



(Photo Source: Underride Network)

**UNDERRIDE SAFETY PROTECTION:  
Benefit-Cost Assessment of Rear-Impact Guards for the  
North Dakota Farm Truck Fleet**

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October 2007

## **Disclaimer**

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## **ABSTRACT**

The North Dakota legislature recently passed a law to exempt the state's agricultural truck fleet from a requirement for rear-guard equipment as federally mandated large trucks. This analysis presents the public safety benefit-cost assessment of the device in terms of crash injury severity associated with agricultural truck rear-end crashes. It is based on North Dakota truck crash data and other research conducted on this type of crash where the passenger vehicle collides with the rear of the truck. The injury avoidance benefits and commercial vehicle safety grant benefits are estimated to be \$11.4 to \$20.2 million over the seven-year depreciable truck life. These public safety benefits are substantially higher than the estimated lifetime cost for the rear-guard equipment and maintenance of \$8.1 million. In addition to the substantial public safety benefit, noncompliance with the federal mandate may be result in the loss of certain transportation infrastructure funds.



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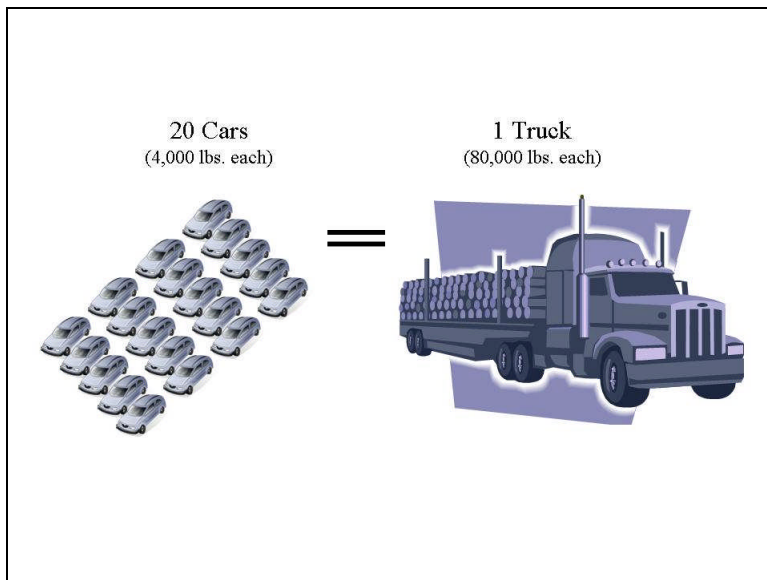
# 1. INTRODUCTION

North Dakota’s farmers depend on trucks to move more than half a billion bushels of grain to market each year. Growing farms, expanding grain terminals, and development of local processing are changing the composition and demands for this segment of state’s truck fleet (Murphy et al., 2005). Throughout these market changes, however, road safety remains a constant critical factor in state’s public goods domain with regard to truck and passenger vehicle occupants.

North Dakota residents’ quality of life includes assurance that they will have safe travel for work and leisure. Road safety includes a wide gamut of issues such as road infrastructure, traffic regulations, driver education, traffic enforcement, driving environment, traffic operations, and truck equipment. The trucks have many safety aspects directed at protecting occupants and others. This paper focuses on the rear-guard as a component of the passenger-vehicle underride protection system. A brief overview of associated federal and state regulatory items are also discussed to provide a better context for understanding the current status and interest in this safety equipment. This paper presents an overview of the rear-guard truck protection for North Dakota’s agricultural truck fleet, including an estimate of the benefits and costs associated with the equipment.

## 1.1 Background

Because trucks are typically much heavier than other vehicles in the traffic stream (Figure 1), a number of studies have shown the consequences of accidents to be more severe when trucks are involved in collisions (Craft, 2001; NTSB, 2001). In collisions involving a large truck and a smaller vehicle, the latter is likely to move underneath the truck. Further, studies have shown that of the 400,000 large trucks involved in motor vehicle crashes each year in the United States, 18 percent are involved in rear-end crashes as the struck vehicle (Craft, 2001; Knipling, 2007). This type of crash increases the already high probability of death or serious injury for smaller vehicle occupants because parts of both the car and the truck often intrude into the smaller vehicle passenger compartment (Rechnitzer, 1993).



