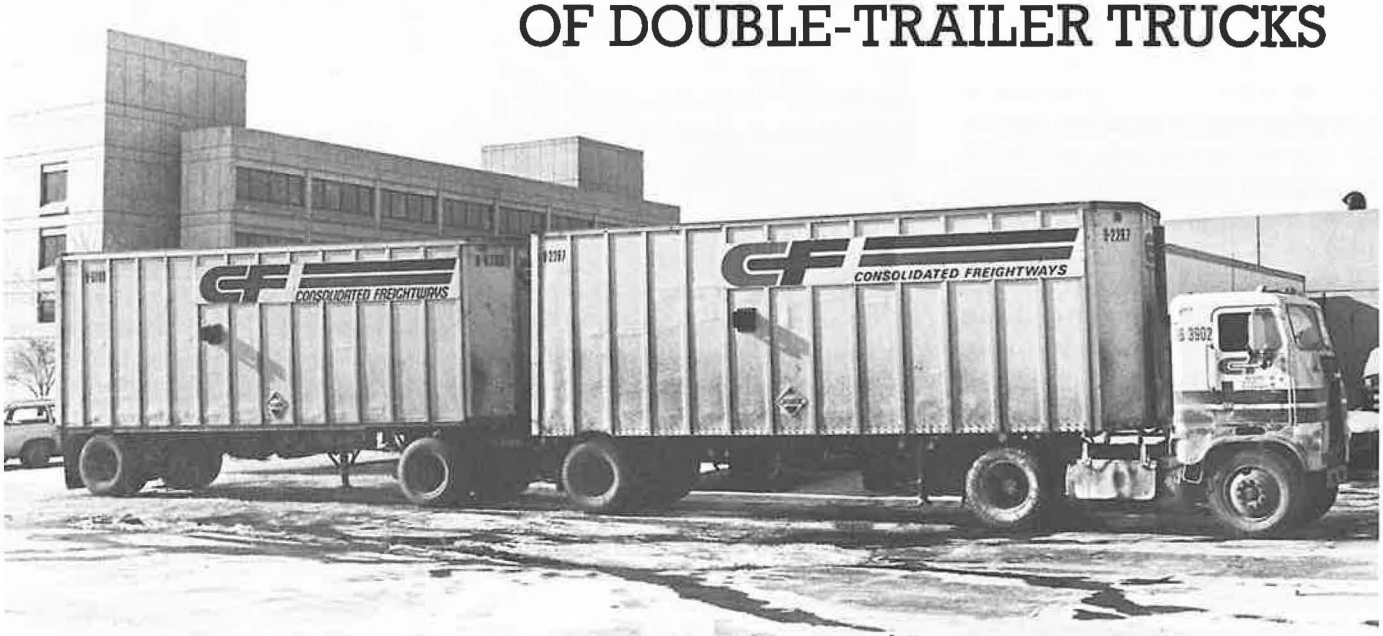
TRB POLICY STUDY: MONITORING THE EFFECTS OF DOUBLE-TRAILER TRUCKS



Double-trailer trucks such as the one above—five-axle vehicles with two trailers, 65 to 68 ft in total length—are appearing more frequently on roads throughout the nation as a result of the 1982 Surface Transportation Assistance Act.

ROBERT E. SKINNER and JOSEPH R. MORRIS

INTRODUCTION

Truck tractors with two trailing units have been operating in portions of the United States, principally the Far West, for more than 35 years. The most common configuration is two 27- or 28-ft semitrailers coupled by a dolly and pulled by a truck tractor. These multitrailer combinations are expected to see greater use, particularly in the East, as a result of the Surface Transportation Assistance Act of 1982. This act provided that the states cannot prohibit the operation of doubles[1] on Interstate highways and on a system of other principal roads to be designated by the U.S. Secretary of Transportation.

Skinner is Program Manager for Policy Studies, and Morris is Program Manager, Special Projects Division of TRB.

The act also directed that the National Research Council monitor the effects of double-trailer truck use on the nation's highways. To conduct this study, the Transportation Research Board established the Double-Trailer Truck Monitoring Study Committee. The 19-member committee is chaired by Kenneth W. Heathington, Associate Vice President for Research of the University of Tennessee. It includes state transportation officials, a trucking industry executive, a union official, and researchers in highway engineering, traffic safety, and freight transportation.

