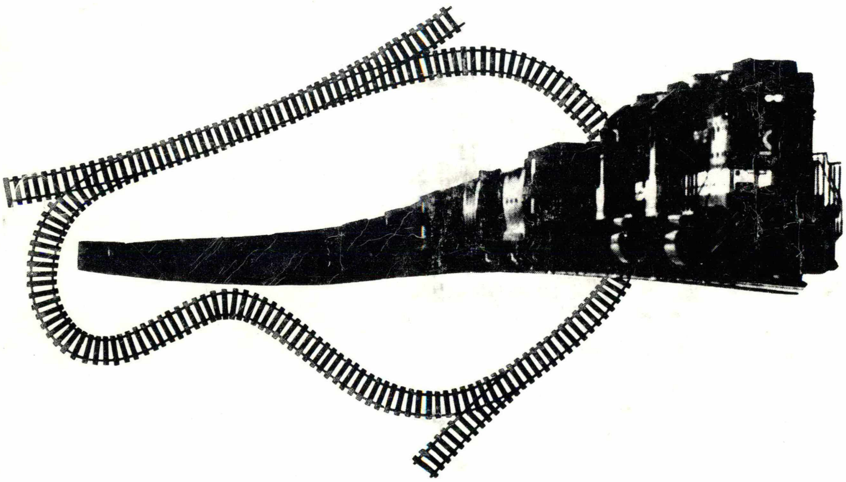
# ISSUES AND DIMENSIONS OF FREIGHT CAR SIZE

A Report by the
Secretary of Transportation



U.S. Department of Transportation

MARCH 1980

**Front Cover:** An illustration of the Facility for Accelerated Service Testing (FAST) at DOT's Transportation Test Center in Pueblo, Colorado. This joint government and industry research project provides valuable insight into the behavior of both track and rolling stock.

**Back Cover:** The Rail Dynamics Laboratory (RDL) at DOT's Transportation Test Center provides controlled dynamic wheel-set inputs for investigations of the dynamic behavior of rolling stock. This photograph shows a flat car with two attached highway trailers undergoing a test on the Roll Dynamics Unit (RDU) within the RDL.

# DEPARTMENT OF TRANSPORTATION
## FEDERAL RAILROAD ADMINISTRATION
WASHINGTON, D.C. 20590

March 17, 1980

Honorable Walter F. Mondale
President of the Senate
Washington, D.C. 20510

Honorable Thomas P. O'Neill, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. President:

Dear Mr. Speaker:

I am transmitting to the Congress the report of a study directed by Section 10(a) (1) of the Federal Railroad Safety Authorization Act of 1978. This report, entitled "Issues and Dimensions of Freight Car Size," completes the first part of a 2-year study concerning the safety and efficiency of rail transportation.

This report deals with "the relationship of the size, weight, and length of rail cars ... to the safety and efficiency of rail transportation." A complementary report to be submitted later this year will address the effects of alternate forms of rail ownership and control of rights of way by individual railroads on the safety and efficiency of rail transportation.

The current report concludes that cars of 50-, 70-, and 100-ton capacity, the standard capacity cars presently in interchange service, can be operated safely over adequately maintained track. In the case of cars of certain designs, such as large covered hopper cars, modifications or operating restrictions may be necessary to improve their level of safety. The railroad industry has imposed a limitation of 263,000 pounds gross rail weight (corresponding to 100-ton capacity) on cars in the interchange fleet. The report notes that further increases in car weight have not proved beneficial.

There can be no doubt that heavier axle loadings have resulted in greater wear on track and roadbed. This increase in wear has been significantly greater than the increase in aggregate ton-miles. More profitable railroads have responded with the widespread use of continuous welded rail, accelerated tie and surfacing programs, and installation of large quantities of heavy rail (132 pounds/yard and greater). Others have reaped the short-term benefits of lower transportation costs without making necessary investments in maintenance of way.

Where track programs have not kept pace with increased dynamic axle loadings, deferred maintenance has become more critical to safety performance. As the Department has reported to the Congress in the past, deferred maintenance and heavier axle loadings, in combination, are responsible for most of the increase in derailments over the past two decades. The capital shortfall predicted by the Department of Transportation's report entitled "A Prospectus for Change in the Freight Railroad Industry" looms as a further threat to the economic health and operational safety of the industry.

Nevertheless, the current report concludes that the transition to cars of greater capacity and dissimilar configurations has been made without major penalty to the safety of operations. No more than an average of five fatalities per year are identified as possibly "related" to size, weight, and length of cars. Since that number includes all fatalities that cannot positively be ruled out, and since it does not take into consideration certain safety benefits from the operation of fewer cars and trains, it represents a high estimate of human costs.

Perhaps the most startling conclusion of the report is that, on a ton-mile basis, larger cars are less likely to be the direct cause of a derailment at speeds in excess of 10 miles per hour. However, that does not hold true for certain car configurations, and the Department will actively examine the feasibility of remedial measures to improve the performance of "bad actor" cars.

The relative "efficiency" of cars of various sizes, lengths, and weights has proved more difficult to define. The mandate for this study prescribed a time frame much shorter than the duration of ongoing basic research into the precise parameters and consequences of higher dynamic axle loadings. Without clear identification of the total costs generated by cars with characteristics such as higher centers of gravity, greater static axle loading, or peculiar dynamic behavior, firm identification of net benefits or detriments has not been possible.

It is known that profitable railroads which have made major investments in maintenance of way have continued to prosper with the advent of 100-ton service and cars of innovative design. This has been true despite stiff competition from trucks and barges.

Larger capacity cars reduce labor costs, save fuel, and make it possible for existing yards and sidings to accommodate increased traffic. These and other benefits have been translated into more competitive tariffs. The determination of an "optimal" car capacity continues to be a desired but elusive goal. In reality, the utility of a single value is questionable, since a host of railroads face a multitude of different safety exposures and economic trade-offs. The existing 100-ton limitation for interchange service appears to be an accepted, practical, and tested upper limit. It serves as a useful base for specifying the requirements of the other components of the system — notably, the track.

The study closes with a serious warning for the future and a description of options for dealing with identified safety problems relating to size, weight, and length of freight cars. The warning concerns the continued increase in hazardous materials traffic, the growth of forces on track and roadbed from larger cars and dynamically unstable cars, and the marginal financial conditions of many railroads. Of course, the lower train speeds associated with poor track conditions materially reduce the risk of hazardous materials release. Nevertheless, the need remains to take every feasible step that will help prevent a major catastrophe.

Evaluation of the options outlined in the report and completion of the regulatory reform effort being undertaken by the Federal Railroad Administration will assure a full agenda in the days ahead. We look forward to discussing this report and ongoing initiatives with the Congress.

Sincerely,

Neil Goldschmidt

Neil Goldschmidt

## PREFACE

The following is extracted from Section 10 of Public Law 95-574, dated November 2, 1978:

> *Section 10. (a) The Secretary of Transportation shall conduct a study and evaluation concerning the safety and efficiency of rail transportation. Such study and evaluation shall include—*
>
> *(1) A determination of the relationship of the size, weight, and length of railroad cars (other than those contained in unit trains) to the safety and efficiency of rail transportation; and*
>
> (2) A determination of the effect of the exclusive ownership and control of rights-of-way by individual railroads on the safety and efficiency of rail transportation, considering, among other things, whether or not such rights-of-way might be better employed under new structures of ownership or other conditions for joint usage.
>
> *(b) Within one year after the date of enactment of this Act, the Secretary of Transportation shall complete the portion of the study described in subsection (a)(1) of this section.*
>
> (c) Within two years after the date of enactment of this Act, the Secretary of Transportation shall complete the portion of the study described in subsection (a)(2) of this section and submit a report to the Congress setting forth the results of such study, together with recommendations for such legislative or other action as the Secretary deems appropriate.

As a result of this mandate, a study was conducted. The italics designate the portion of the mandated study that this report addresses.

## ABSTRACT

This study presents a review and evaluation of the relationships between the safety and efficiency of rail transportation and the size of railroad freight cars. The study concludes that most larger cars can be operated safely over well-maintained track, but that large-capacity cars tend to exert greater forces on the track structure than do smaller cars. Many railroads have not made appropriate adjustments in maintenance-of-way expenditures to compensate for this increased wear. In addition, cars of certain designs have proved unusually susceptible to derailment because of peculiar dynamic characteristics. These factors have contributed materially to the overall increase in derailments over the current decade. However, factors related to car size cannot be said to have been responsible for a significant number of additional train accident fatalities, especially when countervailing safety considerations are taken into account.

The study did not produce a precise conclusion as to whether the financially troubled railroad industry has realized a net benefit from the introduction of larger freight cars. Available information points to the conclusion that profitable railroads have realized net benefits generated by lower transportation costs, while some poorer railroads may have been adversely affected as a result of their inability to make necessary investments in maintenance of way.

Looking to the future, the study predicts a significant challenge for the railroad industry and the government. Unless major changes are made in government regulatory policies and the railroads take advantage of resulting opportunities in the marketplace, deferred maintenance of track will become an even more critical problem in the 1980's. At the same time, an increasing portion of the freight car fleet will be made up of larger cars, and hazardous materials traffic is expected to double. The possibility of additional catastrophic accidents could be heightened considerably, unless the network marginal track is improved or unless severe operating restrictions are imposed.

As to the specific issues of freight car performance, the study found three areas in need of interim attention:

1. The high center-of-gravity covered hopper cars and some long flat cars have a higher accident-causal rate than other cars in the fleet. Accordingly, the Federal Railroad Administration (FRA) will accelerate related ongoing activities and convene an appropriate forum to further identify the magnitude of the problem and explore opportunities for improvement to these types of cars. The FRA will bring together representatives of the Association of American Railroads, the Railway Progress Institute, and the Railway Labor Executives' Association to facilitate a comprehensive examination of corrective actions, such as modifications to car designs, car dynamic behavior controls, train makeup procedures, train-handling methods, routing decisions, maintenance practices, and operating routines. Since the derailing tendencies of cars on tracks of different quality, as measured by the six FRA track classifications, cannot be determined from existing data bases, this group will concentrate on determining the nature of countermeasures which may be required to effectively improve safety by evaluating the consequences of running the questionable cars over specific combinations of real-world track and operating conditions.
2. The need to establish and maintain a more meaningful data base was clearly evident during the

study. A data collection and analysis system should be established to responsively trace meaningful real-time trends.

3. There is the need to continue the development and validation of research tools so that quantitative predictions of effects and interactions can be made and used to guide the formulation of performance requirements. It is necessary to look at a freight car both in terms of its own response characteristics and the way it affects train action as a whole. A discussion of railroad cars out of the context of train makeup and operation is at best a difficult task. While extreme care was taken during this study not to misuse the individual car data in arriving at conclusions as to what actions, if any, are needed for improvement, it was evident that better research tools are required. The FRA, in conjunction with the industry, has been developing the requisite tools. Some are already in operation. Until these tools are validated, decisions should be made with caution. Examples of major tools that will permit meaningful study of car action in varying train consists under different operational scenarios include the following:

   - *The Facility for Accelerated Service Testing (FAST)* — to evaluate the effects of car axle load on track and car maintenance and to determine the economical safe life of track and roadbed structural components.
   - *The Rail Dynamics Laboratory (RDL)* — to determine the dynamic behavior characteristics of various car types and control devices.
   - *The Stability Assessment Facility for Equipment (SAFE)* — to assess the ability of car designs to interact acceptably with track variations.
   - *The Locomotive Research and Train Handling Evaluator (LRTHE)* — to evaluate operating procedures and control devices to ensure that car performance in longer trains is as good as that in shorter trains.
   - *The Track Train Dynamics Program (TTD)* —to uncover ways that cars in the present fleet can be designed to be more forgiving of track irregularities.

