FINAL REPORT

Rail Operations Efficiency Report

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Executive Summary

Alberta Infrastructure commissioned Woodrooffe and Associates to review the safety and the economic efficiency of Energy Efficient Motor Vehicles (EEMV's) in the province of Alberta, as well as to consider the relative efficiency and viability (competitiveness) of the competing railway mode.

Methodology

In order to review rail operations efficiency and viability, our consultant, who is a former senior operations manager from a Canadian Class I Railroad, undertook a literature review of railway journals (eg. Railway Age), publications of the American Association of RailRoads (AAR) and the Railway Association of Canada (RAC) as well as published Statistics Canada sources. Reference was also made to Transport Canada's Annual Report (1999) on Transportation Issues.

The statistical information in these sources was then compiled, and amplifying commentary developed by our senior consulting specialist – based on his (over 25 years) of experience in the railway industry. Our specialist also undertook informal discussions with personnel who are employed within the rail sector, in order to solicit further information, photographs and statistical measures of rail performance efficiency.

The aim was to compile a relatively easy to understand narrative synopsis of changes and trends that have occurred in the North American railway sector, over the past 20 years or so.

Results

The North American Rail industry in Canada and the U.S. has been forced to respond to a very competitive transportation pricing market by increasing efficiency. The transportation market for rail is seen as an extension of global market factors that have seen an ongoing reduction in prices for primary (rail susceptible) commodities (eg. the past five years has seen reductions of 25% to 38% for some commodities).

In addition to the core (primary resource) business, railways have increased their modal share and business volumes for intermodal cargo by dramatic amounts, as much as 45% (monthly rail carloadings in Canada) over the time period 1997 through 1999. The ability to capture this business is evidence of major efficiency gains in railroad operations, generally.

Rail efficiency gains over the past 20 years have stemmed from improved management and system consolidation for the large, Class I railroads; better resource utilization (labour, capital, etc.) and new and improved technology for track maintenance, traffic control, information technology, locomotives, rolling stock design, etc.

The past ten years have seen over-all system operating costs decline approximately 18%, through streamlined operations and better efficiency. Various statistical measures of railroad efficiency are tabulated in the report which show improvements in productivity, for specific factors, ranging from 16% to 100%. There are also narrative discussions of what the various technologies mean, and how they have been implemented to make for system efficiency improvements.

Conclusions

While there had been some concern that EEMV trucking operations have the potential to significantly threaten the viability of railway operations, the inherent strengths and commitment to productivity improvement – demonstrated by the industry over the past 20 years – leave little doubt that the rail sector will effectively "hold its own" in competition with trucks for the foreseeable future time horizon.

Efficient rail and trucking sectors are seen to function complementarily to each other, as beneficial components of the over-all transportation "menu" available to shippers. The competitive efficiency gains of each mode give the other a direct incentive to seek efficiency improvement.

1. INTRODUCTION

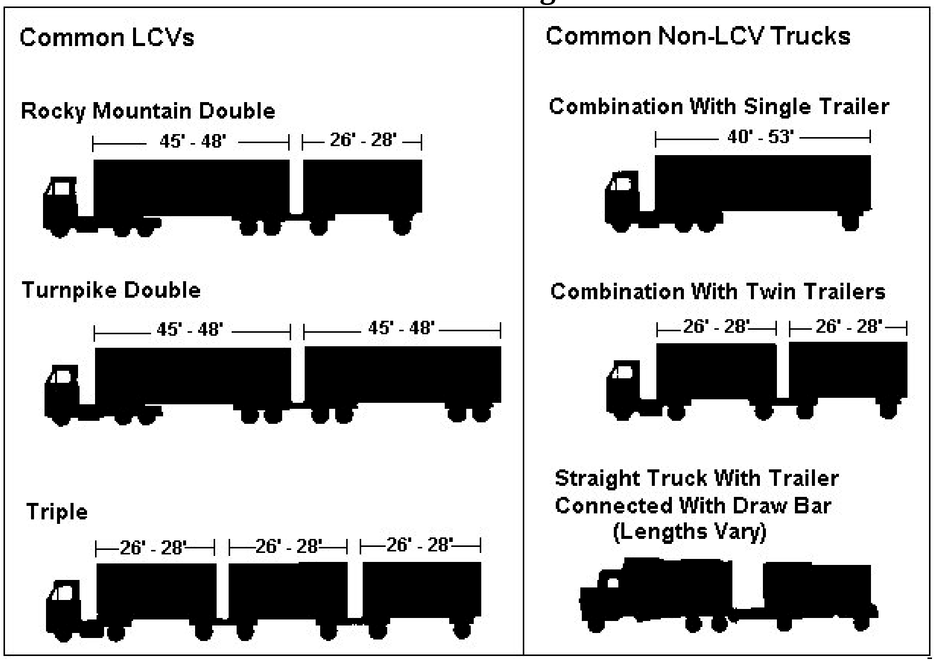
1.1. Background

Energy efficient motor vehicles (EEMVs) have been operating on Alberta highways since 1969. EEMVs are truck and trailer combinations, consisting of a tractor with two or three trailers, or semitrailers, in which the number of trailers and/or the combined length of the combination exceeds normal limits. EEMV equipment and their drivers operate in Alberta under permits with strict safety requirements. Currently in Alberta, the maximum gross vehicle weight applicable to EEMVs is 62,500 kilograms, while the maximum configuration length is 37 metres (121.4 feet).

EEMVs are further defined according to size, with three classifications:

- Rocky Mountain Double. A combination vehicle consisting of a tractor, a 40 to 53 foot semitrailer, and a shorter 24-28-foot semi-trailer, which total length does not exceed 31 metres (101.7 feet).
- Turnpike Double. A Turnpike Double is a tractor plus double trailers which are between 12.2 m (40 feet) and 16.2 m (53 feet) long (each).
- Triple Trailer. A Triple Trailer Combination consists of a tractor with three trailers of approximately the same length. The typical trailer length is approximately 7.3 and 8.5 metres (24-28 feet).

Figure 1: Illustration of Common EEMV Configurations and Standard Configurations



(also referred to in the literature as LCVs, Long Combination Vehicles) *
* Source: Road Management and Engineering Journal

Figure 1 illustrates common EEMV configurations in comparison to standard configurations of trucks used on roadways.

1.2. Project Scope

Within the foregoing context, Alberta Infrastructure's Policy Development Branch commissioned Woodrooffe and Associates to undertake an in-depth review of energy efficient motor vehicles (EEMVs) and the productivity changes within the North American rail industry. For comparative purposes, a review was undertaken of Canadian and U.S. railway operational efficiency and technological changes over the past 20 to 25 years.

2. IMPORTANCE OF RAIL EFFICIENCY

Shippers require access to efficient and low cost transportation services for moving their products to market position in what has become a very globally competitive world trade economy. Surface transportation of goods (by truck and rail) tends to be more expensive than water shipments and hence, for a land locked jurisdiction such as Alberta, exporting industries and consumers of goods require the truck and rail carriers to provide efficient service. Without this, access to markets will shrink and job losses will occur. Furthermore, in absence of efficiency, costs for consumer goods would rise.

The ability to use EEMVs in the truck sector has been demonstrated to enhance the economic cost and the fuel efficiency of the trucking mode. It was further demonstrated to minimize greenhouse gas emissions and pavement wear on highways infrastructure from trucking movements of goods, in comparison to smaller, standard legal semi-trailer truck hauling of the same volume of goods.

Governments wish to ensure cost-effective services in all the surface transportation modes. Since government must pay to maintain the highway infrastructure, there is a concern to see that there not be any costly or unnecessary migration of freight from the railway sector to trucks.

In addition to the impact on highway infrastructure, this concern was echoed by the Canadian Transportation Climate Change Table. In the Delcan Report, prepared with assistance of KPMG and A.K. Socio-Technical Consultants, October 1999, entitled, "Assessment of Modal Integration and Modal Shift Opportunities", it was stated, concerning EEMVs:

> *"The introduction of longer combination vehicles (LCVs) was also considered to have the potential to reduce GHG emissions. However, it must be demonstrated that rail traffic would not shift to truck in sufficient volume which would offset any gains in GHG emission reductions as a result of this opportunity."*.

To clarify the foregoing concern, we need to consider issues related to efficiency. Economists sometimes discuss "efficiency" in the context of two important types: technical efficiency and allocative efficiency.

Technical Efficiency

Technological efficiency means getting the most output from a given set of inputs (productivity). This is largely a micro economic concept that relates output to productivity of input factors of labour, capital and total factor productivity of the particular process or firm. In the case of EEMV's most of Volume 1 of this report series stratifies and "tabulates" the various technical efficiency improvements that have been achieved and which benefit shippers of goods and consumers in the form of lower transportation costs. Further "non user" technical efficiencies are identified in the form of lesser axle loads to move the same volume of freight and reduced fuel use and green house gas emissions are also tracked for the mode. For the rail sector, much of section 4 of this report volume charts the technological efficiency gains that have been achieved.

Allocative Efficiency

The concept of "allocative" efficiency is more of a macro economic viewpoint that takes account of the over-all economy – not just the individual truck or rail firm, or even just the rail "sector". In this framework, allocative efficiency is said to be achieved when each sector of the economy is producing the best combination of outputs, using the lowest-cost combination of inputs. From a transportation sector perspective, both modal competition and modal complementarity contribute to allocative efficiency.

Thus, when trucking and railway modes function efficiently, within themselves, customers have access to a set of competitive "best choices" or complementary (eg. intermodal) services or systems. This leads to overall maximization of production and efficiency of the economy, over all.

For Western Canadian and US shippers, trucks and railways have different yet complementary characteristics, to serve all transportation needs. Combined properly, the modes can maximize overall efficiency with seamless services benefiting all transportation users. Heavy, bulk commodities that are hauled over long distances tend to rely on rail transportation. Hence, rail services predominate for transporting products such as coal, chemicals, lumber and wood products, grain and sulphur. In contrast, truck freight involves high-value goods, perishables (e.g., frozen meats, fruit and vegetables), or time sensitive delivery (e.g., "just-in-time" or "quick response" inventories). In this context, the consultant was tasked to review the current form of the railway industry, both in Canada and the United States and take note of how productivity is evolving within the rail mode.

A picture emerges of a modal capability that is not static, but one which is evolving to provide more efficient services to customers. The overall effect of such change has been to open up competition and a consequent downward pressure on rates and revenue.

This pressure has been also due to worldwide price factors affecting commodity prices – in turn, necessitating rail reductions. The net effect has been to drive industry restructuring and the pursuit of productivity gains through adoption of new technology, redistribution and/or downsizing of the rail network, downsizing of the workforce and to become more customer - driven.

3. RAILWAY REGULATORY & MARKET CONTEXT

The current form of the railway industry in both the United States and Canada is largely a product of one piece of American legislation, the Staggers Rail Act of 1980. This act came about when the bankruptcy of the Rock Island Railroad indicated a crisis within the U.S. rail industry. The Staggers Act ostensibly partially deregulated the industry, and reduced the role of the Interstate Commerce Commission (**ICC**), particularly in the area of rates.

However, the Staggers Act was only one of a series of regulatory and legislative changes in both the United States and Canada, which increasingly deregulated the industry. The changes in Canada generally occurred later, and at a slower rate.

Other significant legislative and regulatory changes in the U.S. included:

- the Railroad Revitalization Reform Act of 1976, which created the Consolidated Rail Corporation (Conrail) from six bankrupt northeast railroads, and set in place other regulatory reforms.
- a 1982 ICC decision to refuse to impose labor-protective provisions in the sale of Class I lines, and in 1985, when it began to rule that shortline sales were exempt from virtually all regulation.
- in 1996, the Surface Transportation Board (STB) assumed responsibility for remaining railroad economic regulation from the ICC, which went out of existence.

Significant legislative changes in Canada over this period included:

- the Western Grain Transportation Act (WGTA) of 1983, which increased compensation for grain transportation, and stimulated rationalization of the grain network and railroad capital investment.
- the National transportation Act (NTA) of 1987, which partially deregulated the industry, allowing confidential contracts with shippers, the abandonment of up to four percent of a railway's total track per year, and introduced competitive line rates (CLRs) for the interlining of freight with other carriers.
- the Canada Transportation Act (CTA) of 1996 replaced both the NTA, 1987, and the Railway Act, mandated the Canadian Transportation Agency with a reduced regulatory role, and was designed to facilitate network rationalization and promote the growth of shortline railways.

The overall effect of these regulatory changes has been to open up competition in the rail sector, which has exerted downward pressure on rates and revenue. This, in turn, has required the industry to restructure, pursue productivity gains through the application of new technology, redistribution and/or downsize the rail network and workforce – all to become more customer-driven.

At the same time that the foregoing North American regulatory environment was put into place, worldwide prices for raw commodities have generally trended downward, in real terms, over the past several years.

As an example, Table 1 illustrates price trends for various forestry and mineral products of Canada, many of which are rail susceptible products, over the past five years. Similar downward price trends trace back over prior time periods.

