# Mobileye AWS

# Accident Prevention and Mitigation System Effectiveness Report

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# MOBILEYE® AWS™ – ADVANCE WARNING SYSTEM FOR THE AUTOMOTIVE AFTERMARKET

## *Executive Summary*

This document provides the reader with supporting evidence that demonstrate Mobileye AWS advantages over its competitors in road accident prevention, based on its encompassing range of driver alert types.

It starts by a general overview of road accident facts and statistics, the heavy burden road accidents pose on society in terms of public health and in damage to economies.

It then presents a groundbreaking result by VTTI & NHTSA's 100-car naturalistic driving study from 2006, demonstrating how driver inattention contributes to nearly 80 percent of all accidents. This new finding makes clear that although much has been done so far in the field of accident prevention, the main problem, which is driver inattention, has not been addressed sufficiently.

The document then presents the Advance Warning System (AWS™) – Mobileye's aftermarket product, designed to supply a comprehensive solution for reducing driver inattention in the critical seconds before an accident. It describes the general principles on which its technology is based, and presents its combination of alert types. It continues to quote estimates recently made by *Frost & Sullivan*, noting the clear advantages of Mobileye AWS over all other driver assistance systems, and nominating it as the leading product of its kind. F&S highlight Mobileye's technology (the heart of AWS) - a technology that is highly accredited worldwide for its selection by the most esteemed automotive OEMs for their production lines. One such OEM is BMW, recently introducing Mobileye's Lane Departure Warning technology in its new 5-Series.

The last part of the document describes Mobileye AWS' position in the forefront of the fast-growing active safety market, which is expected to be one of the two leading market trends in the automotive industry in the foreseeable future.

# ROAD ACCIDENT FACTS AND STATISTICS

According to the World Health Organization, road accidents are the second cause of death globally among people aged between five and 29, and the third cause of death among people between ages 30 and 44.

Reducing the number of road accidents is a major concern of governments all over the world, and defined as a main target also by the World Health Organization.

- There are 1.2 M fatalities yearly worldwide due to road accidents - **3242 people a day!**[1]
- According to the World Health Organization, road accident fatalities worldwide are expected to **rise by 67%** by the year 2020[1]
- As much as 50 million people are injured each year in road accidents[1]

- Financial damages of road accidents are ~2% of world GDP[1]
- In the US, there are approximately 6.4 million police-reported accidents, and over 16 million including those that are not reported. Road accidents cost the US economy over $230 billion; averaging over $38,000 per accident[2]
- From NHTSA: "…deaths and injuries resulting from motor vehicle crashes are the leading cause of death for persons of every age from 2 through 33 years old."[3]
- In 2007 41,059 people were killed and 2.5 million were injured in the USA[4]
- Every year more than 40.000 people die and over one million are injured in road crashes in the EU[5]

# DRIVER INATTENTION – THE MAIN CAUSE OF ROAD ACCIDENTS

A 1997 study by the National Highway Traffic Safety Administration[6] has shown that in 99 percent (!) of all investigated crashes, driver behavior or driver error either caused or contributed to the accident (including driver inattention, speeding, alcohol impairment, perceptual errors, decision errors, and incapacitation).

A later study, also by NHTSA, estimated the impact of driver inattention on accidents to be a leading cause in 25 percent of all accidents[7].

However, the real proportions of driver inattention and its impact on road accidents was recently discovered to be, in fact, much higher.

The *100-Car Naturalistic Driving Study*, whose findings were released by the Virginia Tech Transportation Institute and NHTSA in April 20th, 2006 introduced groundbreaking results, stating that **nearly 80 percent of all road accidents involve an event of driver inattention in the 3 seconds before the accident**.

This has made clear that the main cause of road accidents has been so far greatly underestimated.

Examples from the 100-cars naturalistic study of types of driver inattention, and the rate by which they increase the risk of an accident are:

- Talking on a cell phone (increases risk by 30%)
- Dialing a cell phone (increases risk by 300%)

[1] World Health Organization - http://www.who.int/mediacentre/news/releases/2004/pr24/en/

[2] NHTSA - National Highway Transportation Safety Administration

[3] NHTSA - DOT HS 809 612 – Traffic Safety Facts 2002

[4] NHTSA - Annual Report 2007

[5] Europe Magazine – European Union 2007 http://www.deljpn.ec.europa.eu/home/news_en_newsobj2211.php

[6] NHTSA - The Relative Frequency of Unsafe Driving Acts in Serious Traffic Crashes

[7] NHTSA Driver Distraction Research: Past, Present, and Future (July 5, 2000)

- Drowsiness (increases risk by 400% and responsible for ~23% of all crashes and near-crashes)
- Reaching for moving objects, like a falling cup (increases risk by 900%)
- Eating and drinking was associated with a 57% increase in the odds of being involved in a car crash[8]

Also:

- "**One in every five vehicle accidents in Germany is caused by drowsiness at the wheel**… momentary drowsiness or inattentiveness is responsible for **one in every four accidents on German motorways**… In the United States, **as many as 40 percent of highway accidents are due to drowsiness at the wheel**… The economic loss that such vehicle accidents cause each year is estimated at 5 billion euros ($6.4 billion) in Germany alone.[9]".

