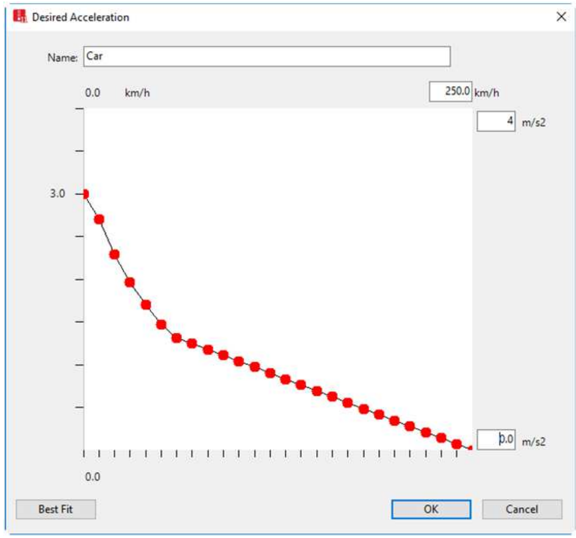
EXPLICIT STOCHASTICS - FUNCTIONS

Assumption: AVs accelerate/decelerate the same/very similar way

- Desired acceleration/deceleration
- Maximum acceleration/deceleration



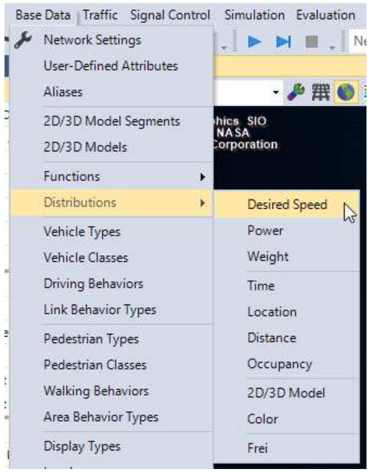


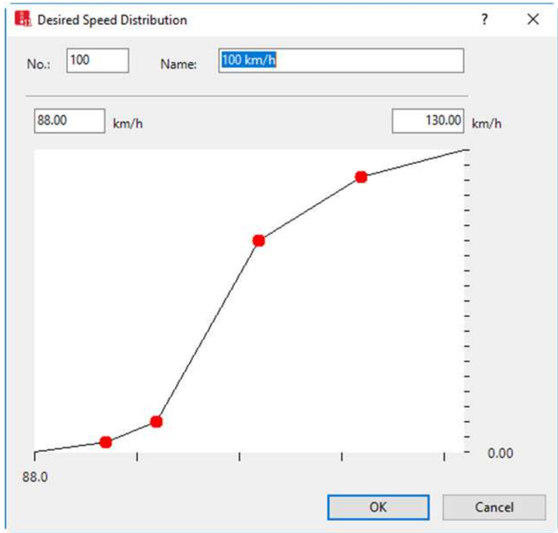


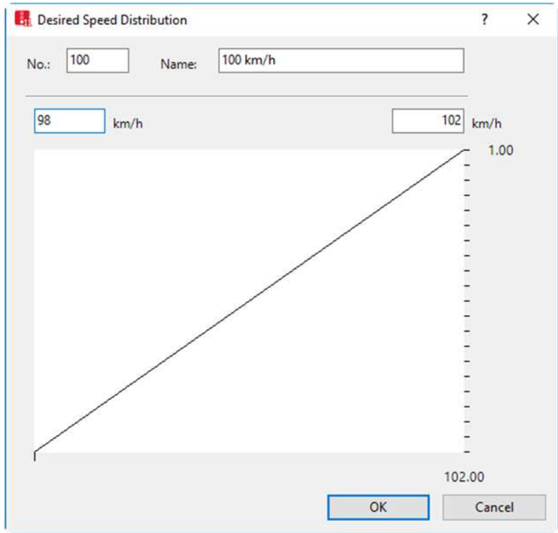
EXPLICIT STOCHASTICS - DISTRIBUTIONS

Assumption: AVs will respect the speed limit and the spread will be minimized

- Desired speed
- Time
- Distance
- Occupancy

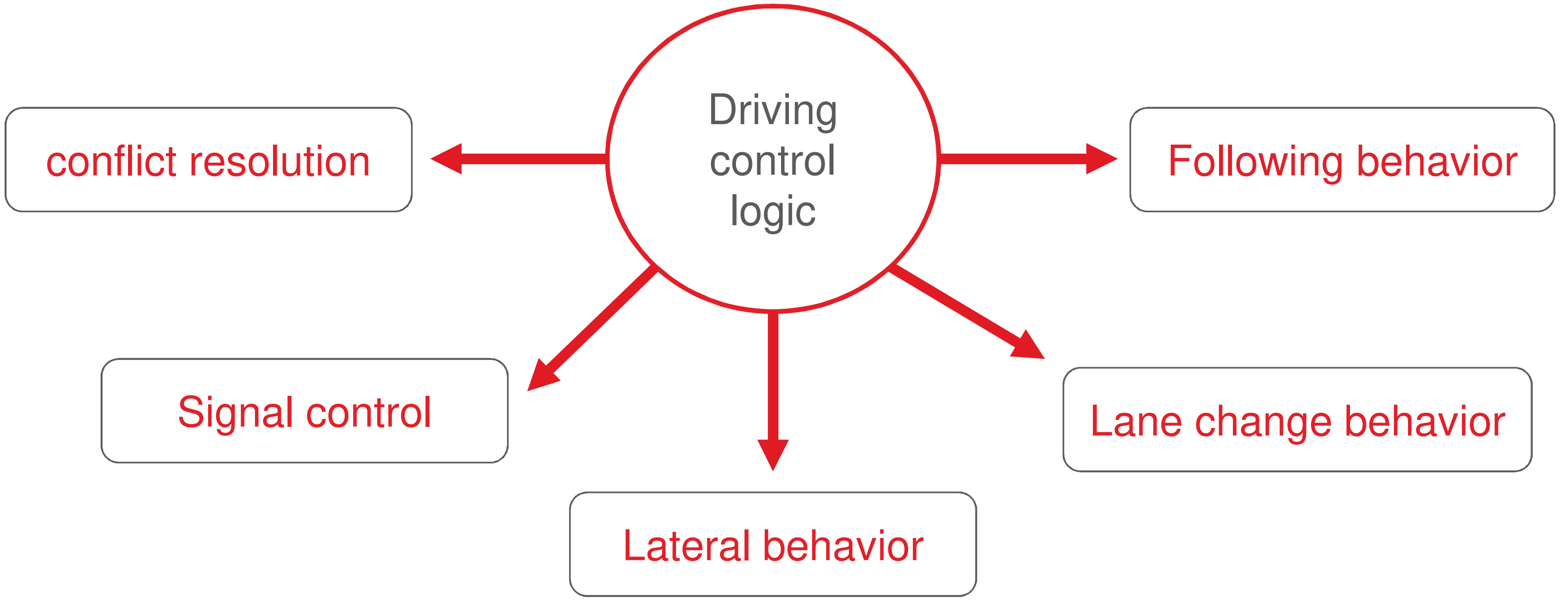






NEW FEATURES

AV DRIVING LOGIC



Definition under CoExist project:

