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TURNER TRUCK HANDLING AND STABILITY PROPERTIES AFFECTING SAFETY

Final Report

Volume II - Appendices

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16. Abstract

Based on a review of large-truck performance and safety literature, discussions with persons involved with manufacturing or using trucks, and computer analyses and limited testing of prototype and baseline vehicles, this study provides findings and recommendations aimed at the following objectives:

--identify vehicle and/or component parameters and size and weight allowances (that is, "design attributes") that will mitigate the crash and injury risk and enhance the operational safety of Turner trucks;

--identify the environment--traffic, roadway, and weather--within which Turner trucks can be safely operated;

--assess crash and injury risks of Turner trucks in comparison with those of the trucks they would be expected to replace; and

--establish minimum performance and handling standards for Turner trucks that seek to limit crash risk to tolerable levels while encouraging innovation in new truck and component design.

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APPENDIX A. VEHICLE 'DESIGN'

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Preliminary Design Considerations

In order to prepare to simulate vehicles, we conducted a preliminary design process. The purpose of this process is to specify the mechanical properties of the vehicles in enough detail so that we can use computerized analyses to predict performance in safety-related maneuvering situations. We were not addressing problems like fatigue or maximum strengths of parts; rather, we were examining performance properties pertaining to tracking, braking, rolling, and steering. With regard to the failing and failure of components, we assumed that our designs are intended for use with "proven" hardware and that the vehicle would not be easily "broken" in some manner. Aside from this limitation, we use a generalized interpretation of the term "performance" in applying it to the operation of Turner trucks.

Furthermore, our ideas are presented in a psuedo-design context because this approach provides a structure for addressing our objectives within the discipline and pragmatism associated with specifying a design (or, designs) in a limited amount of time. Given more time, one might perform more research before making design choices and, hence, before making performance predictions.

Now presume that we are going to design a Turner truck (even though we are not really going to do this in its entirety). Figure 2.1 is a design "wheel" that displays many questions that could be used in starting to develop a design. These questions range from the most basic considerations of performing a job function to how the vehicle will perform and interact with other elements of the highway environment. With the exception of the question "Will it perform its job?" the remaining questions will have some bearing on the study of the handling and stability performances of the prototype vehicles that we design.

With regard to developing a design, one might consider the design questions in the order indicated in Figure A.1. The reason for this is that it is necessary to know more and more about the vehicle to be able to answer the questions as the question numbers increase per the order indicated in figure A.1. The decisions made with respect to answering the earlier questions will come back later, but in the later questions there are more aspects of the vehicle that might be used in finding an acceptable design. Nevertheless, the design solutions to the questions will ultimately involve judgements of the relative importances of the issues and, hence, compromises in the design.

Figure A.2 (with parts A.2.1 through A.2.8) has been constructed to illustrate aspects of a vehicle design that are pertinent to various design issues. By examining the sketches in Figure A.2, it can be seen that safety concerns depend upon many aspects of the vehicle and that decisions about issues other than safety will have a bearing on the design decisions made in behalf of safety.

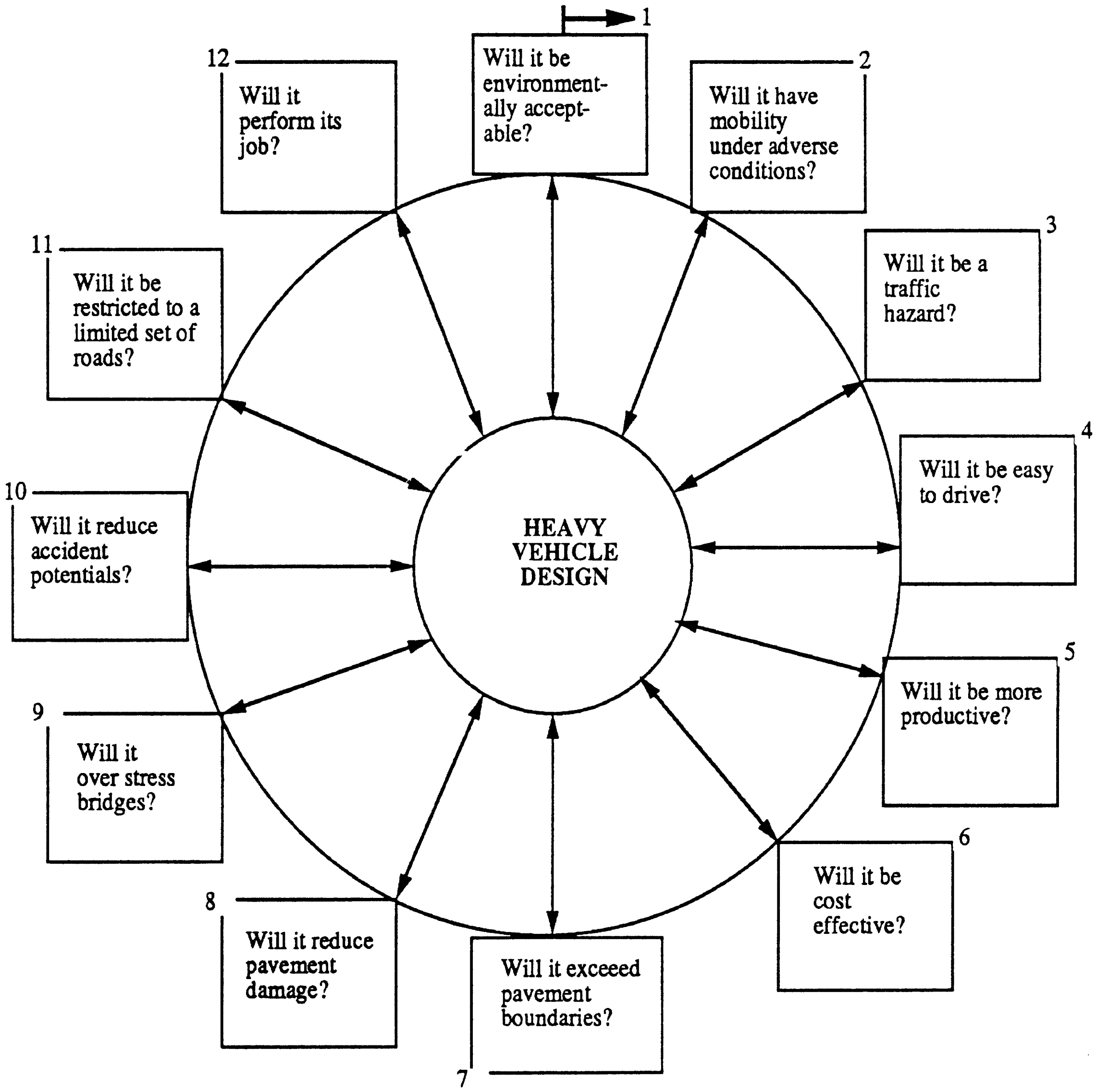


Figure A.1 An ordered set of design questions

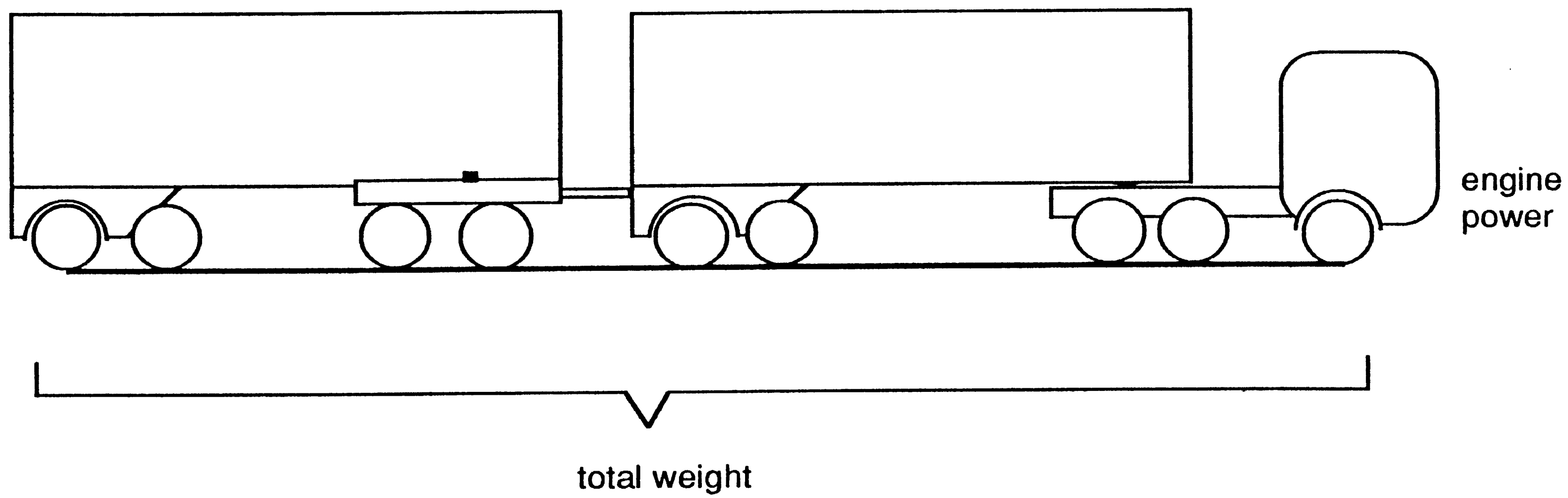


Figure A.2.1. Environmental concerns

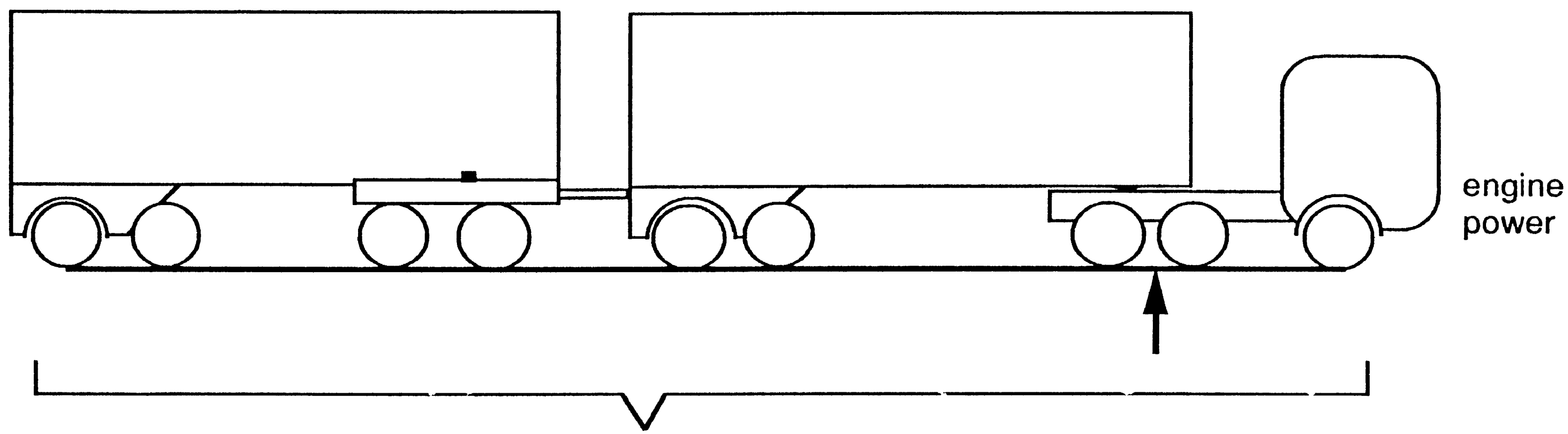
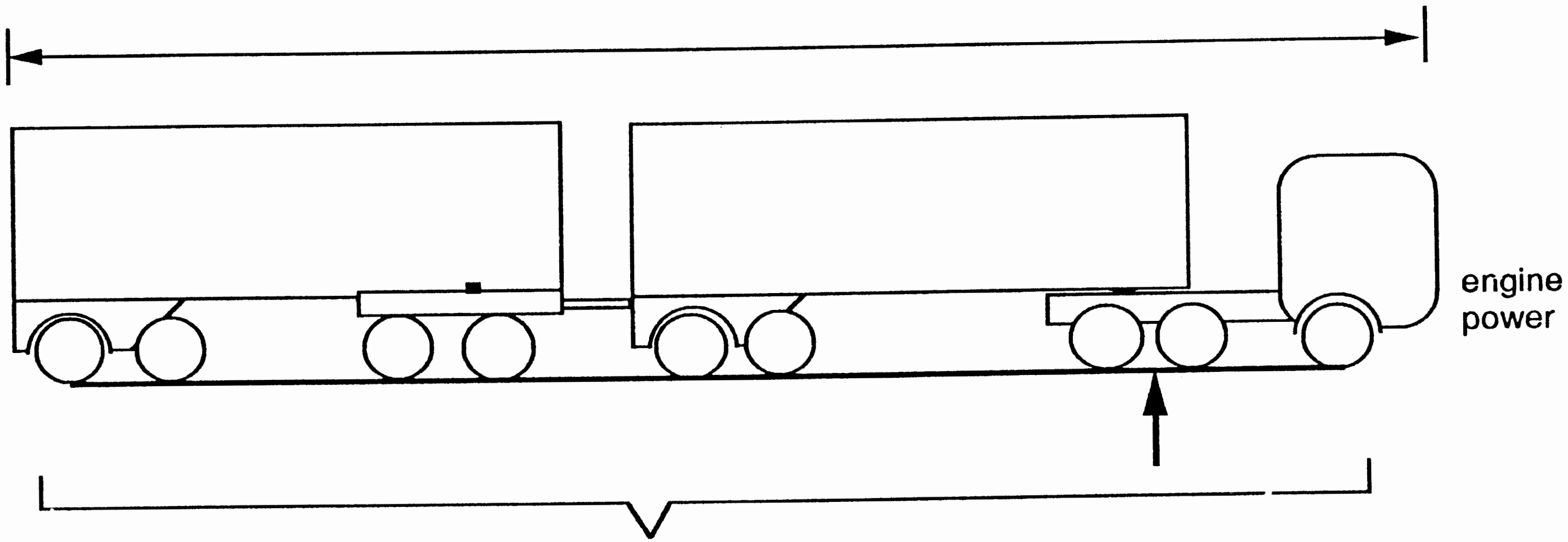


Figure A.2.2. Mobility concerns



(offtracking concerns are important here also)

Figure A.2.3. Traffic concerns

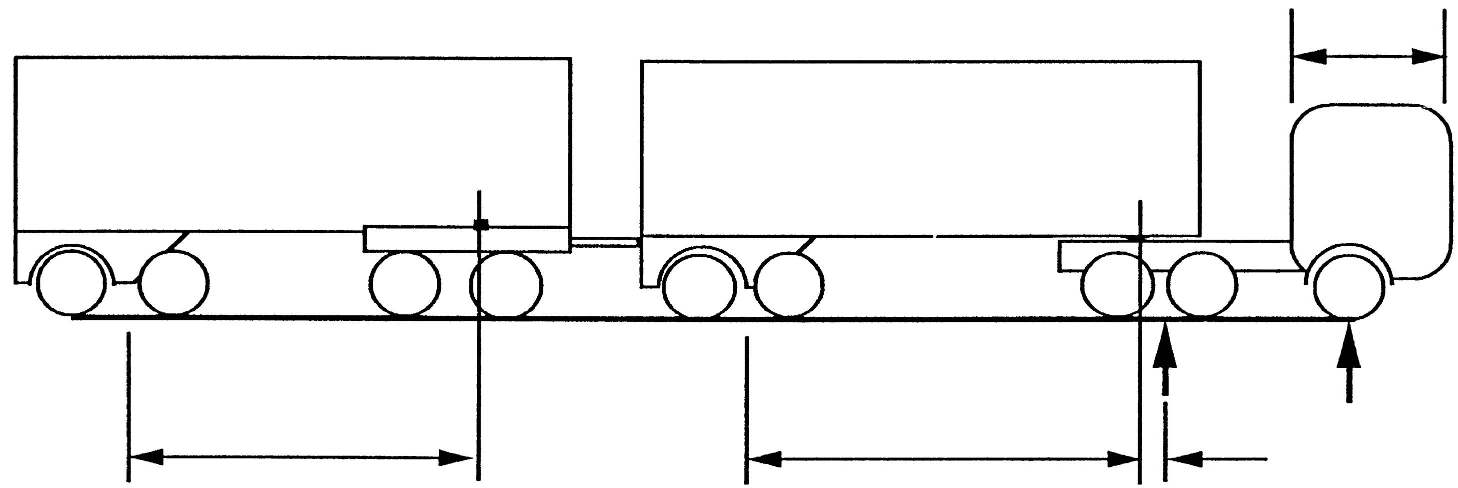


Figure A.2.4 Driver concerns

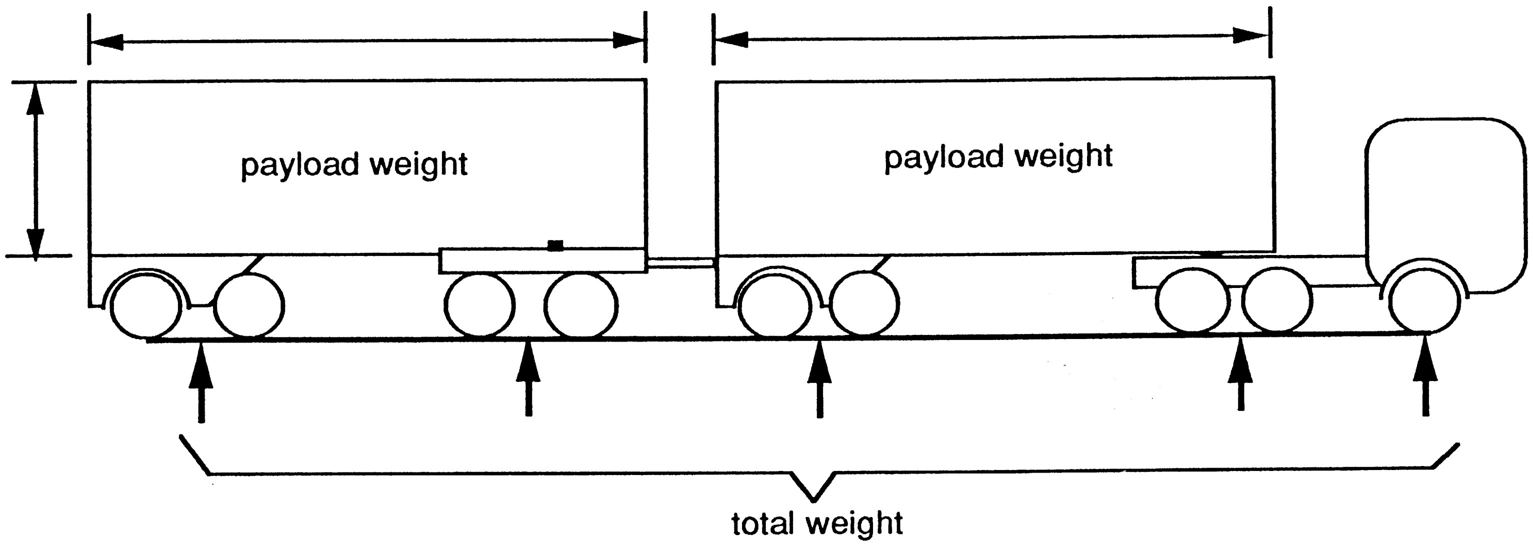


Figure A.2.5 Productivity and cost/effectiveness concerns

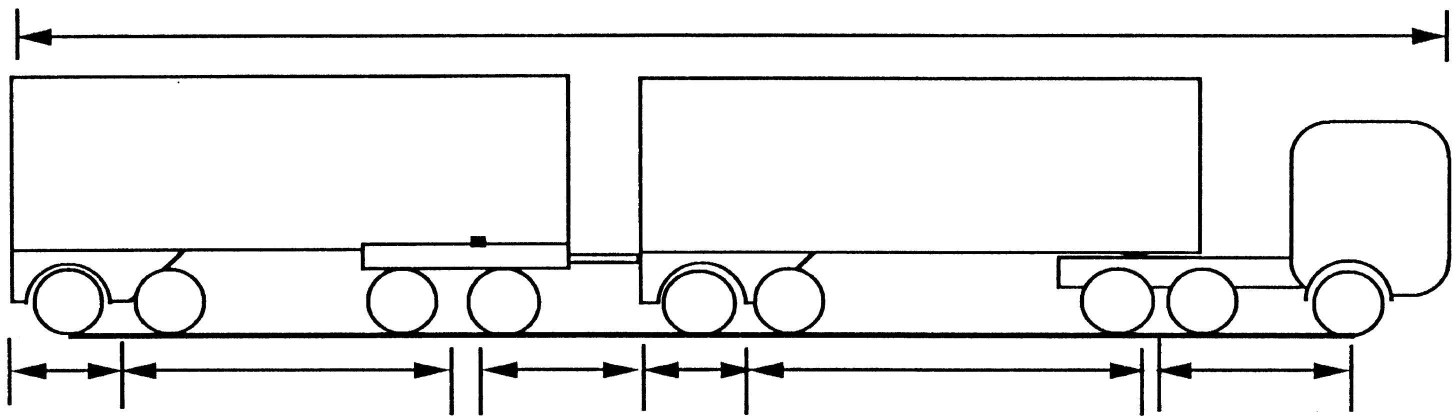


Figure A.2.6 Offtracking concerns plus overall length

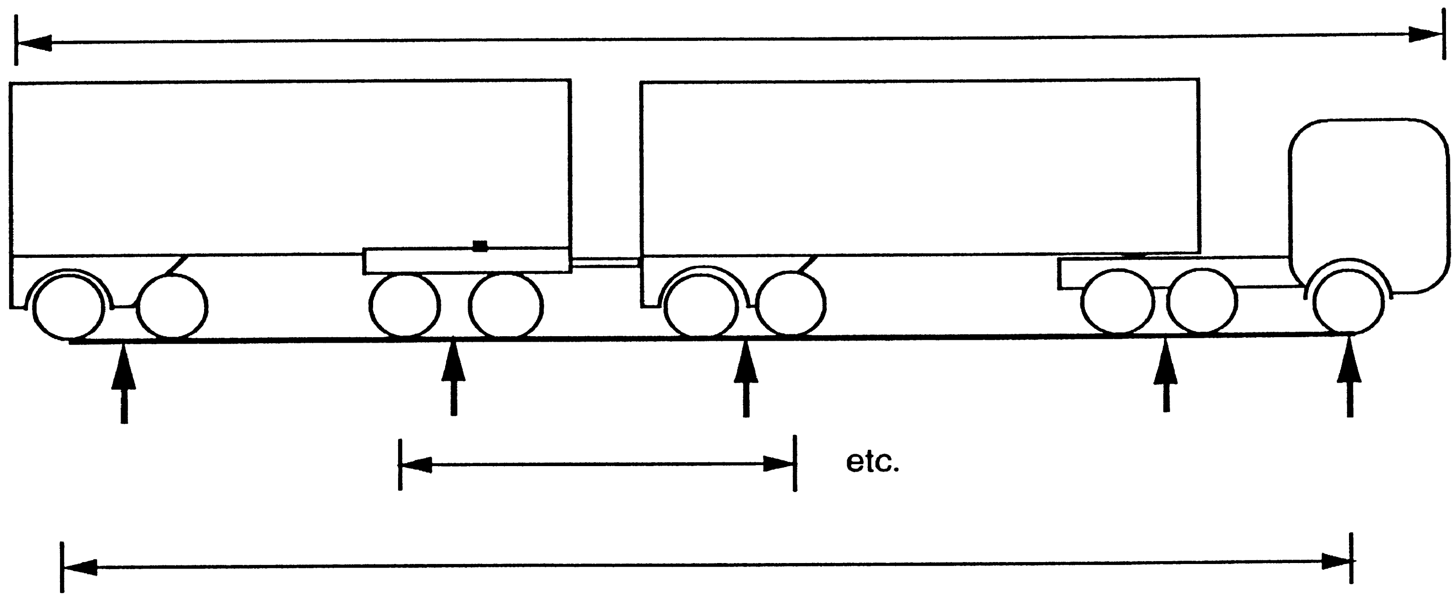
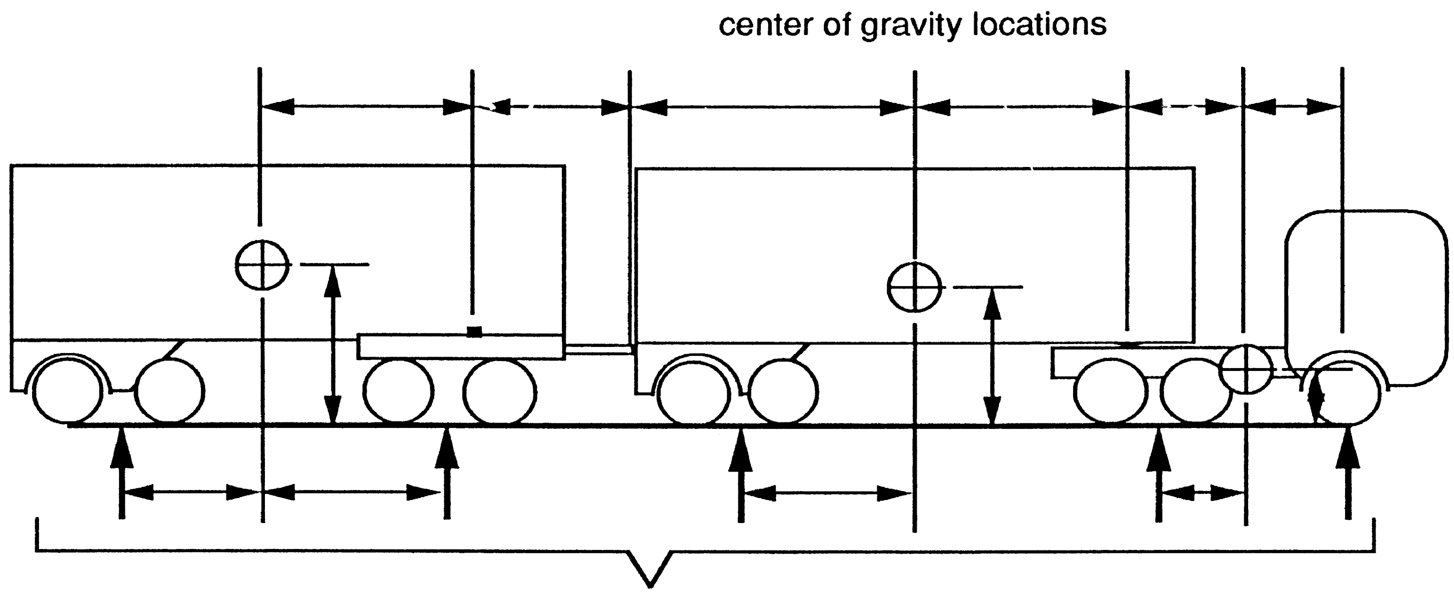


Figure A.2.7 Pavement and bridge concerns plus overall length



Tires, brakes, suspensions, and c.g. heights are safety relevant.

(offtracking, pavement, and bridge concerns are covered within the safety dimensions)

Figure A.2.8 Safety concerns

Preliminary Observations

Environmental issues

Noise is a primary environmental problem that involves trucks. Quiet truck programs have produced heavy vehicles that will pass drive-by-tests for noise. Nevertheless, to first approximation truck noise increases as the weight of the vehicle increases. Or, since weight and engine horsepower tend to increase together, noise increases as engine horsepower increases. Clearly, this implies that noise could be a consideration for Turner vehicles that will be heavier than typical current trucks. Noise considerations are in opposition to selecting high horsepower levels for operations at highway speeds. However, we believe that highway speed and mobility requirements will determine the design and, hence, noise control will have to be treated by means other than restricting engine power.

An environmental problem that is not really addressed explicitly in current rules is the sight obstructions created by large trucks. It could well be that objections to large trucks derive from drivers who are displeased or intimidated because they cannot see around trucks. Although this might be classified as a type of safety problem, it may be that it is usually more of an annoyance in that trucks disturb the view of the highway and its environment. Often drivers can simply stay away from large trucks, but when the highway is packed with cars and trucks that strategy is clearly not readily employed. It seems just as clear that the design of productive Turner trucks cannot compensate for this concern. A possibility would be to consider restrictions on when and where Turner trucks might be utilized, but this again would be counterproductive. Our vehicle designs will not include any explicit feature that is intended as a countermeasure to environmental concerns with vision obstruction. However, the idea that larger trucks can deliver more goods using fewer vehicles pertains to this issue.

Mobility

With regard to Turner trucks, experts from the trucking industry are concerned that Turner trucks will have less load on the drive axles plus greater combination weights than typical tractor semitrailer (TST) combinations. The reason for this concern involves the mobility of the vehicle, especially when the road is slippery. The ratio of drive axle load (DAL) to gross combination weight (GCW) is a first order determinant of the mobility of a heavy truck. For a prototypical Turner double, this ratio (DAL/GCW) might be approximately 25,000 lbs divided by 110,000 lbs, that is, 0.227. For a Western double with 18,000 lbs on the drive axle and 80,000 lb GCW, this mobility ratio is 0.225—about the same as the Turner example. However, for a 5-axle TST the drive axle might be loaded to 34,000 lbs with a GCW of 80,000 lbs yielding a mobility ratio of 0.425. It appears that the example Turner double would have mobility that is comparable to that of the current Western double, but in situations where this level of mobility is not sufficient, the TST would be favored over the Turner example. Clearly, the range of applications of Turner trucks might be restricted by mobility demands, but the mobility of Turner trucks does not appear to be so poor that Turner trucks would be useless.

Now consider the situation when the road is slippery. Rather than the relative comparison made in the previous paragraph, the following discussion is based on an absolute evaluation of mobility. Let A represent some very small level of acceleration that we are willing to accept when the road is very slippery and the vehicle is just creeping along—say 0.01 g (where g is the acceleration of gravity). On a very good road the maximum acceleration level must be less than the mobility ratio times the coefficient of friction of the road. For example, if the tire/road friction were to approach 1.0 at very low speeds on a good uncontaminated road, the Turner double with a mobility ratio of approximately 0.23 would have the possiblity of achieving an acceleration of 0.23 g if there were no other losses in acceleration capability. However, if the friction was 0.2, the upper bound on acceleration is no more than 0.046 g. In this situation, the losses that we have not yet accounted for might make it impossible to achieve an acceleration of 0.01 g.

What are the sources of the losses in acceleration capability? One is rolling resistance which, to a rough approximation, might be equivalent to 0.01 g. Another, is the amount of upgrade that is involved. Each 1 percent of upgrade represents another 0.01 g of loss in acceleration capability. So, if the rolling resistance is 0.01 g and the friction is 0.2, the Turner double (or the Western double) might not be able to climb a 3.6 percent upgrade. Furthermore, if we want A to be at least 0.01g, the vehicle may not be able to operate on a 2.6 percent grade. In fact, since at low speed, the inertia of the engine and drive train is nearly as important as the mass of the vehicle in determining the acceleration capability of the vehicle, there is another source contributing to the loss of acceleration of the vehicle. This loss might be roughly as large as 60 percent of the acceleration capability when the vehicle is in a low gear corresponding to a low speed. This means that the example vehicle might not be able to achieve 0.01g of acceleration if the friction is 0.2 and the upgrade is 2 percent.

(In the case of the TST, the above simplified analysis would say that the TST might not be able to achieve 0.01 g of acceleration if the friction is 0.2 and the upgrade is approximately 6 percent.)

These numbers may seem extraordinary but they are for extreme situations. Tests on packed snow and sanded snow on roads on Mount Hood have indicated coefficients of friction of approximately 0.33 and this level of tractive effort or higher can be obtained with chains on the drive axles. Hence, doubles can usually get through most situations that occur on the highway even in poor weather in mountainous regions.

For the sake of demonstrating that specifying a suitable engine and driveline combination can be done in a straightforward manner, we have made choices by following the selection suggestions provided by a major vehicle manufacturer. Given information on GCW, frontal area, tire type, and required speed, tables based on standard formulas can be used to determine the engine net horsepower. For example, if the GCW is 110,000 lbs, the frontal area is 111 ft^2, and the vehicle has radial ply tires, the engine net horsepower requirement would be 392 horsepower for a top speed of 70 mph on a level road.

A more demanding specification might be the ability to have a sustained speed of 45 mph on a 3 percent grade. For the vehicle above, the design charts indicate that 156 horsepower is needed to obtain 45 mph on the level and 154 horsepower are needed for each 1 percent of grade; that is a total of 618 horsepower for a 3 percent grade. Maybe, the vehicle designer would settle for 45 mph on a 2 percent grade and thereby be satisfied with 464 horsepower. In any event the choice of speed on grade can have a very strong influence on the horsepower of the engine specified.

Proceeding on to specify the gear ratios, we might observe that 70 mph is difficult to meet and try for 65 mph with the vehicle equipped with 10R20 tires. The rear axle ratio might be 3.73 or possibly 3.9 according to the charts. In addition, if we want a gradeability of 23 percent, which is characterized as good for on-highway operation in hilly terrain, the overall ratio would need to be something like 44 for an engine with a torque capability of 1200 ft lb. If the rear axle ratio were 3.73, the transmission low gear ratio would have to be something around 12 to provide good startability (that is an overall ratio around 44).

If the TRB committee accepts this design analysis as an indication that reasonable design choices are possible, we will not continue investigating matters concerning engine and driveline specifications. We will simply presume that the design choices above will be sufficient for our purposes.

There is another matter that might be classified as a mobility issue. This matter has been called "friction demand in a tight turn." For articulated vehicles, friction demand can be a problem when a combination vehicle is turning on a slippery surface. If the tires on the drive axles can not generate enough side force to compensate for the moment generated by scrubbing the wheels on the attached semitrailer, the truck might become immobilized at a tight corner. In a recent study of Canadian trucks, this matter played an important role in evaluating vehicles with multiple axle suspensions and/or wide spreads between axles. Although analytical results have been obtained in the past, we believe that this problem merits more investigation in order to have a better understanding of the phenomenon involved. Nevertheless, typical analyses of semitrailers equipped with tridem axle sets with closely spaced axles indicate that friction demands in tight turns will not be a mobility problem. Since the envisioned prototype Turner trucks have no more than three axles on a semitrailer, we do not anticipate friction demand problems unless the axles are wide spread. In this study we plan to make a few calculations to estimate bounds on acceptable amounts of spreading. (It is likely that tire wear and pavement scrubbing could be more important than the mobility issue per se.)

Traffic

As indicated in Figure A.2.3, overall length, total weight, engine power, and the load on the drive axles are all properties of the vehicle that relate to traffic concerns. Also, offtracking performance is important in determining whether the vehicle will be a traffic obstruction at intersections. In this discussion we will talk mainly about length issues, since (a) mobility/acceleration matters pertaining to engines, GCW's, and drive axle loads have already been touched on and (b) offtracking will be examined later in our simlation/analysis activities.

The length of the truck has a bearing upon the time needed to pass it and, hence, on the sight distance needed to determine if it is safe to pass. In evaluating passing and passing sight distance, the relative speed between the passing vehicle and the vehicle being passed is often taken to be approximately 10 mph or 15 ft/sec. This implies that each additional 15 feet of vehicle requires another second in the passing lane. For example, a Turner double might be about 15 feet longer than current Western doubles, and vehicles passing the Turner double would take about one more second to pass than they would have if the truck had been a Western double. In terms of sight distance, this could mean an additional 200 feet of sight distance if the velocities of the passing vehicle and oncoming vehicles were 100 ft/sec. Our preliminary reaction to these results is that an additional 15 feet of length might create traffic hazards on some two lane roads which have demands for sizeable amounts of high speed travel in areas with restricted sight distance.

Another length related matter has to do with the period of the yellow light at intersections. For purposes of simplifying the arithmetic, assume that the vehicle is 100 ft long and that the intersection is 50 ft wide. Say that trucks approach the intersection at 50 ft/sec (about 35mph). If the vehicle can decelerate at 10 ft/sec^2 (a very high deceleration for a truck), the truck could stop in 125 ft. However, if the driver was 125 ft from the intersection and decided not to stop when the light turned yellow, the vehicle would travel 275 ft (125 + 100 + 50) before it cleared the intersection. At 50 ft/sec this would take 5.5 sec. If the vehicle had been 50 ft long rather than 100 ft long, it would have taken one second less to clear the intersection. On a relative basis, additional length contributes to additional time to clear the intersection by an amount equal to the additional length divided by the velocity. Going back to the Turner double versus the Western double, this might mean an additional 0.3 seconds for an additional 15 ft if the velocity were 50 ft/sec. Yellow light timing for intersections that have proven satisfactory for Western doubles might leave the rearmost 15 ft of the Turner double in the intersection when the light turned red. We leave the importance of this to traffic engineers, but the vehicle would clear the intersection in the next 0.3 sec.

Although we are not going to treat other sight distance problems now, an interesting situation might be the sight distance a heavy truck needs for making a left turn from a stop on to a high-speed road. This sight distance would be longer than that needed for crossing the road safely. Given the acceleration capabilities of heavy vehicles, the entry or merging of these vehicles at intersections and interchanges can be an impedance to traffic and a hazard.

Driver Concerns

The driver is concerned with having enough room in the cab. The STAA of 1982 does not restrict overall lengths so that cab space will not be restricted. (Nevertheless, offtracking concerns with long wheelbase trailers may lead to the demand for short tractors. It seems that if cab room is a goal it needs to be stated specifically.)

Drivers are also concerned with the load on the front axle. Higher loads may lead to higher demands on the amount of steering torque needed to control the vehicle, and higher loads are thought to increase the likelihood of a front tire blowout. Some states have restrictions on the allowable load for the front axle. In the case of the Turner truck, one might consider whether 15,000 lb is too high for the front axle limit. However, we have not addressed this matter in the vehicles considered in the simulation plan because it is not a problem for typical tractors with conventional fifth wheel placements. For typical tractors front axle loads will usually be less than 12,000 lb.

The driver may be concerned with the load on the drive axles for mobility and directional stability reasons. The fifth wheel position may be adjusted by the driver to improve ride comfort (possibly at the expense of losing some measure of directional stability). And finally the driver may be concerned with offtracking at low speeds if the semitrailers are relatively long. (Vehicle dimensions of concern to the driver are indicated in Figure A.2.4.)

Productivity and Cost effectiveness

Productivity is clearly related to the amount of payload weight and/or volume. The effectiveness/cost of the vehicle can be rated by using various ratios. The following list provides a few possibilities for assessing relative productivity:

payload weight / GCW

cargo box length / tare weight

payload weight / number of axles

cargo box length / overall length

cargo box length / maximum offtracking

In creating designs for the simulation study we have tried to make the trailers as long as possible, given offtracking goals, and to make the payload as large as possible, given the maximum axle loads, and, if appropriate, assuming bridge formula relationships for situations in which the axle loads were not more restrictive than bridge formulas. In other words, we tried to make the vehicles as large and as heavy as possible and still meet specified size and weight allowances.

Offtracking

(The discussion of offtracking is presented in Section 5 in Volume 1.)

Pavement and Bridge Concerns

Pavement protection is a key feature of the Turner concept. The meaning of this feature is expressed by the axle loads allowed. This meaning seems clear when it is stated that single axles would be allowed to carry 15,000 lb. However, the choice of loads for tandem and tridem axle sets is not so clear without doing some sort of comparative analysis concerning the amount of pavement damage caused by singles, tandems, and tridems.

In order to make an estimate of the amount of damage caused by tandems and tridems, we have developed a simple model and based its parameters upon the current restrictions of 20,000 lb for single axles and 34,000 lb for tandem axle sets. This model assumes that the influence functions for the effects of pavement loading may be approximated by triangular shapes with maximums directly under the wheels. (Preliminary calculations indicate that this may be a reasonably good approach for making first order estimates of the magnitudes of the major stress (strain) cycles pertaining to the passage of a set of closely spaced axles.)

A key feature in this type of analysis is that fatigue damage depends upon the fourth power of the magnitude of the stress (strain) cycles involved. For example, the damage caused by a 15,000 lb axle load would be proportional to $(15)^4$. The damage caused by two widely separated axles would be proportional to $2(15)^4$. However, if the axles are 4 to 5 ft apart as in a tandem set, the maximum stress (strain) will be influenced by the loadings from both axles. In other words the influence functions overlap when the axles are close together. Let this amount of overlap be represented by the symbol "A" and let the load on one axle be symbolized by "z". Given these definitions and the assumed shape of the influence functions, the maximum stress (strain) from both tandem axles is proportional to $(1+A)z$ and the damage due to one pass is proportional to $[(1+A)z]^4$. Or, if the two closely spaced axles are to do no more damage than two widely spaced axles the following relationship holds:

$$[(1+A)z] = [2(15)^4]^{0.25} \qquad (1)$$

For tridems the corresponding relationship becomes:

$$[(1+2A)z] = [3(15)^4]^{0.25} \qquad (2)$$

In order to evaluate the quantity A, we can apply the above reasoning to the current situation which allows 20,000 lb singles and 34,000 lb tandems. However, in this case the results of the AASHO tests were interpreted with the idea that a tandem set of axles should do no more damage than a single axle. This seems like an extraordinary way to interpret the test results given that the vehicle with the tandem axles would be much more productive than the vehicle with single axles. Nevertheless, it was done that way and we need to interpret the results accordingly. The applicable arithmetic is as follows:

$$(34/2)\,(1 + A) = 20 \qquad (3)$$

The answer is $A = 3/17$ and going back to (1), z would be 15.2 or the closely spaced tandem axle pair would be allowed a load of about 30,000 lb. Using (2) with $A = 3/17$ yields an allowance of 44,000 lb for the load on a tridem axle set.

These results are very close to an arrangement in which single axles carry 15K, tandems carry 30K, and tridems carry 45K. This breakdown of loads would mean that to first approximation the amount of pavement damage (per the amount of overall weight) would be the same regardless of the number and spacing of the axles on the vehicles. The choice of 15K singles, 25K tandems, and 40K tridems would provide a margin of pavement protection beyond that predicted by these simplified calculations. These reductions in productivity might be justified on the grounds that tandem and tridem axle sets may not have perfect mechanisms for achieving load equalization on their axles.

Turning to bridge formulas, these formulas seem to have almost been ignored in the development of the study of Turner vehicles. Possibly, one might feel that with low axle loads, the axle loading allowances might preclude the need for considering bridge formulas. However, in past studies we have observed that bridge formulas tend to produce Turner vehicles. The formulas become more restrictive than the axle loading allowances as GCW's increase to levels beyond 80,000 lb.

In designing vehicles we have considered two formulas referred to as "B" and "TTI". The length to weight relationships involved in these formulas are illustrated in Figure A.3. The TTI formula was developed to protect bridges especially for vehicles that weigh more than 80,000 lb. There are people who point out that formula B was not intended to be applied beyond 80,000 lb. With regard to bridge protection, formula TTI provides a much larger safety margin than formula B for vehicles that have 7 or more axles (see Figure A.3). In our simulation plan we present vehicles designed for either formula B or TTI. We were not so bold as to select one formula over the other, but we have felt that (a) bridge formulas need to be considered in the study and (b) the differences in design caused by the differences in bridge formulas may have safety implications. (Another factor confounding the bridge-formula-issue is that there is an apparent movement to create new bridge formulas because various groups feel that the current ones are inappropriate.)

When all is said and done, perhaps we will find that for the purposes of this analysis of Turner trucks it is enough to note that bridge formulas would lead to roughly 15,000 lb singles, 25,000 lb tandems, and 33,000 lb tridems installed on the prototype vehicles.

(Maybe, highway engineers will want to consider designing pavements and bridges for the same types of vehicles [vehicle loadings]. This could mean that bridges and pavements be designed for the vehicles that will travel on the highway and that the same vehicles serve as design bogies for both bridges and pavements.)

Although the details have not been presented, our simplified results for pavement loading are for closely spaced tridems and tandems. There is a current trend to use wide spread tandems in order to be allowed to carry 40K on the tandem rather than 34K. This means that the pavement damage would be doubled in the sense that a closely spaced 34K tandem does the same damage as one 20K axle. The widely spaced tandem is doing the same damage as two 20K single axles. The prototype designs are based on closely spaced tandem and tridem axle sets.

Safety Concerns

Examination of Figure A.2.8 indicates that all of the dimensions and loadings of the vehicle relate to safety. Any choices that have been made in designing the vehicle have potential safety implications. In addition, the choices of tires, brakes, and suspensions are critical to vehicle performance in safety-related maneuvers. (Clearly safety is the subject of the main body of this report. See Section 5 for a discussion of the measurement of the rollover threshold of the mock-up Turner double.)

A Truck Design Tool for Developing Specifications of Vehicles

Here, we summarize the approach that we have adopted in creating ("designing") prototype Turner trucks. This approach follows the lead of work that we have done in previous studies and its elements are summarized in Figure A.4. The starting point is defined by the size and weight rules that the vehicle must satisfy to be allowed to operate on highways. In this case, these rules are fairly well defined by the Turner concept. (We have made some judgements as to matters such as bridge formulas, and those judgements

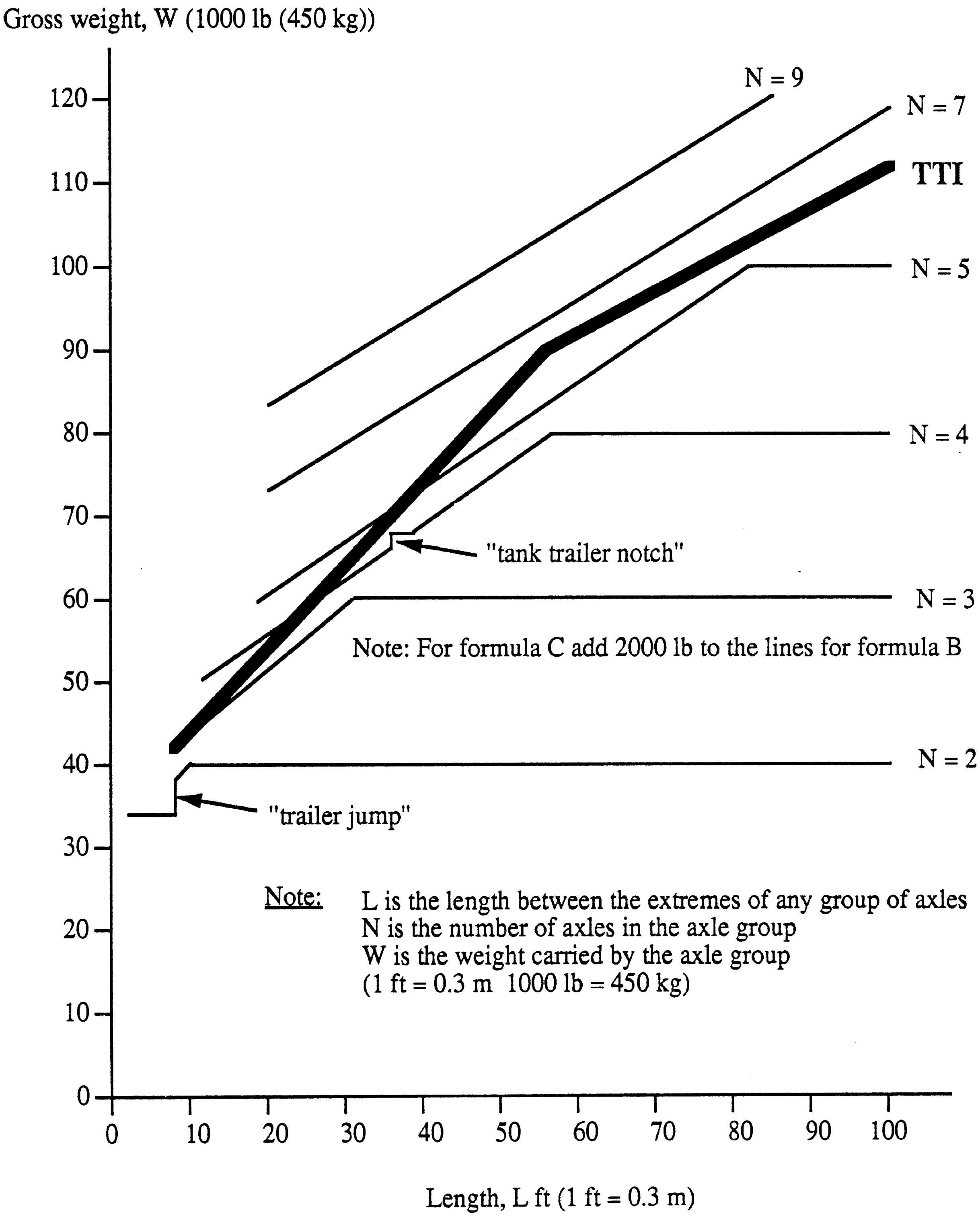


Figure A.3. TTI formula superimposed on the current Table B formula.

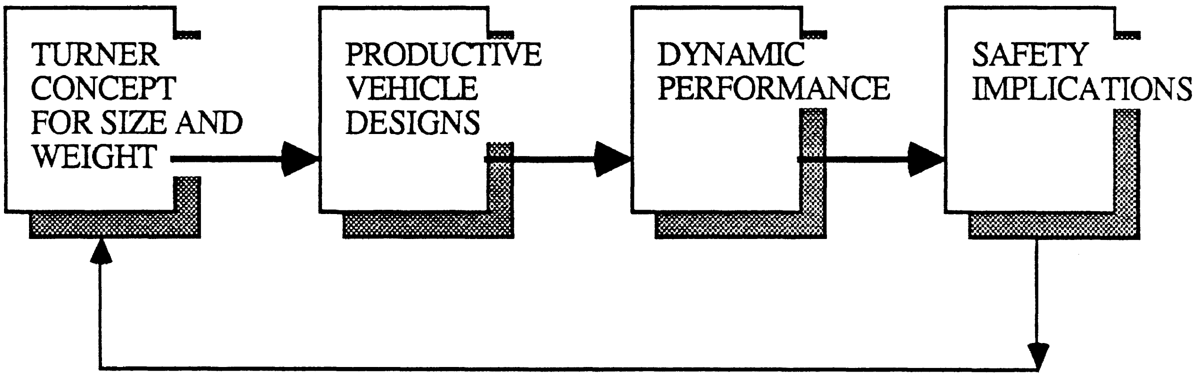


Figure A.4 Approach

influence the designs of the vehicles presented in the simulation plan.) Given size and weight limits, we create vehicles that are intended to be very productive.

As part of the FHWA project, "Safety Implications of Various Truck Configurations," a system in Microsoft Excel (for the Apple Macintosh) was developed to aid in the design and configuring of trucks. The system allows the user to enter an initial vehicle design and evaluates it in terms of user-defined design constraints. The vehicle can be modified, if it initially does not meet all the constraints, until the user is satisfied with the design. Once the design is generated, it is used by the system as the basis for generating data input files for a number of vehicle simulations. In addition, the design data is used as input to a drafting program, which creates an image of the vehicle drawn to scale. Figure A.5 contains a diagram representing the operation of the system.

Design Data Input

There are two types of data input to the system, adjustable input and fixed input. The adjustable dimension inputs are those that can be varied in the design of the vehicle to meet size and weight constraints. The fixed dimension inputs are those which are often close to the same size in similar vehicles currently in use. Within reasonable ranges of these fixed inputs, the values have minimal influence on the overall vehicle performance.

Adjustable Inputs: The system allows the user to enter some basic information pertaining to the general layout of the vehicle, and internally generates additional descriptive data about the vehicle from that data. The user enters data separately for each unit of the vehicle—tractor, trailer, truck and/or full trailer (trailer with dolly). The user must enter the length of the wheelbase for the first unit in the vehicle (tractor or truck). The program calculates the wheelbase for the remaining units from the data supplied. The fifth wheel offset, spread between the front axles, number of front axles, spread between the rear axles, and the number of rear axles must also be entered. The trailer payload and box length must be entered for all units except the tractor, and the dolly tongue length must be entered for full trailers. Table A.1 contains an example of the vehicle data input table. The values that are in italic print are entered by the user, and the values in bold print are calculated by the program (i.e., wheelbase). The question marks in the first column indicate where there have been no units entered.

Fixed Inputs: The system assumes that a number of vehicle parameter inputs are constant values. These inputs are generally of the same value for similar vehicles, and tend to have little significant influence on the performance of the vehicle. The fixed properties required for the design phase are the tare weights of the vehicles and the distance from the kingpin to the front of a semitrailer. The vehicle tare weights that are held fixed are defined in Table A.2.

Constraint Evaluation

After the initial design has been entered into the system, the vehicle can be evaluated in terms of a number of design constraints. These constraints include offtracking, pavement axle loading, friction demand, and bridge formula constraints. A vehicle which does not satisfy the constraints defined by the user should be redesigned in the vehicle data input

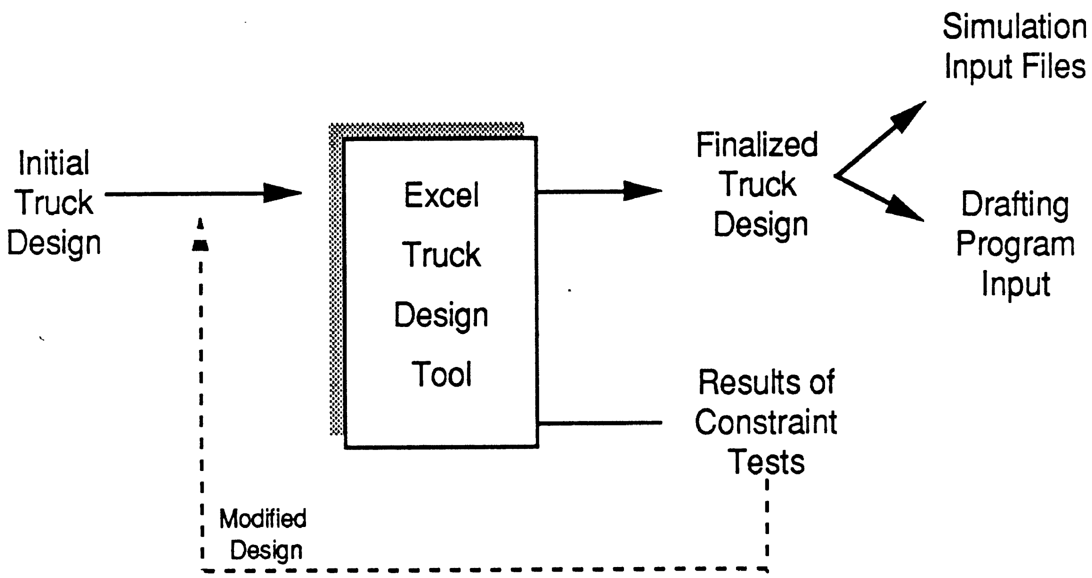


Figure A.5. Excel truck design system.

Table A.1. Vehicle input data table.

Unit type	Unit code	Units 3	Wheelbase WB	Pintle hitch/ 5th Wh OS	Front spread SF	Front axles NF	Rear spread SR	Rear axles NR	Trailer load PL	Box length LB	Dolly tongue DTL
tractor	1	1	*12 '*	*2.5 '*	*0 '*	*1*	*4'*	*2*	*0 lb*	*0 '*	*0 '*
trailer	2	2	**28'**	*3 '*	*0 '*	*0*	*4'*	*2*	*35,250 lb*	*36 '*	*0 '*
full trailer	4	3	**28'**	*3 '*	*4 '*	*2*	*4'*	*2*	*35,250 lb*	*36 '*	*8 '*
?	0	4	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*
?	0	5	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*
?	0	6	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*

Table A.2. Tare weights.

Tractor Tare Weights

# of front axles	Front tare weight	# of rear axles	Rear tare weight
1	8,500 lb	1	5,500 lb
2	10,000 lb	2	8,000 lb
		each additional	+ 1,500 lb

Truck Tare Weights

# of front axles	Front tare weight	# of rear axles	Rear tare weight
1	9,900 lb	1	5,600 lb
2	11,400 lb	2	8,100 lb
		each additional	+ 1,500 lb

Semitrailer Tare Weights

# of front axles	Front tare weight	# of rear axles	Rear tare weight
0	0 lb	each axle	+ 2,000 lb

Note: The weight of the semitrailer's container is included with the weight of the payload.

Full Trailer Tare Weights

# of front axles	Front tare weight	# of rear axles	Rear tare weight
1	3,000 lb	1	2,000 lb
each additional	+ 2,000 lb	each additional	+ 2,000 lb

table and retested. Table A.3 displays the vehicle input data table, and the constraint testing and results tables. The user defines the constraints by modifying the italic text in the constraint boxes, and the results of the constraint tests appear in bold text.

The *Offtracking Constraint* tests for maximum offtracking during a vehicle turn and is defined in terms of the tractor and trailer lengths input by the user. The default case pertains to the offtracking of a vehicle with a tractor wheelbase of 12 feet (3.7 m) and a semitrailer wheelbase of 40 feet (12.2 m). The sum of the squares of the offtracking constraint is compared to the sum of the vehicle units' wheelbases (WB_i) squared minus the sum of units' overhangs (OH_i) squared (for overhangs greater than 2 feet (0.6 m)).

$$12^2 + 40^2 \geq \Sigma_{i=1}^{n} \left(WB_i^2 - OH_i^2 \right)$$

The user is notified as to whether or not the vehicle passed the offtracking constraint through the Offtracking status box, which denotes success or failure. The Offtrack sum of squares box indicates the size of the constraint in comparison to the vehicle results. This data can be useful in estimating how much longer (or shorter) a vehicle within the constraints can be.

The *Pavement Constraint* tests the maximum allowable load on the vehicle's axles. It is defined in terms of the maximum allowable load on tandem axles and single axles. The default case tested is 34,000 lb (15,422 kg) maximum for tandems and 20,000 lb (9,072 kg) maximum for single axles. In order to test this constraint, the load carried on each axle is calculated from the data in the vehicle data input table, and is shown in the Loading Conditions box. The user is notified of the vehicle's success or failure in passing this constraint through the Pavement status box.

The axle loads are calculated under the assumption of "water-level loading", where the vehicle's payload is spread evenly throughout the bed area of the trailer. The pavement and kingpin loads are computed by performing a "force-balance" calculation on each unit in the combination vehicle. The loads are determined by accumulating the kingpin loads, starting with the last unit in the combination and progressing forward to the towing unit, and resolving these loads at the pavement. The axle loads depend upon the weight of the payload and the axle layout of the combination vehicle.

The *Friction Constraint* evaluates the friction required at the rear axles of a tractor or the front axles of a truck to make a small radius low-speed turn. The amount of friction required primarily depends upon the axle layout of the first trailer being towed. Large spreads between axles, caused by multi-axle suspensions or a wide-spread axle layout, create high friction demands. In addition, a light load on the towing unit's drive axles will increase the friction demanded by the vehicle. A vehicle requiring a friction demand level greater than 0.2 should be redesigned to require less friction.

The *Bridge Constraint* tests the loading conditions of the vehicle to determine whether it meets the bridge formula constraint in effect. The length and weight of each axle set is tested against the bridge formula in force. The user has the choice of evaluating the vehicle in terms of two bridge formulas, bridge formula B or bridge formula TTI. Bridge formula

Table A.3. Vehicle input data, constraint testing, and result tables.

Unit type	Unit code	Units 3	Wheelbase WB	Pintle hitch/ 5th Wh OS	Front spread SF	Front axles NF	Rear spread SR	Rear axles NR	Trailer load PL	Box length LB	Dolly tongue DTL
tractor	1	1	*12 '*	*2 '*	*0 '*	*1*	*4'*	*2*	*0 lb*	*0 '*	*0 '*
trailer	2	2	**22'**	*2 '*	*0 '*	*0*	*4'*	*2*	*35,250 lb*	*28 '*	*0 '*
full trailer	4	3	**22'**	*2 '*	*4 '*	*2*	*4'*	*2*	*35,250 lb*	*28 '*	*8 '*
?	0	4	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*
?	0	5	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*
?	0	6	**0'**	*0 '*	*0 '*	*0*	*0'*	*0*	*0 lb*	*0 '*	*0 '*

Offtracking Constraint	
Tractor	*12 '*
Trailer	*40 '*

Offtracking status
Success

Offtrack sum of squares	
Constraint	**1744**
Result	**1156**

Pavement Constraint	
Tandem	*34,000 lb*
Single	*20,000 lb*

Pavement status
Success

Friction
0.020

Loading Conditions	
Axle	Load (lb)
1	**11,170**
2	**10,678**
3	**10,678**
4	**11,613**
5	**11,613**
6	**10,513**
7	**10,513**
8	**11,613**
9	**11,613**
10	**0**
11	**0**
12	**0**
13	**0**
14	**0**
15	**0**
16	**0**
17	**0**
18	**0**
19	**0**
20	**0**
21	**0**
22	**0**
23	**0**
24	**0**
25	**0**
26	**0**

Bridge Constraint	
Formula	*b*

Bridge formula status
Success

Limiting axle set
0 to 0

Maximum Load (lbs)	
Achieved	Allowed
100,000	110,500

B is based on both the length of the axle set and the number of axles in the set, and can be represented as follows.

Bridge Formula B

In general:

$$\text{Allowable load} = 500 * \left[\frac{\text{length of axle set}}{\text{number of axles - 1}} + 12 * \text{number of axles} + 36\right]$$

Exceptions:

If (length of axle set ≤ 8 ft) then (allowable load = 34,000 lb)

If (length = 36 ft) and (number axles = 4) then (allowable load = 68,000 lb)

Bridge Formula TTI is based on the length of the axle set and can be represented as follows.

Bridge Formula TTI

If (length of axle set ≤ 8 ft) then (allowable load = 34,000 lb)

If (length > 8 ft) and (length < 56 ft) then (allowable load = [length + 34] * 1000 lb)

If (length ≥ 56 ft) then (allowable load = [length/2 + 62] * 1000 lb)

The user indicates which formula is to be used in testing the vehicle by entering either B or TTI in the Bridge Constraint Formula box. The Bridge Formula status box indicates whether the vehicle test was a success or failure in terms of the bridge formula being used. If the vehicle fails the bridge formula tests, the Limiting Axle Set box indicates the first set of axles to violate the constraint. The Maximum Load box indicates the maximum load allowable for a vehicle of that design, and the actual load achieved for that vehicle. The actual load may be less than the allowable load due to the need to satisfy other constraints (i.e., pavement or friction constraints). A table listing the load constraint and load achieved for each set of axles on the vehicle is also provided to aid the user in evaluating the vehicle's bridge formula performance. This table can be especially useful in determining how to modify the vehicle to meet the bridge formula constraints if the vehicle fails the initial test. (See Table A.4.)

Vehicle Drafting

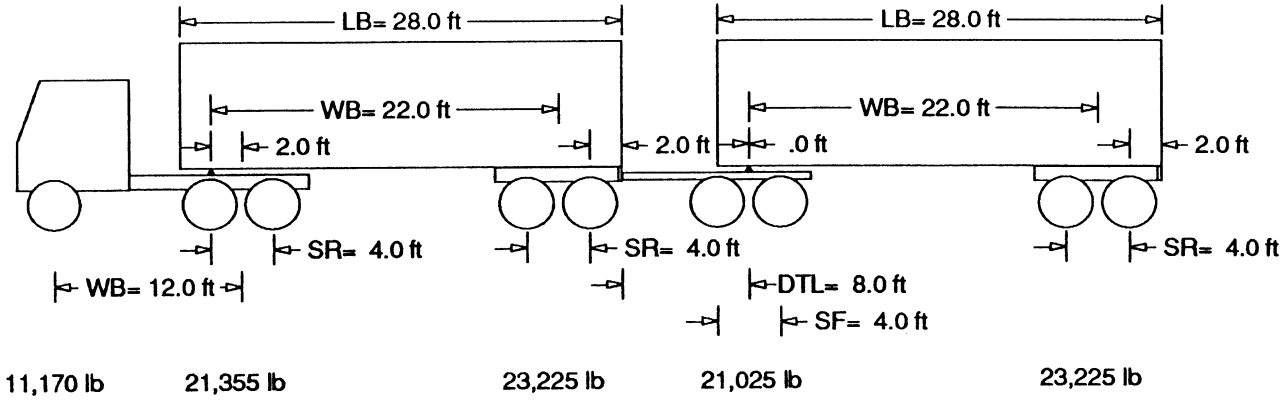
Once the user has developed a satisfactory vehicle design that is within the constraints, the design characteristics can be entered into the drafting program. This program takes input parameters describing the dimensions of the vehicle. Figure A.6 is an example of the output available from this drafting program.

Simulation Input Generation

The complete vehicle design that meets all user-defined constraints is used as input for the generation of input data for vehicle simulation programs. The system creates data files for the following simulations: Offtracking, Static Roll, Handling, Friction, and Straight-

Table A.4. Bridge formula performance tables.

First axle, i	Last axle, j	Length-eij, ft	# of axles	Axle Load, lb	Constraint, lb	Difference, lb
1	2	10.00	2	21,848	40,000	18,153
1	3	14.00	3	32,525	46,500	13,975
1	4	30.00	4	44,138	62,000	17,863
1	5	34.00	5	55,750	69,500	13,750
1	6	42.00	6	66,263	79,000	12,738
1	7	46.00	7	76,775	87,000	10,225
1	8	64.00	8	88,388	102,500	14,113
1	9	68.00	9	100,000	110,500	10,500
2	3	4.00	2	21,355	34,000	12,645
2	4	20.00	3	32,968	51,000	18,033
2	5	24.00	4	44,580	58,000	13,420
2	6	32.00	5	55,093	68,000	12,908
2	7	36.00	6	65,605	75,500	9,895
2	8	54.00	7	77,218	91,500	14,283
2	9	58.00	8	88,830	99,000	10,170
3	4	16.00	2	22,290	46,000	23,710
3	5	20.00	3	33,903	51,000	17,098
3	6	28.00	4	44,415	60,500	16,085
3	7	32.00	5	54,928	68,000	13,073
3	8	50.00	6	66,540	84,000	17,460
3	9	54.00	7	78,153	91,500	13,348
4	5	4.00	2	23,225	34,000	10,775
4	6	12.00	3	33,738	45,000	11,263
4	7	16.00	4	44,250	52,500	8,250
4	8	34.00	5	55,863	69,500	13,638
4	9	38.00	6	67,475	77,000	9,525
5	6	8.00	2	22,125	38,000	15,875
5	7	12.00	3	32,638	45,000	12,363
5	8	30.00	4	44,250	62,000	17,750
5	9	34.00	5	55,863	69,500	13,638
6	7	4.00	2	21,025	34,000	12,975
6	8	22.00	3	32,638	52,500	19,863
6	9	26.00	4	44,250	59,500	15,250
7	8	18.00	2	22,125	48,000	25,875
7	9	22.00	3	33,738	52,500	18,763
8	9	4.00	2	23,225	34,000	10,775



Unit Type	Wheelbase WB	Pintle Hitch/ 5th Wh OS	Front spread SF	Front axles NF	Rear spread SR	Rear axles NR	Trailer load PL	Box length LB	Dolly tongue DTL
tractor	12.0 ft	2.0 ft	.0 ft	1.	4.0 ft	2.	0. lb	.0 ft	.0 ft
trailer	22.0 ft	2.0 ft	.0 ft	0.	4.0 ft	2.	35250. lb	28.0 ft	.0 ft
full trailer	22.0 ft	2.0 ft	4.0 ft	2.	4.0 ft	2.	35250. lb	28.0 ft	8.0 ft

Figure A.6. An example ouput from the vehicle drafting program.

line Braking (empty and loaded conditions). These files are saved in text format and are transferred to an IBM AT for input to the simulations.

The simulation input generation section of the system requires more vehicle descriptive parameters than that required by the initial design phase. The additional information required pertains to the steering system, tires, vehicle units, and axles, including information on brakes and suspensions. This information is input as fixed values to allow direct comparison of the design changes being studied.

Concluding Remarks

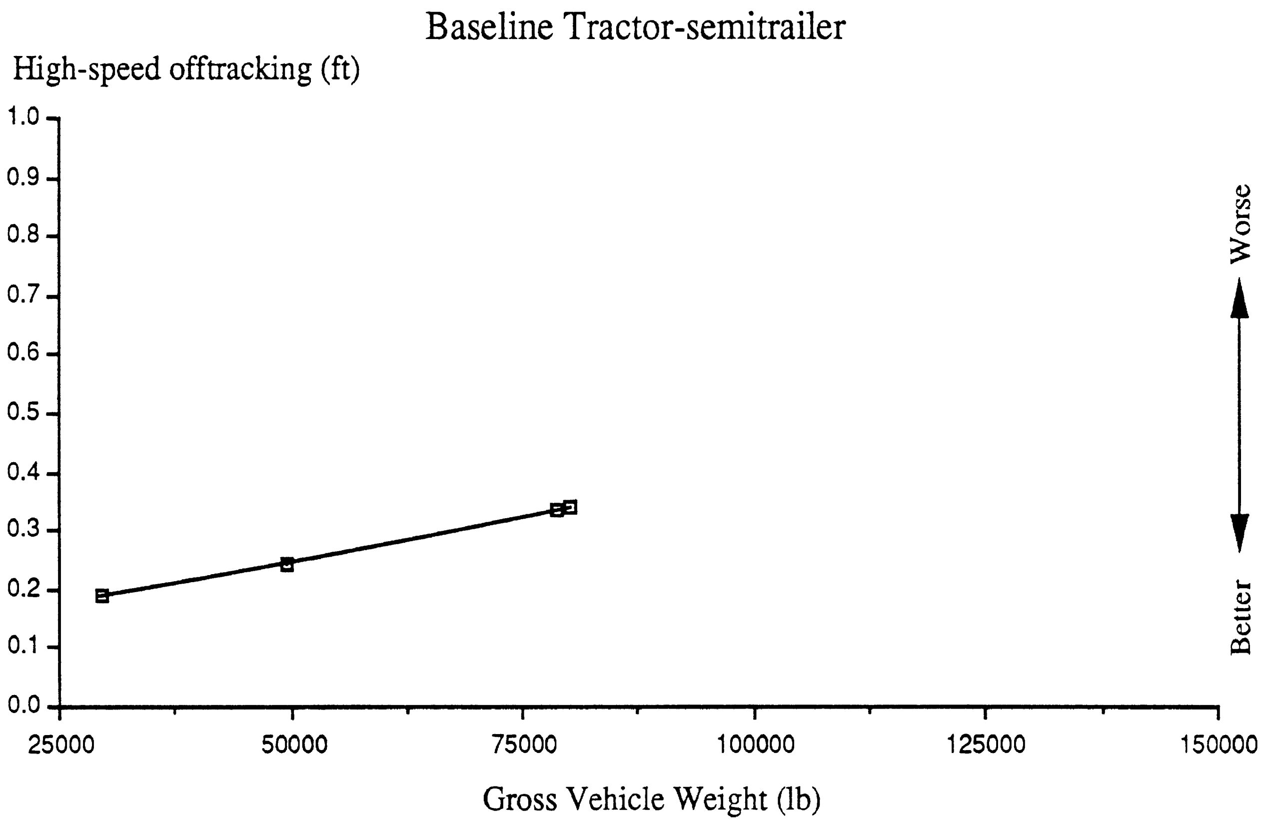
This has been a broad look at many diverse considerations pertaining to the design of Turner trucks. These considerations bear on the simulation study in that they influence the "initial conditions" for studying various design features of the prototype Turner trucks. Although the recommendations to be made at the end of the study will depend upon the results of analyses of vehicle performance in safety-related maneuvers, the initial forms of the vehicles have taken shape on the basis of judgements. These judgements are intended to provide feasible designs that will be starting points for generating information that is useful for mitigating the safety risks involved with operating Turner trucks.

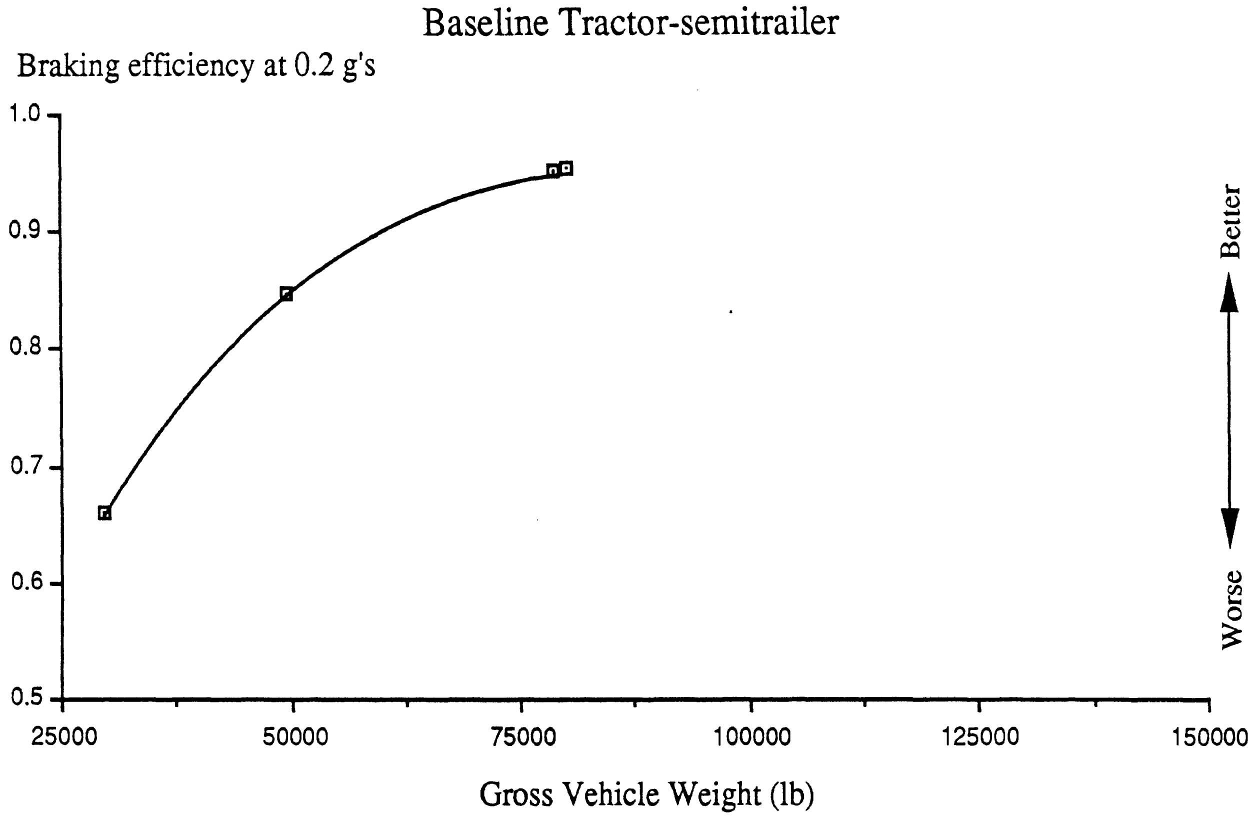
The preliminary information presented in this appendix has not addressed the accident record even though we have been working in this area. Those matters are addressed in Section 7. Nevertheless, the simulation plan is based on assessing the influences of the "pertinent mechanical properties" of the prototype vehicles on vehicle performance in safety-related maneuvers. In other studies, we have referred to the levels of these types of performance as measures of the "intrinsic" or "inherent" safety of the vehicle. Please view the simulation work in the context of evaluating the intrinsic safety of prototype Turner trucks.

