TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

Transportation 2014
PAST-PRESENT-FUTURE

TAC
Transportation Association of Canada

ACKNOWLEDGMENTS

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Geoffrey Noxon (Editor)
Noxon Associates Limited

Luc Couture
MMM Group Limited

Lynne Cowe Falls
University of Calgary

Jeannette Montufar
University of Manitoba

Kumar Ranjan
Regional Municipality of Niagara

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For more information about the Transportation Association of Canada or *Transportation 2014* please contact:

Transportation Association of Canada
2323 St. Laurent Blvd.
Ottawa ON K1G 4J8
Telephone: (613) 736-1350
Fax: (613) 736-1395
Web: www.tac-atc.ca
E-mail: secretariat@tac-atc.ca

This publication is also available in French

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By Michel Gravel - TAC Executive Director

Ucal-Henri Dandurand, CGRA's first President.
(Courtesy: Centre d'histoire de Montréal, fonds Dandurand)

Bleury Street – 1912

1926 conference delegates

In 2014, the Transportation Association of Canada (TAC) is celebrating its centennial, an exciting milestone. Not bad for an organization born in 1914 from the efforts of 302 enthusiastic motorists—pioneers who realized that the automobile would profoundly change transportation, and that Canada needed better roads to accompany this revolution.

To mark its 100th birthday, TAC launched *Transportation 2014*, a celebration of the past, present and future of Canadian transportation. TAC's evolution is tightly linked to Canada's transportation history, from dirt roads to ultramodern highways and multimodal transportation systems. It's been quite a trip!

Even as the association grew and evolved over the last century, it continued to promote the provision of efficient, effective and safe transportation services to support Canada's economic and social development. TAC remains committed to being a neutral forum for transportation professionals to exchange ideas, information and research in line with its motto "Connecting Knowledge and People".

The association's contribution to Canadian transportation over 100 years has been nothing short of outstanding. TAC was a leading voice behind construction of the Trans-Canada Highway, a key step in building our nation. It helped Canada's streets and highways become among the safest in the world by facilitating the development of national standards and practices, and by encouraging harmonized regulations. Over the years, TAC has gained respect and influence through its research, development of best practices, and knowledge transfer activities such as courses and seminars.

TAC has long emphasized the need to support students interested in transportation, and has played a pivotal role in educating Canada's future transportation leaders. For over 60 years, talented Canadian students have benefited from scholarships provided by TAC and, more recently, the TAC Foundation. As Canada's transportation landscape has shifted over the past century, TAC has changed with the times. The association's mandate was broadened throughout the 1970s and 1980s to include all modes of transportation. Then, in the early 2000s, TAC returned to its core focus of roads and associated infrastructure, as well as urban transportation. More recently, it has adapted to tackle emerging issues such as environmental sustainability, climate change and the needs of small municipalities.

TAC's experience over the past century has laid the foundation for its vision: **"Canada will be a world leader in transportation knowledge, for the benefit of our people, our economy and our environment. TAC will be recognized as a leader in creating the technical expertise and exchange of information required to build and maintain this position."**

With the efforts of TAC's members and volunteers, this vision is sure to become a reality in the not-too-distant future!

Happy Centennial!
Michel Gravel
TAC Executive Director

1914 Program

A LOOK BACK THROUGH TIME

In May 1914, the first International Good Roads Congress held in Canada took place in Montreal. It gave birth to the national good roads movement and the incorporation of the Canadian Good Roads Association (CGRA) in 1917. That organization was renamed the Roads and Transportation Association of Canada (RTAC) in 1970, which in turn became the Transportation Association of Canada (TAC) in 1990.

TAC has previously marked two major milestones. In 1964, CGRA celebrated its golden jubilee with an equipment and construction symposium in Toronto, followed by an annual meeting in Montreal to coincide with the 50th anniversary of Quebec's Highways Department.

