

# Intelligent and Communicating Vehicles



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# Outline

- **MIPS laboratory**
- **Intelligent Vehicles -> Communicating Vehicles**
- **Intelligent Vehicles, MIAM Team**
- **Communicating Vehicles, GRTC Team**
- **Autonomous and Communicating Vehicles**



# The MIPS Laboratory of the University of Haute-Alsace



## Modeling, Intelligence Process and Systems

Head: Prof. Olivier HAEBERLE



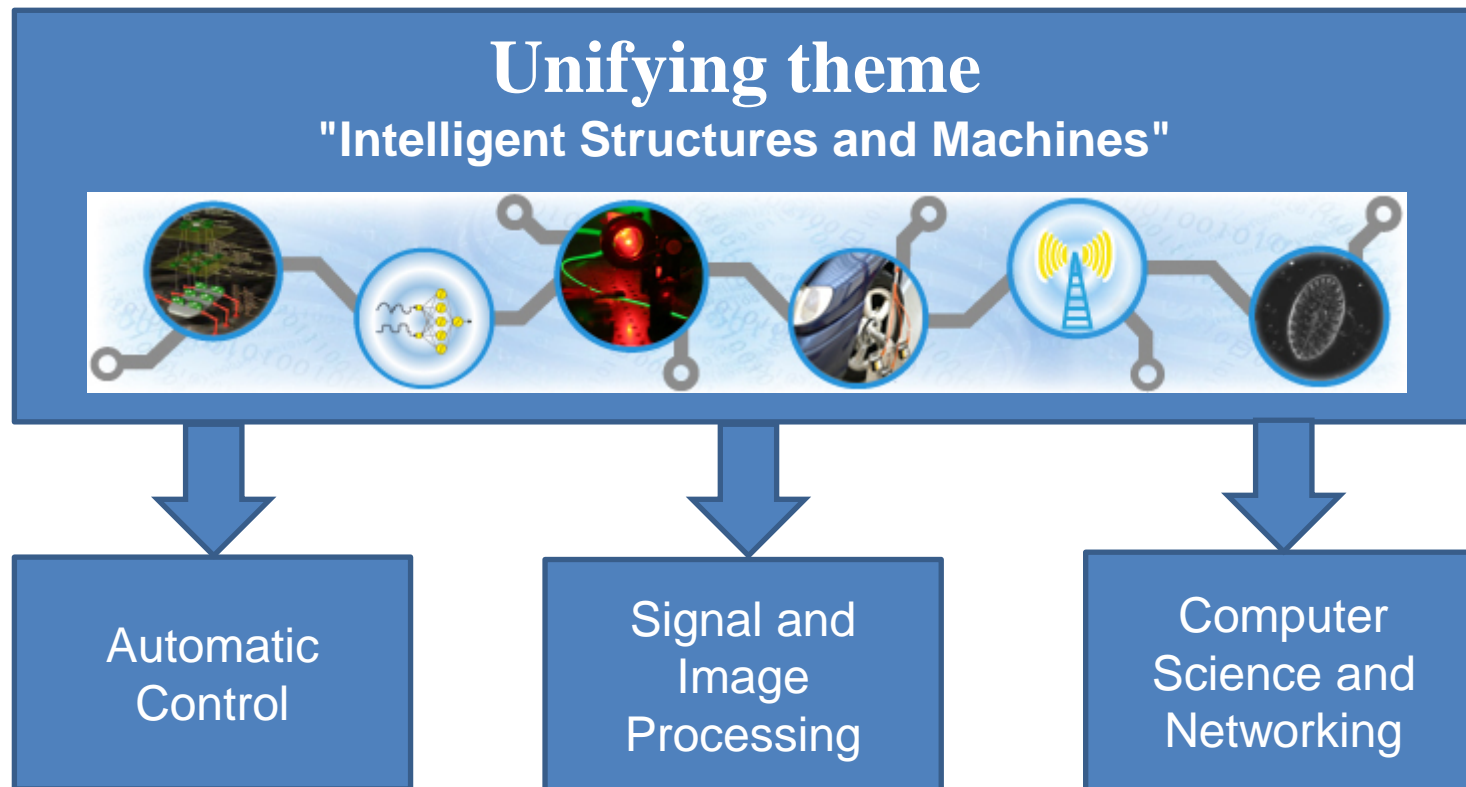
*MIPS laboratory is composed by 70 members including*

- 38 faculty members (13 Professors and 25 "Maîtres de Conférences")*
- 27 PhD students*
- 5 staff members*

# The Research Topics at the MIPS

The MIPS Lab is a research department of the University of Haute-Alsace

The MIPS Lab links together research in control theory and in its border-fields; mechanics, computer science, optics, networking and robotics.



