Autonomous Vehicles

Conference on Autonomous Vehicles - Hasselt University - 15 February 2016

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World is Changing

⇒ **Urbanization**

- 2009: For the first time in history, more than 50% of the world's population lived in cities.
- 2050: 70% of the world's population will live in cities.

⇒**Demographic Change**

- 2012: 7.1 billion people.
- 2050: 9.6 billion people.

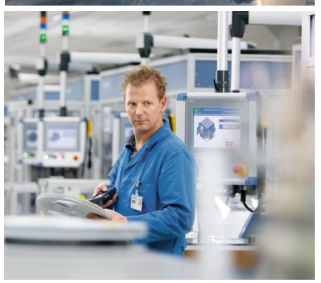
⇒**Climate Change**

- 2012: Highest CO_2 concentration in the atmosphere in 800,000 years.
- 2001 to 2010: Warmest decade on record.

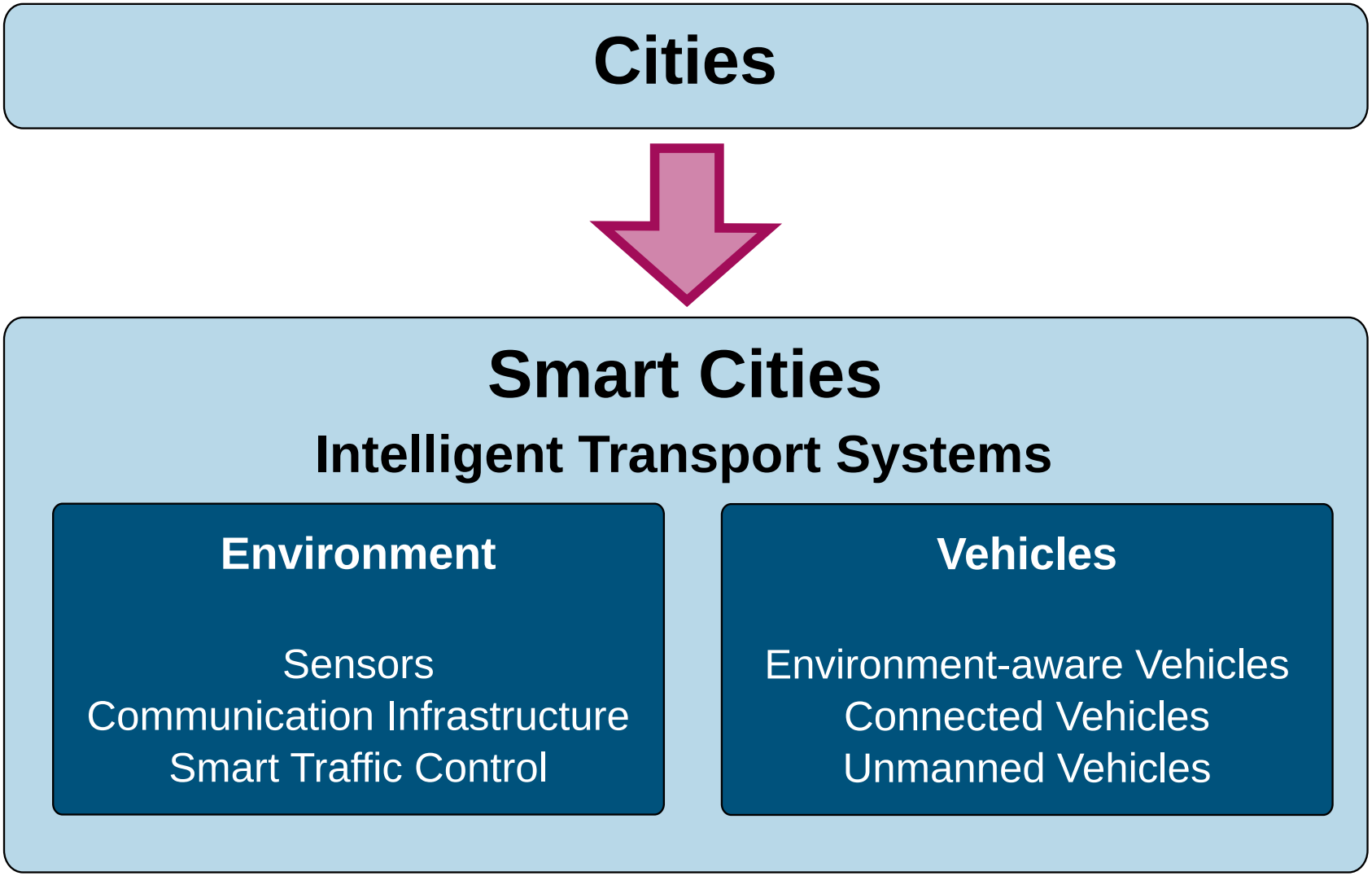
⇒**Digital Transformation**

- Worldwide data volume doubles every two years.