At its first meeting last October, the committee prepared a work plan for a 2-year study that will consider the full range of potential impacts so that a balanced view of the benefits and costs of expanded doubles use will be presented. The study will evaluate effects in three areas: changes in the extent of doubles traffic as the trucking industry responds to the new regulations, and the resultant benefits in transportation productivity; the safety of doubles compared to the singles traffic they will replace; and the effect of doubles on road wear, traffic operations, and geometric design requirements.

Described here are the previous use of doubles, the changes in truck size and configuration regulations enacted in

[1] Throughout this article, the terms *double trailers* and *doubles* refer to combinations of two trailing units with lengths up to 28 ft each (often called Western doubles), as permitted by the 1982 act. Unless otherwise noted, these terms do not include longer combinations, sometimes referred to as turnpike doubles (two 45-ft trailers) or Rocky Mountain doubles (one 45-ft trailer plus one 27-ft trailer). The terms *single trailers* and *singles* refer to the common tractor plus semitrailer unit.

1982, and prior analyses of the effects of doubles. Evaluating this record of experience and research will be a major task of the TRB study.

USE OF DOUBLES BEFORE 1982

A survey of state laws and regulations on truck size and weight undertaken in 1979 *(1)* found that eastern states generally prohibited multitrailer operation while western states permitted double- and, in four cases, triple-trailer operation. Between 1979 and 1982, Mississippi, Florida, Tennessee, and New York changed their laws to permit double trailers on designated highways, and Wisconsin and Iowa accepted 65-ft double-trailer operation on designated highways after Supreme Court rulings set aside existing state statutes. Altogether, 36 states permitted doubles operation at practical vehicle lengths (more than 60 ft) on at least some roads by the end of 1982.

Compared with single trailers, double trailers offer the advantage of increased volume capacity and the potential for added operating efficiency. Two 28-ft trailers have about 20 percent greater cubic space than a 45-ft semitrailer, the largest single trailer in common use nationwide. This advantage will diminish to about 15 percent with the introduction of 48-ft semitrailers on all Interstates and on designated primary routes, also authorized by Congress in 1982.

In addition to the advantage of added "cube" capacity, use of doubles permits truck operators to deliver more shipments of less than a full truck load directly to their consignees without handling over a dock. Doubles also provide greater flexibility in dispatching; and one short trailer operated as a single is easier to maneuver in congested urban areas for pickup and delivery. Together these factors can result in increased efficiency for carriers handling multiple small shipments of low-density freight, but are not important to carriers hauling truckload-sized, high-density shipments; consequently, general commodity common carriers use double trailers most often.

Doubles handled roughly 9 percent of motor freight vehicle-miles traveled before enactment of the new federal regulations *(2)*. Double-trailer use has been heaviest in the West, particularly California. Nationwide truck classification data collected in 1977 *(3)* indicate that doubles accounted for nearly 40 percent of tractor-trailer combinations in California and almost 20 percent in Washington and Oregon. Observed doubles in California amounted to 43 percent of all double-trailer-truck observations nationwide in 1977. Half of 1980 fatal traffic accidents involving doubles nationwide occurred in California, and two-thirds involved trucks registered in California *(4)*.

RECENT CHANGES IN TRUCK SIZE AND WEIGHT REGULATIONS

The 1982 act directed that states may not prohibit the use of double trailers with individual unit lengths up to 28 ft on Interstates and portions of the primary system designated by the Secretary of Transportation. At the same time Congress made a number of other changes in truck size and weight regulations that will also provide new options to the trucking industry and will influence its selection of equipment. These include provisions allowing 48-ft single trailers and vehicle widths of 102 in. on designated roads nationwide, and 80,000-lb trucks on all Interstates. The regulations include the first federal minimum vehicle size and weight requirements ever imposed on the states, and the first federal vehicle size regulations to apply on roads other than Interstates.

All of the changes became effective on April 6, 1983, when the Secretary of Transportation designated an interim network on which vehicles with the authorized dimensions could operate. The composition of this network, particularly in the East, became a point of controversy. Several states disputed the designations, arguing that they included a number of primary highways on which the larger trucks would present a safety threat. The resulting uncertainty slowed introduction of the new vehicles.

After numerous revisions to the network, negotiations with the states, and court challenges brought by several states and private parties, the Department of Transportation published its final rule designating the roads open to the vehicles on June 5, 1984, 8 months after the deadline specified by Congress. The network comprises 181,000 road-miles, including all Interstates and about 55 percent of federal-aid primaries other than Interstates. In addition to the federally designated network, all states must make some provision for the new vehicles to have access to terminals and to food and fuel stops, and several states have opened more extensive portions of their road systems to longer and wider single trailers and doubles.

