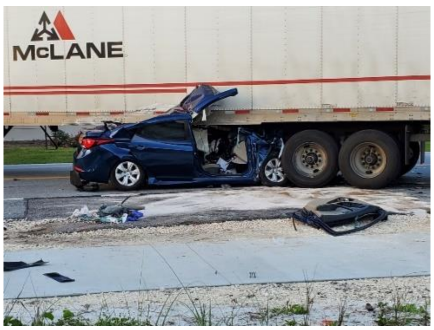
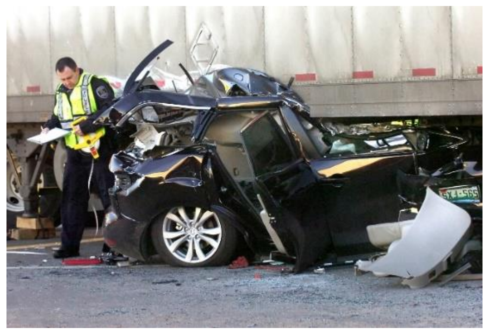
AngelWing ™ SafetySkirt ™





Using Cost-Benefit Analysis to Evaluate the Economic and Societal Benefits of Side Underride Guards for Semi-Trailers

Abstract

This report estimates the effects of implementing a regulation mandating side underride guards on new semi-trailers to evaluate the estimated benefits from a reduction of fatalities and serious injuries in conjunction with the overall costs of the guards. The cumulative 15-year annual societal benefits of mandating the installation of side underride guards on new semi-trailers would save at least 3,560 lives and prevent 35,598 serious injuries. The cost of guards would be fully offset by the estimated benefits, providing a minimum annual Net Present Value of $50,918,789,800. A regulation for side underride guards is considered cost effective because the public safety benefits from installing and maintaining semi-trailers with side underride guards substantially outweigh the costs.

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Since 1993, the U.S. Department of Transportation (USDOT) has issued guidance valuing the reduction of fatalities and injuries by regulations or investments. These recommendations ensure that the economic costs and benefits of road safety measures can be monetized and compared, leading to informed decision making. In this report, estimates of costs to the trucking industry from the installation of side underride guards (SUGs) on new semi-trailers are quantified and compared to the anticipated associated benefits to the traveling public. This report examines the impact of lives lost and serious injuries sustained, and the related financial costs resulting from underride motor vehicle crashes and the benefits of reducing the severity of these collisions. The purpose of presenting the benefits and costs is to place in perspective the economic losses and societal harm that result from side underride crashes, and to provide information to evaluate the effect of the USDOT mandating SUGs to reduce or prevent these impacts.

An "underride" occurs when a vehicle collides with a semi-trailer even at low speeds, due to the height differential. Frequently, the vehicle's windshield is shattered, the roof torn off or crumpled, and the remainder of the vehicle goes partially or completely under the semi-trailer causing catastrophic and horrific injuries to passengers usually by crushing, decapitation, or burning to death by a fire from the underride. Side underride guards can prevent fatalities and minimize the potential for serious injuries to occur. Side underride guards are a solid or flexible metal frame or cable/nylon webbing that can be affixed onto the sides of semi-trailers to prevent vehicles from going under the semi-trailer or truck.

Crash victims and their families, employers, and society are all affected by vehicle underride collisions. For example, the cost of medical care is borne by the victim in the form of payments for insurance, deductibles, uncovered costs, and uninsured expenses. There are also significant costs associated with the lost productivity experienced by an individual and others when the victim dies prematurely or experiences a short or long-term disability from serious injuries.

The USDOT provides cost estimates for crashes for injuries and fatalities. For injuries, the estimate includes the average cost of a crash in which at least one person was injured and includes medical treatment and rehabilitation costs as well as quality of life losses for injured individuals who suffer long-term disability from the crash. For fatalities, the estimate includes the average cost of a crash in which at least one person was killed, and the costs reflect the value of remaining life-years lost by the victims of the crash, in addition to the other costs associated with the crash such as treatment of injured victims, property damage, congestion delays, etc. (e.g., see Federal Motor Carrier Safety Administration (FMCSA) 2008, USDOT 2021, 2021a). These estimates include all costs to society that result from a crash, with the exception of pain and suffering for family and friends of crash victims (FMCSA 2008).

