MOBILEYE®

Our Vision. Your Safety.™

MOBILEYE C2-270 COLLISION PREVENTION SYSTEM

Effectiveness Report 2010

Executive Summary:

We have assessed the effectiveness of three functions of the Mobileye C2-270™ Collision Prevention System. The following is an executive summary of the findings:

1. **Forward Collision Warning (FCW):**

The FCW function is designed to alert the driver with visual and audio warnings up to 2.7 seconds before an imminent collision. The median driver braking time is .66 seconds[1], so FCW gives the driver up to 2 seconds to recognize the obstacle before he breaks. Our research shows that the driver's reaction time is on average between 0.6-0.65 seconds[2], so most drivers rarely require the full 2 seconds of reaction time. In this way, the FCW is extremely effective at reducing collisions, and, according to a study by the U.S. Insurance Institute for Highway Safety (IIHS), it will help prevent up to 74% of all police-reported rear-end crashes[3].

2. **Lane Departure Warning (LDW):**

The LDW function anticipates an unintentional lane change, and gives the driver visual and audio warnings up to .5 seconds before the unintentional lane change occurs. The IIHS estimates that unintentional lane departures account for 7,500 fatal collisions a year in the U.S., and rumble strip estimates and private fleet research indicates that LDW is more than twice as effective as rumble strips at preventing lane deviation (25-30% reduction rate[4] for rumble strips, vs an LDW rate of 65%[5]).

3. **Pedestrian and Bicycle Collision Warning (PCW):**

PCW, Mobileye's newest function, gives the driver a visual and audio warning up to 2 seconds before an imminent collision with a pedestrian or a bicycle. Almost half of those who die on the world's roads every year are "vulnerable road users" – pedestrians, cyclists, and motorized two-wheeler users – since the impact of collision on these unprotected road users is much higher than for automobile users[6]. With the average driver braking time of .66 seconds[7], drivers have up to 1.4 seconds of additional reaction

time. IIHS research shows that this technology can help reduce annual pedestrian collisions by 80,000, and fatal pedestrian collisions by 4,745 in the United States[8].

Rear-end Collisions: Forward Collision Warning (FCW)

Rear-end collisions account for 30% of all US road crashes[9]- in others words, 1.2 million crashes per year, of which 66,000 result in serious or moderate injuries, and 879 are fatal[10]**. Eighty-eight percent of rear-end collisions are due to driver inattention** in the three seconds before the collision, and, according to a Daimler survey, **in 50% of rear-end collisions, drivers say they didn't even have time to brake[11]**. To prevent a collision, a collision prevention system needs to give the driver both the response time to discern the obstacle, and time to physically decelerate the car[12]. **With the forward collision warning (FCW), the Mobileye C2-270™ Collision Prevention System can help prevent many of these collisions by providing a critical warning time of up to 2.7 seconds before an imminent collision**.

Analysis:

The FCW application uses monocular image processing to predict an impending rear-end collision. It issues a warning up to 2.7 seconds before a collision by calculating time to collision (TTC) with the vehicle ahead, taking into account the distance from the vehicle ahead and both vehicles' traveling speeds. The system also takes into account the lateral position of the target vehicle, thus ruling out unnecessary warnings. It operates in daylight, at night, and under a variety of weather conditions, and it will issue a low-visibility notice in cases of poor visibility, such as heavy rain or dense fog.

Whether they are alert or distracted, FCW gives drivers additional time for motorists to recognize the vehicle or motorcycle being approached. By calculating the TTC with the car ahead, the system gives the driver up to 2.7 seconds before an imminent crash to discern the obstacle and attempt to break the vehicle. Therefore, besides the time the driver needs to physically brake the car, **FCW gives the driver up to two seconds of critical time to recognize the automobile in front of him so that he can brake to avoid it**.

Several studies show the following:

- The average driver takes 0.66 seconds to apply the brakes[13]
- Drivers have a median perception-brake reaction time of between 0.6 and 0.65 seconds[14]
- According to a Daimler-Benz study, an extra .5 seconds before an imminent crash would prevent 60% of rear-end crashes, and an extra 1.5 seconds would prevent 90% of rear-end crashes[15]

Obviously circumstances may prevent the driver from receiving the full 2.7 seconds, but with the median reaction time for a distracted driver being between 0.6-0.65 seconds, and average brake time measured at only .66 seconds, the driver often needs less than 2.7 seconds to avoid the collision.

This was proven in a study on collision prevention system effectiveness, which also measured the effectiveness of Mobileye systems. The study, performed by a Dutch governmental organization on Dutch fleets, led to the conclusion that all trucks with the FCW function were able to brake the car and avoid the collision within less than the time provided by the warning. In rare cases, the warning would allow for reduction in collision severity, even if the collision was not avoided[16].