Need Radical Change in Transport Systems



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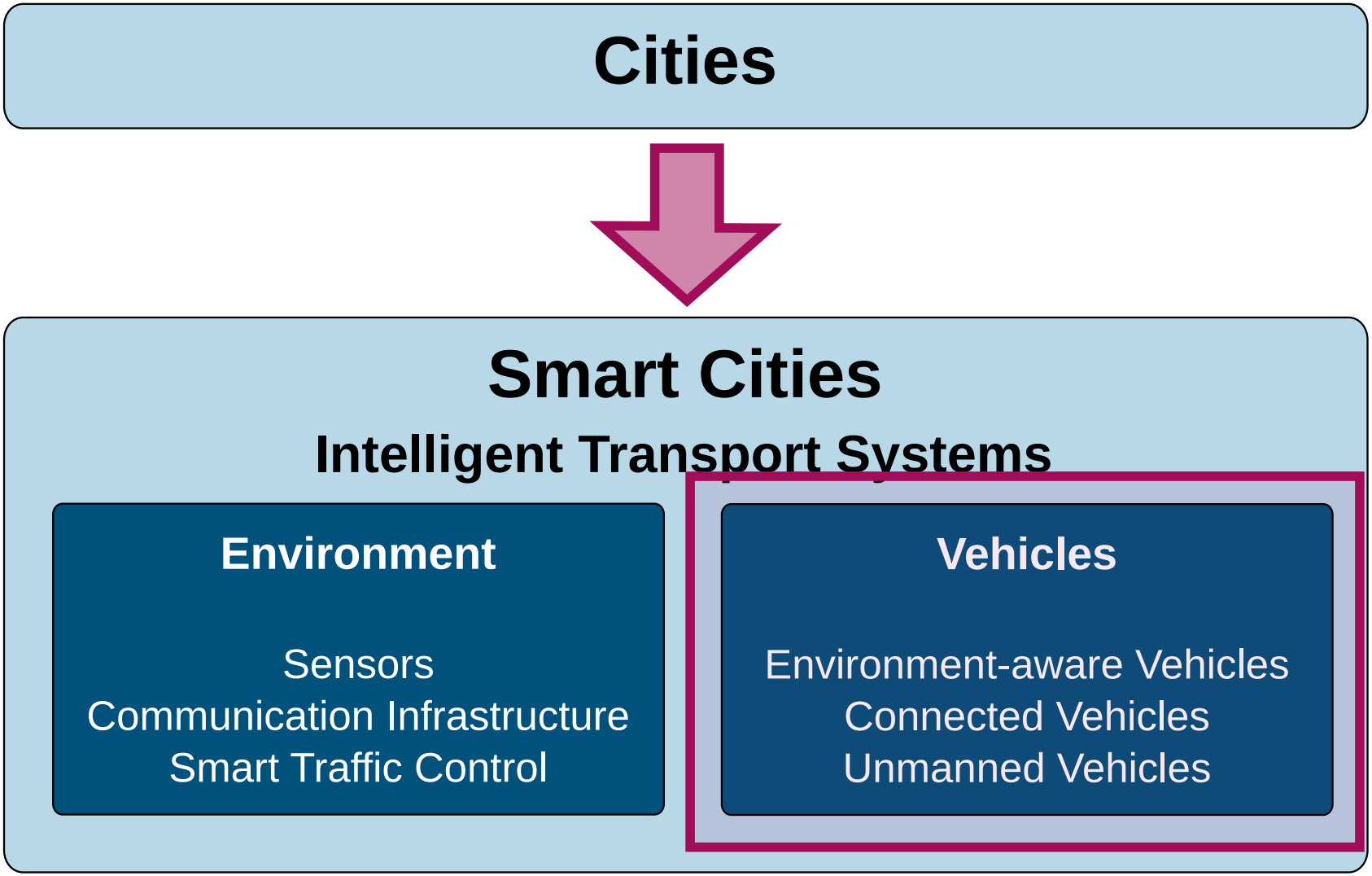
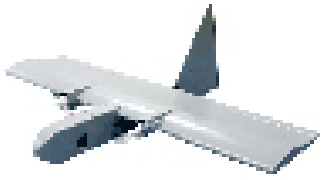


What is an Unmanned Vehicle?

Unmanned System

Any electro-mechanical system which has the capability to carry out a prescribed task or portion of a prescribed task automatically, without human intervention.





Unmanned Vehicle

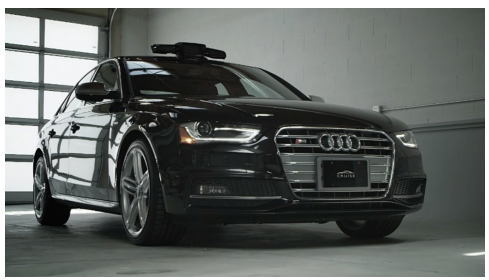
A vehicle that does not contain a person.

- Can be tele-operated.
- Can be autonomous.
- Typically equipped with sensors and actuators.