EXISTING EVIDENCE ON THE EFFECTS OF DOUBLES

Three categories of potential consequences have figured prominently in the debate over doubles: safety, pavement wear, and trucking industry productivity. The TRB committee is reviewing the existing evidence on each of these categories; highlights of that evidence are presented in the discussion that follows.

Safety

Most objections to allowing increased use of doubles can be traced to concern that doubles will be less safe than conventional single-trailer trucks. Safety has been the primary justification for state statutes restricting double trailers, and was the principal criterion in the designation of primary highways for use by doubles and the other congressionally authorized vehicles.

Test vehicle used in University of Michigan Transportation Research Institute measurements of the rollover stability of double-trailer trucks.

Most safety research studies related to double trailers have been statistical analyses that compare accident rates of double trailers with those of singles. Other forms of safety research that do not rely on actual accident data, such as track testing and vehicle simulation, also provide information on the relative safety of doubles, but accident study results are more directly applicable to predicting the changes in life and property losses that would result from a change in the mix of vehicles on the road.

Statistical estimation of accident rates, however, presents some major difficulties: it requires not only accident data but also a corresponding measure of exposure that expresses the number of opportunities that exist for an accident to occur; and because accidents are rare events, large data sets must be assembled to support statistically sound conclusions. The researcher must control for a great number of factors (vehicle and trailer characteristics, driver characteristics, highway features, and other conditions such as weather) that contribute to accidents; and predictions of accidents under new conditions using the estimates will always be uncertain, because statistical models have never had great success in capturing the complex nature of accident events.

Because it is seldom possible to fully overcome these difficulties, the interpretation of statistical accident studies is often clouded. Accident rate studies examining double trailers are no exception. The results of a number of such studies, summarized in Table 1, indicate great variation in the accident rates measured for doubles, and in how these compare to measured rates for single trailers.

Table 1 indicates some of the differences among the studies that complicate comparison of their results. The studies vary regarding the kinds of events for which rates are reported, road classes and geographic areas to which the rates apply, characteristics of the vehicles involved, data quality, and collection methods.

Some of the studies in Table 1 report that doubles have higher accident rates than singles, while others indicate either no appreciable difference, or that doubles are actually safer than singles in certain circumstances. Many of these findings have been questioned, because of methodological shortcomings, doubtful data reliability, or lack of generalizability *(5-7)*.

Given the confusing results of available single- versus double-trailer truck safety studies, it is not surprising that this issue is unresolved and remains a subject of debate. Certainly, the findings vary so widely that policymakers have not been presented with conclusive technical guidance on which to base truck size and configuration regulations.

The committee's initial objective in its assessment of the safety record of doubles will be to narrow the range of uncertainty that emerges from a first reading of these safety studies. The earlier findings will be assessed according to the soundness of their analysis methods, data quality, the inherent statistical uncertainty of the estimates, and whether factors not controlled for may be biasing the accident rate comparisons. The review will then approximate the range of specific conditions to which their results may be applied; for example, whether differences between singles and doubles accident rates for large carriers are applicable to the general population of double-trailer users, and whether estimates from western states are transferable to the often very different traffic and roadway conditions prevailing in the East.

Ultimately, the committee will employ its synthesis of the safety research results, together with current observations of doubles use and accident experience that became available during the study, to produce its best estimate of the accident costs of the new federal doubles regulations.

Pavement Wear

To what extent will the rate of highway pavement deterioration change as a result of double-trailer truck use? This question is related to a longstanding debate over the extent of pavement deterioration that can be attributed to trucks because of their heavy loads. Pavement deterioration is also related to a variety of other factors: traffic characteristics, environmental conditions, pavement design and construction, and maintenance. Not all of these factors are of equal significance with respect to pavement deterioration; for the most part, the empirical and theoretical

TABLE 1 Comparisons of Accident Rates for Single- and Double-Trailer Combinations

