

Programs of the Federal Motor Carrier Safety Administration (FMCSA) encompass a range of issues and disciplines, all related to motor carrier safety and security. FMCSA's Office of Analysis, Research and Technology defines a "research program" as any systematic study directed toward fuller scientific discovery, knowledge, or understanding that will improve safety, and reduce the number and severity of commercial motor vehicle crashes. Similarly, a "technology program" is a program that adopts, develops, tests, and/or deploys innovative driver and/or vehicle best safety practices and technologies that will improve safety and reduce the number and severity of commercial motor vehicle crashes. An "analysis program" is defined as economic and environmental analyses done for the agency's rulemakings, as well as program effectiveness studies, state-reported data quality initiatives, and special crash and other motor carrier safety performance-related analyses. A "large truck" is any truck with a Gross Vehicle Weight rating or Gross Combination Weight rating of 10,001 pounds or greater.

Currently, FMCSA's Office of Analysis, Research and Technology is conducting programs in order to produce safer drivers, improve safety of commercial motor vehicles, produce safer carriers, advance safety through information-based initiatives, and improve security through safety initiatives. The analyses described in this Tech Brief were designed and developed to support the strategic objective to produce safer drivers. The primary goal is to provide an analysis of the economic benefits, expected costs, and industry returns on investment for the safety systems described herein



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Benefit-Cost Analyses of Onboard Safety Systems

Background

The primary safety goal of the Federal Motor Carrier Safety Administration (FMCSA) is to reduce the number and severity of large truck crashes. Over the last several years, FMCSA has collaborated with the trucking industry to test, evaluate, and encourage the deployment of several promising onboard safety systems for commercial motor vehicles (CMV) in an effort to enhance the safety of all roadway users.

As part of an ongoing FMCSA effort to accelerate voluntary adoption of onboard safety systems, this document summarizes the findings in three reports that analyzed the economic costs and benefits for three commercial motor vehicle onboard safety systems:

- Forward Collision Warning Systems (FCWS)
- Lane Departure Warning Systems (LDWS)
- Roll Stability Control Systems (RSC)

To be widely deployed, these systems must be beneficial, cost-effective investments that meet user needs. The purpose of the benefit-cost analysis (BCA) reports was to provide return on investment information for the motor carrier industry in support of future purchasing decisions of the onboard safety system. However, other industry stakeholders such as insurance companies, vendors, and risk managers can equally apply the calculations to their own internal assessments and programs.

The three benefit-cost analysis reports defined and quantified key financial metrics, such as return on investment and payback periods, for commercial motor carriers. For these analyses, the potential benefits, in terms of crash cost avoidance, were measured against the purchase, installation, and operational costs of the technology. Five years of crash data from 2001 to 2005 in the General Estimates System (GES) were used to estimate the average annual numbers of crashes preventable by each of the three different systems. These data were the basis for estimating costs of the different types of crashes involving property damage only (PDO), injuries, and/or fatalities. The primary data source for benefits and crash costs typically paid by the motor carrier industry came from information provided by insurance companies, motor carriers, legal experts, and others. As a result, the assessments incorporated actual motor-carrier-based data on the costs of different crashes that may be avoided by the use of the three different onboard safety systems. These crash costs included:

- Labor Costs
- Worker's Compensation Costs
- Operational Costs
- Property Damage and Auto-Liability Costs
- Environmental Costs
- Legal Costs

To obtain a measure of crash cost avoidance, the number of incidents that each technology is estimated to prevent annually per vehicle miles traveled (VMT) was determined in the analyses. Crash avoidance costs based on VMT and expected crash reduction resulting from deployment of the three systems were calculated for annual VMT values of 80,000, 100,000, 120,000, 140,000, and 160,000 miles.

The following sections of this document provide information about each of the three onboard safety systems and a summary the report findings of their costs and benefits for motor carriers that purchase them. These results were based on the assumption that all of the crash costs in the categories listed above would be incurred by self-insured, large-sized motor carriers or those carriers with insurance deductibles at or above total crash costs.

Forward Collision Warning Systems

FCWS provide audible and/or visual warnings of vehicles or objects that come within a predefined interval in front of the vehicle equipped with FCWS. When a large truck equipped with the FCWS approaches a slower-moving vehicle or stationary object, progressively more urgent warnings are issued by the system according to pre-set thresholds. These warnings are designed to improve driver behavior through targeted feedback about safe following distances.