The anticipated benefits of SUGs reduce the likelihood of fatalities and serious injuries and are expected to be proportionally phased in over a 15-year period as the semi-trailer fleet is replaced. The benefits measure the economic value that is reasonably expected to result from the installation of SUGs on new semi-trailers. These estimates are compared to the anticipated costs of SUGs related to manufacturing, installing, and maintaining new SUGs, including the potential impact of weight or payload displacement. The analysis uses estimates of incremental costs on a per truck basis to calculate a 15-year cumulative cost, the expected period covering fleet replacement. Following the initial 15 years to replace the current fleet of semi-trailers, full benefits would be realized. Fuel savings from the installation of aerodynamic skirts are also estimated by assuming a 1 percent improvement in efficiency (North American Council for Freight Efficiency (NACFE) 2020). This report also identifies sources of data, values of key parameters, and reference materials for SUGs. Calculations are also included (see Appendix A; Excel Spreadsheet).

The analyses assumed that the baseline risk of between 200 and 1,000 annual fatalities and 5,000 annual serious injuries would remain constant from underride collisions in the absence of SUGs. Testing and modeling demonstrate that SUGs are expected to be highly effective and reduce the risk of annual fatalities and serious injuries by up to 89 percent (Brumbelow 2012, Insurance Institute for Highway Safety (IIHS) 2017, Mattos et al. 2021). For example, the IIHS crash tests demonstrate that SUG technology is a simple solution to the known risk of side underride collisions. Side underride guards would prevent almost all underride collisions at a speed differential of 40 mph (note: SUGs prevent underride occurrences when the vehicle and semi-trailer are travelling at highway speeds, because their speed differential would almost always be less than 40 mph). Therefore, SUGs offer significant benefits to society by reducing the risks and associated costs of semi-trailer and vehicle collisions.

Side underride guards will mitigate the main risk factor in underride collisions: a geometric height difference between passenger vehicles and semi-trailers. Underride protection will not avert collisions; rather, SUGs will prevent or diminish passenger compartment intrusion and the devastating and costly effect of fatalities and serious injuries. A SUG is designed to withstand the force of a crash and prevent the car from sliding under the semi-trailer and provide an effective point of impact that will activate the car's safety features to protect the occupants.

The general methodology used to calculate the benefits and costs of SUGs is discussed and demonstrated below. These methods could also be used to evaluate the cost-benefit analysis of SUGs for single unit trucks.

1. Estimate the annual cost of fatalities and injuries from underride crashes.
    a. Use the Fatality Analysis Reporting System (FARS) database and published literature to estimate the average number of fatalities per year from semi-trailer side underride collisions (additional analysis should also consider single unit trucks);

b. Due to the documented undercounting of FARS data, bracket this estimate to examine and capture a range of fatalities of car-truck collisions that would be prevented by SUGs (additional analysis could also include motorcycle, pedestrians, and bicyclists);

c. Estimate the annual cost of fatalities from large trucks using the USDOT valuation by multiplying the average number of fatalities per year and a range of fatalities (USDOT 2021);

d. Use published literature to estimate the average number of injuries per year from semi-trailer side underride collisions (additional analysis should also consider single unit trucks);

e. Estimate the annual cost of serious injuries from large trucks using the USDOT valuation multiplied by the average number of injuries (USDOT 2021); and

f. Use a range of values for the effectiveness of SUGs for reducing serious injuries;

2. Use reported industry data to determine the annual number of semi-trailers manufactured and sold (additional analysis should also consider single unit trucks).

3. Estimate the unit cost of an SUG to be installed on semi-trailer (additional analysis should also consider single unit trucks);

a. Use a range of cost estimates to evaluate, for example, the effect of mass production of a SUG by a semi-trailer manufacturer or other possible costs to the consumer.

4. Estimate the annual amount of fuel used by an average loaded tractor and semi-trailer by using the reported industry data of average annual miles driven divided by the average mpg fuel economy for a tractor semi-trailer.

5. Use the reported industry data of average annual mpg fuel economy for a tractor semi-trailer;

a. To determine the percent miles-per-gallon reduction from the potential weight impact on fuel economy (i.e., 0.5%–0.6% per 1,000 lbs); and
b. To determine the percent miles-per-gallon saved from the potential benefit of an aerodynamic skirt on fuel economy.

6. Estimate the effect of installing an SUG with an aerodynamic skirt using the average annual mileage driven by a tractor semi-trailer mileage divided by the difference between the potential fuel savings and potential weight on the overall mpg;

a. Compare this estimate to number 4 to determine the fuel savings; and
b. Estimate the cost savings by multiplying this fuel savings by the average cost of diesel fuel.

