Using Crash Data to Drive Research and Technology Investments to Improve Motor Carrier Safety

By

Steve Capecci, Senior Associate
Cambridge Systematics, Inc.
100 CambridgePark Drive, Suite 400
Cambridge, Massachusetts 02140
Tel: (617) 354-0167; Fax: (617) 354-1542
E-mail: scapecci@camsys.com

Jeff Loftus, Transportation Specialist
Federal Motor Carrier Safety Administration, Office of Research and Technology
400 Virginia Avenue, SW, Suite 600, Washington, DC 20024
Tel: (202) 385-2363; Fax: (202) 385-2422
E-mail: jeff.loftus@fmcsa.dot.gov

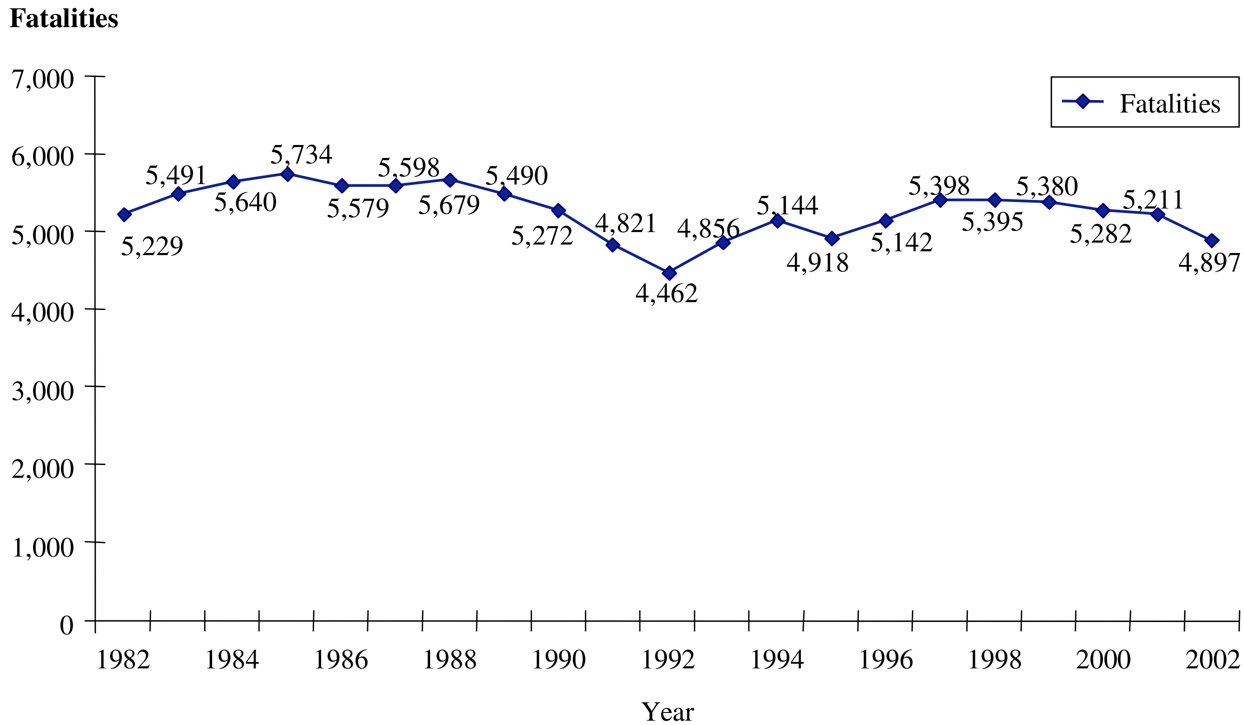
ABSTRACT

The Federal Motor Carrier Safety Administration's new research and technology program – Driver, Vehicle, and Roadside Strategies for 2010 (DVRS for 2010) – adopted a data-driven methodology to maximize its research funds and to ensure that its research activities directly support the agency's mission and safety goals. The chosen methodology combines statistical analyses, a balanced scorecard approach, and the gathering of expert opinion to achieve the program's objectives. DVRS for 2010 is among the first programs within FMCSA to explicitly link its funding decisions to the agency's performance measures and expected safety benefits. A modified form of the DVRS for 2010 methodology currently is being integrated into all of FMCSA's research and technology activities. This paper discusses the DVRS for 2010 methodology, the program's key findings and how some of the program's components are being mainstreamed into research and technology initiatives across FMCSA.

BACKGROUND

The number of fatalities and injuries resulting from large truck crashes remains unacceptably high, despite steady improvements in commercial motor vehicle safety over the past 20 years. As illustrated in Figure 1, 4,897 people were killed in crashes involving large trucks in 2002 – a 4.2 percent decrease from 2001 and a 6.9 percent decrease from 1982. The Federal Motor Carrier Safety Administration (FMCSA) was created within the United States Department of Transportation (U.S. DOT) by the United States Congress to improve commercial vehicle safety. Following the terrorist attacks of September 11, 2001, the agency also became involved in commercial vehicle security activities. FMCSA undertakes a wide array of activities in support of its mission. These activities include vehicle inspections, carrier terminal audits, administration of state grant programs, development, and management of information systems, data analysis, managing the issuance of U.S. DOT numbers, and verification of motor carrier insurance status.

Figure 1 Number of Fatalities Resulting from Large Truck Crashes (1982-2002)



FMCSA's Office of Research and Technology (Office of R&T) conducts innovative and applied research to improve commercial vehicle safety and security and to support the agency's other safety and security-related activities. The potential scope of FMCSA's research activities is massive. Over 100 crash characteristics (speeding, mechanical failure, inclement weather, etc.) can be associated with a commercial vehicle crash individually or in combination with other characteristics – yielding thousands of potential areas of investigation. The Office of R&T is further challenged by limited funding. Senior managers at FMCSA also identified a need to increase the number of innovative and strategic research and technology projects. The DVRS for 2010 program was established in August 2001 to address these challenges and to ensure that innovative research initiatives were funded. The DVRS for 2010 program is part of FMCSA's larger research and technology program. The DVRS for 2010 program has a flexible programmatic structure that enables the investigation of any driver, vehicle, or roadside strategy, technology, or concept that will directly improve motor carrier safety outcomes.

