heudiasyc

Autonomous robotic systems for mobility and transport

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~~Intelligent~~ Autonomous vehicles

- Autonomous vehicle
  - ✓ Robotic vehicle with decision-making and control capabilities
  - ✓ Realization of a task (mission) entrusted to it without intervention of a human driver / operator
- Mains classes

Autonomous Shuttles

Automotive robotic convergence

Autonomous cars

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Social relevance

- Societal Expectations
  - ✓ Road safety
  - ✓ Driving comfort, repetitive and boring situations and better use of time spent traveling
  - ✓ Improved traffic, optimized use of infrastructure, reduced travel times and thus the carbon footprint
  - ✓ Mobility of the elderly, with handicap, etc.
- Political will
  - ✓ March 2016: revision of the Vienna Convention
  - ✓ 14 April 2016: Amsterdam Declaration

Commitment by the 28 EU Member States to work towards the elaboration of common rules and standards to allow the traffic of autonomous vehicles on European roads

Driving Automation Levels (Standard SAE J3016)

Without the hands
Eyes on the road

Without hands and eyes constantly on the road

The mind elsewhere

Neither steering wheel nor pedals

SAE level	SAE name	SAE narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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Some milestones and highlights

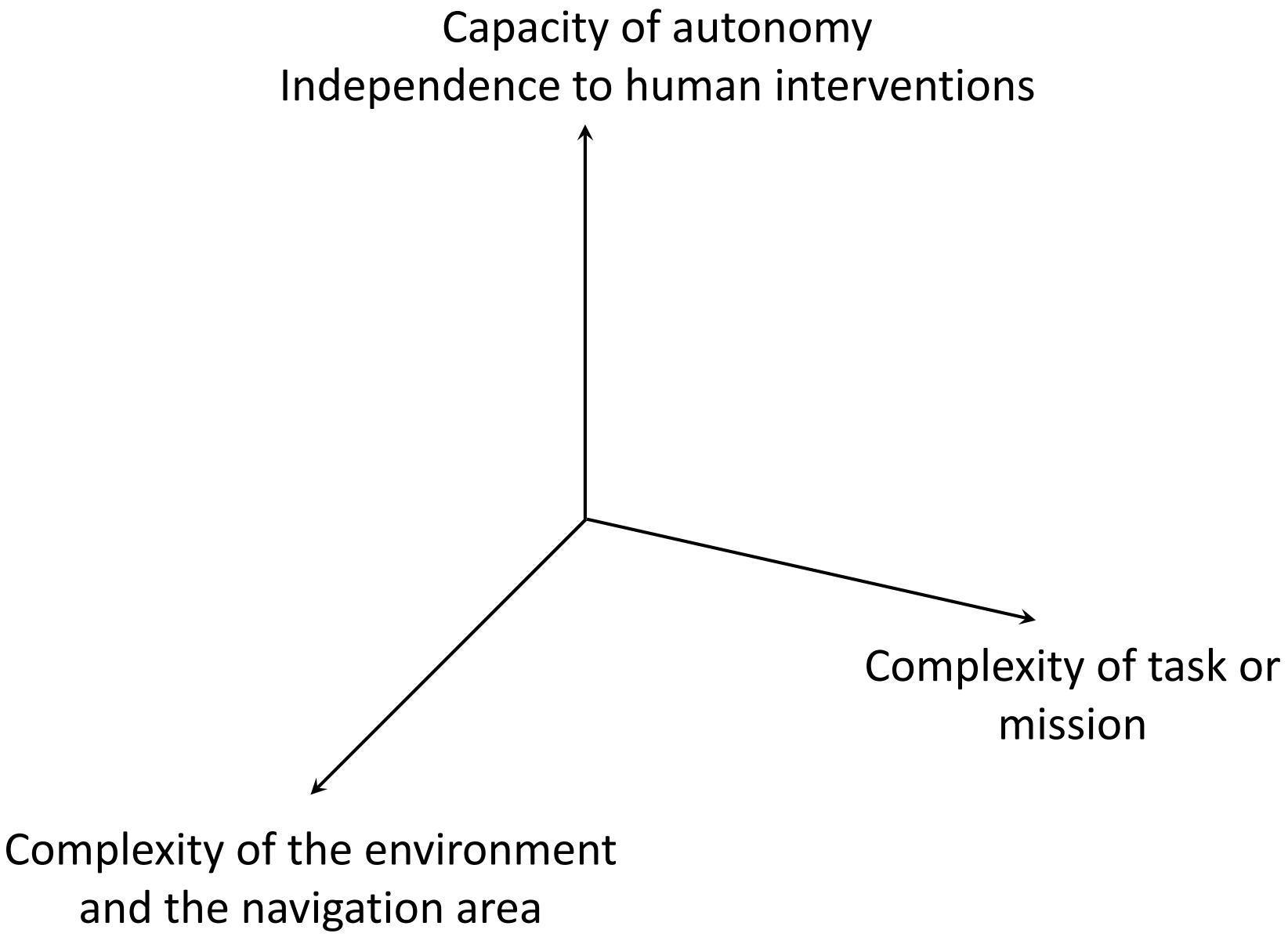
- 1985 beginning of Navlab project at Carnegie-Mellon University
- 1987-1996 European program Prometheus
- DARPA Challenges (2004, 2005) et 2007
- 2010 Intercontinental Autonomous Challenge from Parma to the Shanghai World Expo
- 2015 Delphi Drive from San Francisco to New York City
- Since 2009 Google Self-Driving Car
  - ✓ 2.5 million Km traveled
  - ✓ ~ 40 vehicles
  - ✓ 20 accidents