**Figure 1.1** Gross Vehicle Weight Comparison

The National Highway Traffic Safety Administration (NHTSA) General Estimates System (GES) of crash data showed that all types of rear-end crashes are responsible for 30.0 percent injuries and 29.7 percent property damage (NHTSA, 2003). Although the prevalence of trucks in this data is not discussed, NHTSA reports that a truck is involved in one of every eight traffic fatalities; and that a large truck is 2.6 times more likely than other vehicles to be struck in the rear (NHTSA, 2007).

## 1.2 NHTSA Requirement

To reduce the impact severity of these crashes with passenger vehicles, NHTSA requires that most trailers manufactured after January 1998, with a gross vehicle weight rating (GVWR) of 10,000 pounds and above, have rear impact guards. The guards should be within 12 inches of the rear of the trailer and with a ground clearance of no more than 22 inches (FMVSS, 1996a; FMVSS, 1996b). This safety standard prevents the under-riding of smaller vehicles during rear-end collisions with large trucks. While a 1952 law provided the initial requirement for all trailers and semi-trailer to have these guards, it had a lower standard for energy absorption and equipment placement than was addressed in the 1998 ruling (NHTSA, 2004a). Simulation studies evaluating the effectiveness of heavy vehicle under-ride guards built to the minimum requirements of U.S Federal Motor Vehicle Safety Standard (FMVSS) 223 have had mixed results regarding their ability to completely stop passenger compartment intrusion (Blower and Campbell, 2002; Bloch et al., 1998; Penn, 2003). The post-1998 guard specifications do much to deal with the intrusion issues, but some concern still exists, especially for passenger vehicles in the subcompact class (Atahan, 2007).

Exemptions to the rear-guard requirement are allowed where efforts to develop a practical retractable rear impact guard for trucks have been unsuccessful because it is impractical to comply (NHTSA 2002, NHTSA 2004b). In addition, under 49 C.F.R. Sec. 393.86 (a), special-purpose vehicles, wheels-back vehicles, pole trailers, low chassis trailers, pulpwood trailers, and vehicles engaged in driveaway-towaway operations are exempted from having rear guards, as this would significantly impair their function (Bloch et al. 1998). NHTSA also exempts some single unit trucks because they represent a small portion of the under-ride safety problem (Knipling 1992). A state may also receive a specific variance from the federal motor carrier safety regulations for interstate commerce (49 C.F.R. sec 350.341; 49 C.F.R. sec 350.333; 49 C.F.R. sec 350.339).

Because rear guards on agricultural trucks hinder loading and unloading as described earlier, some states also requested exemptions for these vehicles when they applied for the FMSCA's Motor Carrier Safety Assistance Program (MCSAP). Agricultural trucks and trailers that use hydraulic hoists to dump their loads are designed with an extended rear support bed to facilitate loading and unloading. In Minnesota, farm trucks are allowed exemptions from the rear-end guard safety protection equipment because the requirement conflicts with pre-existing state law under 49 C.F.R. sec 350.341(c) which exonerates a state from the rear guard rule if a conflicting motor carrier safety law was in place before April 1988. The use of a rear guard with vehicles having this kind of movable extended rear support bed presents a problem because the guard touches the ground before the extended rear support bed reaches the inclined position. As with other non-harmonious state regulations, this presents an inconvenience to producers whose trucks cross state borders.



### **1.3 North Dakota Exemption**

Related to this inconvenience, the 60<sup>th</sup> Legislative Assembly of North Dakota passed North Dakota House Bill no.1359. The bill exempts rear-end dump trucks and other rear-unloading truck or trailers from the rear-end protection requirements while they are being used for hauling agricultural and other farm products from a place of production or on-farm storage site to a place of processing or storage. The law is scheduled to become effective on Oct. 1, 2008, or on approval of the state's application to FMCSA for the exemption if it occurs earlier. If FMCSA does not allow the exemption, it will result in North Dakota's noncompliance with MCSAP. "MCSAP is a Federal grant program that provides financial assistance to States to reduce the number and severity of crashes and hazardous materials incidents involving commercial motor vehicles (CMV). The goal of the MCSAP is to reduce CMV-involved crashes, fatalities, and injuries through consistent, uniform, and effective CMV safety programs" (FMCSA, 2007). North Dakota has been the recipient of approximately \$1.3 million in federal grant funds annually over recent years. In addition, the non-compliance may have some implications for the level and use of federal infrastructure funds the state receives (NDDOT, 2007a).