While this indirectly proves Mobileye's effectiveness through logic and testing, some data is available about statistical reduction in actual road traffic collisions. A U.S. National Highway Traffic Safety Administration (NHTSA) study shows that according to countermeasure effectiveness modeling, **FCW will help prevent up to 74% of police-reported rear-end collisions**. [17]

Additionally, in a recent survey by the Insurance Institute for Highway Safety, drivers were pleased with FCW performance, reporting increased alertness, lane-keeping, and following distance. Despite some nuisance warnings, the majority of those surveyed reported reduced workload and improved driving[18]. In fact, a NHTSA survey of FCW users showed that 50% of drivers reported following the preceding car less closely after using FCW.[19]

Conclusion:

The FCW feature of the Mobileye C2-270 Collision Prevention System™ is effective at helping reduce rear-end collisions and promote better driving habits. According to median perception and brake-time data, a warning of up to 2.7 seconds is, in most cases, ample time for drivers to recognize the obstacle in front of them and decelerate the vehicle. In our estimate, FCW reduces rear-end collisions by up to 74% and influences drivers to follow the preceding car less closely.

Lane Deviation: Lane Departure Warning (LDW):

According to a study by the U.S. Department of Transportation, **60% of road fatalities are caused by unintentional lane departure**[20]. Many of these take place when drivers engage in long drives or country driving[21], as **fatigue is a key factor in unintentional lane departure**.

Fatigue, even in its earliest stages, can make it difficult for drivers to stay in their lanes, and consequently, a **collision is 2.5 times more likely to occur because of fatigue than for any other reason**[22]. Additionally, text-messaging while driving results in lane deviation due to the significantly increased time spent looking away from the road[23].

Mobileye's Lane Departure Warning (LDW) **can help avoid many of these collisions by anticipating unintentional lane departures**.

Analysis:

The LDW application uses complex monocular image processing algorithms to detect lane markings on the road, and to measure the position of the vehicle on the road relative to these markings. Operating on all vehicle types on all roads, the system provides indications of unintentional lane departures using a three-parameter road model that accounts for lateral position, slope and curvature. The application can detect various types of lane markings, such as solid lines, dashed lines, and others, and in the absence of lane markings, LDW recognizes road edges and curves.

The LDW application incorporates an advance warning scheme that, based on lateral vehicle motion, predicts the time to lane crossing and issues a warning signal before the vehicle crosses the lane. The device functions at speeds above 55 kilometers per hour and its sensitivity can be adjusted by the user. LDW also detects upcoming curves and adapts warning tolerance accordingly. The **visual and audio warnings are given up to half a second before an unintentional lane departure occurs**, giving the driver time to reposition the vehicle.

The Insurance Institute for Highway Safety (IIHS) estimates that **179,000 U.S. crashes and 7,500 fatal crashes per year may be prevented by LDW technology**. This figure represents the highest amount of fatal crashes relevant to any crash avoidance technology[24].

Several studies show the following:

- LDW is estimated to be capable of eliminating 60% of side collisions and 25% of roadway departure accidents[25].
- Other research has shown a 65% reduction in all lane-departure related collisions in a test conducted with 1000 trucks equipped with LDW technology[26].

Regarding lane deviation prevention, **user response to rumble strips can be very useful in determining effectiveness for LDW technology**. Though both methods warn drivers if they inadvertently deviate from their lane, LDW has significant advantages over rumble strips, such as a more timely warning and a more constant presence. Research shows that rumble strips may prevent 25-30% of lane departure-related accidents, corresponding to up to 54,000 crashes per year[27]. It also shows that Mobileye's LDW feature, with its considerable advantages over rumble strips, **will prevent collisions with an effectiveness rating approaching 65%.**

Additionally, according to the IIHS, 81% of surveyed drivers said that they believed LDW "made them a better driver"[28].

Conclusion:

By anticipating an unintentional lane departure and issuing a warning up to .5 seconds before it occurs, the LDW function gives the driver additional time to avoid a collision. Mobileye's LDW technology **can produce results surpassing the 25-30% effectiveness rating of rumble strips by far,** due to increased effectiveness and timeliness, in a crash category presenting higher fatality rates than any other.

Pedestrian and Bicycle Detection: Pedestrian Collision Warning (PCW)

Almost half of those who die in road traffic collisions are pedestrians, cyclists, or users of motorized two-wheelers, collectively called "vulnerable road users"[29].

Most of the thought put into road construction is centered on allowing automobiles to drive faster, while **infrastructure for pedestrians and bicyclists oftentimes is ignored**, and consequently the risks for this group of road users are severely higher than for drivers and other road users[30].

The chances for survival after a collision for this group of vulnerable road users is significantly less than for any other group of road users. In fact, the chances of survival for a pedestrian involved in a collision at speeds of about 30 km/h are equivalent to those for a motor vehicle occupant in a stationary vehicle hit by another vehicle traveling at 70 km/h for head-on crashes[31]. The rate of pedestrian fatality when hit at 60kmh or higher is 100%[32].