Study	Event Type[a]	Rate (per 10^8 VMT) Singles	Doubles	Road Type	Location	Accident Data Source	Exposure Data Source	Year of Data
Injury/Fatality Studies								
BMCS *(11)*	Injuries and fatalities	92.4	57.5	All	Nationwide (doubles use mainly in West)	5 carriers	5 carriers	1977-1980
	Fatalities	4.8	6.2					
BMCS *(11)*	Injuries and fatalities	81.5	55.9	All	Nationwide (doubles use mainly in West)	10 carriers	10 carriers	1969-1980
	Fatalities	5.5	5.3					
Yoo et al. *(12)*	Injuries and fatalities	62.1	63.5	Rural roads and urban expressways	California	California Highway Patrol—all accidents investigated	Estimated from traffic counts and all-vehicles statewide VMT estimate	1974
	Fatalities	3.8	5.3					
	Accidents with injuries or fatalities	39.5	41.1					
California Highway Patrol *(13)*	Injuries and fatalities	75.1	87.7	Rural roads and urban expressways	California	California Highway Patrol—all accidents investigated	Estimated from traffic counts and all-vehicles statewide VMT estimate	July-Dec. 1972
	Accidents with injuries or fatalities	47.5	51.3					
Campbell and Carsten *(14)*	Involvements in accidents with injuries or fatalities	47.9	126.3	All	Nationwide	FARS, BMCS[b] accidents involving 1974-1977 model year vehicles; with followup survey	Sample survey of purchasers of 1974-1977 model year trucks, scaled to U.S.-total VMT	1976-1977 (injuries) 1967-1978 (fatalities)
	Involvements in fatal accidents	6.5	9.5					
Turnpike Studies								
Scott and O'Day *(15)*	Involvements in all reported accidents	172	84	Turnpike	Indiana Toll Road	Toll Road Commission—all accidents (doubles mainly turnpike doubles)	Toll Road Commission—toll records	1966-1970
Arthur D. Little *(16)*	All reported accidents	139	76	Turnpike	Ohio Turnpike	Turnpike Commission—all accidents (doubles mainly turnpike doubles)	Turnpike Commission—toll records	1960-1973 (doubles) 1968-1972 (singles)
Carrier Data—Involvement Rates								
FHWA *(17)*	Involvements of subject carriers' vehicles in all reported accidents	481	309	All	Nationwide (doubles use mainly in West)	2 carriers	2 carriers	1964-1968
California Highway Patrol *(13)*	Involvements in all reported accidents	364	258	All	Nationwide (doubles use mainly in West)	2 carriers	2 carriers	1972
BMCS *(11)*	Involvements in accidents with injuries or property damage over $2,000	135	107	All	Nationwide (doubles use mainly in West)	7 carriers	7 carriers	1977-1980
Glennon *(18)*	Involvements in all reported accidents	179	189	All	Nationwide	1 carrier; 94,000 matched pairs of singles and doubles trips	Carrier trip data	1978
Other								
BioTechnology *(19)*	Involvements in all reported accidents	110	228	Rural freeways	California and Nevada	All truck accidents reported by police on 8 road segments during study period	Traffic counts on sample road segments	July 1976-Dec. 1977
	Involvements in all reported accidents	99	468	Rural nonfreeway	California and Nevada	11 sample road segments		
	Involvements in all reported accidents	214	388	Urban freeway	California and Nevada	7 sample road segments		
	Involvements in all reported accidents	93	428	Urban nonfreeway	California and Nevada	5 sample road segments		

[a]Accident rates are numbers of accidents involving one or more trucks of a particular type (singles or doubles) per 100 million vehicle-miles traveled by the truck type. Involvement rates are numbers of trucks involved in accidents per 100 million VMT. Injury rates are numbers of injuries in accidents involving one or more trucks per 100 million VMT.

[b]FARS: Fatal Accident Reporting System; BMCS: Bureau of Motor Carrier Safety accident records; both are accident data systems maintained by the U.S. Department of Transportation.

studies used for pavement design have focused on loadings as the primary factor in pavement deterioration.

Increased pavement damage on a vehicle-mile or ton-mile basis might result from double-trailer truck use because of differences in axle configuration compared with conventional single-trailer trucks. Doubles will typically operate with five single axles, whereas the most common single operates with one single axle and two tandem axles. These differences affect the way the weight load is distributed to the pavement surface and therefore can lead to differences in resulting pavement wear. In addition, the added cubic capacity of doubles may lead to higher average loads per vehicle even though the gross vehicle weight limitations for singles and doubles are the same.

