Safe and Efficient Electrical Vehicle

Green ADAS

S. GLASER, D. GRUYER, O. ORFILA
IFSTTAR

Outline of the presentation

From perception to control

- » **Perception architecture and function**
- » **Hardware architecture**
- » **Results**

Safety and efficiency of longitudinal ADAS

- » **Operating range of longitudinal ADAS**
- » **eHorizon and map provided attributes**
- » **Speed and distance control**

Outline of the presentation

From perception to control

- » **Perception architecture and function**
- » **Hardware architecture**
- » **Results**

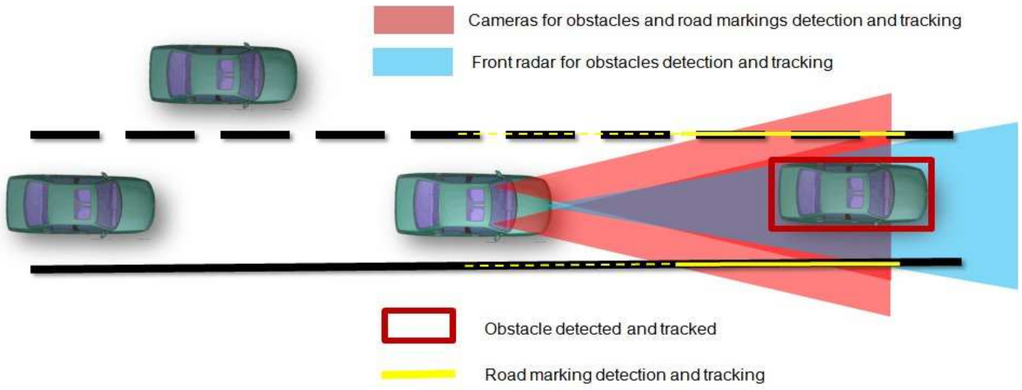
Safety and efficiency of longitudinal ADAS

- » **Operating range of longitudinal ADAS**
- » **eHorizon and map provided attributes**
- » **Speed and distance control**

Sensors choice in order to perceive environment

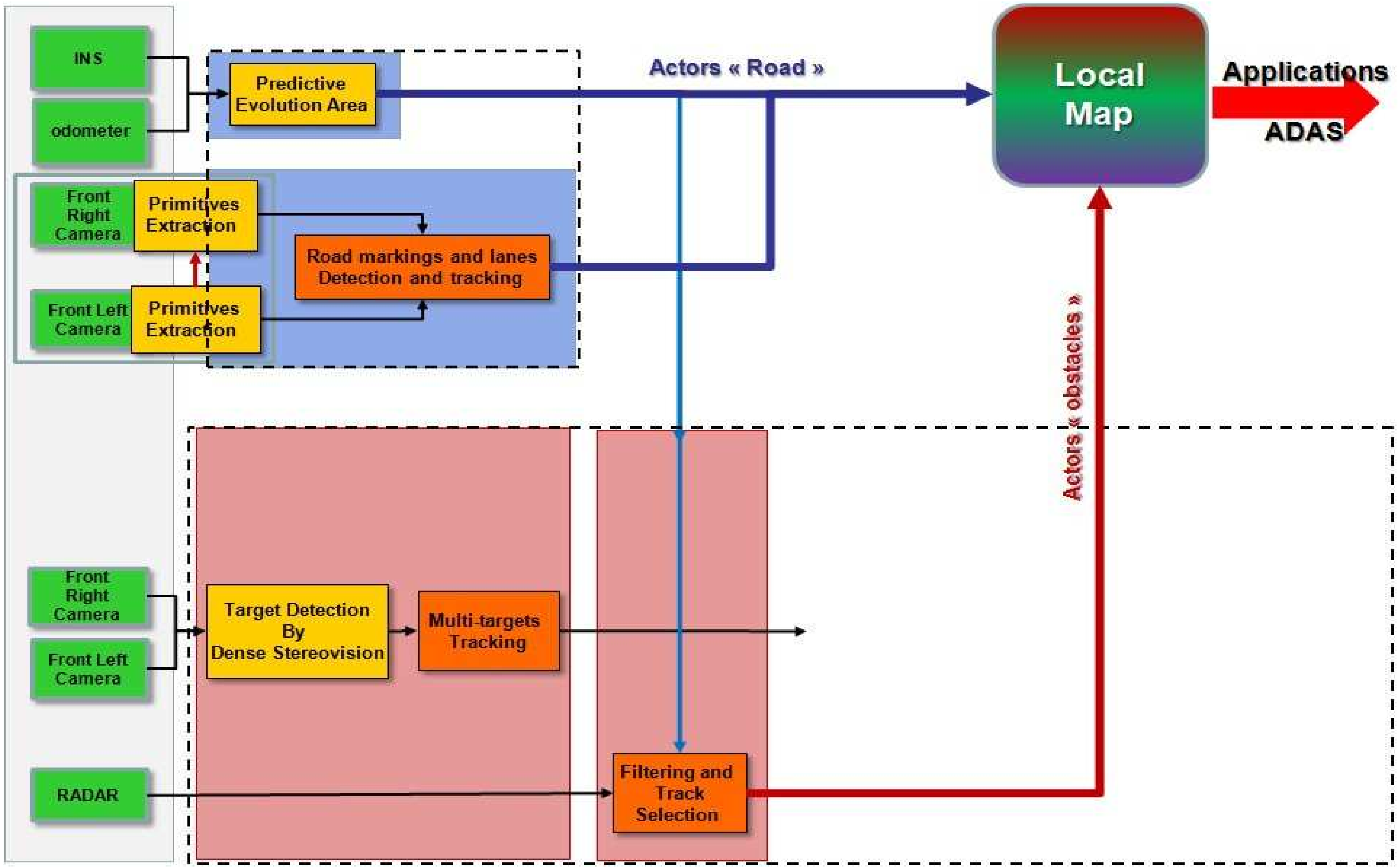
Perception for the on-board longitudinal applications

- **Radar (long range and short range), stereovision, cameras for road markings and lanes detection and tracking,**
- **Ego-perception from CAN bus**
- **Relative and frontal perception**



