Impact of New Railway Technology on Grain Transportation in Western Canada

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The impacts on railway technical productivity, infrastructure, and costs created by the introduction of new railway technology to the movement of grain in Western Canada are evaluated. By creating a geographic information system model of the railway system and assigning grain traffic to individual railway lines, operational and maintenance parameters are determined for each railway segment under a variety of scenarios. The scenarios consider the implementation of new high-horsepower locomotives and heavier freight cars. Because four new trains can do the work of five current trains, new technology decreases the number of trains and amount of equipment required, decreasing the cost of transport. Although the new cars negatively affect the infrastructure through higher axle loads, decreases in the number of trains operated more than offset associated roadway maintenance increases. The benefits of the new technology are more apparent on Canadian Pacific than on Canadian National because of the steep grades and long trains associated with Canadian Pacific operations. Over the service life of the new technology, approximately $260 million [in Canadian dollars (C$1 = US$0.65)] will be saved. Additional benefits can be obtained by performing additional upgrades to the railway infrastructure.

Important advances in railway technology have been developed and implemented by the North American railway industry. These include high-horsepower locomotives and new freight cars with increased gross railcar weight standards. The simultaneous introduction of these technologies has allowed railways to attain new levels of productivity. The analysis presented here considers the interaction of both new locomotives and freight cars and the geographic variation of constraints placed on railway operations to present a complete evaluation of the impact of the new technology on the grain-related operations of the Canadian Pacific Railway (CP) and the Canadian National Railway (CN) in Western Canada.

The impact of the new railway technology on the movement of grain is measured in terms of railway technical productivity, infrastructure, and costs. A geographic information system model of the railway system in Western Canada, which includes grain traffic density on individual railway lines, allows changes in operations and maintenance to be determined for each railway segment under a variety of scenarios (*1*). In a later section of the paper, scenarios are constructed by introducing new railway technology in a manner that still conforms to the existing constraints of the railway infrastructure. The weight standards of rail lines are then varied to determine the amount of additional productivity that can be gained by making infrastructure improvements or through branchline abandonment. Each scenario is evaluated by determining the total cost of the rail movement in Canadian dollars per tonne (C$1 = US$0.65) with a model developed for Transport Canada (*2*).

The research deals with unit train movements of grain on main lines from Western Canada to Vancouver, Prince Rupert, and Thunder Bay in Canada and to the United States via Portal, Saskatchewan, and Fort Frances, Ontario. The collection operation on feeder branchlines is considered only when weight restrictions on the branchlines do not allow the complete implementation of new technology on the connecting main line.

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RAILWAY NETWORK IN WESTERN CANADA

Western Canada is served by approximately 24 000 km of railway. This network of railway lines can be divided into core, secondary, and feeder lines. The core system includes the railway lines that connect major centers and that have the highest traffic densities. The secondary network includes lines that have limited abilities to handle through traffic because of the speed of operation and the length and frequency of passing sidings. The lines considered in this analysis are shown in a North American context in Figure 1.

The feeder network consists of a web of branchlines, regional railways, and short-line railways that cover most of Western Canada. At present, branchlines comprise approximately 14 500 km of track in the region. This is a significant decrease from 1968, when the network of feeder lines totaled 24 000 km. Because of the size of the feeder network, a detailed analysis of operations on each branch is not considered.

Properties of Network and Constraints

Unit grain train operations in Western Canada are constrained by weight restrictions, siding lengths, and ruling grades. These three parameters affect the type of equipment that can be used and the overall weights and lengths of unit trains.

Weight Restrictions

During the 1990s, CN and CP raised the standard four-axle railcar weight on their respective main lines in Western Canada from 119 400 to 129 850 kg (263,000 to 286,000 lb). With two exceptions, all of the CN and CP main lines in Western Canada allow maximum railcar weights of 129 850 kg. The exceptions are the CN line between Jasper and Prince Rupert, which has been upgraded to handle only 125 300-kg (276,000-lb) railcars, and portions of the CN secondary main line, which have not been upgraded and which are still subject to the 119 400-kg limit.

