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Heavier Semis: A Good Idea?

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Executive Summary

Federal and state regulations govern the weight and physical dimensions of trucks, buses, and trailers on US highways. The regulations have important economic consequences because trucking accounts for about 80% of expenditures on freight transportation in the United States, and trucking costs are influenced by the amount of cargo that can be transported per shipment. Current weight limits on semi-trucks (80,000 pounds GVW) have been in place since 1975, but rising fuel costs, periodic labor shortages, and increasing congestion on the nation's roadways have prompted some lawmakers to consider increasing those weight limits to levels approaching 100,000 pounds (lbs.).

Changes to truck weight limits is a highly-charged, often emotional issue. Few automobile drivers look forward to the prospect of sharing the road with vehicles weighing almost 50 tons, particularly since highway truck accidents involving passenger cars—when they occur—are often devastating, and are commonly fatal. And, highly visible concerns about infrastructure integrity—including the recent I-35 bridge collapse in Minneapolis—create obvious concerns about whether the current state of the highway system is adequate to support trucks that could weigh more than 20% over current limits without leading to a higher incidence of catastrophic failure.

This report analyzes, from an economic standpoint, the pros and cons of allowing higher weight limits. It considers not only efficiency and cost savings from the proposed higher limits, but also provides a thorough review of highway safety considerations and infrastructure integrity issues that could be associated with allowing heavier trucks. It finds generally that efficiency gains from higher weight limits could be substantial, although the benefits will vary by industry depending on the characteristics of the cargo shipped. We also find little substantive evidence that heavier trucks would pose a safety hazard, since the addition of another axle would provide the necessary additional braking capacity to handle the added weight. Regarding infrastructure integrity, the results are mixed. The additional axle would mitigate pavement damage that might be associated with heavier trucks, but it would do relatively little to reduce stress on bridges and overpasses. Most bridges would likely be able to handle the additional weight, but older bridges could be in need of replacement or reinforcement to safely handle these trucks.

Future Estimates of Freight Movements by Semis

According to the Department of Transportation, the volume of freight demand by all modes (air, truck, rail and water) is expected to increase from 21.2 billion tons in 2007 to more than 37.2 billion in 2035, an increase of 16 million tons or 75%. Truck volumes are expected to register the largest increase, rising from 12.9 billion tons in 2007 to 22.8

billion in 2035, an increase of nearly 10 million tons or 77% over that time period. Moreover, truck volumes are expected to increase more than the total increase of all other modes combined.

The study found that increasing weight limits from 80,000 lbs. on five-axle truck semitrailers to 97,000 lbs. on six-axle truck semitrailers would reduce the number of truck trips and total truck miles, and result in substantial savings in fuel costs. By 2020, due to the large size of the truck market, even a small percentage decrease in the number of trips will save approximately 16.9 million trips annually, reduce miles driven by 2.7 billion annually, and save 221 million gallons of diesel annually.

It follows that fewer trips and reduced truck mileage will also translate to fewer accidents involving trucks. In 2007, for every 100 million vehicle miles traveled by semi-trucks, traffic accidents resulted in 2.5 fatalities and 38.1 injuries.[1] Applying these same accident rates to the estimated 2.7 billion mile reduction in truck trips allowed by higher weight limits suggests a net reduction of 67 fatalities and 1,028 injuries per year by 2020.

And, there is no compelling evidence to suggest that the higher truck weights would themselves lead to an increase in fatality or injury rates, so long as the additional axle is also included to provide added braking power.

Motorist Safety

Research indicates that if truck weight limits are increased, adding an extra axle with the accompanying brakes increases excess brake capacity and improves stopping performance. Also adding an axle increases the number of tires on a truck from 18 to 22 reducing the load weight per tire also improving tire surface and braking friction.

Research results also indicate that there is very little difference between five-axle 80,000 lb. semitrailers and six-axle 97,000 lb. semitrailers in terms of key characteristics of crash dynamics, such as static roll stability, load transfer ratio and rearward amplification.

Still, proposals to increase truck size and weight maximums likely face opposition because automobile drivers think they are much more dangerous than they are. In reality, fatalities and injuries in accidents involving trucks have been declining steadily for several decades in spite of much greater traffic congestion and much higher highway speeds for all vehicles.

Research also suggests that increasing maximum truck weights could make US highways safer and reduce the number of highway truck crashes by reducing the number of truck miles needed to move any given amount of freight.

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[1] Source: *Large Truck and Bus Crash Facts 2007*, January 2009, Analysis Division Federal Motor Carrier Safety Division.

Infrastructure Integrity

Increasing the allowable weights of trucks has implications for wear-an-tear on bridges and roadways, but the relationship is complicated and the magnitude is uncertain. Pavement and bridge impacts are major concerns associated with changing truck weight limits because of the magnitude of Federal and State investments in pavement on the Nation's highways and in repairing or replacing bridges. Wear-and-tear on paved surfaces (including on bridges) depends on both the volume of traffic and the number of axles over which the weight of the traffic is distributed. The structural integrity of bridges depends not only on the weight of the vehicles that pass over it, but also the number of axles that carry the weight and the distance between those axles—a relationship used to establish the "bridge formula" that guides current weight restrictions.

The principal cost for bridges associated with heavier trucks lies in ensuring that the bridge can safely accommodate the trucks. This involves replacing or strengthening bridges. In addition bridge replacement or repair disrupts traffic and increases motorist time requirements as traffic patterns change. As a general rule, most bridges constructed after the late 1970s can support heavier trucks than are allowed under current rules. However, only about 37% of today's bridges were built since 1979.

Research shows that the use of six-axle 90,000 lb. tractor trailers would not increase stress on bridges at maximum weight compared with five-axle tractor semitrailers. However, the heavier six-axle 97,000/98,000 lb. semitrailers would exceed current bridge formula limits and might cause stresses exceeding bridge design. The removal of the current bridge formula cap of 80,000 lbs. on gross vehicle weight would allow minimal or no increase in gross weight of a five-axle tractor semitrailer, but could allow vehicles with additional axles to operate substantially above 80,000 lbs. However the bridge formula has not been updated since it was developed in the mid-1970s.

The six-axle 90,000 and 97,000 lb. tractor semitrailers were found to cause the same or less road damage than the five-axle semitrailer. Unit pavement costs and pavement costs per unit of payload-mile are also the same or lower for six-axle semitrailers than for five-axle semitrailers.

Enhanced Efficiency of Transporting Soybeans and Products

Based on Informa soybean production forecasts and the average semi-truck size of 80,000 lbs. (900 bushels per shipment), the number of semi-truck trips hauling soybeans to an initial storage location off-farm in the United States (about 40 miles) is forecast to increase 39% from 2.8 million in 2009 to 4.0 million in 2020 and increase 42% among the select states from 2.1 million in 2009 to more than 3.0 million in 2020. For example, the number of truck trips in Iowa is expected to increase 42% and in Illinois 39%. The number of truck trips in North Dakota is forecast to expand the most at 58% because its acreage is expected to expand considerably. Using 97,000 lb. six-axle truck semitrailers will reduce the number of soybean loads nearly 2% from 4.0 million under the current weight limit to 3.9 million in 2020.

The reduction in the number of truck trips will reduce the amount of fuel consumed. Based on various diesel fuel prices and change in fuel consumption, and number of truck trips required under a higher weight limit, soybean farmers could realize savings of between $1.2 million with diesel prices at $2 per gallon and nearly $2.5 million with diesel priced at $4 per gallon.

For secondary users of soybeans or the next trip for soybeans from the initial off-farm elevator, the assumptions remain the same as before except the round trip increases to 100 miles from 40 miles and that 55% of the soybeans will move by truck instead of 100% from the farm. The secondary move includes soybeans that are shipped from the initial elevator to a soybean crushing processor or export location. By 2020, secondary soybean moves will be reduced by 35 thousand trips for select Midwestern states.

Total mileage saved from the farm to the grain elevator is 2.4 million miles (based on 40 mile roundtrips) and from the elevator to processor and export location is 3.5 million miles (based on 100 mile roundtrips).

Almost all grain elevators are equipped to handle an increase in truck weights. All pits and elevators would be able to handle the increase in truck weights with the exception of maybe a few minutes of delay time at some elevators.

Most states allow heavy trucks on the state and county roads; especially during harvest. For short moves, such as farm to elevator, avoiding federal interstates and highways is manageable. As a result, the benefit of increased truck weight limits is marginal. For longer distance moves, avoiding federal interstates and highways is difficult. So, the truck has to be loaded to the federal limit and cannot take advantage of state regulations. The longer hauls will benefit the most from increased federal truck weight limits.

I. Introduction

Federal and state regulations govern the weight and physical dimensions of trucks, buses, and trailers on US highways. The regulations have important economic consequences because trucking accounts for about 80% of expenditures on freight transportation in the United States, and trucking costs are influenced by the amount of cargo that can be transported per shipment. But, the issue is complex, since size and weight limits could also influence highway construction and maintenance costs and the convenience and safety of highway travel. The regulations can affect international commerce and competitiveness as well because the US limits differ from those of Canada and Mexico—each of which have higher weight limits than the United States.

The Federal Aid Highway Act of 1956 (the "1956 Act") established the first uniform federal weight and size restrictions for interstate trucking. Trucks were limited to 18,000 pounds (lbs.) gross vehicle weight (GVW) per single axle and tandem axles to 32,000 lbs., with an overall limit of 73,280 lbs. GVW. The 1956 Act included a "grandfather clause" which provided that the federal weight limits would not apply to trucks in states which permitted weights that exceeded the federal standards. In 1975 Congress increased the weight limits as a means of promoting greater efficiency in transportation, given the energy crisis that was occurring at that time. The weight limit for single axles went to 20,000 lbs., for tandem axles to 34,000 lbs., and the overall weight limit was raised to 80,000 lbs. GVW. These limits remain in effect today.

There has been long-standing interest in further increasing federal truck weight limits, and these efforts now appear to be gaining traction, prompted by recent record-high fuel prices, projections of prolonged labor shortages in the trucking industry, advanced safety equipment (including anti-lock braking systems) on modern trucks, and growing concern about road congestion.

Most legislative efforts to increase truck weight limits currently focus on congressional efforts to pass H.R. 1799, "The Safe and Efficient Transportation Act of 2009." This bill, introduced by Rep. Michael Michaud (D-ME), provides an option for individual states to increase allowable truck weights on a single-trailer truck up to 97,000 lbs on federal interstate highways in each state[2]. Trucks would be required to add a sixth axle for better braking and handling. Each truck adding an additional axle would also be required to pay a higher large vehicle user fee to a Safe and Efficient Vehicle Trust Fund to assist with

[2] The proposed truck weight limit of 97,000 lbs. was derived from the current US truck weight limits that require the tandem axles on the tractor and the trailer to be a maximum of 34,000 lbs. With the addition of an extra axle, the weight limit would increase 17,000 lbs. to 51,000 lbs. for the tridem axle on the trailer. Given the 12,000 lbs. drive axle, the 34,000 lbs. tandem axle on the tractor and the 51,000 lbs. tridem axle on the trailer, the rig configuration would be 97,000 lbs.

maintenance and bridge repair. Industry support for this bill is widespread, and this reform could be included as part of the 2009 Highway Authorization Bill.

However, although the efficiency gains from allowing trucks to carry heavier loads are self-evident these heavier trucks raise concerns about motorist safety and the possibility of accelerated wear-and-tear on bridges and roadways. Reflecting these concerns, Rep. James P. McGovern (D-Mass) is sponsoring legislation that would extend current truck size and weight limits to the entire national highway system, eliminating the common practice for states to adjust the limits on non-interstate roads by issuing overweight load permits or otherwise allowing heavier and longer trucks to travel on local roadways.

It is clear that changes to truck weight limits is a highly-charged, often emotional issue. Few automobile drivers look forward to the prospect of sharing the road with vehicles weighing almost 50 tons, particularly since highway truck accidents involving passenger cars—when they occur—are often devastating, and are commonly fatal. And, highly visible concerns about infrastructure integrity—including the recent I-35 bridge collapse in Minneapolis—create obvious concerns about whether the current state of the highway system is adequate to support trucks that could weigh more than 20% over current limits without leading to a higher incidence of catastrophic failure.

Nevertheless, it is also true that practically all modes of the nation's transportation sector are approaching capacity, while freight volume will continue to grow in lock-step with economic prosperity. An increase in truck weight limits is a quick, low-cost approach to effectively increasing the capacity of the trucking industry even if the number of trucks that adopt these higher weights is small relative to the total truck inventory.

This report analyzes, from an economic standpoint, the pros and cons of allowing higher weight limits. Reflecting current legislative proposals, most of the analysis considers a weight limit increase to 97,000 lbs. GVW, although the results are easily generalized to consider limits with a range from 90,000 lbs. to upwards of 100,000 lbs. This report considers not only efficiency and cost savings from the proposed higher limits, but also provides a thorough review of highway safety considerations and infrastructure integrity issues that could be associated with higher truck weights.

Following this introduction, the report is organized as follows:

- Chapter II considers the overall demand on the nation's transportation infrastructure, freight shipments by mode, and capacity constraints that currently exist in the system. Freight shipment volumes, by mode, are forecast to 2020.
- Chapter III reviews and analyzes information that could link truck weights with motorist safety, considering such variables as braking distance with the added weight and the effect on truck stability or potential for roll-over.
- Chapter IV considers the relationship between truck weights and infrastructure integrity, including wear-and-tear on roadways and the relationship between truck weights and bridge stress.
- Chapter V examines the effect of higher truck weight limits on the efficiency in transporting soybeans and soybean products.

II. The US Freight Transportation System

The US economy depends on the rapid and efficient movement freight to link businesses, their suppliers and retail outlets throughout the nation and the world. The volume of freight shipped across the United States is a direct function of the size of the economy, and freight volume shipments tend to increase in proportion to economic growth since nearly every product produced (excepting information, services and intellectual capital) includes a significant freight component to assemble supplies and transport finished goods to their point of sale.

According to the US Department of Transportation (DOT), the US transportation network (all transportation modes) moved an average of 53 million tons of freight worth $36 billion per day in 2002, and provisional estimates suggest that by 2007 volume shipments grew to over 58 million tons worth nearly $41 billion per day (in constant 2002 dollars). The majority of shipment volume is transported by truck: truck shipments account for 60% of the freight tonnage and 65% of the total value of shipments. Much of this large share of total volume (and value) shipments reflects the fact that nearly every land-based supply and delivery point in the continental US is accessible by road, so practically all freight shipments of modest distance (e.g. less than 100 miles) are moved by truck, along with a significant proportion of longer-distance deliveries that compete to varying degrees with rail, air, waterways and pipelines.

Railways account for about 10% of the total volume of shipments in the United States (1.9 billion tons annually, or 5 million tons per day), but since they tend mostly to ship products over very long distances, the ton-miles of rail shipments per year[3] slightly exceeds the annual ton-mile shipments by truck. For 2006 (the most recent year for which official estimates were compiled by the Bureau of Transportation Statistics) trucks moved 1.3 trillion tons miles of freight, compared to 1.85 trillion ton miles for railroads. Combined, trucks and railways account for about 68% of US ton-mile freight shipments, and both show strong, consistent growth in demand as ton-miles hauled by each of these modes has roughly doubled since 1980.

However, most of the nation's freight transportation network was developed before 1960, and capacity growth since then has proceeded at a modest pace. Although the US transportation infrastructure remains one of the most modern and efficient in the world, its physical extent and capacity has not increased at nearly the rate of freight transportation demand. In fact, since 1980 the miles of public roadways has increased by only about 4.5% and the mileage in the railway system has actually declined by close to 23%. The result is that, especially for trucks and trains, the transportation system is increasingly

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[3] A ton-mile is defined as one ton of freight shipped one mile, so it is a standardized measure of freight demand that reflects both volume and distance.

crowded and congested, and these conditions are expected to only worsen over time as freight volume shipments increase at a pace much faster than future investments in added capacity.

Freight congestion is detrimental to the economy in many ways. Aside from the nuisance of added driving time that affects all vehicles including passenger cars, it also directly increases costs across the economy while providing no offsetting benefits. These added costs ultimately reduce economic output and waste resources that could otherwise be put to more productive use. For instance:

- Congestion anywhere in the transportation system slows the movement of freight and increases the average time to ship products, especially over long distances. It also can increase the variability in the time needed to ship products a given distance, since traffic volume is highly variable by location and often shows considerable daily, weekly and seasonal differences. For any business that depends on delivered inputs, delayed supply shipments can be a considerable risk that in extreme cases can impede production and force temporary shutdowns of production facilities. To offset this risk, firms must maintain larger supply inventories, which add directly to costs in terms of added warehouse space requirements as well as the capital (i.e. financing) costs of investing in and carrying larger inventories to guard against supply risk.
- Traffic congestion increases labor costs, and these higher costs are ultimately passed on to businesses and consumers. By slowing the movement of freight, the labor hours required for each shipment increase while those extra hours are spent in stopped traffic or moving at a slow, inefficient pace.
- Congestion increases fuel costs. For any mode of transportation—but especially trucks and trains—the greatest energy requirements are associated with starting the vehicle from a stopped position and accelerating to a cruising speed. Stop-and-go traffic results in a dramatic reduction in fuel economy. Fuel economy is also compromised by slow-moving traffic since less inertia is produced at lower speeds and trucks must operate in lower gears, thereby increasing the engine RPMs per distance traveled. And, any amount of time spent idling in standing traffic wastes fuel directly. In addition to fuel costs, the environmental consequences of inefficient fuel use are self-evident.

Across the national highway system today, traffic congestion is most pronounced in the densely populated urban areas of the Northeast, Southern California, and in and around Chicago and other major metropolitan areas. Most of the major traffic arteries that extend through the Corn Belt and other agricultural areas remain largely uncongested (Figure 1). Nevertheless, agricultural shipments to many currently-congested areas are substantial, especially to reach processors and export terminals, so even today roadway congestion is a concern for at least some agricultural firms and industries.

However, projecting freight demand on the current highway system into 2035 suggests roadway congestion will become widespread, extending far into the Midwest and affecting most major arteries between population centers (Figure 2).

Figure 1: Peak-Period Congestion on High-Volume Parts of the US Highway System: 2002

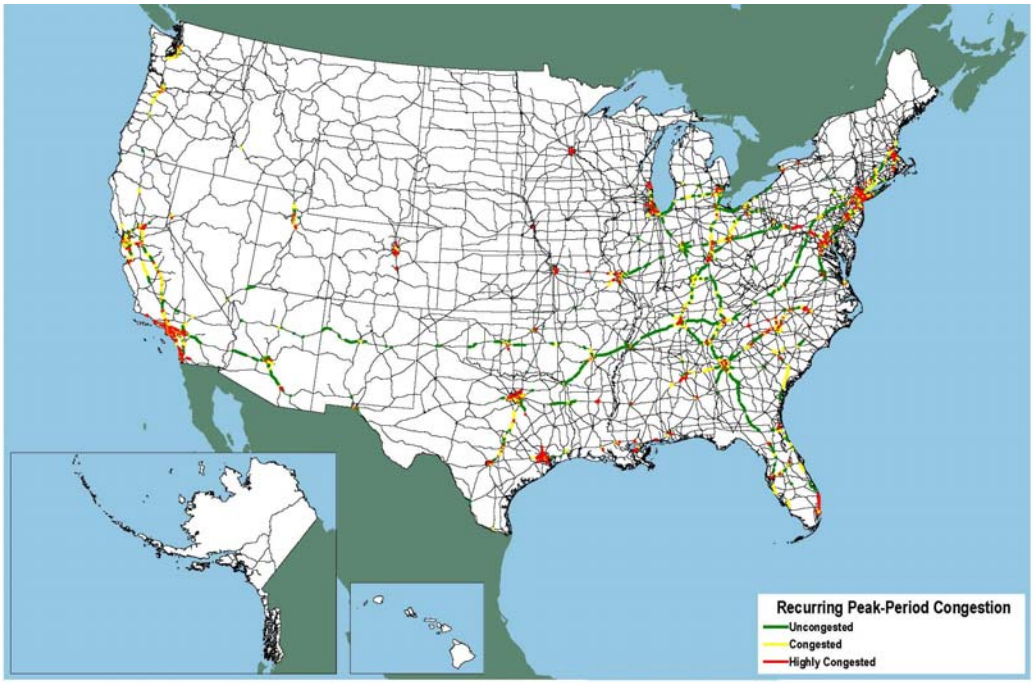
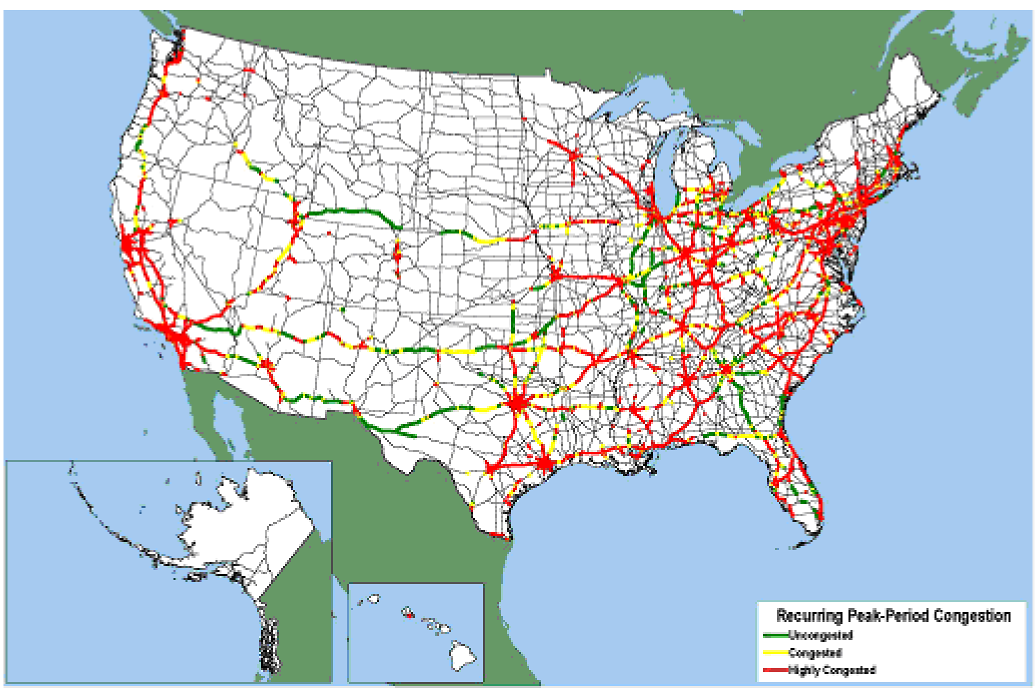


Figure 2: Peak-Period Congestion on High-Volume Parts of the US Highway System: 2035



Notes: High-volume truck portions of the National Highway System carry more than 10,000 trucks per day, including freight-hauling long-distance trucks, freight-hauling local trucks, and other trucks with six or more tires. Highly congested segments are stop-and-go conditions with volume/service flow ratios greater than 0.95. Congested segments have reduced traffic speeds with volume/service flow ratios between 0.75 and 0.95.
Source: US Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 2.2, 2007.

Road Weight Limits

Since 1975, the maximum allowable gross vehicle weight (GVW) for semi-trucks operating on the Federal Highway System has been 80,000 pounds (lbs.) distributed over a minimum of five axles. Prior to 1975, the maximum GVW was set at 73,280 lbs., and the increase to 80,000 lbs. was driven by a desire to increase efficiency in the trucking industry especially given the record-high fuel prices at that time. Today, high fuel prices are also driving up the cost of freight transportation, but the problem is also compounded by the growing strain on the transportation infrastructure as the demand for freight transportation services increases at a rate that far exceeds the rate at which new capacity is added to the system. Hence, there is renewed interest in again increasing the maximum weight limits for semi-trucks.

The result of higher weight limits on trucking efficiency is unambiguous. The ability to haul a greater quantity of freight on a single truck that is currently at its maximum weight limit will decrease the number of trips required per truck, leading to reduction in the per-unit cost of transportation and fewer trucks on the highway, all else equal. However, the magnitude of the system-wide cost savings and the reduction in truck volume on US highways is limited by several factors including:

- *The extent to which truck shipments are currently constrained by weight, instead of volume*. Although there are over 5 million trucks on US roads today traveling more than 145 billion miles per year,[4] a relatively small share of those (less than 25%) currently exceed 60,000 lbs. gross average weight (Table 1). And, even among the heaviest trucks, many likely are constrained by the physical dimensions of their cargo as opposed to the weight of the cargo, so the opportunity to benefit from the higher truck weight limits is limited to a relatively small proportion of the total US truck inventory. Nevertheless, as illustrated in Table 1, the heaviest trucks (those exceeding 60,000 lbs. GVW) still account for more than half of the miles traveled by all trucks on the road today, and the growth of this category is among the fastest, so even a small share of trucks hauling heavier loads should result in a significant net reduction in truck mileage (i.e. density), all else equal.

- *The extent to which heavier weight limits attract new volume to the trucking industry, away from competing modes, particularly rail.* This is one of the fundamental controversies associated with raising the weight limits, as opponents argue that higher weight limits will simply cause the trucking industry to attract modal share from railroads, so that the volume of trucks on the road will stay the same—or even increase—as it becomes more economical to ship products by truck instead of rail.

  Economic theory suggests there could be some increase in truck shipments at the expense of railroads, but the amount of substitution is likely to be very small. For

[4] Based on 2002 statistics (the most recent year of the US Census Vehicle Use Survey). The number of trucks on the road and mileage today certainly exceeds these estimates, but we assume the share of truck volume by weight class is roughly the same.

products shipped long distances, the cost advantages of rail far exceeds shipments by truck, and rail—where it is currently an option—will likely continue to be more cost effective despite a relatively modest increase in maximum truck weights. Furthermore, the rapid increase in containerized shipments that are shipped long distance by train and locally delivered by truck, as well as the use of RoadRailer systems in which truck trailers are specially equipped for railroad intermodal service, highlights the extent to which efficiencies are gained by an increasingly coordinated transportation system—which the higher truck weight limits is unlikely to change. And, for many products—particularly when shipping distances are less than a few hundred miles—trucks are often the only viable shipping method since railroads tend to have less flexibility and connectivity to reach all markets, quickly.