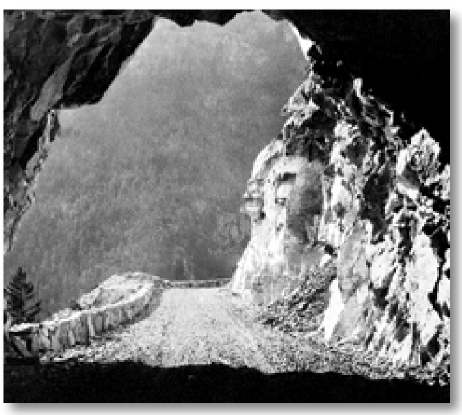
In 1974, RTAC celebrated its diamond anniversary by holding a one-day symposium in Montreal during National Transportation Week with the Quebec Ministry of Transport, which was celebrating its 60th anniversary. This was followed by RTAC's annual meeting in Toronto, which kicked off with an International Day.

TAC: AN ORGANIZATION LOOKING AHEAD

TAC: AN ORGANIZATION LOOKING AHEAD

By Ralph Haas, CM, FRSC, FCAE, Honorary Life Member of TAC

Construction of Lakeshore Boulevard, Island of Montreal
Ministère des Transports du Québec



Fraser Canyon, BC, 1950s
British Columbia Transportation and Infrastructure

This book is part of the centennial celebration of the Transportation Association of Canada (TAC) in 2014. Since its birth as the Canadian Good Roads Association in 1914, TAC has seen the evolution of an extensive and modern transportation system that is second to none. This great success has overcome challenges that include the geographic and climatic diversity of a nation that stretches 10,000 kilometres from sea to sea.

Transportation is vital to Canada's economic health and the day-to-day activities of its citizens. It provides the underlying motivation for this book, which is a combination of text and images. More broadly, the book is a tribute to the pioneers, the achievers, the leaders, the entrepreneurs and the risk takers who had the vision to plan, finance and build the system. They truly made things happen.

Today's transportation system of roads and bridges, railways, ports, airports, public transit and pathways is in fact a legacy of that century of evolution, and a key element of successful nation building. While Canadian transportation goes back to the trails of indigenous peoples, the waterways of the voyageurs and the roads of early settlers, it was the transcontinental railroad that initiated this remarkable story of nation building, marked by the arrival of the first train in Vancouver in 1887, just 20 years after Confederation.

This book reflects a proud history of achievements as it describes the importance of transportation to Canada's economy. It emphasizes the railway's key role in connecting a very young nation across a vast territory that included the new province of British Columbia and the other future western provinces.

Air transportation, from the early days of the bush pilots to the modern era of air service across Canada and into the Arctic, is described in the book as a bridge with both the past and future.

Canadian seaways, such as the St. Lawrence Seaway, have been as essential as roads and rail to the transport of agricultural commodities, natural resources and manufactured products to both domestic and international markets. While Canada has one of the world's longest coastlines these goods largely originate in land-locked regions, and the book describes how this constraint was overcome.

Canada's intensity of road and bridge building, from those few roads existing at TAC's birth to today's million-plus kilometres, is highlighted in the book along with the role of trucking as a driving force in the economy. Indeed, today's modern highways are the lifeblood of the nation. The Trans-Canada highway represents the powerful connection among Canadians across their vast country. The Alaska Highway, built during World War II, provides another example of the vital role that highways play in our transportation system.

Urban transportation, including public transit, is an increasingly important part of the overall sector as population continues to shift from rural to urban areas. Intelligent transportation systems (ITS) play a key role in achieving better efficiency with existing resources in larger urban areas. However, Canada also has a range of medium to smaller municipalities that will continue to benefit from innovations in road design, safety and ITS. The book provides a balanced focus between the large-scale urban areas and our many smaller communities.

The book addresses the increasing emphasis on environmental stewardship and the need for sustainability in designing, building, maintaining and operating transportation facilities. While the basic principles are covered, it is emphasized that this is more than "being green"—it requires long-term continuity of management processes, adequacy of resources, innovation, knowledge and succession planning, and the use of best practices.