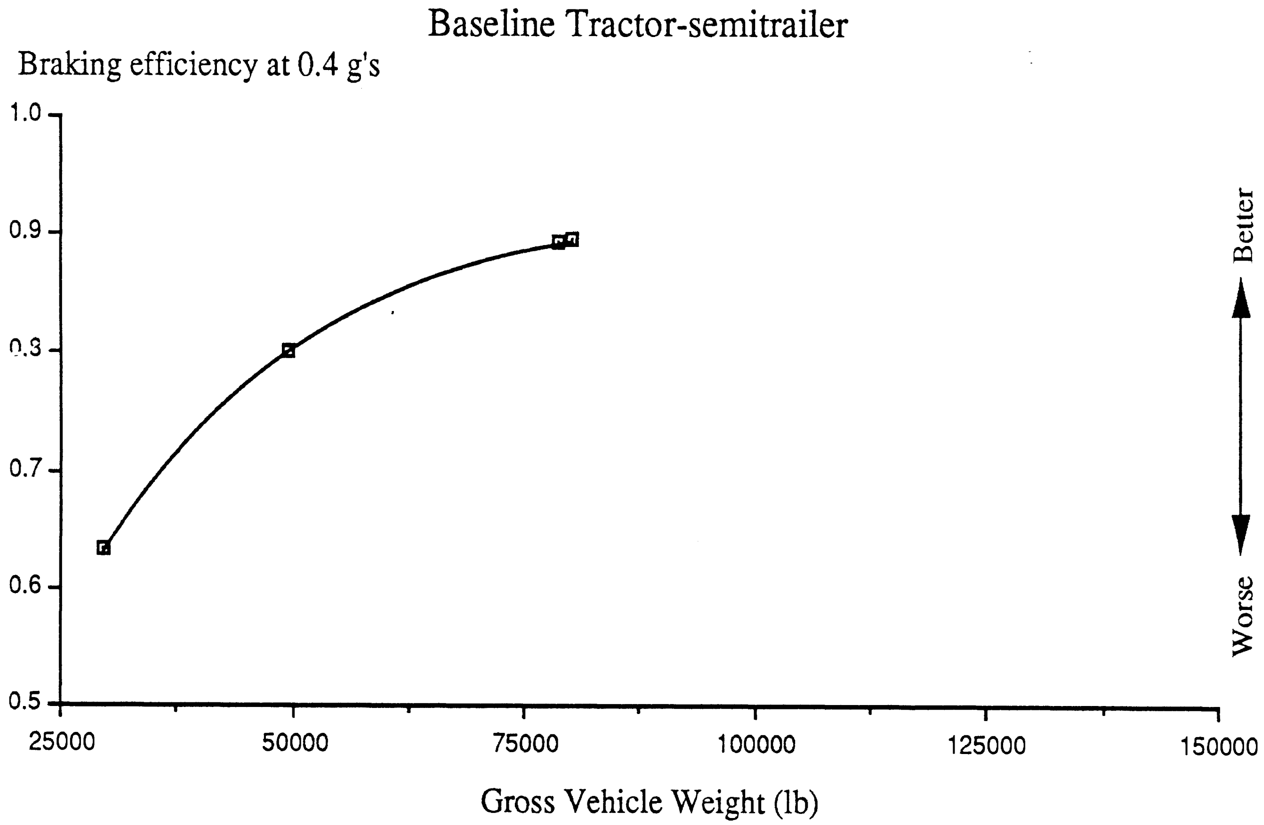
APPENDIX B. PERFORMANCE PREDICTIONS WITH GRAPHS

Baseline Tractor-semitrailer (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
BTST	Transient offtracking (ft)	15.35794	78700
VEHICLE	MEASURE	VALUE	GVW
BTST	High-speed offtracking (ft)	-0.33411	78700
BTST.v1.a	High-speed offtracking (ft)	-0.19165	29545
BTST.v1.b	High-speed offtracking (ft)	-0.24438	49544
BTST.v1.c	High-speed offtracking (ft)	-0.33850	80000
VEHICLE	MEASURE	VALUE	GVW
BTST	Braking efficiency at 0.2 g's	0.95089	78700
BTST.v1.a	Braking efficiency at 0.2 g's	0.65938	29545
BTST.v1.b	Braking efficiency at 0.2 g's	0.84779	49544
BTST.v1.c	Braking efficiency at 0.2 g's	0.95374	80000
BTSTE	Braking efficiency at 0.2 g's	0.65938	29545
VEHICLE	MEASURE	VALUE	GVW
BTST	Braking efficiency at 0.4 g's	0.89375	78700
BTST.v1.a	Braking efficiency at 0.4 g's	0.63466	29545
BTST.v1.b	Braking efficiency at 0.4 g's	0.80211	49544
BTST.v1.c	Braking efficiency at 0.4 g's	0.89627	80000
BTSTE	Braking efficiency at 0.4 g's	0.63466	29545
VEHICLE	MEASURE	VALUE	GVW
BTST	Static rollover threshold (g's)	0.33968	78700
BTST.v1.a	Static rollover threshold (g's)	0.71576	29545
BTST.v1.b	Static rollover threshold (g's)	0.44131	49544
BTST.v1.c	Static rollover threshold (g's)	0.33639	80000
VEHICLE	MEASURE	VALUE	GVW
BTST	Steering sens. at 0.3 g's (deg/g's)	5.78005	78700
BTST.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.92302	29545
BTST.v1.b	Steering sens. at 0.3 g's (deg/g's)	7.54203	49544
BTST.v1.c	Steering sens. at 0.3 g's (deg/g's)	5.63277	80000

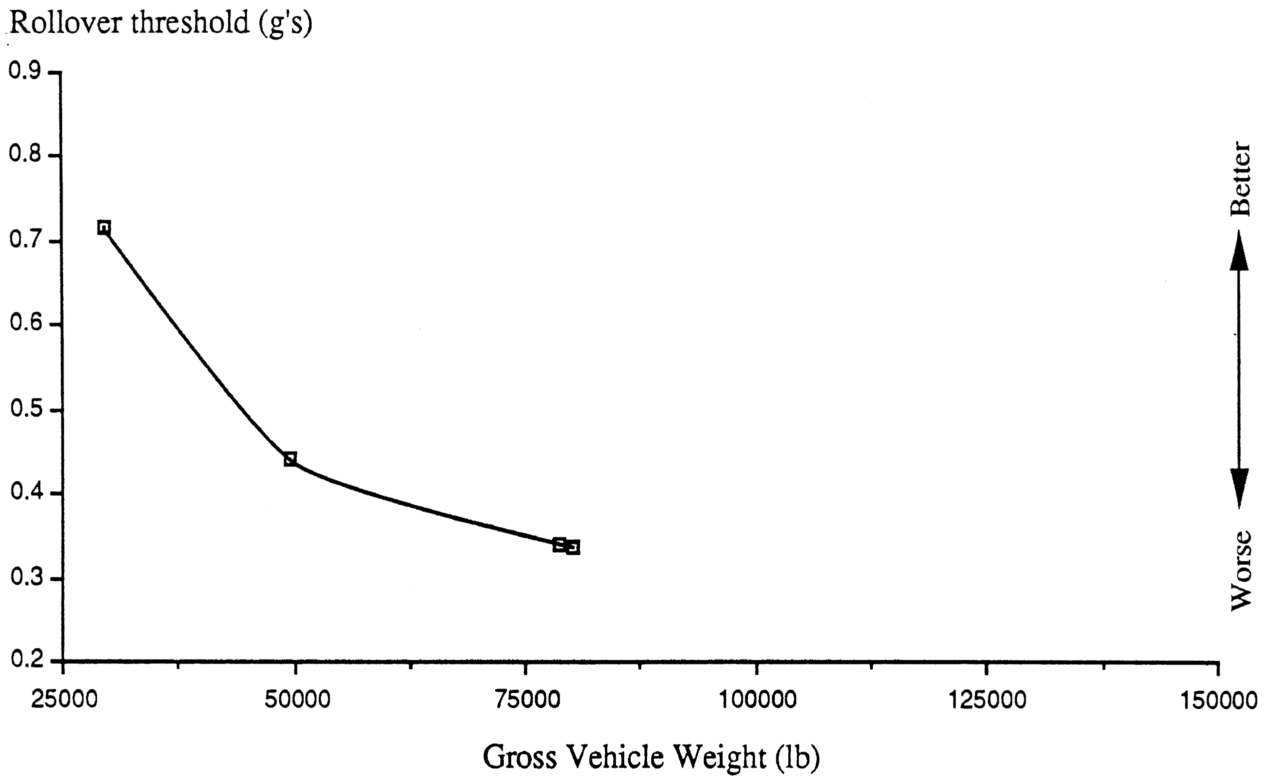

Baseline Tractor-semitrailer
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

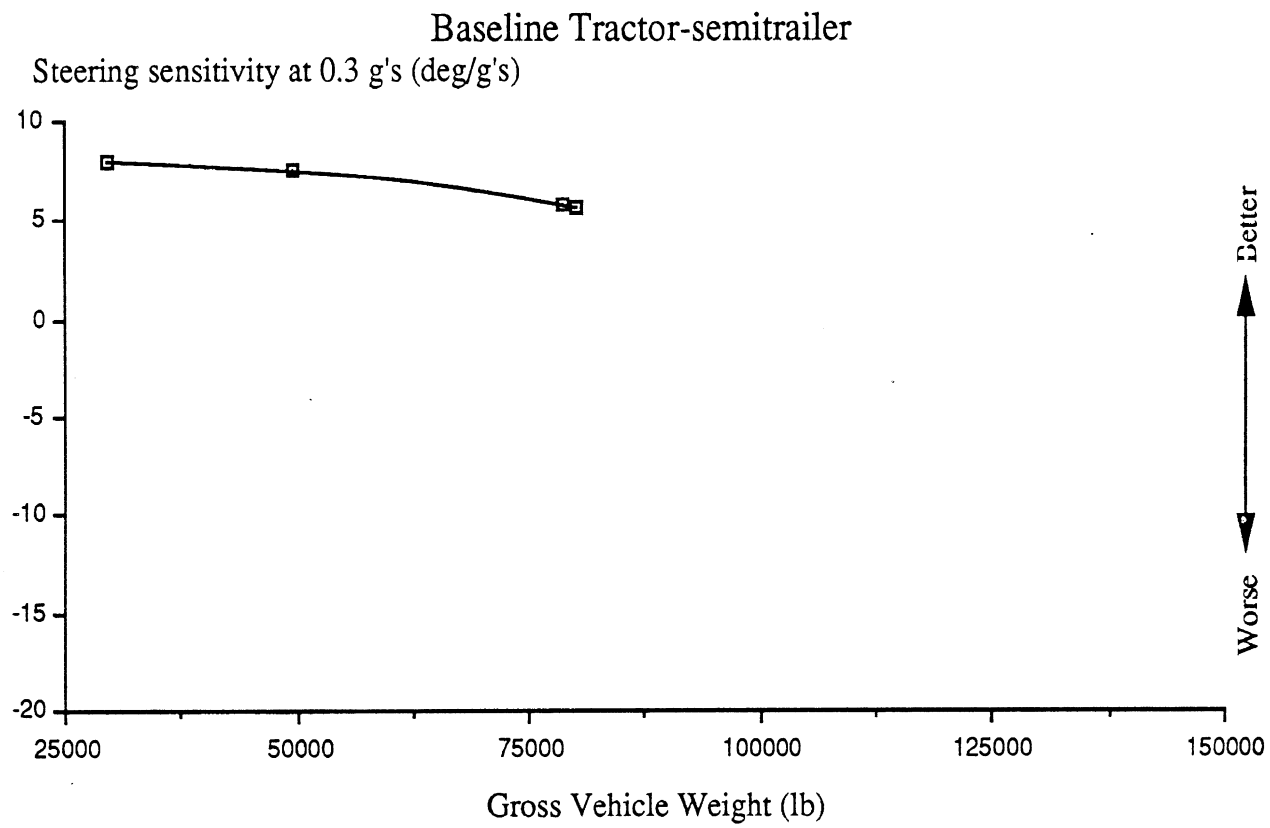

Baseline Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Baseline Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.3
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

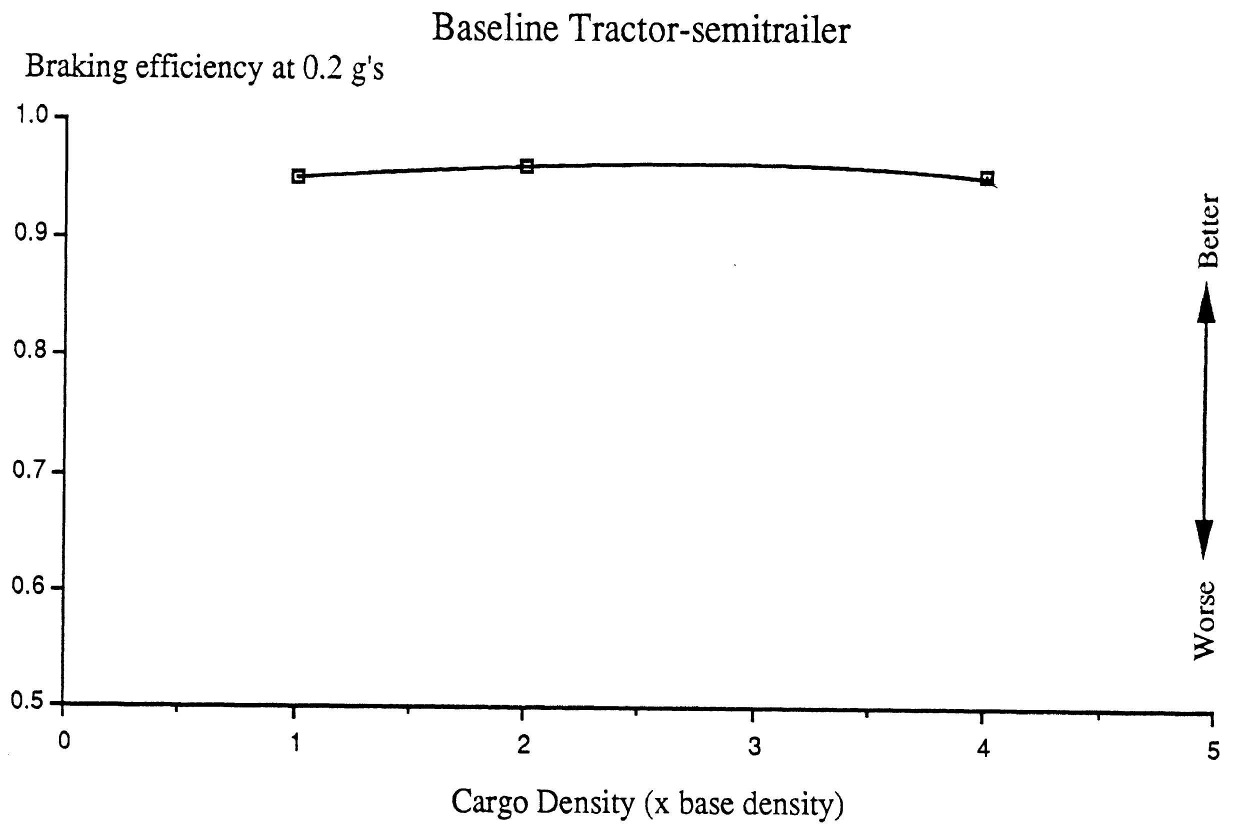
Baseline Tractor-semitrailer



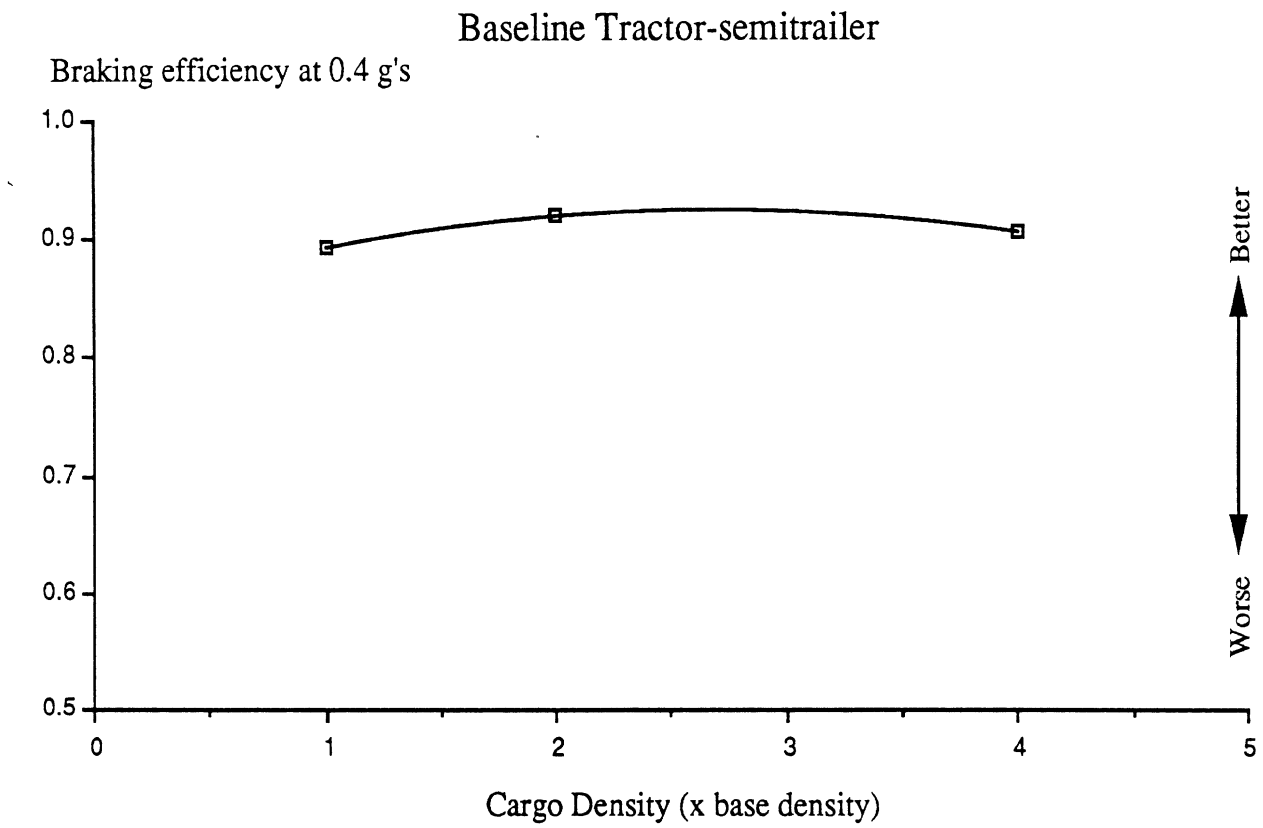

Baseline Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

Baseline Tractor-semitrailer (Cargo density)

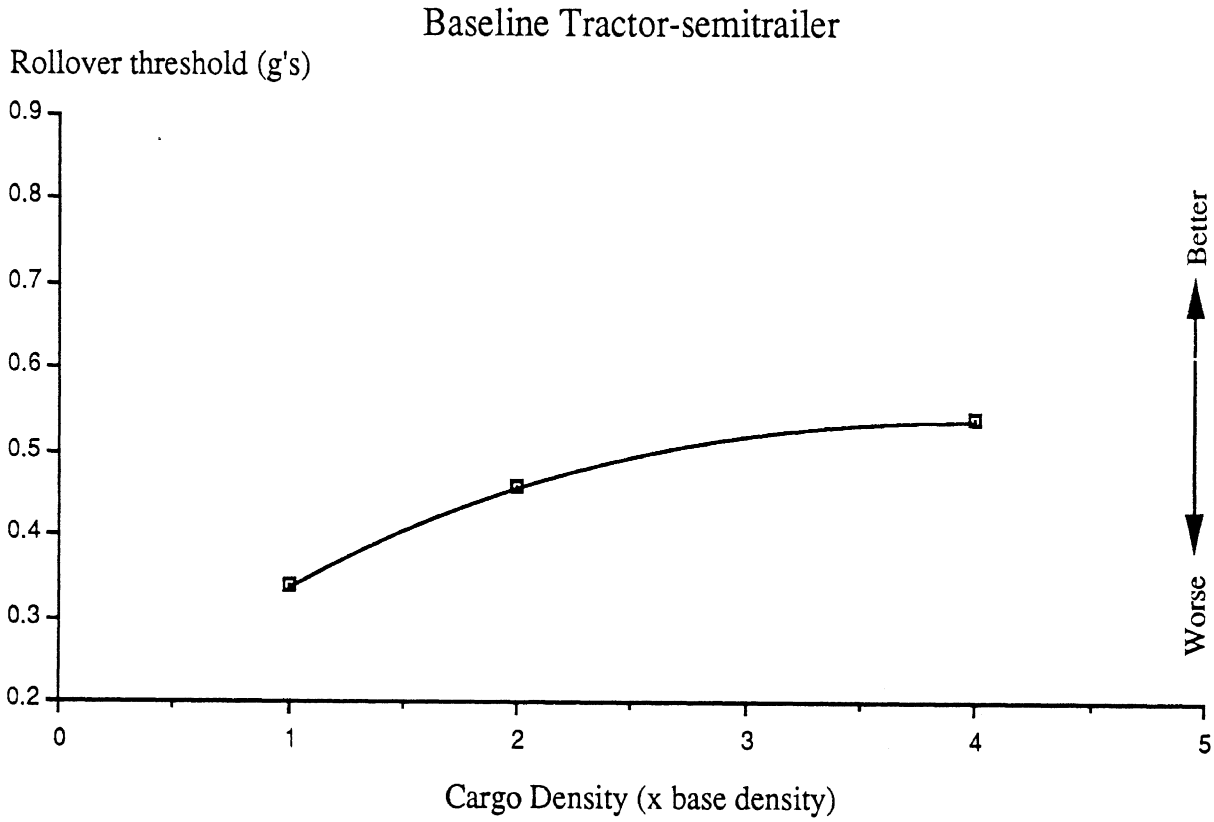
VEHICLE	MEASURE	VALUE	C.DENSITY
BTST	Transient offtracking (ft)	15.35794	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BTST	High-speed offtracking (ft)	-0.33411	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BTST	Braking efficiency at 0.2 g's	0.95089	1
BTST.v2.a	Braking efficiency at 0.2 g's	0.96196	2
BTST.v2.b	Braking efficiency at 0.2 g's	0.95490	4
BTSTE	Braking efficiency at 0.2 g's	0.65938	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BTST	Braking efficiency at 0.4 g's	0.89375	1
BTST.v2.a	Braking efficiency at 0.4 g's	0.92032	2
BTST.v2.b	Braking efficiency at 0.4 g's	0.90619	4
BTSTE	Braking efficiency at 0.4 g's	0.63466	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BTST	Static rollover threshold (g's)	0.33968	1
BTST.v2.a	Static rollover threshold (g's)	0.45772	2
BTST.v2.b	Static rollover threshold (g's)	0.53998	4
VEHICLE	MEASURE	VALUE	GVW
BTST	Steering sens. at 0.3 g's (deg/g's)	5.78005	78700
BTST.v2.a	Steering sens. at 0.3 g's (deg/g's)	6.87822	78700
BTST.v2.b	Steering sens. at 0.3 g's (deg/g's)	7.28269	78700



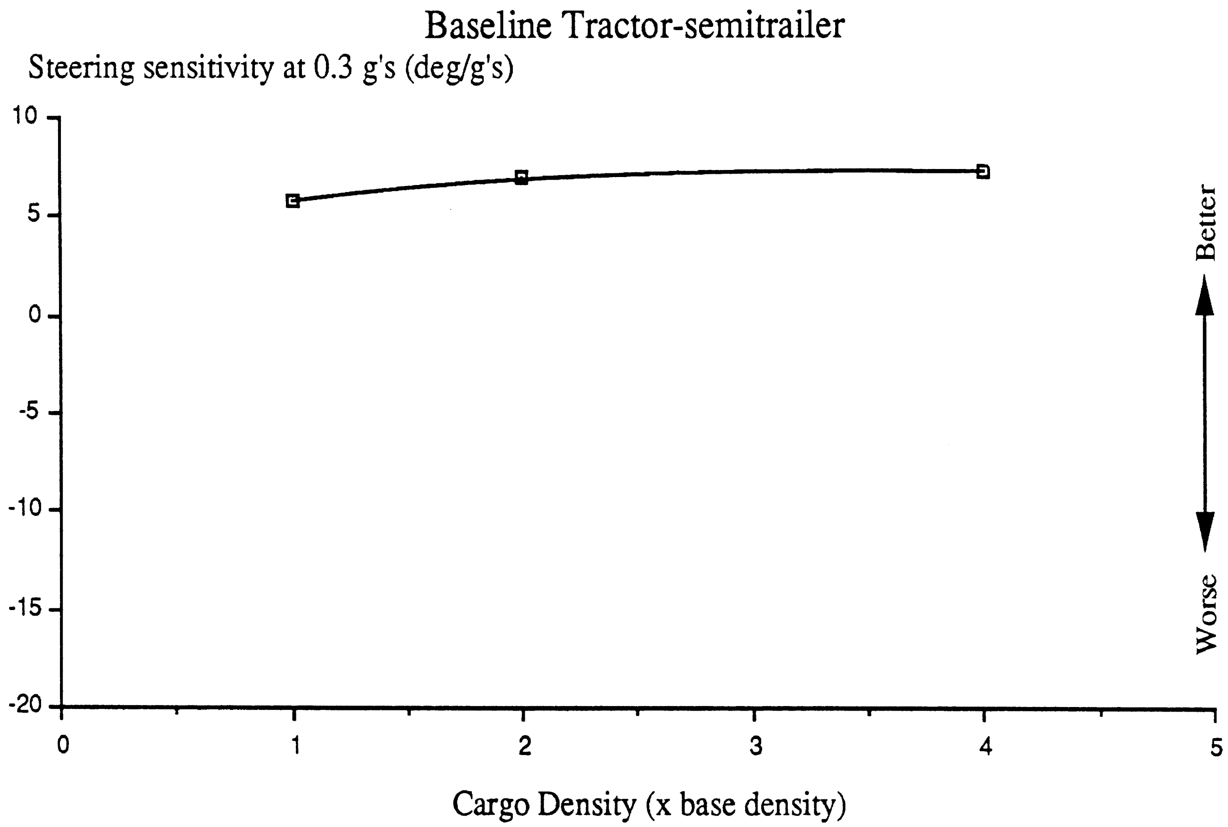
Baseline Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Baseline Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Baseline Tractor-semitrailer
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Baseline Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Baseline Tractor-semitrailer (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	Transient offtracking (ft)	15.35794	45
BTST.v3.c	Transient offtracking (ft)	17.00078	48

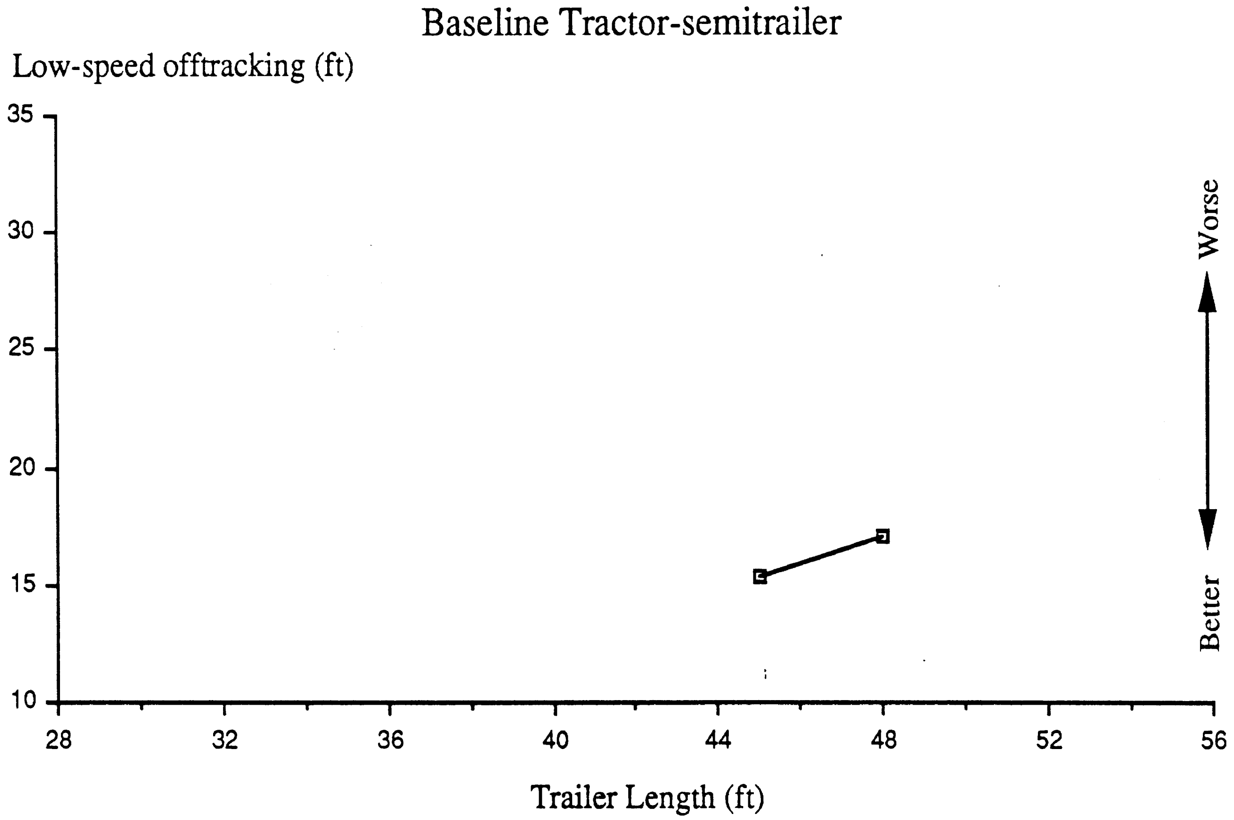
VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	High-speed offtracking (ft)	-0.33411	45
BTST.v3.c	High-speed offtracking (ft)	-0.29395	48

VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	Braking efficiency at 0.2 g's	0.95089	45
BTST.v3.c	Braking efficiency at 0.2 g's	0.95507	48
BTSTE	Braking efficiency at 0.2 g's	0.65938	45
BTST.v3.cE	Braking efficiency at 0.2 g's	0.67278	48

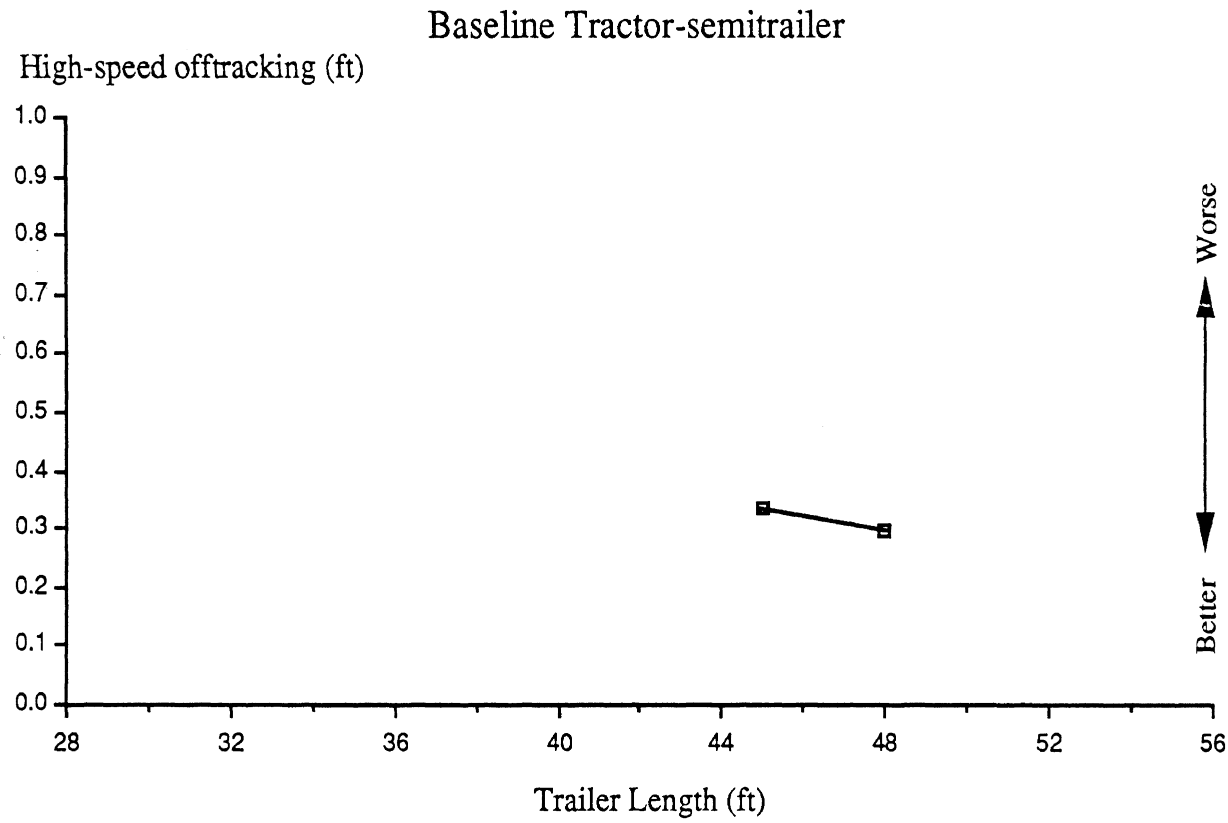
VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	Braking efficiency at 0.4 g's	0.89375	45
BTST.v3.c	Braking efficiency at 0.4 g's	0.90222	48
BTSTE	Braking efficiency at 0.4 g's	0.63466	45
BTST.v3.cE	Braking efficiency at 0.4 g's	0.64939	48

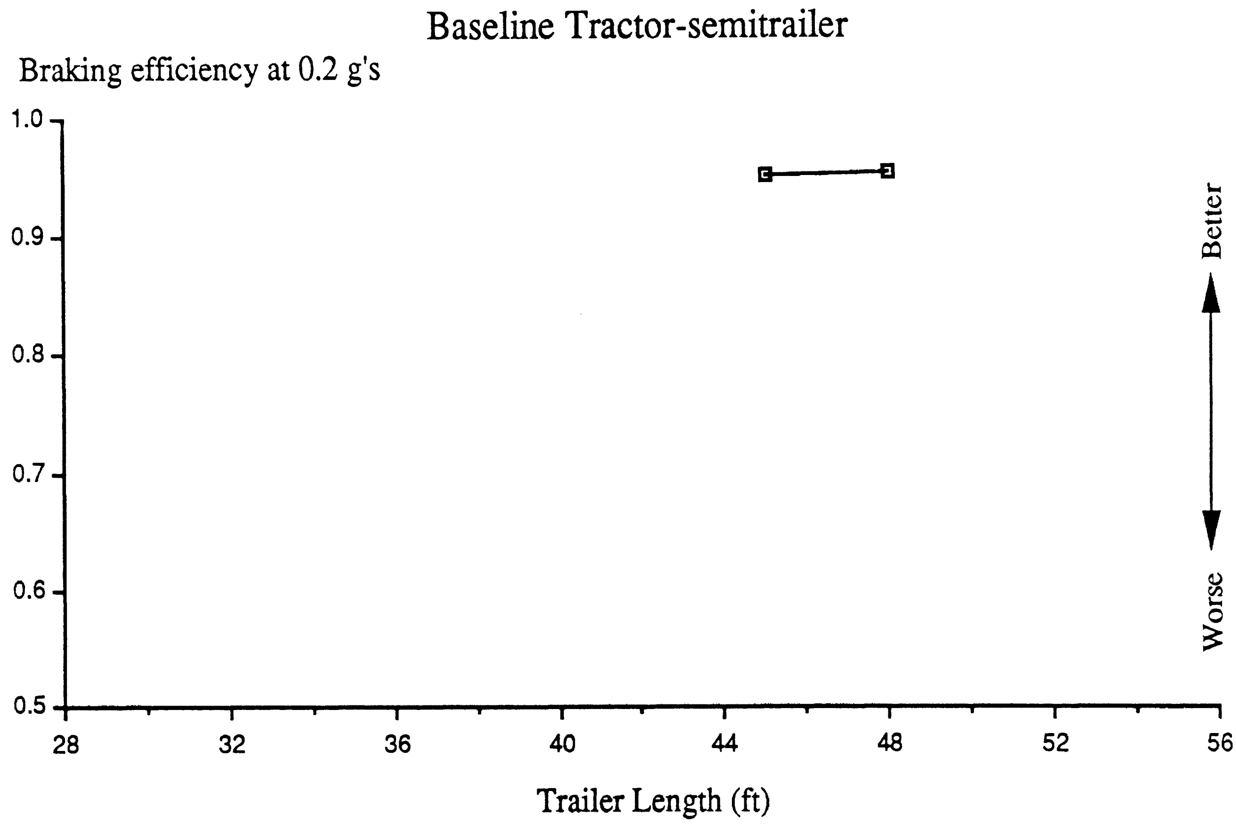
VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	Static rollover threshold (g's)	0.33968	45
BTST.v3.c	Static rollover threshold (g's)	0.33932	48

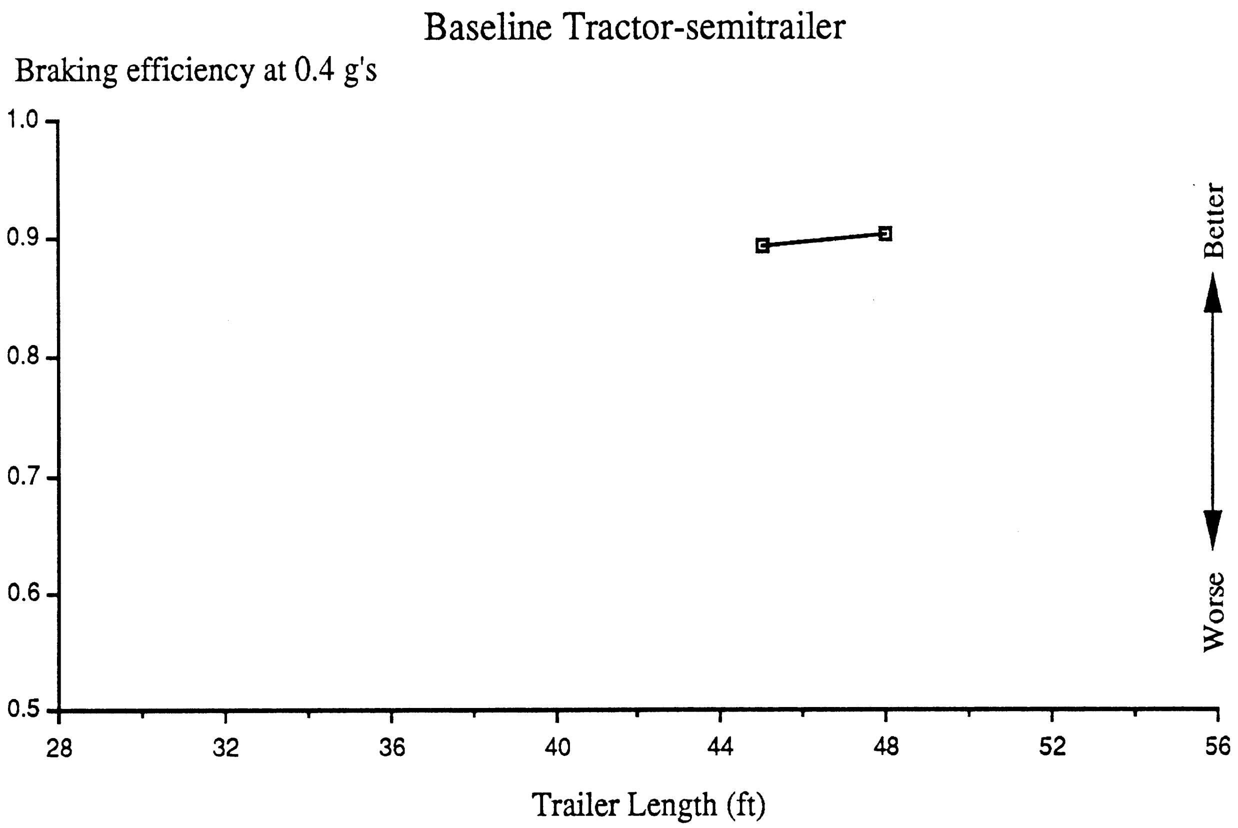
VEHICLE	MEASURE	VALUE	T.LENGTH
BTST	Steering sens. at 0.3 g's (deg/g's)	5.78005	45
BTST.v3.c	Steering sens. at 0.3 g's (deg/g's)	5.73309	48



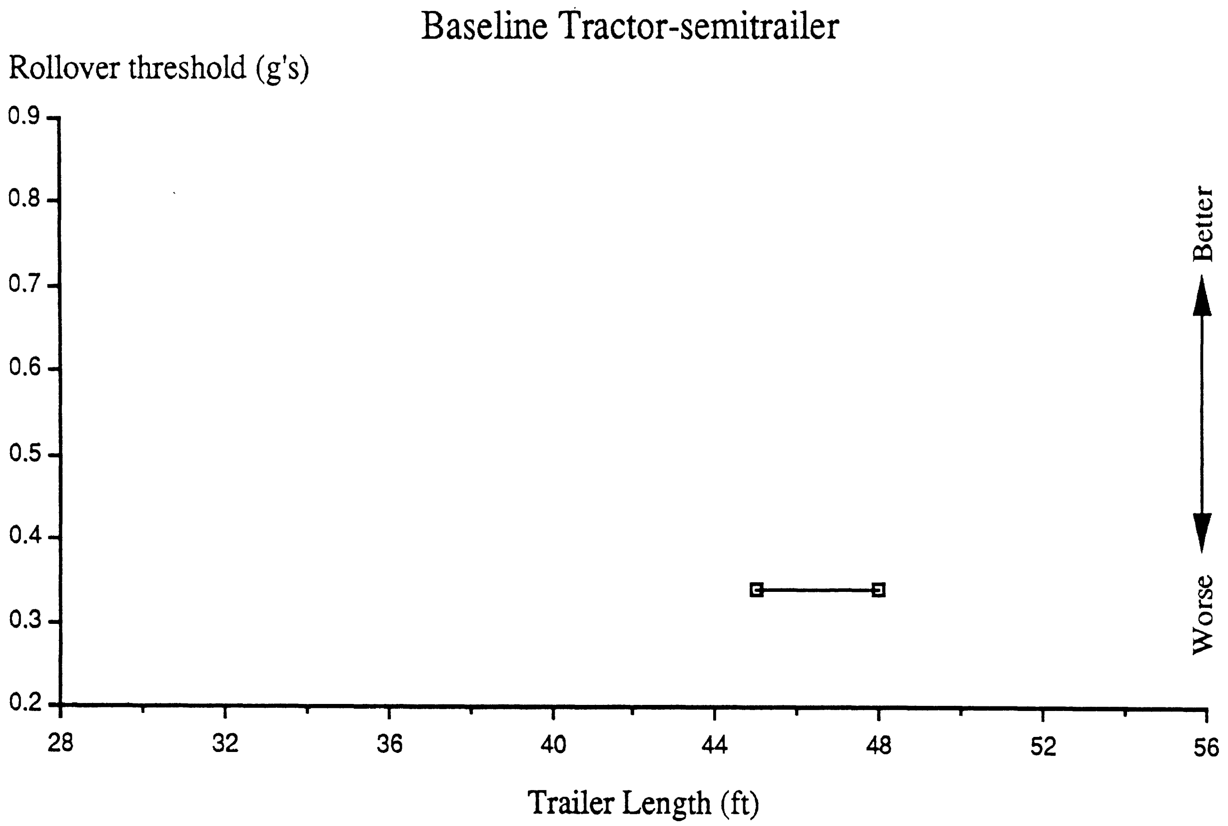
Baseline Tractor-semitrailer
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better


Baseline Tractor-semitrailer
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

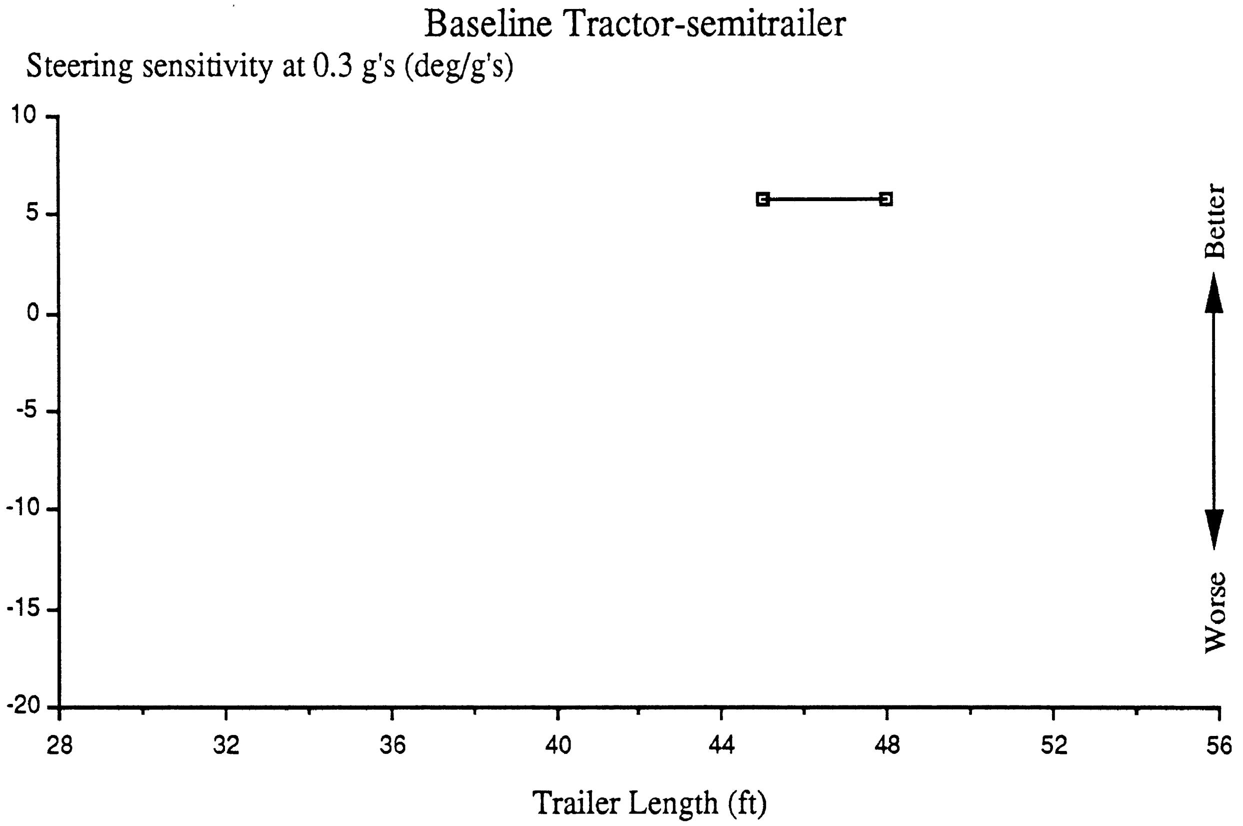

Baseline Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Baseline Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Baseline Tractor-semitrailer
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Baseline Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

Baseline 5-axle Double (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
BDbl1	Transient offtracking (ft)	14.27202	80000

VEHICLE	MEASURE	VALUE	GVW
BDbl1	High-speed offtracking (ft)	-0.73926	80000
BDbl1.v1.a	High-speed offtracking (ft)	-0.55273	30500
BDbl1.v1.b	High-speed offtracking (ft)	-0.62085	50500
BDbl1.v1.d	High-speed offtracking (ft)	-0.88586	110000

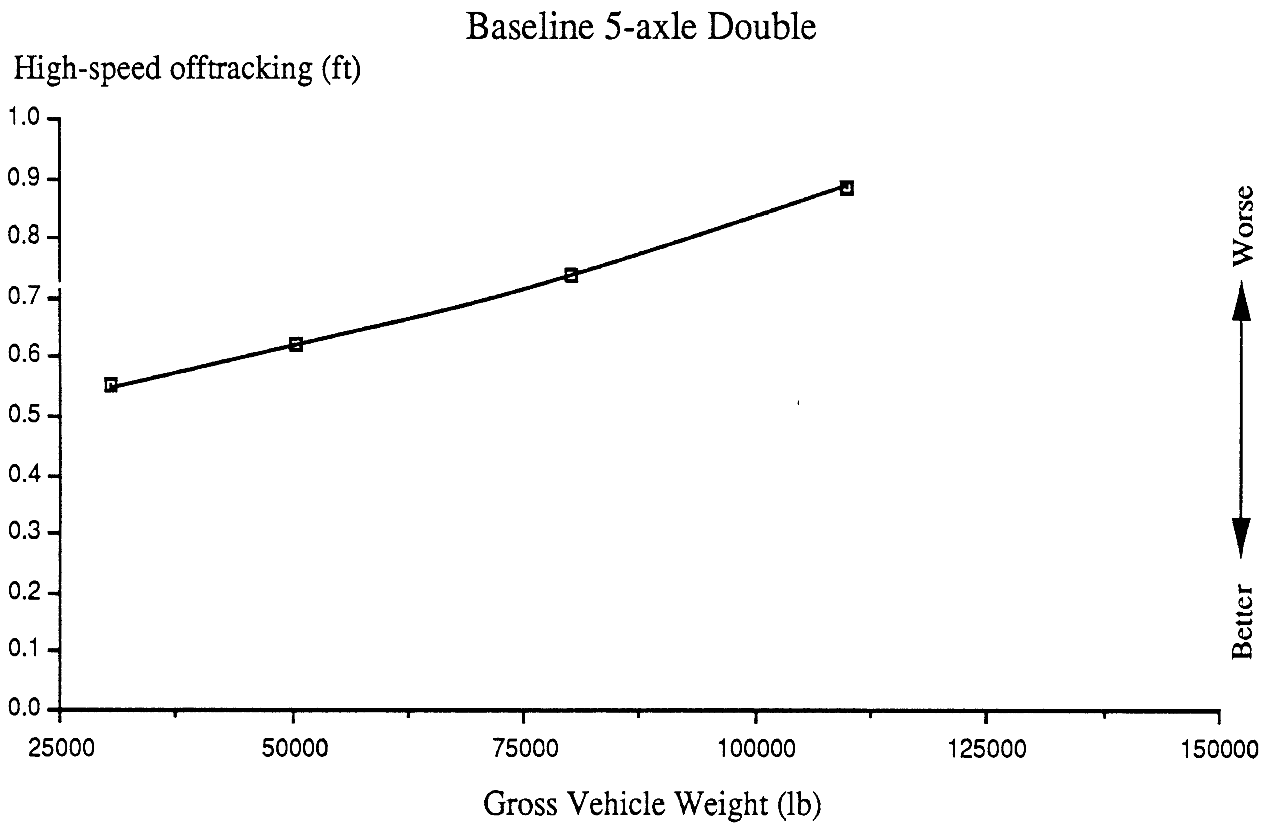
VEHICLE	MEASURE	VALUE	GVW
BDbl1	Braking efficiency at 0.2 g's	0.88730	80000
BDbl1.v1.a	Braking efficiency at 0.2 g's	0.63001	30500
BDbl1.v1.b	Braking efficiency at 0.2 g's	0.79469	50500
BDbl1.v1.d	Braking efficiency at 0.2 g's	0.82364	110000
BDbl1E	Braking efficiency at 0.2 g's	0.63001	30500

VEHICLE	MEASURE	VALUE	GVW
BDbl1	Braking efficiency at 0.4 g's	0.79751	80000
BDbl1.v1.a	Braking efficiency at 0.4 g's	0.59063	30500
BDbl1.v1.b	Braking efficiency at 0.4 g's	0.72305	50500
BDbl1.v1.d	Braking efficiency at 0.4 g's	0.83228	110000
BDbl1E	Braking efficiency at 0.4 g's	0.59063	30500

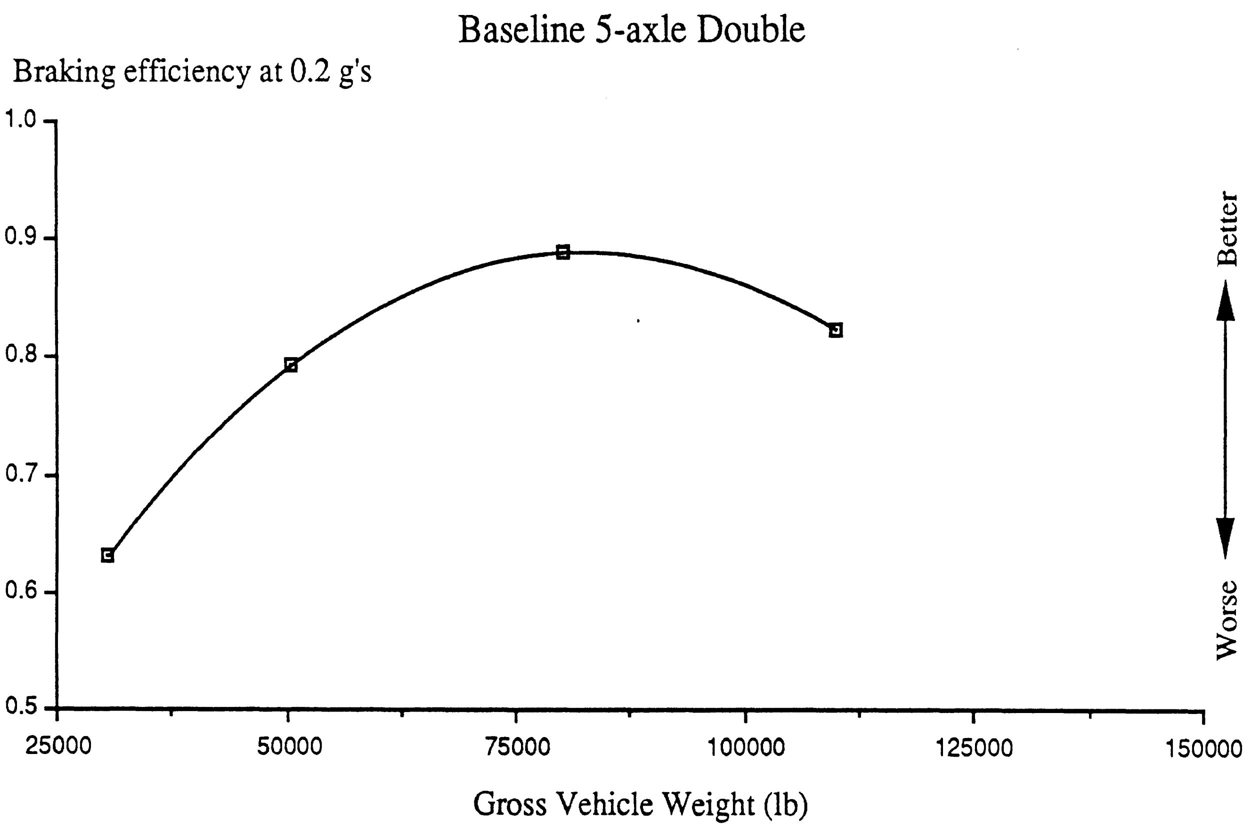
VEHICLE	MEASURE	VALUE	GVW
BDbl1	Static rollover threshold (g's)	0.34743	80000
BDbl1.v1.a	Static rollover threshold (g's)	0.73933	30500
BDbl1.v1.b	Static rollover threshold (g's)	0.44484	50500
BDbl1.v1.d	Static rollover threshold (g's)	0.27982	110000

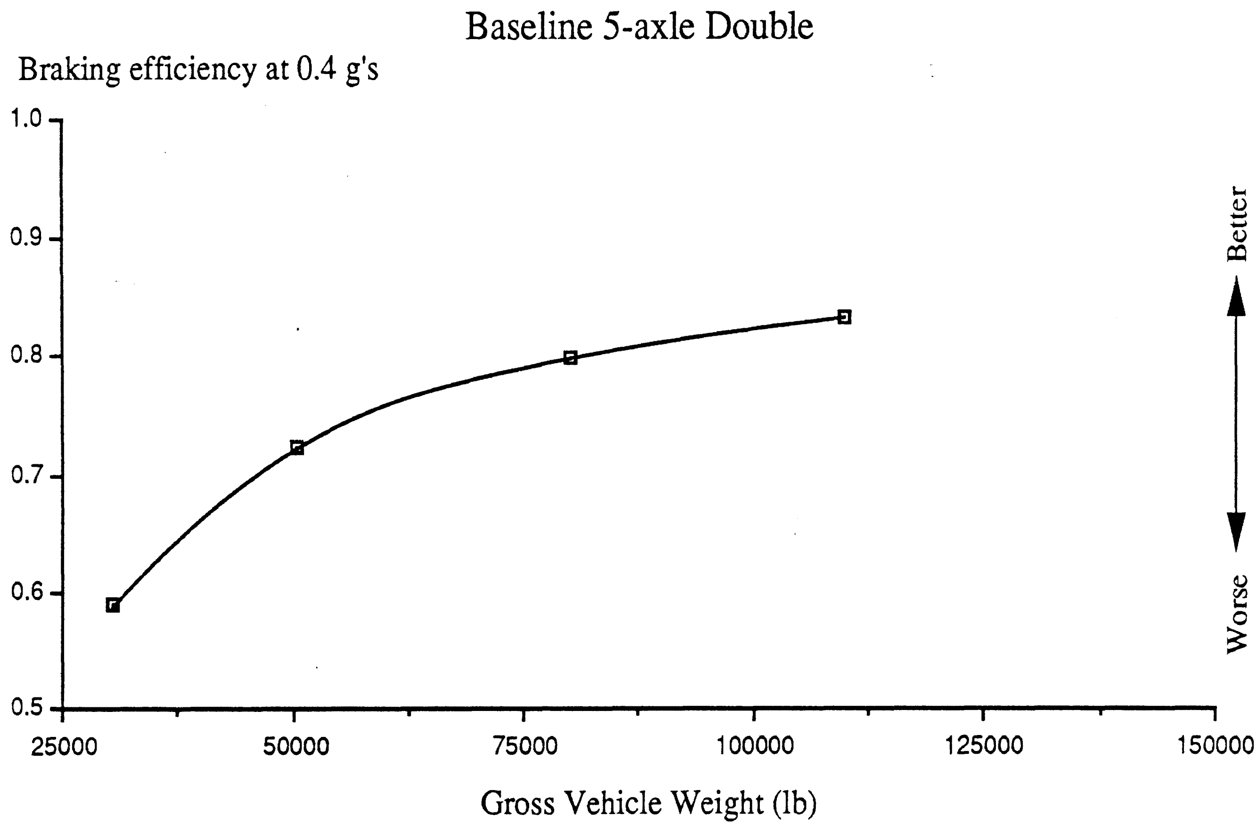
VEHICLE	MEASURE	VALUE	GVW
BDbl1	Steering sens. at 0.3 g's (deg/g's)	4.57836	80000
BDbl1.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.34139	30500
BDbl1.v1.b	Steering sens. at 0.3 g's (deg/g's)	6.65303	50500
BDbl1.v1.d	Steering sens. at 0.25 g's (deg/g's)	1.30094	110000

VEHICLE	MEASURE	VALUE	GVW
BDbl1	Rearward amplification	1.43634	80000
BDbl1.v1.a	Rearward amplification	1.28477	30500
BDbl1.v1.b	Rearward amplification	1.35265	50500
BDbl1.v1.d	Rearward amplification	1.53281	110000

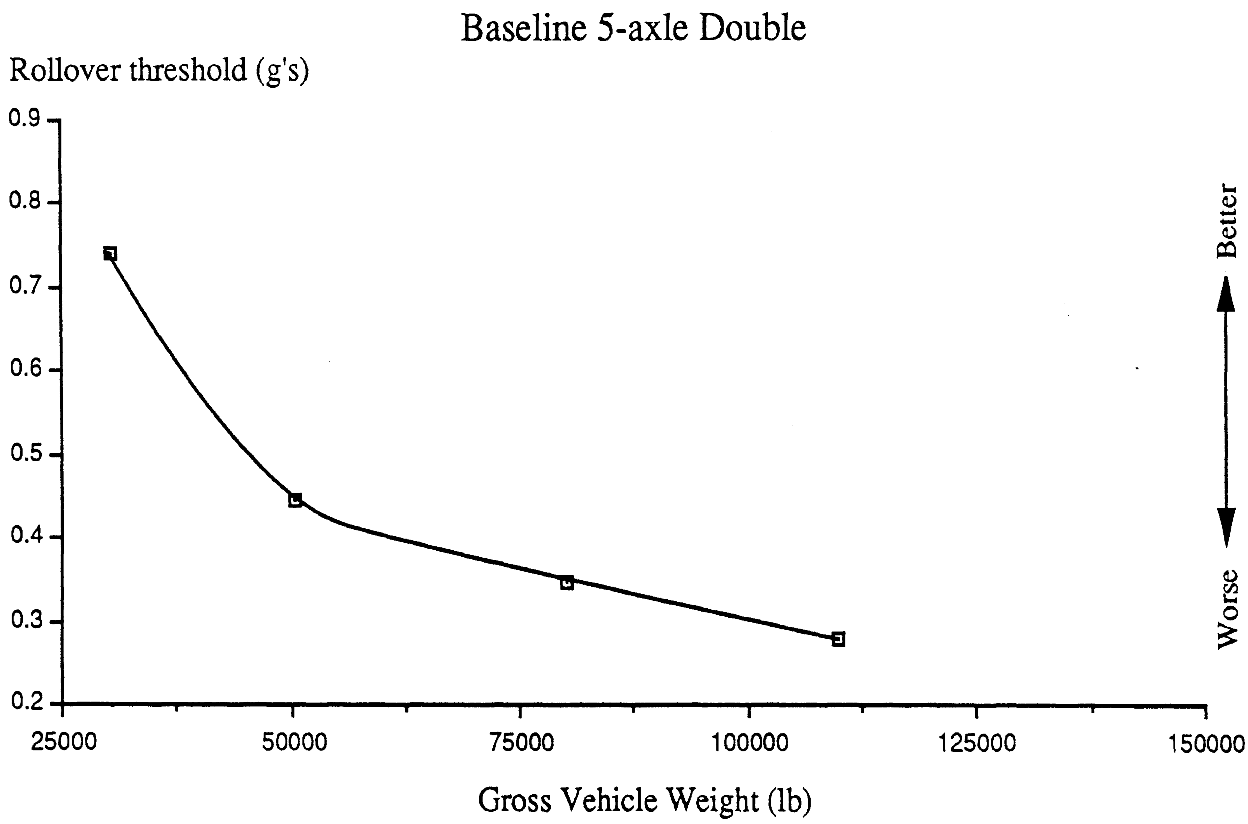


Baseline 5-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

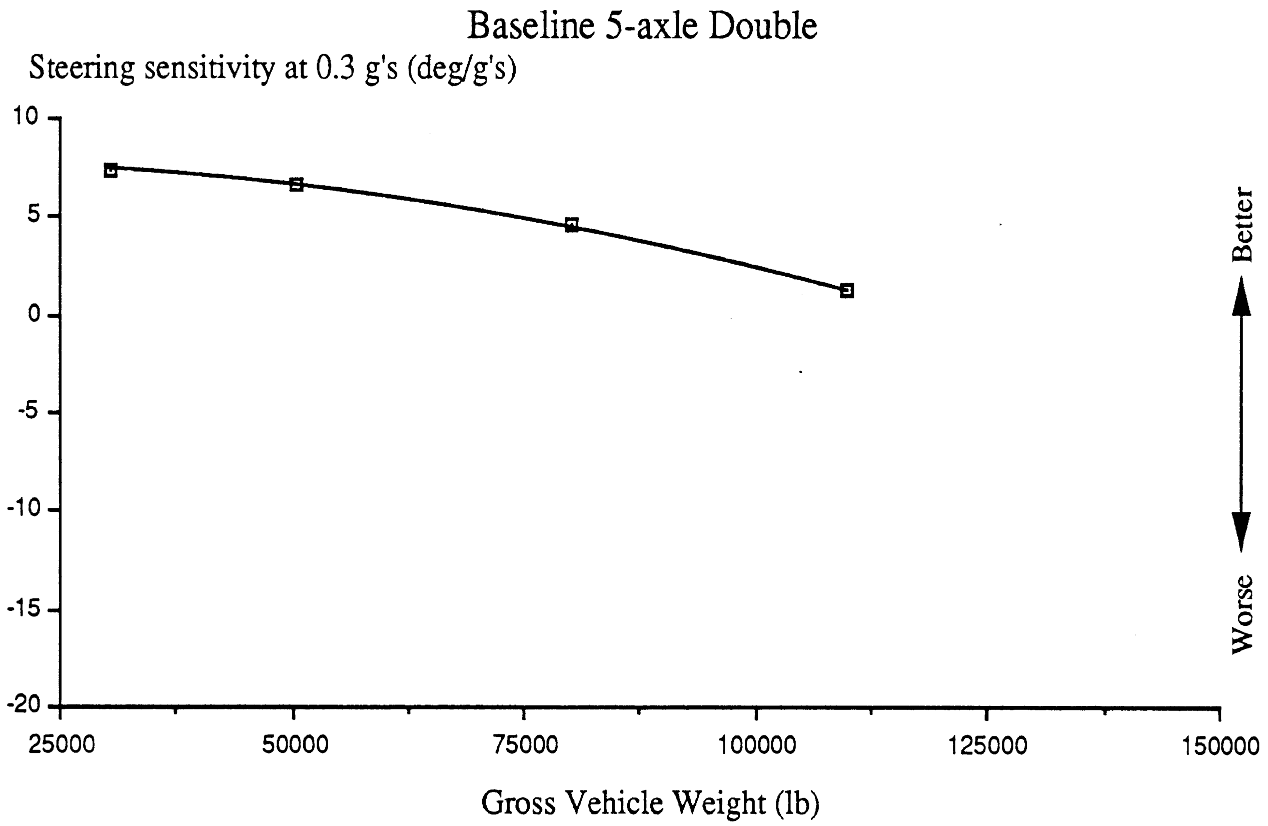

Baseline 5-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



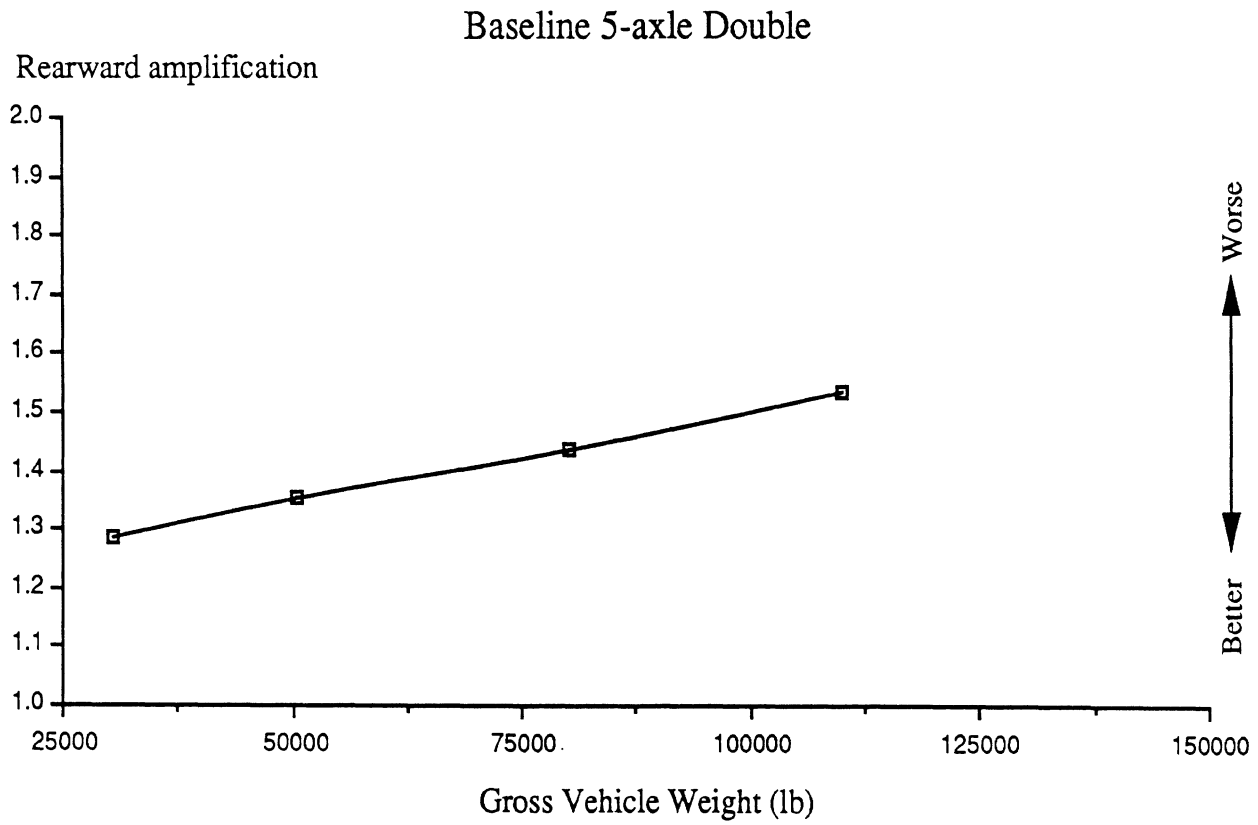
Baseline 5-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Baseline 5-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Baseline 5-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Baseline 5-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

Baseline 5-axle Double (Cargo density)

VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Transient offtracking (ft)	14.27202	1

VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	High-speed offtracking (ft)	-0.73926	1

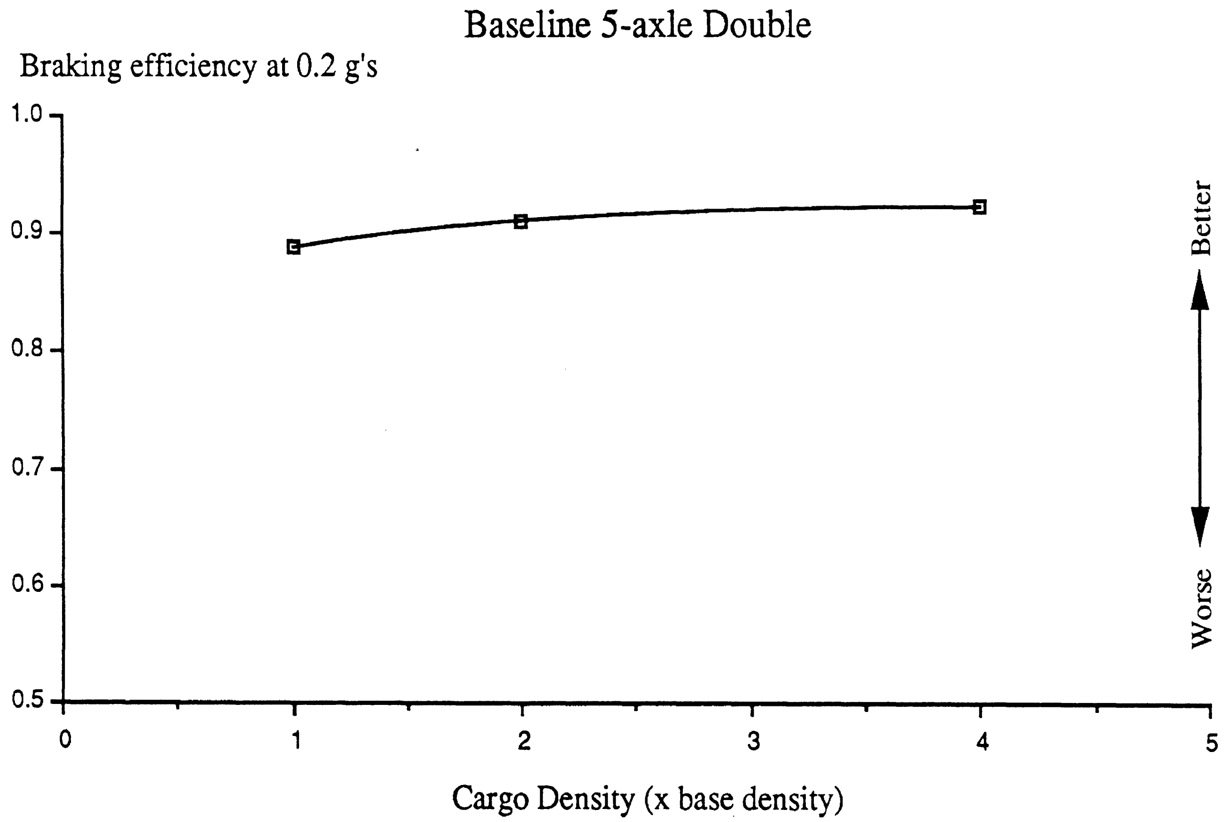
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Braking efficiency at 0.2 g's	0.88730	1
BDbl1.v2.a	Braking efficiency at 0.2 g's	0.91136	2
BDbl1.v2.b	Braking efficiency at 0.2 g's	0.92340	4
BDbl1E	Braking efficiency at 0.2 g's	0.63001	1

VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Braking efficiency at 0.4 g's	0.79751	1
BDbl1.v2.a	Braking efficiency at 0.4 g's	0.84564	2
BDbl1.v2.b	Braking efficiency at 0.4 g's	0.86971	4
BDbl1E	Braking efficiency at 0.4 g's	0.59063	1

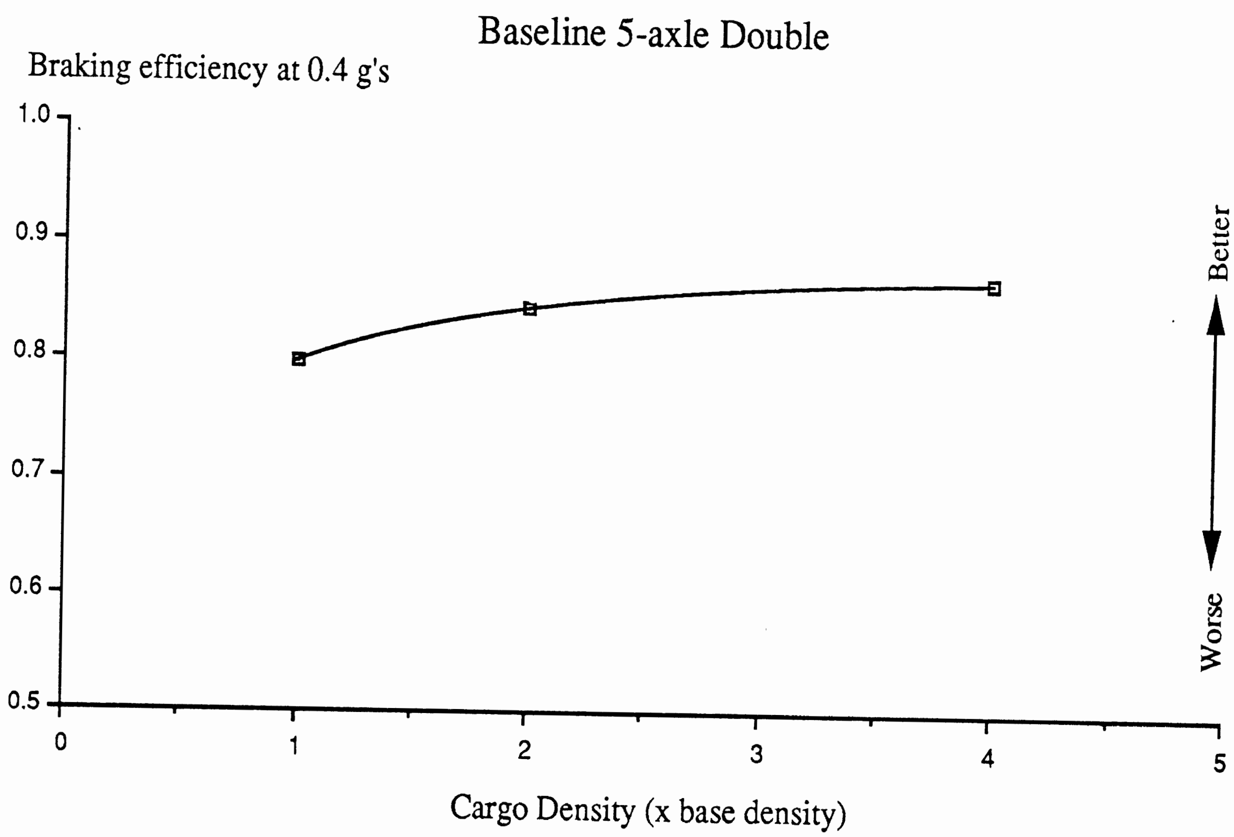
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Static rollover threshold (g's)	0.34743	1
BDbl1.v2.a	Static rollover threshold (g's)	0.46081	2
BDbl1.v2.b	Static rollover threshold (g's)	0.53591	4

VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Steering sens. at 0.3 g's (deg/g's)	4.57836	1
BDbl1.v2.a	Steering sens. at 0.3 g's (deg/g's)	5.54206	2
BDbl1.v2.b	Steering sens. at 0.3 g's (deg/g's)	5.91772	4

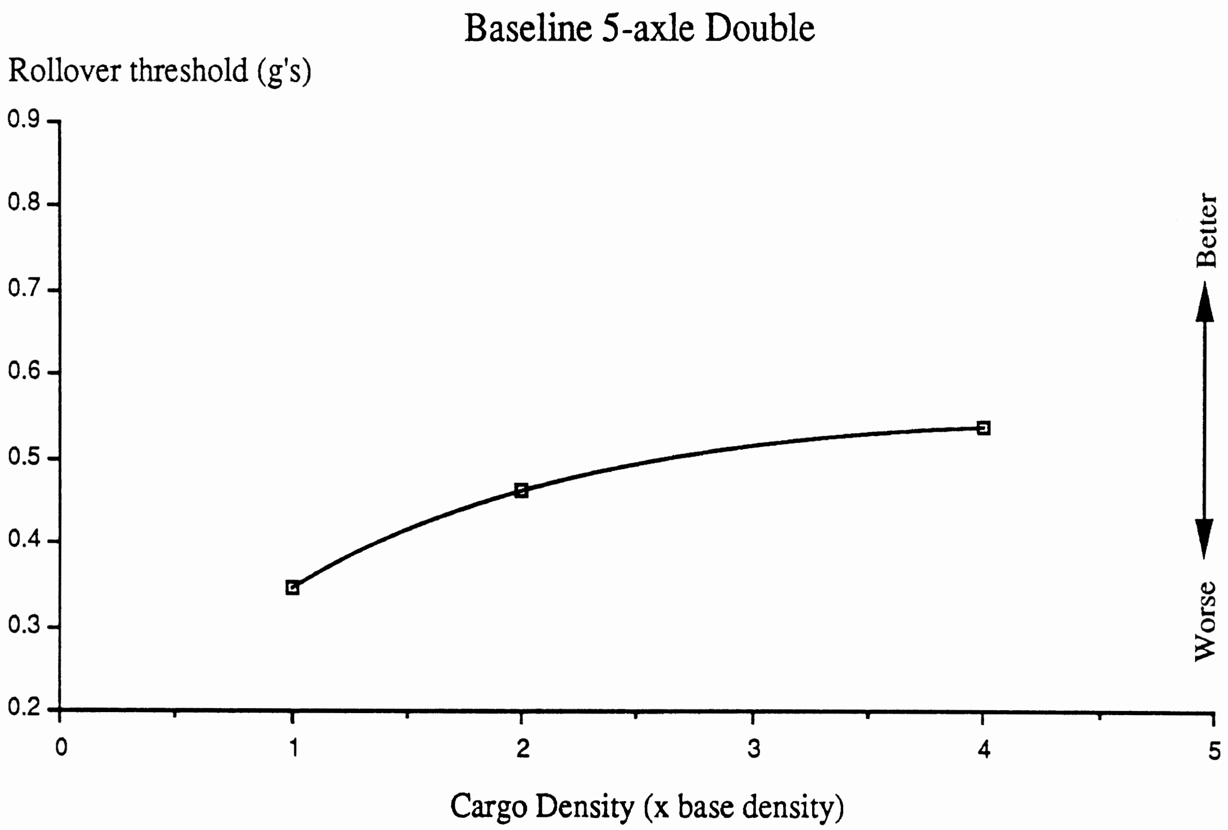
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl1	Rearward amplification	1.43634	1

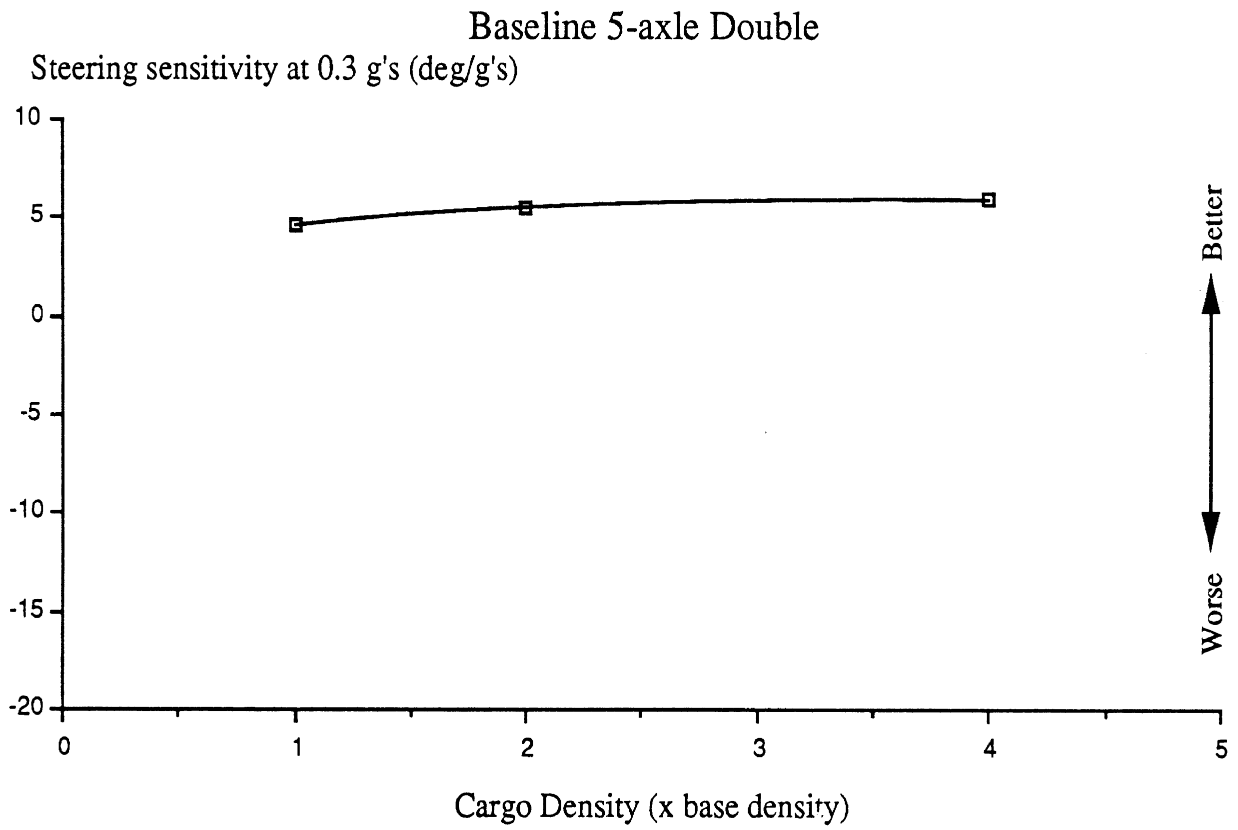


Baseline 5-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Baseline 5-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Baseline 5-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Baseline 5-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Baseline 9-axle Double (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
BDbl2	Transient offtracking (ft)	25.10889	130000

VEHICLE	MEASURE	VALUE	GVW
BDbl2	High-speed offtracking (ft)	-0.67993	130000
BDbl2.v1.a	High-speed offtracking (ft)	-0.44556	47590
BDbl2.v1.b	High-speed offtracking (ft)	-0.49683	67590
BDbl2.v1.d	High-speed offtracking (ft)	-0.61694	110000
BDbl2.v1.f	High-speed offtracking (ft)	-0.74023	148000

