CASE STUDY ANALYSIS OF FACTORS INFLUENCING THE ADOPTION OF HEAVY AXLE LOADING ON CANADIAN SHORT-LINE RAILROADS

by

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ABSTRACT

The purpose of this research is to analyze factors influencing the adoption of heavy axle loading (HAL) on short-line railroads in Canada. The research comprises a series of case studies which characterize selected Canadian short-line railroads. The approach stratifies the industry in terms of the type of ownership and geographic region. It also documents factors influencing the adoption of HAL for each railroad by examining the commodities it hauls (internal motivation) and its network connections to the Class 1 system (external motivation). Where available, infrastructure condition data are also reported. These studies revealed that all of the 31 railroads studied exhibited a medium-high or high overall motivation to adopt HAL. This reflects the nature of the short-line industry in Canada—filling a niche by hauling primarily heavy commodities (thereby providing internal motivation) while relying on Class 1 partners to offer complete services to their customers (thereby providing external motivation).

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this research is to analyze factors influencing the adoption of heavy axle loading (HAL) on short-line railroads in Canada. The research comprises a series of case studies which characterize selected Canadian short-line railroads in terms of three primary factors: the predominant commodities hauled by the short-line railroad, the current condition of its rail infrastructure, and its connectivity to the Class I network. The intent of the research is to reveal issues faced by Canadian short-line railroads when considering adoption of HAL.

1.2 BACKGROUND AND NEED

Since the deregulation of North America's freight rail industry in 1980, short-line railroads have evolved into an extensive and complex system that provides vital linkages within the freight transportation network, particularly in markets and regions unserved by the Class I system (McKinstry & Bounajm, 2010). While Class I railroads have focused on streamlining their businesses for high-volume shippers, the short-line industry in both Canada and the United States aims to offer flexible service for smaller customers (American Short Line and Regional Railroad Association, 2014). Often, a short-line's operations depend on a single commodity and rely on linkages with Class I partners (Babcock & Sanderson, 2004).

Class I carriers have driven the adoption of HAL—that is, the shift from 263-kip (263k) railcars with 33-ton axle loads to 286-kip (286k) railcars with axle loads up to 36 tons—because of the transportation cost reductions afforded by operating rail cars with heavier axle loads. Such a shift required major capital and ongoing infrastructure investments. Research conducted over the past two decades has been directed at evaluating the economic feasibility of HAL within the Class I system, and ultimately provided the technical and economic support for HAL implementation (Babcock & Sanderson, 2004). Although full penetration of 286k railcars into the fleet has not yet occurred, the implementation of HAL has provided cumulative benefits of $6 billion (from 1994 to 2010) and annual benefits between $600 and $700 million in 2010 (Martland, 2013).

The benefits of HAL, however, do not necessarily extend to short-line carriers, as the increased loading (from 263k to 286k) disproportionately impacts short-line railroads relative to Class I carriers if this shift necessitates major infrastructure investments where traffic volumes may not warrant such expenditures. Nevertheless, for certain short-lines to remain viable within the markets they serve, there may be pressures to adopt 286k railcars and absorb the concomitant capital and track maintenance costs. The nature and intensity of these pressures depend on the specific characteristics (e.g., routes, type of service, infrastructure condition, railcar characteristics) of the short-line railroad. Relatively little research—particularly Canadian research—has been conducted to understand how these characteristics influence decisions to adopt HAL.

This thesis aims to contribute to an improved understanding of the factors influencing HAL adoption in the Canadian context. Utilizing publicly available data, three factors will be considered:

Commodities: The types and properties of commodities hauled by the short-line influence the extent to which the short-line could realize the potential benefits of adopting HAL. For example, a short-line which primarily hauls high-density commodities may be more motivated to adopt HAL than a short-line which primarily hauls low-density commodities.

Infrastructure: The condition of the a short-line's infrastructure influences its ability to safely and efficiently convey heavy axle loads. Key infrastructure components include the rail, ties, ballast, and bridges. For example, the decision to adopt HAL may necessitate higher capital expenditures for a short-line with primarily light rail sections compared to a short-line with mainline rail weights.

Connectivity: The connectivity of a short-line railroad to the Class I system influences the type of service that it offers and its ability to link customers and/or commodities with markets. Some short-lines depend substantially on the Class I system and thus rely on effective connections with Class I networks. Others, however, operate entirely independently from the Class I system. Thus, the type of connectivity to the Class I system affects the short-line's need to implement HAL.

1.3 OBJECTIVES AND SCOPE

This research discusses factors that influence the decision to upgrade infrastructure to accommodate HAL in the context of the Canadian short-line industry. Specifically, the objectives of the research are:

- to review the impacts of HAL on short-line railroads;
- to develop an analytical framework for assessing factors that may motivate Canadian short-line railroads to adopt HAL; and
- to apply the analytical framework using a series of case studies representing the range of issues and operating circumstances relevant for short-line railroads in Canada.

The research and analysis conducted pursuant to these objectives rely on published works and publicly-available industry data. Moreover, as no systematic source of data on the level of implementation of HAL by the Canadian short-line is currently available, the findings of the analysis are not intended as a means of identifying candidates for HAL implementation. Numerous factors influence decisions to implement HAL and the degree to which the adoption of HAL will affect a short-line's operation. This thesis focuses on three factors— commodities, infrastructure, and connectivity—for which relevant information could be gathered. Only linear assets are considered in the infrastructure condition assessment; the assessment excludes all structures. Finally, analysis of the economic effects of HAL have been discussed but not included explicitly in the analysis and infrastructure is limited to linear assets and excludes all structures.

1.4 RESEARCH APPROACH

The transportation systems analysis approach provides the framework within which the factors influencing decisions to adopt HAL will be considered. Initially proposed by Manheim (Manheim, 1979), this approach involves three interrelated components, namely:

- The activity system (A), which for the context of this research includes the socio-economic factors that generate the demand for freight transportation on the short-line network;
- The transportation system (T), which for the context of this research includes the physical railroad infrastructure, the cars and train consists used to haul freight from origin to destination, and the regulations governing these movements; and
- The flow system (F), which characterizes the magnitude and nature of short-line rail movements (e.g., tonnage between origin and destination).

As depicted in Figure 1-1, the transportation systems analysis approach is often applied by characterizing the transportation supply (T) and demand (A) to predict future flows. Moreover, the approach recognizes that, over time, these flows influence both supply and demand. Predicting future flows is beyond the scope of this thesis; however, the approach nevertheless offers a useful framework for categorizing the numerous factors that influence decisions concerning HAL implementation.

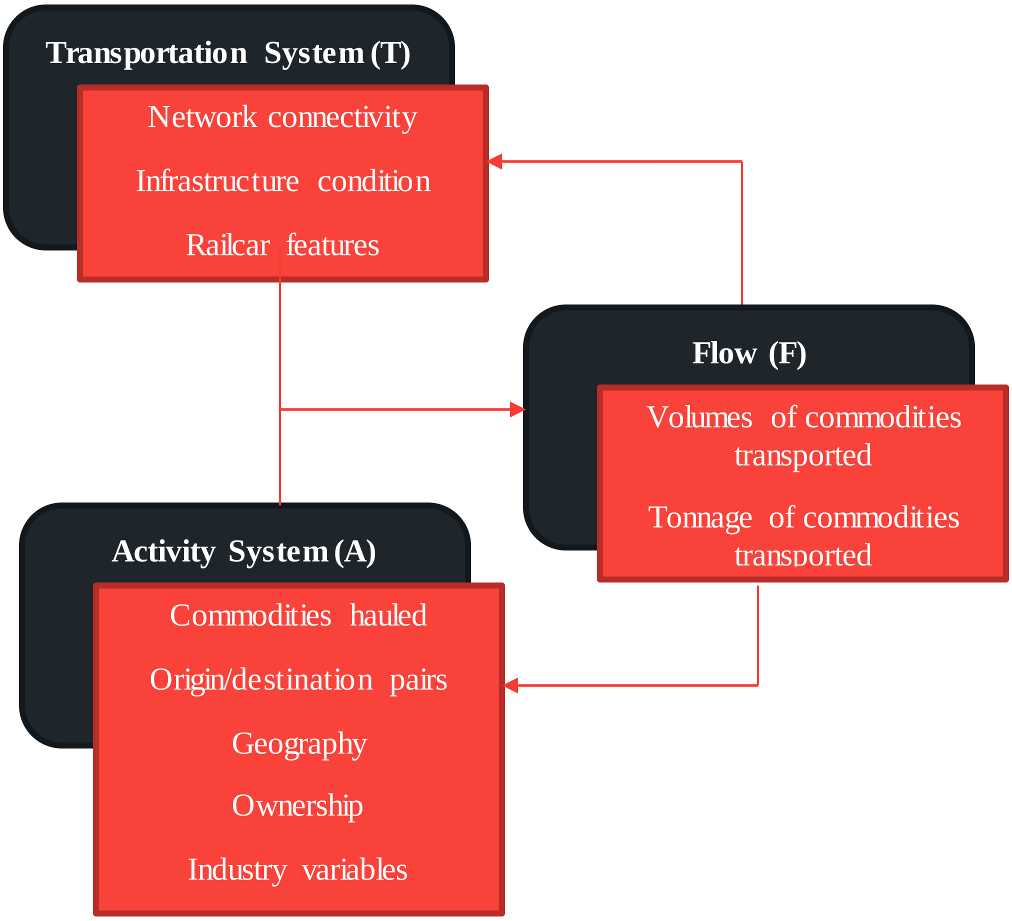

Figure 1-1: Transportation system

Within the broad transportation systems analysis approach, the thesis utilizes case studies to reveal relevant issues for Canadian short-line railroads considering the adoption of HAL. Despite a lack of systematic, publicly-available data, the case studies reveal pertinent issues facing the Canadian short-line industry.

1.5 THESIS ORGANIZATION

This thesis consists of five (5) chapters, including this introductory chapter. Chapter 2 provides an overview of the short-line industry in North America and describes the evolution and impacts of HAL, including the potential effects of adopting HAL within the short-line industry.

Chapter 3 describes the analytical framework developed and applied in this research. To support the selection of representative case studies, the chapter first stratifies Canada's short-line rail industry by ownership classification and geography. Second, the chapter describes the factors influencing the adoption of HAL by Canadian short-line railroads, namely: (1) commodities hauled; (2) infrastructure condition; and (3) network connectivity. The final section of the chapter describes the case study selection and outlines the case study analysis.

Chapter 4 presents the case studies by applying the analytical framework developed in Chapter 3. The chapter summarizes and discusses the key case study findings.

Chapter 5 summarizes the findings from this research and makes recommendations for future research.

2 OVERVIEW OF THE SHORT-LINE INDUSTRY AND HEAVY AXLE LOADING IN NORTH AMERICA

This chapter provides an overview of short-line railroads in North America and the evolution and impacts of HAL, including the potential effects of adopting HAL within the short-line industry.

2.1 SHORT-LINE RAILROADS IN NORTH AMERICA

Since the introduction of the *Staggers Act (1980)*, the United States has seen a 260% increase in the number of short-line railroads (Allen, Sussman, & Miller, 2002). Similarly, the *Canada Transportation Act (1996)* prompted the rise of the short-line industry in Canada; the number of short-line railroads grew from 12 in 1996 to 50 in 2009 (Railway Assoication of Canada, 2011). The short-line industry, in Canada, accounts for approximately 20% of all track miles and generates approximately $650 million in annual revenue (McKinstry & Bounajm, 2010). Very little traffic originates and terminates on a short-line; most short-line railroads feed traffic into and deliver traffic from the mainline system. The short-line railroads provide a vital link to the North American transportation system by allowing shippers access to a vast Canadian and American rail network, a link that would potentially otherwise be abandoned.

2.1.1 REGIONAL AND SHORT-LINE RAILROADS IN THE UNITED STATES

The *Staggers Act (1980)* allowed for the deregulation of the railroad industry, "providing the industry increased flexibility to adjust their rates and tailor services to meet shipper needs and their own revenue requirements" (Palley, 2011) and further allowing more flexible options for entry into and exit from the railroad business. Class

I railroads have become more streamlined and cost-effective, choosing to focus on a "wholesale type of business" (Allen, Sussman, & Miller, 2002), while catering to high volume shippers, allowing the carrier to run high speed, intermodal trains longer distances. This shift has allowed short-line railroads to enter the market and cater to smaller customers, "requiring time intensive switching and slow speed operations (that have been) deemed less profitable by the Class I carriers" (Allen, Sussman, & Miller, 2002).

There are three classes of railroad carriers in the United States, classified based on annual operating revenue. According to the Association of American Railroads (AAR), the Class I carriers generate more than $433.3M while accounting for 69% of route mileage, 90% of rail employees, and 94% of freight revenue (Association of American Railroads, 2013). The Class II or Regional carriers generate between $34.7M and $433.3M and operate a minimum of 350 miles of track while Class III or short-line carriers generate less than $34.7M and include all switching and terminal companies regardless of operating revenue (American Short Line and Regional Railroad Association, 2014). Most literature interchanges the terms short-line and regional, regardless of operating revenue. The United States currently has seven (7) Class I carriers and 561 non-Class I carriers (Allen, Sussman, & Miller, 2002), all of which are regulated by the Federal Railway Administration (FRA) with all Class I financials reported to and regulated by the Surface Transportation Board (STB).

2.1.2 SHORT-LINE RAILROADS IN CANADA

The *Canada Transportation Act* of 1996 allowed for the deregulation of the Canadian railroad industry, growing the short-line railroad sector from 12 short-lines in 1966 to approximately 42 short-lines in 2013. Following the *Canada Transportation Act*, Canadian National and Canadian Pacific, Canada's two (2) Class I carriers, sold or leased their low-density segments to short-line carriers. (McKinstry & Bounajm, 2010) The Railway Association of Canada (RAC) classifies railways primarily based on operational characteristics. Freight – Class I railroads generate more than $250M in annual revenue and operate approximately 80% of route mileage. Freight – short-line/Regional railroads generate less than $250M in annual revenue, originate approximately 28% of total railway tonnage and transport approximately 5% of the industry's total revenue tonne-kilometer (km) (McKinstry & Bounajm, 2010). All carriers that operate international or interprovincial lines are federally regulated, whereas carriers who operate in a single province are governed by provincial regulations (Transport Canada; Rail Traffic Database, 2012). Additionally, certain aspects of railway procedures, primarily safety and the transportation of dangerous goods, are overseen by Transport Canada. In addition to these two freight classifications, railways can be either: (1) commuter, (2) intercity passenger, or (3) tourist.

Currently, Canada's rail industry moves approximately "70% of all non-local surface goods valued at more than $250B per year" (Railway Association of Canada, 2013) and is expected to continue to grow over the next 10 years as the increase in natural resource projects and concerns about road safety and congestion continue to grow. In 2010, the short-line industry in Canada had aggregate revenues in excess of $650M (McKinstry & Bounajm, 2010), moved $19B km and had 22% of all Class I traffic originating on a short-line segment (Railway Assoication of Canada, 2011). The short-line rail sector provides specialized service to regional and remote areas that otherwise would be abandoned or transferred to alternative modes.

2.1.3 ISSUES FACING THE SHORT-LINE RAIL INDUSTRY

The issues facing the short-line rail industry appear to be similar across the sector, regardless of location. The difficulties of the short-line industry are not necessarily shared by their Class I counterparts and if an issue is shared, the short-line carrier will be disproportionately affected, in most instances. The American short-line and Regional Railroad Association (ASLRRA) identifies the following issues regarding short-line operations:

- the introduction of the 286,000-pound car (286k),
- dependence on connecting carriers,
- the inability of interchange due to routing restrictions,
- discriminatory pricing policies, and
- car supply (Allen, Sussman, & Miller, 2002).

Many short-line railroads are dependent on a single commodity, primarily natural resources (coal, lumber, grain, ore, etc.). This dependence makes the industry more susceptible to the dynamic economy and commodity pricing. The short-line sector's relationship with Class I carriers is very important; as the bulk of short-line traffic does not originate and terminate on a short-line. This is especially true when considering that the "shipper (or customer) views service as performance from origin to destination; therefore an excellent job by the short-line can be offset by a poor performance by another operator" (Allen, Sussman, & Miller, 2002).

Car supply is important to short-line carriers. The majority of short-line carriers rely on Class I railroads for car supply (Allen, Sussman, & Miller, 2002). With the introduction of heavy axle loading (HAL) and implementation of 286k cars by the Class I, many short-line railroads will be required to introduce these cars into their fleet because of their dependence on Class I carriers for car supply. The introduction of the 286k car can have adverse effects on the short-line railroad's operational and capital costs.

short-line railroads require upgraded infrastructure and are facing increasing maintenance costs, with limited capacity to increase their revenue. Therefore, an additional challenge for the short-line sector is its ability to secure financing to meet long-term capital requirements. In Canada, there has been an increased interest in cost-sharing for rail infrastructure investment (McKinstry & Bounajm, 2010). Without an increase in revenue, or funding from external sources, the majority of short-line railroads will not be able to maintain their infrastructure. A lack of funding will lead to the degradation of infrastructure or will require the short-lines to abandon their infrastructure, adversely affecting performance, the economy and society.

2.1.4 SOCIAL BENEFITS OF THE SHORT-LINE RAIL INDUSTRY

The short-line rail sector is in direct competition with the trucking industry. Without sufficient infrastructure upgrading, especially the investments required to handle increased axle loading, railways will no longer be an efficient or viable shipping option for customers, and much of the traditional rail traffic will shift to the trucking industry (Babcock & Sanderson, 2004); (McKinstry & Bounajm, 2010). This would have a direct impact on road safety, maintenance, and congestion as well as reduce market choices for shippers.

