



2 FROM DRIVING ASSISTANCE SYSTEMS TO VEHICLE AUTOMATION

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The last three decades have seen the rise of so-called Advanced Driver Assistance Systems (ADAS). These systems enhance the "safety", "energy", "mobility" and "comfort" aspects. However, they do not in any way replace drivers in their task as such but rather provide them with informative and active assistance. More recently, these ADAS systems have emerged as a preliminary step before the implementation of semi- or fully-automated mobility systems. These new driving assistance systems will help better address the challenges by ensuring a high level of reliability while taking into account users' comfort for broader acceptability. At Ifsttar and in particular at the LIVIC laboratory, these aspects have been tackled in many French and European research projects.

Driving assistance systems gaining recognition

Comfort features are meant to make driving easier and more pleasant for the driver. Examples of these are cruise control (ACC³), parking assistance (ParkingAssist), automatic windshield wipers and headlight control (orientation, zone, intensity). Drivers have shown to particularly

welcome these functions: in 2015, the best-seller applications were parking assistance, visual perception and cruise control.

On the safety side, following ABS⁴ in the 1960s, came ESC⁵ in 1995, the ACC cruise control in 1997, enhanced night-time vision in 2000, followed by lane departure alert in 2001 and emergency braking in 2003.

Environmental issues are not overlooked either, with the emergence of information to mitigate consumption (eco-driving) and the development of alternative mobility systems (electric, hydrogen, hybrid). A last societal challenge concerns users' mobility. For the latter, solutions are yet to be found in order to significantly and efficiently improve mobility-related systems. To this end, there is a need to develop specific adaptations to infrastructures and relevant multi-modal mobility systems. The variable message signs (PMV), most of which installed on motorways, were among the first systems rolled out. More recently, new cooperative and communication-enabled systems have looked to mobile technologies in order to optimise the dynamics of a fleet of vehicles (capacity, convoy management, lane insertion or departure, etc.).

On track for autonomous driving

Most of the above-mentioned systems are now available on a wide range of vehicles. The current state of research clearly indicates that we are very close to partial automation of low-speed driving in situations of dense traffic.

1. LIVIC: Laboratory for Vehicle Infrastructure Driver Interactions
2. COSYS: Components and systems Department
3. Adaptive Cruise Control
4. Antilock Braking System (from the German "Antiblockiersystem")
5. Electronic Stability Programme providing electronic assistance for the antilock braking system, distribution, emergency braking assistance, anti-skid, etc.

Research projects

> French national research projects:

- LOVE (detection of vulnerable road users);
- ABV (low-speed automation);
- SCOREF (deployment of transport-dedicated communications).

> European research projects:

- Have-it (automation in the motorway environment);
- eFuture (automated electric vehicle);
- ecoDriver (ecomobility).

> International research projects:

- CooPerCom (perception and cooperative communication for vehicle automation).

Amongst these ongoing projects are:

- SINETIC (multi-level simulation platform for cooperative ADAS systems);
- GameEcar (eco-driving);
- C-ROADS (cooperative systems);
- CARTRE (Cooperative Support Action on vehicle automation).



▲ CARLLA: the Ifsttar prototype dedicated to driving automation (ABV, Have-it, eFuture, and other projects)



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From a more global perspective, these applications and services are still to be fitted separately and independently. Even if several of these ADAS systems can be found in a given vehicle, they are still regarded as driver assistance mechanisms. However, with the growing number of these in-vehicle systems and their increased capabilities, reliability and robustness, the trend is towards fully-automated driving. Now, in the event of a system failure (sensors, actuators, electronic equipment, applications, etc.), the system must be in a capacity to promptly and efficiently warn the human driver for him/her to take over control. To mitigate risks in the man/machine transition situation, it should be possible to predict and anticipate critical situations. At present, this transition stage is a genuine scientific and technological challenge which is currently being investigated, etc.

Up to six levels of driving automation

SAE¹ recently proposed a definition of the six levels of driving automation identified so far. The first 3 are only concerned with the assistance provided to the driver who maintains the task of observing the environment and acting on the vehicle. The next 3 levels define potential automation modes ranging from partial and shared automation to full automation without human driver. More specifically, level 3 allows reproducing the driving task with the human driver taking over control in the event of a problem. Level 4, more complex, should warrant a high level of safety. This level therefore implies that the system should understand the driver's behaviour and develop substitution strategies, even under critical conditions for the automation system. The last level is that of full automation where the human driver has no possible scope for intervention.

1. SAE International is a worldwide association of over 128,000 engineers and technical experts working together with the aerospace, automotive and commercial vehicles industries. <https://www.sae.org/>

Further readings

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D. Gruyer, S. Choi, C. Boussard, B. d'Andrea Novel, "From Virtual to Reality, How to Prototype, Test and Evaluate New ADAS: Application to Automatic Car Parking.", Accepted in *IEEE Intelligent Vehicles symposium (IV2014)*, Dearborn, Michigan, June 8 - 11, 2014, USA.

Automation levels
(as per the Society of Automotive Engineers, SAE International)¹

SAE level	Name	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 <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems.	Human driver	Human driver	Human driver	n/a
1	Driver assistance	The <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i> .	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial assistance	The <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i> .	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional automation	The <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i> .	System	System	Human driver	Some driving modes
4	High automation	The <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i> .	System	System	System	Some driving modes
5	Full automation	The full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i> .	System	System	System	All driving modes

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