IMARA

Informatique, Mathématiques et Automatique pour la Route Automatisée

IMARA

- Project-Team – INRIA Rocquencourt
- ~32 persons + trainees (10/year)
- Research field : Intelligent Transportation Systems
  - Mobility
  - Security
- Topics :
  - Traffic simulation and modeling
  - Communications: V2V – V2I
  - Robotics: perception, planning, control,…

IMARA

- Outstanding team at l'INRIA :
  - Size
  - Profile:
    - ☞ Research lab.
    - ☞ Experimental Plateform
  - Transverse team (collaboration with 8 teams) : 'showcase' pour l'INRIA
  - Financed research activity (today: ~20 contracts)
  - Strong involvment in European projects
- Member of the LaRA consortium: INRIA – MINES PARISTECH – IFSTTAR

IMARA Personnel

- Permanent staff : 5 people
  - Chazelas (ITA) - Fayolle (DR1 – Emeritus) - Lasgouttes (CR1)
  - Le Lann (DR1 – Emeritus) - Yvet (ITA)
- Specialists (Expert Eng.): 15
- Invited professors: 2 (Petrov – Alessandrini)
- Post Doc : 3 (Samsonov – Zhang - Nogushi)
- PhD Students : 8
- External collaborators / advisors : 4 (Parent – Ernst – Noël – Bouraoui)
- Trainees : 10
- « Vacations » : 6

☞ ~53 people in 2011

IMARA Personnel

- Permanent staff
  - Nashashibi (Team Leader)
  - Chazelas (ITA)
  - Lasgouttes (CR1)
  - Yvet (ITA)
  - Fayolle (DR1) – Emeritus
  - Le Lann (DR1) – Emeritus
- Specialists
  - Parent
  - Fortelle
  - Bouraoui
  - Ernst
  - Boussard
  - Resende - Xie
  - Charlot - Lee
  - Feng - Sandu
  - Nicoud - Holgin
  - Lewden - Noël
- Doctors/Postdocs
  - Lefaudeux - Ben Jemaa
  - Mehani - Tsukada
  - Li - Nogushi
  - Martin - Maarouf
- Invited Professors
  - Petrov
  - Alessandrini

La Route Automatisée

- Set of techniques designed to :
  - Improve road transportation
  - Achieve sustainable mobility for people and goods
  - New transportation modes and concepts
- Based on ICST and concerns infrastructures as well as vehicles
- Ranges from driver information, to drivers assistance, to full driving automation

CyCab (1996)

- Small Public Urban Vehicles
- Assisted driving
- Platooning
- Automated Parking
- Automated tracks
- Complement to other modes

CyberCab Yamaha-INRIA (2000)

CYBERGO (INDUCT – 2010)

CYBUS (INRIA – 2011)

LaRA fleet

(ROBOSOFT – 2010)

IMARA Research Themes

- Driving assistance and automation
  - Sensors and Data Fusion
  - Task & trajectory planning
  - Vehicle control (low/high levels)
  - MMI
  - Cooperative behavior
- Modeling and control of transport systems
  - Stochastic models
  - Operation research on logistics
  - Simulation tools
- Communication technologies for mobiles
  - IPv6 deployment
  - Geonetworking
  - Standardization

- **In 2011 ⇨ <u>21</u> living projects !**
- <u>Projects financing :</u>

  EU : 9 / Fench: 11 / Private sector : 1

  <u>Distribution by main area (or « team ») :</u>

MOD : 5

AROS / TRAVESTI / Ma Micro Planete / CATS* / PUMAS

COM : 5

Orange / SANDRA / SCORE@F / Drive-C2X * / ITSSv6 *

ROB : 11

HAVEit * / Intersafe-2 * / CityMobil * / CityNetMobil * /
ABV / PICAV * / AMARE / Co-Drive / Corebots / Merit

Contracts IMARA (2004-2011)

- Com2React (ICT)
- CyberCars-2 (IST)
- PReVENT (IST)
- LOVe (Predit)
- Anemone (IST)
- Cristal (FUI)
- Esteem (SST)
- GAST (DG Edu)
- CVIS (IST)
- GeoNet (ICT)
- CityMobil (EESD)
- CATS (ICT)
- HaveIT (ICT)
- CityNetMobil (SST)
- PICAV (ICT)
- InterSafe-2 (ICT)
- ABV (Predit)
- AMARE (Predit)
- …

IMARA Software (2004-2011)

- TAXI (real-time control)
- CyberMaps (RT-Maps software suite)
- CyberFly (Genetic algo. for vision)
- CyberSim (3D Simulation for Robots)
- SPIKA (Traffic reconstruction)
- CyberCom (Fast Mobile Comm.)
- CarGeo6 (IPv6 + Geonetworking)

Technology Transfer

- Know-how transfered to VU-Log
- Know-how and software transfered to Senda
- Know-how transfered to Intempora
- Know-how transfered to Robosoft
- Patent in negociation with Lohr Industries (Cristal Project)
- IPv6 GeoNetworking transfered to Orange

Cooperation inside INRIA

- Active cooperation with/-out financed R&D projects:

E-Motion
Hipercom

Aoste
TAO

National Cooperations

- Laboratories:
  - LaRA (Mines-Paris, INRETS, LCPC)
  - LASMEA (Clermont)
  - LITIS (Rouen)
  - UTC
  - UTBM
  - CERMICS
  - ENST Bretagne (Telecom Bretagne)
    - Institut Telecom

- Private sector:
  - **VALEO**
  - **PSA**
  - Intempora
  - Mobile Devices
  - Civitec
  - Robosoft
  - Mobile Devices
  - ADM Concept
  - …

European Cooperations

- DLR, Braunschweig
- Dimeca, Genova
- Imperial College, GB
- EPFL, CH
- ISR, Coimbra
- IKA Aachen
- ICT La Sapienza, Rome
- IAI Madrid
- FZI Stuttgart
- TRG, Southampton
- Newcastle Univ., GB
- Eurandom, Eindhoven, NL
- ...

World Cooperations

- SwRI (USA)
- UCR (USA)
- Tokyo U., NAIST, Keio U. (Japan)
- SJTU (China)
- NTU (Singapore)
- Griffith U., NICTA (Australia)
- Moscou Univ., IPPI (Russia)
- Colombia U., Berkeley (USA)
- Yeungnam / SL / ETRI (Korea)
- U. Montreal (Canada)

Activities / Objectives scientific

2008 - 2012

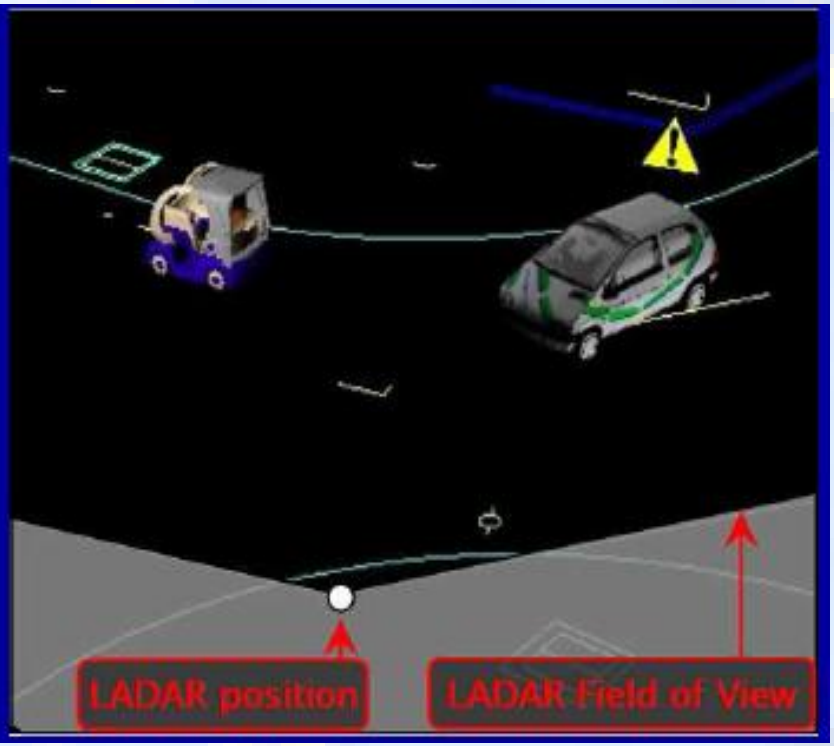
Topics

- Robotics vehicles:
  - ADAS for safe navigation
  - Complex and fast manoeuvres
  - Cooperative systems
- Modeling
  - Advances in modelling of very large random systems: hydrodynamic limits, phase transition, statistical physics models.
- Communications
  - Fast, robust and safe V2V / V2I communications