The rail industry operates within their own right-of-way, typically with exclusive use. The sector absorbs all operation and maintenance costs, and contributes over $30M annually in Canadian taxes (McKinstry & Bounajm, 2010). There is a continuous debate over the treatment of road transportation as a public good, especially when the user does not fully cover the costs of road transportation. Some conclude that "railways do not compete with trucks on an equal footing" (McKinstry & Bounajm, 2010). It was estimated that Kansas short-line and regional railroads generate approximately $58M a year in avoided road damage costs (Babcock & Sanderson, 2004) and Canadian short-lines provide an estimated $339.1M benefit (McKinstry & Bounajm, 2010).

The short-line rail industry has an overall annual social benefit of approximately $673.3M, when compared to the trucking sector (McKinstry & Bounajm, 2010). A greater understanding of the social benefits that the short-line rail sector provides to the Canadian society and their importance in the North American transportation network provides a sound foundation for the cost sharing of infrastructure upgrades. An increase in private-public-partnerships (P3s) for short-line rail infrastructure investments will potentially result in a more efficient and socially optimal freight transportation system. In Canada, partnership between the federal and provincial governments and industry has allowed for the restoration of 1,600km of railway infrastructure in Quebec. The infrastructure improvements will allow for an increased load capacity of rolling stock allowing the short-line to continue providing a vital link between industry and the main line railroad (Railway Assoication of Canada, 2011).

2.2 THE EVOLUTION OF HEAVY AXLE LOADING IN NORTH AMERICA

Research into the economic and technical feasibility of heavy axle loading (HAL) began in 1988, initiated by the AAR at the Facility for Accelerated Service Testing (FAST), in Pueblo, Colorado (Martland, 2013). The primary purpose of the HAL Research Program was to "provide guidance to the North American railroad industry about whether to increase axle loads and to determine the most economic payload consistent with safety" (Martland, 2013). North American railroads continue to look for cost-effective ways to safely increase capacity while reducing overall operational costs. In 2010, 30% of general freight and 100% of coal traffic was being moved by 286k cars (Babcock & Sanderson, 2004), on Class I railroads and the majority of new car purchases were, and continue to be, 286k cars (Casavant & Tolliver, 2001).

The desire to increase the loads on railcars is also evident prior to 1988. In the 1970s, the 200,000lb (200k) car was replaced with the 263,000lb (263k) car with the primary goal of improving overall productivity. The introduction of heavy cars allowed for a decrease in cost-per-ton mile (Babcock & Sanderson, 2004) by reducing the number of cars, trains, crews, and gallons of fuel required to move a given amount of freight. With the introduction of the 263k car, the cause of track replacement shifted from wear or battered joints, to fatigue and risks of broken rails, reducing the overall life of the rail from 416 million gross tons (MGT) to 267 MGT, with 200k and 286k loading respectively (Martland, 2013).

Following the implementation of the 263k, Class I carriers developed better maintenance programs, with rail grinding as a pivotal component, while the supply industry developed harder (stronger) rails. The advancement of technologies, improved maintenance programs, and materials allowed Burlington Northern (BN) railroad to boast a rail life of 1,400 MGT by the mid-1980s (Martland, 2013). These advancements and improvements drove the development of the HAL Research Program to study the effects and potential benefits of increased axle loading.

2.2.1 AN OVERVIEW OF THE HAL RESEARCH PROGRAM

Phase I of the HAL Research Program was concerned with increasing the gross vehicle weight (GVW) limits from 263k to 315k. Phase I of the HAL Research Program concluded in 1991 with the following results:

- increased axle loads were both economically and technically feasible; and
- certain areas of concern (primarily bridges) needed to be further investigated prior to the introduction of increased axle loads (Hargrove, Guis, Otter, Clark, & Martland, 1996).

Phase I evaluated the economics of an increase to a 286k car and 315k car. Testing indicated that an increase to the 286k car from the 263k car would present an economic benefit of 1.6% to 7%, whereas the 315k car presented a benefit ranging from -3.0% to 5.2% (Hargrove, Guis, Otter, Clark, & Martland, 1996). "Increasing to 286k was most cost effective, primarily because costs related to rail fatigue, turnout deterioration, bridge life, routine maintenance, and freight car wheels would rise more than linearly with axle loads" (Martland, 2013). Class I carriers began to introduce 286k into service in 1991 and cite an overall decrease in operating costs per ton mile of 9% (Babcock & Sanderson, 2004); (Martland, 2013).

Phase II of the HAL Research Program was designed to test the effects of improved components and maintenance programs on the costs of HAL operations and the effect of increased axle loads on bridges. Phase II determined that the capital and maintenance costs associated with bridges for the implementation of HAL operations varied by an order of magnitude; it was therefore recommended that all bridges be evaluated on a case-by-case basis. Using updated maintenance and operation costs, combined with improved technologies and maintenance programs, Phase II results show a slight increase in net benefit for the implementation of HAL operations.

Additional analysis was performed to determine the percent increase (base case 286k car) in associated costs with the implementation of the 286k and 315k car. Costs were analyzed in three categories: (1) track maintenance; (2) capital; (3) routine maintenance. To transition from 263k to 286k, there would be a 5 to 20%; 2 to 10%; and 15 to 30%, increase in track maintenance, capital, and routine maintenance, respectively. Further to the above, to transition to 315k equipment there would be a 20 to 40%, 9 to 22%, and 45 to 65%, increase in track maintenance, capital, and routine maintenance, respectively (Martland, 2013).

This analysis further supports the benefit of the 286k car over the 315k, especially when considering the impact of routine maintenance on overall railway operations as it is a cost that cannot be deferred without impacting overall operations and safety.

The HAL research program continued with Phase III, IV, and V, regularly updating costs and incorporating improved technologies and materials. Phase III of the HAL research program investigated the benefit of upgraded equipment, notably suspension systems; Phase IV was focused on reducing the amount of lubrication used with the equipment developed in Phase III; and Phase V concluded the program (Martland, 2013). Heavy axle research continues at the Transportation Technology Centre, under guidance from the Association of American Railroads, with focus on operations, revenue service, monitoring, and track substructure (Vierira, 2014).

2.2.2 BENEFITS FROM HAL OPERATIONS

The majority of analyses surrounding the benefits of HAL operations have been based on Class I carriers; there has been little research on the effects of the implementation of HAL operations on short-line and regional (non-Class I) carriers. Therefore, the benefits discussed are primarily experienced by Class I carriers.

The benefits for short-line carriers associated with the implementation of HAL operations are dependent on the:

- route;
- type and level of service;
- extent of HAL implementation across the rail network;
- car characteristics; and
- overall unit costs (maintenance, crew, operations, etc.) (Martland, 2013); (Hargrove, Guis, Otter, Clark, & Martland, 1996).

The rate of implementation is highly dependent on existing infrastructure characteristics and the available funding required to improve infrastructure to handle the increased axle loading. As of 2011, ASLRRA cited that approximately 55% and 63% of short-line and regional route miles, respectively, were able to handle 286k operations. The majority of coal, grain, aggregate, and approximately a quarter of intermodal traffic moved at 286k capacity on Class I carriers.

Main line carriers have experienced the following benefits from HAL operations:

- a decrease in the number of freight cars and car-miles needed to handle a given amount of commodity;
- a reduction in gross tonnage, allowing a resultant decrease in train-miles, crew miles, locomotives, locomotive miles, and fuel consumption;
- fewer train crews; and
- increased line capacity by 10 to 20% (Martland, 2013); (Hargrove, Guis, Otter, Clark, & Martland, 1996); (Resor, Zarembski, & Patel, 2007).

Like any container used to haul relatively low-density freight, the 286k car has the potential to "cube out" prior to reaching its maximum weight limit, thereby increasing the railroad's interest in shorter cars. Further research into the economic benefit of shorter 286k cars and their impacts on bridges and track structure, could highlight an alternative to increased GVW, while potentially providing equivalent cost and capacity benefits with less infrastructure investment (Babcock & Sanderson, 2004).

For Class I carriers, it is assumed that the costs associated with upgrading track infrastructure and bridges and the increase in operation and maintenance costs would be offset by the economic benefit of HAL operations. These benefits generated over $600M for the railroad sector in 2010, primarily by reducing the overall cost per ton mile (Martland, 2013).

2.2.3 THE IMPACTS OF INCREASED AXLE LOADING ON SHORT-LINE RAILROADS

The benefits associated with HAL implementation disproportionately favor the Class I carriers. Non-Class I carriers tend to require greater capital infrastructure investment to accommodate an increase in axle loading (Babcock & Sanderson, 2004); (Resor, Zarembski, & Patel, 2007) . Short-line railroads will experience a greater impact from HAL implementation, when compared to Class I carriers, mainly in the areas of safety and increased capital requirements and ongoing operation and maintenance costs (Resor, Zarembski, & Patel, 2007). However, due the operational nature of short-line railroads and their dependence on Class I carriers for cars and interchange services, many short-lines will be required to introduce 286k cars into their service, regardless of the associated economics and benefits.

Many studies have documented the effects and benefits of HAL operations on main line carriers; little research has included the effects on HAL implementation on short-lines. The introduction of 286k car operations has the potential to increase the four (4) problem areas of short-line rail operations:

- light rail sections,
- thin ballast sections,
- deferred tie maintenance, and
- old bridges (Babcock & Sanderson, 2004); (Babcock & Sanderson, 2004).

The quality of track on short-line railroads is generally poorer than that of Class I railroads, typically rated between 70 and 90 pounds per yard (Babcock & Sanderson, 2004). HAL operations require a minimum track quality of 90 pounds per yard, provided operating speeds do not exceed 25 miles, and tie and ballast are in good condition (Casavant & Tolliver, 2001). Therefore, it is likely that introducing HAL operations on the short-line rail network will have a greater impact on short-lines because of the required capital investment required to upgrade marginal track.

Additionally, short-line railroads will experience an increase in overall maintenance costs to accommodate HAL operations, primarily in the areas of:

- rail and joints;
- ties and fastening systems;
- ballast and surfacing;
- turnouts and special track work; and
- bridges (Babcock & Sanderson, 2004); (Hargrove, Guis, Otter, Clark, & Martland, 1996).

A trade-off does exist for HAL operations; marginal track would require good ties and ballast but deferred maintenance has the potential to impact railway safety with an increase in derailments due to marginal track, tie, and ballast conditions. Potentially, the greatest capital cost associated with the implementation of HAL operations will be bridge upgrading costs, particularly if the network contains numerous timber structures (Hargrove, Guis, Otter, Clark, & Martland, 1996).

An increase in axle loading allows for an increase in the amount of commodity that can be transported in a single vehicle. This will result in a decrease in the total number of cars required to carry a given commodity by approximately 8 to 10% (Zarembski, 2000). Zeta-Tech Associates, Inc. performed a study on two (2) short-line railroads and determined that maintenance of way costs would increase in the range of 5 to 23%, depending on the volume of HAL traffic. Further to the study, it was determined that the costs associated with HAL operations can be divided into two (2) categories:

- those that must be absorbed prior to HAL implementation (capital expenditures); and
- those that will occur after HAL implementation (typically associated with ongoing operation and maintenance).

Short-line railroads requiring the majority of their track to be upgraded or numerous bridge upgrades will experience large upfront capital expenditures, prior to receiving the benefits associated with HAL operations. Additionally, the benefits may not offset the increased capital and ongoing maintenance costs (Hargrove, Guis, Otter, Clark, & Martland, 1996); (Zarembski, 2000).

3 ANALYTICAL FRAMEWORK

This chapter describes the analytical framework developed and applied in this research. To support the selection of representative case studies, the chapter first stratifies Canada's short-line rail industry by ownership classification and geography. Second, the chapter describes the factors influencing the adoption of HAL by Canadian short-line railroads, namely: (1) commodities hauled; (2) infrastructure condition; and (3) network connectivity. The final section of the chapter describes the case study selection and outlines the case study analysis.

3.1 STRATIFICATION OF CANADA'S SHORT-LINE RAILROAD INDUSTRY

Canada's short-line rail industry is diverse and complex, encompassing numerous ownership structures and disparate geographic conditions. This section stratifies the industry by proposing an ownership classification system and describing the industry at a regional rather than national level. Stratification of the industry by ownership classification and region provides the basis for selecting case studies that represent the range of short-line operations in Canada.

3.1.1 OWNERSHIP

In Canada, there are currently 42 short-line freight railroads (Railway Association of Canada, 2014); (Blanchard, 2011). Together, these railroads comprise approximately one-fifth of the Canadian rail network, originate approximately one-quarter of freight carload traffic for Canadian Class I railroads, and generate in excess of $650 million in annual revenue (McKinstry & Bounajm, 2010); (Railway Association of Canada, 2013).

This research proposes six ownership classifications, as listed in Table 3-1. A range of private sector ownership structures exist, including ownership by: (1) rail transportation management/holding companies, such as OmniTRAX and Genesee & Wyoming Inc. (14 railroads fall into this category), (2) local rail operators (seven railroads), (3) industry shippers, such as mining companies that operate their own railroad (10 railroads), and (4) private co-operatives (four railroads). Public sector ownership includes both government-owned (five railroads) and First Nations-owned (two railroads) properties. Figure 3-1 shows a map of Canada's freight short-line railroads, grouped into these six ownership categories. Table 3-2 and Table 3-3 list the short-line railroads within each ownership category.

Private (PR)		**Public (PU)**	
1	Holding company	**5**	Government
2	Local rail operator	**6**	First Nations
3	Industry		
4	Co-operative		

Table 3-1: Ownership types

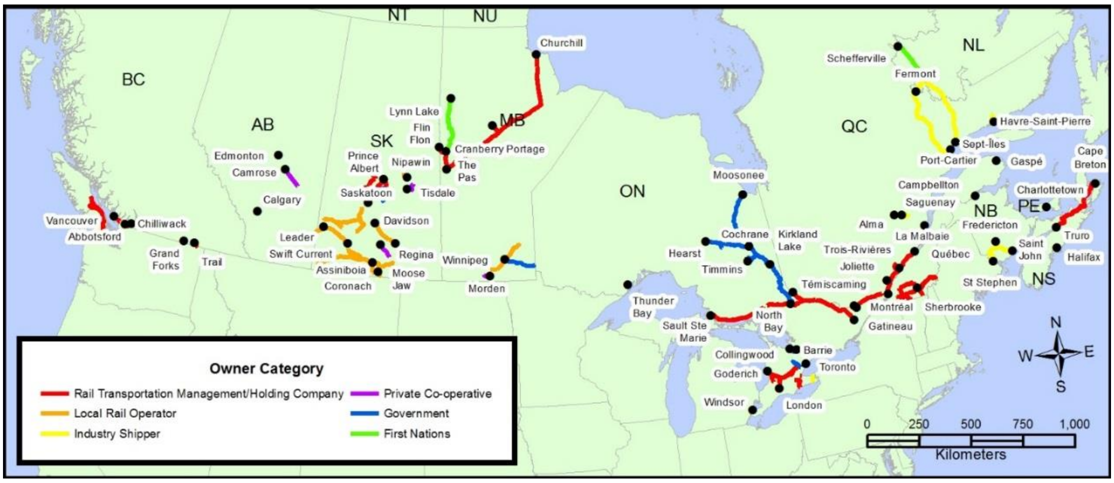

Figure 3-1: Short-line railroads in Canada by ownership type, 2014

Sources: (Blanchard, 2011)

Holding Company (14)		**Industry (10)**
Bloom Lake Railway		Chemin de fer de la Rivière Romaine
Cape Breton & Central Nova Scotia Railway		Grand Forks Railway
Carlton Trail Railway		International Rail Road Systems
Central Maine & Quebec Railway		New Brunswick Southern Railway
Chemin de fer Saint-Laurent & Atlantique		Quebec Cartier Railway
Goderich-Exeter Railway		Quebec North Shore & Labrador Railway
Hudson Bay Railway Company		Roberval & Saguenay Railway
Huron Central Railway Inc.		Sydney Coal Railway
Kettle Falls International Railway		Trillium Railway Company Ltd.
Ottawa Valley Railway		Wabush Lake Railway Company
Quebec Gatineau Railway		
Southern Ontario Railway		
Southern Railway of British Columbia		
Southern Railway of Vancouver Island		
Local Rail Operator (7)		**Co-operative (4)**
Big Sky Railway		Battle River Railway
Central Manitoba Railway		Boundary Trail Railway Company Inc.
Essex Terminal Railway		Southern Rails Cooperative Ltd.
Great Sandhills Railway		Thunder Rail
Great Western Railway		
Last Mountain Railway		
Torch River Rail		

Table 3-2: Railroad by ownership type (private)

Government (5)		First Nations (2)
Barrie-Collingwood Railway		Keewatin Railway Company
Greater Winnipeg Water District		Tshiuetin Rail Transportation Inc
Ontario Northland Railway		
Orangeville-Brampton Railway		
Wheatland Railway Inc.		

Table 3-3: Railroad by ownership type (public)

3.1.2 REGIONAL GEOGRAPHY

Canada's short-line railroads can be classified based on geographical region:

- West – British Columbia;
- Central – Alberta, Saskatchewan, Manitoba;
- Eastern – Ontario, Quebec; and
- Atlantic – New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island.

Each region is further defined in the following sections. The key characteristics explored are:

- Total number of railroads;
- Ownership types;
- Total route-kilometers; and
- Industries served.