Rail safe	Cautious	Normal	„all knowing“
• Brick wall stop distance • Big gaps • Predefined route • No lane change • No unprotected signal phase • Higher lateral distance or physical separation • Mostly closed environment	• Brick wall stop distance • Big gaps • Cautious behavior	• Gaps similar to human drivers but with higher safety	• Smaller gaps but still safe • Cooperative behavior • Communication is a precondition

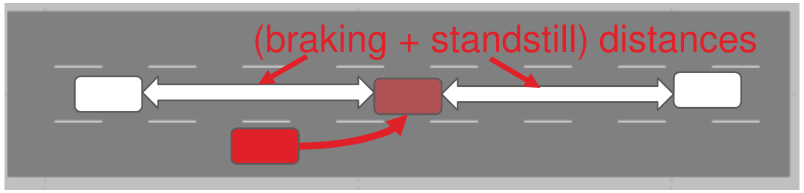
ENFORCE ABSOLUTE BRAKING DISTANCE

Idea: the vehicle can stop safely anytime (without a crash), even if the leading vehicle stops instantly (“turns into brick wall”)

Implications for:

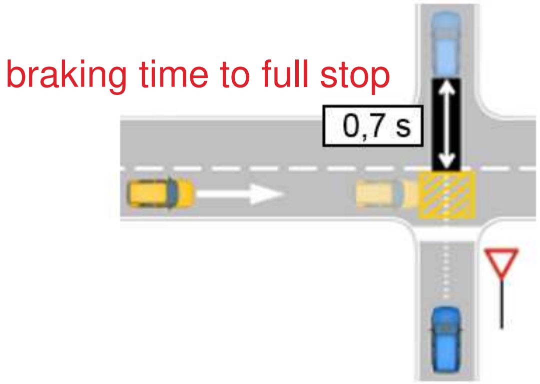
- Following behavior

- Lane change behavior



- Gap acceptance at intersections (conflict areas only)

  Rear gap = time to brake to full stop 1 m in front of the conflict area



NUMBER OF INTERACTION VEHICLES

Vissim 10:

- Number of observed vehicles

The following network objects are modeled as vehicles in Vissim. Vehicles treat these network objects as a preceding vehicle:

- Red signal heads
- Reduced Speed Areas
- Priority rules (if the minimum time gap or minimum headway condition is not met)

Vehicles also treat the following network objects as a preceding vehicle if they have to stop there:

- Stop Signs
- Public transport stops
- Parking Lots

Conflict areas behavior: A vehicle takes into consideration all conflict areas up to the n-th preceding vehicle (for n observed ~~vehicles)~~ interaction objects (up to max. look-ahead distance if there is no object).

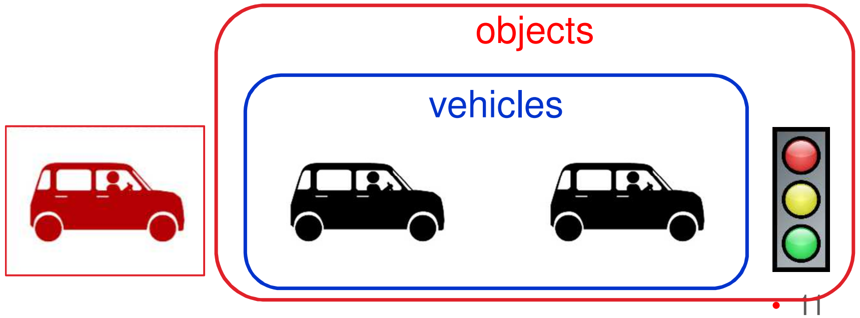
Vissim 11:

- Number of interaction objects
- Number of interaction vehicles

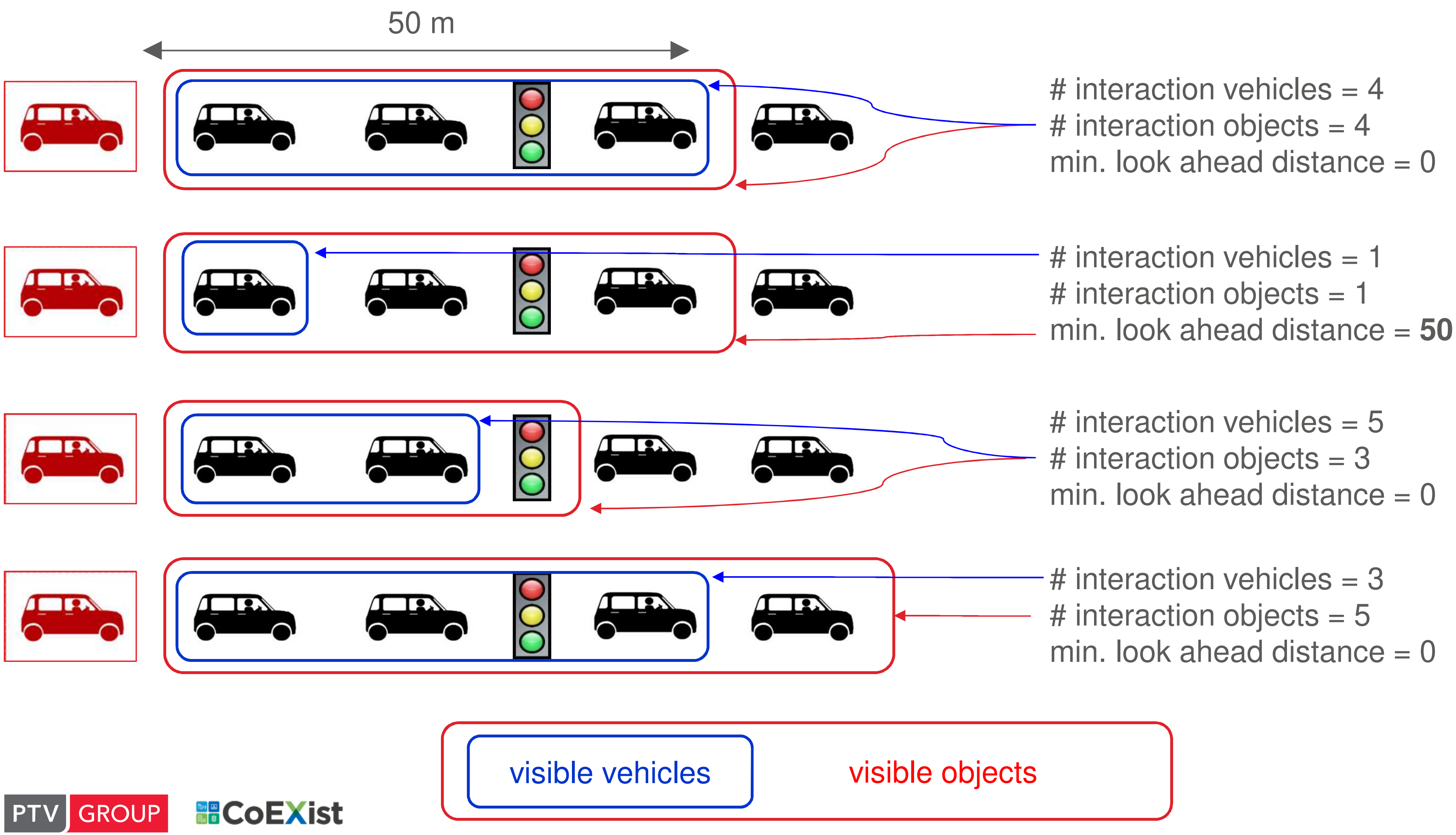
limits the number of visible vehs within the min. look-ahead dist.

Idea: automated vehicle can see the signals ahead, but only one (or two…) vehicle(s) in front of itself because the sensors cannot see through the leading vehicle

Settings	Behavior
#obj < #veh	As Vissim 10
#obj >= #veh	New limited sight and interaction behavior



NUMBER OF INTERACTION VEHICLES – CONFIGURATION EXAMPLES



USE IMPLICIT STOCHASTICS

Idea: the stochastic imperfection of human driving is replaced by deterministic machines.

In the internal behavior model (for humans), there are several stochastic values indicating the spread of human behavior:

- the risk acceptance,
- the ability to estimate distance and speed difference,
- the precision when operating the throttle and braking pedals.

⇨ For AVs, deterministic values for these parameters can be assumed.

If the attribute "use implicit stochastics" is false, a deterministic average value is used instead of such a stochastically distributed value whenever the distribution cannot be set by the Vissim user.

This option affects:

- desired safety distance,
- desired acceleration,
- desired deceleration,

the user may also specify a distribution or function but these are not adjusted automatically, only an implicit stochastic term is suppressed

- decision points (when to start braking / accelerating).

INCREASED ACCELERATION

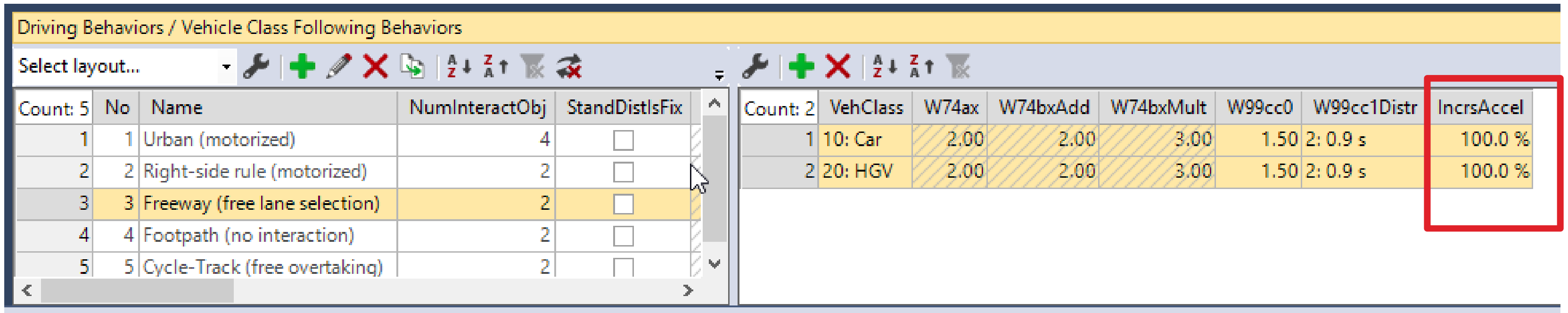
Idea: AVs, especially if using C2C communication, can use a tight coupling with small headways.

The normal “human” acceleration behavior cannot use reliable information about the future behavior of the leading vehicle.

⇨ normal Vissim vehicles tend to fall behind when the leading vehicle is accelerating.

In order to allow vehicles to keep a small headway even during an acceleration process, there is the **new parameter “Increased acceleration”**.

This value defines a percentage (usually > 100%) of the normal acceleration to be used when the leading vehicle is accelerating. The vehicle cannot exceed its maximum acceleration (which defines the technical limit) but it can exceed its desired acceleration in this situation.