Vehicle Cooperation

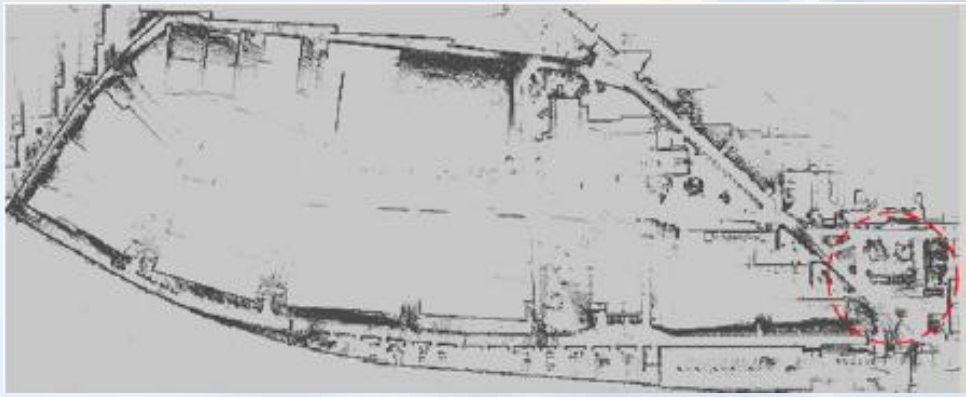
- V2V and V2I Communications
- Passing stopped vehicles
- Overtaking slow vehicles
- Trains of cars
- Merging and splitting
- Crossings, round-abouts

Extended Sensing



Hierarchical multiresolution probabilistic SLAM

INRIA Rocquencourt: a bird view



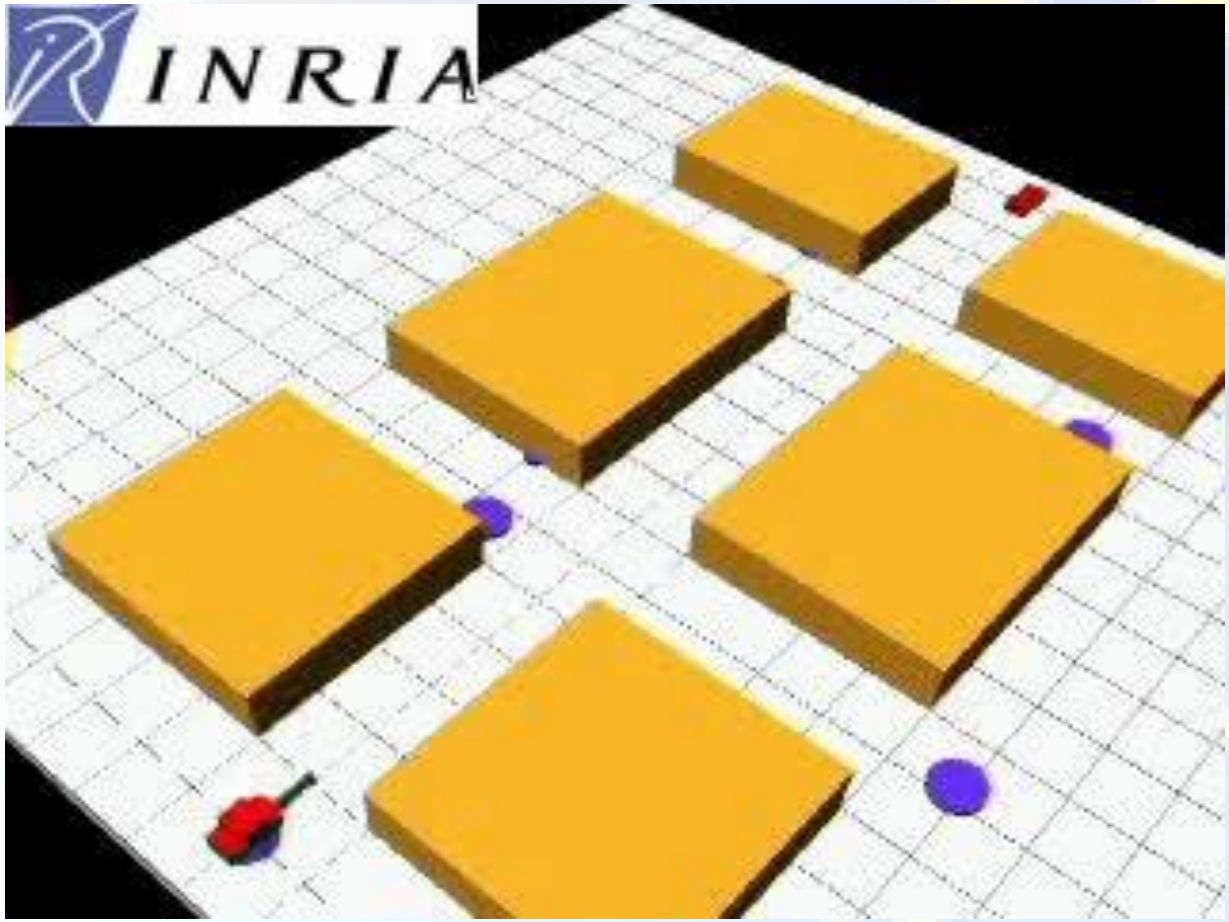
Results with the multi-resolution probabilistic SLAM