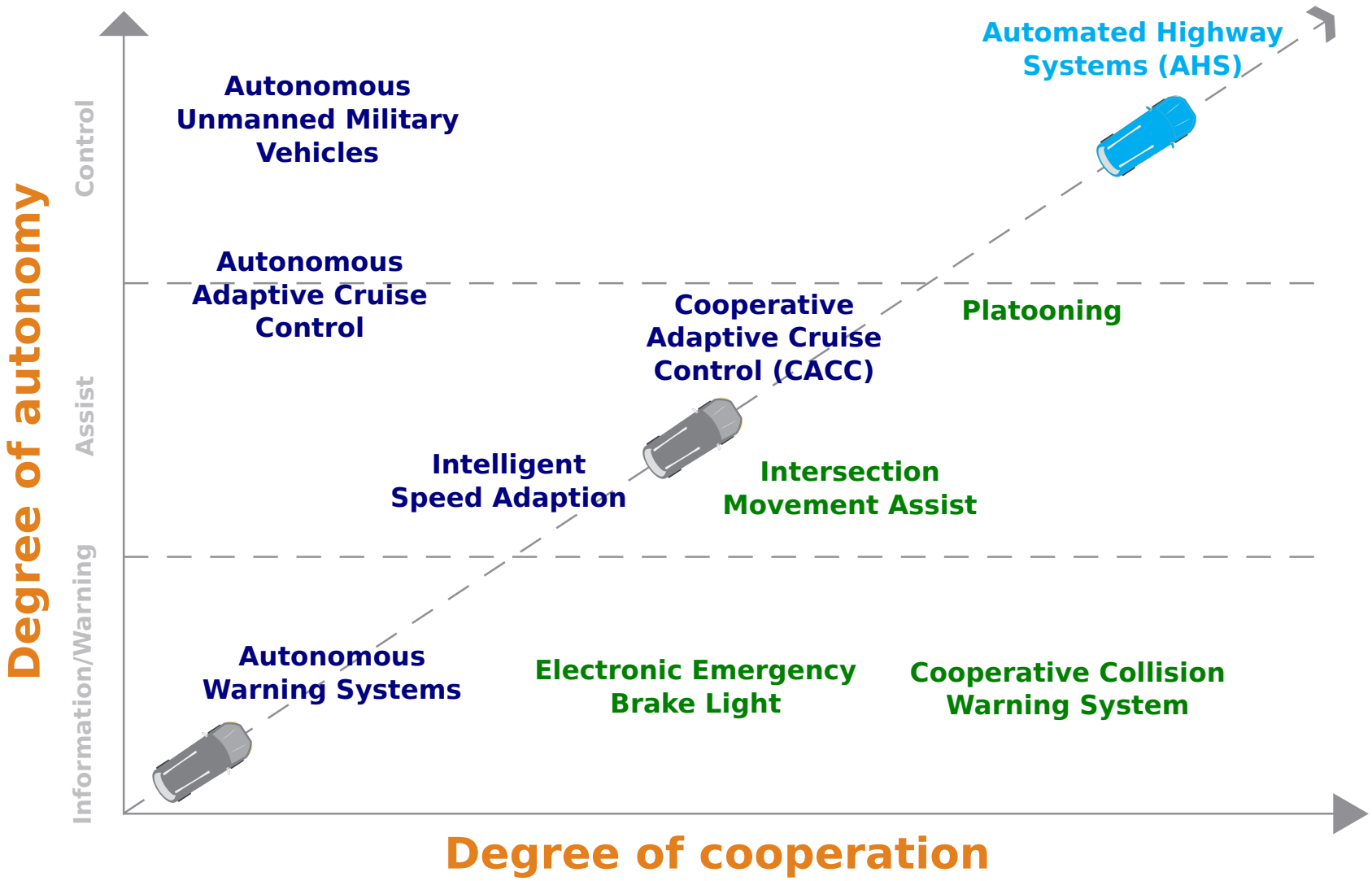
Autonomous Vehicle

A vehicle that is capable of sensing its environment and navigating without human input. Other terms: driverless car, self-driving car, robotic car.