The safety of road users, pedestrians and operational personnel in transportation facilities is another key requirement and indeed an expectation as discussed in the book. It is a complex area that involves technology, human factors, environmental conditions and many other fields, but also represents an opportunity for continuing long-term improvement.

The concluding chapter focuses on continued success in sustainable transportation. Traditional measures of success in terms of greater passenger and freight movements, reduced transit times and economic growth will have to be extended to include the triple bottom line. Quantifiable performance indicators related to social, environmental and economic accounting are identified, and there are many reasons for optimism even if we have yet to see a full paradigm shift.

Finally, this book's contributors represent tremendous collective expertise and experience in the transportation sector. It would not have been possible without the generous contribution of their time and effort.

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THE RAILROAD: KEY TO A NATION'S BIRTH

THE RAILROAD: KEY TO A NATION'S BIRTH

By Jean-Paul Viaud, Exporail

Last spike of the Canadian Pacific Railway at Craigellachie, BC, 1885
CPR Archives

THE BEGINNINGS OF AN ECONOMIC FORCE

As early as the 1820s, the railroad was fast becoming a key symbol of the Industrial Revolution across Europe and North America. Politicians in the United States were promoting the progressive doctrine of "internal improvement" through the development of canals, railways and other major transportation infrastructure.

In Canada, this notion would resonate with the bold and forward-thinking Montreal-based investors who launched Canada's first public railway in 1836, connecting the cities of La Prairie and Saint-Jean-sur-Richelieu. Throughout the 1840s and 1850s, as the idea of a united Canada was beginning to take shape, many canals and railways were built to facilitate interprovincial trade and commerce with border states. Montreal's Victoria Bridge, inaugurated in 1860, provided Canada with a vital link to America, bearing testimony to our progress and emphasizing the importance of a north-south development axis. It is unique and worthy of note that the commitment to build a railway link from Nova Scotia to British Columbia was entrenched in the Canadian Constitution.

The completion of the first transcontinental railway in the United States in 1869 showed the urgent nature of the "Race to the Pacific". However, significant progress in Canada would only materialize as a result of the National Policy, an economic program enacted in 1878 by Prime Minister John A. Macdonald. It included three main components: the expansion of rail networks toward Western Canada and regionally, significant increases in immigration, and import tariffs. Canada would be built and developed along the main transcontinental railroad and numerous secondary branches, as Eastern Canada's industrial capacity blossomed and Western Canada became the British Empire's breadbasket. Although today's immigration numbers are nowhere near the levels achieved in the late 1800s and early 1900s, the effects of the National Policy are still visible in the 21st century: a predominantly industrialized economy in the East and a heavily agricultural economy in the West, with Canadian products and goods flowing cross-country to be shipped to Asia.

In the 1870s, following extensive exploration, surveyors led by engineer Sandford Fleming drew up alternative routes for a transcontinental railway. After the Britain-based Grand Trunk Railway Corporation declined the Government of Canada's invitation to build the transcontinental railway, a Canadian company was founded: the Canadian Pacific Railway (CPR). Construction work began in 1881, and under general manager William C. Van Horne the last spike was driven on November 7, 1885. This was not a moment too soon, for the United States (having established its own extensive rail network) was experiencing rapid economic growth, and the British Empire was counting on Canada to provide a link to promising Asian markets. In fact, Canada would position itself as the "Gateway to the Orient"—a slogan found on most, if not all, railway promotional materials in the late 1800s—by transporting Asian products and goods (notably silk) to European markets.