Table 1: Raw Products Pricing Context (Rail Market Sectors)

Sample Product Price Indices For Raw Products. (1992=100) *Indexed to 1992 $ Cost using CPI					
Year	1995	1996	1997	1998	1999
Wood	160.2	146.1	142.6	120.6	122.6
Pulpwood	137.9	112.1	107.2	107.6	102.9
Copper and nickel Concentrates	140.1	110.2	107.2	82.3	83.1
Lead concentrates	136.6	157.2	141	139.2	124
Zinc concentrates	92.2	89.4	111.9	91.3	92
Sulphur	64.7	38.1	45.2	34.6	41.4
Mineral fuels	99.1	116.1	109.8	81.3	107
Thermal Coal	99.9	104	102.6	97.5	99.1
Crude Mineral Oil	99.4	117.7	110.8	79.7	106.9
Source: Statistics Canada CANSIM INDEX 1879 (Internet) -- Indexed by Consultant					

This information is portrayed graphically in following Figure 2.

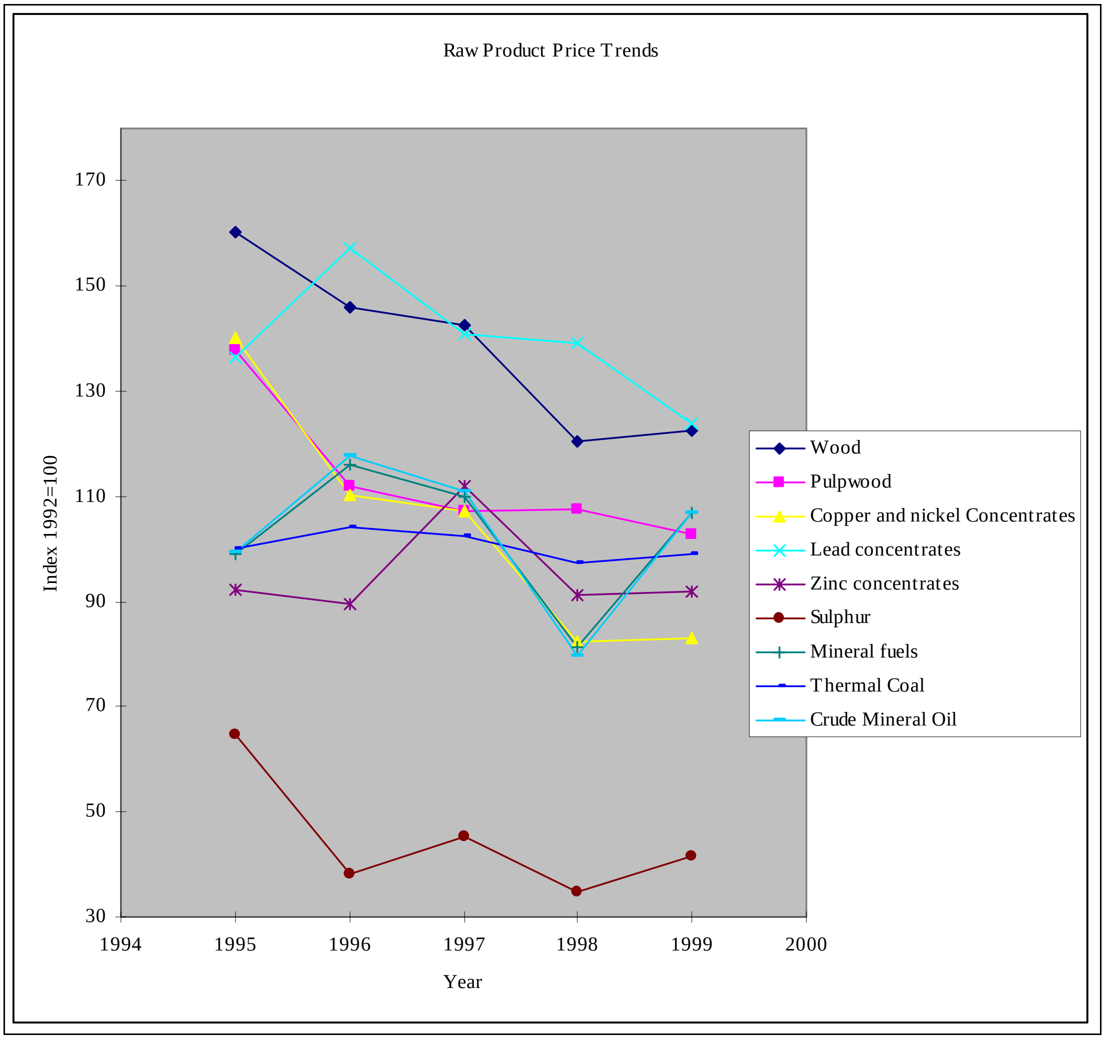


Figure 2: Sample Raw Product Price Trends

In response to generally declining price trends for their customers, railways have generally been forced to become more competitive and efficient in the delivery of services to the marketplace.

In addition to this factor being true for movements of raw products, the growing intermodal traffic sector, as served by new railway intermodal terminals in Calgary and elsewhere in Western Canada, is increasingly required to provide efficient and low cost transportation services to its customer base.

As shown in following Table 2, after a lull in growth in 1998, intermodal traffic leapt by 35 per cent in 1999. Transport Canada reported (Transportation in Canada: 1999) that in 1999 container-on-flat-car tonnage rose to 22.1 million tonnes, 36 per cent higher than in the previous year. Trailer-on-flat-car traffic, after a 28 per cent decline in 1998, recovered 16 per cent to 1.6 million tonnes.

The share of total traffic of this sector rose from 6.9 per cent in 1998 to 9.1 per cent in 1999.

This growth in market share would indicate that, in terms of "holding its own" in relation to trucking, that the rail intermodal sector has maintained itself in an efficient and competitive state.

Table 2: Growth in Canadian Intermodal Traffic

MONTHLY INTERMODAL LOADINGS BY RAIL, 1997 – 1999

(Millions of tonnes)

	1997	*1998*	*1999*
January	1.331	1.232	1.616
February	1.358	1.334	1.775
March	1.547	1.456	2.009
April	1.574	1.469	1.983
May	1.529	1.515	1.991
June	1.416	1.479	1.981
July	1.469	1.471	1.960
August	1.433	1.399	1.978
September	1.469	1.503	2.066
October	1.686	1.669	2.201
November	1.508	1.588	2.095
December	1.382	1.491	2.061

Source: Statistics Canada, Rail in Canada, Cat 52-218 (Transport Canada)

(Extracted from "Transportation In Canada: 1999 Annual Report, by Transport Canada)

4. RAIL OPERATIONAL EFFICIENCY TRENDS

In general, railway operational efficiency gains have occurred in both the U.S. and Canada. The general improvement trends realized in both countries, over all, are approximately the same – reflecting the evolution of a North American transportation market. However, it is generally true that rail improvement trends commenced earlier in the U.S.

The Association of American Railroads (AAR), in the 1999 edition of *Railroad Facts,* details industry trends for the rail sector. Since 1980 (the Staggers Rail Act), the partial deregulation of the rail industry, coupled with erosion of commodity prices has resulted in a situation where freight revenue has increased by 22 percent, yet traffic grew by 50 percent.

Over this same time period, inflation swelled by 87 percent, meaning that revenue declined even more significantly, in real terms. Rail revenue per ton-mile declined again in 1998, and is now 29 percent lower in current dollars and 57 percent lower in constant dollars than it was in 1981.

Over the same period, railroads have realized dramatic productivity gains. For example, current freight revenue ton-miles per employee and per locomotive are 269 percent and 108 percent higher, respectively, than the comparable 1980 figures.

This section of our report reviews the economic productivity changes that have taken place in the railway sector in terms of the various systemic productivity gains and new technology that have been introduced in recent years.

4.1. Overview of the Industry

4.1.1 Mainline Consolidation and Regional Shortline Proliferation

Class I railroads are an AAR classification based on firms having greater than a specified threshold operating revenue, which was $259.4 million (U.S.) in 1998. Using this threshold level, adjusted for inflation, there were **19** Class I rail systems in existence in 1980, and **9** at the end of 1998 - The Burlington Northern and Santa Fe (**BNSF**); Grand Trunk Western Railroad Inc., which is owned by Canadian National Railway (**CN**); Soo Line Railroad Co., which is owned by Canadian Pacific Railway (**CP**); CSX Transportation (**CSX**); Consolidated Rail Corporation (**CR**); Illinois Central Railroad Co. (**IC**); Kansas City Southern Railway Co. (**KCS**); Norfolk Southern Corporation (**NS**); and Union Pacific Railroad Co.(**UP**).

This number was further reduced during 1999, as CN received approval to acquire control of IC in May, and later announced a merger with BNSF in December. Furthermore, CSX and NS began operating their respective portions of CR on June 1.

Even as the large railways have been combining at the top, they have been unraveling at the bottom into short line and regional railroads. This has been most pronounced in the United States, where the number of these railroads has increased from about **250** in 1980 to **550** at the end of 1998**.** While this process started later in Canada, the number of small railroads has been increasing. The Railway Association of Canada (**RAC**) reported **48** common carrier railways as members at the end of 1998, up from **27** in 1993.

This restructuring of the railway industry provides opportunities for enhanced efficiency and cost competitiveness in the following ways:

- Traffic synergy opportunities, more efficient routing of goods, infrastructure, power and rolling stock utilization improvements derive from the merger of Class I railroads into larger business units.
- Simplification of work rules, streamlining of labour agreements, and better acquaintance with local shipper needs and issues derive from the operation of lower density elements of track as “short lines”.

Statistics quoted in this report for U.S. railroads apply only to Class I carriers, unless otherwise stated. As can be seen in Table 3, while Class I railroads comprise only 2 percent of the number of railroads in the U.S., they account for 71 percent of the industry's mileage operated, 89 percent of its employees, and 91 percent of the freight revenue.

Table 3: Structure of the US Railroad Industry

Railroad	Number	Miles Operated	Employees	Freight Revenue ($000)
Class I	9	119,813	178,222	32,247,277
Regional	35	21,356	11,094	1,585,617
Local	515	28,629	11,590	1,462,352
Total	559	169,798	200,906	$35,295,246

(Source: AAR *Railroad Facts* 1999 Edition)

Statistics for Canadian railroads that are quoted in this report will, unless otherwise stated, be taken from the Railway Association of Canada’s (RAC) publication, *Railway Trends*, 1999 Edition. This statistical review contains information from all of its member companies, which includes virtually the entire industry in Canada.

4.2. Business Revenues and Efficiency

4.2.1 Revenue Trends

As noted previously, there has been a trend since 1980 that has seen the railways work output increase at a faster rate than the derived revenue. This is illustrated in Table 4, where freight revenue (in current $) is seen to increase by 22% over a time period that saw output change by 50%. In real $ terms, given the impact of approximately 87% inflation over 18 years, rail freight operating revenues have experienced a net decline.

Table 4: Rail Revenue and Ton-Mile Comparisons For United States

Year	1980	1998	Percent change
Freight Revenue Ton-miles (RTMs) in Billions of ton-miles	919	1,376	49.7 %
Freight operating revenues (billions U.S.$)	26.3	32.2	22.4 %

(Source: AAR *Railroad Facts* 1999 Edition)

Table 5 shows a similar trend for Canada, which began later than in the US.

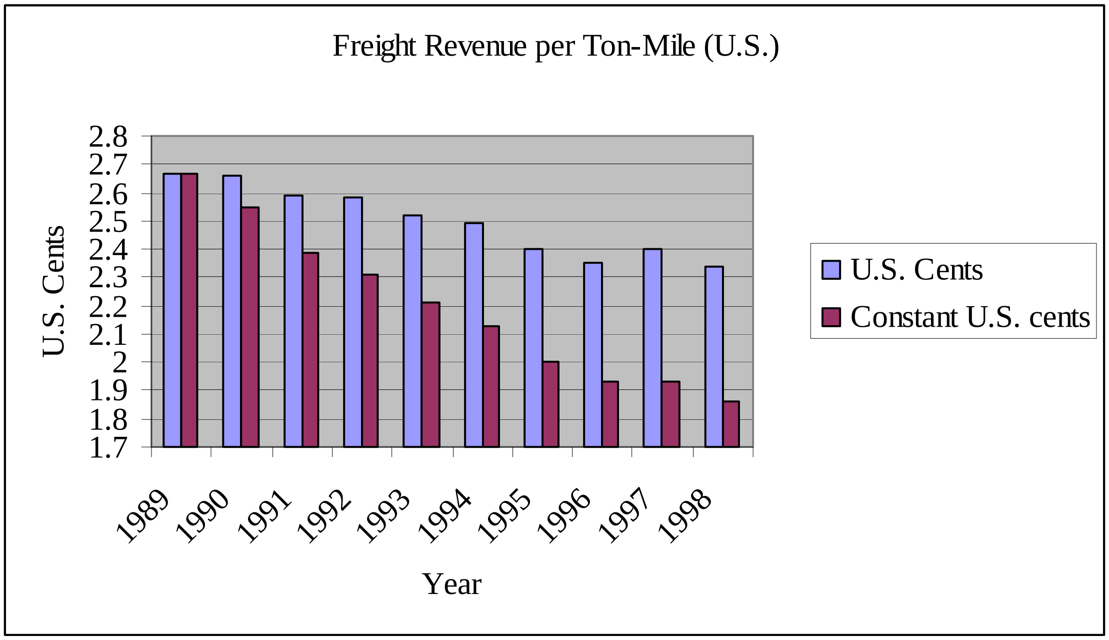
Table 5: Rail Revenue and Ton-Mile Comparisons For Canada

Year	1989	1998	Percent change
Freight RTMs (billions)	160	203	26.8 %
Freight operating revenues (billions Cdn $)	5.9	6.9	16.9 %

(Source: RAC *Railway Trends* 1999 Edition)

Average revenue per RTM has decreased in both current and constant dollars in the United States over the last 10 years, as shown in Figure 3.