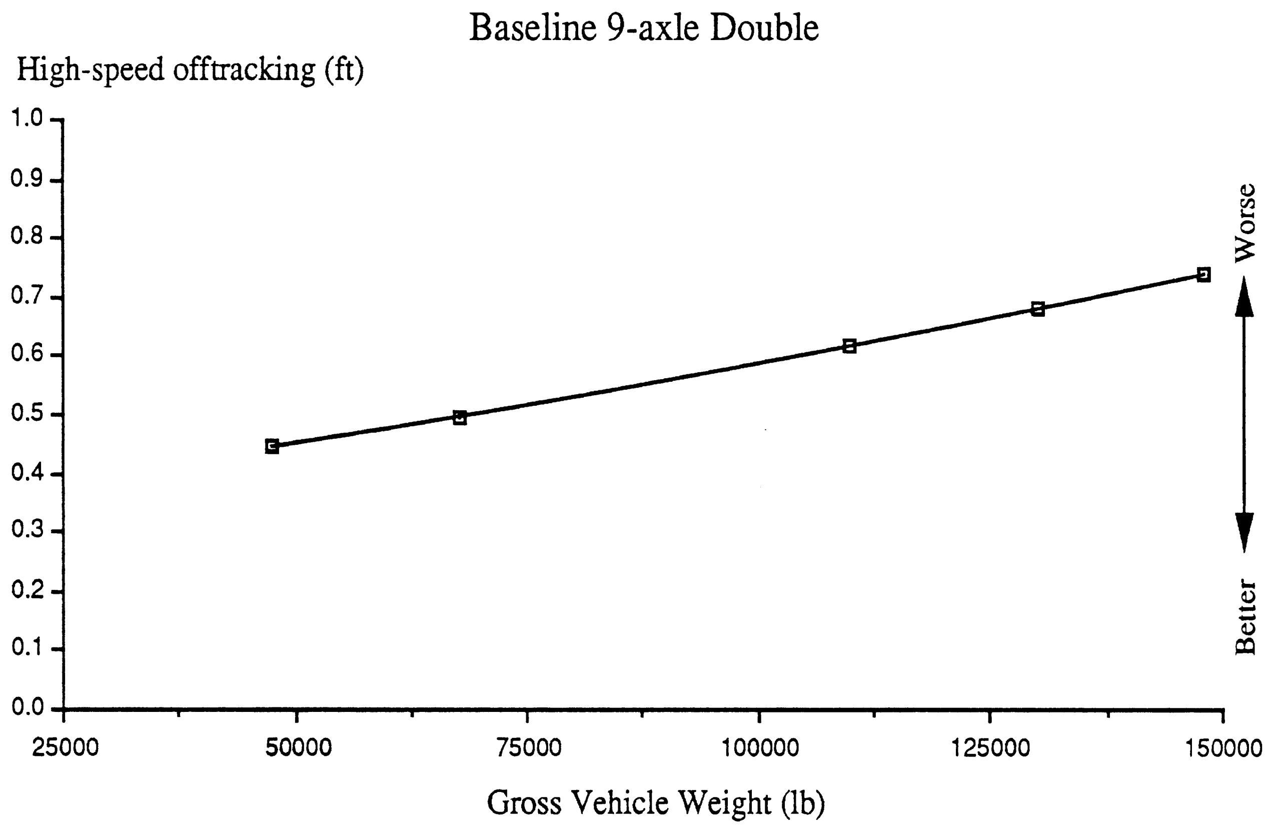
VEHICLE	MEASURE	VALUE	GVW
BDbl2	Braking efficiency at 0.2 g's	0.93025	130000
BDbl2.v1.a	Braking efficiency at 0.2 g's	0.77432	47590
BDbl2.v1.b	Braking efficiency at 0.2 g's	0.86207	67590
BDbl2.v1.d	Braking efficiency at 0.2 g's	0.91682	110000
BDbl2.v1.f	Braking efficiency at 0.2 g's	0.93921	148000
BDbl2E	Braking efficiency at 0.2 g's	0.77432	47590

VEHICLE	MEASURE	VALUE	GVW
BDbl2	Braking efficiency at 0.4 g's	0.90565	130000
BDbl2.v1.a	Braking efficiency at 0.4 g's	0.74836	47590
BDbl2.v1.b	Braking efficiency at 0.4 g's	0.82217	67590
BDbl2.v1.d	Braking efficiency at 0.4 g's	0.88991	110000
BDbl2.v1.f	Braking efficiency at 0.4 g's	0.90942	148000
BDbl2E	Braking efficiency at 0.4 g's	0.74836	47590

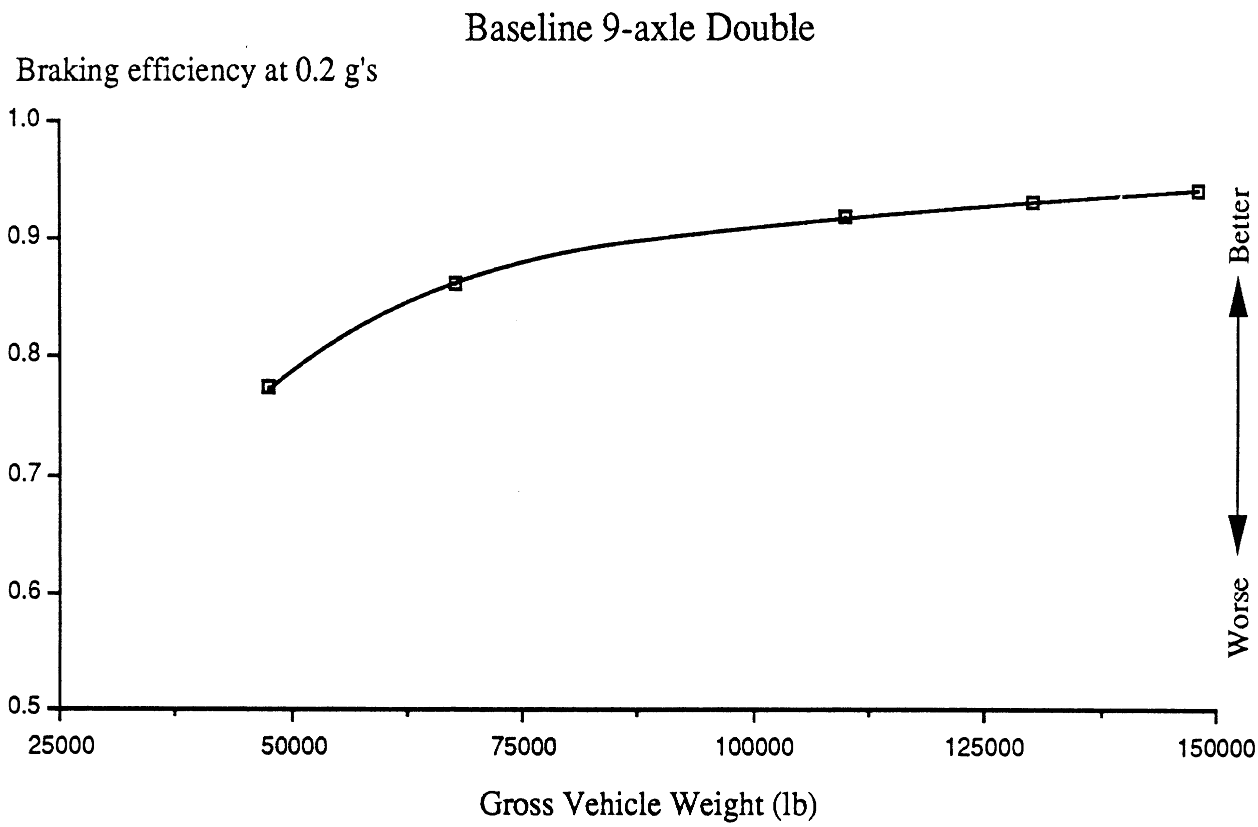
VEHICLE	MEASURE	VALUE	GVW
BDbl2	Static rollover threshold (g's)	0.36326	130000
BDbl2.v1.a	Static rollover threshold (g's)	0.71630	47590
BDbl2.v1.b	Static rollover threshold (g's)	0.51295	67590
BDbl2.v1.d	Static rollover threshold (g's)	0.39395	110000
BDbl2.v1.f	Static rollover threshold (g's)	0.33936	148000

VEHICLE	MEASURE	VALUE	GVW
BDbl2	Steering sens. at 0.3 g's (deg/g's)	6.34247	130000
BDbl2.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.93583	47590
BDbl2.v1.b	Steering sens. at 0.3 g's (deg/g's)	7.80349	67590
BDbl2.v1.d	Steering sens. at 0.3 g's (deg/g's)	7.04790	110000
BDbl2.v1.f	Steering sens. at 0.3 g's (deg/g's)	5.67119	148000

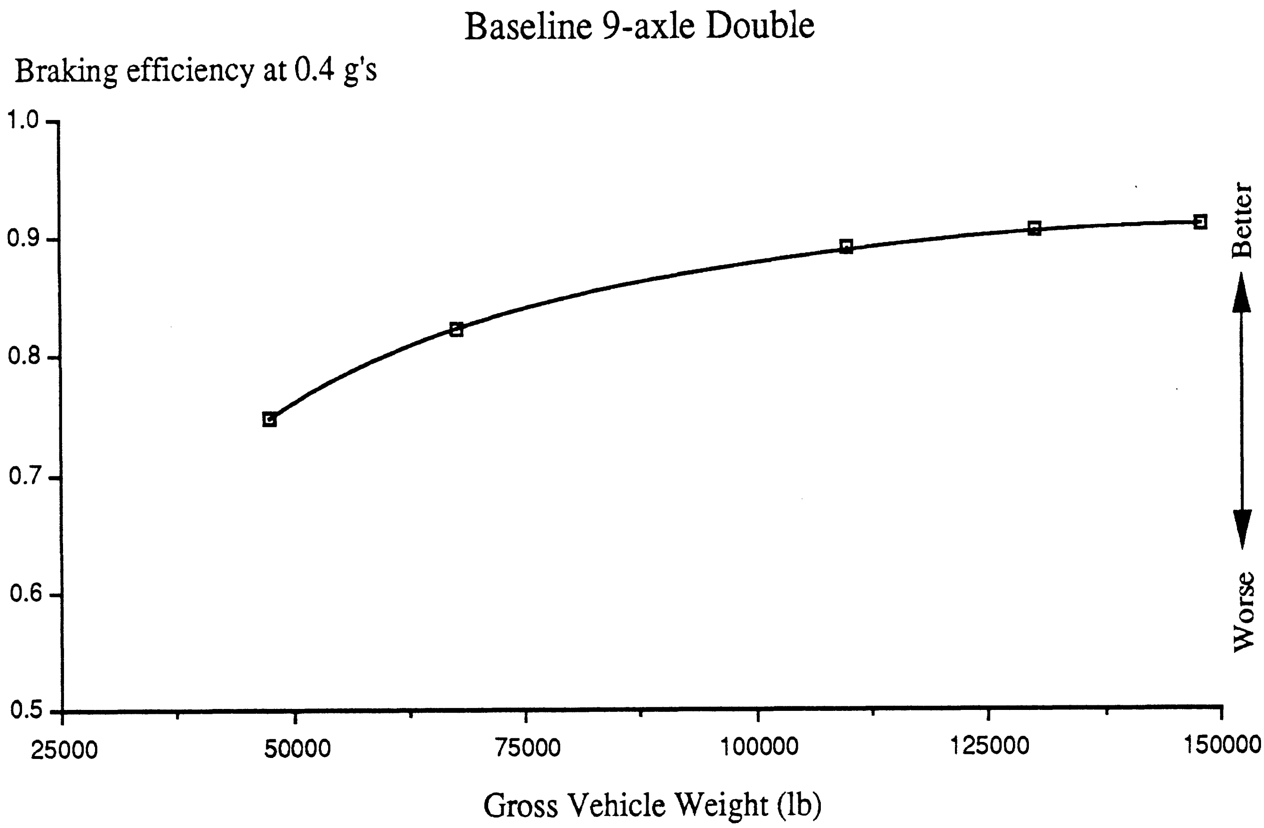
VEHICLE	MEASURE	VALUE	GVW
BDbl2	Rearward amplification	1.15621	130000
BDbl2.v1.a	Rearward amplification	1.08229	47590
BDbl2.v1.b	Rearward amplification	1.10137	67590
BDbl2.v1.d	Rearward amplification	1.13746	110000
BDbl2.v1.f	Rearward amplification	1.17436	148000



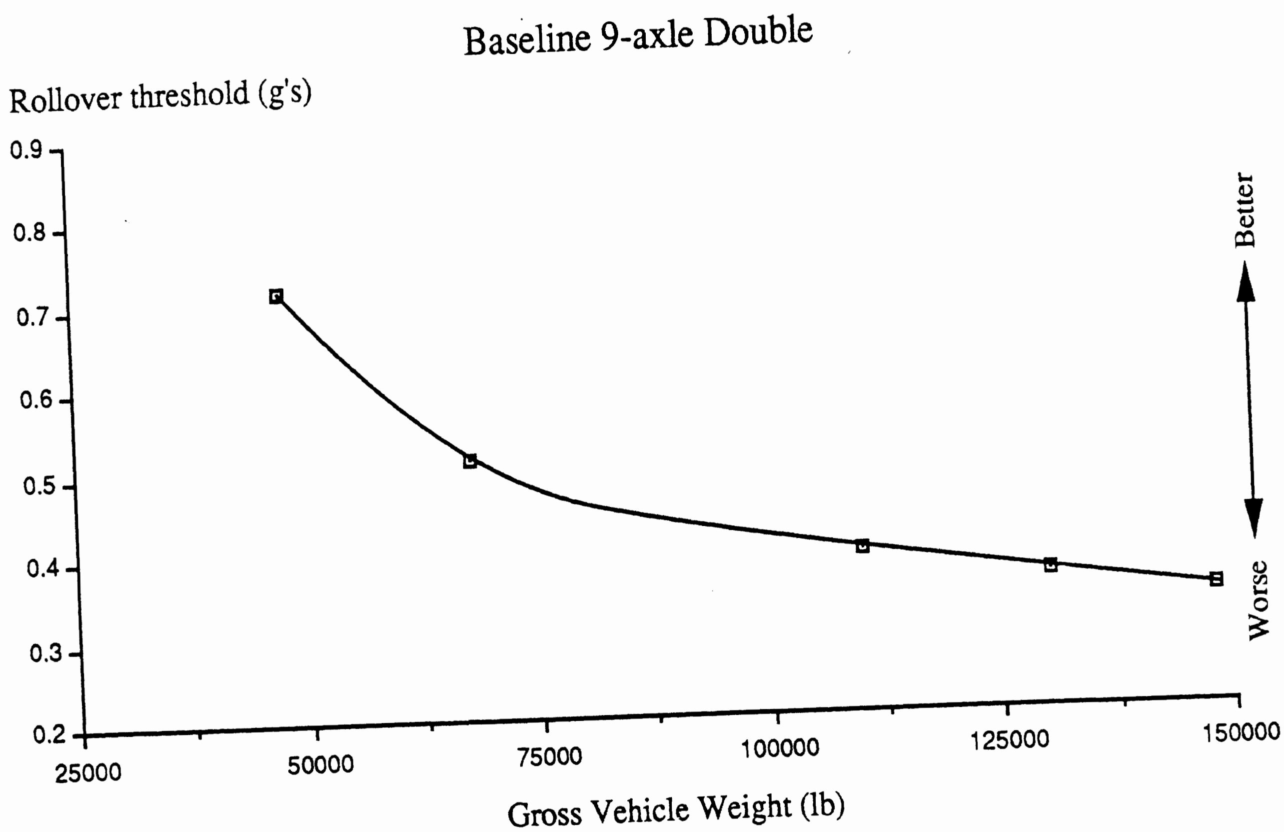
Baseline 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Worse
Better
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)

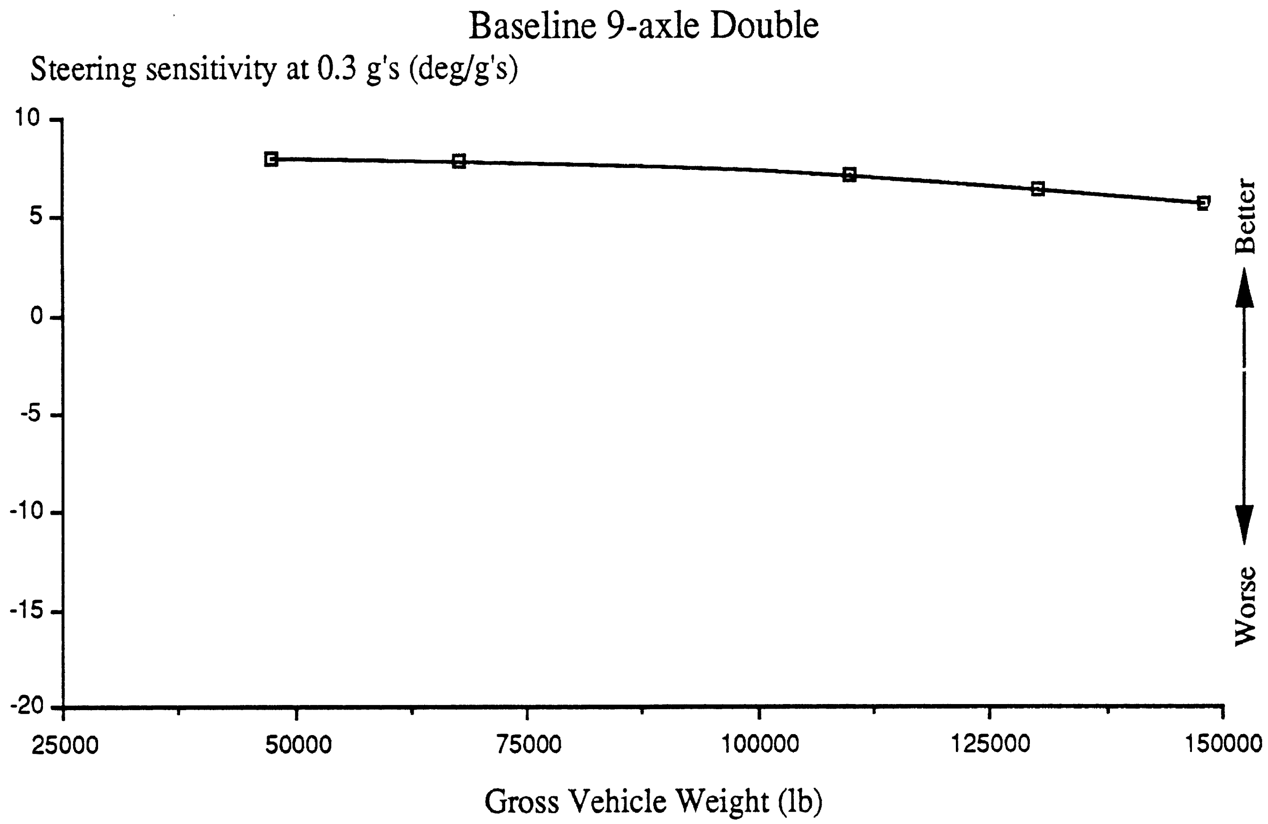


Baseline 9-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

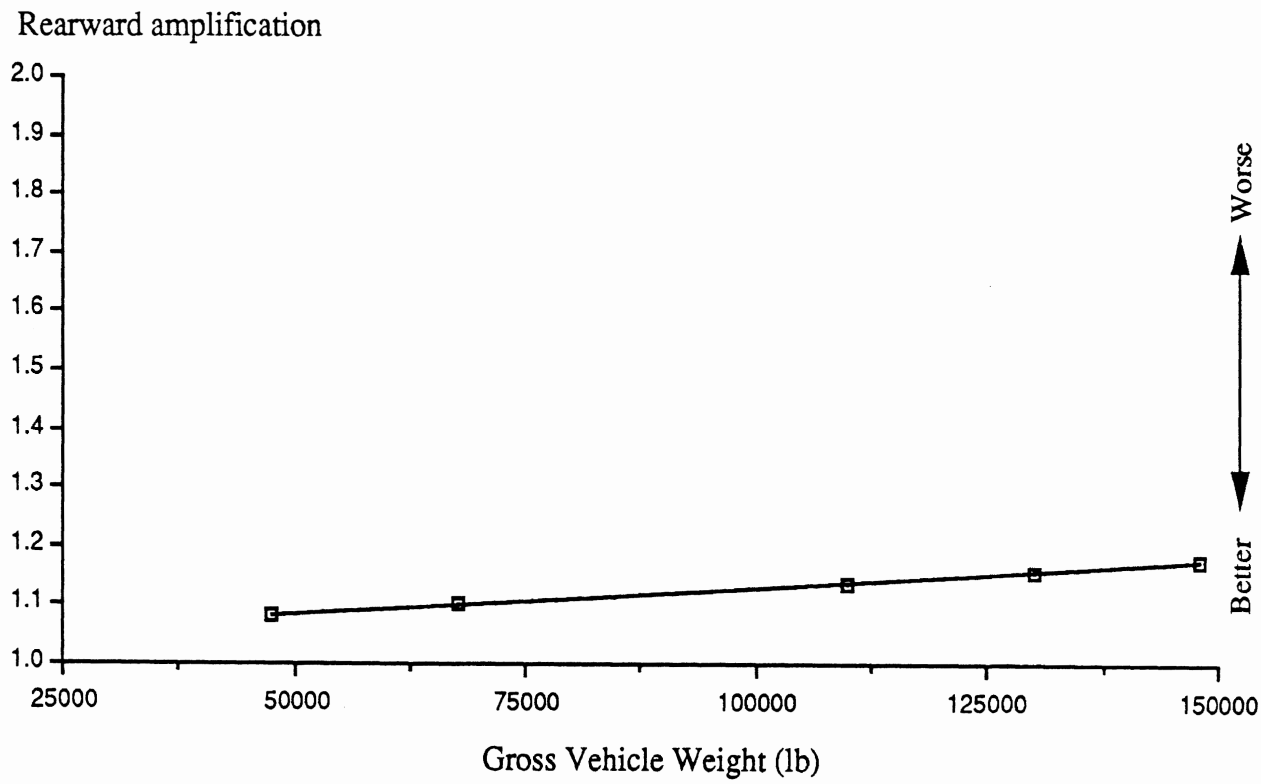


Baseline 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse


Baseline 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

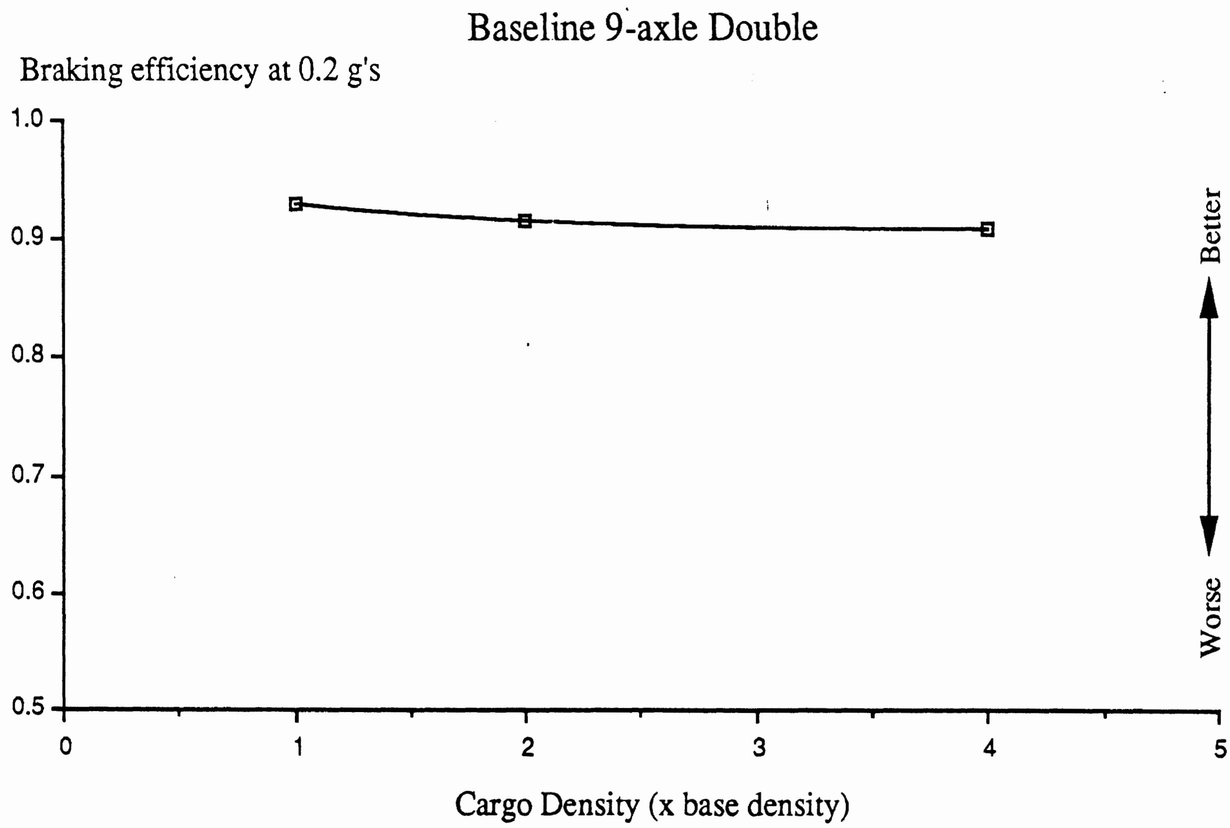

Baseline 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

Baseline 9-axle Double

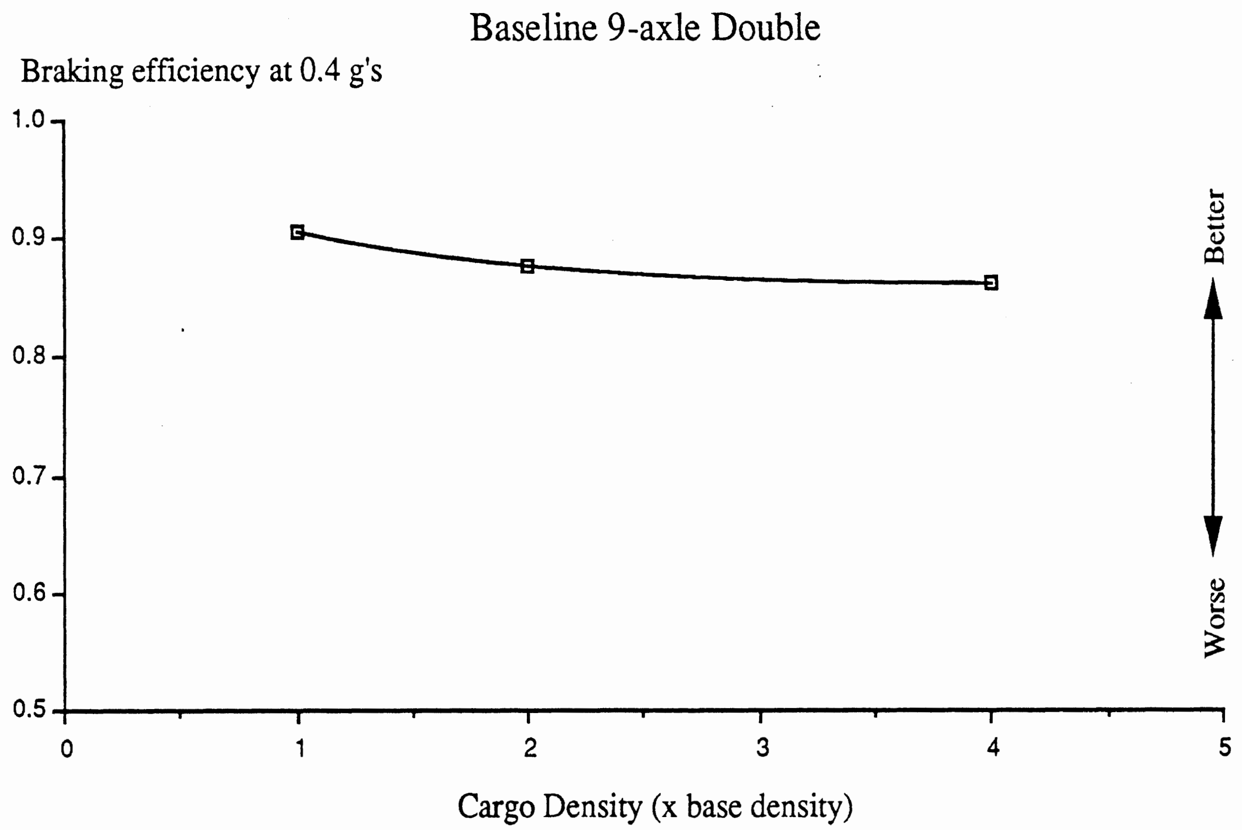


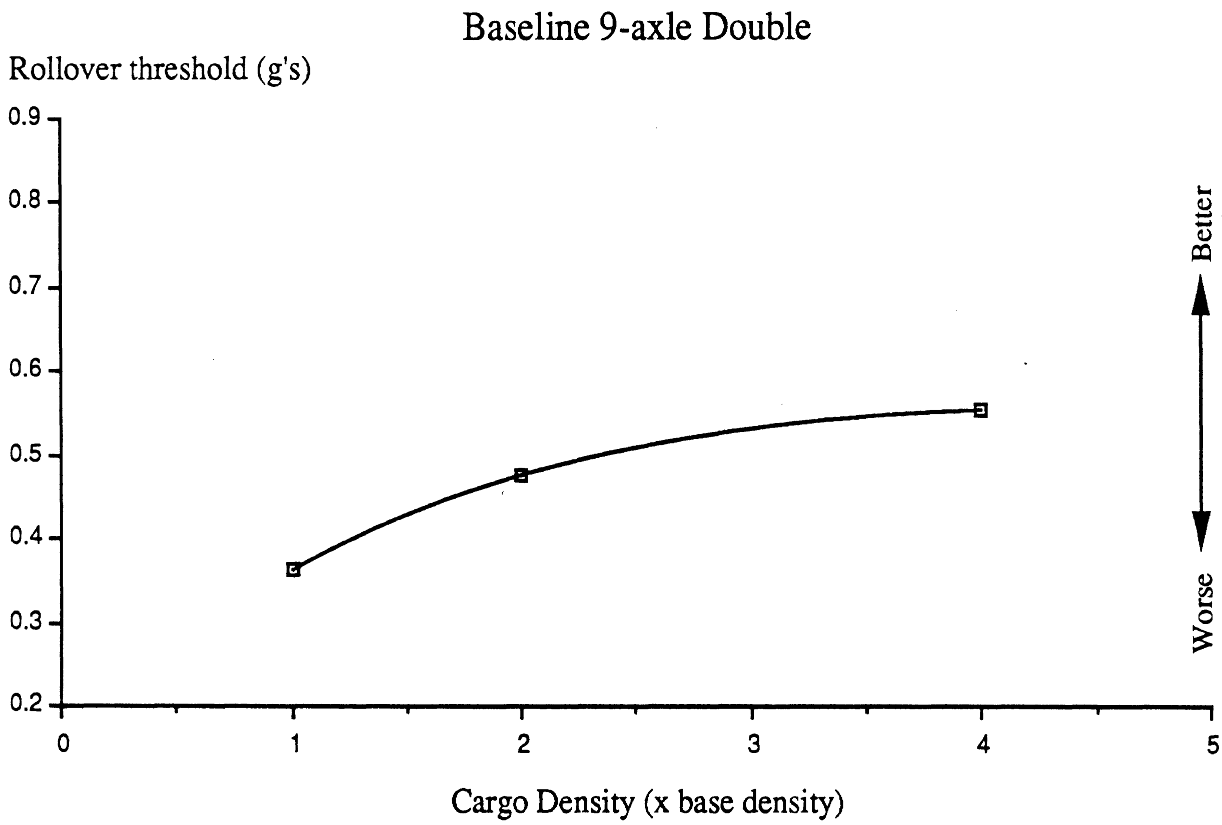
Baseline 9-axle Double (Cargo density)

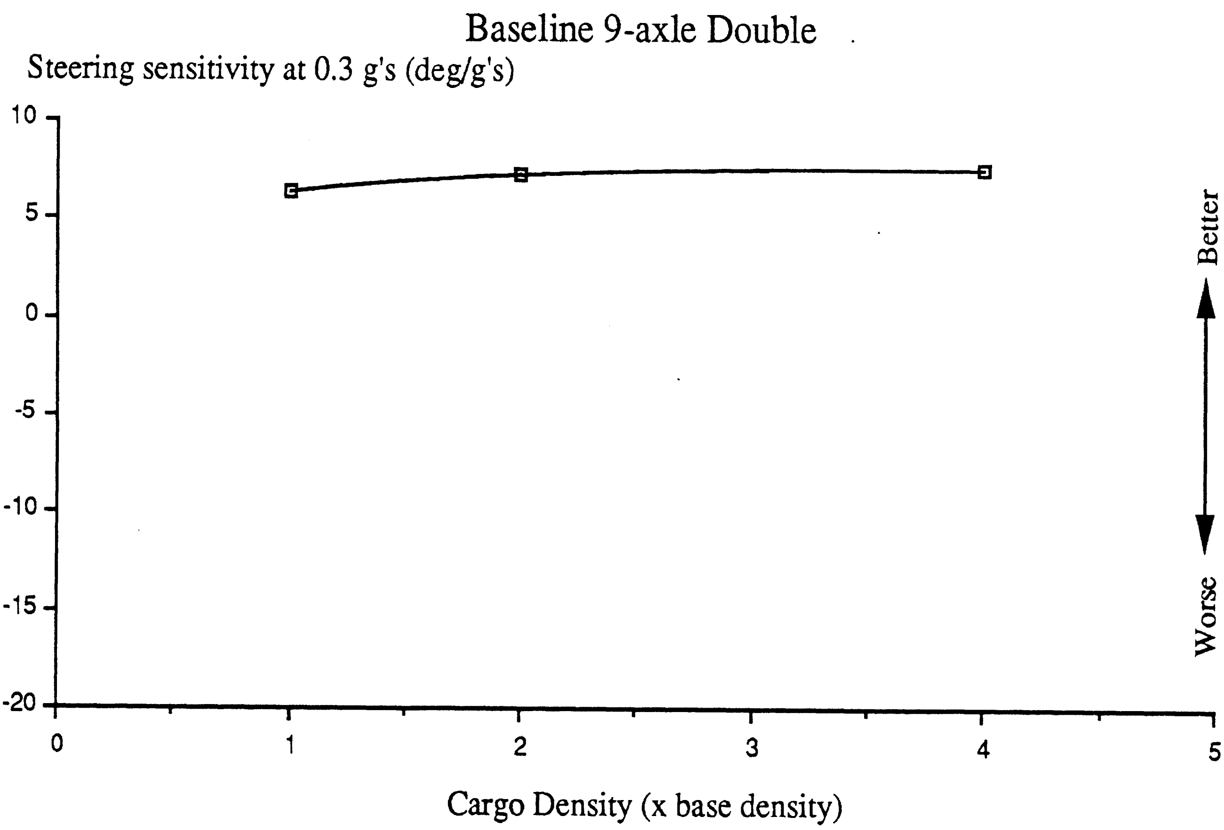
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Transient offtracking (ft)	25.10889	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	High-speed offtracking (ft)	-0.67993	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Braking efficiency at 0.2 g's	0.93025	1
BDbl2.v2.a	Braking efficiency at 0.2 g's	0.91533	2
BDbl2.v2.b	Braking efficiency at 0.2 g's	0.90787	4
BDbl2E	Braking efficiency at 0.2 g's	0.77432	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Braking efficiency at 0.4 g's	0.90565	1
BDbl2.v2.a	Braking efficiency at 0.4 g's	0.87583	2
BDbl2.v2.b	Braking efficiency at 0.4 g's	0.86090	4
BDbl2E	Braking efficiency at 0.4 g's	0.74836	1
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Static rollover threshold (g's)	0.36326	1
BDbl2.v2.a	Static rollover threshold (g's)	0.47672	2
BDbl2.v2.b	Static rollover threshold (g's)	0.55267	4
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Steering sens. at 0.3 g's (deg/g's)	6.34247	1
BDbl2.v2.a	Steering sens. at 0.3 g's (deg/g's)	7.21866	2
BDbl2.v2.b	Steering sens. at 0.3 g's (deg/g's)	7.49934	4
VEHICLE	MEASURE	VALUE	C.DENSITY
BDbl2	Rearward amplification	1.15621	1



Baseline 9-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Baseline 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Better
Worse
Cargo Density (x base density)


Baseline 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Baseline 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Baseline 9-axle Double (Trailer lengths)

VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Transient offtracking (ft)	25.10889	45
BDbl2.v3.c	Transient offtracking (ft)	27.74015	48

VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	High-speed offtracking (ft)	-0.67993	45
BDbl2.v3.c	High-speed offtracking (ft)	-0.60132	48

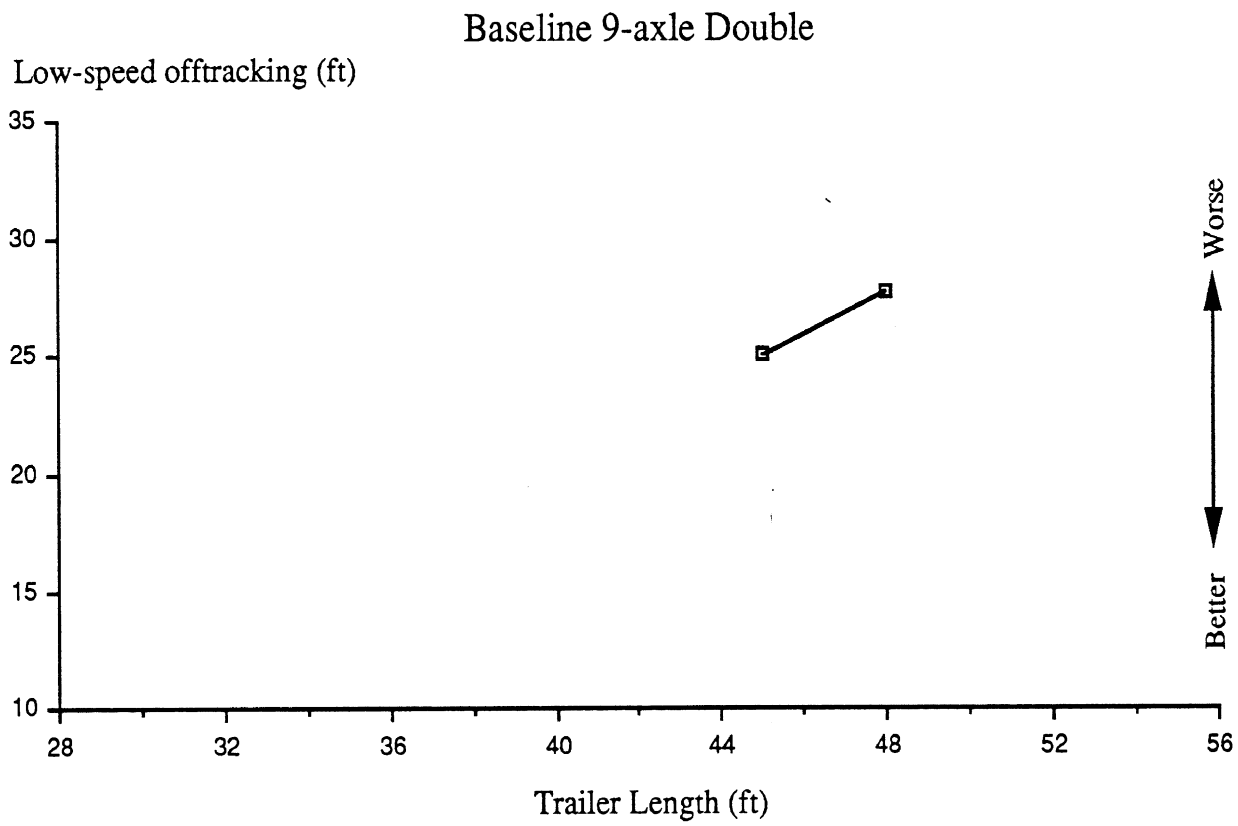
VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Braking efficiency at 0.2 g's	0.93025	45
BDbl2.v3.c	Braking efficiency at 0.2 g's	0.93021	48
BDbl2E	Braking efficiency at 0.2 g's	0.77432	45
BDbl2.v3.cE	Braking efficiency at 0.2 g's	0.78447	48

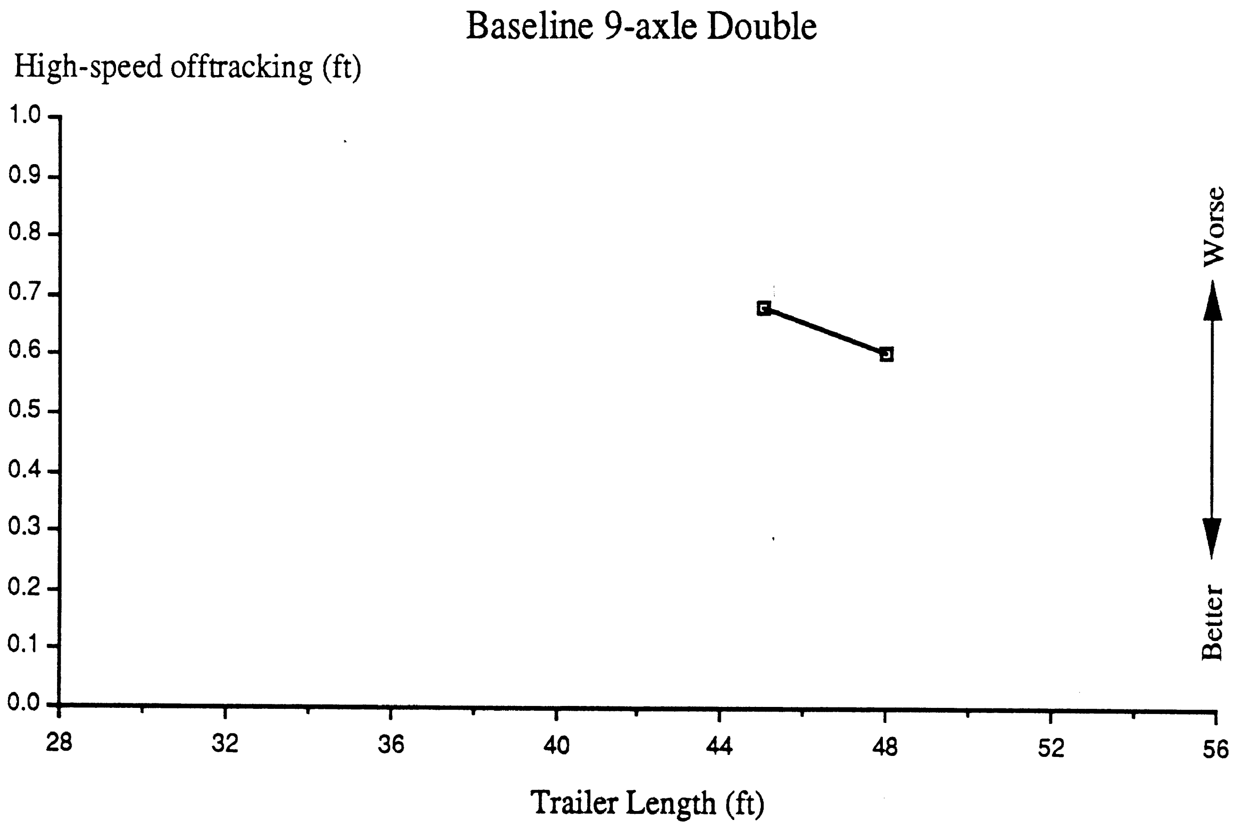
VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Braking efficiency at 0.4 g's	0.90565	45
BDbl2.v3.c	Braking efficiency at 0.4 g's	0.90112	48
BDbl2E	Braking efficiency at 0.4 g's	0.74836	45
BDbl2.v3.cE	Braking efficiency at 0.4 g's	0.75992	48

VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Static rollover threshold (g's)	0.36326	45
BDbl2.v3.c	Static rollover threshold (g's)	0.36274	48

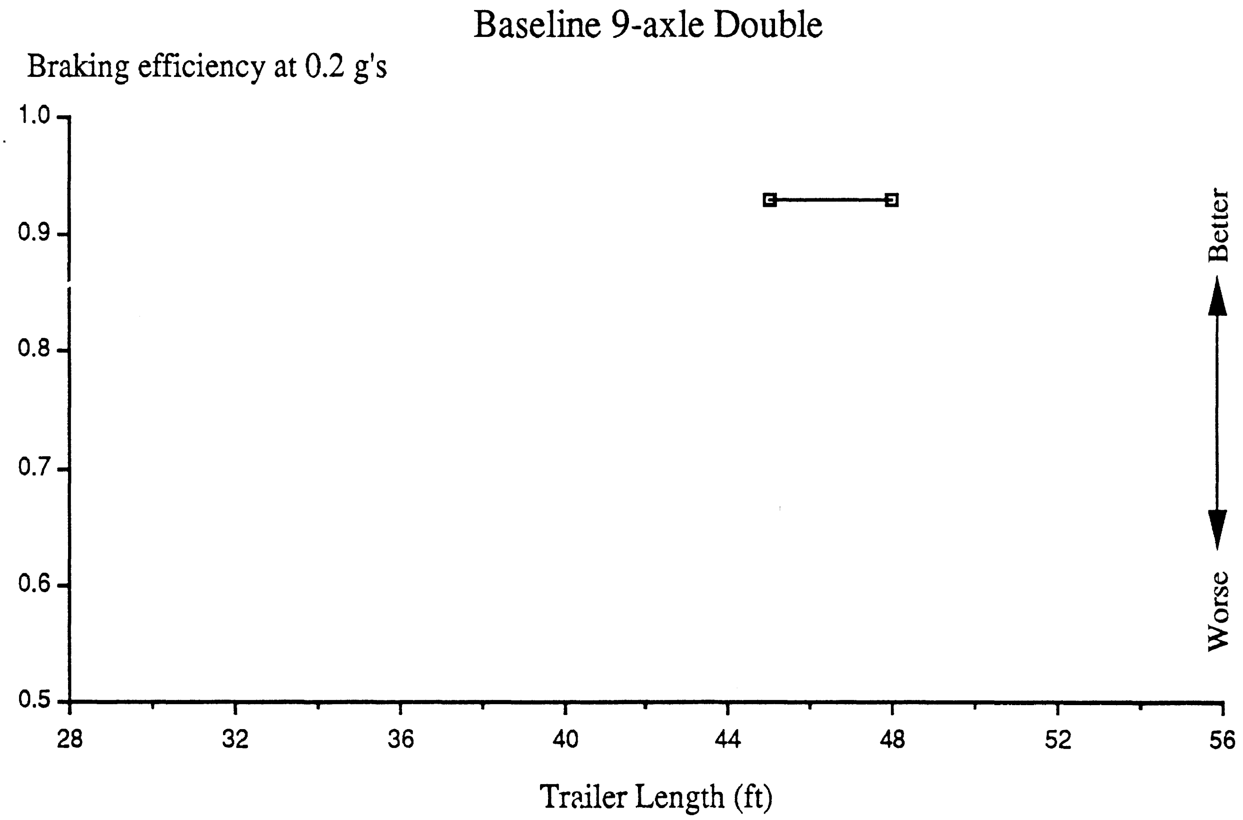
VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Steering sens. at 0.3 g's (deg/g's)	6.34247	45
BDbl2.v3.c	Steering sens. at 0.3 g's (deg/g's)	6.31366	48

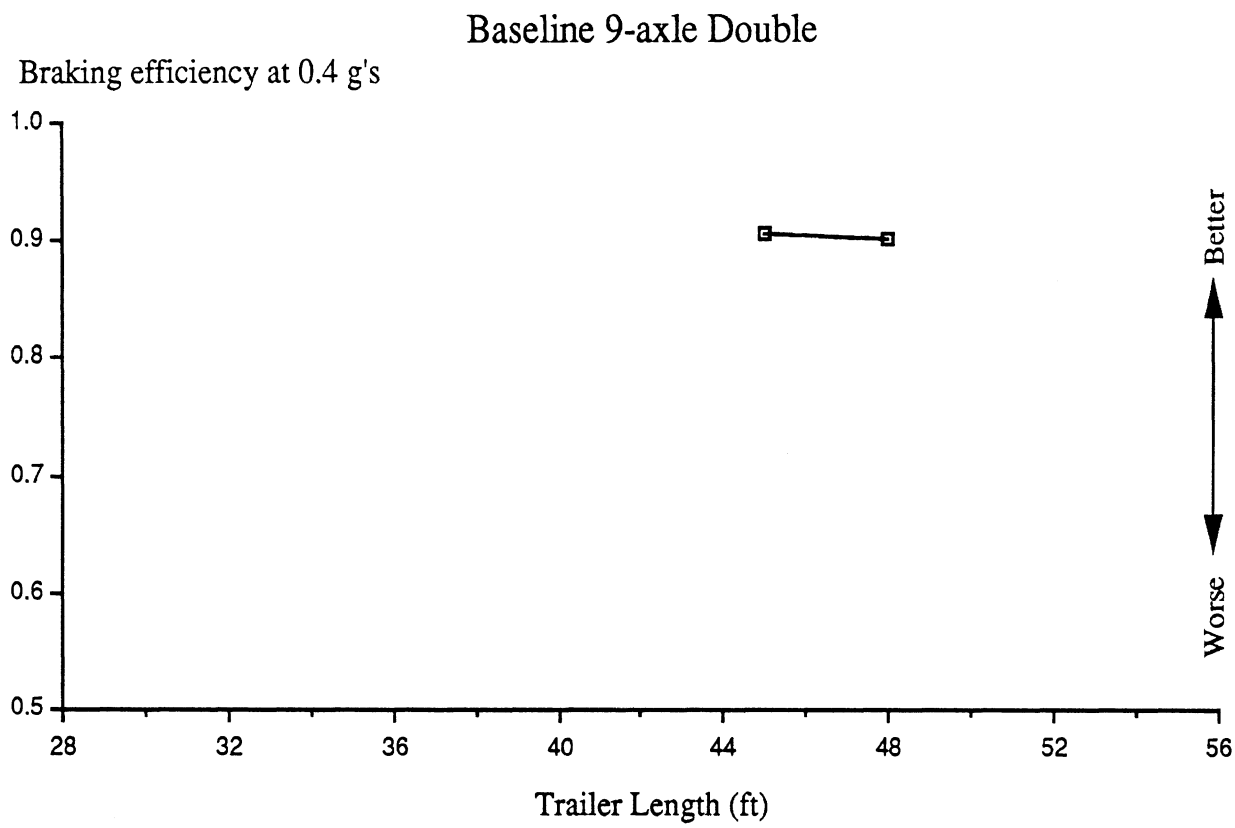
VEHICLE	MEASURE	VALUE	T.LENGTH
BDbl2	Rearward amplification	1.15621	45
BDbl2.v3.c	Rearward amplification	1.10930	48

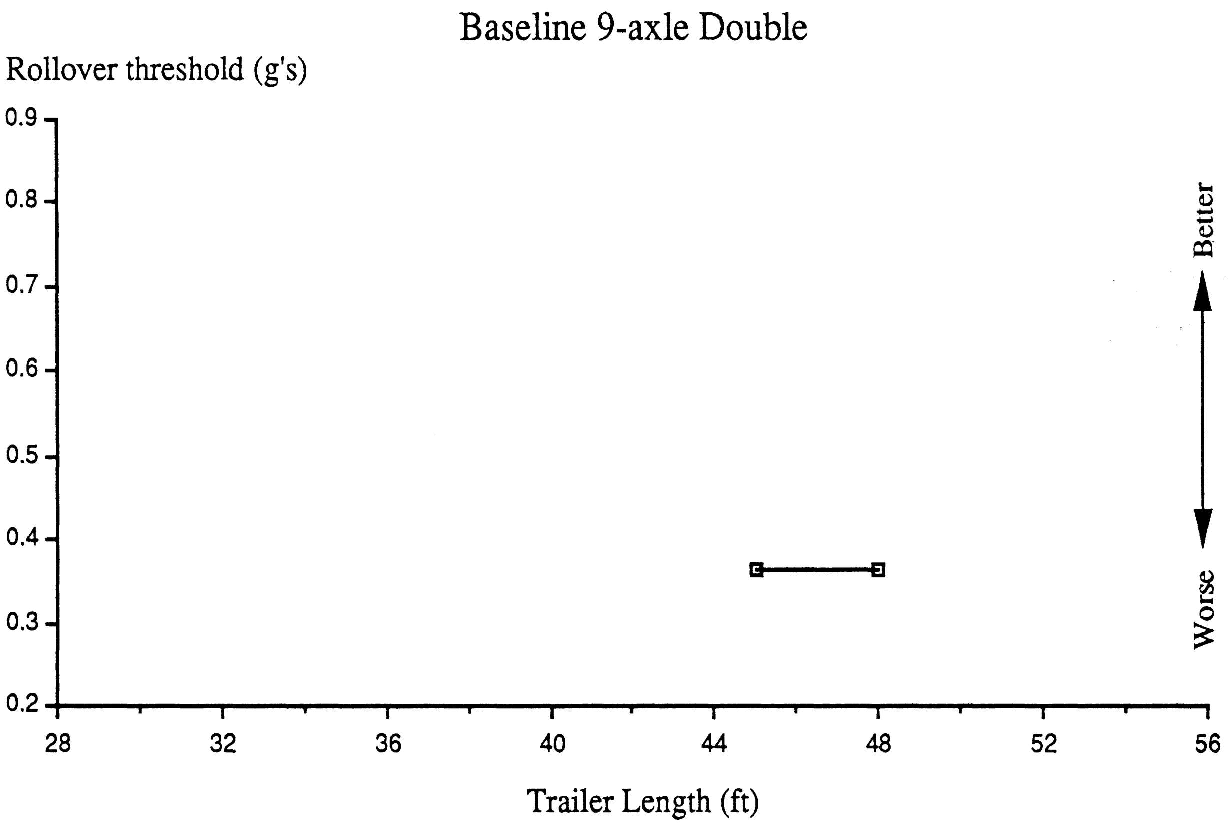

Baseline 9-axle Double
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

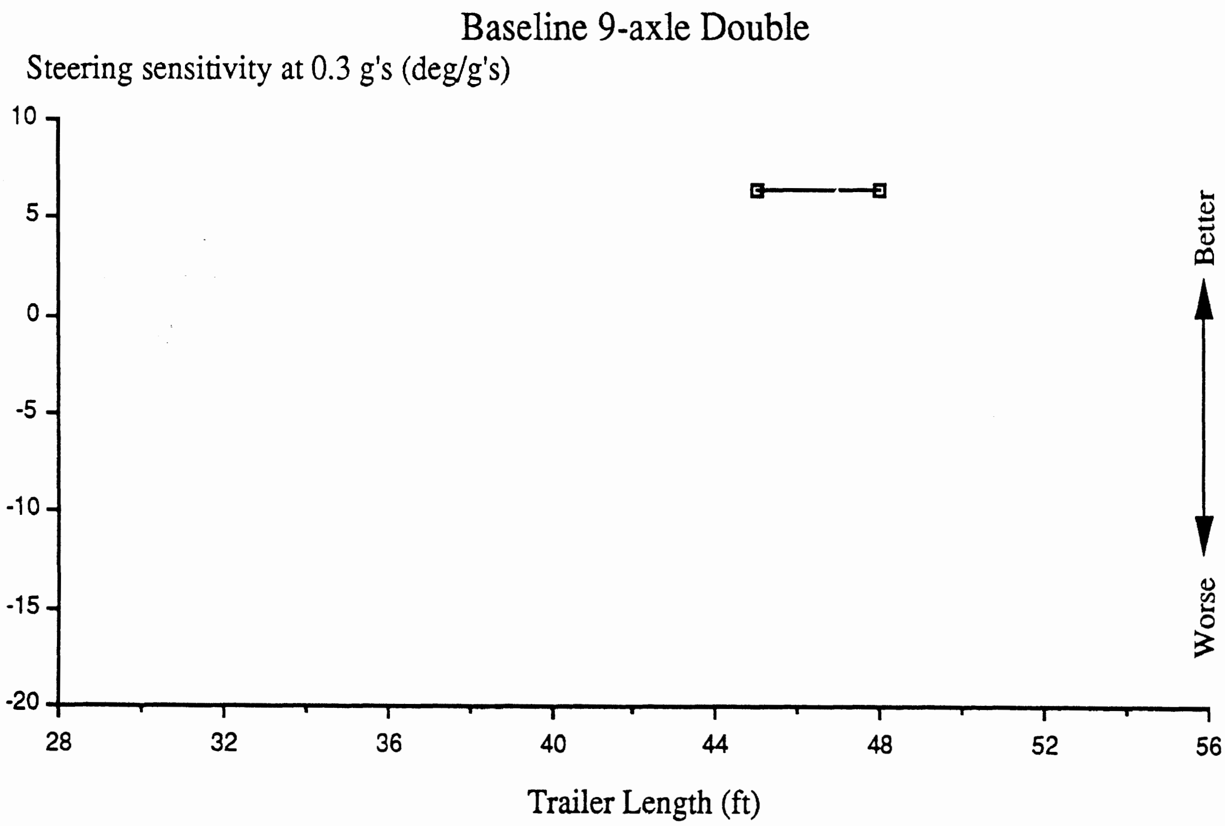


Baseline 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

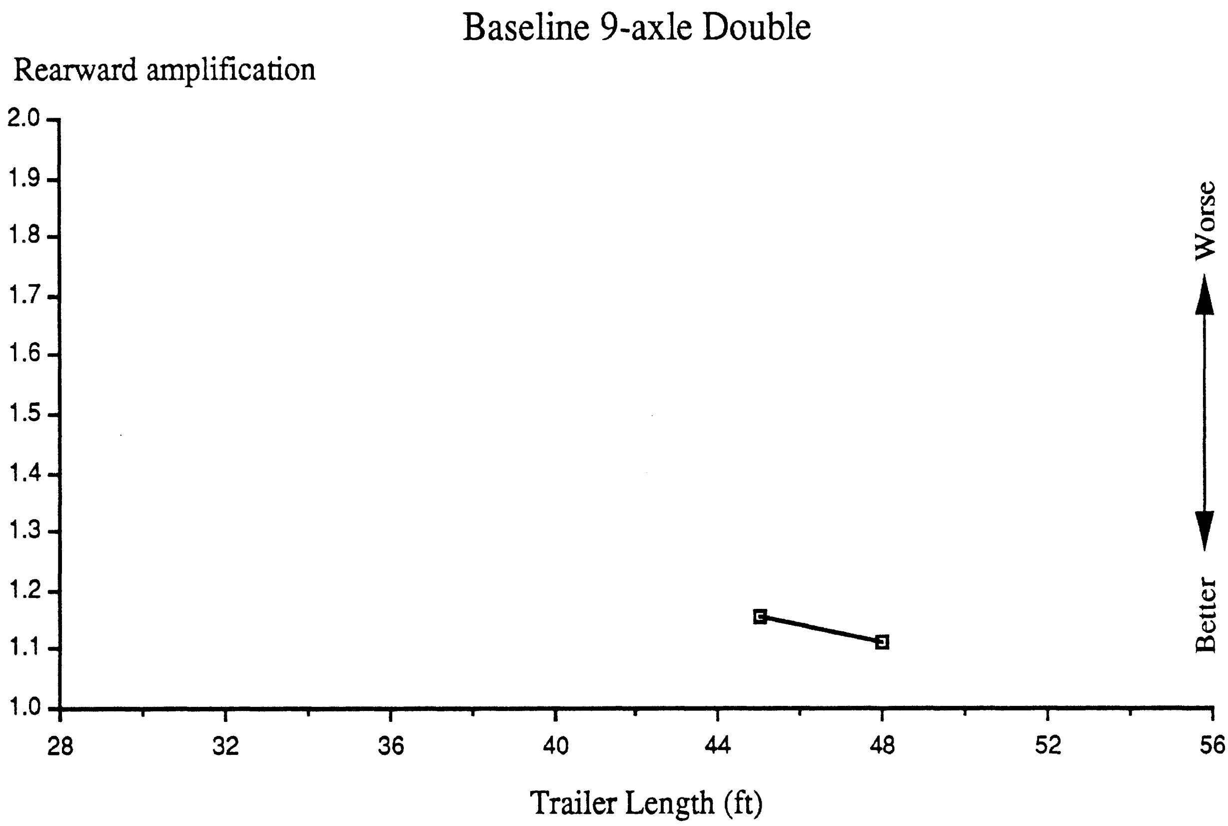

Baseline 9-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse


Baseline 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse


Baseline 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Baseline 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Baseline 9-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

Prototype Tractor-semitrailer (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
PTST	Transient offtracking (ft)	15.80906	86610

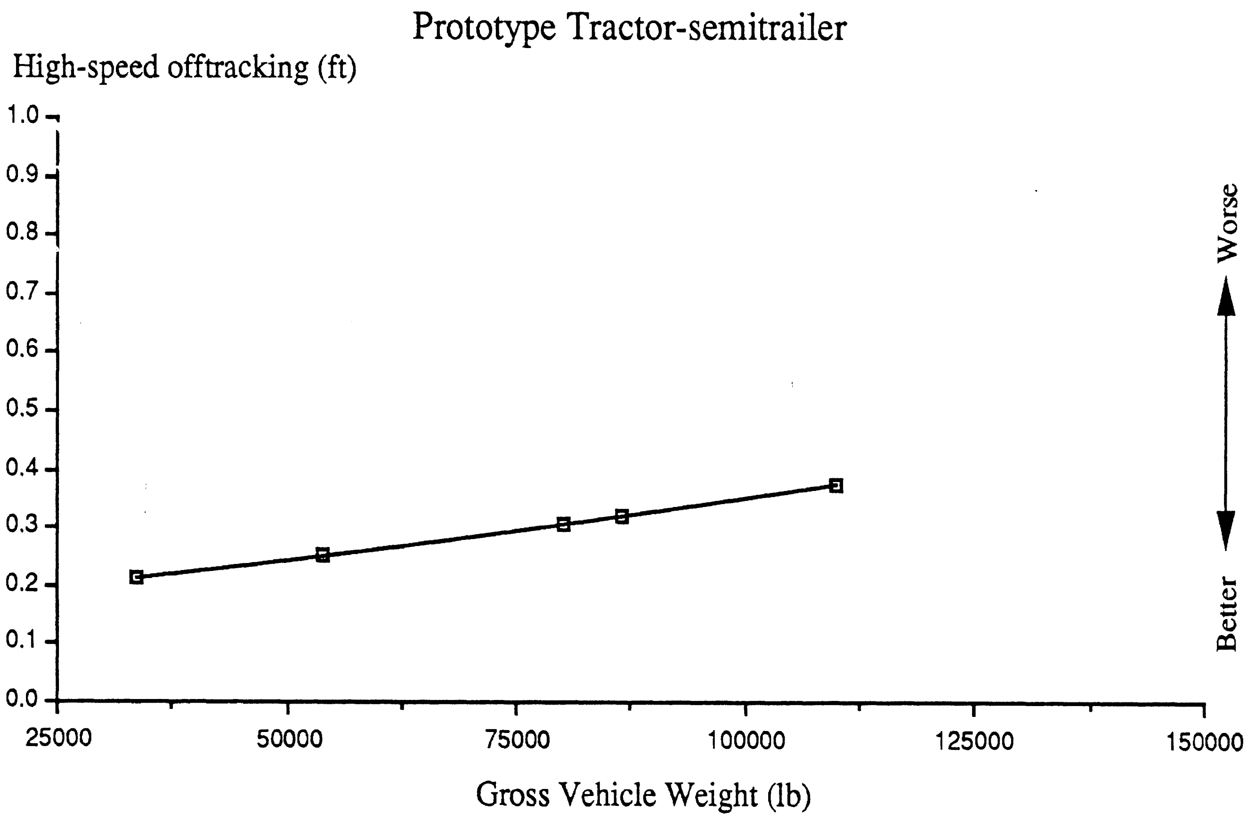
VEHICLE	MEASURE	VALUE	GVW
PTST	High-speed offtracking (ft)	-0.31934	86610
PTST.v1.a	High-speed offtracking (ft)	-0.21436	33800
PTST.v1.b	High-speed offtracking (ft)	-0.25146	53800
PTST.v1.c	High-speed offtracking (ft)	-0.30493	80000
PTST.v1.d	High-speed offtracking (ft)	-0.37463	110000

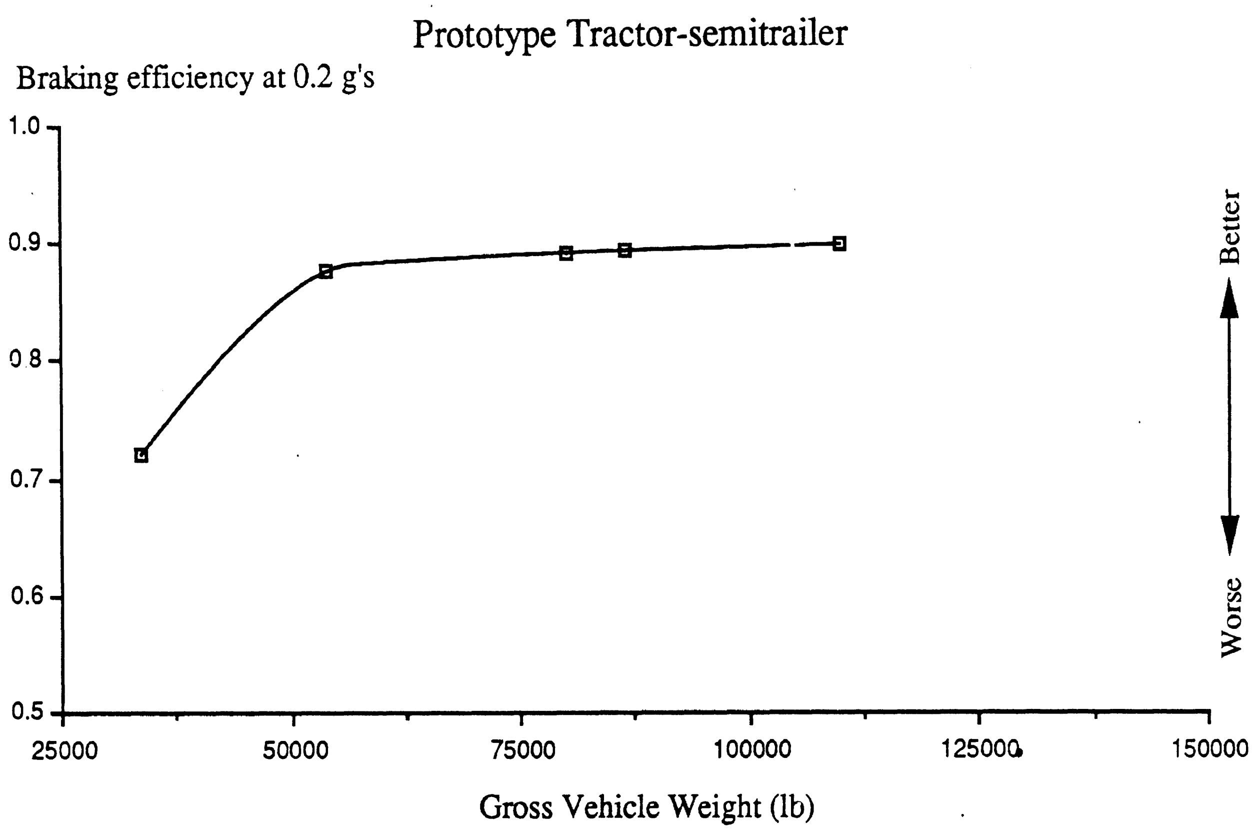
VEHICLE	MEASURE	VALUE	GVW
PTST	Braking efficiency at 0.2 g's	0.89296	86610
PTST.v1.a	Braking efficiency at 0.2 g's	0.72187	33800
PTST.v1.b	Braking efficiency at 0.2 g's	0.87522	53800
PTST.v1.c	Braking efficiency at 0.2 g's	0.89107	80000
PTST.v1.d	Braking efficiency at 0.2 g's	0.89779	110000
PTSTE	Braking efficiency at 0.2 g's	0.72187	33800

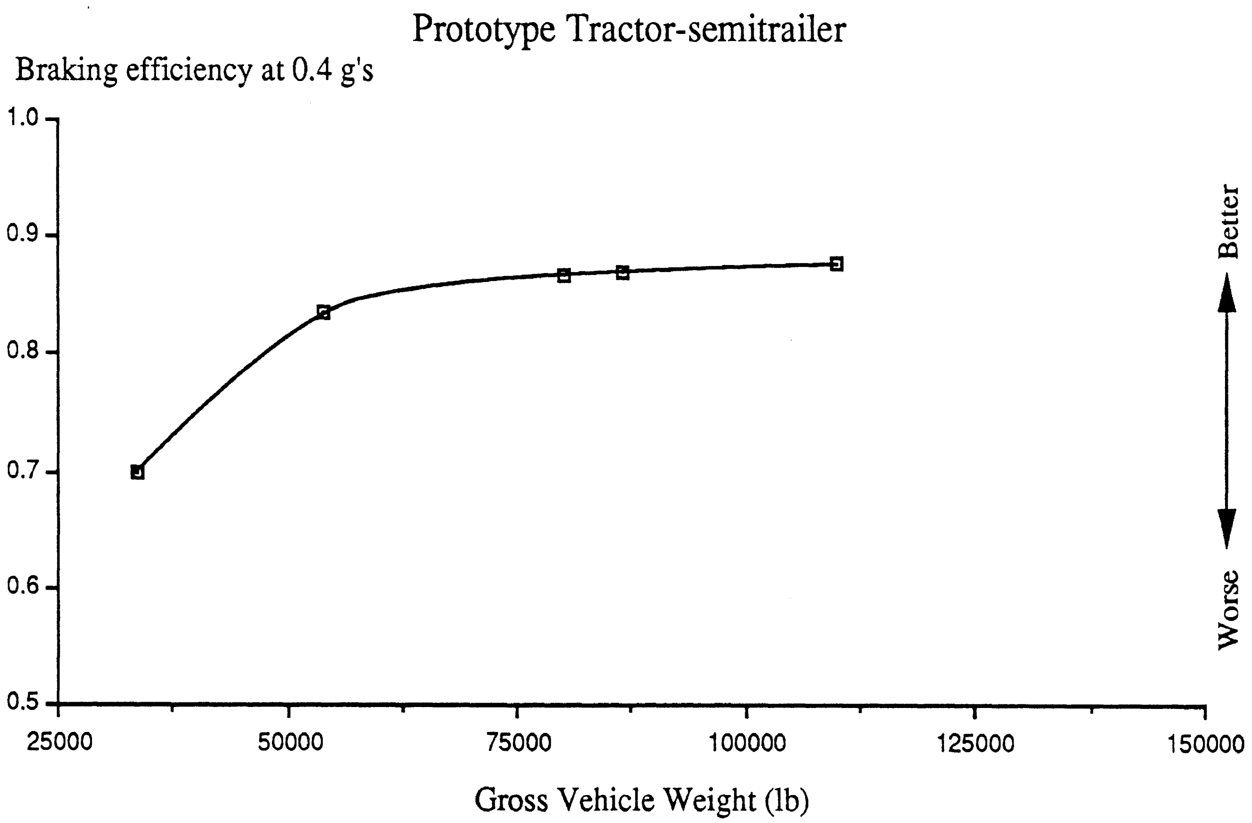
VEHICLE	MEASURE	VALUE	GVW
PTST	Braking efficiency at 0.4 g's	0.86929	86610
PTST.v1.a	Braking efficiency at 0.4 g's	0.69937	33800
PTST.v1.b	Braking efficiency at 0.4 g's	0.83416	53800
PTST.v1.c	Braking efficiency at 0.4 g's	0.86669	80000
PTST.v1.d	Braking efficiency at 0.4 g's	0.87594	110000
PTSTE	Braking efficiency at 0.4 g's	0.69937	33800

VEHICLE	MEASURE	VALUE	GVW
PTST	Static rollover threshold (g's)	0.37573	86610
PTST.v1.a	Static rollover threshold (g's)	0.75892	33800
PTST.v1.b	Static rollover threshold (g's)	0.48269	53800
PTST.v1.c	Static rollover threshold (g's)	0.38968	80000
PTST.v1.d	Static rollover threshold (g's)	0.33346	110000

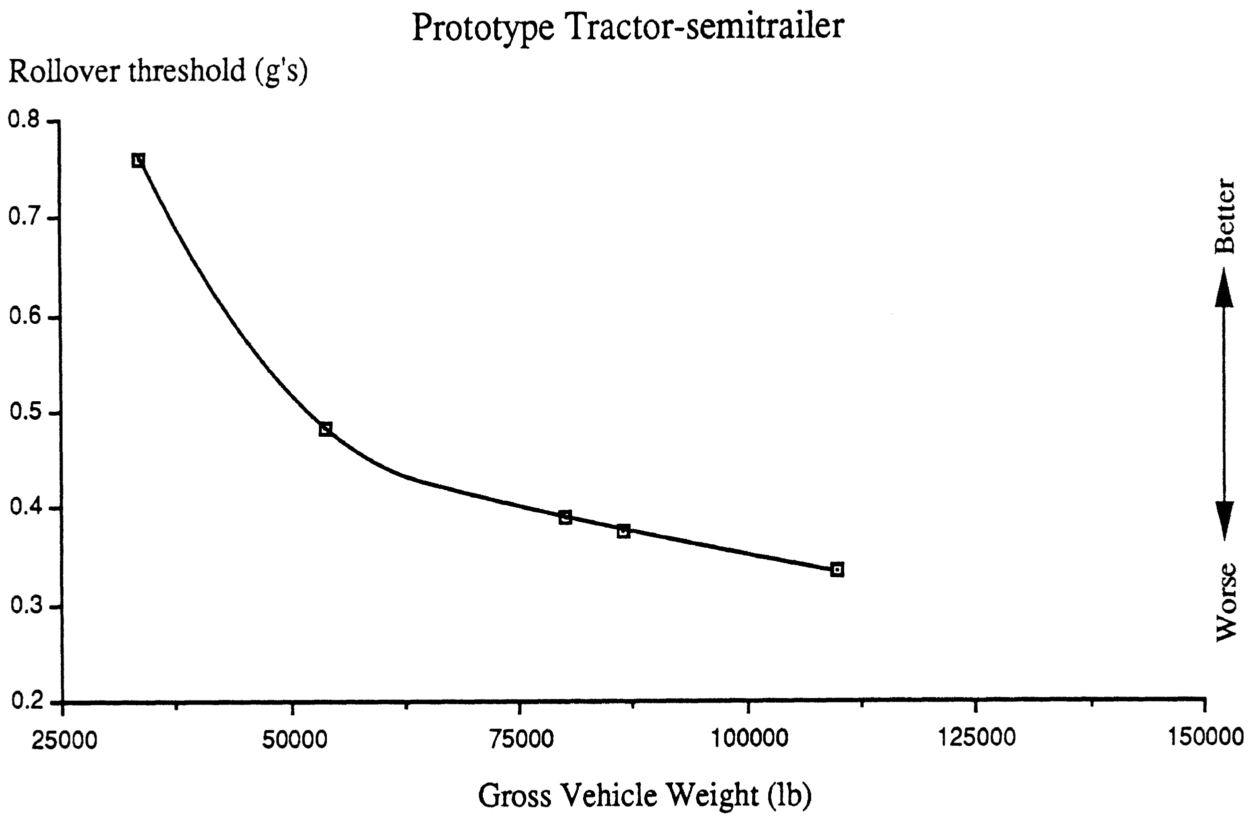
VEHICLE	MEASURE	VALUE	GVW
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	86610
PTST.v1.a	Steering sens. at 0.3 g's (deg/g's)	8.67221	33800
PTST.v1.b	Steering sens. at 0.3 g's (deg/g's)	8.86111	53800
PTST.v1.c	Steering sens. at 0.3 g's (deg/g's)	8.55695	80000
PTST.v1.d	Steering sens. at 0.3 g's (deg/g's)	6.95399	110000

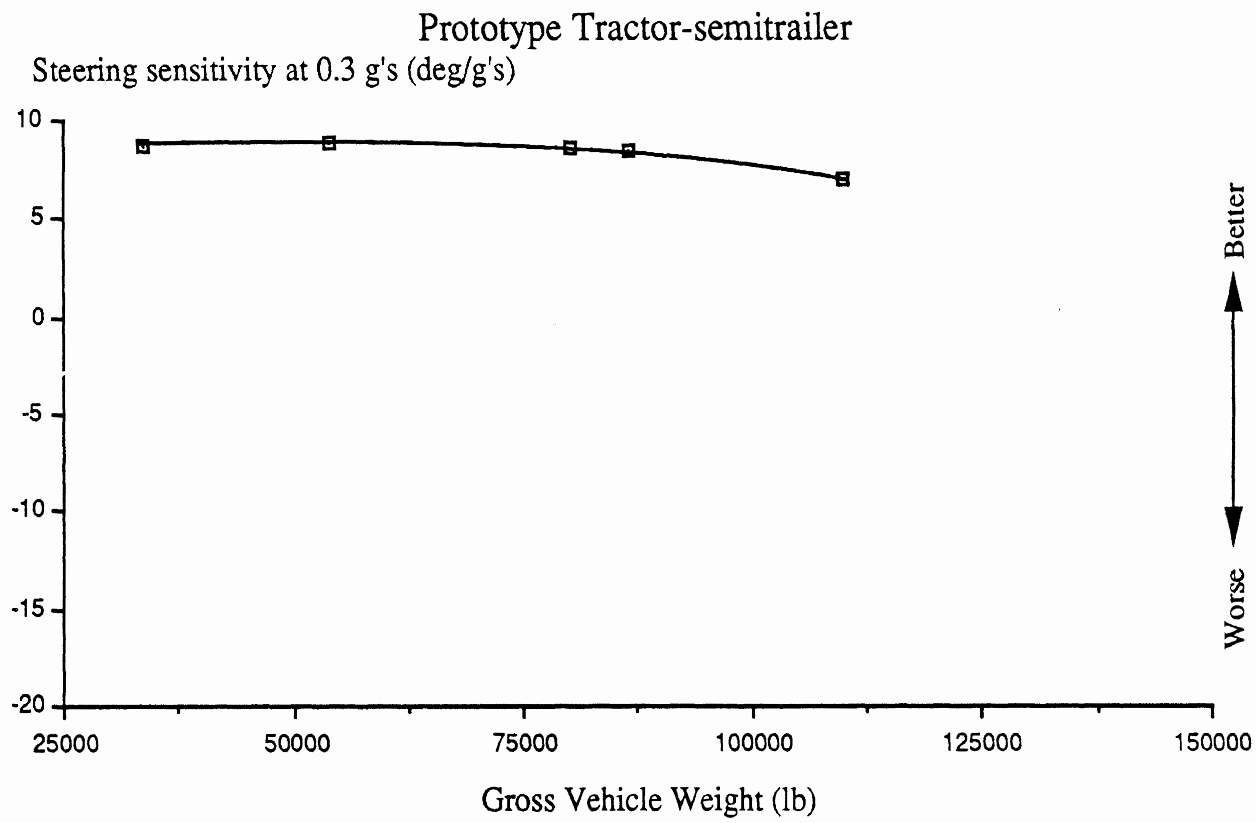

Prototype Tractor-semitrailer
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better


Prototype Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Prototype Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse


Prototype Tractor-semitrailer
Rollover threshold (g's)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Prototype Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

Prototype Tractor-semitrailer (Cargo density)

VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	Transient offtracking (ft)	15.80906	1