To the extent that higher truck weight limits attract any freight volume from railroads, the positive effect of this competition should benefit all industries and consumers. Railroads are unlikely to simply allow a decrease in their freight volume without adopting some measures to attempt to regain that business. Hence, there would likely be some downward pressure on freight rates as well as efforts to increase rail capacity and/or reduce shipment times to better compete with trucks. This would buffer even the modest potential for trucks to gain market share from railroads. The key point is that markets and competition are dynamic, and any improvement in the efficiency of one transportation mode is likely to encourage greater efficiency in competing modes, as well.

Table 1: Truck (over 10,000 lbs) and Truck Mileage by Average Weight

	1987		**2002**		**Percent change, 1987-2002**	
Average weight (pounds)	**Number (1,000)**	**VMT (millions)**	**Number (1,000)**	**VMT (millions)**	**Number**	**VMT**
Total	**3,624**	**89,972**	**5,415**	**145,624**	**49**	**62**
Light-heavy	**1,030**	**10,768**	**1,914**	**26,256**	**86**	**144**
10,001 to 14,000	525	5,440	1,142	15,186	118	179
14,001 to 16,000	242	2,738	396	5,908	64	116
16,001 to 19,500	263	2,590	376	5,161	43	99
Medium-heavy	**766**	**7,581**	**910**	**11,766**	**19**	**55**
19,501 to 26,000	766	7,581	910	11,766	19	55
Heavy-heavy	**1,829**	**71,623**	**2,591**	**107,602**	**42**	**50**
26,001 to 33,000	377	5,411	437	5,845	16	8
33,001 to 40,000	209	4,113	229	3,770	10	-8
40,001 to 50,000	292	7,625	318	6,698	9	-12
50,001 to 60,000	188	7,157	327	8,950	74	25
60,001 to 80,000	723	45,439	1,179	77,489	63	71
80,001 to 100,000	28	1,254	69	2,950	144	135
100,001 to 130,000	8	440	26	1,571	238	257
130,001 or more	4	185	6	329	43	78

Source: US Census, 2002 Vehicle Use Survey
VMT = Vehicle Miles Traveled

Typical characteristics of freight shipments across different modes are described in Table 2. The products that could benefit from an increase in truck weights include high density, low value commodities, including agricultural commodities, gravel, iron, and others. However, nearly half of the volume of all bulk commodities is shipped by modes other than truck, including rail, pipeline and water transport—a relationship that is unlikely to change with an increase in truck weight limits. Nevertheless, there are several categories of high-value, time sensitive products shipped primarily by truck for which higher weight limits could lead to substantial cost savings. These would include dense consumer products such as canned (or bottled) beverages, dairy products, vehicle parts, and various industrial products and machines. Owing to the high-value, time sensitive nature of these products, trucks already hold a majority share of shipments so there could be substantial efficiency gains (in terms of reduced truck trips per year) from an increase in weight limits.

For many high-value products, including furniture, electronics and various consumer goods, trucks are limited by volume constraints instead of weight, so higher weight limits will have no direct effect on shipping patterns or costs. However, indirect cost savings are still possible, particularly if higher weight limits—by improving efficiency at the upper end of the weight spectrum—increase the relative availability of trucks (and drivers) across the lower weight classes.

Table 2: Freight Characteristics by Average Modal Share

	High Value Time Sensitive	**Bulk**
Top 5 Commodity Classes	Machinery Electronics Mixed freight Motorized vehicles Textiles and leather	Natural Gas Gravel Grains & Oilseeds Crude petroleum Coal
Share of Total Tons	30%	70%
Share of Total Value	85%	15%
Key Performance Variables	Reliability Speed Flexibility	Reliability Cost
Share of Tons by Domestic Mode	88% Truck 7% Rail 5% All Other	51% Truck 12% Rail 32% Pipeline 5% Water <1% Air and Intermodal
Share of Value by Domestic Mode	83% Truck 10% Intermodal 3% Rail 4% All Other	36% Truck 5% Rail 53% Pipeline 4% Water 2% Air and Intermodal

Source: US Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, 2007

Estimates of Future Freight Movement via Semis

Historic freight shipment trends for truck, rail, water and air, and future projections of macroeconomic conditions help guide lawmakers as to the type of infrastructure needed to meet demand for transportation. Many freight projections have been prepared by the DOT and private organizations. For this report a review was prepared of three independent forecasts and a fourth forecast that was developed based on comparative analysis of available forecasts and historic trends. The sources of these freight forecasts include the Bureau of Transportation Statistics (BTS) at DOT, the American Association of State Highway and Transportation Officials (AASHTO), the American Trucking Association (ATA) and ICF Consulting (ICF). Informa also prepared its own freight demand forecast. The forecasted growth rates from each of these organizations are presented in Table 3.

The most rapid growth in the BTS forecast was the air freight sector (3.1% annual growth), trucking (2.6%) and rail (0.2%). However, while the growth rate for air freight is large, the volume is quite low and limited to high-value products that are extremely time-sensitive. BTS did not prepare a domestic waterborne freight forecast.

An AASHTO report, Freight-Rail Bottom Line Report, examined the performance and productivity of the nation's freight-rail system. The study claimed the rail system requires significant investment to prevent freight volumes from being transferred to the highway system. The report also forecasted demand for the four major modes of freight transport (truck, rail, water and air), with the highest growth rate expected in the air freight sector (5.7% annual growth), followed by trucking (2.3%) and rail (1.9%). Domestic waterborne freight was forecast to remain relatively flat (0.7% growth).

The ATA's report, US Freight Transportation Forecast to 2014, showed demand for trucking, rail, water and air. The most rapid growth in the ATA report was the air freight sector (4.4% annual growth), followed by trucking (2.2%) and rail (1.7%). Domestic waterborne freight was forecast to grow similar to rail (1.6%).

As part of the National Cooperative Highway Research Program (NCHRP) Project 20-24(33)A, the 21st Century Freight Mobility, ICF Consulting reviewed the freight transportation forecasts described above, as well as other freight industry information, and developed and estimated ton-mile growth rates by mode. According to ICF, the most rapid growth on a ton-mile basis was expected to occur in the air freight sector (4.0% annual growth), followed by trucking (2.5%) and rail (2.0%). Domestic waterborne freight was projected to remain relatively flat (0.7%).

Informa developed a baseline transportation forecast from 2007 through 2020 based on its own economic data and outlook. Informa's forecast of compound annual growth rate for the respective modes was below the other forecasts, reflecting the current outlook for a prolonged recession that significantly lowers near-term freight demand.[5] The Informa forecast suggests that air will have the largest compound annual growth rate (2.6%)

[5] The other forecasts were made between 2000 and 2002, prior to the current economic problems.

followed by truck (2.1%), rail (2.0%), and water (0.3%), which are not too dissimilar to the other four forecasts as summarized in Table 3.

Table 3: Domestic Freight Demand Forecast Comparison (annual growth rates)

Mode	Historic Growth Rate (ton-miles) 1990-2000	Forecasts BTS (ton-miles) 2000-2025	AASHTO (ton-miles) 2000-2020	ATA (tons) 2002-2014	ICF (ton-miles) 2000-2020	Informa (ton-miles) 2007-2020
Truck	3.9%	2.6%	2.3%	2.2%	2.5%	**2.1%**
Rail	3.6%	0.2%	1.9%	1.7%	2.0%	**2.0%**
Water	-2.5%	NA	0.7%	1.6%	0.7%	**0.3%**
Air	5.2%	3.1%	5.7%	4.4%	4.0%	**2.6%**

Sources: BTS, AASHTO, ATA, ICF and Informa Forecast

According to the DOT, the volume of freight demand by all modes will increase from 21.2 billion tons in 2007 to more than 37.2 billion in 2035, an increase of 16 billion tons or 75% as shown in Table 4. Truck volumes are forecast to increase the most, from 12.9 billion tons in 2007 to 22.8 billion in 2035, an increase of nearly 10 billion tons or 77% over that time. Moreover, truck volumes will increase more than the total increase of 6.1 billion tons of all other modes combined (Table 4).

Table 4: Transportation Demand by Mode, 2007 and 2035 (million tons)

Mode	2007 Total	Domestic	Exports	Imports	2035 Total	Domestic	Exports	Imports
Total	21,225	19,268	619	1,338	37,210	33,666	1,112	2,432
Truck	12,896	12,691	107	97	22,813	22,230	262	320
Rail	2,030	1,872	65	92	3,525	3,292	57	176
Water	689	575	57	57	1,041	874	114	54
Air, Air & Truck	14	4	4	6	61	10	13	38
Intermodal	1,505	191	379	935	2,598	334	660	1,604
Pipeline & Unknown	4,091	3,934	6	151	7,172	6,926	5	240

Sources: USDOT-FWHA. Notes: Intermodal includes US Postal Service and courier shipments and all intermodal combinations, except air and truck. Intermodal also includes oceangoing exports and imports that move between ports and interior domestic locations by modes other than water. Pipeline and unknown shipments are combined because data on region-to-region flows by pipeline are statistically uncertain. Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

The value of the shipments increases with shipment volume. The value of shipments totaled $14.9 trillion in 2007 and was forecast to increase 182% by 2035 to $41.9 trillion. The value of shipments will be highest by truck ($23.8 trillion), followed by intermodal ($9.0 trillion), pipeline and unknown ($2.4 trillion), air and truck ($5.9 trillion), rail ($702 billion) and water ($151 billion) as shown in Table 5.

Table 5: Value of Shipments by Transportation Mode, 2007 and 2035 ($billions)

Mode	2007 Total	2007 Domestic	2007 Exports	2007 Imports	2035 Total	2035 Domestic	2035 Exports	2035 Imports
Total	14,869	12,363	904	1,603	41,867	29,590	3,392	8,884
Truck	9,764	9,266	235	264	23,767	21,653	806	1,306
Rail	416	303	36	78	702	483	63	156
Water	51	37	8	7	151	103	31	18
Air, Air & Truck	1,022	235	354	434	5,925	721	1,548	3,655
Intermodal	1,935	870	270	795	8,966	4,315	943	3,708
Pipeline & Unknown	1,680	1,652	1	26	2,357	2,315	1	41

Sources: USDOT-FWHA. Notes: Same as Table 4.

Informa forecasted ton-miles by transportation mode. Growth rates in truck and railroad are similar. Truck trailers and intermodal containers move by truck and on railroads to take advantage of the fuel efficiency rail offers. As a result, the rail and truck industries are partners as well as competitors. Domestic water transportation increased slightly in 2007 because of internal waterway movements. Air ton-miles will increase 39% in 2020 compared to 2000; with its increase starting in 2010. Pipeline shows modest increase in growth at 5.0% from 2000 to 2020 as shown in Table 6.

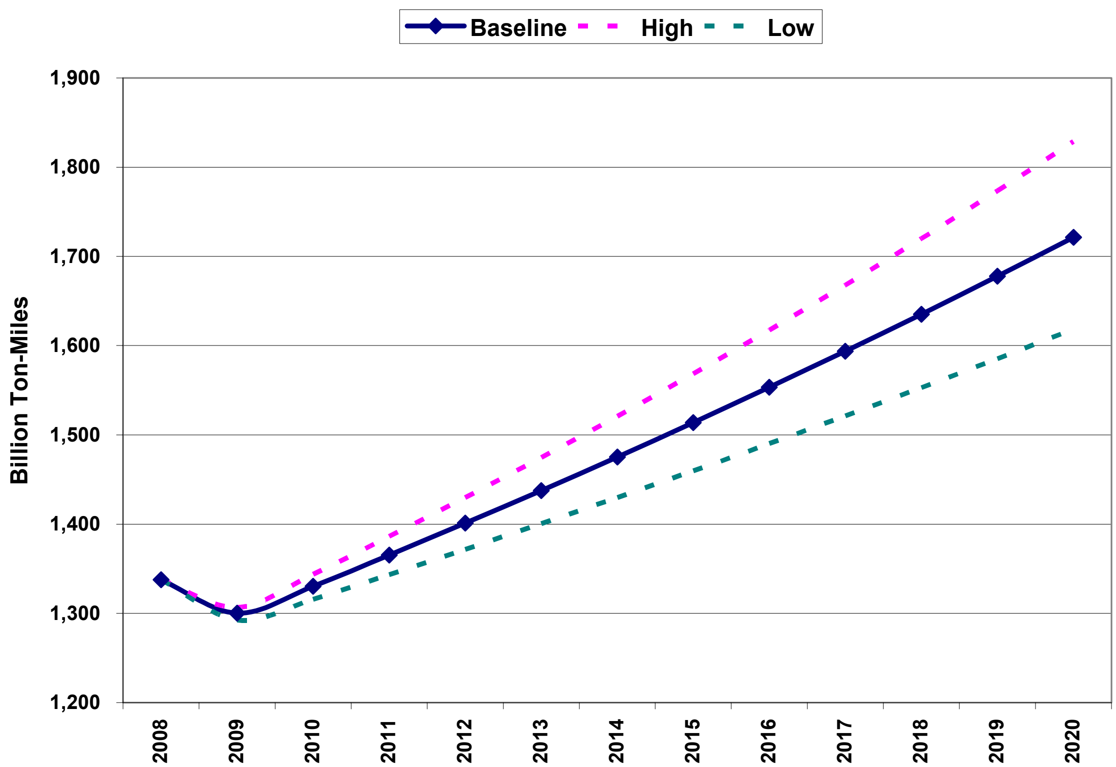
Table 6: Informa Baseline Transportation Projection by Mode (million ton-miles)

Year	Total US Freight	Air	Truck	Railroad	Domestic Water Transportation	Pipeline
2000	4,328,642	15,810	1,192,825	1,546,319	645,799	927,889
2001	4,357,472	13,288	1,213,208	1,599,332	621,687	909,957
2002	4,409,000	13,837	1,245,542	1,605,532	612,080	932,009
2003	4,414,797	15,096	1,264,773	1,603,564	606,146	925,218
2004	4,541,097	16,451	1,281,573	1,684,461	621,170	937,442
2005	4,574,701	15,741	1,291,515	1,733,777	591,276	942,392
2006	4,637,513	15,357	1,294,492	1,852,833	561,629	913,202
2007	**4,711,015**	**15,785**	**1,322,090**	**1,890,370**	**565,560**	**917,210**
2008	**4,721,643**	**16,025**	**1,337,523**	**1,911,362**	**537,282**	**919,451**
2009	**4,631,486**	**15,447**	**1,300,267**	**1,860,688**	**541,043**	**914,041**
2010	**4,710,881**	**15,912**	**1,330,259**	**1,901,483**	**544,831**	**918,396**
2015	**5,192,935**	**18,761**	**1,513,810**	**2,151,142**	**564,169**	**945,053**
2020	**5,736,480**	**21,983**	**1,721,481**	**2,433,610**	**584,193**	**975,213**

Source: BTS and Informa Forecast

Domestic trucking is the major mode of transportation from a volume standpoint as shown in Table 2 but from a ton-mile standpoint the rail sector is nearly 40% greater than truck as seen in Table 4. Overall truck shipments represent two-thirds of the total freight tons moved and 30% ton-miles. The compound annual growth rate for truck ton-miles was forecast to stay in a range of 1.6% and 2.5% using GDP growth rates of 2.0% for a low case scenario and a high growth annual rate of 3.0%. The baseline growth rate assumed the US economy would expand at a 2.5% growth rate starting in 2011. Although this range appears narrow, by 2020 the difference between the high and low forecast is 210 billion ton-miles as shown in Chart 1. Even the low ton-mile forecast is going to require more equipment, labor, and increases in highway mileage. Allowing higher truck weights on the federal highway system will reduce the demand for new trucks and drivers, which will help contain transportation costs, reduce congestion, and lower environmental impacts.

Chart 1: Truck Ton-Miles Forecast (billion ton-miles)



Source: BTS and Informa

The impact of increasing the federal limit on truck weights is small relative to the total transportation market. Based on discussions with various industry representatives and studies, approximately 80% of truck traffic is semi-truck traffic configured as a truck and trailer while the remaining traffic is straight truck or box truck. Moreover, industry representatives indicated that approximately 20% of the semi-truck traffic is constrained by weight limits, meaning that goods and commodities loaded into a semi-truck configuration weigh out at the federal weight limit of 80,000 lbs. before cubing out the trailer or using all the available volume metric space of the trailer.

For industries impacted by the weight limits, those that weigh out before they cube out, the benefits from increasing the federal truck weight limit from 80,000 lbs. to 97,000 lbs. will be significant. If the federal truck weight limit were increased, and given that truck demand is large and will continue to grow, even a small percentage decrease in the number of trips could save approximately 16.9 million trips annually, reduce miles driven by 2.7 billion annually, and save 221 million gallons of diesel annually by 2020, as summarized in Table 7.

Table 7: Truck Weight Limit Increase Impacts

Year	Truck Volume (million tons)	Total Semi Volume (million tons)	Total Semi Volume Weight Constrained (million tons)	Number of Trips (thousands)			Mileage Saved (million miles)	Fuel Saved (million gallons)
				80,000 lbs	97,000 lbs	Saved Trips		
2008	8,360	7,106	1,421	63,161	50,754	12,407	1,985	162
2009	**8,127**	**6,942**	**1,388**	**61,702**	**49,582**	**12,120**	**1,939**	**159**
2010	**8,314**	**7,136**	**1,427**	**63,434**	**50,973**	**12,460**	**1,994**	**163**
2015	**9,461**	**8,318**	**1,664**	**73,938**	**59,415**	**14,524**	**2,324**	**190**
2020	**10,759**	**9,683**	**1,937**	**86,074**	**69,167**	**16,907**	**2,705**	**221**

* Assumes an average trip distance of 160 miles
* Does not include dead head miles
* Assumes 80% of trucks moves in 2008 are Semis, 90% by 2020
* Assumes 20% of Semi truck volume is limited by weight
* 80,000 lb truck = 5.8 mpg, 97,000 lb truck = 5.14 mpg

Source: BTS and Informa

The key benefits to a state from an increase in federal truck weight limits includes the reduction in the number of trucks used to move the same amount of volume and a shift of truck traffic from state highways to federal highways, which would lead to state savings on maintenance cost for roads and bridges on state highways—many of which already permit heavier-weight trucks in some instances.

Cost of New Equipment

To determine how a change in weight limits could affect shipment patterns and truck density, Informa considered a range of economic variables that could affect adoption, including the cost of new trailers, whether or not shipments in excess of 80,000 lbs. would be subject to additional fees/permits, and the type of freight most likely to benefit from higher weight standards.

Industry experts say that the Class 8 semi-trucks would be able to handle the increase in weight from 80,000 lbs. to 97,000 lbs. A typical truck configuration with a gross weight of 80,000 lbs. is assumed to be a Class 8 semi-truck with three axles hauling a two-axle trailer. To haul 97,000 lbs., a three-axle trailer will be required. The cost of a new truck is about $90,000. A trailer with two axles is about $20,000, and a trailer with three axles is about $23,000.

Operationally, an operator's cost will increase for each trip hauling heavier weights. With the gross weight expected to increase 21% to 97,000 lbs., the additional weight will reduce the miles per gallon (mpg) 11% from an estimated average of 5.80 mpg to around 5.14 mpg according to industry representatives.

Other fees could be part of the increased truck weight legislation. Rep. Michael Michaud (D-ME) introduced H.R. 1799, the Safe and Efficient Transportation Act of 2009. This act provides an option for individual states to increase allowable truck weight on a single-trailer truck up to 97,000 lbs. on federal interstate highways in each state. Motor carrier vehicles would be required to add a third axle to the trailer (for a total of six axles on the truck and trailer) for better braking and handling. Each truck configuration adding an additional axle would be required to pay a higher large vehicle user fee into the Safe and Efficient Vehicle Trust Fund to assist with maintenance and bridge repair (Fleet Owner Apr. 7, 2009).

Observations

The US economy requires an effective and efficient freight transportation system to operate at minimal cost and respond quickly to demand for goods. As the economy grows, the demand for goods and related freight transportation activity will increase. Current volumes of freight are straining the capacity of the transportation system to deliver goods quickly, reliably, and cheaply. Anticipated long-term growth of freight could overwhelm the system's ability to meet the needs of the American economy. Increasing truck weight limits will have an unambiguous effect on the efficiency of the nation’s freight transportation system by reducing the number of trucks needed to haul the equivalent volume of freight in the United States. However, relative to the current volume of freight shipments and its anticipated growth, the effect on traffic congestion and overall transportation costs are small. Nevertheless, the cost savings and reduced fuel usage are not insignificant and could provide substantial savings to certain industries. And, given the fact that the capacity of the transportation system is increasing at a much slower rate than the demand for freight services, increasing truck weight limits could represent the quickest, most effective way to increase the capacity of the transportation network, however small that capacity increase might be relative to total demand. Even a modest reduction in truck volume or total ton-mileage on the highway system would be welcome to businesses, consumers and automobiles that share the road with trucks.

However, while the efficiency gains are clear, they must be balanced against the potential for heavier trucks to compromise the safety of public roads or to lead to greater wear-and-tear on roads and bridges that result in higher costs of highway maintenance which are ultimately paid by taxpayers. The following sections explore the relationship between truck weights and public safety and the integrity of roadways and bridges.

III. Motorist Safety

Summary

There is a significant body of research by official federal and state agencies that concludes that increasing truck weight maximums, e.g., from 80,000 to 97,000 lbs. and adding axles could improve braking performance and highway safety. One key reason is the fact that an additional axle with additional corresponding brakes increases excess braking capacity. Also adding an extra axle increases the number of tires from 18 to 22 and reduces the load weight per tire.

The general safety impact of policies that change maximum truck sizes and weights is complex. Larger trucks are more difficult to handle, and can be more dangerous to operate in some situations—but that factor can be offset readily by using better equipment and better trained drivers. In addition, National Highway Traffic Safety Administration (NHTSA) is in the process of requiring better truck brakes and shorter braking-distance standards, so that the long-standing disparity between automobiles and trucks in stopping distances will be reduced/eliminated.

Available research results also indicate that there is very little difference among truck configurations in terms of key characteristics of crash dynamics, such as static roll stability, load transfer ratio and rearward amplification.

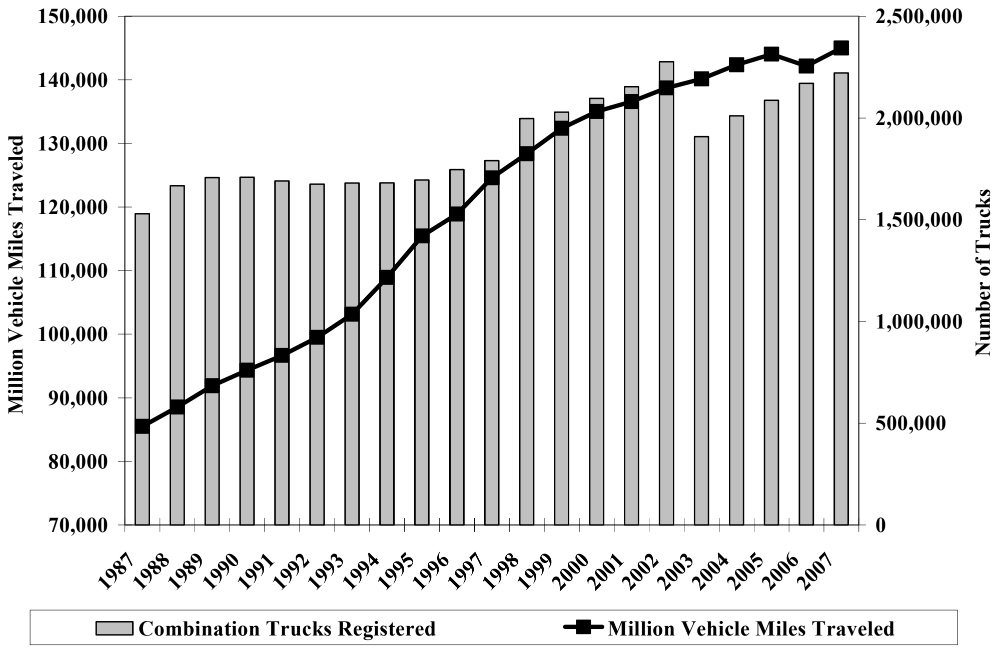
Still, proposals to increase truck size and weight maximums likely face opposition because automobile drivers think they are much more dangerous than they are. In reality, fatalities and injuries in accidents involving trucks have been declining steadily for several decades in spite of much greater traffic congestion and much higher highway speeds for all vehicles.

Available research also indicates that increasing maximum truck weights would make US highways safer and reduce the number of highway truck crashes by reducing the number of truck miles needed to move any given amount of freight.

Need for Heavier Trucks and Concerns about Highway Safety

Increasing freight movement requirements has increased the number of commercial vehicles on roadways and thus the need for more productive and potentially larger commercial trucks. The US Department of Transportation (DOT) reports that there were approximately 2.2 million combination trucks[6] in 2007 compared with 1.5 million twenty years earlier (Chart 2). During this same time period the number of vehicle miles traveled by combination trucks increased 70% to a record 145 billion miles in 2007. The growing number of large trucks has heightened public awareness of the need to improve commercial vehicle safety and preserve highway infrastructure.