- 2016 Version 7.2 of the autopilote of the Tesla S

Field robotics

- Complex, open and dynamic environments
  - ✓ city, road, highway, day, night, in rainy weather, with fog, etc.
  - ✓ interactions with other road users
- Navigation areas
  - ✓ On public roads with rules established for human drivers
  - ✓ On dedicated roads closed to public traffic
- Technological tools still under construction and constantly evolving
  - ✓ Perception and localization sensors
  - ✓ Navigation maps
  - ✓ Sharing of information via means of communication
  - ✓ Embedded computing and information processing

Robotic Vision



Research progress

- Autonomous vehicle navigation
  - ✓ Multi-sensory perception: understanding and prediction of driving scene
  - ✓ Accurate location with integrity monitoring
  - ✓ Navigation Map
  - ✓ SLAM : learning and adaptation to environmental changes
  - ✓ Trajectory planning, decision-making, vehicle control
- Information sharing with infrastructure and other vehicles
  - ✓ Information gathering
  - ✓ Perception and cooperative decision with dynamic and local information
  - ✓ Sharing intentions with other actors
- Operational safety
  - ✓ Design and Validation Methodologies
  - ✓ Redundancy, diversification, self-diagnosis, robustness to external failures and disturbances, dynamic reconfiguration
  - ✓ Safety procedure
- Interaction and cooperation with driver or operator
  - ✓ Human-vehicle interface
  - ✓ Takeover of the vehicle