The DVRS for 2010 program adopted a data-driven methodology to focus its projects on the most frequently recorded crash characteristics and to prioritize its projects based on their likely safety benefits. DVRS for 2010 is among the first programs within FMCSA to explicitly link its funding decisions to the agency's performance measures and expected safety benefits. The DVRS for 2010 methodology includes statistical analyses, a balanced scorecard approach, and the gathering of expert opinion. The approach evolved during the first year of the program based on input from FMCSA staff and commercial vehicle safety experts from across the country. The methodology continues to evolve and is being mainstreamed into all of FMCSA's research activities.

This paper documents the DVRS for 2010 methodology and the program's key results.

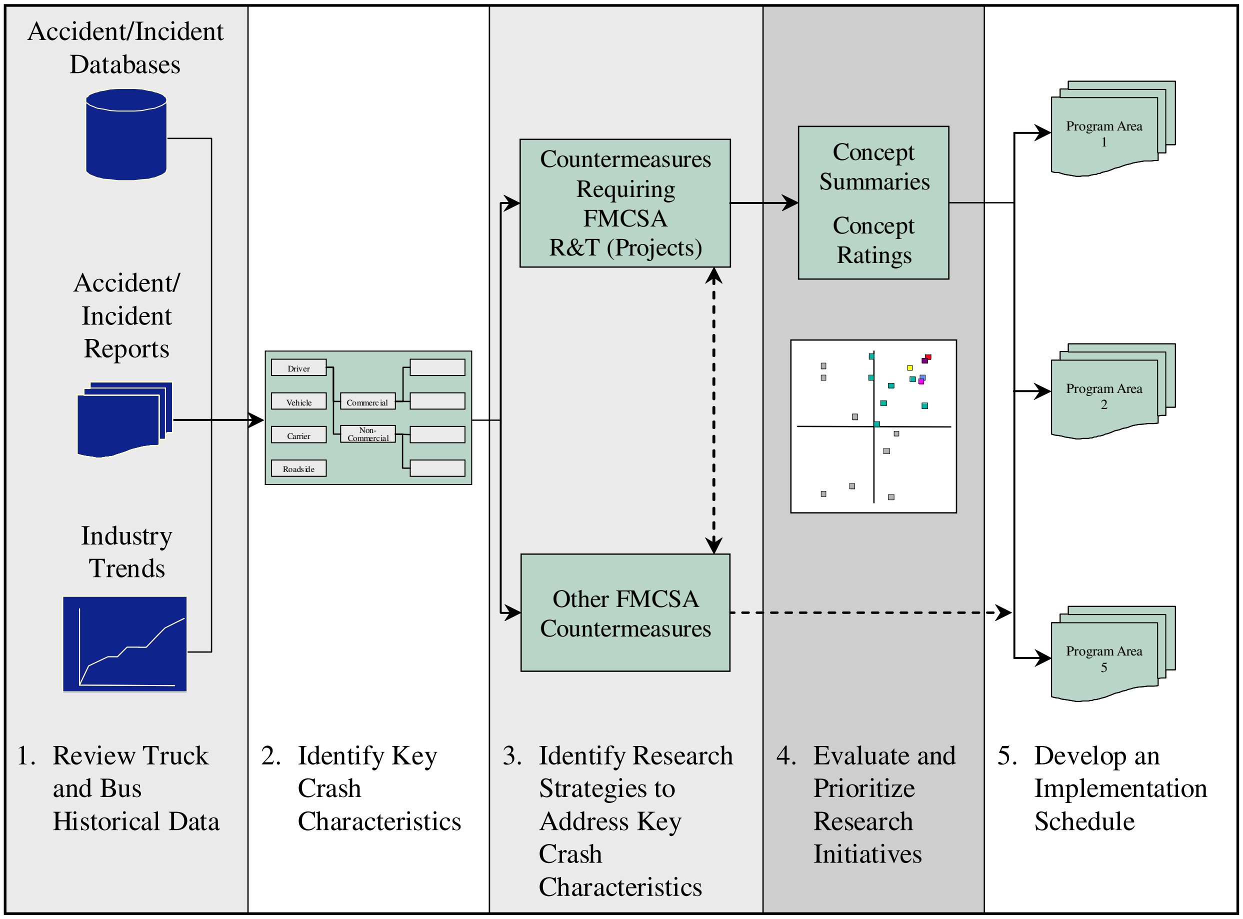
METHODOLOGY

The DVRS for 2010 methodology was based on a Federal Railroad Administration concept (FRA) *(1)*. The FRA approach was modified based on the input of FMCSA staff and commercial motor vehicle experts. The final DVRS for 2010 methodology included:

- Reviewing truck and bus historical crash data;
- Identifying key crash characteristics;
- Identifying research strategies to address the most commonly recorded crash characteristics;
- Evaluating and prioritizing individual research initiatives; and
- Developing an implementation schedule.

These five steps are illustrated in Figure 2 and are described below.

Figure 2 DVRS for 2010 Methodology



Step 1 – Review Truck and Bus Historical Crash Data

The DVRS for 2010 program is designed to conduct research in the areas that will provide the largest safety benefits. As such, a thorough review of crash data was conducted in order to identify the characteristics most often associated with fatal crashes involving large trucks. These statistics offered an initial view of the research topics (characteristics) that could/should be addressed by the program.

The National Highway Transportation Safety Administration's (NHTSA) Fatal Analysis Reporting System (FARS) was the prime data source for this review. Preliminary analysis of these data was based on the *Large Truck Crash Facts 2000 (2)* produced by the FMCSA

Analysis Division. These statistics include driver-related factors, vehicle-related factors, and environmental conditions recorded at the time of fatal crashes, as well as a general description of the crash (i.e., first harmful event, initial point of contact, etc.). Unique queries of the FARS data were conducted in order to answer specific analytical questions. For instance, a cross-tab analysis of driver-related factors and weather conditions was prepared to determine whether factors such as "speeding" or "following too closely" were exacerbated by weather. These queries were conducted in association with FMCSA's Analysis Division.

The FARS data was chosen as the foundation for the analysis because it is the most robust Federal data source. The source also contains detailed data on specific crash characteristics (potential research topics), which was required for the DVRS for 2010 program. Future analyses conducted as part of the DVRS for 2010 program will include data from non-fatal crashes, as well as results from other FMCSA data analyses. Future analyses also may include an assessment of characteristics involved in "near-misses" to identify dangerous, at-risk behavior even if it does not result in a crash.

Step 2 – Identify Key Crash Characteristics

Two criteria were used to determine which crash characteristics identified in Step 1 were "key" to commercial vehicle safety and should become the focus of the DVRS for 2010 effort. These criteria included:

- Number of fatalities with which the crash characteristics was associated; and
- Input from safety experts.