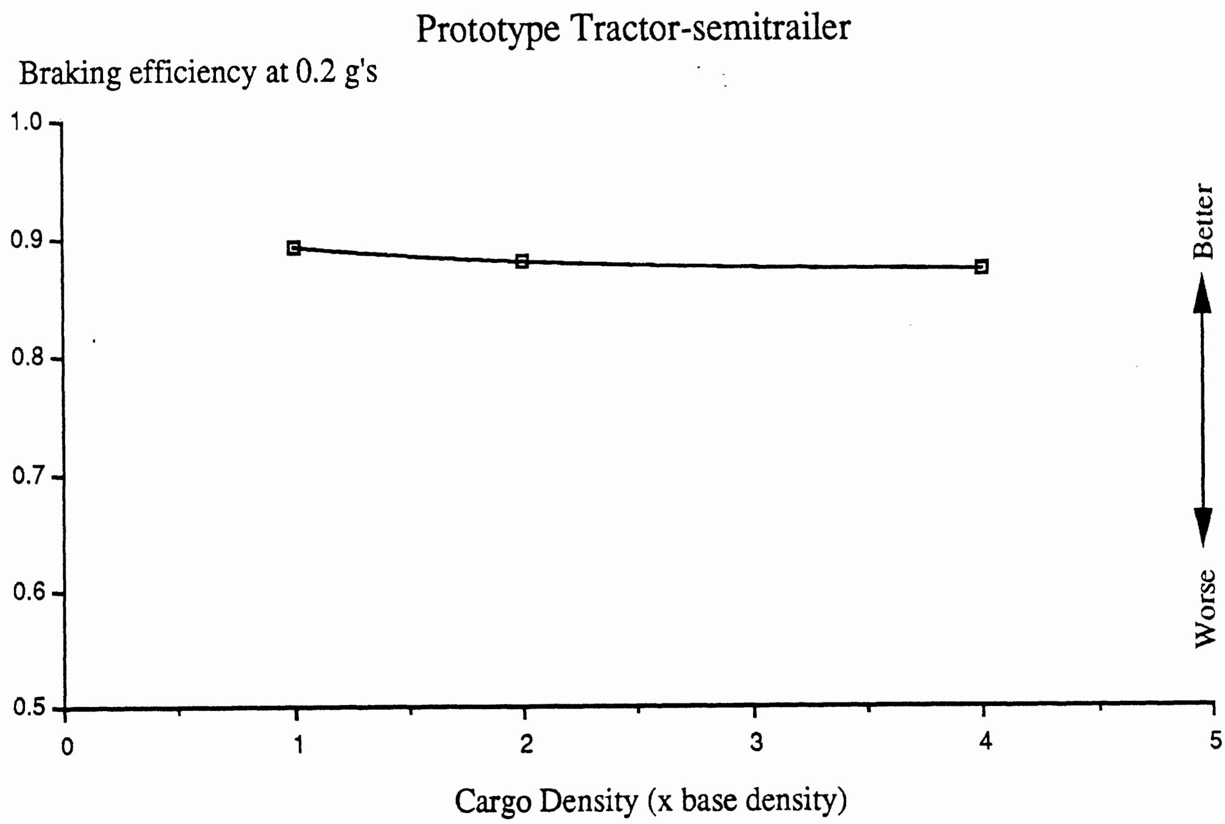
VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	High-speed offtracking (ft)	-0.31934	1

VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	Braking efficiency at 0.2 g's	0.89296	1
PTST.v2.a	Braking efficiency at 0.2 g's	0.88011	2
PTST.v2.b	Braking efficiency at 0.2 g's	0.87368	4
PTSTE	Braking efficiency at 0.2 g's	0.72187	1

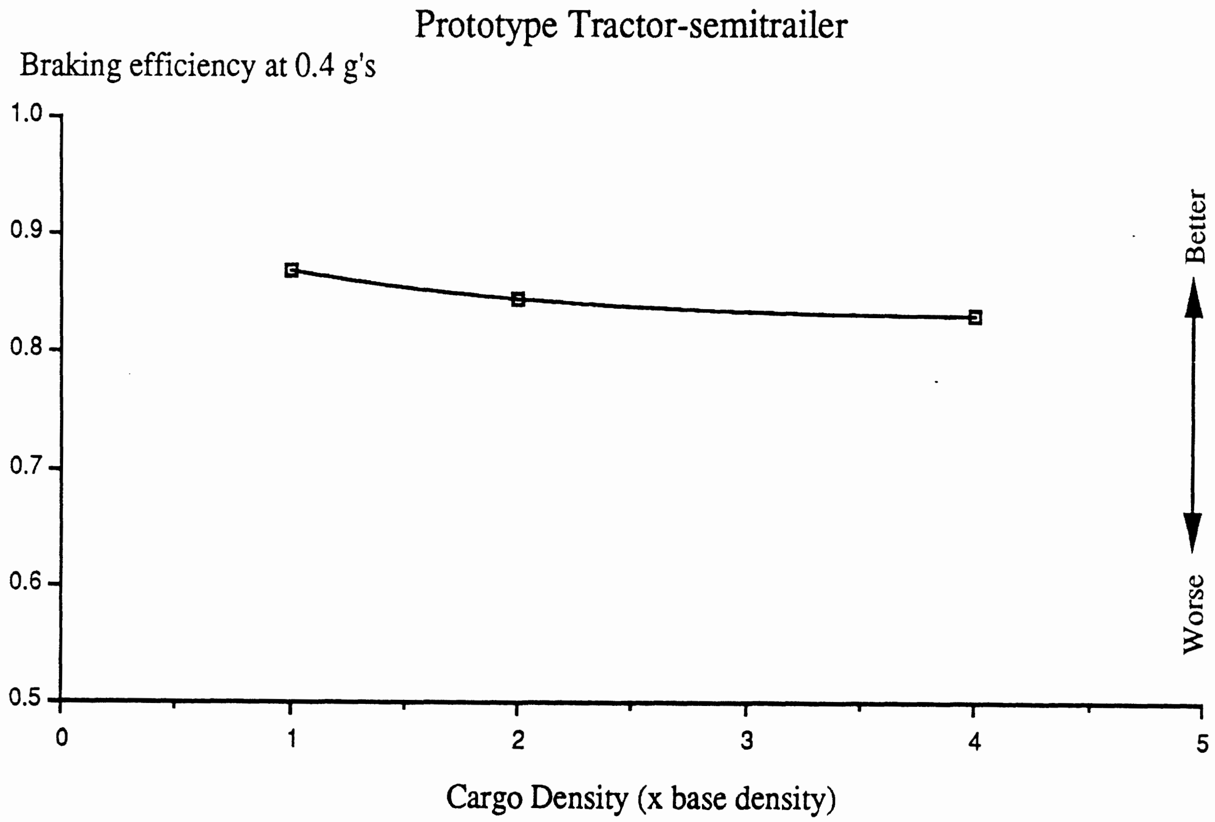
VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	Braking efficiency at 0.4 g's	0.86929	1
PTST.v2.a	Braking efficiency at 0.4 g's	0.84359	2
PTST.v2.b	Braking efficiency at 0.4 g's	0.83074	4
PTSTE	Braking efficiency at 0.4 g's	0.69937	1

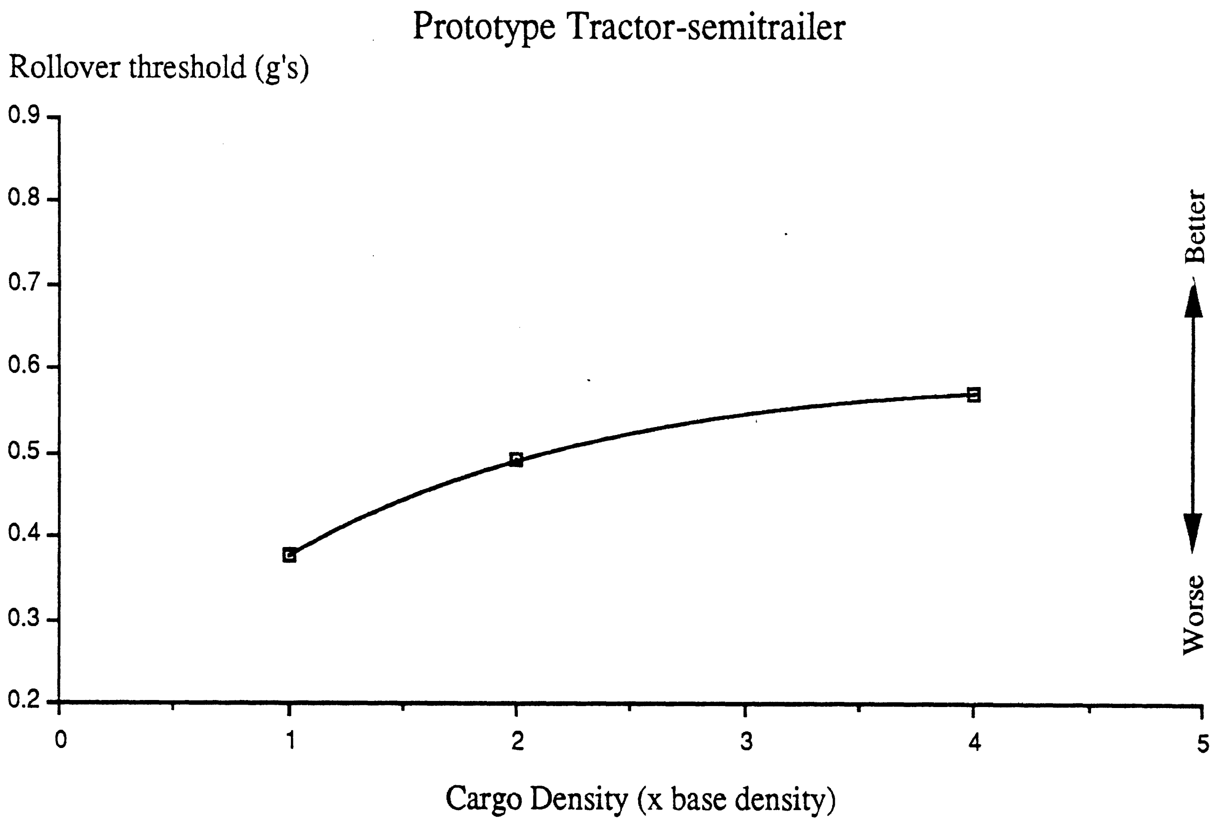
VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	Static rollover threshold (g's)	0.37573	1
PTST.v2.a	Static rollover threshold (g's)	0.49088	2
PTST.v2.b	Static rollover threshold (g's)	0.57116	4

VEHICLE	MEASURE	VALUE	C.DENSITY
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	1
PTST.v2.a	Steering sens. at 0.3 g's (deg/g's)	9.10763	2
PTST.v2.b	Steering sens. at 0.3 g's (deg/g's)	9.35736	4

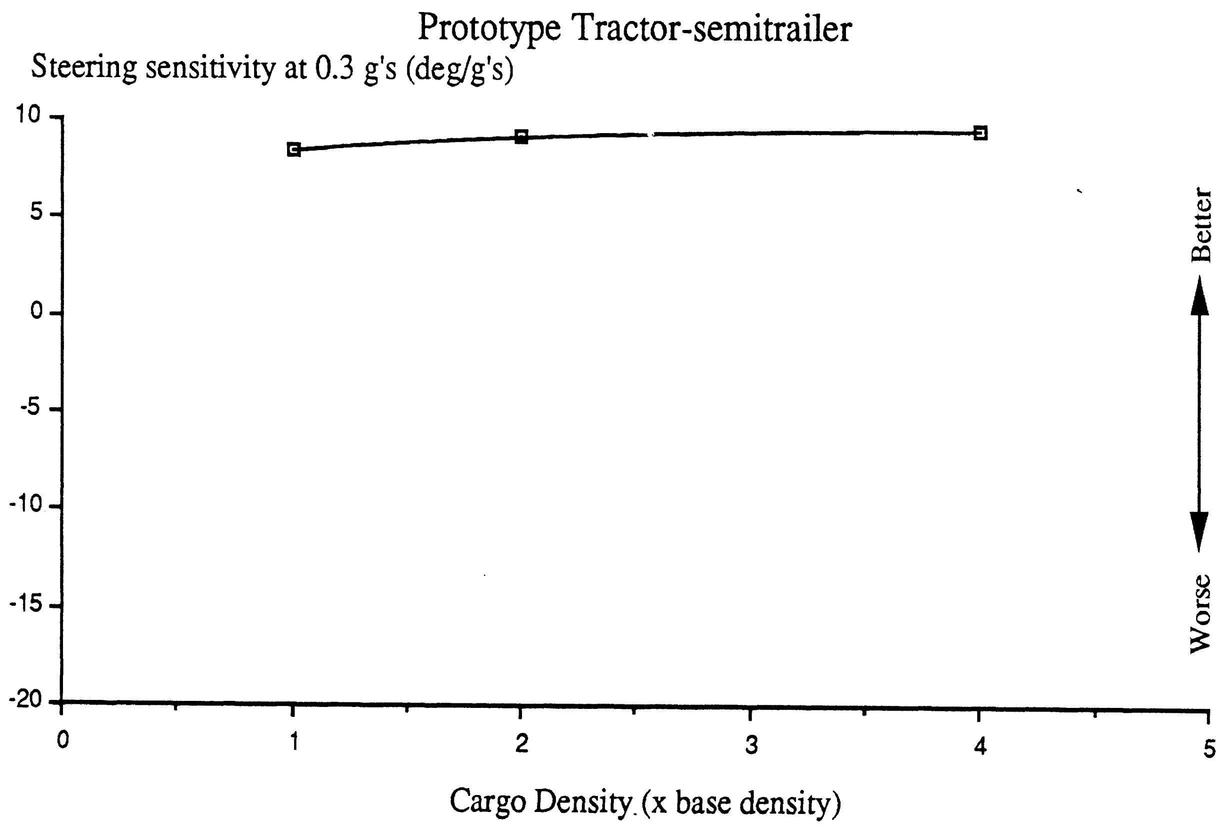


Prototype Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Prototype Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Prototype Tractor-semitrailer
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Prototype Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Prototype Tractor-semitrailer (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	Transient offtracking (ft)	15.80906	48
PTST.v3.d	Transient offtracking (ft)	18.58075	53

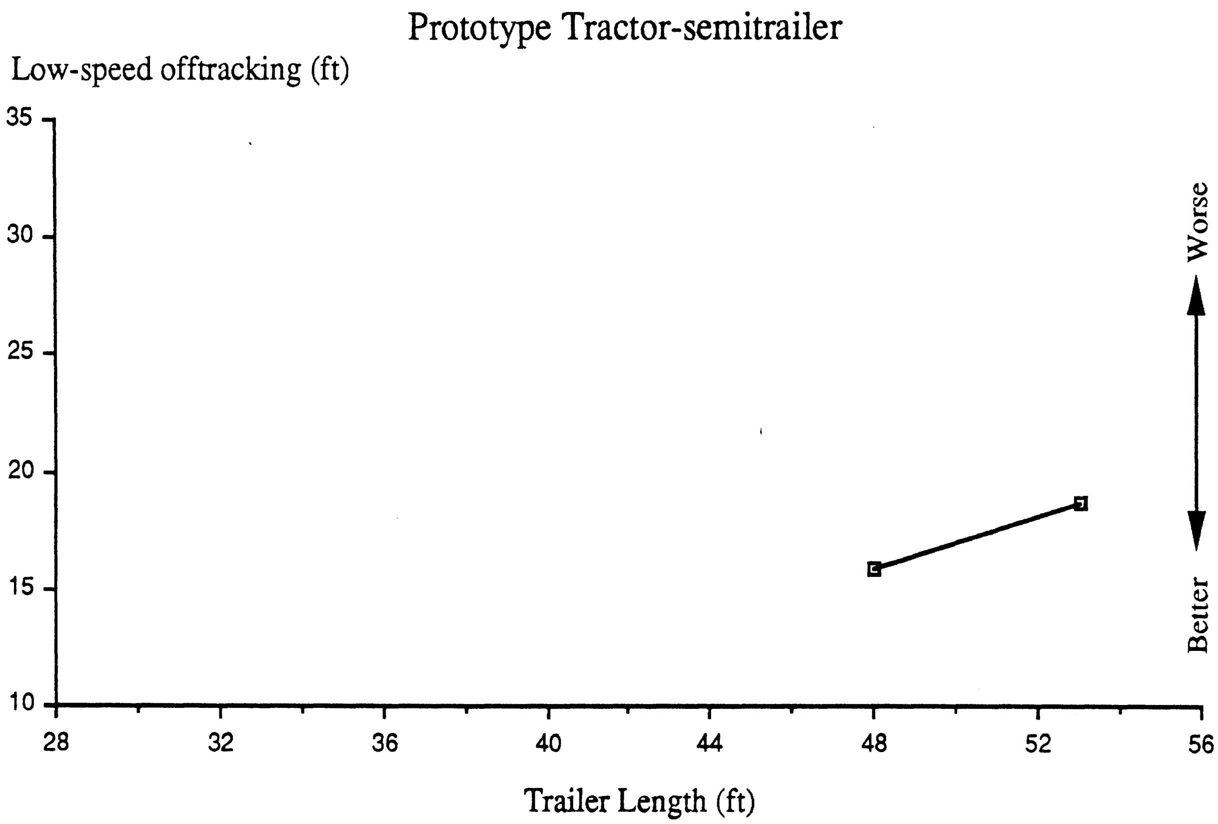
VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	High-speed offtracking (ft)	-0.31934	48
PTST.v3.d	High-speed offtracking (ft)	-0.23828	53

VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	Braking efficiency at 0.2 g's	0.89296	48
PTST.v3.d	Braking efficiency at 0.2 g's	0.89467	53
PTSTE	Braking efficiency at 0.2 g's	0.72187	48
PTST.v3.dE	Braking efficiency at 0.2 g's	0.73693	53

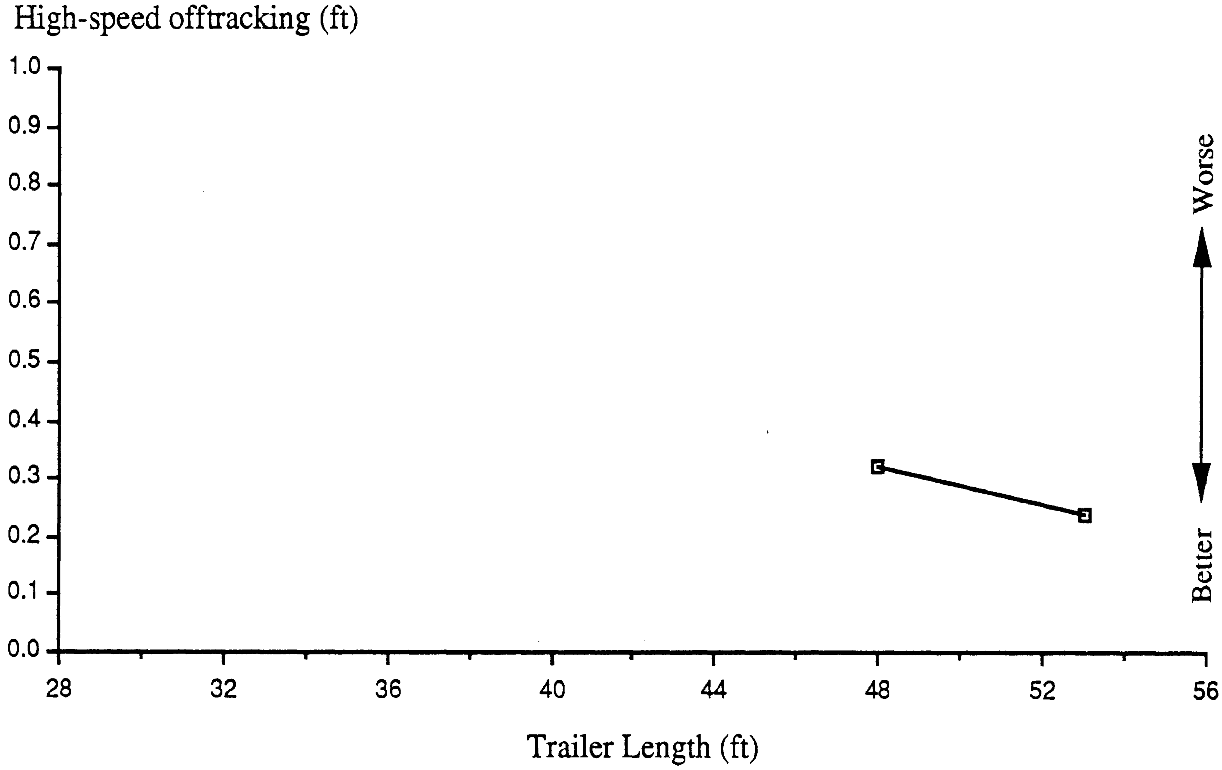
VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	Braking efficiency at 0.4 g's	0.86929	48
PTST.v3.d	Braking efficiency at 0.4 g's	0.86520	53
PTSTE	Braking efficiency at 0.4 g's	0.69937	48
PTST.v3.dE	Braking efficiency at 0.4 g's	0.71633	53

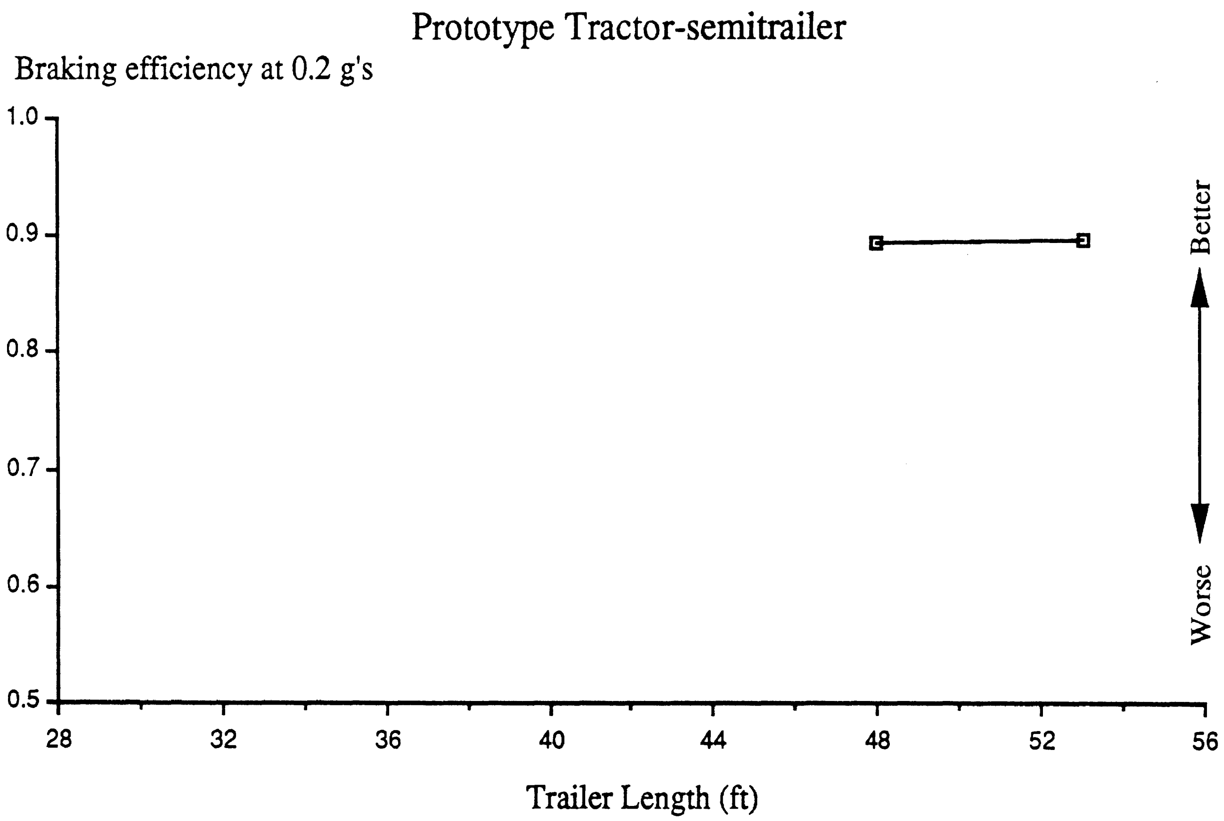
VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	Static rollover threshold (g's)	0.37573	48
PTST.v3.d	Static rollover threshold (g's)	0.37484	53

VEHICLE	MEASURE	VALUE	T.LENGTH
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	48
PTST.v3.d	Steering sens. at 0.3 g's (deg/g's)	8.36058	53

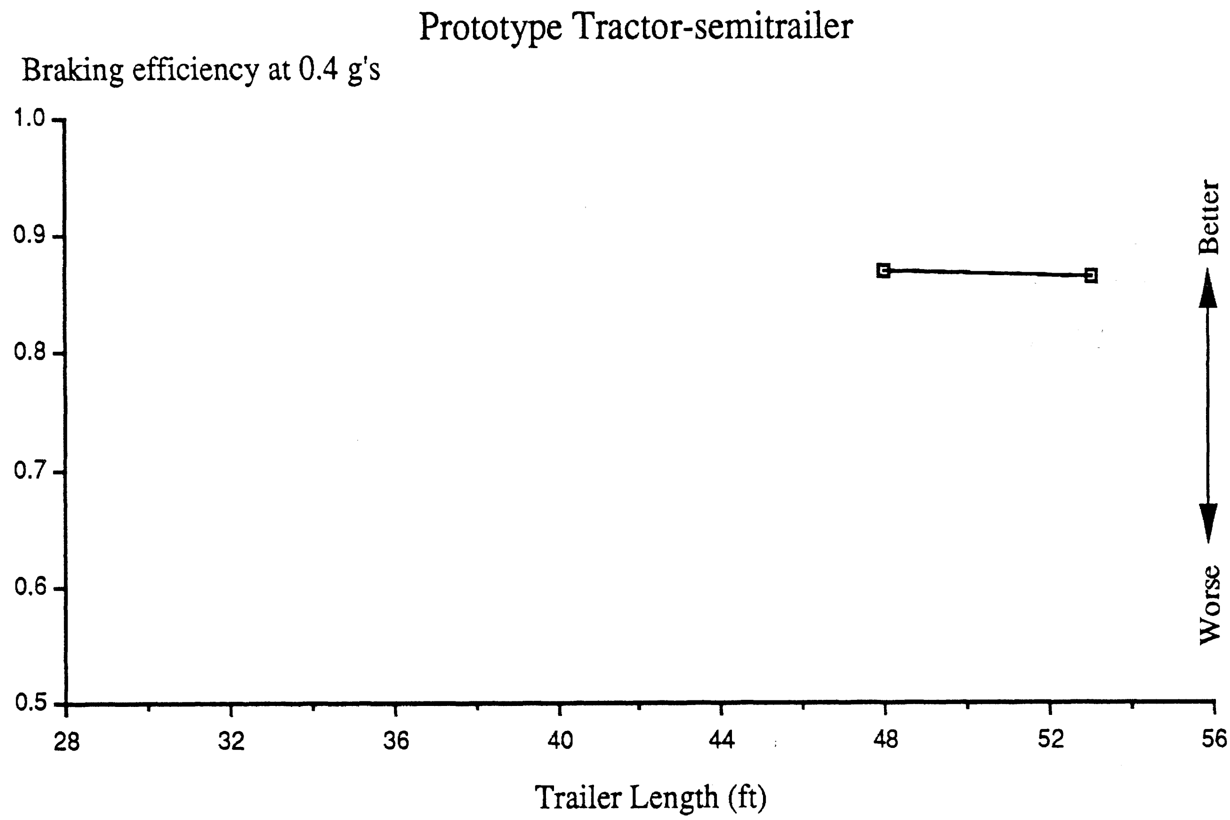

Prototype Tractor-semitrailer
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

Prototype Tractor-semitrailer



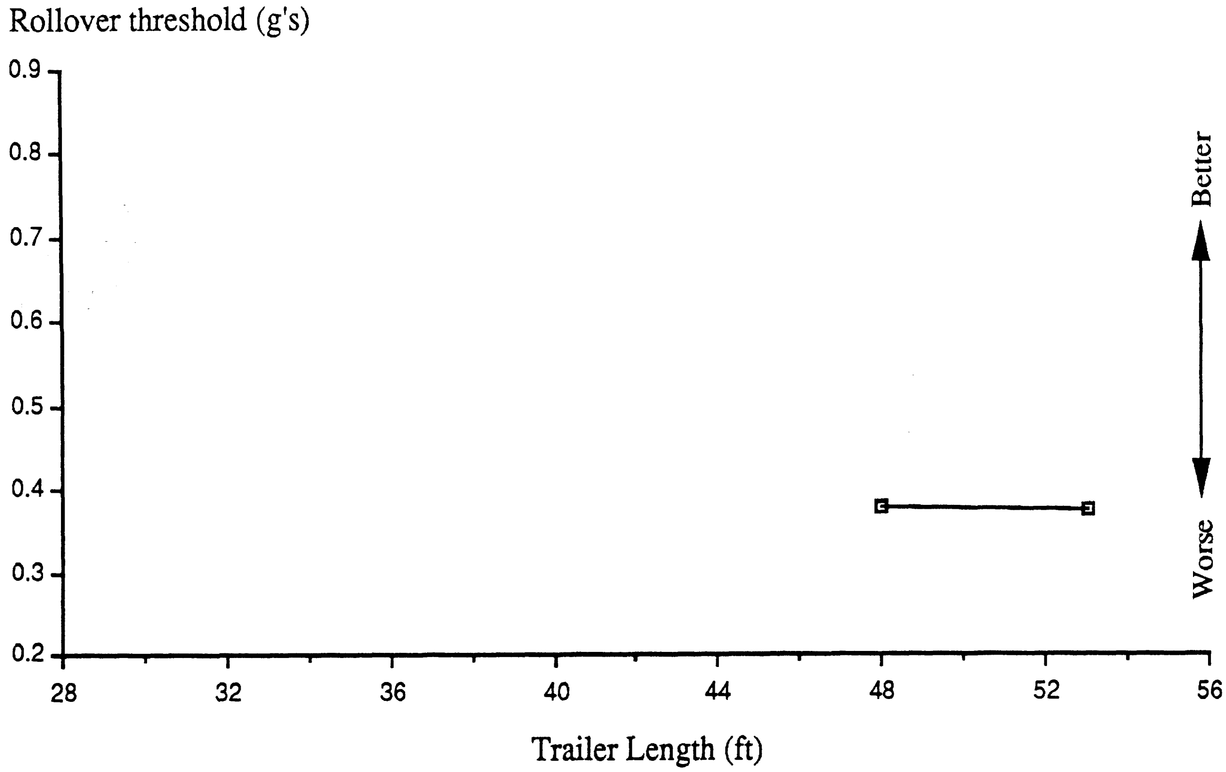


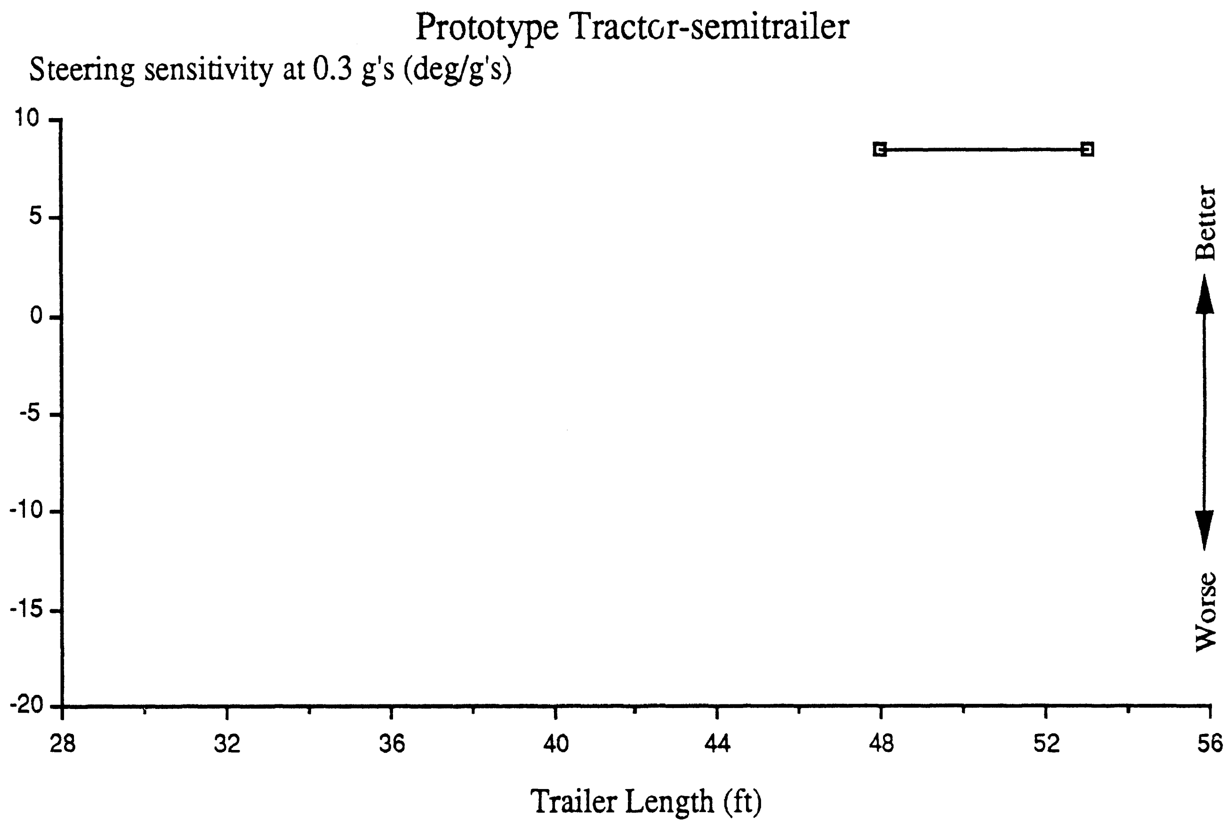
Prototype Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Prototype Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

Prototype Tractor-semitrailer

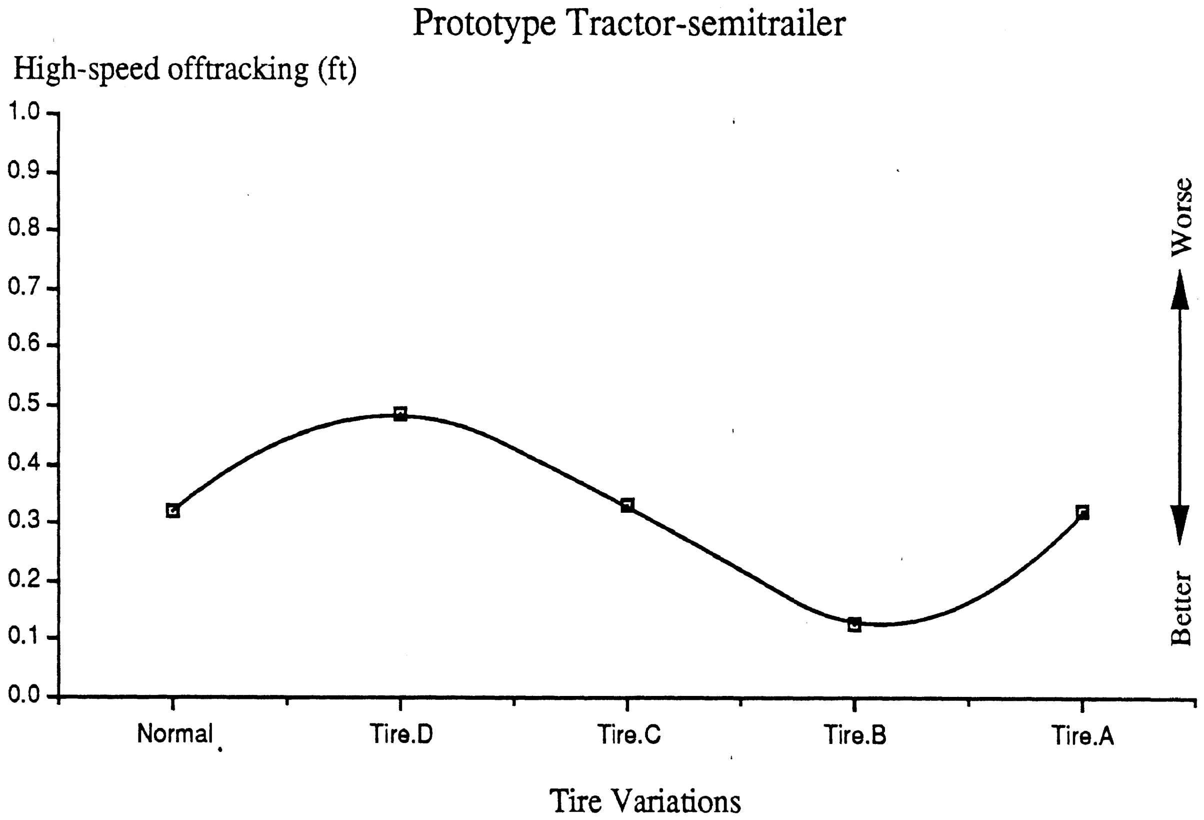


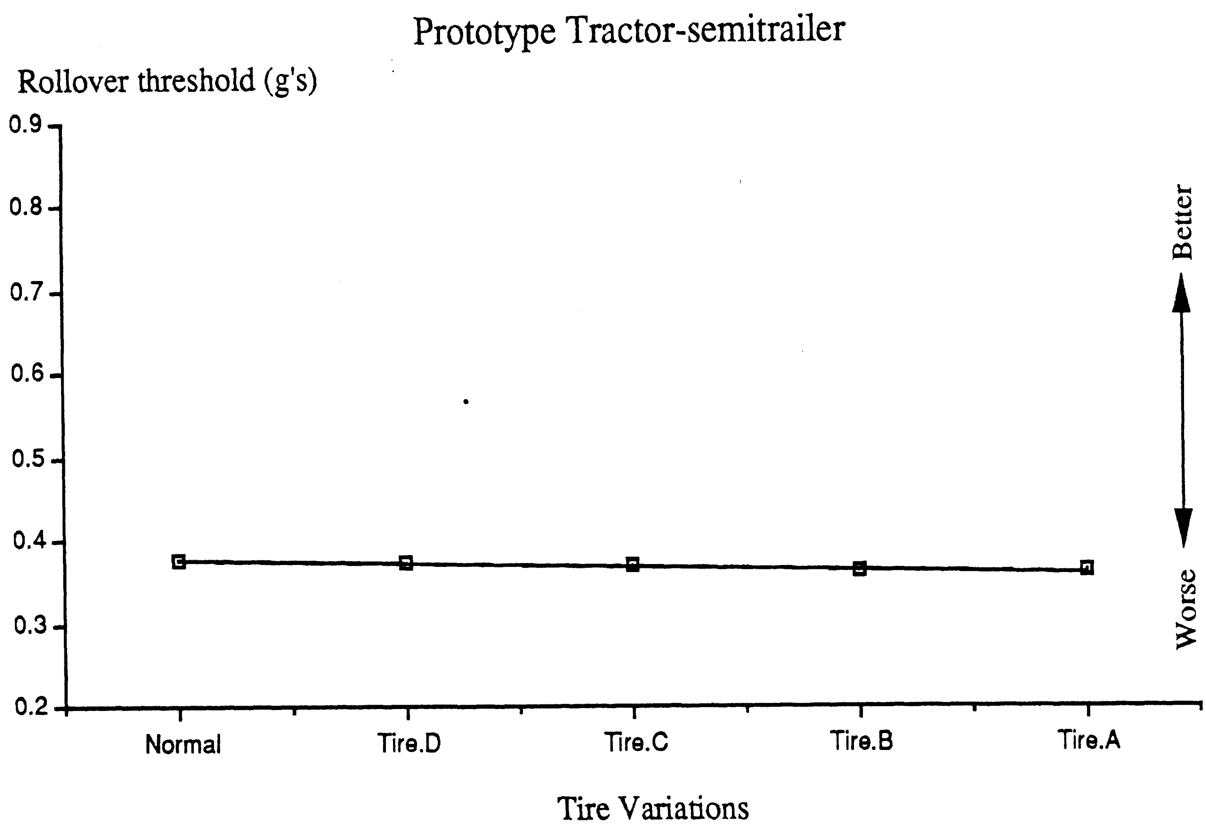


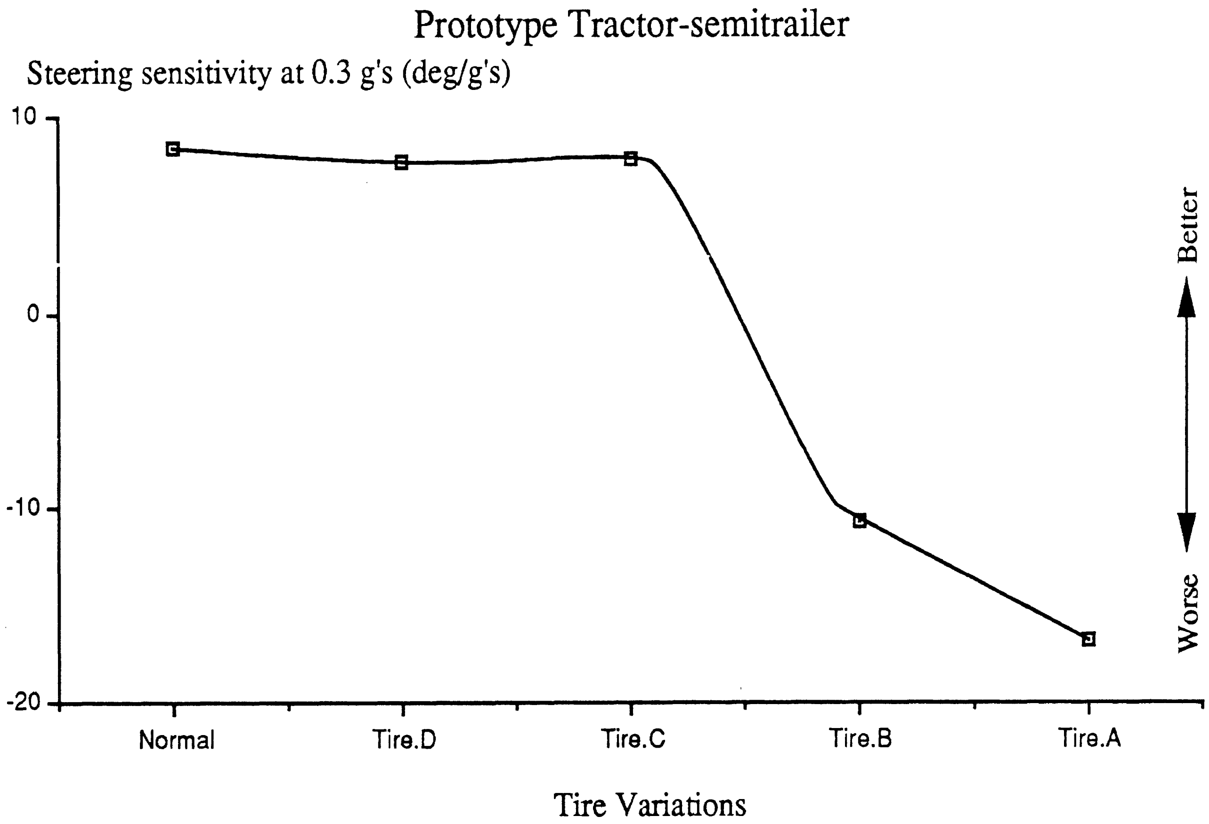
Prototype Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

Prototype Tractor-semitrailer (Wide-base single tires)

VEHICLE	MEASURE	VALUE	TIRES
PTST	Transient offtracking (ft)	15.80906	Normal
VEHICLE	MEASURE	VALUE	TIRES
PTST	High-speed offtracking (ft)	-0.31934	Normal
PTST.v5.a	High-speed offtracking (ft)	-0.32214	Tire.A
PTST.v5.b	High-speed offtracking (ft)	-0.12451	Tire.B
PTST.v5.c	High-speed offtracking (ft)	-0.33252	Tire.C
PTST.v5.d	High-speed offtracking (ft)	-0.48755	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PTST	Braking efficiency at 0.2 g's	0.89296	Normal
PTSTE	Braking efficiency at 0.2 g's	0.72187	Normal
VEHICLE	MEASURE	VALUE	TIRES
PTST	Braking efficiency at 0.4 g's	0.86929	Normal
PTSTE	Braking efficiency at 0.4 g's	0.69937	Normal
VEHICLE	MEASURE	VALUE	TIRES
PTST	Static rollover threshold (g's)	0.37573	Normal
PTST.v5.a	Static rollover threshold (g's)	0.36205	Tire.A
PTST.v5.b	Static rollover threshold (g's)	0.36205	Tire.B
PTST.v5.c	Static rollover threshold (g's)	0.37129	Tire.C
PTST.v5.d	Static rollover threshold (g's)	0.37041	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	Normal
PTST.v5.a	Steering sens. at 0.3 g's (deg/g's)	-16.82095	Tire.A
PTST.v5.b	Steering sens. at 0.3 g's (deg/g's)	-10.71166	Tire.B
PTST.v5.c	Steering sens. at 0.3 g's (deg/g's)	7.83338	Tire.C
PTST.v5.d	Steering sens. at 0.3 g's (deg/g's)	7.72665	Tire.D


Prototype Tractor-semitrailer
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Worse
Better


Prototype Tractor-semitrailer
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Better
Worse
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations


Prototype Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
0
-10
-20
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Better
Worse

Prototype Tractor-semitrailer (Suspensions)

VEHICLE	MEASURE	VALUE	SUSP.
PTST	Transient offtracking (ft)	15.80906	Normal

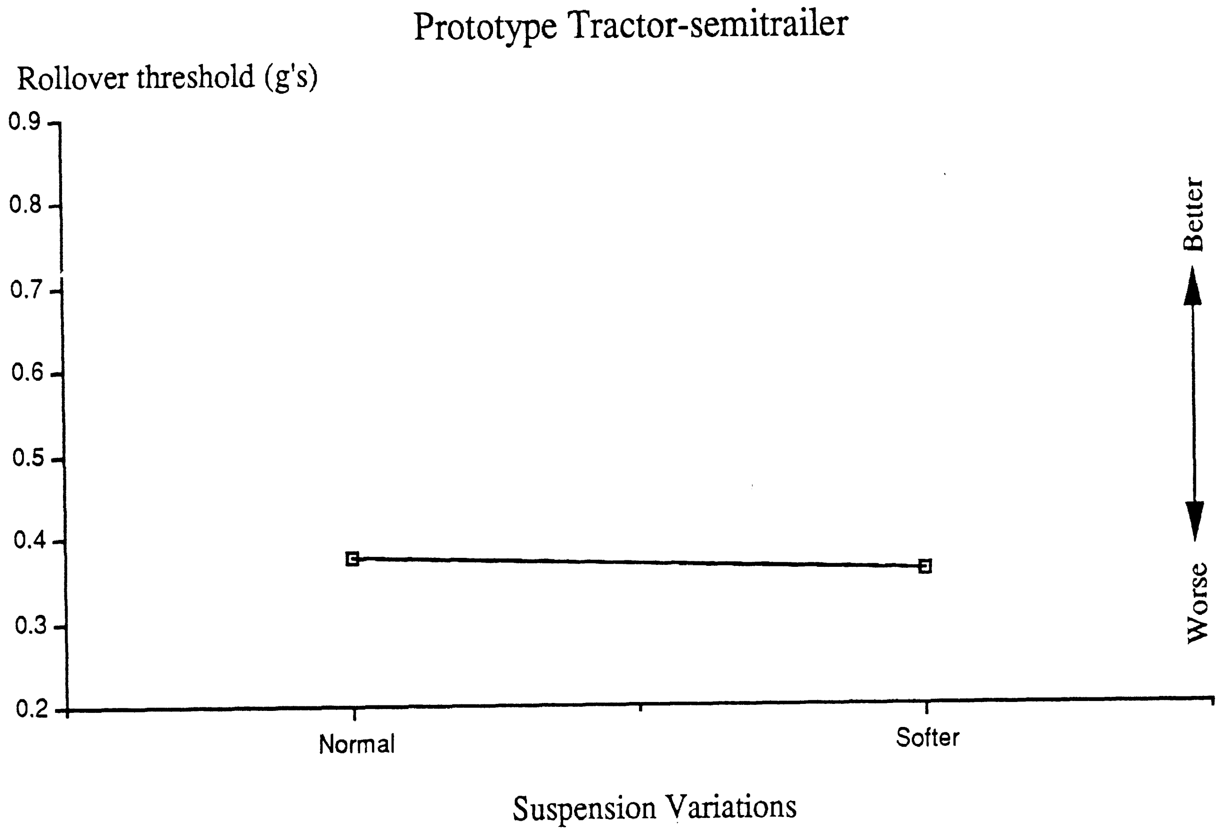
VEHICLE	MEASURE	VALUE	SUSP.
PTST	High-speed offtracking (ft)	-0.31934	Normal

VEHICLE	MEASURE	VALUE	SUSP.
PTST	Braking efficiency at 0.2 g's	0.89296	Normal
PTSTE	Braking efficiency at 0.2 g's	0.72187	Normal

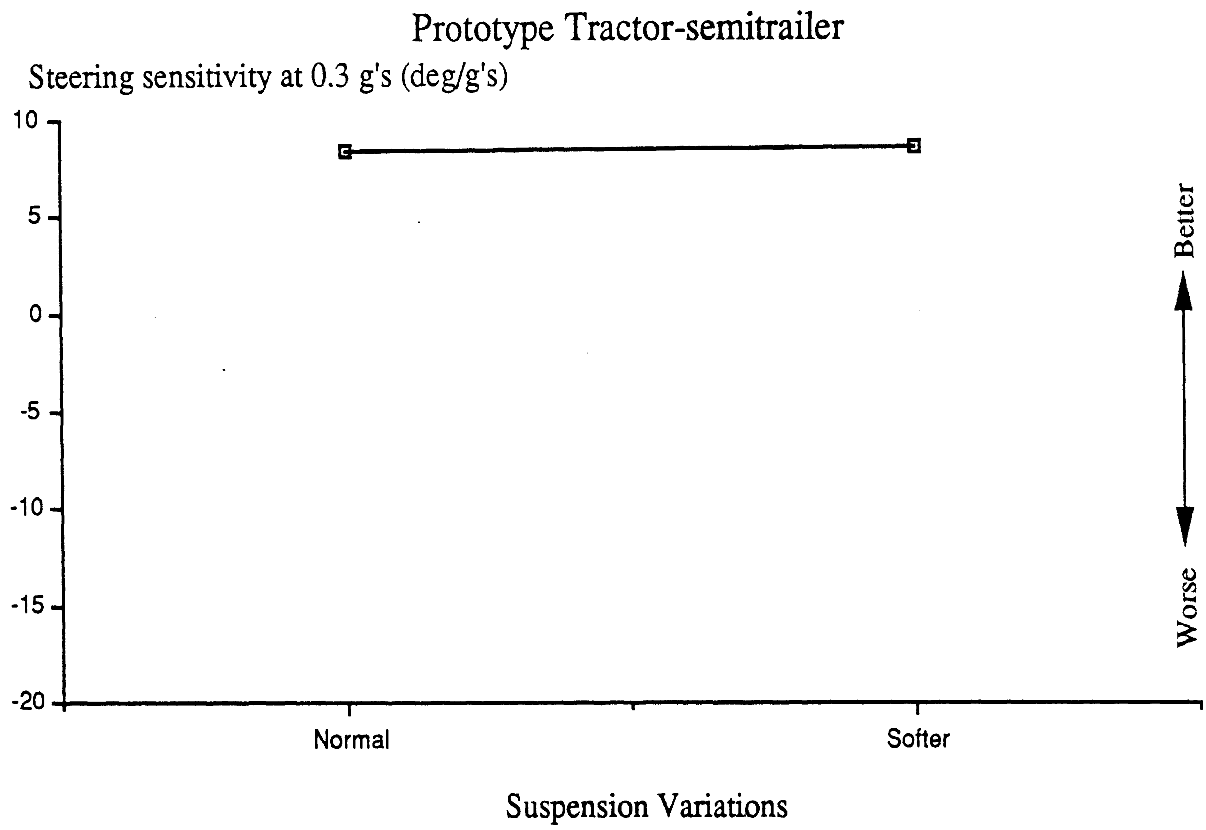
VEHICLE	MEASURE	VALUE	SUSP.
PTST	Braking efficiency at 0.4 g's	0.86929	Normal
PTSTE	Braking efficiency at 0.4 g's	0.69937	Normal

VEHICLE	MEASURE	VALUE	SUSP.
PTST	Static rollover threshold (g's)	0.37573	Normal
PTST.v6.a	Static rollover threshold (g's)	0.35921	Softer

VEHICLE	MEASURE	VALUE	SUSP.
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	Normal
PTST.v6.a	Steering sens. at 0.3 g's (deg/g's)	8.56335	Softer

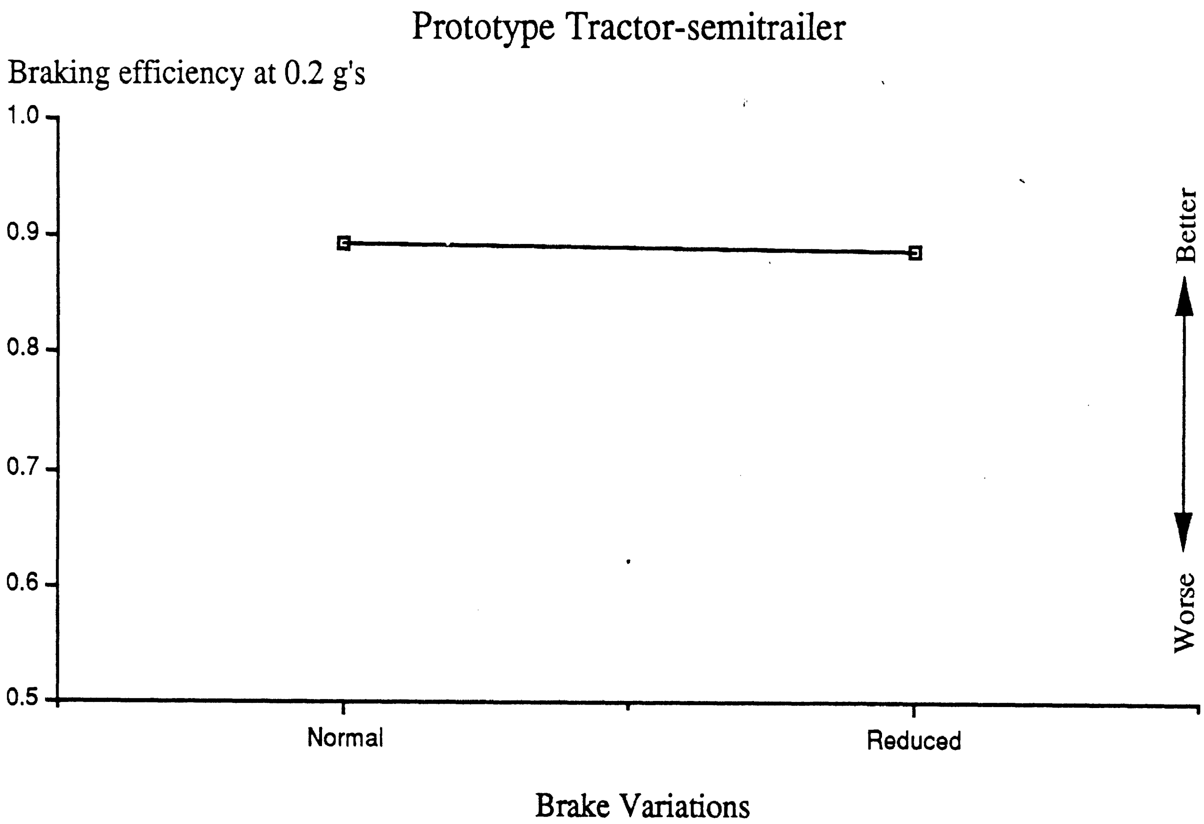


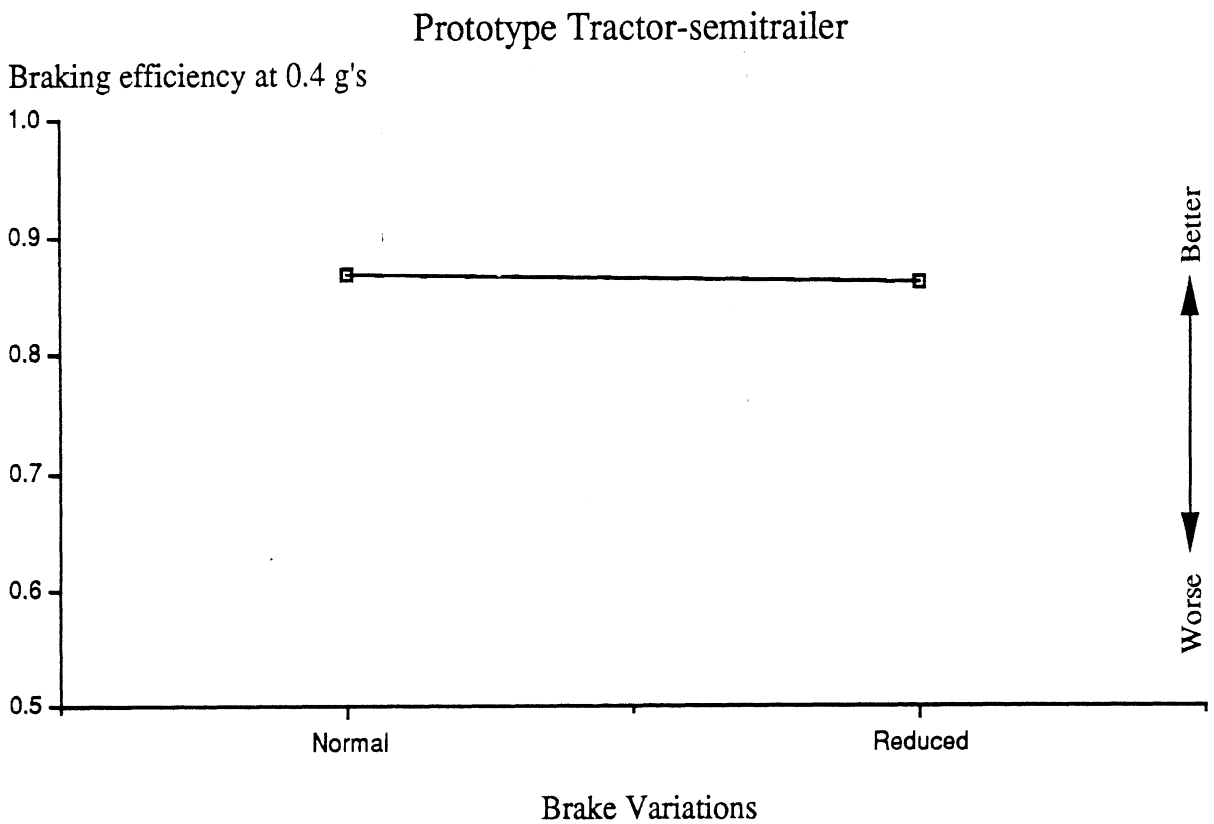
Prototype Tractor-semitrailer
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Better
Worse
Normal
Softer
Suspension Variations


Prototype Tractor-semitrailer
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
Better
Worse
Normal
Softer
Suspension Variations

Prototype Tractor-semitrailer (Brakes)

VEHICLE	MEASURE	VALUE	BRAKES
PTST	Transient offtracking (ft)	15.80906	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PTST	High-speed offtracking (ft)	-0.31934	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PTST	Braking efficiency at 0.2 g's	0.89296	Normal
PTST.v8.a	Braking efficiency at 0.2 g's	0.88488	Reduced
PTSTE	Braking efficiency at 0.2 g's	0.72187	Normal
PTST.v8.aE	Braking efficiency at 0.2 g's	0.71445	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PTST	Braking efficiency at 0.4 g's	0.86929	Normal
PTST.v8.a	Braking efficiency at 0.4 g's	0.86231	Reduced
PTSTE	Braking efficiency at 0.4 g's	0.69937	Normal
PTST.v8.aE	Braking efficiency at 0.4 g's	0.69196	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PTST	Static rollover threshold (g's)	0.37573	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PTST	Steering sens. at 0.3 g's (deg/g's)	8.35311	Normal


Prototype Tractor-semitrailer
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
Normal
Reduced
Brake Variations
Better
Worse


Prototype Tractor-semitrailer
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
Normal
Reduced
Brake Variations
Better
Worse

Prototype 9-axle B-Train (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
PBtrn	Transient offtracking (ft)	18.86950	111658

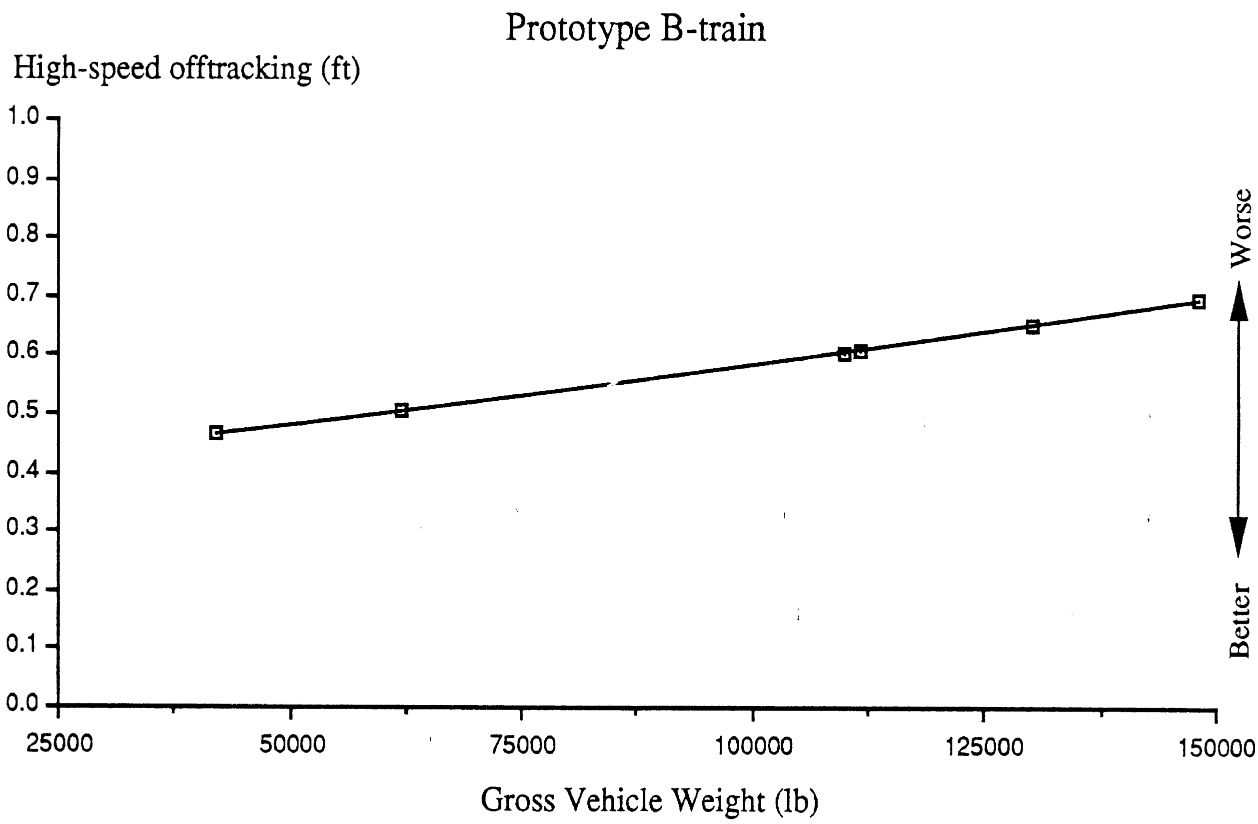
VEHICLE	MEASURE	VALUE	GVW
PBtrn	High-speed offtracking (ft)	-0.60693	111658
PBtrn.v1.a	High-speed offtracking (ft)	-0.46582	42030
PBtrn.v1.b	High-speed offtracking (ft)	-0.50366	62030
PBtrn.v1.d	High-speed offtracking (ft)	-0.60400	110000
PBtrn.v1.e	High-speed offtracking (ft)	-0.65063	130000
PBtrn.v1.f	High-speed offtracking (ft)	-0.69531	148000

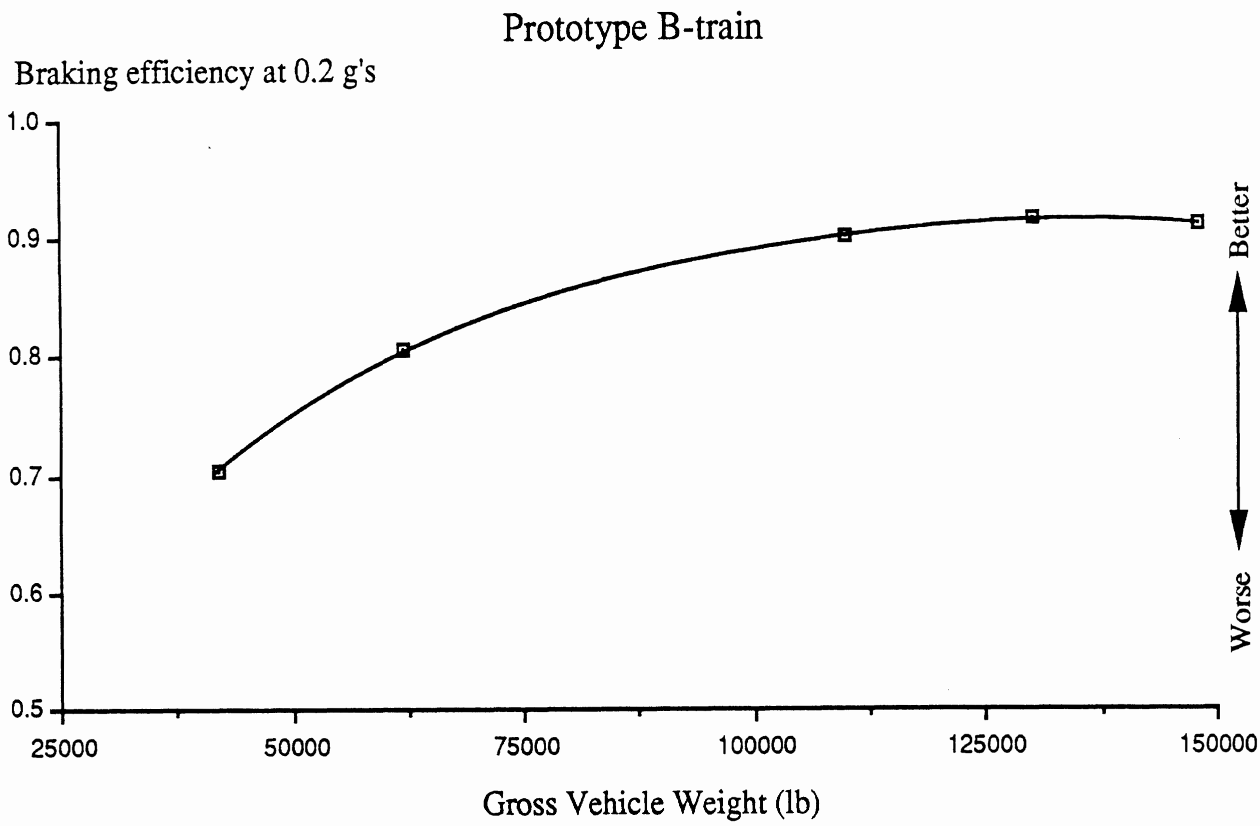
VEHICLE	MEASURE	VALUE	GVW
PBtrn	Braking efficiency at 0.2 g's	0.89046	111658
PBtrn.v1.a	Braking efficiency at 0.2 g's	0.70346	42030
PBtrn.v1.b	Braking efficiency at 0.2 g's	0.80647	62030
PBtrn.v1.d	Braking efficiency at 0.2 g's	0.90088	110000
PBtrn.v1.e	Braking efficiency at 0.2 g's	0.91585	130000
PBtrn.v1.f	Braking efficiency at 0.2 g's	0.90936	148000
PBtrnE	Braking efficiency at 0.2 g's	0.70346	42030

VEHICLE	MEASURE	VALUE	GVW
PBtrn	Braking efficiency at 0.4 g's	0.81071	111658
PBtrn.v1.a	Braking efficiency at 0.4 g's	0.67040	42030
PBtrn.v1.b	Braking efficiency at 0.4 g's	0.74878	62030
PBtrn.v1.d	Braking efficiency at 0.4 g's	0.82062	110000
PBtrn.v1.e	Braking efficiency at 0.4 g's	0.83491	130000
PBtrn.v1.f	Braking efficiency at 0.4 g's	0.84447	148000
PBtrnE	Braking efficiency at 0.4 g's	0.67040	42030

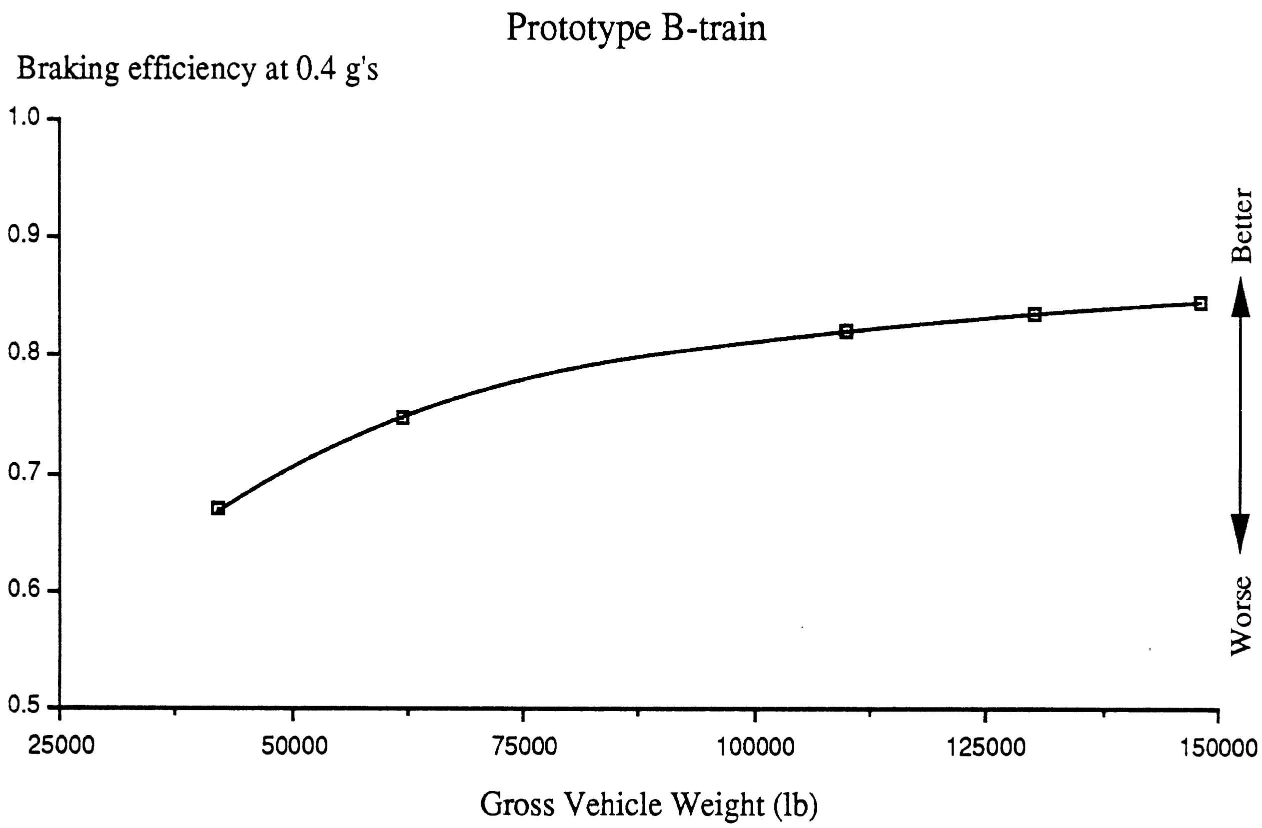
VEHICLE	MEASURE	VALUE	GVW
PBtrn	Static rollover threshold (g's)	0.38144	111658
PBtrn.v1.a	Static rollover threshold (g's)	0.78261	42030
PBtrn.v1.b	Static rollover threshold (g's)	0.52832	62030
PBtrn.v1.d	Static rollover threshold (g's)	0.38552	110000
PBtrn.v1.e	Static rollover threshold (g's)	0.35817	130000
PBtrn.v1.f	Static rollover threshold (g's)	0.33697	148000

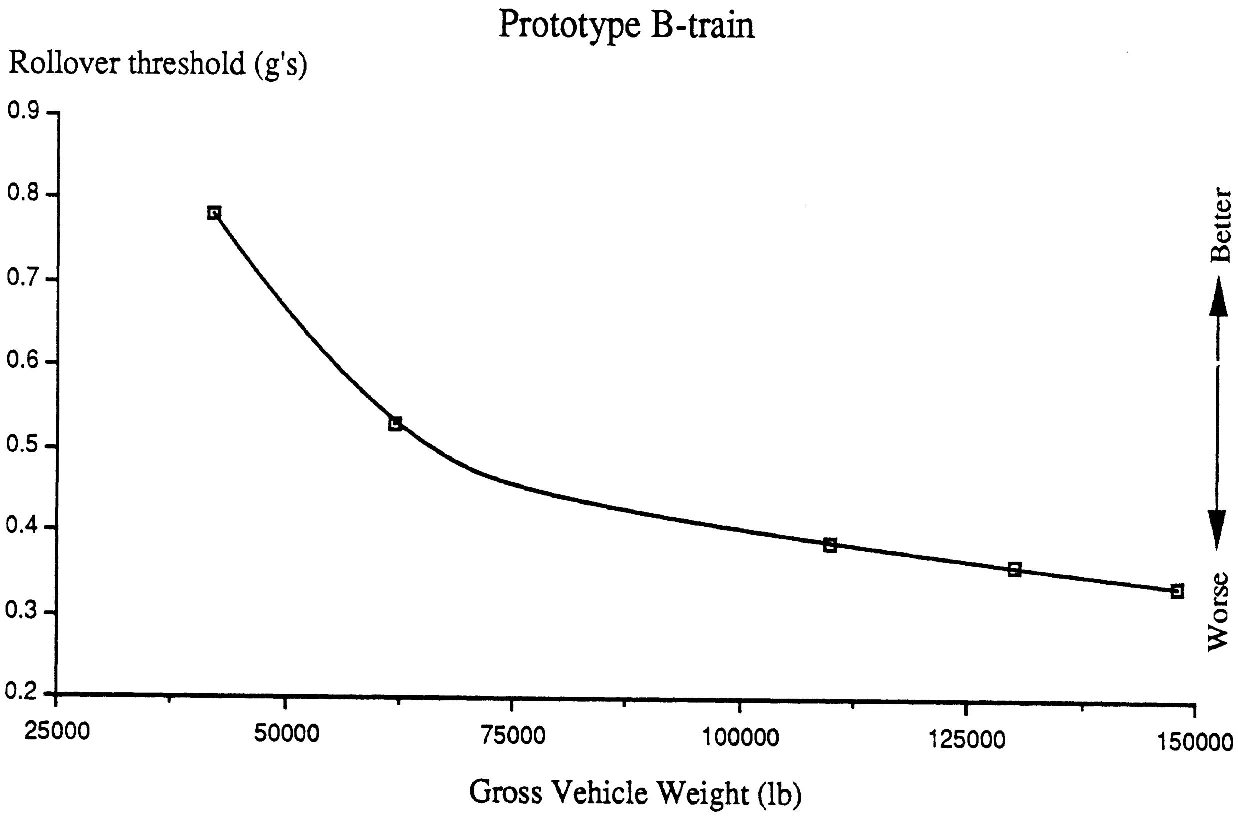
VEHICLE	MEASURE	VALUE	GVW
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	111658
PBtrn.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.89741	42030
PBtrn.v1.b	Steering sens. at 0.3 g's (deg/g's)	7.28589	62030
PBtrn.v1.d	Steering sens. at 0.3 g's (deg/g's)	6.45880	110000
PBtrn.v1.e	Steering sens. at 0.3 g's (deg/g's)	5.80460	130000
PBtrn.v1.f	Steering sens. at 0.3 g's (deg/g's)	4.80675	148000