WESTERN REGION

Figure 3-2 depicts the railroads located in the Western region. As described in Table 3-4, this region has five (5) railroads in two (2) ownership categories, totalling approximately 730 km of track. The primary industries generating demand on the Western short-line network are natural resources (including forestry).

Railroad	Ownership type	Province
Grand Forks Railway	Industry Shipper	British Columbia
International Rail Road Systems	Industry Shipper	British Columbia
Kettle Falls International Railway	Holding Company	British Columbia
Southern Railway of British Columbia	Holding Company	British Columbia
Southern Railway of Vancouver Island	Holding Company	British Columbia

Table 3-4: Western region railroads by ownership type

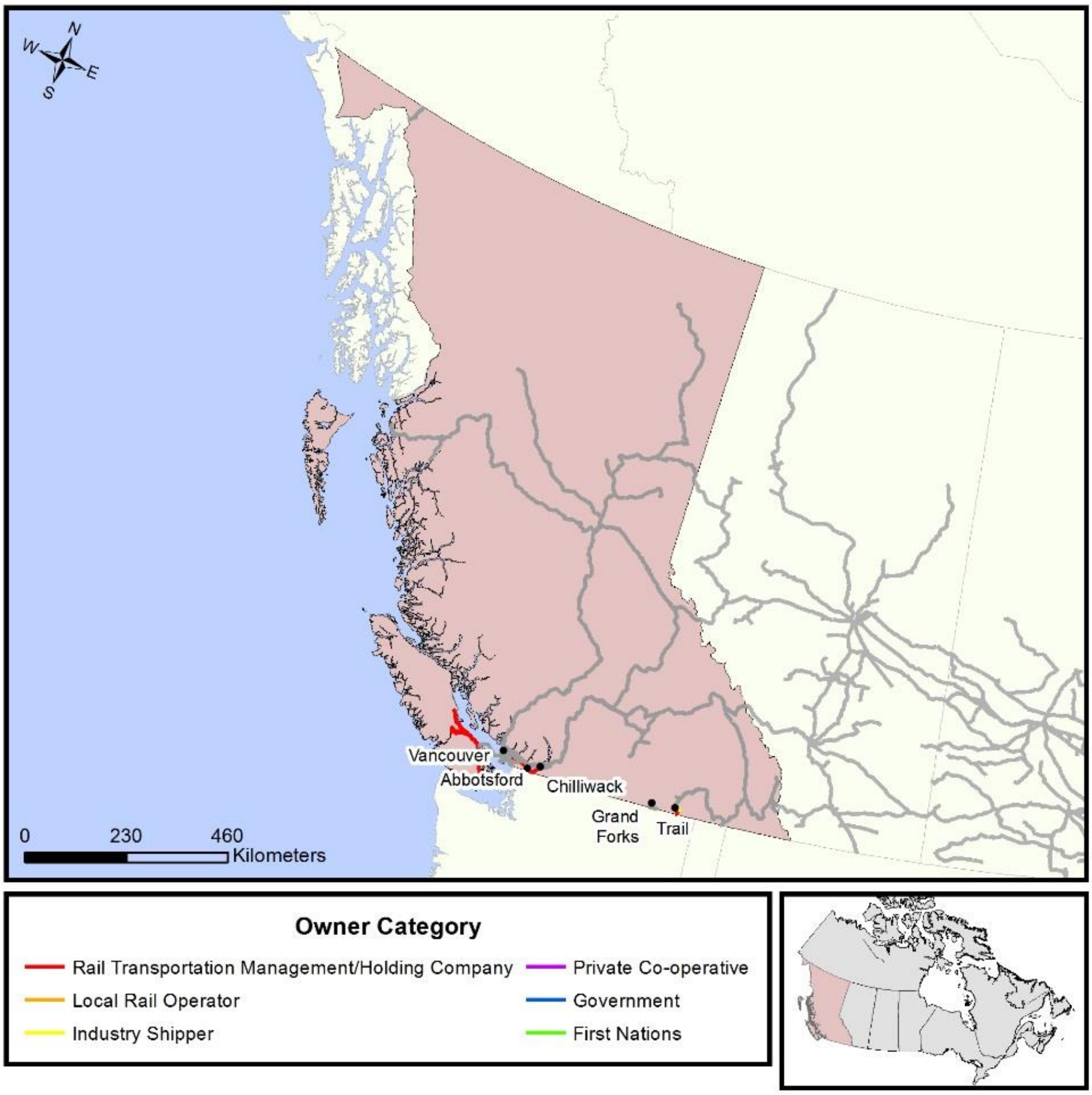

Figure 3-2: Western region railroads by ownership type

CENTRAL REGION

Figure 3-3 depicts the railroads located in the Central region. As described in Table 3-5, this region has fifteen (15) railroads in four (4) ownership categories, totalling approximately 3,640 km of track. In the Central region, the primary industry generating demand on the short-line network is agriculture.

Railroad	Ownership Type	Province
Battle River Railway	Private co-operative	Alberta
Big Sky Railway	Local Rail Operator	Saskatchewan
Last Mountain Railway	Local Rail Operator	Saskatchewan
Southern Rails Cooperative Ltd.	Private co-operative	Saskatchewan
Thunder Rail	Private co-operative	Saskatchewan
Torch River Rail	Local Rail Operator	Saskatchewan
Wheatland Railway Inc.	Government	Saskatchewan
Carlton Trail Railway	Holding Company	Saskatchewan
Great Sandhills Railway	Local Rail Operator	Saskatchewan
Great Western Railway	Local Rail Operator	Saskatchewan
Boundary Trail Railway Company Inc.	Private co-operative	Manitoba
Central Manitoba Railway	Local Rail Operator	Manitoba
Greater Winnipeg Water District	Government	Manitoba
Hudson Bay Railway Company	Holding Company	Manitoba
Keewatin Railway Company	First Nations	Manitoba

Table 3-5: Central region railroads by ownership type

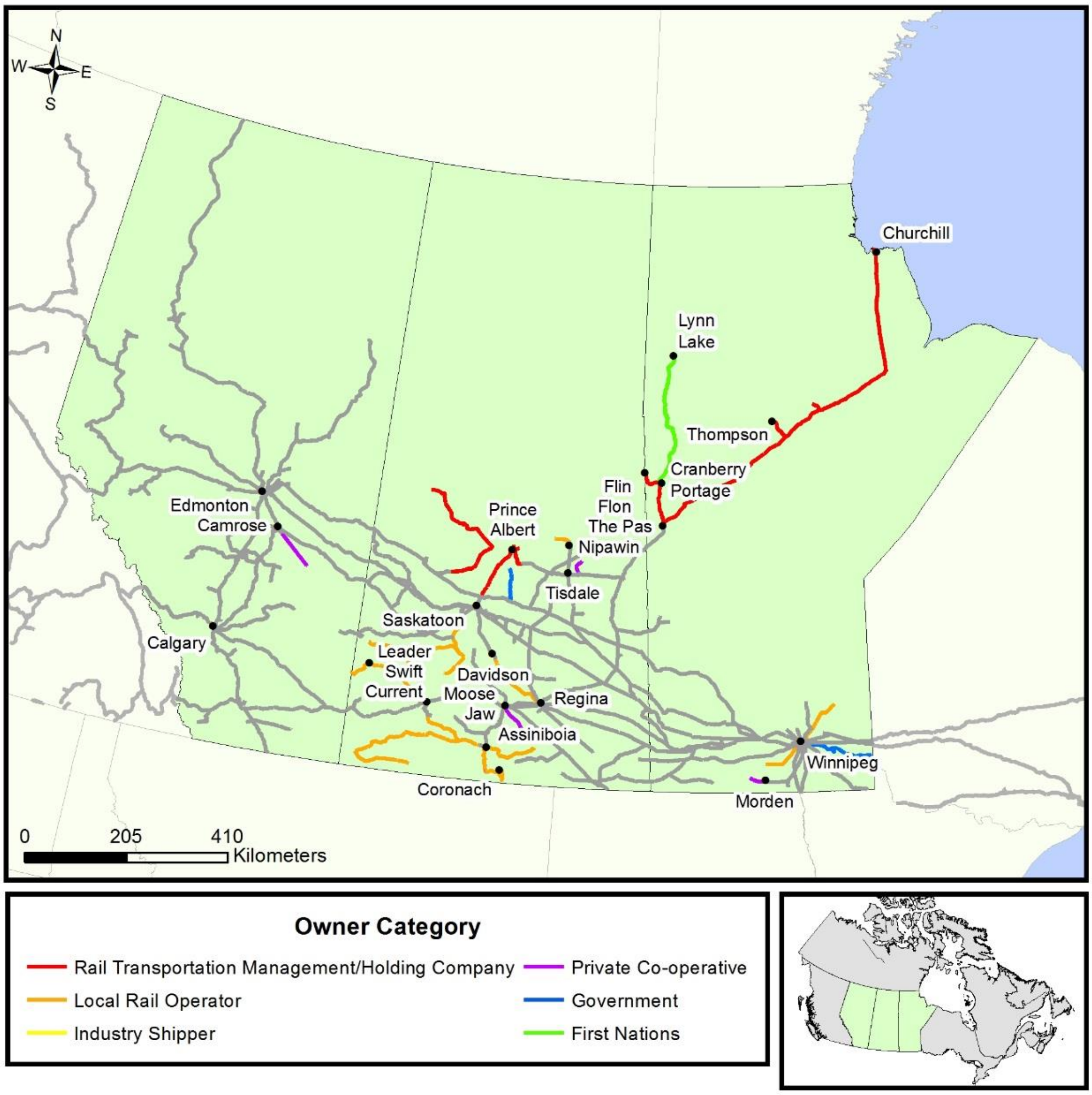

Figure 3-3: Central region railroads by ownership type

EASTERN REGION

Figure 3-4 depicts the railroads located in the Eastern region. As described in Table 3-6, this region has 16 railroads in four (4) ownership categories, totalling approximately 5,025 km of track. In the eastern region, the primary industry fuelling demand on the short-line network is natural resources. This region hosts three (3) railroads which operate mine to port operations.

Railroad	Ownership Type	Province
Barrie-Collingwood Railway	Government	Ontario
Essex Terminal Railway	Local Rail Operator	Ontario
Goderich-Exeter Railway	Holding Company	Ontario
Huron Central Railway Inc.	Holding Company	Ontario
Ontario Northland Railway	Government	Ontario
Orangeville-Brampton Railway	Government	Ontario
Ottawa Valley Railway	Holding Company	Ontario
Southern Ontario Railway	Holding Company	Ontario
Trillium Railway Company Ltd.	Industry Shipper	Ontario
Central Maine & Quebec Railway	Holding Company	Quebec
Chemin de fer de la Rivière Romaine	Industry Shipper	Quebec
Chemin de fer Saint-Laurent & Atlantique	Holding Company	Quebec
Quebec Cartier Railway	Industry Shipper	Quebec
Quebec Gatineau Railway	Holding Company	Quebec
Quebec North Shore & Labrador Railway	Industry Shipper	Quebec
Roberval & Saguenay Railway	Industry Shipper	Quebec

Table 3-6: Eastern railroads by ownership type

Figure 3-4: Eastern railroads by ownership type

ATLANTIC REGION

Figure 3-5 depicts the railroads located in the Atlantic region. As described in Table 3-7, this region has six (6) railroads in three (3) ownership categories, totalling approximately 1, 080 km of track. The short-line railroads present in the Atlantic region serve the natural resources industry, with three (3) of the railroads primarily hauling ore. There are no railroads located in the province of Prince Edward Island.

Railroad	Ownership type	Province
Bloom Lake Railway	Holding Company	Newfoundland
Cape Breton & Central Nova Scotia Railway	Holding Company	Nova Scotia
New Brunswick Southern Railway	Industry Shipper	New Brunswick
Sydney Coal Railway	Industry Shipper	Nova Scotia
Tshiuetin Rail Transportation Inc	First Nations	Newfoundland
Wabush Lake Railway Company	Industry Shipper	Newfoundland

Table 3-7: Atlantic railroads by ownership type

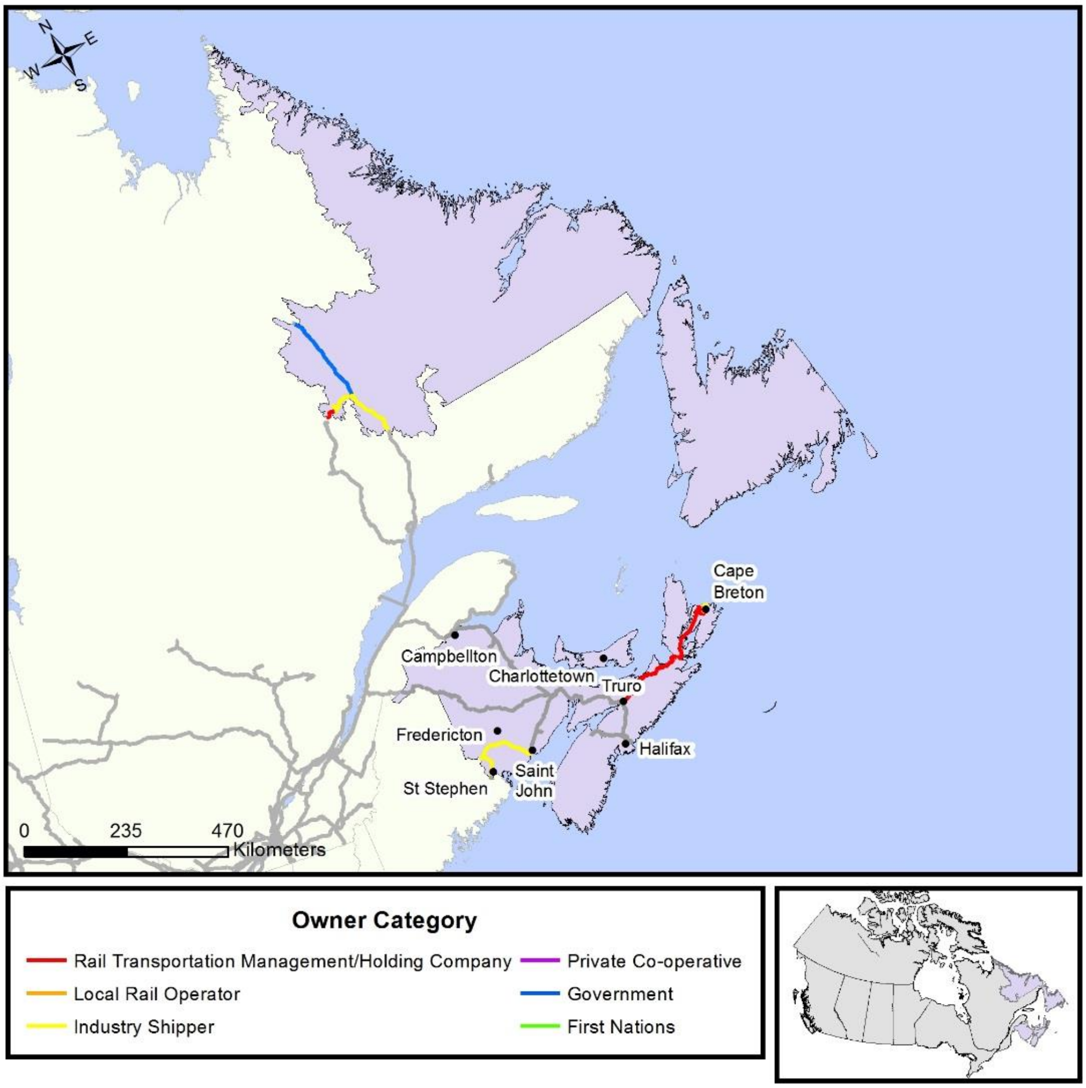

Figure 3-5: Atlantic railroads by ownership type

3.2 FACTORS INFLUENCING THE ADOPTION OF HAL BY CANADIAN SHORT-LINE RAILROADS

This section describes three factors influencing the adoption of HAL by Canadian short-line railroads. As discussed in Chapter 2.2.2, previous research indicates that the benefits of heavy axle loading are dependent on the following factors:

- Route;
- Type and level of service;
- Extent of HAL implementation across the rail network;
- Car characteristics; and
- Overall unit costs.

Data propriety constrains a system-wide investigation of these five factors for the Canadian short-line industry. Nevertheless, this research investigates three factors considered as surrogates to those identified in the literature:

- *Commodities*: As discussed in Chapter 1.4, the commodities hauled by a short-line railroad reflect local or regional industry demands (i.e., the activity system, A, in the transportation systems analysis approach). The properties of commodities hauled dictates a carrier's selection of car type. Commodities with higher densities are likely to cause cars to weigh-out; therefore, railroad's that rely on hauling higher-density commodities may have strong internal motivation to adopt HAL.
- *Infrastructure condition*: As discussed in Chapter 1.4, the condition of a short-line railroad's infrastructure is considered a supply-related element (i.e., an element of the transportation system, T, in the transportation systems analysis approach). The condition of a railroad's infrastructure (i.e., track, ballast, ties, and bridges)

influences how well it performs a freight transport task and the internal costs that may be incurred by adopting HAL.

- *Network connectivity*: As discussed in Chapter 1.4, network connectivity is a supply-related element (i.e., an element of the transportation system, T, in the transportation systems analysis approach), which fundamentally influences the flows of commodities between origin and destination. The type of connectivity between a short-line railroad and the surrounding rail network dictates the degree of external motivation for adopting HAL.

3.2.1 SHORT-LINE COMMODITY DENSITY

This section examines common commodities hauled by Canadian short-lines and determines their suitability for carriage in 286k railcars based on commodity density and railcar specifications.