The number of fatalities associated with each crash characteristic was identified through the statistical review conducted in Step 1. Characteristics associated with at least two percent of all large truck crash fatalities (104 fatalities) were deemed "key" crash characteristics. To address the crash characteristics that might be under-reported in crashes (i.e., driver fatigue), expert opinion was solicited through several stakeholder forums held around the country.

The crash characteristics were organized into four analysis areas:

- **Driver** – performance and behavior on the part of the commercial vehicle or passenger vehicle driver involved in the fatal crash;
- **Vehicle** – condition or failure of component or equipment of the commercial vehicle involved in the fatal crash;
- **Carrier** – safety management practices or characteristics of the motor carrier whose vehicle or driver was involved in the fatal crash; and
- **Roadside/Environment** – road or weather characteristics at the time of the fatal crash.

Table 1 illustrates the results of this analysis.

Table 1 “Key” Crash Characteristics of Commercial Vehicle Safety

Crash Characteristic	Fatalities Associated with Characteristic	Characteristics’ Percent of Total Fatalities*	Expert Opinion
Passenger vehicle driver’s failure to keep in proper lane	986	19%	High priority
Large truck driver’s accident history – driver has at least one accident in past three years	950	18%	High priority
Passenger vehicle driver’s failure to yield right of way	694	13%	High priority
Passenger vehicle driver’s driving too fast for conditions or in excess of posted speed limit	650	12%	High priority
Large truck driver’s driving too fast for conditions or in excess of posted speed limit	441	8%	High priority
Passenger vehicle driver’s inattentiveness	424	8%	High priority
Passenger vehicle driver’s failure to obey traffic signs	415	8%	High priority
Large truck driver’s failure to keep in proper lane	295	6%	High priority
Large truck driver is not licensed or has no license for class of vehicle	169	3%	High priority
Inclement weather (rain, snow, sleet, and fog)	782	15%	Medium priority

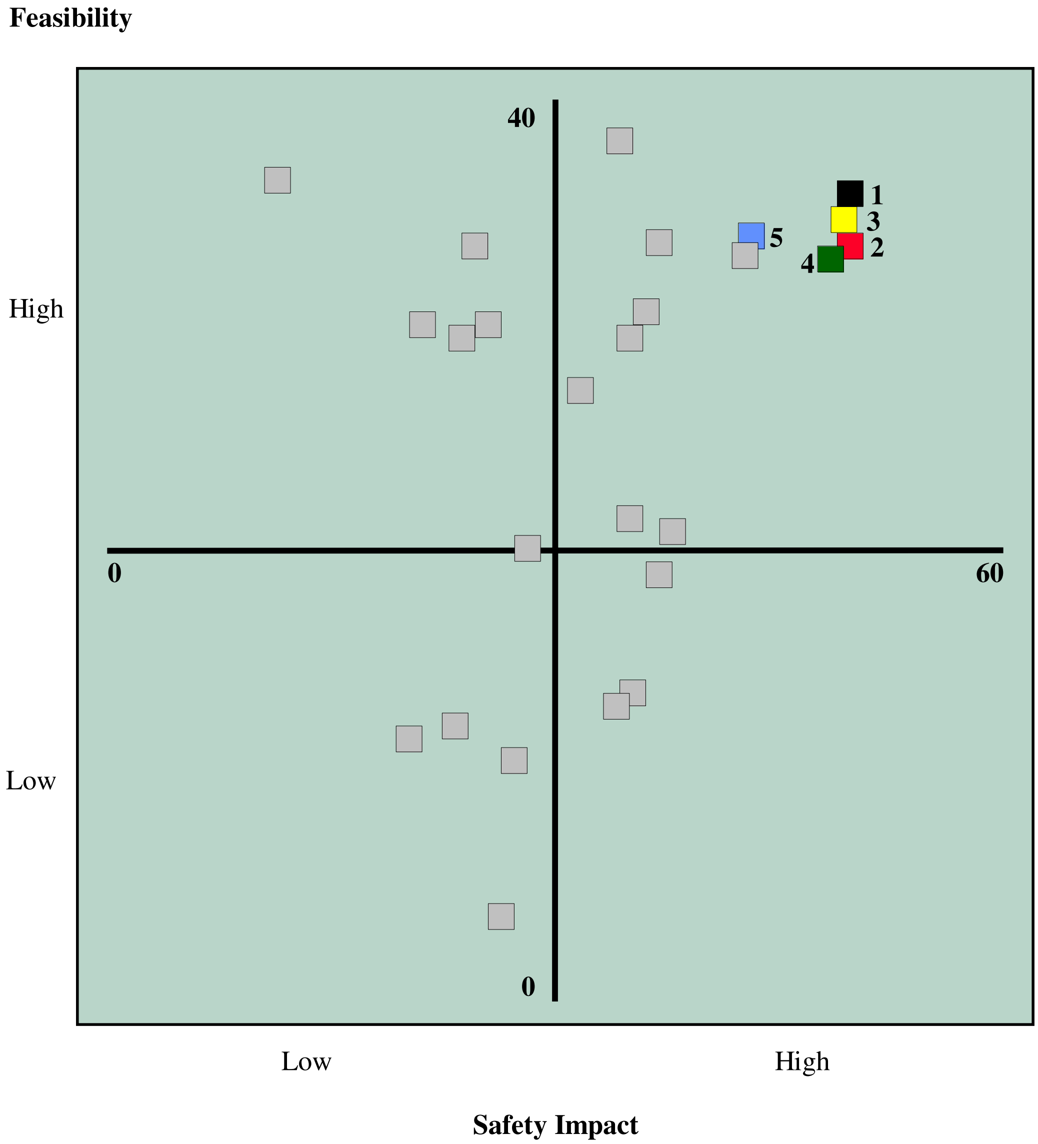
***Note:** Multiple crash characteristics can be associated with each fatal crash. As such, the percent totals for this column due not equal 100 percent.