Chart 2: Trends in the Number of Combination Trucks Registered & Million Vehicle Miles Traveled



Source: *Large Truck and Bus Crash Facts 2007*, Analysis Division Federal Motor Carrier Safety Administration, Department of Transportation

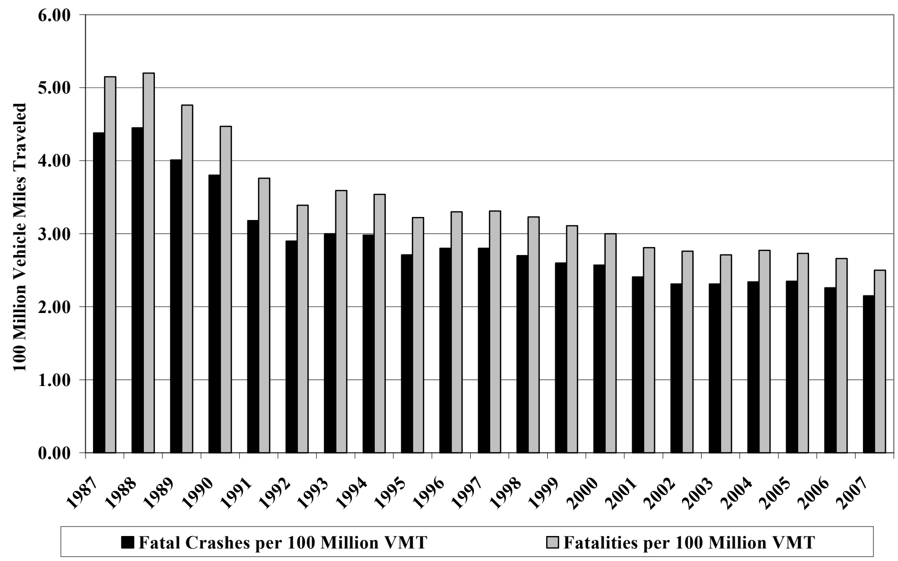
During the same period, the number of fatalities and injuries from combination truck crashes has decreased sharply (Charts 3 and 4) and the number of fatalities from large truck crashes is down more than 50%, from 4.38 per 100 million vehicle miles traveled in 1987 to 2.15 in 2007. The number of injuries involved in large truck crashes decreased by nearly 56%, from 86.2 per 100 million vehicle miles traveled in 1987 to 38.1 in 2007.

Crash rates are perhaps the most important safety consideration, but other factors also must be factored into assessments of the safety of trucks. One intangible factor is the public reaction to larger and heavier trucks. While such perceptions may have little factual basis, they affect attitudes and decisions concerning whether to allow such vehicles. The DOT's "Comprehensive Truck Size and Weight Study" (2000) conducted focus group meetings to delve more deeply into driver perceptions of the safety of various truck configurations in different operating environments. The vast majority of automobile drivers participating in the focus group indicated they prefer the status quo and that if changes are made they

[6] Defined as a truck tractor pulling any number of trailers (including none) or a straight truck pulling at least one trailer.

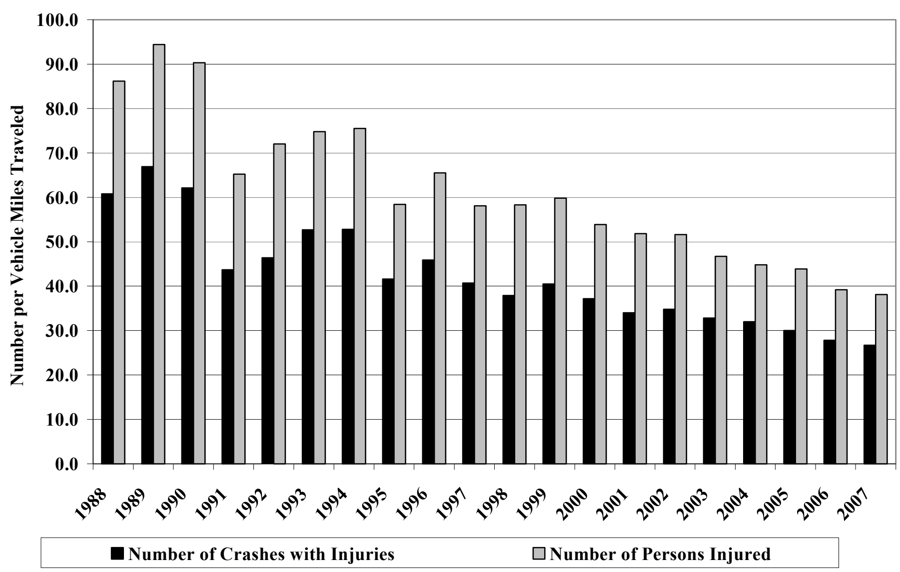
should be in the direction of greater restrictions on truck size and weight limits. Some indicated they could accept a role for longer combination vehicles (LCV), but only under strict limits and conditions. While opinions expressed in the focus groups are not necessarily representative of all drivers, they do provide insights into factors underlying opinions about the truck safety.

Chart 3: Number of Combination Truck Fatal Crashes & Fatalities per 100 Million VMT



Source: *Large Truck and Bus Crash Facts 2007*, Analysis Division Federal Motor Carrier Safety Administration, Department of Transportation

Chart 4. Number of Combination Truck Injuries per 100 Million VMT



Source: *Large Truck and Bus Crash Facts 2007*, Analysis Division Federal Motor Carrier Safety Administration, Department of Transportation

Despite the statistics, there is widespread perception that increasing truck weights would lead to a greater danger of injury or death on highways and interstates and outweigh potential trucking efficiency benefits. Efforts to reasonably predict accident rates associated with this policy change are complicated and often controversial, reflecting limited data for analysis and modeling. The fact that larger trucks generally operate on rural roads and turnpikes provides little basis to predict how they would operate on high-speed interstates and in more urbanized settings.

Despite the common driver concerns about trucks, passenger cars are the most often the cause of crashes with large trucks. The American Automobile Association (AAA) found in July 2002 that 80% of crashes were caused by car drivers. In 2006, Virginia Tech Analysis of two studies conducted for the DOT found that 78% of car-truck crashes were caused by passenger car drivers. In 2006, rear-end collisions where passenger cars strike large trucks were 2.7 times more likely than large trucks rear-ending passenger cars. Head-on collisions where passenger cars enter into the truck's lane are more than 16 times more likely to occur than vice-versa.

A number of factors are stimulating interest in further increasing federal truck weight limits including high fuel prices, prolonged labor shortages in the trucking industry, advanced safety equipment (including anti-locking braking systems) on modern trucks, and growing concern about traffic congestion. For example, legislative proposals are under consideration to increase federal truck weight limits to 97,000 lbs. (or 100,000 lbs.) on interstate highways provided an extra axle is included (six axles versus five).

Many studies have attempted to estimate the difference in crash rates among classes of heavy trucks. The focus of studies has been primarily on double-trailer combinations and, in particular longer combination vehicles (LCVs), but the available research does not yield a clear picture. For example the LCVs or double-trailer combinations have crash rates that are slightly lower in some states and higher in others. National Highway Traffic Safety Administration (NHTSA) truck crash data separates light trucks from heavy trucks, but does not differentiate between different types of heavy trucks making it impossible to compare crashes of five-axle and six-axle trucks.

Truck sizes and weights also affect the safety and traffic operational characteristics. The vehicle dynamics of rollover, maneuverability, and the ability to avoid unanticipated crash threats are directly affected by truck (especially for long and heavy trucks) weight, dimensions (including the height of the loaded truck's center of gravity, number of axles, and number of articulation points in combination trucks. The relevant design features and specifications include:

- Overall vehicle weight;
- Number of axles and tires on vehicle;
- Individual axle weights;
- Overall vehicle length and wheelbase;
- Vehicle track width;
- Number of units in a combination vehicle; and
- Number of articulation points in a combination vehicle

Important vehicle equipment specifications also include the types of tires and braking and suspension systems.

Braking Performance

Braking performance is a factor in a variety of crash types, predominantly those in which the front of a large truck strikes a passenger vehicle. The NHTSA estimates that specific crash types affected by truck stopping distance account for 26% of passenger vehicle deaths in large truck crashes. Other crash types affected include some types of large truck-to-large truck crashes, large truck and pedestrian crashes, and single-vehicle crashes in which large trucks run off the road.

The DOT's "Comprehensive Truck Size and Weight Study" (2000) concluded that braking performance is a general concern that applies to all trucks but is not particularly influenced by changes in truck size and weights, as long as the requisite number of axles and brakes are added as the vehicle's weight increases and all the vehicle's brakes are well-maintained. Some incremental diminution can be expected as truck weights increase, but the greater concern in braking ability relates to longer combination vehicles. More recent studies including the "Minnesota Truck Size and Weight Project" (June 2006) and "Wisconsin Truck Size and Weight Study" (January 2009) support the 2000 DOT study conclusion that braking performance is not a general concern if the requisite number of axles and brakes are added if the vehicle's weight is increased.

The "Wisconsin Truck Size and Weight Study" concluded that adding axles to a truck tractor combination increases its braking ability, which in turn reduces crash rates. To account for this effect the study assumed that increasing the number of axles on a truck by 20%, e.g. from five to six axles reduces its crash rate by 5%. Although crash probability generally increases with weight of a truck, fewer truck trips because of larger loads combined with increased braking power from additional axles results in fewer accidents involving heavy trucks. The net safety benefits from larger truck weights will also include lower costs associated with fatalities, injuries, and property damage. The study analyzed seven truck configurations including the six-axle tractor-trailer with 98,000-pound gross vehicle weight.

The Minnesota study concluded that crash rates per vehicle-mile increased slightly with gross weight primarily because loading a truck heavier raises its center of gravity and thereby increases the possibility of rollover. However, crash rates per payload ton-mile also can decrease with a gross weight increase because fewer truck trips are required to haul a given amount of freight.

More importantly, the Minnesota study results show there is more surplus brake capacity for all the proposed vehicle configurations than for the standard five-axle tractor-semitrailer when categorized on the basis of normal and winter weights. Since multiple axle groups are assembled using standard axles, the braking capacity increases proportionately to the sum of Gross Axle Weight Rating (GAWR) for the axle group. For example, a tandem axle group comprised of two 20,000-pound axles will have braking capacity sufficient to manage 40,000 lbs. However, size and weight regulations limit the tandem axle group to 34,000 lbs., which means the tandem axle group has more braking capacity than required.

The maximum gross vehicle weight (GVW) for each truck configuration studied, the corresponding brake capacity expressed in terms of the vehicle axle load and percent brake surplus available for the vehicle configuration is shown in Table 8. This table shows that there is a surplus brake capacity for all the proposed truck configurations in the study. In all cases the proposed vehicles have more brake capacity than the current commonly used five-axle tractor-semitrailer when categorized on the basis of normal and winter weights. For example, the 6-axle semitrailer has a 24.4% surplus brake capacity compared with a 5-axle semitrailer which has a 15% excess capacity. For winter, the 6-axle semitrailer (99,000 lbs.) has a 13.1% surplus brake capacity while the 5-axle semitrailer has only a 4.5% surplus capacity. It thus can be concluded that under loaded conditions, the other vehicle configurations in the study will have better stopping distance performance than the existing five-axle tractor semitrailers.

Table 8. Surplus Brake Capacity by Configuration

Vehicle Configuration	Regulated GVW	Sum of GAWR Brake Capacity	GAW Brake Requirement	Percent Surplus Brake Capacity
5-axle semi	80,000	92,000	80,000	15.0
5-axle semi winter	88,000	92,000	88,000	4.5
6-axle semi	90,000	112,000	90,000	24.4
6-axle semi winter	99,000	112,000	99,000	13.1
7-axle semi	97,000	132,000	97,000	36.1
7-axle semi winter	99,000	132,000	99,000	33.3
8-axle B-train	108,000	152,000	108,000	40.7
7-axle single-unit truck	80,000	132,000	80,000	65.0

Note: Gross axle weight rating assumptions: steer axle 12,000 pound, driver axle 20,000 pound, trailer axle 20,000 pound.
Source: "Minnesota Truck Size and Weight Project"

According to "Increased Truck Weights Coalition for Transportation Productivity[7]," increasing truck weights from 80,000 lbs. on a five-axle truck tractor combination to 97,000 lbs. on a six-axle truck combination reduces the load weight per tire by approximately 35 lbs. For example, the weight per tire of a five-axle truck combination with 18 wheels carrying 80,000 lbs. is 4,444 lbs. In comparison, the weight per tire of a six-axle truck combination with 22 tires carrying 97,000 lbs. is 4,409 lbs.

The "Effects of Truck Size and Weights on Highway Infrastructure and Operations: A Synthesis Report" conducted for the Texas Department of Transportation concluded that a switch to heavier or larger trucks does not necessarily increase the rate of accidents per vehicle mile of travel. Improvements in the performance and selection of drivers as well as changes in vehicle and roadway design can offset the safety drawbacks of using some heavier or larger vehicles. Improvements in the selection and training of drivers contributed to the decline in the rate of fatal accidents involving medium-to-heavy trucks that occurred between 1985 and 1995. That study referred to the introduction of nationally uniform licensing of truck drivers, tracking of truck drivers' traffic violations and accident experiences, and improved industry programs for driver training.

The Texas study also indicated that there is some evidence that people tend to drive more cautiously in dangerous situations—"risk compensation." So even when a heavier or larger truck has features that, other things equal, would increase the rate of accidents, the driver response to this situation may offset much of the added risk.

As long as vehicle brakes are adequately sized—and virtually all are as a result of Federal regulatory requirements—they are capable of generating enough force to lock most wheels on a vehicle when it is fully loaded[8].

NHTSA Rule Proposes to Reduce Truck Stopping Distances

Truck stopping distance is a factor in a variety of crash types, including those in which the front of a large truck strikes a passenger vehicle. The NHTSA estimates that specific crash types affected by truck stopping distance account for 26% of passenger vehicle deaths in large truck crashes. Other crash types that may be affected include some types of large truck-to-large truck crashes, large truck and pedestrian crashes, and single-vehicle crashes in which large trucks run off the road. Shorter stopping distance would not only reduce the severity of crashes by reducing impact velocity but also prevent some crashes by enabling the truck to stop prior to impact or provide additional time for the truck driver to take

[7] Coalition for Transportation Productivity (CTP) - is a group of more than 100 companies and associations dedicated to safely and responsibly increasing the vehicle weight limit on federal interstate highways—but only for trucks equipped with an additional (sixth) axle. The CTP is asking Congress to responsibly reform truck weight limits in order to secure a safer, cleaner, more productive future for America's transportation network. Companies included in the group are listed in Appendix C.

[8] However, inadequately maintained or maladjusted brakes can fail to generate needed braking power, which leads to longer stopping distances. Improper brake balance can cause downhill runaways and braking instability. Furthermore, adding more load to a given vehicle without adding axles and brakes degrades stopping performance.

evasive action. Reducing stopping distances will benefit all trucks including both five-axle semitrailers and six-axle semitrailers.

The ability to stop in short distances mostly depends on:

- Size and number of brakes on the vehicle,
- Brake adjustment and state of maintenance, and
- Tire properties.

Currently there is a wide gap in stopping distance between large trucks and passenger vehicles. The current federally required stopping distance for passenger vehicles is 230 feet from 60 mph[9]. Actual stopping distances for most passenger vehicles are much shorter, typically 125-150 feet[10]. In contrast the required stopping distance for fully loaded air-braked truck tractors is 355 feet from 60 mph[11]. Actual stopping distances average 298 feet, according to the Preliminary Regulatory Impact Analysis. This disparity exacerbates the risks already associated with disparities in vehicle size and weight, and passenger vehicle occupants, pedestrians, motorcyclists, and other road users bear the brunt of the human property damage losses.

The stopping distance standard for air-braked truck tractors has been unchanged since 1995. Since then the total vehicle miles traveled has increased 25% and truck miles have increased 26%. However, there has only been a 2% increase in lane miles of public roads[12]. Two out of every five urban interstate miles are considered congested[13], and travel conditions are expected to worsen by 2025[14]. Miles traveled by heavy vehicles are expected to increase 60 to 70%[15]. It is estimated that the proportion of urban interstates carrying 10,000 or more trucks per day will increase 69% by 2020 from 27% in 1998[16].

Another concern is that vehicle speeds on roadways have increased dramatically during the past few years, which has increased the stopping distances of all vehicles. In 2003 the Insurance Institute for Highway Safety documented the frequency of excessive speeds on interstates in six states. In the majority of these states more than two-thirds of vehicles on rural interstates were traveling 70 miles per hour (mph) or faster. In two states more than one in five vehicles was traveling faster than 80 mph. Average speeds on urban interstates often were the same or higher than speeds on rural interstates. According to a 2005 study

[9] Federal Motor Vehicle Safety Standard (FMVSS) 135.
[10] Hachette Filipacchi Media US, Inc. 2006. Road test summary. Road & Track 57 (5):118-119
[11] FMVSS 121
[12] Federal Highway Administration (FHWA), 2005a, Highway Statistics, 2004. Washington, D.C.: US Department of Transportation
[13] FHWA, 2005b. Congestion Management Systems. Publication no. FHWA-RC-BAL-04-0015. Washington, D.C.: US Department of Transportation
[14] Shaffer, S.J. Research required ensuring appropriate maintenance and compliance for safe operation of commercial motor vehicles in the year 2025. Presented at TRB Conference on Future Truck and Bus Safety Research Opportunities. Washington, D.C.: Transportation Research Board
[15] Ibid
[16] Hughes, R. The context of commercial vehicle enforcement activity in 2020: forecast of future directions in truck safety and security. Printed at TRB Conference on Future Truck and Bus Safety Research Opportunities. Washington, D.C.: Transportation Research Board

of truck speeds in four states with varying speed limits, about 15% of the large trucks were exceeding 70 mph on rural interstate segments monitored[17].

In December 2005, NHTSA published in the Federal Register a Notice of Proposed Rulemaking (NPRM) to amend its air-brake standard to reduce the stopping distance of truck tractors going 60 mph by 20 to 30%. A 30-percent reduction would shorten the required stopping distance from 355 to 249 feet for fully loaded tractors and from 335 to 235 feet for lightly loaded tractors. This decrease is obtainable with existing brake technologies (i.e., disc brakes, larger drum brakes). The proposed rule was issued in an effort to reduce the disparity in braking distances between trucks and passenger vehicles, and to reduce the number of deaths and serious injuries resulting from large truck crashes. Originally scheduled to be implemented in 2003, the rule is not yet final.

NHTSA proposes a two-year lead time after the final rule is issued, inadequate lead time for manufacturers to comply. Since the announcement of the proposed rule in 2005, truck fleets have been concerned whether they will be mandated to retrofit existing brake units to meet the new stopping distance requirements. However, NHTSA has no retrofit requirement, so long as existing vehicles meet the Federal Motor Vehicle Safety Standards (FMVSS) No. 121[18] standard in place when they were built. NHTSA says data indicates most tractors could comply with a reduction in this range through use of larger drum brakes. NHTSA also is not requiring specific brake component requirements, but is saying this technology is out there and it should be used.

But truck fleets are preparing for higher expenses to comply with the proposed rule which will mean both more costly equipment and increased maintenance costs associated with enhanced drum brakes or brake-by-wire systems.

On the other hand, NHTSA's preliminary regulatory impact analysis claims that enhanced brake system specifications will have net cost savings for truck fleets after considering property damage savings. But, according to NHTSA, truck fleets do not yet have this cost-saving information as only a few are purchasing the improved brake systems. As a result, NHTSA said progress towards improved brake systems is impeded because truck fleets are cost-sensitive to the initial purchase price and reluctant to add different types and sizes of brake components to their specifications.

NHTSA expects that a 30% reduction in required stopping distance would have profound effects on potential accidents between large trucks and passenger vehicles as illustrated by the following example:

- Assume that a fully loaded large truck is following a car (with an estimated stopping distance of 140 feet) by five car lengths (110 feet). Both vehicles are

[17] Johnson, S.L. and Pawar, N. Cost/benefit evaluation of large truck-automobile speed limit differentials on rural interstate highways. Report No. MBTC 2048. Washington, D.C.: Transportation Research Board

[18] The NHTSA has a legislative mandate under Title 49 of the US Code, Chapter 301, Motor Vehicle Safety, to FMVSS and Regulations to which manufacturers of motor vehicle and equipment items must conform and certify compliance. FMVSS Standard Number 121 addresses air brake systems in trucks, buses and trailers.

going 60 mph. If both drivers begin hard braking simultaneously, a truck with brakes upgraded to comply with the reduced stopping distance requirement of 249 feet would stop before striking the car. However, a truck with a stopping distance equivalent to the current standard of 355 feet would strike the car at 32 mph, producing crash forces severe enough to injure the car's occupants. A truck with a stopping distance of 298 feet, the average annual stopping distance according to the Preliminary Regulatory Impact Analysis, would strike the car at 24 mph, still producing a severe impact.

Antilock Brakes

Antilock brakes have improved safety on the highways. In 1995, NHTSA required antilock brakes for heavy trucks, tractors, trailers, and buses. All new truck tractors were required to have antilock brakes after March 1, 1997, and they were mandatory on new air-braked trailers and single-unit trucks and buses after March 1, 1998. Today antilock braking systems are required on all trucks and greatly enhance braking performance.

Antilocks are important for big trucks because of the poor braking capabilities of these vehicles compared with passenger cars. On dry roads, big trucks take much farther to stop — 47% farther in institute tests. On wet and slippery roads, the stopping distance disparity is even worse. Tractor-trailer combinations also have the potential for loss of control and jackknifing on both dry and, especially, slippery roads. (Jackknifing occurs when the rear wheels of a tractor lock up, allowing the tractor to skid and spin so that it folds into the trailer. This also can happen when trailer wheels lock and cause the trailer to swing around the tractor.) Antilock brakes not only reduce stopping distances on wet and slippery roads but also help drivers maintain control.

The standard for tractors requires antilock control on the front axle and at least one rear axle. On at least one of the tractor axles, each wheel must be independently controlled by an antilock modulator. This ensures that a wheel provides shorter stopping distances and optimal braking force on all surfaces, especially on roads where one side is slipperier than the other. For semitrailers, at least one axle must have antilocks. Full trailers must have antilock brakes for at least one front and one rear axle.

Vehicle Stability and Control

Differences in large truck stability and control are perhaps the most important safety-related factors directly related to differences in vehicle weights and dimensions. Where crash rates and other direct evidence of the relative safety of certain large trucks are not available, the stability and control characteristics of different large trucks provide an indication of the relative safety of these vehicles compared to large trucks currently in widespread use such as the five-axle truck tractor trailer.

The most important vehicle stability property is the susceptibility to rollover which occurs in approximately 60% of crashes fatal to heavy truck occupants. In general rollovers result from two basic maneuvers—a steady-state turn at too high a speed or high speed evasive maneuvers[19]. All vehicles are susceptible to rolling over, but heavy trucks are particularly susceptible. The principal attributes that affect a vehicle's rollover tendencies are the height of the center of gravity of the cargo, and the vehicle's track width, suspension and tire properties.

The DOT study[20] compared different large truck configurations with the conventional five-axle tractor-semitrailer combination. The study found that the six-axle semitrailer with 97,000 lbs. had a slightly worse static roll stability and load transfer ratio than the five-axle semitrailer but had a better rearward amplification. Figure 4 shows the percentage difference between the scenario vehicle and reference vehicle for each of these three measures.

Only the two Surface Transportation Assistance Act (STAA) doubles[21] in Figure 3 have better static roll stability than the five-axle semitrailer. The most susceptible vehicles were the three single unit trucks because of their high center of gravity. But each of the other vehicles, including the six-axle semitrailer was within 10% of the five-axle semitrailer.

Rearward amplification shows different relationships between the scenario vehicles. The three single unit trucks (with three and four axles) and the two six-axle tractor semitrailers all have less rearward amplification than the five axle semitrailer reference vehicle. All other truck combinations have much worse rearward amplification than the five-axle semitrailer.

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[19] A measure of a vehicle's propensity to rollover during a steady-state turn is its static roll stability (SRS). The SRS is measured in terms of the lateral acceleration (g forces) required to lift a wheel off the ground. The higher the SRS, the less susceptible the vehicle is to rollover. A typical 80,000 pound semitrailer has an SRS of about 0.3 gs compared to 0.8 gs or higher for automobiles.

There are also two measures that characterize a vehicle's susceptibility to rollover during evasive maneuvers:

- The **rearward amplification factor** is the ratio of the lateral acceleration of the rearmost trailer to the lateral acceleration of the tractor when making rapid steering movements. Tractor-semitrailer combinations have a factor of 1 and Surface Transportation Assistance Act of 1982 (see Appendix Figure 1) doubles a factor of 1.7. In general a rearward amplification factor of 2 or less is considered acceptable.
- The **load transfer ratio** is a measure of the dynamic roll stability of a truck. It measures the proportion of a vehicle's total axle load that is carried on one side of the vehicle relative to the other. A perfectly balanced vehicle would have a load transfer ratio of 0.5, while a vehicle with all its weight on one side of the vehicle (and the other side in the air) would have a transfer ration of 1.0. The Society of Automotive Engineers has developed a standard evasive maneuver for evaluating dynamic stability. Load transfer ratios for each scenario vehicle can be calculated based on this standard evasive maneuver to determine which vehicles are most likely to roll over under that maneuver.

[20] US Department of Transportation's "Comprehensive Truck Size and Weight Study", 2000

[21] The federal Surface Transportation Assistance Act of 1982 (STAA) made it legal for large trucks, referred to as STAA trucks, to operate on routes that are part of the national network. A STAA truck is a truck with a 48-foot semitrailer, an unlimited overall length, and an unlimited kingpin-to-rear-axle (KPRA) distance.

Differences in load transfer ratios between the reference five-axle semitrailer and the scenario vehicles show that many of the scenario vehicles would likely roll over under Society of Automotive Engineers (SAE) standard evasive maneuver, including the conventional STAA double and the three-axle single unit truck. Multitrailer combinations with B and C-train connections and the six-axle tractor semitrailer was the most stable of the scenario vehicles.