Hardware architecture for perception

Modules of the perception task embedded in the PERSEE board and MIPSEE cameras

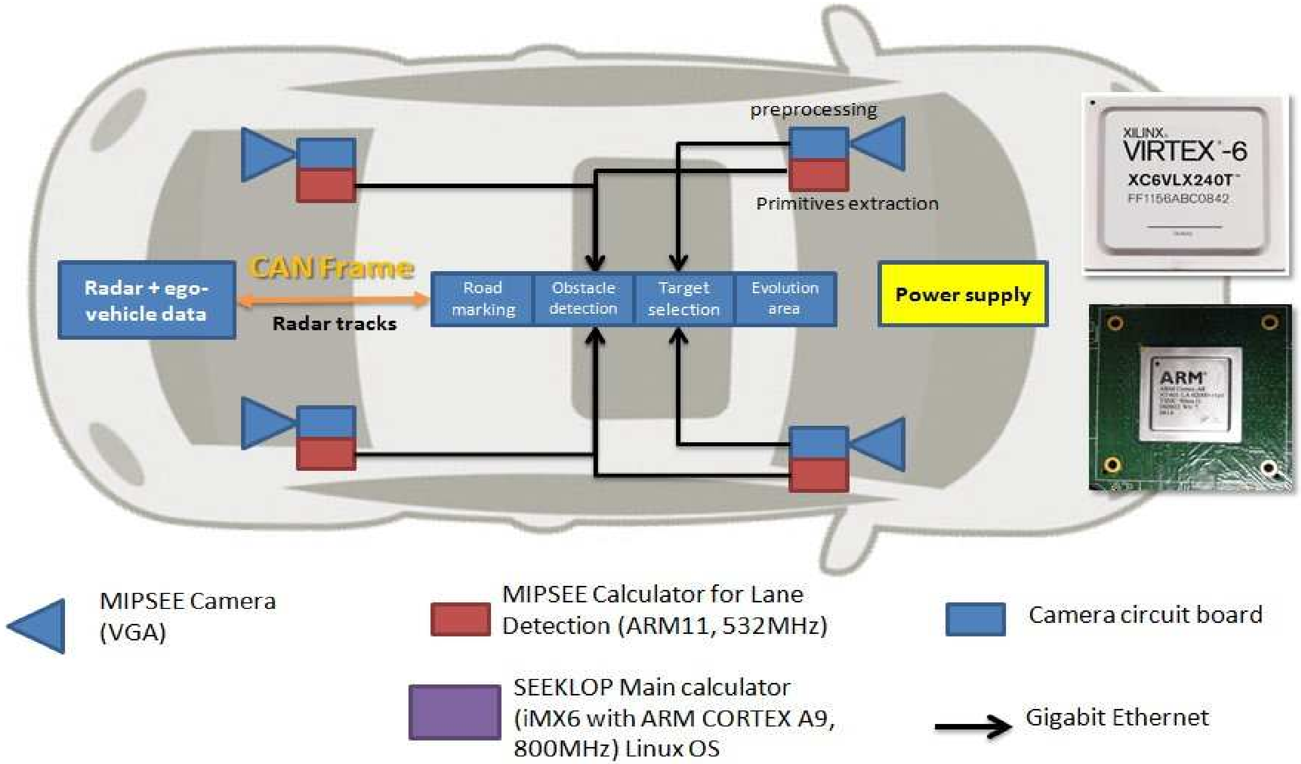


Embedded perception architecture

PerSEE architecture with 1 radar (continental), 2 front cameras (MIPSEE), proprioceptive information from CAN bus

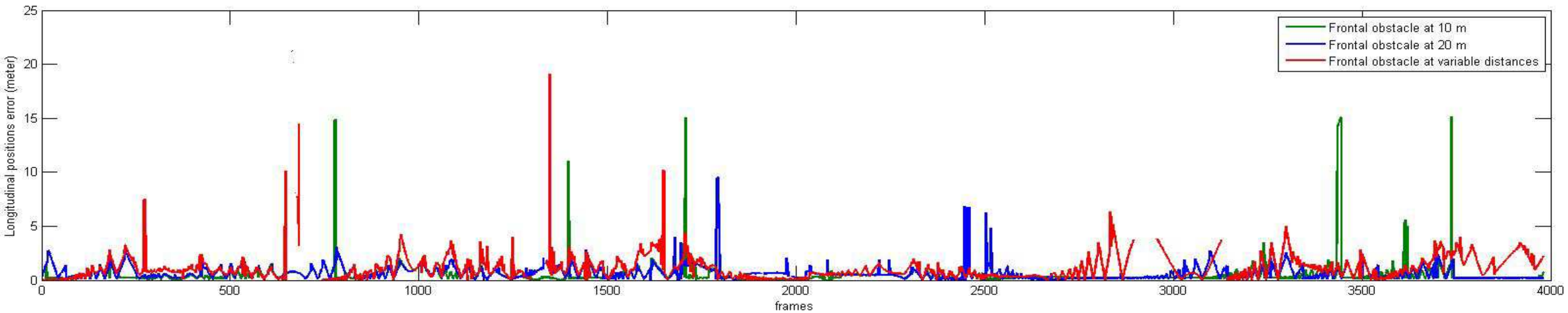
iMX6 board with ARM9Q (quad core)