Count: 5	No	Name	NumInteractObj	StandDistIsFix
1	1	Urban (motorized)	4	☐
2	2	Right-side rule (motorized)	2	☐
3	3	Freeway (free lane selection)	2	☐
4	4	Footpath (no interaction)	2	☐
5	5	Cycle-Track (free overtaking)	2	☐

Count: 2	VehClass	W74ax	W74bxAdd	W74bxMult	W99cc0	W99cc1Distr	IncrsAccel
1	10: Car	2.00	2.00	3.00	1.50	2: 0.9 s	100.0 %
2	20: HGV	2.00	2.00	3.00	1.50	2: 0.9 s	100.0 %

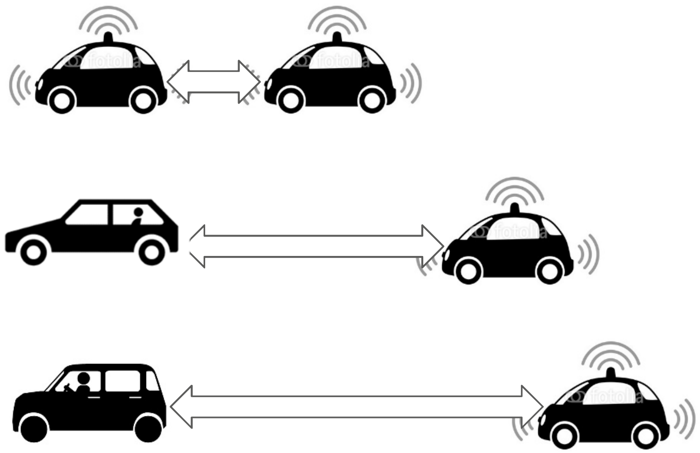
NEW FEATURES & DRIVING LOGICS

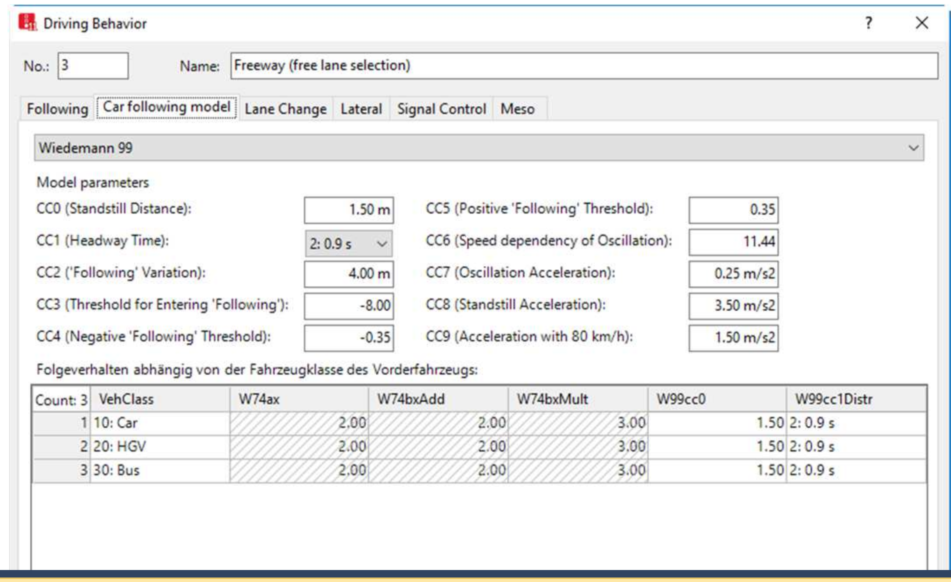
	recommended setting for new features			
driving logic	enforce absolute breaking distance (EABK)	use implicit stochastics	number of interaction vehicles*	increased desired acceleration
rail safe	ON	OFF	1	100%
cautious	ON	OFF	1	100%
normal	OFF	OFF	1	100-110%
all knowing	OFF	OFF	>1	110%

* for advanced sensors and/or communicating vehicles choose more than 1 if information from more than one vehicle ahead is available

HEADWAY BASED ON LEADING VEHICLE CLASS

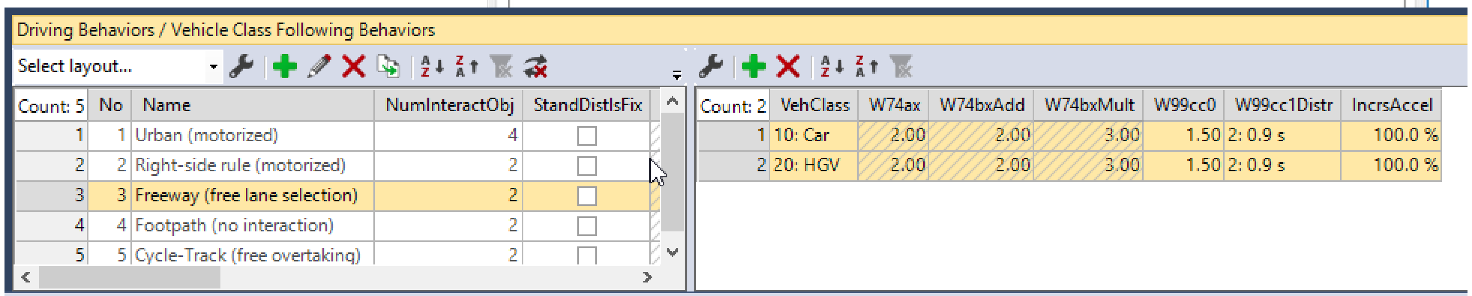
Idea: the headway to followed vehicle depends on the followed vehicle type





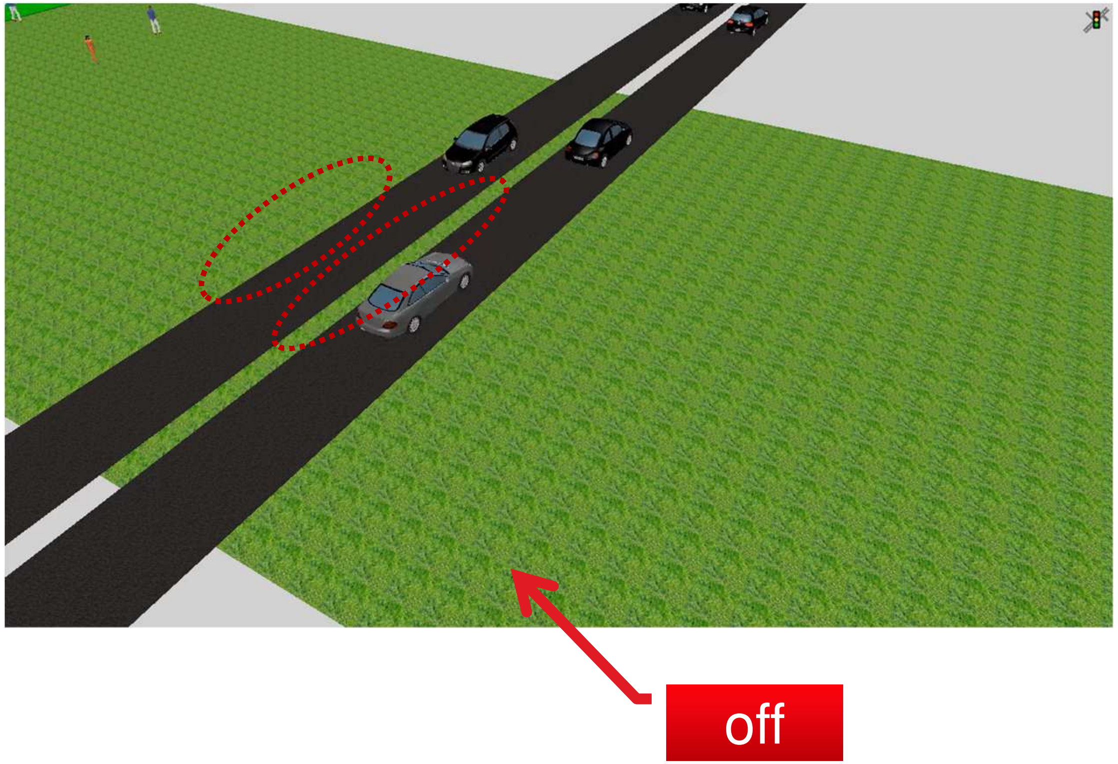
Implementation:

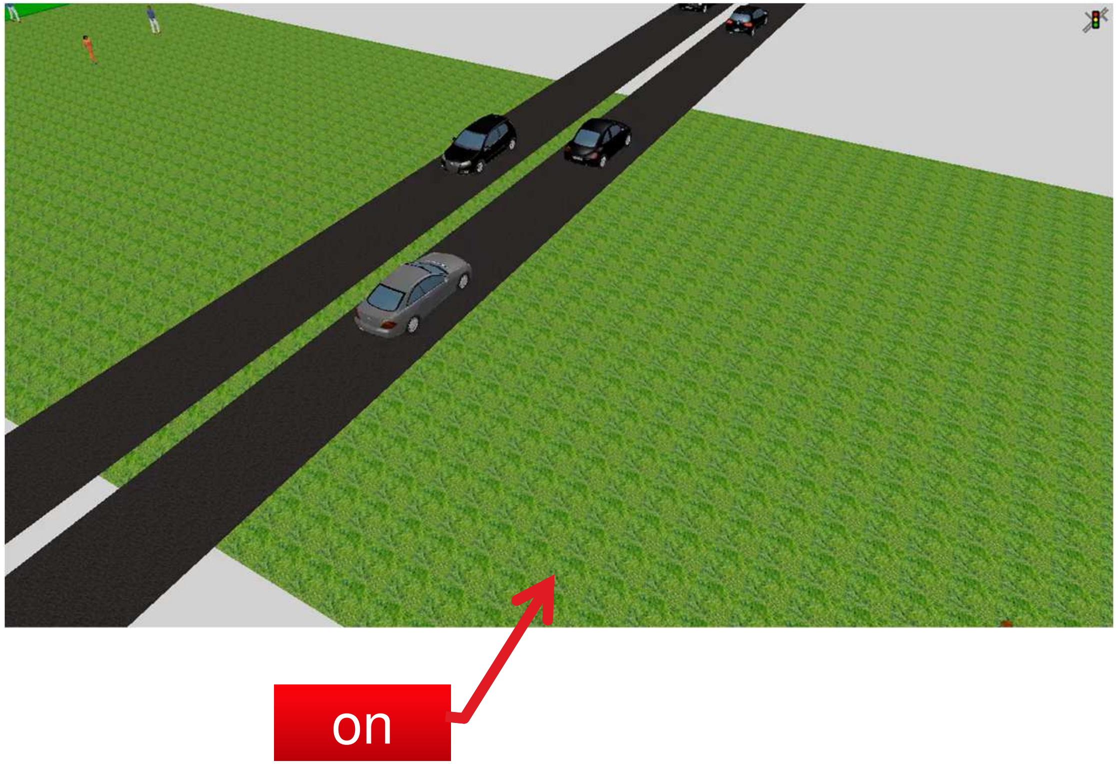
- New field in the dialog
- New coupled list for following analogical to „lateral“



CONSIDER VEHICLES IN DYNAMIC POTENTIAL

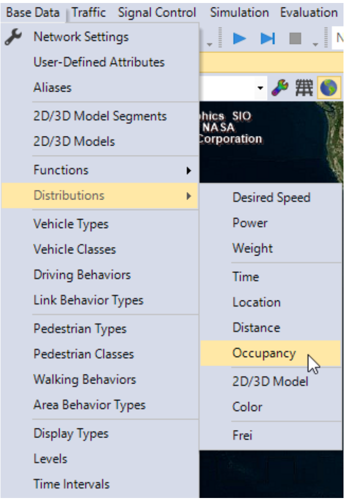
Idea: pedestrians find gaps between standing vehicles to cross the road