To minimize these collisions, Mobileye has applied its obstacle detection technology to pedestrians and bicyclists. **Giving the driver a critical two-second warning gives drivers the braking time they need**, **and up to 1.4 seconds of additional time to avoid the pedestrian.**

Analysis:

Mobileye's pedestrian protection application uses inputs from a forward looking single camera to detect and track pedestrians, and to identify potential collisions. The application measures target range, angular position, and lateral velocity, and then calculates the host vehicle's path. The software then **determines whether the pedestrian, stationary or moving, is in a collision path with the vehicle, and issues audio and visual warnings up to two seconds before an impending collision**. In cases where there are groups of people, the application issues a "crowd warning" signal, notifying the driver to use extra caution.

This function, like Mobileye's FCW function, is **mainly meant to compensate for driver inattention**. The **key determinant in this involves allowing the driver enough time to brake and avoid the passenger**, and if this can't be avoided, to dramatically slow down the car below the critical speed of 30 km/h.

The additional two seconds of critical time before an impending collision **allows for sufficient reaction time under even the most distracting conditions**[33]. Consequently, the IIHS predicts that this type of technology, when compared with only automotive detection abilities, would **prevent or mitigate up to 80,000 nonfatal moderate and serious injury crashes, and 4,754 fatal crashes**[34].

Conclusions:

Mobileye's Pedestrian Collision Warning **provides two additional critical seconds, and gives the driver time to brake** and attempt to avoid a pedestrian collision. This addition to forward crash warning technology promises to expand the collision prevent potential of Mobileye's aftermarket system considerably. The Mobileye C2-270 Collision Prevention System™ is also the first aftermarket driver assistance system with such a wide array of functions, and the first to bring pedestrian detection capabilities to the aftermarket.

Conclusion:

The purpose of this report was to demonstrate the effectiveness of the Mobileye C2-270 Collision Prevention System™. Breaking down the device by function, we displayed the different ways each part of the system was effective at reducing traffic collisions and promoting safer driving.

By issuing audio and visual warnings up to 2.7 seconds before a potential collision, the FCW function was proven effective at reducing rear-end crashes with other automobiles. By giving the driver additional time to recognize the obstacle and attempt to brake the vehicle, the function is said to be able to reduce rear-end collisions by almost three-quarters. Additionally, the function is effective in promoting safer driving, as almost half of the surveyed drivers who used FCW reported following the car in front of them less closely with this technology.

The LDW function proved very effective at fighting fatigue and driver inattention by reducing unintentional lane departure collisions. The warning up to .5 seconds before the driver inadvertently departs the lane acts similarly to rumble strips, and so the data was comparable for effectiveness. Using this information, along with fleet tests done with 1000 trucks, we determined that nearly 65% of collisions tied to inadvertent lane departure could be mitigated with LDW. LDW also proved effective at promoting better driving habits, as a survey from the IIHS reported that 81% of users thought LDW made them a better driver.

Not much data has been tested to provide a conclusive effectiveness estimate on the PCW, as the technology is brand new. However, estimates of this technology, which provides the driver with a 2 second warning preceding a collision with a pedestrian or bicycle, say that PCW may reduce 80,000 pedestrian collisions, as well as 4,754 fatal collisions. Thus, the technology has extraordinary potential to be effective.

Overall, the Mobileye C2-270™ helps to make significant reductions in the amount of rear-end, lane departure, and pedestrian collisions. It also promotes better driving habits, which will further prevent collisions by creating a safer environment for driving. The system is thus effective at reducing collisions, and makes the driving experience much safer.

[1] ISO- 15623 for FCW Systems
[2] National Highway Traffic Safety Administration (NHTSA), Crash Warning System Interfaces, Human Factors Insights and Lessons Learned, Final Report, Jan. 2007 (http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/2007/CWS_HF_Insights_Task_5_Final_Rpt.pdf)

[3] NHTSA, Automotive Collision Avoidance Report (ACAS) program

[4] IIHS- Crash Avoidance Potential of Four Passenger Vehicle Technologies

[5] Fleetowner.com, "Flatbed Fleet cuts accidents with Safety System", 2006. http://fleetowner.com/news/maverick_usa_lane_departure_warning_safety_systems_071706/

[6] World Health Organization (WHO), Global Status Report on Road Safety, 2009
[7] Crash Warning System Interfaces, Human Factors Insights and Lessons Learned, Final Report
[8] IIHS
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[11] Daimler Technology Report, Oct 2008
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[14] NHTSA, ACAS program
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[21] www.rsconference.com, "Acceptability of In-Vehicle Intelligent Transport Systems to Victorian Car Drivers", 2002
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[28] US Department of Transportation
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[32] NTUA: A Comprehensive Cross-Referencing Lookup Table of Available Technologies and their Safety Impact and Potential (http://www.noehumanist.org/documents/Deliverables/TFB/B-5-HUMANIST_NTUA_deliverable_VA1.pdf)
[33] NHTSA, ACAS Program
[34] www.fleetowner.com