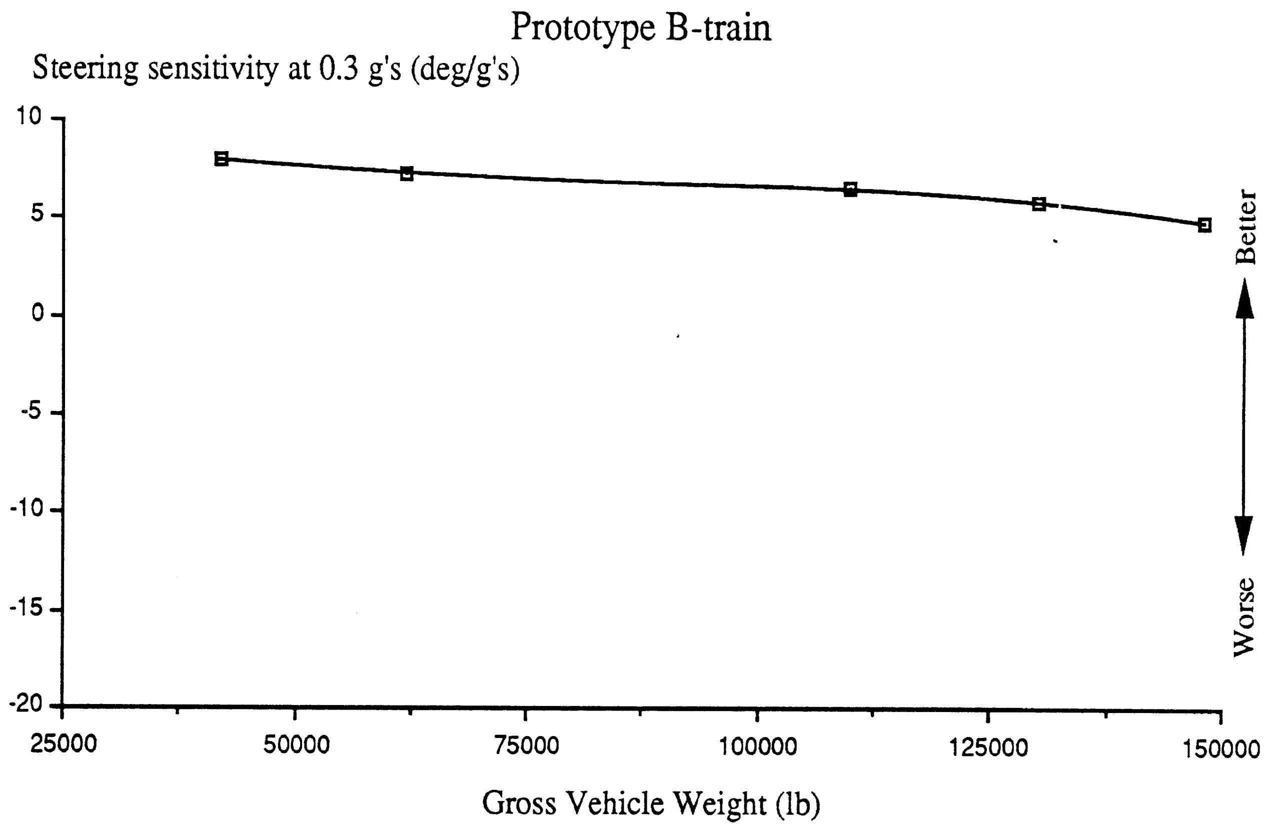

Prototype B-train
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better



Prototype B-train
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse


Prototype B-train
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

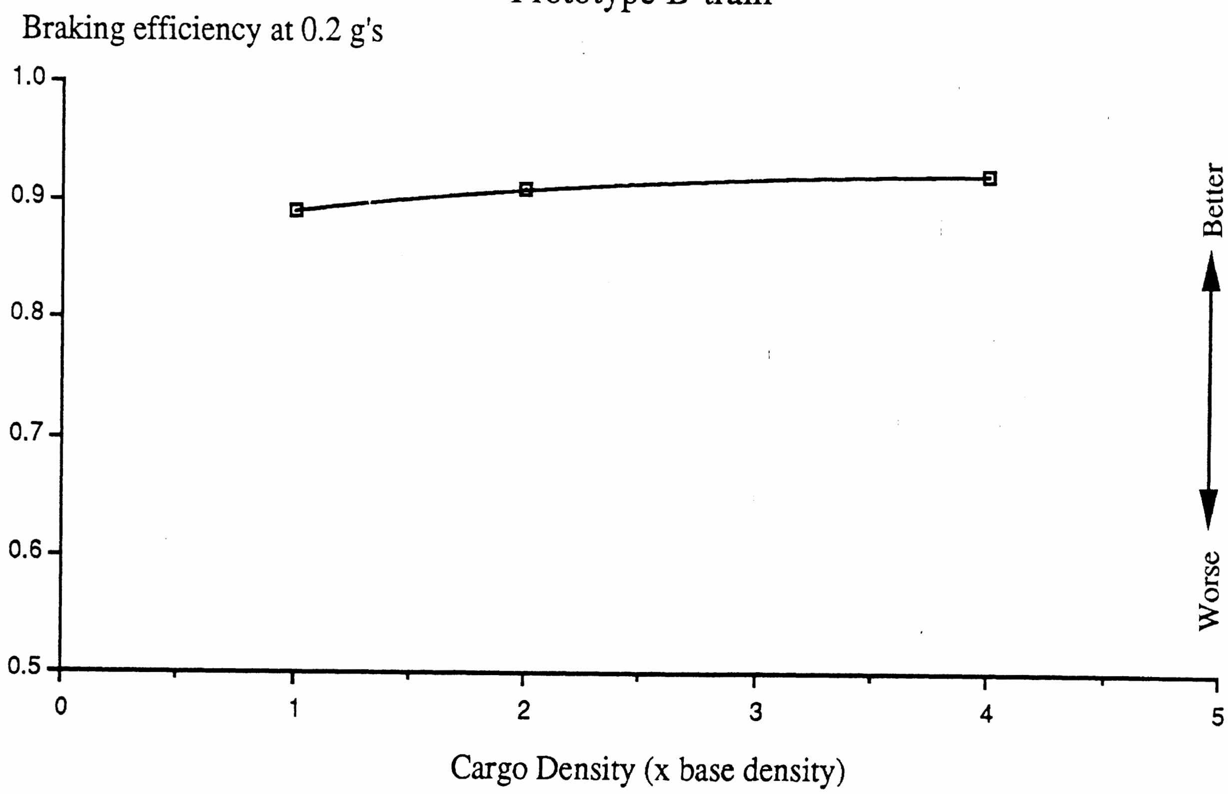

Prototype B-train
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

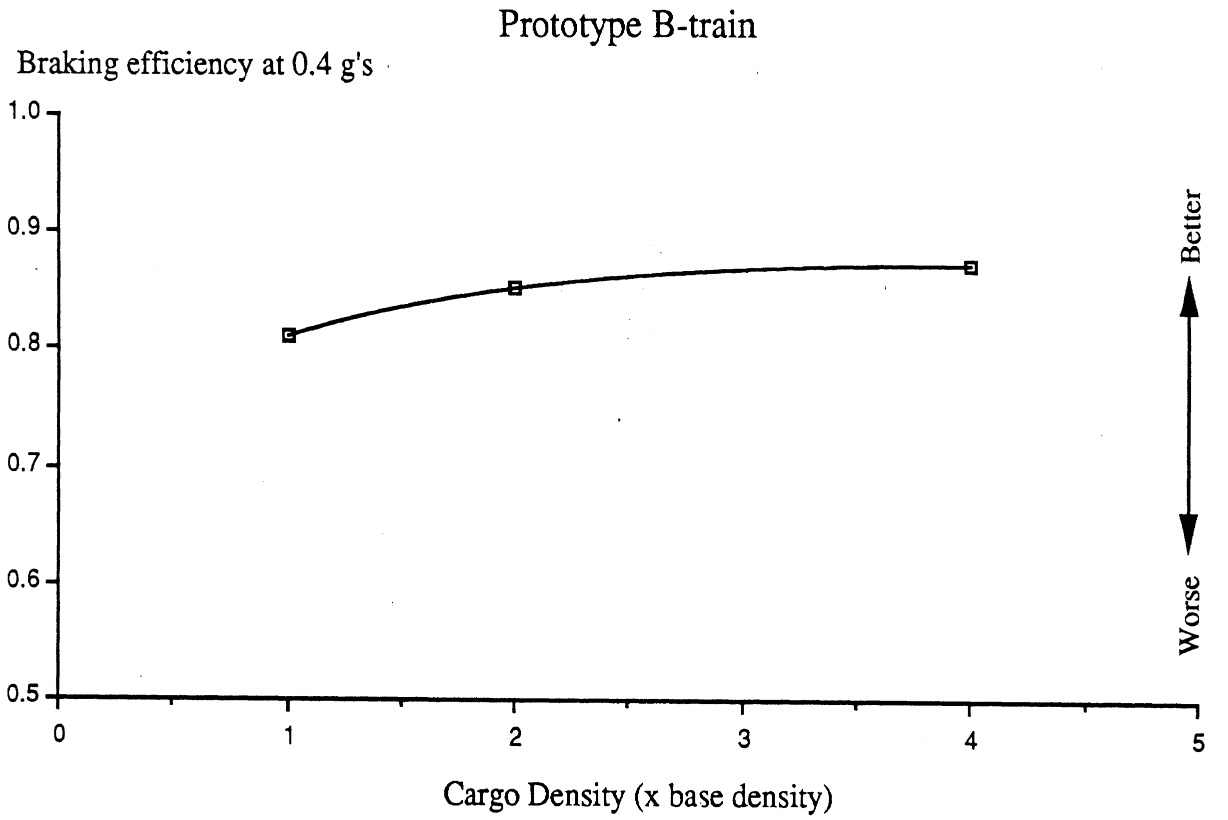

Prototype B-train
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

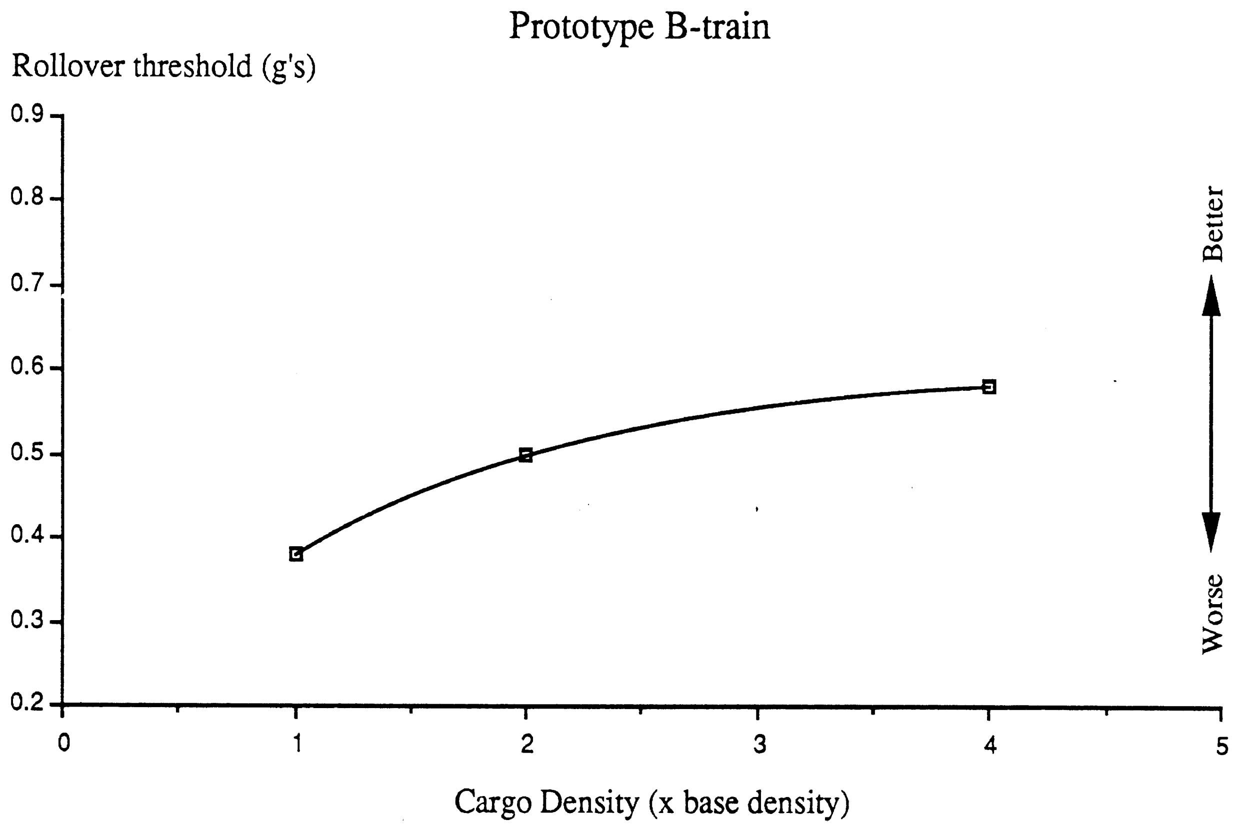
Prototype 9-axle B-Train (Cargo density)

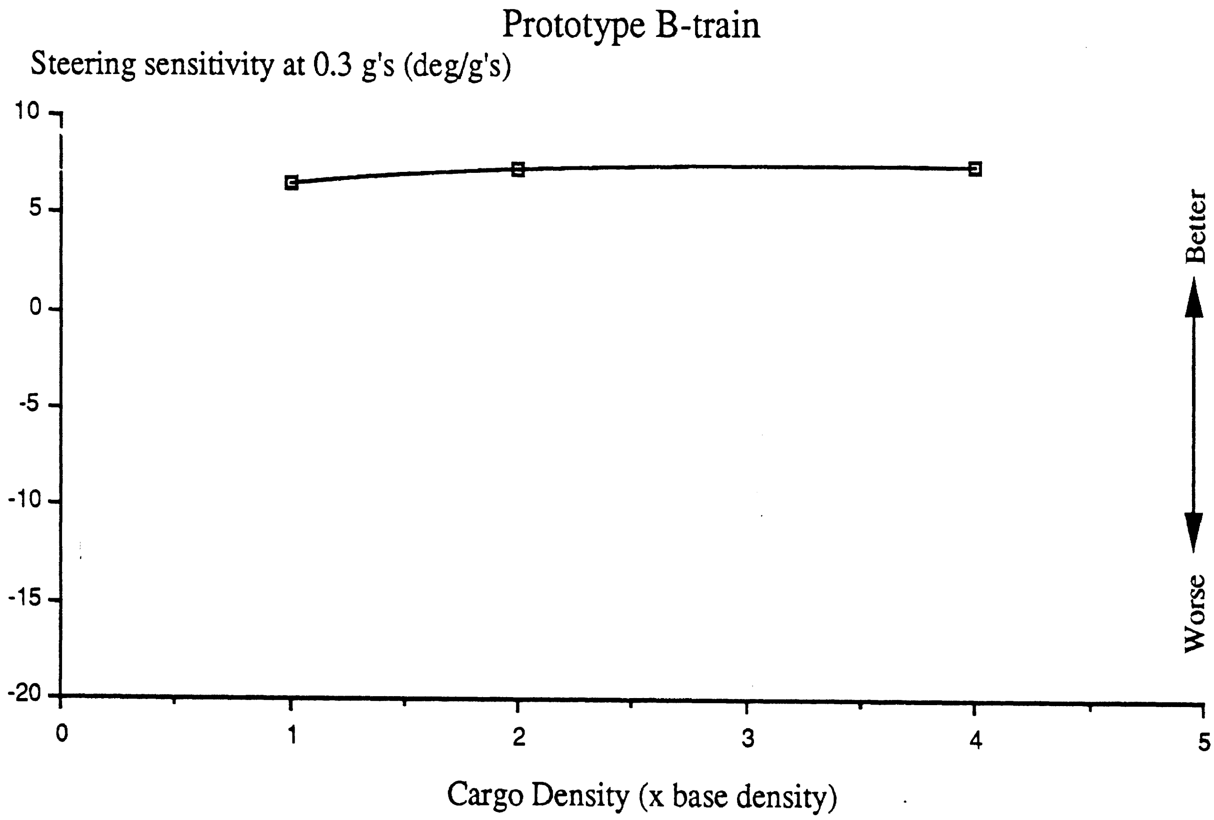
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	Transient offtracking (ft)	18.86950	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	High-speed offtracking (ft)	-0.60693	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	Braking efficiency at 0.2 g's	0.89046	1
PBtrn.v2.a	Braking efficiency at 0.2 g's	0.91099	2
PBtrn.v2.b	Braking efficiency at 0.2 g's	0.92125	4
PBtrnE	Braking efficiency at 0.2 g's	0.70346	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	Braking efficiency at 0.4 g's	0.81071	1
PBtrn.v2.a	Braking efficiency at 0.4 g's	0.85176	2
PBtrn.v2.b	Braking efficiency at 0.4 g's	0.87229	4
PBtrnE	Braking efficiency at 0.4 g's	0.67040	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	Static rollover threshold (g's)	0.38144	1
PBtrn.v2.a	Static rollover threshold (g's)	0.49970	2
PBtrn.v2.b	Static rollover threshold (g's)	0.58220	4
VEHICLE	MEASURE	VALUE	C.DENSITY
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	1
PBtrn.v2.a	Steering sens. at 0.3 g's (deg/g's)	7.19411	2
PBtrn.v2.b	Steering sens. at 0.3 g's (deg/g's)	7.43957	4

Prototype B-train




Prototype B-train
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Prototype B-train
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Prototype B-train
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Prototype 9-axle B-Train (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	Transient offtracking (ft)	18.86950	33
PBtrn.v3.a	Transient offtracking (ft)	14.76024	28
PBtrn.v3.b	Transient offtracking (ft)	24.91382	40
PBtrn.v3.c	Transient offtracking (ft)	32.09504	48

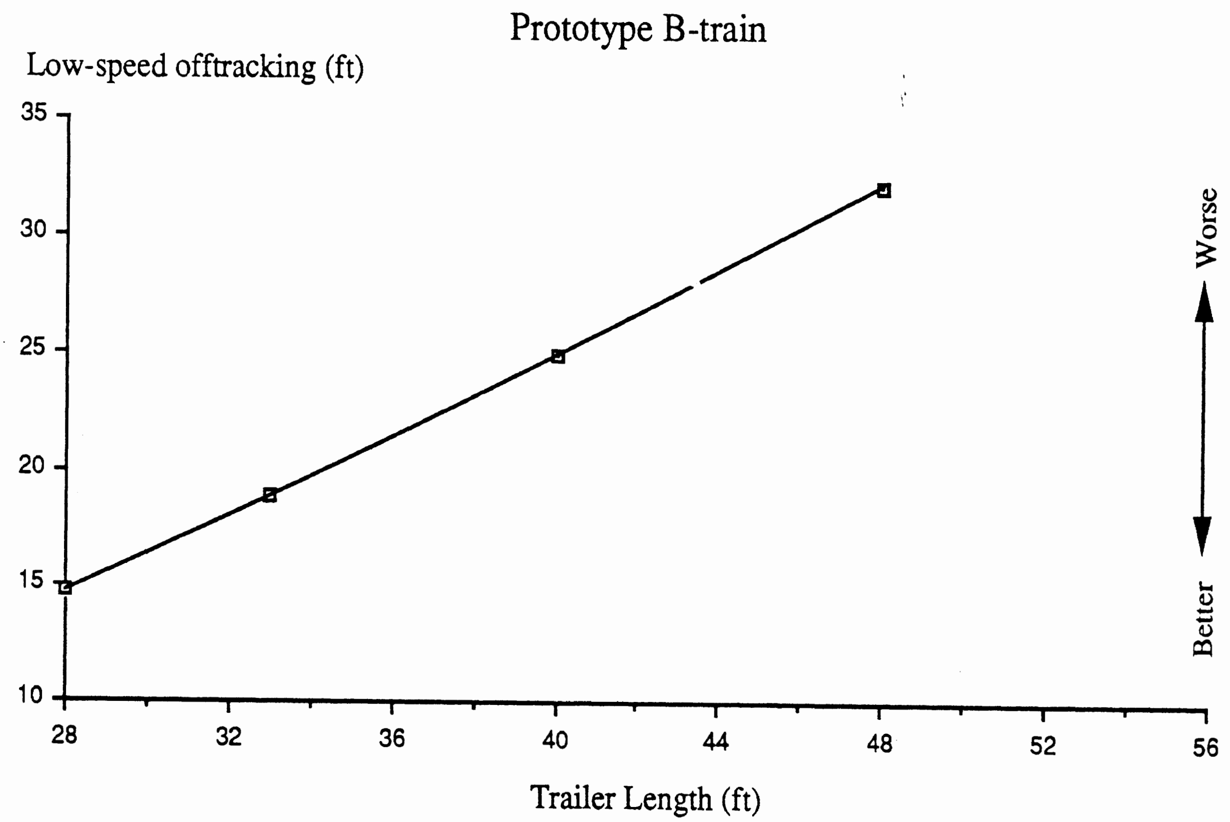
VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	High-speed offtracking (ft)	-0.60693	33
PBtrn.v3.a	High-speed offtracking (ft)	-0.65784	28
PBtrn.v3.b	High-speed offtracking (ft)	-0.46753	40
PBtrn.v3.c	High-speed offtracking (ft)	-0.21228	48

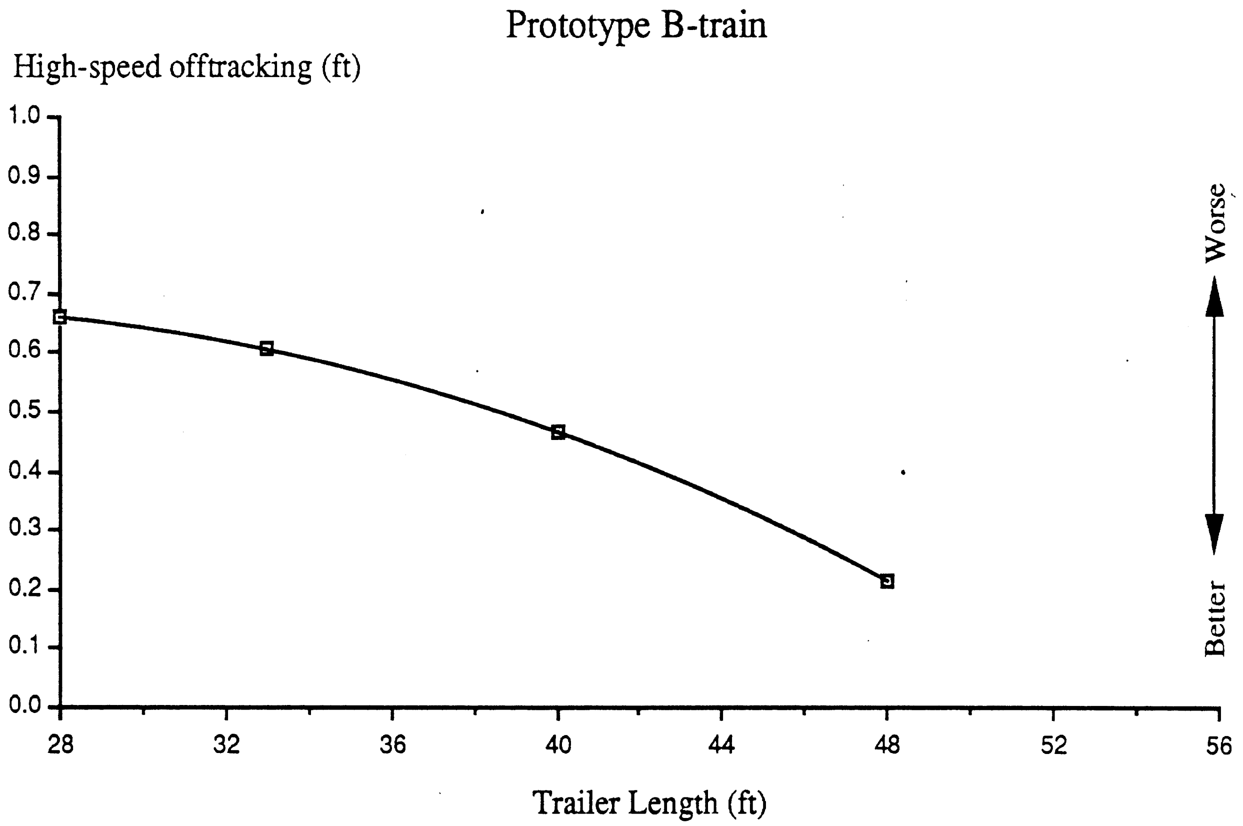
VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	Braking efficiency at 0.2 g's	0.89046	33
PBtrn.v3.a	Braking efficiency at 0.2 g's	0.87562	28
PBtrn.v3.b	Braking efficiency at 0.2 g's	0.90511	40
PBtrn.v3.c	Braking efficiency at 0.2 g's	0.91726	48
PBtrnE	Braking efficiency at 0.2 g's	0.70346	33
PBtrn.v3.aE	Braking efficiency at 0.2 g's	0.67573	28
PBtrn.v3.bE	Braking efficiency at 0.2 g's	0.73551	40
PBtrn.v3.cE	Braking efficiency at 0.2 g's	0.76558	48

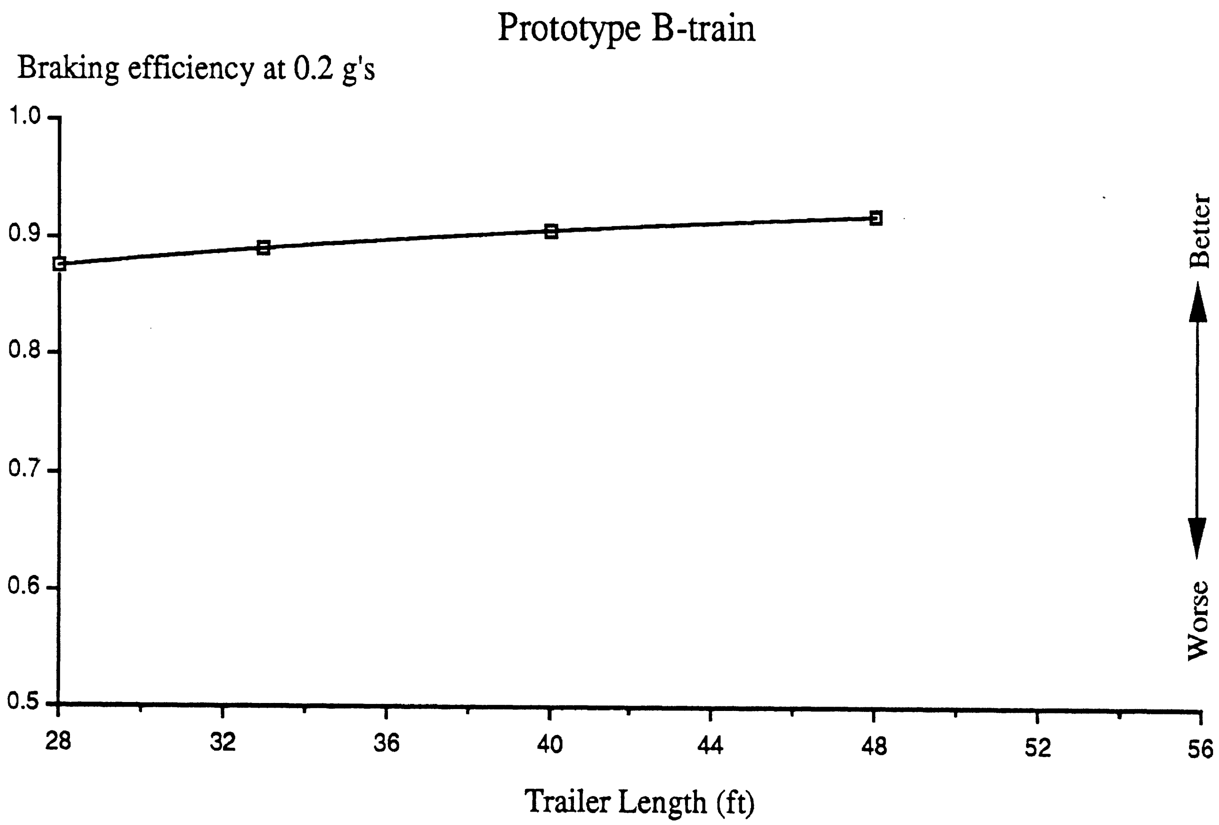
VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	Braking efficiency at 0.4 g's	0.81071	33
PBtrn.v3.a	Braking efficiency at 0.4 g's	0.77639	28
PBtrn.v3.b	Braking efficiency at 0.4 g's	0.84266	40
PBtrn.v3.c	Braking efficiency at 0.4 g's	0.86730	48
PBtrnE	Braking efficiency at 0.4 g's	0.67040	33
PBtrn.v3.aE	Braking efficiency at 0.4 g's	0.63747	28
PBtrn.v3.bE	Braking efficiency at 0.4 g's	0.70739	40
PBtrn.v3.cE	Braking efficiency at 0.4 g's	0.74133	48

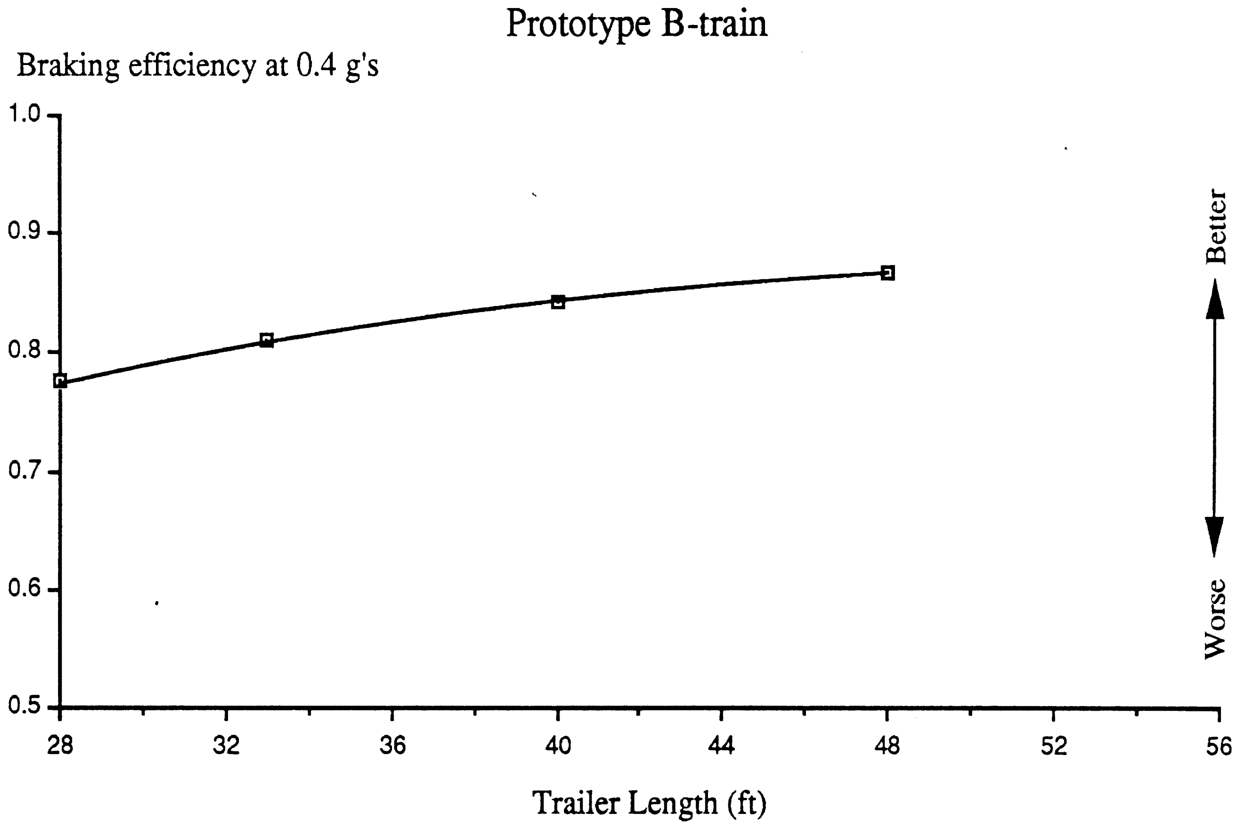
VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	Static rollover threshold (g's)	0.38144	33
PBtrn.v3.a	Static rollover threshold (g's)	0.38140	28
PBtrn.v3.b	Static rollover threshold (g's)	0.38159	40
PBtrn.v3.c	Static rollover threshold (g's)	0.38174	48

VEHICLE	MEASURE	VALUE	T.LENGTH
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	33
PBtrn.v3.a	Steering sens. at 0.3 g's (deg/g's)	6.39904	28
PBtrn.v3.b	Steering sens. at 0.3 g's (deg/g's)	6.41504	40
PBtrn.v3.c	Steering sens. at 0.3 g's (deg/g's)	6.43532	48

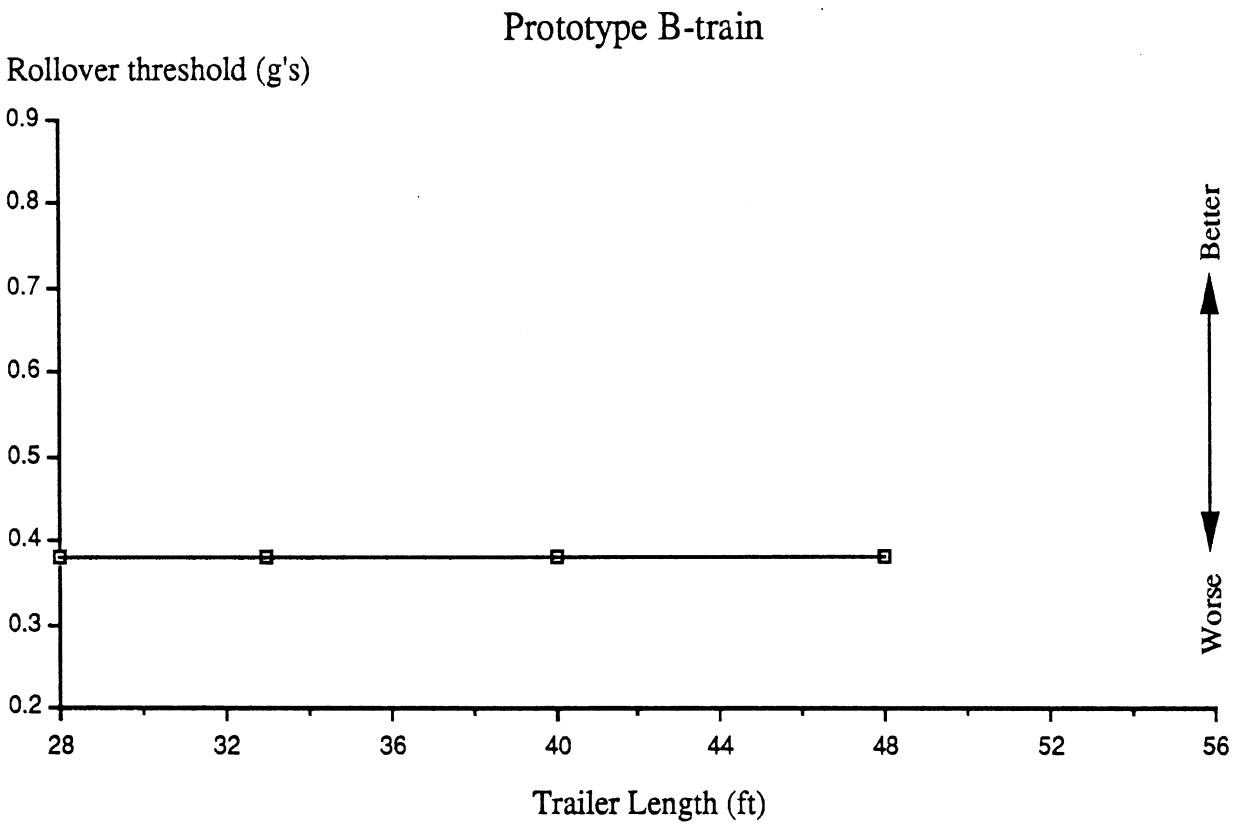

Prototype B-train
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

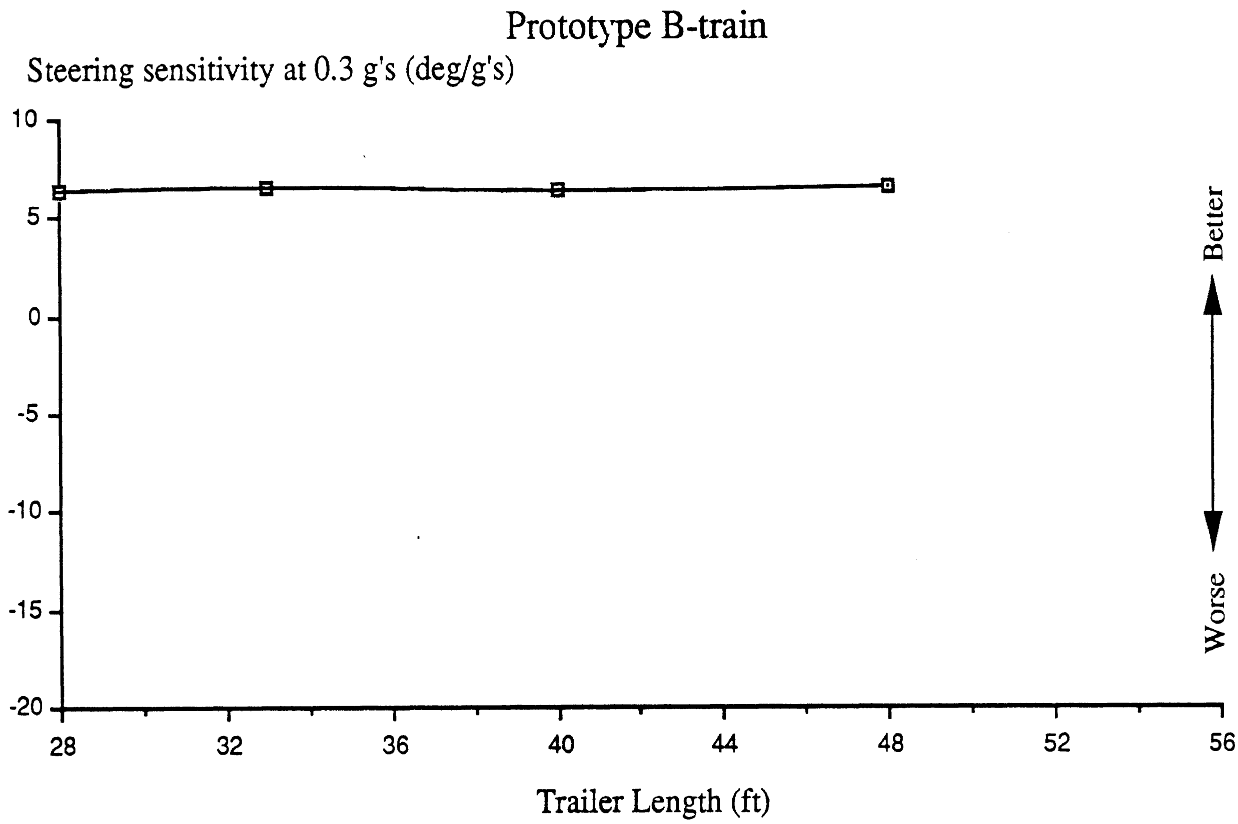

Prototype B-train
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better


Prototype B-train
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse



Prototype B-train
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

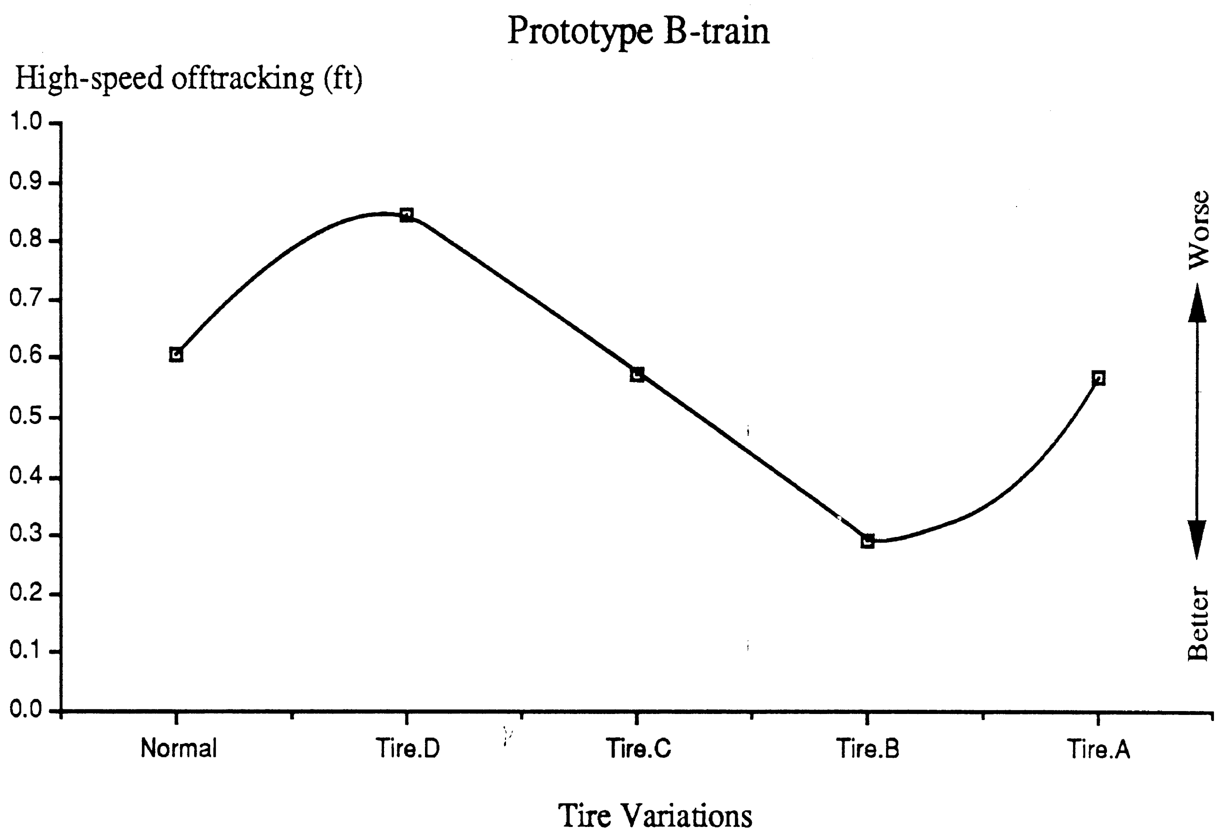

Prototype B-train
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

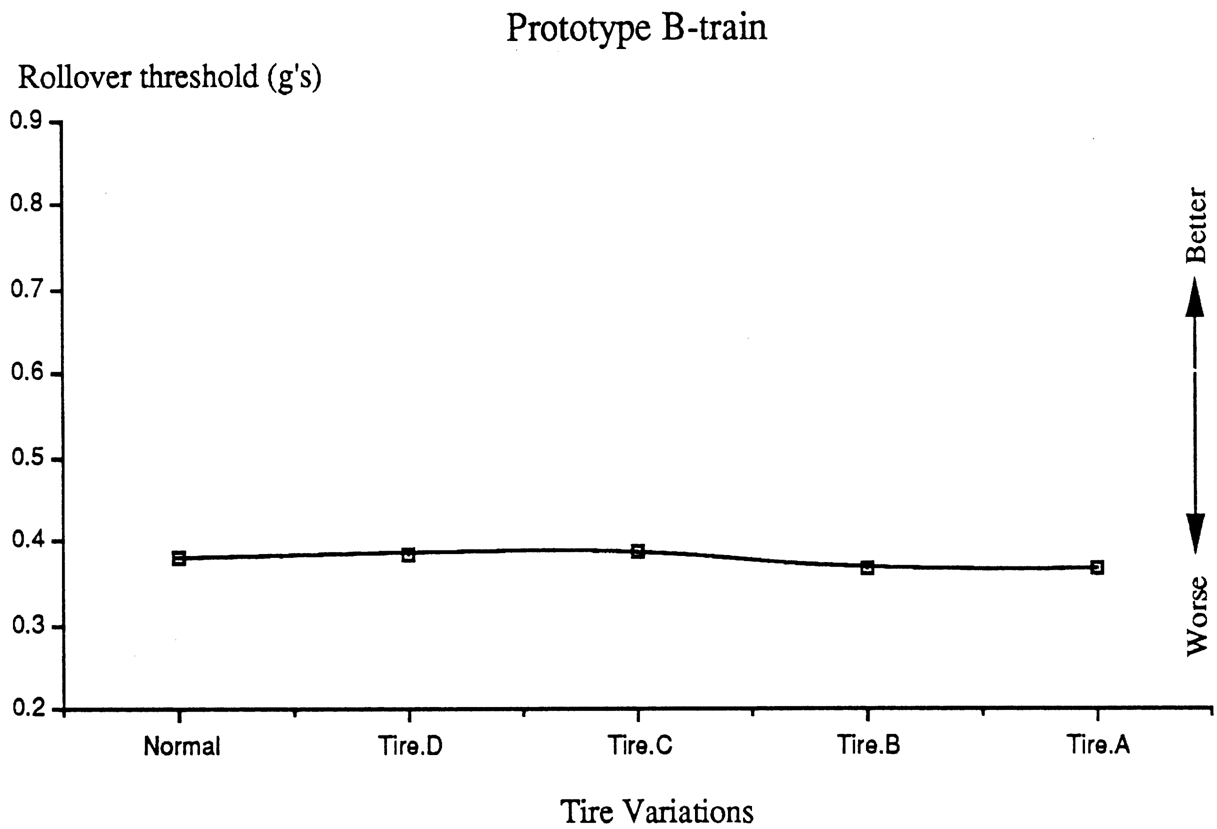


Prototype B-train
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

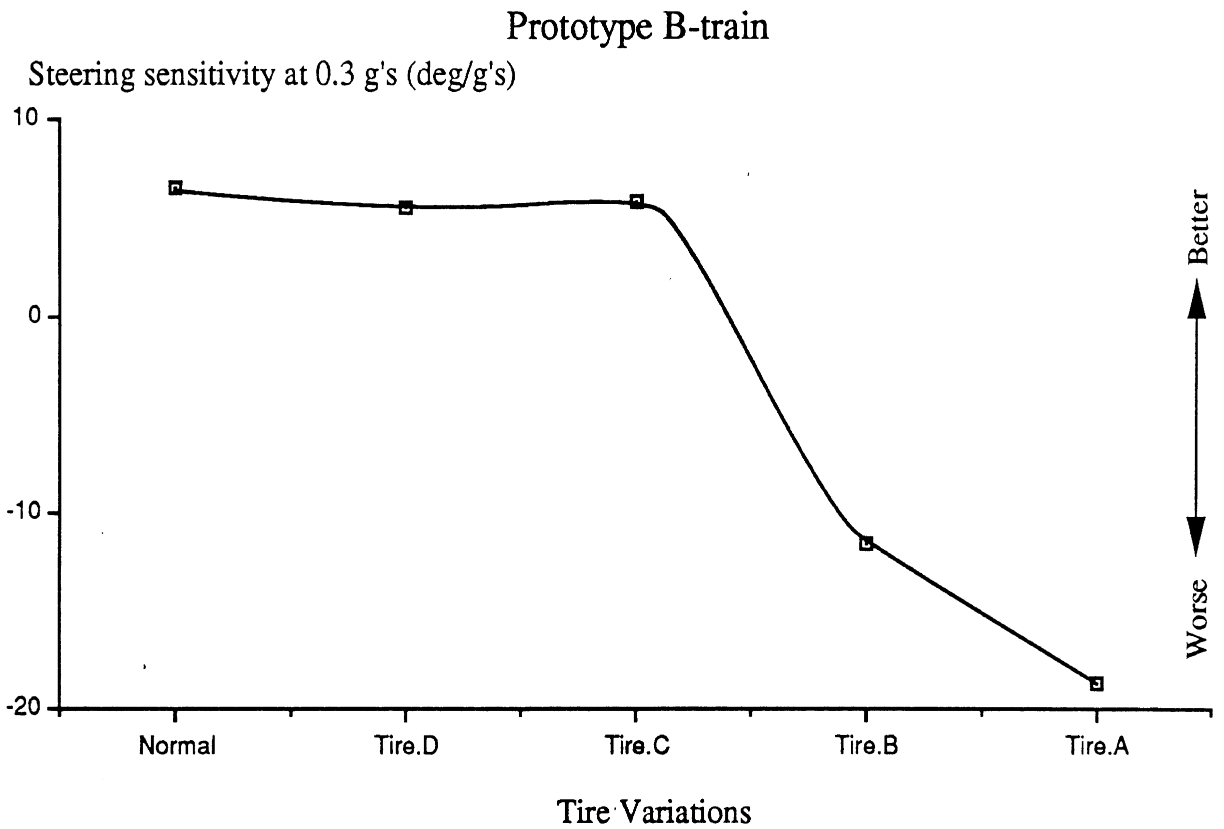
Prototype 9-axle B-Train (Wide-base single tires)

VEHICLE	MEASURE	VALUE	TIRES
PBtrn	Transient offtracking (ft)	18.86950	Normal
VEHICLE	MEASURE	VALUE	TIRES
PBtrn	High-speed offtracking (ft)	-0.60693	Normal
PBtrn.v5.a	High-speed offtracking (ft)	-0.56738	Tire.A
PBtrn.v5.b	High-speed offtracking (ft)	-0.29224	Tire.B
PBtrn.v5.c	High-speed offtracking (ft)	-0.57300	Tire.C
PBtrn.v5.d	High-speed offtracking (ft)	-0.84644	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PBtrn	Braking efficiency at 0.2 g's	0.89046	Normal
PBtrnE	Braking efficiency at 0.2 g's	0.70346	Normal
VEHICLE	MEASURE	VALUE	TIRES
PBtrn	Braking efficiency at 0.4 g's	0.81071	Normal
PBtrnE	Braking efficiency at 0.4 g's	0.67040	Normal
VEHICLE	MEASURE	VALUE	TIRES
PBtrn	Static rollover threshold (g's)	0.38144	Normal
PBtrn.v5.a	Static rollover threshold (g's)	0.36744	Tire.A
PBtrn.v5.b	Static rollover threshold (g's)	0.36744	Tire.B
PBtrn.v5.c	Static rollover threshold (g's)	0.38595	Tire.C
PBtrn.v5.d	Static rollover threshold (g's)	0.38454	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	Normal
PBtrn.v5.a	Steering sens. at 0.3 g's (deg/g's)	-18.75795	Tire.A
PBtrn.v5.b	Steering sens. at 0.3 g's (deg/g's)	-11.55850	Tire.B
PBtrn.v5.c	Steering sens. at 0.3 g's (deg/g's)	5.72669	Tire.C
PBtrn.v5.d	Steering sens. at 0.3 g's (deg/g's)	5.55807	Tire.D


Prototype B-train
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Worse
Better
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations



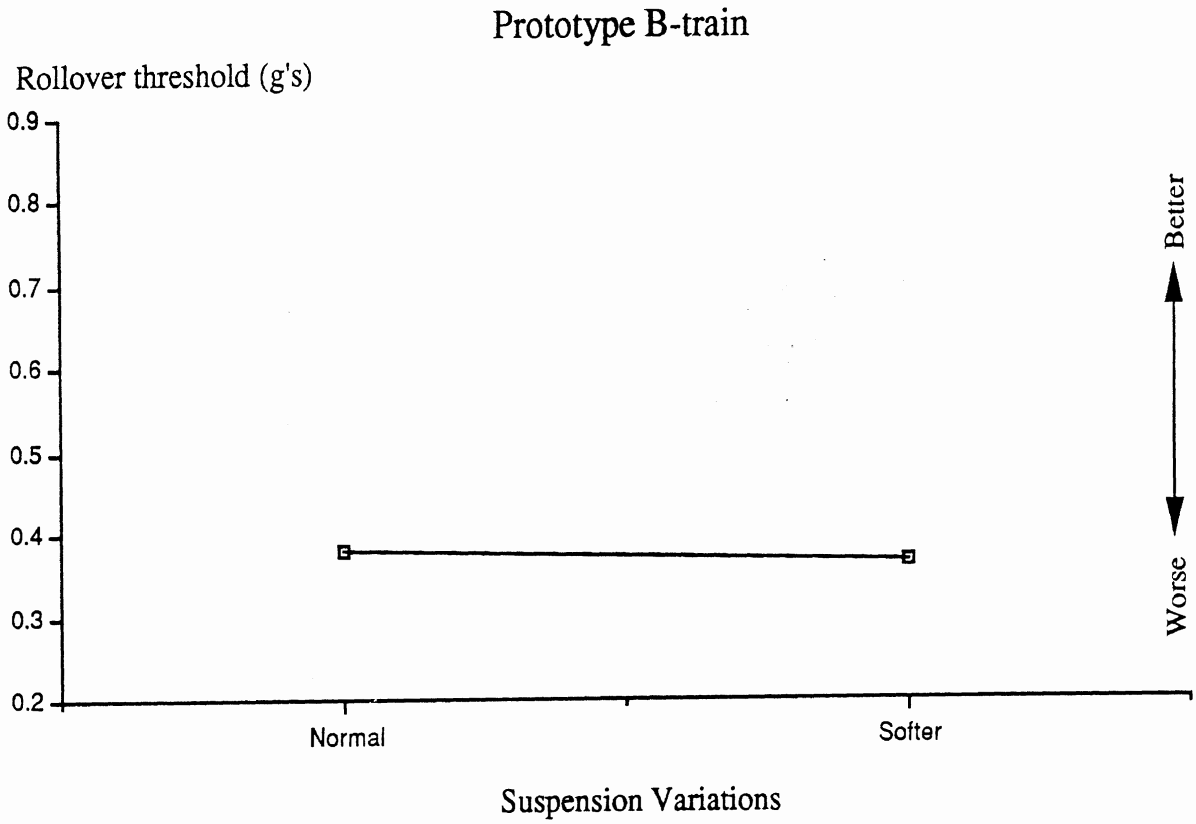
Prototype B-train
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Better
Worse

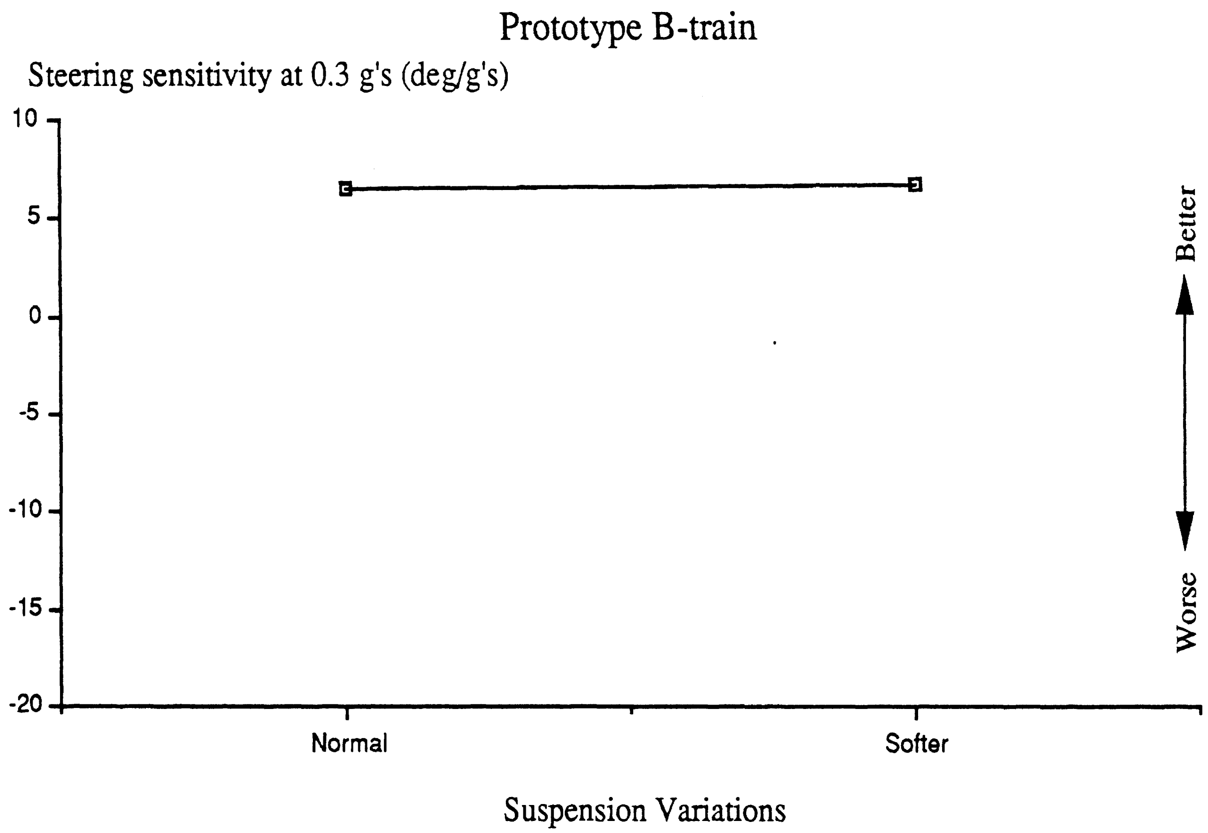


Prototype B-train
Steering sensitivity at 0.3 g's (deg/g's)
10
0
-10
-20
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Better
Worse

Prototype 9-axle B-Train (Suspensions)

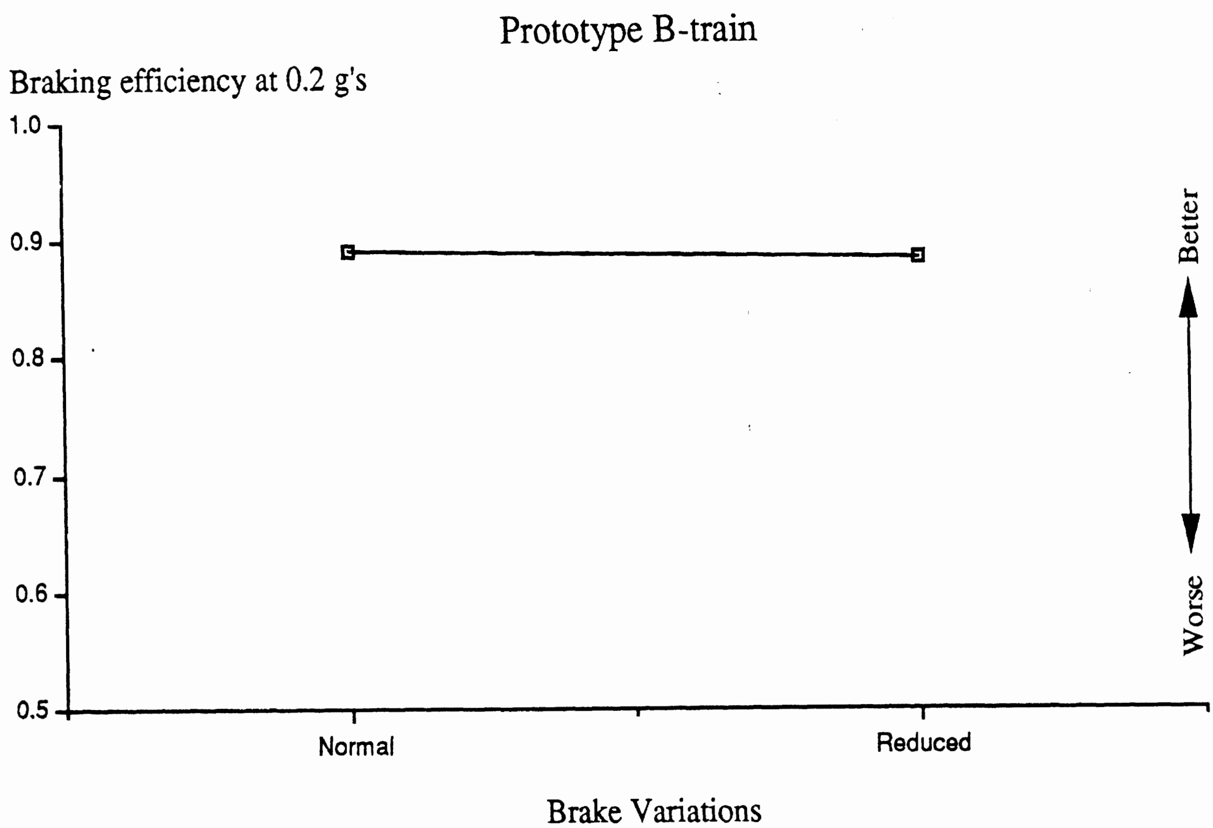
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	Transient offtracking (ft)	18.86950	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	High-speed offtracking (ft)	-0.60693	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	Braking efficiency at 0.2 g's	0.89046	Normal
PBtrnE	Braking efficiency at 0.2 g's	0.70346	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	Braking efficiency at 0.4 g's	0.81071	Normal
PBtrnE	Braking efficiency at 0.4 g's	0.67040	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	Static rollover threshold (g's)	0.38144	Normal
PBtrn.v6.a	Static rollover threshold (g's)	0.36706	Softer
VEHICLE	MEASURE	VALUE	SUSP.
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	Normal
PBtrn.v6.a	Steering sens. at 0.3 g's (deg/g's)	6.65623	Softer


Prototype B-train
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Better
Worse
Normal
Softer
Suspension Variations

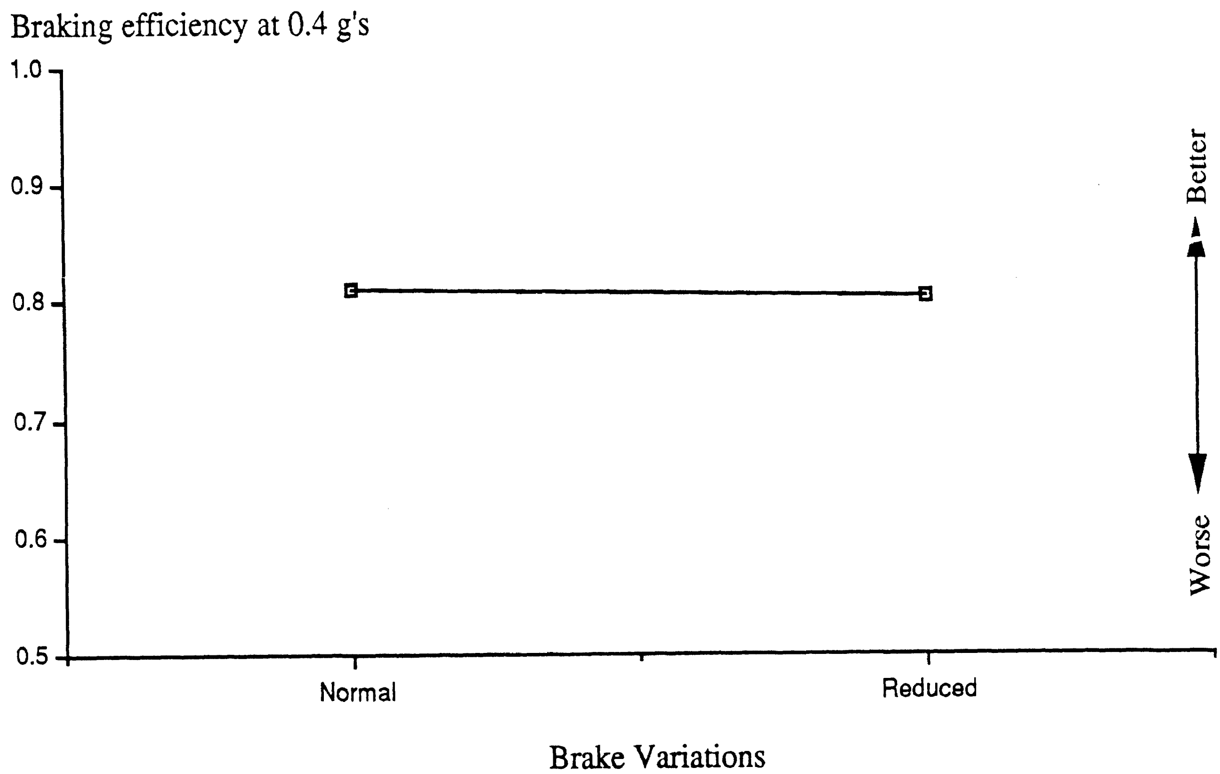

Prototype B-train
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
Normal
Softer
Suspension Variations
Better
Worse

Prototype 9-axle B-Train **(Brakes)**

VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	Transient offtracking (ft)	18.86950	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	High-speed offtracking (ft)	-0.60693	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	Braking efficiency at 0.2 g's	0.89046	Normal
PBtrn.v8.a	Braking efficiency at 0.2 g's	0.88339	Reduced
PBtrnE	Braking efficiency at 0.2 g's	0.70346	Normal
PBtrn.v8.aE	Braking efficiency at 0.2 g's	0.69783	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	Braking efficiency at 0.4 g's	0.81071	Normal
PBtrn.v8.a	Braking efficiency at 0.4 g's	0.80404	Reduced
PBtrnE	Braking efficiency at 0.4 g's	0.67040	Normal
PBtrn.v8.aE	Braking efficiency at 0.4 g's	0.66481	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	Static rollover threshold (g's)	0.38144	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PBtrn	Steering sens. at 0.3 g's (deg/g's)	6.46520	Normal


Prototype B-train
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
Normal
Reduced
Brake Variations
Better
Worse

Prototype B-train



Prototype 9-axle Double (Gross vehicle weight)

VEHICLE	MEASURE	VALUE	GVW
PDbl1	Transient offtracking (ft)	15.96366	109862

VEHICLE	MEASURE	VALUE	GVW
PDbl1	High-speed offtracking (ft)	-0.75305	109862
PDbl1.v1.a	High-speed offtracking (ft)	-0.61377	41530
PDbl1.v1.b	High-speed offtracking (ft)	-0.65161	61530
PDbl1.v1.d	High-speed offtracking (ft)	-0.75317	110000
PDbl1.v1.e	High-speed offtracking (ft)	-0.80005	130000
PDbl1.v1.f	High-speed offtracking (ft)	-0.84460	148000

VEHICLE	MEASURE	VALUE	GVW
PDbl1	Braking efficiency at 0.2 g's	0.90742	109862
PDbl1.v1.a	Braking efficiency at 0.2 g's	0.71239	41530
PDbl1.v1.b	Braking efficiency at 0.2 g's	0.81431	61530
PDbl1.v1.d	Braking efficiency at 0.2 g's	0.90758	110000
PDbl1.v1.e	Braking efficiency at 0.2 g's	0.92579	130000
PDbl1.v1.f	Braking efficiency at 0.2 g's	0.93797	148000
PDbl1E	Braking efficiency at 0.2 g's	0.71239	41530

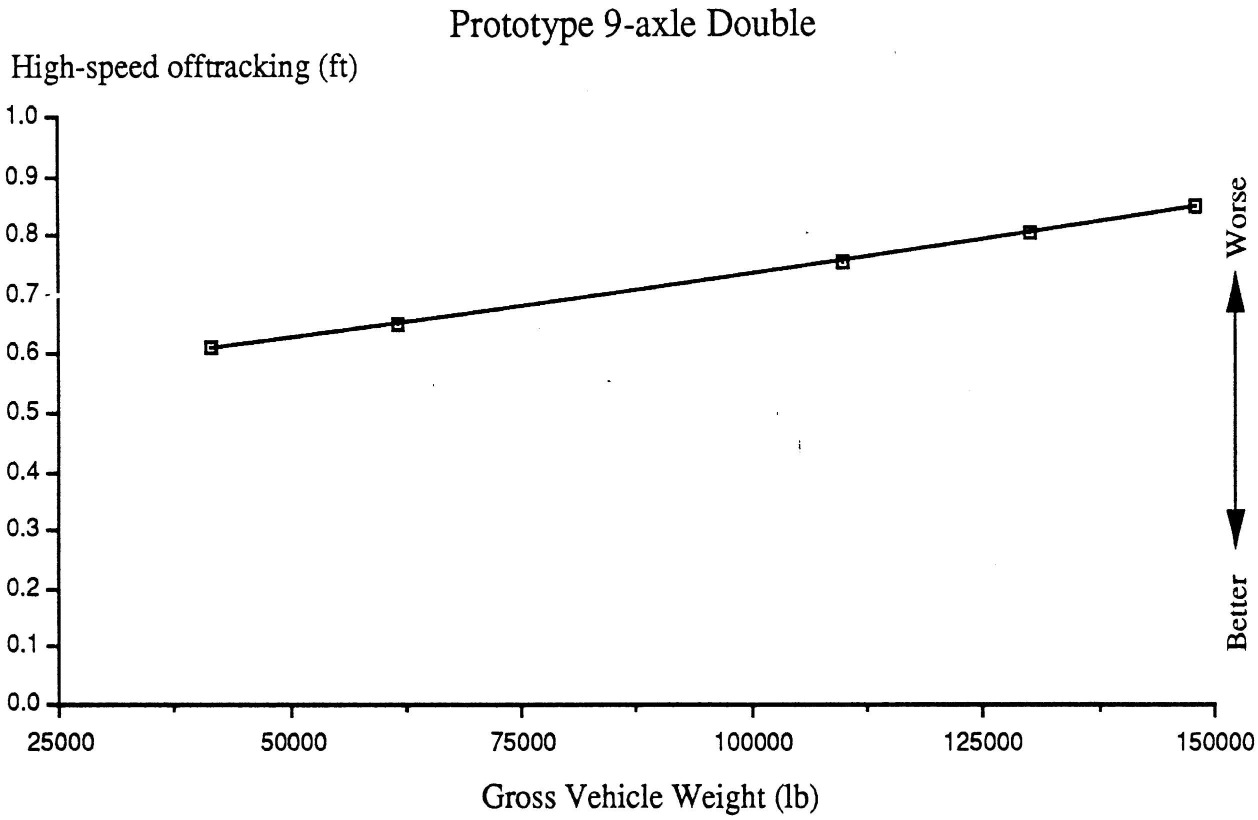
VEHICLE	MEASURE	VALUE	GVW
PDbl1	Braking efficiency at 0.4 g's	0.82875	109862
PDbl1.v1.a	Braking efficiency at 0.4 g's	0.67939	41530
PDbl1.v1.b	Braking efficiency at 0.4 g's	0.75744	61530
PDbl1.v1.d	Braking efficiency at 0.4 g's	0.82888	110000
PDbl1.v1.e	Braking efficiency at 0.4 g's	0.84282	130000
PDbl1.v1.f	Braking efficiency at 0.4 g's	0.85215	148000
PDbl1E	Braking efficiency at 0.4 g's	0.67939	41530

VEHICLE	MEASURE	VALUE	GVW
PDbl1	Static rollover threshold (g's)	0.37915	109862
PDbl1.v1.a	Static rollover threshold (g's)	0.79664	41530
PDbl1.v1.b	Static rollover threshold (g's)	0.51693	61530
PDbl1.v1.d	Static rollover threshold (g's)	0.37880	110000
PDbl1.v1.e	Static rollover threshold (g's)	0.34966	130000
PDbl1.v1.f	Static rollover threshold (g's)	0.32769	148000

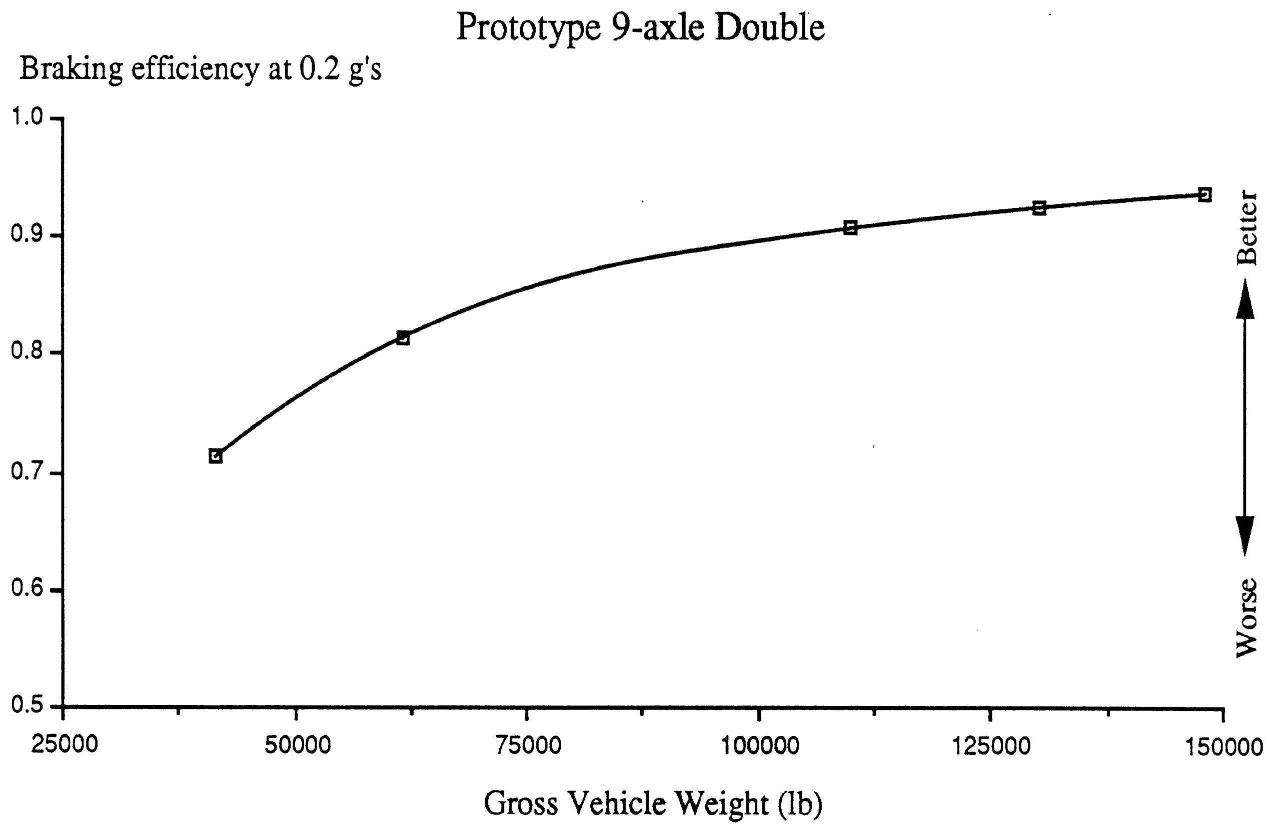
VEHICLE	MEASURE	VALUE	GVW
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	109862
PDbl1.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.97852	41530
PDbl1.v1.b	Steering sens. at 0.3 g's (deg/g's)	7.94543	61530
PDbl1.v1.d	Steering sens. at 0.3 g's (deg/g's)	7.31471	110000
PDbl1.v1.e	Steering sens. at 0.3 g's (deg/g's)	6.66584	130000
PDbl1.v1.f	Steering sens. at 0.3 g's (deg/g's)	6.05753	148000

Prototype 9-axle Double (Gross vehicle weight)

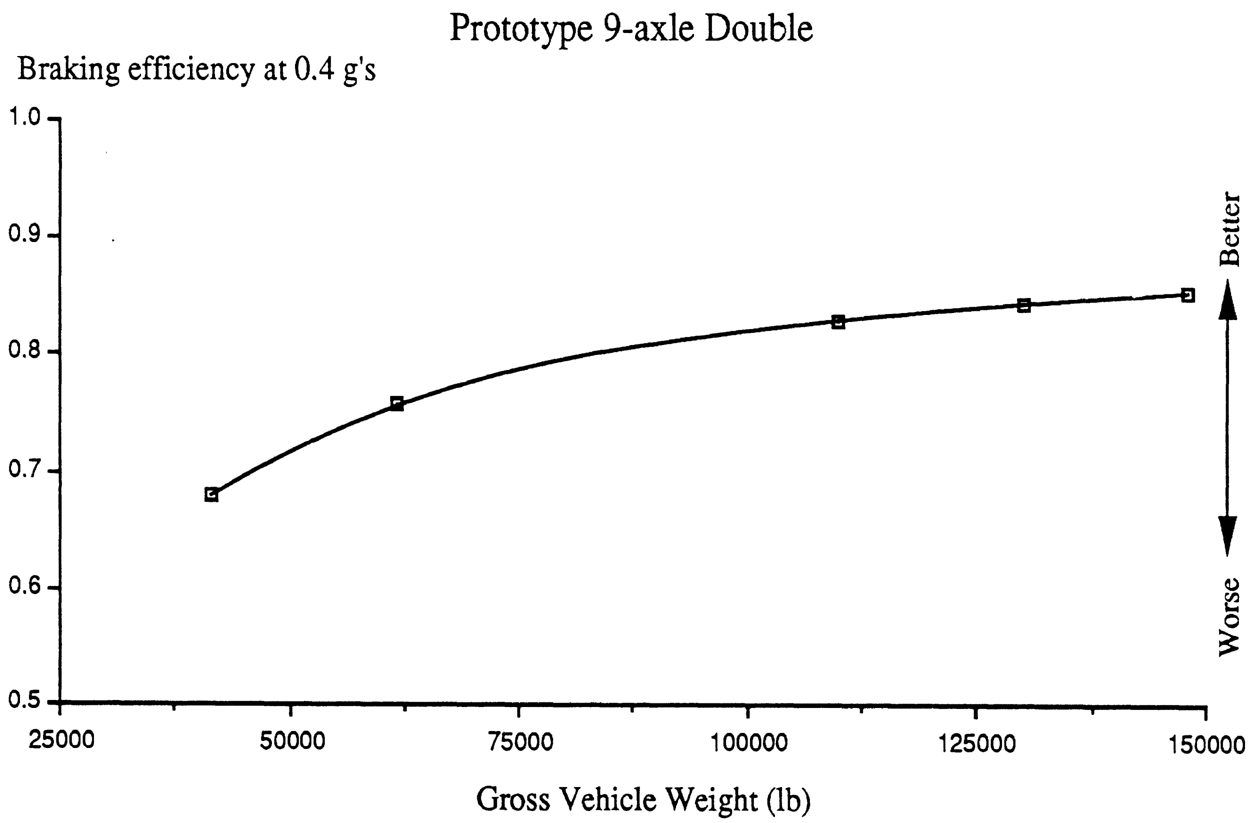
VEHICLE	MEASURE	VALUE	GVW
PDbl1	Rearward amplification	1.39443	109862
PDbl1.v1.a	Rearward amplification	1.27200	41530
PDbl1.v1.b	Rearward amplification	1.32331	61530
PDbl1.v1.d	Rearward amplification	1.39463	110000
PDbl1.v1.e	Rearward amplification	1.42416	130000
PDbl1.v1.f	Rearward amplification	1.45194	148000



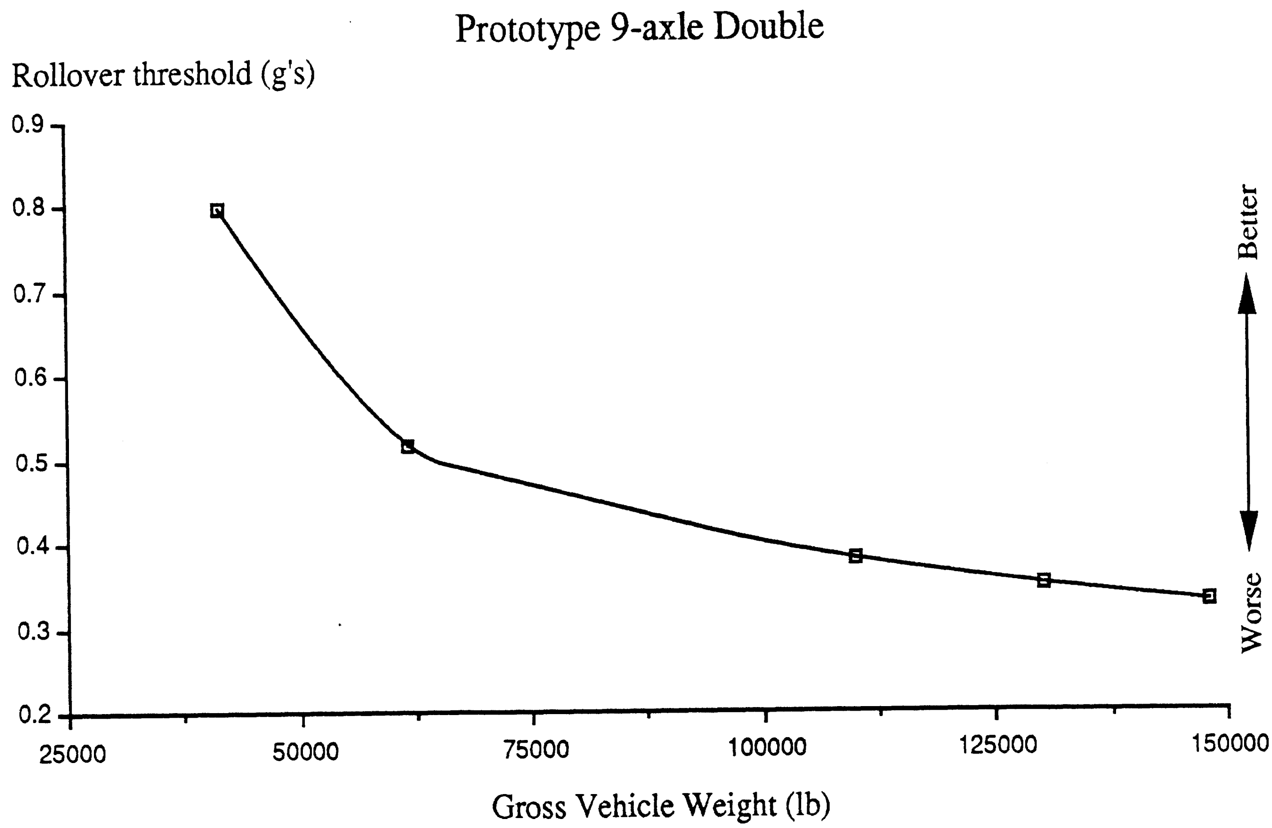
Prototype 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