The utility of a railcar for hauling a commodity is, in part, determined by the railcar design density and the density of the commodity. Morlok defines the design density of a freight vehicle (in this case a railcar) as the density of payload at which the vehicle reaches both its gross weight limit and its volumetric (cubic) capacity (Morlok, 1987). If the density of the commodity is less than the design density of the vehicle, then the volume capacity of the vehicle will be reached before its weight capacity and the vehicle is said to cube-out. Conversely, if the density of the commodity is greater than the density of the vehicle, then the weight capacity of the vehicle will be reached before its volume capacity and the vehicle is said to weigh-out. Introducing railcars with a 286k gross weight limit (lightweight plus payload) changes the range of design densities in the railcar fleet and thus also affects the suitability of these cars for various commodities.

To investigate these impacts in an illustrative rather than exhaustive sense, a four-step analysis approach was developed and applied. First, to scope the analysis, the four most common commodity groups hauled by the Canadian rail industry are identified along with typical commodity densities. In 2011, these were: (1) coal, (2) grain, (3) iron ore and concentrates, and (4) fertilizer materials (Transport Canada, 2014). Second, selected commodities within each of these commodity groups are "loaded" into the railcars typically used to haul them. Table 3-8 summarizes the data used for these first two steps. As shown in the table, the seven selected commodities—bituminous coal, wheat, corn, canola, oats, iron ore, and potash—are all typically hauled by either open top or covered hopper cars. The densities of these commodities range from 27 lb/ft^3 (oats) to 156 lb/ft^3 (iron ore).

Commodity	**2011 carloadings (000s of tons)** [a]	**Density (lb/ft^3)** [b]	**Railcar pairing**
Coal	41,777	-	-
Bituminous [c]	-	68	Open top hopper
Grain [d]	39,044	-	-
Wheat	-	48	Covered hopper
Corn	-	45	Covered hopper
Canola	-	42	Covered hopper
Oats	-	27	Covered hopper
Iron ore and concentrates	37,157	-	
Iron ore, crushed	-	156	Open top hopper
Fertilizer materials	31,733	-	-
Potash	-	80	Covered hopper

Table 3-8: Commodity density and railcar pairings

Notes:

[a] (Transport Canada; Rail Traffic Database, 2012)

[b] (SImetric, 2011)

[c] The density of bituminous coal varies considerably depending on whether it is broken or solid. The density reported in the table represents a median density value.

[d] The density of agricultural commodities depends on moisture content. 1 ton = 907 kg; 1 lb/ft^3 = 16 kg/m^3

Third, based on readily-available railcar specifications, the design densities for both open top and covered hopper cars (large and jumbo) are calculated (as described above) for the 263k and 286k loading conditions. Table 3 provides the details of these calculations. The data provided in Table 3 is from a single source and may not be representative of the range of these specifications across the fleet; nevertheless, the data are useful for illustrative purposes.

Railcar type	**Gross weight (lb)**	**Light-weight (lb)**	**Available payload (lb)**	**Volumetric capacity (ft^3)**	**Design density (lb/ft^3)**
Covered hopper, large	263,000	64,500	198,500	4,750	42
Covered hopper, large	286,000	64,500	221,500	4,750	47
Covered hopper, jumbo	263,000	62,600	200,400	5,161	39
Covered hopper, jumbo	286,000	62,600	223,400	5,161	43
Open top hopper	263,000	61,800	201,200	3,420	59
Open top hopper	286,000	61,800	224,200	3,420	66

Table 3-9: Railcar specifications and design density [a] (BNSF Railway, 2014)

Note:

[a] 1 lb = 0.45 kg; 1 ft^3 = 0.028 m^3;1 lb/ft^3 = 16 kg/m^3

Finally, the analysis results enable a comparison between the commodity densities and the design densities to determine which commodity-railcar pairings cube-out and weigh-out, whether this changes based on the maximum car loading, and whether an increase in gross loading makes the car more or less suitable for the commodity (*i.e.*, by bringing the design density closer to or further from the commodity density). The analysis results, shown in Table 4, reveal two main points, both of which confirm that commodity-railcar pairings influence the decision to upgrade to 286k loading capacity.

Commodity and average density (lb/ft^3)	**Railcars and design density (lb/ft^3) under 263k loading**			**Railcars and design density (lb/ft^3) under 286k loading**		
	Covered hopper, large (42)	Covered hopper, jumbo (39)	Open top hopper (59)	Covered hopper, large (47)	Covered hopper, jumbo (43)	Open top hopper (66)
Oats (27)	CO	CO	-	further	further	-
Canola (42)	DD	WO	-	further	closer	-
Corn (45)	WO	WO	-	closer	closer	-
Wheat (48)	WO	WO	-	closer	closer	-
Coal (68)	-	-	WO	-	-	closer
Potash [b] (80)	WO	-	-	closer	-	-
Iron ore [c] (156)	-	-	WO	-	-	closer

Table 3-10: Comparison of cube-out and weigh-out conditions for 263k and 286k loading [a]

Notes:

[a] 1 lb/ft^3 = 16 kg/m^3

[a] CO = cube-out, WO = weigh-out, DD = design density, (-) indicates not applicable for the commodity. On the right side of the table, shaded cells indicate a change in the cube-out and weight-out condition between the 263k and 286k loading. 'Closer' indicates that the railcar's design density is closer to the commodity's density under 286k compared to 263k loading. 'Further' indicates that the railcar's design density is further from the commodity's density under 286k compared to 263k loading.

[b] Certain shippers may use a specialized covered hopper car for potash that has different specifications than those used in this analysis.

[c] Certain shippers may use a specialized open top hopper car for iron ore that has different specifications than those used in this analysis.

First, as indicated by the grey shaded cells on the right side of the table, a shift from 263k to 286k loading changes the cube-out or weigh-out condition for canola and corn. Under 263k loading, canola loads to the design density of a large covered hopper car and weighs-out in a jumbo car. Comparatively, under 286k loading, canola cubes-out in both large and jumbo covered hopper cars. Corn weighs-out if hauled in a large covered hopper car limited to 263k, but cubes-out if hauled by a 286k large covered hopper car. In contrast, when comparing railcars loaded at 263k and 286k, there is no change in the cube-out or weigh-out condition for oats (cubes-out in large and jumbo covered hopper cars; and therefore these cars would not reach their maximum weight capacity), wheat (weighs-out in large and jumbo covered hopper cars), coal (weighs-out in open top hopper cars), potash (weighs-out in large covered hopper cars), or iron ore (weighs-out in open top hopper cars).

Second, as the design densities change for the various car configurations, railcar productivity is impacted by the increase in allowable loading. Of the 11 commodity-railcar pairings examined, there are eight pairings in which the railcar design density is closer to the commodity density under 286k compared to 263k loading. For example, it is more productive to haul wheat in a large covered hopper car loaded to 286k compared to 263k because the design density of the 286k car (47 lb/ft^3) is closer to the commodity density (48 lb/ft^3). Notably, the table does not provide direct comparisons between the large hopper car loaded to 263k (design density of 42 lb/ft^3) and the jumbo hopper car loaded to 286k (design density of 43 lb/ft^3), which may be a more appropriate comparison for hauling agricultural commodities in certain cases. As the design density of these two cars is nearly identical for these two railcars, this shift essentially always improves productivity since the 286k railcar has a higher volumetric capacity and can carry heavier payloads.

3.2.2 INFRASTRUCTURE CONDITION

A railroad's linear infrastructure is composed of rail, ties, and ballast. Rolling stock theoretically applies a single point load to the underlying railroad infrastructure, where the rail functions as a continuous beam and spreads the wheel load through the tie plates to the crossties. The crossties then distribute the load to the ballast section in a uniform vertical nature. The ballast further distributes the load to the subgrade and underlying undisturbed soils. The ties, ballast, and rail work together to provide the support for the rail traffic and to effectively distribute axle loads. As an integrated system, it is possible that some components compensate for the lack of strength or durability of another, provided that the overall system is still capable of handling the axle loading.

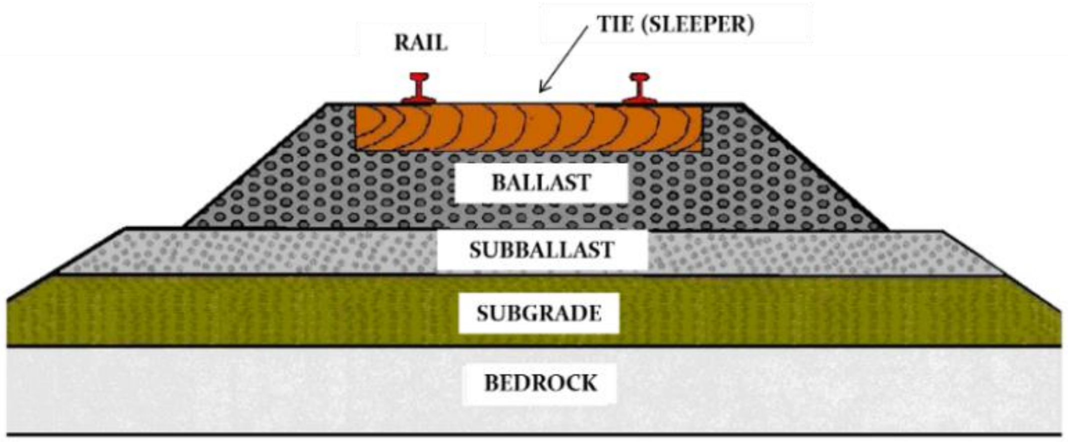

Figure 3-6: Typical railroad track cross-section

LOADING

A 286k car applies a static wheel load that is approximately 9 percent greater than the 263k car, and 30 percent greater than the 220k car. A 263k car generates a static load of approximately 131,500psi (or a wheel load of 36,000lbs) and the track structure must distribute the load so that the resulting load on the subgrade is no greater than 20psi (Casavant & Tolliver, 2001). This loading creates vertical deflection in the system's components resulting in differential movement and wear in the rail, ties, and ballast; the impacts of vertical deflection are the prime source of track deterioration (Casavant & Tolliver, 2001). As increased axle loading applies a greater stress on the system there will be an increase in vertical deflections and track deformation and associated maintenance costs.

A transportation system that exhibits light rail sections (less than 90lbs/yrd), moderate to poor tie condition, and poor ballast will be more susceptible to infrastructure degradation with the introduction of increased axle loading.

RAIL

Rail is the prime component in the railroad infrastructure. Its purpose is to: (1) transfer a train's weight to cross ties, (2) provide a smooth running surface, and (3) guide wheel flanges. Rail is categorized based on rail weight, section, and the type of joints.

The weight of rail is based on how much the rail weighs in pounds per yard and can range from 85lbs to 152lbs. With the introduction of increased axle loads, heavier rail weights are required to adequately distribute the static and dynamic loads. Heavier rail increases the stiffness of the track system and reduces vertical deflection.

The Federal Railway Administration has determined that 85lb and 90lb rail can support static wheel loads of 30,000lbs and 40,000lbs, respectively. Heavy axle loads exhibit a wheel loading of approximately 36,000lbs deeming 85lb rail inadequate and 90lb rail marginal for HAL operations. Marginal rail can operate under HAL conditions if accompanied by low operating speeds and good support (ties and ballast). The section of rail refers to the shape of the cross-section of rail and influences the types of tie plates, rail anchors, and joint bars used to secure the rail to the crossties. Rail can either be jointed (JR) or continuously welded (CWR). In CWR, all joints are welded, reducing the dynamic loads at joints and corresponding track wear. The vast majority of North American mainline (Class 1) is CWR.

TIES

Crossties or sleepers maintain gauge (the distance between rails) and cushion and transmit the load of the rolling stock to the ballast section of the railroad infrastructure system. Ties are composed of either timber, concrete, steel, or alternative materials.

Most freight railroads, especially short-line railroads, utilize timber ties, whereas concrete ties are more common in passenger operations.

The dimensions and condition of crossties and the effective tie spacing affect the load distribution per tie within a section of track (typically 39ft sections). Cross ties are available with nominal dimensions of 6”x8”x8’-0” or 7”x9”x8’6” or 7”x9x9’-0”. Mainline ties should be 7”x9”x9’0” for moderate to heavy traffic conditions and 6”x8”x8’-0” ties should only be utilized in sidings, industry tracks, or light density lines. AREMA recommends 24 good ties per section of track for heavy tonnage lines and 22 good ties per section of track for moderate to medium tonnage lines (ARMEA, 2016). Fewer effective (or good) ties under a section of rail means that each good tie must assume a larger percentage of the loading. Good tie condition is considered to be a key factor in operating heavy axle loads.

BALLAST

The principal purpose of ballast is to anchor the track and provide resistance against lateral, longitudinal, and vertical movement of the ties and rail. Additionally, the ballast bears and distributes the applied load with diminished unit pressure to the subgrade beneath, gives immediate drainage to the track, facilitates maintenance, and provides a necessary degree of elasticity and resilience. Good drainage is of utmost importance to assure required stability (Martland, 2013).

The depth of ballast should be sufficient to distribute the pressures to within the bearing capacity of the subgrade. An overall depth of 18” to 24” between the ballast and sub ballast is recommended by AREMA to ensure a uniform distribution of loads (ARMEA, 2016). The depth of ballast required for 286k operations depends on operating speed, rail weight, and tie condition.

INFRASTRUCTURE RECOMMENDED FOR 286K OPERATIONS

ZETA-TECH has developed the following as a guideline to HAL implementation on short-line railroads:

- As a general rule, rail of less than 90 lbs per yard is not considered adequate for 286k loads, even with good support conditions. A minimum of 10 good ties per rail length (39 feet), and at least two inches of clean, good quality ballast are the minimum support conditions required.
- A minimum of two inches of good clean ballast under the ties is required even for operations at 10 mph on the lightest-density lines, if 286K cars are to be operated. For railroads with poor ballast or no ballast, at a minimum two inches of ballast must be added. More may be required, depending on tonnage, operating speed, and ballast condition (Zarembski, 2000).

The condition of Canada's short-line railroad's infrastructure is not publicly available. However, for federally-regulated railroads (including short-line railroads that cross a provincial or international boundary) infrastructure condition is monitored and inspected by Transport Canada, who issues notices and orders under the Rail Safety Act to mitigate threats to rail safety. For these properties, these orders and notices can give a surrogate indication of a railroad's infrastructure condition and are publicly available through Transport Canada.

3.2.3 NETWORK CONNECTIVITY BETWEEN SHORT-LINE AND CLASS I RAILROADS IN CANADA

Connectivity is a critical aspect of the performance of any transportation system. In the context of short-line railroads, the ability to connect customers and/or commodities to markets is vital for their economic viability. Moreover, the nature of this connectivity and where the short-line originates the traffic influence the potential motivation for a short-line to consider upgrading its operations to accommodate 286k loading (although no data on current loading capacity were available for this research). This analysis proposes a four-tier hierarchy for assessing network connectivity between short-line and Class I railroads in Canada:

- *Tier 1*: short-line railroads in the first tier in the hierarchy are those without a physical connection to the Class I system. Although most short-lines depend on a physical interchange with the Class I network, this is not imperative for all short-lines to serve their customers. For example, a mining company may operate a railroad for the sole purpose of hauling product from the mine to a marine port; no Class I interchange is necessary for this operation. A potential decision to upgrade to accommodate 286k loading is therefore independent of the influence of the Class I carriers. Some railroads in this tier may be connected to other short-lines, which are also separate from the Class I system.
- *Tier 2*: short-line railroads in the second tier are those with a physical connection to another short-line railroad which is connected to the Class I network. Railroads in this tier rely on a third party to provide connectivity to the Class I system, and by extension, are influenced by the loading capacity of the third party short-line railroad.
- *Tier 3*: short-line railroads in the third tier have a direct physical connection to a secondary line in the Class I system. Depending on the loading capacity of the secondary line, the short-line railroad may or may not face pressure to upgrade to 286k loading capacity and, conversely, may or may not have direct access to a 286k network.

- *Tier 4*: short-line railroads in the fourth tier have a direct physical connection to a Class I mainline. These short-lines are most likely to face pressure to upgrade and most likely to have access to a 286k network.

To assess connectivity, this analysis determines the number of railroads (by ownership category) that fall into each of the four tiers, and calculates the total route mileage in each tier. For this analysis, only network connectivity was considered as no data was readily available on loadings. Table 1 shows the results of this analysis. The analysis reveals the following:

- Six of the 42 short-line railroads do not connect to the Class I system (*i.e.*, they fall into Tier 1). These railroads comprise 11 percent of total short-line route distance, with nearly all of this mileage owned by industry shippers (79 percent) or First Nations (18 percent).
- Five of the 42 short-line railroads fall into Tier 2. These railroads comprise six percent of the total short-line route distance, with most of this mileage owned by First Nations (50 percent) and rail management/holding companies (40 percent).
- Thirteen of the 42 short-line railroads fall into Tier 3. These railroads comprise 29 percent of the total short-line route distance. Of this mileage, nearly half (48 percent) belongs to rail management/holding companies and about one-quarter (23 percent) belongs to local rail operators. All route distance owned by private co-operatives falls into Tier 3.
- Eighteen of the 42 short-line railroads fall into Tier 4. These railroads comprise 55 percent of the total short-line route distance. Of this mileage, more than half (57 percent) belongs to rail management/holding companies and about one-quarter (24 percent) belongs to government. Almost all (95 percent) government-owned short-line mileage falls into Tier 4.

- Nearly all (94 percent) mileage owned by rail transportation management/holding companies falls into Tiers 3 or 4 and all of the mileage owned by local rail operators and government falls into these two tiers.