# The Research Topics at the MIPS

## Automatic Control

*Modelling and Identification in Automatics and Mechanics (MIAM)*  
led by M. Basset, E. Aubry based at ENSISA

*Control and Learning*  
led by J.P. Urban, J. Mercklé based at FST

## Signal and Image Processing

*Optical functions and Information Processing*  
led by P. Ambs, L. Bigué based at ENSISA

*3D microscopy imaging and image processing*  
led by O. Haeberlé, A Dieterlen based at IUT Mulhouse

## Computer Science and Networks

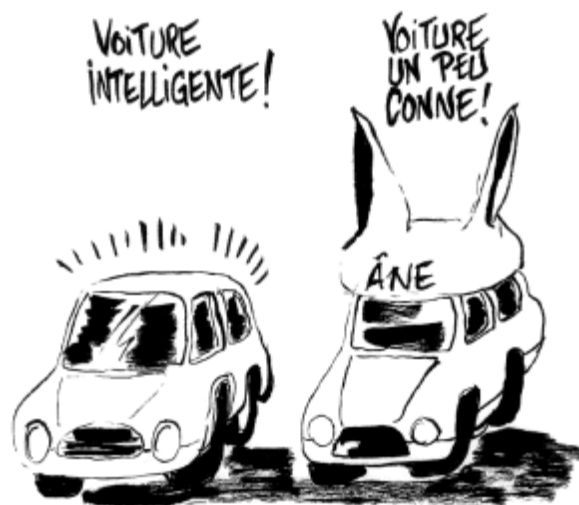
*Software engineering*  
led by B. Thirion, M. Hassenforder based at ENSISA

*Telecommunications and Networks (GRTC)*  
led by P. Lorenz based at IUT Colmar

# Intelligent & Communicating Vehicles

Automotive vehicle is the main used individual means of locomotion

- Constantly growing number of personal vehicles
- Road safety can be severely degraded
- Driving pollution increases highly



Nuit des chercheurs 2012, Veesse

Intelligent and Communicating Vehicles are a promising way to mitigate these drawbacks...

# The Autonomous Vehicle theme in the MIPS Lab

Intelligent vehicle needs Advanced Driver Assistance Systems (ADAS)

Research at the **MIAM-team** deals with :

- New ADAS design and validation
- Development of global control architectures for an **automatized driving**



