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Crash avoidance and driver assistance technologies – Are they used?

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ABSTRACT

Crash avoidance technologies have potential to mitigate collisions, and actual crash reductions have been identified for some systems. This study measured observed on-off rates of these technologies as an indicator of use, with a focus on lane maintenance systems (i.e., designed to keep vehicles within lanes by warning, braking, and/or steering) and studied factors that might increase their acceptance and use. Vehicles from nine manufacturers fitted with lane maintenance systems were observed at service departments during 2016. Systems were turned on in 51% of 983 vehicles. The activation rate was higher for systems with braking/steering interventions and vibrating warnings and decreased with total mileage. Large proportions of front crash prevention (93%), blind spot monitoring (99%), rear cross-traffic alert (97%), and driver monitoring alert (90%) systems were enabled, and most optional settings were set to factory defaults. Owner surveys linked to observations showed that drivers who had lane maintenance systems turned off believed warnings were distracting and unnecessary compared with drivers whose systems were on.

1. Introduction

Research has identified significant potential for crash avoidance technologies. For example, Jermakian (2011) estimated that forward collision warning had the potential to address 70% of all police-reported front-to-rear crashes and 48% of fatal front-to-rear crashes. Lane departure warning would be relevant to a 6% of single-vehicle, 27% of head-on, and 27% of sideswipe crashes of all severities, and higher proportions of these crash types involving fatalities (31%, 46%, and 35%, respectively).

Forward collision warning, automatic emergency braking, and lane departure warning technologies have been represented in the vehicle fleet long enough to permit analyses to assess whether the systems reduce crashes. The Highway Data Loss Institute (HLDI) has compared claims experiences for the same make-model vehicles with and without a technology. Beginning in 2011, HLDI reported significant reductions in insurance claim rates for early implementations of forward collision warning, with and without automatic emergency braking, and continues to find consistently lower rates of insurance claims for vehicles with front crash prevention across manufacturers (HLDI, 2012, 2015, 2016a, 2016b, 2016c, 2016d) when compared with vehicles that do not have the systems. The reductions have been particularly robust for property damage liability claims, which cover damage to other vehicles or property caused by an at-fault vehicle and would be expected to be reduced by effective front crash prevention systems.

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A limitation of insurance claims analyses is that details of the claims do not provide confirmation that the crash scenarios associated with the claims are relevant to a technology (for example, rear-end crashes for front crash prevention). However, research that used state crash databases, which contain more detailed information on crash circumstances than insurance data, found that rear-end striking crash rates for vehicles with forward collision warning or forward collision warning with automatic emergency braking were 27% and 50% lower, respectively, than among the same vehicle models without front crash prevention (Cicchino, 2017a). It is becoming increasingly clear that, while not 100% effective, vehicles with front crash prevention systems are crashing at lower rates than vehicles without them.

In contrast to front crash prevention, lane departure warning systems have not been linked with consistent crash reductions. Analyses of insurance data have not found benefits for the system (HLDI, 2012, 2015, 2016a, 2016b, 2016d, 2016e). However, Cicchino (2017b) reported a reduction in police-reported single-vehicle, sideswipe, and head-on crashes in vehicles equipped with lane departure warning, and a Swedish study found that lane departure warning reduced single-vehicle and head-on injury crashes under certain conditions among of Volvo vehicles (Sternlund, Strandroth, Rizzi, Lie, & Tingvall, 2017).

The effectiveness of collision avoidance technologies depends in part upon their activation. Surveys of drivers with systems have found that a lower percentage of owners report driving with lane departure warning turned on all the time than forward collision warning, and a higher percentage indicate that lane departure alerts are more annoying than forward collision alerts (Braitman, McCartt, Zuby, & Singer, 2010; Cicchino & McCartt, 2015; Eichelberger & McCartt, 2014, 2016).