FCWS may also be integrated with an adaptive cruise control (ACC) system, which automatically maintains a set following interval between the large truck and a vehicle in front of it. As a result, FCWS with ACC have the potential to prevent rear-end collisions in which the truck is striking another vehicle; however, they do not automatically decelerate or stop the truck. Next-generation systems now in development will use direct braking as an extended benefit of FCWS.

Benefit-Cost Analysis Findings

Using efficacy rates of 21 percent and 44 percent, it was estimated that between 8,597 and 18,013 rear-end crashes could be prevented through use of FCWS. Based on the average estimates of the crash cost elements, a PDO rear-end crash would cost \$122,650, an injury rear-end crash would cost \$239,063, and a fatal rear-end crash would cost \$1,056,221. These avoided costs or potential benefits of the FCWS were based on a typical or median-cost incident; therefore, they should be interpreted as approximations of typical expected values.

The technology and deployment cost estimates for FCWS included the technology purchase, maintenance costs, and cost of training drivers in the use of the technology. Purchasing the technology with or without financing was also considered in these costs, as well as Federal tax savings due to depreciation of the FCWS equipment. These total costs ranged from approximately \$1,415 to \$1,843 per vehicle.

The net present values of FCWS were computed by discounting future benefits and costs for the values using discount rates of 3 and 7 percent. Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement. These values were calculated over the first five years of deployment, since estimates of product lifecycles are speculative beyond five years. When the anticipated present value costs and benefits of the FCWS were compared, the benefits of using the system over a period of five years outweighed the costs associated with purchasing the systems at each efficacy rate and for each VMT category. For every dollar spent, carriers would get more than a dollar back in benefits that could be quantified for the analysis, ranging from \$1.33 to \$7.22 based on different VMTs, system efficacies, and technology purchase prices.

Payback periods were also calculated to estimate the length of time required to recover the initial investments made for the FCWS. Following the deployment of FCWS, the payback periods ranged from eight to 37 months, depending on the different VMTs, system efficacy estimates, and technology purchase costs.

Lane Departure Warning Systems

LDWS warn drivers of a lane departure when the vehicle is traveling above a certain speed threshold and the vehicle's turn signal is not used to make an intended lane change or departure. LDWS also notify drivers when lane markings are inadequate for detection, or if the system malfunctions. LDWS do not take any automatic action to avoid a lane departure or to control the vehicle; drivers remain responsible for the safe operation of their vehicles. Crashes that can be prevented through the use of LDWS include:

- Single-vehicle roadway departures (SVRD): Crashes where a truck departed the roadway from its lane of travel, either to the left or the right
- Same-direction lane departures (SDLD): Crashes where a truck departed its lane of travel and entered into a lane of traffic traveling in the same direction
- Opposite-direction lane departures (ODLD): Crashes where a truck departed its lane of travel and entered into an oncoming lane

These lane departure crash types can include different crash outcomes, such as rollovers, head-on collisions, and sideswipes.

Benefit-Cost Analysis Findings

Using low and high estimates of efficacy rates ranging from 23 percent to 53 percent, it was estimated that LDWS has the potential to reduce approximately 1,069–2,463 SVRD collisions, 627–1,307 SVRD rollovers, 1,111–2,223 SDLD sideswipes, 997–1,992 ODL D sideswipes, and 59–118 ODL D head-ons. Based on the average estimates of the crash cost elements, PDO crashes range in cost from \$100,150–\$196,958; injury crashes are in the range of \$135,096–\$455,936; and fatal crashes are in the range of \$885,150–\$1,252,872. These avoided costs or potential benefits of the LDWS were based on a typical or average incident.

The technology and deployment cost estimates for LDWS included the technology purchase, maintenance costs, and the cost of training drivers in the use of the technology. Purchasing the technology with or without financing was also considered in these costs, as well as Federal tax savings due to depreciation of the LDWS equipment. These total costs ranged from approximately \$765.00 to \$866.40 per vehicle.

The net present values of the LDWS were computed by discounting future benefits and costs for the values using discount rates of 3 and 7 percent calculated over the first five years of deployment. When the anticipated present value costs and benefits of the LDWS were compared, the benefits of using the system over a period of five years outweighed the costs associated with purchasing the systems at each efficacy rate and for each VMT category. For every dollar spent, carriers get more than a dollar back in benefits that could be quantified for the analysis, ranging from \$1.37 to \$6.55 based on different VMTs, system efficacies, and technology purchase prices. Following the deployment of LDWS, payback periods ranged from 9 to 37 months, depending on the different VMTs, system efficacy estimates, and technology purchase costs.