Typology of Unmanned and Autonomous Vehicles

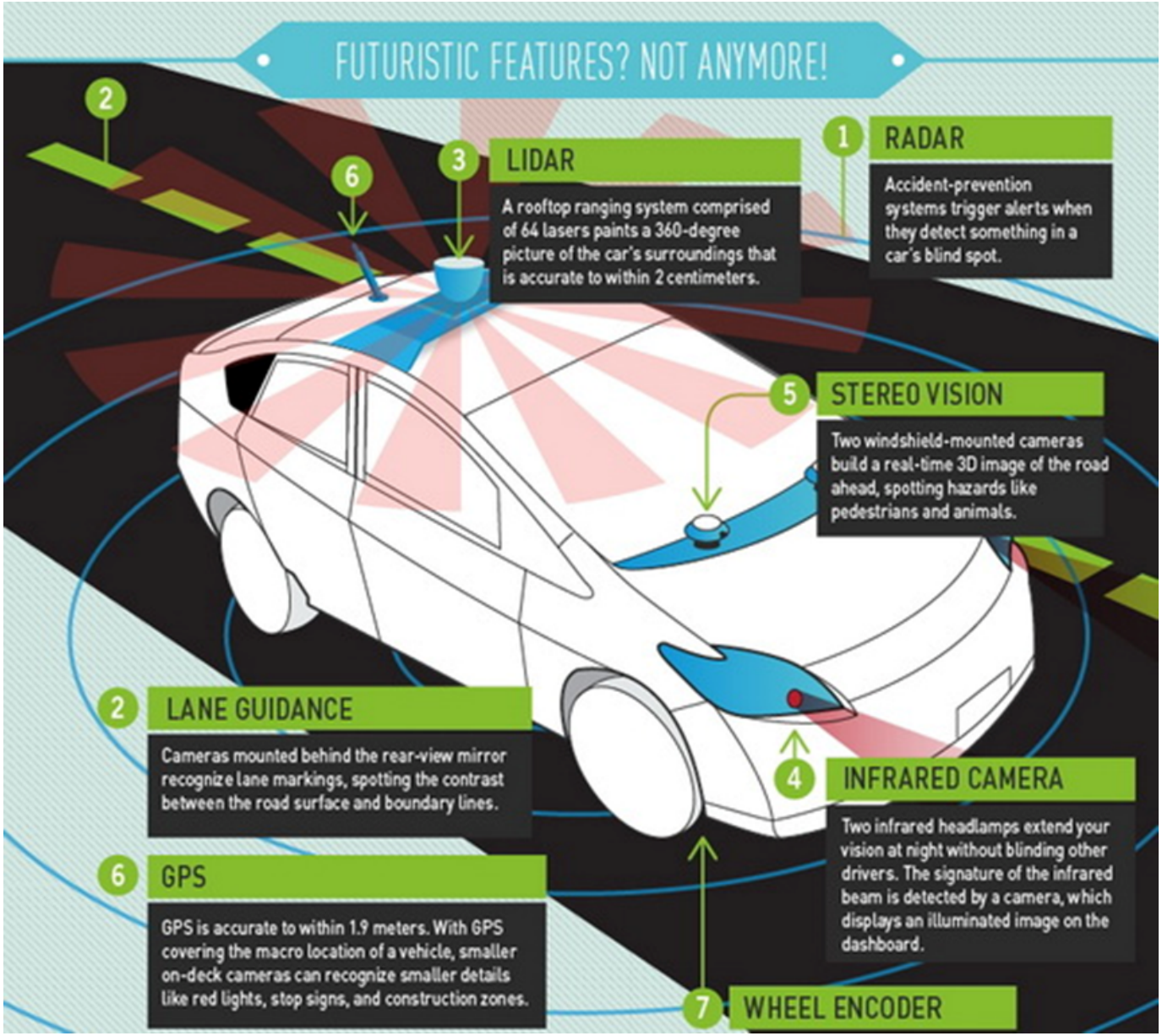


Autonomous Vehicle Components

Vehicular automotion needs:

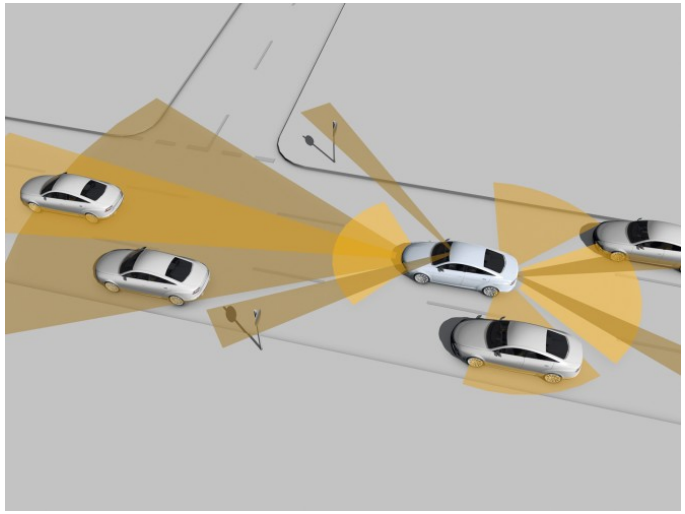
1. Mechatronics:
   - Perceiving the surrounding environment with sensors.
   - Controlling the vehicles with actuators.
2. Artificial intelligence:
   - Analyzing data from sensors.
   - Controlling the vehicle.
3. Agent-based systems:
   - Smart interaction with the other vehicles.
   - Smart interaction with the environment.

Typical Hardware Components



Features

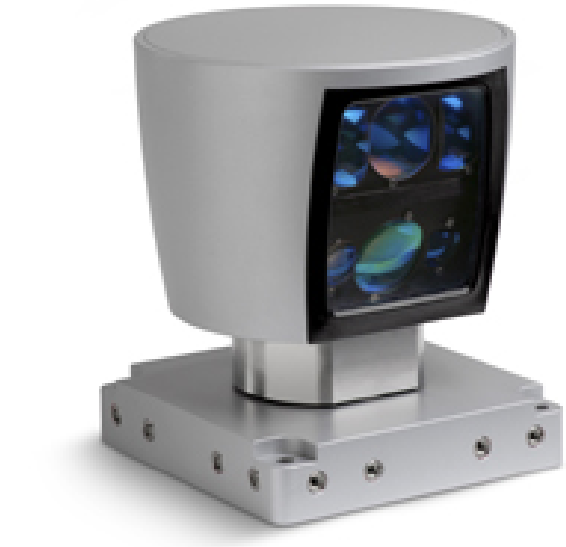
- Antenna cone emits a 10-11 Ghz signal over a 5ms period.
- Two receiving cones, separated by 14 inchs, receive the reflected signal.
- Detect dangerous objects in the vehicle's path that are more than 100m away.
- Accident prediction system triggers alerts when something is detecting in a blind car's blind spot.