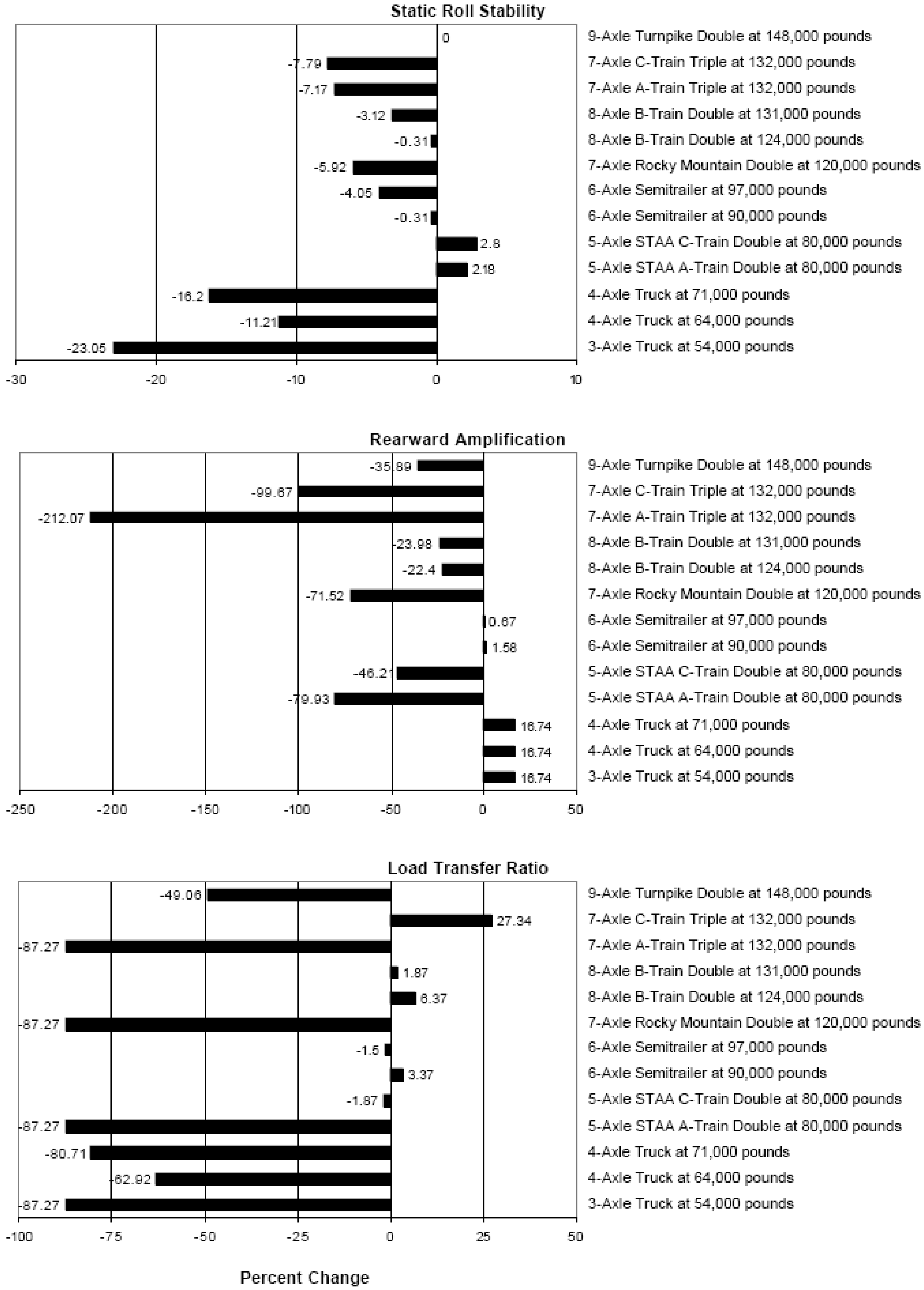
The “Minnesota Truck Size and Weight Project” found similar results to the DOT 2000 study in comparing the static rollover threshold, load transfer ratio, and rearward amplification for different truck configurations.

All vehicles examined in the Minnesota study had acceptable rollover threshold performance (Figure 4). For example the static rollover threshold for five-axle semitrailers was only slightly better than for six-axle semitrailers. However the static rollover threshold among truck configurations was best for the eight-axle A-double with 80,000 lbs. weight.

The Minnesota study found that the load transfer ratios, arguably the most powerful performance measure since it combines the influence of rearward amplification and static rollover threshold, were all below 0.5 or a perfectly balanced vehicle (Figure 5). Only the eight-axle A-double at 80,000 lbs. and the eight-axle A-double at 108,000 lbs. significantly exceeded 0.5 and were close to 1.0.

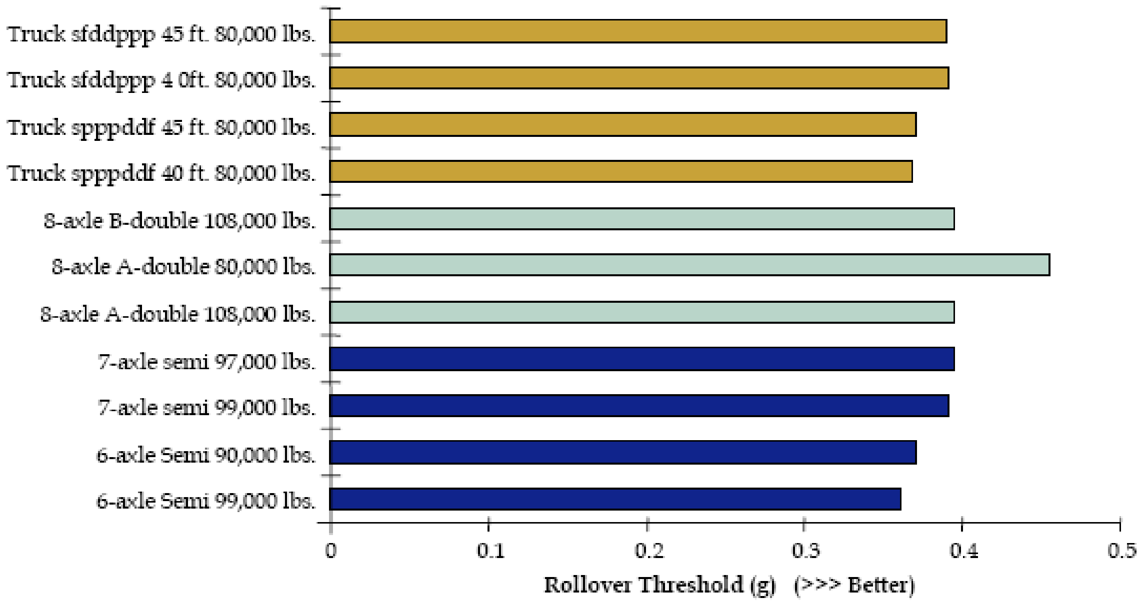
As indicated earlier rearward amplification is a measure specifically developed to assess the dynamic qualities of articulated vehicles. Generally the measure becomes more active as the number of articulation joints increases. Based on Minnesota study data, the rearward amplification is acceptable (under 2.0) for all vehicle configurations except the eight-axle A-double with 80,000 lbs. and the eight-axle A-double with 108,000 lbs. (Figure 6).

Figure 3: Comparison of Stability and Control Measures for Scenario Vehicles Relative to Five-Axle Tractor Semitrailer



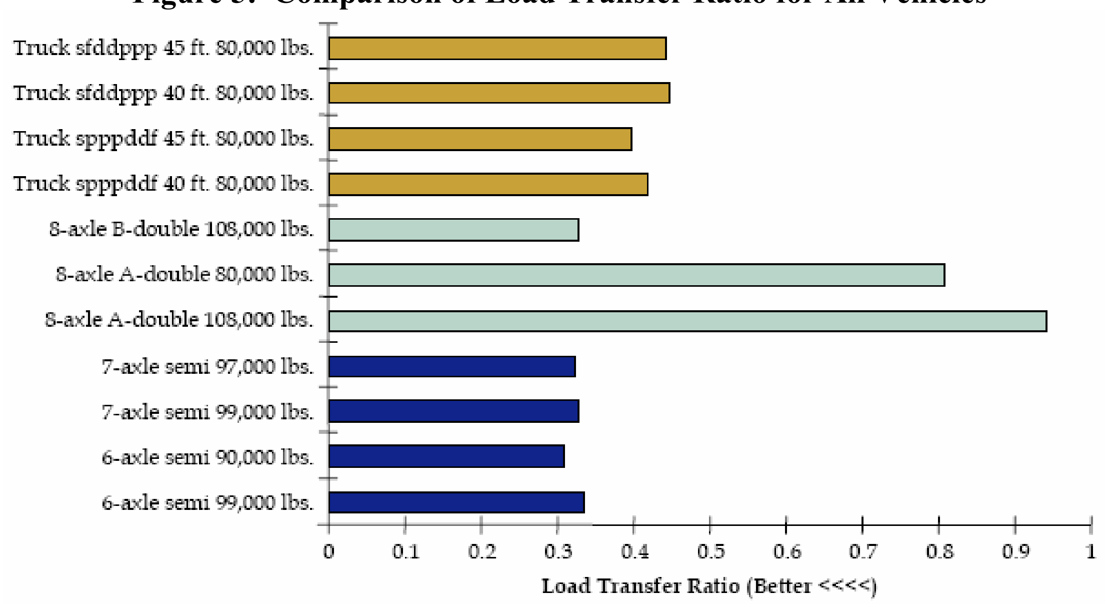
Source: DOT's "Comprehensive Truck Size and Weight Study," 2000

Figure 4: Comparison of Static Rollover Threshold for All Vehicles



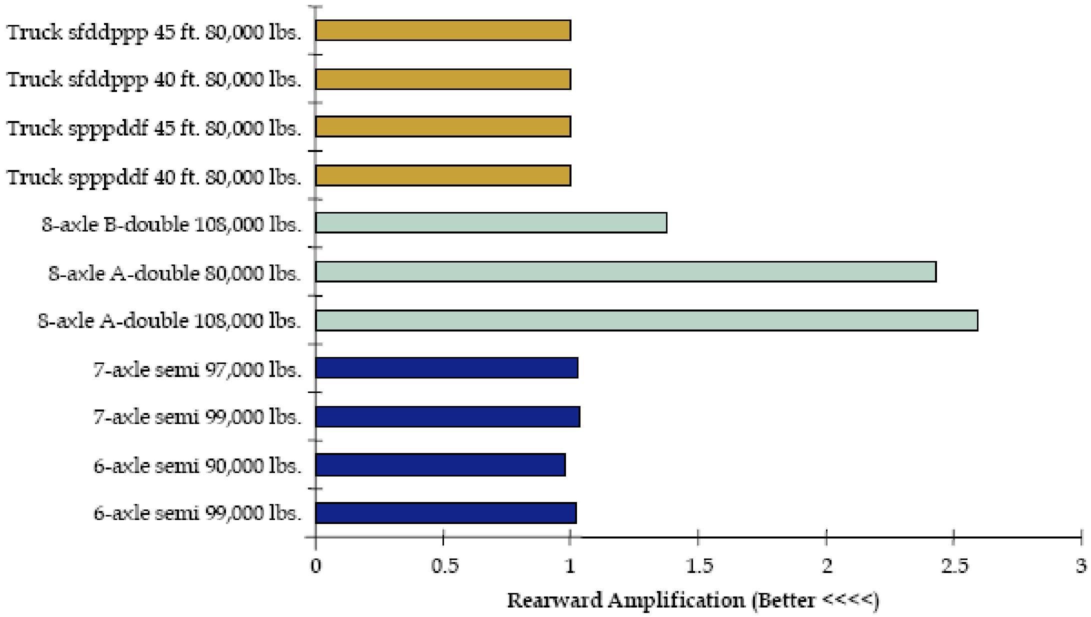
Source: "Minnesota Truck Size and Weight Project"

Figure 5: Comparison of Load Transfer Ratio for All Vehicles



Source: "Minnesota Truck Size and Weight Project"

Figure 6: Comparison of Rearward Amplification for All Vehicles



Source: "Minnesota Truck Size and Weight Project"

IV. Infrastructure Integrity

Summary

Freight volumes are expected to double over the next 30 years, increasing pressure on all freight modes to increase productivity to handle the movements. Today the use intensity is 10,500 trucks per day per mile, and by 2035 use intensity is expected to increase to 22,700, with the most heavily used portions of the system handling upwards of 50,000 trucks per day per mile. This burden will be a significant issue for both highway and bridge capacity and conditions.

Pavements and bridges have limited lives, depending on their design, the local environment and the repeated loadings to which they are subjected. Average pavement life depends on the design employed. Many pavements and bridges constructed in the 1960s and 1970s are reaching the end of their useful lives and will soon require significant rehabilitation or replacement. Use by heavy trucks and overweight trucks is a major determinant of pavement and bridge design and a major factor in costs of roadways and bridge maintenance[22].

These factors are also increasing pressure to increase truck size and weights (TS&W). Virtually all TS&W studies show large reductions in shipping costs associated with an increase in TS&W limits, with the magnitude of the reductions depending on specific assumptions concerning allowable vehicle weights and dimensions.

Such studies also show potential adverse impacts of increasing TS&W limits on infrastructure costs. Pavement and bridge impacts are major concerns associated with changing TS&W limits because of the magnitude of federal and state investments in pavement on the nation's highways and in repairing or replacing bridges. Wear-and-tear on paved surfaces (including on bridges) depends on both the volume of traffic and the number of axles over which the weight of the traffic is distributed. The structural integrity of bridges depends not only on the weight of the vehicles that pass over it, but also the number of axles that carry the weight and the distance between those axles—a relationship used to establish the "bridge formula" that guides current weight restrictions.

Most TS&W studies show that switching to heavier trucks with additional axles can leave pavement damage about the same or slightly lower. First, allowing heavier trucks increases the payload per truck, so fewer trips are required to move the same freight and resulting in fewer vehicle miles and less pavement damage. Second, heavier trucks

[22] "Factors Affecting the State of Our Transportation Infrastructure," Sponsored by Center for Transportation Studies University of Minnesota, 2007.

distribute their weight over a larger number of axles, as compared with the trucks they replace. Because pavement damage increases sharply with axle weight, the reduced weight per axle of the heavier trucks means less pavement damage. On the other hand, adding more payload to a current truck configuration (such as increasing the weight on a five-axle truck tractor semitrailer from 80,000 to 100,000 lbs.) will increase pavement damage sharply. Thus an increase in truck weight limits that does not encourage a switch to more axle-trucks can have substantial pavement costs.

For example, the DOT "Comprehensive Truck Size and Weight Study" concludes that the six-axle 90,000 and 97,000 lb. tractor semitrailers cause less road damage than the five-axle semitrailer. This study also shows that unit pavement costs and pavement costs per unit of payload-mile are the same or lower for six-axle semitrailers than for five-axle semi-trailers. The "Wisconsin Truck Size and Weight Study" found the six-axle 98,000 lb. semitrailer generated the most total net benefits of the truck configurations studied. Although the six-axle 98,000 lb. semitrailer ranked third out of seven vehicles in terms of pavement net benefits, such vehicles showed substantial savings in transport, safety and congestion costs. "The Minnesota Truck Size and Weight Project" found that the seven-axle 97,000 lb. semitrailer had the smallest impact on roads of the studied vehicles. The six-axle 90,000 lb. semitrailer also had a smaller impact than the 80,000 lb. five-axle semitrailer.

Some TS&W studies found that the stress to bridges depends more on trucks total load than on the number of axles, suggesting that increases to truck weight limits can create large costs for bridges, even when additional axles are added. For bridges the principal cost associated with heavier trucks lies in ensuring that the bridge can safely accommodate the trucks. This involves replacing or strengthening bridges. In addition bridge replacement or repair disrupts traffic and increases motorist time requirements as traffic patterns change.

The TS&W studies reviewed found that the use of six-axle 90,000 lb. tractor trailers would not increase stress on bridges at maximum weight compared with five-axle tractor semitrailers. However, the DOT and Wisconsin studies found that the heavier six-axle 97,000/98,000 lb. semitrailers would exceed current bridge formula limits and would cause stresses exceeding bridge design stresses if fully loaded. In addition, the Wisconsin study found that bridge replacement costs were the highest for the six-axle 98,000 lb. semitrailer of the vehicles studied. The removal of the current bridge formula cap of 80,000 lbs. on gross vehicle weight would allow minimal or no increase in gross weight of a five-axle tractor semitrailer, but could allow vehicles with additional axles to operate substantially above 80,000 lbs. However, none of the studies reviewed tried to develop a new bridge formula. The bridge formula was developed in 1975 and according to some sources bridges built since the late 1970s should accommodate higher truck weight limits. But, about 37% of the total bridges in the US in 2008 were built since the late 1970s.

Status of Bridge Infrastructure

Bridges are key components of the highway system. In 2008 there were 601,411 bridges (over 20 feet long) on the nation's highways (federal, state and local) that are tracked by the federal bridge inventory system, and the average age is over 40 years. Most were built at a time when vehicular traffic and weights were much less than they are today, when bridge material standards were lower, and when a lower level of non-redundancy was acceptable. As these structures age, there is inevitable deterioration, often accelerated by increasing traffic. As of 2008 more than 150,000 bridges (25% of all bridges) were classified as deficient and the number of deficient bridges has been reduced only 12% over the last decade. Of the total US deficient bridges in 2008, 71,469 were classified as "structurally deficient" and 79,922 as "functionally obsolete". The structurally deficient category decreased 23% over the last 10 years while functionally obsolete category has been relatively flat over the same time period.

A structurally deficient bridge is not necessarily unsafe, but they require significant maintenance attention, rehabilitation, or replacement. Depending on the rating it receives in inspection and evaluation the bridge may be identified for certain types of maintenance or rehabilitation, for weight limit posting or closed altogether.

A "functionally obsolete" bridge has older design features (inadequate lane widths, shoulder widths, vertical clearances) or may be unable to handle occasional roadway flooding. While not unsafe, it cannot accommodate all the traffic or vehicle types[23].

As structural deficiencies may imply safety problems, they are considered more critical; thus a bridge that is both structurally deficient and functionally obsolete is identified only as structurally deficient. Approximately 50% of structurally deficient bridges also have functional problems that need correction. Bridges indicated as functionally obsolete do not have structural deficiencies.

The selected Midwest states noted in Table 9 have more bridges that are structurally deficient (13.6%) than the rest of the country (11.9%). More than 20% of the bridges in Iowa and South Dakota and about 16% of the bridges in North Dakota and Nebraska are structurally deficient. The states of South Dakota, North Dakota and Nebraska currently allow trucks weights on non-interstate highways at respectively 129,000 lbs., 105,500 lbs., and 95,000 lbs., significantly above the 80,000 lbs. allowed on interstate highways. The maximum weight allowed on all highways in other selected states is 80,000 lbs.

[23] Structural deficiencies and functional obsolescence are not mutually exclusive, and a bridge may have both types of deficiencies. Factors considered in determining whether bridges are deficient include load-carrying capacity, clearances, waterway adequacy and approach alignment. Structural assessments along with condition ratings determine whether a bridge should be classified as structurally deficient. Functional adequacy is assessed by comparing the geometric configurations to current standards and demands. Disparities between the actual and desired configurations used to determine whether a bridge should be classified as functionally obsolete. When deficiency percentages are presented, however, bridges are indicated as being one of three categories—structurally deficient, functionally obsolete, or non-deficient.

As a general rule, most bridges constructed after the late 1970s, when the American Association of State Highway and Transportation Officials (AASHTO) Load Factor Design (LFD) standards were implemented, can support heavier trucks than are allowed under current rules. More recent standards, including the new (2007) AASHTO Load and Resistance Factor Design Bridge Design Specification allow heavier vehicle loads. However, significant numbers of older bridges and other structures not designed for a heavier vehicle loading present the greatest challenge to carrying heavier vehicle loads.

Table 9: US Road Bridge Conditions, 2008

Selected States	Total Number of Bridges	Number Structurally Deficient	Number Functionally Obsolete	Total Number Deficient	Percent Structurally Deficient	Percent Functionally Obsolete	Percent Total Deficient
Illinois	26,102	2,454	1,815	4,269	9.4	7.0	16.4
Indiana	18,543	2,005	2,172	4,177	10.8	11.7	22.5
Iowa	24,798	5,164	1,381	6,545	20.8	5.6	26.4
Nebraska	15,471	2,397	1,167	3,564	15.5	7.5	23.0
North Dakota	4,451	716	250	966	16.1	5.6	21.7
Ohio	28,065	2,809	3,952	6,761	10.0	14.1	24.1
South Dakota	5,920	1,224	249	1,473	20.7	4.2	24.9
Total Select States	**123,350**	**16,769**	**10,986**	**27,755**	**13.6**	**8.9**	**22.5**
Other States	478,061	54,700	68,936	123,636	11.4	14.4	25.9
Totals	**601,411**	**71,469**	**79,922**	**151,391**	**11.9**	**13.3**	**25.2**

Source: US DOT, Federal Highway Administration

About 37% of the total US bridges or 221,836 bridges were built since 1979, and could support heavier trucks. By comparison, 39% of the bridges in the study's seven selected Midwest states were built after 1978 (Table 10). This implies that more than 60% of those states' bridges are older bridges and may need repair or replacement if heavier truck weights are allowed.

Table 10: Number of US Bridges Built Before and From 1979 in Select States

Selected States	Total Number of Bridges	Bridges Built from 1979 Onward	Bridges Built Before 1979
Illinois	26,102	11,881	14,221
Indiana	18,543	7,474	11,069
Iowa	24,798	8,779	16,019
Nebraska	15,471	6,217	9,254
North Dakota	4,451	1,464	2,987
Ohio	28,065	10,213	17,852
South Dakota	5,920	1,734	4,186
Total Select States	**123,350**	**47,762**	**75,588**
Other States	478,061	174,074	303,987
Totals	**601,411**	**221,836**	**379,575**

Source: US DOT, Federal Highway Administration

Impact of Increasing Truck Weight Limits on Bridges

Currently the Federal Bridge Formula[24] (FBF) controls weights to protect the nation's bridges. In particular it limits the weight on groups of axles depending on their configuration and is intended to assure that stresses placed on bridges do not exceed the design stress[25]. Although design stresses are well below stresses at which a bridge will fail, prolonged repetitions of high stresses can accelerate bridge deterioration. Bridges found deficient from being overstressed may need to be replaced. However some bridges could be improved by strengthening them rather than replacing them and bridges with low volumes of damaging vehicles may not have to be improved.

If the legally allowable truck weight limits change, in cases where limits exceed design criteria, the bridge must be posted (signed for restricted use) to prevent heavier vehicles from using it, and heavy trucks will face longer routes as additional bridges are posted. Noncompliance to bridge postings (a safety risk and significant infrastructure costs) will also be a major enforcement issue. Another impact of changing allowable bridge weight limits is increased costs for inspecting and rating bridges and structures for posting signs.

The impact of increasing truck weights on bridges depends on several factors including the gross weight of the vehicle (GVW); the weight on various groups of axles; the distance between axle groups; truck length, width and height; and the type and length of bridge (Table 11). The affect of axle weight is more important on short bridges, but GVW *is* an important factor for long-span bridges; that is, bridge spans longer than the wheelbase of the truck. Bridge bending stress is more sensitive to the spread of axles than to the number of axles.

Although additional axles on a truck can substantially reduce pavement damage, most studies have found that the stress to bridges depends more on the truck's total load than the number of axles. This is the major reason that increases in truck weight limits can create large costs for bridges even when additional axles are added. The main cost associated with using heavier trucks on bridges lies in ensuring that the bridge can safely accommodate the trucks. This is a major concern since 25% of all bridges are classified

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[24] The US federal bridge formula was developed in 1975 to protect the Interstate bridge inventory from damage from excessive truck weights. Bridge formula establishes the maximum weight any set of axles on a motor vehicle may carry on the interstate highway system. Compliance with Bridge Formula weight limits is determined by using the following formula: W=500[LN/N-1 +12N +36] Where:
W=the overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds.
L=the distance in feet between the outer axles of any group of two or more consecutive axles.
N=the number of axles in the group under consideration

In addition to Bridge Formula weight limits, federal law states that single axles are limited to 20,000 pounds and axles closer than 96 inches apart (tandem axles) are limited to 34,000 pounds. Gross vehicle weight is limited to 80,000 pounds.

[25] The two most typical bridge designs in the United States are H-20 which is common on higher class highways and H-15 which is typical of bridges on lower class highways. The FBF is intended to assure that stresses placed on H-20 bridges do not exceed the design stress by more than five percent and stresses on H-15 bridges are no more than 30% greater than the design stress.

deficient, with about half of those considered “structurally” deficient implying those bridges may have to be strengthened, replaced or posted restricting use of heavier trucks. Although studies indicate that bridges built since the late 1970s should be able to accommodate heavier trucks, only 37% of current US bridges were built after 1979.

Table 11: Bridge Infrastructure Elements Affected By Truck, Size and Weight Limits

Bridge Feature	Axle Weight	GVW	Axle Spacing	Truck Length	Truck Width	Truck Height
Short-Span	**E**		**E**	**E**		
Long-Span		**E**	**e**	**E**		
Clearance					**e**	**E**

Key: E-significant impact and e-some effect
Source: DOT’s “Comprehensive Truck Size and Weight Study,” 2000

The DOT’s “Comprehensive Truck Size and Weight Study” found that bridge impacts are mixed depending on the gross weights allowed but vehicles heavier than the commonly used 5-axle 80,000 lb. trucks would require substantial bridge improvements. The study concluded that the impact of trucks on bridges varies primarily by the weight on each group of axles on a truck and the distances between axle groups. The number of axles in each group was found to be less important than the distance between adjacent groups. Generally, except for some continuous bridges with long spans, the longer the spacing between the two axle groups, the less the impact.

The DOT study based its analysis on using different truck configurations and weight loads on the Federal Bridge Formula rather than developing an alternative formula. The results showed that all the heavier vehicles increased stress on bridges (Table 12). Only the three-axle truck, four-axle truck, five-axle semitrailer and the six-axle 90,000 lb. semitrailer had no increased stress on bridges if loaded to their maximum weight. All other trucks, including the heavier six-axle 97,000 lb. semitrailer would increase stress on bridges if loaded to their maximum weights.