- « Loop closure »
- Centimetric accuracy
- Real time
- Intagrated on our AGV

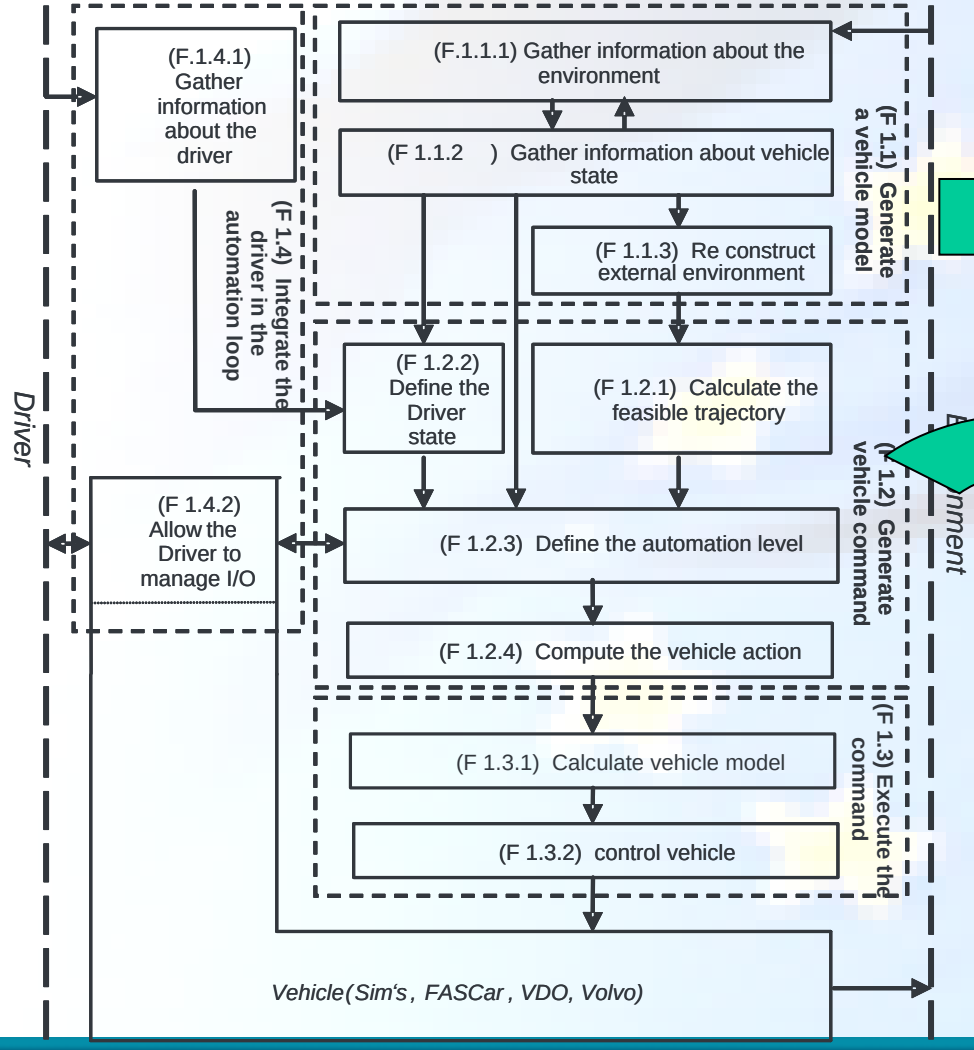
DEMO


Pedestrian:-2.230,10.956
Pedestrian:0.1693,8.4018

Slammot + PMP



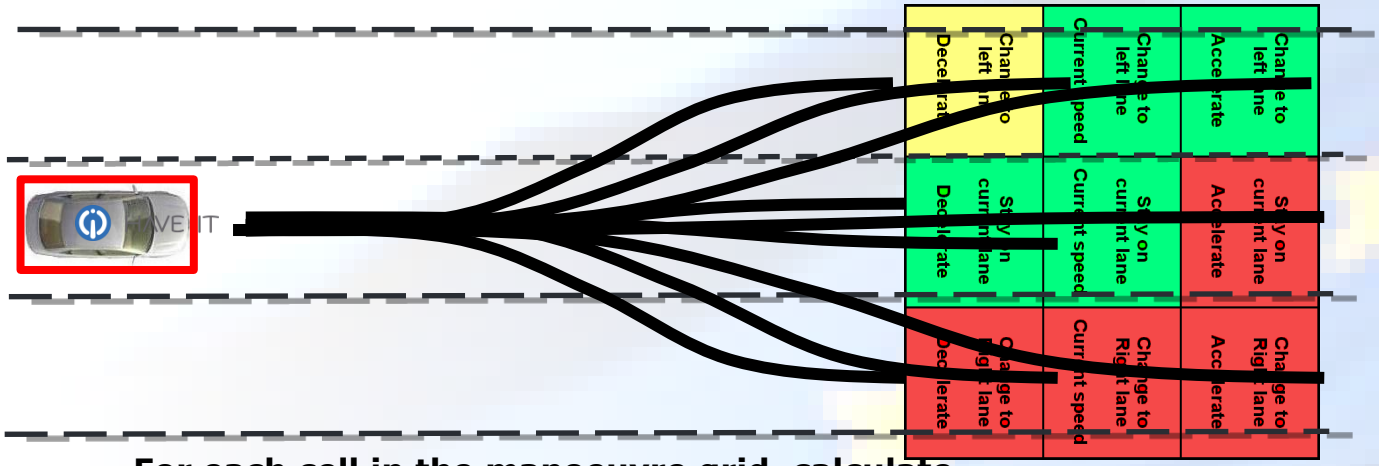
Path planning & Control : HAVEit use case



Datasensor Fusion

Selection of the best manoeuvres

Calculate the refined trajectories

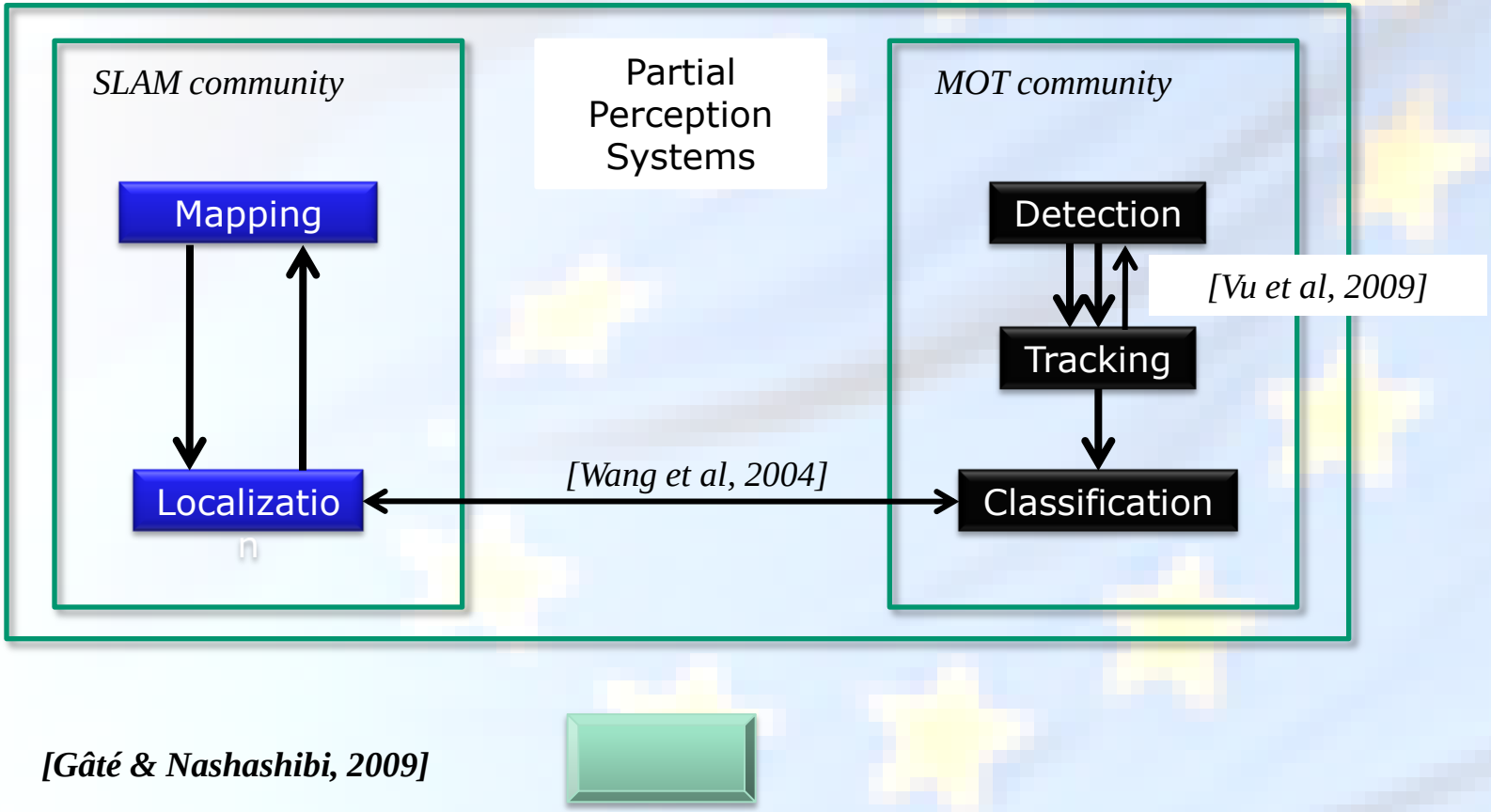


- **For each cell in the manoeuvre grid, calculate different costs:**
  - 1. RISK COST = GravityOfCollision x ProbabilityOfCollision
  - 2. SPEED COST = DistanceAtLegalSpeedLimit – RealDistance
  - 3. COMFORT COST = Sum of X and Y jerks during trajectory
  - 4. CONSUMPTION COST = Combination of X accelerations and speed
  - 5. OFFENCE COST = Penalties for right overtaking, excessive speed
  - 6. WISH COST = Cost of not following driver wishes: e.g. indicators, …

TOTAL COST = Weighted sum of all PARTIAL COSTS

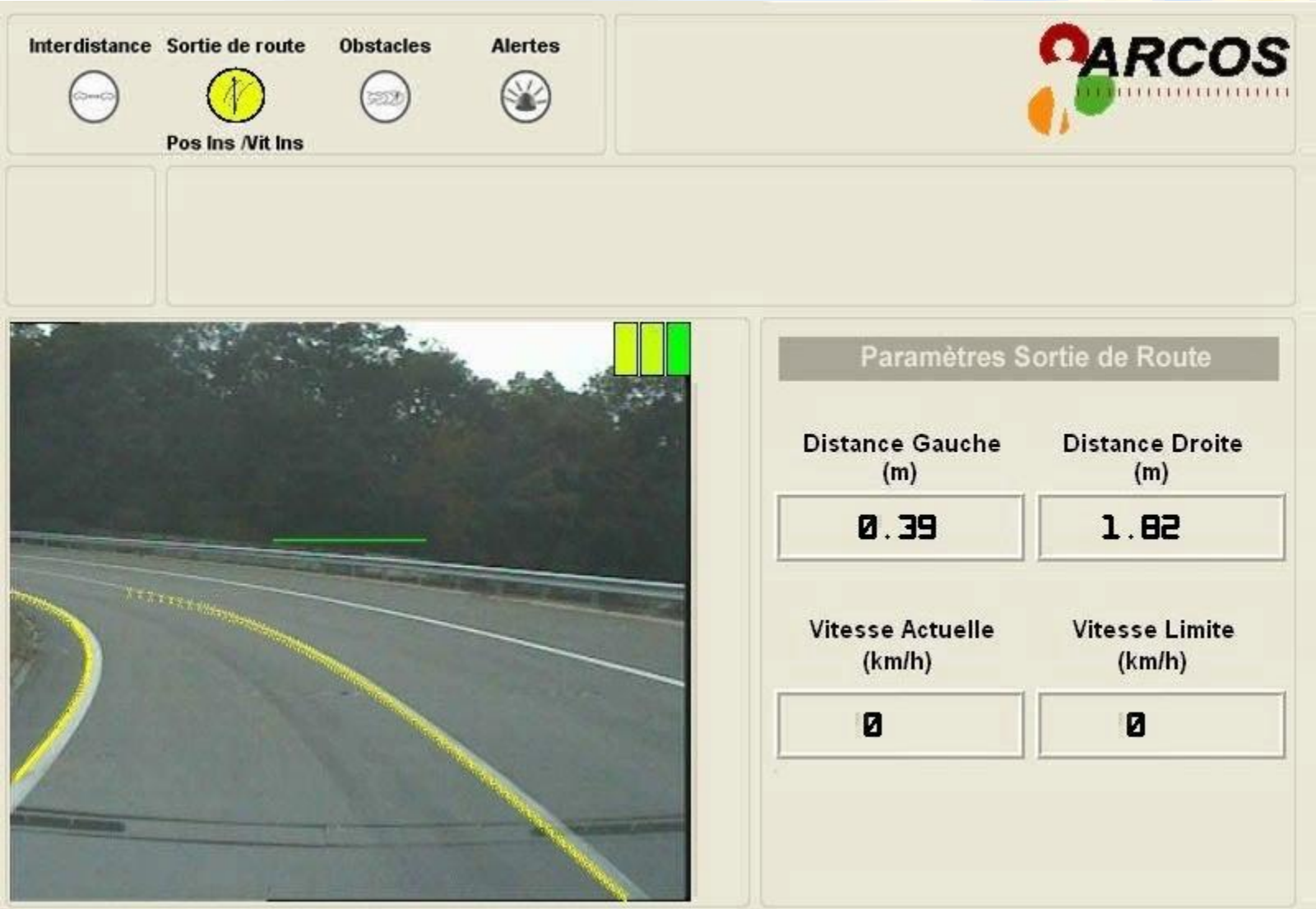
☞ **Output : the ranking of the manoeuvres**