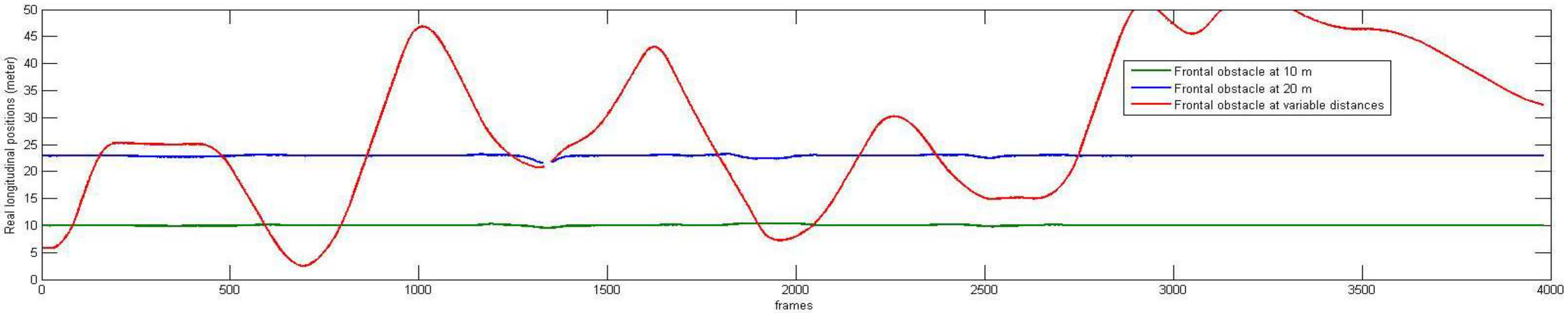
Primitives extraction in MIPSEE cameras



Results and evaluation of the Obstacle detection and tracking with stereo-vision

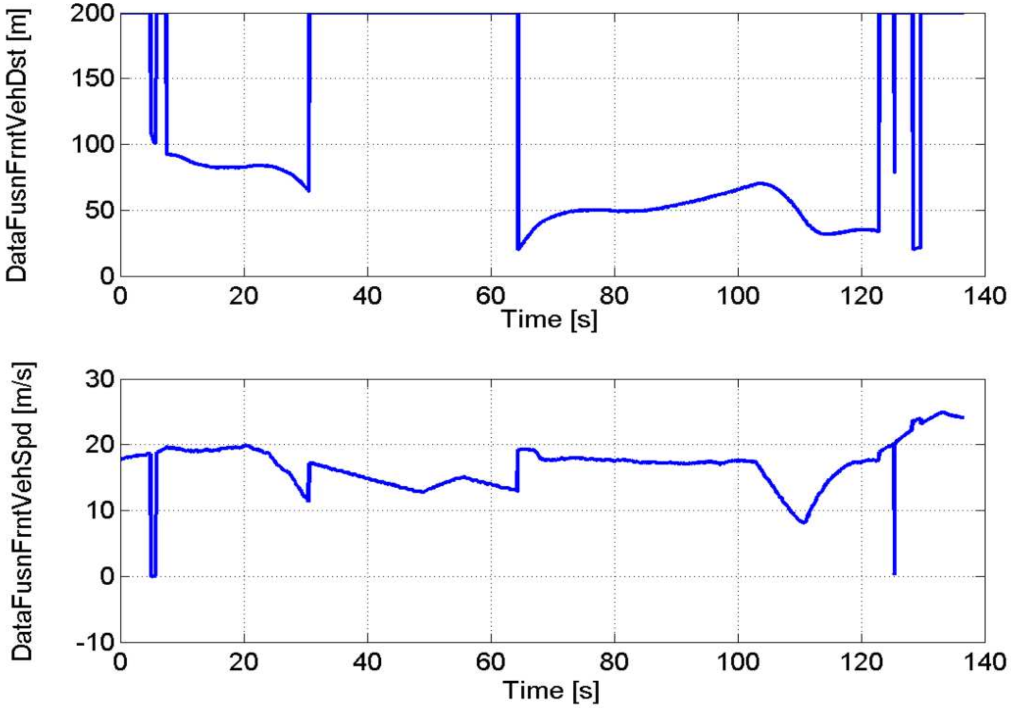
- The error of longitudinal positions (meter) for frontal obstacles: At 10m (green), 20m (blue) and variable distances (red).





Results and evaluation of the Obstacle detection on vehicle

- Direct output of the function for a vehicle following case. By default, the system output is 200m and the ego vehicle speed if no vehicle is detected



Outline of the presentation

From perception to control

- » **Perception architecture and function**
- » **Hardware architecture**
- » **Results**

Safety and efficiency of longitudinal ADAS

- » **Operating range of longitudinal ADAS**
- » **eHorizon and map provided attributes**
- » **Speed and distance control**

Longitudinal ADAS

Aims

- Develop the copilot system with several objectives
  - Reproduce existing driving assistance on an electric vehicle
  - Enhance the driver safety
  - Increase the vehicle efficiency

Final Results

- Conventionnal ADAS
  - LSF, ACC, FSRACC
- Development of new ADAS
  - eACC, Gr-ACC, SAGA

Operating range of Longitudinal ADAS

eFuture

Long range information

Consumption constraint

	Without eHorizon	With eHorizon
Dynamic Mode	ACC	E-ACC
Eco Mode	Gr-ACC	SAGA

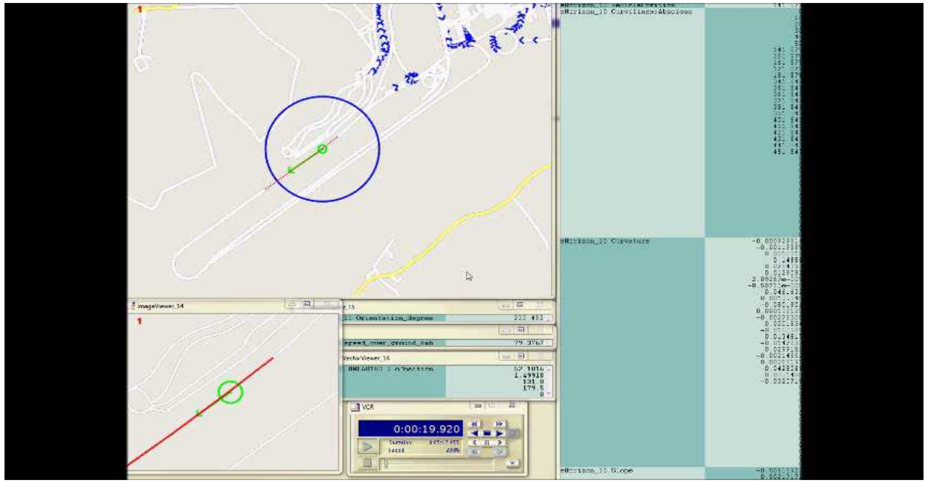
eHorizon

Aims

- Provide the knowledge of the future of the road
- Subcontracted to Ecoles des Mines de Paris for the Geographic database

Results during the project

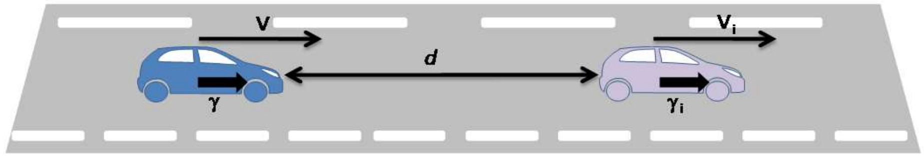
- Generation of digital map, using Open Street Map as a base layer
- Automated collection of data from GPS and inertial measures
- Generation of the possible paths, extraction of curvature, slope, speed limit …