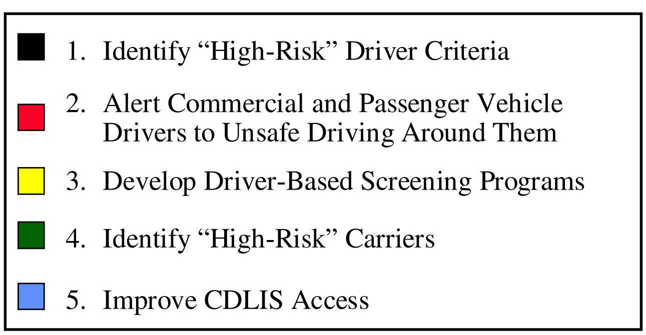
Step 3 – Identify Research Strategies to Address "Key" Crash Characteristics

The DVRS for 2010 program team identified a series of strategies to address the "key" crash characteristics from Step 2. The program team identified a candidate list of strategies and countermeasures that had the potential to address the assumed underlying causes of the most prevalent crash characteristics. To ensure no duplication of effort and to validate the causal assumptions, the program team discussed the candidate projects with FMCSA program offices and the R&T staffs from Federal Highway Administration (FHWA), NHTSA, and the U.S. DOT Joint Program Office for Intelligent Transportation Systems. The team also reviewed the existing and planned R&T budgets for these agencies.

Each of the candidate strategies was evaluated to determine if additional research was warranted. Those requiring additional research were prioritized based on their anticipated safety impact, technological feasibility, and institutional feasibility. Crash characteristics that could not benefit from research (i.e., normal weather conditions) were not included in this evaluation. This exercise yielded potential strategies that could be incorporated into the DVRS for 2010 program. Figure 3 illustrates the scores of the five highest priority strategies.

Figure 3 High-Scoring Technology Program Areas





Step 4 – Evaluate and Prioritize Research Initiatives

Specific research projects were identified for the five highest ranked strategies identified in Step 3. These research projects included finite scopes of work, defined schedules, as well as clear objectives and outcomes. In total, 65 projects were identified as possible initiatives for the DVRS for 2010 program.

Due to the number of potential projects identified and the limited financial and personnel resources available, it was imperative to prioritize the research. Projects were evaluated and ranked using a balanced scorecard approach *(3).* This scorecard, developed as part of a project to evaluate and prioritize all FMCSA R&T projects, included an assessment of the project's potential safety impact, feasibility, and cost. The safety assessment analyzed the project's potential impact on reducing the number of crashes involving commercial vehicles and the number of resulting fatalities, as well as the timeframe in which the safety benefits could be realized. The feasibility element considered the technical, institutional, and political likelihood that the project could be deployed. The cost element evaluated the project's total budget, ability to leverage other initiatives, and the likelihood that another organization would share in the costs. Table 2 details the evaluation criteria.

Each of the evaluation criteria was weighted to reflect the agency's organizational priorities. The project's safety assessment accounted for 60 percent of its total score because safety is FMCSA's highest priority. Feasibility accounted for an additional 40 percent. Cost was a secondary evaluation criteria (10 percent) used primarily to differentiate between projects that had the same total safety and feasibility scores. Cost was not emphasized in the evaluation because the agency did not want to overlook a research initiative that could deliver sizeable safety improvements simply because it was expensive.

Table 2 DVRS For 2010 Evaluation Criteria

Evaluation Element	Element Scores	Element Values	Evaluation Scores
1. Safety Factor (60 %)			
Associated Number of Fatalities			
Number of fatalities addressed	1	The project would have a potential impact on less than 100 fatalities per year	
	25	The project would have a potential impact on 100-249 fatalities per year	
	50	The project would have a potential impact on 250-499 fatalities per year	
	75	The project would have a potential impact on 500-750 fatalities per year	
	100	The project would have a potential impact on more than 750 fatalities per year	
		A. Fatality Element Score (50%)	
Associated Number of Crashes			
Number of crashes addressed	1	The project would have a potential impact on less than 7,500 crashes per year	
	25	The project would have a potential impact on 7,500-19,999 crashes per year	
	50	The project would have a potential impact on 20,000-39,999 crashes per year	
	75	The project would have a potential impact on 40,000-59,999 crashes per year	
	100	The project would have a potential impact on more than 60,000 crashes per year	
		B. Crash Element Score (30%)	
Safety Results Realized			
Time until safety impact will be seen	1	The project impact would be visible in 10 or more years	
	25	The project impact would be visible in 5 to 10 years	
	50	The project impact would be visible in 4 to 5 years	
	75	The project impact would be visible in 2 to 3 years	
	100	The project would have immediate impact	
		C. Safety Results Realized Score (20%)	
		1. Safety Element Subtotal: .6*((.5*A)+(.3*B)+(.2*C))	

2. Feasibility Factor (40 %)			
Research Approach or Technology Maturity			
Extent to which approach or technology used in project has been developed	1	Untested	
	25	Research approach conceptualized/Technology concept formulated	
	50	Research approach developed/Technology validated in lab	
	75	Research approach proven/Technology validated in relevant environment	
	100	Research approach successfully implemented/Technology proven through successful operation	
		D. Research Approach or Technology Maturity Score (40%)	
Level of Public Support			
Degree of support from driving public, safety advocates, NTSB, etc.	1	Strong opposition	
	25	Moderate opposition	
	50	Neutral	
	75	Moderate support	
	100	Explicit support	
		E. Strength of Public Support Score (20%)	
Strength of Industry Support			
Degree of support from motor carrier and motor coach communities	1	Strong opposition	
	25	Moderate opposition	
	50	Neutral	
	75	Moderate support	
	100	Explicit support	
		F. Strength of Industry Support Score (20%)	
Ability to Support Rulemaking, Standards and Policy			
Ability of project results to support other FMCSA activities	1	It would be hard to translate the conclusions of the project into policies, standards and regulations	
	25	More research would be needed to translate the conclusions of the project into policies, standards and regulations	
	50	The conclusions of the project could be translated into policies, standards and regulations	
	75	The conclusions of the project could be translated into policies, standards and regulations immediately	
	100	The conclusions of the project must be translated into policies, standards and regulations immediately (i.e., there is a Congressional mandate)	
		G. Ability to Support Rulemaking, Standards and Policy (20%)	
		2. Feasibility Element Subtotal: .4*((.4*D)+(.2*E)+(.2*F)+(.2*G))	