Roll Stability Control Systems

RSC systems include sensors that monitor vehicle dynamics and estimate the stability of a large truck based on its mass and velocity. RSC systems address roll instability by actively reducing the vehicle's throttle and applying its brakes to decelerate the vehicle if a high rollover risk or instability threshold is detected. Rollovers involving combination trucks (tractor trailers) with a pre-crash movement of negotiating a curve are the primary type of crash preventable by RSC systems. As a result, the benefits of RSC systems for combination vehicles versus all large trucks were the focus of this benefit cost analysis.

Benefit-Cost Analysis Findings

Using efficacy rates of 37 percent and 53 percent, it was estimated that between 1,422 and 2,037 combination vehicle rollover crashes in curves could be prevented through use of the RSC. Based on the average estimates of the crash cost elements listed in the previous section, a PDO rollover crash would cost \$196,958, an injury rollover crash would cost \$462,470, and a fatal rollover crash would cost \$1,143,018. These avoided costs or potential benefits of the RSC system were based on a typical or median-cost incident.

The technology and deployment cost estimates for the RSC systems included the technology purchasing price (with and without the added cost of traction control), maintenance costs, and the cost of training drivers in the use of the technology. Purchasing the technology with or without financing was also considered in these costs, as well as Federal tax savings due to depreciation of the stability control system equipment. These total costs ranged from approximately \$440 to \$866 per vehicle.

The net present values of the RSC systems were computed by discounting future benefits and costs for the values using discount rates of 3 and 7 percent calculated over the first five years of deployment. When the anticipated present value costs and benefits of the RSC systems were compared, the benefits of using the system over a period of five years outweighed the costs associated with purchasing the systems at each efficacy rate and for each VMT category. For every dollar spent, carriers get more than a dollar back in benefits that could be quantified for the analysis, ranging from \$1.66 to \$9.36 based on different VMTs, system efficacies, and technology purchase prices. Following the deployment of RSC systems, payback periods ranged from six to 30 months, depending on the different VMT, system efficacy estimates, and technology purchase costs.

"Analysis of benefits and costs of roll stability control systems for the trucking industry," by Murray D, Shackelford S, Houser A.

"Analysis of benefits and costs of lane departure warning systems for the trucking industry," by Houser A, Murray D, Shackelford S, Kreeb R, Dunn T.

"Analysis of benefits and costs of forward collision warning systems for the trucking industry," by Murray D, Shackelford S, Houser A.

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Sensitivity Analyses

For a significant number of motor carriers that incur the entire costs of crashes preventable by onboard safety systems, the above findings revealed that the systems were cost beneficial investments. Yet, certain industry segments will experience different costs and benefits than those presented above due to differences in operating practices. As a result, the three benefit-cost analysis reports also included sensitivity analyses to determine some of these differences. The sensitivity analyses focused on small carriers.

For the sensitivity analyses, it was important to consider small carriers separately from large carriers due to discrete differences in their financial and operating environments. For instance, small carriers are unlikely to be self-insured; therefore, out-of-pocket costs per crash will initially be much lower for small carriers. Since the median deductible for a motor carrier will fall in the \$5,000 to \$50,000 range, these low and high deductibles were considered as part of the sensitivity analyses of the costs and benefits.

The sensitivity analyses revealed that based on the overall probability of involvement in crashes, small carriers that utilize lower deductibles, such as \$5,000 per truck, may not achieve a break-even point—a dollar or more of benefits for each dollar spent on financing the technology—in the first five years. However, as the number of crashes and/or their severity increases, insurance premium costs typically increase until the carrier's insurance costs equal or exceed the investment costs of onboard safety systems; or the carrier is altogether dropped by the insurance provider. For this reason, an investment in safety technology may still be considered judicious for added protection against rising insurance costs for carriers that are not self-insured. In addition, indirect costs of crashes, such as impacts on safety ratings, public image, and employee morale can add to the benefits of purchasing onboard safety systems.

Conclusion

In conclusion, large truck crashes involve a complex series of critical events and factors, many of which can be prevented through the use of onboard safety systems. In addition to safe carrier operational practices and initiatives, onboard safety technologies can be cost effective investments for reducing injuries and fatalities in crashes involving large trucks.