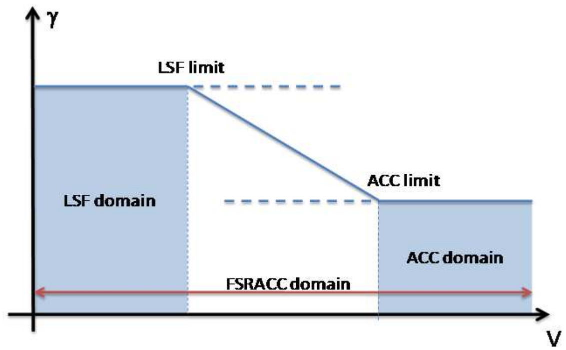


ACC, LSF and FSRACC specification

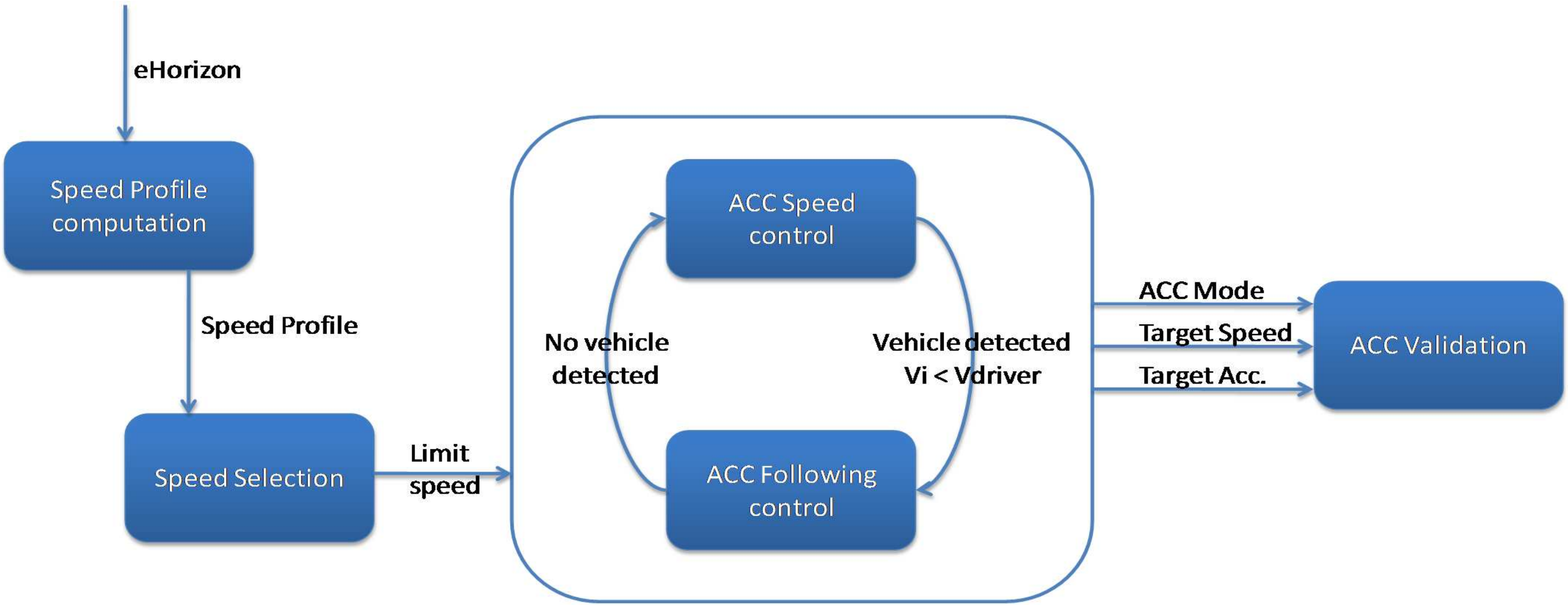
ACC, LSF and FSRACC

- Specification and requirements described by ISO-Norms
- Speed range, acceleration and deceleration limits, jerks are defined
- The functions aim at
  - Regulating the gap between vehicle to a given time headway
  - Maintaining a driver desired speed
  - Whatever is the lower

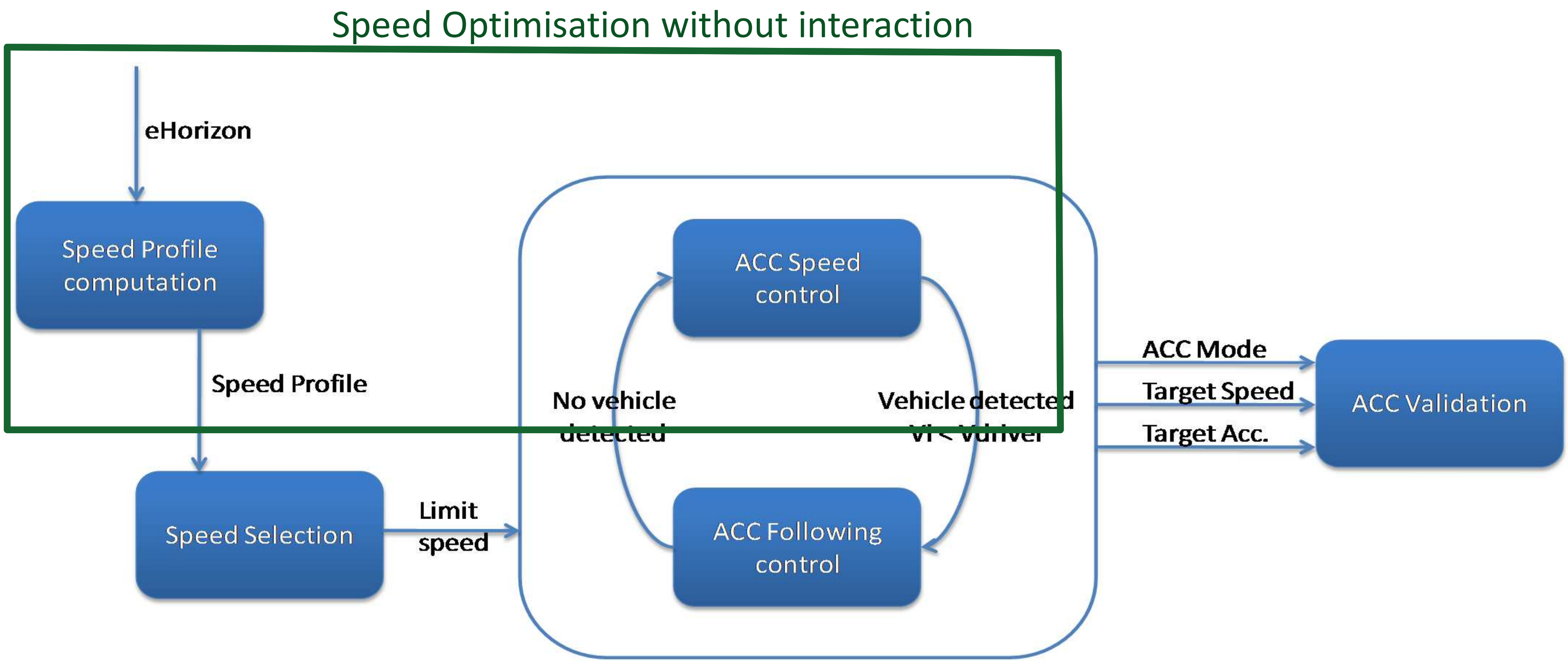




From ACC to E/Gr/SAGA



From ACC to E/Gr/SAGA



Speed profile optimisation

Main results of the second year

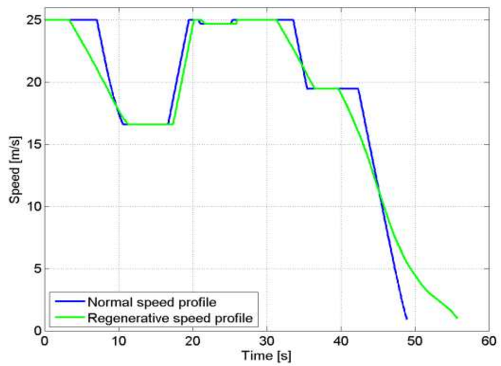
- Generation of a speed profile that optimizes energy consumption and regeneration