Short-line ownership category	**Route distance (mi.)**	**Route distance by ownership category and connectivity tier (mi.)**			
		Tier 1	**Tier 2**	**Tier 3**	**Tier 4**
1. Holding company	3088	20	147	884	2037
2. Local rail operator	1027	0	0	421	606
3. Industry shipper	973	570	40	313	50
4. Private co-operative	197	0	0	197	0
5. Government	907	0	0	46	862
6. First Nations	316	132	184	0	0

Table 3-11: Connectivity of Canada's short-line railways, 2014

Note: 1 mi. = 1.61 km

3.3 CASE STUDY SELECTION AND ANALYSIS

3.3.1 CASE STUDY SELECTION

As an initial step in the selection of representative case studies, consideration was given to the ownership category and geographic region of each of the 42 short-lines. Table 3-12 summarizes the 42 short-line railroads based on these two stratification variables, as discussed in Chapter 3.1.

Geographical Category	**Ownership type**					
	Holding Company (1)	***Local rail operator (2)***	***Industry (3)***	***Co-operative (4)***	***Government (5)***	***First Nations (6)***
Region – West						
BC	3		2			
Region – Central						
AB				1		
MB	1	1		1	1	1
SK	1	5		2	1	
Region – Eastern						
ON	3	1	1		3	
PQ	4		4			
Region – Atlantic						
NB			1			
NFLD	1		1			1
NS	1		1			

Table 3-12: Railroad classification matrix

Based on the above matrix, two additional considerations were applied to determine the railroads selected for case studies. First, railroads classified as either Class 5 or 6, were removed from the scope. These lines are government owned and operated or operate as passenger lines, not freight. The government owned railroads have minimal publicly available data, limiting the ability to assess their motivation for adopting HAL.

This removed seven (7) railroads from case study consideration:

- Wheatland Railway Inc. (Saskatchewan);
- Keewatin Railway Company (Manitoba);
- Greater Winnipeg Water District (Manitoba);
- Ontario Northland Railway (Ontario);
- Orangeville-Brampton Railway (Ontario);
- Barrie-Collingwood Railway (Ontario); and
- Tshiuetin Rail Transportation Inc (Newfoundland).

Second, four (4) railroads were removed from the scope because limited publicly-available on data were available concerning the types of commodities being hauled available data was available:

- International Rail Road systems (British Columbia);
- Torch River Rail (Saskatchewan);
- Southern Rails Cooperative Ltd. (Saskatchewan); and
- Chemin de fer de la Riviere Romaine (Quebec).

Case studies were completed on all 31 remaining short-line railroads (i.e., 42 total minus 11 removed as described above). Table 3-13 shows the distribution of these 31 railroads by ownership category and geographic region. Chapter 4 presents the results of these case studies.

Geographical Category	**Ownership type**			
	Holding Company (1)	***Local rail operator (2)***	***Industry (3)***	***Co-operative (4)***
Region – West				
BC	3		1	
Region – Central				
AB				1
MB	1	1		1
SK	1	4		1
Region – Eastern				
ON	3	1	1	
PQ	4		3	
Region – Atlantic				
NB			1	
NFLD	1		1	
NS	1		1	

Table 3-13: Railroad classification matrix – case study analysis selection

3.3.2 SHORT-LINE CASE STUDY ANALYSIS

Each case study highlights a short-line railroad's operation in the form of a template. Figure 3-7 describes the components of the template.

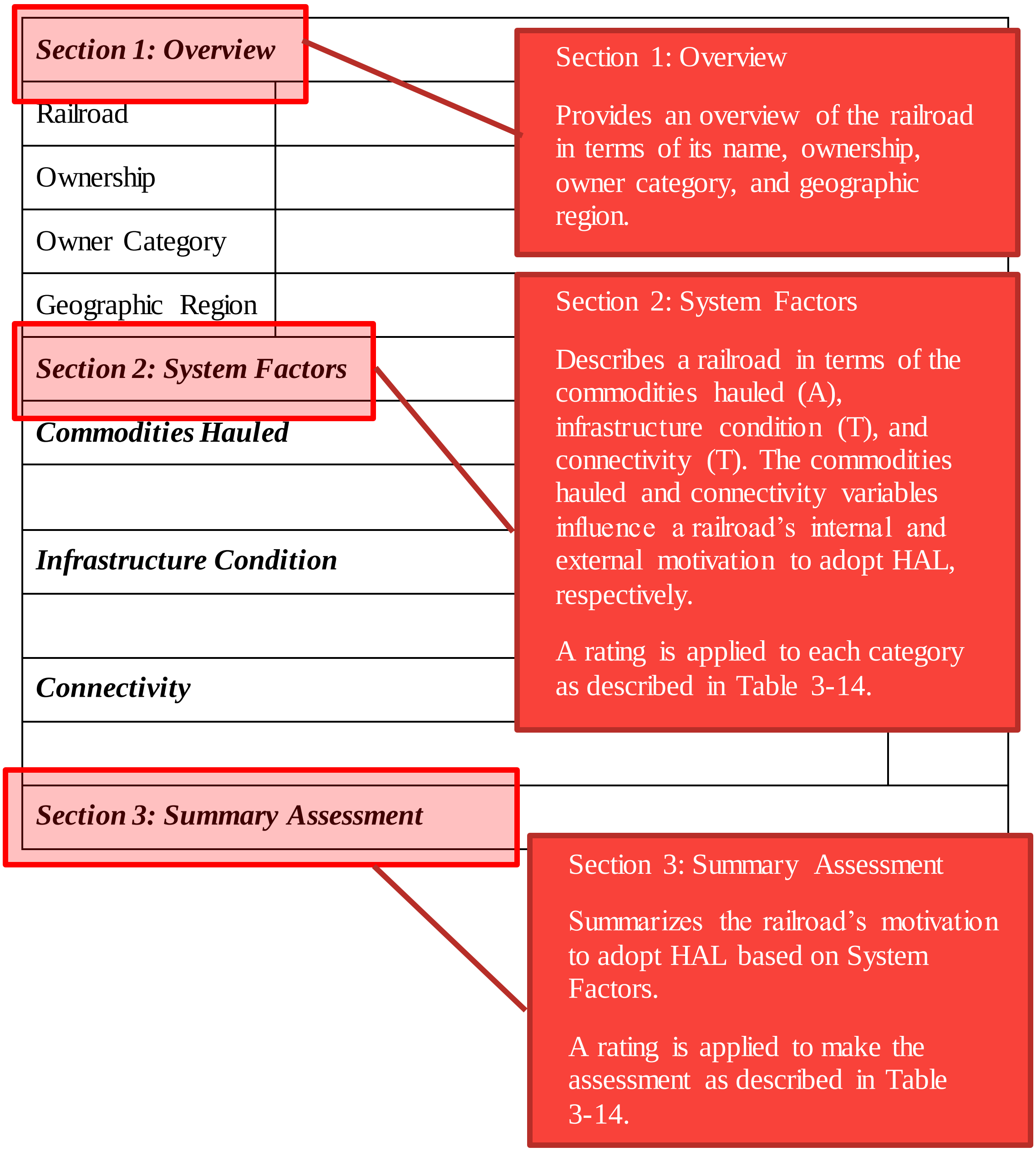

Figure 3-7: Case study template

A multi-criteria analysis (MCA) was undertaken to assess the overall motivation for a a short-line railroad to adopt HAL. The MCA utilized broad publicly-available indicators including: (1) commodities hauled, (2) infrastructure condition (where available), and (3) connectivity. Each category was assigned a score, as detailed in Table 3-14. No weighting was applied to the analysis. The analysis did not consider cost or available capital associated with upgrading infrastructure or associated improvements in economic position.

System Variable	Rating
Commodities Hauled (A)	
Low internal motivation to adopt HAL because no evidence of high-density commodities being hauled	0 (Green)
Some internal motivation to adopt HAL because some evidence of high-density commodities being hauled	1.5 (Orange)
Strong internal motivation to adopt HAL because the short-line's operation is highly dependent on hauling high-density commodities	3 (Red)
Infrastructure Condition (T)	
Provincially-regulated railway; no data	n/a (Grey)
Federally-regulated railway; no Transport Canada notices or orders	Go (Green)
Federally-regulated railway; Transport Canada slow order or similar	Slow (Orange)
Federally-regulated railway; Transport Canada stop order or track maintenance required	Stop (Red)
Connectivity tier (T)	
Tier 1; low external motivation to adopt HAL	0 (Green)
Tier 2; low-medium external motivation to adopt HAL	1 (Yellow)
Tier 3; medium-high external motivation to adopt HAL	2 (Orange)
Tier 4; high external motivation to adopt HAL	3 (Red)
Summary assessment	
Overall motivation to adopt HAL	0 (Green) 1, 1.5, 2, 2.5 (Yellow) 3, 3.5, 4, 4.5 (Orange) 5, 6 (Red)
Evidence of infrastructure condition (if any)	-

Table 3-14: Scoring matrix

4 CANADIAN SHORT-LINE RAILROAD CASE STUDIES

This chapter presents 31 case studies. The case studies are organized by geographic region, beginning with the western region and ending with the Atlantic region. Within each region the case studies are ordered by classification tier (see Table 3-1 in Chapter 3.1.1), from tier 1 through to tier 4. The final section of the chapter presents and discusses findings from the case studies.

4.1 WESTERN REGION

Figure 4-1 depicts the short-line railroads located in the Western region. This region comprises British Columbia and includes six (6) short-line carriers. Four (4) railroads were selected for case study analysis in this region and are presented in Table 4-1, Table 4-4, Table 4-2, and Table 4-3.

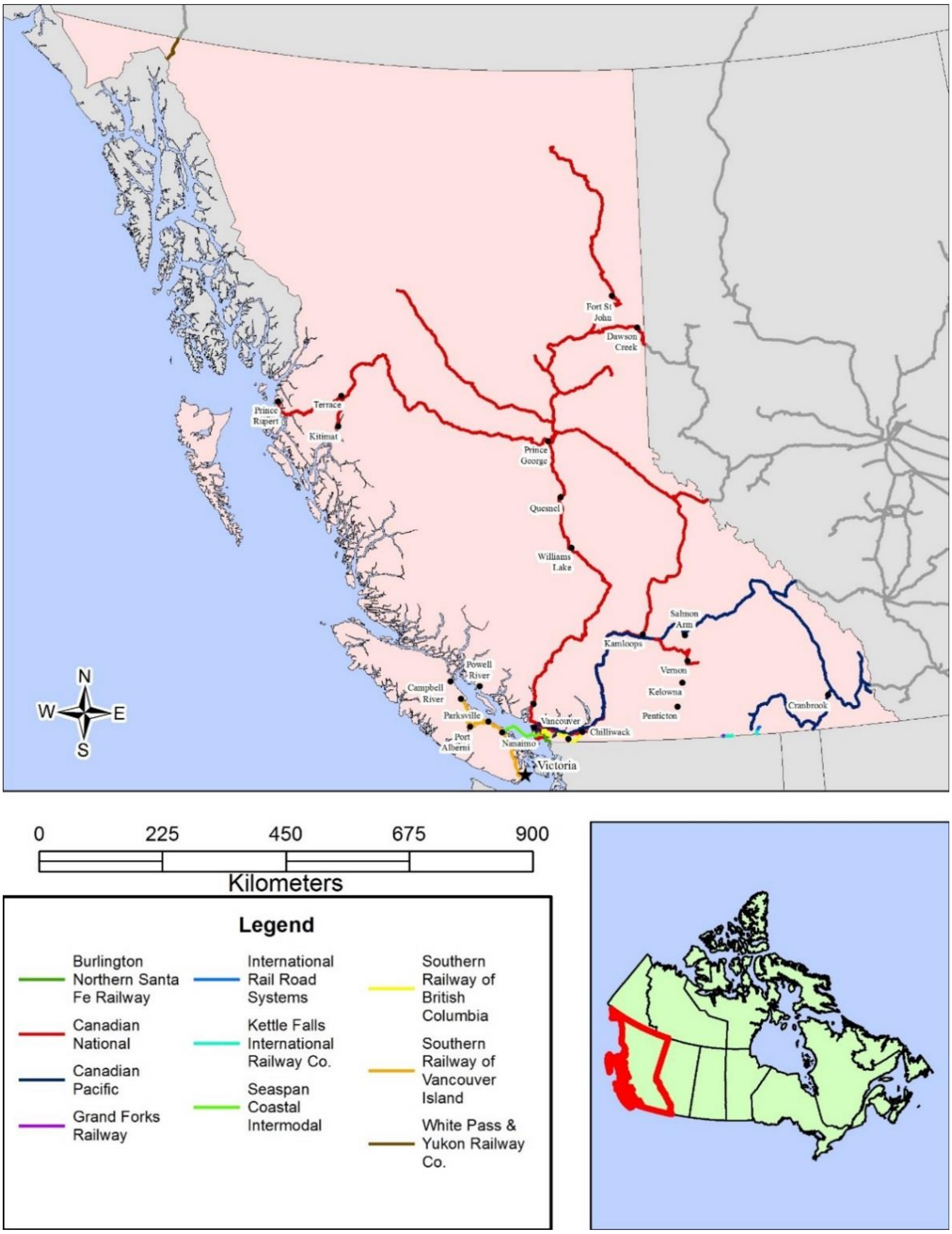

Figure 4-1: Western region – British Columbia

Section 1: Overview		
Railroad	Kettle Falls International Railway	
Ownership	OmniTRAX	
Owner Category	Holding Company (1)	
Geographic Region	Western	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Kettle Falls International Railway is owned and operated by OmniTRAX, Inc., an affiliate of Broe Group. The railway commonly hauls lumber, plywood, wood products, minerals, metals, fertilizer, industrial chemicals, and abrasives. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**SLOW**
A Transport Canada notice relating to switching and descending grades between mile 145.0 and 146.0 was imposed on 01/12/2009 (27/04/2017). This condition is regarded as a slow order.		
Connectivity (external motivation to adopt HAL)		**2**
Kettle Falls International Railway operates from Northeastern Washington, USA to Southeastern British Columbia, with an estimated 250km of track. The railroad interchanges with BNSF at Chewelah, Washington and exhibits a Tier 3 connectivity. The railroad may have high external motivation to adopt HAL.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3.5/6**

Table 4-1: Western region - Case Study A

Section 1: Overview		
Railroad	Southern Railway of British Columbia	
Ownership	Washington Companies	
Owner Category	Holding company (1)	
Geographic Region	Western	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Southern Railway of British Columbia is owned and operated by the Washington Companies, a privately held organization. The railroad handles approximately 65,000 carloadings annually. The railway commonly hauls automobile, forest, building, agricultural, chemical, consumer and steel products. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Southern Railway of British Columbia operates approximately 200km of track across southern British Columbia. The railroad interchanges with CN, CP, BNSF, and UP and exhibits a Tier 4 level of connectivity. The railroad may have high external motivation to adopt HAL.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-2: Western region - Case Study B

Section 1: Overview		
Railroad	Southern Railway of Vancouver Island	
Ownership	Washington Companies	
Owner Category	Holding company (1)	
Geographic Region	Western	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Southern Railway of Vancouver Island is owned and operated by the Washington Companies, a privately held organization. The railway commonly hauls natural resources and consumer goods. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**1**
Southern Railway of British Columbia operates approximately 235km of track across the western extent of Vancouver Island. The railroad does not directly interchange with any mainline carriers, and moves fright to the mainland via. Seaspan Coastal Intermodal. The railroad interchanges with SRBC – a short-line carrier and exhibits a Tier 2 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**2.5/6**

Table 4-3: Western region - Case Study C

Section 1: Overview		
Railroad	Grand Forks Railway	
Ownership	International Forest Products Ltd.	
Owner Category	Industrial (3)	
Geographic Region	Western	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Grand Forks Railway is owned and operated by International Forest Products Ltd. The railway exclusively hauls forest products, which are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**1**
Grand Forks Railway operates from Grand Forks, British Columbia, with an estimated 6km of track. The railroad interchanges with Kettle Falls International Railway and BNSF and exhibits a Tier 2 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4/6**

Table 4-4: Western region - Case Study D

4.2 CENTRAL REGION

The Central region comprises Alberta, Saskatchewan, and Manitoba. There are 15 short-line carriers in this region. Ten (10) railroads were selected for case study analysis in this region and are presented in the following sections. The case studies are organized by geographic region, progressing from west to east.

4.2.1 ALBERTA

Figure 4-2 illustrates the railroad selected for Central Region - Case Study A. Particulars of this railroad are described in Table 4-5.