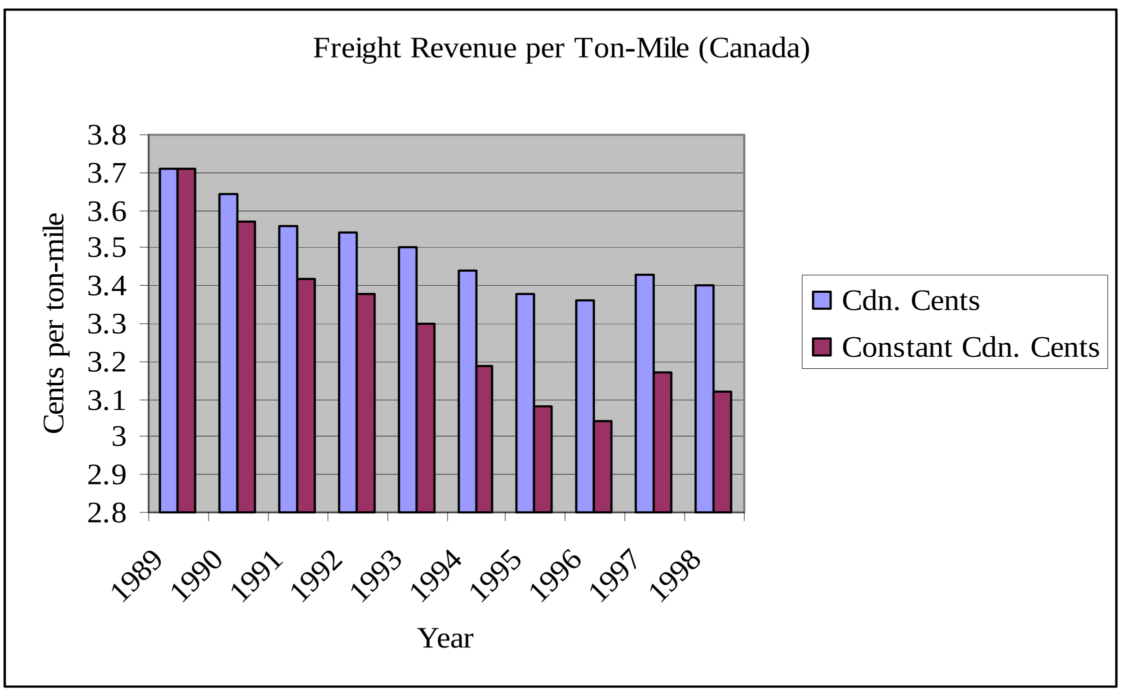
Figure 3: Revenue Per Ton Mile (U.S.)



(Source: AAR *Railroad Facts* 1999 Edition)

Figure 4 shows that this has also occurred in Canada.

Figure 4: Revenue Per Ton Mile (Canada)



(Source: RAC *Railway Trends* 1999 Edition)

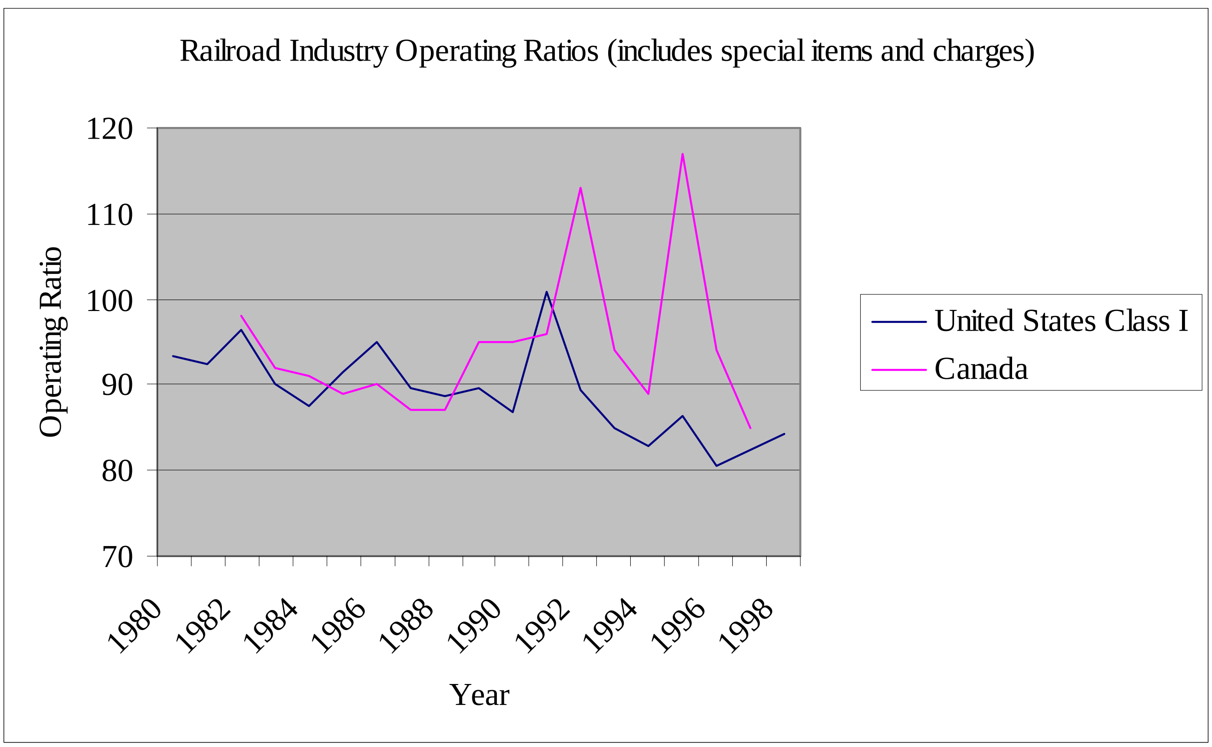
4.2.2 Operating Ratio Trends

In order to cope with the reduction of available revenue, as seen in the foregoing figures, the industry has achieved even greater increases in operating efficiency, to offset the revenue trend.

To better view this situation, we introduce the concept of a railroad "operating ratio."

An "operating ratio" is a calculation, for a transportation enterprise, derived by dividing total costs of operation (including allocated recovery for capital asset depreciation) by the revenues that are derived from the business. Using this measure, if a transportation enterprise reports an operating ratio of less than one, then it is profitable; an operating ratio of one is a "break even" situation, and; an operating ratio in excess of one represents a "loss". For example, if a transportation company reports an operating ratio of 0.9, this means that the total of all the costs incurred, to earn a dollar of revenue is 90 cents. The pre-tax (income tax) margin for such an enterprise is seen to be 10 cents of every dollar earned, or a 10% margin on sales.

Figure 5: Operating Ratio Trends For Railways



Sources: RAC and AAR publications

Figure 5 illustrates the rail industry operating ratios since 1980. In reviewing this figure, we generally note the following:

- U.S. Class I railroads have been generally profitable, and generally more profitable than the Canadian railroads, from an operating ratio standpoint, throughout the period.
- The over all trend, from 1980 through 1999, is for a generally decreasing operating ratio (i.e. a significant efficiency improvement) in both Canada and the US. Since 1980, "operating ratio" for U.S. Class 1 railroads has "generally trended" downward from 0.93 to approximately 0.85 in 1998. In Canada, despite wider fluctuations, the same period has seen a reduction from about 0.98 to approximately 0.85 in 1997
- The Canadian railroads have shown wider "swings" in their operating ratio(s) since 1990 than have the US. – (see years 1992 and 1996, when the Canadian railroads failed to fully cover their costs.)

4.2.3 Operating Cost Trends

Combining the results of the foregoing revenue and operating ratio trends, we see that significant operating cost reductions (efficiencies) have been effected by the rail sector in Canada and the U.S. Over the past ten years, these cost reductions appear to total 17.8% , as follows:

Table 6: Rail Sector Operating Cost Reductions

Country	Revenue Reduction (%)	Operating Ratio Reduction (%) 1989 - 99	Operating Cost Reduction (%) (Composite Effect of Revenue and Operating Ratio Reductions)
USA Class I	14.8	5.6	17.8
Canada	8.1	10.5	17.8

These operating cost efficiency improvements have been achieved through a variety of measures including:

- Workforce reductions including management consolidation, contracting out activity, and train crew reductions which have contributed to a significant rise in the revenue ton-miles per employee.
- Network consolidation (reduction of low density branchline operations) that have contributed to significant increases (approximately 50%) in revenue ton-miles of hauling per mile of rail.
- Improvements in train control and dispatching efficiency
- Acquisition of more efficient locomotives of larger horsepower (6000 HP) facilitated by AC traction motors and microprocessor technologies.

- Fuel efficiency gains from new train technology and improved switching efficiency, etc.
- Increases in freight car capacity.
- Fleet reductions / improved car "cycle times" resulting in increases in average miles per day per car
- Introduction of multiplatform container cars and double stack technology.
- Introduction of bimodal technology (RoadRailerTM)
- Increases in average tons per trainload, average length of haul and train length.
- Safety improvements (contributing to a cost reduction) that have reduced accidents per million train miles since 1980

The foregoing factors are described in further detail in following sections.

4.3. Railroad Employment

Railroad employment has been reduced dramatically on both sides of the border.

Table 7: U.S. Railway Employment

TOTAL RAILWAY EMPLOYMENT		
Year	**1980**	**1998**
U.S. Class I	458,000	178,000
Total U.S. Railroad Industry	532,000	252,000

(Source: AAR *Railroad Facts* 1999 Edition)

The total employment figure for the U.S. railroad industry above exceeds the figure found earlier in this report, because it includes freight, passenger, rail-related unions and trade associations, and other employees.

The decrease in Canadian railroad employment is shown in Figure 6:

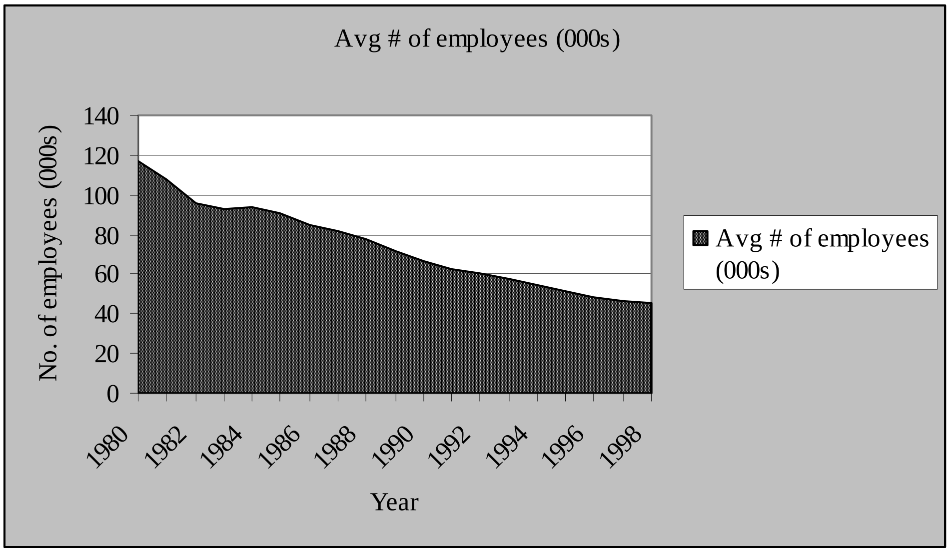


Figure 6: Average Number of Rail Employees -- Canada
Employment graph. Source: Stats Canada 1980-88, RAC 89-98

Note that the foregoing decrease in rail employment in both Canada and the U.S. was during periods of gross ton mileage increase in railroad output. The reduction in railroad industry employment has come about through constant consolidation and implementation of technological, operational and organizational change. Consolidation has occurred at all levels of the railway industry from management groups, maintenance personnel and train crew reductions.