The study analyzed the use of tridem axles for the six-axle semitrailers based on spacing of nine feet between the outer two axles of the tridem group[26] (Table 13) and found that at the 44,000 lb. limit (six-axle 90,000 lb. semitrailer) there would be no increase in bridge stress but at the 51,000 lb. limit (97,000 lb. semitrailer) there would be a considerable increase in bridge stress and that vehicle did not meet the bridge formula based on its axle weights.

[26] Adding nine feet, places the distance in feet between the extremes of any group of 2 or more consecutive axles at 60 feet, with a weight of 90,000 lbs. on a six-axle vehicle.

Table 12: Truck Configuration Parameters for Analysis of Bridge Impacts

Configuration	Scenarios	Gross Vehicle Weight (pounds)	Trailer Lengths (feet)	Outside Axle Spread (feet)	Highways Assumed Available	Maximum Weight for ANo Impact@ (pounds)
Three-Axle Truck	Uniformity	54,000	C	24.0	All	54,000
Four-Axle Truck	North American Trade	64,000	C	24.5	All	63,500
		71,000	C		All	63,500
Five-Axle Semitrailer	Uniformity	80,000	40	54.3	All	80,000
Six-Axle Semitrailer	North American Trade	90,000	40	54.8	All	90,300
		97,000	40	54.8	All	90,300
Five-Axle STAA double	Uniformity	80,000	28, 28	64.3	All	92,000
Seven-Axle Rocky Mt. Double	LCVs Nationwide	120,000	53, 28	94.3	42,500-mile System	115,300
Eight-Axle B-Train Double	North American Trade and LCVs Nationwide	124,000	33, 33	79.3	All	111,600
		131,000	33, 33	79.3	All	111,600
Nine-Axle Turnpike Double	LCVs Nationwide	148,000	40, 40	119.3	42,500-mile System	122,200
Seven-Axle C-Train Triple	LCVs Nationwide and Triples	132,000	28, 28, 28	97.2	65,000-mile System	116,100

Source: DOT's "Comprehensive Truck Size and Weight Study," 2000

The DOT study also estimated costs for replacing bridges that would be overstressed (Table 13). The study's Uniformity scenario vehicles[27] would reduce current bridge investment requirements by $20 billion[28] and user costs by $42 billion. The bridge impacts of the North American Trade scenario vehicles[29], dominated by the six-axle 90,000 and 97,000 lb. semitrailers would increase capital costs by $51 billion for the 90,000 lb. semitrailer and $65 billion for the 97,000 lb. semitrailer. However the study admits these costs are somewhat overstated because not all overstressed bridges would have to be replaced. Some could be strengthened and others could be posted to prevent use by heavier trucks.

Table 13: Scenario Bridge Impacts

Analytical Case		Costs ($Billion)			Change from Base Case ($Billion)		
		Capital	User	Total	Capital	User	Total
1994 Base Case		154	175	329	0	0	0
2000 Base Case		154	175	329	0	0	0
SCENARIO							
Uniformity		134	133	267	-20	-42	-62
North American Trade	44,000-pound tridem axle	205	378	583	51	203	254
	51,000-pound tridem axle	219	439	658	65	264	329
LCVs Nationwide		207	441	648	53	266	319
H.R. 551		154	175	329	0	0	0
Triples Nationwide		170	276	446	16	101	117

Source: DOT's "Comprehensive Truck Size and Weight Study," 2000
Notes: See Appendix B, Figures 2 and 3, for description of LCV Nationwide and H.R. 551

The 2009 "Wisconsin Truck Size and Weight Study" reached similar conclusions as the 2000 DOT study regarding six-axle tractor semitrailers. It concluded that the six-axle 90,000 lb. semitrailer did not increase stress on bridges but the six-axle 98,000 lb.

[27] Includes three-axle single unit truck at a maximum weight of 51,000 lbs., five-axle semitrailer at a maximum weight of 80,000 lbs., and the five-axle STAA double at a maximum weight of 80,000 lbs.
[28] In 1994 dollars.
[29] Includes the four-axle single unit truck at 64,000 lbs. or 71,000 lbs. maximum weight, the six-axle tractor semi-trailer at 90,000 lbs. or 97,000 lbs., and the eight-axle B-train double at 124,000 lbs. or 131,000 lbs. maximum weight.

semitrailer did increase stress on bridges and did not meet the Federal Bridge Formula. The study did not try to develop a new bridge formula.

The Wisconsin study evaluated six truck configurations to determine the vehicle impact on various types of bridge structure configurations. Four of the six truck configurations met the Federal Bridge Formula including:

- Configurations meeting Federal Bridge Formula:
  - **Six-Axle Tractor-Trailer with 90,000-Pound Gross Vehicle Weight**. The axle spacing is 12 feet, 4 feet, 33.5 feet, and two spaces at 5.25 feet. The axle load is 12,000 lbs., two at 17,500 lbs. each and three at 14,667 lbs. each.
  - **Seven-Axle Tractor-Trailer with 97,000-Pound Gross Vehicle Weight**. The axle spacing is 10 feet, two spaces at 4.25 feet, 34 feet, and three spaces at 5.25 feet. The axle load is 12,000 lbs., three at 14,000 lbs., and three at 14,333 lbs. each.
  - **Seven-Axle Tractor-Trailer with 80,000-Pound Gross Vehicle Weight**. The axle spacing is 11 feet, two spaces at 5.5 feet, 9 feet, and two at 5.5 feet. The axle load is 11,000 lbs., three at 11,500 lbs., and three at 11,500 lbs. each.
  - **Eight-Axle Tractor-Trailer with 108,000-Pound Gross Vehicle Weight**. The axle spacing is 12 feet, 4 feet, 21.5 feet, two at 5.5 feet, 21.5 feet, and 4 feet. The axle load is 12,000 lbs., two at 13,500 lbs., three at 14,000 lbs., and two at 13,500 lbs.

- Configurations not meeting Federal Bridge Formula:
  - **Six-Axle Tractor-Trailer with 98,000-Pound Gross Vehicle Weight**. This vehicle **did not meet the Bridge Formula** because the rear tridem exceeds allowable weight. The axle spacing is 12 feet, 4 feet, 37 feet, and two spaces at 5 feet. The axle load is 12,000 lbs., two at 17,500 lbs. each and three at 17,000 lbs. each.
  - **Six-Axle Tractor-Trailer and Pup with 98,000-Pound Gross Vehicle Weight**. The axle spacing is 11 feet, 9 feet, 4.5 feet, 11 feet, and 16 feet. The axle load is 18,000 lbs., 15,320 lbs., two at 15,330 lbs., 17,000 lbs., and 17,000 lbs.

The study team fine-tuned the axle spacing and axle weight to meet the restrictions and guidelines of the Federal Bridge Formula where possible. But even with this fine tuning it was not possible for the 98,000 lb. vehicles to satisfy the formula.

The Wisconsin study also annualized costs for replacing bridges on state routes and local routes for each of the studied vehicle configurations (Table 14). The six-axle tractor-trailer with 98,000 lbs. GVW has the highest annual costs of the six vehicle configurations studied.

Table 14. Estimated Annual Bridge Replacement Costs ($ million) per Year[30]

Special Vehicle Configuration	State Route Bridge Replacement Costs	Local Route Bridge Replacement Costs
6-Axle Tractor-Trailer, 90,000 Pound GVW	$0.04	$2.14
6-Axle Tractor-Trailer, 98,000 Pound GVW	$1.54	$6.94
6-Axle Tractor-Trailer and Pup, 98,000 Pound GVW	$0.72	$3.50
7-Axle Tractor-Trailer, 97,000 Pound GVW	$0.28	$2.80
7-Axle Tractor-Trailer, 80,000 Pound GVW	$0.78	$5.24
8-Axle Tractor-Trailer, 108,000 Pound GVW	$0.04	$2.22

Source: Wisconsin Truck Size and Weight Study, January 2009

The "Minnesota Truck Size and Weight Project" found that increases in truck weight limits can affect bridges and bridge related costs in several ways:

- If the vehicles made legal by changes in limits exceeds the overstress criteria for a bridge, the bridge must be posted to prevent those vehicles from using it.
- The possibility that a bridge might need to be posted will increase agency costs for inspecting and rating bridges and also for placing bridge posting signs.
- Agencies may be pressured to replace posted bridges so that bridges can be used by all trucks.
- Illegal overloads can overstress bridges, resulting in permanent damage, and, in extreme cases, catastrophic bridge failure.
- Concrete decks and other bridge elements can wear out with repetitive loadings by heavy vehicles.
- If legal loadings are increased, it may be necessary to increase the loadings used in designing new and replacement bridges, which, in turn will increase costs for these structures.

The Minnesota study also concluded that the six-axle 90,000 lb. semitrailer met the Federal Bridge Formula and did not increase bridge stress.

Impact of Heavier Vehicles on Road Pavement

Potential impacts associated with changes in truck weight limits are of intense concern because of the magnitude of Federal and State investments in pavement on the US highway systems. Factors contributing to pavement impacts expected following truck weight policy changes include:

- Allowable axle load limits,
- Changes in vehicle miles traveled (VMT) by different vehicle classes, and
- Changes in VMT and axle loads on different highway classes.

In terms of vehicle-specific characteristics, pavement wear increases with axle weight, the number of axle loadings, and the spacing between axle groups, such as for tandem- or

[30] Costs are annualized over a 10-year period using a 5% interest rate.

tridem-axle groups. Vehicle suspensions, tire pressure and tire type also have an impact on pavement.
Most studies show that switching to heavier trucks with additional axles can leave pavement damage about the same or slightly reduced.

- Allowing heavier trucks increases the payload per truck, so fewer trips are required to move the same freight. The resulting reduction in vehicle miles of travel means less pavement damage.
- Heavier trucks distribute their weight over a larger number of axles, as compared with the trucks they replace. Because pavement damage increases sharply with axle weight, the reduced weight per axle of the heavier trucks means less pavement damage.

On the other hand, adding more payload to a current truck configuration (increasing the weight on a five-axle truck tractor semitrailer from 80,000 to 100,000 lbs.) will increase pavement damage sharply. Thus an increase in truck weight limits that does not encourage a switch to more axle-trucks can have substantial pavement costs. On the other hand significant savings in transportation costs by increasing truck weight limits more than offset higher pavement costs as well as higher bridge costs for the heavier trucks.

The DOT's "Comprehensive Truck Size and Weight Study" (2000) focused on axle weight and pavement type characteristics as having the most impact on pavement. The study found that adding one or two axles to a single axle to make a tandem- or tridem-axle group allows higher gross weights without increasing pavement damage. These axle groups reduce pavement damage by spreading the load along more pavement. Also the spread between two consecutive axles in a tandem- or tridem-axle group affects pavement life or performance. The greater the spread the more each axle in a group acts as a single axle. The study focused on two types of pavement: flexible[31] and rigid[32]. About 50% of the Interstate System mileage has rigid or composite pavement.

The study used load equivalency factors (LEFs)[33] to evaluate the relative pavement impact of various axle groups and truck configurations at their maximum allowable weights. Table 15 shows total LEFs for various scenario vehicles at their maximum allowable weights.

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[31] Flexible pavements are surfaced with asphalt materials. The total pavement structure bends or deflects in response to a load. In addition, a flexible pavement structure is usually composed of several layers that absorb most of the deflection. Flexible pavements are expected to last from 10 to 15 years while rigid pavements can last for 30 years or more. But when flexible pavement needs repair, the work is generally less expensive and quicker to perform than for rigid pavements.

[32] Rigid pavements are made from Portland cement concrete and are substantially stiffer than flexible pavements. Some rigid pavements have reinforcing steel to help resist cracking due to temperature changes and repeated loading. Only 11% of all hard surfaced highways have rigid or composite pavements (rigid pavements with flexible overlays).

[33] Comparisons were based on the effects of axle groups and their load relative to a 18,000 lb. single axle load. These relative effects were expressed in LEFs that are defined as the number of repetitions of a reference load and axle combination (such as the 18,000 lb. single axle) that is equivalent in pavement life consumption to one application of the load and axle configuration in question.

Switching to heavier trucks with additional axles can have the same or lower pavement damage (Table 15). For example the six-axle 90,000 lb. semitrailer has lower LEFs than the conventional five-axle 80,000 lb. semitrailer for rigid and flexible pavement fatigue while it has a slightly higher flexible pavement rutting. The six-axle 97,000 lb. semitrailer has a lower rigid pavement fatigue than the five axle semitrailer but higher flexible pavement fatigue and rutting.

Table 15: Theoretical Load Equivalency Factors for Scenario Vehicles

Configuration	Gross Vehicle weight (pounds)	Number of Axles in Each Group (S=Steering Axle)	Load Equivalency Factors***		
			Rigid Pavement Fatigue (10-inch thickness)	Flexible Pavement (5-inch Wearing surface)	
				Fatigue	Rutting
Three-Axle Single Unit Truck	54,000	S,2	4.2	5.6	4.1
Four-Axle Single Unit Truck	64,000	S,3	3.6	5.4	4.6
	71,000	S,3	4.1	6.5	5.0
Five-Axle Semitrailer	80,000	S,2,2	2.8	4.6	5.1
Five-Axle Semitrailer (10-foot Spread)	80,000	S,2,2 (spread)	3.1	6.0	5.4
Six-Axle Semitrailer	90,000	S,2,3	2.2	4.4	5.6
	97,000	S,2,3	2.7	5.5	6.0
STAA Double (five-axle)	80,000	S,1,1,1,1	4.2	5.0	4.9
B-Train Double (eight-axle)	124,000	S,2,3,2	3.3	6.0	6.5
	131,000	S,2,3,2	3.8	7.1	6.9
Rocky Mt. Double (seven-axle)	120,000	S,2,2,1,1	6.0	7.6	7.3
Turnpike Double (nine-axle)	148,000	S,2,2,2,2	5.0	7.8	7.3
Triple (seven-axle)	114000 (LTL operation)*	S,1,1,1,1,1,1	6.0	6.8	6.7
	132000 (TL operation)**	S,1,1,1,1,1,1	10.2	10.4	7.9

*LTL=Less-than-truckload
**TL=Truckload
***(based on 18,000-pound single axle with dual tires)
The lower the LEF the less road damage done
Source: DOT's "Comprehensive Truck Size and Weight Study", 2000

Table 16 presents pavement impacts of different vehicle configurations from a different perspective. It shows total LEFs that would be accumulated by different vehicle configurations in hauling 100,000 lbs. of freight. This measure reflects both absolute pavement damage caused by each vehicle at the maximum weight at which it can operate, as well as the benefits of moving the same volume of cargo in fewer trips. It also shows that pavement impacts vary by type of pavement.

Both the six-axle 90,000 lb. semitrailer and 97,000 lb. semitrailer have lower LEFs than the conventional five-axle 80,000 lb. semitrailer for both rigid and flexible pavement (Table 16). At the same time the six-axle 90,000 lb. semitrailer has lower LEFs than the six-axle 97,000 lb. semitrailer. Among the combination vehicles, many can haul the same quantity of cargo as the conventional five-axle semitrailer with less pavement damage, but relative damage depends on the types of axles on each vehicle (single, tandem, or tridem) and the type of pavement upon which the vehicle is operating.

Table 16: Theoretical Load Equivalency Factors per 100,000 Pounds of Payload Carried by Study Vehicle Configurations

Configuration	Gross Vehicle Weight (pounds)	Empty Weight (pounds)	Payload Weight (pounds)	No. Of Vehicles per 100,000 pounds of payload	Load Equivalency Factors***		
					Rigid Pavement Fatigue (10-inch thickness)	Flexible Pavement (5-inch wearing surface)	
						Fatigue	Rutting
Three-Axle Single Unit Truck	54,000	22,600	31,400	3.18	13.4	17.8	13.0
Four-Axle Single Unit Truck	64,000	26,400	37,600	2.66	9.6	14.4	12.2
	71,000	26,400	44,600	2.24	9.2	14.6	11.2
Five-Axle Semitrailer	80,000	30,500	49,500	2.02	5.7	9.3	10.3
Five-Axle Semitrailer (10-foot Spread)	80,000	30,500	49,500	2.02	6.3	12.2	10.9
Six-Axle Semitrailer	90,000	31,500	58,500	1.71	3.8	7.5	9.6
	97,000	31,500	65,500	1.53	4.1	8.4	9.2
STAA Double (five-axle)	80,000	29,300	50,700	1.97	8.3	9.9	9.7
B-Train Double (eight-axle)	124,000	38,700	85,300	1.17	3.9	7.0	7.6
	131,000	38,700	92,300	1.08	4.1	7.7	7.5
Rocky Mt.Double (seven-axle)	120,000	43,000	77,000	1.30	7.8	9.9	9.5
Turnpike Double (nine-axle)	148,000	46,700	101,300	0.99	5.0	7.7	7.2
Triple (seven-axle)	114,000 (LTL)*	44,500	69,500	1.44	8.6	9.8	9.6
	132,000 (TL)**	44,500	87,500	1.14	11.6	11.8	9.0

*LTL=Less-than-truckload; **TL=Truckload; ***(based on 18,000-pound single axle with dual tires)
Source: DOT's "Comprehensive Truck Size and Weight Study

The DOT study also compared unit pavement costs and pavement costs per unit of payload-mile by truck configuration, which shows that the addition of axles allows for increased payloads, and at the same time reduces pavement deterioration. The most significant comparisons were between the 3- and 4-axle single unit trucks, the 5- and 6-axle semitrailer combinations, and the 5- and 8-axle doubles. In comparing the 5-axle and 6-axle semitrailers, the unit pavement costs and unit costs per payload mile were similar or slightly lower for the 6-axle 90,000 lb. semitrailers (Tables 17 and 18).

Table 17: Unit Cost per Payload-Mile for Various Truck Types
$1,000 Ton Miles

		Truck Type								
		Single-Unit		Semitrailer		Double-Trailer			Triple	
	Weights (Pounds)	3-Axles	4-Axles	5-Axles	6-Axles	5-Axles	7-Axles	8-Axles	7-Axles	
	GVW	54,000	64,000	80,000	90,000	80,000	100,000	105,000	100,000	115,000
	Tare	22,600	26,400	30.490	31,530	29,320	38,600	33,470	41,700	41,700
	Payload	31,400	37,600	49,510	58,470	50,680	61,400	71,530	58,300	73,300
Area Type	Functional Class									
Rural	Interstate	0.006	0.004	0.002	0.002	0.001	0.003	0.001	0.001	0.002
	Prin. Art.	0.011	0.009	0.005	0.004	0.003	0.005	0.003	0.006	0.008
	Min. Art.	0.024	0.018	0.012	0.008	0.013	0.013	0.006	0.013	0.020
	Maj. Col.	0.088	0.072	0.036	0.027	0.046	0.034	0.018	0.050	0.080
	Min. Col.	0.145	0.111	0.060	0.042	0.076	0.055	0.030	0.083	0.133
	Locals	0.376	0.299	0.156	0.110	0.197	0.143	0.078	0.215	0.344
Urban	Interstate	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	Freeway & Expressway	0.006	0.003	0.002	0.002	0.002	0.002	0.001	0.003	0.005
	Prin. Art.	0.008	0.006	0.004	0.003	0.004	0.003	0.002	0.004	0.007
	Min. Art.	0.019	0.013	0.009	0.006	0.007	0.006	0.003	0.011	0.019
	Collectors	0.042	0.037	0.022	0.017	0.018	0.011	0.007	0.030	0.050
	Locals	0.149	0.136	0.077	0.060	0.065	0.039	0.024	0.105	0.176

Source: DOT's "Comprehensive Truck Size and Weight Study

Table 18: Unit Pavement Cost for Various Truck Types
Dollars per 1,000 Miles

		Truck Type								
		Single-Unit		Semitrailer		Double-Trailer			Triple	
		3-Axles	4-Axles	5-Axles	6-Axles	5-Axles	7-Axles	8-Axles	7-Axles	
	GVW (Pounds)	54,000	64,000	80,000	90,000	80,000	100,000	105,000	100,000	115,000
Area Type	Functional Class									
Rural	Interstate	0.09	0.07	0.05	0.05	0.03	0.10	0.05	0.04	0.08
	Prin. Art.	0.17	0.16	0.12	0.11	0.07	0.15	0.10	0.17	0.31
	Min. Art.	0.37	0.33	0.29	0.22	0.32	0.41	0.21	0.39	0.75
	Maj. Col.	1.38	1.35	0.90	0.80	1.17	1.03	0.65	1.46	2.95
	Min. Col.	2.27	2.08	1.49	1.24	1.92	1.69	1.07	2.42	4.87
	Locals	5.90	5.63	3.87	3.23	4.99	4.40	2.79	6.27	12.60
Urban	Interstate	0.06	0.04	0.04	0.04	0.03	0.04	0.02	0.03	0.05
	Freeway & Expressway	0.09	0.06	0.06	0.05	0.04	0.07	0.04	0.09	0.18
	Prin. Art.	0.13	0.12	0.10	0.09	0.11	0.09	0.06	0.13	0.26
	Min. Art.	0.30	0.24	0.22	0.17	0.19	0.18	0.12	0.34	0.70
	Collectors	0.66	0.70	0.54	0.49	0.46	0.34	0.25	0.86	1.82
	Locals	2.34	2.53	1.91	1.75	1.64	1.19	0.88	3.06	6.45

Source: DOT's "Comprehensive Truck Size and Weight Study

The Wisconsin Truck Size and Weight Study (2009) evaluated six truck configurations including two six-axle 98,000 lb. configurations which did not meet the Federal Bridge Formula but are both currently in use on non-interstate highways through exceptions in Wisconsin law[34]. The study analyzed the vehicle configurations both in terms of their use only on non-interstate highways and on interstate highways. In both analyses the six-axle tractor semi-trailer generated the most net statewide benefits.

In analyzing costs and benefits for trucks operating only on non-interstate highways, five of the six truck configurations generated net statewide benefits if the impacts on bridges are limited to the direct impacts of the new truck configurations (Table 19). In terms of pavement costs and benefits the 97,000 lb. seven-axle tractor semi-trailer generates the

[34] The Federal Bridge Formula would have to be changed to allow the operation of the six-axle 98,000 lb. trucks on interstate highways.

most net benefits followed by the 108,000 lb. eight-axle double and the 90,000 lb. six-axle tractor semitrailer. However, 98,000 lb. six-axle tractor semitrailer was the most successful configuration with the most savings in transport costs, safety, and congestion. The next most successful configurations were the 97,000 lb. seven-axle tractor semitrailer and the 90,000 lb. six-axle tractor semitrailer. However, because the state of Wisconsin faces baseline maintenance needs to support existing truck traffic on its structures, the backlog of total state bridge costs overwhelms the benefits for all trucks in this evaluation, unless they are also allowed to operate on the Interstate system. Under this scenario (with all bridge costs), all vehicle configurations had negative net benefits.

Table 19: Wisconsin Annual Costs and Benefits for Truck Configurations Operating on Non-Interstate Highways Only, All Values in Millions

		System User Benefits			Public Agency Benefits & Impacts			Net benefits	
Meets Federal Bridge Formula	Configuration	Transport Savings	Safety	Congestion	Pavement	Bridge Costs for TSW Config	Baseline Bridge Costs	With TSW Bridge Costs	With All Bridge Costs
Yes	5-axle 80,000 lb tractor semitrailer	0.00	0.00	0.00	0.00	0.00	-55.50	0.00	-55.50
Yes	6-axle 90,000 lb tractor semitrailer	5.50	0.46	0.92	2.57	-2.18	-55.50	7.26	-48.24
Yes	7-axle 97,000 lb tractor semitrailer	6.27	0.70	0.85	3.87	-3.08	-55.50	8.62	-46.88
Yes	7-axle 80,000 pound single unit truck	2.46	0.11	0.08	0.40	-2.26	-55.50	0.78	-54.72
Yes	8-axle 108,000 lb double	3.42	0.46	0.49	3.34	-6.02	-55.50	1.69	-53.81
No	**6-axle 98,000 lb tractor semitrailer**	**19.19**	**1.52**	**1.89**	**1.1**	**-8.48**	**-55.5**	**15.23**	**-40.27**
No	6-axle 98,000 lb straight truck trailer	2.19	0.09	0.06	0.03	-4.22	-55.5	-1.85	-57.35

Source: Wisconsin Truck Size and Weight Study

The Wisconsin study found that allowing heavier trucks on Interstate highways would decrease the impact on state and local roads. Net benefits for this scenario were greater because Interstate highways are frequently better designed to handle heavy trucks because Interstate pavements tend to be thicker than non-Interstates and truck crash costs per vehicle mile are lower on Interstates.

Taking into account the total bridge costs and the ability to operate on the Interstate, the most successful truck configuration, in terms of total benefits again was the six-axle 98,000 lb. semitrailer which again generated the highest savings in transport costs, safety and congestion (Table 20). The next most beneficial truck configuration was the seven-axle 97,000 lb. semitrailer followed by the marginally beneficial six-axle 90,000 lb. semitrailer. The other four truck configurations in the study had negative benefits. In terms of pavement costs and benefits the 97,000 lb. seven-axle tractor semi-trailer generates the most net benefits followed by the 108,000 lb. eight-axle double and the 90,000 lb. six-axle tractor semitrailer.