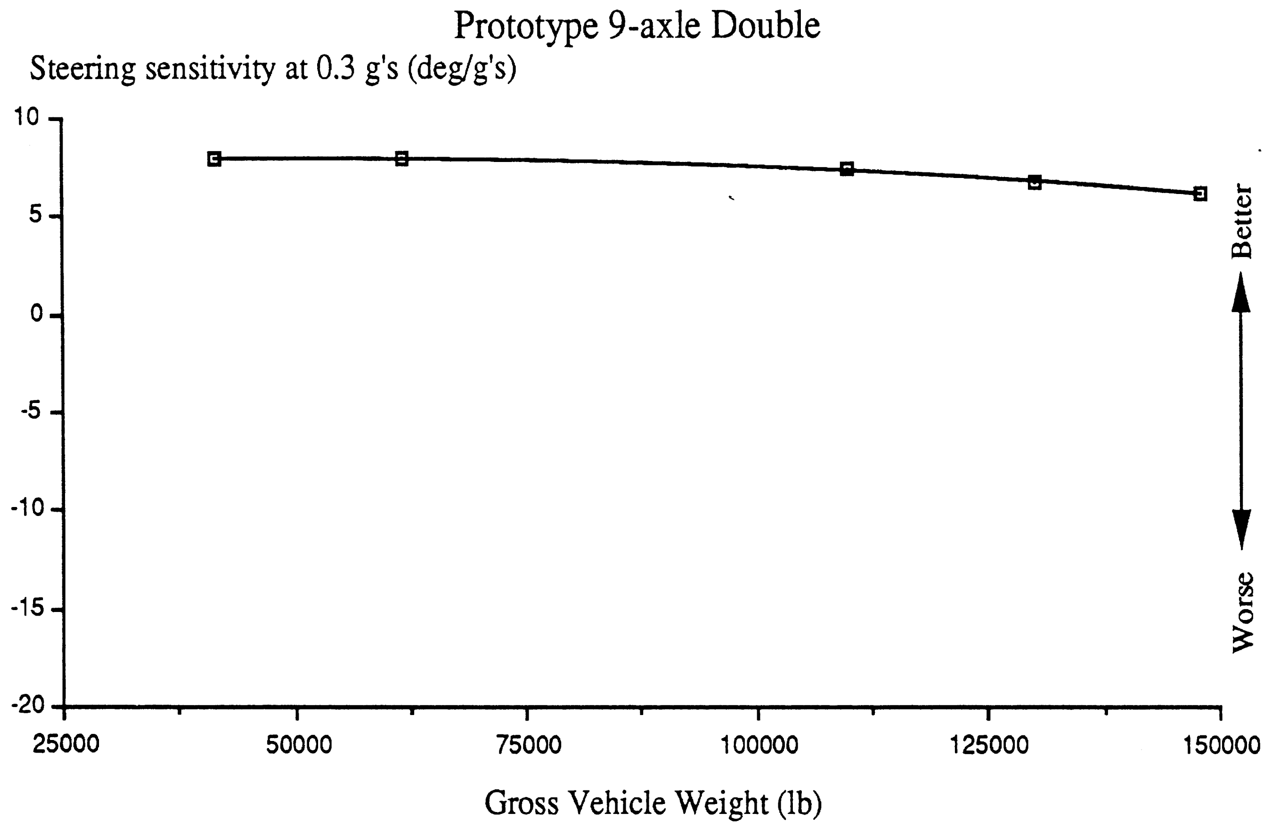


Prototype 9-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



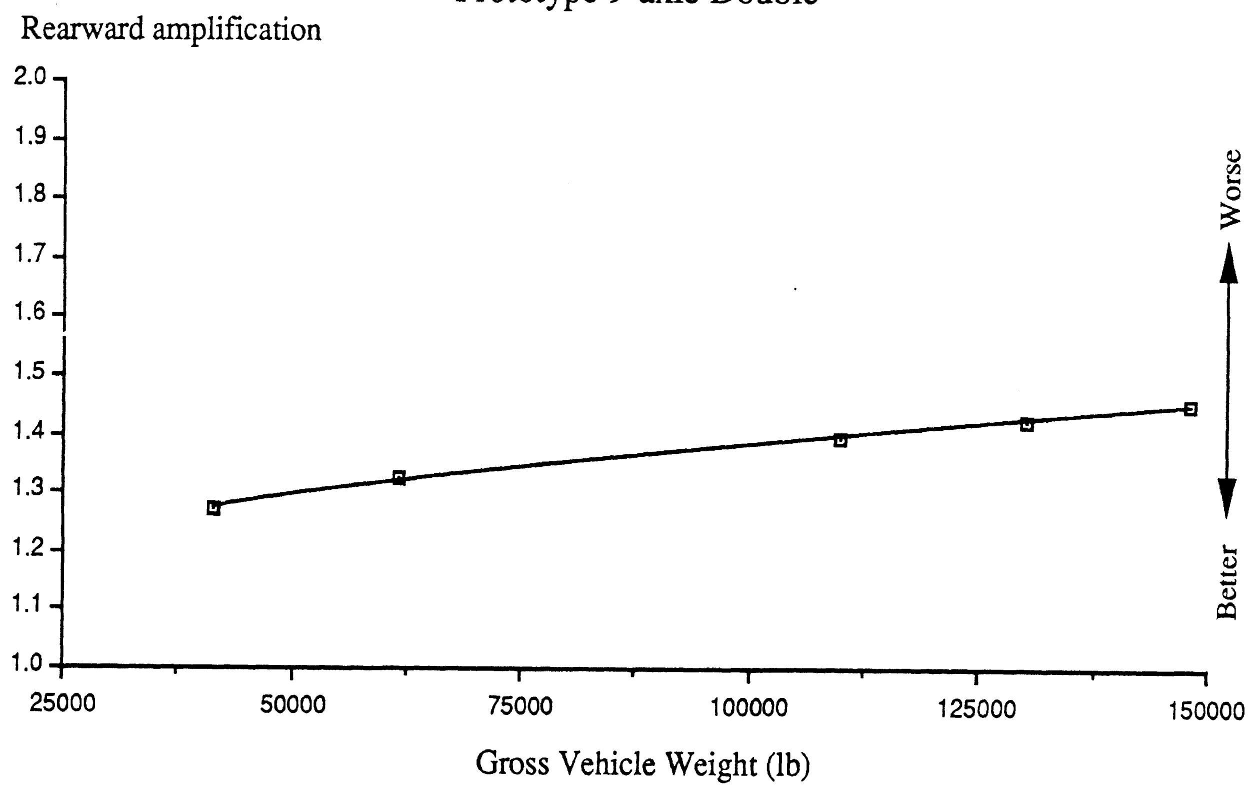
Prototype 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse


Prototype 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse



Prototype 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

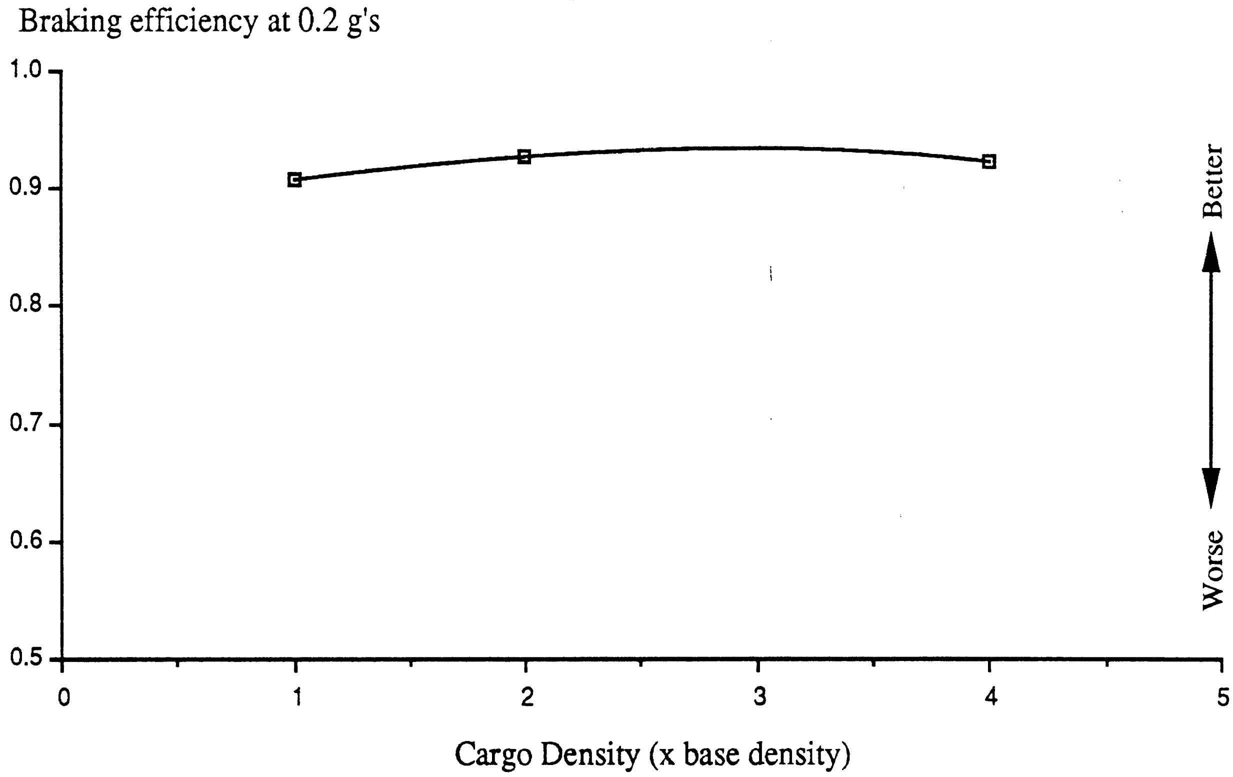
Prototype 9-axle Double

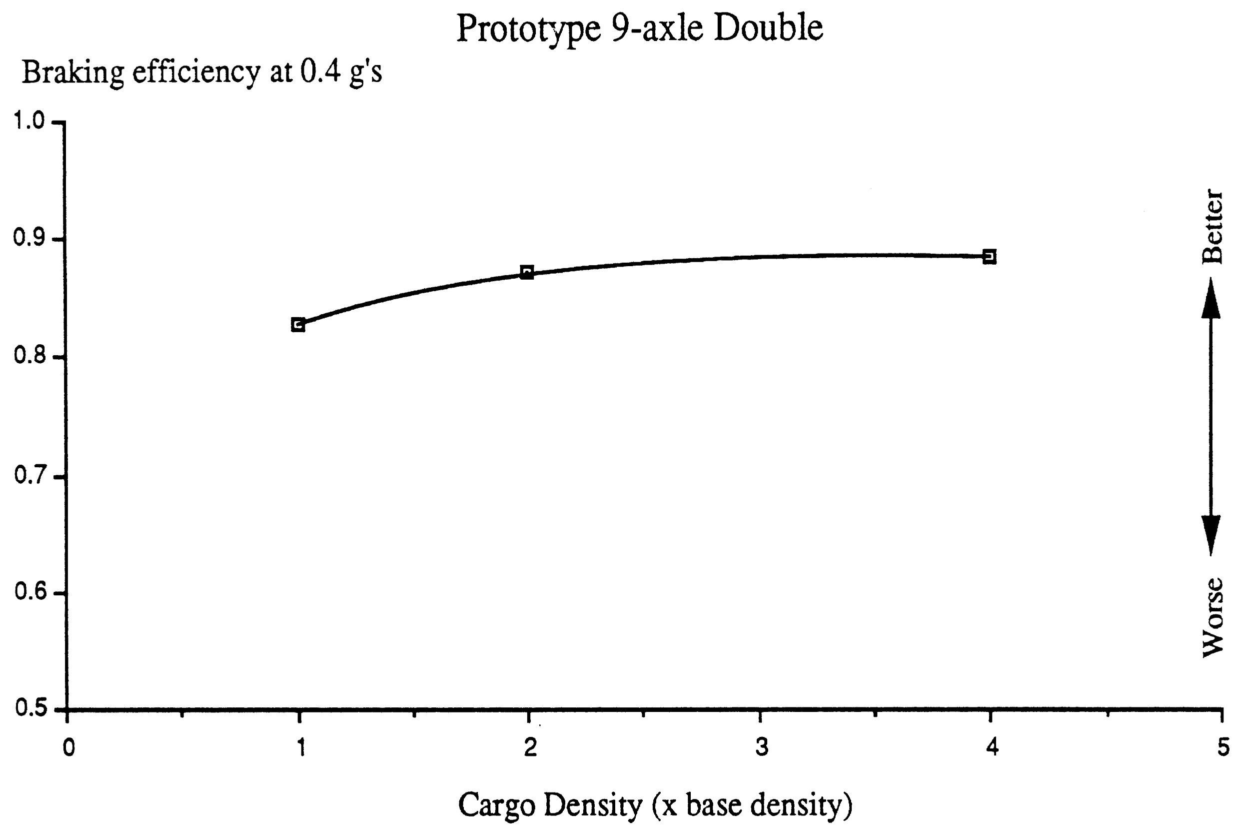


Prototype 9-axle Double (Cargo density)

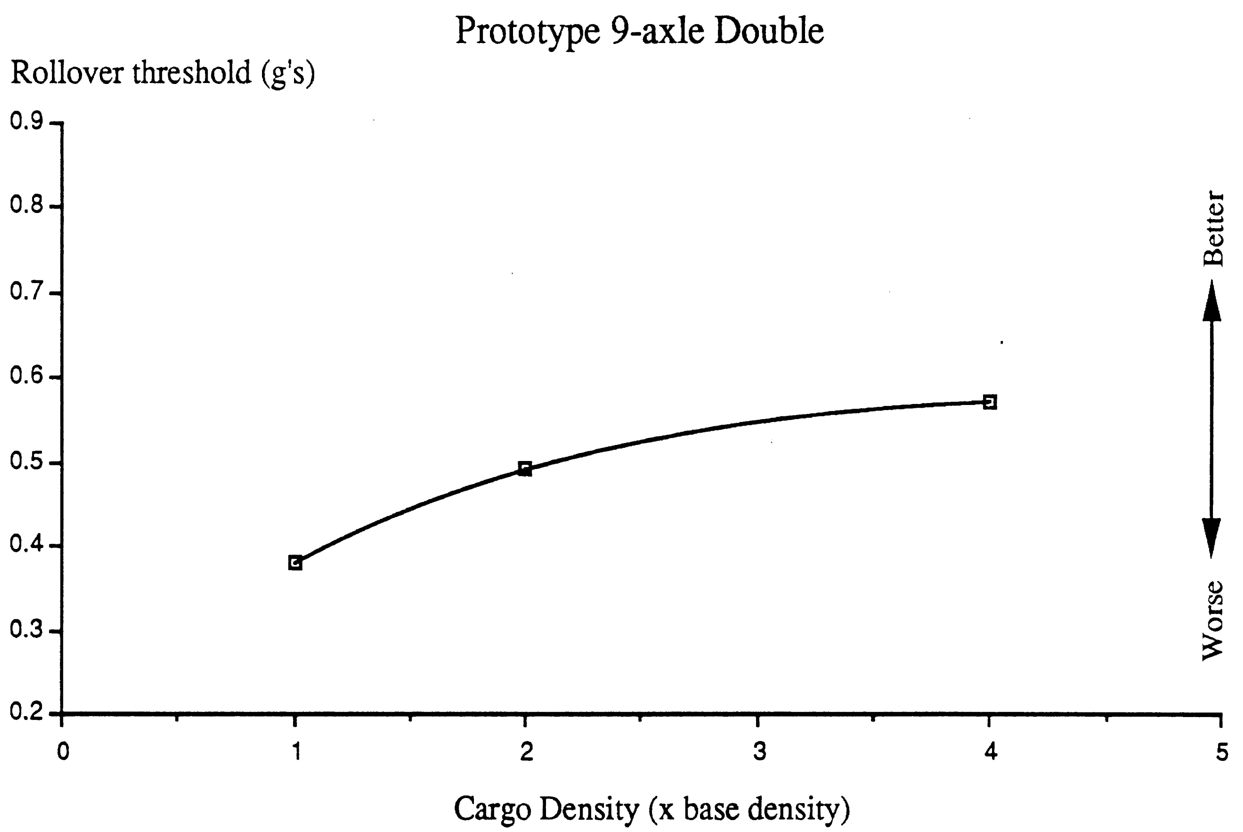
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Transient offtracking (ft)	15.96366	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	High-speed offtracking (ft)	-0.75305	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Braking efficiency at 0.2 g's	0.90742	1
PDbl1.v2.a	Braking efficiency at 0.2 g's	0.92828	2
PDbl1.v2.b	Braking efficiency at 0.2 g's	0.92133	4
PDbl1E	Braking efficiency at 0.2 g's	0.71239	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Braking efficiency at 0.4 g's	0.82875	1
PDbl1.v2.a	Braking efficiency at 0.4 g's	0.87047	2
PDbl1.v2.b	Braking efficiency at 0.4 g's	0.88431	4
PDbl1E	Braking efficiency at 0.4 g's	0.67939	1
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Static rollover threshold (g's)	0.37915	1
PDbl1.v2.a	Static rollover threshold (g's)	0.49305	2
PDbl1.v2.b	Static rollover threshold (g's)	0.57066	4
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	1
PDbl1.v2.a	Steering sens. at 0.3 g's (deg/g's)	7.85045	2
PDbl1.v2.b	Steering sens. at 0.3 g's (deg/g's)	8.02654	4
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl1	Rearward amplification	1.39443	1

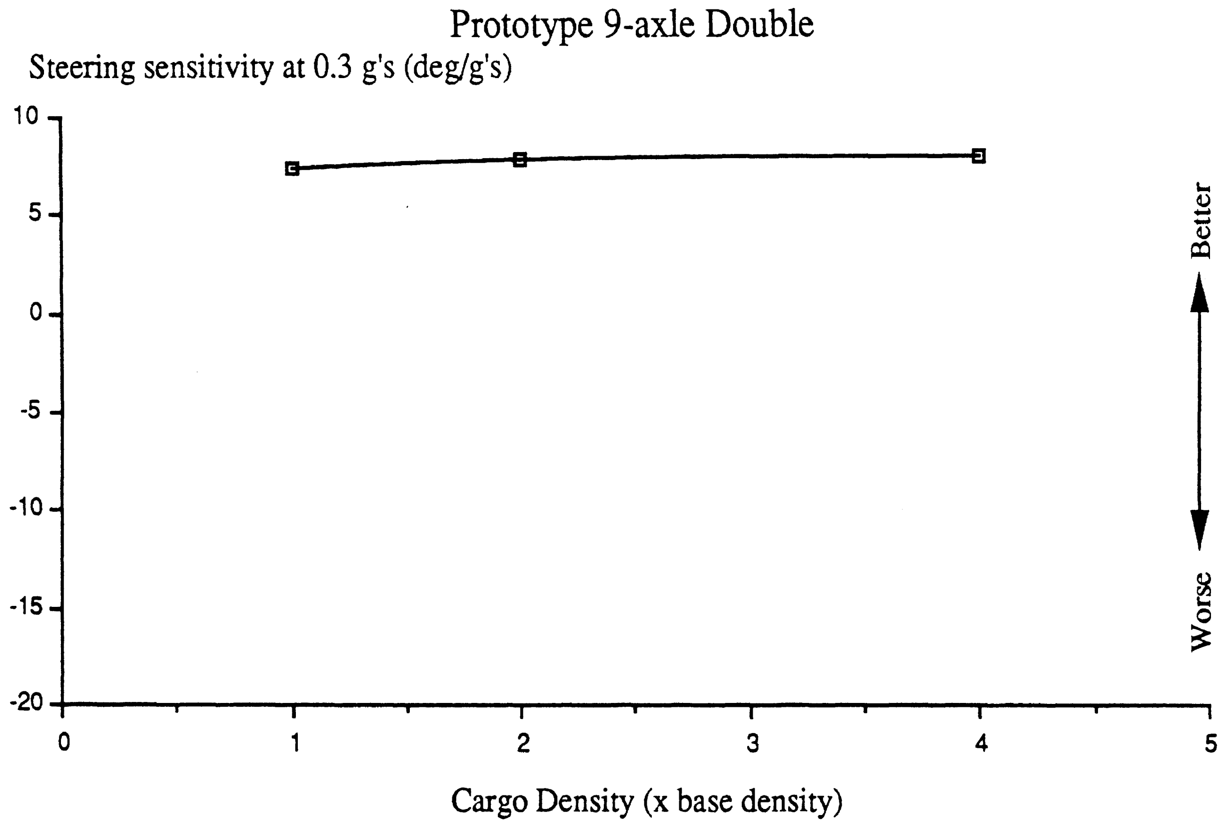
Prototype 9-axle Double





Prototype 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Prototype 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse



Prototype 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Prototype 9-axle Double (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl1	Transient offtracking (ft)	15.96366	33
PDbl1.v3.a	Transient offtracking (ft)	12.15742	28
PDbl1.v3.b	Transient offtracking (ft)	21.70681	40
PDbl1.v3.c	Transient offtracking (ft)	28.65685	48

VEHICLE	MEASURE	VALUE	GVW
PDbl1	High-speed offtracking (ft)	-0.75305	109862
PDbl1.v3.a	High-speed offtracking (ft)	-0.76843	107332
PDbl1.v3.b	High-speed offtracking (ft)	-0.66345	113392
PDbl1.v3.c	High-speed offtracking (ft)	-0.46509	117432

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl1	Braking efficiency at 0.2 g's	0.90742	33
PDbl1.v3.a	Braking efficiency at 0.2 g's	0.89322	28
PDbl1.v3.b	Braking efficiency at 0.2 g's	0.92135	40
PDbl1.v3.c	Braking efficiency at 0.2 g's	0.93284	48
PDbl1E	Braking efficiency at 0.2 g's	0.71239	33
PDbl1.v3.aE	Braking efficiency at 0.2 g's	0.68476	28
PDbl1.v3.bE	Braking efficiency at 0.2 g's	0.74419	40
PDbl1.v3.cE	Braking efficiency at 0.2 g's	0.77391	48

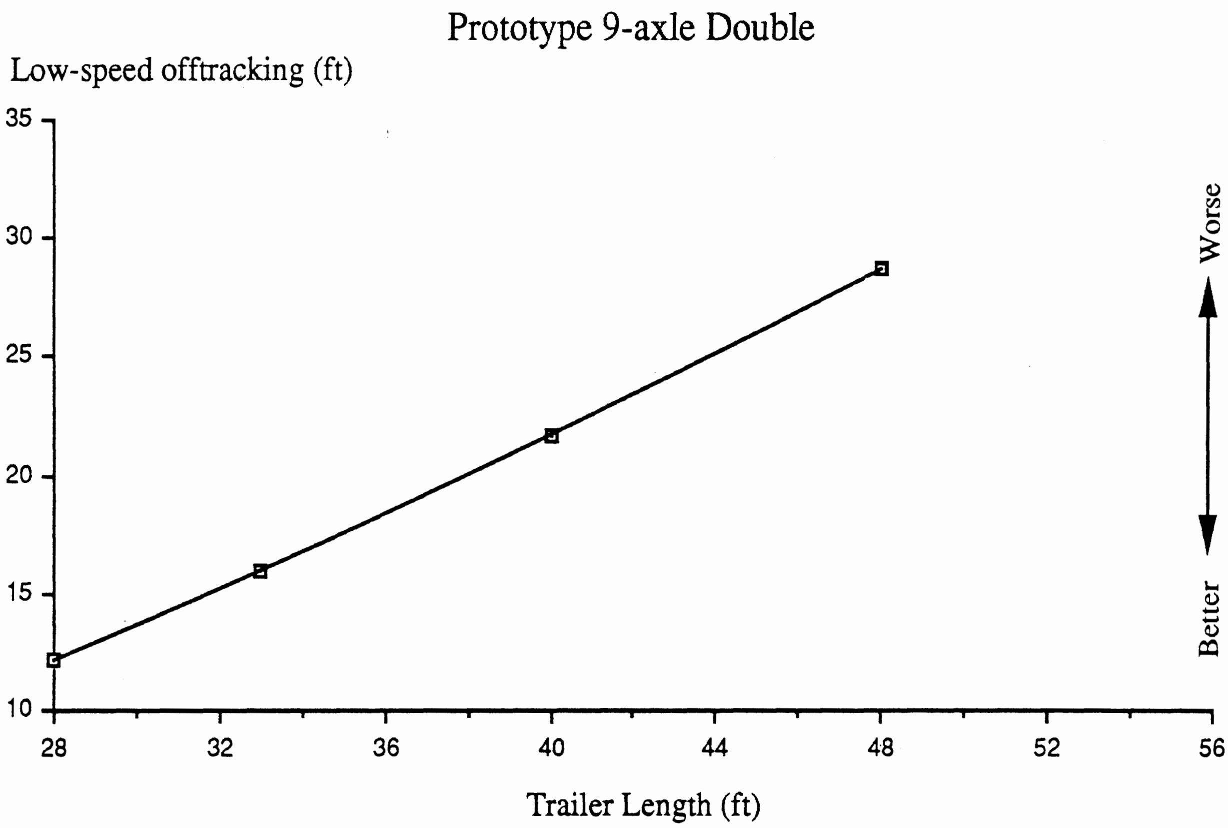
VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl1	Braking efficiency at 0.4 g's	0.82875	33
PDbl1.v3.a	Braking efficiency at 0.4 g's	0.79526	28
PDbl1.v3.b	Braking efficiency at 0.4 g's	0.85980	40
PDbl1.v3.c	Braking efficiency at 0.4 g's	0.88364	48
PDbl1E	Braking efficiency at 0.4 g's	0.67939	33
PDbl1.v3.aE	Braking efficiency at 0.4 g's	0.64637	28
PDbl1.v3.bE	Braking efficiency at 0.4 g's	0.71628	40
PDbl1.v3.cE	Braking efficiency at 0.4 g's	0.74996	48

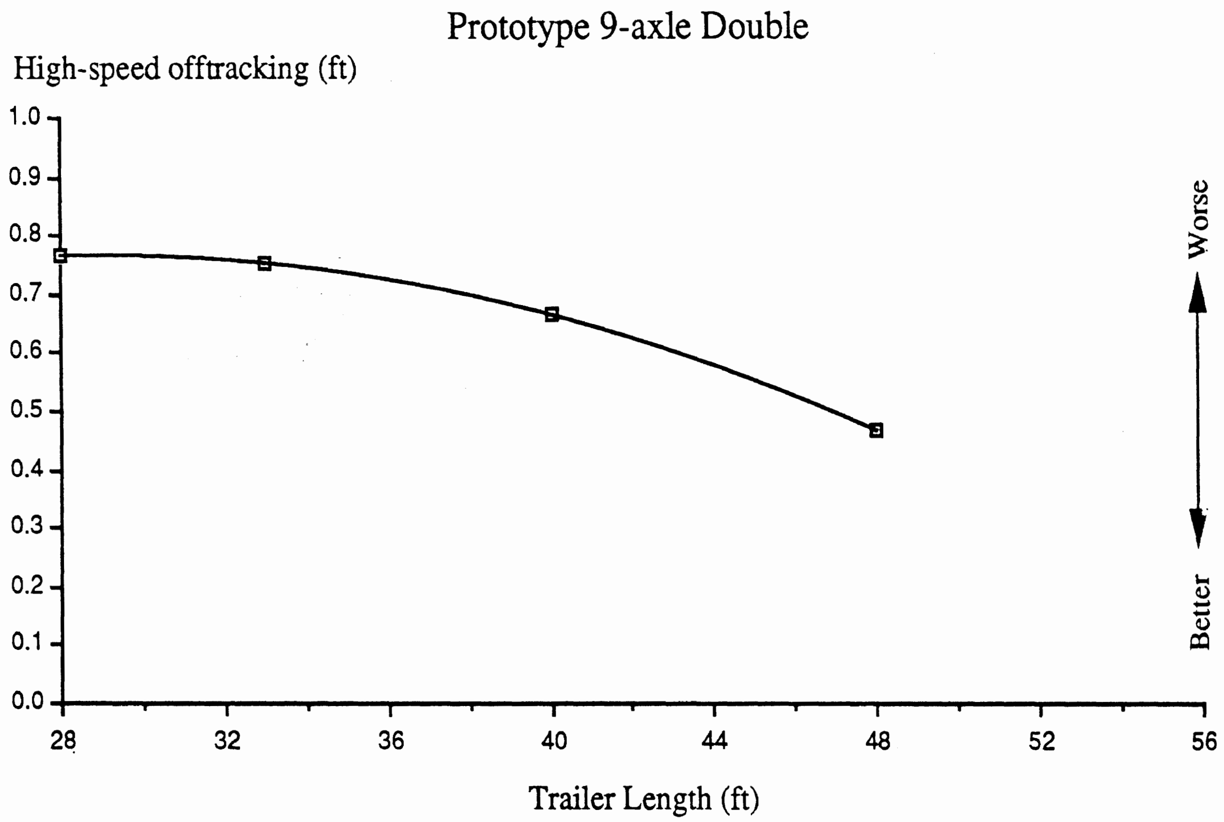
VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl1	Static rollover threshold (g's)	0.37915	33
PDbl1.v3.a	Static rollover threshold (g's)	0.37941	28
PDbl1.v3.b	Static rollover threshold (g's)	0.37977	40
PDbl1.v3.c	Static rollover threshold (g's)	0.37841	48

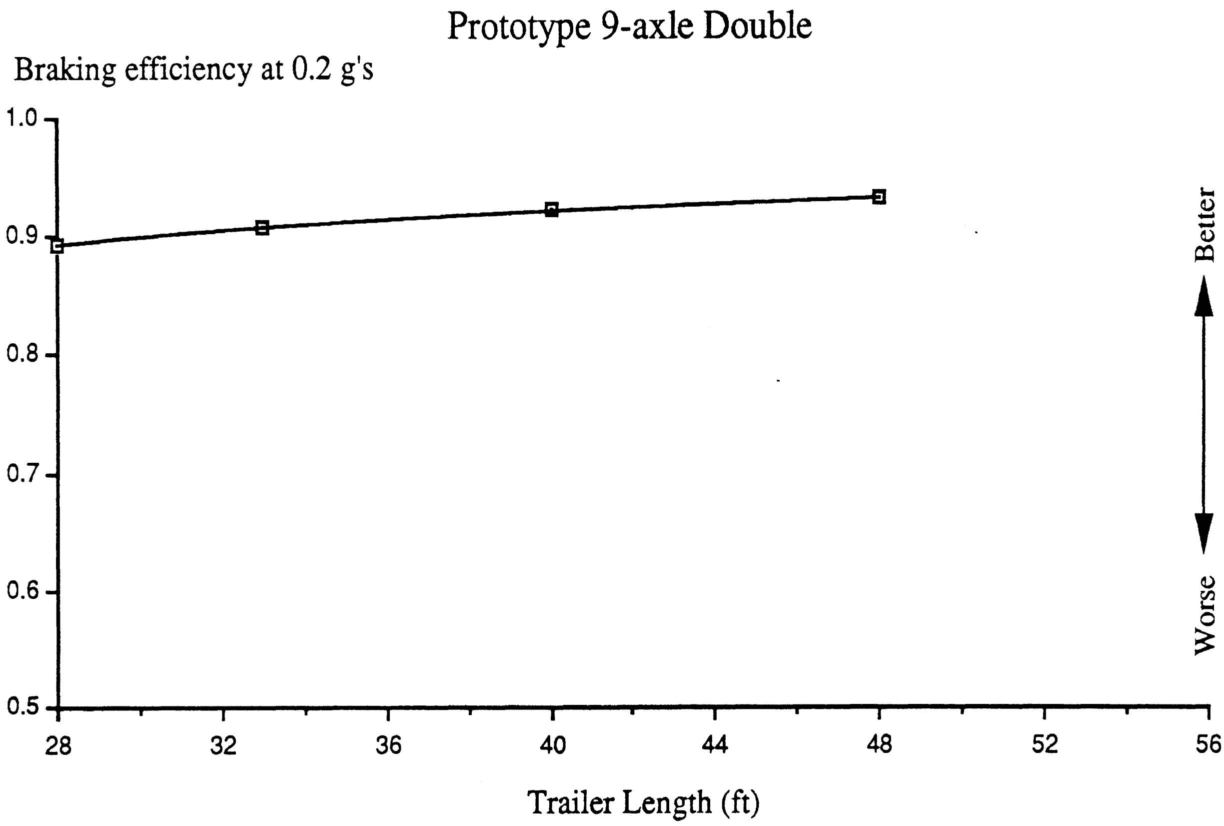
VEHICLE	MEASURE	VALUE	GVW
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	109862
PDbl1.v3.a	Steering sens. at 0.3 g's (deg/g's)	7.33925	107332
PDbl1.v3.b	Steering sens. at 0.3 g's (deg/g's)	7.28162	113392
PDbl1.v3.c	Steering sens. at 0.3 g's (deg/g's)	7.22720	117432

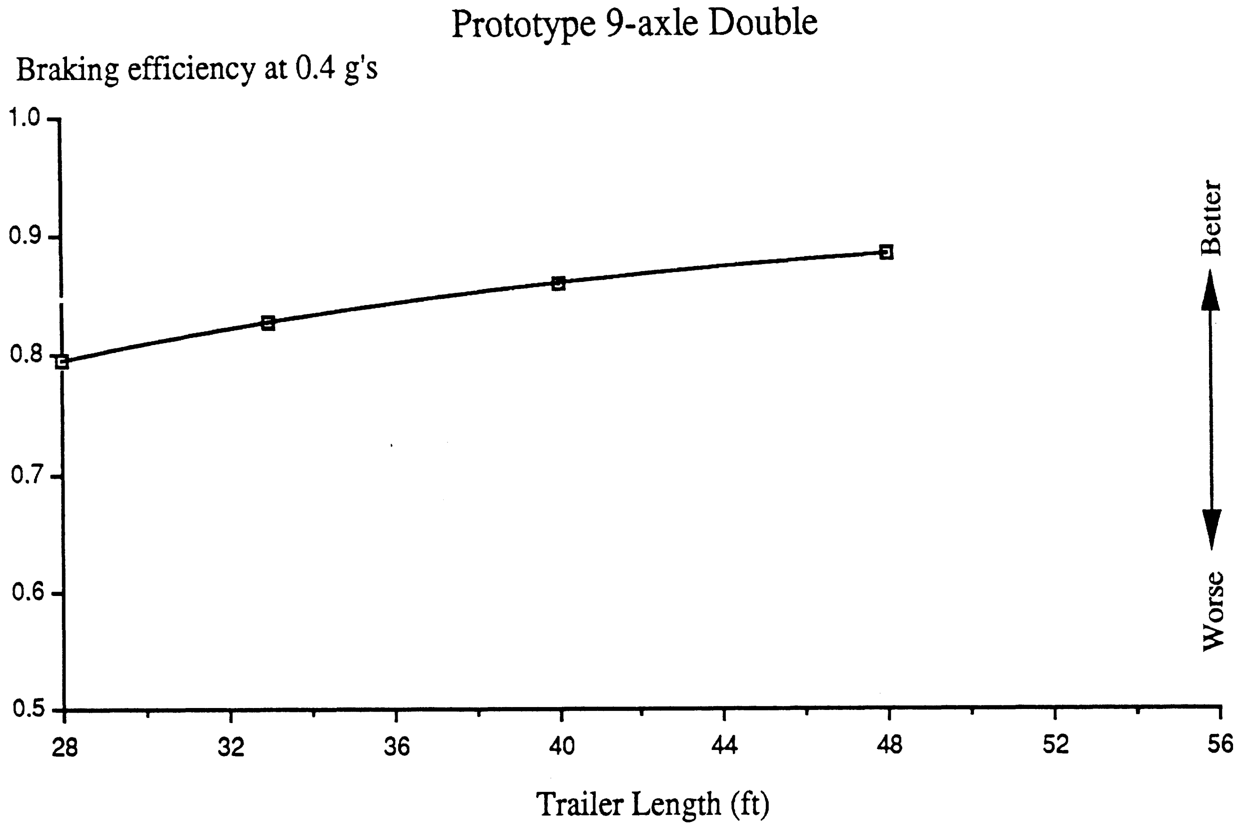
Prototype 9-axle Double (Trailer length)

VEHICLE	MEASURE	VALUE	GVW
PDbl1	Rearward amplification	1.39443	109862
PDbl1.v3.a	Rearward amplification	1.62965	107332
PDbl1.v3.b	Rearward amplification	1.19748	113392
PDbl1.v3.c	Rearward amplification	1.07347	117432


Prototype 9-axle Double
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

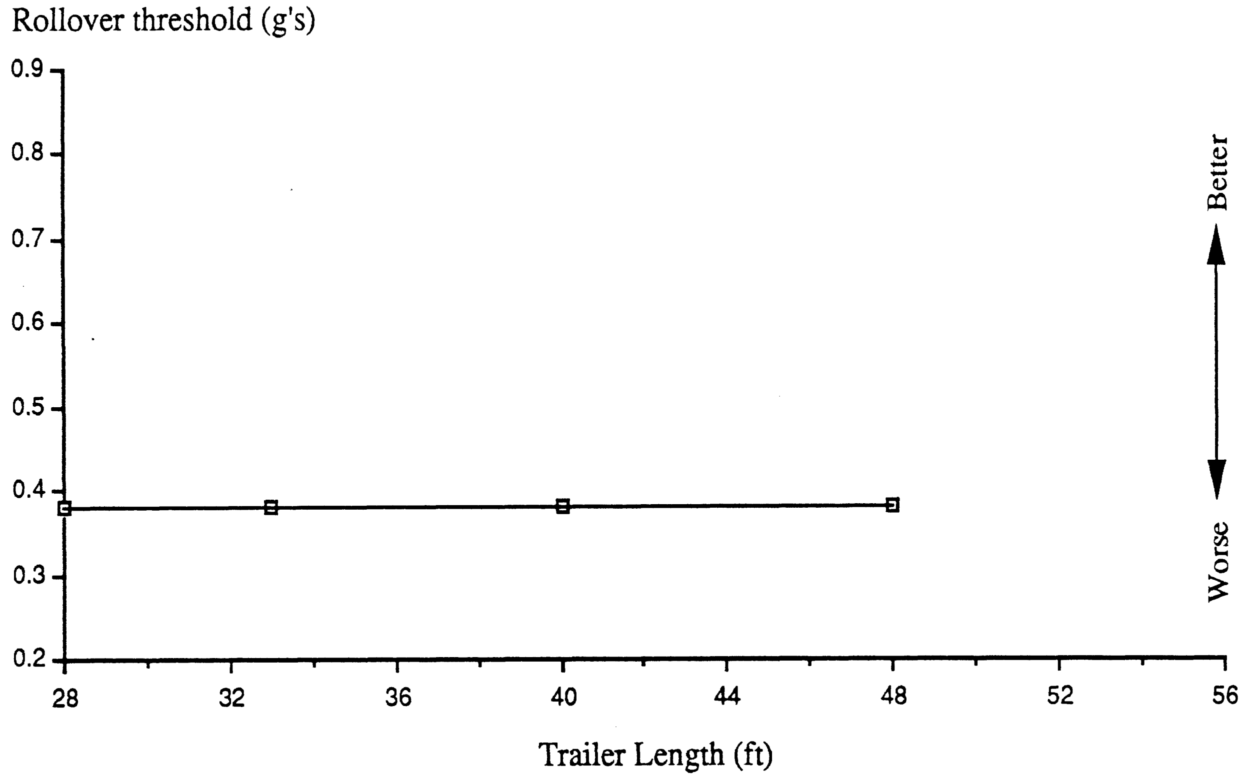

Prototype 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

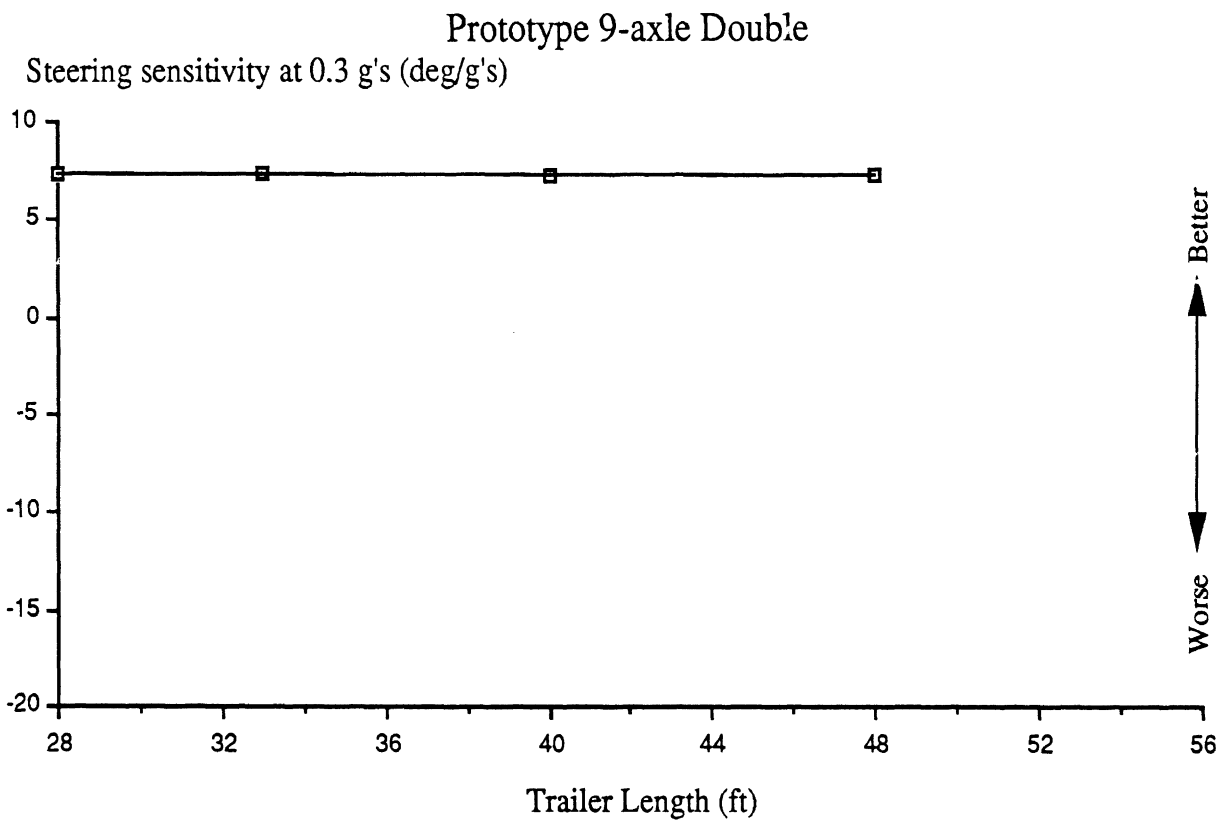

Prototype 9-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

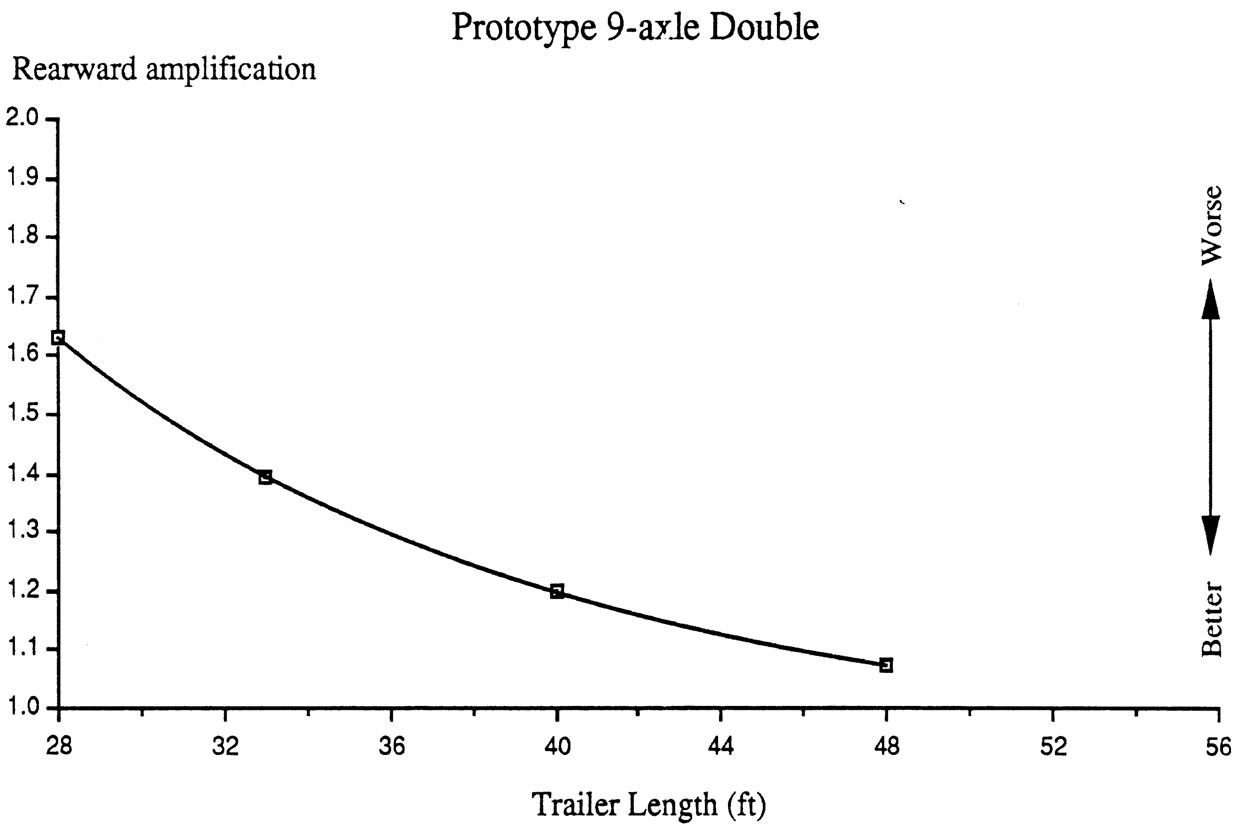


Prototype 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

Prototype 9-axle Double

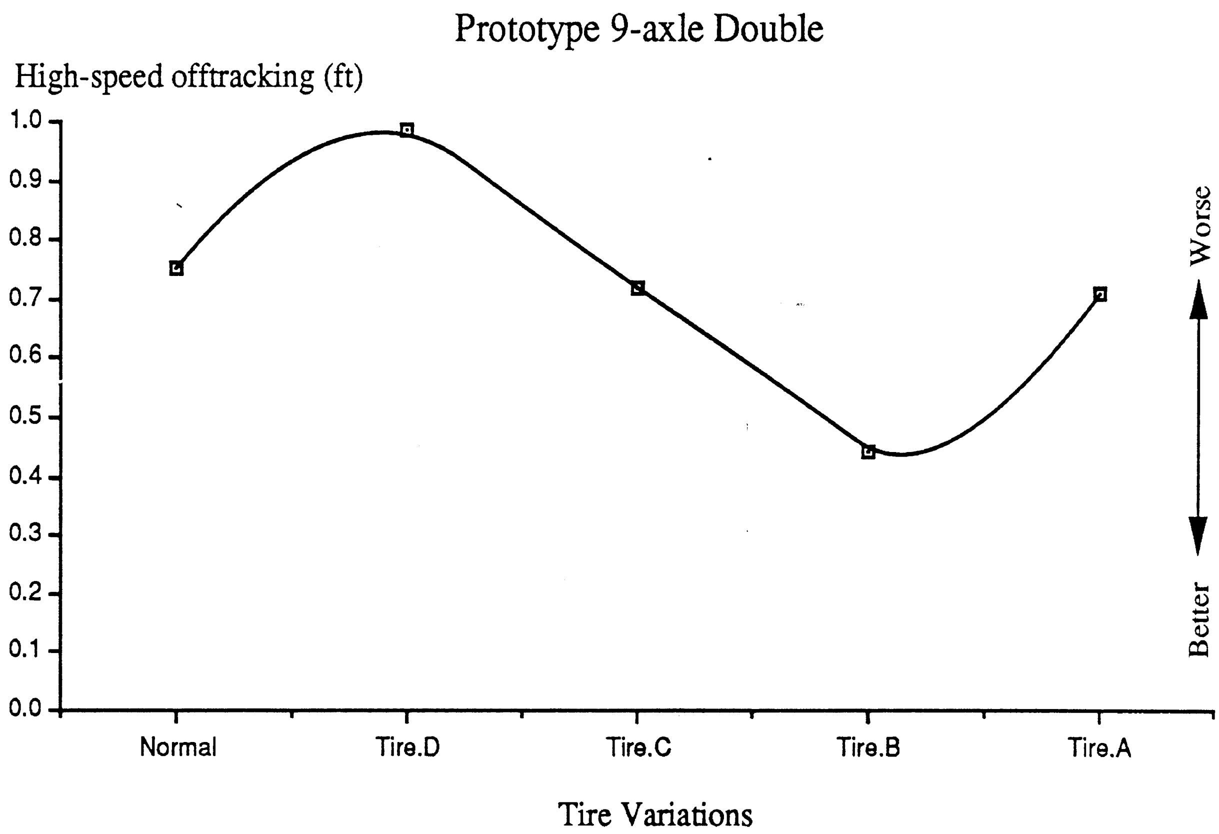



Prototype 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

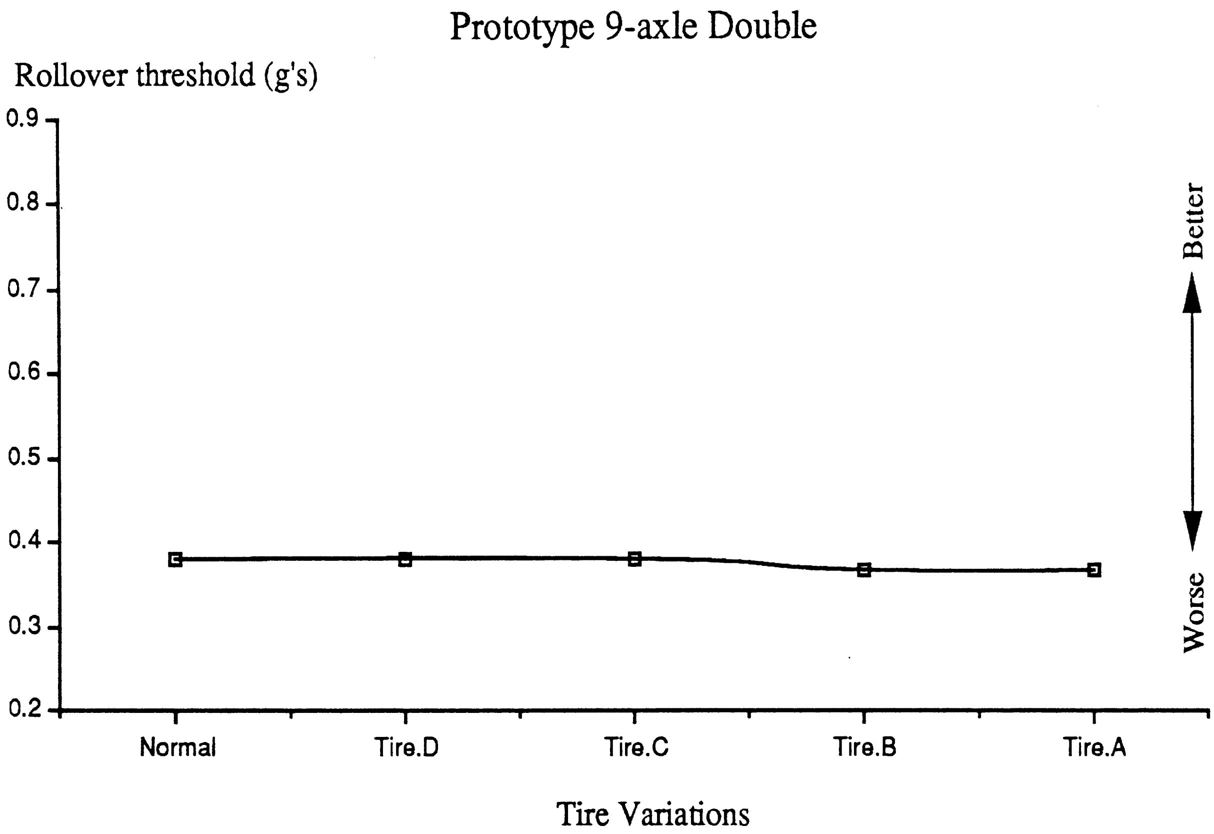

Prototype 9-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

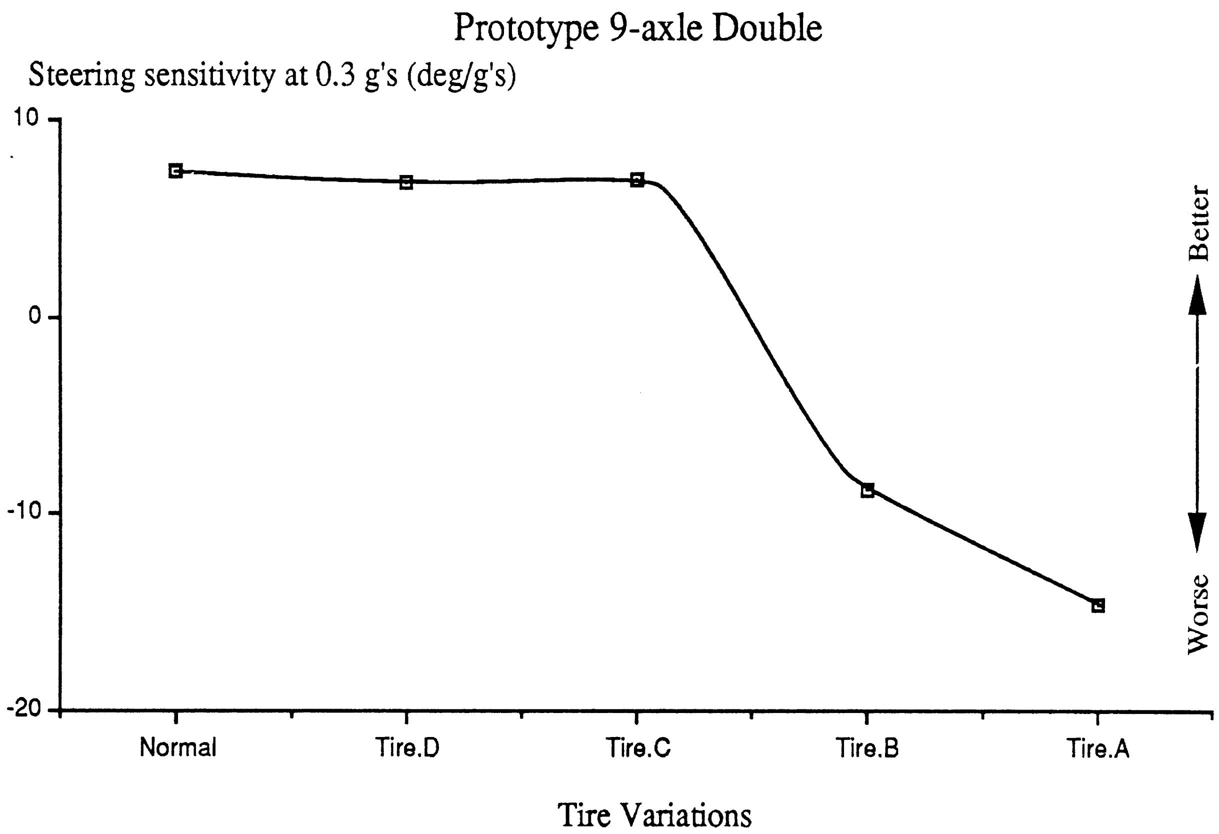
Prototype 9-axle Double (Wide-base single tires)

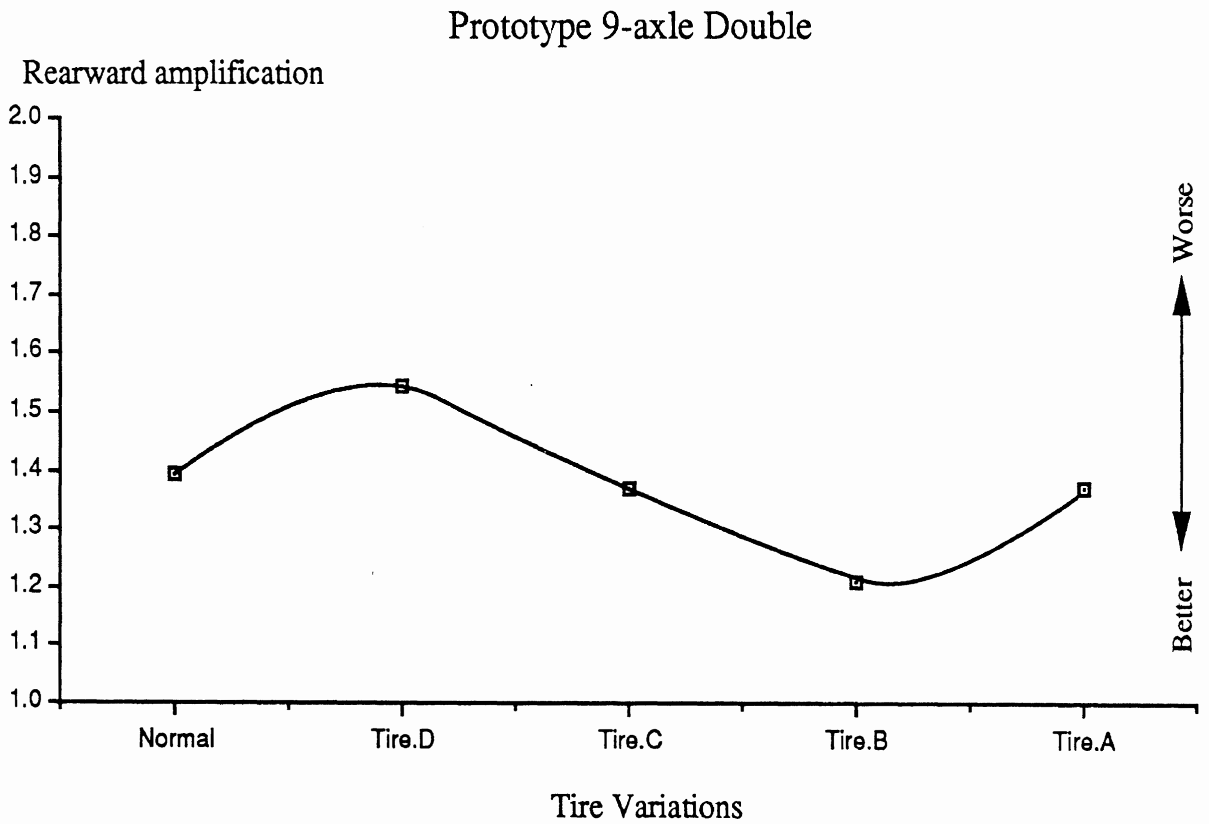
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Transient offtracking (ft)	15.96366	Normal
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	High-speed offtracking (ft)	-0.75305	Normal
PDbl1.v5.a	High-speed offtracking (ft)	-0.71069	Tire.A
PDbl1.v5.b	High-speed offtracking (ft)	-0.44189	Tire.B
PDbl1.v5.c	High-speed offtracking (ft)	-0.71680	Tire.C
PDbl1.v5.d	High-speed offtracking (ft)	-0.98413	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Braking efficiency at 0.2 g's	0.90742	Normal
PDbl1E	Braking efficiency at 0.2 g's	0.71239	Normal
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Braking efficiency at 0.4 g's	0.82875	Normal
PDbl1E	Braking efficiency at 0.4 g's	0.67939	Normal
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Static rollover threshold (g's)	0.37915	Normal
PDB11.v5.a	Static rollover threshold (g's)	0.36748	Tire.A
PDbl1.v5.b	Static rollover threshold (g's)	0.36748	Tire.B
PDbl1.v5.c	Static rollover threshold (g's)	0.38122	Tire.C
PDbl1.v5.d	Static rollover threshold (g's)	0.37961	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	Normal
PDbl1.v5.a	Steering sens. at 0.3 g's (deg/g's)	-14.62088	Tire.A
PDbl1.v5.b	Steering sens. at 0.3 g's (deg/g's)	-8.77840	Tire.B
PDbl1.v5.c	Steering sens. at 0.3 g's (deg/g's)	6.89209	Tire.C
PDbl1.v5.d	Steering sens. at 0.3 g's (deg/g's)	6.84940	Tire.D
VEHICLE	MEASURE	VALUE	TIRES
PDbl1	Rearward amplification	1.39443	Normal
PDbl1.v5.a	Rearward amplification	1.36937	Tire.A
PDbl1.v5.b	Rearward amplification	1.20940	Tire.B
PDbl1.v5.c	Rearward amplification	1.36937	Tire.C
PDbl1.v5.d	Rearward amplification	1.54391	Tire.D



Prototype 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Worse
Better


Prototype 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Better
Worse


Prototype 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
0
-10
-20
Better
Worse
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations


Prototype 9-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Worse
Better
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations

Prototype 9-axle Double (Suspensions)

VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Transient offtracking (ft)	15.96366	Normal

VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	High-speed offtracking (ft)	-0.75305	Normal

VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Braking efficiency at 0.2 g's	0.90742	Normal
PDbl1E	Braking efficiency at 0.2 g's	0.71239	Normal

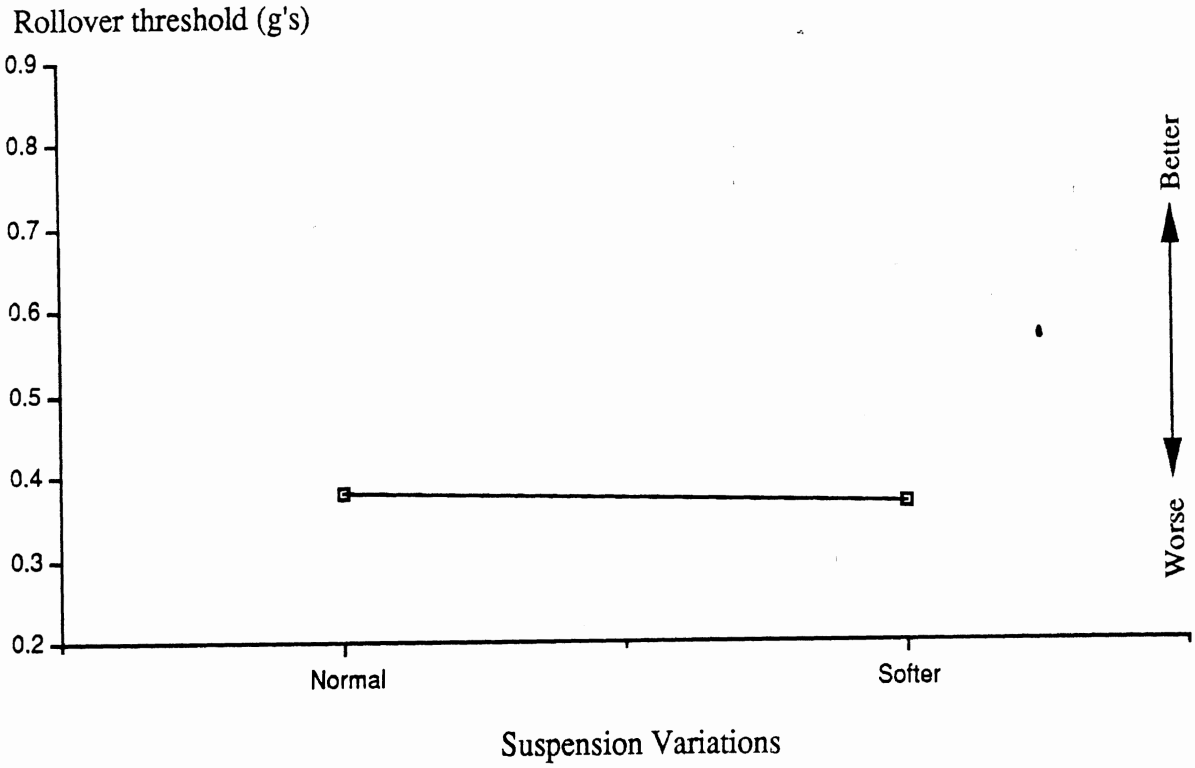
VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Braking efficiency at 0.4 g's	0.82875	Normal
PDbl1E	Braking efficiency at 0.4 g's	0.67939	Normal

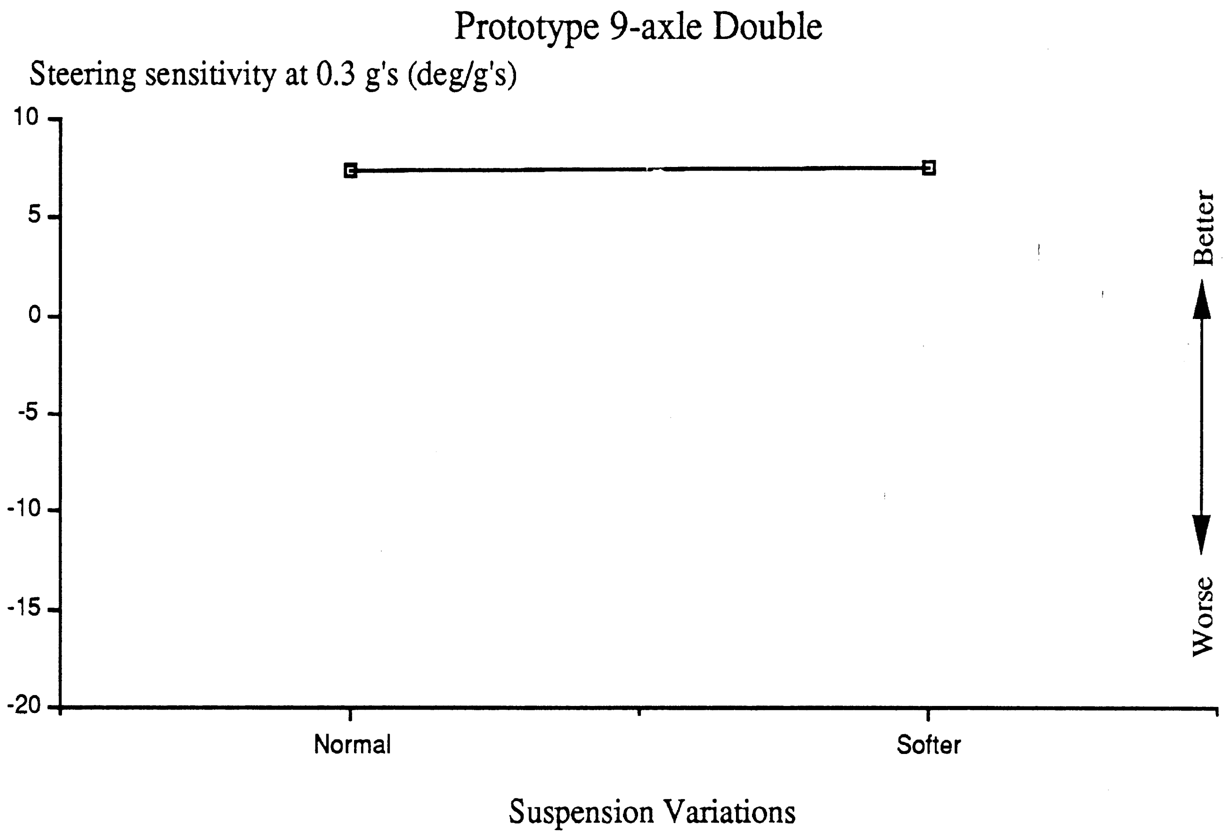
VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Static rollover threshold (g's)	0.37915	Normal
PDbl1.v6.a	Static rollover threshold (g's)	0.36586	Softer

VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	Normal
PDbl1.v6.a	Steering sens. at 0.3 g's (deg/g's)	7.50894	Softer

VEHICLE	MEASURE	VALUE	SUSP.
PDbl1	Rearward amplification	1.39443	Normal

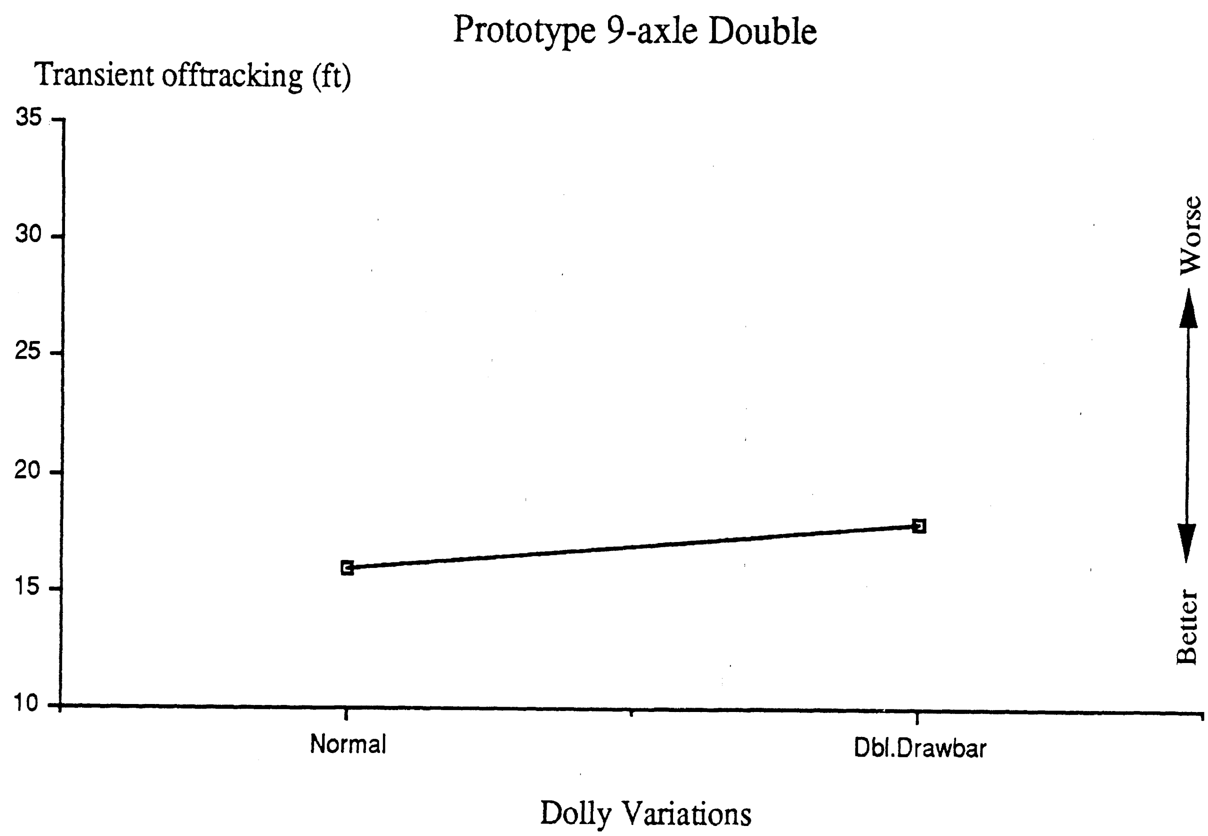
Prototype 9-axle Double

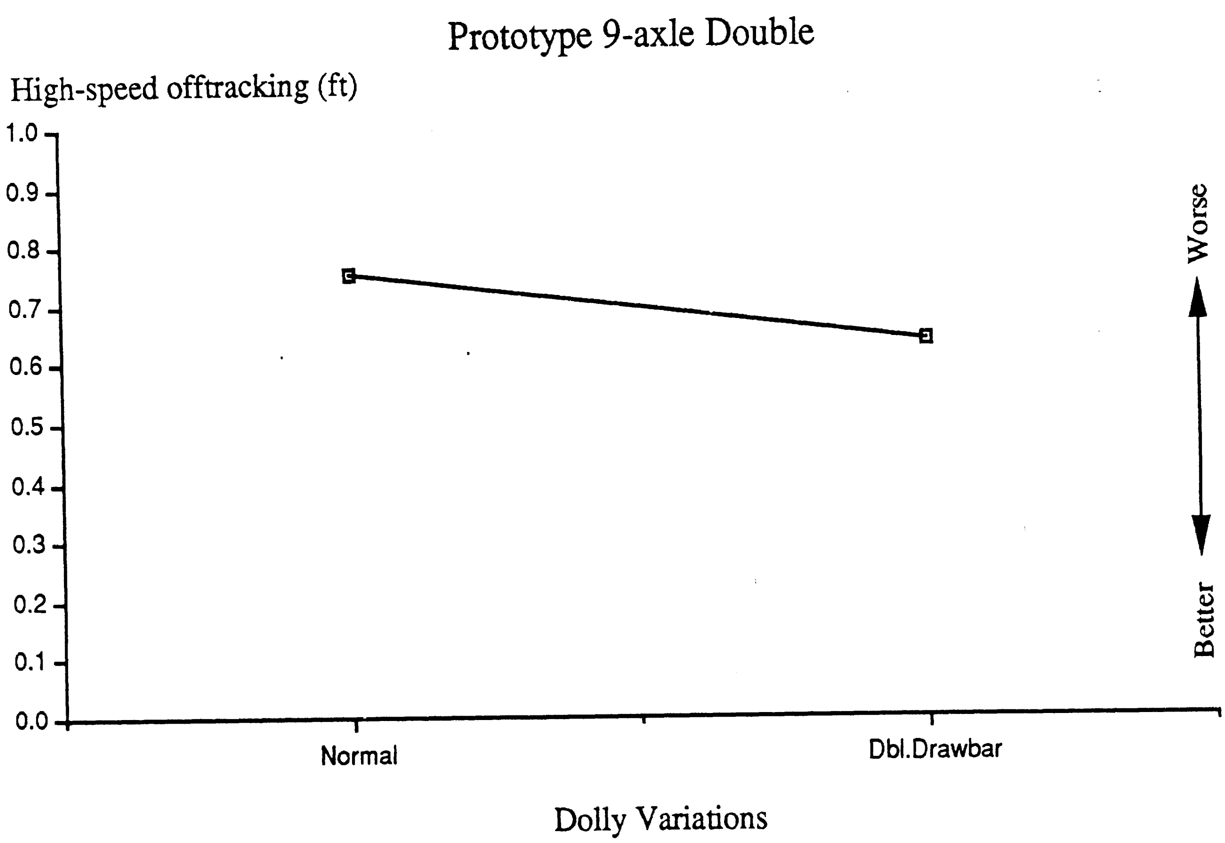


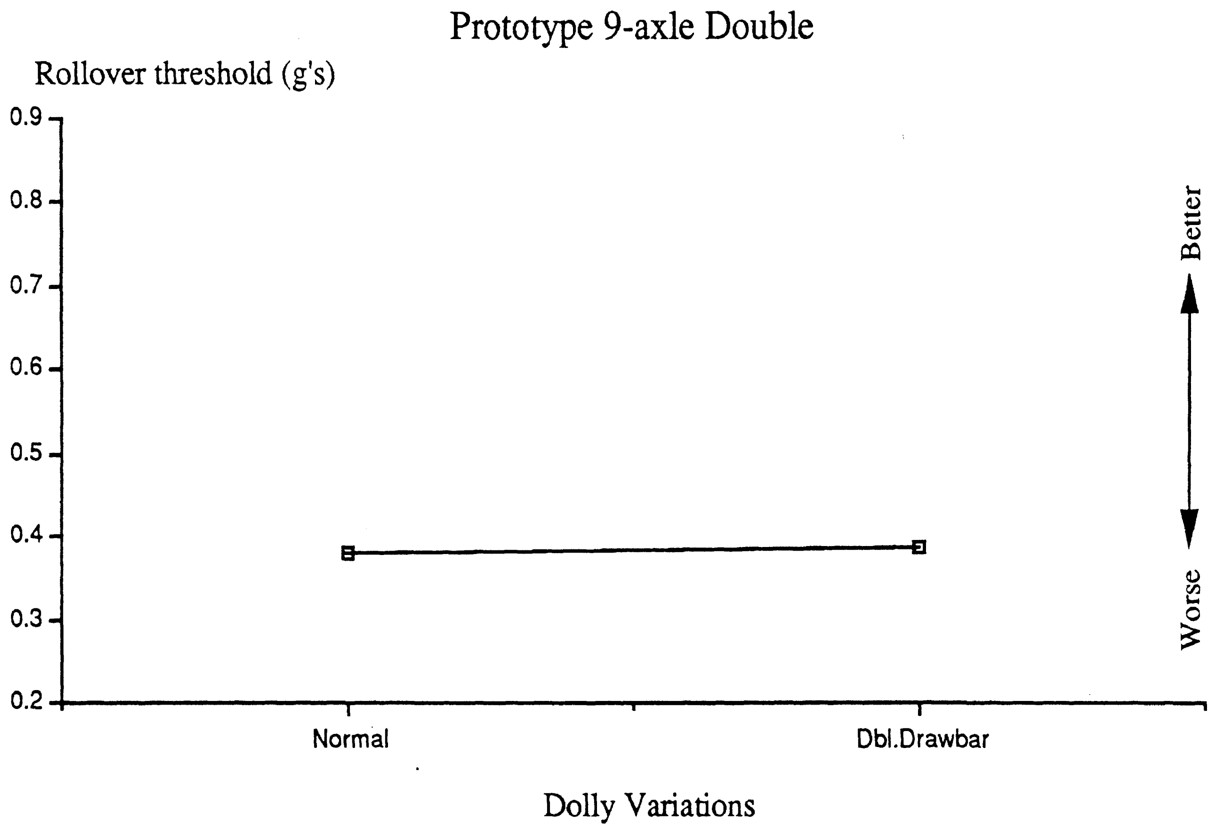

Prototype 9-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
Normal
Softer
Suspension Variations
Better
Worse

Prototype 9-axle Double (Dolly)

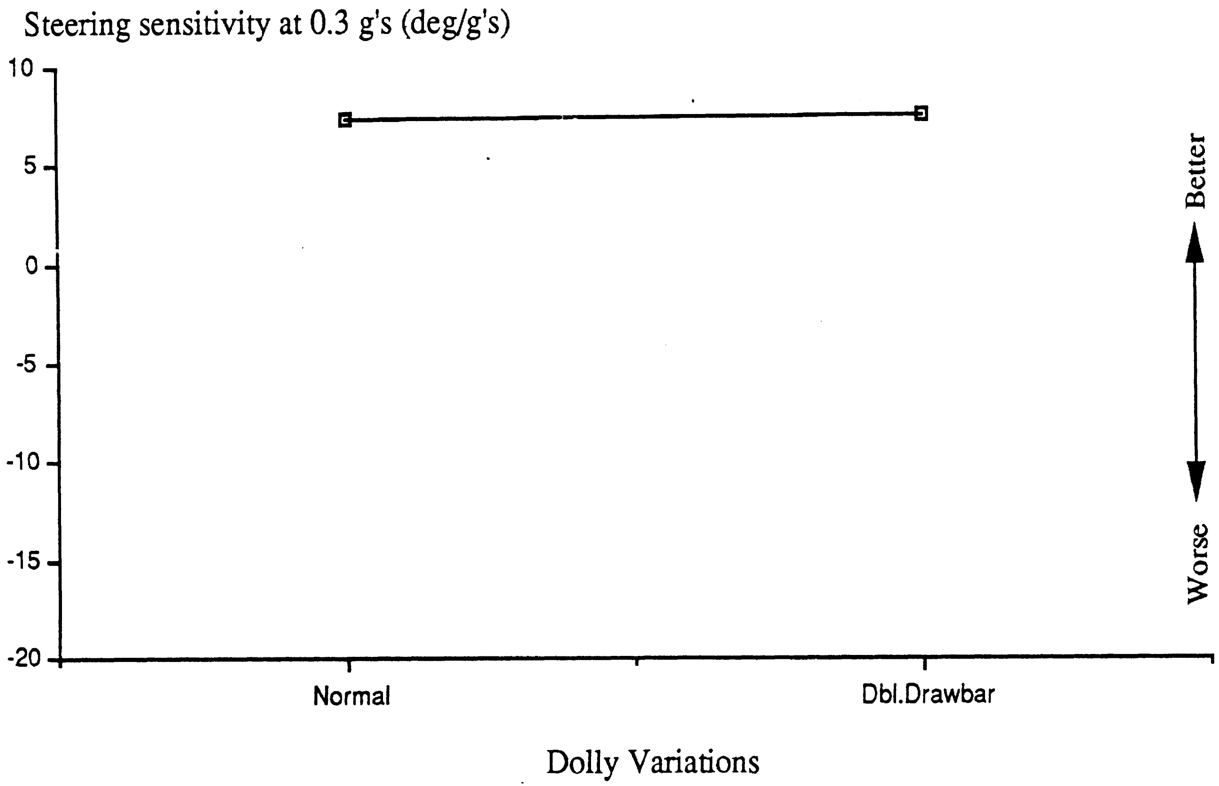
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	Transient offtracking (ft)	15.96366	Normal
PDbl1.v7.a	Transient offtracking (ft)	17.91574	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	High-speed offtracking (ft)	-0.75305	Normal
PDbl1.v7.a	High-speed offtracking (ft)	-0.63672	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	Braking efficiency at 0.2 g's	0.90742	Normal
PDbl1E	Braking efficiency at 0.2 g's	0.71239	Normal
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	Braking efficiency at 0.4 g's	0.82875	Normal
PDbl1E	Braking efficiency at 0.4 g's	0.67939	Normal
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	Static rollover threshold (g's)	0.37915	Normal
PDbl1.v7.a	Static rollover threshold (g's)	0.38780	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	Normal
PDbl1.v7.a	Steering sens. at 0.3 g's (deg/g's)	7.54950	Dbl.Drawbar