There have been many corporate mergers, as witnessed by the vastly reduced numbers of large railways. Interestingly, mergers are now also occurring at the regional railroad level, for example where RailAmerica, Inc. has acquired RaiLink Ltd. of Edmonton and RailTex, Inc. of San Antonio, Texas in 1999.

Consolidation has also been occurring within each railway company. Some common patterns across the industry have been the reduction, or complete elimination, of operating divisions, centralization of car management and freight accounting functions, and consolidation of transportation planning, and train and crew dispatching, into one, or a few, large centers. This has all been facilitated by the application of the information technology and the voice and data networks that are now available. These processes have eliminated thousands of management and administrative / clerical jobs, such as in local yard offices and calling bureaus.

Consolidation has also been a continuing process within the functional groups, such as mechanical, engineering, and signals within each railway. The administrative and technical groups of these functions have become increasingly concentrated into fewer locations, while locomotive and car shops, and other facilities such as rail plants and track machine and signal shops have been continually rationalized.

All of this has been facilitated by the fact that there are fewer locomotives and cars and less track to maintain. These factors will be discussed in later sections on power efficiency gains, car productivity, and network rationalization.

Wherever possible, the railway industry has contracted out various functions, from car repair to track maintenance to train dispatching to local switching. However, the large railways have substantial contractual limitations on their ability to contract out work traditionally done by members of their various bargaining units. This is less of an issue with the short line / regional railroads, who generally have more flexible work rules.

Another approach is where the locomotive and car manufacturers have entered into a variety of arrangements with the large railways for maintenance of the fleets.

Train crews are another illustration of the reduction in railroad employment. In the late 1970's, the basic train crew consisted of four persons - locomotive engineer, conductor, and a front and rear brakeman, or trainman. The rear trainman rode in the caboose with the conductor. In addition, many trains also had a fireman, an anomaly dating back to work rules that predated dieselization, which positions were still being slowly reduced through attrition.

Currently, the basic train crew is the locomotive engineer and the conductor. The rear trainman was eliminated first, with the front trainman following in the early 1990's, soon after the removal of the caboose, which began in the late 1980's on most railways.

However, trainmen continue to be employed on many trains, either because of workload, such as substantial switching, or by virtue of their seniority, because more senior trainmen enjoy varying degrees of job protection.

Canadian and United States railroads have been reluctant to employ single person train crews, although there have been a few instances on regional and short line railroads. However, single person crews are the norm in other parts of the world, including Britain and New Zealand

CN has been the industry leader in implementing remote control technology of switching locomotives, where the yard engines are controlled by yardmen on the ground, eliminating the locomotive engineer on designated yard assignments. While CP also uses this technology in Canada, the U.S. railways have largely been prevented from implementing it thus far, because of regulatory issues. In the U.S., remote control applications have been limited to a handful of small carriers.

Combining the reductions in railway employment, from all of the foregoing sources, we note a significant decline in over-all railway employment at the same time as over-all gross ton miles of rail transportation have increased. The result is a significant corresponding increase in productivity (between 80% and 100% over the past ten years) by railway employees, illustrated below:

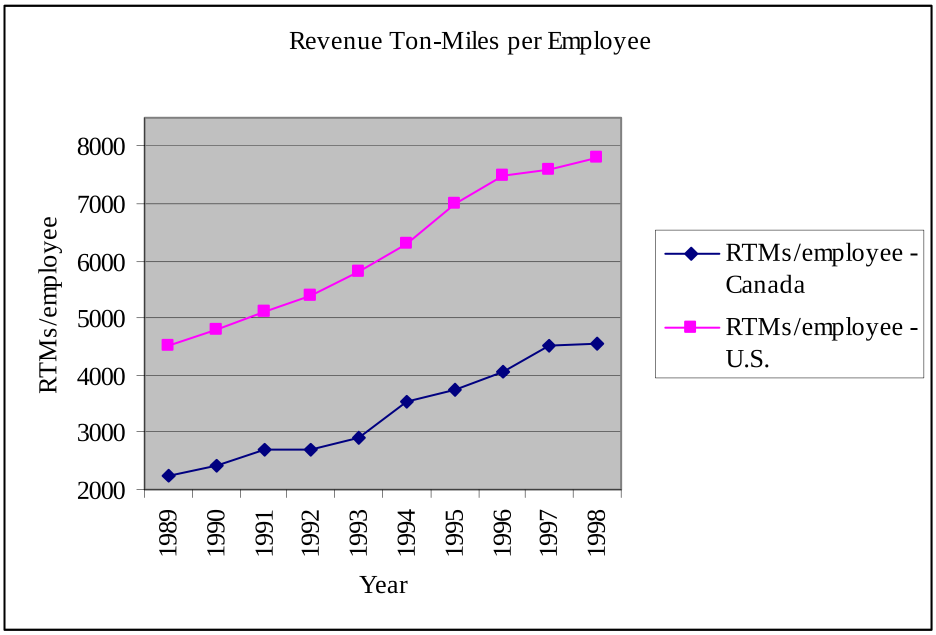


Figure 6: Revenue Ton-Miles per Employee for Canada and U.S.

4.4. Track and Structures/Plant

At a May, 1999, meeting of the American Short Line and Regional Railroad Association, Michael Sabia, former CN Executive Vice President and Chief Financial Officer, reported that total Class I rail miles have diminished at a compound rate of 2.7% a year in the U.S., and at a rate of 4.8% in Canada. Many of these miles have wound up in with regional and short line railroads, and the rest abandoned.

The miles of rail owned, which is the aggregate length of railway, excluding yard tracks, sidings, and double or multiple main tracks, for U.S. Class I railroads declined from 164,822 miles in 1980 to 100,570 in 1998. In Canada, the miles of rail operated declined from 36,469 miles in 1989 to 31,237 miles at the end of 1998.

While the miles of rail operated have declined impressively in both Canada and the U.S., there is still proportionately more track in Canada, resulting in a considerably lower density of traffic, as illustrated by Table 8.

Table 8: Freight Density (Revenue Ton Miles Per Mile of Rail)

	1989	1990
U.S. - RTMs/mile of rail	8,160	13,690
Canada - RTMs/mile of rail	4,631	6,512

This lower traffic density is one of the major reasons why the Canadian labor productivity, expressed in RTMs per employee, is lower than in the U.S. (refer to previous Figure 6)

In addition to there being less plant to maintain, advances in technology and a series of plant improvements have reduced maintenance costs and the number of people required to maintain a given mileage of track and structures.

The last 20 years have seen the almost total elimination of bolted rail on the mainlines of the major railways. It has been replaced by continuous welded rail (CWR). The historic standard length for a rail is 39 feet. With CWR, rails are welded together at a plant into lengths of approximately 1500 feet. These strings are then transported to the site and unloaded by a specially-equipped train. After the rail is laid in place, the remaining joints, which are a high maintenance item, are further reduced or eliminated by field welding.

The rail itself has become larger and heavier. Rail is described in terms of weight per yard, and the nominal standard for main lines across North America is 136 pounds per yard. The AAR reports that 59.4% of the rail in place on the U.S. Class I's is between 130 and 139 pounds. The use of heavier rail tends to facilitate larger car payloads, which especially benefits the movement of heavy bulk commodities.

Rail life has been extended by various means. Different alloys and steel making processes for the rails, head hardening, rail grinding, lubrication by wayside or locomotive-mounted systems all contribute to less rail wear and longer rail life.

Wood is still the primary choice for crossties, currently accounting for 93 percent of the market. (Railway Track &Structures, Sept '99). It is attractive in terms of initial cost and product longevity. Improvements and developments with wood ties include increases in length and cross-section, and exclusive use of hardwood for main line applications. Engineered wood products, such as laminated materials and fiberglass tie-wrapping, as well as exotic woods have been used for crossties, but are restricted to special situations. Concrete ties have been widely used, particularly on heavy haul and high curvature lines. Steel ties are likewise used for special applications, such as high degree of curvature, chemically contaminated environments, or restricted vertical clearance.

Other plant engineering developments include improvements in switches and turnouts, in tie plates and fastenings, in track ballast, and the replacement of older bridges with more maintenance free designs, such as ballast decks.

The methods for maintaining and renewing the track have changed drastically. Long gone is the section crew which traveled around its assigned territory on a gasoline powered track motor car and performed most routine maintenance tasks with an assortment of hand tools. "Hi-Rail" vehicles, which are equipped to travel on both highway and railway, are now the standard method of transportation. They come in a diversity of forms and sizes, from light Sport Utility Vehicles, for inspection and light maintenance, to an assortment of trucks of all sizes equipped with hydraulic tools, hoists, heavy duty jacks, welding equipment, etc…, according to the maintenance tasks to which it is assigned.

Large maintenance and plant renewal projects are handled by large maintenance of way production gangs. These gangs are highly mechanized with specialized machinery that is also designed to either be easily lifted from the track by a crane assigned to the gang, or to be capable of fast travel on the rails to a clearing point. The gangs normally work in assigned track time windows. On the busy lines of the major railways, the engineering departments face ever-decreasing track time windows, requiring the equipment to be highly productive and reliable.

4.5. Train Control Systems

In the late 1970's, there were two basic methods of train control, or train dispatching in Canada :

- Centralized Traffic Control (CTC), where a train dispatcher remotely controls switches and signals, and trains proceeded by signal indication.
- Time Table and Train Order operation, based the relative superiority of trains defined by operating rules and published schedules, supplemented by written authorities, or train orders, issued verbally by train dispatchers, usually over railway owned telephone lines, and copied by train order operators in the field, who then delivered them directly to trains.

The basic functionality of CTC has not changed. However, PCs have replaced room sized electro-mechanical control panels and banks of vacuum tube signal relays, and now control transmissions to the field are through radio or fiber optics, rather than over an open wire code line mounted on poles, which was very vulnerable to the elements.

Time Table and Train Order operation has evolved into what is now termed the Occupancy Control System (OCS) in Canada. The train dispatcher, prompted by PC menu items that are prevalidated by the system to prevent any conflicts, transmits authorities for train movement directly to the train crew by radio.

These developments have eliminated Train Order Operators, who used to number in the thousands in Canada, facilitating an employment gain. Freight train schedules in railway timetables have disappeared, and the railway dependency on time has been greatly reduced. As a result, the once ubiquitous railway watches and clocks are disappearing.

More importantly, the PC based systems have allowed the train dispatcher, now termed Rail Traffic Controller (RTC) in Canada, to handle an increased workload with greater safety and efficiency. RTC territories have been expanded, and dispatching offices have been consolidated and centralized on every major railway in North America. Where a major railway could have had dozens of dispatching offices across its system, they now have only a few, or even only one.

The computer support of the RTC has also facilitated the ability for train dispatch systems to cope with increased preventive maintenance activity in relation to track and infrastructure maintenance. Beginning in the mid-80's, railway engineering departments have largely converted to fleets of "hirail" vehicles (equipped to travel on both highway and railway). This has created a large dispatching workload, as these vehicles must be afforded similar operating authorities to those of trains.

Conversely, when track motor cars were the main method of transportation, they operated on the principle that they could be easily lifted on and off the track virtually anywhere. Their most common authority for movement was a "lineup", a list of trains expected to run over the next few hours, and they had no formal protection from these trains. RTC workload under these circumstances was comparatively minor.

Current development in train control technology is directed toward Positive Train Control (**PTC**), which is described as a concept, rather than a single technology or system. The various systems are still mostly in development and test phases, and full PTC will likely be built and implemented in a series of incremental stages.

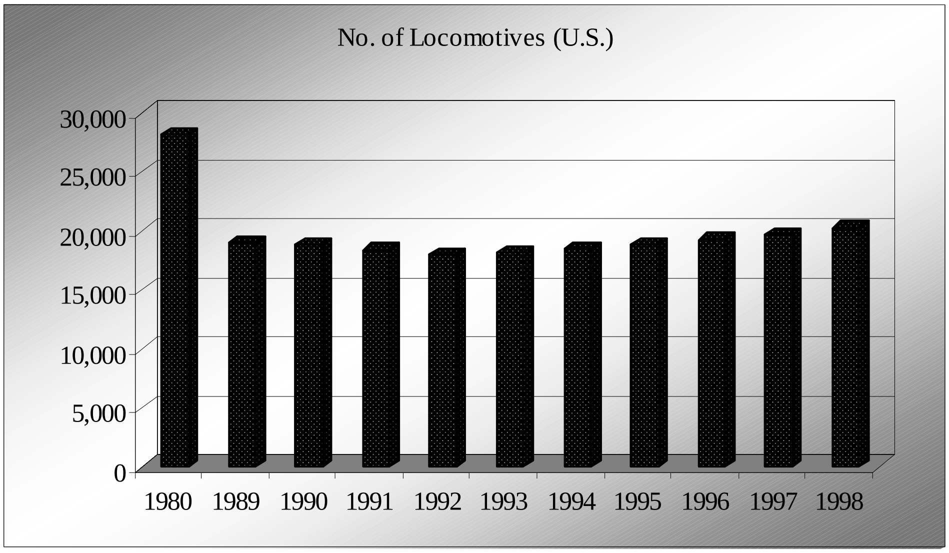
The initial stages of PTC address a number of safety objectives, with the basic one being the avoidance of train collisions, otherwise known as Positive Train Separation (**PTS**). Other safety objectives include the enforcement of speed restrictions and protection of workers and machinery on the track.