Pedestrian detection: fusion of camera and laser scanner

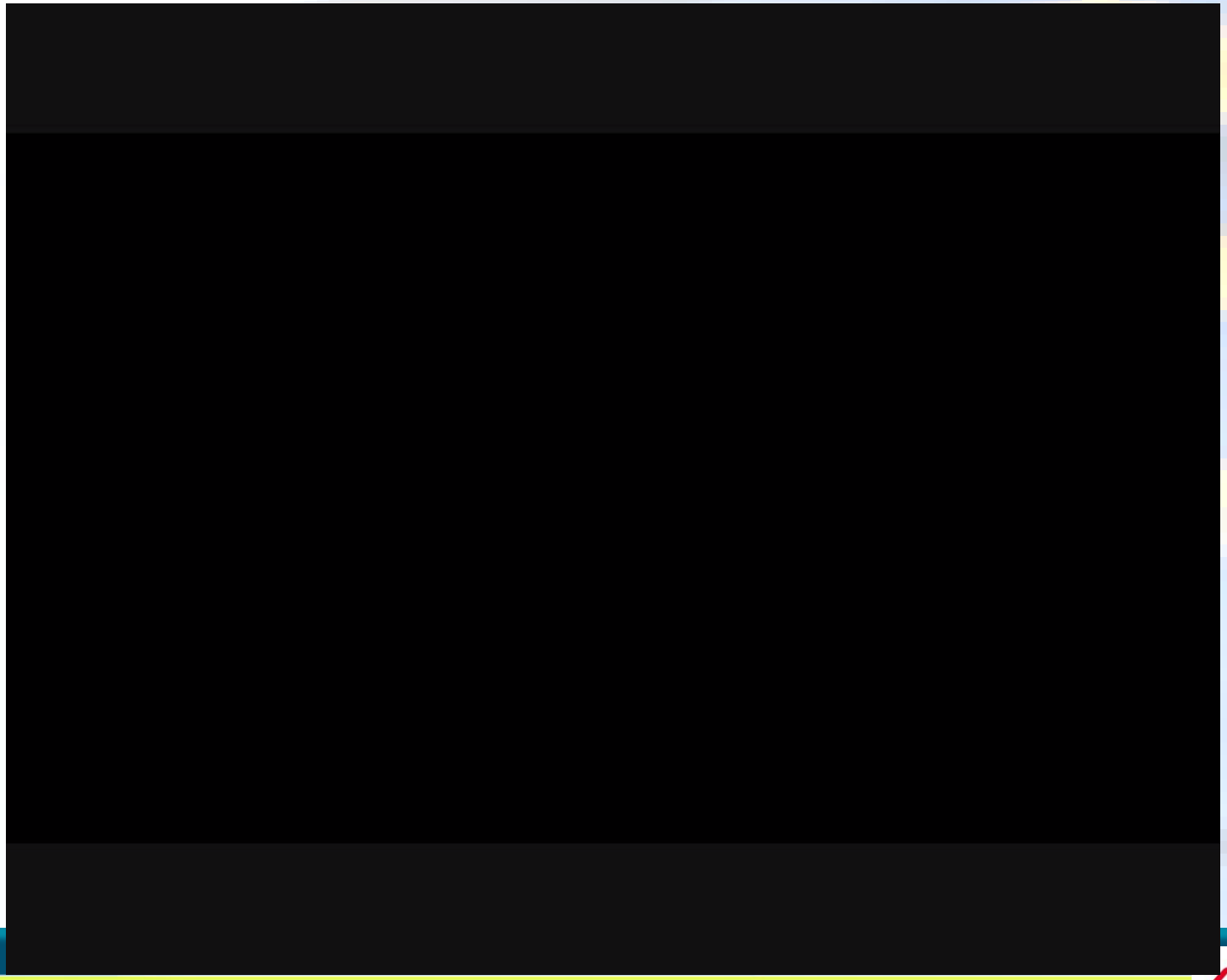


[Gâté & Nashashibi, 2009]

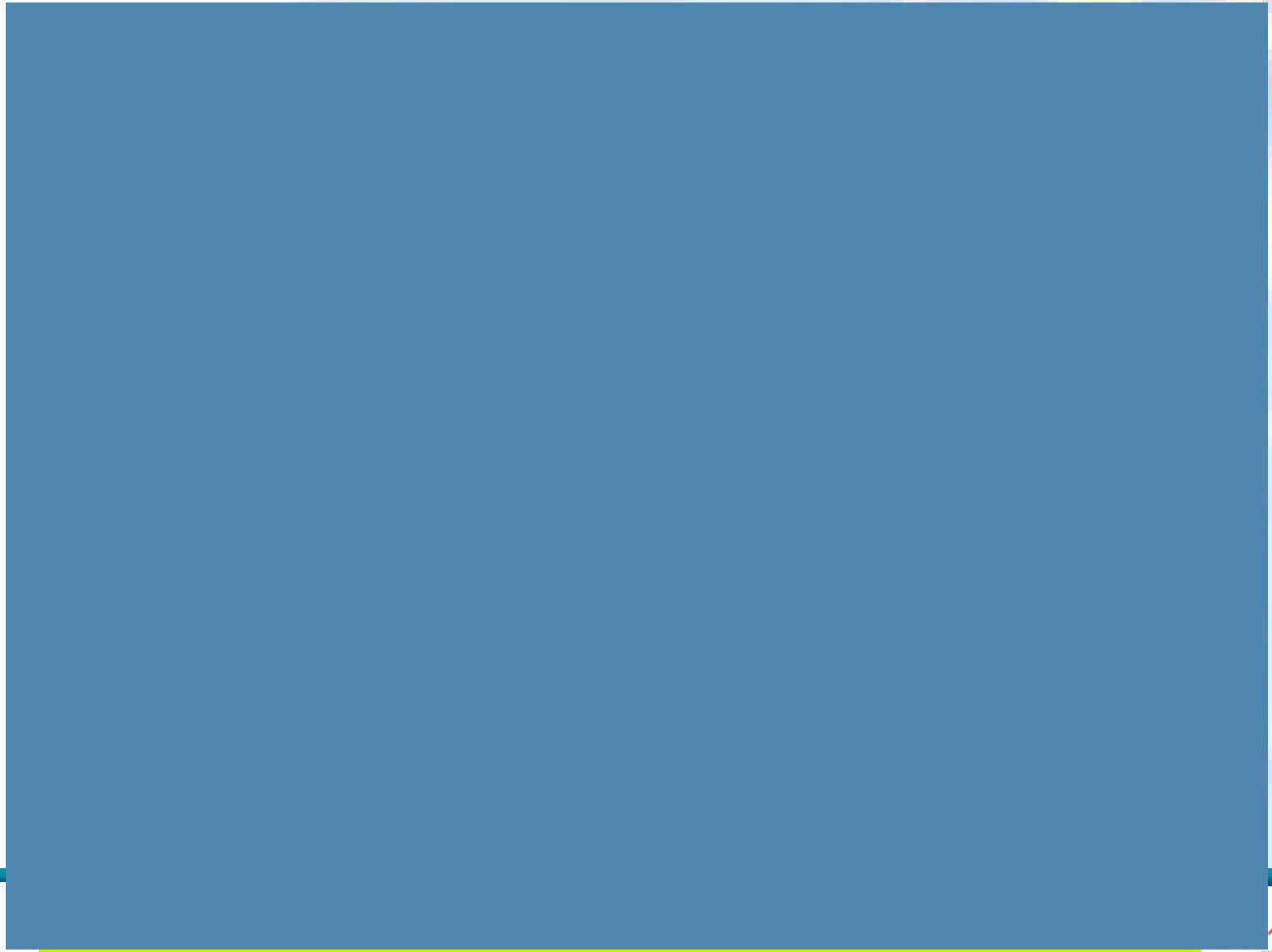
Vision-based lane markings detection: LDWS