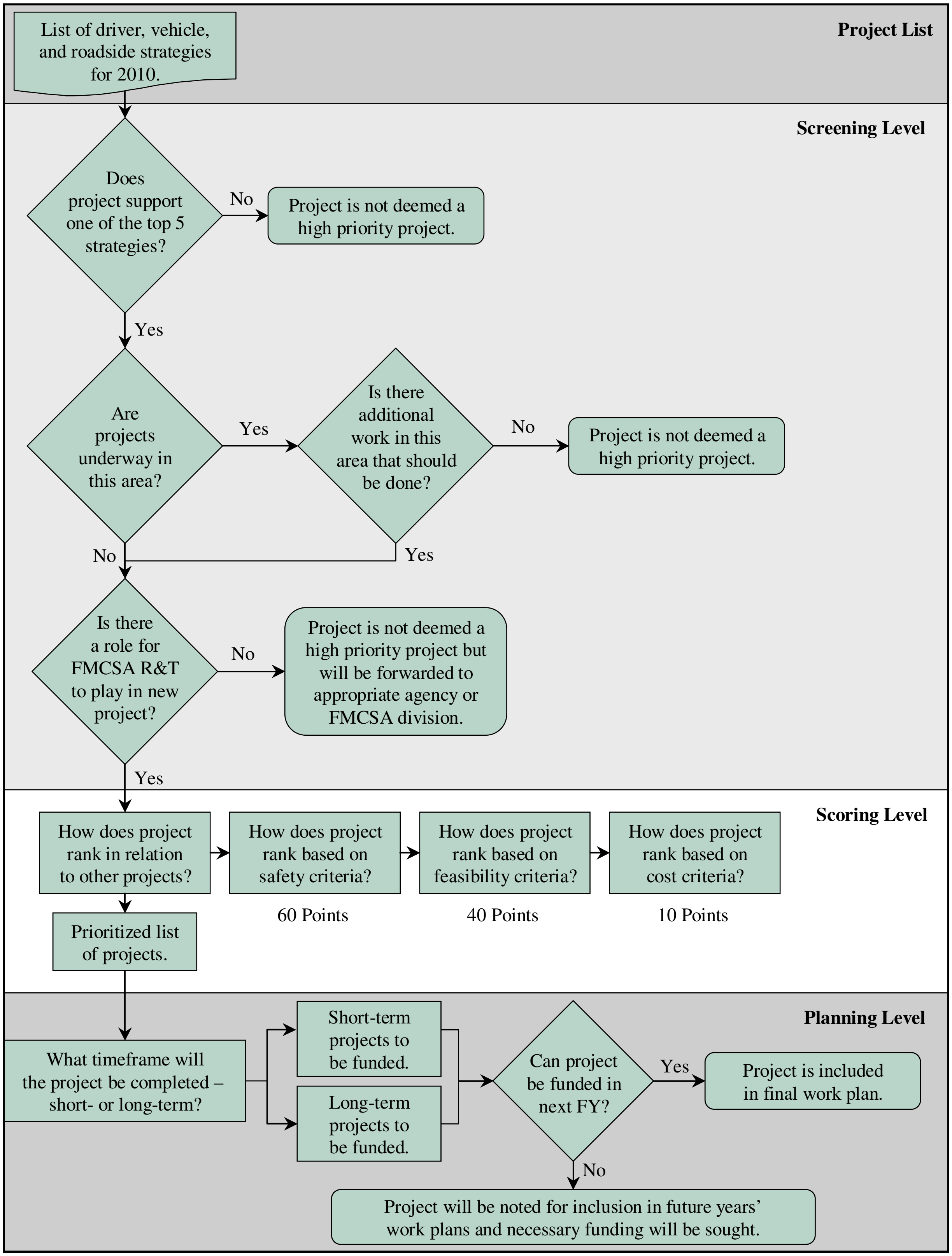
3. Cost Factor (10 %)			
Cost Estimate			
Estimate cost for project	25	The cost of the project would be more than $1.5 Million	
	50	The cost of the project would be between $750K and $1.5 Million	
	75	The cost of the project would be between $500K and $750K	
	100	The cost of the project would be between $100K and $500K	
		H. Cost Estimate Score (10%)	
Cost Sharing			
Ability to share project cost within another organization	50	There are no known opportunities to share the cost of the project with other organizations	
	75	There are some known opportunities to share the cost of the project with other organizations	
	100	The cost of the project can be shared with other organizations	
		I. Cost Sharing Score (50%)	
Leverage Existing Efforts			
Ability to leverage existing efforts/projects as part of proposed project	50	The project is new and there is no previous effort to leverage on	
	75	The project can take advantage of previous research efforts	
	100	The project is the continuation of a previous research effort	
		J. Leverage Existing Efforts Score (40%)	
		3. Cost Element Subtotal: .1*((.1*H)+(.5*I)+(.4*J))	

Safety and Feasibility Score (1+2)	
Total Project Score (1+2+3)	

The evaluation of strategies and projects was completed using an automated Microsoft Access 2000 Database tool – the Driver, Vehicle, and Roadside for 2010 Evaluation Tool. The Evaluation Tool contains the most current crash statistics and automatically calculates the number of fatalities and crashes addressed by a research project based on user inputs. The tool also calculates an overall evaluation score for each strategy and project and prepares a series of management and summary reports. Based on this scorecard approach, six projects were identified as "high-priority" projects and were recommended for future funding. Figure 4 illustrates the logic used to recommend these research projects.

The highest ranked project – Development, Implementation, and Evaluation of a Driver Safety History Indicator into the Roadside Inspection Selection System (ISS) – is investigating a new commercial driver safety indicator that will be included in existing roadside safety inspection and electronic screening deployments. This indicator will integrate commercial drivers' license data (traffic convictions) into the inspection selection decision at the roadside. This project addressed the second "key" crash characteristic – driver's accident history. The project also scored high because it builds on existing data sources, can be integrated into an existing roadside enforcement model (FMCSA's Inspection Selection System), and could be deployed within 12 months.

Figure 4 Project Evaluation Logic



Step 5 – Develop an Implementation Schedule

An implementation schedule was developed for the DVRS for 2010 program to document the timing and key milestones of the program's multi-year implementation. This schedule includes a phased approach to project deployment that will allow for a coordinated and effective deployment of the initial six projects. These projects are detailed in the Results Section of this paper. The implementation schedule also includes a regular feedback cycle to incorporate the latest crash data and study findings into the DVRS for 2010 analysis and evaluation metrics. This feedback cycle is critical to ensure that the program remains focused on the most important factors of commercial motor vehicle safety.

Validation

The DVRS for 2010 methodology was refined and validated through a series of four expert focus groups *(4).* These sessions were held from January 2002 through June 2002 in Washington, DC (two); Orlando, FL; Sacramento, CA. Each focus group was designed to solicit input on a specific element of the approach.