Montreal central station, 1964
Archives de la Ville de Montréal

THE CANADIAN CENTURY

From 1886 until the start of World War I in 1914, Canada experienced considerable growth in its population and in industrial, mining and agricultural activity. A climate of euphoria had set in, and Canada was seen at home and abroad as a land of opportunity and prosperity. The timing could not have been better, as there was a nearly boundless country to colonize, and manpower was needed on the farms of the West and in the mines and lumber camps of Ontario and Quebec. The government gave the two main railway operations—the CPR and the Grand Trunk—a mandate to bring in the best possible candidates for this massive undertaking. Although previous colonization initiatives had focused on persons of Anglo-Saxon extraction, this new wave of immigrants had diverse sources including the Ukraine, Germany, Iceland, Scandinavia, Italy, Greece and Portugal. At that time, however, there were no efforts to include immigrants from China, Japan or elsewhere in Asia.

Generous government subsidies were offered, including the release of broad tracts of land to CPR. An ingenious promotion system gave Western settlers free land—and in some cases free prefabricated farm buildings transported by train—and enabled Canada to reach its settlement and colonization objectives. This new wave of immigrants (most arriving between 1886 and 1914) played a key role in making the railways very profitable, by increasing the use of railway infrastructure in previously unpopulated areas and by giving Canada the population it needed to develop its natural resources.

During those years, new immigrants were given training on farming techniques and home economics during their westbound train journey. Also, in an effort to improve productivity and performance, CPR and the federal government jointly established a cross-Canada network of experimental farms dedicated to applied agronomic research. It was at the Ottawa Experimental Farm that a ground-breaking discovery was made—Marquis Wheat, a revolutionary strain that matured two to three weeks faster than the norm, a critical advantage in a country where winter comes early. The export of Marquis Wheat would help Canada become Europe's breadbasket.

Grain transportation—at reduced tariffs regulated by the 1897 Crow's Nest Pass Agreement—would create considerable wealth in port cities along the Great Lakes (Port Arthur, among others) and Eastern Canada (Montreal, in particular). Massive grain elevators, long since unused, mark the landscape of these cities to this day.

DIVERSIFICATION AND CONVERGENCE

The main players in the Canadian railroad industry remained in fierce competition while seeking to diversify their activities. CPR, under the energetic leadership of William C. Van Horne, was the first to see the potential market for leisure travel, and played a key role in making Canada a sought-after travel destination. Luxury hotels, winter and summer sports, hunting, fishing and tourism opportunities were offered to a discerning public. The railways not only supported these new ventures, but took control and added more services to generate new revenues—a business approach now called convergence.

The arrival of new immigrants and the rapid development of tourism—both of which were closely connected to train travel—generated considerable increases in rail traffic. Immigrants and tourists mostly travelled to Canada by ship, so

Go Train inaugural run, Richmond Hill, ON, 1978
Archives of Ontario

VIA Rail passenger train, 2011
Ministère des Transports du Québec

providing continuous and high-quality travel was essential to the survival of the railway companies. In 1903, CPR became the first railway company to acquire a transoceanic steamship line (the Beaver Line, founded in 1867 as Canada Steamships and eventually rechristened the Canadian Pacific Line) and evolve into a true multimodal transportation enterprise. Its main competitor, the Grand Trunk (from 1909 to 1923) and its later iteration the Canadian National Railway (CN), would follow suit in this lucrative diversification endeavour.

Convergence in passenger transportation continued at a rapid pace through the 1930s, with the rise of civil aviation. In 1937, CN founded Canada's first civil aviation company, Trans-Canada Airlines, which would become Air Canada in 1964. Meanwhile, in 1940 CPR was awarded the contract to deliver bombers from factories in Ontario and Quebec to the European front, and shortly thereafter ventured into civil aviation. In 1942, it assembled a series of bush airlines into what would become Canadian Pacific Airlines (later renamed CP Air then Canadian Airlines, finally merging with Air Canada in 2000).

THE RISE AND FALL OF PASSENGER TRANSPORTATION

By the 1940s, Canada's two major railway companies had become fully multimodal and offered travel by rail, air and sea. World War II marked the height of rail transport in Canada, with over 200 million passenger-days travelled. Afterward, urbanization and population growth fuelled the increased use of tramways, subway and commuter rail, but long-distance rail travel began an inexorable decline. The arrival of civil aviation had spelled the end of rail travel's monopoly, even though the railways (which controlled the major airlines) were still essentially competing with each other.