Vision-based Platooning



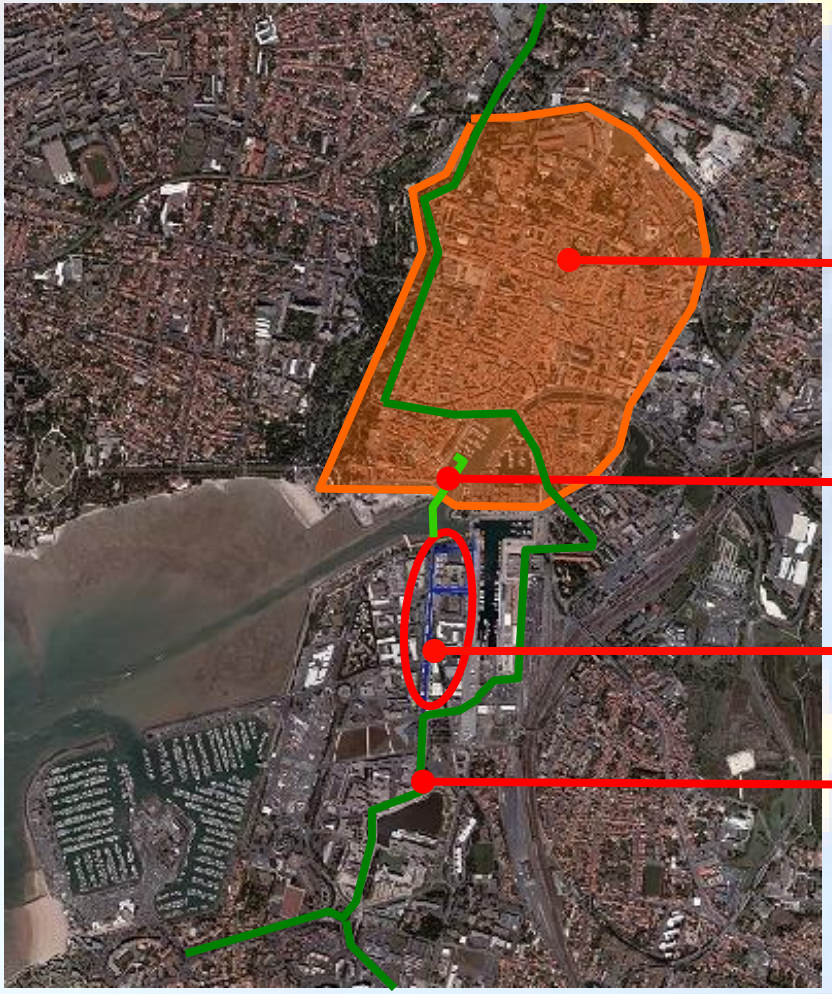
GPS and perception-based autonomous navigation



La Rochelle demonstration

- 2-3 INRIA's CyBus (Yamaha)
- 1 INRIA CyberGo (INDUCT)
- On-demand service as an "horizontal elevator"
- Speed limited to 10 Km/h
- An operator is always on-board
- Demonstration expected to run between April and July 2011

La Rochelle: site



La Rochelle: site

INRIA's CyBus vehicles

Capacity: 5 pax

Max. speed: 18 Km/h

Mass: 500 Kg

Front & rear LIDARs

Ultrasounds

Guidance: LIDAR-based SLAM

DEMO

INRIA's CyberGo vehicle

Capacity: 8 pax

Speed: 30 Km/h

Mass: 700 Kg

Sensors :

4 LIDARs guidance

US

Camera(s)

AMARE

AMARE

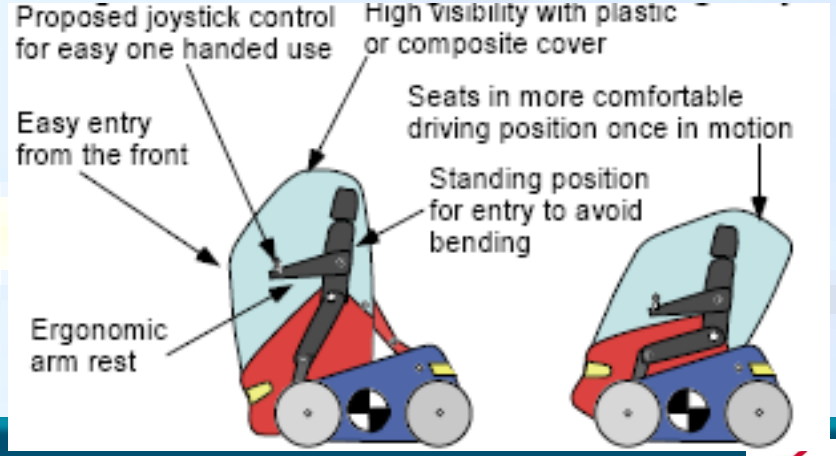
AMARE – the concept

AMARE

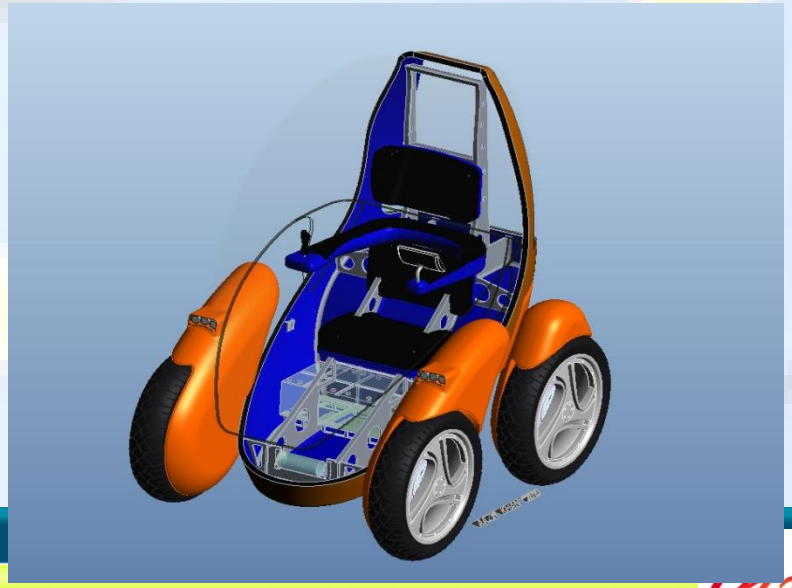
PICAV

Personal Intelligent City Accessible Vehicle System

- Funded under 7th FWP (Seventh Framework Programme)
- New mobility concept for passengers ensuring accessibility for all in urban pedestrian environments.
- The transport system will ensure accessibility for everybody and some of its features are specifically designed for people whose mobility is restricted for different reasons, particularly (but not only) elderly and disabled people.
- Ergonomics, comfort, stability, assisted driving, eco-sustainability, parking and mobility dexterity as well as vehicle/infrastructures intelligent networking are the main drivers of PICAV design.



PICAV



New driving interfaces

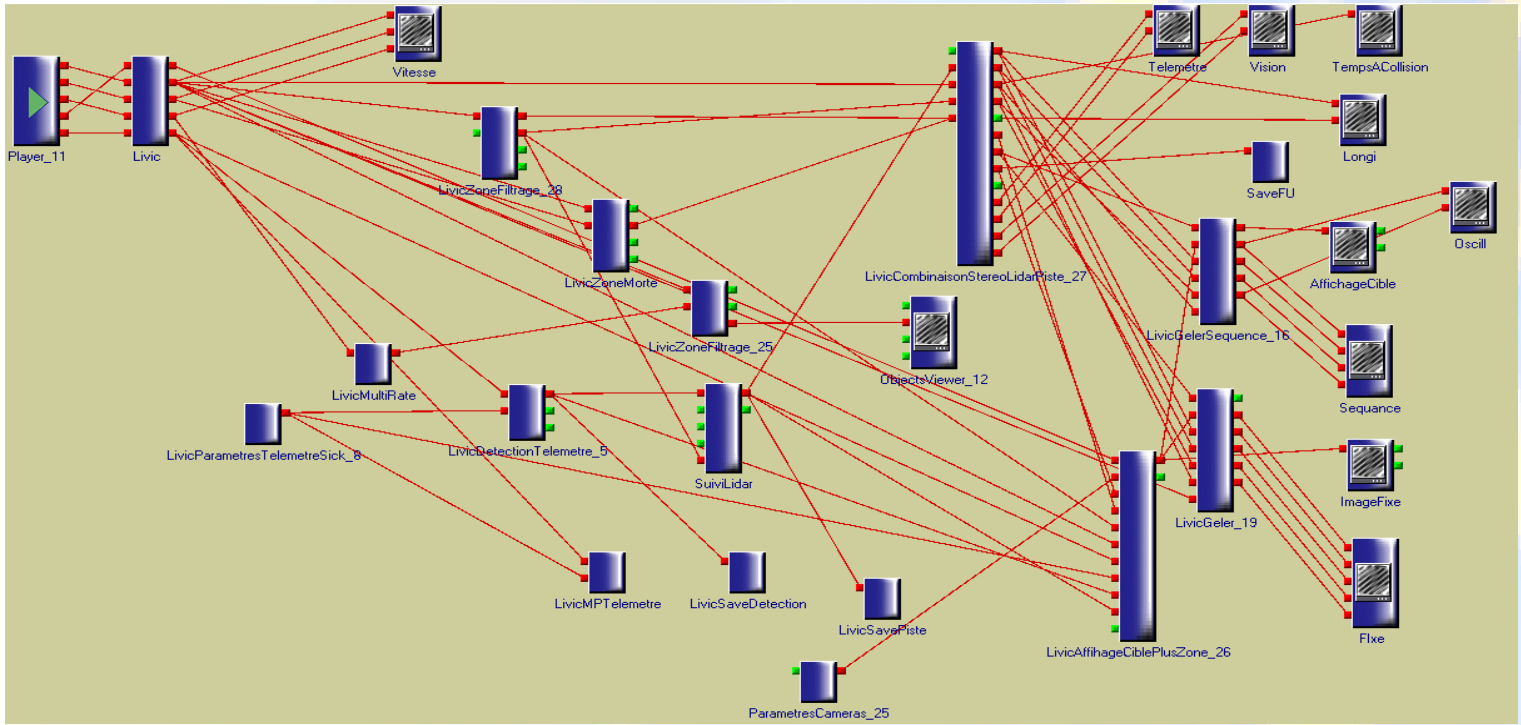
- New interfaces & sensors
- New driving modes