Prototype 9-axle Double
Transient offtracking (ft)
35
30
25
20
15
10
Normal
Dbl.Drawbar
Dolly Variations
Worse
Better


Prototype 9-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Worse
Better
Normal
Dbl.Drawbar
Dolly Variations


Prototype 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Normal
Dbl.Drawbar
Dolly Variations
Better
Worse

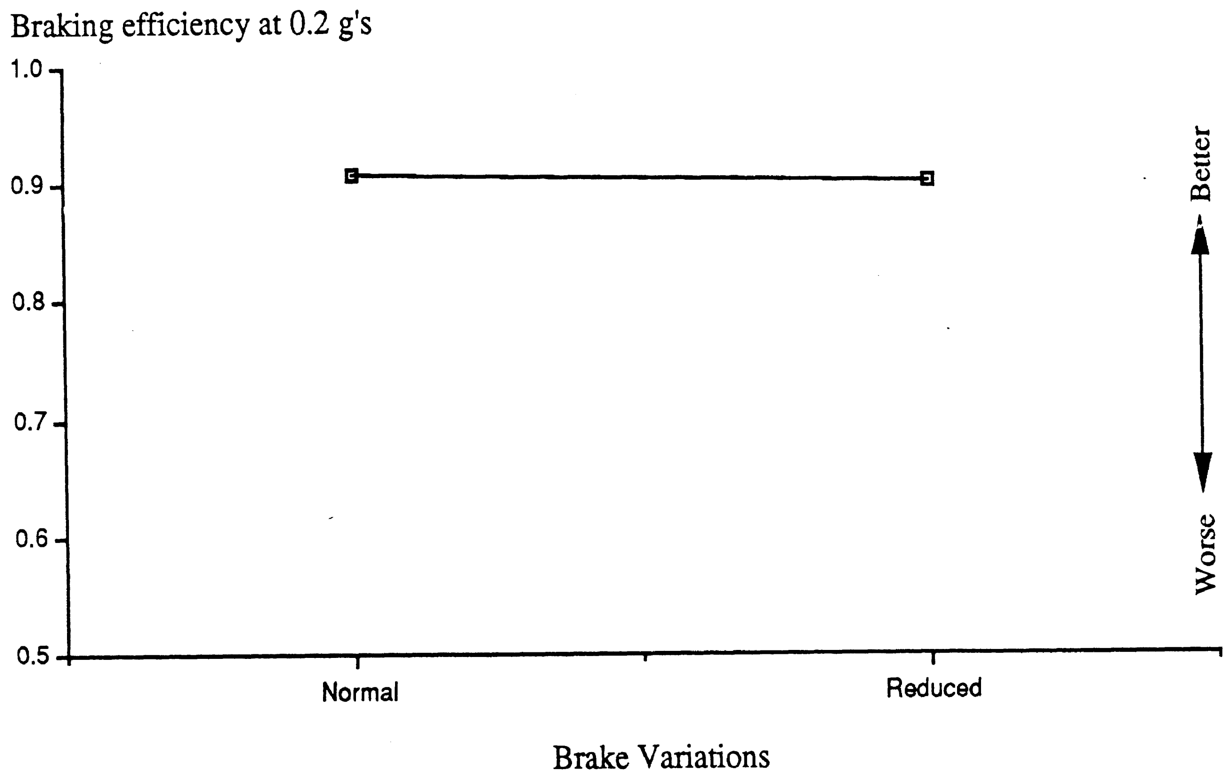
Prototype 9-axle Double

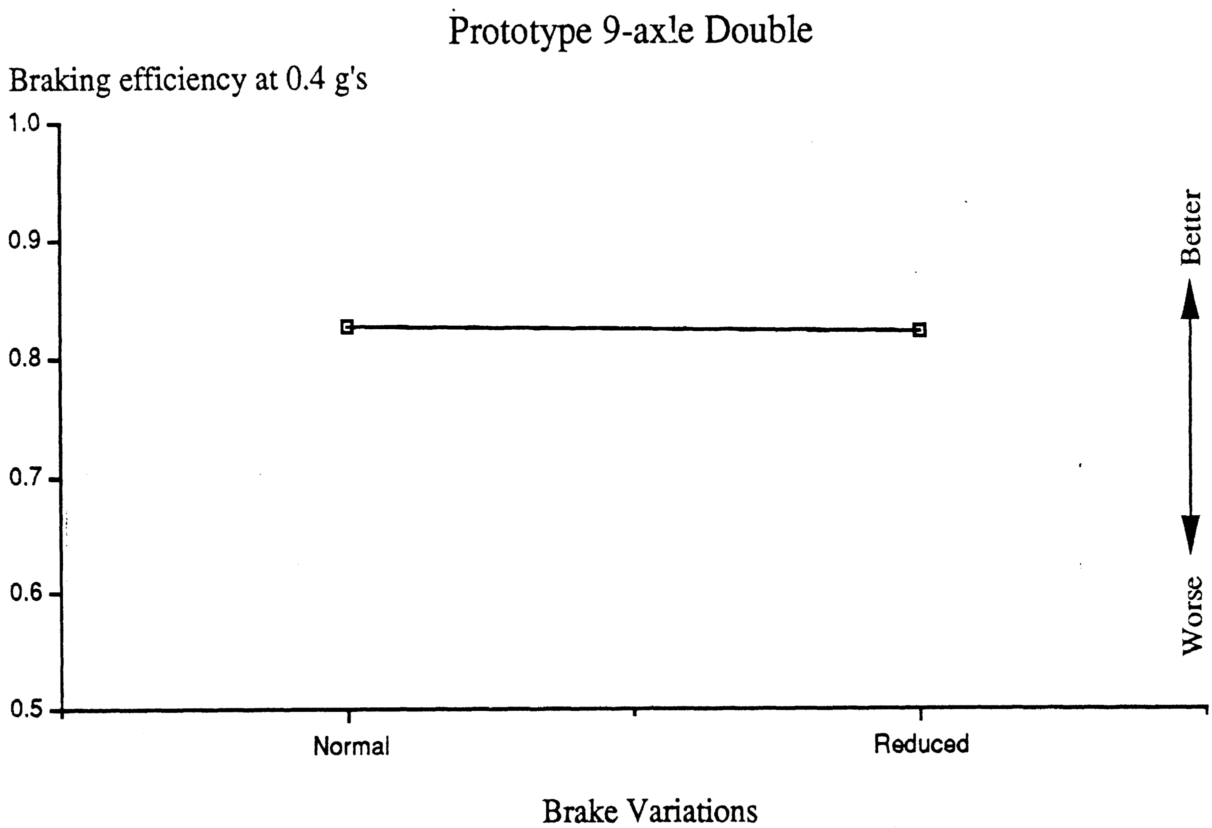


Prototype 9-axle Double (Brakes)

VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Transient offtracking (ft)	15.96366	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	High-speed offtracking (ft)	-0.75305	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Braking efficiency at 0.2 g's	0.90742	Normal
PDbl1.v8.a	Braking efficiency at 0.2 g's	0.90020	Reduced
PDbl1E	Braking efficiency at 0.2 g's	0.71239	Normal
PDbl1.v8.aE	Braking efficiency at 0.2 g's	0.70667	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Braking efficiency at 0.4 g's	0.82875	Normal
PDbl1.v8.a	Braking efficiency at 0.4 g's	0.82189	Reduced
PDbl1E	Braking efficiency at 0.4 g's	0.67939	Normal
PDbl1.v8.aE	Braking efficiency at 0.4 g's	0.67368	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Static rollover threshold (g's)	0.37915	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Steering sens. at 0.3 g's (deg/g's)	7.31364	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl1	Rearward amplification	1.39443	Normal

Prototype 9-axle Double





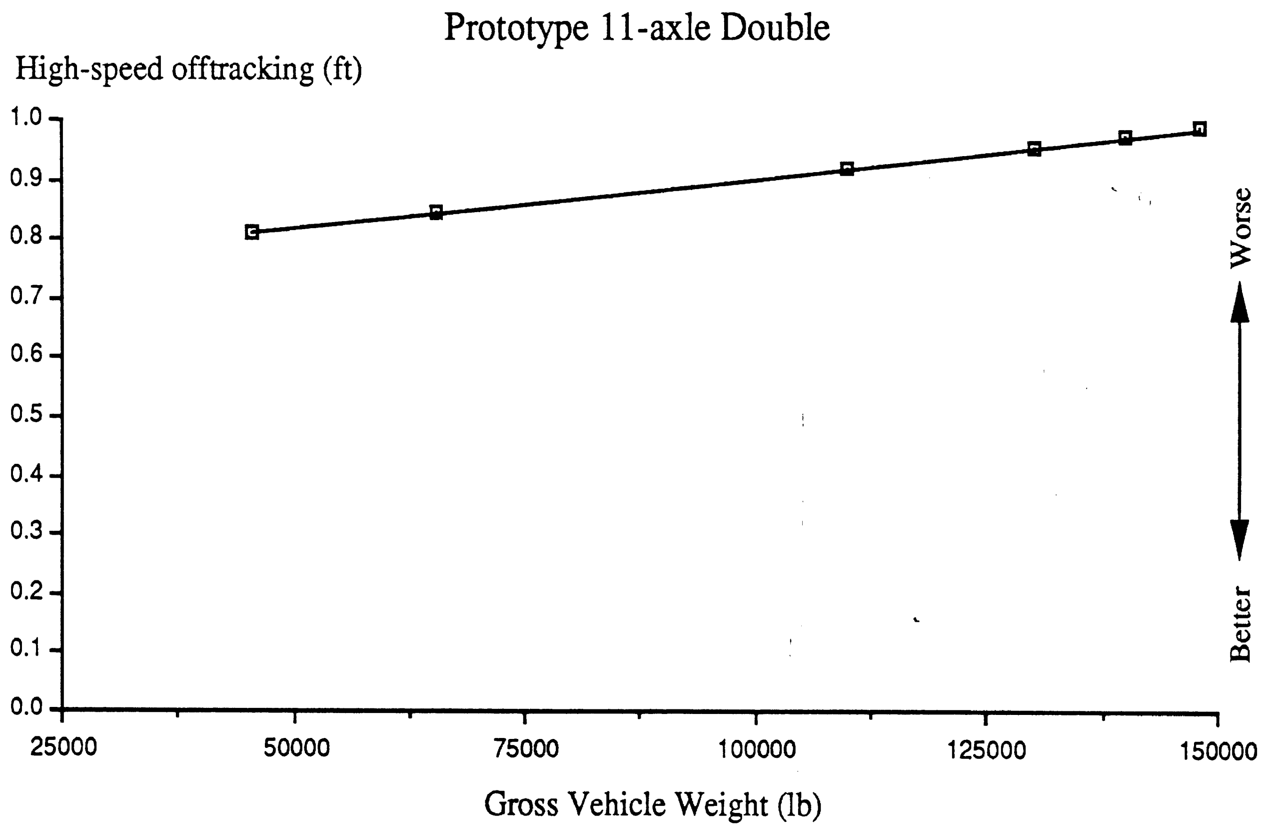
Prototype 9-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
Normal
Reduced
Brake Variations
Better
Worse

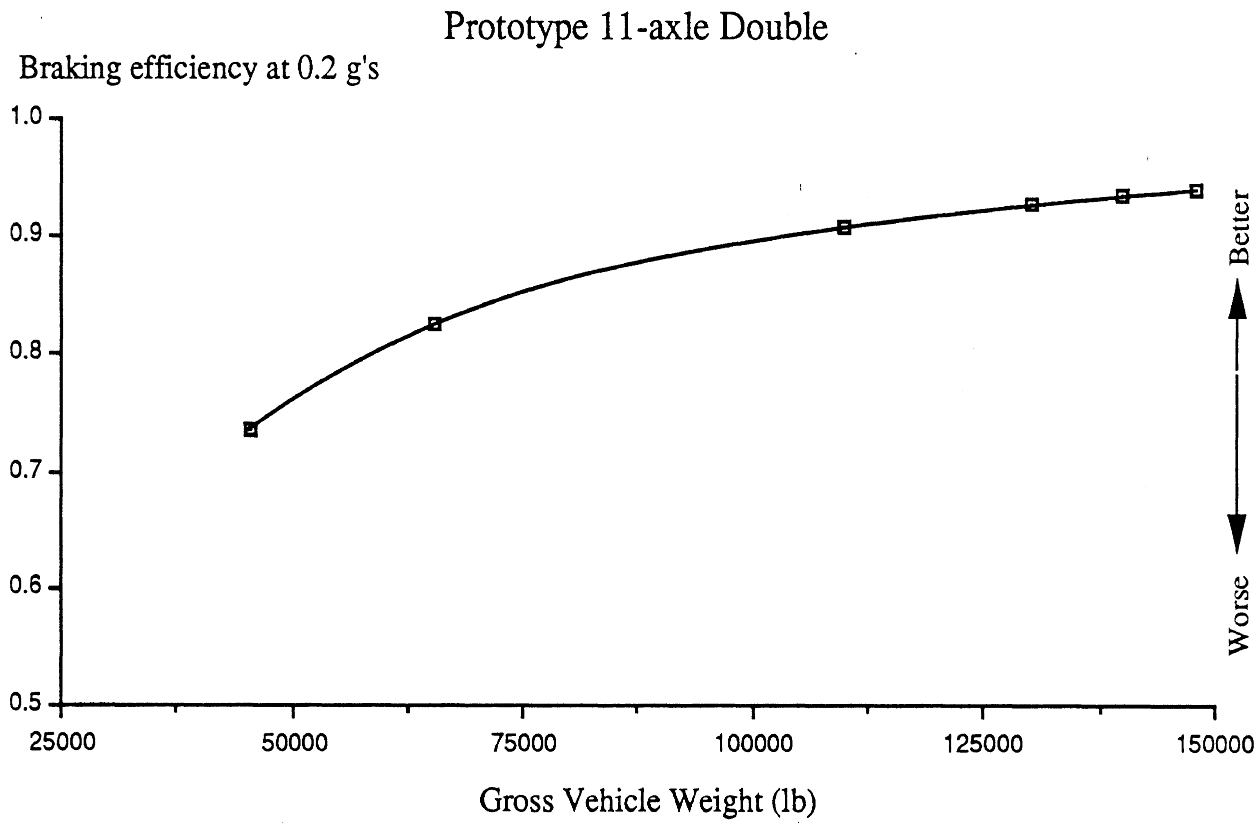
Prototype 11-axle Double (Gross vehicle weight)

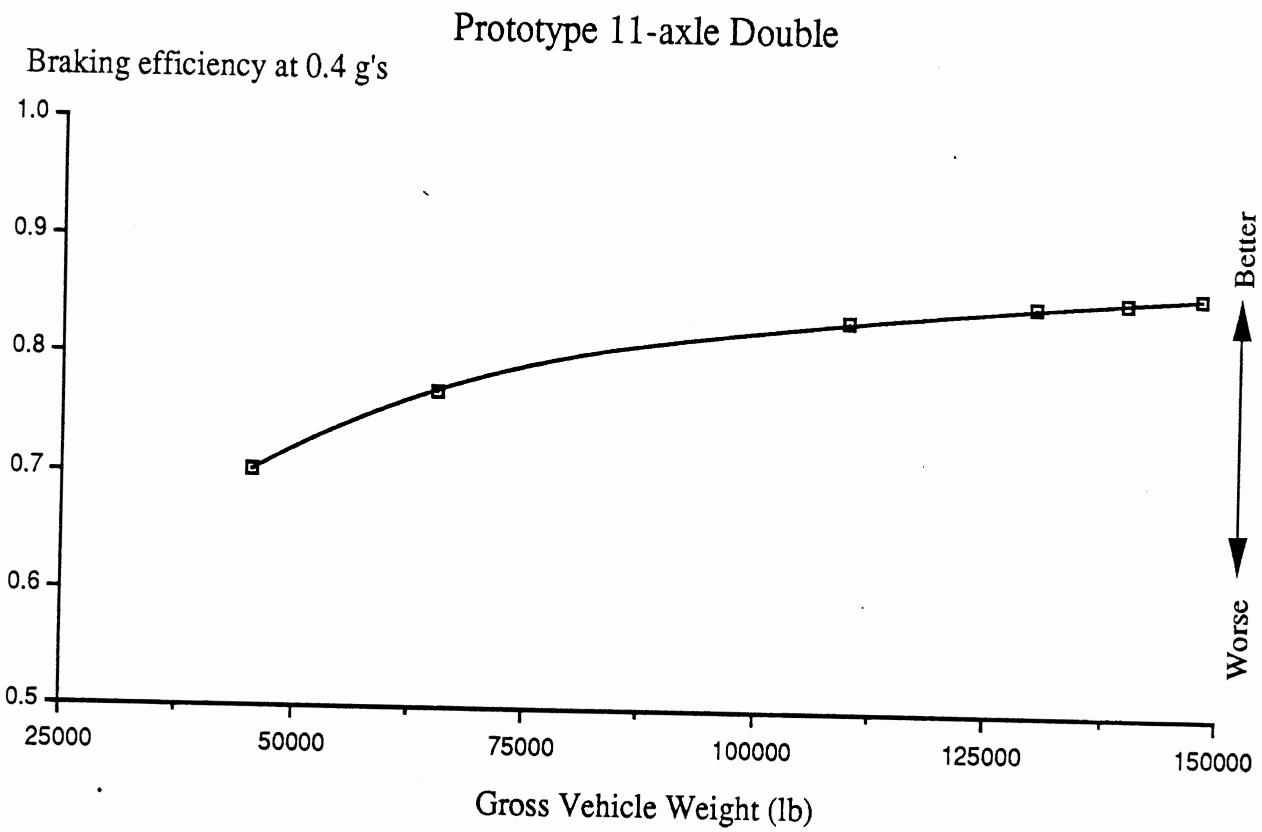
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Transient offtracking (ft)	13.16592	139815
VEHICLE	MEASURE	VALUE	GVW
PDbl2	High-speed offtracking (ft)	-0.97046	139815
PDbl2.v1.a	High-speed offtracking (ft)	-0.81213	45530
PDbl2.v1.b	High-speed offtracking (ft)	-0.84253	65530
PDbl2.v1.d	High-speed offtracking (ft)	-0.91638	110000
PDbl2.v1.e	High-speed offtracking (ft)	-0.95239	130000
PDbl2.v1.f	High-speed offtracking (ft)	-0.98633	148000
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Braking efficiency at 0.2 g's	0.93484	139815
PDbl2.v1.a	Braking efficiency at 0.2 g's	0.73524	45530
PDbl2.v1.b	Braking efficiency at 0.2 g's	0.82557	65530
PDbl2.v1.d	Braking efficiency at 0.2 g's	0.90871	110000
PDbl2.v1.e	Braking efficiency at 0.2 g's	0.92756	130000
PDbl2.v1.f	Braking efficiency at 0.2 g's	0.94017	148000
PDbl2E	Braking efficiency at 0.2 g's	0.73524	45530
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Braking efficiency at 0.4 g's	0.85245	139815
PDbl2.v1.a	Braking efficiency at 0.4 g's	0.70149	45530
PDbl2.v1.b	Braking efficiency at 0.4 g's	0.76981	65530
PDbl2.v1.d	Braking efficiency at 0.4 g's	0.83268	110000
PDbl2.v1.e	Braking efficiency at 0.4 g's	0.84695	130000
PDbl2.v1.f	Braking efficiency at 0.4 g's	0.85649	148000
PDbl2E	Braking efficiency at 0.4 g's	0.70149	45530
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Static rollover threshold (g's)	0.37372	139815
PDbl2.v1.a	Static rollover threshold (g's)	0.84199	45530
PDbl2.v1.b	Static rollover threshold (g's)	0.55122	65530
PDbl2.v1.d	Static rollover threshold (g's)	0.41643	110000
PDbl2.v1.e	Static rollover threshold (g's)	0.38591	130000
PDbl2.v1.f	Static rollover threshold (g's)	0.36513	148000
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	139815
PDbl2.v1.a	Steering sens. at 0.3 g's (deg/g's)	7.91022	45530
PDbl2.v1.b	Steering sens. at 0.3 g's (deg/g's)	7.89848	65530
PDbl2.v1.d	Steering sens. at 0.3 g's (deg/g's)	7.62847	110000
PDbl2.v1.e	Steering sens. at 0.3 g's (deg/g's)	7.35526	130000
PDbl2.v1.f	Steering sens. at 0.3 g's (deg/g's)	6.98280	148000

Prototype 11-axle Double (Gross vehicle weight)

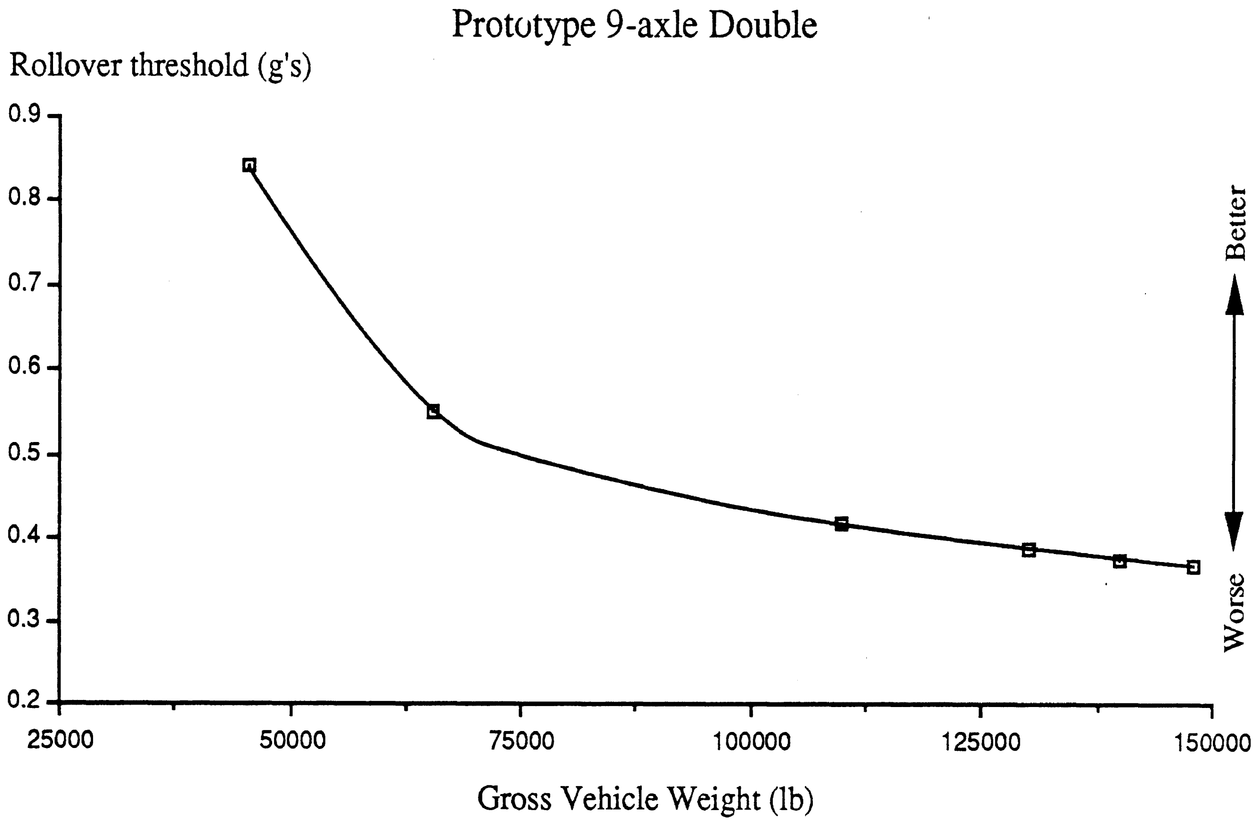
VEHICLE	MEASURE	VALUE	GVW
PDbl2	Rearward amplification	1.74382	139815
PDbl2.v1.a	Rearward amplification	1.51535	45530
PDbl2.v1.b	Rearward amplification	1.60990	65530
PDbl2.v1.d	Rearward amplification	1.69619	110000
PDbl2.v1.e	Rearward amplification	1.72830	130000
PDbl2.v1.f	Rearward amplification	1.75677	148000


Prototype 11-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

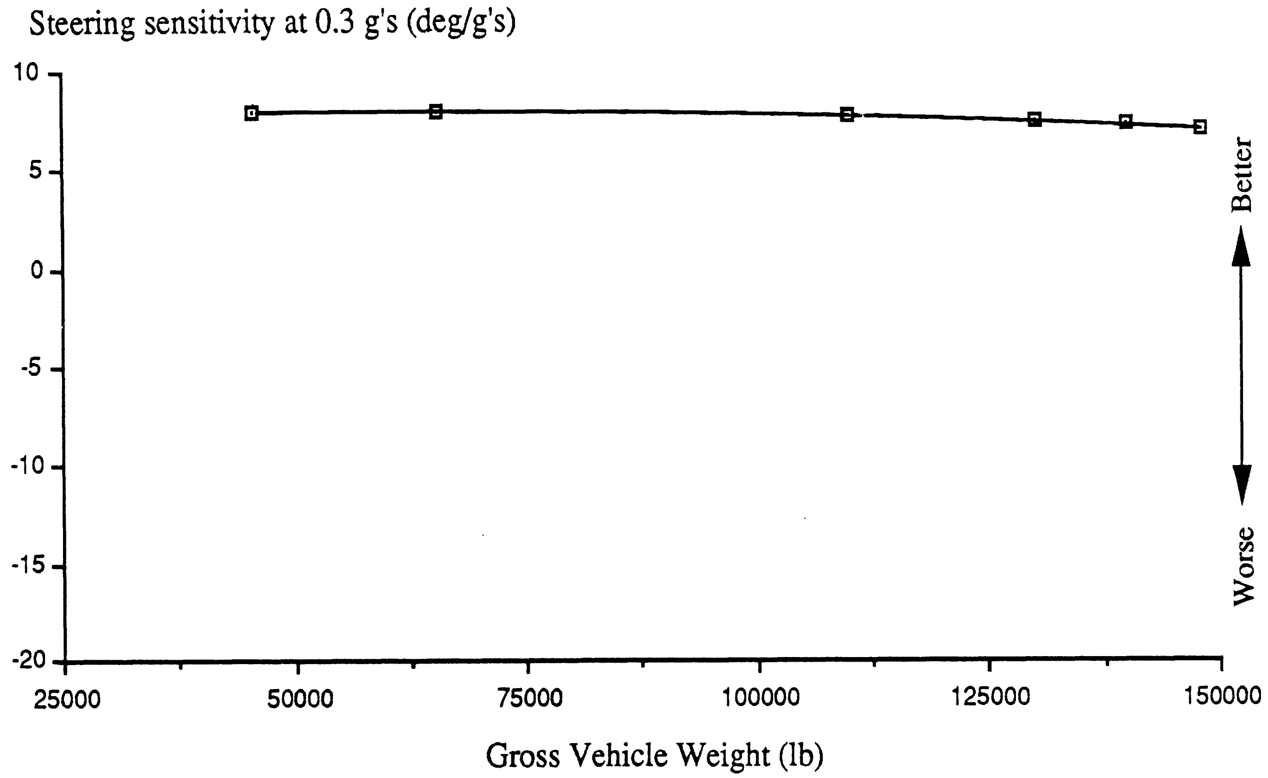

Prototype 11-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

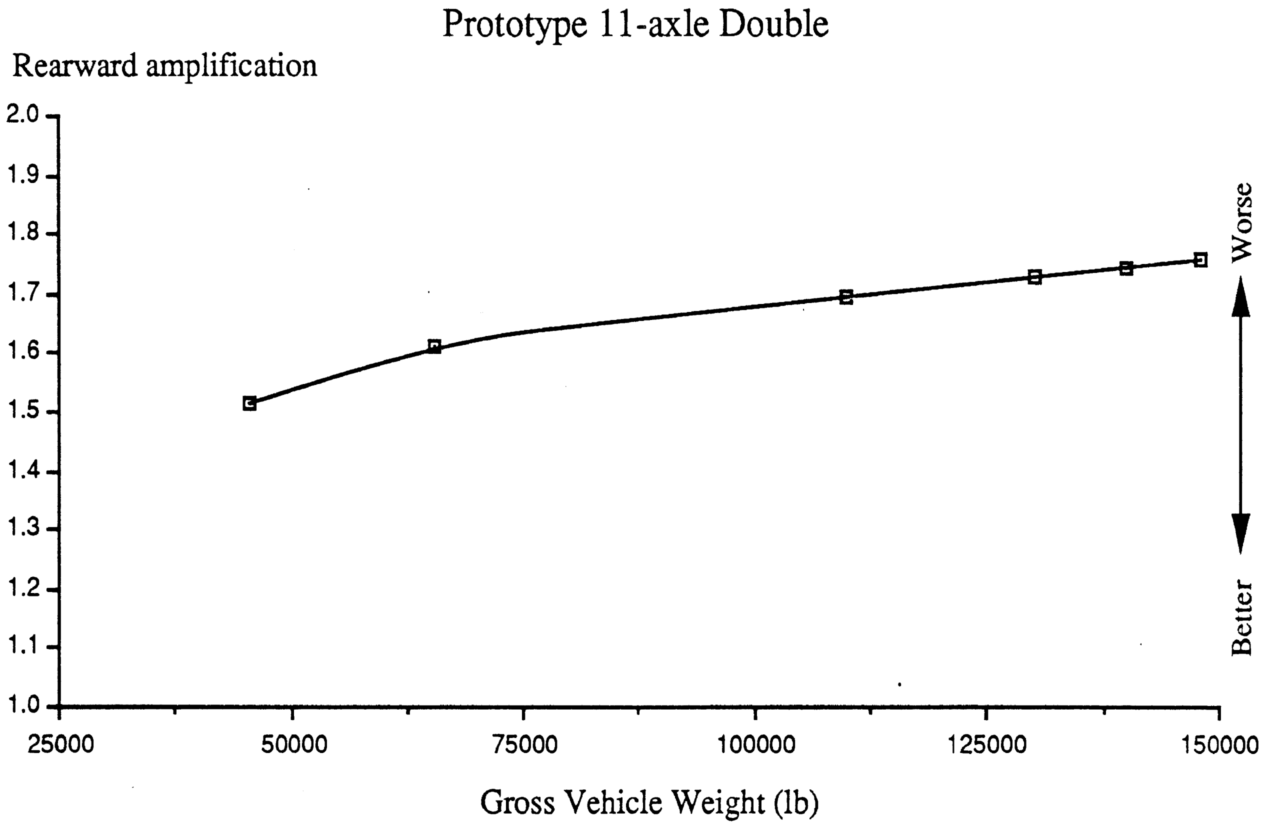


Prototype 11-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse


Prototype 9-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Better
Worse

Prototype 11-axle Double





Prototype 11-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
25000
50000
75000
100000
125000
150000
Gross Vehicle Weight (lb)
Worse
Better

Prototype 11-axle Double (Cargo density)

VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Transient offtracking (ft)	13.16592	1

VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	High-speed offtracking (ft)	-0.97046	1

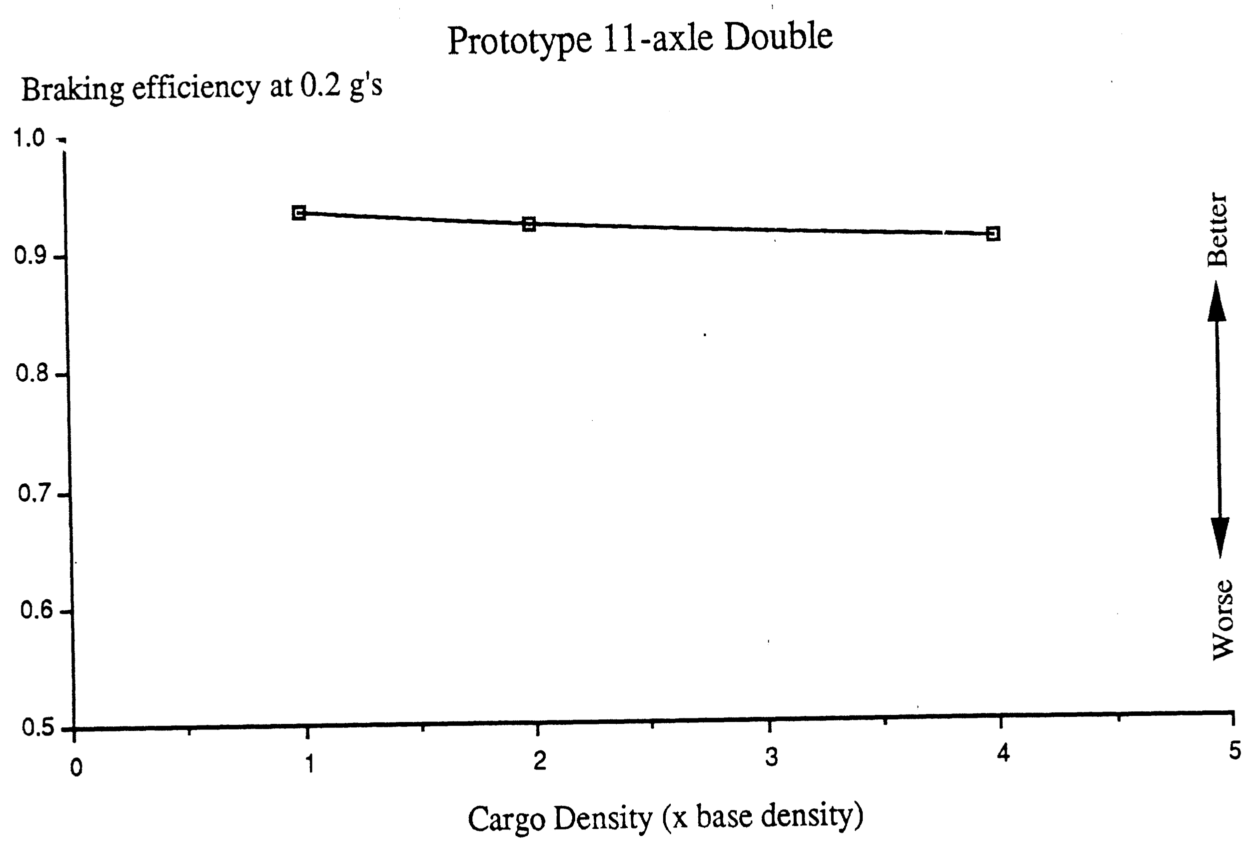
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Braking efficiency at 0.2 g's	0.93484	1
PDbl2.v2.a	Braking efficiency at 0.2 g's	0.92198	2
PDbl2.v2.b	Braking efficiency at 0.2 g's	0.90809	4
PDbl2F	Braking efficiency at 0.2 g's	0.73524	1

VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Braking efficiency at 0.4 g's	0.85245	1
PDbl2.v2.a	Braking efficiency at 0.4 g's	0.89475	2
PDbl2.v2.b	Braking efficiency at 0.4 g's	0.87159	4
PDbl2E	Braking efficiency at 0.4 g's	0.70149	1

VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Static rollover threshold (g's)	0.37372	1
PDbl2.v2.a	Static rollover threshold (g's)	0.49305	2
PDbl2.v2.b	Static rollover threshold (g's)	0.57530	4

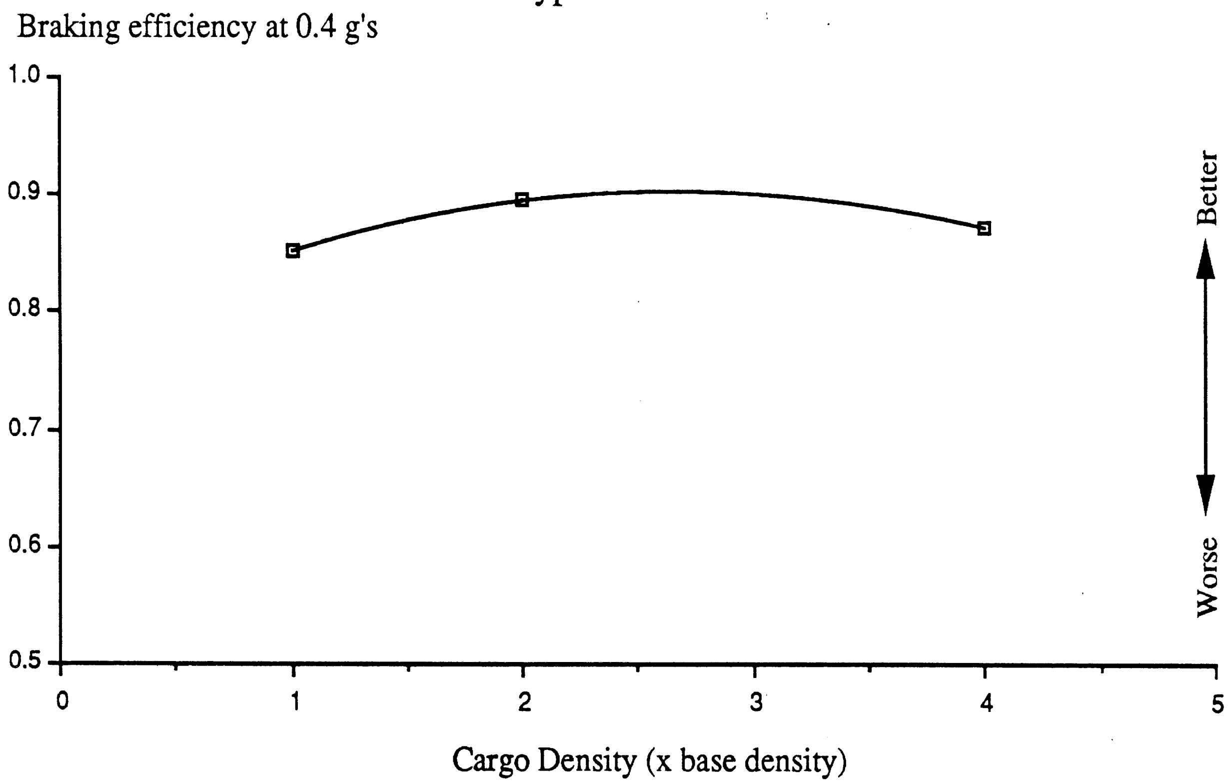
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	1
PDbl2.v2.a	Steering sens. at 0.3 g's (deg/g's)	7.76721	2
PDbl2.v2.b	Steering sens. at 0.3 g's (deg/g's)	7.96037	4

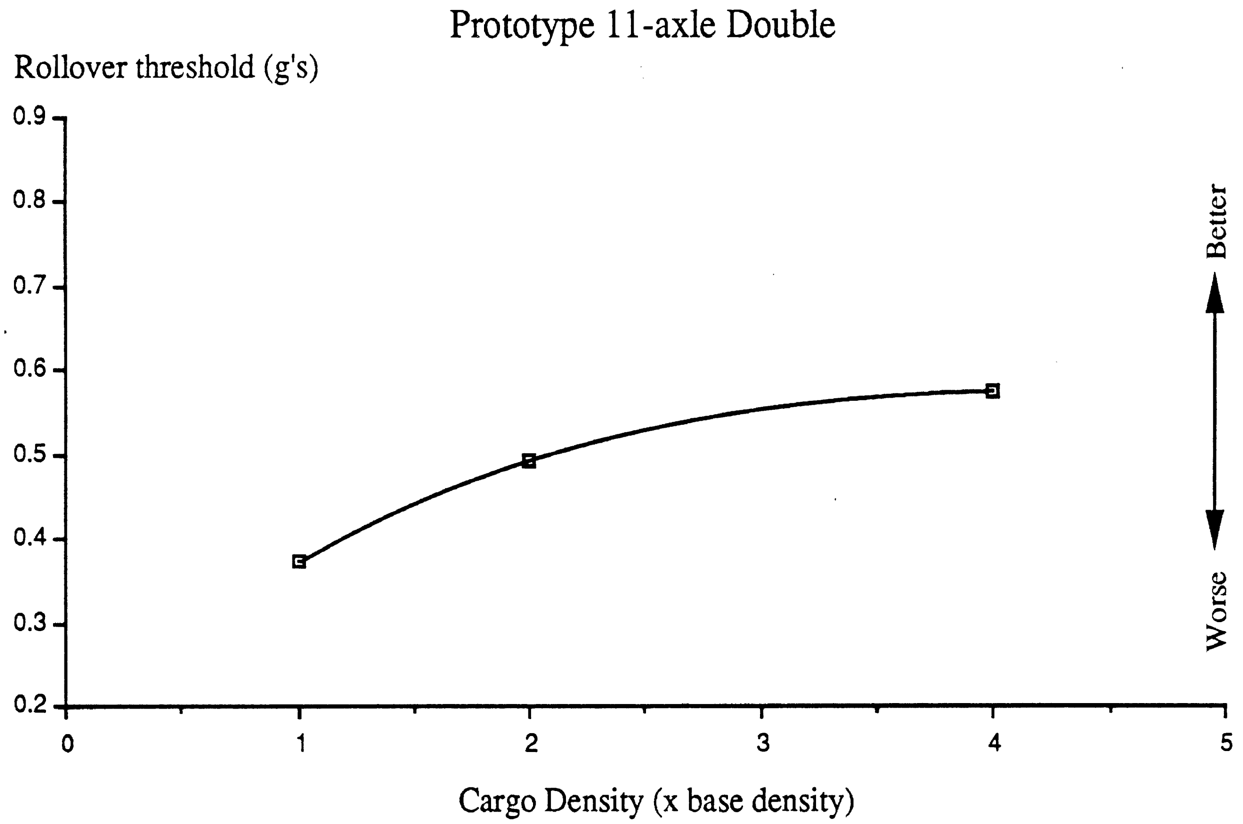
VEHICLE	MEASURE	VALUE	C.DENSITY
PDbl2	Rearward amplification	1.74382	1

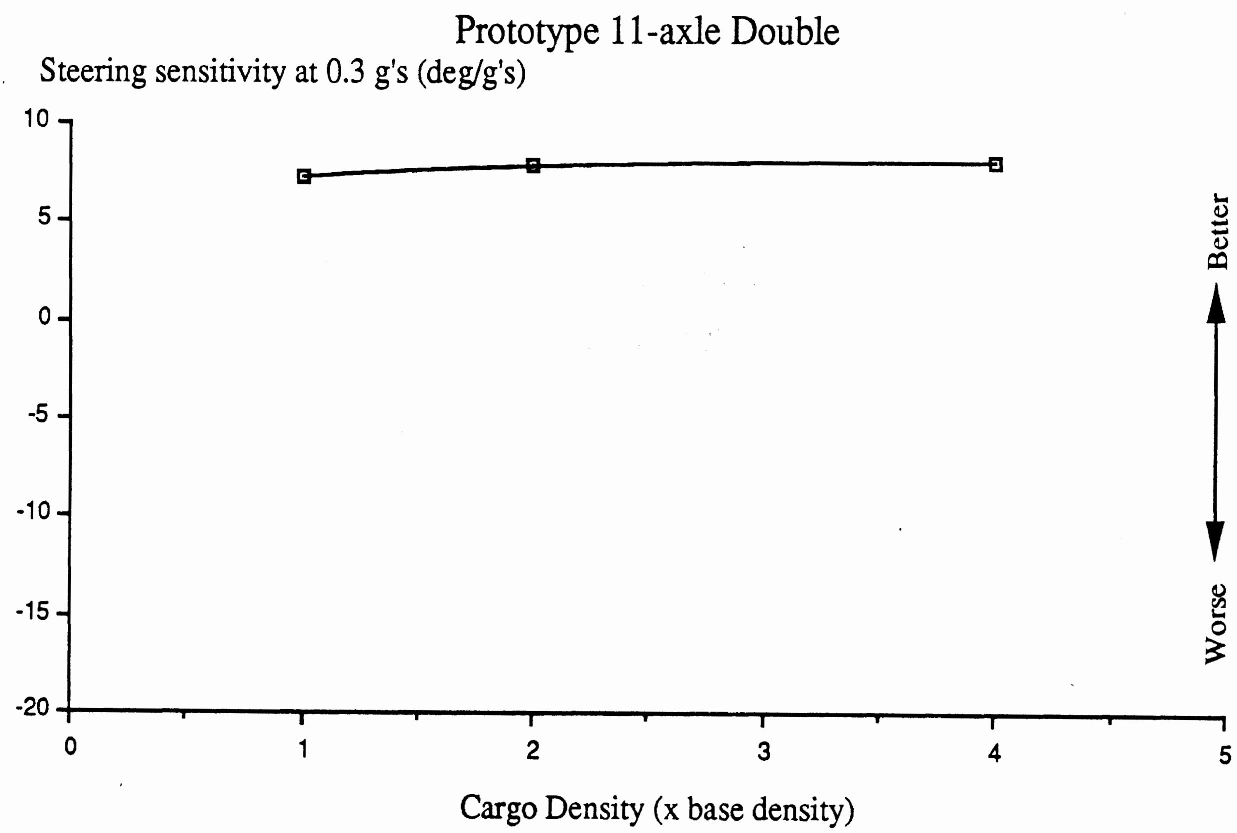


Prototype 11-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Prototype 11-axle Double




Prototype 11-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse


Prototype 11-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
0
1
2
3
4
5
Cargo Density (x base density)
Better
Worse

Prototype 11-axle Double (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Transient offtracking (ft)	13.16592	33
PDbl2.v3.a	Transient offtracking (ft)	9.54217	28
PDbl2.v3.b	Transient offtracking (ft)	18.75940	40
PDbl2.v3.c	Transient offtracking (ft)	25.61129	48

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	High-speed offtracking (ft)	-0.97046	33
PDbl2.v3.a	High-speed offtracking (ft)	-0.96228	28
PDbl2.v3.b	High-speed offtracking (ft)	-0.91406	40
PDbl2.v3.c	High-speed offtracking (ft)	-0.75061	48

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Braking efficiency at 0.2 g's	0.93484	33
PDbl2.v3.a	Braking efficiency at 0.2 g's	0.90610	28
PDbl2.v3.b	Braking efficiency at 0.2 g's	0.91265	40
PDbl2.v3.c	Braking efficiency at 0.2 g's	0.89792	48
PDbl2E	Braking efficiency at 0.2 g's	0.73524	33
PDbl2.v3.aE	Braking efficiency at 0.2 g's	0.72203	28
PDbl2.v3.bE	Braking efficiency at 0.2 g's	0.74931	40
PDbl2.v3.cE	Braking efficiency at 0.2 g's	0.76186	48

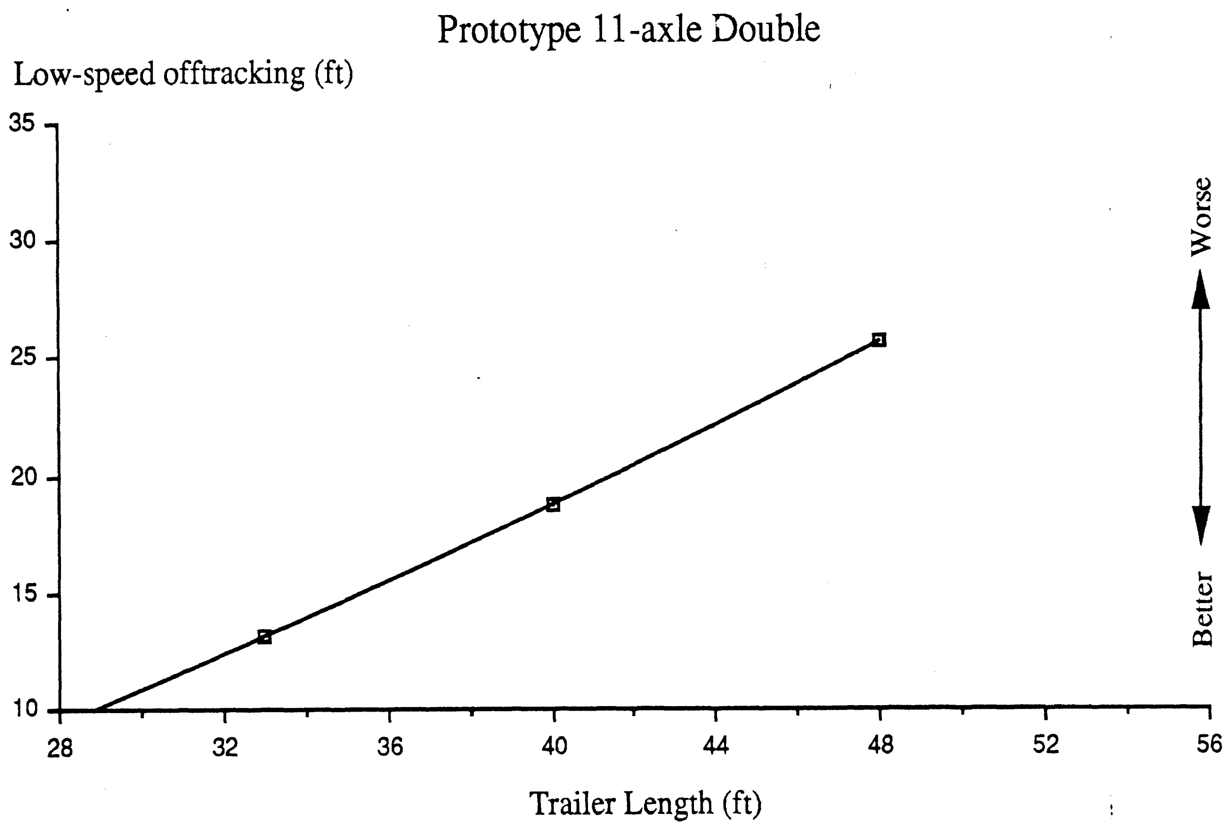
VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Braking efficiency at 0.4 g's	0.85245	33
PDbl2.v3.a	Braking efficiency at 0.4 g's	0.85596	28
PDbl2.v3.b	Braking efficiency at 0.4 g's	0.85000	40
PDbl2.v3.c	Braking efficiency at 0.4 g's	0.84883	48
PDbl2E	Braking efficiency at 0.4 g's	0.70149	33
PDbl2.v3.aE	Braking efficiency at 0.4 g's	0.68120	28
PDbl2.v3.bE	Braking efficiency at 0.4 g's	0.72170	40
PDbl2.v3.cE	Braking efficiency at 0.4 g's	0.73872	48

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Static rollover threshold (g's)	0.37372	33
PDbl2.v3.a	Static rollover threshold (g's)	0.38186	28
PDbl2.v3.b	Static rollover threshold (g's)	0.36836	40
PDbl2.v3.c	Static rollover threshold (g's)	0.36437	48

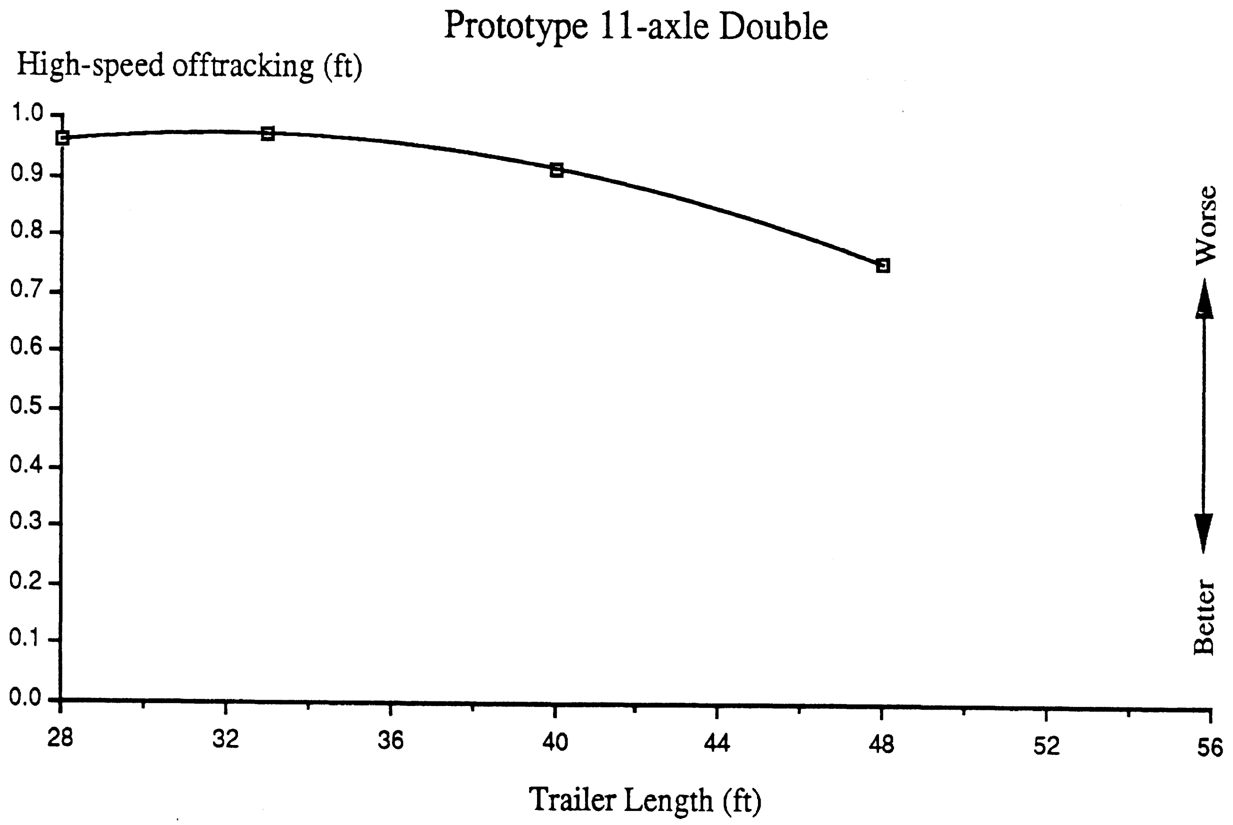
VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	33
PDbl2.v3.a	Steering sens. at 0.3 g's (deg/g's)	7.05751	28
PDbl2.v3.b	Steering sens. at 0.3 g's (deg/g's)	7.23147	40
PDbl2.v3.c	Steering sens. at 0.3 g's (deg/g's)	7.24320	48

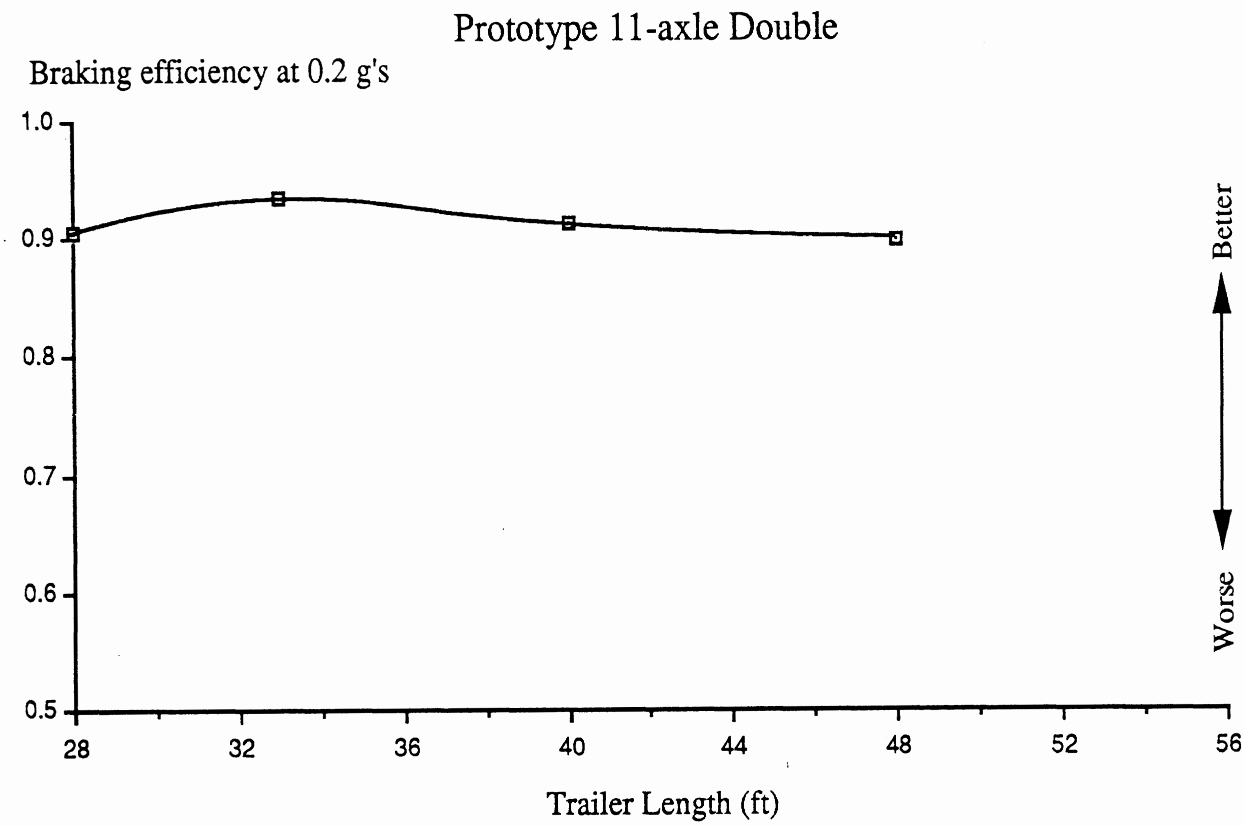
Prototype 11-axle Double (Trailer length)

VEHICLE	MEASURE	VALUE	T.LENGTH
PDbl2	Rearward amplification	1.74382	33
PDbl2.v3.a	Rearward amplification	2.23076	28
PDbl2.v3.b	Rearward amplification	1.39117	40
PDbl2.v3.c	Rearward amplification	1.17833	48

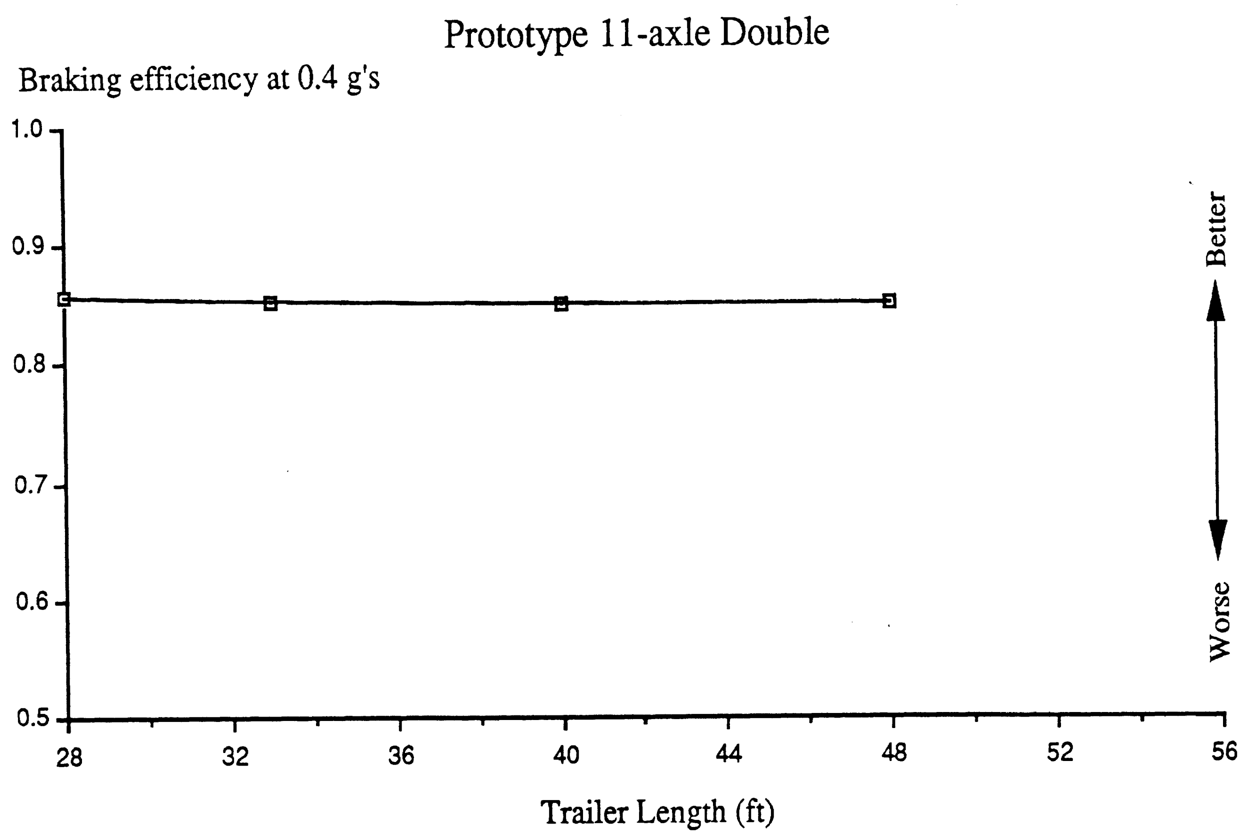


Prototype 11-axle Double
Low-speed offtracking (ft)
35
30
25
20
15
10
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

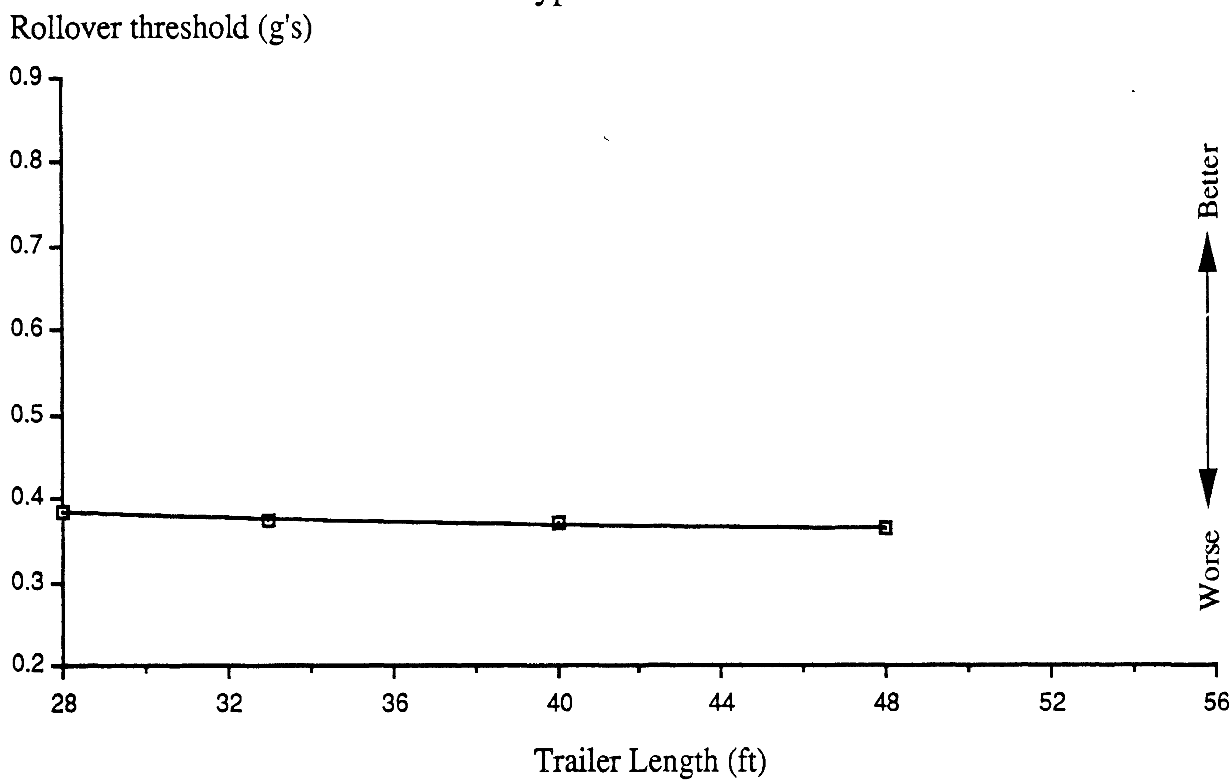

Prototype 11-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better



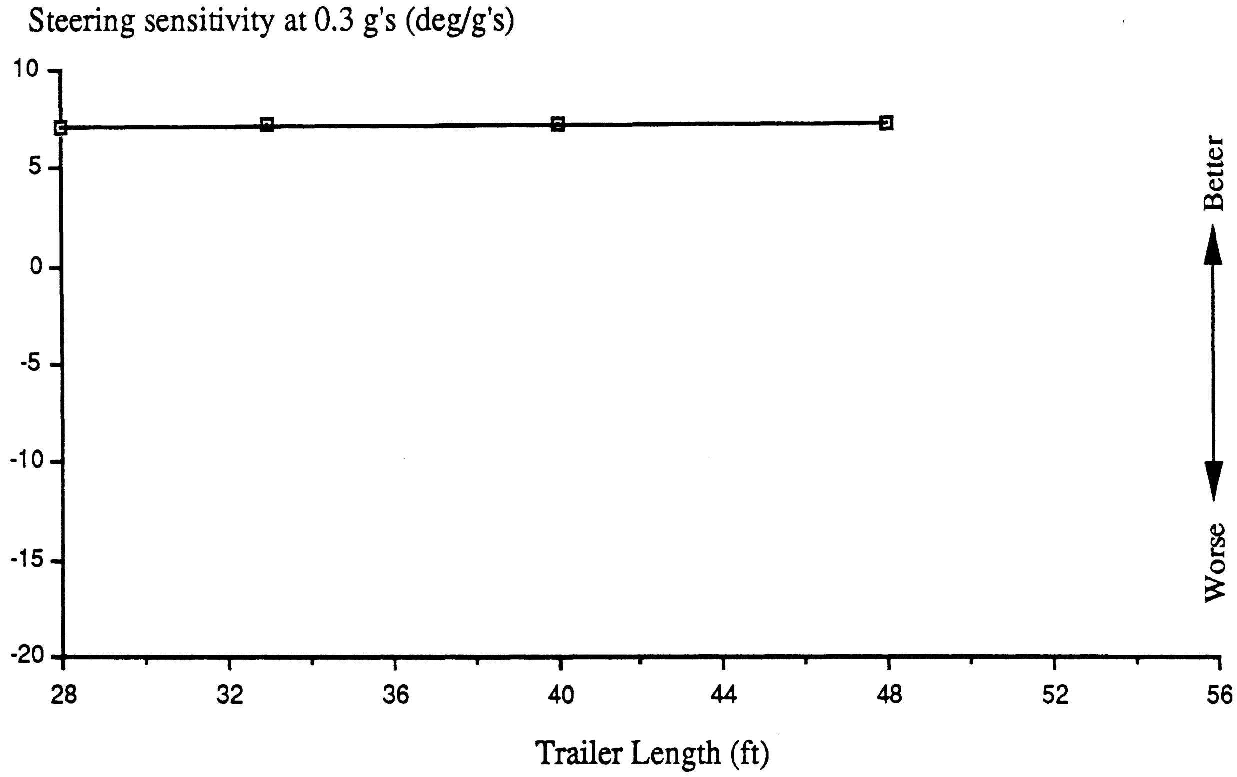
Prototype 11-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

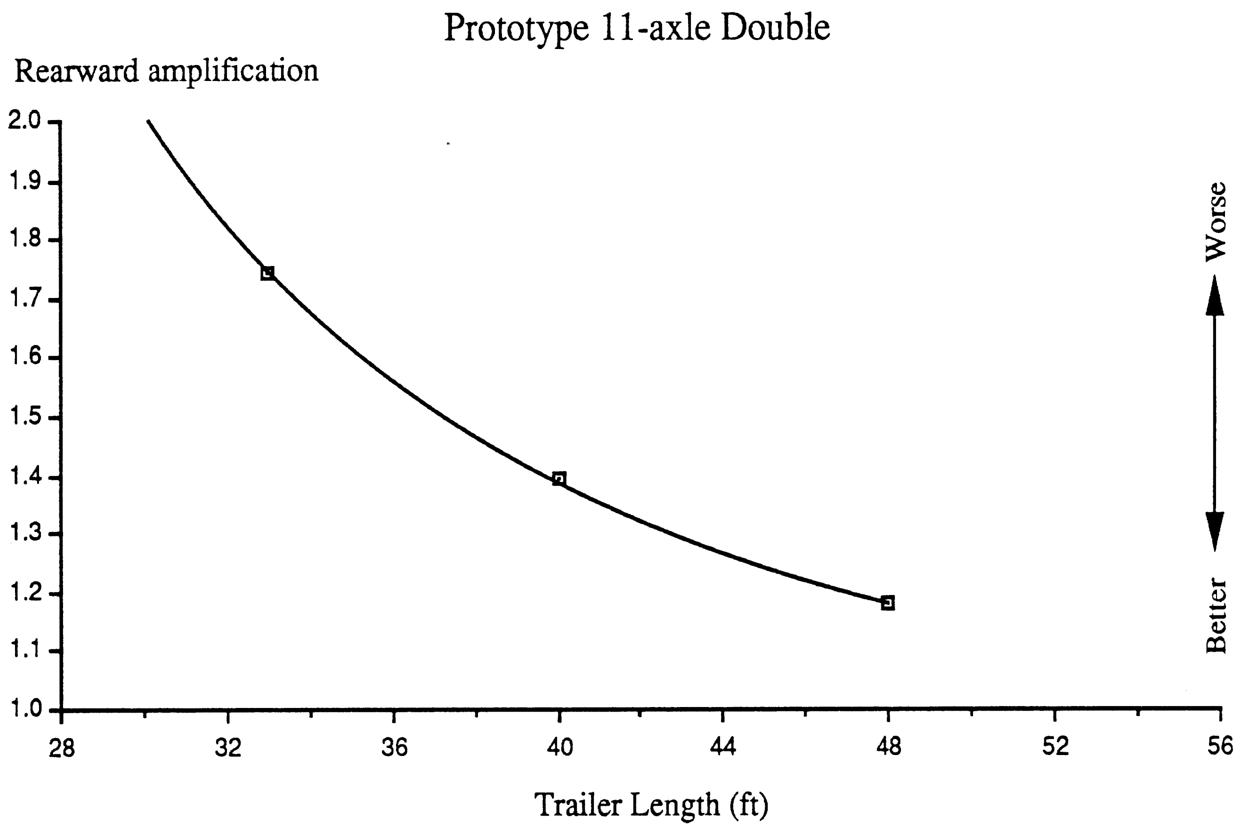

Prototype 11-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
28
32
36
40
44
48
52
56
Trailer Length (ft)
Better
Worse

Prototype 11-axle Double



Prototype 11-axle Double




Prototype 11-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
28
32
36
40
44
48
52
56
Trailer Length (ft)
Worse
Better

Prototype 11-axle Double (Wide-base single tires)

VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Transient offtracking (ft)	13.16592	Normal

VEHICLE	MEASURE	VALUE	TIRES
PDbl2	High-speed offtracking (ft)	-0.97046	Normal
PDbl2.v5.a	High-speed offtracking (ft)	-0.97510	Tire.A
PDbl2.v5.b	High-speed offtracking (ft)	-0.68774	Tire.B
PDbl2.v5.c	High-speed offtracking (ft)	-0.98120	Tire.C
PDbl2.v5.d	High-speed offtracking (ft)	-1.23096	Tire.D

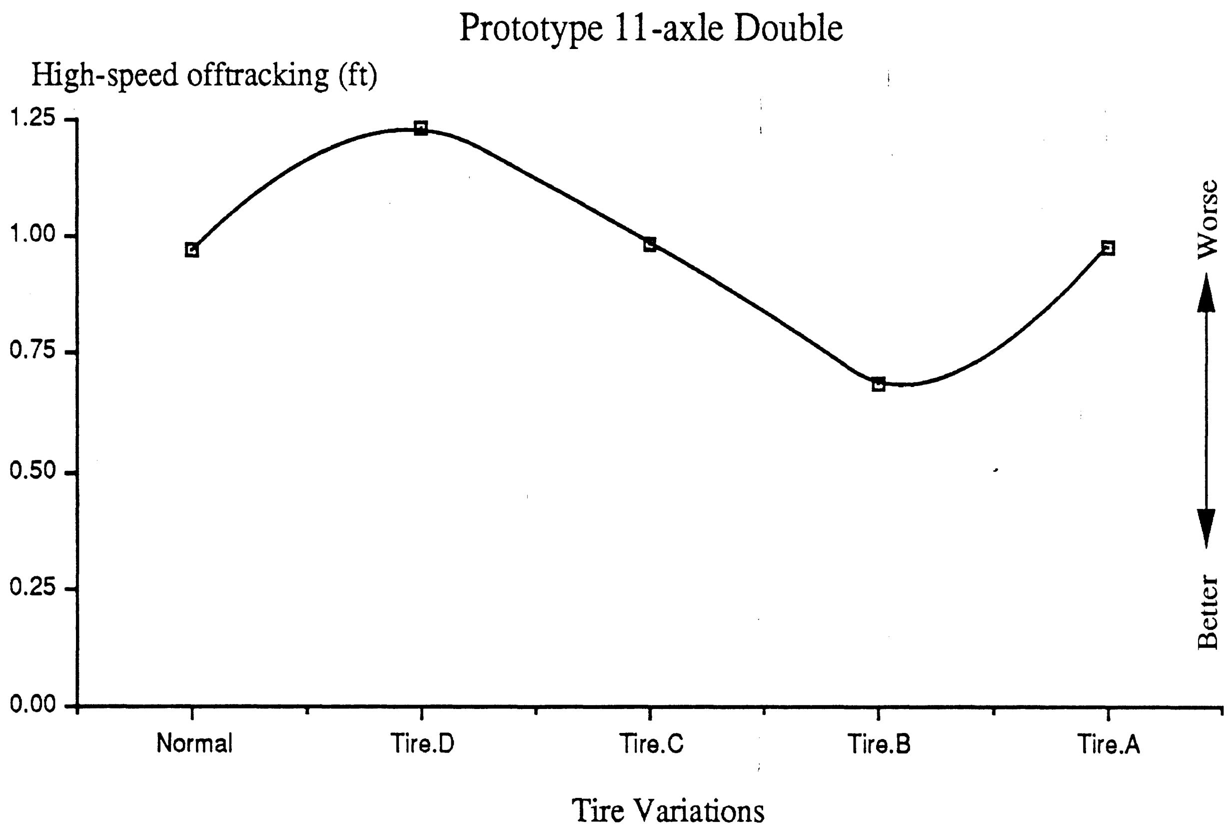
VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Braking efficiency at 0.2 g's	0.93484	Normal
PDbl2E	Braking efficiency at 0.2 g's	0.73524	Normal

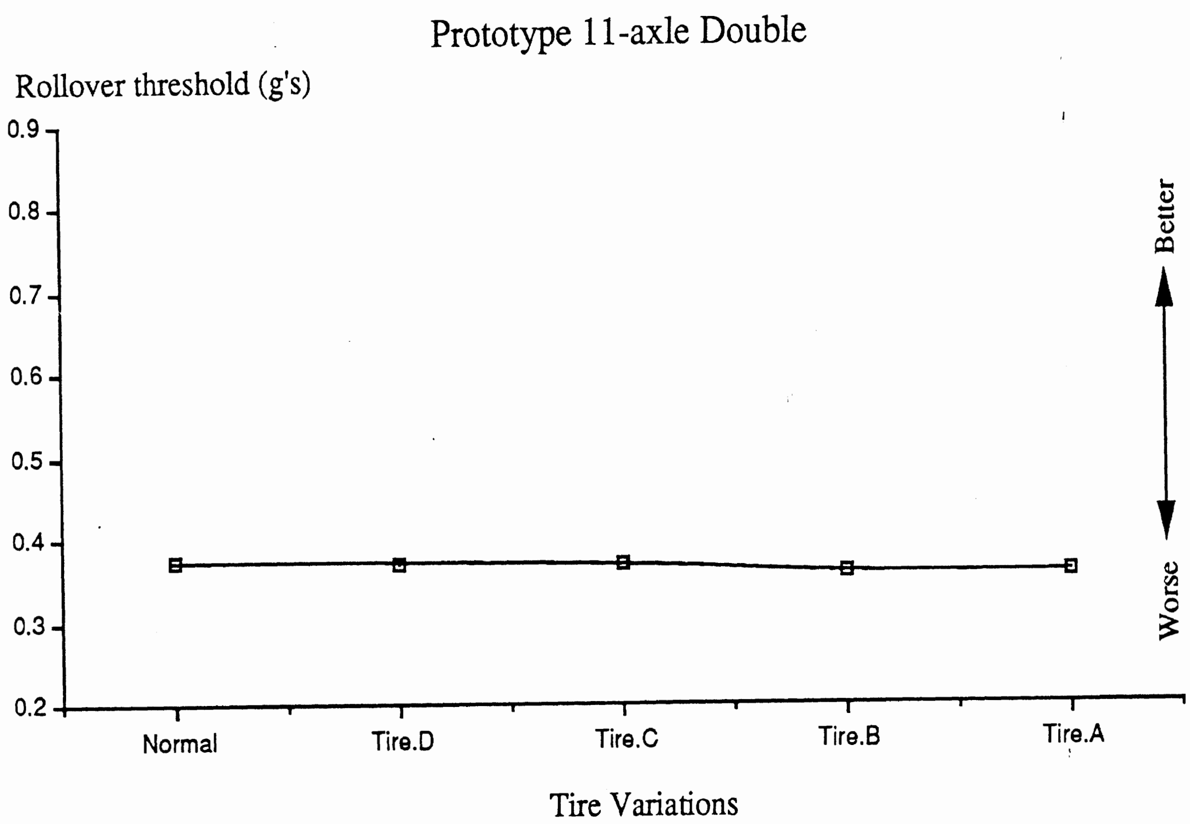
VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Braking efficiency at 0.4 g's	0.85245	Normal
PDbl2E	Braking efficiency at 0.4 g's	0.70149	Normal

VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Static rollover threshold (g's)	0.37372	Normal
PDbl2.v5.a	Static rollover threshold (g's)	0.36094	Tire.A
PDbl2.v5.b	Static rollover threshold (g's)	0.36094	Tire.B
PDbl2.v5.c	Static rollover threshold (g's)	0.37069	Tire.C
PDbl2.v5.d	Static rollover threshold (g's)	0.36982	Tire.D