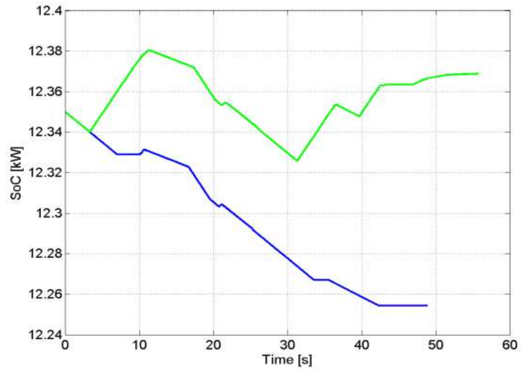
- Based on the computation of torque request and simple battery / traction model

$$T = \frac{R_w}{2}\left(\frac{1}{2}\rho S\, C_x V^2 + Mg\, C_{rr} + M\, G \sin\phi_r + M\gamma\right)$$

- Three methods were evaluated
  - Direct computation
  - Dijkstra
  - A*

- Direct computation is integrated in the vehicle
  - Optimisation at High speed
  - Conventional braking at low speed





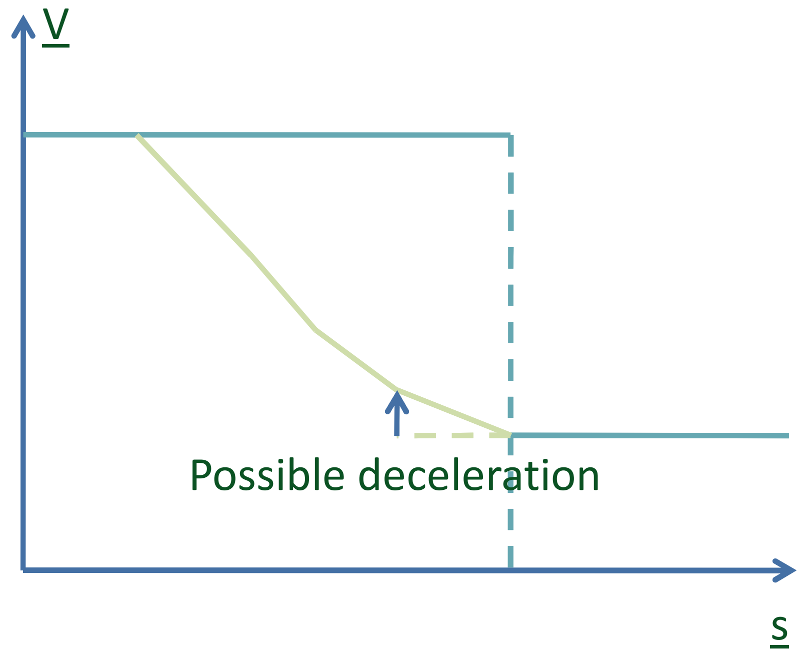
Direct computation

Method

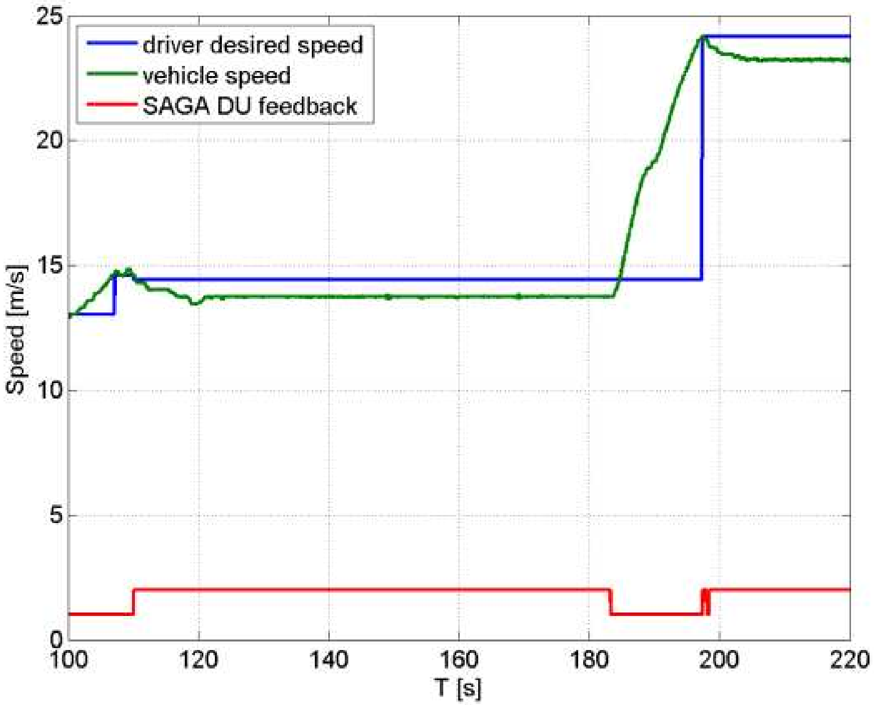
- Find the highest speed possible that allows a regenerative bracking

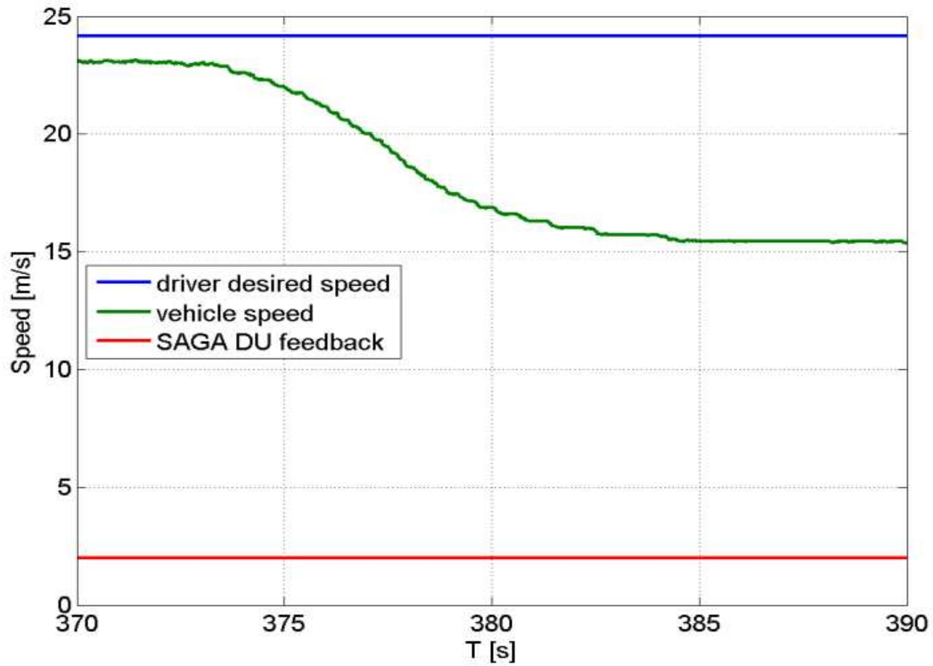
- First define a safe speed profile which take into account
  - Road geometry, speed limit and intersection
  - Vehicle parameter and coupled tyre road force boundaries