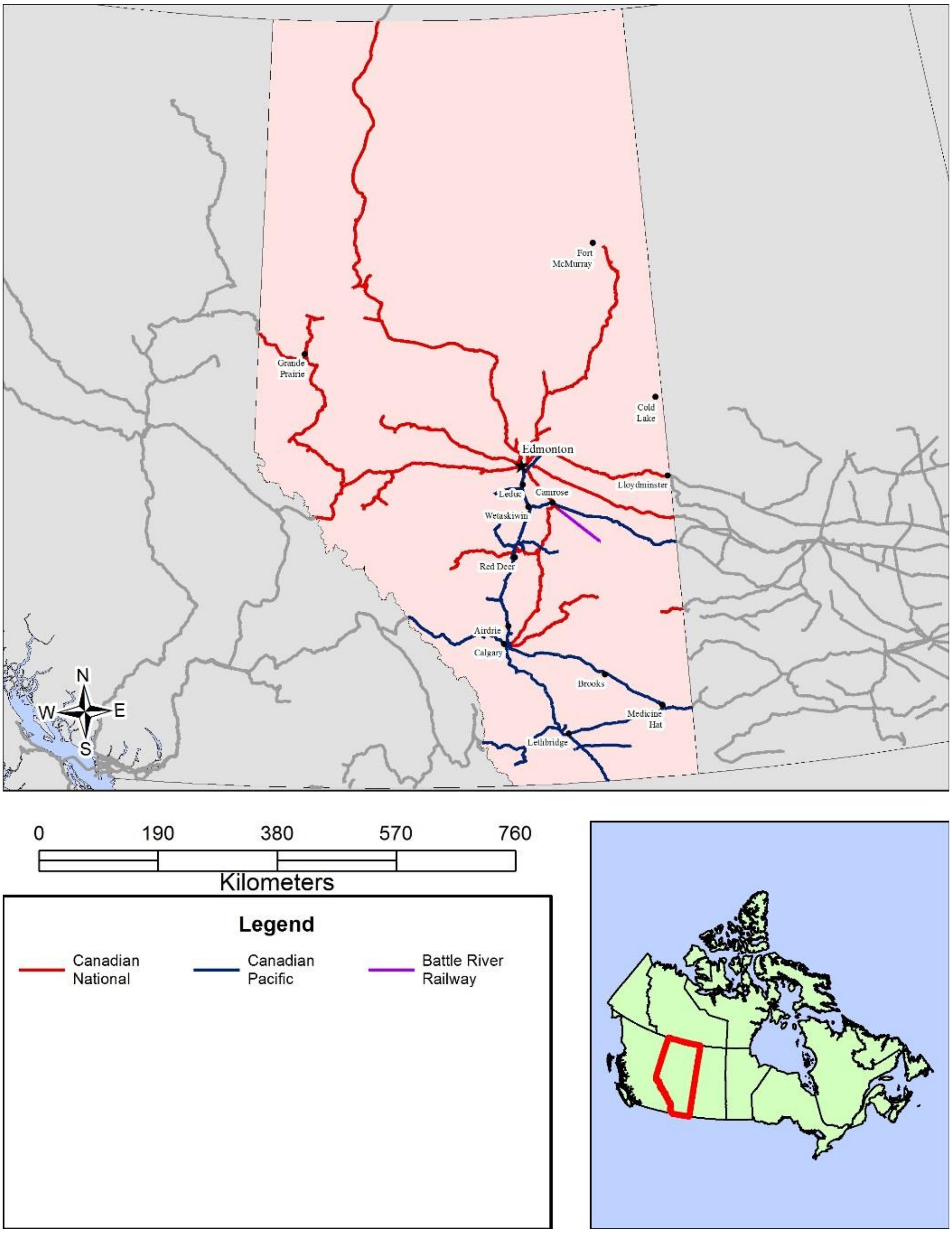

Figure 4-2: Central region – Alberta

Section 1: Overview		
Railroad	Battle River Railway	
Ownership	Co-op (shipper owned)	
Owner Category	Private co-operative (4)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Battle River railway is a community owner co-operative. The railway exclusively hauls grain products. These products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**2**
Battle River railway operates approximately 80km of infrastructure in central Alberta. The railroad interchanges with branch line CN track, in Camrose, Alberta. It exhibits a Tier 3 level of connectivity.		
Section 3: Probability of HAL adoption		
Overall motivation to adopt HAL		**5/6**

Table 4-5: Central Region - Case Study A

4.2.2 SASKATCHEWAN

Figure 4-3 depicts the railroads in Saskatchewan. Six (6) railroads were selected for case study analysis in this province; particulars of the selected railroads are described in Table 4-6, Table 4-7, Table 4-10, Table 4-8, and Table 4-9. Two (2) railroads have been analyzed together as they are owned by the same parent company and operate as a single entity.

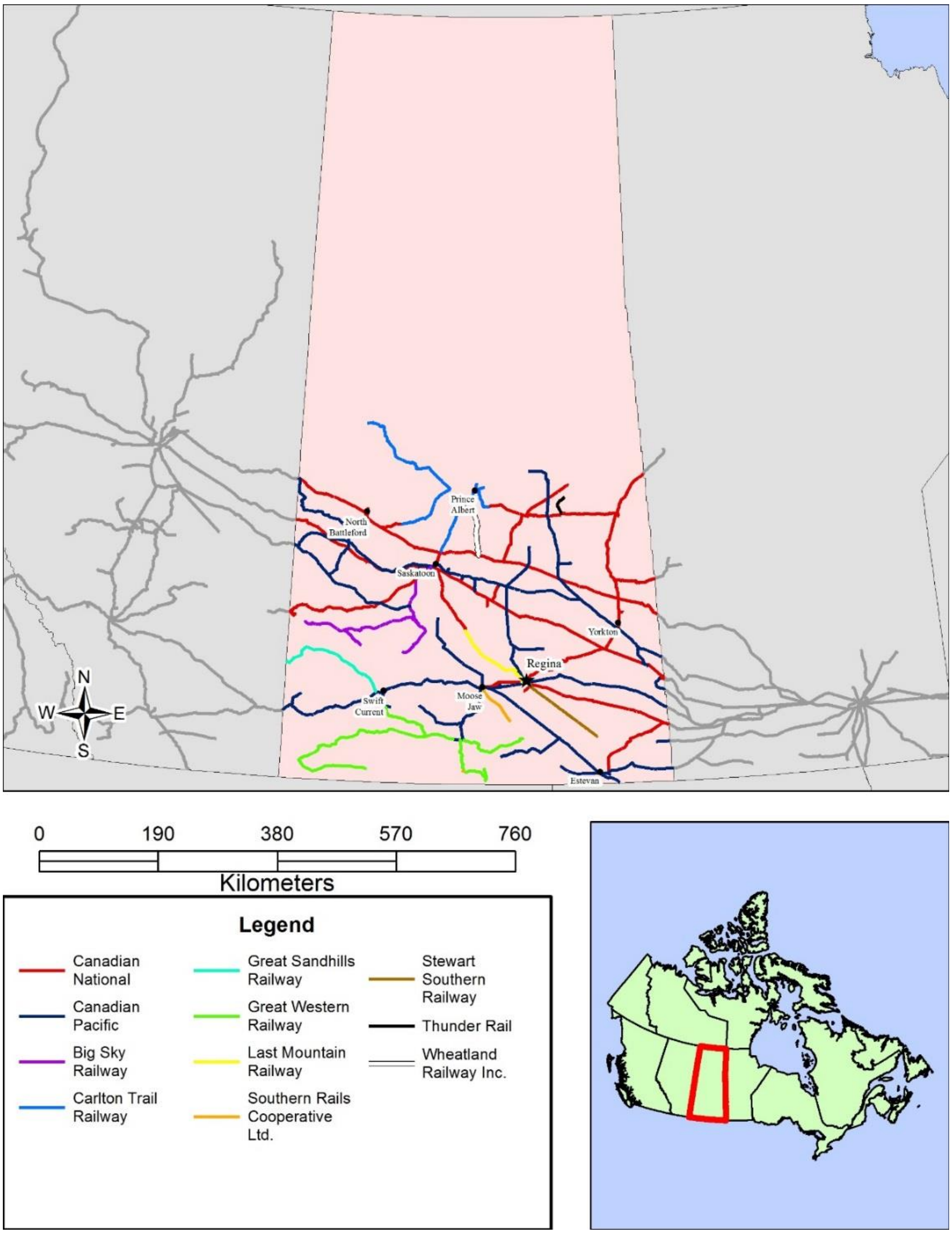

Figure 4-3: Central region – Saskatchewan

Section 1: Overview		
Railroad	Carlton Trail Railway	
Ownership	OmniTRAX	
Owner Category	Holding Company (1)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Carlton Trail Railway is owned and operated by OmniTRAX, Inc., an affiliate of Broe Group. The railway commonly hauls lumber, wheat and other grain products. These products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**2**
Carlton Trail Railway operates from Saskatoon to Prince Albert, SK, with an estimated 165km of track. The railroad interchanges with CN at Saskatoon and exhibits a Tier 3 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**5/6**

Table 4-6: Central region - Case Study B

Section 1: Overview		
Railroad	Great Western Railway	
Ownership	Local	
Owner Category	Local Rail Operator (2)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Great Western Railway hauls approximately 6,400 cars annually. The primary commodities are grain, fertilizer, crude oil, and recycled rubber. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**2**
Great Western Railway operates approximately 498km of track throughout southwestern Saskatchewan. The railroad interchanges with CP mainline railroad at Assiniboia and Swift Current. It exhibits a Tier 3 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**5/6**

Table 4-7: Central region - Case Study C

Section 1: Overview		
Railroad	Big Sky Railway and Last Mountain Railway	
Ownership	Mobile Grain	
Owner Category	Local rail operator (2)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Big Sky Railway and Last Mountain Railway are owned and operated by Mobil Grain, a privately held company. The railroad operates throughout central Saskatchewan. The railway hauls grain, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
The railroad operates approximately 540km of track southwest of Saskatoon. The railroad interchanges with CN at Saskatoon, Saskatchewan.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-8: Central region - Case Study D

Section 1: Overview		
Railroad	Great Sandhills Railway	
Ownership	Private ownership	
Owner Category	Local rail operator (2)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled		**3**
Great Sandhills Railway operates throughout central Saskatchewan. The railway hauls grain, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Great Sandhills Railway operates approximately 315km of track previously owned by CP. The railroad interchanges with CP at Swift Current, Saskatchewan. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-9: Central region - Case Study E

Section 1: Overview	
Railroad	Thunder Rail
Ownership	Co-op (farmer owned)
Owner Category	Private co-operative (4)
Geographic Region	Central
Section 2: System Factors	
Commodities Hauled (internal motivation to adopt HAL)	**3**
Thunder Rail operates on decommission Class 1 track, previously owned by OmniTrax. The co-operative was established in 2005 to ensure continued connectivity for local farmers. The railway hauls grain, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.	
Infrastructure Condition	**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.	
Connectivity (external motivation to adopt HAL)	**2**
Thunder Rail operates approximately 32km of track in the south-east region of Saskatchewan. The railroad interchanges with CN branch line track in Zenon Park, Saskatchewan. It exhibits a Tier 3 level of connectivity.	
Section 3: Assessment Summary	
Overall motivation to adopt HAL	**5/6**

Table 4-10: Central region - Case Study F

4.2.3 MANITOBA

Figure 4-4 illustrates the short-line railroads located in Manitoba. Three (3) railroads were selected in this province for further analysis; particulars of these case studies are detailed in Table 4-13, Table 4-11, and Table 4-12.

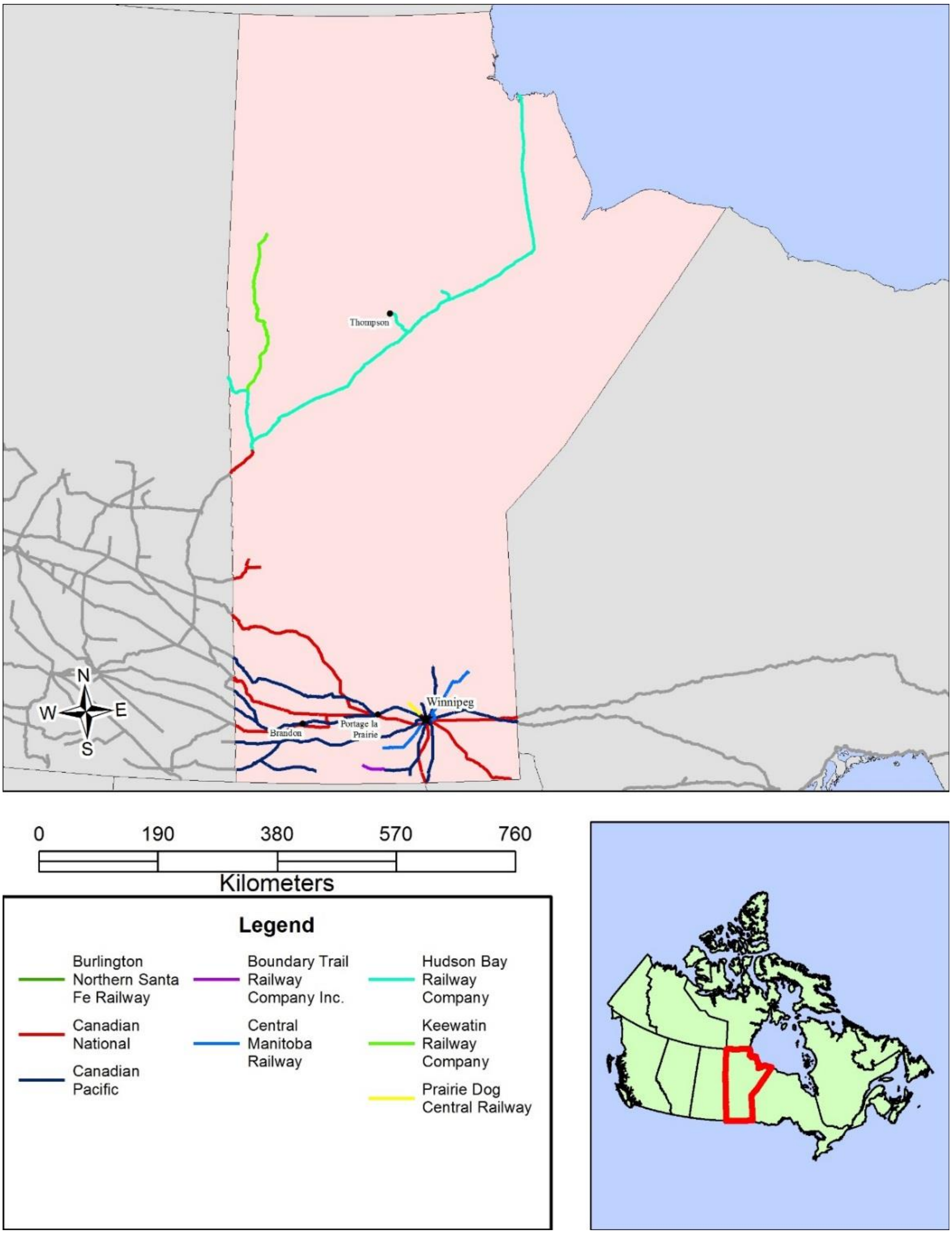

Figure 4-4: Central region – Manitoba

<table>
<tr><td colspan="2">Section 1: Overview</td></tr>
<tr><td>Railroad</td><td>Hudson Bay Railway</td></tr>
<tr><td>Ownership</td><td>OmniTRAX</td></tr>
<tr><td>Owner Category</td><td>Holding company (1)</td></tr>
<tr><td>Geographic Region</td><td>Central</td></tr>
<tr><td colspan="2">Section 2: System Factors</td></tr>
<tr><td>Commodities Hauled (internal motivation to adopt HAL)</td><td>1.5</td></tr>
<tr><td colspan="2">Hudson Bay Railway is owned and operated by OmniTRAX, Inc., an affiliate of Broe Group. The railway hauls diverse commodities including perishables, automobiles, construction material, heavy and dimensional equipment, scrap, hazardous materials, kraft paper, concentrates, containers, fertilizer, wheat and other grain products. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.</td></tr>
<tr><td>Infrastructure Condition</td><td>STOP</td></tr>
<tr><td colspan="2">This is a federally-regulated railroad. A Transport Canada notice relating to substandard track inspection practices and numerous track geometry defects not meeting minimum requirements between mile 345.0 and 480.0 was imposed on 06/05/2009 (27/04/2017). This condition is regarded as a slow order. As at July 2017, this railroad is unable to operate due to severe track damage caused by flooding.</td></tr>
</table>

Connectivity (external motivation to adopt HAL)	**2**
Hudson Bay Railway operates from western Manitoba (The Pas and Flin Flon) to The Port of Churchill in north eastern Manitoba, with an estimated 1000km of track. The railroad interchanges with CN at The Pas, Manitoba and exhibits a Tier 3 level of connectivity.	
Section 3: Assessment Summary	
Overall motivation to adopt HAL	**3.5/6**

Table 4-11: Central region - Case Study G

Section 1: Overview		
Railroad	Central Manitoba Railway	
Ownership	Cando	
Owner Category	Local Rail Operator (2)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Central Manitoba Railway was established by Cando, an employee owned organization, in 1999. The railroad primarily services industrial customers and exhibits a main commodity hauling of: grain, fertilizers, paper, fuel, steel products and chemicals. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Central Manitoba Railway operates over approximately 107km of infrastructure from Selkirk, Manitoba to Carman, Manitoba. The railroad interchanges with CN and CP mainline railroads in Winnipeg, Manitoba. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-12: Central region - Case Study H

Section 1: Overview		
Railroad	Boundary Trail Railway Company Inc.	
Ownership	Co-op (producer owned)	
Owner Category	Private co-operative (4)	
Geographic Region	Central	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Boundary Trail Railway is a producer owned operation, which was established in 2008 with the intent to ensure continued connectivity for local farmers. The sole commodity hauled is grain, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**2**
Boundary Trail Railway operates approximately 134km of track in southern Manitoba, from Morden to Binney. The railroad has running rights on a segment of CP track from Morden to Rosenfeld, Manitoba, where it interchanges with a CP branch line track. It exhibits a Tier 3 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**5/6**

Table 4-13: Central region - Case Study I

4.3 EASTERN REGION

The Eastern region comprises Ontario and Quebec. There are 16 short-line carriers in this region. 12 railroads were selected for case study analysis in this region and are presented below. The case studies are organized by geographic region, progressing from west to east.