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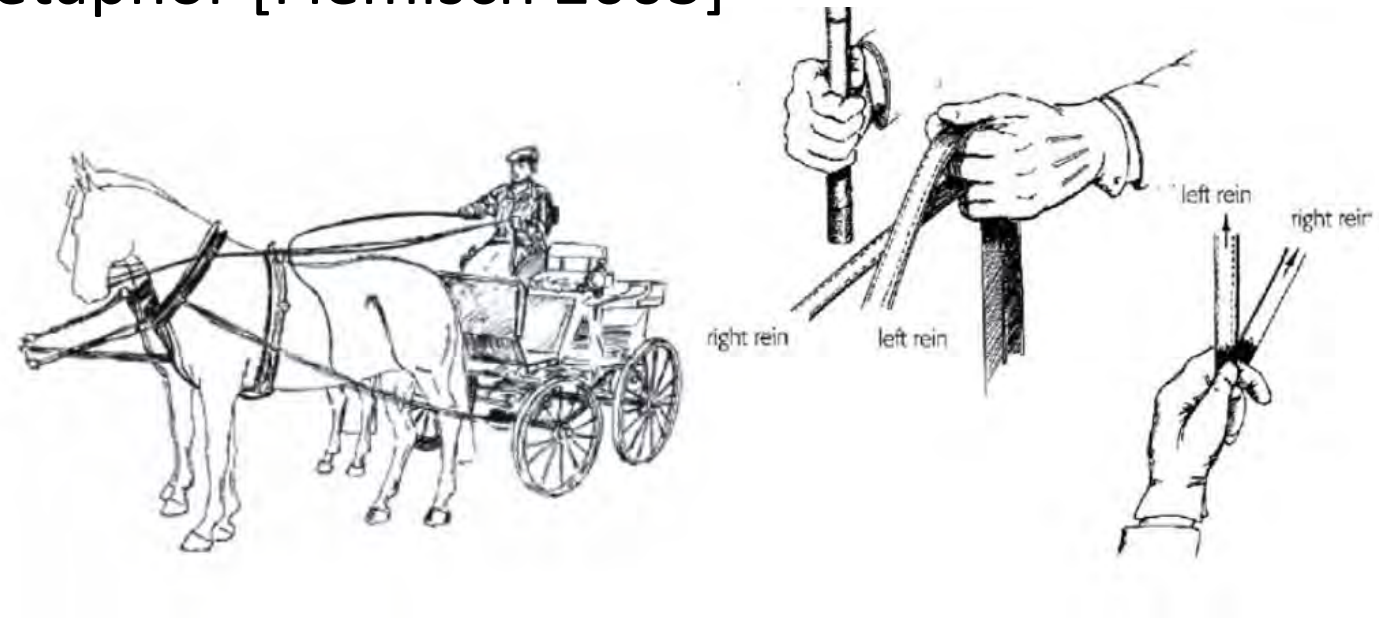
Autonomous Vehicle Partner of the driver

Horse metaphor [Flemisch 2003]