PTC is also foreseen to provide a number of business benefits, including movement planning technology and facilitation of the movement of trains from different railroads onto each others' territories.

4.6. Locomotives, Cars, And Trains

4.6.1 Locomotives

In both Canada and the United States, the number of freight locomotives declined significantly from 1980 until the early 1990's when they started to gradually increase in numbers once again.



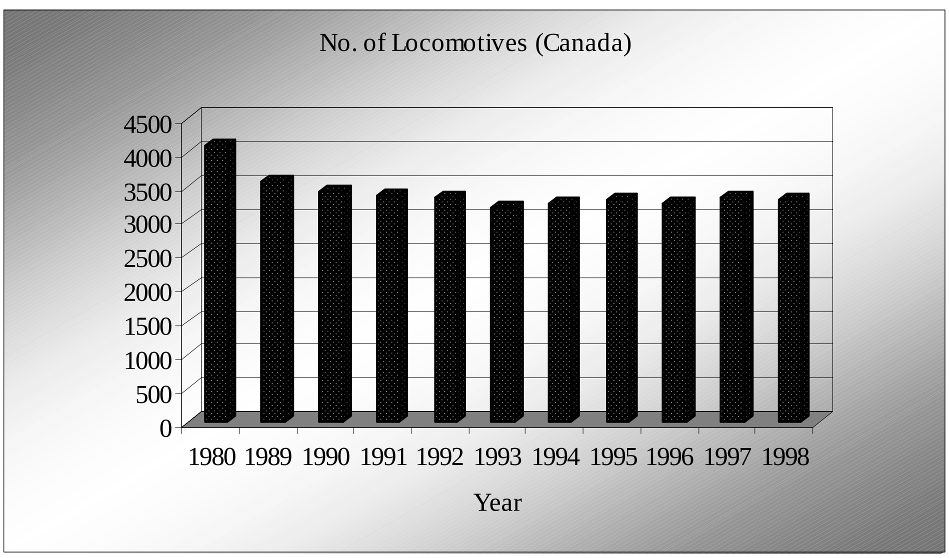


Figure 7: Numbers of Locomotives in Service

The number of locomotives does not tell the whole story, as the new locomotives are generally more powerful than their predecessors are. For instance, the number of locomotives operated by U.S. Class I railroads grew from 19,684 units in 1997 to 20,261 in 1998, an increase of 2.9%. However, aggregate horsepower increased by 5.2% to 63.3 million. (Railway Age, September, 1999, from AAR sources)

The acquisition of these new units allows the railways to retire older locomotives, generally on a one-for-two or two-for-three basis. In doing so, service is improved by the increased productivity, reliability and availability of the new units. Locomotive maintenance costs drop, including the effect of having fewer different locomotive models in service. Lowering the average age of the fleets will allow the railways to more easily meet the stricter emission requirements that will be coming into effect.

Locomotive fuel efficiency has also progressively improved through the years, as illustrated by the chart below.

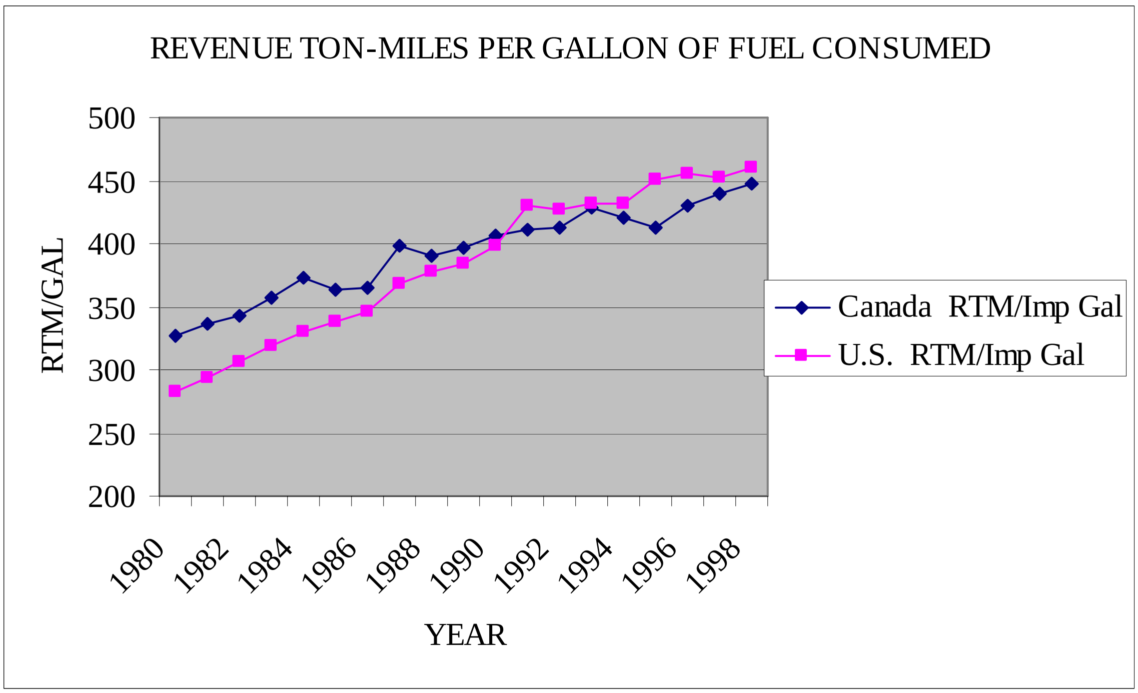


Figure 8: Rail Fuel Consumption Per Revenue Ton-Mile

As noted in Figure 8, with improved locomotive technology, revenue ton-miles per gallon of fuel used has improved by approximately 50% since 1980.

The apparent slight difference in fuel consumption improvement between the U.S. and Canada may not be significant, as changes in traffic mix will impact the observed statistic. For example, a manifest train consumes fuel at almost twice the rate of a bulk commodity train.

In addition to locomotive improvements, another factor contributing to fuel efficiency of railroads is the introduction of double stack container car technologies. Double stack trains are known to have improved fuel / aerodynamic / payload characteristics over single stack flatcar technologies. Double stack car technologies will be illustrated in the following section.

The most powerful locomotives currently available are 6,000 hp. However, the development of locomotives this powerful did not come in one easy step.

Around 1980, the largest locomotives were in the 3,000 to 3,600 hp range. Further development had been stalled because wheel-to-rail adhesion had been a limiting factor to the usable horsepower of locomotives. In other words, wheel slip prevented the practical use of more power, particularly in starting trains.

A diesel-electric locomotive does not pull a train with diesel power. Rather, the diesel engine is connected to a main generator/alternator, which converts crankshaft motion into electrical energy to power electric traction motors mounted on each axle. The *tractive effort* of a locomotive is defined as "the turning force produced at the rails by the driving wheels". Some important determinants of tractive effort include diesel engine HP, capacity of the main generator and of the traction motors, and weight on the driving wheels of the locomotive. *Adhesion* is friction between the wheel and the rail, and maximum friction available is called the adhesion limit. Any attempt to develop a tractive effort which exceeds the adhesion limit results in wheel slip. Thus the maximum tractive effort that can be applied to the wheels is limited by this maximum adhesion available.

In the late 1970's, a state of the art road locomotive weighed approximately 360,000 pounds, developed 3000 HP and 70,000 to 90,000 pounds of tractive effort with 18% to 21% of available adhesion.

Throughout the 1980's, adhesion levels were continually improved, first through electronic traction control, then through the application of microprocessors technology. As microprocessor computing power and speed developed, reliable adhesion levels rose to the 30% range, and locomotives in the 4000 HP range were introduced.

By the 1990's, advancements in microprocessors allowed the introduction of alternating current (AC.) traction systems on locomotives. While the technology involved in AC locomotives is very complex and precise, these locomotives deliver more tractive effort and adhesion than their direct current (DC.) predecessors, yet utilize a simpler electric motor design, featuring fewer moving parts and reduced maintenance.

General Motor's Electro-Motive Division (EMD) describes their SD90MAC as having the world's highest tractive effort of any six-axle locomotive - 200,000 pounds, with 48% adhesion, for starting trains. While these 6000 hp locomotives are now in service, most of the AC. locomotives are in the 4400 to 5000 hp range. In some cases, the 6000 hp diesel engines can be retrofitted into the existing locomotives.

Figure 9: General Motors SD90MAC Locomotive

At the end of 1998, AC. locomotives in service in the U.S. numbered 2,216, 10.9% of the total, and approximately 275 in Canada, 8.4% of the total number of locomotives.

The AC. traction locomotives come at a higher cost than their DC. counterparts, and their main advantage is that they can fully utilize the high horsepower at slow speeds. They are most efficient on heavy trains, such as bulk commodities, and on steep grades. For these reasons, AC. traction is not for all railways and/or for all applications. For instance, CN, with its comparatively gentle grades, does not have any AC. locomotives. UP recently announced that it would lease over the next 3 or 4 years 1000 DC. traction 4,000 hp locomotives. The new units are intended to be used primarily on manifest trains, with their high hp/ton ratios, where AC. traction is not warranted.
(RA, Nov '99, and UP News Release)

Other significant developments in locomotives include radial trucks, which increase adhesion, increase fuel efficiency, and lower wear and tear on the track structure; improved dynamic braking and cab ergonomics; and computer systems on the locomotive to support operator information display, self-diagnostics, and other railway systems, such as PTS, PTC, and ECP braking, which are described elsewhere in this report.

4.6.2 Car Equipment

Car utilization efficiency has increased with respect to two main factors. Firstly, average car payloads have increased and, secondly, the car cycle times have been reduced / days in active service per car has increased. As a result, despite increased tonnage hauled, the number of freight cars in service has decreased significantly in both Canada and the U.S. This is tabulated in Table 9.

Table 9: Size of Railcar Fleets in Service

	1980	**1989**	**1998**
Freight cars in service - U.S.	1,710,827	(not available)	1,315,667
Freight cars in service - Canada	(not available)	123,375	110,912

Since 1993, however, traffic gains have resulted in some expansion of the U.S. fleet from its low point of 1,173,132 that year. In Canada, there have been some fluctuations of the numbers up and down since 1992, with a low point of 110,704 cars in 1995.

In addition to the overall shrinking of the freight car fleet, there has been a significant shift in ownership away from the Class I railways toward car companies and shippers. A beneficial impact of this shift has been to “incent” shippers and consignees to “turn around” railcars faster, through expedited loading and unloading of the cars. When the shippers “own” the cars, there is a direct incentive for them to monitor the car “cycle times” (i.e. how many days it takes a car to return to origin, for the next load) themselves and to not expect the cars to sit for extended periods awaiting loading or unloading. Reductions in average car cycle turn around days directly reflect in increased numbers of loads per car per year – resulting in an improvement in the capital productivity of monies invested in cars.

Table 10: Railcar Ownership Trends (More Shipper Provided Cars)

	Total	**Class I Railroads**	**Car Companies and Shippers**	**Percentage**
1980	1,710,827	1,168,114	440,552	25.8%
1998	1,315,667	575,604	618,404	47.0%

Note: Freight cars not tabulated above, 102,161 in 1980, and 121,659 in 1998, belong to Other Railroads

Average freight car capacity, which is calculated by dividing the total number of freight cars in service by their aggregate capacity, has increased from 79.4 tons in 1980 to 92.5 tons in 1998.

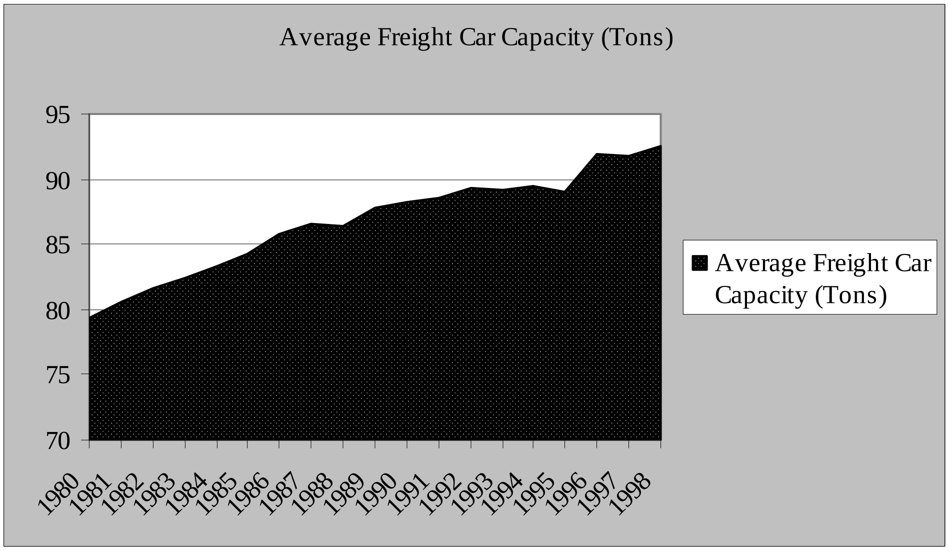


Figure 10: Chart Of Average Freight Car Capacity

In addition to the increase in average freight car capacity, the makeup and characteristics of the freight car fleet have changed significantly.