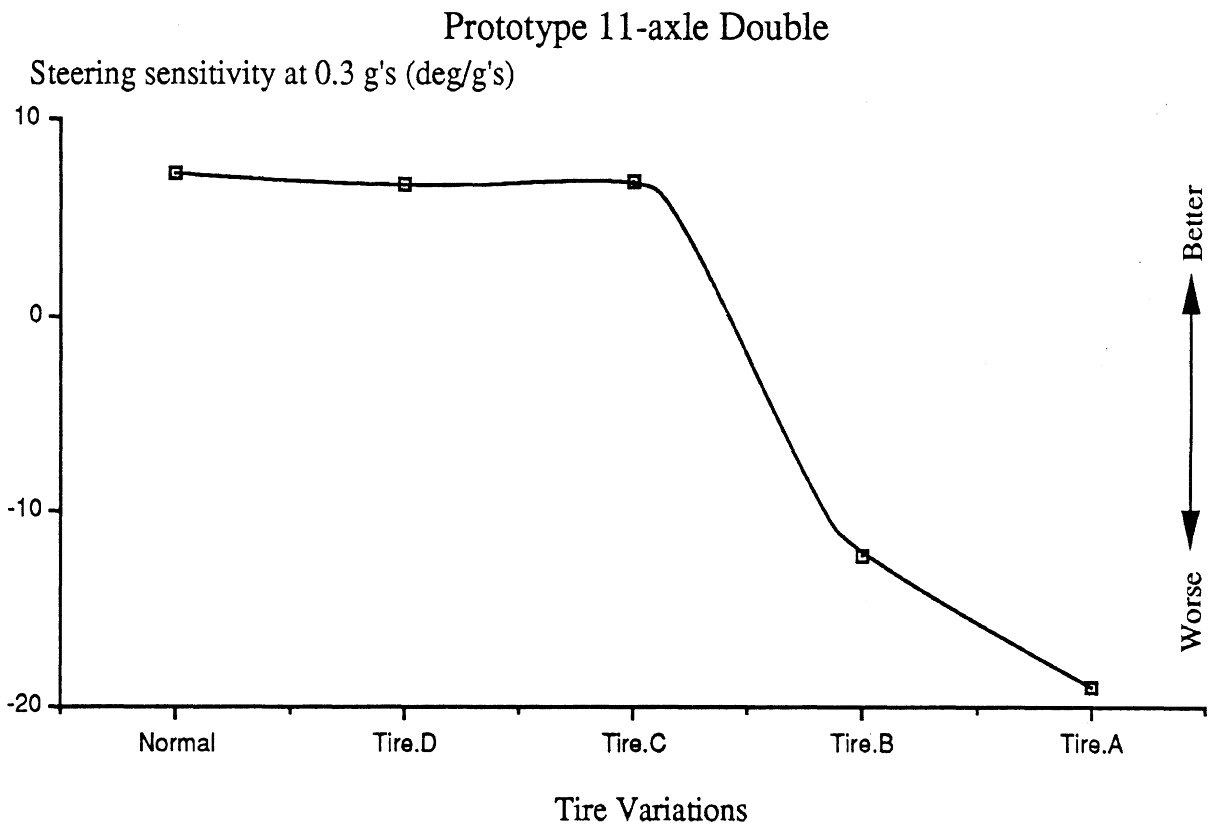
VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	Normal
PDbl2.v5.a	Steering sens. at 0.3 g's (deg/g's)	-19.00794	Tire.A
PDbl2.v5.b	Steering sens. at 0.3 g's (deg/g's)	-12.30075	Tire.B
PDbl2.v5.c	Steering sens. at 0.3 g's (deg/g's)	6.72454	Tire.C
PDbl2.v5.d	Steering sens. at 0.3 g's (deg/g's)	6.58366	Tire.D

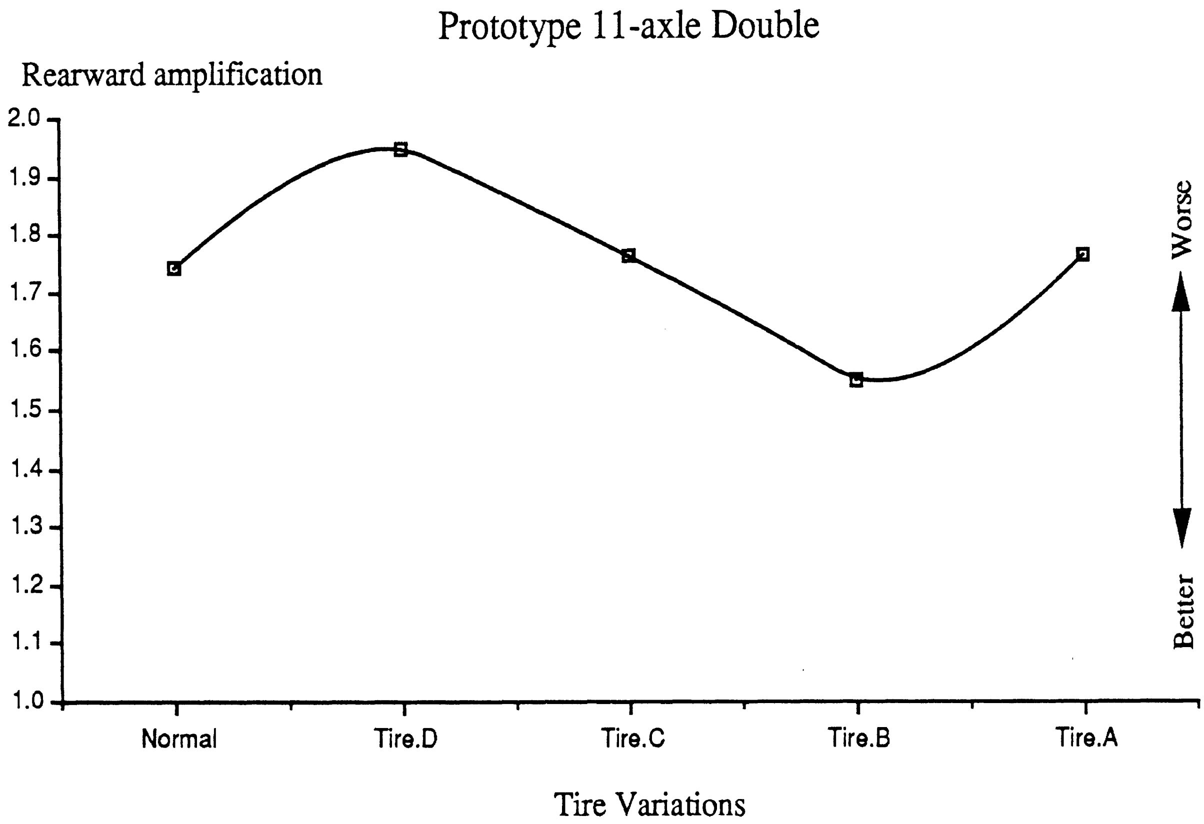
VEHICLE	MEASURE	VALUE	TIRES
PDbl2	Rearward amplification	1.74382	Normal
PDbl2.v5.a	Rearward amplification	1.76161	Tire.A
PDbl2.v5.b	Rearward amplification	1.54665	Tire.B
PDbl2.v5.c	Rearward amplification	1.76161	Tire.C
PDbl2.v5.d	Rearward amplification	1.94621	Tire.D


Prototype 11-axle Double
High-speed offtracking (ft)
1.25
1.00
0.75
0.50
0.25
0.00
Worse
Better
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations



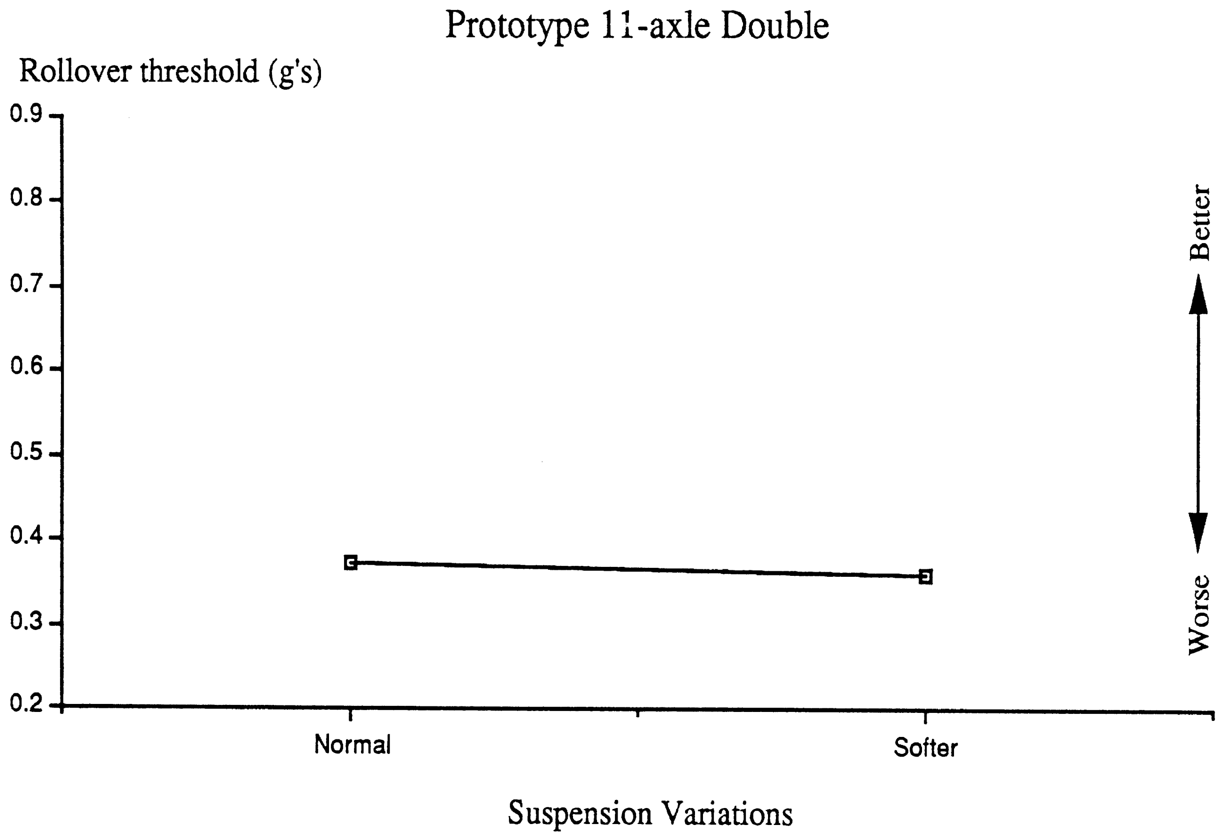
Prototype 11-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Better
Worse
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations

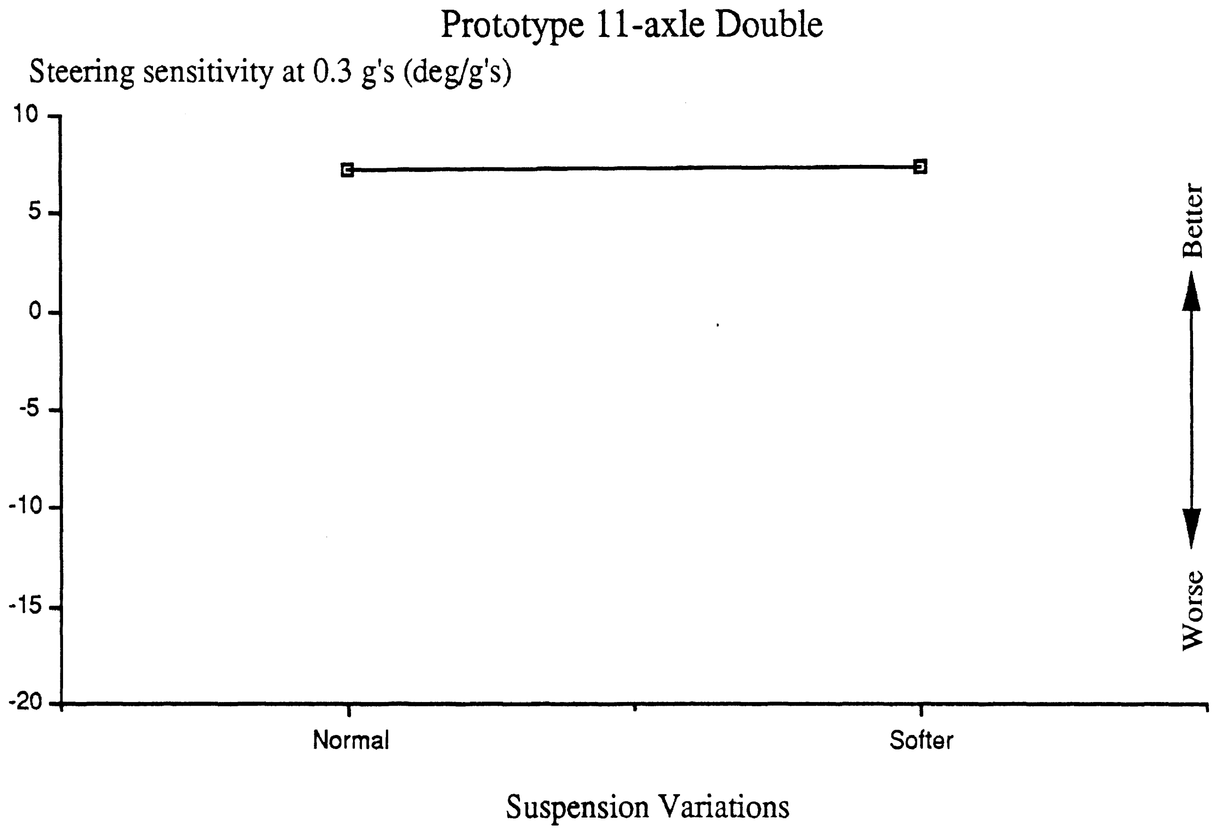

Prototype 11-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
0
-10
-20
Better
Worse
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations


Prototype 11-axle Double
Rearward amplification
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Normal
Tire.D
Tire.C
Tire.B
Tire.A
Tire Variations
Worse
Better

Prototype 11-axle Double (Suspensions)

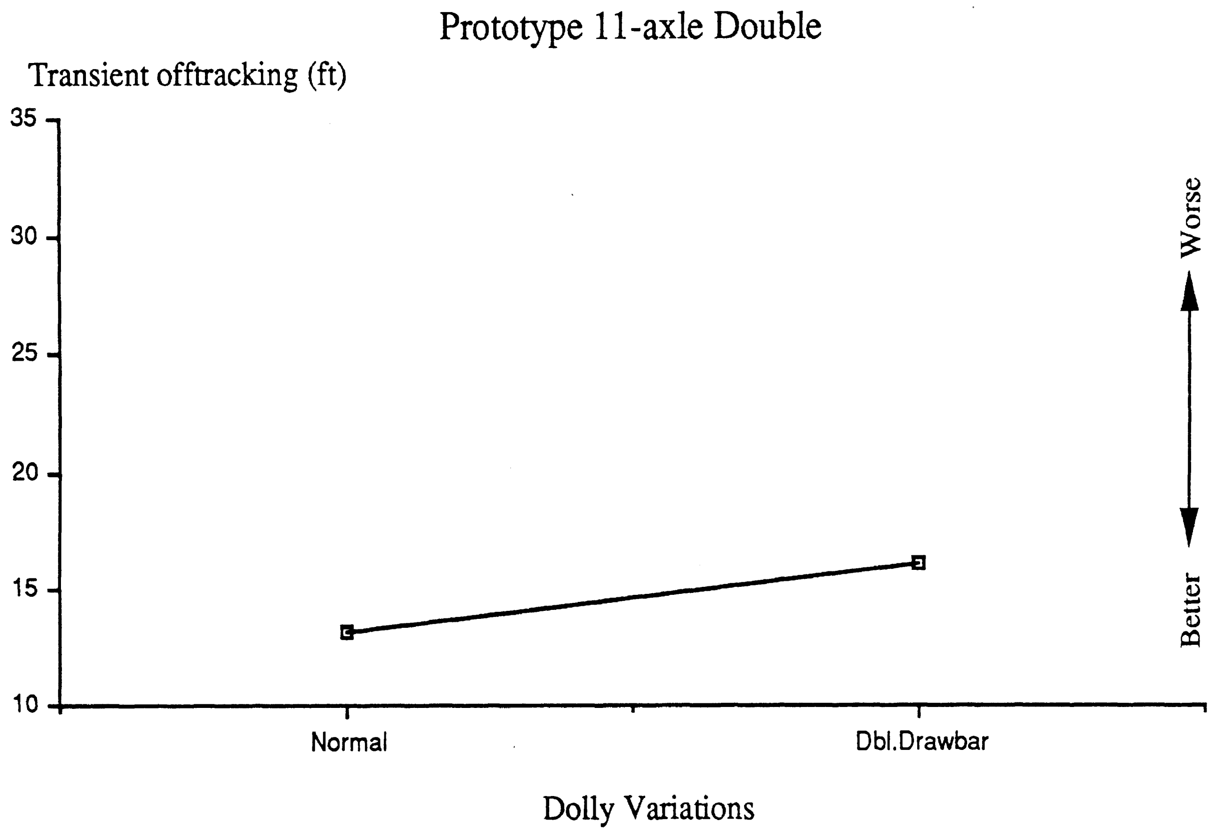
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Transient offtracking (ft)	13.16592	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	High-speed offtracking (ft)	-0.97046	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Braking efficiency at 0.2 g's	0.93484	Normal
PDbl2E	Braking efficiency at 0.2 g's	0.73524	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Braking efficiency at 0.4 g's	0.85245	Normal
PDbl2E	Braking efficiency at 0.4 g's	0.70149	Normal
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Static rollover threshold (g's)	0.37372	Normal
PDbl2.v6.a	Static rollover threshold (g's)	0.35813	Softer
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	Normal
PDbl2.v6.a	Steering sens. at 0.3 g's (deg/g's)	7.37234	Softer
VEHICLE	MEASURE	VALUE	SUSP.
PDbl2	Rearward amplification	1.74382	Normal

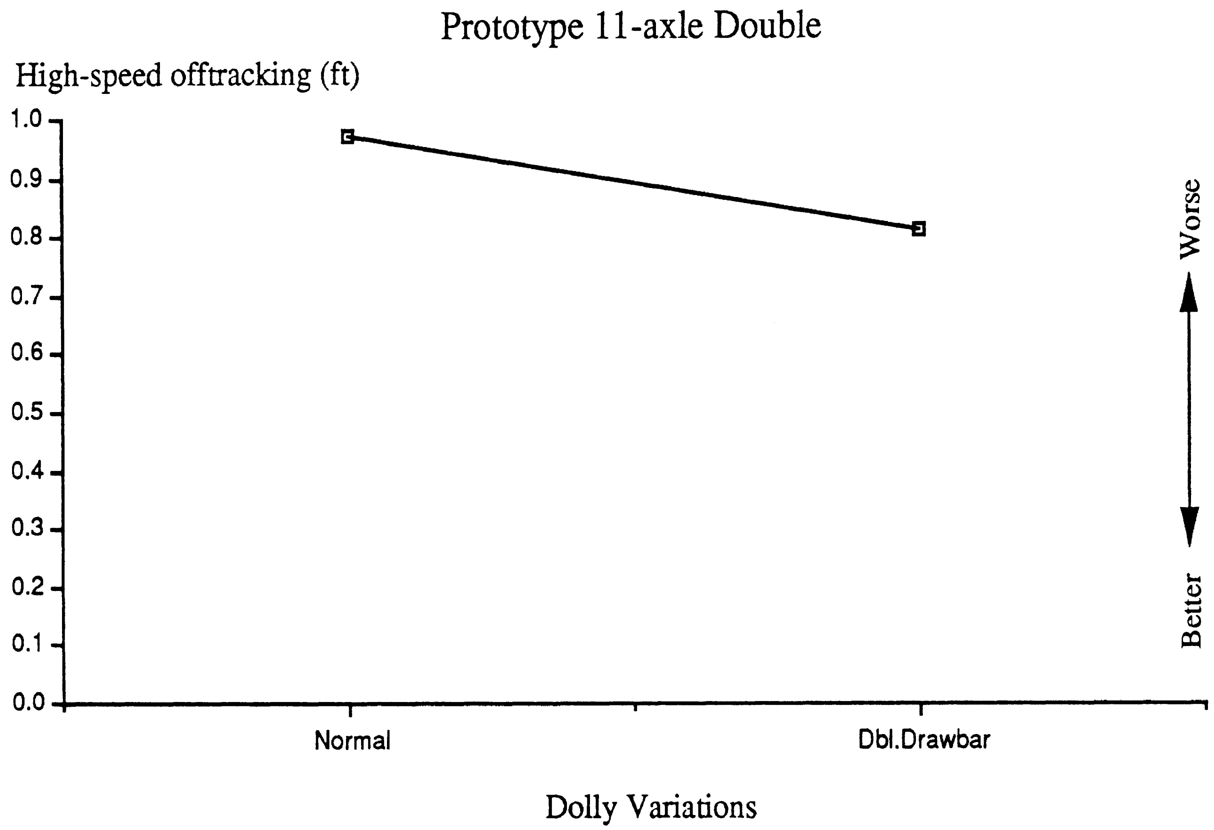

Prototype 11-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Normal
Softer
Suspension Variations
Better
Worse


Prototype 11-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
Better
Worse
Normal
Softer
Suspension Variations

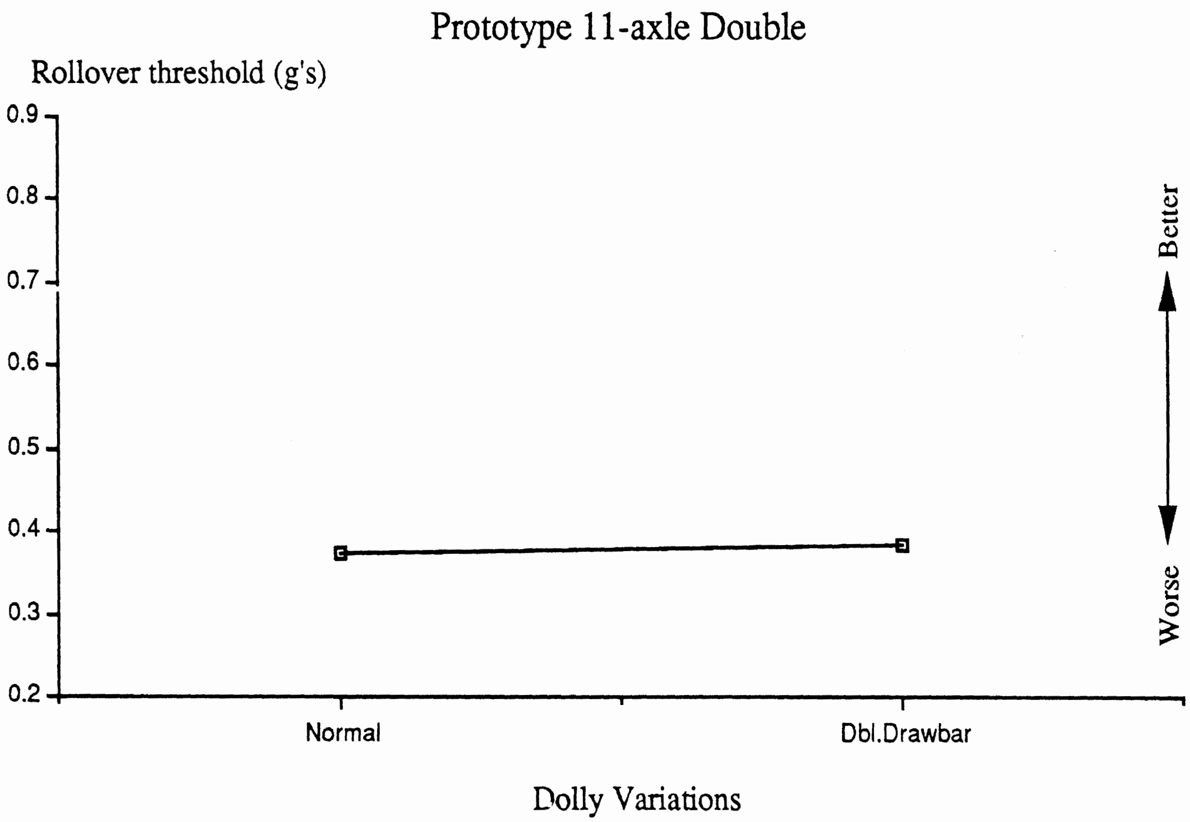
Prototype 11-axle Double (Dolly)

VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	Transient offtracking (ft)	13.16592	Normal
PDbl2.v7.a	Transient offtracking (ft)	16.05833	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	High-speed offtracking (ft)	-0.97046	Normal
PDbl2.v7.a	High-speed offtracking (ft)	-0.81030	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	Braking efficiency at 0.2 g's	0.93484	Normal
PDbl2E	Braking efficiency at 0.2 g's	0.73524	Normal
VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	Braking efficiency at 0.4 g's	0.85245	Normal
PDbl2E	Braking efficiency at 0.4 g's	0.70149	Normal
VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	Static rollover threshold (g's)	0.37372	Normal
PDbl2.v7.a	Static rollover threshold (g's)	0.38196	Dbl.Drawbar
VEHICLE	MEASURE	VALUE	DOLLY
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	Normal
PDbl2.v7.a	Steering sens. at 0.3 g's (deg/g's)	7.36593	Dbl.Drawbar

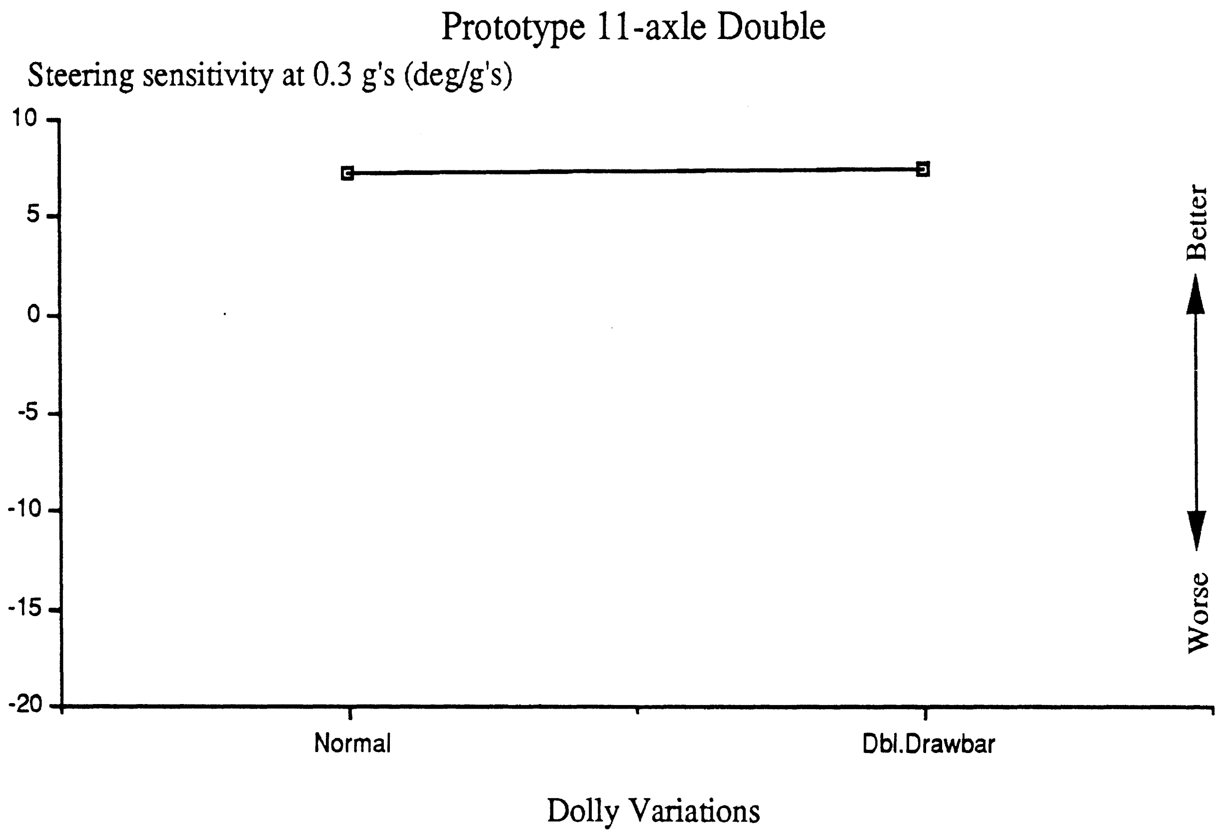

Prototype 11-axle Double
Transient offtracking (ft)
35
30
25
20
15
10
Normal
Dbl.Drawbar
Dolly Variations
Worse
Better



Prototype 11-axle Double
High-speed offtracking (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Worse
Better
Normal
Dbl.Drawbar
Dolly Variations

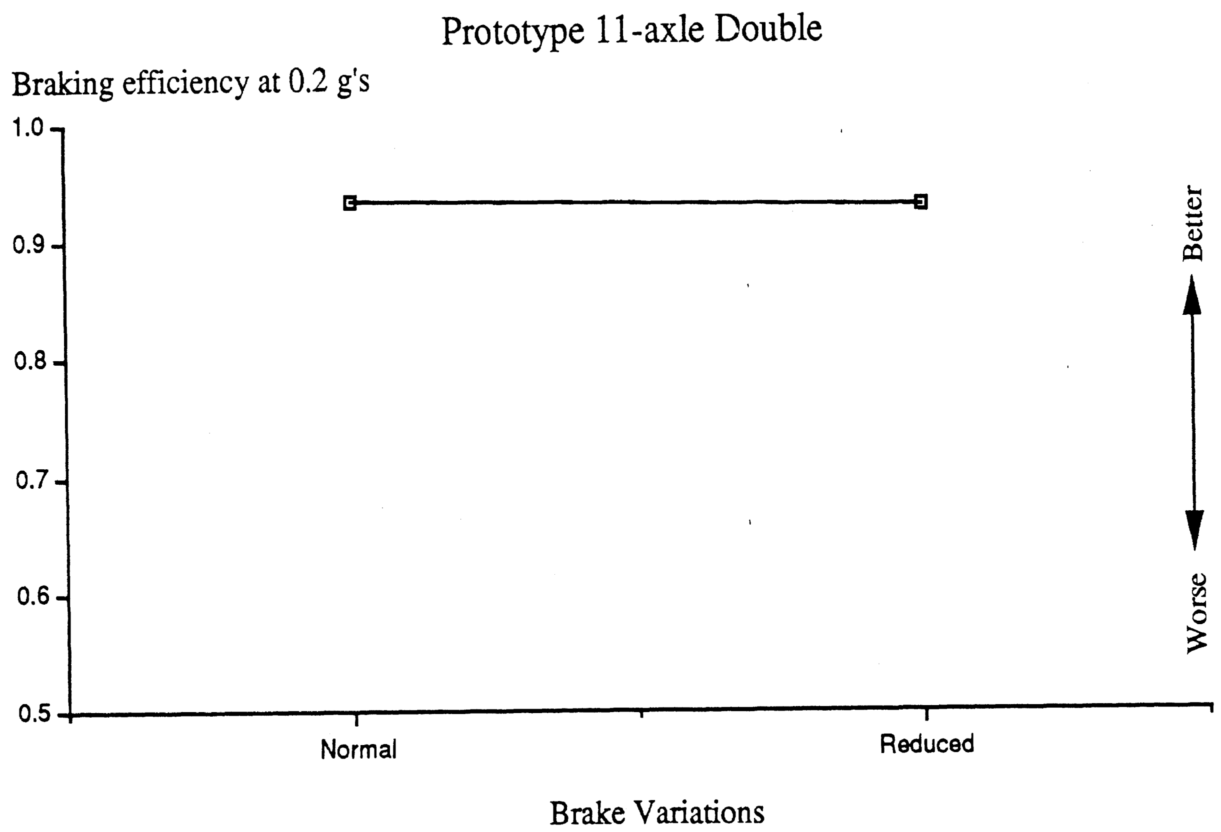


Prototype 11-axle Double
Rollover threshold (g's)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Better
Worse
Normal
Dbl.Drawbar
Dolly Variations

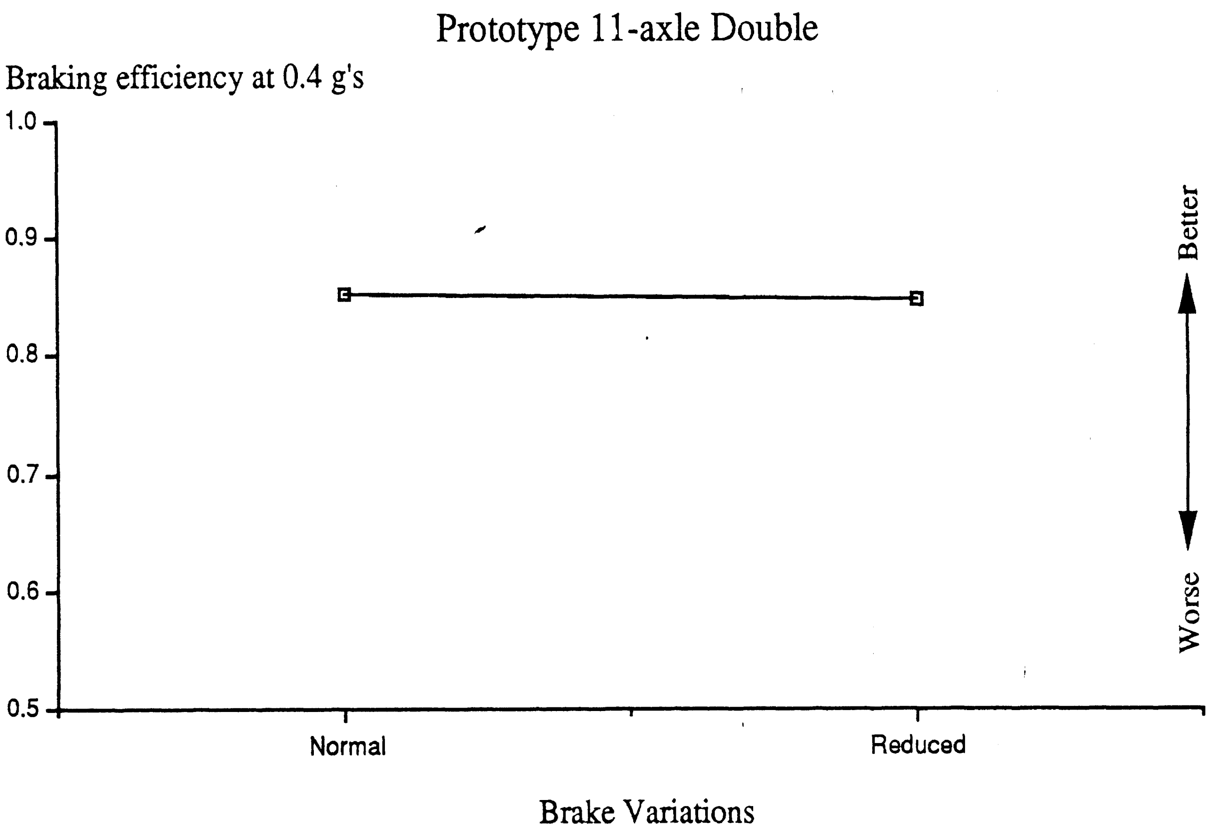

Prototype 11-axle Double
Steering sensitivity at 0.3 g's (deg/g's)
10
5
0
-5
-10
-15
-20
Better
Worse
Normal
Dbl.Drawbar
Dolly Variations

Prototype 11-axle Double (Brakes)

VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Transient offtracking (ft)	13.16592	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	High-speed offtracking (ft)	-0.97046	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Braking efficiency at 0.2 g's	0.93484	Normal
PDbl2.v8.a	Braking efficiency at 0.2 g's	0.92877	Reduced
PDbl2E	Braking efficiency at 0.2 g's	0.73524	Normal
PDbl2.v8.aE	Braking efficiency at 0.2 g's	0.73043	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Braking efficiency at 0.4 g's	0.85245	Normal
PDbl2.v8.a	Braking efficiency at 0.4 g's	0.84668	Reduced
PDbl2E	Braking efficiency at 0.4 g's	0.70149	Normal
PDbl2.v8.aE	Braking efficiency at 0.4 g's	0.69666	Reduced
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Static rollover threshold (g's)	0.37372	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Steering sens. at 0.3 g's (deg/g's)	7.16957	Normal
VEHICLE	MEASURE	VALUE	BRAKES
PDbl2	Rearward amplification	1.74382	Normal



Prototype 11-axle Double
Braking efficiency at 0.2 g's
1.0
0.9
0.8
0.7
0.6
0.5
Better
Worse
Normal
Reduced
Brake Variations



Prototype 11-axle Double
Braking efficiency at 0.4 g's
1.0
0.9
0.8
0.7
0.6
0.5
Normal
Reduced
Brake Variations
Better
Worse

APPENDIX C. TRACK TESTING DEMONSTRATIONS

This appendix contains the script written to describe the maneuvering tests demonstrated on the Chrysler Proving Grounds and the tilt table tests conducted at the University of Michigan Transportation Research Institute. The maneuvering demonstration was held on May 31, 1989. The tilt table tests were demonstrated on August 15, 1988.

In the following script, the "**bold**" phrases indicate the scenes and the plain text pertains to the narration. A video has been assembled using this script. The video was presented to the TRB committee (entitled "Committee for the Study of Relationships Between Vehicle Configurations and Highway Design") on June 15, 1989. A copy of the video was delivered to the program officer, Mr. Ted Chavala, on June 15.

SCRIPT FOR A VIDEO DEMONSTRATION

Turner on a 300 foot circle

This video presentation shows demonstrations of the manuevering characteristics used in evaluating the handling and stability properties affecting the intrinsic safety of Turner trucks.

right after Demo during wigglies

Turner trucks are a proposed class of heavy vehicles that are intended to be less damaging to pavements and also more productive than current trucks.

fade to side view—wheel sets

Here is a mock-up of a 9 axle Turner double. This mock up was assembled using existing tires, brakes, and suspensions.

at end of the dolly shot just before the Western double

The mock up differs from the currently used 5 axle Western double in that it might be allowed to weigh 30,000 lbs more than the Western double.

side view

The vertical black lines on the cargo boxes are placed at 28 feet to indicate the increased length of the mock up over that of the Western double.

underneath shot

The mock up Turner truck has wide spreads between the tires and between the springs. This gives the vehicle added roll stability which is an important contributor to intrinsic safety.

1st rollover accident—braking squeeze—jackknife—fire—2nd rollover

Straight forward goals pertaining to accident situations are: The vehicle should be able to stop quickly. The rear should track the front. The vehicle should be easily controlled to follow a selected path. And, of course, the vehicle should remain standing upon its tires.

low speed off tracking

The ability of Turner trucks to mitigate the risks of accident involvements has been evaluated in selected tests. Here is the mock up Turner double performing a test called "low speed off tracking". The driver is making a 90 degree turn with an inside radius of 37 feet. As indicated by the cones, the rear wheels offtrack towards the center of the turn.

moving the bar forward

The important vehicle characteristics for this manuever are the wheelbases of the trailers. Now the wheels and axles of the trailers have been moved forward.

low speed offtracking again

Here comes the mock up with the wheelbases shortened. The yellow marks on the pavement indicate the path taken by the Turner double when its axles were at their rear positions. Clearly offtracking is reduced by several feet in this case. However there are also disadvantages of short wheelbases.

high speed offtracking

Now the vehicle is following a circle with a diameter of 300 feet. At low speed, the tires track well to the inside of the turn. As speed is increased the wheels move towards the outside. At even higher speeds, the wheels would move to the outside of the turn.

sliding wheels to the rear—high speed offtracking

With the wheels moved to the rear the low speed offtracking is greater. However as speed is increased the tendency to track outboard is reduced and the risk of tripping the vehicle on a curb or a roadside obstacle is also reduced.

roll of the front axle—semi at Ford—tilt table front semi

Vehicle roll towards the outside of a turn. Although the approach to rollover can be demonstrated on a proving grounds, a more controlled determination of the rollover threshold can be made using a tilt table. Here is the tractor semi trailer portion on the tilt table.

picture of the load

In this case the semi trailers are fully laden with a center of gravity height of 86 inches.

full trailer on the tilt table

Here is the full trailer portion on the tilt table. As the angle of the table is increased the rear wheels lift off first before the full trailer rolls over.

close up of rolling

Let's look at that again. The rear wheels lift off first. Then the unit goes through some lash, then all the axles lift off and the rollover threshold is reached.

300 circle

Steady turning is used to measure the stability margin involved with steering controllability.

driver steering

In this case the driver has little difficulty in controlling the 9 axle double.

Western double R.A.

On the other hand, obstacle avoidance or rearward amplification is an important issue.

rear view of Western double

Let's take a look at this manuever from the rear. This loaded Western double would have rolled over if it were not for the outrigger.

Turner 1st front RA—2nd RA—

The mock up is being tested empty. Nevertheless, the vehicle with shortened wheelbases exhibits a large amount of rearward amplification.

Turner front wigglies

Here is another test in which several cycles of steering are used to excite rearward amplification.

sliding to the rear

Now let's see what happens when the axles are moved rearward.

Turner rear RA—rear wigglies

The vehicle with the longer wheelbases has less rearward amplification

—the rear follows the front with greater fidelity.

braking empty wheel lock

Studies of accidents show that empty vehicles are over-involved in jackknifing. This is because wheels are likely to lock up when the vehicle is empty.

dolly jackknife

In this run the dolly wheels lock and a dolly jackknife ensues.

tractor jackknife

In this case the tractor's rear wheels lock and the tractor jackknifes.

Music.

wigglies in the cab—UMTRI

This concludes the video demonstration of the manuevering tests. Quantitative information is given in the UMTRI final report entitled "Turner Truck Handling and Stability Properties Affecting Safety."

fade out

APPENDIX D. ACCIDENT AND TRAVEL TABLES AND CHARTS

TABLE D-1

Travel, Pedestrian/Bicyclist Involvements, and Involvement Rates By Offtracking For Singles and Doubles

Offtracking	Miles (10^9)	Percent	Involves.	Percent	Average Offtrack.	Involvement Ratio
Day Time (6:00 AM – 9:00 PM)						
< 17	2.44	75.0%	228	80.9%	13.742	1.08
> 17	0.82	25.0	54	19.2	19.159	0.77
Total	3.26	100.0%	282	100.0%	14.779	1.00
Night Time (9:00 PM – 6:00 AM)						
< 17	0.22	62.7%	52	89.7%	15.146	1.43
> 17	0.13	37.3	6	10.3	18.054	0.28
Total	0.36	100.0%	58	100.0%	15.447	1.00

TABLE D-2

Travel, Turning Involvements, and Involvement Rates By Offtracking For Singles and Doubles

Offtracking	Miles (10^9)	Percent	Involves.	Percent	Average Offtrack.	Involvement Ratio
Day Time (6:00 AM – 9:00 PM)						
< 17	2.44	75.0%	133	72.3%	13.489	0.96
> 17	0.82	25.0	51	27.7	18.643	1.11
Total	3.26	100.0%	184	100.0%	14.918	1.00
Night Time (9:00 PM – 6:00 AM)						
< 17	0.22	62.7%	73	76.0%	14.929	1.21
> 17	0.13	37.3	23	24.0	18.445	0.64
Total	0.36	100.0%	96	100.0%	15.771	1.00

TABLE D-3

Travel, Jackknifes, and Involvement Rates By Braking Efficiency For 5-Axle Singles and Doubles

Braking Efficiency	Miles (10^9)	Percent	Jackknifes	Percent	Average Brake. Effic.	Involvement Ratio
< .5	0.25	1.1%	17	1.6%	0.443	1.48
.5 – .7	7.24	30.7	448	41.9	0.616	1.36
.7 – 1	16.07	68.2	605	56.5	0.845	0.83
Total	23.57	100.0%	1,070	100.0%	0.743	1.00

TABLE D-4

Travel, Rearends, and Involvement Rates By Braking Efficiency and Type of Road For 5-Axle Singles and Doubles

Braking Efficiency	Miles (10^9)	Percent	Rearends	Percent	Average Brake. Effic.	Involvement Ratio
High Speed						
< .5	0.19	0.9%	4	0.5%	0.476	0.54
.5 – .7	6.10	29.4	195	23.7	0.616	0.80
.7 – 1	14.44	69.7	625	75.9	0.855	1.09
Total	20.72	100.0%	824	100.0%	0.796	1.00
Low Speed						
< .5	0.07	2.3%	0	0.0%	0.000	0.00
.5 – .7	1.14	40.0	42	43.8	0.630	1.09
.7 – 1	1.64	57.6	54	56.3	0.841	0.98
Total	2.85	100.0%	96	100.0%	0.749	1.00

TABLE D-5

Travel, Rearends, and Involvement Rates By Gross Combination Weight and Type of Road For 5-Axle Singles and Doubles

GCW	Miles (10^9)	Percent	Rearends	Percent	Average GCW	Involvement Ratio
High Speed						
< 35K	6.09	29.2%	208	23.7%	28,594	0.81
35K - 50K	2.36	11.3	95	10.8	43,452	0.95
50K - 65K	2.97	14.2	138	15.7	59,433	1.10
> 65K	9.42	45.2	437	49.8	73,426	1.10
Total	20.84	100.0%	878	100.0%	57,363	1.00
Low Speed						
< 35	1.17	40.0%	40	40.0%	29,586	1.00
35K - 50K	0.42	14.4	12	12.0	41,847	0.83
50K - 65K	0.32	10.8	9	9.0	59,179	0.83
> 65K	1.02	34.7	39	39.0	74,209	1.12
Total	2.93	100.0%	100	100.0%	51,123	1.00

TABLE D-6

Travel, Rollovers, and Involvement Rates By Rollover Threshold For Three Combinations

Roll Threshold	Miles (10^9)	Percent	Rollovers	Percent	Average Roll Thresh.	Involvement Ratio
5-Axle Van Singles						
< .35	1.31	12.1%	134	17.4%	0.326	1.44
.35 – .4	2.51	23.2	280	36.3	0.374	1.56
.4 – .5	2.24	20.7	183	23.7	0.446	1.14
.5 – .6	1.73	16.0	102	13.2	0.544	0.82
> .6	3.03	28.0	73	9.5	0.667	0.34
Total	10.81	100.0%	772	100.0%	0.433	1.00
5-Axle Tank Singles						
< .35	0.09	3.9%	14	4.3%	0.313	1.08
.35 – .4	0.75	32.4	186	56.5	0.381	1.75
.4 – .5	0.29	12.3	87	26.4	0.422	2.16
.5 – .6	0.09	3.9	13	4.0	0.539	1.00
> .6	1.11	47.5	29	8.8	0.688	0.19
Total	2.33	100.0%	329	100.0%	0.422	1.00
5-Axle Van Doubles						
< .4	0.04	6.8%	5	11.1%	0.367	1.63
.4 – .5	0.23	34.2	18	40.0	0.441	1.17
.5 – .6	0.21	32.1	15	33.3	0.543	1.04
> .6	0.18	26.8	7	15.6	0.645	0.58
Total	0.66	100.0%	45	100.0%	0.499	1.00

TABLE D-7

Travel, Single Vehicle Involvements, and Involvement Rates By Steering Sensitivity and Type of Road For 5 Axle Van and Tank Singles and 5 Axle Van Doubles

Steering Sensitivity	Miles (10^9)	Percent	Involvements	Percent	Average Steer. Sens.	Involvement Ratio
High Speed						
< 6	0.95	7.6%	115	9.7%	4.778	1.27
6 – 9	3.84	30.6	509	42.7	7.604	1.39
> 9	7.73	61.7	568	47.7	10.621	0.77
Total	12.51	100.0%	1,192	100.0%	8.769	1.00
Low Speed						
< 6	0.07	5.7%	12	5.6%	3.203	0.97
6 – 9	0.24	18.6	60	27.8	7.600	1.50
> 9	0.97	75.7	144	66.7	10.753	0.88
Total	1.28	100.0%	216	100.0%	9.458	1.00

TABLE D-8

Travel, Single Vehicle Involvements, and Involvement Rates By Rearward Amplification For 5-Axle Doubles

Rear. Ampli.	Miles (10^8)	Percent	Involve.	Percent	Average Rear. Ampli.	Involvement Ratio
High Speed Roads						
< 1.4	0.21	2.7%	2	2.7%	1.377	1.01
1.4 – 1.7	6.36	78.8	38	51.4	1.562	0.65
> 1.7	1.49	18.5	34	45.9	1.854	2.48
Total	8.06	100.0%	74	100.0%	1.691	1.00
Low Speed Roads						
< 1.4	0.03	4.9%	0	0.0%	0.000	0.00
1.4 – 1.7	0.40	67.5	9	47.4	1.544	0.70
> 1.7	0.16	27.6	10	52.6	1.802	1.91
Total	0.59	100.0%	19	100.0%	1.680	1.00

TABLE D-9

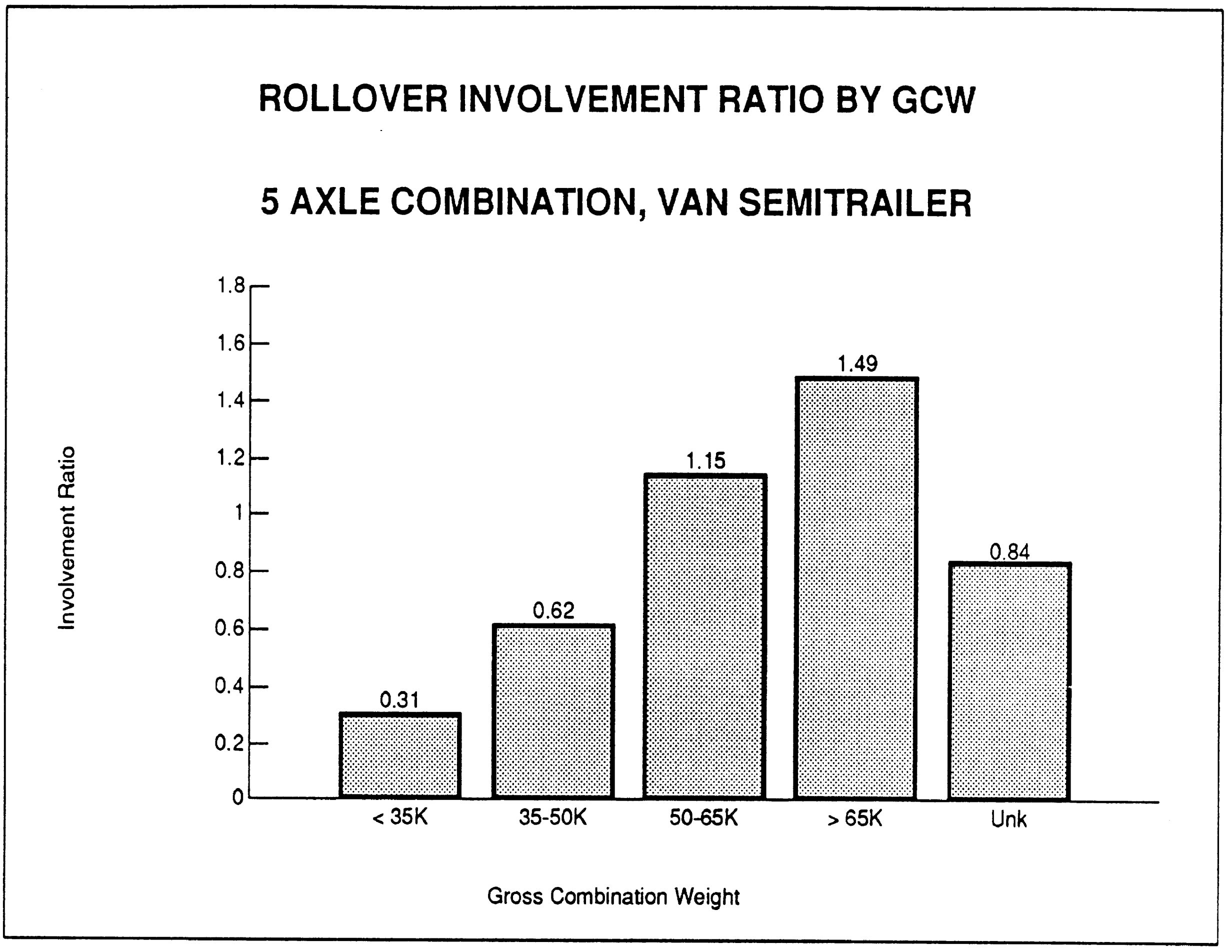
Travel, Sideswipe, Ramp, or Curve Involvements, and Involvement Rates By Rearward Amplification For 5-Axle Doubles

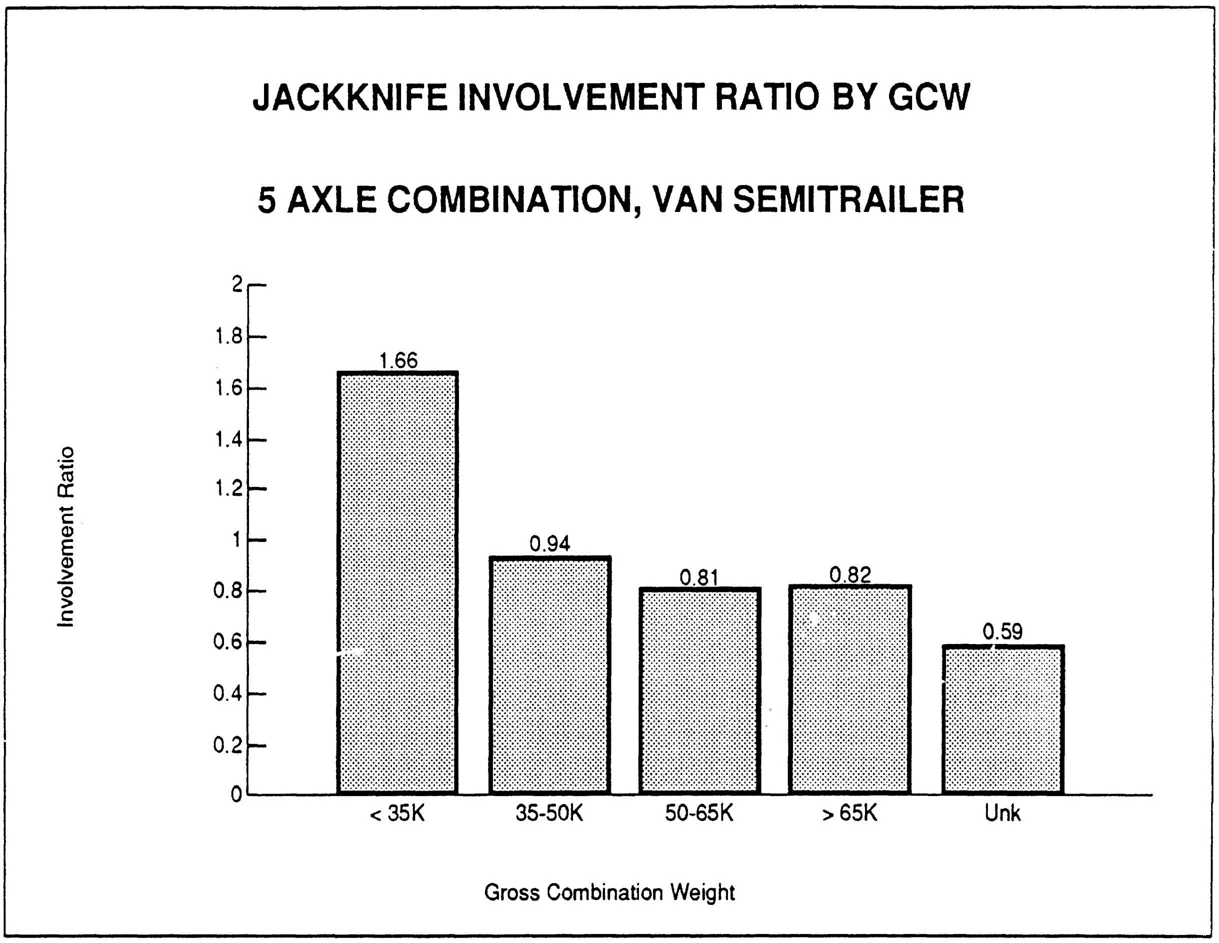
Rear. Ampli.	Miles (10^8)	Percent	Involve.	Percent	Average Rear. Ampli.	Involvement Ratio
High Speed Roads						
< 1.4	0.21	2.7%	2	2.7%	1.370	1.00
1.4 – 1.7	6.36	78.8	30	40.0	1.571	0.51
> 1.7	1.49	18.5	43	57.3	1.884	3.10
Total	8.06	100.0%	75	100.0%	1.745	1.00
Low Speed Roads						
< 1.4	0.03	4.9%	1	5.6%	1.384	1.14
1.4 – 1.7	0.40	67.5	7	38.9	1.547	0.58
> 1.7	0.16	27.6	10	55.6	2.008	2.01
Total	0.59	100.0%	18	100.0%	1.794	1.00

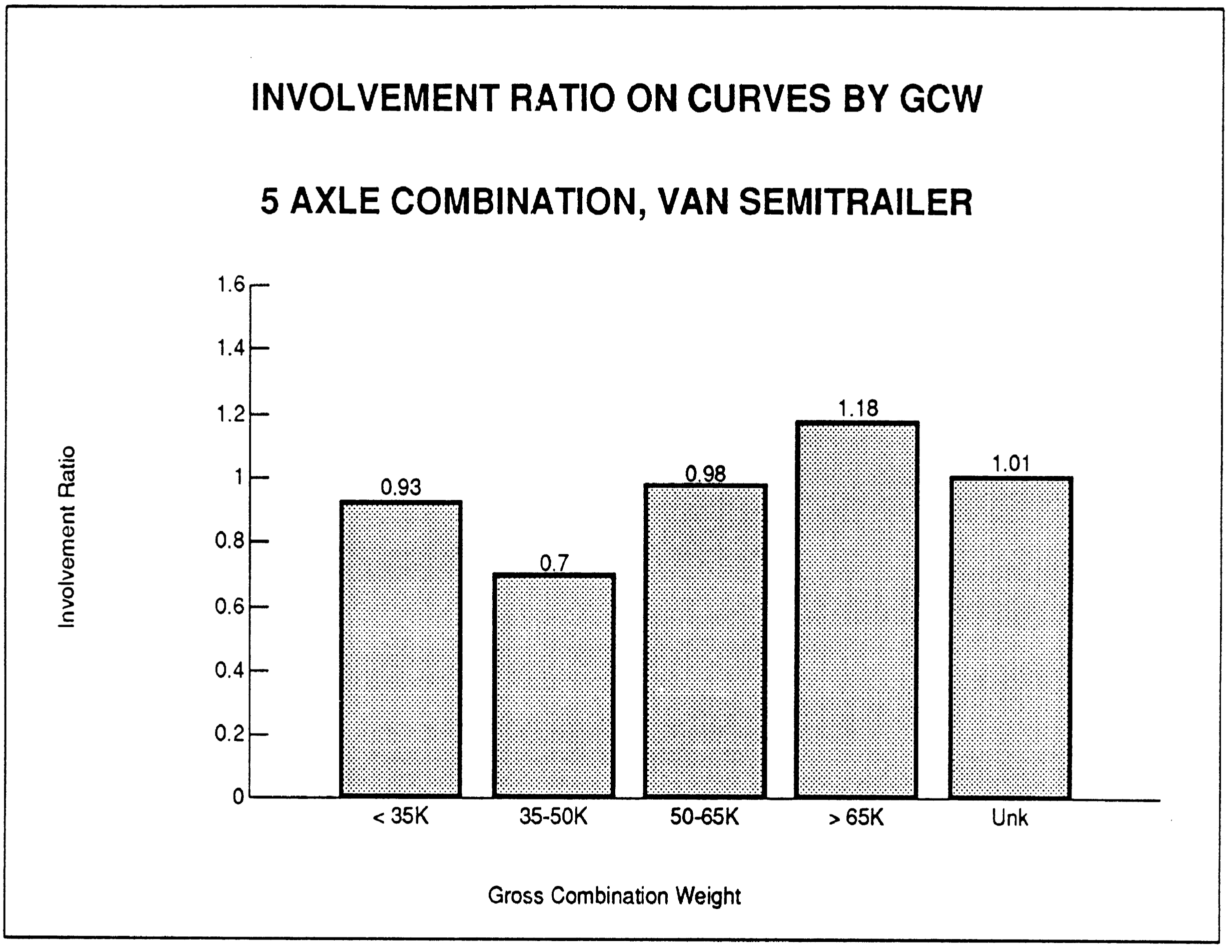
TABLE D-10

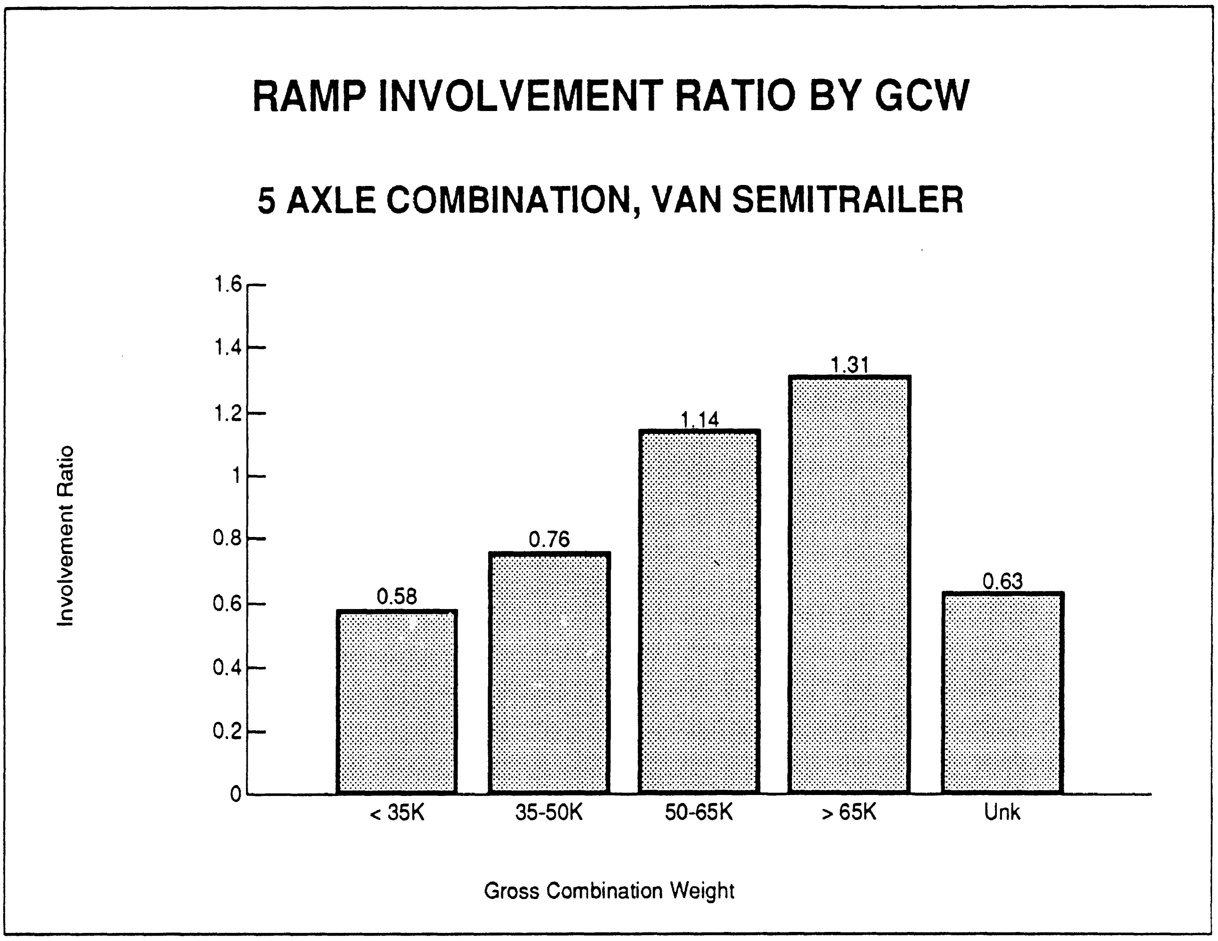
Travel, Rollovers, and Involvement Rates By Rearward Amplification For 5-Axle Doubles

Rear. Ampli.	Miles (10^8)	Percent	Involve.	Percent	Average Rear. Ampli.	Involvement Ratio
High Speed Roads						
< 1.4	0.21	2.7%	2	2.4%	1.377	0.89
1.4 - 1.7	6.36	78.8	29	34.5	1.591	0.44
> 1.7	1.49	18.5	53	63.1	1.901	3.41
Total	8.06	100.0%	84	100.0%	1.782	1.00
Low Speed Roads						
< 1.4	0.03	4.9%	1	8.3%	1.384	1.72
1.4 - 1.7	0.40	67.5	4	33.3	1.625	0.49
> 1.7	0.16	27.6	7	58.3	1.893	2.11
Total	0.59	100.0%	12	100.0%	1.761	1.00

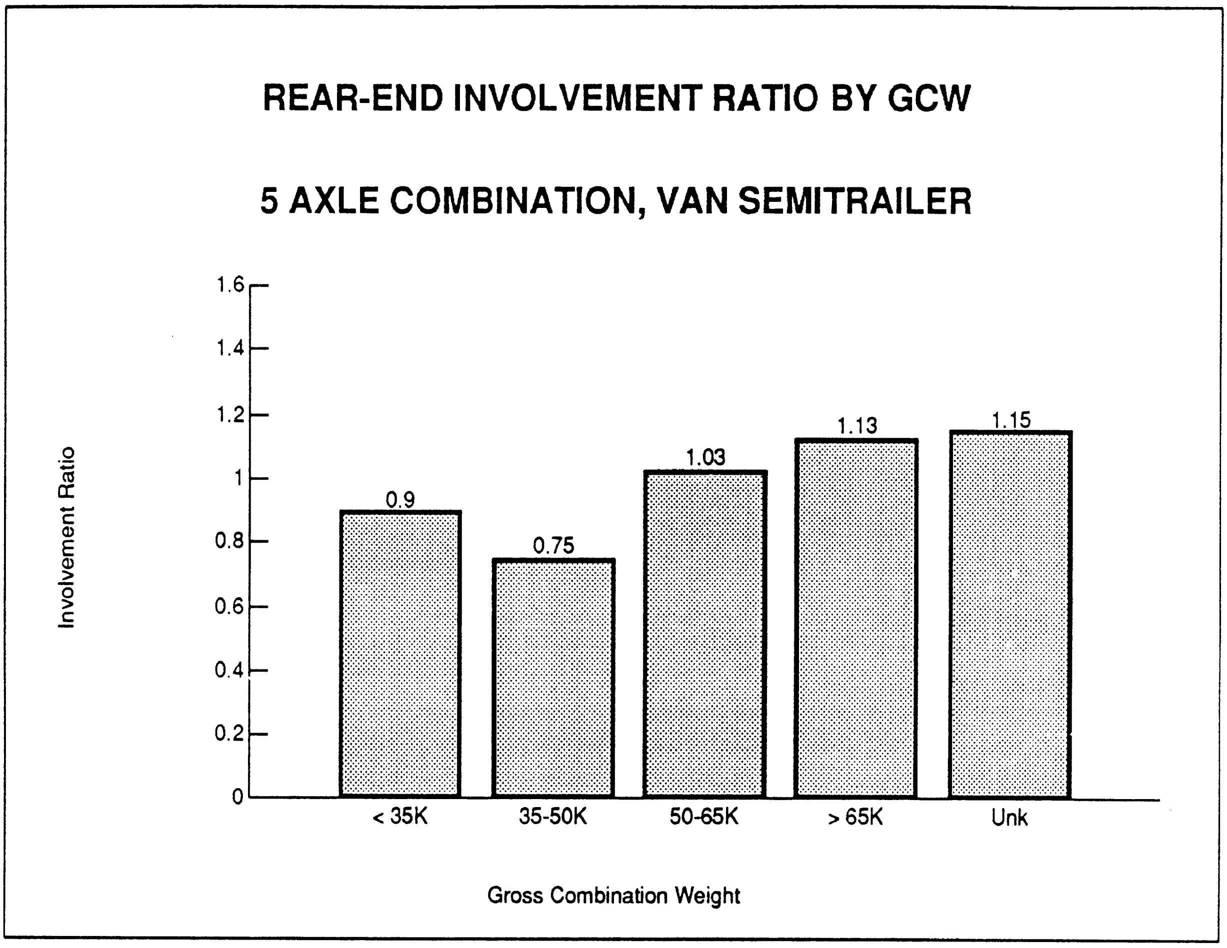

ROLLOVER INVOLVEMENT RATIO BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.31
0.62
1.15
1.49
0.84
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight

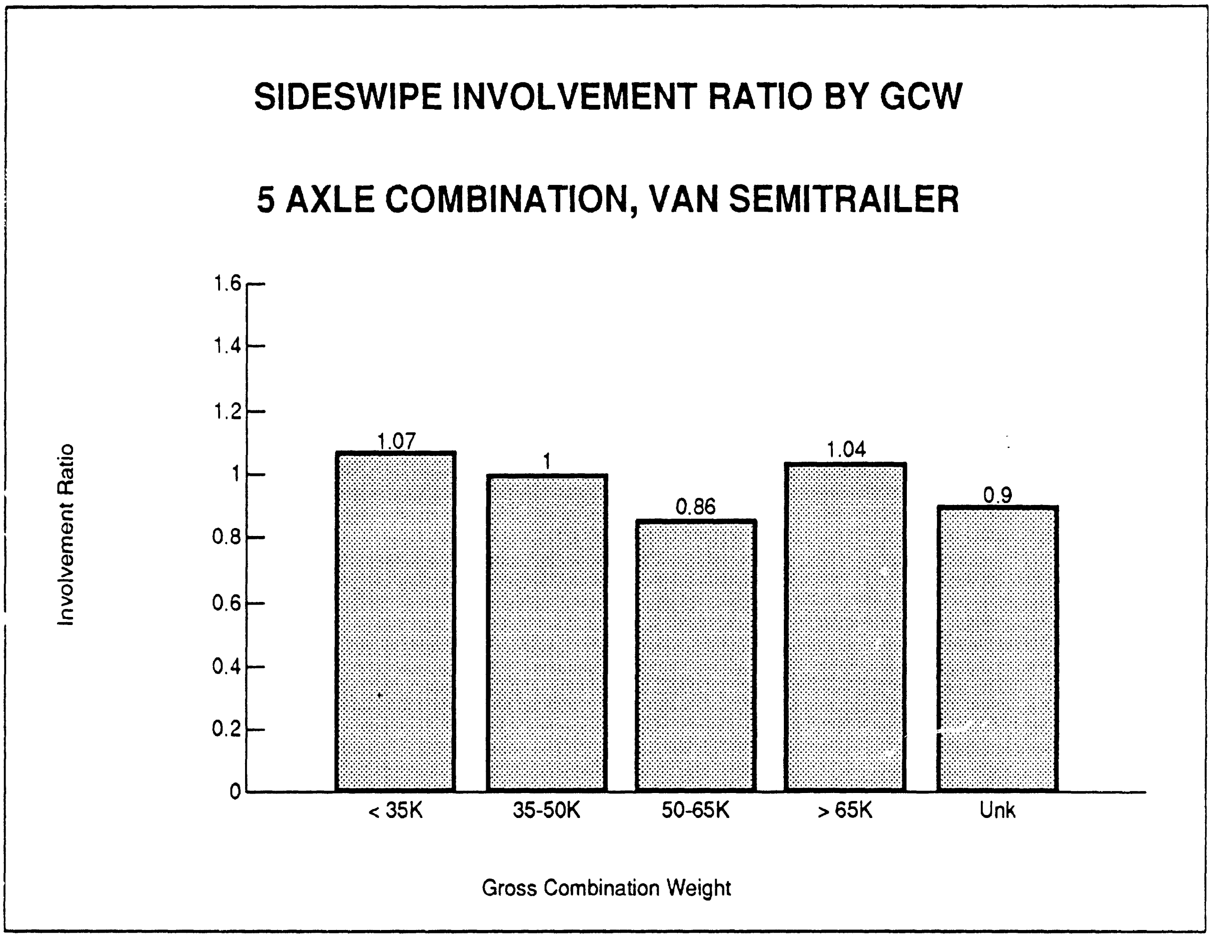

JACKKNIFE INVOLVEMENT RATIO BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.66
0.94
0.81
0.82
0.59
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight

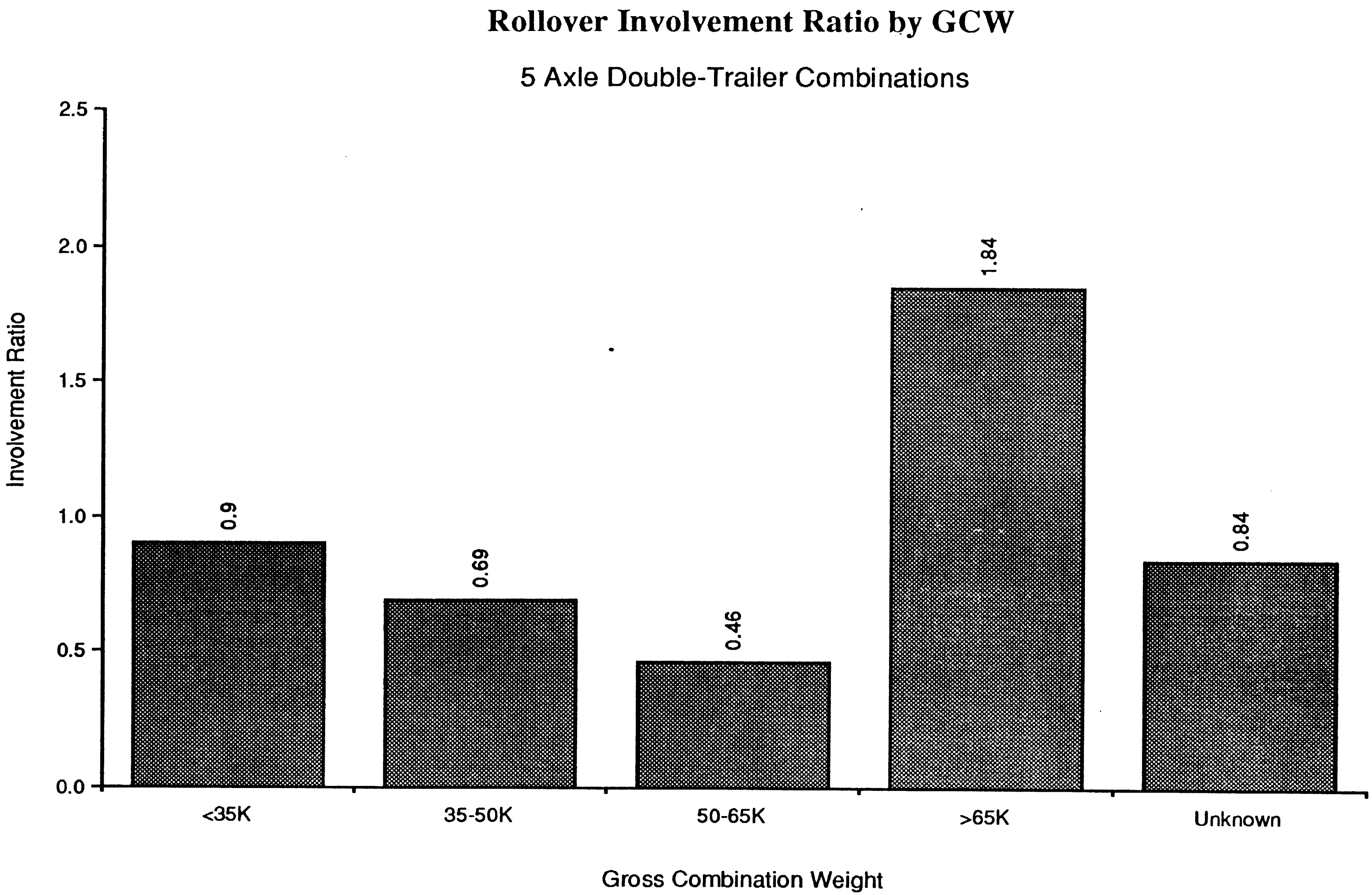

INVOLVEMENT RATIO ON CURVES BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.93
0.7
0.98
1.18
1.01
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight



RAMP INVOLVEMENT RATIO BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.58
0.76
1.14
1.31
0.63
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight


REAR-END INVOLVEMENT RATIO BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.9
0.75
1.03
1.13
1.15
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight

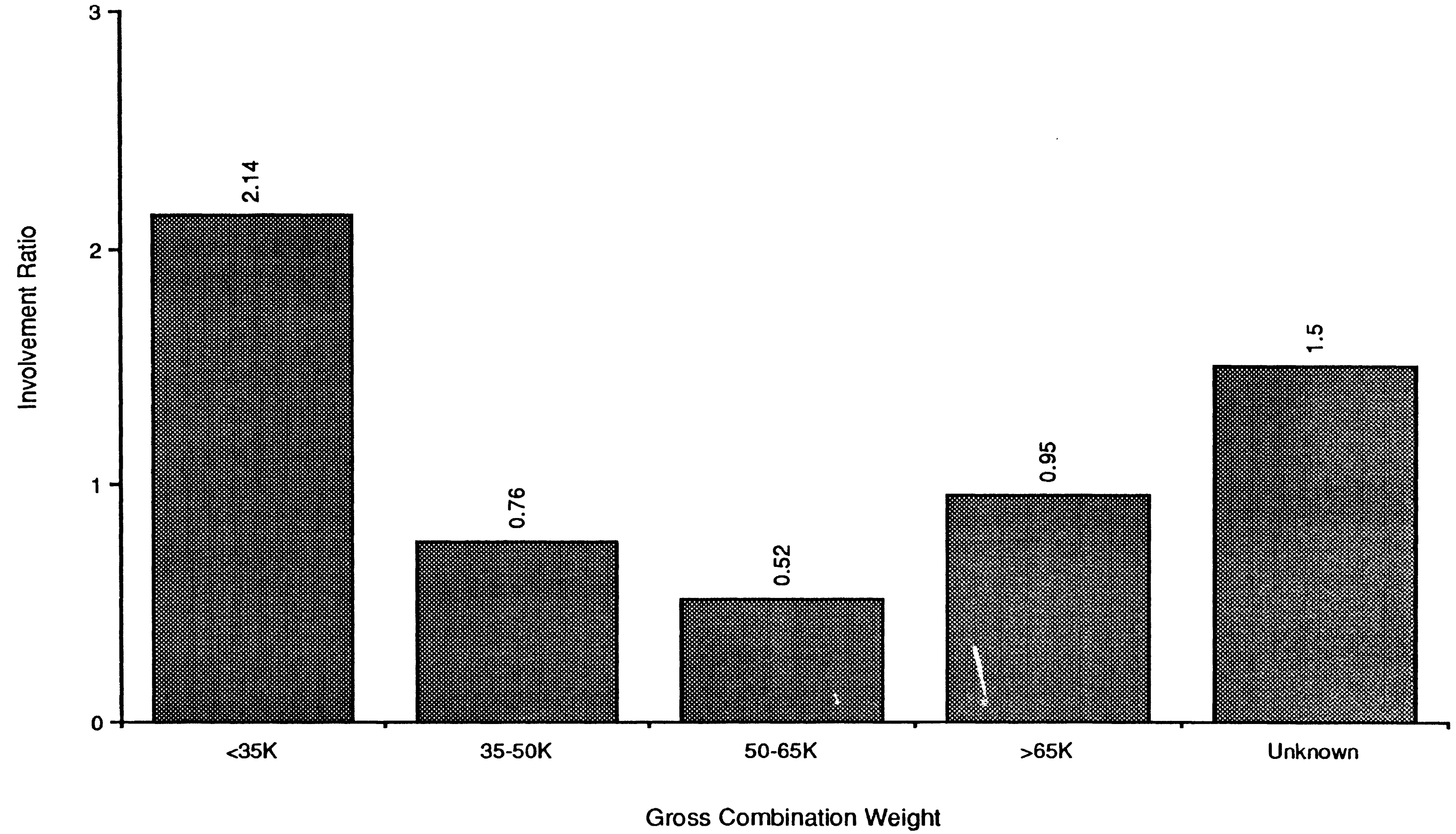

SIDESWIPE INVOLVEMENT RATIO BY GCW
5 AXLE COMBINATION, VAN SEMITRAILER
Involvement Ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.07
1
0.86
1.04
0.9
< 35K
35-50K
50-65K
> 65K
Unk
Gross Combination Weight



Rollover Involvement Ratio by GCW
5 Axle Double-Trailer Combinations
Involvement Ratio
2.5
2.0
1.5
1.0
0.5
0.0
0.9
0.69
0.46
1.84
0.84
<35K
35-50K
50-65K
>65K
Unknown
Gross Combination Weight

Jackknife Involvement Ratio by GCW

5 Axle Double-Trailer Combinations



Percent of Crash Types for Singles and Doubles Involved in Fatal Accidents

Accident Type	Singles Percent	Doubles Percent
Jackknife	9.8%	14.5%
Rearend	8.0	8.3
Rollover	16.7	23.5
Pedestrian/Bicyclist Related to Low-Speed Offtracking	2.7	3.4
Turning Related to Low-Speed Offtracking	2.2	3.3
Single Vehicle	22.0	23.5