The study identifies possible options to further improve the performance of heavier railroad cars. Long-term options would include government actions to improve the economic condition of railroads, establishment of incentives to shorten the implementation period for improvements, and encouragement for the development of performance criteria for new cars. Other options, which are not as clear-cut or supported by an adequate data base, are left for further consideration, refinement, and development of a position as to what government or industry actions are warranted. These options include utilization of information from operating employees, review of present standards and specifications pertaining to car size, and review of operational requirements for cars carrying hazardous materials.

## INTRODUCTION

The objective of this study was to determine the relationships between freight car size, weight, and length and railroad safety and efficiency. In recent years, most new freight cars can be classed as large cars because of their long length (e.g., 90-foot-long trailer on flat cars [TOFC] or container on flat cars [COFC]), their large load-carrying capacity (e.g., 100 tons), or their large cubic capacity (e.g., 33,000-gallon tank cars). The trend to larger and heavier cars has coincided with an increase in train derailments (approximately 4% per year over the last 9 years) and with an increase in accidents involving cars carrying hazardous materials. The scope of the study included a review of the options available for making railroad transportation safer and of the problems of assigning responsibilities to carry out these options.

The investigation was complicated by the fact that parameters other than simple descriptions of car length, weight, and load capacity had to be considered; for example, dynamic stability. Also, the various aspects of safety had to be evaluated, such as employee injuries, train derailments, grade-crossing accidents, and the potential of catastrophes involving hazardous materials. The determination of options to improve safety had to consider the fact that freight cars are freely interchanged among more than 40 major North American railroads and numerous smaller ones with different operating environments, facilities, track conditions, operating procedures, and economic constraints.

The findings of the investigation were derived from the following major information sources:

- The historically collected statistical data and trends pertaining to safety and efficiency. The Federal Railroad Administration's (FRA) Rail Accident and Incident Statistics, the Association of American Railroads' (AAR) Universal Machine Language Equipment Register (UMLER file), the FRA 1% Waybill Sampling, and several Interstate Commerce Commission (ICC) information sources were cross-analyzed by individual car characteristics to establish trends such as derailments per car-mile traveled and derailments per ton-mile hauled.
- Prior research and technical tests, data, and findings.
- Surveys, questionnaires, and interviews of directly involved management of railroads, the supply industry, and responsible government representatives.
- An extensive questionnaire survey, conducted by the United Transportation Union (UTU). This survey provided an important contribution to the study. Over 900 operating railroad employees who routinely work with freight cars for many carriers at locations throughout the country took part in this survey. Their tabulated responses have a remarkably good correlation with the other data sources of the study and

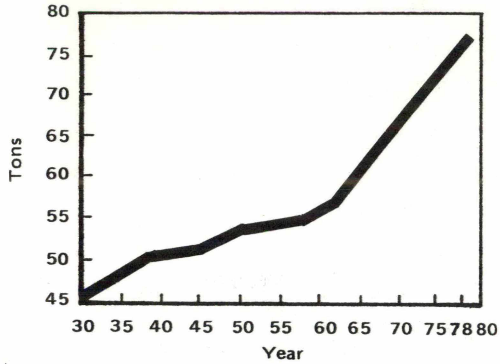
form a valuable base of first-hand experience for evaluation.*

It is necessary to emphasize, however, that these sources do not contain the full amount of information necessary to vigorously address the determination of the effects on safety and efficiency of size, weight, and length of rail cars. The FRA accident data base is the most comprehensive transportation safety data base in existence, but meaningful references to types of cars have been included only since 1975. Moreover, exposure data, which relate the number of train-miles run and the freight tons hauled to the number of accidents, are incomplete. The annual one-percent waybill sampling maintained by the FRA is currently the best means to predict fleet utilization (or exposure) figures, but extrapolations based on it are subject to normal statistical error. Also, although ongoing research, such as the Facility for Accelerated Service Testing (FAST) experiment at the FRA's Transportation Test Center, is aimed at determining the maintenance and operating differences caused by various levels of axle loads, specific conclusions are not yet available. For these reasons, surveys, questionnaires, and interview results were used to supplement statistical data. Each source was important, and each was used to cross-check the others.

## HISTORY

Both the capacity to haul heavier loads and the weight of the loads being hauled in a freight car are increasing (Figures 1 and 2). This growth is attributable to the introductions of progressively larger freight cars. At present, more than 30% of the freight cars can carry 100-ton loads.

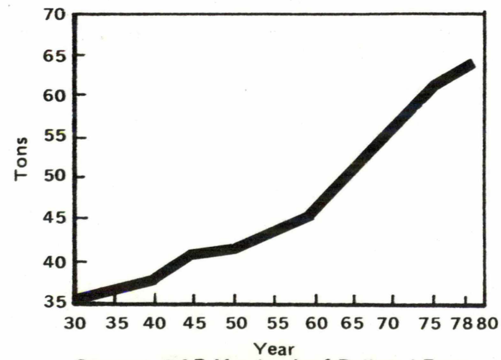
Originally, cars carried about ten tons of cargo. By the turn of the century, new cars that could carry 40 or 50 tons of cargo had been developed and were in use. The 70-ton cars were introduced a few years later. By 1950, cars that could carry 100 tons were in service. Relatively few problems were encountered in the transition from 50- to 70-ton cars. The introduction of 100-ton cars required more attention to design details and operating procedures, as did the attempt to go to 125-ton cars. The results of tests and operational experience led to a voluntary decision some years ago to restrict normal interchange movements to cars of 100-ton capacity or less. Operating under different conditions and constraints, international railroads generally have limited static axle loads to 20-25% less than North American practices.




**Note:** Average for 1978 from Car Service Division, AAR.

**Source:** *AAR Yearbook of Railroad Facts,* 1979.

**FIGURE 1 AVERAGE FREIGHT CAR CAPACITY TREND**

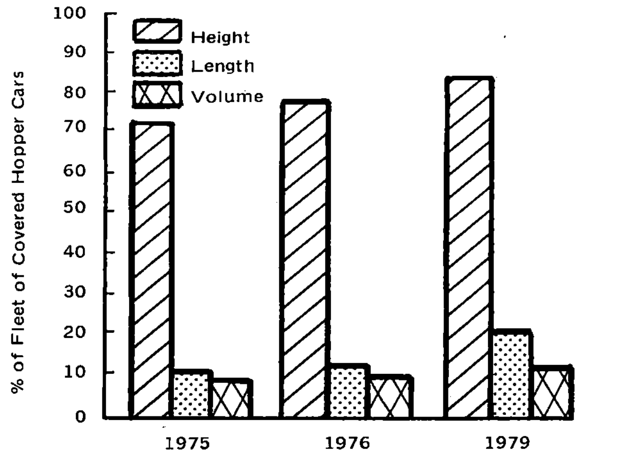



**Source:** *AAR Yearbook of Railroad Facts,* 1979

**FIGURE 2 AVERAGE FREIGHT CARLOAD TREND**

The increase in freight car size has led to the present fleet which is characterized by the fact that some of the largest cars now being used by the railroads are more than 90 feet long, some are more than 16 feet high, and some have more than 5,000 cubic feet capacity. Figure 3 shows how the outside length, ex-

* A more detailed reporting of the responses, as well as other data upon which this report is based, can be found in "Issues and Dimensions of Freight Car Size: A Compendium," FRA/ORD-79/56.

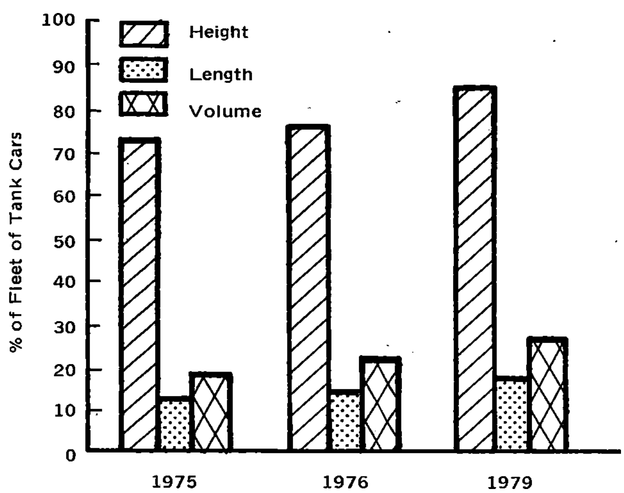



Height = % with extreme height ≥ 14 ft.
Length = % with outside length ≥ 70 ft.
Volume = % with volume ≥ 5000 $ft^3$

**Source:** AAR UMLER Files

**FIGURE 3 COVERED HOPPER CAR GROWTH**

treme height, and cubic capacity of covered hopper cars have grown. Figure 4 contains similar data for tank cars.




Height = % with extreme height ≥ 14 ft.
Length = % with outside length ≥ 70 ft.
Volume = % with capacity ≥ 22,000 gallons

**Source:** AAR UMLER Files.

**FIGURE 4 TANK CAR GROWTH**

There are numerous combinations of the size, weight, and length of cars for each particular type of car, such as hopper, gondola, box, tank, and flat. This study places primary emphasis on the load-carrying capacity of the cars and groups them into three categories—100, 70, and 50 tons—since these are the common designations used by the industry. Different lengths and heights, as well as other characteristics, and their combinations were analyzed in this context. It should be noted that the average load carried in a 100-ton car is currently about 83 tons versus 43 tons for a 70-ton capacity car and 31 tons for a 50-ton capacity car.

## IS THERE A SAFETY PROBLEM?

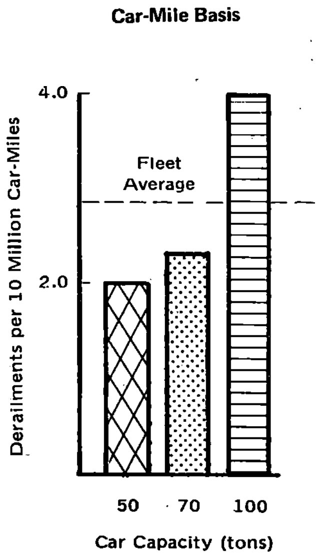
### The Safety Record

A comprehensive review of the railroad safety record must examine different categories of accidents, including injuries to employees working in yards, train derailments, accidents with hazardous materials cars, injuries to trespassers, and grade-crossing accidents. Measures of safety include injuries, fatalities, and property damage.

With respect to injuries to employees working in yards, aggregate industry statistics and the UTU railroad worker survey indicate that larger freight cars per se are not more dangerous to personnel working around them (e.g., yard switchmen). However, the safety risk is higher with certain types of cars (e.g., flat cars) and certain designs and locations of components equipment (e.g., handbrakes).

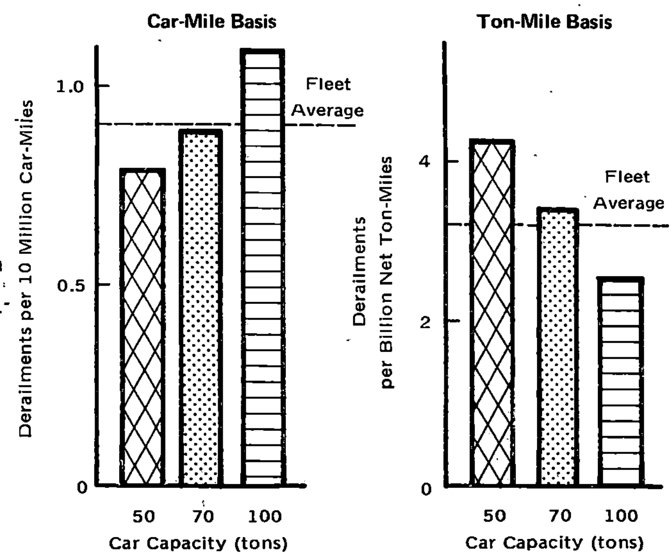
Grade-crossing accident data show no evidence that the size, weight, and length of railroad cars passing through a crossing have any direct influence on the probability or severity of an accident at that crossing for a particular train. Nevertheless, since accident frequency is a function of train frequency, policies that increase the number of trains, such as lowering the maximum allowable load-carrying capacity of a freight car, would lead to a small, but perceptible, increase in the frequency of grade-crossing accidents.