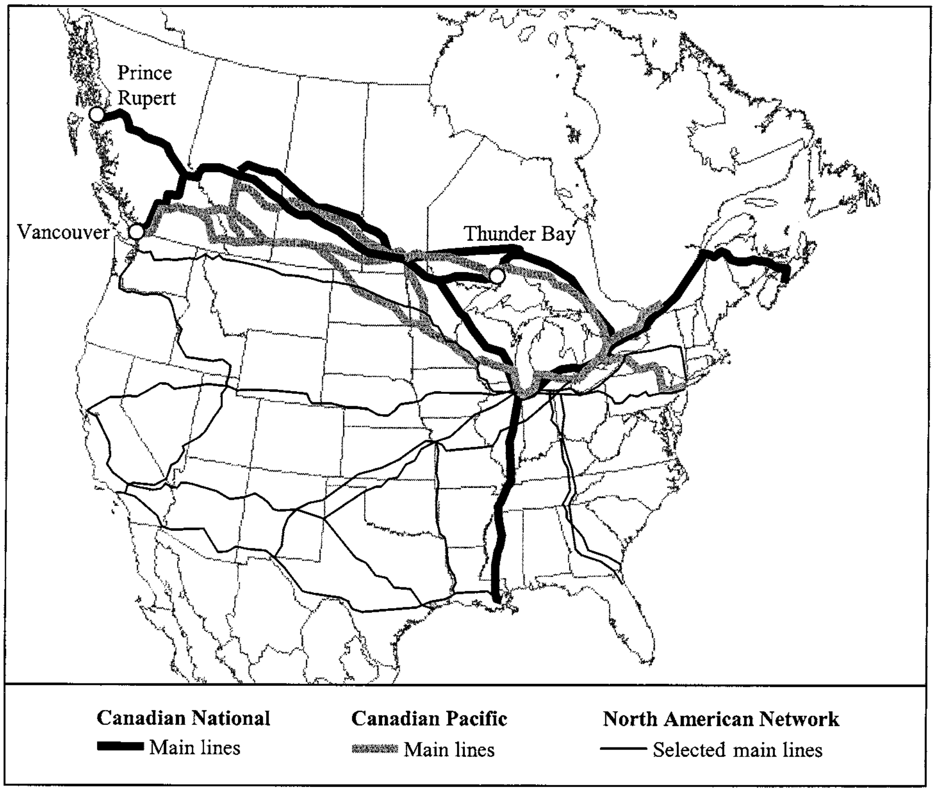

FIGURE 1 Canadian National and Canadian Pacific main lines in North America.

Through branchline rehabilitation and abandonment of lines in poor condition, 97 percent of the feeder network is now subject to railcar weight limits between 119 400 and 129 850 kg. In this analysis, all branchlines are subject to 119 400-kg weight restrictions.

Siding Length

Siding length dictates the maximum practical length of train that can be operated between two terminals. Examination of siding lengths in Western Canada highlights a major difference in operations on CP and CN (*1*). Most sidings on CP have enough capacity to hold a 120-car train. However, most sidings on CN can hold only a 100-car train. Thus, CP has a 20-car advantage over CN on unit grain train movements, and siding length is a constraint on CN when train size is increased. As a competitive response to the fact that five CP trains can do the work of six CN trains, CN has begun to run 150-car trains of empty cars in a single direction on certain routes.

Ruling Grade

The ruling grade of a railway subdivision determines the tractive effort required to move a train at track speed. In unit train operations, these factors can set limits on the maximum practical weight—and therefore the payload—of a train.

To compare the ruling grades of each railway, a standard train of 100 cars with a tare weight of 28 tonnes and a payload of 91 tonnes was analyzed on both CP and CN. Because it is the only road freight locomotive common to both CP and CN, the 2250-kW (3,000-hp) SD40-2 locomotive was selected to measure the power requirements of the standard unit train. The most important conclusion drawn from this analysis is that CP requires, on average, one more SD40-2 locomotive than CN in the eastbound direction. In the westbound direction, CP requires one, two, or three more locomotives. Thus, when train weight is increased, grades are more of a constraint on CP than on CN.

Grain Traffic

In 1997, CP and CN moved approximately 27 million tonnes of grain from the prairie provinces to Thunder Bay, Vancouver, and Prince Rupert in Canada and to the United States. CP moved 56 percent of this grain, whereas CN moved 44 percent (*3*). These figures have been established from a variety of sources and reflect the 1996–1997 crop year. These were the latest data available at the commencement of the research.

Grain traffic density in Western Canada is indicated on the map in Figure 2. The traffic density map was created by obtaining individual grain deliveries to prairie points from the Canadian Grain Commission and integrating them into existing geographic information system railway databases (*4, 5*). Expert knowledge was used to assign direction and routes to the traffic.

From the traffic density map, the amount of grain that each railway can load at a particular weight level can be determined. On CP, one-half of grain traffic can be loaded into railcars weighing 129 850 kg. The remaining half is loaded on branchlines and is restricted to 119 400-kg cars. On CN, 15 percent of grain traffic can be loaded at the 129 850-kg level and 8 percent can be loaded in 125 300-kg cars.