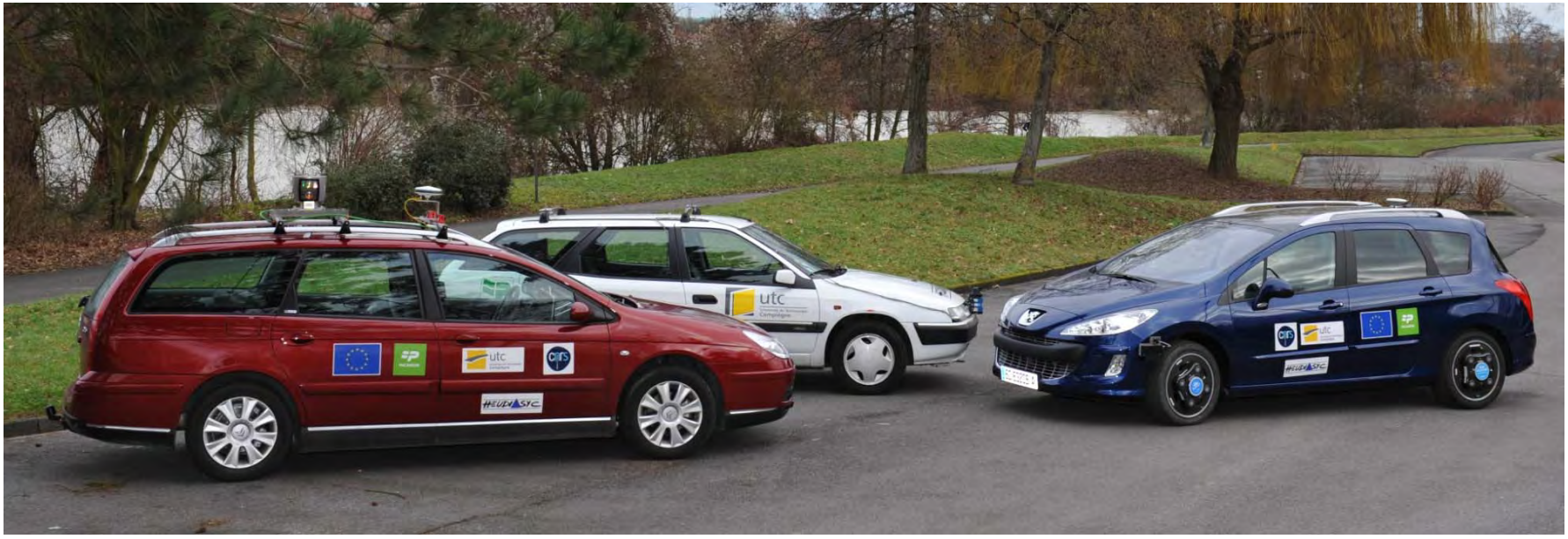


There must be a partnership relationship between the vehicle and the human

- ✓ Since the vehicle does not know how to navigate autonomously in all conditions, it must be helped by the human
- ✓ The human partner has a superior hierarchical position and must retain control of the vehicle

Intelligent vehicles R&D in Heudiasyc

- First European project in 1991 (Prometheus)
  Since then: regular collaborations and projects with National and European laboratories.
  Several test-bed vehicles to demonstrate the algorithms.
- 2011 Equipex Robotex
- 2017 Sivalab shared laboratory Renault/Heudiasyc



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An Intelligent vehicle

- *Observes the environment and the driver behaviour*
- *Monitors itself*
- *Controls itself autonomously*
- *Informs the driver*
- *Cooperates with other vehicles*

Experimental vehicles at Heudiasyc

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Cooperative systems for autonomous cars. The Grand Cooperative Driving Challenge

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Grand Cooperative Driving Challenges

- GCDC 2011
  - ✓ A270 highway between Helmond and Eindhoven.
  - ✓ Cooperative platooning (sensor based-control with speed and acceleration exchange)
  - ✓ 9 teams (with cars and trucks)

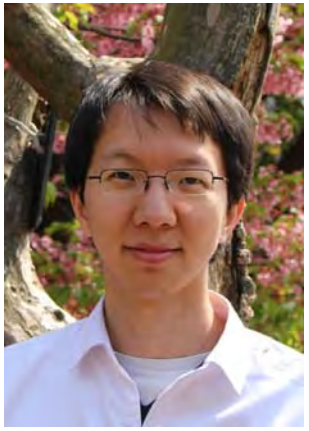
- GCDC 2016
  - ✓ Same place
  - ✓ May 28-29, 2016
  - ✓ Autonomous driving with interactions with vehicles and infrastructure
  - ✓ Three different traffic scenarios
  - ✓ 10 European teams.

Teams signed up for the GCDC 2016

- Universidad de Alcalá, Spain
  - ✓ UAH
- Chalmers University of Technology, Sweden
  - ✓ Car team
  - ✓ Truck team
- KTH Stockholm, Sweden
  - ✓ Experimental Car
  - ✓ Truck team
- University of Latvia / Institute of Electronics, Latvia
  - ✓ EDI
- KIT Karlsruhe, Germany
  - ✓ KIT
- Halmstad University, Sweden
  - ✓ Halmstad
- Eindhoven (Fontys and TU/e), The Netherlands
  - ✓ A-Team
- Université de technologie de Compiègne, France
  - ✓ Heudiasyc laboratory

Heudiasyc team

- Team Leader: Philippe XU



- First participation

- People involved
  - ✓ 5 Profs and Researchers
  - ✓ 3 Engineers
  - ✓ 2 Phd students
  - ✓ 2 interns
  - ✓ 12 Master students