Parameters:

1. Annual Cost of Fatalities and Injuries from Underride Crashes.

a. Average Number Fatalities/Year: 500[a,b,c,d]

b. Range of Fatalities/Year: 200 – 1,000[a,b,c,d]

c. Cost of Average Truck-Involved Fatality: $12,071,000[e]

d. Average Number Injuries/Year: 5,000[f]

e. Cost of Average Truck-Involved Injury: $284,100[e]

f. Effectiveness of preventing fatalities and injuries: 50 percent (range 40 to 89 percent[a])

2. Annual number of semi-trailers manufactured and sold: 300,000[h]
3. Average annual number of semi-trailers manufactured and sold with SUG for entire fleet adoption of SUGs over 15 years: 513,300
4. Unit cost of an SUG to be installed on semi-trailer: $1,000, $2,000
4. Average annual tractor semi-trailer fuel economy (miles per gallon): 6.6[i]
5. Average tractor semi-trailer pounds of operating weight (2019): 63,000[i]
6. Average tractor semi-trailer moving speed (mph): 51[i]
7. Average annual tractor semi-trailer mileage driven: 105,041[j]
8. Percent Miles-per-gallon reduction from weight: 0.0025 – 0.003 (500 lbs); 0.00375 – 0.0045 (750 lbs)[j]
9. Percent Miles-per-gallon saved with an aerodynamic skirt: 0.01 – 0.05[k]
10. Average cost of fuel (2019): $3.06 [i]

Results and Discussion

Using Brumbelow's (2012) estimate of 89 percent effective rate for SUGs with an average annual proportional fatality rate (i.e., calculated as the proportion of guarded to unguarded trailers) of 500 fatalities, the 15-year cumulative monetized estimate from installing SUGs is $42,972,760,000 by saving at least 3,560 lives (societal benefit) plus the 15-year cumulative reduction of $10,113,391,800 by preventing 35,598 serious injuries (societal benefit). The 15-year cost of $4,500,000,000 (cost for trucker drivers or trucking companies) was subtracted from this estimate to calculate the net present value (NPV) benefit of $ $48,586,151,800 (Table 2). As demonstrated below, the addition of an aerodynamic skirt would save an additional $2,332,638,000 (1 percent of fuel) to $16,587,648,000 (5 percent of fuel; benefit to trucker drivers or trucking companies) and *fully offset* the entire cost of SUGs to provide a minimum NPV 15-year benefit of $50,918,789,800 to $65,173,799,800. After the fleet is replaced in 15 years, the annual estimated benefit from SUGs is at least $5,371,595,000 attributed to 445 lives saved per year and $1,264,245,000 attributed to the reduction of 4,450 serious injuries per year. Please also see additional computations below for the full range of estimates (Appendix 1).

In 2019, the average moving speed of a tractor semi-trailer combination was 51 mph, indicating a high potential for fuel savings when aerodynamic drag is reduced by the addition of a skirt (NACFE 2020). In fact, trailer skirts offer 1 to 5 percent fuel savings than non-skirted trailers (NACFE 2020). Ponder (pers. comm. 2017) reported that an AngelWing SUG with an aerodynamic skirt increased fuel efficiency by 8.3 percent. Nevertheless, the addition of a 500-pound SUG without an aerodynamic skirt would add approximately 48 gallons ($146.00 using $3.06/gallon) of diesel annually using the highest estimate of fuel impact of 0.003 percent. However, the addition of a 250-pound aerodynamic skirt (total weight of 750 pounds with an SUG plus a skirt) would increase the average of 6.6 mpg by 1 to 5 percent to achieve an annual fuel reduction savings of 98 to 704 gallons ($302.00 to $2,153.00 using $3.06/gallon) of diesel fuel (NACFE 2019, 2020). Average diesel fuel costs decreased by 9 percent between 2018 ($3.18) to 2019 ($3.06) (Williams and Murray 2020). The lack of car travel due to COVID-

19 has severely decreased the demand for gasoline and diesel – resulting in one of the steepest decreases in fuel prices recently (Williams and Murray 2020). Williams and Murray (2020) reported that fuel prices are expected to continue decreasing; however, if fuel prices rise, the savings would be greater.