Table 20: Wisconsin Annual Costs and Benefits for Truck Configurations Assuming Interstate Operation is Allowable, All Values in Millions

Meets Federal Bridge Formula	Configuration	System User Benefits			Public Agency Benefits & Impacts			Net benefits	
		Transport Savings	Safety	Congestion	Pavement	Bridge Costs for TSW Config	Baseline Bridge Costs	With TSW Bridge Costs	With All Bridge Costs
Yes	5-axle 80,000 lb tractor semitrailer	0.00	0.00	0.00	0.00	0.00	-55.50	0.00	-55.50
Yes	6-axle 90,000 lb tractor semitrailer	36.64	3.48	3.44	14.65	-2.18	-55.50	56.03	0.53
Yes	7-axle 97,000 lb tractor semitrailer	41.83	4.43	4.08	19.91	-3.08	-55.50	67.18	11.68
Yes	7-axle 80,000 pound single unit truck	9.83	0.53	0.09	1.53	-2.26	-55.50	9.73	-45.77
Yes	8-axle 108,000 lb double	22.77	2.90	1.65	16.76	-6.02	-55.50	38.06	-17.44
No	**6-axle 98,000 lb tractor semitrailer**	**127.94**	**9.40**	**11.03**	**10.19**	**-8.48**	**-55.50**	**150.09**	**94.59**
No	6-axle 98,000 lb straight truck trailer	14.61	0.68	0.26	0.32	-4.22	-55.5	11.65	-43.85

Source: Wisconsin Truck Size and Weight Study

"The Minnesota Truck Size and Weight Project" also found that adding axles to a truck can greatly reduce its effect on pavement. For example, a conventional five-axle tractor semi-trailer operating at 80,000 lbs. is about 2.4 equivalent single axle loads (ESALs)[35]. If the weight on this vehicle was increased to 90,000 lbs. (12.5% increase), its ESAL value would increase to 4.1 (up 70.8%), because pavement damage increases at a geometric rate with weight increases. In comparison, a six-axle tractor-semitrailer at 90,000 lbs. has an ESAL value of only 2.0 because its weight is distributed over six axles instead of five (Table 21). An added pavement benefit of using a six-axle semitrailer is that fewer trips would be needed to carry the same amount of payload. As a result, the six-axle truck at 90,000 lbs. produces almost 30% fewer ESAL miles per payload ton-mile than the five-axle truck at 80,000 lbs. Based on ESAL factors, all truck configurations in the Minnesota study are better for pavements than the current five-axle tractor semi-trailer at 80,000 lbs.

The Minnesota study recommended that in the winter months the weight limit for the six-axle tractor-semitrailer be increased to 99,000 lbs. because pavements are less vulnerable to damage. During the spring, pavement layers are generally in a saturated, weakened state due to partial thaw conditions and trapped water. A given traffic loading during spring thaw results in five to eight times more damage to pavements than that same loading at other times of the year.

[35] Although it is not too difficult to determine a wheel or an axle load for an individual vehicle, it becomes quite complicated to determine the number and types of wheel/axle loads that a particular pavement will be subject to over its design life. Furthermore, it is not the wheel load but rather the damage to the pavement caused by the wheel load that is of primary concern. The most common historical approach is to convert damage from wheel loads of various magnitudes and repetitions ("mixed traffic") to damage from an equivalent number of "standard" or "equivalent" loads. The most commonly used equivalent load in the US is the 18,000 lb. (80 kN) equivalent single axle load (normally designated ESAL).

Table 21: Equivalent Single-Axle Load (EASL) Values of Flexible Pavements

Configuration	Total ESALs
Current 5-Axle Tractor-Semitrailer at 80,000 pounds	2.4
6-Axle Tractor-Semitrailer at 90,000 pounds	2.0
7-Axle Tractor-Semitrailer at 97,000 pounds	1.5
8-Axle Double at 108,000 pounds	1.8
Single Unit 6-and7-Axle respectively	0.7 to 0.9

Source: "Minnesota Truck Size and Weight Project"

Based on the analysis conducted in the Minnesota study regarding the impact of increasing truck weight limits:

- Increased payloads and fewer truck trips will lower transport costs significantly.
- Additional axles and fewer truck trips will result in less pavement wear.
- The increase in bridge postings and future design costs necessary will be modest.
- Proposed trucks have slightly higher crash rates but, given fewer overall truck miles (due to increased payloads) than would be experienced otherwise under existing weight limits, safety would improve slightly.

The Transportation Research Board's 1990 Report, "Truck Weight Limits: Issues and Options, Special Report 225, also affirms that pavement damage from heavy vehicles depends mainly on axle weights. Study results showed that heavier trucks can be pavement-friendlier than some lighter trucks with fewer axles (Table 22). For example, ESALs for a six-axle tractor-semitrailer carrying 88,000 lbs. are less than a five-axle semitrailer carrying 80,000 lbs. Thus trucks can be configured to carry heavier loads and at the same time cause less pavement damage.

Table 22: Relative Pavement Impacts of Different Trucks as Measured by Number of Equivalent Single-Axle Loads (EASL)

Truck Type	GVW (lb)	ESALs for Flexible Pavements	ESALs for Rigid Pavements
3-Axle Single-Unit Truck	48,000	1.48	2.10
4-Axle Single-Unit Truck	56,000	1.11	1.78
5-Axle Tractor Semitrailer	80,000	2.37	4.07
5-Axle Double	80,000	4.05	4.09
6-Axle Tractor Semi-Trailer	88,000	1.88	3.57
7-Axle Double	101,000	2.57	3.56
8-Axle B-Train Double	122,000	2.97	5.52
9-Axle Double	129,000	2.66	4.43

Source: Transportation Research Board, 1990

Table 23 shows a typical ranges for ESAL's per truck based on assumed gross vehicle weight and assumed distributions of loading to the various axles or axle groups. The six-axle 80,000 lb. semitrailer has significantly lower ESALs than the five-axle 80,000 lb. semitrailer. If the six-axle semitrailer weight is increased to 100,000 lbs. it has higher ESALs than the five-axle vehicle, although its lower range ESAL of 2.2 is close to the higher range ESAL of the five-axle vehicle at 2.1. Even more significant if both the five-axle and six-axle semitrailer weights are increased to 100,000 lbs., the six-axle semitrailer has significantly lower ESALs.

Table 23: Equivalent Single-Axle Loads (EASL) Ranges by Select Vehicles

Vehicle Type	Number of Axles	Gross Vehicle Weight (lbs)	ESAL's per Truck
Single Unit Truck	**Two Axles**	13,000	0.1 to 0.2
		26,000	1.1 to 1.3
		40,000	1.7 to 1.9
	Three Axles	42,000	0.8 to 1.0
		46,000	1.2 to 1.4
		50,000	2.2 to 2.4
		90,000	28.0 to 52.0
	Four Axles	66,000	1.3 to 1.5
		70,000	2.3 to 2.5
		74,000	2.7 to 2.9
		100,000	9.0 to 11.0
Semi-Trailer Combination Truck	**Three Axles**	48,000	2.5 to 2.7
		56,000	2.8 to 3.0
	Four Axles	60,000	1.7 to 1.9
		64,000	2.2 to 2.4
		70,000	3.0 to 3.2
	Five Axles	**80,000**	**1.9 to 2.1**
		100,000	**4.8 to 5.2**
		120,000	11.0 to 13.0
	Six Axles	**80,000**	**1.4 to 1.6**
		100,000	**2.2 to 2.6**
		120,000	6.4 to 8.4
Automobiles		4,000	0.01

Source: Pavement Design Guide, September 1997, Division of Highway Design Pavement Branch

V. Efficiency of Transporting Soybeans and Soy Products

Soybean Production Forecast

Since the 1990s, the area planted to soybeans has expanded from nearly 60 million acres in 1990 to about 75 million starting in 2000. Since 2000, there were two noticeable contractions in plantings first in 2005 then in 2007 to less than 65 million acres. During 2008, farmers planted nearly 76 million acres and are expected to plant a record 76 million acres in 2009 as shown in Table 24. Additionally, the amount harvested per acre has increased, from 34.1 bushels per acre in 1990 to 38.1 in 2000 and setting a record 43.1 in 2005. The 2008 soybean harvest netted 39.6 bushels per acre and is forecast to average 42.8 for the 2009 harvest as summarized in Table 25.

Through 2020, acreage changes in nine select states will vary by state. For example, North Dakota's planted acreage will expand from 3.9 million acres estimated for 2009 to 4.4 million in 2020. However, Illinois acreage will expand initially from 9.1 million in 2009 to 9.3 million in 2010 then contract slightly to 9.1 million in 2020. Planted acreage by select state through 2020 is summarized in Table 24.

Despite a relatively steady outlook for area planted to soybeans, there will be significant increases to yield. Soybean yields are expected to increase from an estimated 42.8 bushels per acre in 2009 at the national level to 53.0 bushels per acre in 2020 as shown in Table 25. As new technologies and increases in production efficiency continue into the future, yields will continue to improve.

Table 24: Soybean Area Planted by Select States (thousand acres)

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Tot
2001	74,075	4,600	5,600	10,700	7,300	11,000	4,950	2,150	4,500	4,950	55,750
2002	73,963	4,750	5,800	10,600	7,200	10,450	5,050	2,670	4,250	4,700	55,470
2003	73,404	4,300	5,450	10,300	7,500	10,600	5,000	3,150	4,250	4,550	55,100
2004	75,208	4,450	5,550	9,950	7,300	10,200	5,000	3,750	4,150	4,800	55,150
2005	72,032	4,500	5,400	9,500	6,900	10,050	4,950	2,950	3,900	4,700	52,850
2006	75,522	4,650	5,700	10,100	7,350	10,150	5,150	3,900	3,950	5,050	56,000
2007	64,741	4,250	4,800	8,300	6,350	8,650	4,700	3,100	3,250	3,870	47,270
2008	75,718	4,500	5,450	9,200	7,050	9,750	5,200	3,800	4,100	4,900	53,950
2009	**76,024**	**4,600**	**5,400**	**9,100**	**7,000**	**9,850**	**5,050**	**3,900**	**3,950**	**5,000**	**53,850**
2010	**75,000**	**4,600**	**5,450**	**9,300**	**7,150**	**9,800**	**5,000**	**3,900**	**3,800**	**4,850**	**53,850**
2015	**74,250**	**4,600**	**5,550**	**9,000**	**7,200**	**9,950**	**4,900**	**4,150**	**3,750**	**4,800**	**53,900**
2020	**76,000**	**4,650**	**5,850**	**9,100**	**7,400**	**10,050**	**4,900**	**4,450**	**3,800**	**4,950**	**55,150**

Source: USDA and Informa Economics
Notes: Bold numbers represent Informa forecasted acres. Select Tot is the total amount for the 9 Midwestern states.

Table 25: Soybean Yield (bushels per acre) by Select States

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Ave
2001	39.6	41.0	49.0	45.0	37.0	44.0	38.0	34.0	32.0	46.0	40.7
2002	38.0	32.0	42.0	43.0	44.0	48.0	34.0	33.0	31.0	39.0	38.4
2003	33.9	38.5	38.0	37.0	32.0	32.5	29.5	29.0	27.5	40.5	33.8
2004	42.2	47.0	51.5	50.0	33.0	49.0	45.0	23.0	34.0	46.0	42.1
2005	43.1	45.0	49.0	46.5	45.5	52.5	37.0	36.5	35.0	50.5	44.2
2006	42.9	47.0	50.0	48.0	44.5	50.5	38.0	31.5	34.0	50.0	43.7
2007	41.7	47.0	46.0	43.5	42.5	52.0	37.5	35.5	42.0	51.0	44.1
2008	39.6	36.0	45.0	47.0	38.0	46.0	38.0	28.0	34.0	46.5	39.8
2009	**42.8**	**44.5**	**49.4**	**48.1**	**42.3**	**49.8**	**39.6**	**33.6**	**35.9**	**49.3**	**43.6**
2010	**43.5**	**45.1**	**50.2**	**48.8**	**42.9**	**50.6**	**40.2**	**34.1**	**36.5**	**50.1**	**44.3**
2015	**47.7**	**49.5**	**55.0**	**53.5**	**47.0**	**55.4**	**44.1**	**37.4**	**40.0**	**54.9**	**48.5**
2020	**53.0**	**55.0**	**61.1**	**59.4**	**52.3**	**61.6**	**49.0**	**41.5**	**44.5**	**61.0**	**53.9**

Source: Informa Economics
Notes: Bold numbers represent Informa's forecast. Select Ave is the average amount for the 9 Midwestern states.

Total soybean production will expand from an estimated 3,225 million bushels in 2009 to more than 3,974 million bushels in 2020. Among the select states production will increase from 2,398 million bushels in 2009 to 3,029 million bushels in 2020 as shown in Table 26.

Table 26: Soybean Production (million bushels) by Select States

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Tot
2001	2,891	188	274	478	266	480	186	72	143	225	2,313
2002	2,756	151	242	454	312	499	170	87	127	179	2,221
2003	2,454	165	204	380	238	343	146	88	116	182	1,862
2004	3,124	208	284	495	233	497	223	82	140	219	2,381
2005	3,068	202	264	439	309	525	182	106	135	235	2,397
2006	3,197	217	284	482	323	510	194	122	131	251	2,514
2007	2,677	199	220	360	267	449	175	109	136	196	2,112
2008	2,959	161	244	428	264	445	191	105	138	226	2,203
2009	**3,225**	**204**	**266**	**435**	**292**	**488**	**198**	**129**	**141**	**245**	**2,398**
2010	**3,219**	**207**	**272**	**451**	**302**	**493**	**199**	**130**	**137**	**240**	**2,431**
2015	**3,494**	**227**	**304**	**479**	**334**	**549**	**214**	**152**	**148**	**261**	**2,666**
2020	**3,974**	**255**	**356**	**538**	**381**	**616**	**237**	**181**	**167**	**299**	**3,029**

Source: USDA and Informa Economics

As soybean production has increased, the number of truck loads required to transport the harvest has increased as well. A typical semi-truck used to haul grain can be loaded with about 900 bushels of soybeans, which when combined with the weight of the truck and trailer is under the federal gross legal weight limit of 80,000 lbs. According to elevator operators about 80% of grain and soybeans are currently hauled in a semi-truck, and this has been increasing over time as more farmers have purchased larger trucks to more efficiently move their harvest. The remaining 20% of grain and soybeans are hauled in grain wagons or straight trucks (less than 80,000 lbs gross vehicle weight). By 2020 the amount of grain and soybeans hauled in semi-trucks will increase to 90%.

Based on the soybean production forecast and the average semi-truck size of 80,000 lbs. (900 bushels per shipment), the number of semi-truck trips hauling soybeans to an initial storage location off-farm in the United States is forecast to increase 39% from 2.8 million in 2009 to 3.9 million and increase 42% among the select states from 2.1 million in 2009 to more than 3.0 million in 2020 as shown in Table 27. The number of truck trips in Iowa is expected to increase 42% and 39% in Illinois. The number of truck trips in North Dakota is forecast to expand the most at 58% because its acreage is expected to expand considerably.

Table 27: Number of Soybean Truck Loads Using Current Federal Weight Limit of 80,000 pounds by Select States from Farm

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Tot
2009	2,866,891	181,079	236,408	386,738	259,385	433,899	176,438	114,908	125,023	217,510	2,131,388
2010	2,893,759	185,781	244,590	405,599	271,657	443,062	178,687	117,166	122,940	215,986	2,185,469
2015	3,317,910	215,164	288,471	454,594	316,821	520,989	202,809	144,395	140,510	247,566	2,531,319
2020	3,974,171	254,524	355,820	537,882	381,047	615,795	237,329	181,188	166,619	298,759	3,028,963

Source: Informa Economics

Notes: Based on 900 bushels per truck. Assumes 80% of soybeans were moved by semi-truck in 2009, 90% by 2020.

There are many proposed higher federal truck weight limits. The consensus has focused on a 17,000 lb. or 21% increase from 80,000 lbs. to 97,000 lbs. For many semi-truck configurations, a sixth axle will be required to properly distribute the weight across the trailer. According to trucking industry representatives, the new sixth axle and complementing equipment will add about 6,000 lbs. to the weight of the trailer. By adjusting for the sixth axle, the net payload weight could increase 11,000 lbs. This is equivalent to 183 additional bushels per truck load (on a soybean bushel weight of 60 lbs.). The number of soybean truck loads under this proposed weight limit will reduce the number of loads by nearly 2% from 3.97 million under the current weight limit to 3.89 million in 2020 as shown in Table 28. Not all farmers will upgrade equipment to the higher truck weight limits. To account for those farmers who will upgrade equipment, an assumed adoption rate to the larger hauling equipment was used to calculate the reduction in the number of truck trips. The adoption increased from no change in 2009, 10% change in 2010, 50% in 2015, and 75% by 2020. The reduction in the number of truck trips by select state is shown in Table 29. It is assumed that 80% of grain and soybeans in 2009 will be hauled in a semi-truck from the farm to an initial storage location and will increase to 90% in 2020.

Table 28: Number of Soybean Truck Loads Using Truck Weight of 97,000 pounds by Select States from Farm

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Tot
2009	2,866,891	181,079	236,408	386,738	259,385	433,899	176,438	114,908	125,023	217,510	2,131,388
2010	2,836,092	182,079	239,716	397,516	266,243	434,233	175,126	114,831	120,490	211,682	2,141,916
2015	3,251,790	210,876	282,722	445,535	310,507	510,607	198,767	141,518	137,710	242,633	2,480,875
2020	3,894,973	249,452	348,729	527,163	373,453	603,524	232,600	177,577	163,299	292,805	2,968,602

Source: Informa Economics

Notes: Based on 1,083 bushels per truck. Assumes 80% of soybeans were moved by semi-truck in 2008, 90% by 2020.

Table 29: Reduction in Soybean Truck Loads through Adoption of 97,000 pound Truck Weight Limit by Select States from Farm

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Tot
2009	-	-	-	-	-	-	-	-	-	-	-
2010	57,667	3,702	4,874	8,083	5,414	8,829	3,561	2,335	2,450	4,304	43,552
2015	66,120	4,288	5,749	9,059	6,314	10,382	4,042	2,878	2,800	4,934	50,444
2020	79,198	5,072	7,091	10,719	7,594	12,272	4,730	3,611	3,320	5,954	60,362

Source: Informa Economics
Notes: 2009 is blank because it was assumed no farmers would change equipment until 2010.

The reduction in the number of truck trips will reduce the amount of fuel consumed. Nearly all soybeans are initially hauled by truck, whether to a local elevator, processing plant or river terminal, and most within a 35 mile radius. However, according to elevator operators, about 80% of the loads originate between 18 and 20 miles.

To estimate how much fuel consumption would be saved and the number of truck miles reduced, it was assumed that each roundtrip was 40 miles. Based on various diesel fuel prices and change in fuel consumption, and number of truck trips required under a higher weight limit, soybean farmers could realize between $1.2 million with diesel prices at $2 per gallon and nearly $2.5 million with diesel priced at $4 per gallon as summarized in Table 30. The savings in truck miles per year would total about 3.2 million miles.

Table 30: Fuel Cost Savings from Increase in Truck Weights

Input	$2 Diesel	$3 Diesel	$4 Diesel
Number of Trucks	79,198	79,198	79,198
Miles round trip	40	40	40
Truck Miles per Year	3,167,920	3,167,920	3,167,920
Miles per Gallon	5.14	5.14	5.14
Gallons of Diesel	616,327	616,327	616,327
Cost per Gallon	$ 2.00	$ 3.00	$ 4.00
Fuel Cost Savings	$ 1,232,654	$ 1,848,981	$ 2,465,307

Source: Informa Economics

For secondary users of soybeans or the next trip for soybeans from the initial off-farm elevator, the assumptions remain the same as before except the round trip increases to 100 miles from 40 miles and 55% of the soybeans will move by truck instead of 100% from the farm (the Department of Agriculture estimated the truck modal share for soybeans moves to final market position at a processor and export location is about 55%; it was assumed this will increase to 58% by 2020). The secondary move includes soybeans that are shipped from the initial elevator to a soybean crushing processor or export location. By 2020, secondary soybean moves will be reduced by 35 thousand trips for select Midwestern states and nearly 46 thousand for the US as shown in Table 33.

Table 31: Number of Soybean Truck Loads using Current Federal Weight Limit of 80,000 pounds by Select States from Initial Elevator

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Total
2009	1,576,790	99,593	130,024	212,706	142,662	238,645	97,041	63,200	68,763	119,630	1,172,263
2010	1,599,460	102,686	135,192	224,186	150,152	244,892	98,765	64,761	67,952	119,381	1,207,968
2015	1,879,143	121,861	163,380	257,465	179,436	295,069	114,864	81,780	79,580	140,213	1,433,647
2020	2,305,019	147,624	206,375	311,972	221,007	357,161	137,651	105,089	96,639	173,280	1,756,799

Source: Informa Economics

Notes: Assumes 55% of second move soybeans are moved by truck, 80% of that amount by semi-truck.

Table 32: Number of Soybean Truck Loads Using Truck Weight of 97,000 pounds by Select States from Initial Elevator

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Total
2009	1,576,790	99,593	130,024	212,706	142,662	238,645	97,041	63,200	68,763	119,630	1,172,263
2010	1,567,585	100,640	132,498	219,718	147,160	240,012	96,797	63,470	66,598	117,002	1,183,896
2015	1,841,696	119,432	160,124	252,335	175,860	289,189	112,574	80,150	77,994	137,418	1,405,077
2020	2,259,084	144,682	202,263	305,755	216,603	350,044	134,908	102,995	94,713	169,827	1,721,789

Source: Informa Economics

Table 33: Reduction in Soybean Truck Loads through Adoption of 97,000 pound Truck Weight Limit by Select States from Initial Elevator

Year	US	OH	IN	IL	MN	IA	MO	ND	SD	NE	Select Total
2009	-	-	-	-	-	-	-	-	-	-	-
2010	31,874	2,046	2,694	4,468	2,992	4,880	1,968	1,291	1,354	2,379	24,073
2015	37,448	2,428	3,256	5,131	3,576	5,880	2,289	1,630	1,586	2,794	28,570
2020	45,935	2,942	4,113	6,217	4,404	7,118	2,743	2,094	1,926	3,453	35,010

Source: Informa Economics

Based on the above analysis, total mileage saved from the farm to the grain elevator is 2.4 million miles (based on 40 mile roundtrips) and from the elevator to processor and export location is 3.5 million miles (based on 100 mile roundtrips)

Flowchart of Soybean Value Chain and Distances

The journey for soybeans from the farm to the final consumer goes through many steps and miles of travel along the marketing chain as shown in Figure 7. Many various companies provide services throughout the marketing chain creating more value from the soybean as its gets closer to the consumption source. An increase in truck weight could impact each part in the soybean marketing chain. The marketing chain is divided into six steps: inputs, production, storage and distribution of whole soybeans, processing, product distribution and retail.

Inputs consist of machinery, chemicals/fertilizers, and certified seed. The distance from manufacturer to dealership varies by input. Machinery includes combines, tractors, drills, etc. If a combine is manufactured in Moline, IL, it will be trucked to a local dealer in the Midwest. However, combines can and are transported by train to equipment dealers' located long distances from Moline. Fertilizers and chemicals produced in the US are usually transported by barge or rail to local distribution facilities then trucked to individual dealerships for delivery to farmers. In the case of fertilizer imported through east coast ports, it will be railed from those ports fertilizer warehouse in the Corn Belt and transferred to storage. That stored fertilizer will then be delivered by truck to farms and fields for application. Certified seed follows a similar transportation path as fertilizer and chemicals.

The next step in the soybean marketing chain is production. Conversations with fertilizer, chemical, and seed dealers showed that most of their clientele is within a 40 mile radius to their stores with most being within 10-20 miles. For stores that are within 10 miles of a farm, the fertilizer will be transported on a one-axle truck that would load the farmer’s spreader cart that is usually located in the field. This single axle truck helps when dealing with freeze-thaw laws in the spring time which may restrict trucks to 6 tons per axle. Any moves over 10 miles will typically be transported by larger two axle trucks or individual farmers having to shuttle their spreader carts to and from the fertilizer store.

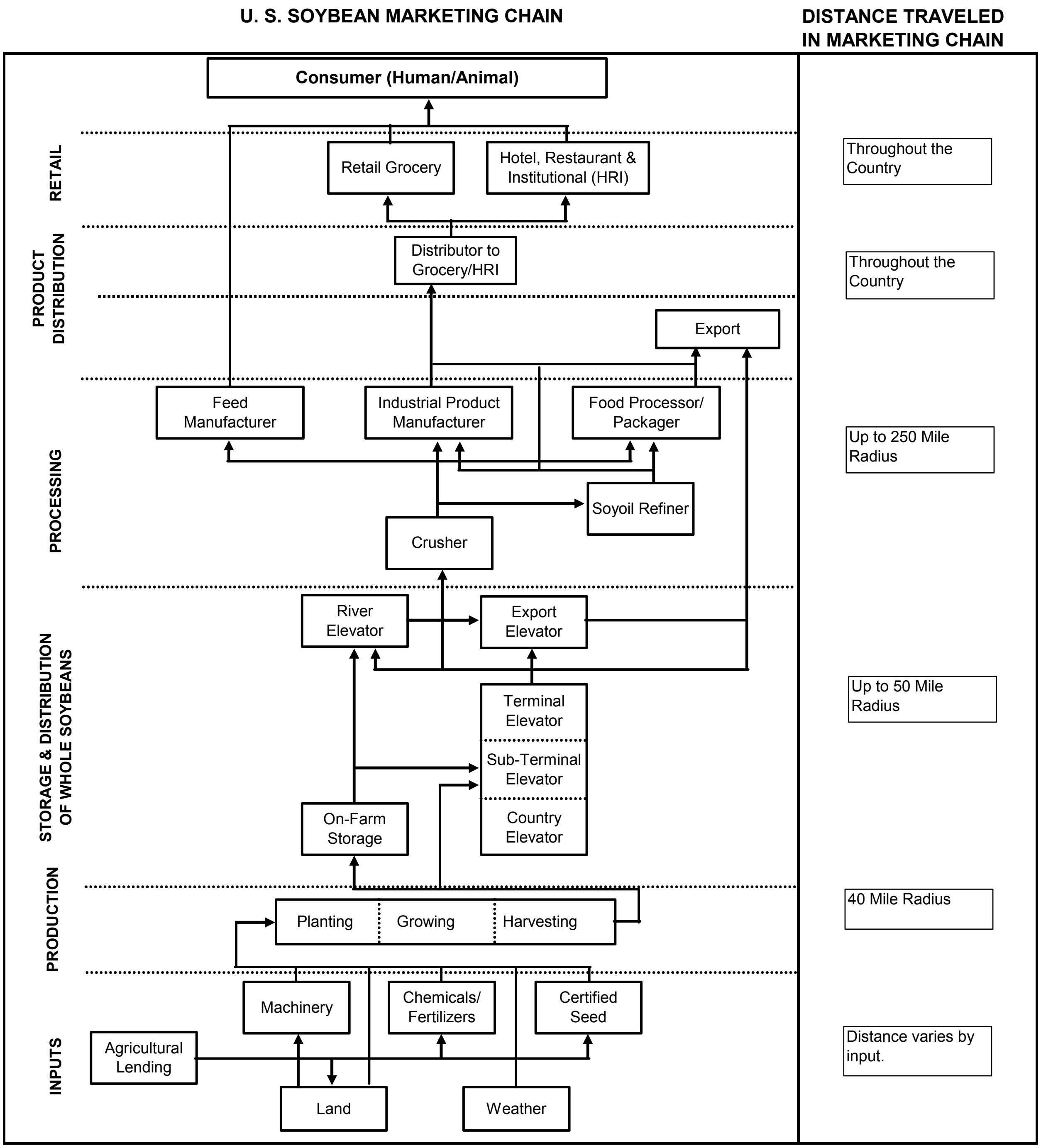
Storage and distribution of whole soybeans takes place at on-farm storage, country elevators, sub-terminal elevators, terminal elevators, river elevators, or export elevators. According to many grain elevator managers, a typical draw area is within a 50 mile radius. This distance depends on the type of grain being secured, specialty grains may originate from greater distances. These elevators will then send the grain to a processor or river terminal or export elevator. Either way, the grain will be transported by truck, rail or barge, or in some cases to an ocean vessel.