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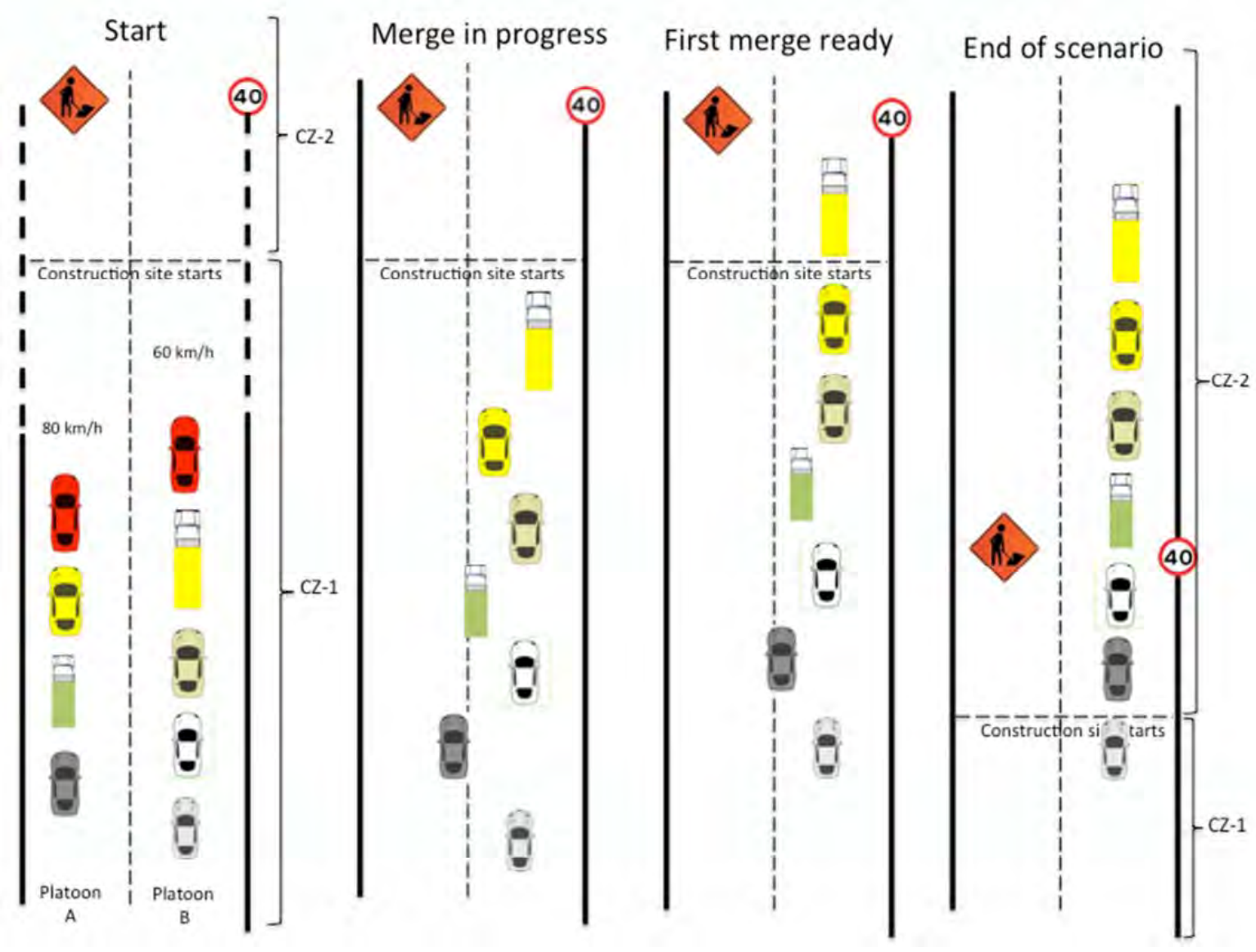