Train derailment is the aspect of railroad safety that is most likely to be influenced by car size, weight, and length parameters. A review of the derailment record shows that a substantial portion of train accidents occurs at low speeds, but these accidents account for only a small percentage of total derailment casualties and costs. In 1978, of over 8,000 derailments, less than 25%, regardless of the reported cause, occurred at speeds greater than 10 miles per hour.




**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample.

**(a) All Speeds.**

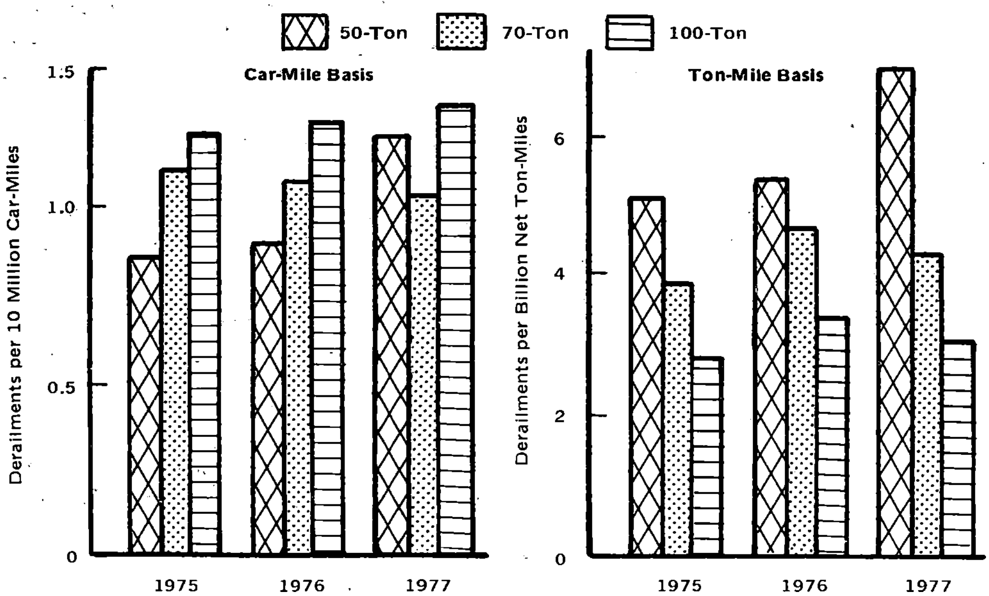



**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample.

**(b) Speed Greater Than 10 MPH**

**FIGURE 5 DERAILMENT FREQUENCIES FOR CARS OF VARIOUS TONNAGE CAPACITIES, 1975–1978**

It is necessary to enhance and interpret raw data on the number of derailments to obtain meaningful safety comparisons by car capacity or car type. This analysis must rely on the designated causing car or the first car derailed as reported to the FRA and does not account for other cars that may have been a "contributing" cause. Figure 5 presents a concise safety status of the three major load capacity groupings of freight cars. Illustrated is the comparative derailment history of 50-, 70-, and 100-ton cars for the period 1975-1978 based on two of the most appropriate measures, car-miles and ton-miles. Figure 6 shows similar comparisons for each of the years 1975 through 1977.




**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample.

**FIGURE 6 RELATIVE ACCIDENT HISTORY ON CAR-MILE AND TON-MILE BASIS**

**(Speed Greater Than 10 MPH)**

Many approaches can be used to interpret past results and predict likely future consequences. However, these different approaches will produce different views of the problem, and definite pitfalls must be avoided when relying on data groupings collected from dissimilar railroads. For example, Figure 7 contains statistics which show that the 50-ton cars have the best safety record when related to either the actual number of accidents, the number of loadings, or the car-miles; the 70-ton cars have the best safety record when related to the number of cars in the fleet; and the 100-ton cars have the best safety record when related to tons originated and ton-miles. Each of these computations uses identical accident data.

| Basis | Car Capacity | | |
|---|---|---|---|
| | 50 ton | 70 ton | 100 ton |
| Total Number of Accidents | $\boxed{1}$ | 2 | 3 |
| Accidents per Car in Fleet | 2 | $\boxed{1}$ | 3 |
| Accidents per Car Loading | $\boxed{1}$ | 2 | 3 |
| Accidents per Ton Originated | 3 | 2 | $\boxed{1}$ |
| Accidents per Car-Mile | $\boxed{1}$ | 2 | 3 |
| Accidents per Ton-Mile | 2 | 3 | $\boxed{1}$ |

$\boxed{\phantom{1}}$ indicates best safety record

**Source:** FRA Safety Data/AAR UMLER Files/ 1% Waybill Sample.

**FIGURE 7 RELATIVE SAFETY RANKINGS (Accident Speed Greater than 10 MPH)**

During this study, a special effort was devoted to ascertaining the best statistical basis for comparison. Over 10 different bases were examined. Finally, car-miles and ton-miles were selected as the most valid indicators for use in comparing cars of different capabilities. "Car-miles" is the best descriptor to assess safety on a "per trip" basis, and "ton-miles" is more appropriate to a description of the relative safety of moving a given amount of tonnage. Using car-miles, the 100-ton car shows the poorest safety ranking. Paradoxically, on a ton-mile basis, the 100-ton cars are indicated as having the best safety statistics. Both of these statements can be consistent and believable. Responses from the UTU survey of over 900 working railroad employees support this conclusion. From a switchman's viewpoint, the risk per trip could be greater as he observes obvious "bad actor" large cars in the train. From a total system safety perspective, the overall risk might be lower with large cars because fewer trips are needed to transport the required tonnage.

Both the UTU survey and the industry management survey identified the loaded covered hopper car, which has a high center of gravity, as the car type most likely to derail. The aggregate rail safety statistics clearly show the same result. The industry has long recognized this problem, conducted tests, and initiated changes to correct the problem. However, implementation of corrective improvements is proceeding at a slow pace.

Table 1 provides additional insights into the derailment tendencies of the four types of cars with poor records, based on either the aggregate rail industry statistics or the UTU survey. It confirms recent FRA testing results that empty vehicles such as the long flat cars can apply as large lateral loads during side-to-side oscillations (known as "hunting") on the track structure as loaded locomotives with very heavy axle loads.

The most important measure of safety in any field of endeavor is the total loss of life attributable to the variable under consideration. During the period 1975-1978, the average number of fatalities per year that could conceivably be attributed to the size, weight, and length of cars was less than 5. On an annual basis, the number of fatalities ranged from 1 to 9 for the last 4 years. The average number of fatalities per year amounts to less than 1% of all fatalities connected with railroad operations. Table 2 shows how these estimates of fatalities were derived.

However, it can also be said that some fatalities are avoided by the use of larger capacity cars. As noted in the following discussion of efficiency, the use of larger capacity cars reduces the exposure of employees to hazards associated with switching (fewer cars to switch) and reduces the frequency of rail/highway grade-crossing accidents (fewer trains). Since fatalities from rail/highway grade-crossing accidents average approximately 1,000 each year, it is obvious that any significant increase in the number of trains operated could produce human consequences as

## TABLE 1
## DERAILMENT TENDENCIES OF "WORST" CAR TYPES

| Car Type | Aggregate Industry Statistics | | United Transportation Union Survey | | | Associated Car Characteristics | Industry Action/ Recognition |
|---|---|---|---|---|---|---|---|
| | Car-Miles | Ton-Miles | Overall | Loaded | Empty | | |
| Covered Hopper | Highest | High | High | Highest | Medium | High center of gravity (98 inches) when loaded. | Dynamic control problem, under study for some years, has led to additional snubbing requirements. |
| General Flat | High | High | High* | High* | High | Many are more than 80 feet long. | Historical curving problems, especially when empty. |
| Auto Flat | Medium | Highest | High | High | High | Long lengths. High center of gravity when loaded. | Curving problems. Tendency for dynamic interactions with adjacent cars. |
| Tank | Medium** | Medium** | Highest*** | High*** | Medium** | Jumbo's have center of gravity above 84 inches. Hazardous material commodities carried make derailment particularly costly. | Early dynamic structural problems. Special studies over past 10 years, culminating in petition resulting in HM—144 regulations. |

* TOFC (Trailer on Flat Cars) Only.
** All Tank Cars.
*** Jumbo Tanks Only.

## TABLE 2
## TRAIN DERAILMENT FATALITY ANALYSIS BY YEAR

| | 1975 | 1976 | 1977 | 1978 | 4-Yr. Total | Average/ Yr. |
|---|---|---|---|---|---|---|
| Total Fatalities from all Derailments* | 2 | 15 | 8 | 41 | 66 | 16.5 |
| Less Passenger Train Derailments | 0 | 1 | 0 | 6 | 7 | 1.75 |
| Less Vandalism | 0 | 0 | 0 | 8 | 8 | 2.0 |
| Less Locomotive - Caused | 1 | 3 | 3 | 1 | 8 | 2.0 |
| Less Track Washout, Slide, etc. | 0 | 0 | 0 | 2 | 2 | 0.5 |
| Less Identified Human Factors | 0 | 0 | 0 | 16 | 16 | 4.0 |
| Less Miscellaneous Causes Not Related to Size, Weight, or Length of Rail Cars | 0 | 2 | 2 | 3 | 7 | 1.75 |
| Remaining Fatalities | 1 | 9 | 3 | 5 | 18 | 4.5 |

*From FRA Accident Bulletin.

**Source:** FRA Study of Accident Data.

serious as the 5 fatalities per year that may be related to car size, weight, or length (absent increased protection at affected crossings). Also, larger cars and fewer trains mean less chance of collision between trains and less hazard to railroad employees and others who may be on the railroad right of way.

With total fatalities as the yardstick, then, it does not appear that the trend to larger cars has resulted in a net diminution of operational safety. However, the occurrence of one or more accidents involving the exposure of a large number of people to explosive or toxic hazardous materials could radically alter this assessment. Over the last 3 years, approximately 160 tank cars have released hazardous materials as a result of train accidents. With a few notable exceptions, the consequences of most of these accidents have been minor. However, the destructive accidents that have occurred provide ample support for a standard rule of caution in the transportation of these materials.

## Car Performance and Track Conditions

Statistics indicate that railroads, in the aggregate, have greatly increased investments to improve track and equipment, even though recent FRA analysis shows that much more needs to be done. During the last decade, the tons of rail and number of cross ties laid have approximately doubled. The present rate for the industry as a whole, however, is still only what it was in the middle 1950's, even though ton-miles have increased by 25%; and certain railroads continue to incur sizeable amounts of "deferred" maintenance.

While aggregate industry statistics can assist in measuring past performance, they contain a mixture of variables. Case studies can isolate these variables and provide valuable supplemental data. In this instance, the record shows that specific railroads are able to profitably operate larger cars while maintaining, comparatively, a good safety record. These railroads attribute their success to additional investments in track inspection and maintenance. The data in Table 3 quantify the reported maintenance performed from 1955 through 1978 by one railroad that operates a substantial number of larger cars and that has a derailment rate approximately equal to the industry average.