Figure 11: Example of a Railway Boxcar.

In 1980, boxcars were the most common car type on American and Canadian railroads. For unrestricted interchange between railways, the maximum gross weight of cars was 263,000 pounds, but cars of 220,000 pounds and 177,000 pounds - the most common boxcar size - were numerous. Plain journal bearings were common, with sealed roller bearings only having been mandated on new and rebuilt cars variously between 1966 and 1970. (1984 Car and Locomotive Cyclopedia)

At present, covered hoppers are the most common car type. An AAR specification, effective January 1, 1995, allowed the interchange of cars of 286,000 pounds gross weight, although cars of this size had already been operated by some railways on their own lines for several years. After 1994, plain bearings were no longer allowed on interchange cars, after being first prohibited in interchange on placarded tank cars.

The capacity of freight cars was generally increased by increasing the size of the axle and/or by reducing the car tare, thereby allowing a corresponding increase in lading weight. Efforts to increase car capacity by increasing the number of axles to six have not successful, mainly because of the problems with increased maintenance and adverse car dynamics. Cars with three axle trucks are mainly restricted to special heavy-duty service.

Cars of 315,000 pounds gross weight are currently in some restricted service. They are the subject of an ongoing research project into the effects of heavy axle loads on track components and rolling stock at the AAR's principal research center, near Pueblo, Colorado.

The research is partly directed at quantifying the economic benefits and costs of heavy axle load cars. Benefits include savings in car ownership, car maintenance and train crew costs, lower fuel consumption, and increases in train and route capacity. Offsetting the cost savings are increased track and bridge maintenance costs. However, the negative effects on the track structure can be mitigated significantly by advances in freight car trucks.

The decline in the size of the freight car fleet, while the total traffic tonnage increased required that more than the average capacity of the cars be increased. In fact, much progress has been made in improving freight car utilization. Information technology has been a major factor, allowing better management and planning for the car fleets, and improved control of railroad operations. Some other factors include an increase in average freight train speed and a reduction in the proportion of empty car miles through better car pooling arrangements and incentives and penalties for more efficient use by shippers. In addition, the spate of mergers in the U.S. has led to an improvement in car utilization by reducing the frequency of interchange of cars, with its attendant delay.

One source reports that average daily car mileage increased 40% between 1984 and 1995, from 48.7 to 68.3 miles per day. (*1997 Cyclopedia*)

Car re-design and engineering has brought changes to all types of freight cars. Two car types will be examined - covered hoppers, and intermodal equipment.

4.6.2.1. Covered Hoppers

Covered hopper cars are the most common freight car type, making up over 29 percent of the total freight car fleet in the U.S. at the end of 1997. They tend to be quite specialized, with the weight and volumetric capacity, as well as the configuration of roof hatches and bottom outlets specific to a particular commodity or narrow range of commodities.

The efficiency gains in the move to cars with 286,000 pounds gross rail load, combined with the advances in car engineering is demonstrated in covered hoppers in grain service.

Table 11 lists the weights and dimensions (approximate) of a Government of Canada or Alberta covered hopper, which were typically built between 1972 and 1984, with a typical new 286,000 pound car built after 1994. Size wise, the 286,000 pound car has the same length and width, and is only 6 inches more in height. Yet, as seen in the table, the payload capability has been increased by 12% more weight per car. This can be fully utilized for those products which are sufficiently dense enough to achieve the higher weight level within the cubic capacity constraint of the car.

Table 11: Comparison of 1970's Design Hopper Cars with Post 1994 Technology

	"Gov't of Canada" Hopper	"New" Hopper
Gross rail load	263,000 pounds	286,000 pounds
Light weight (estimated)	62,500 pounds	61,500 pounds
Load limit (estimated)	200,500 pounds	224,500 pounds
Capacity	4550 cu. ft.	4850 cu. ft.
Length (overall)	59 feet	59 feet
Width (extreme)	10 feet 8 inches	10 feet 8 inches
Height (extreme)	15 feet	15 feet 6 inches

Covered Hopper Car of GVW 263,000 lbs

High Volume and High Payload Capacity Hopper Car of GVW 286,000 lbs and 6300 cu ft capacity

Figure 12: Picture Of Gov't Of Canada And New Hopper Cars

For lighter materials, high volume covered hoppers, designed to carry light density, dry bulk loadings, have increased volume capacity from approximately 5800 cu ft to approximately 6300 cu ft with the advent of 286,000 lb cars.

4.6.2.2. Intermodal Service

Intermodal service is the movement of trailers and containers on flat cars, often referred to as TOFC and COFC, respectively. It has been the fastest growing segment of rail traffic, showing a general pattern of 7% annual growth. (Railway Age, April1999; 1997 Cyclopedia)

The development of more efficient intermodal technologies has directly enhanced the railroads' ability to compete with truck, by providing a "door to door delivery service" that makes use of truck technology for the local pick up and deliveries and rail line haul services for the longer distance movement component. The attempt is to combine the most advantageous element of each mode into a very competitive combined service.

Intermodal service started as "piggyback", where trailers were sequentially loaded and unloaded at circus style ramps onto flat cars with permanently mounted, hinged bridge plates to facilitate trailer handling from car to car.

Since that time, the increasing length of trailers, and the variety of domestic and ISO containers, has driven the development of versatile cars to allow flexibility in handling all sorts of mixed trailer/container combinations.

The car of choice became the articulated car, a multi-platform(3 or 5 units) where each platform shares an inboard truck. They appeared first as single stack cars, also known as spine cars, and then in double stack versions in the mid-1980's. Their advantages include low tare weight, the almost total elimination of slack action , and good car dynamics. In the late 1980's, the truck at the articulated connections was more or less standardized at 125 tons, giving each interior well a capacity of approximately 120,000 lbs. The end trucks are 70 to capacity.

Heavier loads are handled by stand alone cars, which have trucks at each end of the car. They come in single car versions, or in drawbar connected (versus couplers) units of three, which again saves tare and eliminates slack action.

Depending on the particular car design, trailers of varying lengths, assorted stacked containers, or a combination of the two can be carried.

As the double stack cars evolved, the interbox connector version (IBC) won wide acceptance over the version with bulkheads, as it afforded the flexibility to handle containers of varying lengths and widths.

In 1991, the AAR adopted a standard for double-stack container cars, with a maximum permissible height of 20 feet, 2 inches.

In the late 1980's, the truck at the articulated connections was more or less standardized at 125 tons, giving each interior well a capacity of approximately 120,000 lbs. The end trucks are 70 ton capacity.

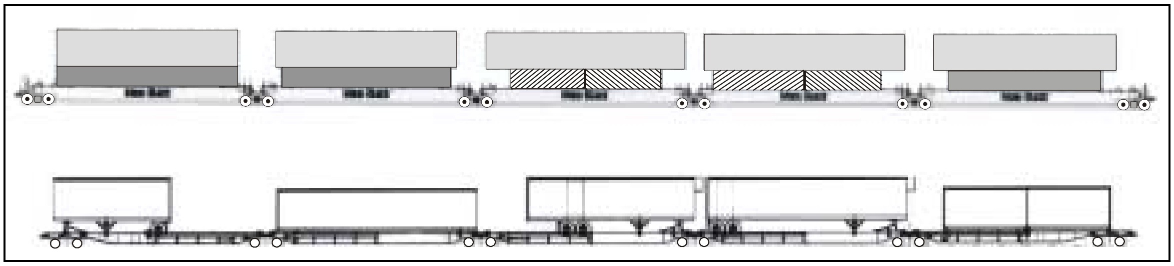


Figure 13: Articulated Cars

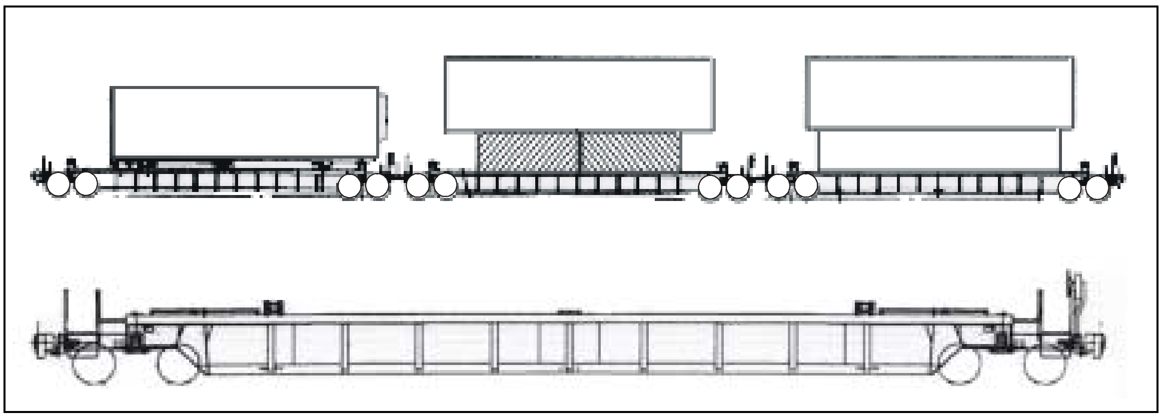


Figure 14: Stand Alone Cars

Following Figure 15 illustrates the foregoing difference, photographically.

Figure 15: Photo of an Articulated (left) versus a Stand-Alone Connection (right)

In the U.S., Intermodal Traffic grew from 3,059, 402 trailers and containers in 1980 to 8,772,663 in 1998. In Canada, there has been 16 percent growth over the last 4 years from 1.176 million containers and trailers in 1995 to 1.364 in 1998.

It is interesting to note that there is far higher proportion of containers to trailers in Canada than in the U.S. as shown in Table 12.

Table 12: Intermodal Equipment Fleets In Canada and the U.S.

	Intermodal Traffic	**Trailers**	**Containers**
U.S.	8,772,663	3,353,032	5,419,631
Canada	1,364,000	105,000	1,364,000

Intermodal traffic for 1998

There may be various reasons for this imbalance. Domestic containerization evolved at different rates in the two countries - CPR was the first railway to successfully implement domestic containers in 1979. The U.S. freight has an enormous investment in trailers and railcars to handle trailers, and there is more wholesale versus retail business in the U.S., favoring the flexibility of trailers. In addition, the transcontinental nature of CN and CPR, with their longer hauls, allows a more favorable ratio of chassis to containers.

4.6.2.3.New Car Technologies Promote Rail Competitiveness with Highway

There are railway initiatives to build business in the short and medium-haul - 300 to 700 mile - markets. One approach has been bimodal technology, which is essentially trailers that are also designed to travel by rail. There have been several designs of this technology, but the most successful has been RoadRailer™ equipment. RoadRailer is in service across North America, including on Amtrak passenger trains. CPR has operated RoadRailers between Toronto and Detroit for several years now, and CN launched service between Toronto and Montreal in September of 1999.

The latest version of RoadRailer trailers are 53 feet in length, and feature air ride, 110-inch interior height, more than 4,000 cubic feet of capacity and maximum payload of 70,000 pounds.