Brumbelow's (2012) evaluation of the potential benefits of SUGs strongly suggested that they would also reduce injury severity. Of passenger vehicle occupants with serious to fatal injuries attributed to side impacts with semi-trailers, 89 percent were considered injuries that could have been mitigated by SUGs. As a passive safety device, underride protection guards do not affect the risk of collision, but evidence shows that these guards would have a large a reduction in crash risk and severity of accidents as measured through the preventing injuries and fatalities, and the associated property damage from collisions (e.g., Brumbelow 2012, NTSB 2014, IIHS 2017). Future analysis should strongly consider the additional benefit of a reduction in property damage using the cost per crash of property damage only (e.g., see NHTSA Table 10, $11,953 per crash in year 2000 dollars).

For example, Brumbelow (2012) estimated that 530 passenger vehicle occupants died each year during 2006–2008 in two-vehicle collisions between passenger vehicles and the sides of large trucks. Brumbelow (2012) also reported that injuries and deaths from side underride collisions into heavy trucks and trailers are a significant public health issue. Side underride guards are designed to engage car safety systems (e.g., airbags, crumple zones, seat belts) during a collision to reduce the degree of passenger compartment intrusion (Mattos et al. 2001). Significant expenses went into developing these car safety systems, but without a SUG they are rendered useless.

Following USDOT's Cost-Benefit Guidance (2021), NPV is estimated because it is the most straightforward measure. Benefits are considered in present dollars tallied over a 15-year period to mandate phasing out and full turnover of the semi-trailer fleet, whereas the costs are also present dollars tallied over the 15-year period and are subtracted from the benefits to yield an NPV. An SUG with an aerodynamic skirt would offset the entire cost to truck drivers or trucking companies.

The benefits and costs of SUGs would be phased in and not fully accrue until the current fleet of semi-trailers has been replaced. The average semi-trailer is replaced every 12.8 years; however, the average age of semi-trailers is 6.2 years (Williams and Murray 2020). Because of significant cost savings, some fleets are replacing semi-trailers every five to seven years through leasing programs, which are gaining in popularity, as opposed to legacy practices of operating them for 10 years (Straight 2019). Based on these data, by year 6 many of the semi-trailers on the road would have SUGs, with the current fleet of semi-trailers replaced by year 12. Nevertheless, to be more conservative in the length of time to fully penetrate the semi-trailer fleet (i.e., older trailers are replaced by newer trailers), costs and benefits were estimated using a 15-year phased approach (Table 4).

The NPV should be considered minimum estimates because they do not incorporate additional benefits to the trucking industry such as lower legal (e.g., jury verdicts) and court costs, insurance cost reductions on premiums and settlements, or less workplace impacts (e.g., potential jail time or PTSD for drivers). When the USDOT conducts a cost-benefit analysis for SUGs, qualitative measures of benefits or costs that are difficult to quantify, but nevertheless essential, should also be considered (Executive Order 12866). Further, in choosing among regulatory approaches to underrides, the USDOT should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages).

The cost-benefit calculations used the likely cost of $1,000 for the unit cost of a SUG, but also doubled this estimate and evaluated $2,000 per SUG to account for the possible range of costs that could be related to purchase price, maintenance, or other potential costs (e.g., aerodynamic skirt; Appendix 1). For example, if the maximum unit cost of an SUG is $4,000, with 500 annual fatalities, an 89 percent effective rate, and a 1 percent fuel efficiency from an aerodynamic skirt, the NPV would still be an estimated $37,418,789,800. As a result, the highest cost could also account for any additional expenses borne by the consumer. Ranges of estimates were also used in the cost-benefit analysis to account for under-reporting of data (e.g., using 500 as the average of annual fatalities from side underride collisions and a range of 200 to 1,000 fatalities per year), but could also explore unclear market responses (e.g., considering how fewer deaths and injuries to the traveling public may affect insurance premiums for trucker drivers or trucking companies).

The most common trailer type is the standard dry van or box trailer, which is enclosed and can haul most types of mixed freight (Environmental Protection Agency (EPA) 2016). One common type of box trailer is the refrigerated van trailer (reefer). This is an enclosed, insulated trailer that hauls temperature sensitive freight, with a refrigeration unit or heating unit mounted in the front of the trailer powered by a small (9-36 horsepower) diesel engine. The most common type of trailer in use is the dry van trailer, followed by the reefer. Together, the standard box vans and reefers are the likely types of trailers for SUGs and make up greater than 70 percent (7.7 of 11 million) of the registered semi-trailers (EPA 2016).