Automated urban transport systems

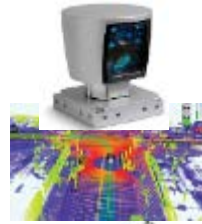
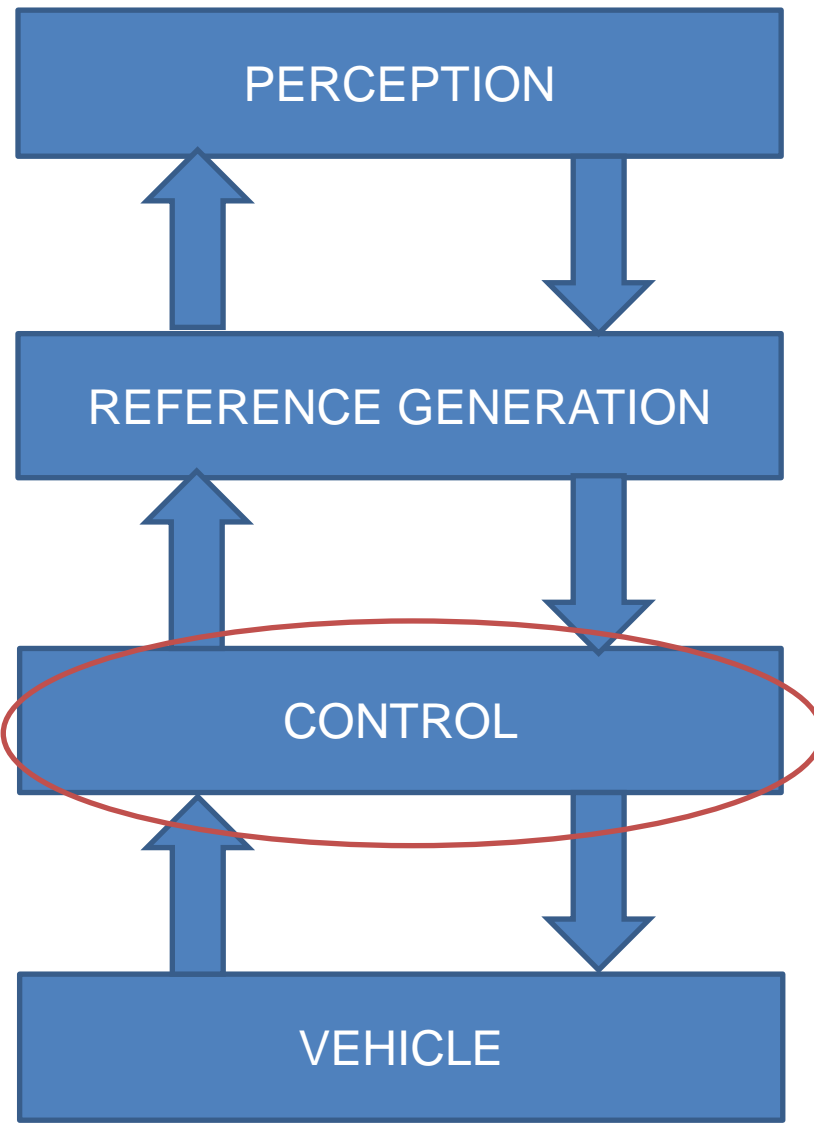


Driverless car technology

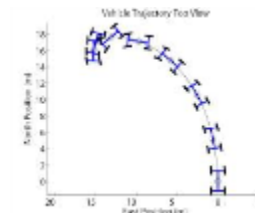


Automated highway driving systems

# Autonomous Vehicle Global Architecture



Provides instantaneous information about road / vehicle / environment



Computes the trajectory to be tracked (path and speed)