Scroll Driving-1

Scroll Driving-2

1. Presentation of our platform SiVIC/RTMaps
2. Single-Track Platooning
3. Optimal Automatic Parking
4. Innovative HMI

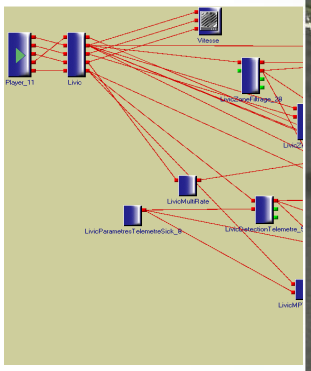
RTMaps: Real Time Multi Applications

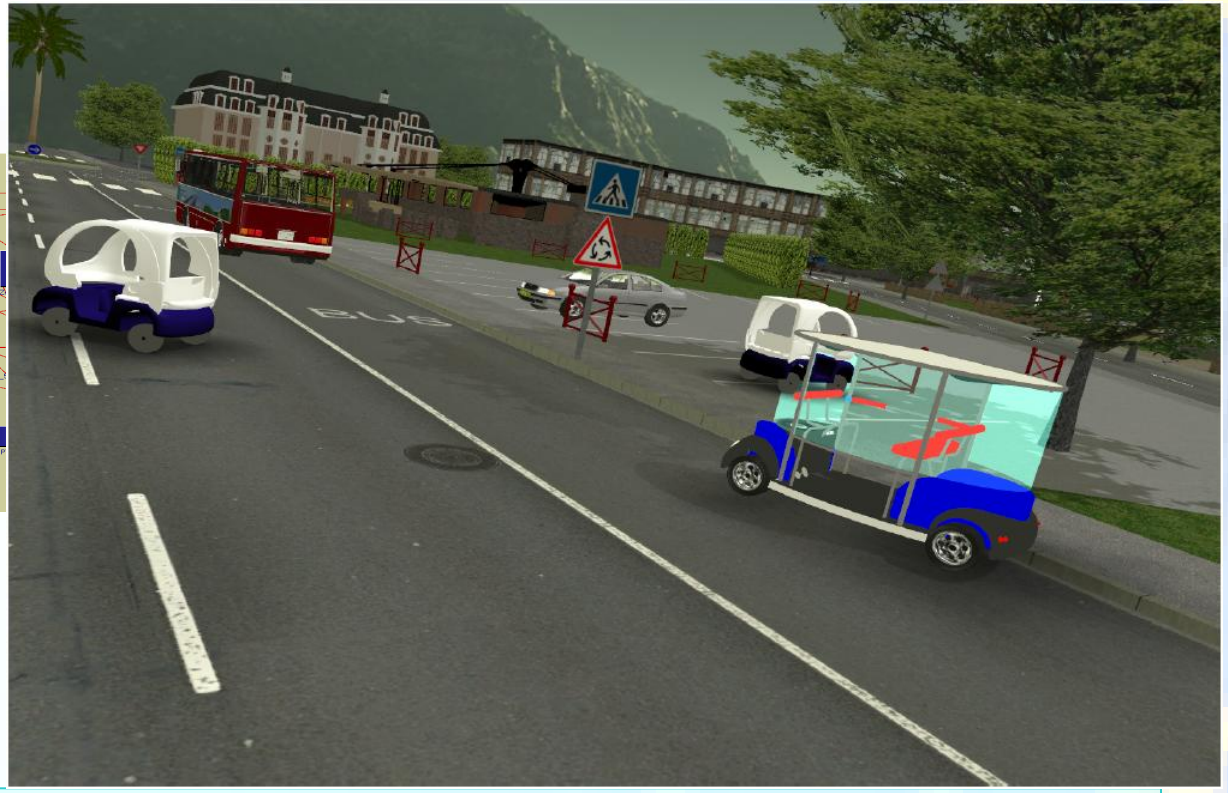


- Synchronized Vehicle sensor data
- Real-time data processing

[Steux, 2002]

SiVIC: Vehicle-Infrastructure-Sensors simulator



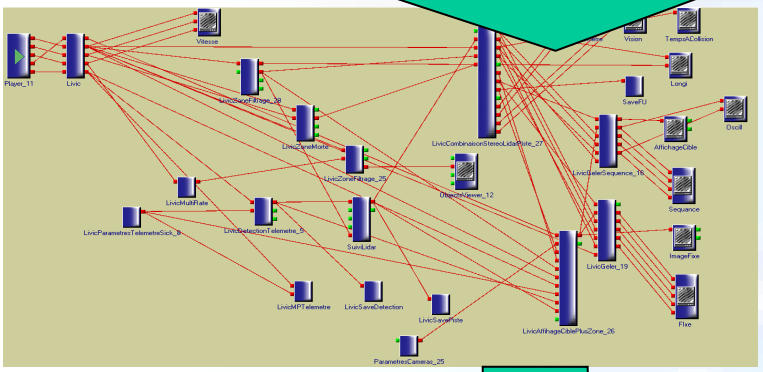


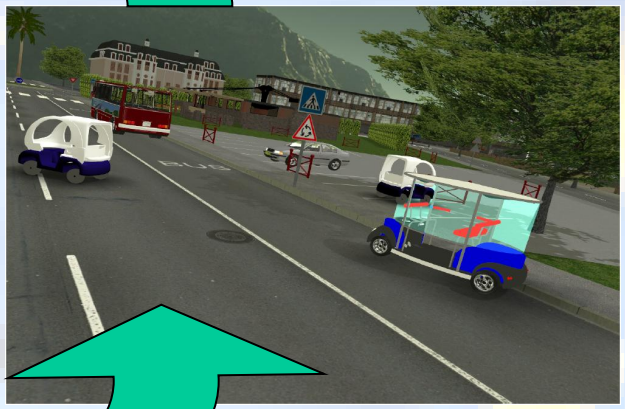
- Vehicle-Infrastructure-Sensors Simulator
- Dynamic Vehicle model
- Camera, odometers, IMU simulations

[Gruyer, 2005]