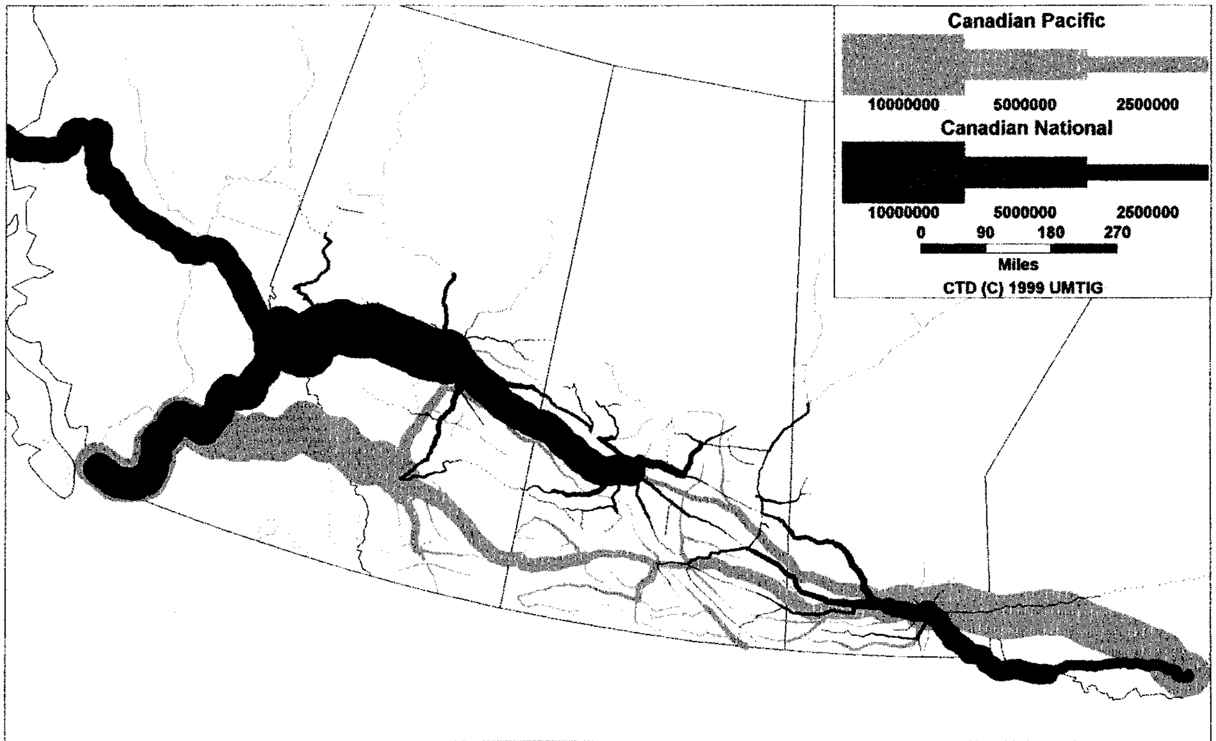

FIGURE 2 Grain traffic density (tonnes per year).

The remaining 77 percent is loaded on branchlines and is restricted to 119 400-kg cars.

NEW RAILWAY TECHNOLOGY

New Locomotive Technology

In the early 1990s, both CP and CN road locomotive fleets were dominated by the SD40-2. This 2250-kW (3,000-hp) locomotive is capable of producing 378 kN of tractive effort at an average adhesion factor of 25 percent.

In the mid-1990s, a variety of new technologies were successfully incorporated into locomotive design. The result was locomotives operating at 3300 kW (4,400 hp) and producing 534 kN of tractive effort at 30 percent adhesion. In theory, the improved capability of the new locomotives allows three new locomotives to replace five older locomotives on a single train. The new locomotives have the additional advantage of being more fuel efficient and reliable than the locomotives that they are gradually replacing.

Both CN and CP have acquired new locomotives in large numbers. CN has purchased 324 locomotives rated between 3000 and 3300 kW (4,000 and 4,400 hp, respectively) from General Electric and General Motors Diesel Division. Although all of CN's new locomotives feature the conventional direct-current (DC) traction system, CP's new high-horsepower locomotives use the alternating-current (AC) traction system.

AC traction is a new system of transferring the power generated by the locomotive's diesel engine prime mover to the wheels. The major problem with the present DC system is the DC traction motors, which are very complex and sensitive to thermal overload and the effects of the environment. AC traction eliminates the problems of the DC system by replacing the DC traction motors with electrical inverters and AC traction motors. The AC motor does not have any of the brushes and commutators found in DC motors. This reduces maintenance, removes the potential for short circuits, and decreases motor slippage. In addition, AC motors have no thermal limit, allowing locomotives to operate at maximum power and slow speeds for long periods of time. Operation at slower speeds allows the generation of more tractive effort. The combination of reduced motor slippage and higher resistance to thermal loads allows AC traction locomotives to develop adhesion levels between 38 and 42 percent.

Currently, the CP fleet of AC4400CW locomotives manufactured by General Electric totals 284 units. These six-axle locomotives use AC traction technology to produce 3300 kW (4,400 hp) and 645 kN of tractive effort. CP has also purchased 65 SD90MAC locomotives from General Motors Diesel Division. When fitted with the new General Motors prime mover, the SD90MAC can produce 4500 kW (6,000 hp) and an estimated 756 kN of tractive effort. This level of performance allows one SD90MAC locomotive to replace two SD40-2 locomotives in main-line service.

CN has not invested in AC traction locomotives. As discussed in a later section, CN has mild grades on its transcontinental main line. CN officials cited the mild grades, in combination with short train lengths, to explain the decision not to incur the extra expense of AC traction locomotives. Train performance simulation demonstrates that AC traction locomotives are most advantageous when operating heavy trains on steep grades, as on the CP main line in Western Canada (*1*).