### **1.4 Study Objectives**

This research is a contribution to the exploratory process that began with the proposal and hearing associated with the legislation. It provides an assessment of the quantitative safety benefit resulting from passenger-vehicle underride protection during rear-end crashes involving large trucks in North Dakota. A cost-benefit analysis is developed based on the state's truck fleet composition, rear-guard safety equipment cost, crash probability, and resulting injury costs. Specific objectives are to:

- Describe the ND farm truck fleet.
- Estimate the likelihood that a large truck will be involved in a rear-end collision.
- Approximate injury severity for rear-end collisions involving large trucks in North Dakota.
- Calculate the cost of rear-end protection over the life of a truck.
- Enumerate the economic impact of rear-guard exemption for North Dakota's farm truck fleet.



## 2. DATA AND METHODS

Several data sources associated with the truck fleet, crash incidence, and traffic injury costs are used. The U.S. Census 2002 Vehicle Inventory Use Survey (VIUS) contains the most recent public data profile for the North Dakota truck fleet. The VIUS data is a stratified sample of all registered or licensed commercial and private trucks in the United States. It specifies the vehicle home state, vehicle configuration, body type, gross vehicle weight registered (GVWR), and primary business. The share of large truck fleet involved in agriculture in North Dakota is identified using a VIUS business variable in which the respondent specifies primary use for the truck.

Crash data is obtained from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS). The records are a census of fatal crashes with profiles on drivers, occupants, vehicles, and accidents. It is used in estimating the cost of crashes for 2001-2005. In addition, several FMCSA reports related to truck crashes are referenced in the research, including the GES, Crashworthiness Data System (CDS), and National Accident Sampling System (NASS, 2007). To give more local specificity to the crash outcome data, the North Dakota Department of Transportation (NDDOT) crash record data are used to estimate the distribution of injury severity for crashes involving large trucks in the state (NDDOT, 2007b).

Chi-square tests are used to assess the significance of various relationships between variables, and a two-way analysis of variance (ANOVA) method without replication ( $\alpha=0.05$ ) is conducted to assess the mean difference in costs within years and within categories of crash severity. Poisson distribution is employed to estimate the cost of protecting the rear of a truck in its lifetime. The benefit-cost assessment relies on these results in a net present value (NPV) calculation of rear guard safety equipment using the most recent seven years as a representative traffic pattern. It is calculated as,

### Equation 2.1

$$NPV = I + \sum_{t=1}^{t=i} \frac{B_t}{(1+r)^t}$$

where,

I = initial investment

B = annual benefit

r = rate of return, based on opportunity cost of capital, and

t = project years.

An 8 percent rate of return is used to account for the opportunity cost of the resource allocation to the rear guard. NPV estimates the value created by an underlying initial investment.<sup>1</sup> The following section presents an application of the NPV method to the rear-guard safety equipment for the fleet of large agricultural trucks in North Dakota.

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<sup>1</sup> Net present value considers an initial investment and the stream of benefits over time using a discount rate to account for the opportunity cost of capital during the investment life.



### 3. RESULTS

The North Dakota farm truck fleet includes an estimated 31,358 active, licensed farm vehicles based on the most recent U.S. Census VIUS (2003). These represent about 79 percent of the total licensed truck fleet. Numbers do not include van, pickup, and sport utility truck body vehicles. Within this fleet, 67 percent are above the 10,000-pound minimum associated with the rear-guard regulation (Figure 3.1). Approximately 2 percent of these larger agricultural trucks are subject to the newer rear-guard protection requirement since the vehicles are above the 10,000-pound GVWR minimum and manufactured in 1998 or later. The balance of the vehicles, assuming they are 1952 and newer, fall under the requirements for the less substantial manufacturer-mandated rear impact guards in place for vehicles manufactured prior to January 1998.