The general rectangular shape of these trailers allows operators to maximize freight volume within the regulated dimensional limits. For semi-trailers, the majority of freight hauled in semi-trailers cubes-out (is volume-limited) before it grosses-out (is weight-limited) (EPA 2016). Federal Highway Administration (2000) estimated that about 80 to 90 percent of "cubes out before it weighs out". This means that cargo space in a semi-trailer usually fills before reaching the 80,000 pound limit. Indeed, Williams and Murray (2020) reported that the average operating weight of a tractor and semi-trailer in 2019 was 63,000 pounds, leaving 17,000 pounds on average before reaching the weight limit. The average weight of a SUG is currently about 500 pounds; however, other braided cable or nylon webbing designs are about half of this weight (Vanguard 2019; Radio Canada (Fortier) 2018; SafetySkirt 2020). Future engineering after SUGs are mandated will undoubtedly bring about further innovations in reducing guard weight leading to additional cost savings.

Regardless of loading configuration of semi-trailers, the addition of any weight to a semi-trailer has the potential to negatively affect the fuel consumption of the tractor unless the increase in fuel consumption is offset by a sufficient reduction in aerodynamic drag by the device itself. For example, approximately 40 percent of new box trailers are sold with aerodynamic side skirts (NACFE 2019). Still, the current aerodynamic skirt designs leave a portion of the semi-trailer underbody uncovered and exposed to air currents that affect fuel efficiency. SUGs cover the entire area exposed under a semi-trailer and the addition of a skirt to cover this area would improve the aerodynamics and save additional fuel likely even beyond the estimates below (Table 3). Aerodynamic-device-equipped semi-trailers can also reduce drag by improving air flow around the truck and semi-trailer, which also helps reduce splash and spray generated by trucks in wet weather (NACFE 2019; 2020).

Conclusion

As demonstrated, societal benefits exceed and fully offset the overall cost to the trucking industry. The cumulative 15-year annual societal benefits of mandating the installation of SUGs on new semi-trailers would save at least 3,560 lives and prevent 35,598 serious injuries. ***The estimated NPV is positive and a regulation for SUGs is considered cost effective*** because the public safety benefits from installing and maintaining semi-trailers with side underride guards substantially outweigh the costs.

Note: This report also includes an unprotected Excel spreadsheet with embedded calculations to allow USDOT reviewers to conduct further sensitivity analyses or update parameters, as necessary and warranted. Sensitivity analysis could be used to help illustrate how the results of the cost-benefit analysis would change if it employed alternative values for key data elements. For example, the estimates use multiple annual fatalities from side underride collisions and variations in the effectiveness of SUGs to conduct a straightforward sensitivity analysis to estimate the benefits under different crash reduction assumptions (USDOT 2021).

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Appendix 1

Computations

Table 1. Estimated benefits of side underride guards for reducing annual fatalities and injuries.

	40 Percent Effectiveness	50 Percent Effectiveness	89 Percent Effectiveness
Benefit of reducing 200 Annual Fatalities	$7,725,440,000	$9,656,800,000	$17,189,104,000
Benefit of reducing 500 Annual Fatalities	$19,313,600,000	$24,142,000,000	$42,972,760,000
Benefit of reducing 1,000 Annual Fatalities	$38,627,200,000	$48,284,000,000	$85,945,520,000
Benefit of reducing 5,000 Annual Injuries	$4,545,315,900	$5,681,715,900	$10,113,391,800
Total Benefit Reducing 200 Fatalities and 5,000 Injuries	$12,270,755,900	$15,338,515,900	$27,302,495,800
Total Benefit Reducing 500 Fatalities and 5,000 Injuries	$23,858,915,900	$29,823,715,900	$53,086,151,800
Total Benefit Reducing 1,000 Fatalities and 5,000 Injuries	$43,172,515,900	$53,965,715,900	$96,058,911,800

Table 2. Net Present Value of Side Underride Guard using $1,000.

	40 Percent Effectiveness	50 Percent Effectiveness	89 Percent Effectiveness	1% Fuel Savings With Aerodynamic Skirt	5% Fuel Savings With Aerodynamic Skirt
Net Present Value of Reducing 200 Fatalities and 5,000 Injuries	$7,770,755,900	$10,838,515,900	$22,802,495,800	$25,135,133,800	$39,390,143,800
Net Present Value of Reducing 500 Fatalities and 5,000 Injuries	$19,358,915,900	$25,323,715,900	$48,586,151,800	$50,918,789,800	$65,173,799,800
Net Present Value of Reducing 1,000 Fatalities and 5,000 Injuries	$38,672,515,900	$49,465,715,900	$91,558,911,800	$93,891,549,800	$108,146,559,800

Table 3. Net Present Value of Side Underride Guard using $2,000.