TABLE 3
TRACK MAINTENANCE RECORD OF A SELECTED RAILROAD

| Time Frame | Tie Replacements per Year | Rail Replacement in Tons per Year |
|---|---|---|
| 1955—59 | 38,800 | 3,900 |
| 1960—64 | 45,100 | 3,400 |
| 1965—69 | 68,800 | 5,700 |
| 1970—74 | 70,520 | 6,460 |
| 1975—78 | 74,150* | 6,075* |

*Based on 4-year average
Source: AAR Railroad Industry Survey

On the basis of accident statistics that specify the number of derailments per million train-miles caused by track or equipment, there is a wide disparity in the abilities of individual railroads to safely transport cars. Table 4 shows that the ratio of the derailment rates among railroads can vary by more than 10 to 1. Most of the differences in derailment rates among railroads can be attributed to variations in track conditions.

TABLE 4
COMPARISON OF DERAILMENT RATES AMONG VARIOUS U.S. RAILROADS

| Railroad | Track & Equipment Derailment Rate (per million train-miles) | Ratio Relative to Railroad "A" |
|---|---|---|
| A | 2.1 | 1.0 |
| B | 3.3 | 1.6 |
| C | 6.0 | 2.8 |
| ↓ | ↓ | ↓ |
| X | 16.7 | 8.0 |
| Y | 23.7 | 11.3 |
| Z | 31.7 | 15.1 |

Source: Accident/Incident Bulletin No. 146, 1977, Federal Railroad Administration Office of Safety, August 1978.

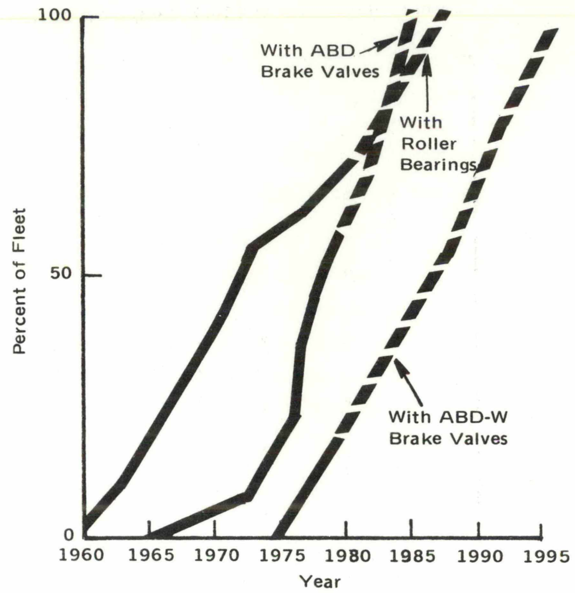
As further discussed below, 100-ton cars and certain other cars tend to produce greater stresses on track structure than do smaller cars. The accumulated rail fatigue, tie cutting, and other degradation of the track structure generated by larger cars will eventually increase the overall derailment rate for all rail equipment unless adequate programs of restoration and upgrading are implemented. The railroads that have successfully adjusted to heavier axle loading and dynamic stability problems have done so by transforming jointed rail into continuous welded rail, by investing in heavier rail sections for mainline operations, and by giving increased emphasis to roadbed stabilization. These measures promote the reduction of derailment rates, although cars with dynamic stability problems will tend to derail more frequently than other cars.

## Countermeasure Development and Implementation

When the 100-ton cars were introduced into service, the types of dynamic performance, structural strength, and fatigue life problems experienced were similar to those periodically encountered by the automobile and aircraft industries in introducing new systems. Some early mistakes were difficult to discover and correct in a short period of time; for example, the manufacture of cars with 39-foot truck centers that matched the rail lengths and contributed to "rock-and-roll" instabilities. Where major safety problems visibly surfaced, however, government and industry efforts accelerated the installation of corrective improvements in both new and existing rail vehicles. Examples of such efforts are the retrofit of jumbo tank cars mandated under DOT Regulation HM-144* and actions taken with respect to 6-axle locomotives. Normally, a long period of time is consumed in introducing and equipping the railroad car fleet with a product improvement. Figure 8 shows estimates of the amount of time required to incorporate typical design fixes and improvements. When safety is of prime concern, much shorter implementation times have been specified. For example, the modifications required under HM-144 are to be completed in 3 years, with major portions of the program having been completed in the first 2 years.

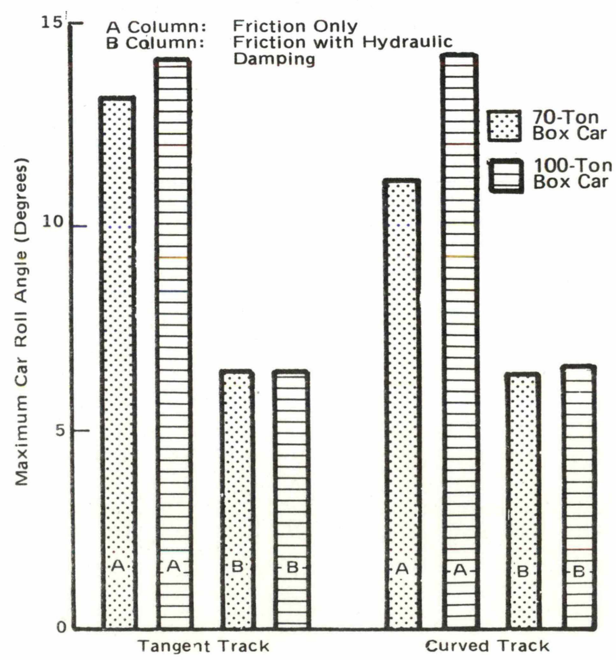
The industry continues to become more technically knowledgeable and is steadily developing capacities to detect problems, evaluate potential solutions, and initiate countermeasures. Figures 9, 10, and 11 are

* See Title 49 of the Code of Federal Regulations, Parts 173 and 179. HM-144 requires improved protection of certain hazardous materials tank cars.



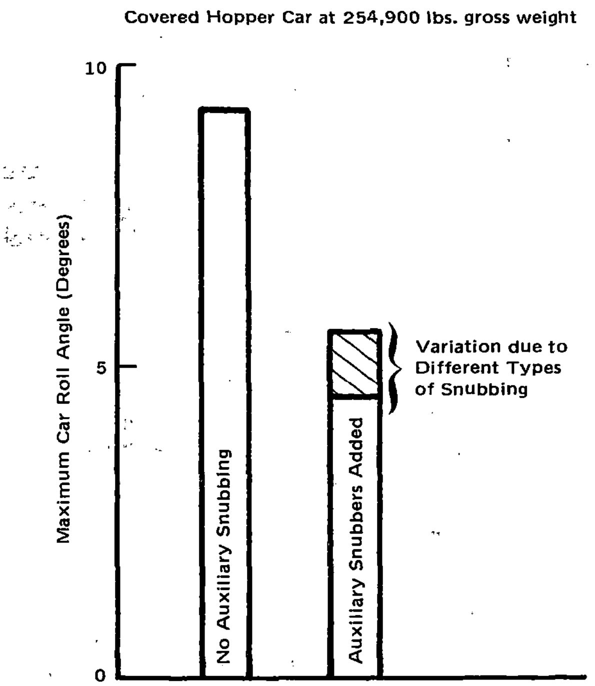

**Source:** AAR 4% Annual Projections for Roller Bearing Data Beyond 1979; Shaker Research for Roller Bearing Data Up to 1979; Manufacturers for Brake Valve Data.

**FIGURE 8 RATE OF INTRODUCTION OF CAR IMPROVEMENTS**




**Source:** An Individual Carrier's Study.

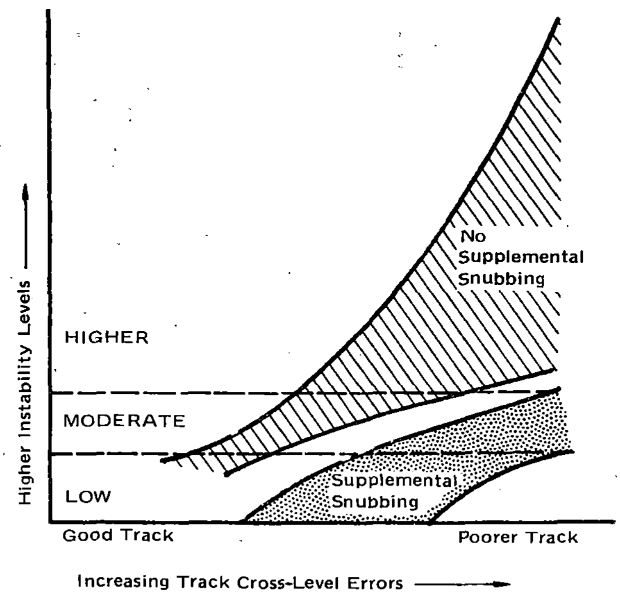
**FIGURE 9 IMPROVEMENT FROM ADDITION OF HYDRAULIC DAMPING**
**(1-Inch Surface Variation, ½ Stagger, 39-Ft. Rail, 13–19 MPH)**




Source: An Individual Carrier's Study.

**FIGURE 10 IMPROVEMENT POSSIBLE WITH ADDITION OF SNUBBERS**

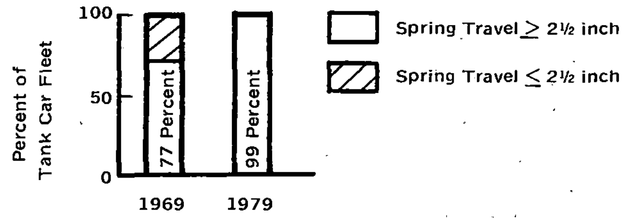
**(3/4-Inch Cross-Level Variations, ½ Stagger, 39-Ft. Rail, 12–20 MPH)**




Source: An Individual Carrier's Study.

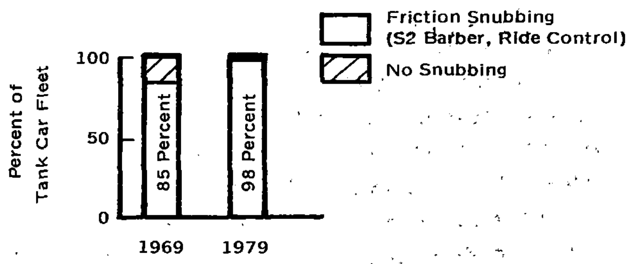
**FIGURE 11 RANGE OF EXPERIMENTAL RESULTS FOR 100–TON OPEN HOPPER CAR**

examples of the degree to which countermeasures applied to cars can be effective in controlling car dynamics over relatively severe track conditions. Figure 12 contains examples to illustrate how the industry is implementing car-located dynamic control devices to realize the potential improvement levels depicted in Figures 9, 10, and 11.




Note: Today, only about 1% of tank cars, about ½ percent of coal hoppers, and a few other cars have D2 (less than 2½ inch travel) springs. The remaining D2 springs are primarily on 40- or 50-ton cars.

**(a) Implementation Record: Improved Spring Travel on Tank Cars (based on a survey of approximately 75% of the tank car fleet)**

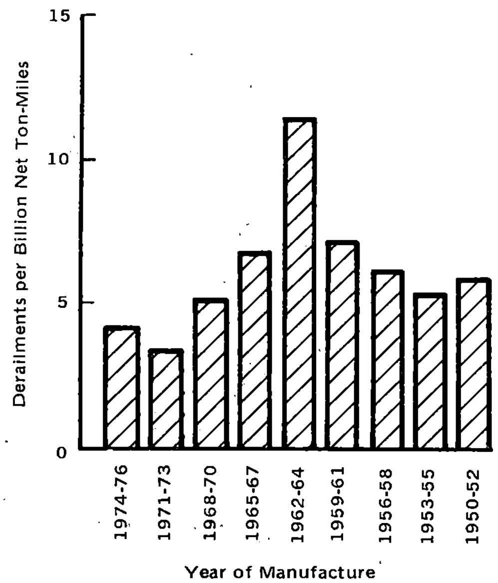



**(b) Implementation Record: Improved Snubbing on Tank Cars (based on a survey of approximately 75% of the tank car fleet)**

Source: AAR Survey of Tank Car Owners.