The initial focus group was designed to gather input on the overall project methodology and to review the initial crash statistics (Step 1). The second focus group was organized to gather feedback on the revised crash statistics and to begin the process of developing general areas of countermeasures (Steps 1 and 2). The third focus group was focused on identifying general research programs that should be investigated to improve commercial vehicle safety (Step 3). This focus group also addressed the issue of commercial vehicle security – given the importance of that topic in light of the terrorist attacks of September 11, 2001. The final focus group identified specific research projects that could be conducted to improve commercial vehicle safety and security. Participants at this session also provided feedback on the initial construct of the balanced scorecard approach, which ranked projects based on Safety Impact, Technological Feasibility, and Institutional Feasibility (Steps 3 and 4).

Participants in these stakeholder forums included representatives from universities, state personnel responsible for regulating commercial vehicle operators, motor carrier representatives, industry association representatives, private sector safety and data consultants, FMCSA personnel, FHWA, and NHTSA staff. Based on this expert input, the DVRS for 2010 methodology was finalized and the program's initial round of candidate research projects was identified.

RESULTS

In its two-year history, the DVRS for 2010 program has identified and funded six innovative research projects. In addition, the program's methodology is being incorporated into all FMCSA research activities. The program's key results are described below.

Projects Funded

The initial round of DVRS for 2010 projects are primarily focused on driver-related characteristics. These characteristics can be associated with either the commercial vehicle driver or the passenger vehicle driver. These characteristics became the focus of the program because:

- Recent internal FMCSA and external studies indicate that the actions of a passenger vehicle contribute to 70 to 80 percent of car-truck crashes;
- A driver-related factor is recorded for 37 percent of all commercial vehicle drivers involved in a fatal crash; and
- Driver-related factors dominated the list of "key" crash characteristics identified during the DVRS for 2010 program (see Table 2).

The DVRS for 2010 projects address these factors through incremental improvements to existing enforcement/analytical activities, as well as developing new and innovative approaches to improving driver-targeted enforcement and management activities.

- **Development, Implementation, and Evaluation of a Driver Safety History Indicator into the Roadside Inspection Selection System (ISS) –** This project will integrate a promising new driver-based data measure into FMCSA's existing safety algorithm used at roadside safety inspection stations to identify which commercial vehicle operators should be inspected. The project will refine, implement, and test this algorithm. The updated algorithm will be tested in the inspection stations on roadside inspectors' laptops and at highway speeds as part of electronic screening systems.
- **Feasibility Study of Driver Violation Notification Programs –** This project will determine if driver violation notification programs should be deployed more widely across the country. Nine states currently have some type of driver violation notification program where states notify motor carrier safety managers when one of their drivers receives a traffic conviction against his/her CDL. The study will analyze the costs and benefits of existing driver violation notification programs and determine if their benefits warrant future investment. If nationwide deployment is feasible, the study will recommend a deployment approach and work plan to facilitate the expansion of these programs.
- **Development of Specifications and Pilot Testing of a Commercial Drivers License Third-Party Tester Anti-Fraud System –** This project will develop specifications and pilot test an anti-fraud system for Commercial Driving License (CDL) third-party testing activities. If successful, the system could be expanded to additional states. The project will identify vulnerabilities in the nation's current CDL program and recommend means by which these vulnerabilities can be eliminated. The new system will monitor CDL testing and verify the identity of a CDL applicant at the time of testing.
- **Enhanced Rear-end Signaling Safety Study –** This project will analyze the factors contributing to rear-end crashes involving commercial vehicles. The project will document the problem and identify innovative concepts of operation to address the root cause of this problem. If likely countermeasures can be identified, the project will develop the necessary technical specifications, implement, and test the new concept.

- **Car-Truck Crash Countermeasure Technologies Project –** This project will investigate technology countermeasures that will reduce light vehicle – heavy vehicle conflicts (near misses and crashes). This project will mine the 12 terabytes of video data from NHTSA's 100-vehicle Naturalistic Driving Study to gain insights into the recorded car-truck near-miss and crash interactions. The analyzed interactions will provide the basis for proposing effective crash-reducing technology countermeasures.
- **Safety Data Risk Feasibility Study –** This study will investigate the feasibility of identifying commercial vehicle driver factors that increase the risk of a large truck crash occurring. If feasible, the follow-on study will provide an important complement to the ongoing FMCSA/NHTSA Large Truck Crash Causation Study. The study will employ a case control methodology in which the characteristics and performance of crash-involved drivers will be compared to those of control/non-crash-involved drivers. If successful, the study will derive odds ratios and other measures of relative risk associated with various driver factors.

In all cases, the researchers conducting these projects are considering the anticipated safety benefits identified during the DVRS for 2010 initial evaluation and updating these results as necessary. For instance, the researchers conducting the commercial driver safety indicator research have estimated that 32 lives can be saved annually through the integration of this indicator into ISS. This initial assessment will be revisited after a six-month operational test of the safety indicator. Future investment in all research areas will be based on their ability to deliver their anticipated safety benefits. This feedback loop is critical to ensure that the program remains focused on delivering real-world safety outcomes.