New Freight Car Technology

A fundamental fact of freight transportation systems is that the level of resistance per unit of payload decreases as the overall payload

TABLE 1 Specifications of New Covered Hoppers

	Current	New A	New B	New C
Capacity (m^3)	127.4	144.2	135.8	148.4
Load Limit (kg)	90830	101470	102150	102600
Tare Weight (kg)	27970	28380	27700	26970
Gross Railcar Weight (kg)	118800	129850	129850	129570
Length (m)	18	18	17	17

capacity of a vehicle increases. This decrease in resistance translates into a decrease in the energy and cost required to move each unit of payload. Railways have applied this theory and increased four-axle railcar gross weight levels from 80 350 and 99 900 kg to 119 400 kg during the 1970s and 1980s (*6*). The technology of freight cars in Canada is changing once again with the introduction of four-axle gross railcar weights of 129 850 kg.

New Covered Hopper Cars

Today, the majority of the covered hoppers in grain service are the cylindrical-style covered hoppers purchased by the Canadian federal government in the 1970s and 1980s. These cars operate at a gross railcar weight of 118 800 kg, carry 90.7 tonnes of payload, and are 18 m in length. The fleet of 90.7-tonne cylindrical covered hoppers is now being replaced by covered hoppers that use advances in materials and construction techniques to reduce tare weight while increasing gross railcar weight and increase cubic capacity while decreasing overall length.

The new hopper cars operate at a gross railcar weight of 129 850 kg and carry a payload of 102 tonnes. The specifications of both the current 90.7-tonne hoppers and three types of the new 102-tonne hoppers are outlined in Table 1 (*7, 8*). Two of the new designs are shorter than the current covered hopper, even though they still have an increased cubic capacity. This is accomplished by the use of an inverted-teardrop shape in cross section, which uses space much more efficiently than the current cylindrical shape.

Because of their shorter lengths and greater payload capacities, the new covered hopper cars allow railways to operate unit trains in more efficient consists. Two possible consists of 129 850-kg, 17-m hoppers are outlined in Table 2, along with two existing unit train consists. The consists are conservative with respect to train length, as they reflect the most tightly constrained routes. As a result of the new consists, both CP and CN gain 20 percent increases in payload per unit train. Thus, five of the new trains can do the work of six of the current trains.

New Freight Car Trucks

The introduction of railcars with increased gross weights prompted the introduction of new freight car trucks capable of carrying the increased loadings. The standard 30-tonne-per-axle truck is being replaced by a 33-tonne-per-axle truck. The Association of American Railroads (AAR) Heavy Axle Load test program at the Transportation Technology Center has conducted extensive research and full-scale testing to determine the impact of the switch to the heavier trucks. Research in Phases 1 and 2 of the program compared the 30- and 33-tonne-per-axle trucks and determined that track maintenance costs are expected to increase by 20 to 40 percent (*9*).

Additional research into the effect of the increased loading on the fatigue life of the railway infrastructure has also been conducted. Full conversion to the 129 850-kg loading, equivalent to 33 tonnes per axle, will result in a 25 percent shorter life (*10*). If it is assumed that the same total amount of maintenance activity is being performed over the reduced life, a life reduction of 25 percent will result in a 33 percent increase in maintenance activity per year. The corresponding 33 percent increase in maintenance costs agrees with the results of the AAR Heavy Axle Load operations.

METHOD OF ANALYSIS

Defining Scenarios

To determine the impact of new railway technology on main-line unit grain train operations, various scenarios are created. Scenarios are defined by changing the various parameters of the transportation and flow systems to reflect new railway technology. The transportation system parameters describe the types of locomotives and grain cars in use. The flow system is derived from the grain traffic density map. The main parameter in the flow system is the gross railcar load at which grain can be loaded at any specific point. This value can vary from 119 400 to 129 850 kg. From these parameters and infor-

TABLE 2 Possible Unit Train Consists

	Canadian Pacific		Canadian National	
	Current	New	Current	New
Number of Cars	113	120	100	106
Train Length[a] (m)	2034	2040	1800	1802
Train Weight (tonnes)	13420	15550	11880	13730
Train Tare (tonnes)	3160	3236	2797	2859
Payload (tonnes)	10260	12310	9083	10870
Increase in Payload (percent)	-	20.00	-	19.67

[a] Excluding locomotives.
- Not applicable.

mation on siding length and ruling grade, appropriate train consists are developed. Given the capacity of each train consist and the traffic density on a particular railway subdivision, equipment and crew requirements are calculated for each railway subdivision across Western Canada. These values are then used as inputs to an engineering unit cost model to determine the average cost per tonne of unit train operation on main lines.

Specifically, for each main-line subdivision in Western Canada, the required numbers of loaded trains, crews, locomotives, and covered hoppers are calculated. These values are used to determine the number of car kilometers, locomotive kilometers, train kilometers, and gross tonne kilometers accumulated on the subdivision.

To conduct this analysis, it is assumed that all grain traffic moves in unit grain trains. Thus, the required number of loaded trains can be calculated by dividing the volume of grain traffic by the payload capacity of each train. This is a valid method, as the covered hopper cars are sized to reach their weight limit before the cubic capacity of the car is filled with grain. Given that a locomotive can complete an average round trip in 5 to 6 days, it is assumed that each locomotive makes 60 round trips per year. The number of locomotives is increased by 15 percent to account for peak demand periods and spare units for maintenance. Currently, the railways are moving toward 9- to 10-day car cycles (*8*). Over the 43 weeks that the railways move grain traffic, cars in these cycles could make 31 loaded trips. An allowance of 5 percent on the number of cars is made to account for car maintenance and peak demand. Finally, it is assumed that a two-person crew operates each train across a single railway subdivision.