- In the EU, the country with the highest number of car accidents and fatalities is Italy followed by Poland. The UK also has a relatively high rate as compared to other EU countries. Around 10,000 car accidents occur in the UK each day, and most of these are the result of a mistake on the driver's part[10]
- "In a study done at Volkswagen, an analysis of the pre-crash braking behavior shows that **in severe accidents about 85% of drivers either did not brake at all or not to the full possible deceleration.**"[11]
- A University of Adelaide study showed that in **29% of cases the driver did not attempt to brake at all** before the accident [12] either because they were not aware of the danger at all, or had insufficient time to react.

*Mobileye AWS is aimed to prevent road accidents by reducing their main cause: **driver inattention**. The uniqueness of Mobileye AWS lies in its ability to alert an inattentive driver in the widest range of dangerous road situations, by providing a combination of **three** different alert types (Forward Collision Warning, Lane Departure Warning, and Headway Monitoring and Warning) in one system.*

# PREVENTING ROAD ACCIDENTS

The concept of passenger safety is one a main emphasis by automotive OEMs in recent years, causing continuous development, and massive OEM investment in both active safety (improved visibility from driver's seat, low noise level in interior, legibility of instrumentation and warning symbols, good chassis balance and handling, good grip, ABS braking, ESP Chassis assist, all wheel drive, secure luggage and passengers, etc.), and in passive safety, for minimization of outcome (passenger safety cell, deformation zones, seat

[8] AAA Foundation for Traffic Safety www.aaafoundation.org

[9] http://www.siemensvdo.com/press/releases/commercialvehicles/2006/sv-200609-005-en.htm

[10] Database – Cars Articles, Statistics from Around the World 2008

[11] Final Report of the eSafety Working Group on Road Safety – November 2002

[12] http://casr.adelaide.edu.au/speed/vol-1.html

belts, load-space barrier-nets, air-bags, laminated glass, correctly positioned fuel tanks, fuel pump kill switches etc.).

However, currently, the major focus worldwide in accident prevention is increasingly turning towards the development and application of new technologies that will reduce driver inattention, and enable them to avoid an impending accident. Reducing driver inattention using driver assistance technologies is targeted both by NHTSA in its regulatory priorities for 2005-2009[13],and by the European Committee of the European Union through the eSafety initiative and its PReVENT project[14].

In the NHTSA-Virginia Tech study, researchers fitted 100 cars with video cameras and sensors and monitored drivers' behaviors for more than a year. The results showed that in 78% of wrecks, the driver had taken his eyes of the road within 3 seconds before the wreck occurred[15]

**Forward Collision and Lane Departure accidents are key**

- Run Off Road accidents account for nearly 20% of road accidents and are responsible for **60% of all road accident fatalities**[16].
- Rear-end collision accidents account for about **28% of road accidents**[17]

**FCWS – Forward Collision Warning Systems**

- A study by Daimler Benz shows that an extra 0.5 second early warning can prevent 60% of rear-end accidents, and 1.5 seconds will prevent 90% of them[18].
- 85% reduction in accidents was achieved using FCW and ACC systems [19]
  - Tested in 8 vehicle fleets (1,900 vehicles) over 3 years
- FCW systems in fleets have shown empirical success [12] in reducing:
  - All accidents by 73%
  - Fixed-object crashes by 81%,
  - Rear End accidents (in one fleet) by 100% (!)
- ROI Testing for Collision Warning Systems done by the US Army:

  **"…U.S. Army Testing.** In 1995, the U.S. Army tested a CWS on six convoy vehicles traveling throughout the United States and nine heavy vehicles in Texas to demonstrate and evaluate the use of commercial technologies on military vehicles. The convoy data were analyzed, and the CWS facilitated in avoiding 10 accidents in the 15,000 miles of convoy driving…. The CWS improved the safety of the convoy, and a **positive payback (benefits [reduction in accidents]**