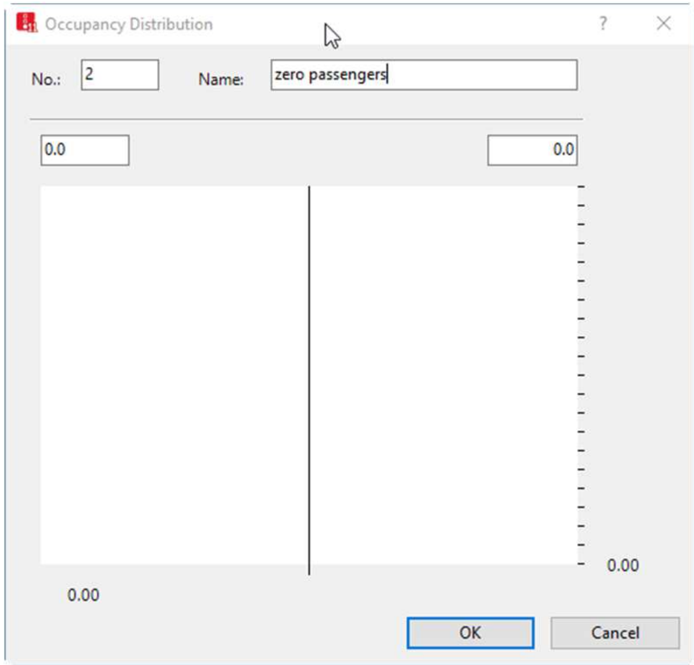


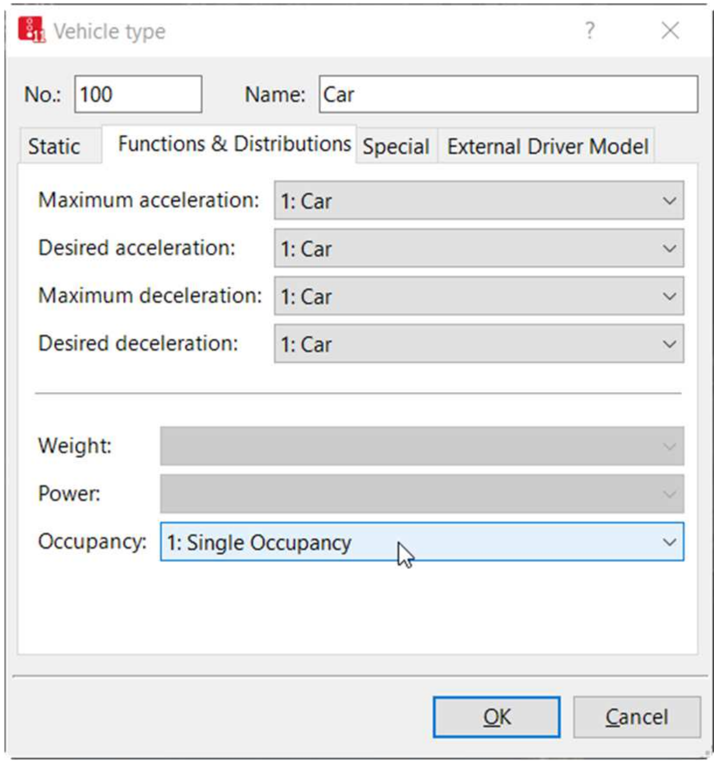


ZERO PASSENGERS

- Occupancy distribution (empirical) with value 0 possible now
- Simply to allow empty trips for future autonomous vehicles







OPENDRIVE IMPORT (INFO)

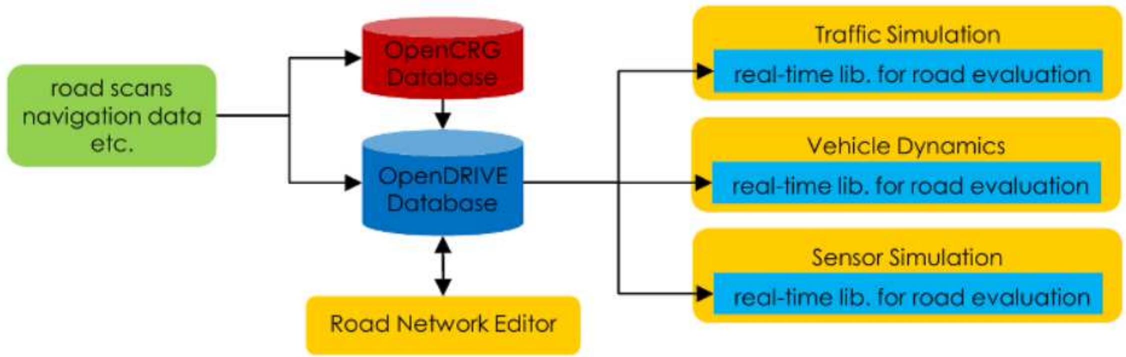
http://www.opendrive.org

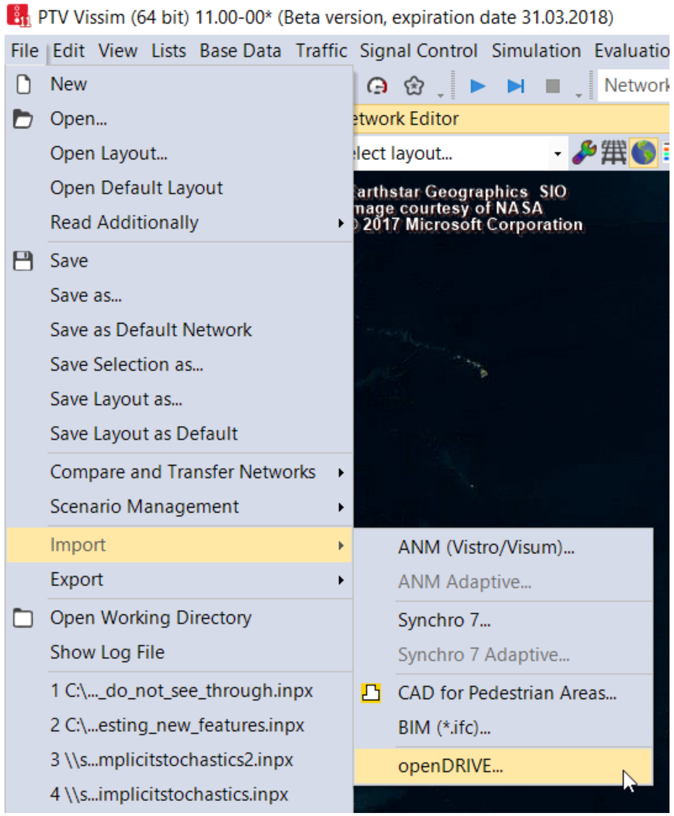
OpenDRIVE = open file format for the logical description of road networks. It has been developed and is being maintained by a team of simulation professionals with large support from the simulation industry. Its first public appearance was on January 31, 2006.

- Import restricted to links & connectors

Usage

The following figure shows the typical incorporation of an OpenDRIVE® file into a simulation tool-chain:





DRIVING BEHAVIOR PARAMETERS

DRIVING BEHAVIOR PARAMETERS: FOLLOWING

PTV Vissim uses the Wiedemann models.