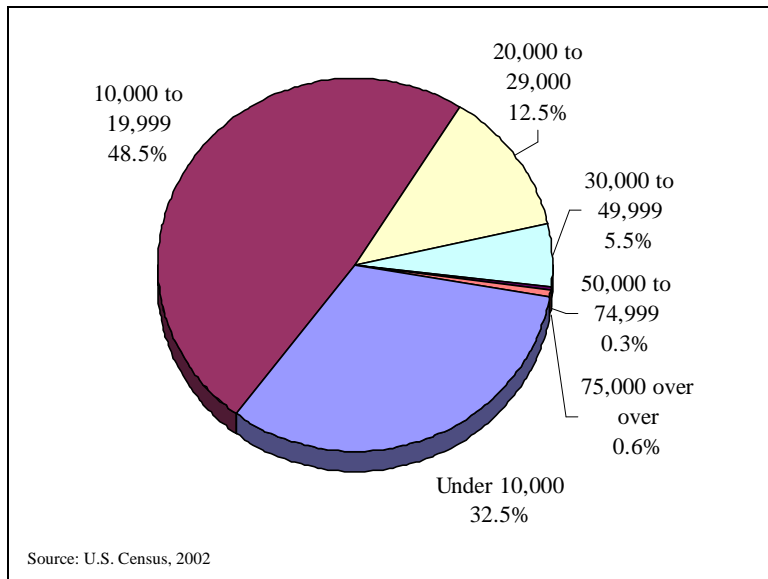


Figure 3.1 ND Agricultural Truck Fleet

#### 3.1 Likelihood that a Large Agricultural Truck Will Be Involved in a Rear-End Collision

Analysis of the North Dakota crash data is conducted to derive the probabilities of rear-end collisions involving large trucks for various categories of injury severity. The results are shown in Table 3.1. The truck weight is not available in the crash data, so the fleet of large trucks with GVWR greater than or equal to 10,000 pounds is defined to include single unit trucks, truck tractors, trucks with three or more axle single units, and any unknown heavy trucks.

In more than 3,200 crashes in North Dakota involving large trucks between 2001 and 2005, 58.3 percent included another vehicle (Table 3.1). The crash severity in collisions, based on resulting injury, includes 57 fatalities, 453 injuries, and 1,370 property damage only (PDO). Angle and sideswipe, as the initial points of impact, are the most common among truck crash collisions, accounting for nearly 70 percent of the crashes. Rear-end impact is reported in 27 percent of large truck collision-crashes. Head-on collisions are the least common among all initial points of impact, accounting for 4 percent of the large truck

crashes. PDO is the most commonly reported type of crash accounting for approximately 73 percent of all crashes, followed by injury (24 percent) and fatal collisions (3 percent). Rear-end is the initial collision-impact point in 12 percent of all fatal cases, 32 percent of all injury crashes, and approximately 26 percent of all PDO events.

**Table 3.1** Large Trucks Crash Severity in North Dakota from 2001 to 2005, by Initial Point of Impact

Initial point of Impact	Crash Severity			Overall
	Fatal	Injury	PDO	
Collisions	Number of Crashes			
Head On	11	34	32	77
Rear End	7	145	361	513
Angle/Sideswipe	39	274	977	1,290
Non-Collision	4	198	1,145	1,347
<i>Total Number</i>	<i>61</i>	<i>651</i>	<i>2,515</i>	<i>3,227</i>

Source: Crash Data, North Dakota Department of Transportation

### 3.2 Cost Estimate of Rear-End Guard Equipment Over the Life of a Truck

The initial cost for installing rear-guard as standard safety equipment during the manufacturing process is estimated to be \$375. The cost to purchase and install a rear-end guard as a retrofit or replacement part costs approximately \$1,250 based on the current value of estimates provided in the final rule regarding the equipment upgrade (USDOT, 1999). Poisson distribution was used to estimate the cost of protecting the rear of a truck in its lifetime given the likelihood that it will need to be replaced due to a crash. Poisson distribution is a discrete probability distribution that expresses the probability of a number of events occurring in a fixed period, if these events occur with a known average rate, and are independent of the time since the last event. For instance, the probability that a truck will have a certain number of rear-end collisions in its lifetime is calculated as based on the following assumptions and formulae:

Average lifetime of a truck = 7 years

Rear-end crashes involving large trucks in ND, 2001 to 2005 = 513

Average number of registered large trucks in the ND, 2001 to 2005 = 46,953

The probability that a large truck had a rear-end collision during 2001-2005 is

**Equation 1**

$$\lambda = \frac{513}{46,953} = 0.010926$$

therefore,

**Equation 2**

$$f(x) = \frac{e^{-\lambda} \lambda^x}{x!}$$

for,  $x = 0, 1, 2, 3, \dots$

where  $x$ : number of rear-end collisions in the lifetime of a truck  
 $\lambda$ : average number of accidents for the period 2001-2005  
 $e$ : base of natural logarithmic function  $\approx 2.718$

**Table 3.2** Poisson Distribution of Rear-End Collisions  
 Involving Large Trucks in North Dakota

Number of rear-end collisions (x)	f (x)
0	0.98913
1	0.01081
2	0.00006
3	0.00000002
.	.
.	.

There is a high probability that a large truck will not be involved in a rear-end collision in its lifetime (0.989). Given that the probability of the rear-end collision involving a large truck is very low (0.0109), it is very unlikely that the same truck will be involved in more than one rear-end collision. Hence, the probability of a large truck having one rear-end collision is 0.0108; the probability that the same truck will have a second rear-end collision is 0.00006 and so on. With the replacement cost of the rear impact guard at \$1,250, the estimated cost for the subsequent rear-end collisions is;

$$\$375*f(0) + \$1250*f(1) + \$2501*f(2) + \$3751*f(3) + \dots = \$385$$

Thus, the rear-end protection cost for a large truck over its lifetime is \$385 in manufacturing and potential replacement costs. Given the North Dakota agricultural truck fleet of 21,154 vehicles, the total cost of the equipment is \$8.1 million.

### 3.3 Estimated Crash Benefits of Having a Rear Impact Guards on Large Trucks

To estimate the savings for preventing or reducing injury incurred during rear-end collisions involving large trucks, crash costs and injury severity are considered. North Dakota crash data for fatal crashes and all crashes indicate 513 rear-end crashes involving trucks between 2001 and 2005. It cannot be determined if these trucks are equipped with the required underride safety equipment or to what degree the equipment may have lessened injury severity, but it is assumed that all vehicles were equipped with, at minimum, the 1952-based rear-guard equipment. Since NHTSA requires the rear-guard equipment as a protection against passenger vehicle underride, the potential benefits will be calculated as an estimated increase in injury severity associated with the crash types that would occur in absence of the equipment. Alternative scenarios for injury severity are used to estimate a benefit range.

Crash severity is grouped into levels including fatal, injury, and PDO. The FMCSA crash cost estimates by severity of crash include medical, emergency services, property damage, lost productivity, and monetized quality-of-life years (QALY). Monetized QALY is a systematic tool for valuing functional capacity loss in standardized non-monetary units related to individual utility. It measures the utility loss associated with health impairment. Cost estimates for each of the crash severity categories are shown in Table 3.3.

**Table 3.3** Per-Crash Cost for All Large Trucks in 1999 Dollars

Type of cost	Crash Severity		
	PDO	Injury	Fatal
Medical	\$ 182	\$ 8,448	\$ 28,429
Emergency services	\$ 70	\$ 343	\$ 1,757
Property Damage	\$ 2,764	\$ 6,409	\$ 17,975
Lost Productivity	\$ 7,565	\$ 65,739	\$ 969,247
Monetized QALY	\$ 718	\$ 136,066	\$ 2,401,793
<b>Total</b>	<b>\$ 11,299</b>	<b>\$ 217,005</b>	<b>\$ 3,419,202</b>

Source: Zaloshnja et al. 2000.