SiVIC / RTMaps

Sensors data

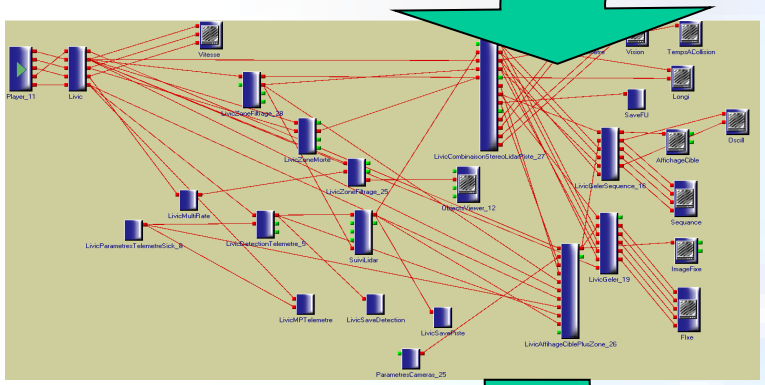




Actuator control

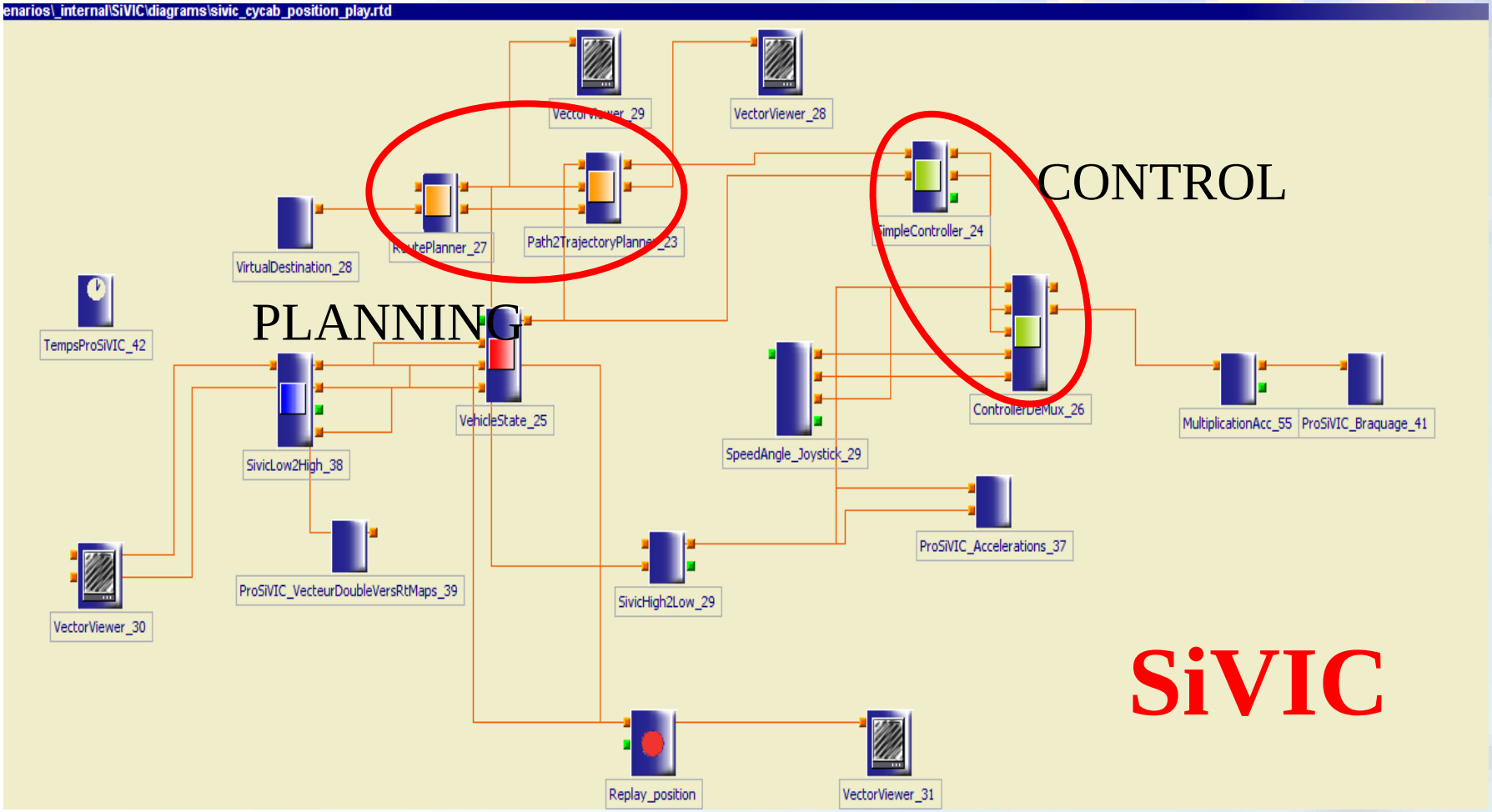
Cycab / RTMaps

Sensors data

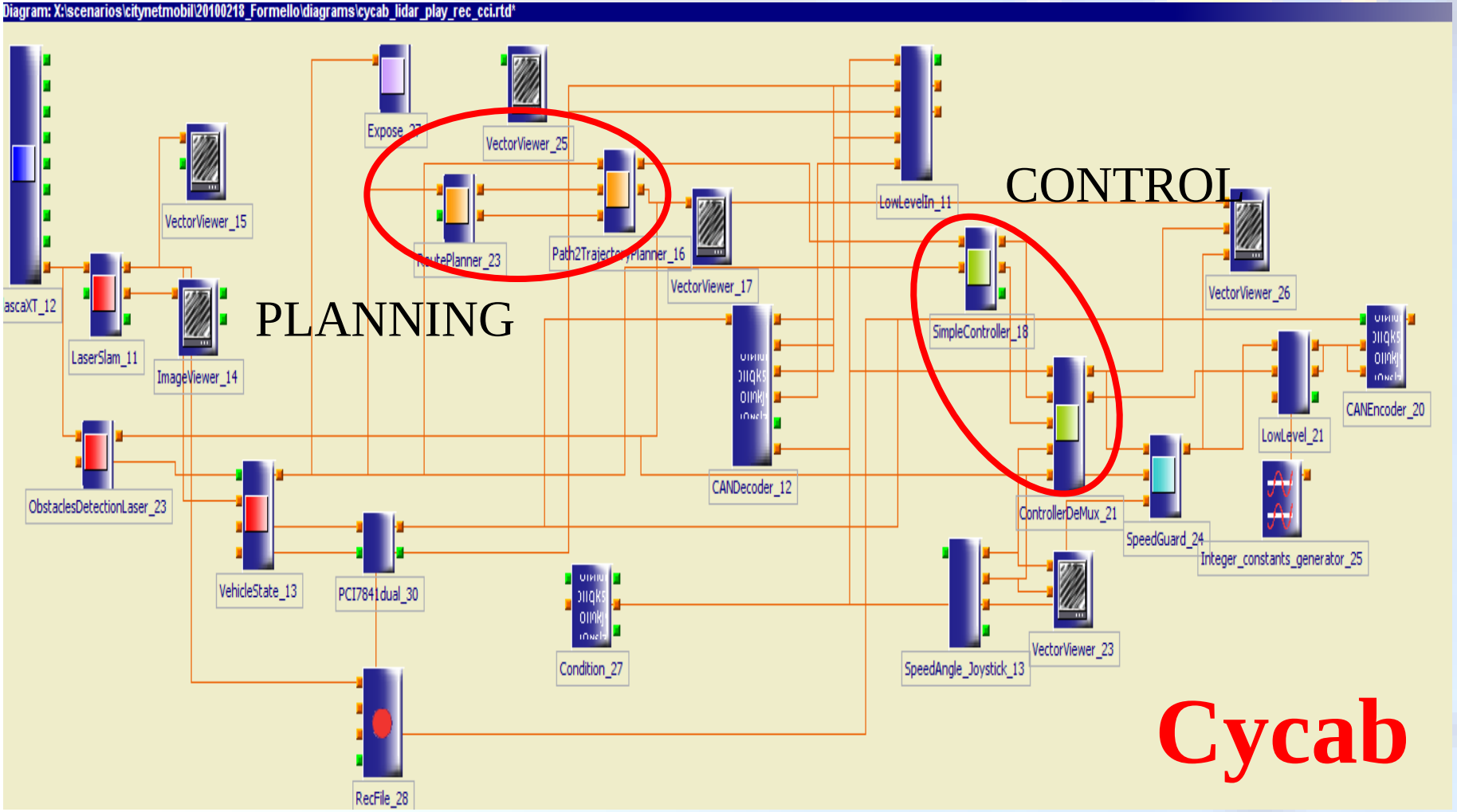


Actuator control

Platform SiVIC / RTMaps



Platform SiVIC / RTMaps



1. Presentation of our platform SiVIC/RTMaps
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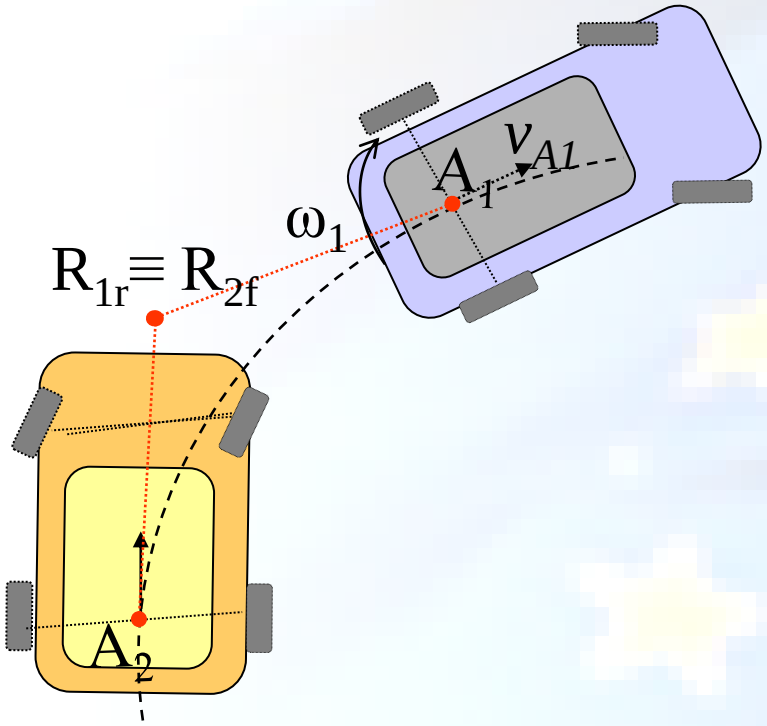
Single-Track Platooning



- Control Objective :
- Given the relative position and orientation between the two vehicles, the **control objective** is to asymptotically track the virtual reference point R_{1r} associate with the lead vehicle with the reference point R_{2f} of the following vehicle in the presence of unknown lead vehicle linear an angular velocities.