Pavement design methods commonly describe pavement loading in terms of an equivalent number of standard axle loads. The most well-known procedure for making such calculations is based on the results of the AASHO (now the American Association of State Highway and Transportation Officials) road test, a major research effort completed in the early 1960s. AASHTO's *Interim Guide for Pavement Structures–1972 (8)* contains procedures for converting any single or tandem axle load to an equivalent number of standard single axle loads (ESALs). Once such conversions are made, different axle loads can be compared with respect to their relative effect on pavement wear, as predicted by the AASHTO method.

For flexible pavements the AASHTO method predicts that a double trailer will generate about a 50 percent higher ESAL rating than a five-axle single, at typical fully loaded weights. For rigid pavements the difference is much smaller but favors the double. These differences are due in part to different axle loadings and spacings for the two vehicles, and in part to the higher average fully-loaded weight of doubles. Of course, if a double carries more weight on average, fewer vehicles will be required to carry the same total payload; but because pavement damage predicted by the AASHTO method increases at a more than proportional rate with increasing axle weights, doubles on flexible pavements still produce higher ESALs per unit of payload than do singles.

To put these numbers into perspective, the prevalence of rigid and flexible pavements should be considered as well as the significance of ESAL differences in terms of pavement repair costs. Because half of the Interstate system and 85 percent of other arterials were constructed with flexible pavements *(9)*, the impact of heavy trucks, including doubles, on flexible pavements is of greater significance than the impact on rigid pavements.

Using estimates from the federal highway cost allocation study *(10)* that traffic-related life-cycle maintenance costs for Interstates are about 1 to 5 cents per ESAL-mile, depending on location and pavement type, and assuming that under the new regulations the doubles share of intercity truck freight will increase from 5 percent to 10 percent of ton-miles [as suggested by the federal Truck Size and Weight Study *(2)*], the ESAL differences cited above for fully loaded singles and doubles imply roughly a $30 million annual increase in pavement repair costs.

The significance of ESAL differences must be judged with caution. In reality, pavement deterioration is a complex process depending on the interaction of many factors, only a few of which are taken into account in the AASHTO methodology.

The committee will analyze pavement damage predictions derived by the AASHTO method and by alternative models, and develop approximations of the pavement wear costs of the new doubles traffic. These estimates will necessarily be speculative because of analytical uncertainties as well as questions about which relationships are most applicable to the many different forms of pavement construction now in place. If, however, as the evidence available suggests, pavement costs continue to appear to be small in comparison to either total annual road maintenance costs or the productivity benefits of doubles, then the lack of precise pavement cost estimates may not be critical.

Trucking Industry Productivity

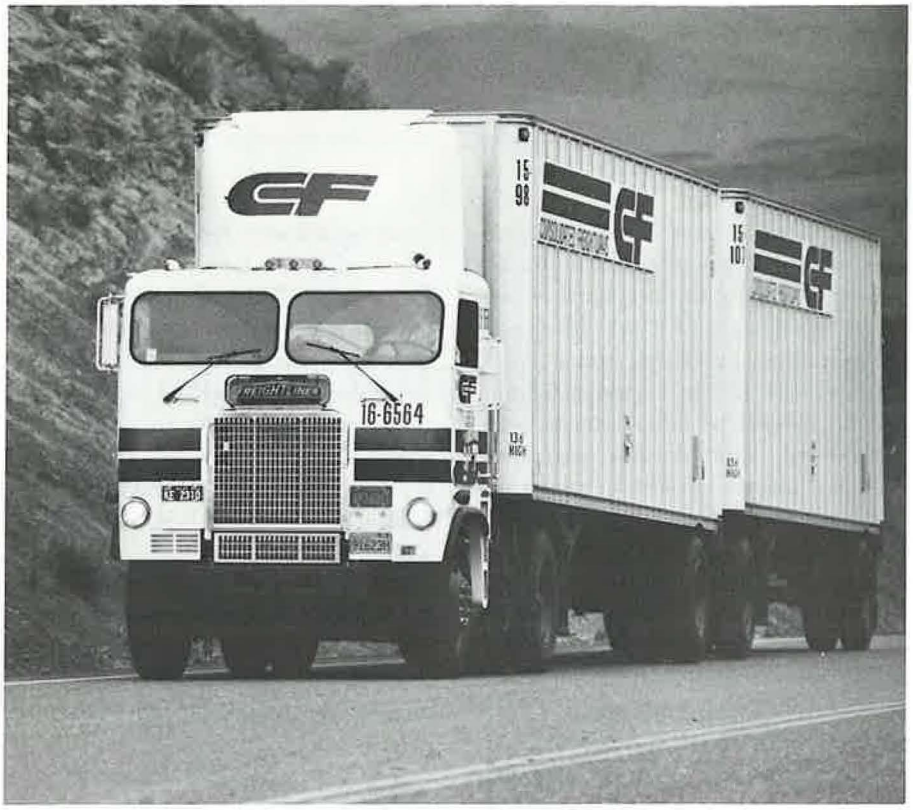
The expanded use of double trailers is expected to produce economic benefits that will offset possible safety and pavement wear costs, derived from reduced transportation costs for goods moved by trucks.