- Optimize the speed profile for a regenerative braking using the real vehicle possibilities

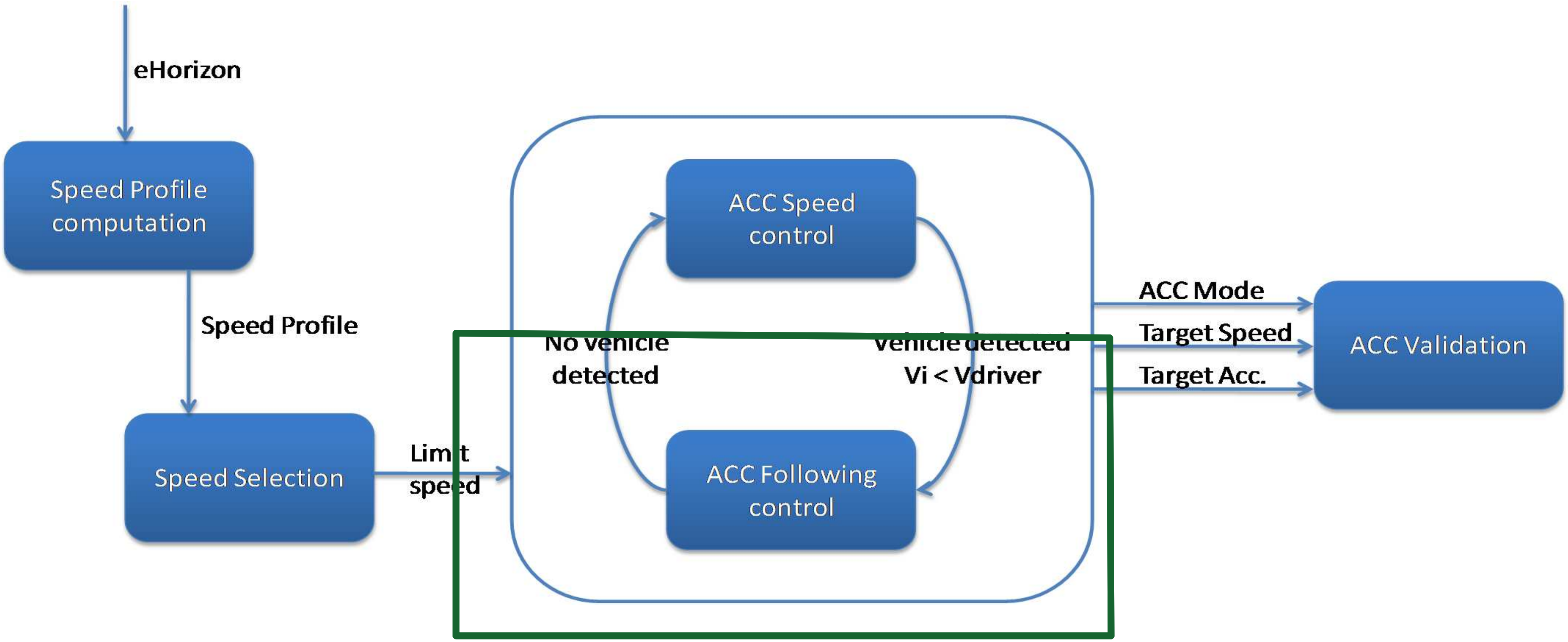


Results on vehicle





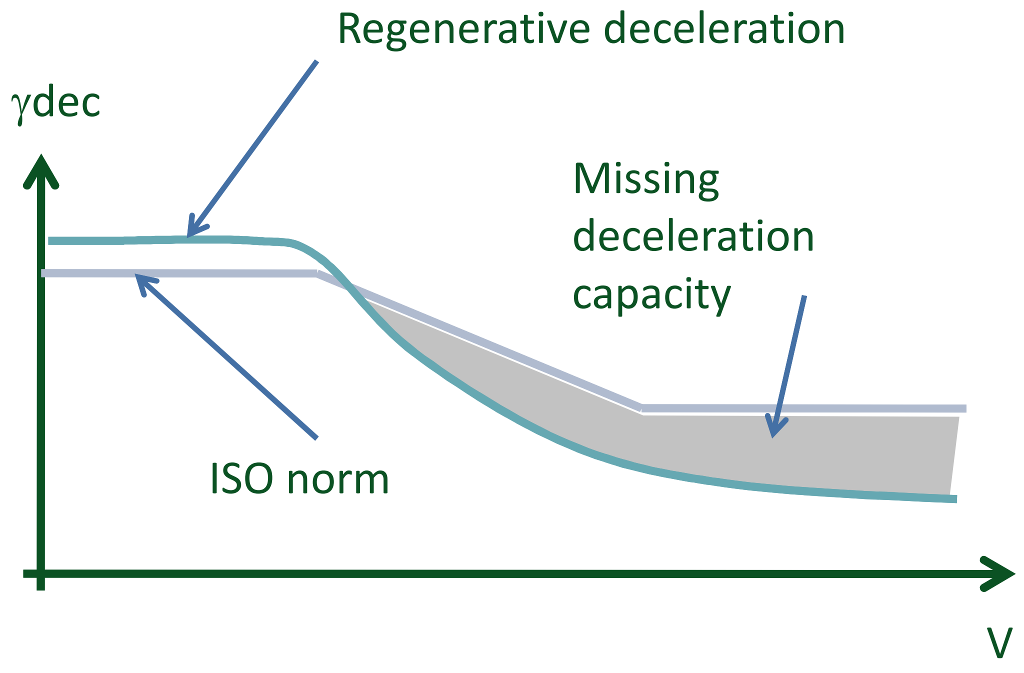
From ACC to E/Gr/SAGA



Speed Optimisation with interaction

Distance Control

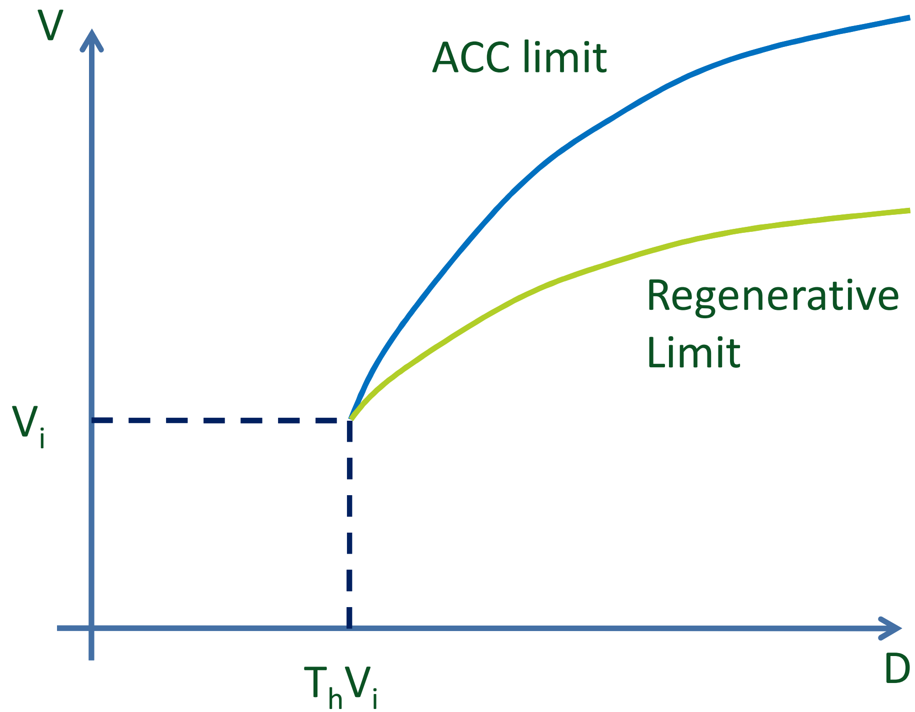
- Handle the interaction, taking into account regenerative capacity
- Safety critical, we need to evaluate the risk related with bracking variation
- Definition of the safety domain and evaluation of the different strategies



Safety domain

How to define the safety domain of an ADAS function? Two situations arise

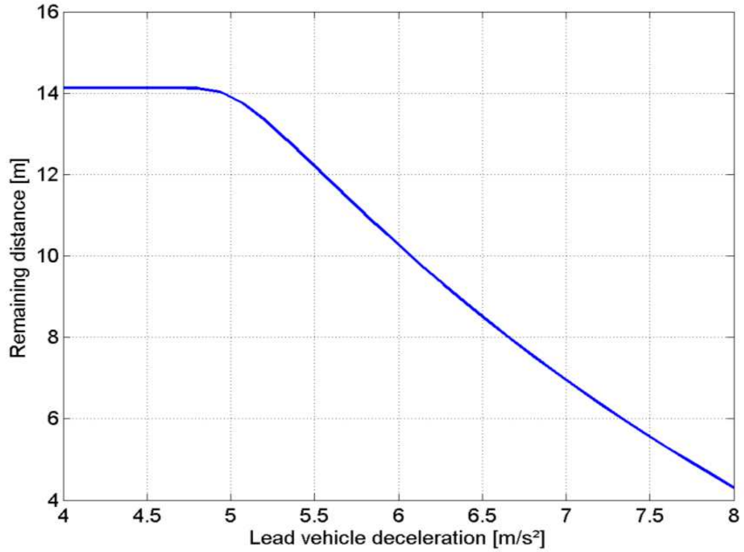
- When the function changes from speed control to distance control
- During a distance control, when the lead vehicle brakes



Safety domain

How to define the safety domain of an ADAS function? Two situations arise

- When the function changes from speed control to distance control
- During a distance control, when the lead vehicle brakes

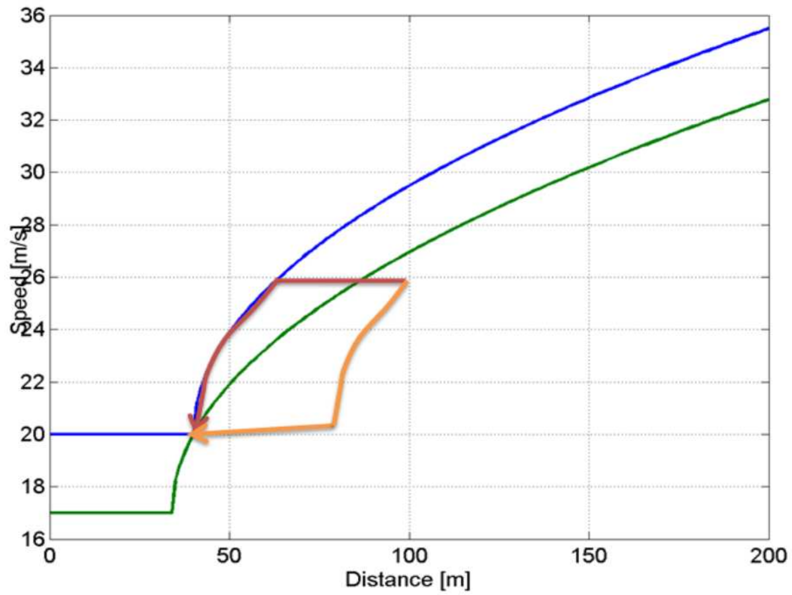


Both vehicles drive at 30m/s, the lead vehicle decelerates up to 7m/s. What is the remaining distance ?

Safety domain