Development of Annual Long-Run Variable Costs

Railway cost estimates are developed through the use of a railway cost model prepared for Transport Canada. The cost estimates focus on a long-run movement and do not account for switching and branchline operating costs. This cost structure can be used, as only unit train operations are being considered. The final output of the model is the current average cost per tonne for all main-line railway movements being considered during a 1-year period (*2*).

This analysis assumes that the equipment currently used in unit grain train operations is at the end of its useful service life and must be replaced by either a new locomotive or a new freight car that is identical to the one being replaced or by a new locomotive or a new freight car that implements new technology. If new technology is not implemented, the model assumes that the railway will incur the capital cost of replacing its current locomotive and freight car fleets with new equipment that does not make use of new technology.

The model takes an incremental approach to cost estimates and examines costs in 10 areas: train crew, fuel, locomotive maintenance, freight car maintenance, roadway maintenance, other transportation expenses, locomotive capital, freight car capital, roadway capital, and general expenses.

EVALUATION OF NEW TECHNOLOGY ON EXISTING INFRASTRUCTURE

The scenarios presented in this section are designed to determine the impacts of new locomotive and freight car technologies on the existing infrastructure. Thus, the current main-line weight restrictions are held constant. New, heavier freight cars are loaded at the higher weight levels only when they are loaded at points on lines that have already been upgraded.

Description of Scenarios

Four scenarios for each of the two railways involving the operation of new technology on the existing infrastructure are considered in this section. The scenarios follow the general pattern of a base case, a scenario with a new locomotive, a scenario with new locomotives and cars on main lines, and a scenario with new locomotives and cars on all lines. Details of each scenario follow.

Canadian Pacific

- CP1base. The CP1base scenario models the operations on CP before the introduction of new railway technology. Grain is moved in 120-car trains of 90.7-tonne hoppers to Thunder Bay and 113-car trains of 90.7-tonne hoppers to Vancouver. Each of the 90.7-tonne hoppers has a gross railcar weight of 119 400 kg and can carry 90 800 kg of payload. The locomotives are the CP SD40-2 with a tractive effort of 378 kN.
- CP2newlocos. The CP2newlocos scenario determines the impact of the new AC traction locomotives without a change in freight car technology. The 90.7-tonne hopper car train configurations in this case are the same as those used in the CP1base scenario. The new CP AC4400CW locomotives are assigned a tractive effort of 645 kN.
- CP3newlocos_cars. Both new locomotives and new freight cars are implemented in the CP3newlocos_cars scenario, but some of the old cars are retained for branchline service. Grain loaded at the 119 400-kg weight level is moved in 113- or 120-car trains of 90.7-tonne hoppers. Grain loaded at the 129 850-kg level is moved in 120- or 125-car trains of 102-tonne hoppers. The AC4400CW is used to move all trains.
- CP4newlocos_crs_all. The CP4newlocos_crs_all scenario implements the new technology to the fullest extent possible without upgrading the infrastructure. All 90.7-tonne hoppers are replaced with 102-tonne hoppers. If loaded at points not served at the 129 850-kg weight level, the new cars are filled with only 90.7 tonnes of payload. Because the new cars are shorter, more of the cars can be included on each train. Grain loaded at the 119 400-kg level is moved in 120- or 125-car trains of 102-tonne hoppers loaded with 90.7 tonnes of payload. Grain loaded at the 129 850-kg weight level is moved in 120- or 125-car trains of 102-tonne hoppers loaded to capacity. The AC4400CW is used to move all of the trains.

Canadian National

- CN1base. The CN1base scenario evaluates operations on CN before the implementation of new railway technology. All grain is moved in 100-car trains of 90.7-tonne hoppers. Each of the 90.7-tonne hoppers has a gross railcar weight of 119 400 kg and can carry 90 800 kg of payload. The scenario uses CN SD40-2 locomotives.
- CN2newlocos. The CN2newlocos scenario determines the impact of the new high-horsepower DC traction locomotives without a change in freight car technology. The 90.7-tonne hopper car train

configurations are identical to those in the CN1base scenario. The new CN C44-9W locomotives are assigned a tractive effort of 423 kN.

- CN3newlocos_cars. In the CN3newlocos_cars scenario, both new locomotive technology and new freight car technology are implemented, but some of the old cars are retained for branchline service. Grain loaded at the 119 400-kg weight level is moved in 100-car trains of 90.7-tonne hoppers. Traffic moving to Prince Rupert at the 125 300-kg level is handled by 106-car trains of 102-tonne hoppers loaded with 98 tonnes of payload. Grain loaded at the 129 850-kg level is moved in 106-car trains of 102-tonne hoppers. The C44-9W is used to move all of the trains.
- CN4newlocos_cars_all. The CN4newlocos_cars_all scenario implements the new technology to the fullest extent possible under the current railcar weight restrictions. New 102-tonne hoppers replace the 90.7-tonne hoppers. When loaded at points not served at the 129 850-kg weight level, the new cars are filled with only 90.7 or 98 tonnes of payload when required to move on railcars at the 119 400- or 125 300-kg weight level, respectively. Because the new cars are shorter, more of the cars can be included on each train. Grain loaded at the 119 400-kg level is moved in 106-car trains of 102-tonne hoppers loaded with 90.7 tonnes of payload. Traffic destined for lines restricted to the 125 300-kg level is moved in 106-car trains of 102-tonne hoppers loaded with 98 tonnes of payload. As in the previous scenario, grain loaded at the 129 850-kg weight level is moved in 106-car trains of 102-tonne hoppers loaded to capacity. The C44-9W is used to move all of the trains.