The total fatal crash costs were 15 times higher than both injury and PDO costs put together. The monetized QALY and lost productivity were much higher compared to other types of expenses. The Consumer Price Index (CPI) was used to convert the 1999-dollar value for individual years in the period of study. The adjusted cost estimates, the probability of rear-end collisions (Table 3.2), and the annual crashes by severity (Table 3.4) were used to estimate the costs for rear-end truck crashes in North Dakota.



**Table 3.4** Large Truck Crashes in North Dakota, 2001-2005

Year	Crash Severity			Total
	Fatal	Injury	PDO	
2001	10	136	431	577
2002	14	124	502	640
2003	15	150	501	666
2004	13	116	563	692
2005	9	125	518	652
Total	61	651	2,515	3,227

Source: North Dakota DOT Crash Data

The total costs of fatal, injury, and PDO were significantly different (P-value<0.0001). The values do, however, not vary significantly across years (P-value=0.6794). The crash severity costs are calculated as:

$$\sum_{i,j=1}^{5,3} \sum_{k,l=1}^{5,3} \sum_{m=1}^3 (x_{ij} y_{kl} z_m)$$

where  $X_{ij}$ = number of large trucks in fatal crashes (Table 3.4)  
 $Y_{kl}$ = severity of crash: using adjusted dollar values for various years (Table 3.3)  
 $Z_m$ = probabilities of rear-end collisions (Table 3.1),

For  $i$ =year (Table 3.4)  
 $j$ = severity of crash (Table 3.4)  
 $k$ =type of cost (Table 3.3)  
 $l$ =severity of crash (Table 3.3)  
 $m$ = severity of crash (Table 3.1).

Table shows the resulting estimated injury costs for rear-end crashes involving trucks in North Dakota from 2001 to 2007. As noted in the methods section, actual injury level data is presented for 2001 to 2005 based on the North Dakota Department of Transportation crash records. The remaining two years of the injury costs in the benefit-cost life cycle are based on an average of the previous three years of injury case numbers and severity.

**Table 3.5** Estimated Injury Costs for Rear-End Truck Crashes in North Dakota

Year	Crash Severity			Total
	Fatal	Injury	PDO	
2001	\$4,168,007	\$3,597,596	\$593,637	\$8,359,240
2002	\$5,945,308	\$3,342,051	\$704,475	\$9,991,834
2003	\$6,487,936	\$4,117,670	\$716,091	\$11,321,697
2004	\$5,776,229	\$3,271,177	\$826,656	\$9,874,062
2005	\$4,140,483	\$3,649,753	\$787,505	\$8,577,741
2006*	\$5,867,977	\$3,935,577	\$829,103	\$10,632,657
2007*	\$5,625,062	\$3,861,182	\$870,768	\$10,357,012
Total	\$38,011,002	\$25,775,006	\$5,328,235	\$69,114,243

\*Estimated based on previous three years.

Over a seven-year period from 2001 to 2007, it is estimated that North Dakota incurred more than \$69 million in injury costs for rear-end crashes involving large trucks (Table 3.5). The largest share of these costs is attributed to fatal crashes, resulting in an average annual cost of \$5.4 million. A cost of \$4.1 to \$6.5 million is attributed annually to deaths in fatal rear-end truck crashes.

Rear-end crashes resulting in injuries range from \$3.3 million to \$4.1 million annually resulting in an annual average cost of \$3.7 million. PDO due to rear-end crashes over the seven year period is estimated to range from \$600,000 to \$900,000 resulting in an annual average of \$760,000. The total costs of fatal, injury, and PDO were significantly different (p-value<0.0001), but not significantly different by year (p-value=0.297).

Because of the insignificant difference in total costs across the years, the most recent seven years of crash data are used to estimate the benefit from rear-guards. A seven-year period is used to make the comparison to cost of the rear-guard equipment based on a depreciable truck life of seven years. Although there would not be an expected increase in crash rates or probabilities associated with rear-end truck crashes, it would be expected that injury severity would increase in accidents if the farm truck fleet were exempted from the underride protection requirement. Therefore, overall crash numbers and point-of-impact probabilities are not changed, but the injury severity is increased to estimate the benefit of rear-guard equipment.