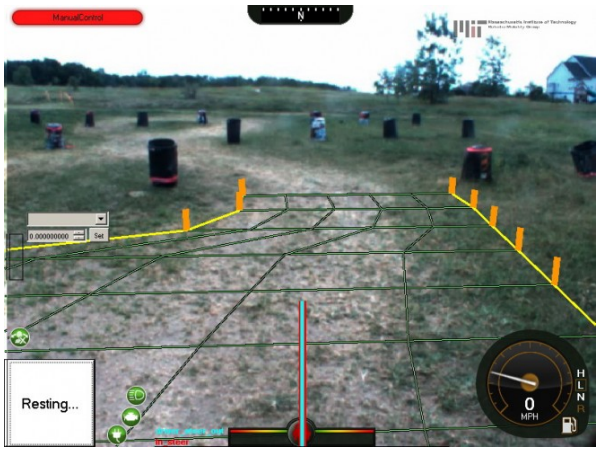


Features

- Vertical and horizontal setup of the system possible.
- Image acquisition with fully integrated NIKON DSLR camera.
- 3D mode of the VZ scanner with continuous rotation of the scanning head for highly efficient mobile data acquisition.
- 360 degree static scanning.
- Used by Google Inc. for detecting the surroundings of the vehicle.

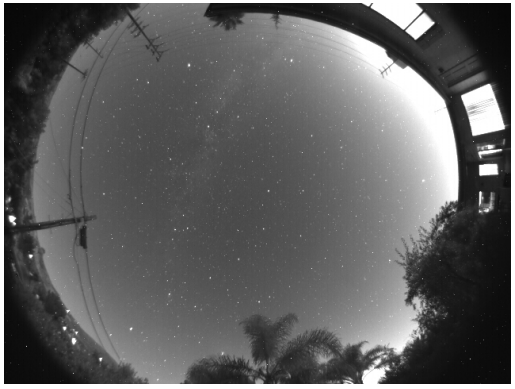
Cameras





Features

- 2D camera, or 3D camera.
- Permits to build a view of the vehicle surroundings.
- Detect dangerous objects that are close to the vehicle.
- Detect road markings and traffic signs.



Features

- Global Positioning System tracks the vehicle position with 30cm of accuracy.
- Positionning systems using on-ground signal emitters may have accuracy close to 1cm.
- Sky cameras may be used for solving the canyoning problem of GPS.