Evaluation of CP Scenarios

The results of the analysis of new technology on the existing CP infrastructure are summarized in Table 3. Table 3 illustrates the total cost per tonne (in 1998 Canadian dollars) of the unit train movements and the number of trains, locomotives, and freight cars required for each of the four scenarios with new technologies (the CP5all286 scenario is discussed in a later section) and the base case. The operational costs of each scenario are summarized in Figure 3.

New Locomotives

Introduction of the new AC traction locomotives, as simulated in the CP2newlocos scenario, results in a C$0.85 decrease in the total cost per tonne of unit train operations on CP. A total of 79 new 3300-kW (4,400-hp) AC traction locomotives are required to perform the work of 114 old 2250-kW (3,000-hp) SD40-2 locomotives. This represents a replacement ratio of 7 new locomotives for every 10 old locomotives. As shown in Figure 3, the cost savings occur in the areas of locomotive maintenance (35 percent decrease) and fuel (10 percent decrease). Because the hopper cars used in the unit trains remain unchanged, all other operational costs remain the same. In terms of capital cost, the increased purchase price of the new locomotives is balanced by the fact that fewer of the locomotives are required. Thus, the capital cost for the scenario involving new locomotives is the same as that for the base case.

Combination of New Locomotives and Hopper Cars

In the CP3newlocos_cars scenario, both the new locomotives and the new freight cars are implemented, but grain loaded at the 119 400-kg level is still moved in the old 90.7-tonne hoppers. The combined introduction of the new covered hoppers to grain being moved at the 129 850-kg level and the new AC traction locomotives to all trains results in a total cost decrease of C$1.69 per tonne compared with the cost for the base case. All costs except roadway maintenance costs decrease. Roadway maintenance costs increase by 4 percent.

In the CP4newlocos_cars_all scenario, the new hopper cars and the new locomotives are implemented on all trains. Grain loaded at the 119 400-kg level is moved in new 102-tonne covered hoppers filled with 90.7 tonnes of payload. These train configurations further reduce the cost to C$16.93 per tonne. This cost reduction is the result of a 15 percent decrease in the number of trains required, a 40 percent decrease in locomotive maintenance, a 22 percent decrease in fuel consumption, and a reduction in freight car maintenance by 7 percent. The impact of the new freight cars on the infrastructure is minimal, as roadway maintenance expenses increase by only 3 percent. The areas that experience the greatest impacts are the secondary main line from Saskatoon to Winnipeg, the main line from Portage to Winnipeg, and the main line to the United States between Moose Jaw and Portal.

Conclusions

Overall, the analysis of the CP scenarios indicates that the new locomotive and freight car technology can be implemented on the existing infrastructure and decrease the cost of main-line unit train operation by C$2.00 per tonne or C$32 million annually.

Evaluation of CN Scenarios

The results of the analysis of scenarios implementing new technology on the existing CN infrastructure are summarized in Table 4. Table 4 illustrates the total cost per tonne of the unit train movements and the number of trains, locomotives, and freight cars

TABLE 3 Comparison of CP Cases

	CP1base	CP2	CP3	CP4	CP5
$/tonne [a]	18.91	18.06	17.22	16.93	16.49
Trains	1436	1436	1312	1253	1190
Locomotives	114	79	72	70	67
Covered Hopper Cars	5706	5706	5369	5319	5017

[a] 1998 Canadian Dollars.