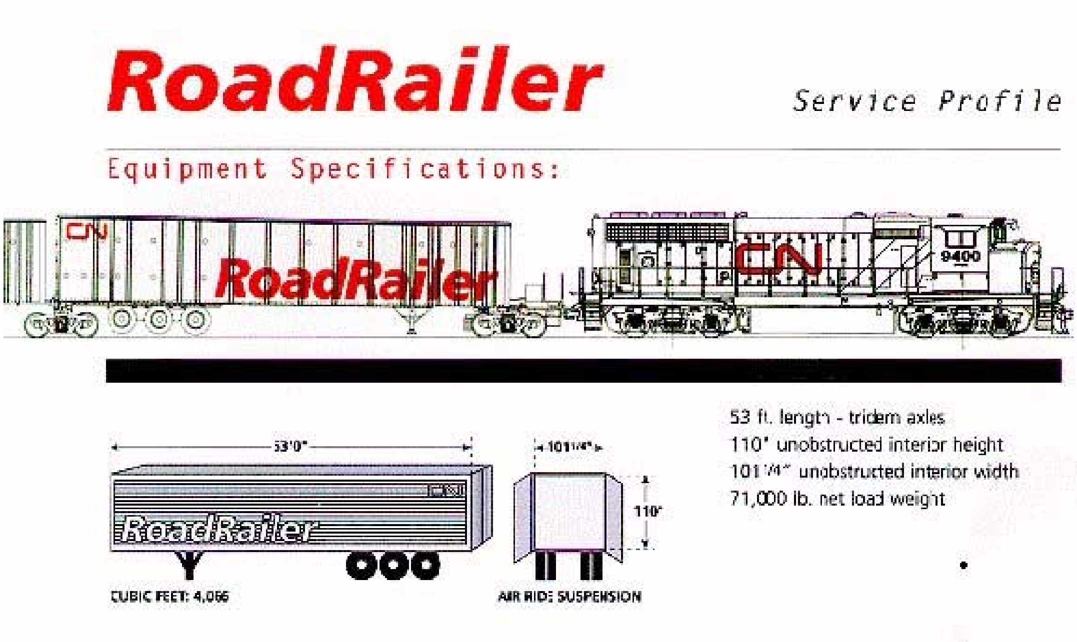


Figure 16; RoadRailer Technology

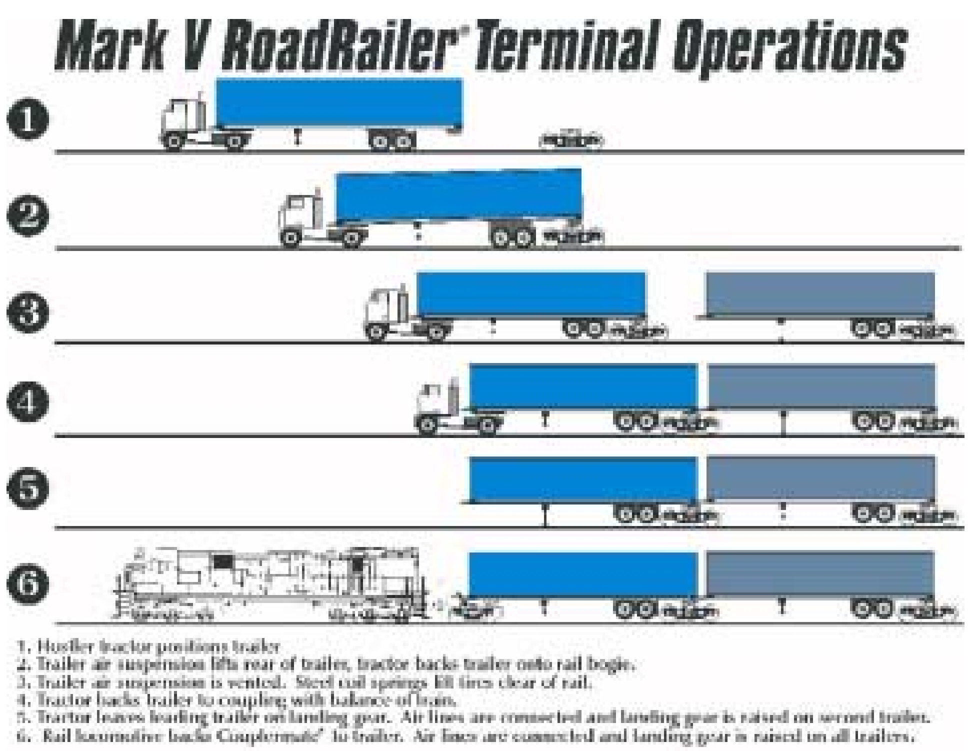


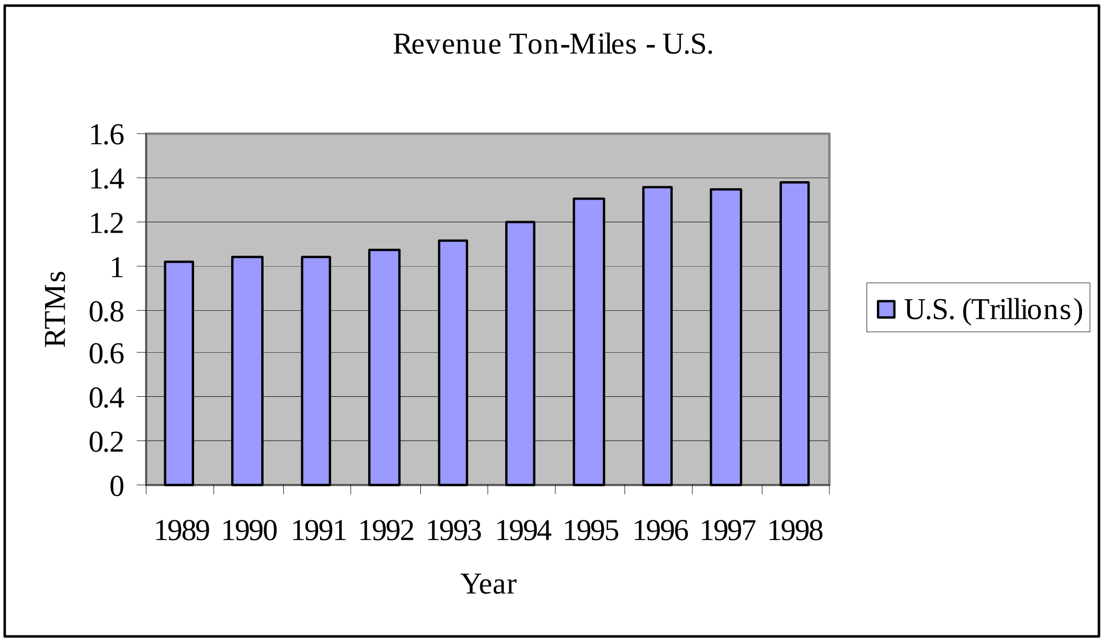
Figure 17: "How RoadRailers Work"

CPR is pioneering an updated version of a roll-on, roll-off concept known as Expressway between Toronto and Montreal, with plans to expand service to Detroit in the year 2000. Features of this service include expedited service on specialized railcars that can handle any length of non-reinforced trailer. Space on the train is by reservation, which can be done over the Internet, and short (15 minute) trucker connections, in and out of the dedicated terminals, are guaranteed by the railway.

4.6.3 Rail Operations

Over the last 10 years, since 1989, Revenue Ton-Miles, Average Tons per Freight Train, and Average Length of Haul have all increased, although at varying rates, in both the U.S. and Canada.

These trends are illustrated in following figures 18, 19, and 20.



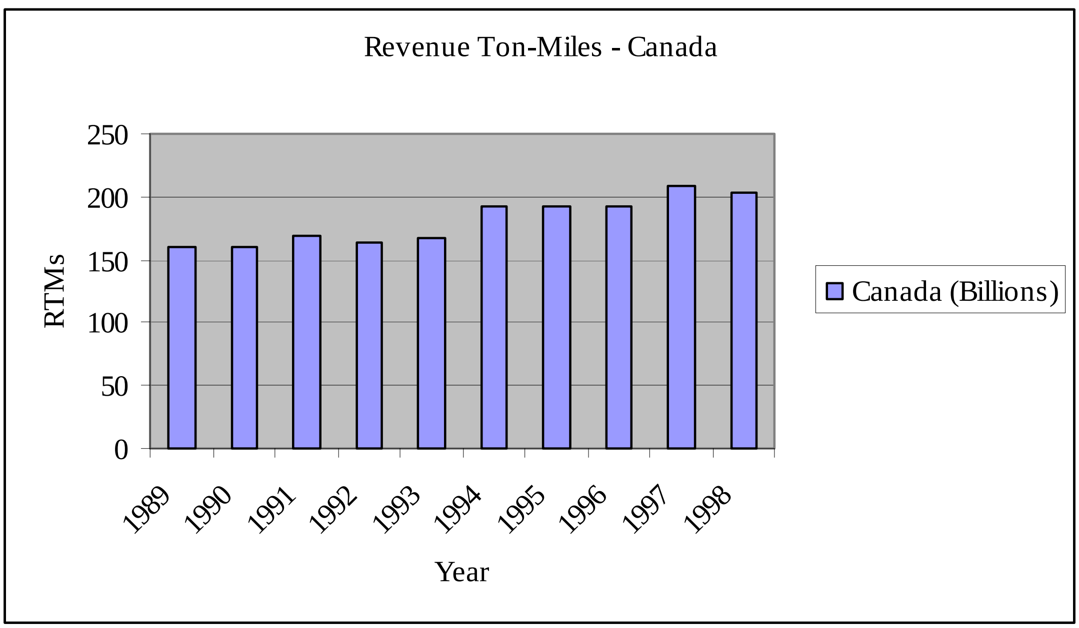


Figure 18: Growth in Railway Revenues in Canada and the US

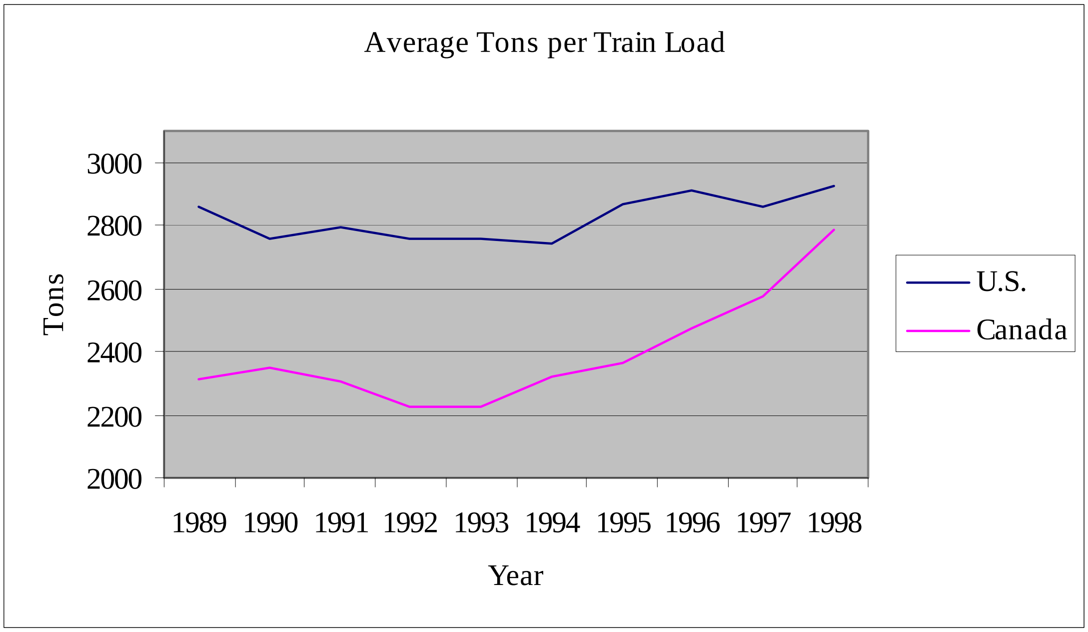


Figure 19: Growth in Average Tons Per Train Load

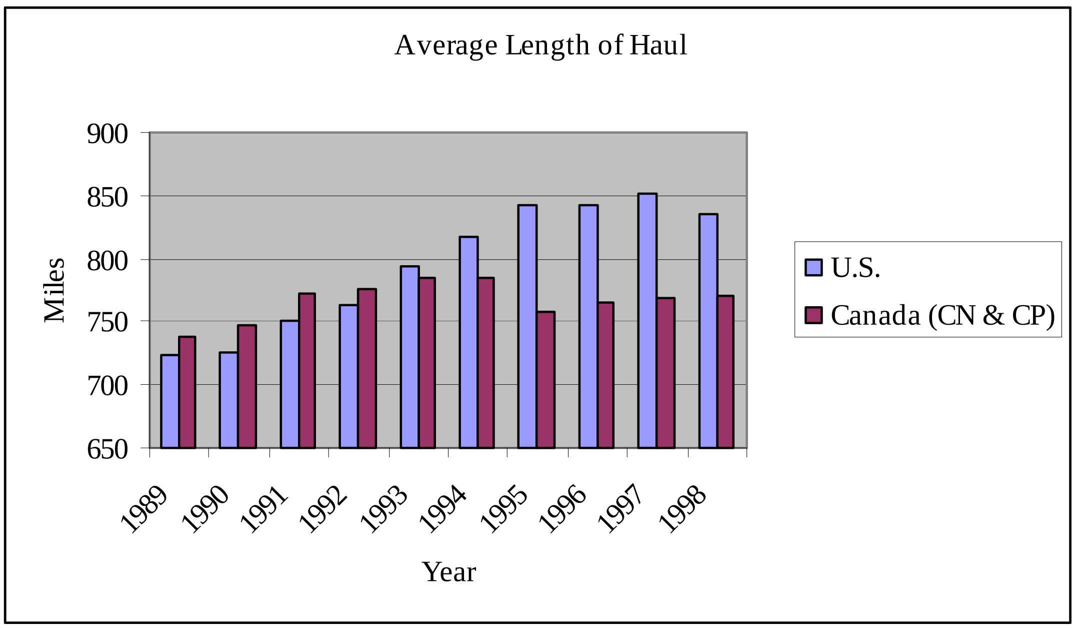


Figure 20: Growth in Average Length of Haul

Over the same period, the Average Cars per Freight Train has not changed appreciably, nor indicated any particular trend, as illustrated below.