[13] www.nhtsa.gov/cars/rules/rulings/PriorityPlan-2005.html

[14] http://www.prevent-ip.org/en/about_preventive_safety/european_context/

[15] NHTSA – Virginia Tech Transportation Institute Study

[16] Road Safety Fact Sheet - FHWA Safety (2003)

[17] http://www.its.dot.gov/ivi/3DC.html

[18] D.R. Ankrum, "Smart Vehicles, Smart Roads," Traffic Safety 92(3) (1992): 6-9

[19] www.roadranger.com

**exceeded costs)** was identified for truck applications. **The study recommended that the CWS should be installed on all new Army truck procurements and on major rebuilds."**[20]

*Mobileye AWS provides a Forward Collision Warning to the driver **2.7 seconds on average before colliding with the vehicle ahead**. The average driver takes 0.66 seconds to press the brakes [21].Thus, on average, the AWS enables the driver a critical **2 seconds of actual braking!***

**LDWS – Lane Departure Warning Systems, and Rumble Strips**

- *Maverick Transportation* reported a 65% decrease in all lane-departure-related crashes using vision-based LDW systems in its trucks [22]
  - Tested on 1000 trucks driving 110 million miles over 2 years
- "A New York study showed…on the New York State Thruway. ROR crashes were reduced 88 percent, from a high of 588 crashes in 1993 to 74 in 1997. Total injuries were reduced 87 percent, from a 1992 high of 407 to 54 in 1997. Fatalities were reduced 95 percent, from 17 in 1991 and 1992 to 1 fatality in 1997." [5]
- "After Delaware DOT installed centerline rumble strips on U.S. Route 301--a two-lane, undivided rural highway with a high fatality rate--the head-on collision rate decreased 90 percent, and fatalities decreased to zero. These dramatic safety improvements were achieved despite a 30 percent increase in traffic." [23]

*Mobileye AWS provides an intelligent Lane Departure Warning that anticipates an unintentional crossing of a lane in 0.5 seconds, thus providing the driver longer time to respond than actual rumble strips on the road shoulders would do. Also, with Mobileye LDW, the vehicle takes its virtual rumble strips wherever it goes.*

# MOBILEYE AWS – GENERAL PRINCIPLES OF OPERATION

The *Mobileye™ AWS* (Advance Warning System) is a driver assistance system for accident prevention and accident mitigation. AWS is based on a camera located on the vehicle's front windshield that watches the road ahead. The AWS utilizes advanced vision technologies for:

- **Lane detection and road curvature calculation** – the AWS detects and measures lane position relative to the vehicle and provides distance to lane marks, detection of lane crossing including lane crossing prediction (by calculating Time to Lane Crossing - TLC) for earlier warnings than received from actual rumble-strips.

[20] http://www.ntsb.gov/Publictn/2001/SIR0101.pdf

[21] ISO-15623 for FCW Systems

[22] http://fleetowner.com/news/maverick_usa_lane_departure_warning_safety_systems_071706/

[23] Rumble Strips - Corporate Research & Technology - FHWA

- **Vehicle detection** – the AWS detects vehicles ahead, and measures their distance, azimuth, relative speed and Time To Contact (TTC). The AWS uses these calculations for providing continuous headway and potential collision related information. The road curvature calculation provided by the lane detection capability enables to identify which of the vehicles ahead is in the same lane as the "host vehicle"

***Mobileye AWS – warnings overview***

Its detecting of vehicles and lanes markings allows Mobileye AWS to provide the driver with:

- **Forward Collision Warning (FCW)** – alerting the driver of an impending collision with the vehicle ahead (up to 2.7 seconds before collision occurs)
- **Lane Departure Warning (LDW)** – acting as "audible rumble strips", LDW produces a rumble sound up to 0.5 seconds *before* unintentionally departing from the lane or the road altogether
- **Headway Monitoring and Warning (HMW)** – enables continuous monitoring of the driving distance (headway) kept from the vehicle ahead, and warns the driver when headway decreases to a dangerous level

These features correspond with the leading types of road accidents:

- Rear-end accidents caused by driver inattention
- Lane departure, and Run Off Road (ROR) accidents
- Rear-end accident caused by insufficient distance keeping

- FCW (Forward Collision Warning) - A Forward Collision Warning alerts the driver of an upcoming rear-end collision with the vehicle ahead. The AWS calculates the Time To Contact (TTC) from the car ahead, and identifies an imminent collision scenario with the vehicle ahead generating an FCW alert. The issued FCW alert continues as long as the dangerous condition persists; until the driver reacts by pressing the brakes or by steering away from the vehicle ahead. Studies conducted for the National Highway Traffic Safety Administration demonstrate a direct relationship between driver inattention and automobile accidents. Just glancing away from the roadway for more than two seconds can increase your risk of a crash. AWS generates an FCW alert approximately 2.7 seconds on average before imminent collision with the vehicle ahead.

