CoEXist

D2.1 : Tested and calibrated control logic AV-simulator connection (software)

Brief note of the software

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1 General introduction and context

The purpose of this document is to provide a brief note about deliverable D2.1, it is the software developed to have a real-time closed loop connection (software) between the autonomous vehicle (AV) control logics, PreScan and Vissim. The complete CoEXist platform report will be produced as part of deliverable D2.2, with deadline date on 30th November 2017, on the 7th project month. This platform report would be a technical one describing how the closed loop connection was set up.

Preliminary works for the CoEXist project consist in building a simulation framework to enable cities to conduct investigations around the impact of AVs. City investigations will be about mobility and new services deployment issues. Simulation framework will rely on two already existing softwares: PreScan and Vissim. The final platform - the fundamental concept of CoEXist project - for cities to conduct investigation will be based on PTV Vissim software and the adaptation of existing AV control logic (CL) currently developed by partners: VEDECOM and Renault.

Both simulation tools PreScan and Vissim deals with traffic simulation but on different kind of resolution. PreScan is a microscopic simulator focused on the ego-vehicle whereas VISSIM deals with macroscopic point of view. The interaction between them define a global platform that allow us to observe AV driving behavior in different traffic situations. To allow realistic scenarios, the platform will integrate the following elements: automated vehicle controlled by Vedecom algorithms, other conventional vehicles, other traffic entities such as: pedestrians, cyclist and traffic signals.

The first step of the CoEXist platform definition is the integration of VEDECOM CL (VCL) with PreScan[1]. The Control Logic (CL) defined in this document is the set of algorithms and rules that characterize the behaviour of the AV. Typically the CL deals with the lateral and longitudinal control. By the end of the project, the VCL will also been integrated into the VISSIM software. To fulfil the VISSIM integration, it is important for PTV to understand the differences between autonomous vehicle and human driver behavior.

Figure 1 below presents the global architecture of the VCL, and the different embedded functionalities:

- Path / Trajectory following
- Speed Regulation (mandatory speed limit, obstacle, road curvature)
- Emergency Break

The VEDECOM CL takes as inputs the current vehicle state, a planned trajectory, a list of in-range-obstacles and different legal recommendations such as mandatory speed limit. Then it computes orders for the actuators.

[1] "PreScan is a physics-based simulation platform that is used in the automotive industry for development of Advanced Driver Assistance Systems (ADAS) that are based on sensor technologies such as radar, laser/lidar, camera and GPS. PreScan is also used for designing and evaluating vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication applications as well as autonomous driving applications. PreScan can be used from model-based controller design (MIL) to real-time tests with software-in-the-loop (SIL) and hardware-in-the-loop (HIL) systems." (Tass International, 2017). See https://www.tassinternational.com/prescan

