Lane keeping systems

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Important: *This document is an "abbreviated synopsis". The way it was drafted differs from the other synopses contained in the SafetyCube Decision Support System. In particular, given the absence of sufficient relevant peer reviewed scientific papers on this topic, the content of this abbreviated synopsis is not based on the typical literature review process applied within SafetyCube but predominantly on the knowledge and the expertise of the author(s).*

1 Summary

Jänsch, M., November 2017

1.1 COLOUR CODE: GREY

Some literature was found on Lane Departure Warning (LDW) systems, but no relevant literature evaluating the effect of Lane Keeping Assist (LKA) systems was found. The available literature mostly describes the benefit of LDW systems by identifying the target population (share of crashes that could have been addressed by a LDW system). Little is known however about the number of cases where LDW would have been effective.

1.2 KEYWORDS

Lane keeping, Lane departure warning, Lane keeping assist, LKA, LDW

1.3 ABSTRACT

Available literature was mostly found on Lane Departure Warning (LDW) systems while no relevant study was identified on the effect of Lane Keeping Assistants (LKA).
The available literature mostly describes the benefit of LDW systems by identifying the target population (share of crashes that could have been addressed by a LDW system). Little is known however about the number of cases where LDW would have been effective. It is questionable if LDW can restore the attention of a driver that has fallen asleep in time to avoid an unintentional lane departure.
Jermakian (2010) describes the crash avoidance potential of LDW by analysing crash data from two American databases maintained by NHTSA (NASS GES and FARS).Here the crashes where a LDW could have been effective were identified accounting for circumstances where LDW cannot work such as lane markings not available/not visible, loss of control before leaving the lane, low speeds under 40 mph (≈ 65 km/h) or intentional manoeuvres (avoidance manoeuvre). The analysis found that 4-6% of the single vehicle crashes had a potential to be avoided by LDW, 23-27% of head on crashes, and 22-29% of sideswipe crashes.
Kuasno et al. (2014) analysed the potential injury reduction in the U.S. vehicle fleet by LDW. The study simulated single vehicle crashes from the NASS-CDS 2012, taking into account driver reaction times to LDW signals which were found in literature. Crashes with prior loss of control or a medical condition (e.g. heart attack) were excluded when mentioned in the database. The study finds that LDW could prevent 28.9% of all road departure crashes, resulting in a 24.3% reduction in the number of seriously injured drivers (MAIS 3+; computed using injury risk curves)
Sternlund (2017) studied fatal lane departure crashes in Sweden in 2010 using the in-depth studies from the Swedish Transport Administration. The potential crash prevention of LDW was quantified by identifying the target population while also accounting for circumstances where LDW could not have been effective (loss of control prior to lane departure, intentional lane departure (evasive manoeuvre), already available rumble strips or excessive speeding). The target population where LDW systems may have been of benefit was identified to be 33 crashes from 100 analysed fatal head on and single vehicle crashes.
When looking at truck crashes, Hickman et al. (2014) conducted a retrospective cohort study comparing the reported crashes of trucks (>11.8 t), with and without LDW systems, from large carriers in the U.S. for the years 2007-2009. With the known mileage of all trucks in the cohort a

crash rate was calculated for trucks with and without LDW for relevant crash types (run off road, head on crash, sideswipe), accounting for exclusion criteria such as the result of an avoidance manoeuvre, turn signal was used, covered/missing lane markings or incapacitated drivers. Hickman found that for trucks, the non-LDW cohort had an LDW-related crash rate that was 1.9 times higher than the LDW cohort ($p = 0.001$).

1.4 BACKGROUND

1.4.1 What is Lane departure warning?

Lane keeping assist systems (LKA) and lane departure warning systems (LDW) are drivers' assistance systems for vehicles intended to prevent crashes which occur due to an unintentional lane departure. The systems do so by utilising cameras to detect the lane by its lane markings and road edge lines and warn the driver about a lane departure when no turn signal was used by an acoustic signal or by a haptic signal (e.g. vibrating steering wheel). LKA systems not only warn the driver but help the driver to stay in lane usually by actively applying torque to the steering wheel in to the opposite-direction thus LKA systems provide a higher level of assistance to the driver and the benefit is likely to be higher than that of a LDW.

1.4.2 How does LDW and LKA affect road safety?

In Germany Lane departure crashes account for 29% of German insurance claims between 2002 and 2006; In Sweden 77% of passenger car fatalities were due to head on and single vehicle crashes; in the US, lane departure crashes are one of the most common crash types accounting for 1.6 million road collisions per year. These crashes are addressed by LDW and LKA systems by informing the driver about an unintended lane departure and steering back into the lane to avoid an accident.

1.4.3 Which safety outcomes are affected by LDW and LKA?

Unintentional lane departures are a common cause of accidents. Often these lane departures occur because the driver of a vehicle is distracted or has fallen asleep while driving. In these cases LDW or LKA has the potential to avoid the accident by attempting to bring the attention of the driver back to the driving task

1.4.4 How is the effect of LDW and LKW studied?

Most studies on LDW investigate the population of crashes due to an unintended lane departure where such a system could have been effective. However little is known about the reasons for the unintended lane departure and in which cases an LDW system or a LKA system could have been effective.

2 Supporting document

2.1 METHODOLOGY

2.1.1 Literature search strategy

For the literature search the database Web of Science was used including articles and reports from various road safety journals and conference proceedings. The search was limited to article titles, abstracts, and keywords fields and filtered in order to acquire only recent articles published after the year 1990. Several combinations of keywords were used for the search (**Table 1**). The search resulted in 103 studies.

Table 1: number of hits generated in Web of science

search no.	search terms / operators / combined queries	Hits
#1	"Lane departure warning"	85
#2	LDW AND "driver assistance"	2
#3	"Lane keeping assist*"	16
#4	LKA AND "driver assistance"	1
#1 OR #2 OR #3 OR #4		**103**

The 103 studies which resulted from the search were screened by reviewing the titles and abstracts to identify potentially relevant studies which match the topic (**Table 2**). After screening, 8 studies remained which potentially refer to the LDW and LKA topic. One study was not freely available and 3 studies did not specifically refer to the measure and its effects of LDW and LKA. Thus 4 studies remained as eligible for this synopsis. The studies from Hickman et al. and Kusano et al. were found to be relevant for coding in the DSS.

Table 2: total number of elligible studies

Total number of studies screened (title and abstract)	103
Potentially relevant studies after screening	8
Eligible papers after reading	**4**

Eligible Studies from literature search:

Hickman, J., Guo, F., Camden, M., Hanowski, R., Medina, A., Mabry, J. (2014) "Efficacy of roll stability control and lane departure warning systems using carrier-collected data" Journal of Safety Research 52 (2015) 59–63

Jermakian, J.: "Crash avoidance potential of four passenger vehicle technologies." Accident Analysis and Prevention 43 (2011) 732–740.

Kristofer Kusano, Thomas I. Gorman, Rini Sherony & Hampton C. Gabler (2014) Potential Occupant Injury Reduction in the U.S. Vehicle Fleet for Lane Departure Warning–Equipped Vehicles in Single-Vehicle Crashes, Traffic Injury Prevention, 15:sup1, S157-S164, DOI: 10.1080/15389588.2014.922684

Simon Sternlund (2017) The safety potential of lane departure warning systems—A descriptive real-world study of fatal lane departure passenger car crashes in Sweden, Traffic Injury Prevention, 18:sup1, S18-S23, DOI: 10.1080/15389588.2017.1313413