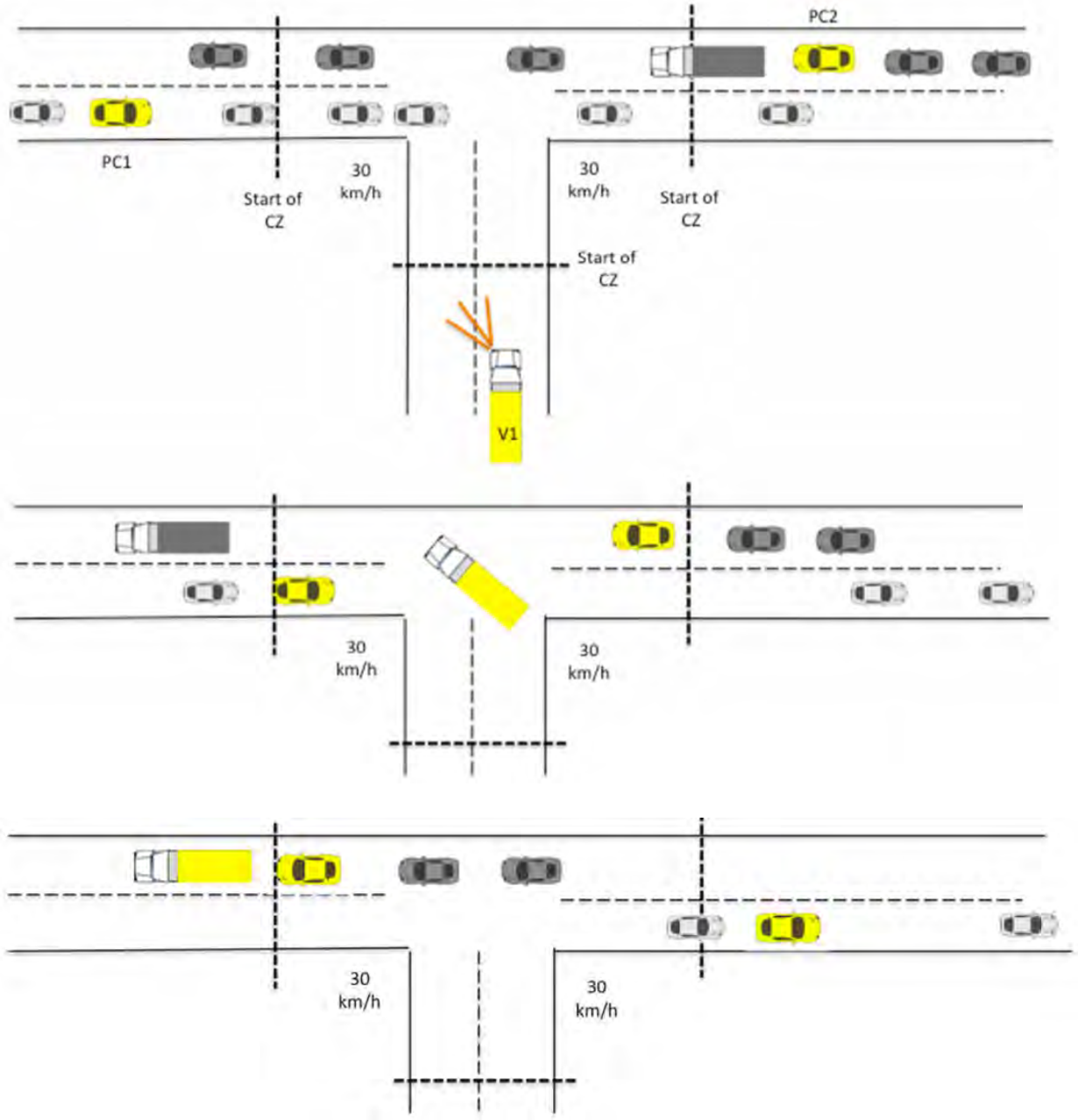
Communication