Part of the annoyance may be due to physical characteristics of the alert. A laboratory study by Edworthy, Loxley, and Dennis (1991) demonstrated that temporal and acoustical patterns of auditory warnings affect perceived urgency of the signal. Marshall, Lee, and Austria (2007) found increases in perceived urgency of simulated in-vehicle alerts were associated with increased annoyance, although the association between ratings of annoyance with and suitability of the alert increased when urgent alerts sounded with low-risk driving scenarios. Stanley's (2006) simulator work with lane departure warnings showed that auditory warnings were found more annoying than vibratory warnings, although drivers indicated a preference for an alert that combined both.

The functional aspects of current lane departure warning systems may also contribute to false or unnecessary alerts that decrease acceptance. For example, the systems rely on cameras to detect lane lines; when lanes are detected and a lane drift occurs, the system determines the drift was unintended based partly on the absence of turn-signal use. An observational study of turn-signal use suggests that many drivers change lanes without using turn signals (Ponziani, 2012). Drivers who knowingly change lanes without using a signal may deem warnings issued in such instances as false alarms, despite the system functioning as designed. Drivers may intentionally deviate from a lane for other reasons, which could lead to an unnecessary alert. A separate functional issue is that camera sensors at times misidentify lane lines (for example, in construction zones where lanes have shifted) or fail to identify lanes at times. Self-report data (Eichelberger & McCartt, 2014, 2016) indicate that 40% and 27% of owners of Volvo and Toyota models, respectively, have experienced such unnecessary alerts, whereas 17% and 25% of owners of these respective brands reported that the systems had failed to warn them, for example, when lane lines were faded. Finally, research has identified considerable performance differences in lane departure warning systems across the vehicle fleet; for example, Brown, Reimer, Mehler, and Dobres (2015) conducted an on-road comparison of two vehicles and found differences in alert frequencies and drivers' steering responses following alerts.

Ghazizadeh, Lee, and Boyle's (2012) automation acceptance model is a relatively recent addition to an extensive body of research (e.g., Lee & Moray, 1992; Lee & See, 2004; Parasuraman & Riley, 1997; Venkatesh & Davis, 2000) about factors that affect use and acceptance of technology. Ghazizadeh et al. (2012) integrate trust in automation with perceived usefulness and ease of use as factors that largely determine user acceptance. Salient false or nuisance alerts that poorly correspond with the situation's true urgency could increase annoyance and may decrease future use by lowering trust and perceived usefulness of the system. This may lead to complacency about warnings or disuse of the systems (Lee & See, 2004; Parasuraman & Riley, 1997). Additionally, systems that differ only in the perceived annoyance of the warning (e.g., vibration versus beeping) may also affect acceptance as experience with the system increases (Ghazizadeh et al., 2012; Venkatesh & Davis, 2000).

Two prior studies have collected objective evidence of drivers' use of lane departure warning and forward collision warning. Flannagan et al. (2016) collected on-road data on approximately 2000 General Motors (GM) production vehicles equipped with lane departure warning and forward collision warning that were driven 19 million miles by their owners over one year. Lane departure warning was turned on during about 50% of driving time, and systems that warned by vibrating the driver seat were more likely to be turned on than those that warned by a series of beeps. Forward collision warning was turned on 91% of the time. Reagan and McCartt (2016) conducted a small pilot study where the on-off status of these systems on Honda models was observed when equipped vehicles arrived for service at dealership service centers. Only one-third of Honda vehicles equipped with lane departure warning had the system turned on, whereas 99.5% of vehicles had forward collision warning turned on. The current study expands efforts to measure driver disuse of lane maintenance systems across several manufacturers to identify characteristics associated with increased use and driver acceptance.

For the current study, observations of the on-off status of lane maintenance systems installed in Cadillac, Chevrolet, Ford, Honda, Lexus, Lincoln, Mazda, Toyota, and Volvo vehicles were conducted at 14 dealerships in the Washington, DC, metro area to record one-time point measurements of the on-off status to provide insight on the degree of disuse of the technologies. The term 'lane maintenance systems' refers collectively to systems designed to avoid crashes caused by lane drifts and includes lane departure warning systems, lane departure prevention systems that provide steering or braking at the point of a lane drift, and active lane-keeping systems that provide more continuous steering input designed to keep the vehicle