The net present value estimate for rear-impact crashes within the agricultural fleet is \$6.9 million over the seven-year life of the truck. This value is based on the injury severity and costs detailed in previous tables. The share of the total crash costs is attributed to the agricultural fleet based on the 40 percent representation of the fleet in all trucks, and the 11.5 percent probability that the crash will be a rear impact, based on the most recent five years of state crash data. In addition, the value is adjusted downward to account for the 0.40 estimated likelihood that it will be the truck that is the struck vehicle in a rear-end collision between a passenger car and a large truck (Craft, 2001).

Table 3.66 includes the estimated benefit based on a range of upward injury severity scenarios that may be experienced with the agricultural fleet rear-guard exemption. The estimated benefit ranges from \$3.0 to \$11.8 million considering a range of 5 to 20 percent for the potential upward shift of injury severity in the absence of the rear-guard equipment on the North Dakota agricultural fleet.

**Table 3.6** NPV Estimated Crash Prevention Benefit, Based on Increased Injury Severity for ND Agricultural Rear Impact Crashes Under Rear-Guard Exemption

	Crash Severity			Total
	Fatal	Injury	PDO	
<b>20 percent upward injury severity</b>				
Estimated Injury Costs	\$14,088,022	\$5,448,647	\$466,984	\$20,003,844
Benefit	\$9,583,962	\$2,394,802	(\$156,414)	\$11,822,541
<b>15 percent upward injury severity</b>				
Estimated Injury Costs	\$11,744,448	\$4,847,076	\$506,043	\$17,097,760
Benefit	\$7,240,388	\$1,793,231	(\$117,354)	\$8,916,457
<b>10 percent upward injury severity</b>				
Estimated Injury Costs	\$9,353,715	\$4,247,948	\$545,119	\$14,146,783
Benefit	\$4,849,655	\$1,194,103	(\$78,278)	\$5,965,480
<b>5 percent upward injury severity</b>				
Estimated Injury Costs	\$6,960,045	\$3,651,732	\$584,252	\$11,196,028
Benefit	\$2,455,985	\$597,886	(\$39,146)	\$3,014,725

The total benefits of the rear-guard equipment would also include the \$1.2 million annually in MCSAP grant funds. Therefore, the total benefit over the seven-year life of the truck would be an estimated \$11.4 to \$20.2 million, considering the traffic injury prevention and federal commercial vehicle safety grant funds implications. Any federal infrastructure related funds that are associated with the safety compliance should also be considered in this benefit summation.



## 4. SUMMARY AND CONCLUSION

North Dakota's agricultural truck fleet is an important asset in moving farm goods from field to market. As this fleet continues to evolve to serve market demands, road safety remains a constant critical factor in the state's public goods domain with regard to these vehicle occupants and the larger population of passenger vehicle occupants. The state of North Dakota has requested an exemption from FMCSA for rear guards on the state's agricultural truck fleet under the MCSAP. The analysis developed here shows that the rear-guard safety equipment has injury severity benefit that far outweighs equipment cost.

The public safety benefit is measured as crash injury prevention by estimating injury severity reduction attributed to the equipment. Given a 10 percent reduction in injury severity attributed to the rear-guard devices on agricultural trucks, in the relevant crash population, the benefit is estimated \$14.4 million over the 7-year depreciable life of a truck. This figure accounts for \$6 million in traffic injury savings plus \$8.4 million in MCSAP grant funds associated with this safety device compliance. The rear-end guard protection costs over the seven-year truck life are estimated to be \$385 in manufacturing and potential replacement costs per truck. Total equipment and maintenance cost for the North Dakota agricultural truck fleet is estimated to be \$8.1 million. Although aforementioned operational inconvenience costs may accrue to individual truck owners, these costs were not considered in this public safety assessment of the safety requirement. An estimated safety benefit of \$1.76 is generated from each dollar spent on rear guards for North Dakota's agricultural truck fleet. These gains are associated with preventing injury to passenger vehicle occupants through required rear-guard underride protection equipment and with associated federal grants for commercial vehicle safety programs.



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