**FIGURE 12 EXAMPLES OF INDUSTRY COUNTERMEASURE IMPLEMENTATION**

A recent special study to understand more fully the covered hopper problem revealed that the performance of manufacturing designs should be looked at more closely. A certain combination of parameters such as length and center of gravity height may be unique to cars built during a limited period. Figure 13 indicates that covered hopper cars manufactured in the early 1960's currently have a much higher rate of derailment than those built in either preceding or succeeding years.




**Note:** FRA Safety Data from Years 1975-1977.

**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample.

**FIGURE 13 VARIATION IN CURRENT DERAILMENT RISK WITH YEAR OF MANUFACTURE FOR COVERED HOPPER CARS**

Numerous tests and technical analyses have disclosed that there is no simple relationship between the size, weight, and length of a rail car and the wheel-rail interface forces which are generated. The forces are complex and depend on variables such as train speed; the way the train is made up (i.e., the location of loaded and empty cars); the way the engineer handles the train; the dynamic control devices used; and especially, the local track conditions over which the train operates. The analytical tools predict that under certain conditions, lighter or shorter cars are a greater derailment threat. However, in general, these same analytical models predict that larger cars have a demonstrated tendency to exert greater forces against adjacent cars and against the rail and cause its more rapid deterioration.

Since the early 1970's, the research and development office of the FRA has used a considerable portion of its budgeted funds in conducting analyses, making field tests, evaluating improvements, and demonstrating countermeasures for controlling rail vehicle dynamics. The performance of heavy 6-axle locomotives over a variety of track conditions, the behavior of jumbo tank cars during impacts, and the mechanism of locomotive-to-caboose collisions were explored in the context of the size, weight, length, structure, and configuration of cars. In addition, with major support from the FRA, the railroad industry has been very active in determining ways to control the dynamics and mitigate the adverse wheel loads of freight cars. The activities in Track Train Dynamics (TTD), the Facility for Accelerated Service Testing (FAST), the Rail Dynamics Laboratory (RDL), the Truck Design Optimization Program (TDOP), and other facilities and special studies are producing valuable data. Validated improvements and upgrades are scheduled and introduced as part of routine car maintenance.

## Safety Regulation

The FRA has responded to the increased frequency of derailments in a variety of ways. Enforcement of the present Track Safety Standards emphasized the remediation of problems on major hazardous materials routes. Violation sanctions, speed reduction orders, and emergency orders have been employed to bring about repairs, improvements, or appropriate reductions in train speeds.

As previously noted, the tank car retrofit order in HM-144 was in response to the more frequent derailments involving certain tank cars carrying compressed gas. The Department will also propose the application of improved safety systems to additional portions of the tank car fleet in the near future.

Several options are discussed below which may lead to further regulatory action directed at discrete problems that cannot be resolved within a reasonable time through voluntary action. However, in light of already existing AAR restrictions on cars in the interchange fleet, currently there is not sufficient justification for broad government mandates directly limiting the size, weight, or length of freight cars.

Ultimately, the need for immediate attention, whether or not spurred by the government, is based on how the future threats to the public are assessed. If track deterioration continues to persist on important track segments in the National Rail Distribution Network, the answer as to whether a more serious safety problem is developing is obviously, yes. Continually degrading track has increasingly less tolerance to heavier and larger cars, and it is extremely unlikely that improvements made to freight cars or in operations can be a dominant offsetting factor under these conditions.

## IS THERE AN EFFICIENCY PROBLEM?

Some observers question whether the trend toward freight cars of larger capacity has produced a net economic benefit to the railroad industry. Citing major increases in maintenance-of-way costs and deferred maintenance, they argue that the national system of standard gage track was not designed to support current axle loadings. Other analysts point to the significant savings in transportation expenses made possible by increased per-car capacity and the role of those savings in more competitive rates for bulk products. These advantages are said to have been crucial to the survival, or profitability, of some railroads.

The limited time period of this study and the unavailability of basic cost data prevented the Department from reaching a definitive conclusion as to whether the railroad industry as a whole has benefited from larger cars. It does appear likely, however, that the marginal value of larger cars, like their safety record, depends on the vitality of the operating railroad—in particular, on how well the railroad maintains its track system. Operation of larger cars on deteriorating track will hasten the accumulation of deferred maintenance and necessitate speed and other restrictions, thereby eroding the quality of rail service and driving traffic to other railroads or competing modes of transportation. Healthy, well-managed railroads are able to make compensating investments in maintenance of way and evidently realize overall savings from the use of larger cars.

The efficiency of freight cars of various sizes is best measured by the total cost of transporting a ton of cargo on a per-mile basis. This parameter is obviously a function of carload weight capacity because a low capacity means that more cars will be required at greater expense and a large car capacity increases the likelihood of higher track maintenance and repair expenses. The problem is in determining the optimum carload capacity that would provide minimum total transportation cost. Some insight and guidance can be obtained by reviewing the factors associated with car size—both the factors tending to raise costs and the factors tending to reduce costs. An evaluation of the efficiency of railroad usage of cars by size, weight, and length must be derived primarily from past experience. The transition to heavier carloads clearly has produced some negative factors that, from a financial perspective, have increased certain costs; but because of the lack of a suitable accounting system that reflects the total cost of interchange service, it is difficult to even roughly isolate the aggregate railroad industry effects caused by the introduction and use of 100-ton car service. Costs have risen in the following areas:

- *Track Maintenance.* The heavier service cars definitely tend to increase maintenance frequencies and costs. In addition to investments to stabilize the roadbed, heavier rail and head-hardened rail are being procured in higher quantities to combat rail wear.
- *Car Maintenance.* The heavier loads in the cars, the larger lateral forces that they exert in curves, and elevated coupling masses cause wear and increase maintenance costs for certain components; i.e., wheels, couplers, centerplates, brake shoes, etc.
- *Increased Derailment Costs.* If certain portions of track are degraded faster and reach marginal states, the larger cars with higher loadings will mean a higher frequency of derailments. Also, these heavier cars have more momentum and thus tend to incur more damage when involved in accidents. The costs of derailments, including societal costs, are a major expenditure that has

been steadily increasing. Table 5 shows the calculated total for 1977.

**TABLE 5**
**ESTIMATED COSTS OF DERAILMENTS FOR 1977**

| | | |
|---|---|---|
| 1. Property Loss | | |
| (a) Reported Track Damage ($D_T$) = $ 44.3 Million | | |
| (b) Reported Equipment Damage ($D_E$) = $148.7 Million | | |
| (c) Estimated Total Property Loss (Including 3d-Party Loss, Wreck Clearing, Lading Transfer, and Non-Reportable Accidents) = $1.66 \times D_E + 1.28\, D_T$ | = | $303.6 Million |
| 2. Loss of Life | | |
| (a) Number of Fatalities = 8 | | |
| (b) Estimated Loss to Society per Fatality = $300,000 | | |
| (c) Estimated Total Loss Resulting from Fatalities | = | $ 2.4 Million |
| 3. Loss Resulting from Injuries | | |
| (a) Days of Work Lost Resulting from Injuries = 3,340 | | |
| (b) Estimated Loss to Society per Workday Lost = $130 | | |
| (c) Estimated Total Loss Resulting from Injuries | = | $ 0.4 Million |
| 4. TOTAL LOSS | = | $306.4 Million |

**Source:** Arthur D. Little, Inc., Estimates.

- *Testing and Upgrade Expenditures.* Over the last decade, the rail industry has incurred considerable costs in determining solutions and fixes to the problems that occurred upon introduction of the 100-ton cars. Some of the costs, as in the case of the regulated tank car retrofit, are not borne by the railroads alone. Shippers, as car owners, many times bear a large part of the costs and, inevitably, pass them on to the public.
- *Miscellaneous Expenses.* Increases in inspection, training, and third-party liability insurance costs are examples of these expenses.

On the other hand, benefits that have accrued from the use of larger cars include the following:

- *Lower Direct Transportation Costs.* The direct costs associated with train movements to transport certain bulk commodities have been significantly reduced. This reduction has enabled the railroads to maintain or improve their share of the market and to better their cash flow positions while keeping rates competitive.
- *Reduced Fuel Costs.* With fewer car trips to transport the required tonnage, fuel savings are realized.
- *Reduced Operating Costs.* Fewer cars need to be loaded, switched, inspected, and accounted for, reducing operating costs.
- *Reduced Car Replacement Costs.* A 100-ton car costs less than two 50-ton cars.
- *Ability To Transport Increased Volumes.* Since a 100-ton car is not twice as long as a 50-ton car, an equivalent increase in the capacity of yards and sidings is realized. This has allowed the railroads to avoid additional investments to plant and property that would have been necessary to transport increased volumes.
- *Costs Associated With Less Exposure of Railroad Workers.* With fewer cars needed to transport the same tonnage, there is a reduction in the required number of high-risk yard tasks (e.g., riding cars, coupling air, getting on or off cars, etc.).
- *Costs Associated With Less Exposure of Motorists at Grade Crossings.* With fewer cars required to move the same tonnage, there are fewer car passages per grade crossing—and less chance for an accident.
- *Miscellaneous Cost Savings.* Car loading and unloading costs tend to decrease since fewer "set ups" are required. The consumer shares in some of the resultant cost savings.

Some of the expected direct railroad impacts of varying car size that might occur can be quantified by using actual 1978 railroad operating data. Table 6 contains estimates of the effects of hypothetically reducing the maximum carload by 15% (i.e., to 85 tons instead of 100 tons) during this one year. Freight car and track maintenance considerations are not listed because of the lack of agreement on allocations of such costs to a single year. In addition, the estimates do not include allowances for changes in practices of rolling stock and locomotive power utilization that probably would occur in the real situation, but that are difficult to predict.

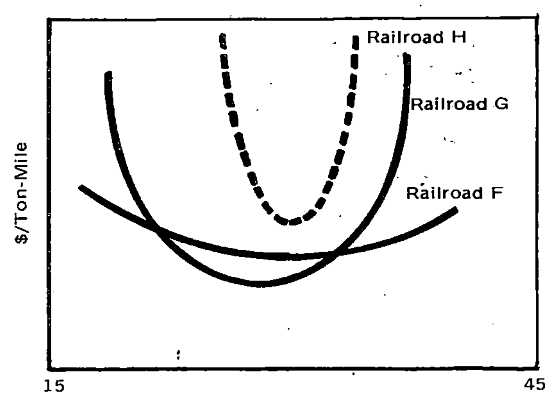
**TABLE 6**
**ADVERSE INDUSTRY IMPACTS FROM A 15% REDUCTION IN THE MAXIMUM PERMISSIBLE LOADING IN 100–TON CARS**

| Item | Estimated Adverse Effect |
|---|---|
| Car Loadings | 1.8 Million Additional Loadings |
| Car Trips | 2.9 Million Additional Trips |
| Trains | 46,000 Additional Trains |
| Freight Cars | 83,300 Additional Cars |
| Locomotives | 465 Additional Locomotives |
| Train-Miles | 7.3 Million Additional Train-Miles |
| Car-Miles | 1.5 Billion Additional Car-Miles |
| Fuel | 113 Million Additional Gallons |
| Train Accidents | 540 Additional Accidents |
| Fatalities Resulting from Train Accidents/ Incidents and Grade-Crossing Accidents | 32 Additional Fatalities |

Source: Arthur D. Little, Inc., Estimates.