4.3.1 ONTARIO

Figure 4-5 illustrates the short-line railroads located in Ontario. Five (5) railroads were selected in this province for further analysis; particulars of these case studies are detailed in Table 4-18, Table 4-14, Table 4-17, Table 4-15, and Table 4-16.

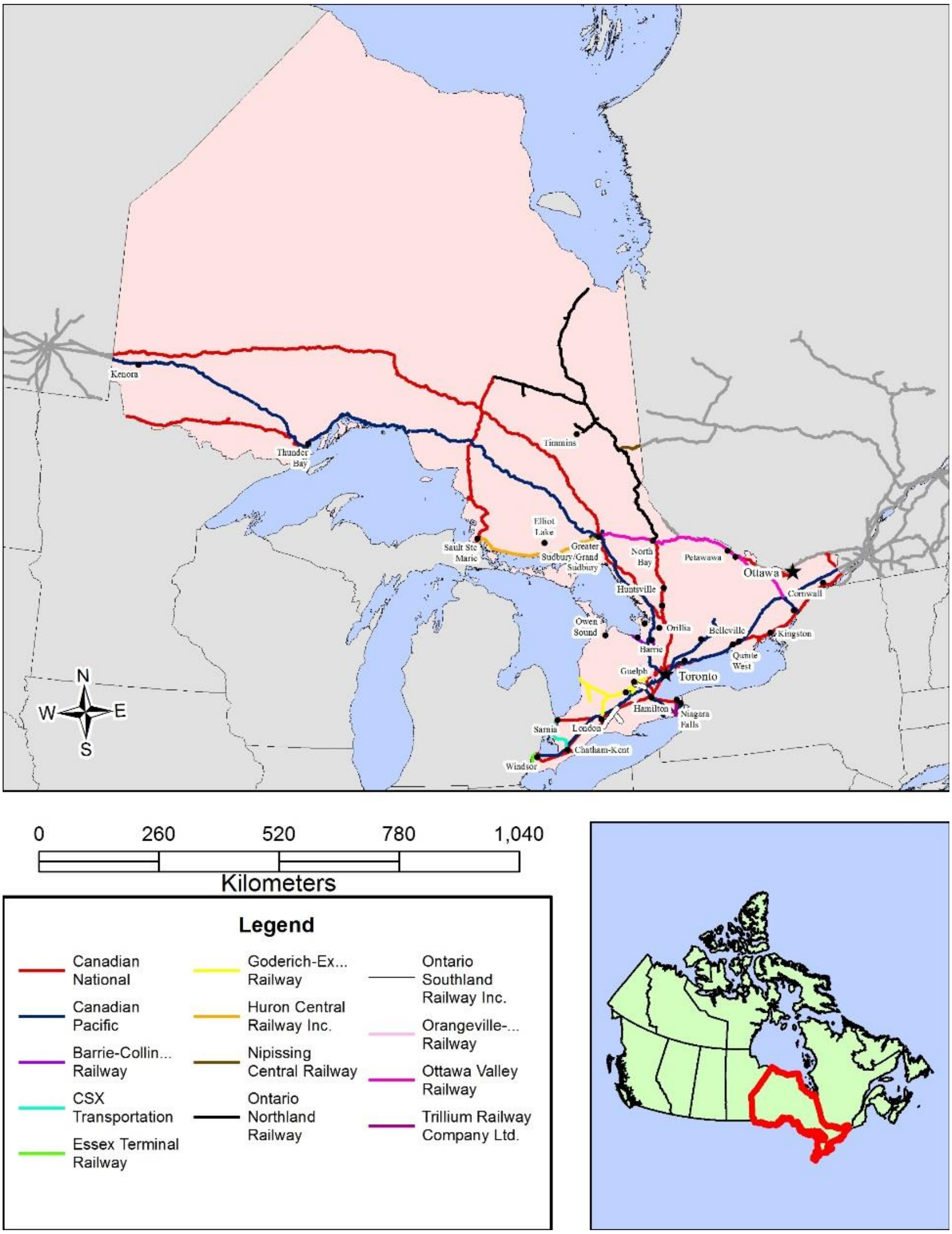

Figure 4-5: Eastern region – Ontario

Section 1: Overview		
Railroad	Huron Central Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding Company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Huron Central Railway is owned and operated by GWRR. The railway commonly hauls chemicals, forest products, petroleum products, pulp and paper, steel and scrap. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Huron Central Railway operates from Sault Ste. Marie, ON to Sudbury, ON, with an estimated 280km of track. The railroad interchanges with CN mainline at Sault Ste. Marie and with CP at Sudbury. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-14: Eastern region - Case Study A

Section 1: Overview		
Railroad	Goderich-Exeter Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Goderich-Exeter Railway is owned and operated by GWRR. The railway commonly hauls chemicals, natural resources, lumber products, grain, and fertilizer. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure. A segment of the railroad currently handles 286k loading.		
Connectivity (external motivation to adopt HAL)		**3**
GWRR operates approximately 290km of track from Goderich, Ontario to Georgetown and London, Ontario. The railroad interchanges with CN and CP mainline railroads. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-15: Eastern region - Case Study B

Section 1: Overview		
Railroad	Southern Ontario Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Southern Ontario Railway is owned and operated by GWRR. The railway commonly hauls chemicals, natural resources, lumber products, grain, and fertilizer. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure. A segment of the railroad currently handles 286k loading.		
Connectivity (external motivation to adopt HAL)		**3**
GWRR operates approximately 110km of track from Brantford, Ontario to Nanticoke, Ontario. The railroad interchanges with CN mainline at Brantford, Ontario. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-16: Eastern region - Case Study C

Section 1: Overview		
Railroad	Essex Terminal Railway	
Ownership	Local	
Owner Category	Local Rail Operator (2)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Essex Terminal Railway was founded in 1902. Currently the railroad provides services to the industrial, lumber, steel, agricultural, scrap metal, alcohol, and liquid petroleum gas industry. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**SLOW**
There is a Transport Canada order related to at grade rail crossings, which could potentially lead to a crossing collision. (30/07/2017)		
Connectivity (external motivation to adopt HAL)		**3**
The Essex Terminal Railway operates approximately 35km of track from Windsor, Ontario to Amherstburg, Ontario. The railroad interchanges with CN, CP, and CSX mainline railroads, at the Port of Windsor and exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-17: Eastern region - Case Study D

<table>
<tr><td colspan="3">Section 1: Overview</td></tr>
<tr><td>Railroad</td><td colspan="2">Trillium Railway Company Ltd.</td></tr>
<tr><td>Ownership</td><td colspan="2">Industrial (mining)</td></tr>
<tr><td>Owner Category</td><td colspan="2">Industry Shipper (3)</td></tr>
<tr><td>Geographic Region</td><td colspan="2">Eastern</td></tr>
<tr><td colspan="3">Section 2: System Factors</td></tr>
<tr><td colspan="2">Commodities Hauled (internal motivation to adopt HAL)</td><td>1.5</td></tr>
<tr><td colspan="3">Trillium Railway Company has operated and maintained the Port Colborne Harbour Railway since 1997. The main commodities hauled are: biodiesel, glycerine, vegetable oil, wheat, mustard seed, scrap metal, woodpulp, alumina, corn syrup & sweeteners, steam boilers and vessels, steel billet, steel ingots and fabricated steel parts. Some of these products may cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.</td></tr>
<tr><td colspan="2">Infrastructure Condition</td><td>SLOW</td></tr>
<tr><td colspan="3">A Transport Canada notice relating to mechanical defects was imposed on 05/26/2016. (27/04/2017). This condition is regarded as a slow order.</td></tr>
<tr><td colspan="2">Connectivity (external motivation to adopt HAL)</td><td>3</td></tr>
<tr><td colspan="3">Trillium Railway operates approximately 80km of track from Port Colborne, Ontario to St. Catharines, Ontario. The railroad interchanges with CN and CP mainline railroads. It exhibits a Tier 4 level of connectivity.</td></tr>
<tr><td colspan="3">Section 3: Assessment Summary</td></tr>
<tr><td colspan="2">Overall motivation to adopt HAL</td><td>4.5/6</td></tr>
</table>

Table 4-18: Eastern region - Case Study E

4.3.2 QUEBEC

Figure 4-6 illustrates the short-line railroads located in Ontario. Seven (7) railroads were selected in this province for further analysis; particulars of these case studies are detailed in Table 4-23, Table 4-19, Table 4-24, Table 4-25, Table 4-20, Table 4-21, and Table 4-22.

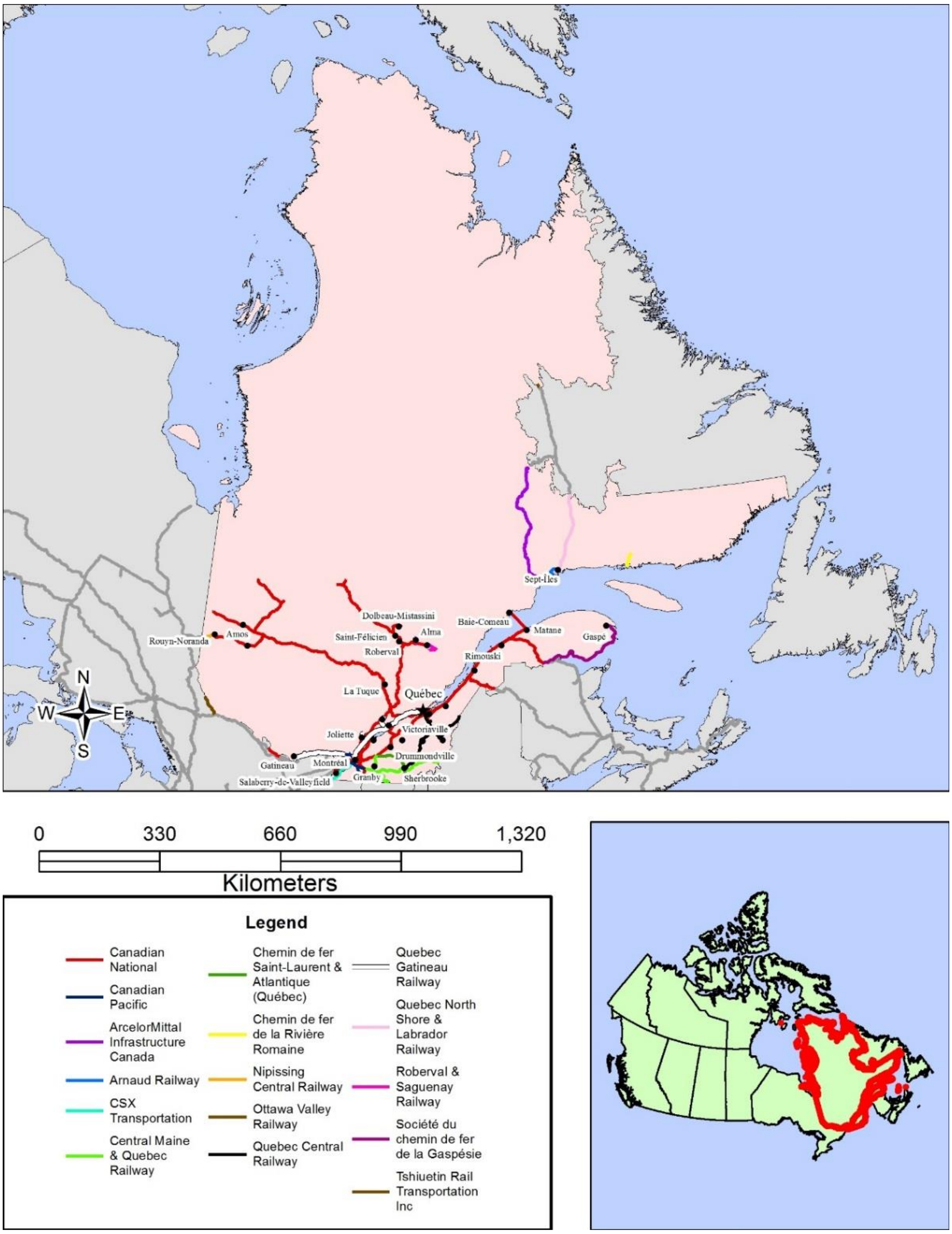

Figure 4-6: Eastern region – Quebec

Section 1: Overview		
Railroad	Central Maine and Quebec Railway	
Ownership	Fortress Transportation & Infrastructure	
Owner Category	Holding Company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
CMQR Railway is owned and operated by Fortress Transportation & Infrastructure, an affiliate of Fortress Investment Group LLC. As of September 30, 2016, FTAI had total consolidated assets of $1.6 billion and total equity capital of $1.2 billion. The railway primarily transports pulp and paper, construction products, and chemicals. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**STOP**
There are numerous Transport Canada notices relating to this railway, including those associated with infrastructure defects inducing stop orders.		
Connectivity (external motivation to adopt HAL)		**3**
Central Maine and Quebec Railway (CMQR) operates from Montreal, PQ to eastern Maine, USA with an estimated 775km of track. The railroad interchanges with CN mainline track at St. Jean, PQ and exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-19: Eastern region - Case Study F

Section 1: Overview		
Railroad	Chemin de fer Saint-Laurent & Atlantique	
Ownership	Genesee & Wyoming	
Owner Category	Holding Company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Chemin de fer Saint-Laurent & Atlantic is owned and operated by GWRR. The railway commonly hauls grain, paper products, plastics, and propane. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**SLOW**
A Transport Canada notice relating to substandard track components and numerous track geometry defects not meeting minimum requirements was imposed on 08/29/2016. (27/04/2017). This condition is regarded as a slow order.		
Connectivity (external motivation to adopt HAL)		**3**
Chemin de fer Saint-Laurent & Atlantique Railway operates from Sainte-Rosalie, Quebec to Danville Junction, Maine, with an estimated 250km of track. The railroad interchanges with mainline Pan Am Railways in Danville Junction, Maine and New Hampshire Central Railroad in North Stratford, NH. It exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-20: Eastern region - Case Study G

Section 1: Overview		
Railroad	Quebec Gatineau Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding Company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Quebec Gatineau Railway is owned and operated by GWRR. The railway commonly hauls chemicals, paper products, plastics, and winter wheat. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Quebec Gatineau Railway operates from the city of Quebec, Quebec to Gatineau, Quebec, with an estimated 720km of track. The railroad interchanges with mainline CP and exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-21: Eastern region - Case Study H

Section 1: Overview		
Railroad	Ottawa Valley Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding Company (1)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
Ottawa Valley Railway is owned and operated by GWRR. The railway commonly hauls chemicals and forest products. Some of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**0**
This is a federally-regulated railroad; there are currently no special orders or the condition of its infrastructure listed with Transport Canada. A segment of the railroad can handle 286k loading.		
Connectivity (external motivation to adopt HAL)		**3**
Ottawa Valley Railway operates from the Coniston, Ontario to Temiscaming, Quebec, with an estimated 265km of track. The railroad interchanges with mainline CP and CN mainline track and exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**4.5/6**

Table 4-22: Eastern region - Case Study I

Section 1: Overview		
Railroad	Quebec North Shore and Labrador Railway	
Ownership	Industrial (Mining)	
Owner Category	Industry Shipper (3)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
In 2016, 10.7 million tonnes of concentrate and pellets were transported over the railway with earnings of $64 million USD. The commodity hauled is iron ore, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**SLOW**
A Transport Canada notice relating to rail safety and obstructed sightlines at mile 31.36 was imposed on 10/04/2016. (27/04/2017). This condition is regarded as a slow order.		
Connectivity (external motivation to adopt HAL)		**0**
QNS&L is a mine to port route running from Sept-Iles, Quebec to Labrador City, NL, with an estimated 401km of track. The railroad does not intersect a mainline carrier and solely operates a mine to marine, origin-destination pair. As a Tier 1 railroad, QNS&L has minimal external motivation to adopt HAL.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3/6**

Table 4-23: Eastern region - Case Study J

Section 1: Overview		
Railroad	Roberval & Saguenay Railway	
Ownership	Industrial (Mining)	
Owner Category	Industry Shipper (3)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
The Roberval & Saguenay Railway links the Rio Tinto mining operations in Vaudreuil, Arvida, Grande-Baie, Laterriere, and Alma, Quebec. The commodity hauled is iron ore, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**2**
Roberval & Saquenay is a mine to port route running an estimated 140km of track. The railroad intersects CN branch track and exhibits a Tier 3 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**5/6**

Table 4-24: Eastern region - Case Study K

Section 1: Overview		
Railroad	Quebec Cartier Railway	
Ownership	Industrial (Mining)	
Owner Category	Industry Shipper (3)	
Geographic Region	Eastern	
Section 2: System Factors		
Commodities Hauled		**3**
The Quebec Cartier Railway links ArcelorMittal mining operations from Mont-Wright to Port-Cartier. The commodity hauled is iron ore, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**0**
The Quebec Cartier Railway operates a mine to port route running an estimated 420km of track. It is not connected to other railroads. It exhibits a Tier 1 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3/6**

Table 4-25: Eastern region - Case Study L

4.4 ATLANTIC REGION

Figure 4-7 depicts the short-line railroads located in the Eastern region. The Atlantic region comprises New Brunswick, Nova Scotia, and Newfoundland. There are six (6) short-line carriers in this region. Five (5) railroads were selected for case study analysis in this region and are presented in Table 4-26, Table 4-28, Table 4-29, and Table 4-27. Two (2) railroads have been analyzed together as they are owned by the same parent company and operate as a single entity.