Parent, Petrov, Boussard
IASTED International Conference on Robotics (ROBO 2010)
November 24-26, 2010, Phuket, Thailand

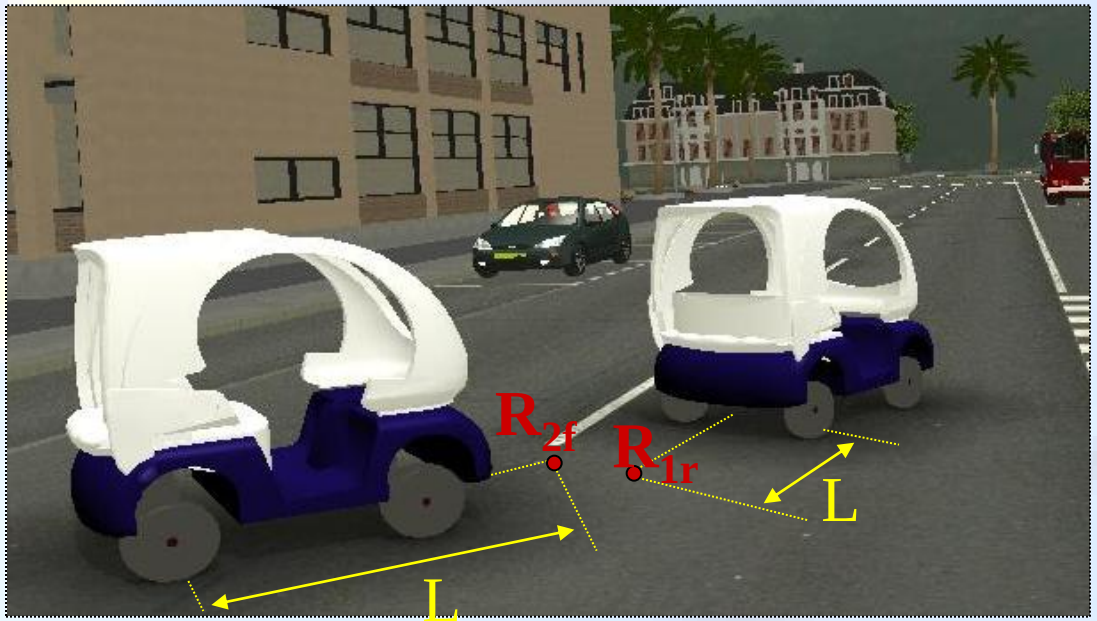
Single-Track Platooning

Problem Formulation

- Two virtual reference points R_{1r} and R_{2f}

  - R_{1r} located on the longitudinal axis of the lead vehicle at a distance L behind the rear vehicle axle.

  - R_{2f} located on the longitudinal axis of the following vehicle at a distance L in front of the rear vehicle axle.



Single-Track Platooning

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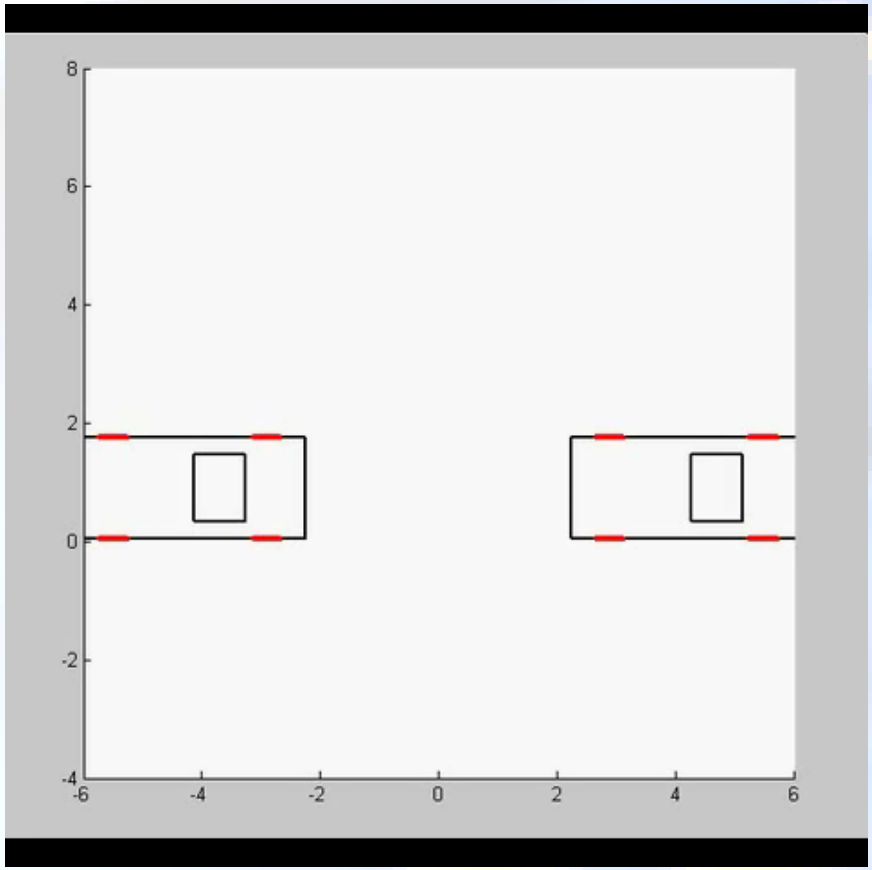
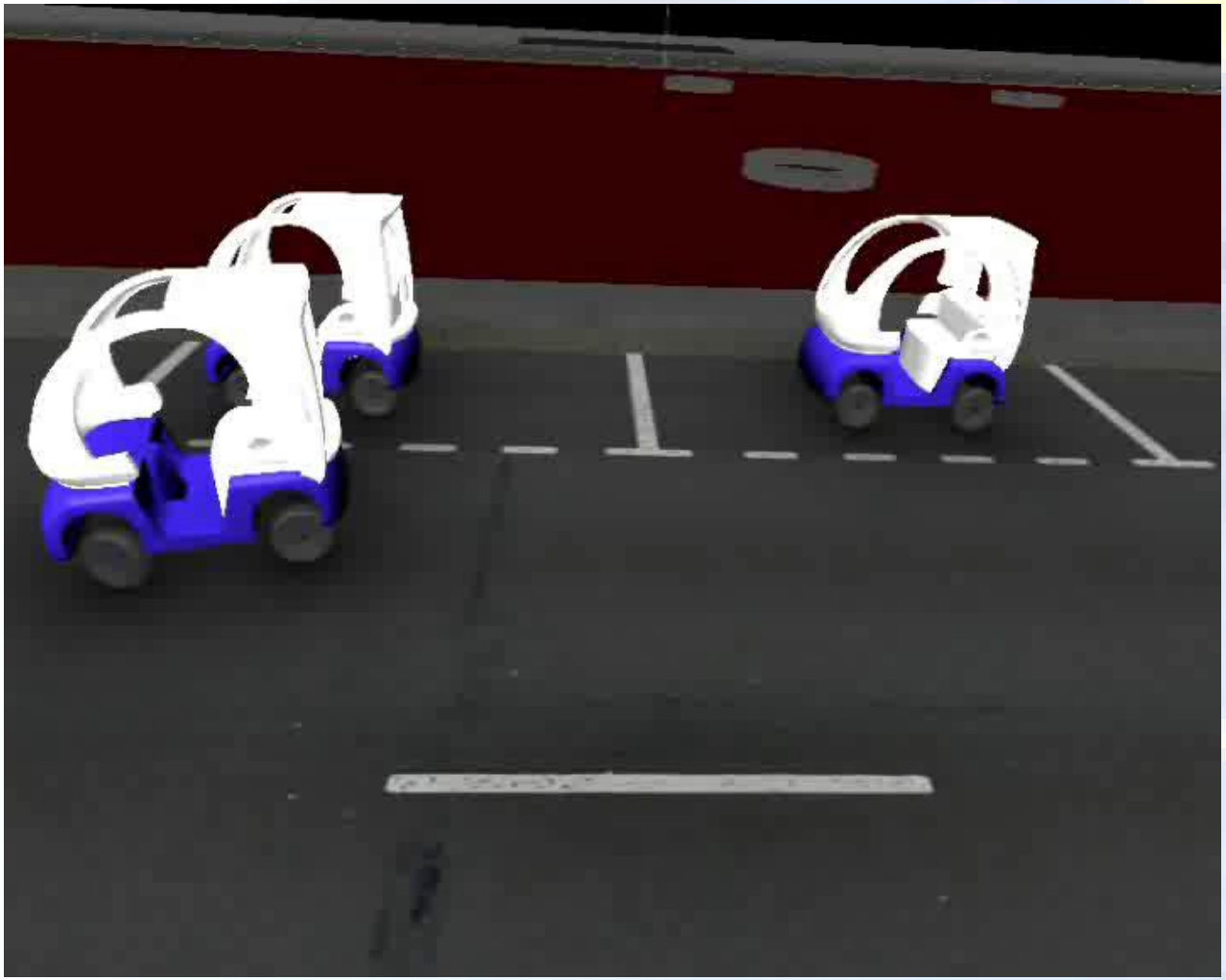
Optimal Automatic Parking



Choi, Boussard, and d'Andréa-Novel,
for VALEO

Optimal Automatic Parking



… and more

- Road signs detection
  - Speed limit determination
  - Fusion with GIS
- Traffic lights detection
- Rain detection
- GIS development
- …

Key events in 2011

La Roc

CAROT

AROS

HAVEit

ITS LY