- Wireless communication on ETSI C-ITS standards
  - ✓ Cooperative-Intelligent Transport System
- Wifi mode, 5.9 GHz band (802.11p)
  - ✓ both Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications.
  - ✓ Implementation: ETSI ITS-G5 standard (GeoNetworking protocol and Basic Transport Protocol)
- Messages
  - ✓ CAM (Cooperative Awareness Message)
  - ✓ DENM (Distributed Environment Notification Message)
  - ✓ iCLCM (i-GAME Cooperative Lane Change Message) (non standard)

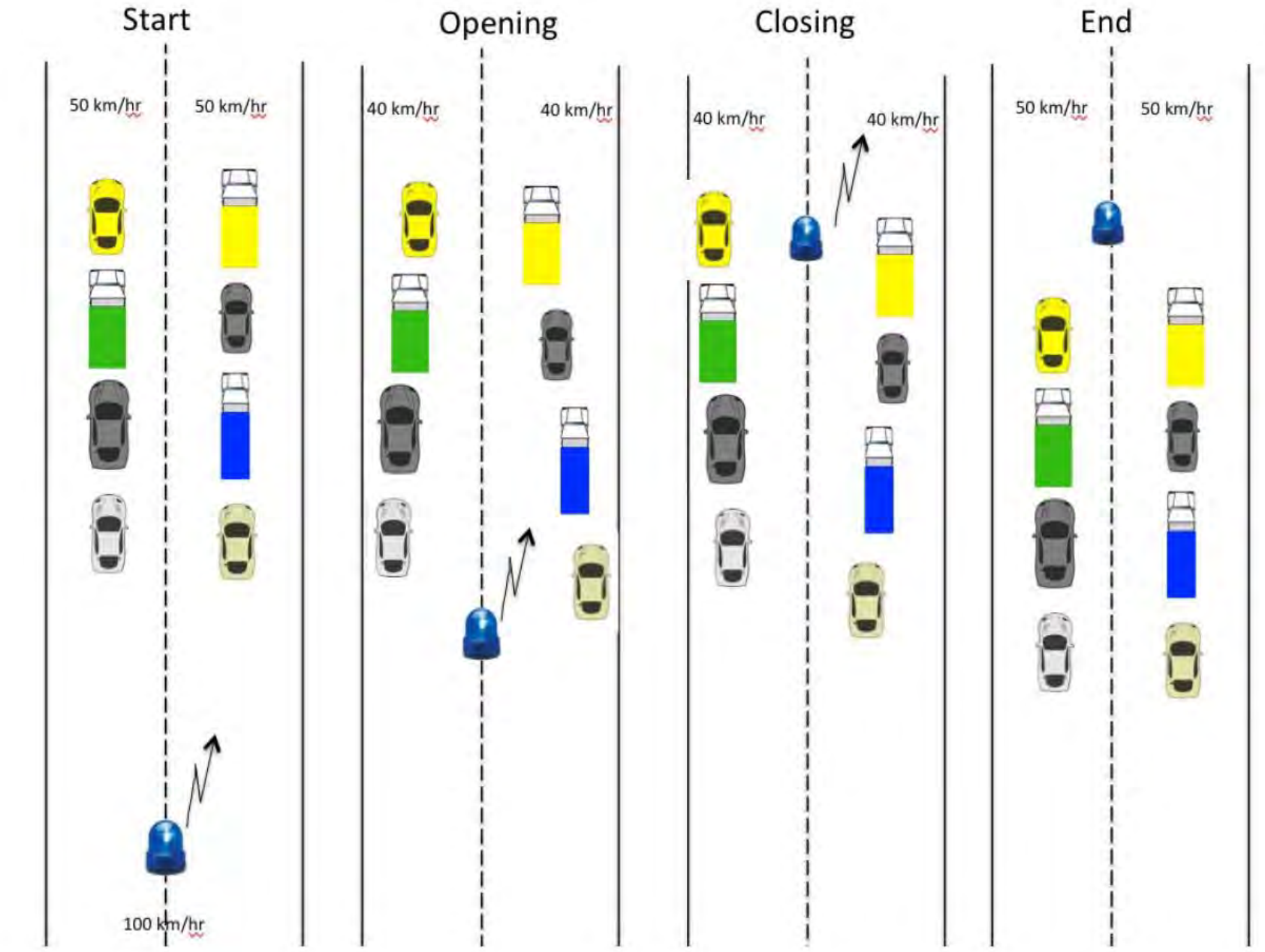
Scenario 1: cooperation on highway (merging)



Scenario 2: cooperative intersection (crossing)