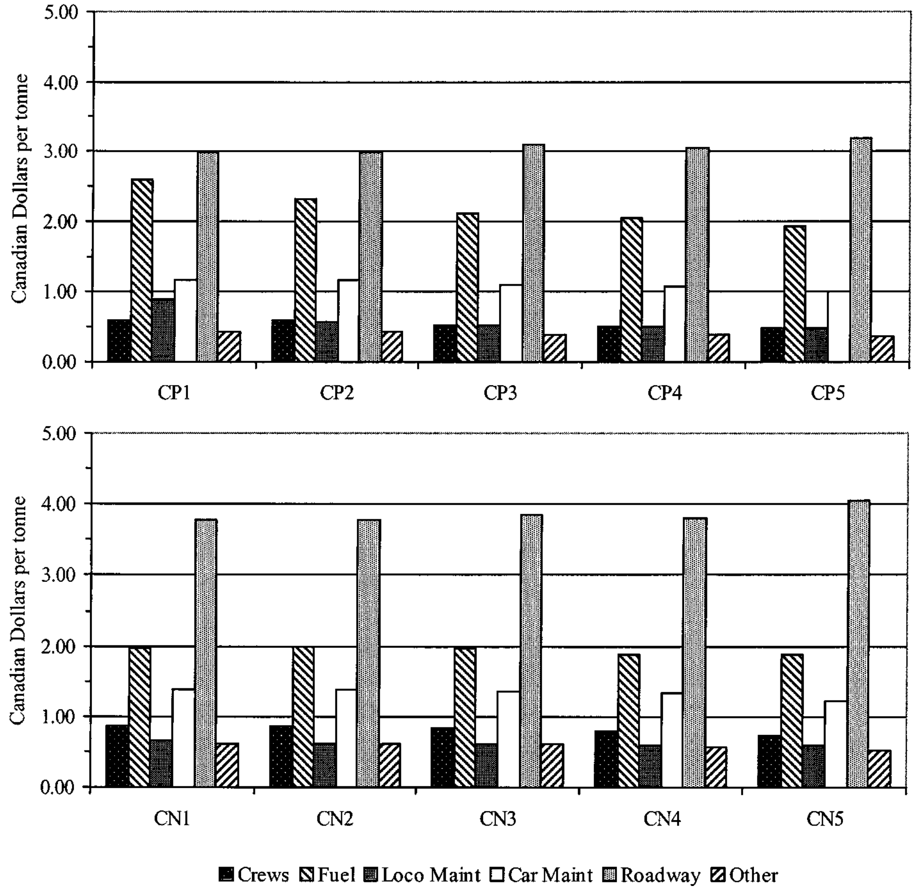

FIGURE 3 CP and CN operational cost comparison.

required for each of the four scenarios with new technologies (the CN5all286 scenario is discussed in a later section) and the base case. The operational costs of each scenario are summarized in Figure 3.

New Locomotives

Introduction of the new high-horsepower locomotives, as simulated in the CN2newlocos scenario, results in only a C$0.07 decrease in the total cost per tonne of unit train operations on CN. A total of 57 new 3300-kW (4,400-hp) DC traction locomotives are required to replace 63 old 2250-kW (3,000-hp) locomotives. Thus, CN does not achieve the locomotive replacement ratio required to obtain substantial operating and capital cost reductions. This is because two 2250-kW (3,000-hp) locomotives can handle the relatively short trains and moderate grades on many CN lines. Because one 3300-kW (4,400-hp) locomotive cannot replace two of the older locomotives, two new locomotives must be assigned and no reduction in the number of locomotives is achieved.

Combination of New Locomotives and Hopper Cars

In the CN3newlocos_cars scenario, both the new locomotives and the new freight cars are analyzed. In this scenario, grain loaded at the 119 400-kg level is still moved in the old 90.7-tonne hoppers. The combined introduction of the new covered hoppers to grain being moved at the 125 300- and 129 850-kg levels and the new high-horsepower locomotives to all trains decreases the cost of

TABLE 4 Comparison of CN Cases

	CN1base	CN2	CN3	CN4	CN5
$/tonne[a]	19.76	19.69	19.55	19.10	18.85
Trains	1356	1356	1310	1240	1133
Locomotives	63	57	58	56	59
Covered Hopper Cars	4593	4593	4490	4452	4068

[a] 1998 Canadian Dollars.

transporting grain by C$0.21 per tonne compared with the cost for the base case. All costs except roadway maintenance costs decrease. Roadway maintenance costs were increased, as elevated railcar weights increase maintenance costs by 2 percent.

The implementation of the new hopper cars and the new locomotives on all trains is analyzed in the CN4newlocos_cars_all scenario. The new train configurations reduce the cost of transporting grain on main-line unit grain trains to C$19.10 per tonne. This cost reduction is the result of a 10 percent reduction in the numbers of trains and crews required. Locomotive maintenance decreases by 10 percent, fuel consumption decreases by 5 percent, and freight car maintenance decreases by 4 percent. The impact of the new freight cars on the infrastructure is minimal, as roadway maintenance expenses only increase by 1 percent.

Conclusions

Overall, the analysis of the CN scenarios indicates that the new locomotive and freight car technology can be implemented on the existing infrastructure and decrease the cost of main-line unit train operation by C$0.66 cents per tonne or C$8 million annually. The benefits of the new technology on the existing CN infrastructure are minimized by ruling grades that do not allow locomotive unit reduction and weight restrictions that allow only a small portion of CN grain traffic to move in new covered hoppers loaded to the 102-tonne limit.

NEW TECHNOLOGY WITH IMPROVED INFRASTRUCTURE OR ABANDONED BRANCHLINES

The previous section demonstrates that new railway technology can decrease the cost of unit grain train operations on the existing infrastructure without increasing railcar weight restrictions. This section examines the impact of allowing all of the grain traffic to move at the new higher railcar weight restrictions. Increasing the amount of grain that can move at higher weight levels can be accomplished by a combination of two methods. The first is to improve the infrastructure and increase the weight restrictions on all lines, allowing the new freight cars to be loaded to their maximum capacities at all of the grain delivery points. The second method is to continue with rationalization of the branchline and elevator system. The construction of new terminals, closure of smaller elevators, and abandonment of branchlines attract more grain to main-line loading points. Since these main-line points are on lines that have already been upgraded, more grain can be moved at the higher weight level.