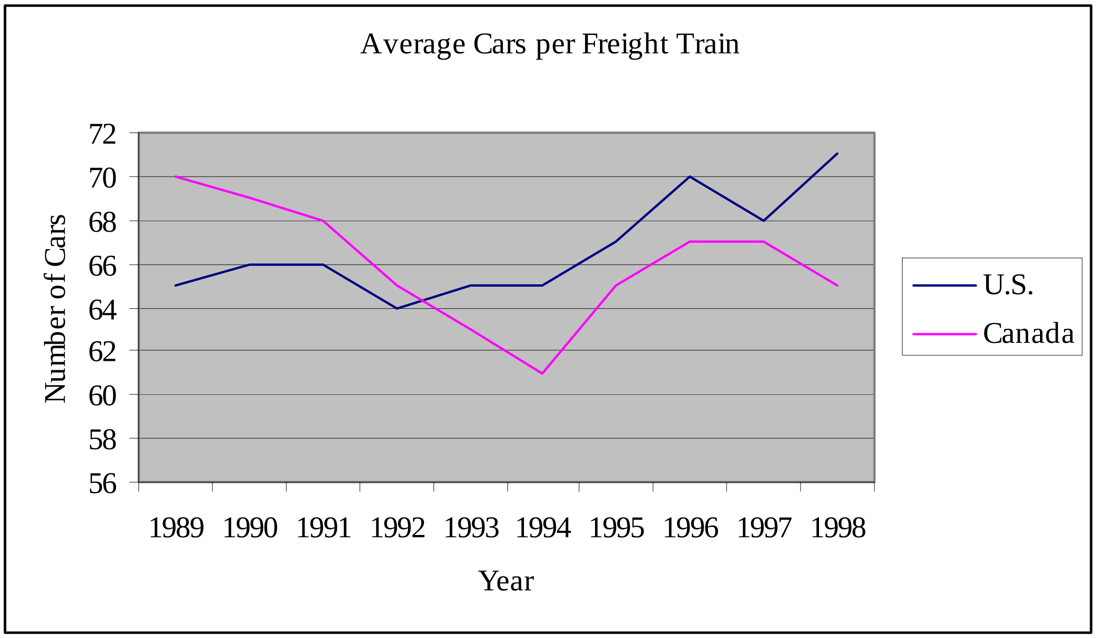


Figure 21: Average Cars per Freight Train

The main reason for trains being heavier without any significant increase in the number of cars is that the average tons per carload has increased with the increase in the average capacity per car. In addition, there are inconsistencies in the way the various railways report the multi-platform articulated intermodal cars. Some report a three or five unit car as only one, because there is a single car number, while others report them in accordance with the number of brake valves on the car, which would be three for a five-unit car.

In any event, there are practical constraints to increasing freight train lengths. Siding lengths are one factor, as are service effects. Extremely long trains are large consumers of both time and space in yards and terminals, which are often already congested. Train handling dynamics can be a problem, particularly with time lags associated with the serial application and release of air brakes. In addition, maintaining adequate air pressure on longer trains can be difficult or impossible during periods of extremely cold winter weather.

Even so, both CN and CPR have recently adopted a strategy of running some trains to lengths of up to 10,000 feet. (Calgary Herald, July 31, 1999) Both railways cite improvements in asset utilization and increased productivity with the longer trains. CPR is currently testing mid-train air repeater cars as a means to maintain the required air pressure on the long trains through the winter months.

An emerging technology that may allow longer trains, among its several benefits, is called Electronically-Controlled Pneumatic (**ECP**) Brake systems. It differs from the conventional train braking system in that the brakes on each car are controlled electronically rather than by an air pressure actuated brake valve. ECP brake systems can be either cable or radio-based. ECP systems are currently being tested in service in Canada, the U.S. and Australia. The main advantage of an ECP system is simultaneous brake application and release throughout the train, affording superior stopping and train-handling abilities. Other benefits include reduced brake shoe wear and fuel consumption.

In July 1999, an Australian heavy-haul railroad successfully operated a 240 car, 37,500 ton, 8,300 foot long revenue train equipped with ECP brakes a distance of 375 miles. (RA, August, 1999)

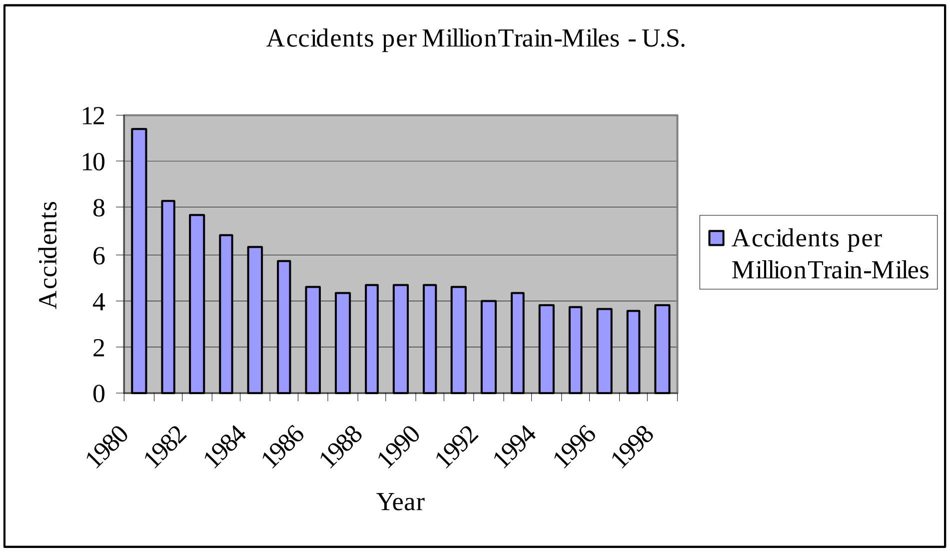
Distributed power train operations, where one or more locomotive consists are dispersed in a train and controlled by radio commands from an operator (locomotive engineer) at the front of the train, are currently in service on several railroads in Canada and the U.S., as well as in other countries. These distributed power trains have exhibited a variety of operating and economic benefits, depending on the application and operating environment. These include optimum tonnage hauling capacity while reducing in-train forces, improved train performance, improved brake performance, and improved locomotive asset utilization.

The application of the new information technology now available on modern high horsepower/high tractive effort locomotives, together with ECP brake and distributed power technology, may permit the operation of trains of longer length and higher tonnages than ever before practical.

4.7. Railway Safety

Safety improvements contribute to cost reductions for railways through less damage to cargo and rolling stock, reduced numbers of service disruptions, improvement in productive power utilization and enhanced car cycle times.

Recent years have seen rail safety improvements (contributing to a significant cost reduction) through introduction of new technologies and approaches. The number of train accidents per million train-miles has declined significantly in both the U.S. and Canada since the early 1980's.



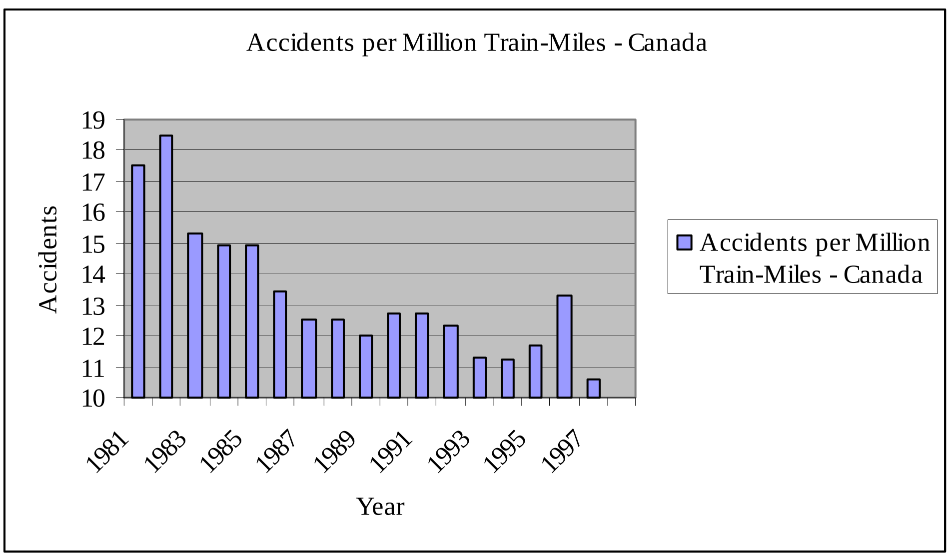


Figure 22: Rail accident rates for U.S. and Canada

While the rates for the U.S. are lower than the rates for Canada in Figure 22, they are not directly comparable. Basically, the statistics shown for Canada are more comprehensive. The U.S. rates principally cover collisions and derailments, although for all railways - Class I freight, non-Class I freight, and Passenger. The Canadian statistics, in addition to collisions and derailments, also cover crossing accidents, trespasser accidents, and a separate category of reportable incidents, which include a range of occurrences where there is no accident, such as some operating rule violations.

While employee and public education has had an effect on lowering the accident rates, new standards and new and/or improving technology has been the major contributor to the downward trend in the accident rates.

Examples of these standards and technology are:

- replacement of plain bearings by sealed roller bearings
- trackside detectors for various defects, including overheated bearings and wheels, dragging equipment, and skidded wheels
- heat treated curved plate wheels
- reduction in bolted rail, and replacement with heavier rail sections of CWR
- automated inspection of track for internal rail defects and defects in track geometry

In fact, the single largest proximate cause of train accidents is direct human error. This is a demonstration of how far accident prevention and safety related technology has progressed.

5. RAIL CONCLUSIONS

From the foregoing review of rail sector developments over the past 20 years, the consultant has found that rail efficiency growth has been significant in response to the competitive market pressures after deregulation and to the customer needs driven by price pressures (downward) for raw bulk commodities – which is the principal rail market served.

Beyond the bulk commodity sector, substantial growth in rail intermodal traffic is occurring, a factor which indicates that the rail sector is offering a truck competitive door to door service using TOFC (Trailer on flat car), COFC (Container on flat car) RoadRailer technologies.

Rail efficiency growth has stemmed from:

- improved management / system consolidation approaches for the large Class I railroads
- better utilization of labour and other resources for lower density branchline operations at the local level through shortline operations, etc.
- new and improved technology for track maintenance, control systems, information technology, locomotives, rolling stock design, etc.

Following Table 13 summarizes the magnitude of product price pressures on rail, growth in intermodal business and various rail system technical improvements that have occurred. These changes are very significant.

While there was some concern that EEMV trucking operations would significantly impact or threaten rail hauling viability, resulting in traffic shifts to truck from rail, the inherent strengths in rail management, mergers of rail operations and new technologies should enable the rail sector to “hold its own” in competition with trucks over the foreseeable future time horizon.

Table 13: Summary of Important Rail Sector "TRENDS"

Item / Statistic	Timeframe	Percentage Change	Reference
PRICE DRIVERS (Products)			
Wood Products	1995 to 1999	- 25%	Table 1
Pulpwood	1995 to 1999	- 33%	Table 1
Copper / Nickel Concentrates	1995 to 1999	- 38%	Table 1
Lead Concentrates	1995 to 1999	- 9%	Table 1
Zinc Concentrates	1995 to 1999	0	Table 1
Sulphur	1995 to 1999	- 33%	Table 1
Mineral Fuels	1995 to 1999	+ 7%	Table 1
Thermal Coal	1995 to 1999	0	Table 1
Crude Mineral Oils	1995 to 1999	+ 7%	Table 1
INTERMODAL TRAFFIC GROWTH			
Monthly Carloading Statistics	1997 to 1999	+45%	Table 2
PRICE FOR RAIL SERVICES			
U.S. Rev. per ton-mile (Constant $)	1989-1998	-30%	Figure 3
Can. Rev. per ton-mile (Constant $)	1989-1999	-30%	Figure 4
TECHNICAL EFFICIENCY INDEXES			
Over-all Operating Cost (U.S. / Canada)	1989-1999	- 17.8%	Table 6
Revenue Ton Miles / Employee (U.S.)	1989-1999	+80%	Figure 6
Revenue Ton Miles / Employee (Can)	1989-1999	+100%	Figure 6
Revenue Ton Miles / Mile of Railroad (US)	1989-1999	+75%	Table 8
Revenue Ton Miles / Mile of Railroad (Can)	1989-1999	+40%	Table 8
Revenue Ton Miles / Gallon of Fuel (US)	1980-1999	+50%	Figure 8
Revenue Ton Miles / Gallon of Fuel (Can)	1980-1999	+35%	Figure 8
Average Freight Car Capacity (North America)	1980-1999	+16%	Figure 10
Tons Per Train Load (Canada)	1989-1999	+40%	Figure 19
Accidents Per Million Train Miles (US)	1980-1999	- 60%	Figure 22
Accidents Per Million Train Miles (Can)	1981-1999	- 35%	Figure 22