On the other hand, responding to a question in the industry management survey, one railroad calculated that a 15% increase in car capacity would result in a 13% increase in total variable costs per net ton-mile for bulk commodities and a corresponding 8% increase for merchandise commodities. Individual railroads that haul bulk commodities consistently contend that usage of the 100-ton car has resulted in a net favorable benefit for them, but most agree that they are now approaching or are just beyond the "break-even" point in car size. The consensus in the railroad industry based on past experience is that the balance of pros and cons is favorable. Regardless of the 100-ton car's benefit to the industry, however, it certainly would cost the industry considerable amounts in the short run to reverse the trend toward these cars.

Will the 100-ton car continue to be as valuable to the industry in the future? When all of the costs and savings enumerated above are combined to produce a total cost per ton-mile figure, it is clear that these costs will decrease as axle loadings become heavier up to a point. Beyond this point, the cost components will outweigh the savings components and total cost will increase with heavier axle loadings. The difficulty in determining an "optimal" car weight or axle load in this fashion is that costs and savings vary from railroad to railroad; e.g., a railroad with a softer roadbed will have a steeper rise in the maintenance-of-way expense curve as axle loads are increased than another railroad with a stiffer roadbed. Some railroads estimate increased maintenance-of-way costs of up to 40% with 100-ton car usage. However, under controlled conditions, analysis and small-scale laboratory test data show more exaggerated results; i.e., wear expectations for curves are nearly doubled under a 100-ton car simulation compared to that of a 70-ton car simulation. Figure 14 is an example of the variations that the total costs per ton-mile might assume for different carrier conditions.




Source: American Railway Engineering Association Bulletin 673.

**FIGURE 14 VARIATIONS OF TOTAL COSTS PER TON-MILE**

This inability to define future conditions in cost terms (including those associated with the quality of track on interchange railroads) causes uncertainties as to how the location of the low cost point in Figure 14 will shift in respect to axle loading. For the aggregate railroad industry, any evaluation of future efficiency will ultimately depend on the extent to which derailments are forecast to increase as a result of usage of 100-ton cars over degrading track segments. The costs of an increasing frequency of derailments or erosion of service through operating restrictions can rapidly offset any savings. Furthermore, the importance given to future injury or damage to the public and the likelihood that vital traffic might be seriously interrupted determine the outcome of a cost/benefit analysis.

## THE FUTURE

Even though economic considerations and third-party liability implications pressure the industry to ensure safety consciousness, separate studies show that there is increased wear of track and increased wheel-rail forces when axle loads are heavier, cars are longer, and center of gravity dimensions are higher. Therefore, the ability of the industry to implement countermeasures more rapidly than in the past may be crucial. Projections into the future must consider existing overall trends such as the following:

- Each successive year, there are larger percentages of heavier, longer, and higher center of gravity cars in the fleet.
- There is an increasing rate of derailments, especially those attributed to track problems.
- Because of poor earnings and a low rate of return on investment, certain railroads are finding it increasingly difficult to meet their track maintenance requirements.
- The number of long, heavier trains is increasing.
- Hazardous materials rail movements are likely to double in the next ten years.

These trends have been going on for many years, and although most railroads (and the industry as a whole for the most part) have been able to meet vital freight demands without serious safety or efficiency problems, certain track segments have become or are becoming "weak links" in the total network. The continuing interchange of longer, heavier cars into these links can only increase the deterioration rate. The demand for passage of increased volumes of hazardous materials over these weak links will increase the probability of tank car derailments.

Are there actions in process (or any that could be implemented) which will head off adverse predictions for the future? At a cost of over $200 million to the industry, the HM-144 mandated retrofit of compressed gas tank cars to minimize the consequences of accidents involving flammable compressed gases will alleviate a large portion of the total hazardous materials problem, but not all of it. Train speeds have been reduced in accordance with track conditions, and train-handling and train makeup revisions have been made, but the trends of increased derailments from track deterioration persist. This deterioration of track can eventually overwhelm any improvement that is installed on cars.

The advisability of actions and the determination of who should take the lead can only be ascertained through additional in-depth trade-off delineations and cost/benefit analyses. In some areas, there is a need for additional basic cause-effect data before effective cost/benefit studies can be conducted. Several ongoing FRA/Industry cooperative research and development projects at FAST and in TDOP are aimed at obtaining such data to support engineering specifications of performance requirements together with proof-testing procedures. Steps concerned with the general health of the industry or of specific groups of carriers probably require additional government initiatives. (Some are already in process.) There are certain options that the railroad industry itself has the power to voluntarily exercise—once it is convinced of the future advantages.

## OPTIONS

In light of the study findings, is there anything that should be done to improve the safety and efficiency of rail transport as influenced by the size, weight, and length of freight cars? If so, by whom, in what time frame, at what costs, and with what benefits? Answers to these types of questions must consider the following:

- Specific cars of certain design characteristics, as opposed to larger cars as a group, are found to have derailment frequencies higher than their exposure warrants.
- While derailment costs are relatively high, few fatalities over the past five years, if any, can be attributed solely to the size of cars.
- If the rail network is reduced by mergers and consolidations, the traffic volume per mile of mainline track will increase. A fleet composed of lower capacity cars, with the attendant increase in train densities, would present increased operational traffic control demands that might strain existing signaling systems and increase safety risks.
- The greatest threat from larger cars lies in the future when such cars might accelerate track wear on segments of the network where the track owner is not in a financial position to perform appropriate maintenance. This could set in motion the downward spiral of lower speeds, poorer service, loss of traffic, and decreased revenues on additional rail properties.
- The diversion of traffic to other routes and modes to avoid "weak-link" track would be costly, would probably not be as safe, and might not even be feasible in many cases.
- Increased shipment of hazardous materials by rail in the future has the potential for dramatically expanding the consequences of derailments.
- A rigorous determination of costs versus benefits of stipulated actions is hindered by the usual hazards involved in anticipating the magnitudes of future problems (which is the controlling factor in this case) and the degree to which current countermeasures by the government or industry will be effective.
- A number of government and industry initiatives in various stages of implementation are aimed at safer hazardous materials transport, the creation of freight car and track specifications to enhance safety, and the guaranteeing of the viability of important rail connecting links in the national rail network.

There is not sufficient information to integrate the above considerations into a defensible government/industry mandate for action. The available evidence indicates that certain longer range efforts are advisable and that some short-term actions may assist in bridging the gap until the longer range solutions can become effective. The options listed here are meant as a starting point for joint government/industry/labor examination of those beneficial actions that can reasonably be accomplished within:

- Realistic time frames;
- Funding limitations;
- The realm of other ongoing improvement or regulatory actions; and
- The scope of feasible actions by the government or, on a voluntary basis, by the rail industry.

## Long-Term Options

Dealing with the problems of heavier cars seems to involve efforts that will, optimistically, take at least 10 years to institute and become effective. These long-term major options are the following:

*1. Legislation and government/industry actions to ensure the health of essential hazardous-materials-carrying railroads so that even the crucial marginal ones will have track that can resist heavier loads. Deregulation and federal assistance are examples of supporting efforts now under way. The second study mandated by Public Law 95-574 addresses the roadbed problem and may result in additional answers.*

Cars with more than 70-ton capacity or which impose higher dynamic loads will tend to push the dominant cause of track failure from "wear" to "fatigue" (i.e., crack growth). Both occur over a relatively long period of time, but fatigue poses a more serious threat to safety since the result is a sudden failure. Heavier rail sections, better and more frequent inspection, or increased maintenance are necessary to avoid a deterioration in safety. Because of long-standing financial conditions, however, some railroads are not in a position to meet the near-term demands for increased expenditures generated by the greater usage of 100-ton car service; to survive, these railroads have had to use 100-ton cars with their associated larger physical dimensions and increased payload per car.

The rail transport network depends upon several financially marginal railroads to deliver vital goods to various geographical locations. It would be in the long-term best interest of these railroads to be able to invest in better track. Therefore, any actions to assist the rail carriers in restoring those rail links to a healthy condition for 100-ton car service (which the more prosperous ones have found appropriate and profitable) would contribute to the safety and efficiency of rail service.

*2. Development and establishment of incentives for railroads to shorten the implementation period for improvements. The latest innovation to improve freight car curve negotiation (i.e., the self-steering truck) will, after lengthy trials, if proved beneficial, take an extended period to be installed on a significant portion of the fleet.*

Analytical tools indicate and testing confirms that cars with certain dimensional, structural, and suspension characteristics are more prone to derail (than an average car) when traveling over marginal track. While this fact may be well recognized in the industry, the derailment risk for these cars is still low from a "probability" viewpoint. The rate at which improvements or "upgrades" are applied to cars (or track) is dependent upon many factors which the industry handles by trading off economic, customer service, and safety (including liability) considerations. Car (or track) owners make decisions based on their particular set of circumstances, and seldom are these decisions a result of predetermined national fleet policies. (Specially mandated rules and regulations with schedules [e.g., HM-144] are the exceptions.)

The reasons for this situation are numerous and complex. Rail carriers have a large investment in the over 1.7 million cars in the total fleet. Most of these cars are routinely interchanged among many railroads with diverse interests and financial conditions. For the most part, a freight car can be off the property of the owner (often, the shipper) or not under the owner's control a large percentage of the time. Thus, the owner may realize only a small portion of the benefits of upgrades for which it must pay. Compensation by "leasing" railroads, along with the criteria for replacement of worn-out components, often does not provide a sufficient return to the owner to stimulate "upgrading."

Any revision in car components, track, operating practices, and inspection methods, in order to be interchanged to the system of railroads, must be compatible with the existing parts of the system; i.e., it takes tremendous efforts to radically change certain car interfaces such as the coupler. Spare parts must be available, details of operation and construction circulated, procedures agreed upon, and administrative machinery instituted so that proper handling and repairs can be made at any of several hundred repair locations. Also, the availability of materials, workload of manufacturing facilities, seasonal factors, and individual financial considerations can inhibit retrofits for extended periods of time.

The established mechanism for routinely detecting problems, coordinating studies, and resolving safety issues among railroad carriers resides with designated AAR committees. The AAR derives its responsibilities from its member railroads because of their need for uniformity and compatibility in the passage of individually owned railroad cars from one railroad to another, via "interchange." As a part of its duties, the AAR regularly enacts and enforces interchange rules that impinge on the size, weight, and length of freight cars (e.g., limits on maximum weight on rail, center of gravity height, and car length are self-imposed). The historical record reflects the degree to which the process has succeeded. It should be pointed out, however, that the AAR has little influence on the track maintenance expenditures of railroad carriers. Accordingly, there is some question as to whether such a mechanism will be able to respond satisfactorily to any future crises on carriers where track deterioration is occurring beyond safe limits. Of critical importance is the creation of a competitive, innovative climate that will give the railroad industry the incentive to identify important improvements and accelerate upgrades on a more uniform and consistent basis among the rail carriers and car owners. Significant regulatory reforms should create such a climate, along with the financial capability to support the implementation of such improvements.

In particular, some way should be found to make it attractive to owners to invest in improvements to cars that will be interchanged to other railroads. Presently, railroads are more prone to invest in such improvements on unit trains that remain under their control. For example, assume that self-steering trucks have the potential of reducing lateral forces on curves by as much as 60% and that in addition to a lower probability of derailment in curves on track of marginal quality, overall curve wear will be reduced by 90%. However, the estimated additional cost per car is in excess of $3,000. If the car spends a large percentage of the time on track other than the owner's, how can the stockholders be convinced to diminish immediate earnings to equip their large (i.e., perhaps 10,000) car fleet when other railroads will accrue most of the long-term benefits?