Parameters control the driving behavior during the following process.

	model	parameter**	driving logic: rail safe	cautious	normal	all knowing
following behavior	Wiedemann 99	CC0	def	def	def	smaller
		CC1	def/higher*	def/higher*	def	smaller
		CC2	def/smaller	def/smaller	smaller	smaller
		CC3	def/higher	def/higher	def	def
		CC4	Smaller	def/smaller	def/smaller	smaller
		CC5	Smaller	def/smaller	def/smaller	smaller
		CC6	def/smaller	def/smaller	def	smaller
		CC7	def/smaller	def/smaller	def/smaller	smaller
		CC8	Smaller	smaller	def	def
		CC9	Smaller	smaller	def	def
	W74	ax	def	def	def	smaller
		bxadd	def/higher*	def/higher*	def	smaller
		bxmult	def/higher*	def/higher*	def	smaller

* if EABK is on, brick wall stop distance is guaranteed ** see PTV Vissim manual for detailed description

	model	parameter**	driving logic: rail safe	cautious	normal	all knowing	def
following behavior	Wiedemann 99	CC0	1.5	1.5	1.5	1	1.5
		CC1	1.5	1.5	0.9	0.6	0.9
		CC2	0	0	0	0	4
		CC3	-10	-10	-8	-6	-8
		CC4	-0.1	-0.1	-0.1	-0.1	-0.35
		CC5	0.1	0.1	0.1	0.1	0.35
		CC6	0	0	0	0	11.44
		CC7	0.1	0.1	0.1	0.1	0.25
		CC8	2	3	3.5	4	3.5
		CC9	1.2	1.2	1.5	2	1.5
	W74	ax	2	2	2	1	2
		bxadd	2	2	2	1.5	2
		bxmult	3	3	3	2	3

PTV GROUP CoEXist

DRIVING BEHAVIOR PARAMETERS: LANE CHANGE

Parameters controlling the necessary lane change behavior (because of the route):

	rail safe		cautious**		normal		all knowing	
parameter for necessary lane change*	own	trailing vehicle	own	trailing vehicle	own	trailing vehicle	own	trailing vehicle
maximum deceleration	n.a.	n.a.	smaller/def	smaller/def	def	smaller/def	def	higher/def
- 1 m/s per distance	n.a.	n.a.	smaller/def	smaller / def	def	def	def	smaller/def
accepted deceleration	n.a.	n.a.	smaller/def	smaller/def	def	def	def	higher/def

*necessary lane change means a lane change which is necessary in order to follow a defined route (it is not overtaking because of higher own desired speed)

** EABD (enforce absolute breaking distance) must be on

n.a. = not applicable

	control logic									
	rail safe		cautious**		normal		all knowing		def	
parameter for necessary lane change*	own	trailing vehicle	own	trailing vehicle	own	trailing vehicle	own	trailing vehicle	own	trailing vehicle
maximum deceleration	n.a.	n.a.	-3.5	-2.5	-4	-3	-4	-4	-4	-3
- 1 m/s per distance	n.a.	n.a.	80	80	100	100	100	100	100	100
accepted deceleration	n.a.	n.a.	-1	-1	-1	-1	-1	-1.5	-1	-1

DRIVING BEHAVIOR PARAMETERS: LANE CHANGE

Parameters controlling the necessary (because of the route) & free (overtaking) lane change behavior:

	control logic			
behavioral functionality	**rail safe**	**cautious****	**normal**	**all knowing**
Advanced merging*	n.a.	on***/off	on***	on
Cooperative lane change*	n.a.	on***/off	on***	on
Safety distance reduction factor	n.a.	higher+EABD	def/smaller	def/smaller
min. headway (front/rear)	n.a.	higher	def	def
max. deceleration for cooperative braking	n.a.	smaller***	smaller***/def	def

*depends on technical equipment and implemented connectivity & cooperation functions

** EABD (enforce absolute breaking distance) must be on

*** If the AV cannot detect that the other vehicle wants to change lanes, the value should be off/zero

n.a. = not applicable

	control logic				
behavioral functionality	**rail safe**	**cautious****	**normal**	**all knowing**	**def**
Advanced merging*	n.a.	on***/off	on***	on	on
Cooperative lane change*	n.a.	on***/off	on***	on	off
Safety distance reduction factor	n.a.	1+EABD	0.6	0.5	0.6
min. headway (front/rear)	n.a.	1	0.5	0.5	0.5
max. deceleration for cooperative braking	n.a.	-2.5	-3	-6	-3

DRIVING BEHAVIOR PARAMETERS: SIGNAL CONTROL

Parameters control the reactions on signals.

	driving logic			
attribute	**rail safe***	**cautious****	**normal**	**all knowing**
behavior at amber signal	continuous check	continuous check	one decision***	one decision
behavior at red/amber signal	stop	stop	stop/go	stop/go
reaction time distribution	-	-	-	-
reduced safety distance factor	higher+EABD	higher+EABD	def	def/lower
reduced safety start upstream of stop line	lower/def	lower/def	def	def/higher
reduced safety end upstream of stop line	lower/def	lower/def	Def	def/higher

*only protected phase possible in AV-certified environment

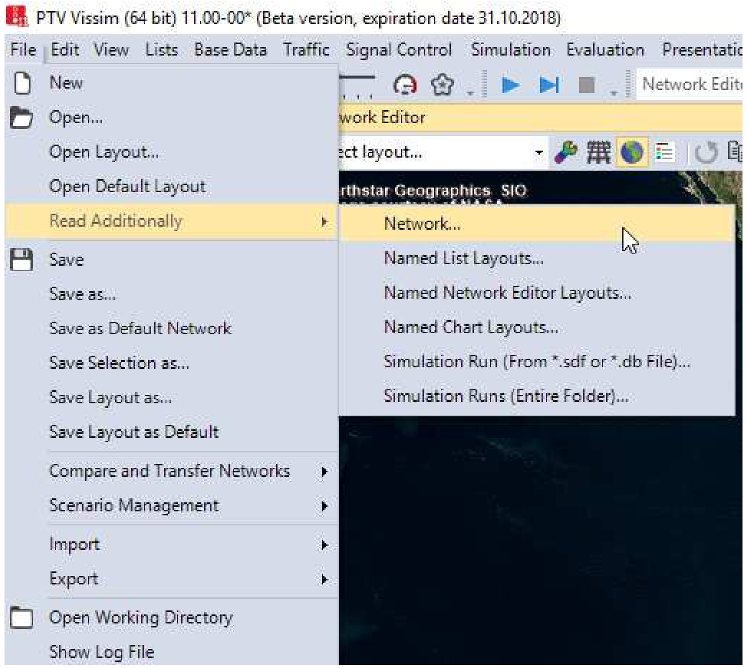
** probably protected phases only, EABD must be on