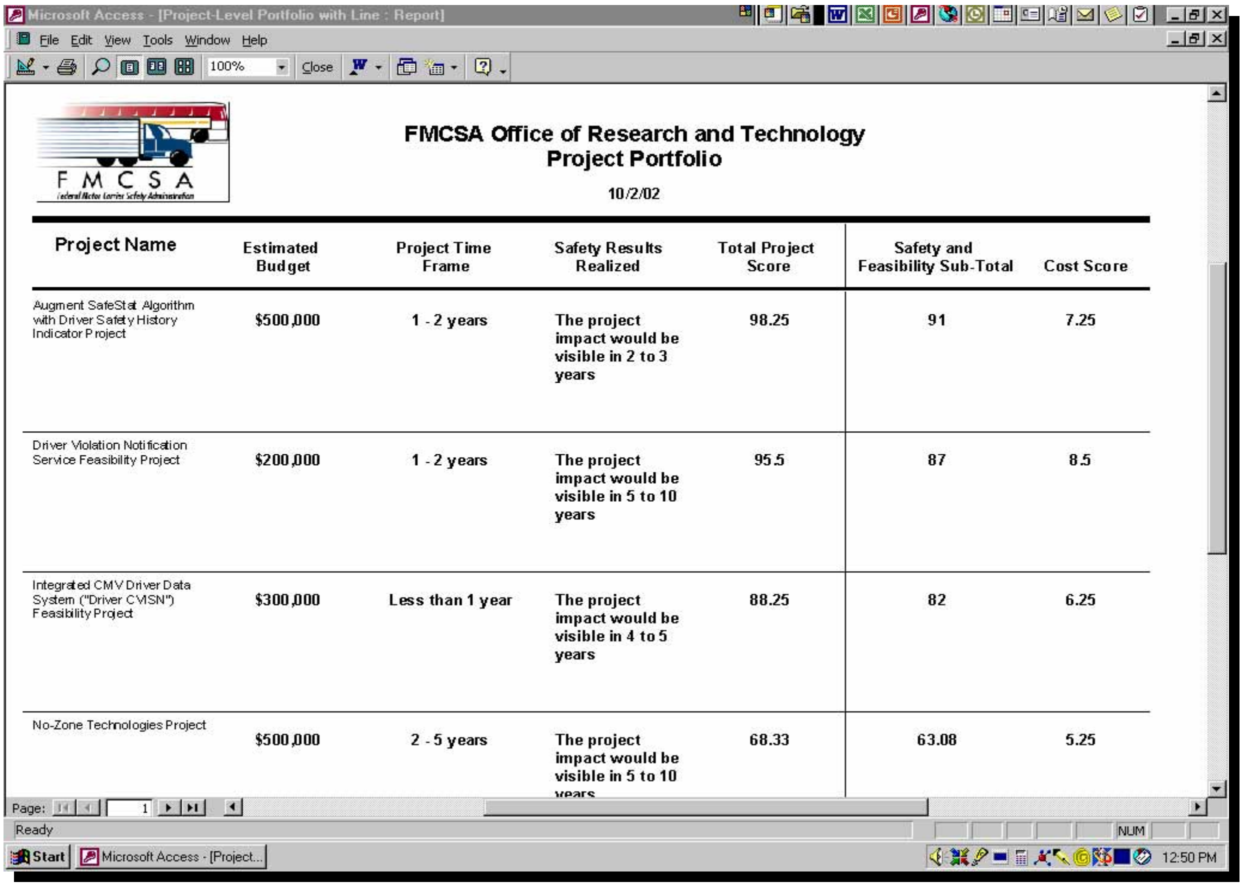
Mainstreaming

FMCSA is one of the first agencies within U.S. DOT to move towards performance-based budgeting. As such, the agency's investments must be justified in terms of safety/operational impacts. The DVRS for 2010 methodology has been chosen as the means for integrating performance-based budgeting into the agency's research activities. The DVRS for

2010 methodology ensures that all candidate research projects are objectively scored based on their anticipated safety impact, technical and institutional feasibility, and cost. Projects are then prioritized based on these scores for funding.

FMCSA developed an agencywide E-Scorecard, an adaptation of the DVRS for 2010 Evaluation Tool, to automate the prioritization of the agency's research projects and the generation of management reports. Figure 5 illustrates a project portfolio – one of the E-Scorecard's senior management reports. A key component of the E-Scorecard is the Safety Impact Estimator (see Figures 6 and 7), which automates the calculation of each project's potential safety impact through the use of the latest crash statistics. DVRS for 2010 focus groups also are being integrated into broader Office of R&T stakeholder forums designed to provide expert opinion to all agency research projects.

Figure 5 Sample Screenshot of Project Portfolio



FMCSA Office of Research and Technology
Project Portfolio
10/2/02

Project Name	Estimated Budget	Project Time Frame	Safety Results Realized	Total Project Score	Safety and Feasibility Sub-Total	Cost Score
Augment SafeStat Algorithm with Driver Safety History Indicator Project	$500,000	1 - 2 years	The project impact would be visible in 2 to 3 years	98.25	91	7.25
Driver Violation Notification Service Feasibility Project	$200,000	1 - 2 years	The project impact would be visible in 5 to 10 years	95.5	87	8.5
Integrated CMV Driver Data System ("Driver CVISN") Feasibility Project	$300,000	Less than 1 year	The project impact would be visible in 4 to 5 years	88.25	82	6.25
No-Zone Technologies Project	$500,000	2 - 5 years	The project impact would be visible in 5 to 10 years	68.33	63.08	5.25