After 1945, the formidable growth of a competitor the railway companies could not control—the automotive industry—proved to be an insurmountable challenge that would accelerate the decline of rail passenger travel. In the face of this new threat, rolling stock builders (Budd being at the forefront) would develop state-of-the-art all-steel railcars that were the height of comfort throughout the 1950s. In 1955, CPR launched the soon-to-be famous "Canadian" all-steel passenger car, and CN followed with its own "Super Continental." At the same time, the rail industry as a whole was quickly transitioning from steam to diesel locomotives. In the United States, there was even talk of nuclear-powered trains, and General Motors was busy promoting its "Train of Tomorrow" to sustain and enhance public interest. These efforts were to no avail, as public interest in train travel was rapidly declining—even in toy stores, where model rocket ships were outselling electric trains.

During the 1960s, CPR withdrew from long-distance passenger transportation and transferred its passenger rolling stock to CN which, as a federal crown corporation, was obliged to continue providing services seen as "essential." Attempts to adapt high-speed rail technology—such as United Aircraft Limited's TurboTrain—did not succeed. Fortunately, a less ambitious, more adaptable new technology was destined to gain world attention: the Bombardier LRC (Light, Rapid, Comfortable). As of 1978, Via Rail Canada would take over all long-distance rail passenger services, as CPR and CN refocused their attention on freight transportation.

The 1990s were marked by the first waves of service cuts at Via Rail. Despite quality improvements and a broader offering of services as of 2001, the future of rail passenger transportation in Canada remains uncertain outside of large urban centres. Rumours of high-speed train travel—a technology that Bombardier, Canada's largest rolling stock manufacturer, has implemented elsewhere—have yet to come to fruition, and proposed high-speed links from Montreal to both Toronto and New York City remain on the drawing board. At this stage, the future of passenger rail travel is contingent upon modernizing rail infrastructure in major urban areas.

GOODS AND RAW MATERIALS

In 1897, in light of the nation's ever-increasing thirst for the West's mineral resources, CPR requested government financial support to develop the necessary infrastructure. In exchange for its financial support the federal government implemented the Crow's Nest Pass Agreement, a special tariff that allowed Western farmers to ship their products by rail at a reasonable rate. This agreement was made viable by the fact that the railways extracted considerable profits from the mining and energy resource industries.

Products transported by rail are generally divided into four broad categories:

- **Category 1 –** Food products and associated products (e.g. grains and related products such as fertilizer, fruits and vegetables, livestock, canned goods)
- **Category 2 –** Industrial products (e.g. raw materials such as coal, bauxite, iron ore and potash, or semi-finished goods such as smelted metals, chemicals, plastics)
- **Category 3 –** Energy products (e.g. petroleum, gas)
- **Category 4 –** Manufactured products (e.g. machinery, automobiles, household appliances)

Category 1 products dominated rail traffic by volume until the late 1940s. The top position was then taken over by Category 2 products, a situation that remains to this day. The transport of Category 3 products has become increasingly important. Category 4 products, which are a direct reflection of Canada's manufacturing output and consumption, are highly reliant on multimodal transport infrastructure.

As brought to the fore by the Lac Mégantic accident, the transport of crude oil by rail has grown significantly in recent years, and could soon become the primary source of revenue for the railways. Two numbers tell the tale: 500 and 140,000. The first is the total number of tank cars of crude oil transported in Canada in 2009, and the second is the number in 2013. This also illustrates the pipeline industry's difficulties in responding to increased demand, especially in terms of moving petroleum products eastward.

Today's societal aspirations in the areas of sustainable development, environmental responsibility and public safety can be at odds with the increased industrial risks associated with the transport of hazardous materials, by any mode of transportation. Railways may be a part of the problem, but they are also part of the solution. The key challenge before them will be to persevere in their capacity to adopt and promote new technologies and to establish new standards and practices, as they have done since the early 1800s as key players in Canada's economic, industrial and social development.