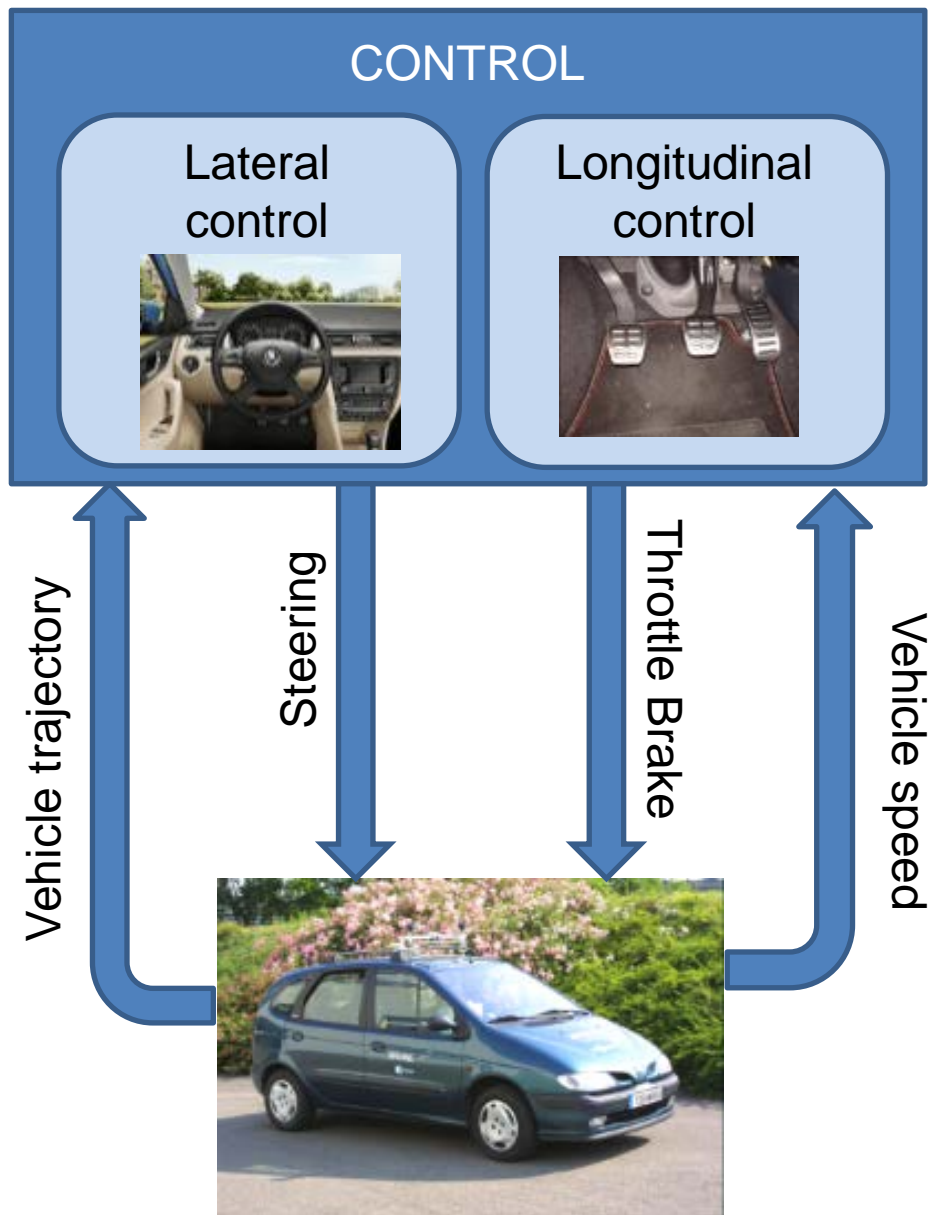


Ensures the automated vehicle guidance





# Control for an Autonomous Vehicle



## Lateral control

- ensures an effective **path tracking**
- improves lateral stability of the vehicle

## Longitudinal control

- ensures an effective **speed tracking**
- adapts speed according to the driving situation



Control of the vehicle is not easy !

# Control of an Autonomous Vehicle

Development of global control architectures for an **automatized driving**

*Complex system*

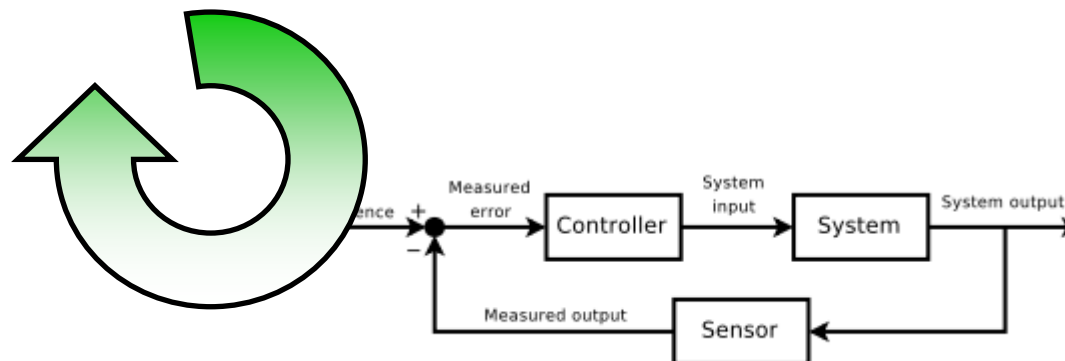


- **Mathematical model**
- **Physical laws**

$$m\ddot{x} = m\dot{y}\dot{\psi} + F_{x_f} + F_{x_r}$$
$$m\ddot{y} = -m\dot{x}\dot{\psi} + F_{y_f} + F_{y_r}$$
$$I\ddot{\psi} = aF_{y_f} - bF_{y_r}$$



*Computer simulation*



System Theory &  
Automatic Control &  
Applied Mathematics

*How our developments are validated?*

# Bench test available in the Lab



Instrumented vehicle  
GPS, sensors, inertial central...