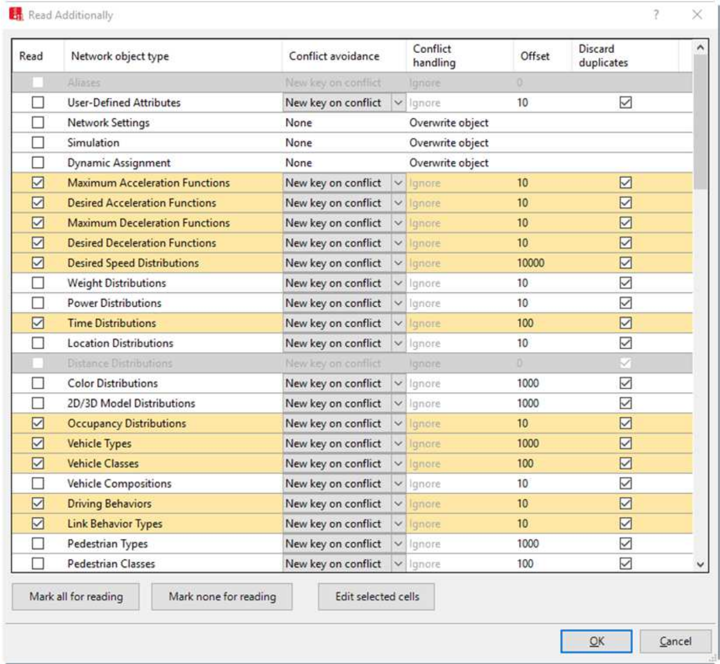
*** requires that the AV can remember that it has made a decision for that particular signal head already, else: continuous check

	driving logic				
attribute	**rail safe***	**cautious****	**normal**	**all knowing**	**def**
behavior at amber signal	continuous check	continuous check	one decision***	one decision	cont. Check
behavior at red/amber signal	stop	stop	stop	stop	go
reaction time distribution	-	-	-	-	-
reduced safety distance factor	1	1	1	1	0.6
reduced safety start upstream of stop line	100	100	100	100	100
reduced safety end upstream of stop line	100	100	100	100	100

IMPORT OF PREDEFINED PARAMETERS INTO YOUR NETWORK

PTV Vissim file “base network” available – contains recommended values for cautious, normal & all knowing driving logic – of course these can be adjusted if needed.





COOPERATION & COMMUNICATION

Questions to answer:

- What is the impact of a communication/cooperation?
- Can I replicate expected behavior with standard PTV Vissim or do I need an interface?

Available interfaces:

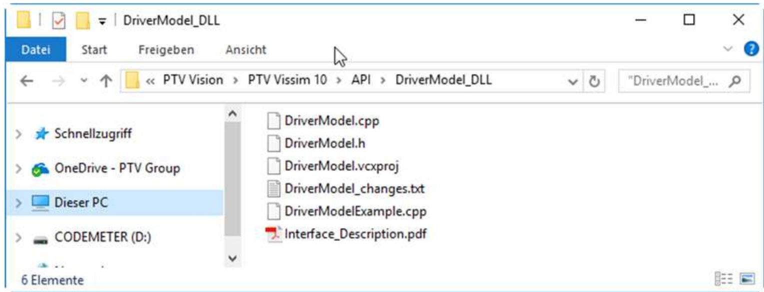
- **COM** => allows to read & set attributes of Vissim objects or to manipulate them
  - Usable for V2V or V2I communication, e.g. for platooning or time slot based intersection control
  - Examples available in …\Documents\PTV Vision\PTV Vissim 10\Examples Training\Autonomous Vehicles (AV)
- **DriverModel.dll** => replace internal car following behavior model of Vissim by own algorithm + optionally:
  - Own algorithm for lane changing
  - Own algorithm for reaction on signals
- **DrivingSimulator.dll** => couple own control algorithm (full behavior) with Vissim + optionally integration of:
  - Vehicle dynamics
  - Sensors

  ⇨ nanosimulation

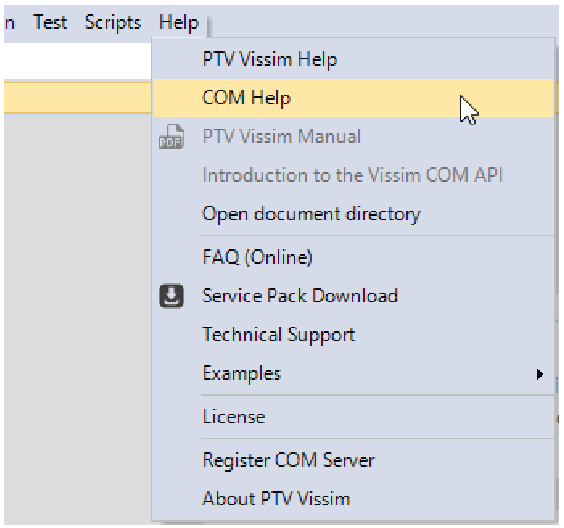
  Third party software (PreScan, CarMaker…) can be coupled with Vissim => co-simulations.

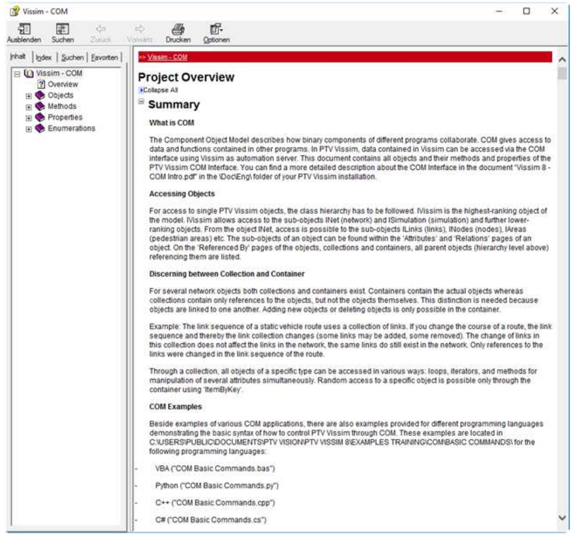
MATERIALS FOR INTERFACES

- Interface descriptions & example files – see the installation directory
  - C:\Program Files\PTV Vision\PTV Vissim 10\API\DriverModel_DLL
  - C:\Program Files\PTV Vision\PTV Vissim 10\API\DrivingSimulator_DLL



- COM Help & Examples – see the examples directory
  - …\Documents\PTV Vision\PTV Vissim 10\Examples Training\COM
  - Recommended: “…COM\Basic Commands” for instruction & tips in different programming languages
  - …\Documents\PTV Vision\PTV Vissim 10\Examples Training\Autonomous Vehicles (AV)



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