*3. Development, establishment, and use of performance criteria for the introduction of new cars, which in essence would dictate the kinds of track and the conditions under which the new car can run safely without undue wear or deterioration of components.*

Based upon extensive work in Track Train Dynamics (TTD), other dynamic tests, and output from available analytical tools, arbitrary limits on the size, weight, and length of cars should be avoided. The real proof as to the safety and efficiency of a moving freight car is in its dynamic performance or how it interacts with the track. Certain "bad actor" cars can be converted to better-than-average performers by the installation of, for example, a better suspension system, an improved snubbing device, or a new type truck. Certain innovations now being tested (e.g., self-steering trucks) promise to make freight cars far more forgiving of track deficiencies. Such innovative effort should be encouraged. A performance standard indicating the minimum level of car performance over a range of severe track conditions should be established, and all new cars and certain types of existing cars should conform.

## Interim Options

While longer range solutions are being implemented, it is debatable which particular interim "stop gap" measures (i.e., within the next ten years) are advisable or can be justified. Regulatory initiatives by DOT such as the recent FRA Notice of Proposed Rulemaking on the Track Standards and other ongoing rulemaking activities are aimed at creating performance requirements to alleviate safety problems associated with freight cars of many varieties traveling over track of various configurations and attributes. Nonetheless, this study strongly suggests four major interim activities that should be pursued jointly by government, industry, and labor. These activities are directed toward concerns associated with the following:

- *"Bad Actor" Cars* — Organize a special task force made up of representatives from railroads, the supply industry, rail labor, and the FRA to investigate the feasibility and to quantify the advantages of instituting corrective measures that will counter the below-average safety record of high center-of-gravity covered hopper cars and long flat cars.
- *Real-Time Safety and Efficiency Comparisons* — Encourage and take steps to set up a real-time data collection and analysis system that will detect abnormalities in safety records as they occur.
- *Research Aimed at Establishing Performance Requirements and Evaluating Conformance* — Accelerate ongoing government and industry efforts to lay the technical groundwork for performance standards.
- *Other Concerns or Options* — Consider, in terms of relative value and contribution, the improvements in the areas of concern that are identified below.

## Bad Actor Cars

The relatively higher derailment rates of certain types of cars (e.g., long flat cars and higher center-of-gravity covered hopper cars) were identified in this study. Figure 15 is an example of how derailment statistics can be quantified to depict comparisons of different types of cars. Further breakdowns can reveal the disparate derailment record of any particular design within each larger grouping. A special task force of the concerned parties would provide a proper forum for determining what corrective actions may be warranted for identified bad actor cars in the existing fleet.

## Real-Time Safety and Efficiency Comparisons

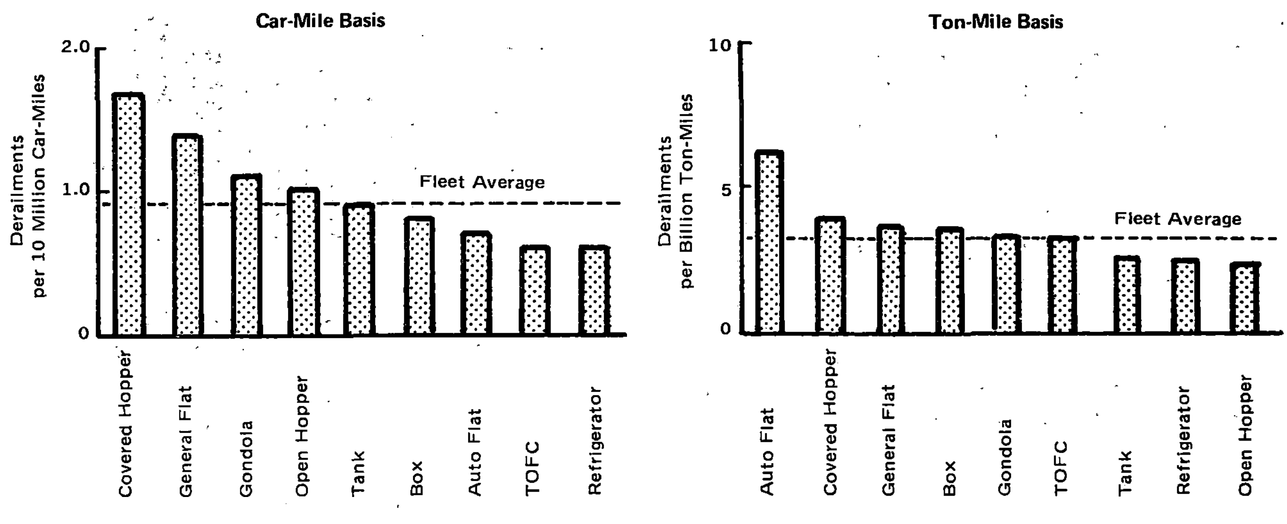
This investigation was handicapped (as were previous studies) by the paucity of information in the various data bases currently being maintained. The safety statistics and the mileage, tonnage, and age figures were received from the FRA, the ICC, and the National Transportation Safety Board. Facts on the size of the car fleet, retrofit rates, research results, industry practices, etc., were secured from the AAR, the UTU, and separate shippers, suppliers, railroads, and government/industry study groups. An inordinate amount of time had to be spent in determining the best sources, extracting the information, and matching up the time periods of coverage with other information.

Appropriate data should be routinely collected so that comparisons based on current derailments per car-mile and per ton-mile can be maintained in some detail (e.g., by car type and size). The behavior of such trends could provide a forewarning of potential problems and allow timely remedial actions.

## Research Aimed at Establishing Performance Requirements and Evaluating Conformance

Research initiatives and activities have spurred much of the increasing technical awareness and knowledge of the railroad industry. Analytical tools and testing facilities developed in recent years have much advanced the understanding of car and train dynamics. The basis for the eventual specifications of performance requirements is being generated in the related government/industry efforts. When requirements can be stated in terms of minimum performance and the performance can be measured, arbitrary limits based solely on past experience can be abolished. The Track Train Dynamics Program (TTD), the Rail Dynamics Laboratory (RDL), AAR's Track Structure Laboratory, the Locomotive Research and Train Handling Evaluator (LRTHE), and the proposed Stability Assessment Facility for Equipment (SAFE) are existing efforts toward this end.

Encouragement should be given to government/industry research and test facility activities to assist in timely accomplishment of both short- and




**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample

FIGURE 15 DERAILMENT FREQUENCIES OF VARIOUS TYPES OF CARS long-range countermeasures and in the establishment of performance requirements.

### Other Concerns and Options

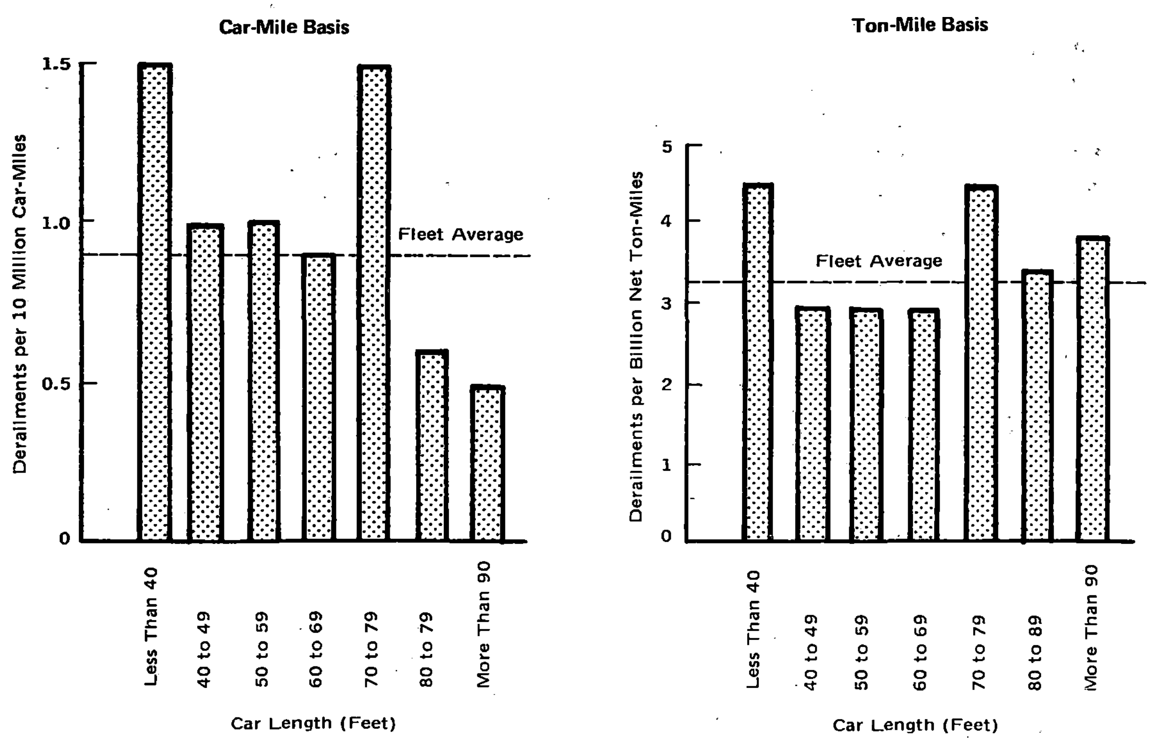
There is an opportunity for a variety of actions to improve car dynamic behavior and to reduce the likelihood of derailments. While it is premature to prescribe a comprehensive program at this time, it is possible to outline potentially fruitful options for investigation. The following list of options contains examples prompted by the findings of this study. These options must be subjected to further evaluation as to their effectiveness, benefits, penalties, and costs.

*Establish a mechanism that will continually utilize inputs from operating employees to determine what interim and long-range actions might be most effective.*

The information obtained in this study from over 900 railroad operating personnel is a good starting point toward gaining a better understanding of and resolving inconsistencies in the less-than-complete reporting system and resulting statistics which now exist. Management receives inputs from employees as a routine part of daily business. Most of these interactions are at the local level. Insights can be gained from requesting and collecting structured information as perceived by those closest to the operations. This information can then be aggregated and analyzed to produce industry-wide trends. The Rail Safety Research Board, composed of various government, industry, and labor members, was an effort in this direction.

*Review existing controls that limit the size of cars, and examine new approaches for achieving satisfactory performance of cars. Consider:*

- The poorer record of certain cars shorter than 40 feet or longer than 70 feet (Figure 16). Several groups of evidence from this investigation suggest that the long cars and very short cars tend to present a somewhat higher risk, especially during curving and when coupled to certain other cars with non-complementary "overhangs."




**Source:** FRA Safety Data/AAR UMLER Files/1% Waybill Sample.

**FIGURE 16 DERAILMENT FREQUENCIES FOR VARIOUS CAR LENGTHS**

- The effect of heavier axle loads in the unrestricted interchange of cars. Theoretical analyses and actual tests agree that a 32-ton axle load is approaching the wheel-rail contact strain limit for new wheels and new rail. The railroads that have successfully operated 100-ton (or heavier) cars have justified and made considerable investments in track, equipment, operations, and inspection betterments. Considering the projected interchange environment, the railroads, on their own, have imposed a 263,000-pound 4-axle car weight-on-rail limit for normal interchange movements. In lieu of eventual performance specifications, there is no justification for relaxation of restrictions on cars used in interchange service.
- The implications of large-volume hazardous materials cars (i.e., those larger than 34,500 gallons). In the event of puncture during derailment and subsequent rocketing of the tank, the range of potential casualties to the surrounding public becomes larger as the capacity increases. There is no justification for relaxing the present 34,500-gallon restriction that limits the expected maximum rocketing range.