Another step is transporting soybeans to a processing or crushing facility. At these facilities, the soybeans are crushed into soybean meal or soybean oil. Typically the soybeans that are brought to a crushing facility are drawn within 35-50 miles, and in some cases as far as 250 miles. Most of the soybeans received by processors arrive by truck. Rail is used for long haul moves from a terminal or shuttle elevator for transport to a processor that is further than 250 miles or located in a soybean deficit region.

After leaving a processing facility, the soybean meal and soybean oil is transported to its next destination. Most of the time this next step is for further processing. One example is in the case of a railroad that moves soybean meal from a crush facility located in the eastern Corn Belt to the Southeastern animal feed market. For human consumption, soybean meal and soybean oil then used as ingredients for numerous products such as protein bars, salad dressings, vegetable oil, etc. This step in the marketing chain requires various distances throughout the US and around the world. If the product does not go for further processing or towards animal feed, it will be exported.

The final step in the soybean marketing chain is toward distribution facilities for grocery stores and livestock feed distributors. The ultimate product will then be transported to retail stores, hotels, restaurants and institutional facilities, or to a livestock operation. At these points of the supply chain, soybeans have now parted ways from bulk trailers to become products that are carried on pallets and in barrels or tanks transported by commercial trucking companies. These products will move through distribution centers and be placed on multiple trucks and other modes of transportation throughout the process as they find their way to consumers.

Figure 7: Soybean Marketing Chain and Distance Transported between each Step towards Final Consumption



Source: Informa and Discussions with Industry Experts

Global Truck Weights and its Effect on Containers and Intermodal Transportation

Most foreign countries have higher standard truck weights than the US. A summary of truck weights by select country is shown in Table 34. Of the Scandinavian countries, Sweden has the highest truck weight at 60 metric tons while Russia allows 38 metric tons. In Canada, some trucks have a weight of 62.5 metric tons; however 39.5 metric tons is the Memorandum of Understanding weight of the 5-axle semi throughout all Canadian provinces. Brazilian soybean farmers have a distinct competitive advantage hauling soybeans by being able to haul 57% more volume than US farmers.

Table 34: Maximum Truck Weights of Foreign Countries Compared to USA

Country	Metric Tons	Pounds
USA	36.3	80,000
Russia	38.0	83,776
Canada*	39.5	87,083
European Union	40.0	88,185
China	43.0	94,799
Mexico	48.5	106,924
South Africa	56.0	123,459
Brazil	57.0	125,663
Scandinavia	60.0	132,277

Source: The Linde Group; Prof. Johan Wideberg; and Heavy Truck Weight and Dimension Limits in Canada.
Notes: Many trucks in Canada are larger, 8-axle B-Train is 62.5 metric tons or 137,789 lbs.

Containers play an important role in international trade. Countries ship goods to and from each other in containers that can be 20, 40 or 45 foot in length. Trade between the US and other countries can be slowed by inefficiencies with different weight requirements for trucks. If a container is overweight, the truck must be configured in the US to meet the 80,000 lb. limit. In Georgia, for example, permits are available for $150 to allow a truck shipment to total 100,000 lbs. One impediment however, is that the truck driver must abide by other state and interstate rules if the container is being hauled through multiple state borders.

Weight specifications vary by container size. When exporting grain, dry containers are used. Grain shipments for export in a container are usually loaded into 20 (TEU, twenty-foot equivalent) or 40 (FEU, forty-foot equivalent) foot containers. The maximum gross weight for an FEU dry container is 67,200 lbs. while a TEU is 52,900 lbs. as shown in Table 35. The tare weight is the weight of a clean and empty container. The gross weight equals the tare weight and the weight of the payload.

Table 35: Typical Container Dimensions

Description	20 Foot (TEU)	40 Foot (FEU)	45 Foot
Maximum Gross Weight	52,900	67,200	71,656
Tare Weight	4,850	7,782	10,449
Payload	48,050	59,417	61,200
Capacity (cu. ft.)	2,376	2,376	3,037

Source: http://www.export911.com/e911/ship/dimen.htm and http://www.shipping-container-housing.com/shipping-container-standard-dimensions.html

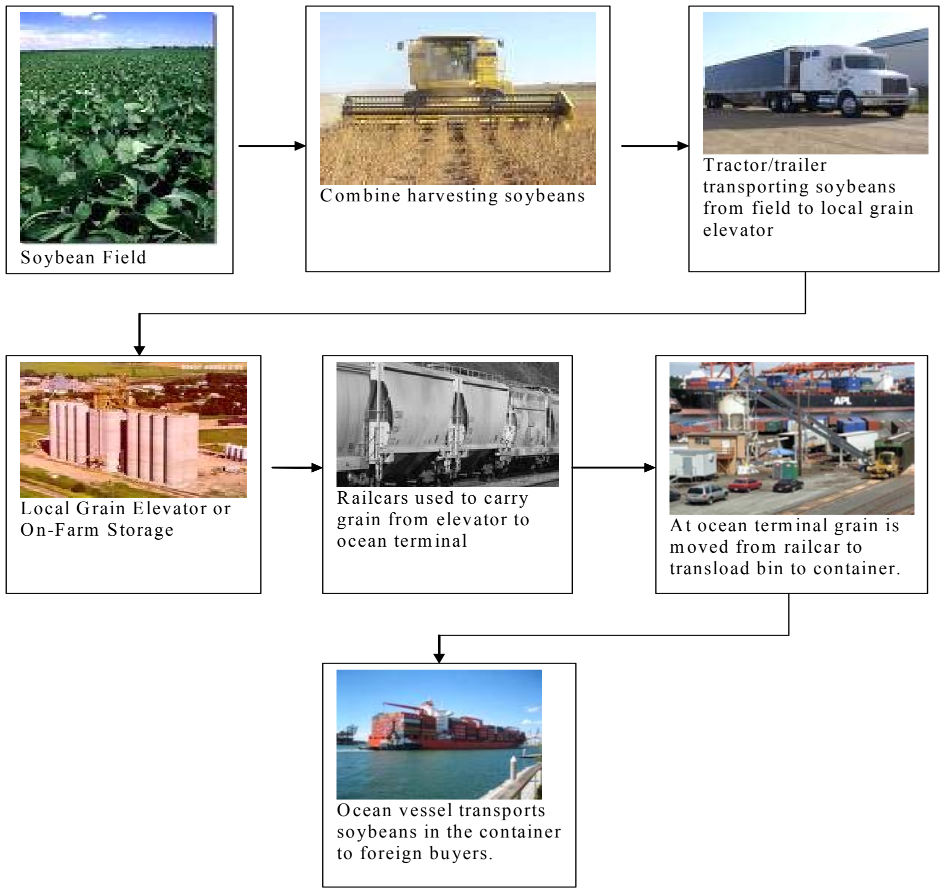
Over the past three years there has been a shift from bulk exports to containerized exports, especially when dry bulk ocean freight rates were at record levels. Shippers took advantage of containers that returned to Asia empty. Most containers arrived into the United States loaded with various consumer goods and returned empty to be reloaded and sent back to the US.

The weights mentioned above apply for intermodal rail moves as well. Many of those loaded containers originated on the West Coast and near high population centers such as Chicago. Once railed to an inland intermodal yard the container was trucked to a distribution facility. Once emptied the container would be railed back to the West Coast to be loaded back on a container ship destined for Asia. However, the grain market found the empty containers to be a back haul opportunity and loaded the containers with grain before being positioned back to the West Coast and loaded on a container vessel.

However, the weight of a container heading back to the West is limited by the railroads. Rail weight limits vary by railroad and track locations. Class I railroads publically list their track weight limits. According to BNSF, weight limits across their network range from 220,000 lbs. to 286,000 lbs. for 4-axle railcars. As a result of track weight limits, the configuration of railcars and the proper loading pattern on a double-stack intermodal railcar (stacking containers two high, two FEUs, one on top of the other, or two TEUs on the bottom and on FEU on top) is important for efficient moves. Twenty foot containers have lower centers of gravity requiring two TEUs be placed below an FEU in the double-stack intermodal railcar "well." However, two FEUs can be stacked on top of each other.

In another example of a container move soybeans are trucked from the farm to a local elevator. The grain is then loaded into a covered hopper railcar (approximately 105 tons per car) and railed to a port where the soybeans are transloaded from the covered hopper car into a surge bin and then into a container. The standard ratio of containers per railroad covered hopper grain car is about 4 to 1. The containers are then moved to a container terminal and loaded onto the ship for export. Most container shipments of soybeans are shipped to China, Japan, or Taiwan. A flowchart showing the movement of soybeans from field to export position by container is shown in Figure 8.

Figure 8: Flowchart of Containerized Grain from Farm to Export



Source: Informa Economics

Individual Cost Scenarios

Grain travels long distances from elevator to processor as shown in Figure 8. Although most grain moves off the farm to an elevator within 20 miles, specialty grain and specific varieties that processors demand could travel distances up to 250 miles by truck one-way. Specialty growers will benefit the greatest from an increase in truck weights.

The impact of a higher truck weight at 97,000 lbs. at two fuel price scenarios was evaluated at distances of 250 miles and 20 miles. The first scenario was the 250 mile move with diesel priced at $3 and $4 per gallon and the second scenario was a 20 mile move with diesel priced at $3 and $4 per gallon. The scenarios were developed from discussions with various participants in the marketing chain.

The scenarios assumed the average farmer planting 500 acres of soybeans per farm and an average soybean yield of 45 bushels per acre. The current average yield per acre is around 43 bushels per acre; however, yields are forecast to increase further. With production of 22,500 bushels, the farmer would require four fewer trips under the higher truck weight limit. Under the current law of 80,000 lbs. (900 bushels), a Class 8 truck achieves about 5.80 miles per gallon (mpg). Under a heavier weight limit at 97,000 lbs. (1,083 bushels), it is estimated that fuel consumption will fall by 11% to 5.14 mpg.

Labor costs were assumed to be $12.50 per hour based on enterprise budgets in several eastern Corn Belt states. Discussions with elevators indicated that the average wait time at the elevator was 1 hour during harvest. It was understood that a heavier truck would have a slightly longer unload time, but the reduction in the number of trucks would result in a 10% lower wait time or a 6 minute time savings overall. Travel time assumes an average speed of 50 miles per hour.

Most elevators and processors have already upgraded their equipment to handle the extra weight. As a result, the system should not incur extra expenses retrofitting for a higher weight limit.

The 250 mile scenario is summarized in Table 36. A farmer delivering soybeans 250 miles at the higher truck weight limit will save $403 annually with diesel priced at $3 per and $537 at $4 per gallon, and this despite a lower fuel mileage with a heavier weight limit. Labor costs will be lowered $607 annually. The total savings on a per bushel basis is approximately $0.045 with fuel at $3 and $0.050 per bushel with fuel at $4. A farmer driving 250 miles essentially makes one trip per day and with a heavier truck weight the farmer will save four days travel time.

A truck that travels 250 miles is likely to run on an interstate. In states where truck weights are heavier, the farmer may not be able to fully take advantage of the state regulations. As a result, the increase in federal truck weight limits is very important for longer distance moves. For the state, shifting some of the overweight traffic to federal interstates would result in fewer repairs needed for state highways. In addition, a properly configured 97,000 lb. truck is safer than an overweight 80,000 lb. truck.

Table 36: Comparison of Diesel Prices for a 250 Mile Soybean Shipment

250 Miles	$3 Diesel		$4 Diesel	
Inputs	**80,000 lbs**	**97,000 lbs**	**80,000 lbs**	**97,000 lbs**
Distance Traveled	250	250	250	250
Roundtrip (miles)	500	500	500	500
Number of Acres	500	500	500	500
Average Yield	45	45	45	45
Total Production	22,500	22,500	22,500	22,500
Bushels per Truck	900	1,083	900	1,083
Annual Trips	25	21	25	21
Miles per Gallon	5.80	5.14	5.80	5.14
Cost per Gallon	$3.00	$3.00	$4.00	$4.00
Annual Diesel Cost	$6,466	$6,063	$8,621	$8,084
Annual Savings		**$403**		**$537**
Average Weight Time (minutes)	60	54	60	54
Travel Time (minutes)	600	600	600	600
Labor Costs (hour)	$13	$13	$13	$13
Annual Labor Costs	$3,438	$2,831	$3,438	$2,831
Annual Savings		**$607**		**$607**
Fuel and Labor Annual Savings		**$1,009**		**$1,144**
Savings per Bushels		**$0.0449**		**$0.0508**

Source: USDA, State Extension Offices, Industry Sources, Informa

The second scenario is for a 20 mile shipment and is summarized in Table 37. A farmer with a heavier truck hauling the soybeans 20 miles with diesel at $3 per gallon will save $32 dollars annually in fuel costs or $43 with diesel at $4 per gallon. Labor costs will be lowered $121 annually. The total savings on a per bushel basis is approximately $0.0068 at $3 fuel and $0.0073 per bushel with $4 diesel. A farmer driving 20 miles essentially will save one day of travel time during harvest. Furthermore, having the flexibility to haul more soybeans at one time, especially during harvest, translates into less waiting time when truck lines at elevators extend for several hours.

For states that already allow heavy trucks during harvest, from the farm to the elevator it is likely the farmer will travel a state or county road. As a result, the economic savings for the farmer is minimal. For the state, the adoption of 97,000 lb. truck configuration by the farmer would save money by reducing the wear and tear on the infrastructure that occurs with trucks operating above prescribed weight limits.

Table 37: Comparison of Diesel Prices for a 20 Mile Soybean Shipment

20 Miles	$3 Diesel		$4 Diesel	
Inputs	**80,000 lbs**	**97,000 lbs**	**80,000 lbs**	**97,000 lbs**
Distance Traveled	20	20	20	20
Roundtrip (miles)	40	40	40	40
Number of Acres	500	500	500	500
Average Yield	45	45	45	45
Total Production	22,500	22,500	22,500	22,500
Bushels per Truck	900	1,083	900	1,083
Annual Trips	25	21	25	21
Miles per Gallon	5.80	5.14	5.80	5.14
Cost per Gallon	$3.00	$3.00	$4.00	$4.00
Annual Diesel Cost	$517	$485	$690	$647
Annual Savings		**$32**		**$43**
Average Weight Time (minutes)	60	54	60	54
Travel Time (minutes)	48	48	48	48
Labor Costs (hour)	$13	$13	$13	$13
Annual Labor Costs	$563	$441	$563	$441
Annual Savings		**$121**		**$121**
Fuel and Labor Annual Savings		**$153**		**$164**
Savings per Bushels		**$0.0068**		**$0.0073**

Source: USDA, State Extension Offices, Industry Sources, Informa

Interviews and Discussions with Industry Representatives

Informal surveys and discussions with industry representatives were conducted to estimate the number of loading or receiving facilities that would need to upgrade their scales to accommodate heavier trucks. Interviews were conducted with state trucking associations and managers at grain and soybean processing facilities.

The use of heavier weight limits is currently in place in 22 states that were given special exemptions and grandfathered rights to allow trucks to haul in excess of 80,000 lbs. In addition, during harvest, most states allow a 10% overweight policy for grain trucks. This is very important because out of the 4 million miles of highway in the US, 150,000 are national highways, 45,000 to 64,000 miles are interstates, and the rest are state and county roads. A list of states that allow heavier trucks is shown in Table 38.

Most associations' interest in raising the truck weight limits is limited due to the fact they believe 80% of trucks cube out before reaching 80,000 lbs. As a result, only industries that are limited by the weight restrictions express an interest towards increasing the weight limit.

Table 38: List of States that Allow Trucks over 80,000 pounds

Pounds	Truck Tractor and 2 Trailing Units	Truck Tractor and 3 Trailing Units
86,400	New Mexico	
90,000	Oklahoma	Oklahoma
95,000	Nebraska	
105,500	Idaho, North Dakota, Oregon, Washington	Idaho, North Dakota, Oregon
110,000	Colorado	Colorado
115,000		Ohio
117,000	Wyoming	
120,000	Kansas, Missouri	Kansas, Missouri
123,500		Arizona
127,400	Indiana, Massachusetts, Ohio	Indiana
129,000	Arizona, Iowa, Nevada, South Dakota, Utah	Iowa, Nevada, South Dakota, Utah
131,060		Montana
137,800	Montana	
143,000	New York	
164,000	Michigan	

Source: American Transportation Research Institute

Associations discussed how increased truck weights have worked in states that allow heavier truck weights. In South Dakota for example, a truck could be carrying a load over 100,000 lbs., but in order to cross the border into another state, it must abide by that state's weight limit law. Long-haul movers would like to eliminate this inefficiency. A first step in eliminating the different weight limits across states is to increase the federal limit to 97,000 lbs., which would pressure on states to follow suit. Shorter distance moves within South Dakota, such as moves early in the marketing chains, are realizing the efficiencies of a higher truck weight limit.

For example, a large beer manufacturing company advocates increased truck weights. One scenario that the company uses to promote its position involves trucks traveling from a brewery in Houston to retail stores in San Antonio. Their trucks weigh 35,000 lbs. empty and can carry approximately 45,000 lbs. of beer before reaching 80,000 lbs. If the weight limit was to increase to 97,000 lbs., each truck could increase its load to 60,000 lbs. Every week, about 5.9 million lbs. of beer is shipped from Houston to San Antonio in 128 trucks, the increase in truck weight would decrease the amount of truck trips to 96. The impact for the company and environment would be a reduction of 807 gallons in diesel fuel per week, depending on the cost of fuel; this could be $3,000 to $4,000 per week just from one brewery to one location. The impacts to the entire system would be significant. In addition, there would be a reduction in CO_2 emissions of 17,996 lbs each week. The impact to roads and bridges would be felt as well, as the total weight reduction would be 1.1 million lbs.

According to associations, the opposition to heavier truck weights comes from state politicians, unions and other civic organizations. There is minimal opposition for heavier trucks hauling grain from the farm to the elevator or processor. The opposition comes when products are moved from the processor to further processing or to retail. These moves typically are longer hauls and on more congested highways where safety concerns are greatest.

Those that oppose higher truck weight limits include unions, railroads, and other highway safety advocates. For example, the general public is often concerned about the safety of children and represents a strong contingency for politicians. Unions are opposed to the decrease in labor, and railroads fear a shift of cargo to trucks and possible damage to its infrastructure if intermodal shipments result in heavier trains carrying heavier containers. There would be a large cost involved in converting shortline railroad tracks to support heavier trains, not to mention the importance shortlines have for local agriculture. For example, according to the Minnesota Department of Agriculture, shortline railroads have provided continued operation of rail service to the agricultural community that otherwise would have lost service through rail abandonment. Due to low freight volumes in rural areas, shortline railroads (Class II & III railroads) are the primary carriers to haul agricultural products to connect with Class I railroads that move commodities and products to final market destination" (Assessing Feasibility of Intermodal Transport of Agricultural and Related Products on Short Line and Regional Railroads, 2008).

An example of an industry that is not for higher truck weight limits is the tank truck industry; where the costs of new trucks and trailers outweigh the benefit of a heavier load. As a result, the tank truck industry is not for the increase in truck weight in the short term. In the long term, a new generation of tank trucks with larger liquid hauling capacity would be developed to take advantage of the increase in cubic space.

Some of the associations mentioned their research has shown that trucks are more efficient at 97,000 lbs. with an additional axle on the trailer. The addition of the sixth axle would increase payloads between 6,000 to 15,000 pounds according to various contacts. The sixth axle helps distribute the weight in a more balanced manner.

Results from Conversations with Grain Elevator and Soybean Processing Managers

Grain elevator managers from the seven states mentioned earlier were contacted to discuss additional cost that would be needed at their grain elevators if the increase in truck weight takes place. The key points from these conversations are summarized below.

- Nearly all grain elevators in the Midwest have updated to larger scales with dimensions of 75-85 feet in length and 120,000 lb. weight limits during the last 10 years.
- The cost to upgrade to these larger scales ranged from $50,000 to $150,000 based on the amount of concrete added and the brand name of scale.
- Most managers were not aware of the possibility of an increase in truck weight; scales were upgraded because of the need for a new scale and most farmers now use semi trucks and trailers to haul grain to elevators, and in some cases these arrive at elevators overweight already.

- All respondents contacted said they have already upgraded their scales to accommodate heavier and longer trucks; however, it was mentioned that some of the smaller grain elevators still have scales that have 90,000 lb. limits.
- These smaller elevators handle mostly straight-trucks and grain wagons (less than 650 bushels) which have draw areas within 10 miles.
- In South Dakota, most trucks moving grain already exceed 100,000 lbs. The semis pull extra “pups” behind their trailers for increased efficiency.
- Most of the pits at Midwestern elevators are capable of handling the increase in weights. Some elevators have four pits with the ability to unload 75,000 bushels per hour during harvest.
- Some elevators pits would slow down the unloading of extra volume by only a few minutes.
- Under current weight limits, unloading wait times are 45 minutes.
- In the spring time, most Midwestern states are affected by the spring thaw weight laws. Usually the trucks are only allowed to carry 6 tons per axle. This has an impact on planting (fertilizer, chemicals, and seed).

The focus of the conversations with soybean processors was based on the same questions asked to grain elevator managers. However, additional questions focused on the distance of travel the soybean oil and soybean meal take to the next processor or feedlot. The infrastructure at these processors is very similar to the grain elevators in that the scales are capable of handling 120,000 lbs.

Similar to grain elevators, the draw areas are within a 35 to 50 mile radius for most of the grain; however, some of the processors will draw grain from 250 miles away. Usually these cases are based on the farmer sending a specialty grain to a processor. Upon leaving the processor, the meal will travel by truck or rail. Usually this is about 250-300 miles by truck and to the southeastern US by rail. Soybean oil is mostly transported by truck up to 250-300 miles; however some of the processors do sent the oil by rail.

A former soybean processing manager said the issue of an increase in truck weight limits will find more support from companies that handle human consumption products instead of animal consumption. The reason is human consumption involves more steps and more transportation cost to process an edible human product compared to feeding animals, which may have half the total transportation cost because of fewer moves. This is consistent with what Informa discovered during literature reviews.

Appendix A: Soybean Production & Balance by State

Most soybeans produced in the United States are harvested across the Corn Belt. More than three-quarters of the 2008 harvest took place in ten states including Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Over the last decade, US soybean production has ranged from 2,454 million bushels in 2003 to 3,197 million in 2006 as shown in Table 1. For 2009, soybean harvest is forecast at 3,224 million bushels. Iowa and Illinois have consistently led the country in soybean production. In 2008, Iowa produced 445 million bushels of soybeans while Illinois produced 428 million bushels. These states are followed by Minnesota and Indiana; they each produced 264 and 244 million bushels respectively.

A soybean balance sheet is used to show which states are surplus or deficit states. A surplus state either produces more than it demands for international export, feeding, processing and ending inventories while a deficit state demands more than it produces and has available in ending stocks. The ten states mentioned above historically have been surplus states as summarized in Table 2. During the 2008/09 crop year (September to August), the soybean deficit states included Alabama, Georgia, Louisiana, Maryland, North Carolina, Texas and Washington.