Because both of these factors will act together to eventually convert all of the traffic to the new 102-tonne cars, it is impossible to assign a cost to the conversion. If all of the branchlines are upgraded, a significant capital investment would be required by the railways. If all of the branchlines are abandoned and grain delivery is consolidated at terminals on previously upgraded main lines, the cost to the railways may be very small. However, the cost of conversion will be shifted to other components of the grain transportation system through the construction of new terminal elevators, longer truck hauls, and increased highway maintenance. For this reason, the scenarios presented in this section are done so as to determine the additional benefit of moving more of the grain traffic at higher weight levels. Since an incremental cost cannot be assigned to the upgrades or conversion, the absolute benefit and the actual cost of operation of the new scenario cannot be determined.

Description of Scenarios

The CP scenario involving upgrading of the infrastructure is given the code CP5all286. In this scenario, all CP grain traffic is transported at the 129 850-kg level. All of the traffic moves in 120- or 125-car trains of 102-tonne hoppers loaded to capacity and is pulled by new AC4400CW locomotives.

The CN scenario involving upgrading of various CN lines to the 129 850-kg level is coded CN5all286. In this case, all CN traffic is allowed to move at the 129 850-kg level, with C44-9W locomotives pulling 106-car trains of 102-tonne hoppers loaded to capacity.

Evaluation of CP Scenarios

Conversion of all traffic to 129 850-kg hopper cars carrying 102 tonnes of payload decreases the cost of unit train grain transport on main lines by C$2.42 to C$16.49 per tonne. When applied to all CP grain traffic, this represents a potential savings of C$37 million per year. The amount of this savings that is actually realized depends on the method of conversion, as described earlier. Full conversion to 129 850-kg hoppers results in a decrease in the number of trains by 20 percent compared with the number in the base case. This means that instead of delivering five loaded unit grain trains each day during the shipping season, CP will be required to deliver only four trains each day with no change in total traffic or revenue. In addition to a reduction in the number of trains, the number of locomotives required decreases by 40 percent, whereas the number of hopper cars decreases by 12 percent.

The only area in which costs are significantly increased is in roadway maintenance, for which costs increase by 8 percent on all main lines. At the same time, the fatigue life of the infrastructure is decreased by 25 percent. This indicates that civil engineers can expect more defects and will need to accelerate maintenance programs when all of the grain traffic is converted to the new 102-tonne covered hopper cars.

Evaluation of CN Scenarios

The full conversion of all CN grain traffic to the 129 850-kg weight level is analyzed in the CN5all286 scenario. Full conversion of the traffic will decrease the cost of main-line grain transport by C$0.91 to C$18.85 per tonne. This results in overall savings of C$11 million per year. Costs are reduced by approximately 15 percent in the areas of crew wages, locomotive maintenance, and hopper car maintenance. The decrease in hopper car maintenance is the result of a 10 percent decrease in the required number of covered hopper cars.

In terms of operations, the total number of unit trains required is decreased by 17 percent. Instead of delivering 28 loaded unit grain trains per week during the shipping season, CN will be required to deliver only 23 unit trains per week, with no change in total traffic or revenue. This will increase capacity on CN main lines and reduce delays to priority trains by decreasing the number of meets between trains. Just as with the CP full conversion scenario, all of the CN lines experience an 8 percent increase in maintenance costs.

CONCLUSIONS

The introduction of new railway technology to unit grain train operations in Western Canada affects railway technical productivity, infrastructure, and costs. Operations are positively affected, as the new equipment facilitates a reduction in the numbers of unit trains and crews required to transport grain. If the new technology is fully implemented on all lines, CP will be required to operate only 28 instead of 35 unit grain trains per week, whereas CN will be required to operate only 23 instead of 28 unit trains per week. The 20 percent decrease in the number of trains will free capacity on main lines for other traffic and reduce delays to priority trains by eliminating many main-line train meets.

New covered hopper cars operating at higher gross railcar weight levels do have a negative impact on the railway infrastructure. However, if the new technology is implemented on the existing infrastructure, a decrease in the total number of trains more than offsets increases in required maintenance. On CP, this amounts to a 3 percent increase, whereas CN experiences a 1 percent increase. When fully implemented and applied to all traffic on all lines, both CP and CN experience 8 percent increases in maintenance costs. This indicates that the railways will be required to monitor the infrastructure closely to ensure that it is performing adequately.

The slight increases in maintenance costs created by the new technology are not enough to offset the cost savings created by decreases in the number of trains and the amount of equipment required. Without improving infrastructure, the new technology allows a cost reduction of C$32 million per year on CP and C$8 million per year on CN. Over a 30-year service life, this amounts to savings of C$260 million. By improving the infrastructure or abandoning branchlines with restricted loading—with the latter being the chosen course—further cost reductions are obtained. Overall, the implementation of new technology on grain-related railway operations in Western Canada will result in a system that is more efficient for the railways and additional system capacity by reducing the number of trains required.

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