*Review existing operational requirements and performance standards, and examine new approaches for minimizing the frequency of hazardous materials release incidents. Consider:*

- Reducing the magnitude and frequency of occurrence of excessive dynamic axle loads—especially on cars with centers of gravity greater than 84 inches high—by installation of improved suspensions. Priority should be given to hazardous materials cars and high mileage cars with high centers of gravity. Cars with high (90 inches or more) or relatively high (over 84 inches) centers of gravity are more sensitive to conditions in track which excite "rock-and-roll" behavior in cars. Many of the cars which transport hazardous materials (e.g., tank cars) have higher torsional stiffness which increases tendencies toward wheel lift when track warp irregularities are encountered. Some of the existing "snubbing" systems on freight cars are meant to dampen car oscillations through frictional resistance, but become erratic or are much less effective when worn. High mileage and hazardous-materials-carrying tank cars pose the greatest exposure risk and should receive corrective upgrades (i.e., hydraulic snubbing or other control units) on a priority basis over other cars.

- Taking steps to ensure that hazardous-materials-carrying tank cars are outfitted with selected improvements such as self-steering trucks or better suspension systems at a priority rate—at least compared to other cars. Although the derailment of other cars can cause the involvement of hazardous-materials-carrying cars, the relatively higher severity of derailment consequences for hazardous materials cars may justify special precautions.

- Minimizing the likelihood of hazardous materials cars being involved in derailments through careful placement in the consist. Over marginal track, hazardous materials cars which immediately follow other cars with higher risks of derailment virtually assume the higher risk of the car ahead. Some restriction might be warranted on the minimum proximity of a hazardous-materials-carrying tank car in a train to loaded 100-ton covered hopper cars or to some flat cars that are not equipped with improved snubbing devices. However, revising train makeup practices can be a costly step. This suggestion is aimed at uncovering more practical train makeup practices that might lower the probability of involvement of hazardous materials cars in derailments.

- Formalizing guidelines, similar to those already in use by several railroads, to reduce the severity of derailments involving tank cars carrying hazardous materials. Lower classes of track generally have less ability to resist increased wheel-rail forces. Reducing the maximum authorized speed of trains that contain a number of such tank cars and that travel over track with a lower FRA classification is an obvious action which tends to reduce both the lateral track forces on curves and the magnitude of the consequences of derailment.
- Identifying ways to minimize the extent to which train action and variations in train-handling can increase the derailment risk of tank cars carrying hazardous materials. In lieu of performance specifications, interim restrictions on allowable train consists and the methods employed in handling tank cars may be necessary when the movement of hazardous materials cars over track of classification 3 and below is involved. Some relaxation of any resulting, more stringent restrictions might be in order in individual cases, as, for example, where the controlling locomotive has an effective feature for maintaining brake pipe pressure; the carrier has demonstrated the adequacy of the braking systems on its trains and its operating instructions; and the carrier has reasonably proved that compliance with published safety requirements is regularly achieved. Train-handling variations can influence the level of in-train and lateral track forces to a large degree. Longer trains and undulating terrain are more of a challenge. The engineer and crew may need special training or indoctrination in the safe operation of certain trains carrying hazardous materials over undulating terrain. Train control systems (e.g., better operating brakes or the use of remote control locomotive units) can make longer trains as safe as many shorter trains. Transport of hazardous materials warrants better performing trains.

*Investigate means for speeding up implementation of car designs that are more tolerant of track irregularities. Consider:*

- Devising an approach to ensure faster implementation of important improvements on all cars identified as less stable. Accelerated retrofit schedules should be promoted. Priorities for installation of known and recognized effective improvements are usually set by the AAR through interchange requirements. Incentives and other rewards to owners that accelerate upgrades have been studied in the past. Some of the less complicated schemes might be applied on an accelerated priority basis to one or two identified improvements.
- Renewing dedication to responsible development of performance guidelines that can be applied on a case-by-case basis to size limitations on cars and trains (i.e., avoid arbitrary across-the-board limits). Wherever possible, even interim steps should be described in terms of the minimum performance required. This allows maximum flexibility and ingenuity in accomplishment and will not "lock in" today's technology in the future.

## CONCLUSIONS

Problems have occurred as a result of increases in size of freight cars. Overall, the rate of derailments is increasing as is the percentage of track-caused derailments, but on an exposure basis, the larger cars are not substantially worse than other cars. It is evident that certain identifiable *types* of cars that have dimensional extremes in length and height pose a relatively higher derailment threat (i.e., inability to operate over existing trackage with as good safety records as other cars) unless dynamic control improvements are made. The rail industry is becoming technically more competent and more willing to take actions to solve such specific problems. Fleetwide implementation, either through introduction of better design in new cars or retrofit of existing ones, however, is still a long process.

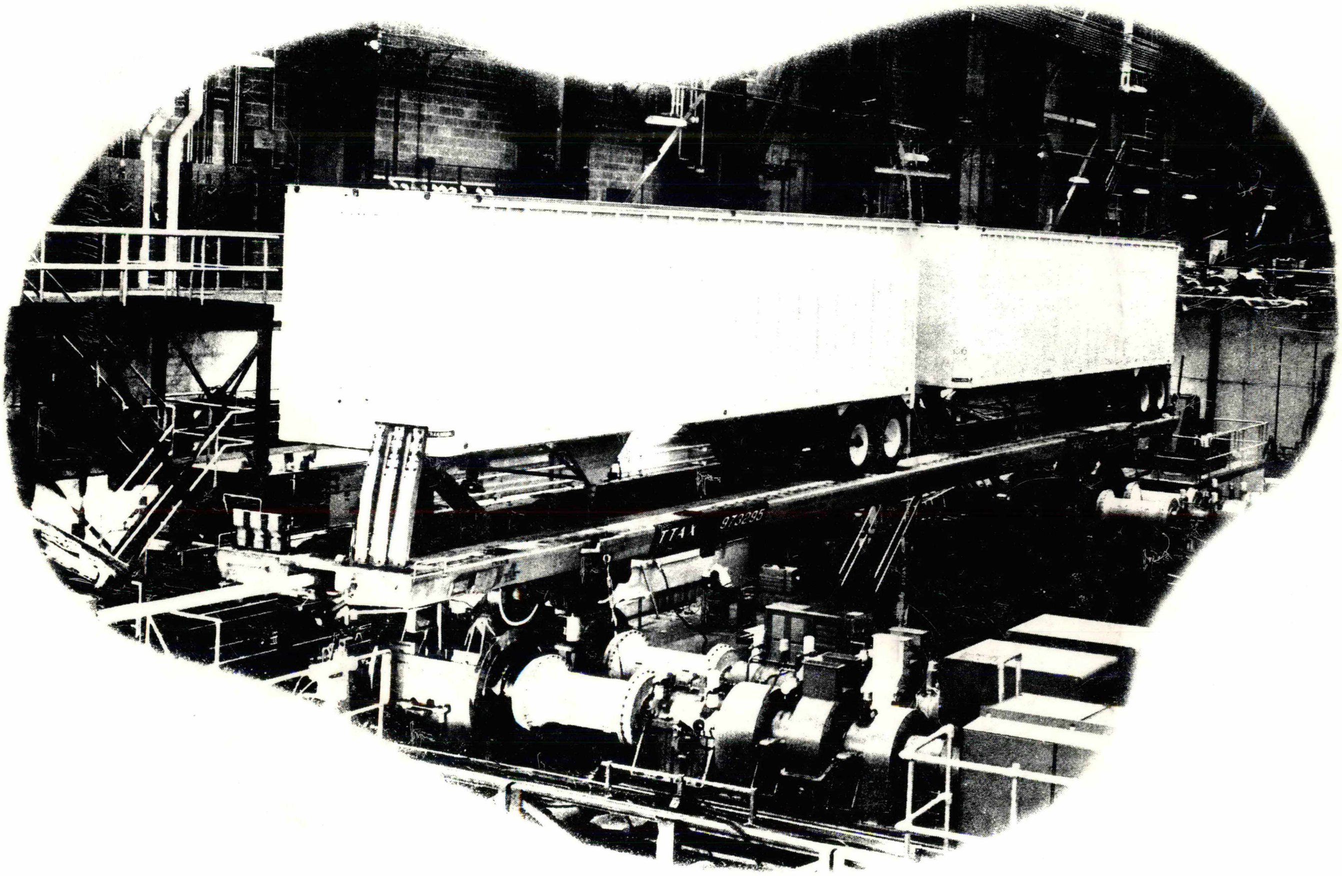
From a current perspective, and in an aggregate sense, it is the industry's strong contention that the growth to 100-ton load service has resulted in net economic benefits to the majority of railroads and shippers without the incurrence of safety problems that result in significant fatalities. This study did not find convincing evidence to the contrary. There are disturbing indicators, however, that the future picture might not look as good. The need to *interchange* cars from one railroad to another to reach important city and rural population centers is the major reason. While the larger 100-ton cars can successfully be run at reasonable speeds on rail properties which invest in and maintain track at a level commensurate with the increased loading on rail, these same cars can cause more rapid deterioration (and ultimate failure) of lesser trackage.

It is true that enforcement of the present FRA Track Standards, which require reductions in train speed according to specified classifications of track quality, tends to maintain tolerable levels of wheel-rail forces and, in the event of a derailment, is a favorable factor in limiting consequences. It is well recognized, though, that since individual types of cars exhibit a wide variance in dynamic performance, the standards should ideally either differentiate between cars or be based on the "worst case" car. In spite of several extensive studies, the implications of such an approach in standards are not yet fully understood. Without car improvements, an additional slowing of rail traffic will certainly result, and without standards revisions of this kind, poorer performing cars will continue to represent a higher derailment risk. While individual car improvements can reduce wheel-rail forces, it does not appear that the rate of dynamic control improvements in the car fleet can offset the rate of track deterioration on some railroad properties. Therefore, as projected annual tonnage increases, at any given speed range, there is an increased likelihood of derailment. Concurrently, there is a higher probability of hazardous materials cargo involvement on rail properties that receive a larger proportion of 100-ton cars operating over trackage with a decreasing ability to withstand the loading.

Thus, size, weight, and length of cars are contributing elements to railroad safety, but not the direct problem. The exclusive use of 70-ton cars would only delay the time to failure. Continued emphasis on long-term and lasting measures for ensuring adequate trackage in the vital links of the national rail network is needed to prevent an "epidemic" situation in the future. Arbitrary limits (which do not consider improved performance) on maximum car or train sizes which require additional mechanical and operating investments may serve to accentuate the problem by further reducing the financial ability of the railroads to perform necessary maintenance and upgrading. Interim actions can help and may be necessary in order to buy time for the longer range solutions to be implemented. However, justification of the attendant costs is complicated by the inability to isolate causes to the size of cars alone.

In the longer range, it appears that the trend is toward a more streamlined and efficient U.S. rail network that will annually carry increasing amounts of freight tonnage. The result will be less trackage and much higher freight densities over the remaining track. Pressures to use a greater portion of the inherent efficiency of rail transport, resulting from the need to conserve energy, could further elevate future amounts of traffic per mile of track. Under these conditions, the existing larger capacity cars (even without the technological breakthrough needed to go beyond 32-ton axle loads) support the required increases in overall transportation capability. Positive actions to decrease the derailment probability of the 100-ton capacity cars operating over the future network would enhance the efficiency by which the future transportation needs of the nation can be met.

Issues and Dimensions of Freight Car Size: A Report to the Secretary of Transportation,
1980
US DOT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