Table 1: Soybean Production by State (million bushels)

STATE	2000	2001	2002	2003	2004	2005	2006	2007	2008	**2009**
ALABAMA	3	5	4	6	7	5	3	4	12	12
ARIZONA	0	0	0	0	0	0	0	0	0	0
ARKANSAS	80	91	96	111	123	102	107	102	124	127
CALIFORNIA	0	0	0	0	0	0	0	0	0	0
COLORADO	0	0	0	0	0	0	0	0	0	0
CONNECTICUT	0	0	0	0	0	0	0	0	0	0
DELAWARE	9	8	5	6	9	5	6	4	5	6
FLORIDA	0	0	0	0	1	0	0	0	1	1
GEORGIA	3	4	3	6	8	5	4	9	12	12
IDAHO	0	0	0	0	0	0	0	0	0	0
ILLINOIS	460	478	454	380	495	439	482	360	428	434
INDIANA	252	274	239	204	284	264	284	220	244	264
IOWA	465	480	499	343	497	525	510	449	445	500
KANSAS	50	87	58	57	111	105	99	86	120	117
KENTUCKY	45	49	43	54	57	53	60	30	47	60
LOUISIANA	20	20	21	25	33	29	30	26	31	35
MAINE	0	0	0	0	0	0	0	0	0	0
MARYLAND	22	20	11	16	21	16	16	11	15	17
MASSACHUSETTS	0	0	0	0	0	0	0	0	0	0
MICHIGAN	73	64	79	55	75	77	92	72	70	78
MINNESOTA	293	266	309	238	233	309	323	267	264	297
MISSISSIPPI	35	37	44	56	62	58	43	58	78	81
MISSOURI	175	186	170	146	223	182	194	175	191	195
MONTANA	0	0	0	0	0	0	0	0	0	0
NEBRASKA	174	223	176	182	219	235	251	196	226	248
NEVADA	0	0	0	0	0	0	0	0	0	0
NEW HAMPSHIRE	0	0	0	0	0	0	0	0	0	0
NEW JERSEY	4	3	2	3	4	3	3	2	3	3
NEW MEXICO	0	0	0	0	0	0	0	0	0	0
NEW YORK	4	5	5	5	7	8	9	8	10	12
NORTH CAROLINA	44	43	31	42	51	39	44	30	55	53
NORTH DAKOTA	59	71	87	88	82	106	122	109	105	127
OHIO	186	188	151	165	208	202	217	199	161	215
OKLAHOMA	4	5	7	6	9	8	4	5	9	8
OREGON	0	0	0	0	0	0	0	0	0	0
PENNSYLVANIA	17	14	10	15	20	17	17	18	17	17
SOUTH CAROLINA	11	9	7	12	14	9	11	8	17	12
SOUTH DAKOTA	153	143	127	116	140	135	131	136	138	145
TENNESSEE	29	35	35	47	48	42	44	19	50	56
TEXAS	7	6	6	5	9	6	4	3	5	6
UTAH	0	0	0	0	0	0	0	0	0	0
VERMONT	0	0	0	0	0	0	0	0	0	0
VIRGINIA	18	17	11	16	21	16	16	14	18	17
WASHINGTON	0	0	0	0	0	0	0	0	0	0
WEST VIRGINIA	1	1	1	1	1	1	1	0	1	1
WISCONSIN	60	58	67	47	53	70	72	56	56	70
WYOMING	0	0	0	0	0	0	0	0	0	0
UNITED STATES	2,758	2,891	2,756	2,454	3,124	3,068	3,197	2,677	2,959	3,224

Source: Informa Economics

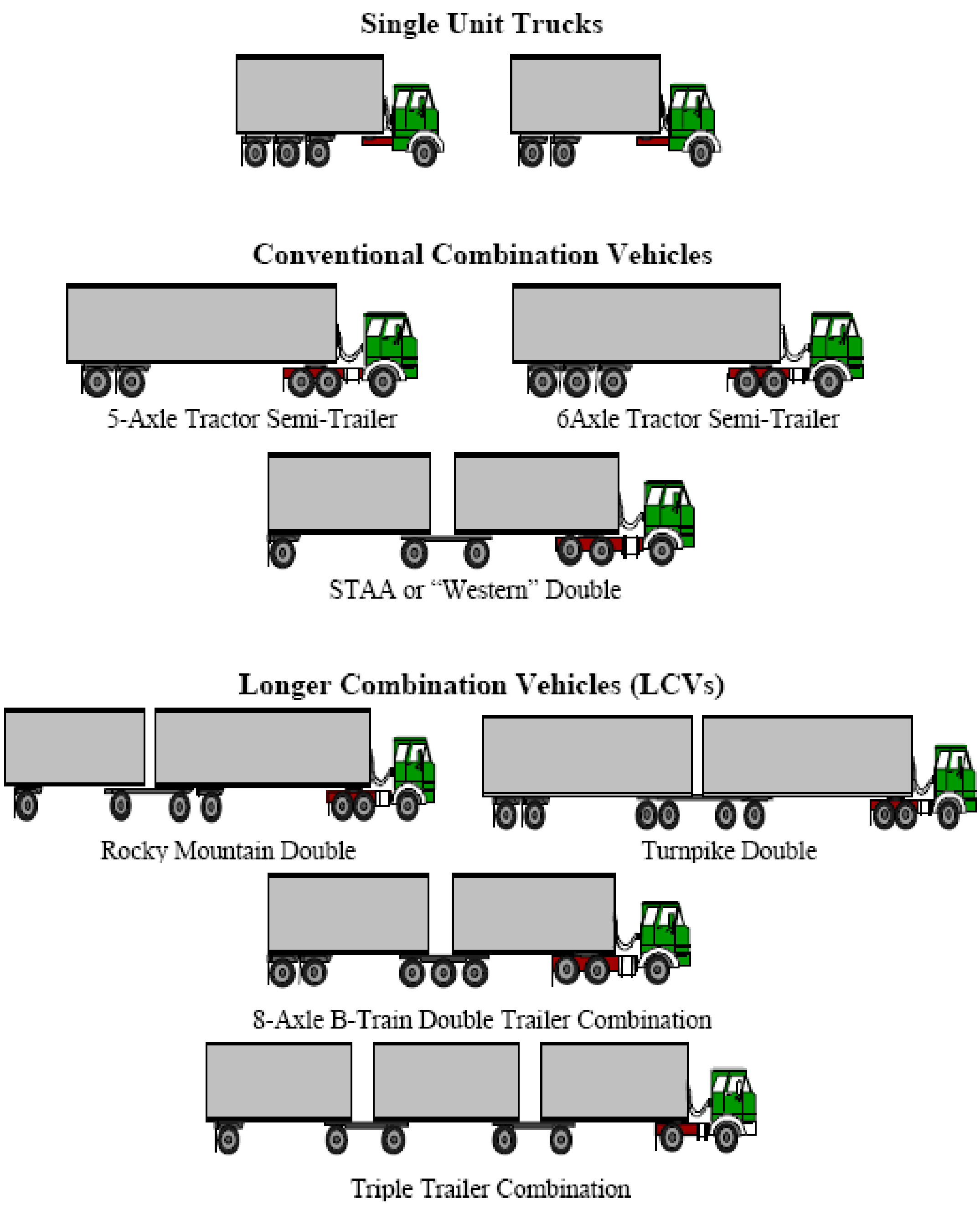
Table 2: Soybean Balance Table for Select States (million bushels)

State	Description	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	**2008/09**	**2009/10**
ILLINOIS	Beginning Stocks	39.0	34.7	27.2	23.3	16.5	51.4	73.4	96.6	34.7	16.0
	Production	459.8	477.9	453.7	379.6	495.0	439.4	482.4	360.2	427.7	434.4
	Total Supply	498.8	512.6	480.9	402.9	511.5	490.8	555.8	456.8	462.4	450.4
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	262.2	263.3	247.6	226.5	250.4	256.6	266.7	266.4	238.6	229.1
	Ending Stocks	34.7	27.2	23.3	16.5	51.4	73.4	96.6	34.7	16.0	30.1
	Net Shipments	201.8	222.1	209.9	160.0	209.6	160.9	192.5	155.6	207.8	191.2
INDIANA	Beginning Stocks	11.7	10.5	11.2	11.7	7.1	11.1	16.3	23.4	12.0	5.5
	Production	252.1	273.9	239.5	204.1	284.3	263.6	284.0	220.3	244.4	263.6
	Total Supply	263.8	284.4	250.6	215.8	291.3	274.7	300.3	243.8	256.3	269.2
	Exports	18.4	21.2	15.9	17.6	27.5	23.8	33.0	16.3	12.5	47.1
	Processing	148.4	149.6	140.7	128.4	142.3	146.0	151.7	151.3	135.7	130.4
	Ending Stocks	10.5	11.2	11.7	7.1	11.1	16.3	23.4	12.0	5.5	9.4
	Net Shipments	86.5	102.4	82.4	62.7	110.4	88.7	92.1	64.2	102.7	82.3
IOWA	Beginning Stocks	80.0	61.4	55.4	53.1	30.6	57.9	110.3	144.0	57.2	26.9
	Production	464.6	480.5	499.2	342.9	497.4	525.0	510.1	448.8	444.8	499.8
	Total Supply	544.6	541.9	554.6	396.0	527.9	582.9	620.4	592.7	502.1	526.7
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	372.6	373.3	363.3	331.2	367.8	377.1	392.1	390.9	350.6	336.9
	Ending Stocks	61.4	55.4	53.1	30.6	57.9	110.3	144.0	57.2	26.9	57.3
	Net Shipments	110.6	113.1	138.2	34.2	102.3	95.4	84.3	144.6	124.6	132.5
MINNESOTA	Beginning Stocks	40.6	34.9	27.7	19.6	12.8	29.3	64.5	68.9	21.1	10.0
	Production	293.2	266.4	308.9	238.4	232.7	309.4	322.6	267.3	264.1	296.7
	Total Supply	333.7	301.3	336.6	258.0	245.4	338.7	387.1	336.2	285.2	306.7
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	109.2	105.7	105.7	96.2	107.0	109.8	114.2	113.6	102.0	98.1
	Ending Stocks	34.9	27.7	19.6	12.8	29.3	64.5	68.9	21.1	10.0	30.3
	Net Shipments	189.7	167.9	211.3	149.0	109.1	164.4	204.0	201.5	173.2	178.2
MISSOURI	Beginning Stocks	14.1	14.7	11.1	6.5	5.5	15.6	23.2	19.4	9.4	3.8
	Production	175.0	186.2	170.0	146.0	223.2	181.7	194.2	175.1	191.1	195.4
	Total Supply	189.1	200.9	181.1	152.5	228.7	197.3	217.3	194.5	200.5	199.2
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	98.5	96.1	91.2	83.3	92.2	94.5	98.2	98.1	87.9	84.4
	Ending Stocks	14.7	11.1	6.5	5.5	15.6	23.2	19.4	9.4	3.8	9.7
	Net Shipments	75.8	93.7	83.4	63.7	120.9	79.6	99.7	87.1	108.8	105.1
NEBRASKA	Beginning Stocks	22.3	16.0	13.2	11.9	6.5	15.8	35.3	59.2	14.9	10.3
	Production	173.9	223.0	176.3	182.3	218.5	235.3	250.5	196.4	226.0	248.0
	Total Supply	196.2	238.9	189.6	194.2	225.0	251.1	285.8	255.5	240.9	258.3
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	78.7	92.0	79.0	72.3	79.9	81.9	85.1	85.1	76.2	73.1
	Ending Stocks	16.0	13.2	11.9	6.5	15.8	35.3	59.2	14.9	10.3	20.5
	Net Shipments	101.5	133.7	98.6	115.5	129.2	133.9	141.5	155.6	154.4	164.6
NORTH DAKOTA	Beginning Stocks	2.2	2.7	2.2	3.0	1.8	4.7	13.6	18.9	4.7	4.1
	Production	59.2	70.7	86.8	88.5	82.1	105.9	121.9	108.6	105.3	127.1
	Total Supply	61.4	73.3	89.0	91.4	84.0	110.6	135.5	127.5	109.9	131.1
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	29.3	38.2	42.6	38.8	43.1	44.2	46.0	45.8	41.1	39.5
	Ending Stocks	2.7	2.2	3.0	1.8	4.7	13.6	18.9	4.7	4.1	5.9
	Net Shipments	29.4	32.9	43.5	50.8	36.2	52.7	70.6	77.1	64.8	85.7
OHIO	Beginning Stocks	11.3	8.0	12.6	9.6	3.6	9.6	14.8	23.6	7.6	2.4
	Production	186.5	187.8	151.0	164.8	207.7	201.6	217.1	199.3	161.3	215.3
	Total Supply	197.7	195.8	163.6	174.3	211.4	211.2	232.0	222.9	168.8	217.7
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	115.6	118.1	108.0	98.7	109.1	111.9	116.3	116.2	104.0	99.9
	Ending Stocks	8.0	12.6	9.6	3.6	9.6	14.8	23.6	7.6	2.4	8.6
	Net Shipments	74.1	65.2	46.1	72.0	92.6	84.5	92.0	99.2	62.4	109.1
SOUTH DAKOTA	Beginning Stocks	16.9	15.0	8.3	5.1	4.1	9.5	25.1	25.4	6.4	5.1
	Production	153.0	143.0	126.8	115.5	140.1	134.8	130.9	136.1	138.0	144.7
	Total Supply	169.8	158.0	135.1	120.6	144.2	144.3	156.0	161.4	144.5	149.8
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Processing	22.9	26.4	25.1	22.9	25.4	26.1	27.1	27.0	24.2	23.3
	Ending Stocks	15.0	8.3	5.1	4.1	9.5	25.1	25.4	6.4	5.1	9.3
	Net Shipments	132.0	123.4	104.8	93.7	109.2	93.2	103.5	128.0	115.1	117.2
WISCONSIN	Beginning Stocks	8.1	7.2	4.5	4.7	3.2	8.3	13.1	15.9	5.8	5.6
	Production	60.0	58.1	66.9	46.8	53.5	69.5	72.2	55.9	55.7	69.7
	Total Supply	68.1	65.3	71.4	51.5	56.7	77.8	85.2	71.8	61.4	75.3
	Exports	43.7	36.9	37.9	17.8	8.6	8.4	6.6	0.0	1.1	1.0
	Processing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ending Stocks	7.2	4.5	4.7	3.2	8.3	13.1	15.9	5.8	5.6	7.3
	Net Shipments	17.1	23.8	28.8	30.5	39.8	56.4	62.7	66.0	54.7	66.9

Source: Informa Economics

Appendix B. Truck Configurations

Figure 1: Vehicle Configurations



Source: US Department of Transportation's "Comprehensive Truck Size and Weight Study," 2000

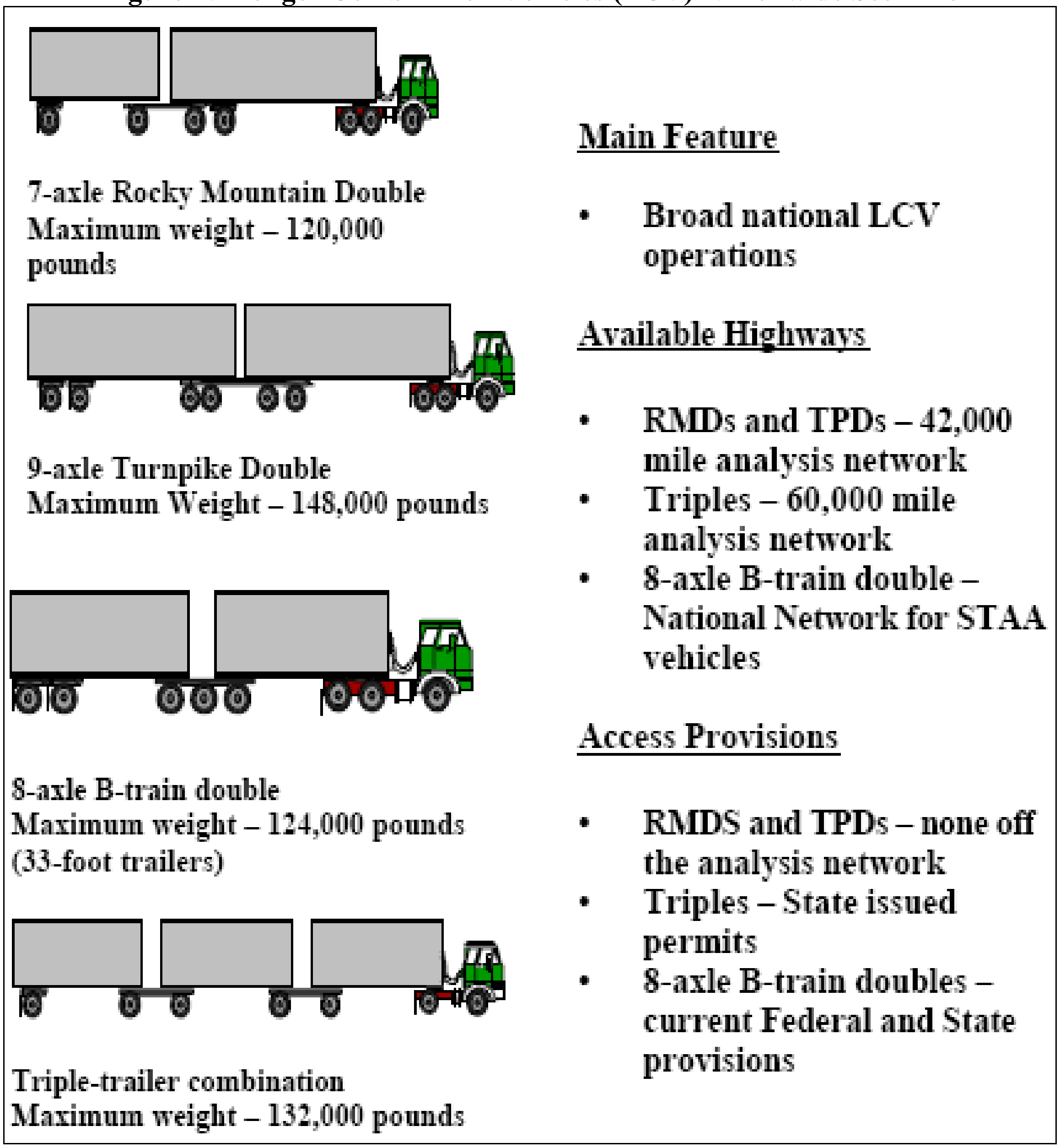
Table 3: Characteristics of Typical Vehicles and How They are Currently Used

Configuration Type	Number of Axles	Common Maximum Weight (Pounds)	Current Use
Single-Unit Truck	3	50,000 to 65,000	Single-unit trucks (SUT) are the most commonly used trucks. They are used extensively in all urban areas for short hauls. Three-axle SUTs are used to carry heavy loads of materials and goods in lieu of the far more common two-axle SUT.
	4 or more	62,000 to 70,000	SUTs with four or more axles are used to carry the heaviest of the construction and building materials in urban areas. They are also used for waste removal.
Semitrailer	5	80,000 to 99,000	Most used combination vehicle. It is used extensively for long and short hauls in all urban and rural areas to carry and distribute all types of materials, commodities, and goods.
	6 or more	80,000 to 100,000	Used to haul heavier materials, commodities, and goods for hauls longer than those of the four-axle SUT.
STAA Double	5, 6	80,000	Most common multitrailer combination. Used for less-than-truckload (LTL) freight mostly on rural freeways between LTL freight terminals.
B-Train Double	8	105,500 to 137,800	Some use in the northern plains States and the Northwest. Mostly used in flatbed trailer operations and for liquid bulk hauls.
Rocky Mountain Double	7	105,500 to 129,000	Used on turnpikes in Florida, the Northeast, and Midwest and in the Northern Plains and Northwest in all types of motor carrier operations, but most often it is used for bulk hauls.
Turnpike Double	9	105,500 to 147,000	Used on turnpikes in Florida, the Northeast, and Midwest and on freeways in the Northern Plains and Northwest for mostly truckload operations.
Triple	7	105,500 to 131,000	Used to haul LTL freight on the Indiana and Ohio Turnpikes and in many of the most western States, used on rural freeways between LTL freight terminals.

Source: US Department of Transportation's "Comprehensive Truck Size and Weight Study," 2000

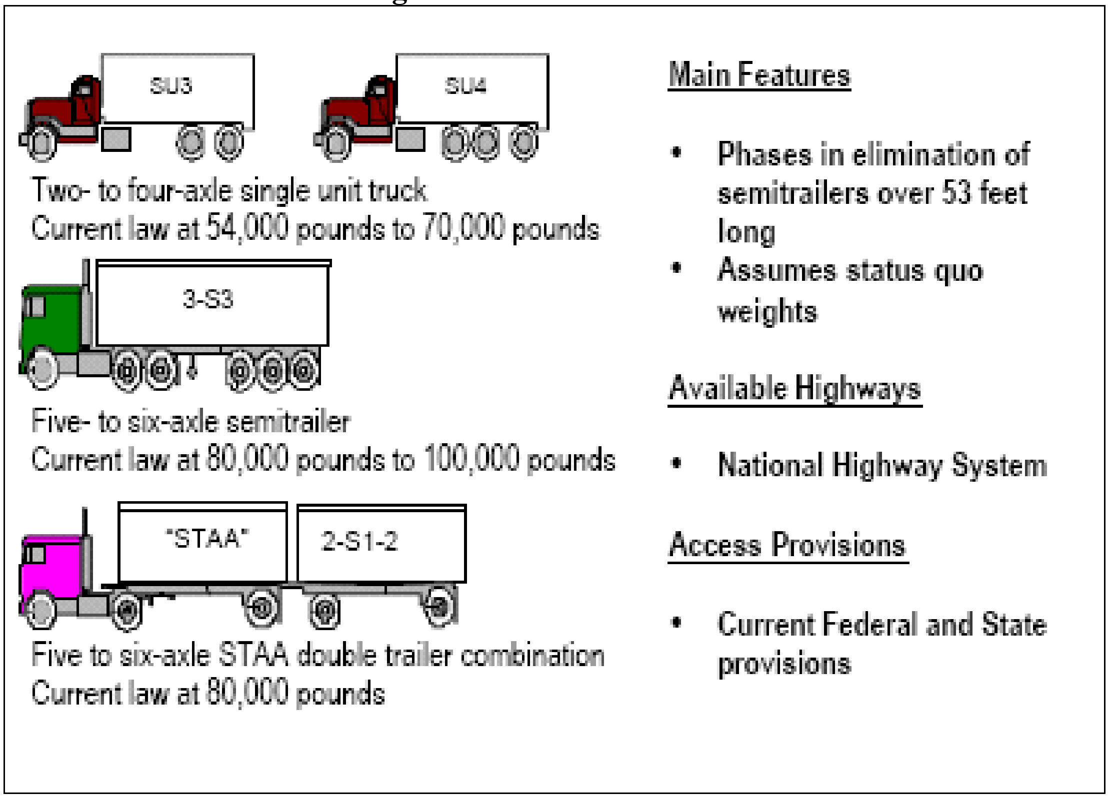
LCV's Nationwide – These are longer combination vehicles that operate in 16 states west of the Mississippi River and on turnpikes in 5 states east of the Mississippi River. The 2000 DOT study's LCV Nationwide scenario assumed LCV operations on a nationwide network.

Figure 2: Longer Combination Vehicles (LCV) Nationwide Scenario



H.R. 551 Scenario Vehicles used in 2000 DOT Study – "The Safe Highways and Infrastructure Preservation Act" was introduced in 1994 and again in 1997. The bill would federalize certain areas of truck regulation that are now state responsibilities. Specifically H.R. 551 contains three provisions related to Federal truck, size and weight (TS&W) limits: (1) it would phase out trailers longer than 53 feet, (2) it would freeze state grandfather rights, and (3) it would freeze weight limits (including divisible load permits) on non-interstate portions of the National Highway System.

Figure 3. H.R. 551 Scenario



Source: US Department of Transportation's "Comprehensive Truck Size and Weight Study," 2000

Appendix C. Coalition for Transportation Productivity

Table 4: Companies Included in Coalition for Transportation Productivity

Supporting Associations	Supporting Companies
American Frozen Food Institute Agricultural Transportation Efficiency Coalition (AgTEC) Alabama Forestry Association American Forest & Paper Association Black Hills Forest Resource Association Council for Citizens Against Government Waste(CCAGW) Colorado Potato Administrative Committee Colorado Timber Industry Association Florida Forestry Association Fresh Produce Association Food Marketing Institute Forest Resources Association Grocery Manufacturers Association Hardwood Federation Idaho Grower Shippers Association Idaho Potato Commission Intermountain Forest Association International Foodservice Distributors Association International Dairy Foods Association Kentucky Forest Industries Association Louisiana Forestry Association Maine Pulp and Paper Association Manufacture Alabama Michigan Forest Products Council Mississippi Forestry Association Mississippi Loggers Association Missouri Forest Products Association National Association of Manufacturers (NAM) National Black Chamber of Commerce National Confectioners Association National Industrial Transportation League (NITLeague) National Lumber and Building Material Dealers Association National Milk Producers Federation National Potato Council National Private Truck Council National Taxpayers Union Northeastern Loggers Association North Carolina Forestry Association Northwest Food Processors Association Ohio Forestry Association Oregon Potato Commission Paper and Forest Industry Transportation Committee Shelf-Stable Food Processors Association Snack Food Association United Fresh Produce Association Virginia Forest Products Association Washington State Potato Commission Western Growers Wisconsin Manufacturers & Commerce Wisconsin Paper Council	AbitibiBowater Anthony Forest Products Archer Daniel Midland(ADM) Ball Brothers Produce Basic American Foods Boise Cascade LLC Boise Inc. Campbell Soup Company Claremont Forest Inc. Coca-Cola Company Con-way Dannon Dean Foods Deere & Company Delta Timber Company Domtar Flambeau River Papers Floyd Wilcox & Sons, Inc. (Wilcox Marketing Group) FMC Corporation General Mills, Inc. GPOD of Idaho Glatfelter Green Bay Packaging H-E-B Idaho Forest Group Idahoan Foods International Paper Kraft Foods, Inc Larsen Farms Longview Fibre Paper and Packaging Inc LP Corp. LyondellBasell Industries Mennel Milling Company MillerCoors Modern Transportation Services MWV National Frozen Foods Corp Neiman Enterprises, Inc. Nestlé USA Nestlé Waters North America Newark Group NewPage Oldcastle Architectural, Inc. Potandon Produce Rayonier R.R. Donnelley & Sons Co. Safe Handling Inc. Schwan Food Company Simplot Smurfit Stone Container Corp Sun Glo of Idaho, Inc. Sunny D SuperValu Inc. Taylor Produce, Inc. Temple-Inland Total Transportation Services US Foodservice/Alliant Logistics Verso Paper Wada Farms