Suspension Bench



Steering system

# Autonomous Vehicle

- Currently, our control results are only validated considering a single vehicle
- Others vehicles must be taken into account to improve the autonomous vehicle guidance



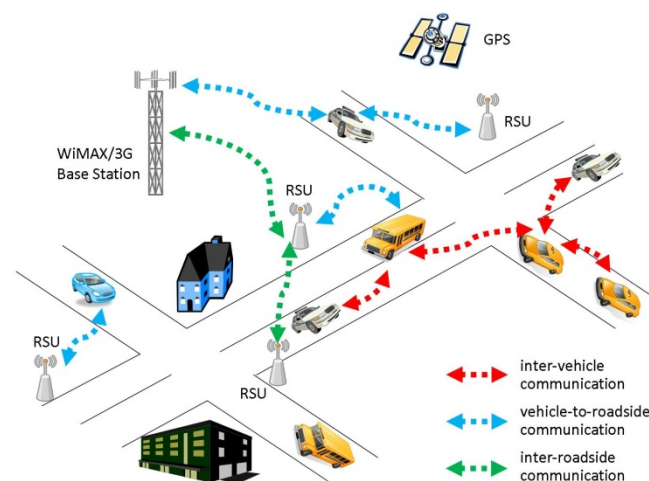
Inter-vehicles communication  
is then required

**To this end, the MIAM team and the GRTC team collaborate...**

# The Networking theme in the MIPS Lab

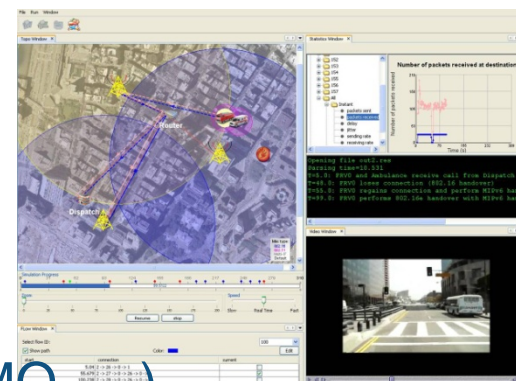
## Research themes in Networking

- Multimedia for next generation networks
- Telecommunication of wired/wireless networks
- Study and modeling of wireless networks, new architectures and communication protocols with QoS (Quality of Service)
- Vehicular Ad-Hoc Networks (VANETs)



## Methods

- Study and modeling of communication protocols
- Simulation of protocols (NS-2, NS-3, OpenStreetMap, SUMO, ...)
- Engineering for protocols and models (all ISO layers)



# Vehicular communications – GRTC Team

**Goal: improve safety, go towards ubiquity**

Available technologies:

- Wifi **not** deployed (for cars),
- Cellular **deployed**

Economic models:

- Wifi **free** and **shared**,
- Cellular **paying** and **personal**

Future used technology:

- Will probably be chosen by market
- Will probably not be unique

***Research helps in discovering the limits***



Shared property: use of radio waves as communication medium

# Vehicular communications – Characteristics

## Drawbacks:

coverage area, shared media access, high mobility

## *Evaluation: Real measurements vs Simulation*

### *Real measurements*

- expensive
- non reproducible
- realistic

### *Simulation*

- cheap
- reproducible
- lacks in realism

## *Focus on Simulation*

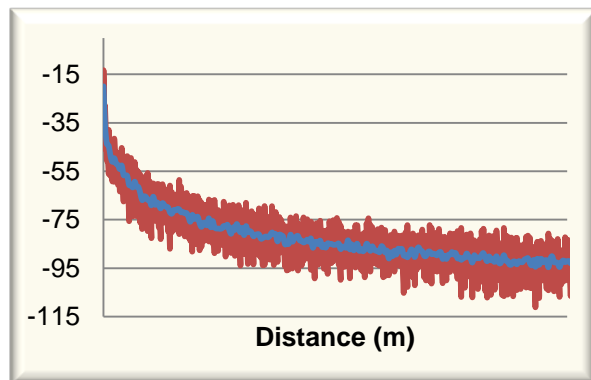
- Realism in simulation tools (with Network Simulator)
- Modeling and engineering of communication protocols