Chicago Express cargo train, Prince Rupert, BC
Prince Rupert Port Authority

A HISTORY OF INNOVATION

Time and time again, railways have shown their ability to be at the forefront. Learning from past tragedies and errors, they have continually implemented state-of-the-art technological improvements. For example, automatic braking systems were developed by Westinghouse in 1869, and the remotely controlled signal systems invented by Robinson in 1872 would lead to the development of centralized rail traffic control systems in the early 1900s. The railways played a key role in the development and promotion of time zones, principally as a safety measure. They were also early proponents and avid users of telecommunications (from the telegraph to CN-CP satellites) and radio communications (the radio system developed by CN for its trains would later become the Canadian Broadcasting Corporation), were among the first to fully commit to computerized systems as early as the 1960s, and were quick to see the opportunities provided by containerization and piggyback rail networks (especially CPR, starting in the 1950s).

Today, the rail industry's innate propensity to adopt, promote and even invent new technologies, methods and practices is reflected in the search for energy-efficient and environmentally effective innovations. The use of long trains (equipped with radio-controlled locomotives) and the introduction of hybrid locomotives are making the rail industry more competitive and efficient. In the face of a major streamlining of rail linkages at the national level, Canadian railways have embarked on a continental expansion drive, with new linkages through the United States to the Gulf of Mexico. The railways remain active in creating sustainable development opportunities by connecting communities, supporting the economy and creating high-wage jobs for thousands of Canadians. They continue to play a central role in our country's growth and development, as they have for almost 180 years.

TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

TRUCKING : AN ECONOMIC DRIVER

TRUCKING : AN ECONOMIC DRIVER

By Jonathan D. Regehr, University of Manitoba

INTRODUCTION

Canada's trucking industry is vital to the nation's economy. It employs 400,000 people and generates tens of billions of dollars in annual revenue from both domestic and international trade. The industry comprises for-hire carriers, private companies that haul their own goods, independent owner-operators and couriers. It is dominated by small enterprises, with about three-quarters of Canadian trucking companies employing fewer than five people in 2012[1]. In 2011, the for-hire industry alone accounted for 224 billion tonne-kilometres of movement, 61 percent of which occurred domestically[2]. A familiar adage states, "If you bought it, a truck brought it." Indeed, virtually everything in a typical Canadian home has been transported by truck at some point on its journey.

Trucking is perhaps the most diverse of the freight transportation modes. Figures 1 to 4 illustrate the many operators, trips, commodities and vehicles that characterize trucking activity in Canada.

(Figure 1.) This trip, hauling a container in a single-trailer truck configuration, likely involved marine and rail modes in a global supply chain.

(Figure 2.)This turnpike double configuration (two 16.2-metre trailers) operates subject to the conditions of special permits in all but four provinces and territories.

(Figure 3.) Many small packages and parcels make part of their trip by air and are initiated by online orders. These commodities are often high-value and require time-sensitive delivery.

(Figure 4.) This shipment from a producer's storage facility to a regional elevator uses a B train configuration on a network of rural intraprovincial routes.

Figure 1. For-hire carrier makes the "last mile" of an intermodal trip in an urban area
J.D. Regehr

Figure 2. Private company makes an interprovincial trip hauling general freight
J.D. Regehr

Figure 3. Courier uses single-unit trucks to make urban deliveries
J.D. Regehr

Figure 4. Independent owner-operator delivers grain
J.D. Regehr

A BRIEF HISTORY OF TRUCKING IN CANADA

The extent and diversity of today's trucking industry represents significant progress from its humble beginnings over a century ago. Trucking emerged as an industry in the early 1900s when highway networks were not well established and the industry was limited to short, usually intraprovincial hauls. Through the 1920s and 1930s as the industry grew in size and longer interprovincial truck trips became feasible, governing authorities initiated regulatory oversight of the industry and introduced vehicle size and weight restrictions. In addition, government controlled participation in the industry (i.e. who could obtain an operating license) and pricing (i.e. how much a trucking company could charge). Though trucking was still small by comparison, its growth during this period did not go unnoticed by the railways. Faced with government controls and resistance from the railways, the trucking industry began to organize itself into associations in an effort to protect and grow its business interests[3].