How to define the safety domain of an ADAS function? Two situations arise

- When the function changes from speed control to distance control
- During a distance control, when the lead vehicle brakes



Safety domain

What are the possible strategies :

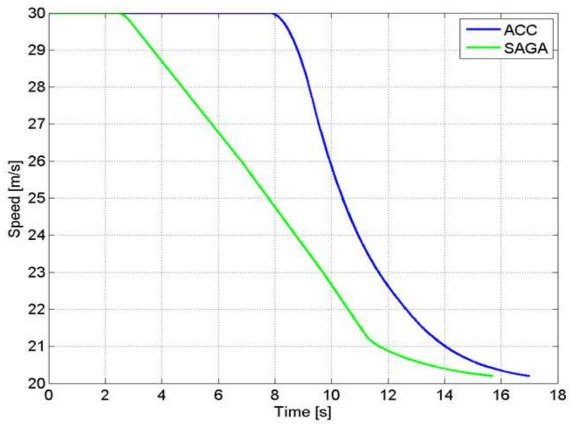
- Increase the time Headway
  - To reach the same distance control safety, we need to increase the time headway of the function up to 5s. The resulting distance is hard to achieve from a perception point of view, and the gap will allow other vehicles to cut in.
- Couple the Regenerative distance control with a conventional distance control
  - We can obtain a collision free system if the time headway is set at 3.7s, with a switch to a conventionnal bracking when the headway drop below 1s. The initial time headway is still huge, but remains possible. Vehicle cut-ins remain problematic
- Couple the regenerative distance control with an emergency bracking
  - If we aim at a small time headway, we can have a collision free system with an headway of 3s and an AEBS which activates if the headway decreases below 2s. The behavior of the system for the driver may be difficutly acceptable.