	40 Percent Effectiveness	50 Percent Effectiveness	89 Percent Effectiveness	1% Fuel Savings With Aerodynamic Skirt	5% Fuel Savings With Aerodynamic Skirt
Net Present Value of Reducing 200 Fatalities and 5,000 Injuries	$3,270,755,900	$6,338,515,900	$18,302,495,800	$20,635133,800	$34,890,143,800
Net Present Value of Reducing 500 Fatalities and 5,000 Injuries	$14,858,915,900	$20,823,715,900	$44,086,151,800	$46,418,789,800	$60,673,799,800
Net Present Value of Reducing 1,000 Fatalities and 5,000 Injuries	$34,172,515,900	$44,965,715,900	$87,058,911,800	$89,391,549,800	$103,646,559,800

Table 4. Cumulative lives saved over 15 years, using an average of 500 annual fatalities, 5,000 annual serious injuries, and an 89 percent effective rate, as older trailers are replaced with new trailers and side underride guards.

	Trailers Replaced	**Remaining Unguarded**	**Proportion of Trailers with SUGs Replaced to Unguarded**	**Annual Lives Saved**	**Annual Injuries Prevented**
Year 1	513,300	7,186,700	0.066662338	29.66474026	296.6474026
Year 2	1,026,600	6,673,400	0.133324675	59.32948052	593.2948052
Year 3	1,539,900	6,160,100	0.199987013	88.99422078	889.9422078
Year 4	2,053,200	5,646,800	0.266649351	118.658961	1186.58961
Year 5	2,566,500	5,133,500	0.333311688	148.3237013	1483.237013
Year 6	3,079,800	4,620,200	0.399974026	177.9884416	1779.884416
Year 7	3,593,100	4,106,900	0.466636364	207.6531818	2076.531818
Year 8	4,106,400	3,593,600	0.533298701	237.3179221	2373.179221
Year 9	4,619,700	3,080,300	0.599961039	266.9826623	2669.826623
Year 10	5,133,000	2,567,000	0.666623377	296.6474026	2966.474026
Year 11	5,646,300	2,053,700	0.733285714	326.3121429	3263.121429
Year 12	6,159,600	1,540,400	0.799948052	355.9768831	3559.768831
Year 13	6,672,900	1,027,100	0.86661039	385.6416234	3856.416234
Year 14	7,186,200	513,800	0.933272727	415.3063636	4153.063636
Year 15	7,699,500	500	0.999935065	444.9711039	4449.711039
Totals				3,560	35,598

Example calculations from SUG installation (see Excel spreadsheet for others):

1. (Cumulative number of lives saved over 15 years using the annual proportion of guarded and unguarded trailers multiplied by an annual average of 500 fatalities *x* 40 percent effectiveness) *x* (Average fatality cost)

   For example, Year 1 is: ((1-(0.389)) *x* (500 *x* 0.40)) *x* (12,071,000) = $11,286,385,000

2. (Cumulative number of lives saved over 15 years using the annual proportion of guarded and unguarded trailers multiplied by an annual average of 500 fatalities *x* 50 percent effectiveness) *x* (Average fatality cost)

   For example, Year 1 is: ((1-(0.389)) *x* (500 *x* 0.50)) *x* (12,071,000) = $14,110,999,000

3. (Cumulative number of lives saved over 15 years using the annual proportion of guarded and unguarded trailers multiplied by an annual average of 500 fatalities *x* 89 percent effectiveness) *x* (Average fatality cost)

   For example, Year 1 is: ((1-(0.389)) *x* (500 *x* 0.89)) *x* (12,071,000) = $25,119,751,000

4. (Cumulative number of serious injuries prevented over 15 years using the annual proportion of guarded and unguarded trailers multiplied by an annual average of 5000 injuries *x* 50 percent effectiveness) *x* (Average injury cost)

5. For example, Year 1 is: ((1-(0.389)) *x* (5000 *x* 0.50)) *x* (284,100) = $3,320,560,800

6. Costs of SUGs (purchase of side guard, payload displacement, maintenance) *x* average annual number of semi-trailers purchased over 15 years

   (1,000 *x* 300,000) *x* 15 = $4,500,000,000

7. Fuel savings with Aerodynamic skirt (average mpg+(percent fuels savings *x* average mpg)) – (average mpg *x* weight impact to fuel)

   (6.6+(0.01 *x* 6.6))- (6.6 *x* 0.003)