The Department of Transportation's 1981 Truck Size and Weight Study *(2)*, undertaken at the direction of Congress, provided the major technical foundation for the liberalized size and weight limits enacted in 1982. The study included forecasts of the effects of legalizing doubles on trucking productivity and doubles use.

The forecasts that were closest in their assumptions to the size and weight provisions actually enacted estimated the effects of federally mandated 65-ft length and 80,000-lb weight limits, and legalization of doubles with 27-ft twin trailers, on all Interstates and federal-aid primaries. These assumptions differ somewhat from the limits now in effect, but the projections provide an order-of-magnitude indication of the likely effects of the new regulations on doubles use and trucking productivity.

The doubles share of intercity motor freight under these assumptions climbs from 9 percent of vehicle-miles to 15 percent, and from 5 percent of ton-miles to 10 percent, after all adjustments to the new regulations have been made, compared to doubles traffic under actual 1980 size and weight limits. The doubles share of intercity freight vehicle-miles in the East and Southeast increases from 2 percent to 4 percent in the projections, but doubles traffic in these states still accounts for only 10 percent of the U.S. total.

The combined effects of greater use of doubles and higher weight limits are



Doubles are expected to increase trucking productivity; however, some states are concerned about the safety of these vehicles.

forecast to produce shipper cost savings in 1985 of $2.1 billion (in 1977 prices). Of this, $1.6 billion is attributable to the shift of freight to doubles, due to lower terminal handling costs and line-haul savings from the larger capacity of doubles. Average small-shipment freight costs fall 2 cents per ton-mile (about 6 percent).

The estimated present value of cost savings resulting from the change in regulations was approximately $30 billion (in 1980 prices), including changes in road maintenance costs and in property losses from accidents, but excluding nonmonetary impacts associated with traffic injuries and fatalities. The Truck Size and Weight Study concluded that savings in freight costs would dominate the expected cost increases for road maintenance by roughly 20 to 1.

The TRB committee will rely on existing estimates of the unit cost savings from doubles operations, together with data on the change in the doubles share of truck traffic since passage of the new truck size regulations, to assess whether these predicted substantial economic benefits are in fact being realized.

Estimating the actual economic impact of double trailers will be confounded by several factors. One is the concurrent introduction of 48-ft single trailers and 102-in. wide trailers. Another is the deregulation of the motor carrier industry, which could have long-term implications for operations, including the way truckers use doubles.

THE DOUBLE-TRAILER TRUCK MONITORING STUDY

The major efforts of the TRB study will be a synthesis of past research and historical experience concerning doubles, and a short-term monitoring activity relying mainly on existing data collection programs that gather current vehicle use and accident data. The short-term monitoring study will also include interviews with truck operators to observe their responses to the new doubles regulations, and contacts with state transportation agencies to obtain information on the characteristics of the designated system, state administration and enforcement of the new size regulations, and state officials' observations of impacts.

A careful assessment of the safety implications of increased doubles use will be a major component of the study, because doubles safety has been a contentious issue, and because previous research results about accident losses for doubles are widely divergent and not easily reconciled. The pavement wear effects of doubles will receive less attention because the range of likely impacts makes this a secondary issue and because the inherent uncertainties cannot be resolved through short-term research.

The committee recognizes that its findings will necessarily be limited because the introduction of new double-trailer trucks will lag well behind statutory changes, and therefore the full impact of increased doubles use will not occur within the 2-year study period. Its report will include recommendations concerning the structure of a monitoring program addressing the long-term impacts of doubles as well as a broader range of truck size and weight issues. Such a monitoring program appears necessary because issues related to truck configuration, size, and weight will continue to be the focus of public policy, and a reliable, well-designed program of monitoring could substantially assist future deliberations on these policies.

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