Autopilot system for road vehicles

# Authors

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# Context

The need for autonomous road vehicles, such as cars, trucks or motorcycles, has been increasing over the last months. The idea is to delegate control to the machine to reduce the pilot workload and avoid potential pilot errors. Autopilot systems for road vehicles will take the control of every part of the vehicle including direction, speed, roadmap follow-up and traffic management.

Recent studies show a great interest from market leaders – such as Tesla – for such a system. At the time I write down these lines, the most advanced autopilot system for road vehicle is the one develop by Elon Musk’s company (<https://www.tesla.com/presskit/autopilot>). Google or Uber are also producing similar systems.

# History

We experienced system engineering from the aerospace industry. We participated in building the greatest aircrafts in the world, such as the most recent aircraft, the Airbus A350. We also have a background in software development and experience in developing software for the aerospace industry.

I personally have experience in radio navigation systems as I led the team that built the digital radio altimeter embedded in the A350. I also have experience in the world of maintenance, which is a good thing to have in mind while designing a critical system. I worked on some digital factory projects and spatial tools.

Mickaël has experience in the design and testing of flight controls systems, including devices that interact with the pilot, system feedbacks and control laws. He also knows the basics of aircraft piloting.

We also both worked for the flight simulation industry, where we learn the behavior of the most critical systems in an aircraft, including electrical, fuel, hydraulics, flight controls, cockpit panels, displays and braking systems.

# Product Description

Today, we are designing and building an autopilot system for road vehicle that can be part of the future generation of autonomous vehicle. The design shall respect the following key concepts:

* The engineering development lifecycle shall include at least a product analysis, a complete requirement definition, verification and validation activities, software development, safety compliance to the most critical rules, failure modes and effects analysis, maintainability topics and achieve the same certification items than for an aircraft system.
* The system shall be switch from automatic to manual mode on demand with the highest reliability to give back the main controls to the pilot (braking/speed control, guidance, start&stop).
* Every branch of the system decision tree shall include a man-in-the loop feedback.
* The system shall operate within a defined scope of operations that limits its control of the vehicle.
* The system shall demonstrate the highest accuracy and the lowest failure rate while doing nominal and critical maneuvers.

# Hypothesis

To develop such a system, we need to make some hypothesis about the environment as the system is not standalone but part of an autonomous vehicle, which means that:

* The system relies on inputs provided through a communication mean and will deliver output using a communication mean.
* The system will not directly operate any device but only send commands to interfaced systems that will process them.
* The system will be active from the start of the vehicle until the stop, unless manually deactivated by the pilot.
* There is a mean to easily restart the system and reset its behavior to a factory mode.
* The system will always be connected to a source of electricity.
* In case of failure, the system shall send an alert to the pilot and other systems.

# Interfaces

In order to operate, the autopilot shall get input and transmit output data from and to other systems using a communication mean.

## Inputs

The autopilot system shall receive the following data, with performance requirements:

* Measured instant speed, in mph or km/h, +/- 3% accuracy
* Measured velocity, in mph or km/h, +/- 3% accuracy
* Latitude/Longitude, in coordinates, +/- 3% accuracy
* Automatic/Manual switch position (On, OFF, by default OFF)
* Closest distance to a surrounding object, in meters
* Remaining Fuel Quantity, in L
* Measured Fuel Consumption, L/m
* Roadmap, as a set of waypoints and distances, including origin and destination
* Static Road Rules (speed limits, traffic lights, stops and yields, …)
* Measured Road Rules (i.e. captors that interpret road signs)
* Current position of pedal brakes (ON, OFF, default OFF)
* Current position of park brake (ON, OFF, default ON)
* Current measure of pitch angle (default 0)
* Current measure of yaw angle (default 0)
* Current measure of roll angle (default 0)
* Power status (Powered, Not Powered, default Not Powered)
* Target speed, in mph or km/h,
* Engine status (Running, OFF, default OFF)
* Vehicle gross weight, in kg
* Vehicle maximum weight, in kg
* Measured vehicle weight, in kg, +/- 3% accuracy
* Number of Passengers
* Traffic Control system feedback :
  + Collision risk, from 0 to 5, 5 being the critical situation
  + Suggested Order: stop, accelerate, decelerate, move right, move left