*Rear-End accidents account for approximately 28% of all accidents*

- LDW (Lane Departure Warning) – the AWS produces a Lane Departure Warning when it detects an unintended deviation of the vehicle towards the lane boundary/marking. It then generates an LDW Audio and Visual alert approximately 0.5 seconds before the crossing the lane marking (only if the respective turn signal is not turned on).

*Lane Departure accidents account for 60% of all road accident fatalities!*

- HMW (Headway Monitoring and Warning) – Research has shown that drivers have difficulty in estimating safe headway. HMW assists the driver in keeping a safe driving distance from the vehicle in front, reducing a priori the chances of a rear-end accident. The AWS Headway Monitoring feature helps the driver acquire better driving habits and improve their estimation of sufficient headway using a clear digital display of their kept headway in seconds. Should the driver fail to keep a safe distance, the Headway Warning will remind them, using a single chime along with a car icon on the display that changes its color to amber and then to red as the headway decreases.
- "… drivers tend to overestimate their headway and consequently drive with short and potentially dangerous headways…"[24]
- "…IVCAWS (in-vehicle collision avoidance warning systems) are a useful tool for educating drivers to estimate headway more accurately… after a relatively short exposure to the system, drivers were able to maintain longer and safer headways for at least six months…"[14]
- "…In the U.S., rear-end collisions represent approximately 30% of all car crashes on public roads [NHTSA, 1999]. One of the major causes of such accidents is the failure of the following car to maintain the proper distance from the lead car. In most cases, failure to maintain safe headway can be attributed to driver inattention and/or misjudgment of distance [Knipling et al.,1993]… "[25]
- Tailgating is widely cited as a common road danger, that contributes to a very large portion of crashes: "Highways Agency research suggests that tailgating contributes to **29% of all injury accidents** in the UK."[26]

*Mobileye AWS reduces further the chances of accidents by introducing Headway Monitoring and Warning (HMW). This enables drivers to monitor their driving distance from vehicles in front helping them to improve their estimation of what is a safe Vs. a dangerous driving distance.*

*In addition to the monitoring feature, HMW issues a timely audio warning if the driver gets too close to the car ahead, notifying them they should increase their driving distance.*

*The Headway Monitoring and Warning feature not only improves actual driver abilities, but also plants the term "safe distance" deeper into drivers' consciousness, helping them adopt safer driving habits, and increasing their safety awareness.*

[24] Effects of an In-Vehicle Collision Avoidance Warning System on Short and Long-Term Driving Performance - Avner Ben-Yaacov, Masha Maltz, and David Shinar, Ben-Gurion University

[25] Effects of an In-Vehicle Collision Avoidance Warning System on Short and Long-Term Driving (Avner Ben-Yaacov, Masha Maltz, and David Shinar, Ben-Gurion University)

[26] www.fleetnewsnet.co.uk – article from 9 October 2006

*The HMW feature can transform what would otherwise be a certain crash, into a situation drivers can safely handle.*

# FROST & SULLIVAN: MOBILEYE AWS - A WINNING TECHNOLOGY

Mobileye is the winner of the ***2006 Entrepreneurial Company of the Year Award in the Automotive Industry by Frost & Sullivan***, who have stated:

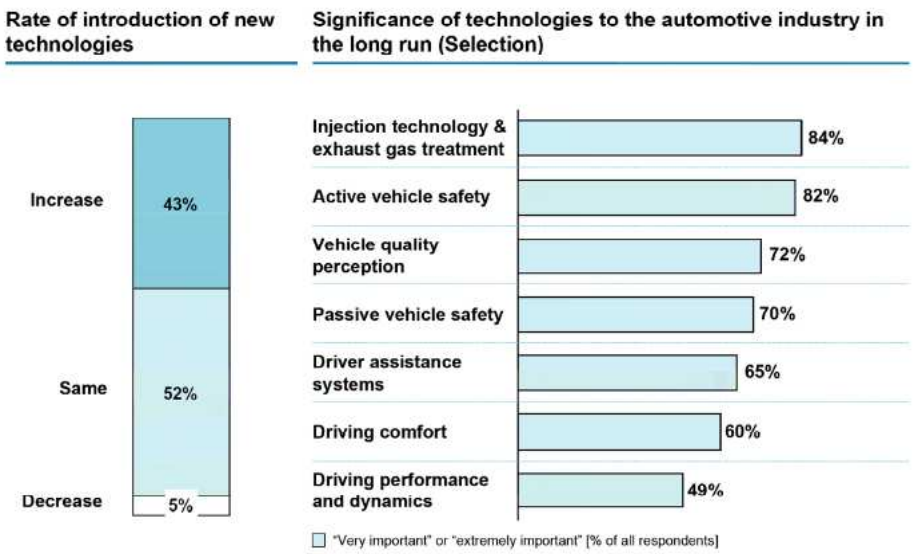
"The passenger cars in Europe are likely to be factory installed with the vision-based LDW starting from 2007 and **at least five car platforms are expected to be installed with this system supplied by Mobileye in 2007**. By 2010, all major vehicle manufacturers are expected to introduce the vision-based safety systems in the market. **Mobileye has got a head start over its competitors, since its system is capable of performing functions such as forward collision warning, headway warning and LDW in addition to the video-accident recording option**."