During the war years, trucks played a vital role in freight transport despite the effects of human resource shortages and fuel rationing. Interestingly, it was during this time that the railways entered the trucking industry, renewing debate between the two modes and setting the stage for some major policy developments. In the 1950s, the Canadian government realized that in order for transportation to be economic and efficient, government control of both rail and trucking would need to be relaxed. This work eventually found its way into the *National Transportation Act* of 1967, which officially recognized the legitimacy of trucking as a freight transportation mode.

Despite relaxed government controls, full economic deregulation of the freight industry did not happen until the early 1980s after similar developments in the United States. This led to increased internal competition in the trucking industry which in turn led to lower rates. In the wake of economic deregulation, the government increased its emphasis on safety-related regulations, which were formalized in Canada through the 1987 *National Safety Code*.

Paralleling all of this were major changes in truck size and weight law. These coincided with improvements to the connectivity and robustness of the highway network made possible in part through federally-sponsored highway strengthening programs in the 1970s and 1980s. In particular, the landmark *Memorandum of Understanding (MOU) on Interprovincial Vehicle Weights and Dimensions* in 1988 had profound effects on the industry. This policy remains the foundation of trucking regulation in Canada today and has gained considerable international attention due to its unique regulatory approach. The next section discusses this policy, which is commonly referred to as the Roads and Transportation Association of Canada (RTAC) MOU because of the leading role played by TAC's predecessor in its development.

THE LEGACY OF THE RTAC MOU

Through the mid-1980s, RTAC engaged in a major technical study of truck size and weight limits and trucking operations in Canada. The research and analysis was directed at achieving inter-jurisdictional uniformity, economic benefits through increased truck productivity, and improved safety by specifying dynamic vehicle performance criteria for trucks. The culmination of this work occurred in 1988, with representatives from all provinces and territories signing the RTAC MOU[4]. It

Figure 5. Permitted highways for RTAC truck configurations, 1988
Roads and Transportation Association of Canada

Figure 6. Tridem axle group
J.D. Regehr

specified performance-based truck weight and dimension "envelopes," and also identified major highways in all provinces on which the newly regulated vehicles could operate. As an example, Figure 5 shows the Alberta highways on which RTAC truck configurations were originally allowed to operate. Over the years, this network has expanded to provide connectivity to communities and industries wishing to capitalize on the economic benefits offered by more productive trucks.

In addition to increases in axle and gross vehicle weight limits and vehicle and trailer lengths, the key technical development from the RTAC MOU was the specification of a new tridem axle group (see Figure 6) which could be used on both single-trailer and double-trailer truck configurations[5]. A closer examination of the introduction of the tridem in a double-trailer configuration (commonly referred to as a B-train) exemplifies the unique contribution of the RTAC study. Compared to other double-trailer configurations, the B-train has superior dynamic performance (for example, it is less prone to rollover) and so was allowed higher weights. But because these heavier payloads were spread over more axles, they were found to cause less pavement deterioration. They also provided environmental advantages in terms of fuel consumption and emissions per unit of freight hauled, and also improved productivity, an economic advantage for the carrier and society. These many benefits, which are sometimes considered to be trade-offs, were achieved simultaneously[6].

Beyond these more technical advances, the true legacy of the RTAC MOU may be as a model for inter-jurisdictional regulatory harmonization. The MOU is a living document and is updated regularly through collaborative interprovincial mechanisms. For example, there have been significant recent efforts to harmonize permit conditions governing the operation of longer combination vehicles (LCVs)[7], which are routinely permitted for use on certain highways in most Canadian jurisdictions. These mechanisms are, of course, imperfect, and differences exist. However, the spirit of working together for a common goal still underpins much of the technical efforts in today's trucking industry.