... but we are also making  
*real world measurements*

# Vehicular communications – Realism in simulations

*Propagation models:* reproducing the full process of OFDM based numeric transmission (coding + propagation)



Facing models with real world:  
Measurement campaigns  
with *Software Defined Radio (SDR)*

*Protocol goal* : making physical layer  
information available for forecasting link  
degradation/disruption due to vehicular motion

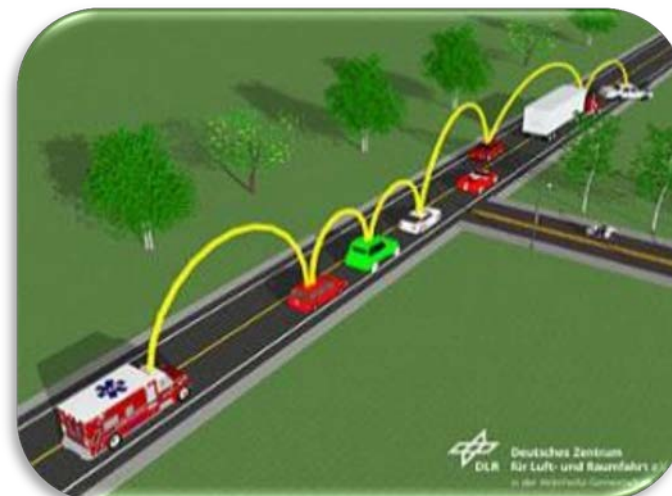




# Vehicular communications – Routing protocols

*Multihop*: a challenge for information dissemination

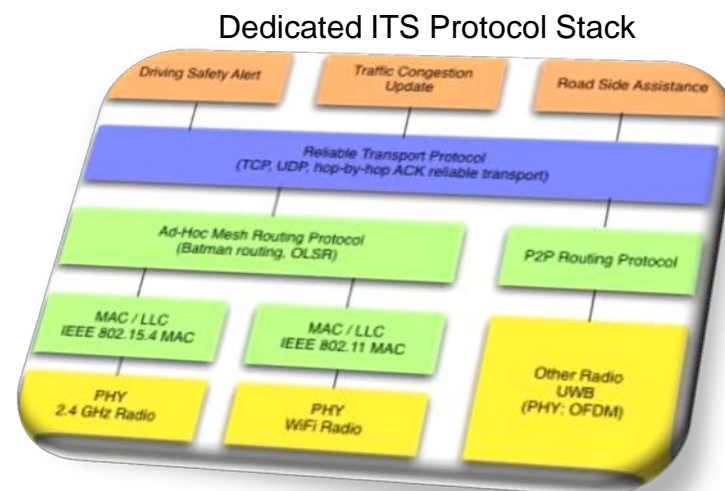
*Relies on routing protocols that are not initially designed for fast surrounding modifications*



Requires new and adapted routing metrics coming from physical layer up to routing layer

The entire protocol stack should be adapted to the communication media high variability

BER (Bit Error Ratio) based routing mechanism.



# Autonomous and Communicating Vehicles

Autonomous and Communicating vehicle is an interesting research field

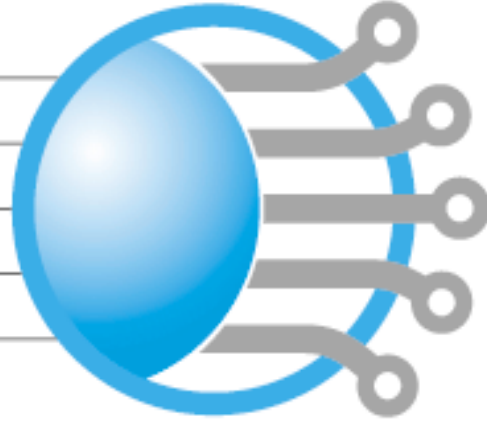
*The dream of cars driving themselves is becoming a reality.  
Before, the question was whether it was possible.  
Now we know it is.*

**Sebastian Thrun (Google self-driving car)**



- Autonomous Vehicle is now a **reality** but Communicating/Collaborative Vehicles stands as an **open problem**
- New solutions must be proposed to cope with this challenge
- This introduces a **new mobility paradigm**

modélisation  
intelligence  
processus  
systèmes



mips

**Thank you for your attention**