"Market participants have advocated the cost and life saving potential of the LDW system and fleet owners are beginning to realize the value in utilizing the LDW system. **Mobileye is expected to launch its product for the truck aftermarket shortly. Currently, the aftermarket system supplied by other market participants offer only the LDW function. However, by providing more functions over and above the LDW function, for the same price as the companies' competitors, Frost & Sullivan expects Mobileye to capture a large chunk of the truck aftermarket**."

# ACTIVE SAFETY - LEADING MARKET TREND

***Active vehicle safety (82%)*** is considered to be one of the two most important technology areas in the medium to long term according to automotive suppliers.[27]

[27] Roland Berger – "Study on what automotive suppliers expect in 2007"




Picture 5: Importance of new technologies

Active Safety technology in general has received 82 percent of all supplier votes, while Driver Assistance Systems specifically (a sub-section of active safety), have received a notable 65 percent on it own merit.

***Rising costs of accidents improves ROI on active safety***

""If you are…getting involved in several accidents per year, safety technology is really going to help, and help you quickly," says Bob Inderbitzen, VP-safety for the National Private Truck Council (NPTC). "Preventing accidents — big and small — can help a fleet save big money, usually more than enough to pay for the cost of buying, installing and maintaining a high-tech safety system.""[28]

## *Mobileye AWS – declared effective: Discount agreements signed with insurance companies*

A few months after Mobileye AWS was launched in Israel (where Mobileye's R&D center is located) in the summer of 2006, following an agreement with Clal insurance (Israel's largest insurance company), any of their customers who installs the AWS will receive a 25 percent rebate on their insurance payments. Since Clal, other insurance companies in Israel have joined this initiative, showing their trust in AWS and its ability to prevent road accidents. Other Insurance companies outside of Israel (Norway, Denmark, and more) have started to show interest in similar possible agreements incorporating Mobileye AWS.

28 "ADVANCED SAFETY SYSTEMS: Finding the ROI" – FleetOwner.com - http://fleetowner.com/management/feature/fleet_advanced_safety_systems/

## *Mobileye AWS – Multi-Warning system*

While other driver assistance systems offer the driver only a single type of warning (typically – LDW or FCW), Mobileye AWS is the only automotive aftermarket system worldwide to provide, in one system, three types of driver alerts: **LDW, FCW**, and also **Headway Monitoring and Warnings**. Basing on a single camera for producing its warnings makes Mobileye AWS an exceptionally intelligent, as well as cost-effective solution.

# CONCLUSION

Nearly 80 percent of all accidents are caused by or contributed-to by driver inattention. Mobileye AWS increases driver attention in the following road scenarios: unintended lane departure (responsible for up to 60 percent of all road fatalities), forward collision, and insufficient driving distance (for a-priori accident prevention).

Mobileye AWS aims to prevent accidents both by supplying early warnings to the driver in the critical seconds before an impending accident, and by increasing the general level of awareness - assisting the driver in keeping their lane, and driving at a safe distance from vehicles ahead.

Mobileye AWS relies on its renowned vision-based safety technology, that has been selected by leading automotive OEMs such as BMW, as well as other leading US and EU major automobile manufacturers. At least 6 platforms by these OEMs, containing Mobileye technology will be in production starting 2007 (BMW 5-Series already in market).

Its world-renowned vision technology, as well as its ability to bring forth an encompassing road safety solution makes Mobileye AWS a cost-effective product for accident prevention and mitigation, aiming to improve the quality of life by saving lives, preventing injury and reducing the costs of road accidents that are constantly increasing (damage to equipment and goods, medical and healthcare expenditures, insurance payments, etc.).

Mobileye AWS is intended both for commercial fleet vehicles and private car owners.