Simulation results

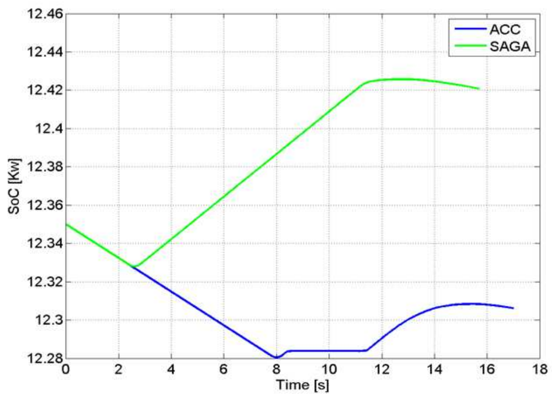
Several trials are realized

› Distance control

– To compare the evolution of the SoC with respect to conventionnal strategy. A regeneration is possible during distance control



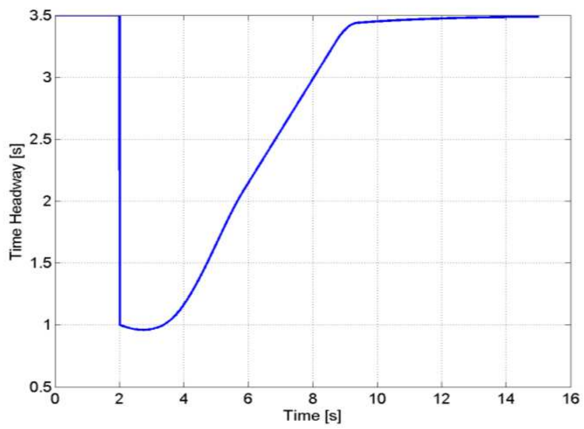
› Vehicle cut-in

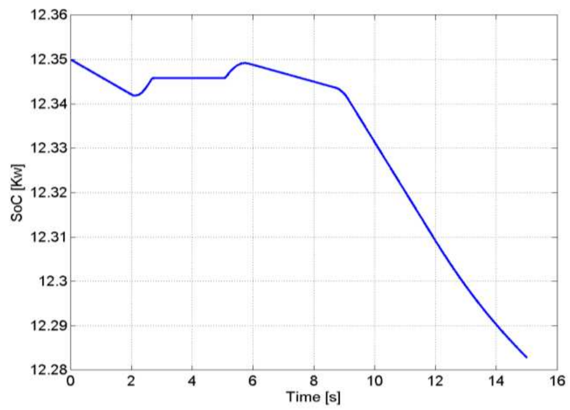


Simulation results

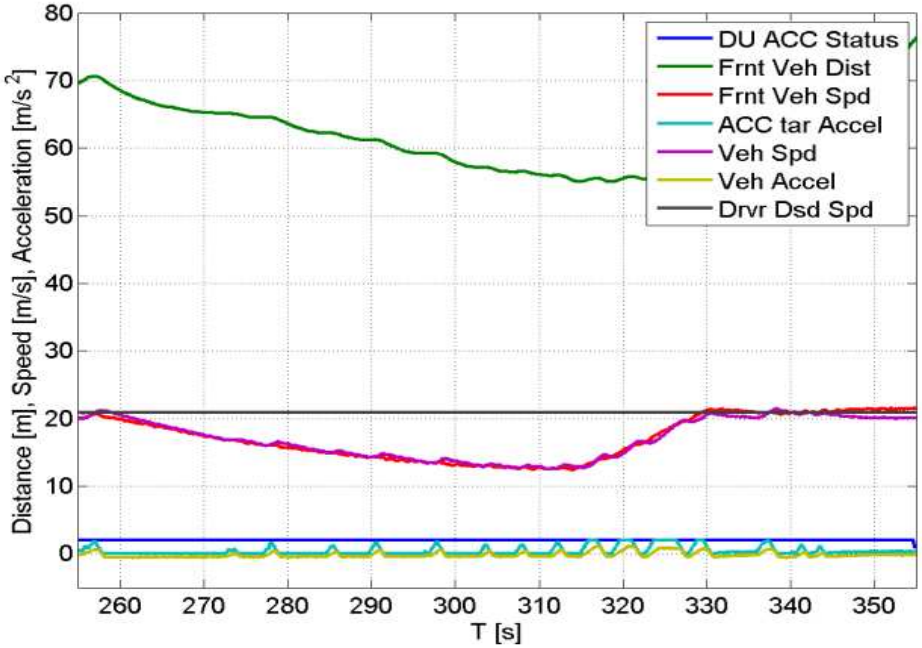
Several trials are realized

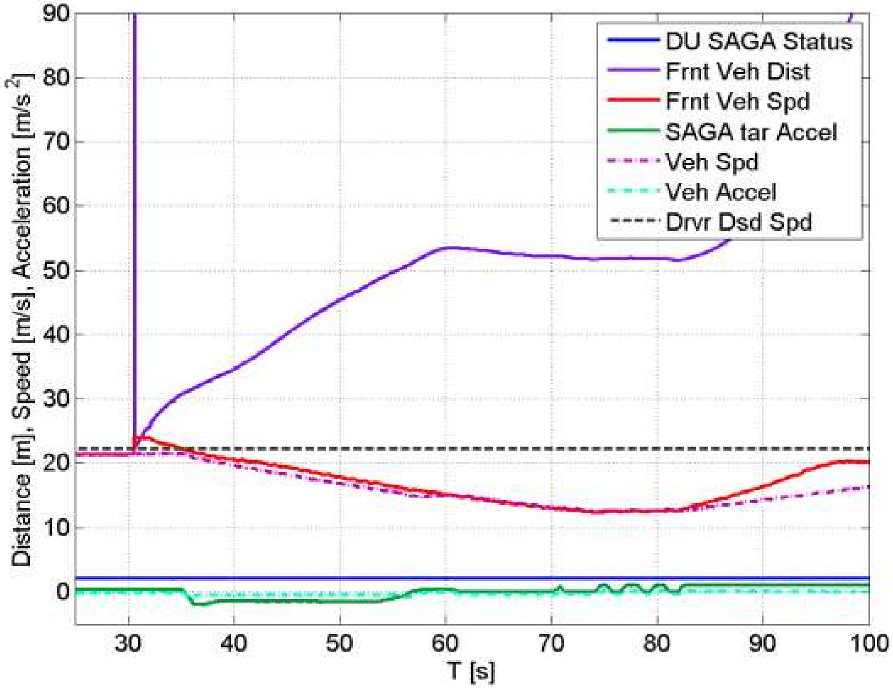
- Distance control
- Vehicle cut-in
  - Safety is ensured, however, the So
    is not the main objective.





Vehicle results





Thanks for your attention

Sébastien GLASER

IFSTTAR

www.ifsttar.fr

Vehicle-Infrastructure-Driver Interactions Research Unit

14, route de la Minière, Bâtiment 824

F-78000 Versailles - Satory