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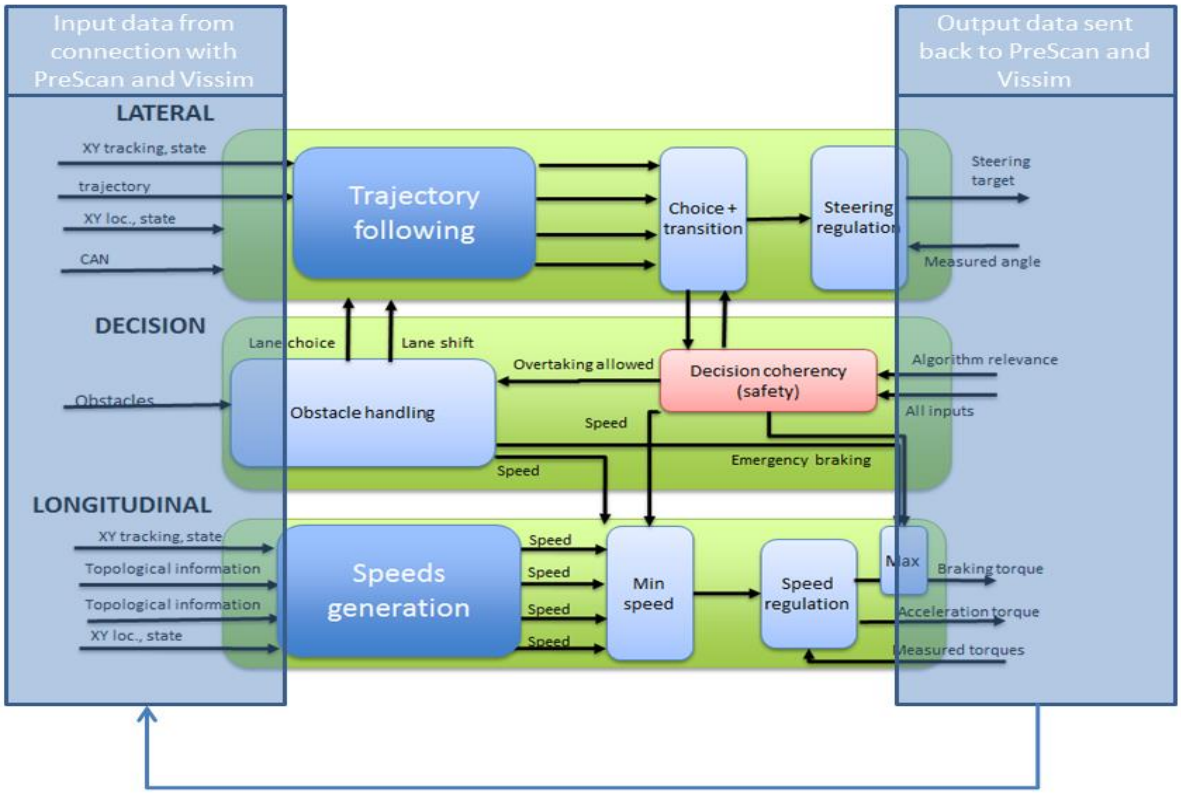

Figure 1 Overview of VEDECOM Control Logic 1

2 Connection between VEDECOM's CL and PreScan

To proceed a vehicle behaviour simulation acting as Autonomous Vehicle, some AV behaviour models have to be introduced into the simulation framework. One of these models operated with PreScan is a simplified VEDECOM Control Logic. It is currently developed with Simulink: a part of the MATLAB product that enable developers to build complex system based on a diagram for interaction between the different subsystems that compose the defined software. It embeds different already existing components and permits user to also build their own, typically for the concern of CoEXIst, the different parts that compose the Control Logic for AV. (see. https://fr.mathworks.com/products/simulink.html).

As PreScan provides native integration with Simulink, the integration of the VEDECOM CL into the simulation loop doesn't suffer technological issue about interfacing.

Figure 2 below provides an overview of the VEDECOM CL integration into the simulation loop of PreScan.