Figure 6 Sample Screenshot of Safety Impact Estimator

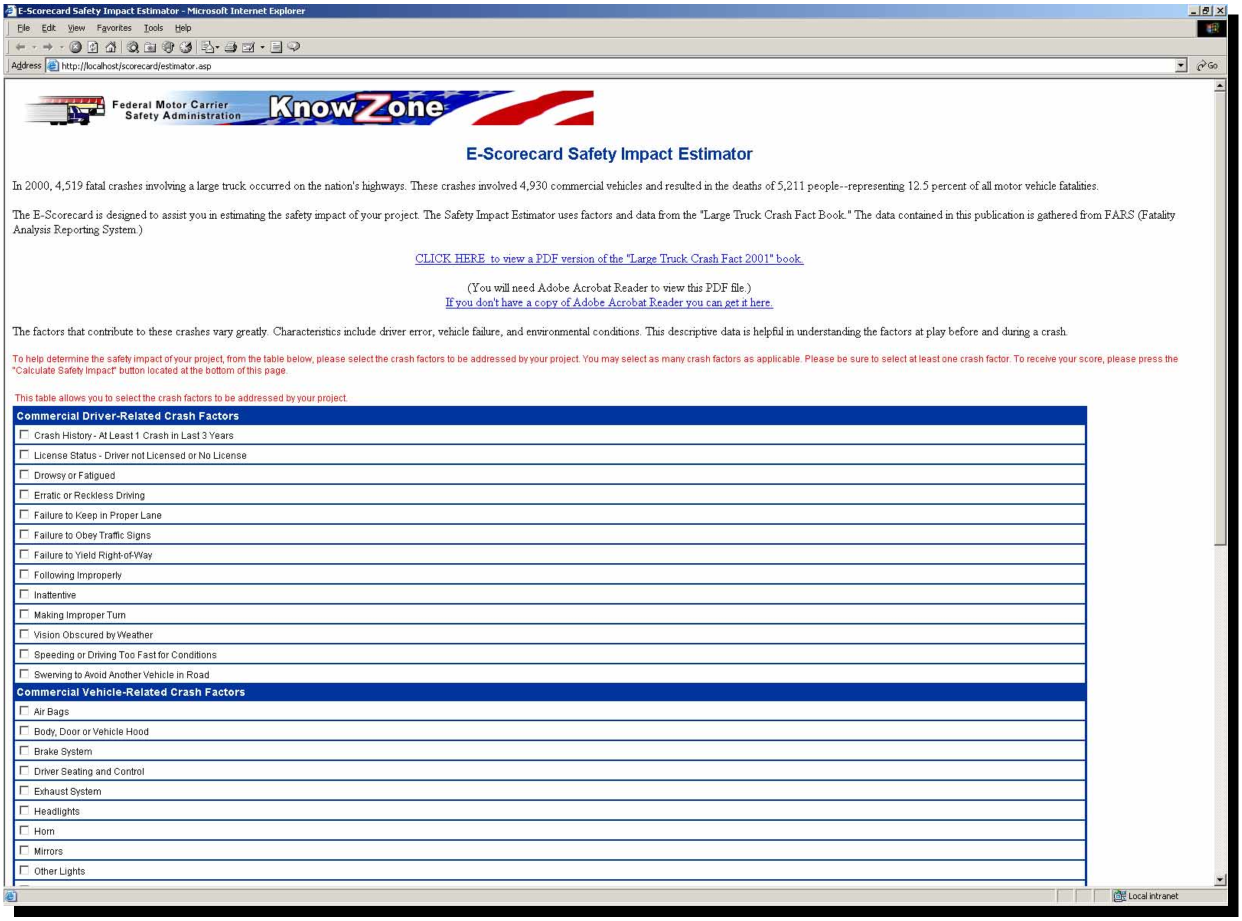
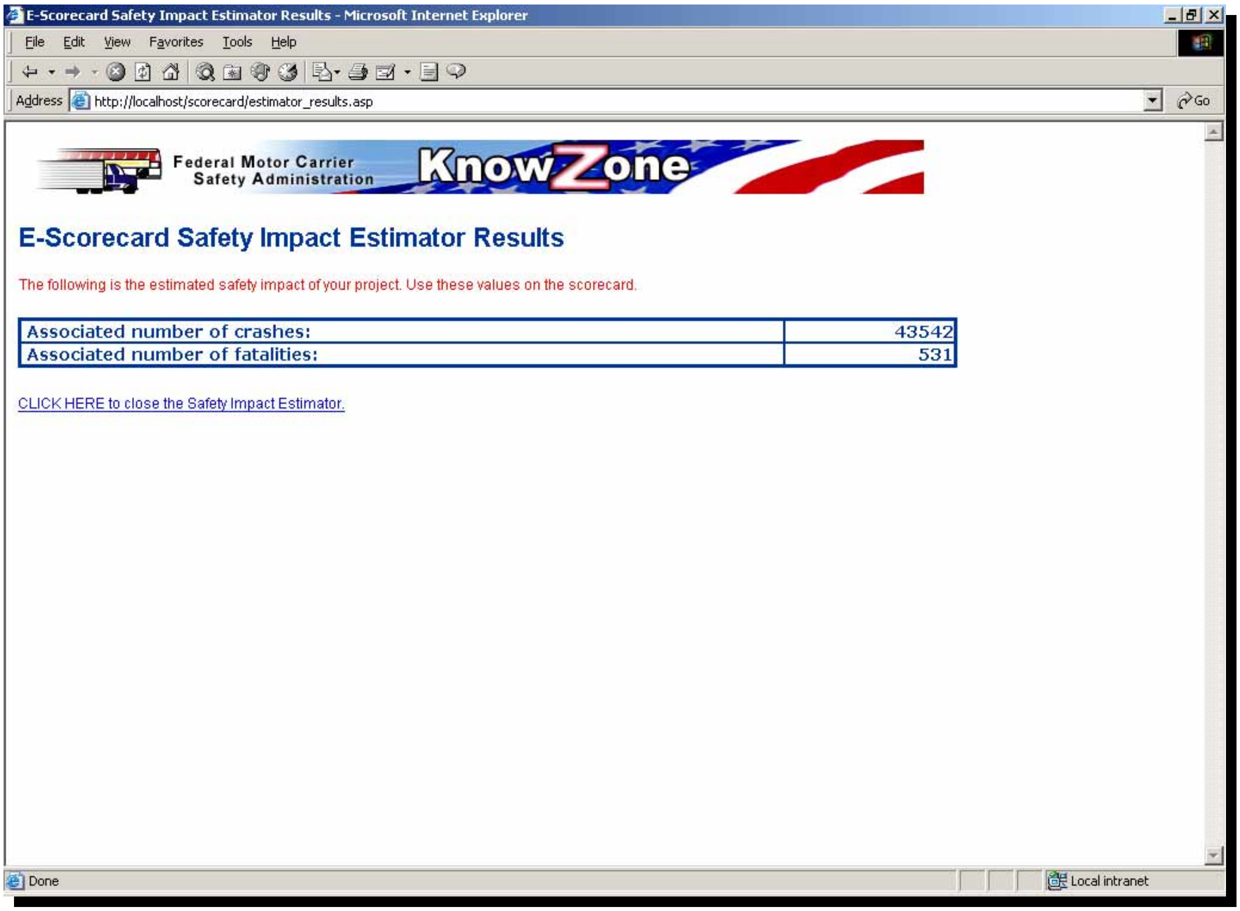


Figure 7 Sample of Safety Impact Estimator Result Page



CONCLUSION

FMCSA developed a new research program – Driver, Vehicle and Roadside Strategies for 2010 – in order to overcome some of the challenges facing its research and technology program. Using a combination of statistical analyses, a balanced scorecard approach, and expert opinion, the DVRS for 2010 program links its research agenda directly to the agency's mission and safety goals. The methodology, driven by the latest crash statistics, ensures that the most commonly recorded crash characteristics remain the focus of the program. The approach also is flexible enough to allow for the integration of alternate data sources (i.e., relative risk calculations/odds ratios, video-based near-miss data, and non-fatal crash data).

Programmatically, DVRS for 2010 has been successful at integrating its data-driven and objective approach throughout FMCSA's research activities. The program also has been successful at identifying cutting-edge commercial vehicle safety research projects. In several cases (driver notification program, and CDL anti-fraud system), the program has identified research concepts that also were being contemplated by safety experts at other organizations. In these cases, FMCSA has forged a partnership with these other organizations to complete the proposed research.

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ENDNOTES

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2. *Large Truck Crash Facts 2000*, FMCSA, March 2002.
3. R.S. Kaplan, D.P. Norton, The Balanced Scorecard: Translating Strategy into Action. *Harvard Business School Press*, September 1996, Cambridge, Massachusetts.
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