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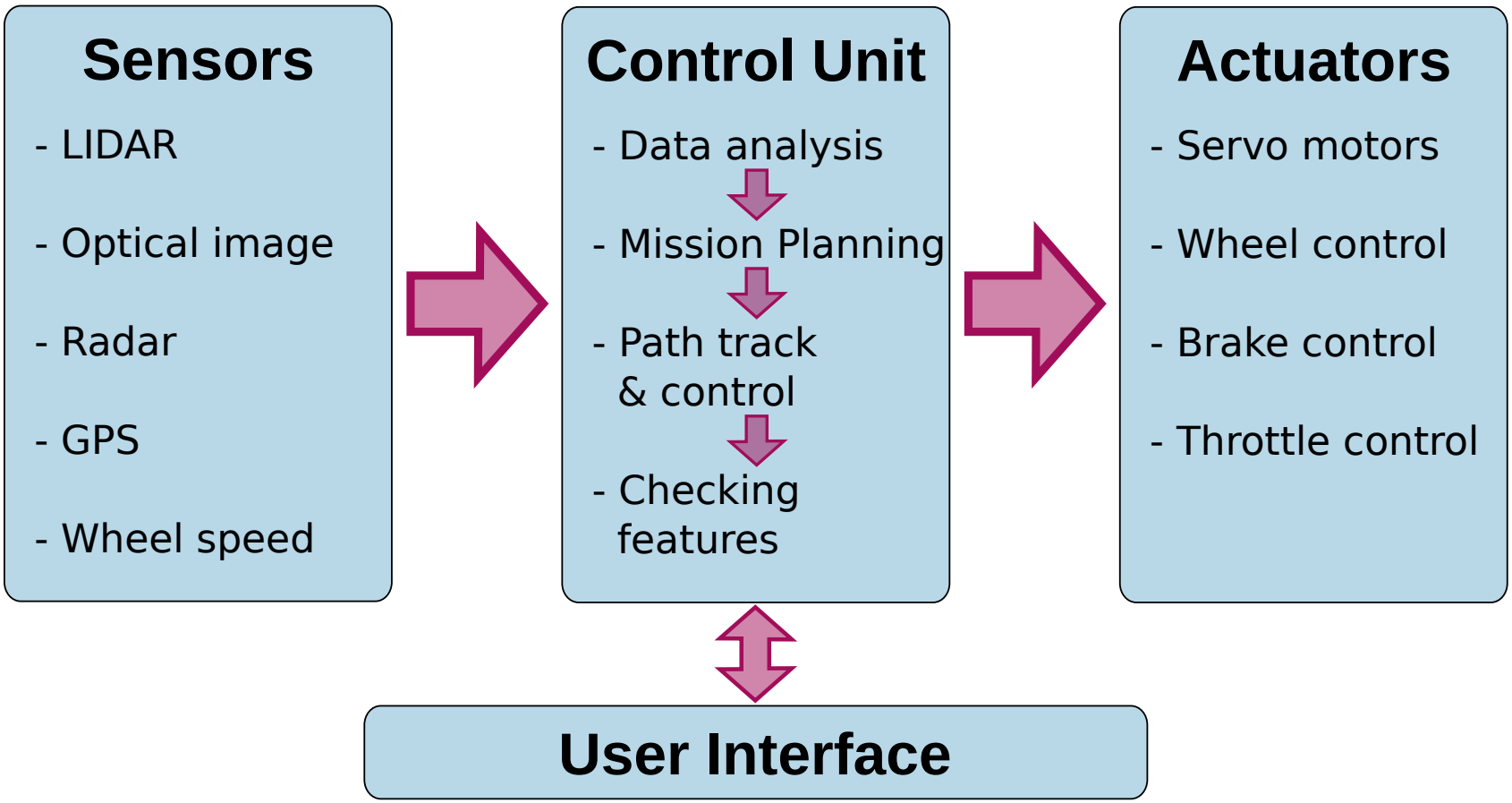
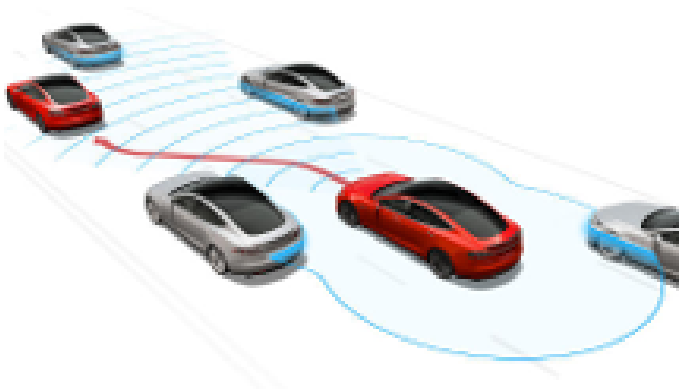

Sensors
- LIDAR
- Optical image
- Radar
- GPS
- Wheel speed
Control Unit
- Data analysis
- Mission Planning
- Path track & control
- Checking features
Actuators
- Servo motors
- Wheel control
- Brake control
- Throttle control
User Interface

Features

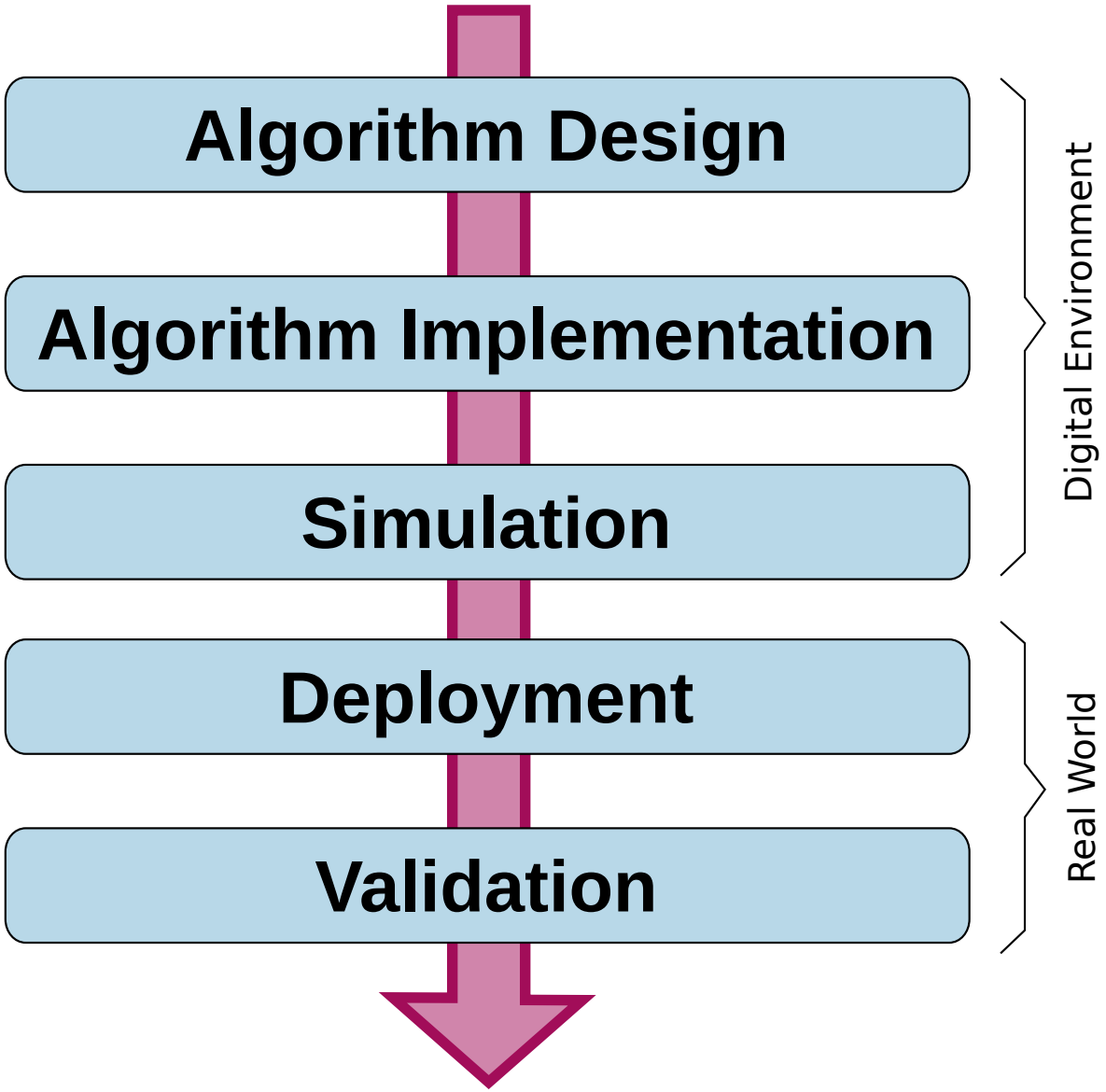
- Each vehicle has the mission to reach its goal:
  - a destination on the map, or
  - a vehicle to follow.
- missions decomposed into atomic tasks.
- Each task is a path to follow, and becomes command-units to the patch controller module.
- ITS may be used for computing the task plan.