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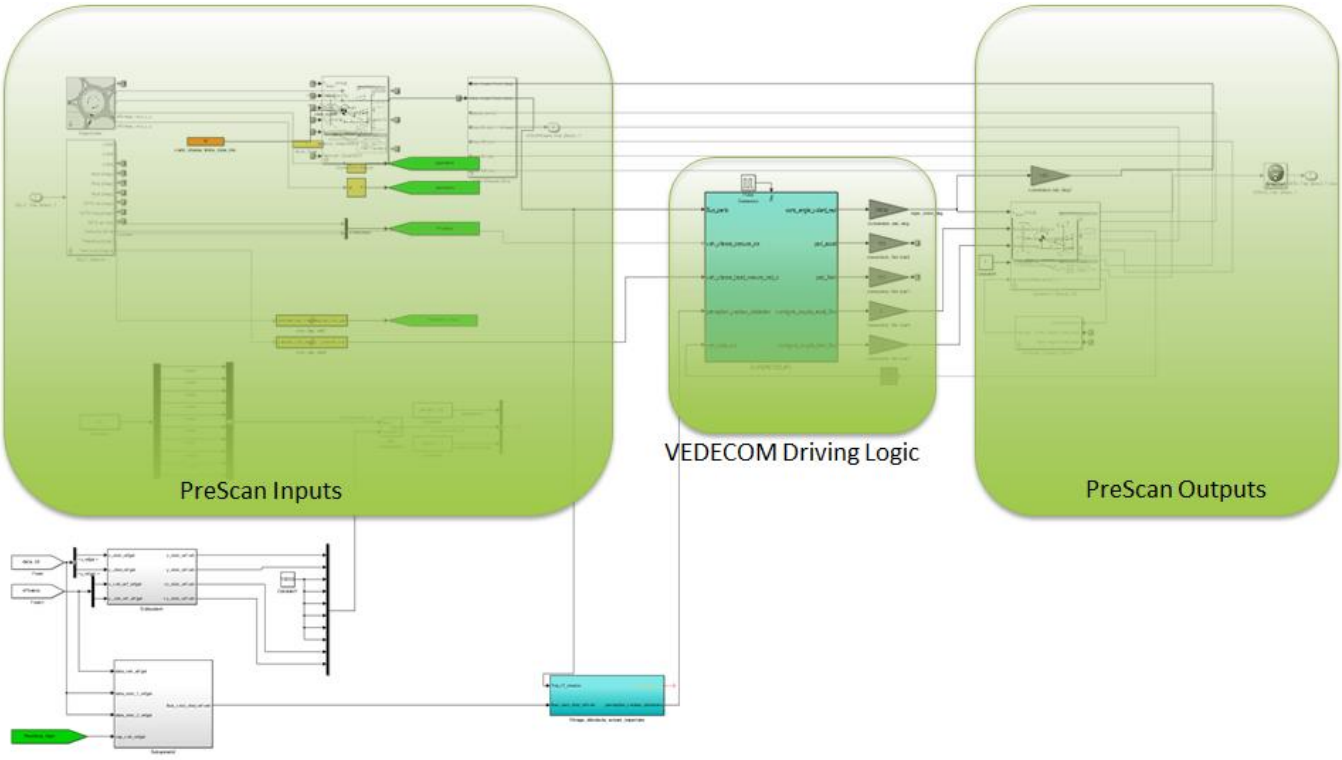

Figure 2 Overview of the VEDECOM CL integration into the simulation loop of PreScan

From left to right, we find PreScan information needed by VCL, the Control Logic that compute the requested trajectory based on these information, ie the actuator orders which are then send back to PreScan to control the vehicle model.

2.1 Adaptation of VEDECOM'S CL

The current AV CL of VEDECOM integrates a lot of functionalities that requested information not yet defined in the CoEXist environment.

The preliminary integration into the CoEXist platform of this AV CL rely then on a simplified version of this CL.

2.1.1 Inside the VEDECOM'S CL

The figure 3 (see below) presents the integrated version of VEDECOM CL. It has already integrated several aspect of the complete AV CL: Lateral and longitudinal control, speed and steering regulation.

Currently Lateral and Longitudinal Control rely on a pre-defined trajectory, but already take into account several aspects of a more complex control logic (see Section 3: Some results and proof of technology (software)).

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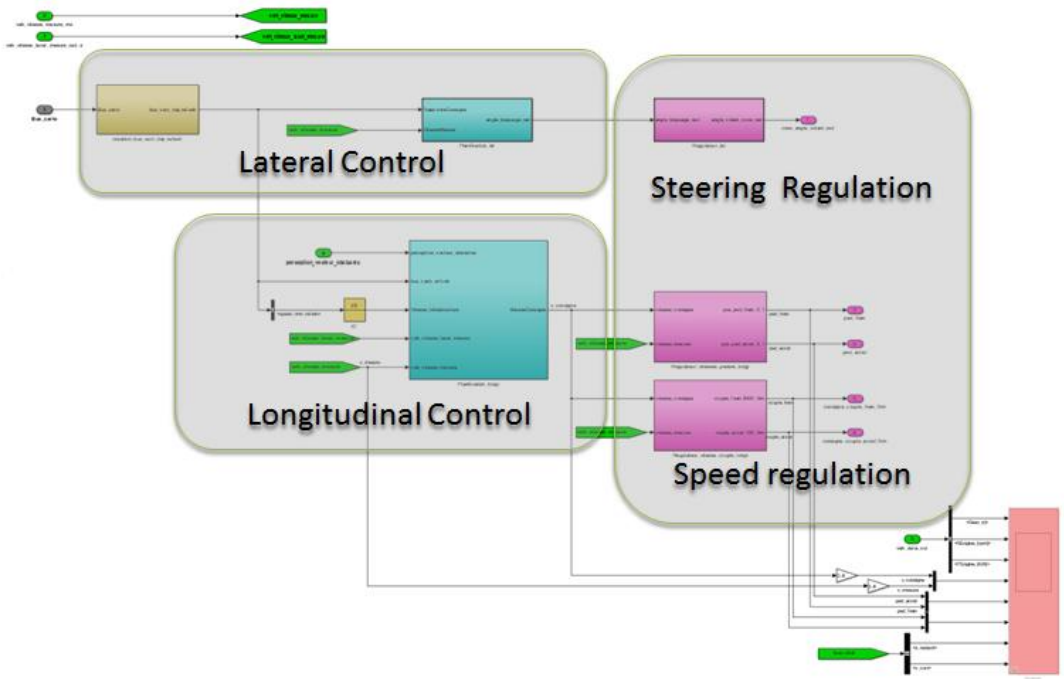