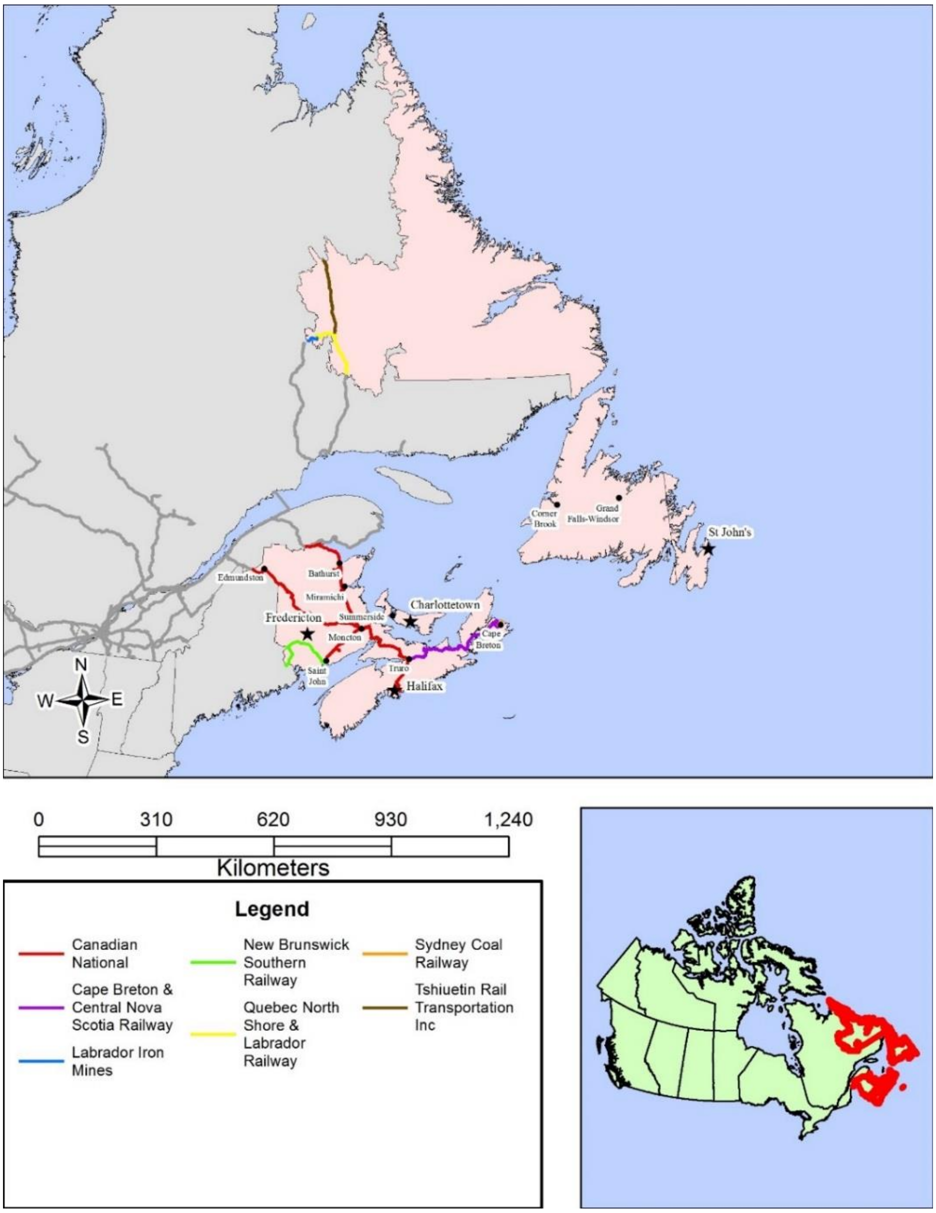

Figure 4-7: Atlantic region

Section 1: Overview		
Railroad	Cape Breton & Central Nova Scotia Railway	
Ownership	GWRR	
Owner Category	Holding Company (1)	
Geographic Region	Atlantic	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Cape Breton & Central Nova Scotia Railway is owned and operated by GWRR. The railway primarily transports chemicals, coal, lumber, paper, petroleum products. Most of these products have densities that are likely to cause cars to weigh-out; therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**3**
Cape Breton & Central Nova Scotia Railway operates from Truro, NS to Sydney, NS with an estimated 400km of track. The railroad interchanges with CN mainline at Truro and exhibits a Tier 4 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**6/6**

Table 4-26: Atlantic region - Case Study A

Section 1: Overview		
Railroad	Bloom Lake Railway and Wabush Lake Railway	
Ownership	Genesee & Wyoming	
Owner Category	Holding Company (1)	
Geographic Region	Atlantic	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
Bloom Lake railway operates as industry shipper line from Bloom Lake mine located in Fermont, Quebec to Wabush Lake Railway in Wabush, Newfoundland. Wabush Lake Railway operates from this interchange to Labrador City, Newfoundland. The commodity hauled is coal, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**0**
This is a federally-regulated railroad; there are currently no special orders or the condition of its infrastructure listed with Transport Canada.		
Connectivity (external motivation to adopt HAL)		**0**
Genesee & Wyoming operates approximately 32km of track under Bloom Lake Railway and 61km of track under Wabush Railway. The railroad serves a mine to port origin/destination pair and exhibits a Tier 1 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3/6**

Table 4-27: Atlantic region - Case Study B

Section 1: Overview		
Railroad	New Brunswick Southern Railway	
Ownership	Industrial (forestry)	
Owner Category	Industry (3)	
Geographic Region	Atlantic	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**1.5**
New Brunswick Southern Railway is owned by JD Irving Ltd, a privately held company. The railroad operates under the organization's Logistics and Transportation division and serves the local forestry, energy, construction and manufacturing sectors. Some of the products related to these industries have densities that are likely to cause cars to weigh-out; therefore, the railway may have moderate internal motivation to adopt HAL.		
Infrastructure Condition		**0**
This is a federally-regulated railroad; there are currently no special orders or the condition of its infrastructure listed with Transport Canada.		
Connectivity (external motivation to adopt HAL)		**2**
New Brunswick Southern Railway operates track across New Brunswick, Canada and Maine, USA, with an estimated 362km of track. The railroad interchanges with CN at Saint John, New Brunswick and Van Buren, New Brunswick, it exhibits a Tier 3 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3.5/6**

Table 4-28: Atlantic region - Case Study C

Section 1: Overview		
Railroad	Sydney Coal Railway	
Ownership	Industrial (mining)	
Owner Category	Industry Shipper (3)	
Geographic Region	Atlantic	
Section 2: System Factors		
Commodities Hauled (internal motivation to adopt HAL)		**3**
The Sydney Coal Railway, Inc. operates as a component of Logistec, a marine and environmental service company. The commodity hauled is coal, which typically causes cars to weigh-out. Therefore, the railway may have strong internal motivation to adopt HAL.		
Infrastructure Condition		**n/a**
This is a provincially-regulated railroad; therefore, there is no publicly-available data on special orders or the condition of its infrastructure.		
Connectivity (external motivation to adopt HAL)		**0**
Sydney Coal Railway Inc. operates approximately 24km of track in Sydney, NS. The railroad serves a mine to port origin/destination pair and exhibits a Tier 1 level of connectivity.		
Section 3: Assessment Summary		
Overall motivation to adopt HAL		**3/6**

Table 4-29: Atlantic region - Case Study D

4.5 CASE STUDY FINDINGS AND DISCUSSION

A total of 31 railroads were detailed in the case study analysis. This represents 71% of Canada's short-line railroads. A summary of case study findings is presented in Table 4-30.

System Variable	**No. of railroads per region**			
	Western	Central	Eastern	Atlantic
Commodities Hauled (A)				
Low internal motivation to adopt HAL because no evidence of high-density commodities being hauled				
Some internal motivation to adopt HAL because some evidence of high-density commodities being hauled	**3**	**2**	**6**	**1**
Strong internal motivation to adopt HAL because the short-line's operation is highly dependent on hauling high-density commodities	**1**	**8**	**6**	**4**
Infrastructure Condition (T)				
Provincially-regulated railway; no data	**3**	**9**	**6**	**2**
Federally-regulated railway; no Transport Canada notices or orders			**1**	**3**
Federally-regulated railway; Transport Canada slow order or similar	**1**		**4**	
Federally-regulated railway; Transport Canada stop order or track maintenance required		**1**	**1**	

System Variable	No. of railroads per region			
	Western	Central	Eastern	Atlantic
Connectivity tier (T)				
Tier 1; low external motivation to adopt HAL			**2**	**3**
Tier 2; low-medium external motivation to adopt HAL	**2**			
Tier 3; medium-high external motivation to adopt HAL	**1**	**6**	**1**	**1**
Tier 4; high external motivation to adopt HAL	**1**	**4**	**9**	**1**
Summary assessment				
Low motivation to adopt HAL				
Low-medium motivation to adopt HAL	**1**			
Medium-high motivation to adopt HAL	**3**	**2**	**8**	**4**
High motivation to adopt HAL		**8**	**4**	**1**

Table 4-30: Overview of case study analysis

The summary assessments shown in Table 4-30 revealed that, of the 31 railroads analyzed in the case studies, none (0 of 31) had low overall motivation to adopt HAL; 3% (1 of 31) had low-medium overall motivation to adopt HAL; 55% (17 of 31) had medium-high overall motivation to adopt HAL; and 42% (13 of 31) had high overall motivation to adopt HAL. This overall finding reflects the nature of the short-line industry itself. The rail mode is uniquely capable of hauling heavy (often bulk) commodities efficiently over long distances, thus providing a strong internal motivation for adopting HAL. Moreover, many short-lines in Canada serve markets which do not have direct access to Class 1 carriers, but which expect short-lines to offer a connecting service to these carriers. This creates a strong external motivation for adopting HAL.

All railroads that exhibited high overall motivation to adopt HAL exhibited either high internal motivation (i.e., they are particularly dependent on hauling high-density commodities) or high external motivation (i.e., they have a direct connection to a Class 1 mainline). Although mathematically, internal and external motivating factors equally contributed to the overall assessment, all of the railroads (13 of 13) which had a high overall motivation to adopt HAL were assessed as such because of their reliance on hauling high-density commodities.

Regarding internal motivation to adopt HAL, all railroads hauled at least some commodities that would typically cause cars to weigh-out. Specifically, 12 of 31 railroads were assessed as having moderate internal motivation and the remaining 19 railroads were assessed as having strong internal motivation.

Regarding external motivation to adopt HAL, 5 of 31 railroads were assessed as having low external motivation (i.e., Tier 1), 2 of 31 were assessed as having low-medium motivation (i.e., Tier 2), 9 of 31 had medium-high motivation (i.e., Tier 3), and 15 of 31 had high motivation (i.e., Tier 4). All railroads with low external motivation had high internal motivation to adopt HAL; these railroads were all located in Quebec or the Atlantic region.

The case studies identified 11 railroads that fall under federal regulation; the remainder are regulated provincially. Of these 11 railroads, evidence of SLOW or STOP orders from Transport Canada existed for 7 railroads. No such data were available for the provincially-regulated railroads. While these orders did not contribute to the overall assessment score, they provided an indication of a railroad's infrastructure condition, which influences the costs associated with adopting HAL.

Geographically, the case study analysis revealed the following:

- *West*: Nearly all (3 of 4) western short-lines had a medium-high overall motivation to adopt HAL.
- *Central*: Nearly all (8 of 10) central railroads had a high overall motivation to adopt HAL. This reflects the strong reliance on hauling heavy agricultural products in this region and the extensive connections to the Class 1 systems.
- *East*: Over half (8 of 12) eastern railroads had a medium-high overall motivation to adopt HAL; the remainder had a high overall motivation.
- *Atlantic*: 4 of 5 Atlantic railroads had a medium-high overall motivation to adopt HAL; the remainder had a high overall motivation.

From an ownership classification perspective, the case study analysis revealed the following:

- *Holding company*: 1 of 14 railroads in this category had low-medium overall motivation to adopt HAL; 8 of 14 railroads in this category had a medium-high overall motivation to adopt HAL; the remainder had a high overall motivation.
- *Local rail operator*: 2 of 6 railroads in this category had a medium-high overall motivation to adopt HAL; the remainder had a high overall motivation.
- *Industry*: 7 of 8 railroads in this category had a medium-high overall motivation to adopt HAL; the remainder had a high overall motivation.
- *Co-operative*: 3 of 3 railroads in this category had a high overall motivation to adopt HAL.

The foregoing case study findings are subject to two key limitations. First, the case studies rely on surrogate data to assess a railroad's internal and external motivation to adopt HAL. Specifically, the types of commodities hauled provided an indication of internal motivation. In most cases, this information was obtained from the short-line's website and typically did not provide details in terms of the proportions of commodities hauled by the railroad. Similarly, the level of network connectivity was used to assess external motivation. While this assessment is objectively made based on available network characteristics, it does not necessarily reflect whether a short-line railroad experiences pressure from its Class 1 partners to upgrade to HAL.

Second, as has been stated, there is a lack of systematic, publicly-available data on infrastructure condition and currently permitted axle loads on Canadian short-lines. To an extent, this lack of data underscores the motivation for and contribution of this research. Nevertheless, these data would help validate the overall assessments and calibrate the findings to actual conditions currently being experienced by the Canadian short-line industry. For example, as indicated in the case study analysis, three (3) railroads (Goderich-Exeter, Southern Ontario, and Ottawa Valley Railroads) reported an ability to haul fully-loaded 286,000-lb cars (i.e., they allow HAL). Two of these three railroads exhibited a high overall motivation to adopt HAL, according to the assessment approach developed and applied in this thesis. All three are directly connected to a Class 1 mainline. These findings help validate the assessment approach.

5 CONCLUSION

5.1 SUMMARY OF FINDINGS

Since deregulation, the North American short-line rail sector has experienced dramatic growth, primarily through the acquisition of low-density Class 1 lines. The extensive network of short-line railroads across Canada and the United States provides critical service to shippers without access to the Class 1 system. Often, these railroads focus on hauling one commodity or a small number of commodities related to a single industry. In this way, the short-line rail industry provides economic and social benefits to North American society while reducing congestion, emissions, and roadway deterioration.

The North American rail sector is continuously seeking methods to increase productivity, capacity, and efficiency. The Class 1 railroads have achieved this goal, in part, by implementing progressively heavier axle loads, thereby reducing the overall cost per ton mile. The potential benefits of introducing heavy axle loads (HAL)—that is, the shift from 263-kip (263k) railcars with 33-ton axle loads to 286-kip (286k) railcars with axle loads up to 36 tons—do not necessarily extend to short-line carriers in the same way as Class 1 carriers. The degree to which short-lines may benefit from HAL and the extent of a short-line's internal and external motivation to adopt HAL depend on a host of infrastructure and operational factors. This thesis focuses on the influence of three factors: the types of commodities hauled by a short-line, the condition of its infrastructure, and the nature of the connection between a short-line railroad and the Class I network.

To date, no systematic review of the adoption of HAL by the Canadian short-line industry has been completed. Therefore, despite a lack of literature and publicly-available data, this thesis contributes new knowledge by developing and applying a case study approach to systematically and representatively characterize the diverse nature of the Canadian short-line industry. The approach stratifies the industry in terms of the type of ownership and geographic region. It also documents factors influencing the adoption of HAL for each railroad by examining the commodities it hauls (i.e., internal motivation) and its network connections to the Class 1 system (i.e., external motivation). Where available, infrastructure condition data are also reported.

Case studies of 31 Canadian short-line railroads were completed. These studies revealed that all of the 31 railroads studied exhibited a medium-high or high overall motivation to adopt HAL. This reflects the nature of the short-line industry in Canada—filling a niche by hauling primarily heavy commodities (thereby providing internal motivation) while relying on Class 1 partners to offer complete services to their customers (thereby providing external motivation). Despite these findings, there are examples of railroads with moderate internal motivation to adopt HAL; these railroads typically hauled a diverse range of commodities. Moreover, several railroads are completely independent of Class 1 networks; therefore, they experience no external motivation to adopt HAL. However, each of these railroads hauls high-density commodities (e.g., iron ore) so their internal motivation remains high.

Geographically, the short-lines in the central region appeared to be the most highly motivated to adopt HAL. This is because most of these railroads focus on hauling agricultural commodities (which generally benefit from HAL) and because these railroads operate within a region which is extensively served by Class 1 carriers. Railroads in the other regions exhibited a wider range of characteristics.

Finally, from an ownership perspective short-lines in category 4 (co-operative) appeared to be the most highly motivated to adopt HAL. This is because these railroads primary commodity was agriculture and the railroads exhibit a connection to Class 1 track.

Overall, despite the evident data limitations, the findings from the case studies help improve the understanding of Canada's short-line industry.

5.2 RECOMMENDATIONS FOR FUTURE RESEARCH

Further research is needed to study the status of implementation, associated costs and benefits, and return on investment of the introduction of HAL operations on short-line railroads in Canada. Additionally, more detailed work is needed to characterize infrastructure condition for short-line railroads. This includes all infrastructure elements (i.e. track, roadbed, bridges).

The framework developed for the case study analysis can be further validated through more comprehensive interactions with industry representatives. This was attempted but was unsuccessful through the course of this research. Further research could be conducted in association with or supported by the Railway Association of Canada. This partnership would leverage the relationship between the Association and the short-line railroad operators. Research being conducted in the United States on short-line railroads has been successful under a similar partnership.

To enhance these findings, further research using more detailed operational data for individual short-lines in Canada is needed. Specifically, data concerning the existing load capacity of the track, the types of commodities hauled, the specifications of rolling stock being utilized, and the markets being served would add value to the results of this analysis. Enhancing the approach described in this research in these ways could support decisions concerning where and when upgrades should occur, how they should be financed, and expected economic benefits.

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