Features

- Get tasks from the mission controller: the path to follow.
- Generate steering angles and drive velocities along the path.
- Pass them to the checking features before going to the actuator controllers.
- Two major missions for this module:
  1. Follow the given path, and
  2. Avoid collision.

Design Process of the Control Unit



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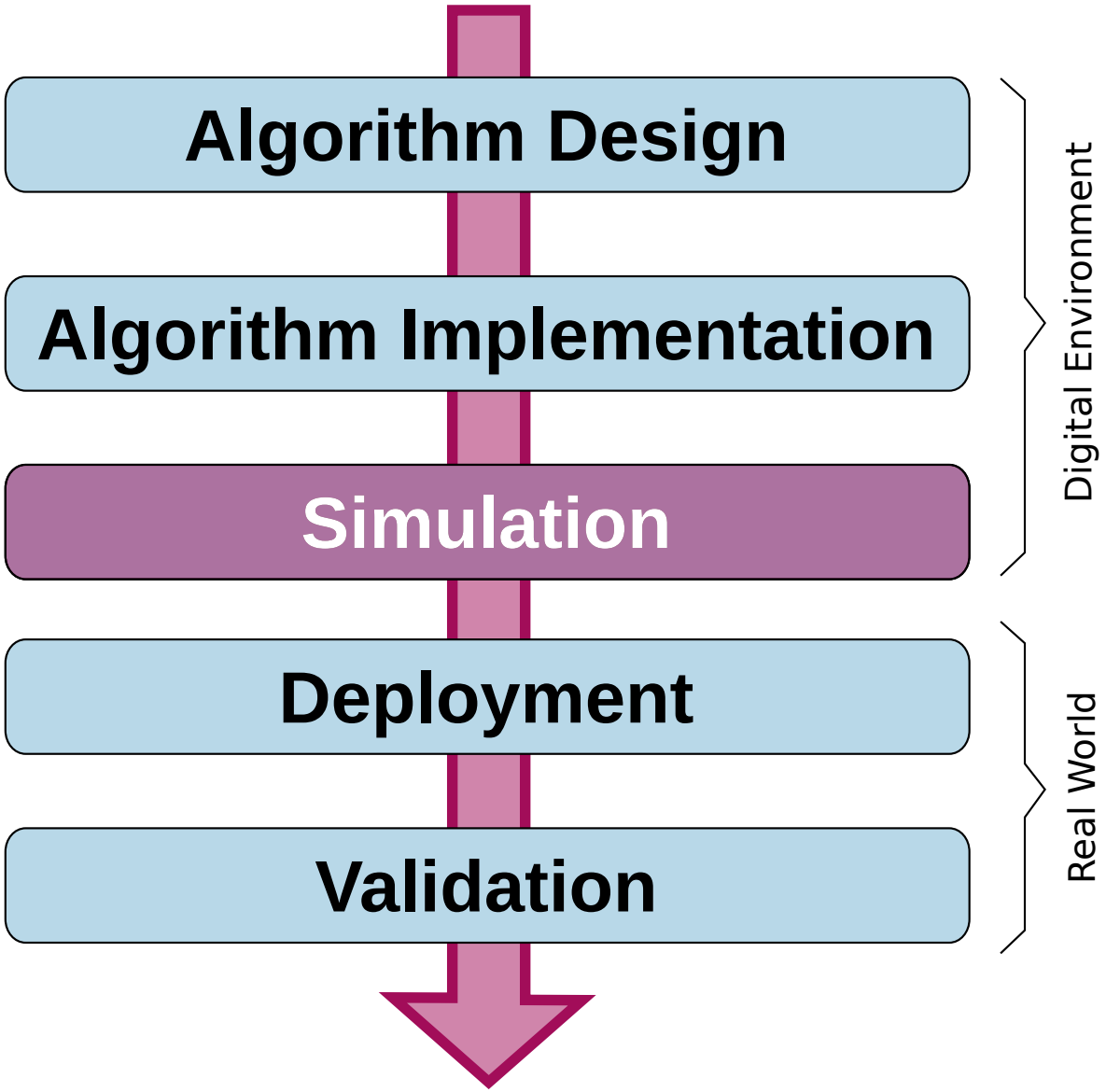


