A Critical Review of Advanced Driver Assistance Systems and Effectiveness Analysis

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Vehicle safety is a key strategy to address ambitious long-term and interim goals and targets.

New in-vehicle technologies under development have the potential to decrease crash injury risk.

More promising safety technologies that address large road safety problems and where benefits have been demonstrated are being promoted in only a few countries or are being taken up at a lesser rate across EU countries.
The objective of the present research is to record and categorize advanced driver assistance systems as well as to discuss a variety of measures mainly in the European Union and worldwide that are being promoted widely as ADAS, e-Safety or active safety measures.

Vehicle safety comprises measures:

- targeting at crash avoidance and injury prevention (primary safety)
- targeting at the reduction of injury in the event of a crash (secondary safety)
- assisting post-impact care, i.e. reducing the consequences of injury.
Vehicle Technologies

- **Crash avoidance systems**, aiming to casualty reduction
- **Crash mitigation systems**, active in-vehicle systems aiming to mitigate the severity of the crash
- **Crash protection systems**, aiming to reduce injury severity during the impact phase
- **Post crash response systems**, aiming to alert and advance emergency medical system support in the event of crash
- **Integrated systems**

*The Holistic View of Safety (Source: Swedish Transport Administration 2010)*
• ADAS are defined as **vehicle-based intelligent safety systems** which could improve road safety in terms of crash avoidance, crash severity mitigation, crash protection and post-crash phases.

• ADAS can be defined as **integrated in-vehicle or infrastructure based systems** which contribute to more than one of these crash-phases.

• Based on current knowledge about safety impacts and feasibility:
  - Safety related ADAS - safety effects known
  - Safety related ADAS - safety effects unknown
• ISA informs, warns and discourages the driver to exceed the statutory local speed limit or other desired speed thresholds.

• **Reductions in fatalities** between 19-28%, were predicted in a market-driven scenario for voluntary systems and 26-50% for a regulated scenario (PROSPER).

• **15% reduction in hospital admissions** and 21% in fatalities in the Netherlands (Loon, van & Duynstee, 2001).

• **Benefit to costs ratios** ranged between 2,0-3,5 for the market driven scenario and 3,5-4,8 for the regulation driven scenario (Carsten & Tate, 2006).
Seat-belt Reminders

- Intelligent, visual and audible devices that detect whether seat belts are in use and give out increasingly urgent warning signals.

- An observation study in several EU countries showed that the total seat belt wearing rate was 97.5% in cars with seat belt reminders, and 86% in cars without (Lie at al., 2008).

- US studies found a 7% increase in seat belt use among drivers of cars with seat belt reminders (Williams, 2002).

- It is estimated in Sweden that reminders in all cars could contribute to a further reduction of 20% of car occupant deaths.

- The benefit to cost ratio of seat belt reminders was estimated at 6:1 after 12 years of mandatory introduction (ETSC, 2004).
Electronic Stability Control (ESC)

- ESC aims to **stabilize the vehicle and prevent skidding** under all driving conditions and situations, within physical limits, especially on wet or icy roads or in rollovers.

- A Swedish study showed that cars with ESC were **22% less likely to be involved in crashes** than those without (Tingvall, 2003).

- In Japan, ESC was found to **reduce crash involvement by 30-35%** (Aga & Okada, 2003).

- A German study indicated a **reduction in ‘loss-of-control’ crashes** from 21% to 12% (Breuer, 2002).

- A British research showed a **decrease of serious crashes** involving skidding (33%) and rollover (59%) (Frampton 2007).

- A US study indicated a 5% overall reduction in all impacts and a **23% reduction in passenger car fatalities** (Sivinski, 2011).

- A **Norwegian benefit to cost analysis** considered two scenarios for ESC fitment (Elvik, 2007).
  - The benefit-cost ratio was estimated to be 4 in the scenario of gradual fitment in the vehicle fleet.
  - The second scenario was ESC retrofitted on all cars of whatever age producing a benefit-cost ratio of about 0.4.
Alcohol interlock systems prevent driving with excess alcohol by requiring the driver to blow into an in-car breathalyser before starting the ignition.