Figure 3 Composition of the VEDECOM CL for CoEXist

2.2 Adaptation of the vehicle model in PreScan

One major issue for the interface between PreScan and VEDECOM CL was about the dynamic model of the controlled vehicle and particularly about the defined engine system.

Indeed, all PreScan defined vehicle models are based on thermal motor which use a gear box, whereas the VEDECOM CL is defined for an electric vehicle.

One of the main task about this issue was to adapt an existing thermal engine model to fullfil VEDECOM CL requirement. This adaptation have been made in partnership with PreScan engineer Bart Heijke.

3 Some results and proof of technology (software)

During the PreScan training session on 13.07.2017, which took place at the VEDECOM institute, a very simple scenario have been developed in order to make initial tests for the VCL/PreScan integration.

From this scenario, we were able to test several functionalities actually working, among them, we can cite:

- Trajectory following
    - Speed regulation is computed according to several aspects

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- Road curvature: depending on the curvature, the vehicle adapts its velocity for passenger safety and comfort. It is possible to make it more reactive depending on the payload (passenger or goods)
- Obstacles: if an obstacle is on the trajectory of the AV, the CL adapts the velocity to always respect a security gap between the previous mobile and the AV, in order to be able to realize an emergency break if something goes wrong.
- Mandatory Speed Limit: the third aspect of Speed Regulation is about MSL, the AV have to respect them and the defined CL takes them into account to compute the current velocity.

➢ Steering regulation

- This parameters only relies on the road geometry, it is associated to the lateral control

3.1 Video demonstration of the software

Here is the link to the video. This video (see link) illustrates all these aspects in a minimalist scenario where all use cases have been demonstrated.

Table 1 Accompanying description of the software according to timeline in the video

Time	Description
0:00-0:45	Vehicle try to reach the mandatory speed limit but have to adapt its velocity on road curvature (Road curvature speed regulation scenario)
2:10	The vehicle accelerates to reach the defined mandatory speed limit (Mandatory speed regulation scenario)
2:50	An obstacle in front of vehicle have a lower velocity, the AV adapts its speed to keep a safety gap between itself and obstacle (Obstacle speed regulation scenario)
3:30	The obstacle brutally stopped on road, the vehicle stops its journey before have a collision with the static obstacle (Brick wall emergency scenario)

4 Next steps

This first version of the Simulation Framework (PreScan/VEDECOM CL) is already compliant with the CoEXist expectations.

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Next steps by Vedecom: running co-simulations in PreScan and Vissim in several traffic situations in simple (principial) models providing outputs for Vissim developers. Vedecom is also working on additional solution using Vissim´s “driver model interface” which would allow to run the Vedecom´s control logic directly in Vissim, without Prescan. Of course, this approach does not include the simulation of sensors (that part can be done only with co-simulation), but would be a big help for the further development of Vissim.

Next steps by PTV Group: analysis of the outputs from co-simulations and incorporating necessary results into Vissim driving behavior model. Providing support for Vedecom for successful transfer of the control algorithms with Vissim´s driver model interface. Using the dll from Vedecom with driver model interface for simulation test – observing and analyzing the driving behavior (especially differences to actual human driver behavior model).

The results of the next step will be documented in the comprehensive report about the software in D2.2: Technical Report on connecting AV control logic and AV simulator.

5 Development partners for D2.1

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