What is simulation?

The process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or a set of criteria) for the operation of the system.

Why Simulating?

- Too dangerous to deploy in real World.
- Too costly to deploy in real World.
- Rapid prototyping.
- Testing standard and extrem scenarios.
- Debugging of the algorithms.

Basic Requirement

Software must be the same in the simulated and real environments.

Realistic Sensors

For validating the control models, data provided by simulated sensors must have the same accuracy as data provided by real sensors.

Dynamic Behavior of the Vehicle

The simulation vehicle must have the same dynamic behavior as the real car:

- pitch , roll, yaw.
- velocity, acceleration.

Video

Project ANR CATS — 2012

Example of the collision avoidance

Problem

How to ensure the vehicle will not collide an object?

Solutions

- Trajectory equations resolution.
- Repulsive forces of the objects around.
- Agent-based system for solving the collision-free problem.
- etc.

Video

Project ANR SafePlatoon — 2012

What is Platooning?

Collection of vehicles that are moving autonomously, and:

- coordinating their movements for maintaining a geometrical configuration: line, square, etc.;
- adapting the geometrical configuration to the environment and the context;
- supporting insertion, ejection of individual cars;
- supporting merging of car groups.

Offset Problems

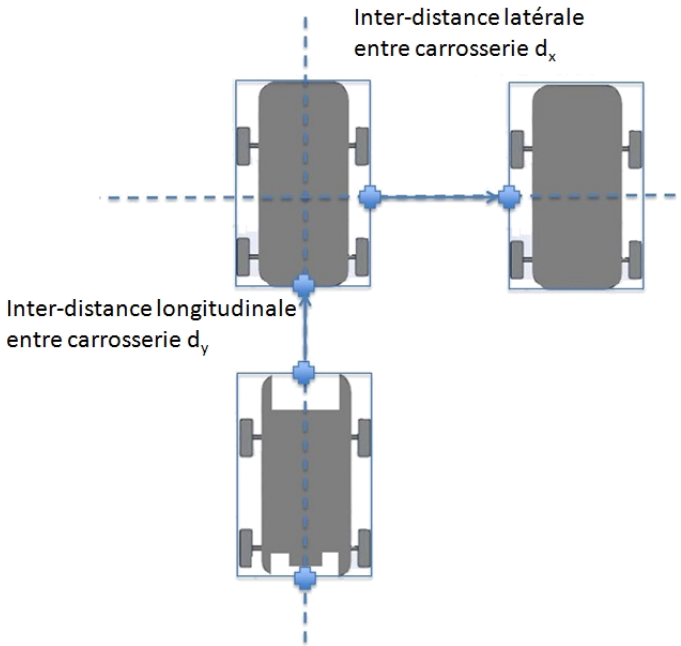
Two distance offsets to the reference vehicle must be considered when platooning.

Lateral Offset

The expected lateral distance offset between the current vehicle and its neighbours.

Longitudinal Offset

The expected longitudinal distance offset between the current vehicle and its neighbours.



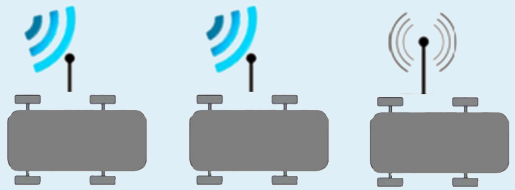
Usual Problems with Platooing

- Safety problems.
- Different geometrical configurations.
- Dynamic evolution of the convey.
- Application domains: urban mobility, agriculture, military.

Global or Local Control

Global Control

The speed and direction instructions are made by an entity that is responsible for sending them to all vehicles.



Local Control

Each vehicle calculates its speed and direction, based on its perceptions of its environment.

Video

Project ANR SafePlatoon — 2012

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Appendix

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Topics: Multiagent systems, Agent-based simulation, Agent-oriented software engineering, Mobility and traffic modeling

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Open-source contributions:

- `http://www.sarl.io`
- `http://www.janusproject.io`
- `http://www.aspecs.org`
- `http://www.arakhne.org`
- `https://github.com/gallandarakhneorg/`