They are 40 to 95% more effective in preventing drink-driving recidivism than traditional measures (ICADTS, 2001; SUPREME, 2007).

A literature review (UK Department for Transport, 2004) showed a recidivism reduction of about 28-65% in the period where the alcohol interlock is installed.

Swedish companies report that fitting alcohol interlocks prevented excess alcohol amongst commercial drivers.

The results of cost benefit analyses for implementing alcohol interlocks for drivers caught twice with a BAC between 0,5g/l and 1,3g/l and for drivers caught with a BAC above 1,3g/l vary between 0,7 and 4,5 in several European countries (Vlakveld et al., IMMORTAL, 2005).
In-vehicle event data recorders

- A valuable research tool to monitor or validate new safety technology, to establish human tolerance limits and to record impact speeds.
- Two types are currently used: crash data recorders and journey data recorders.
- Crash data recorders fitted to trucks and vans lead to an average reduction of 20% in crashes and damage (Wouters & Bos, 2000).
- A study for the Netherlands estimated the benefits and cost ratios of journey data recorders as 20:1 (Langeveld & Schoon, 2004).
Anti-lock braking systems (ABS)

- ABS aim to prevent skidding where loss of steering and control result from locked wheels when braking hard.
- **ABS in cars** give a relatively small, but statistically significant reduction in the number of crashes.
- There are statistically significant decreases in collisions with pedestrians/cyclists/animals and collisions involving turning vehicles.
- ABS brakes in cars do not appear to have any effect on rear-end collisions.
- One study indicates that ABS in cars may not contribute to crash prevention at all (Cummings & Grossman, 2007).
- A German study concludes that in **93% of cases where the motorcyclist fell of the vehicles**, ABS would have avoided the crash or at least reduced the severity of the accident (Winkelbauer, 2006).
- Induced exposure analysis showed that the **overall effectiveness of ABS in motorcycles** was 38% for all injury crashes and 48% for severe and fatal crashes.
Emergency Brake Assist aims to address the problem of insufficient pressure being applied to the brake by drivers in emergency situations.

In marketing material, Daimler Chrysler indicate that for a car braking at 100km/h, Emergency Brake Assist can reduce the normal stopping distance by 45%.

There is no standard method to assess the safety performance of these devices, which makes it difficult to estimate their potential benefits.

A Swedish study of real-world pedestrian crashes found that the isolated effects of Emergency Brake Assist on pedestrian safety were not significant enough (Strandroth et al., 2011).
Collision Avoidance Systems

- The usefulness in addressing high-risk crash scenarios typical of most European roads as well as their feasibility has yet to be determined.
- Very large estimates of the safety potential of such systems have been claimed following laboratory studies.
- The range of technical and behavioural issues involved in many of the concepts require full on-road assessment.
These systems aim to **reduce the time between the occurrence of the crash and the provision of medical services**, and thus, to reduce the consequences of injury.

A **prospective Finnish study** estimated a reduce between 4-8% of road deaths and 5-10% of motor vehicle occupant deaths (Virtanen et al., 2006).

The overall impact of the system which involves additional players **has not been evaluated**.

The **American estimation** for the decrease in traffic accident fatalities based on field studies was smaller (2–3%) than in this study.

The EC believes that a **pan-European eCall** is estimated to potentially save up to 2,500 fatalities annually (Bouler, 2005).

The **benefits to cost ratios** of eCall in Finland have been found to be in the range of 0.5 (min estimate) to 2:3 (max estimate).
Conclusions

- Vehicle safety plays a **key role in the protection of all road users** and in the achievement of long term goals and targets.

- New in-vehicle technologies have the potential to **decrease crash injury risk**.

- However, they may also increase it through introducing new driver distraction and inadvertent behavioral change.

- While research has attempted to **record and classify ADAS by their impacts**, various problems need to be addressed in the assessment of both existing and new systems.

- It is not possible to predict **eventual casualty reduction** on the basis of experimental studies, field trials or simulators for most new systems.

- Naturalistic driving studies and the establishment of a **European in-depth crash injury database** are required to evaluate current measures and identify future problems and solutions.
Ευχαριστώ για την προσοχή σας!

Ερωτήσεις;

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