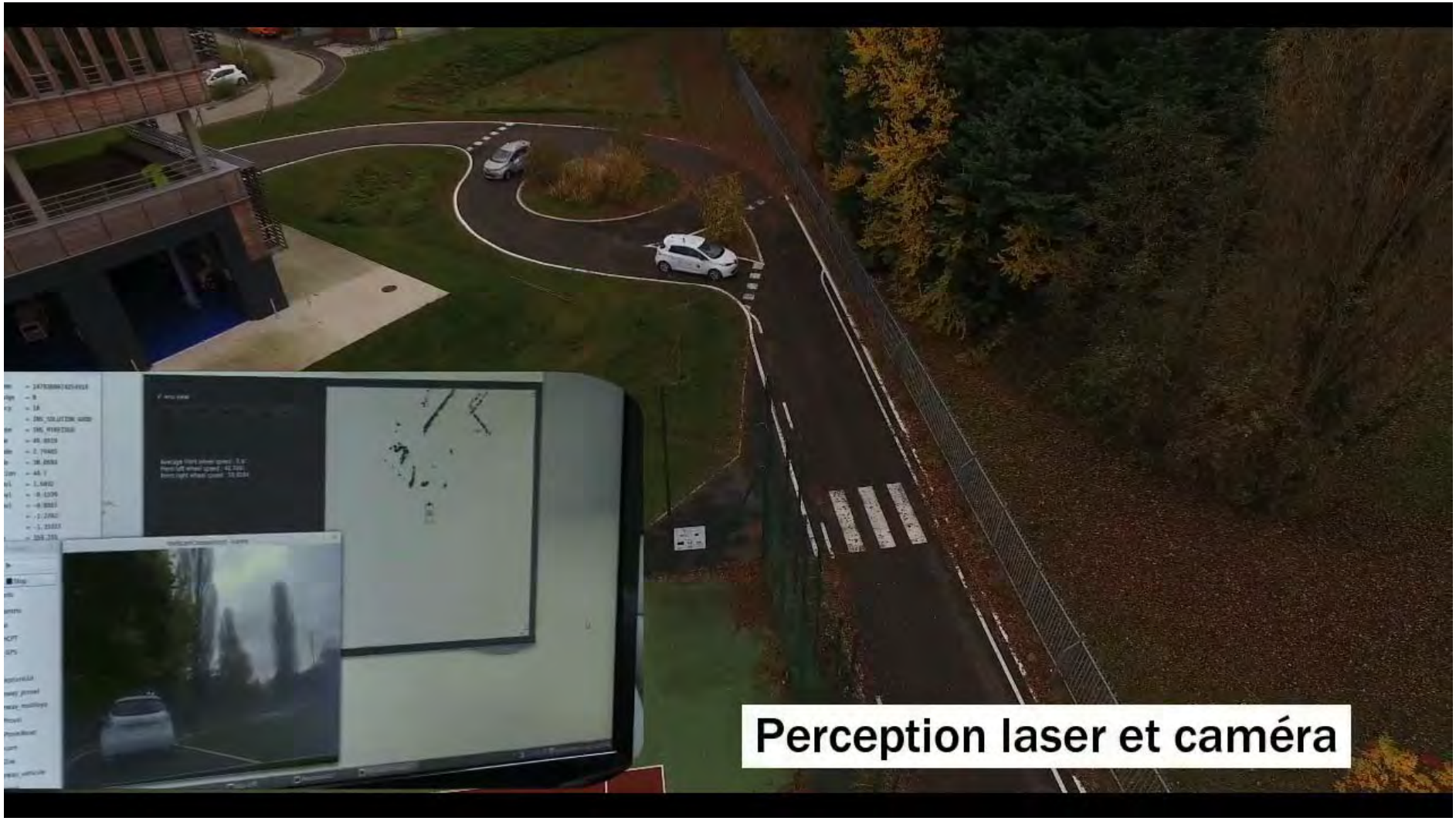


Scenario 3 : emergency vehicle



Snapshot of the GCDC 2016 (May 28-29)

Cooperative vehicles experiments at Compiègne



Thank you for your attention!

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