TRENDS, CHALLENGES, AND THE FUTURE OF TRUCKING IN CANADA

The Canadian trucking industry has grown from modest beginnings to become a robust and diverse contributor to the Canadian economy. Some of the trends and challenges for today's industry echo those of the past. Examples of these include overcoming Canada's vast and rugged geography, optimizing operations within a regulated and competitive environment, and continually repositioning itself in the dynamic freight supply chain. The following points describe several other new challenges that will influence the industry into the future:

- **Emissions reduction and fuel efficiency –** Like many Canadian industries, the trucking industry has acted to reduce its emissions and improve fuel efficiency. Regulatory standards have reduced criteria pollutant emissions from truck diesel engines, but reducing greenhouse gas emissions has proven more difficult. Increased use of LCVs (which use less fuel per unit of freight transported), technologies to reduce aerodynamic drag, specialized driver training, and exploration of alternative fuels such as liquid and compressed natural gas have the potential to make trucking greener.

- **Trucking and urban livability –** In general, urban trucking is poorly understood. This is partially due to the lack of data on intracity truck movements. Current transportation planning and engineering are heavily oriented toward sustainability, active transportation and livability—themes that seem to challenge the provision of efficient urban truck transportation systems. While solutions to this issue are not readily apparent, jurisdictions such as Ontario have taken leadership in developing guidance to ensure urban trucking can contribute to, rather than constrain, sustainability and livability objectives.

- **Integrated multimodal freight systems –** The history of trucking in Canada cannot be viewed from a mode-centric perspective. The competitive interface between trucking and rail in Canada has always been central to transport policy. To some degree, the advent of intermodalism (that is, the use of containers to ship goods globally and domestically) over the last 30 years or so has revealed the need to consider freight transportation as an integrated supply chain, with less regard to mode-specific interests. As data and information systems improve, shippers seeking the best mode (or combination of modes) for any single shipment will be able to make more informed decisions.

- **Innovations in manufacturing –** While off-shore manufacturing and containerization went hand-in-hand with integrated global supply chains, 3D printing (one of a host of additive manufacturing technologies) may have the opposite effect in the future. Proponents of 3D printing suggest that the ability to manufacture a vast array of products locally—even at home—and with an expanding repertoire of materials, may revolutionize current supply chains. Although critics claim the industry serves only niche markets, the technology is gaining traction and has caught the attention of politicians and business leaders.

- **Smart vehicles and information systems –** Both incremental and groundbreaking changes in vehicle design and related information systems continue. At the incremental level, Ontario's new Safe, Productive, Infrastructure-Friendly (SPIF) regulations aim to take performance-based regulation beyond the RTAC MOU. Thinking more aggressively, self-driving vehicles (cars and trucks) operating on smart highways and relying on integrated, real-time information systems are becoming a real possibility.

The future of trucking in Canada remains uncertain and unpredictable, but past experience can help address the challenges ahead. Over the last century, the Canadian trucking industry has grown accustomed to adversity and has emerged resilient, diverse, and fundamental to the Canadian economy. Competition with other modes and within the trucking industry has sharpened the industry's business acumen to a point that enables many trucking companies to operate on the narrowest of margins. The industry has learned how to participate with government in the regulatory dance—whether concerning pricing, weights and dimensions, safety or emissions—and has exported this model internationally. These experiences will help trucking remain a safe, sustainable, and productive component of Canada's transportation system into the future.

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TRANSPORTATION IN CANADA
TRANSFORMING THE FABRIC OF OUR LAND

AVIATION: A CENTURY OF FLIGHT

AVIATION: A CENTURY OF FLIGHT

By Dr. Stéphane Guevremont, Mount Royal University, Calgary

Vancouver Airport, 1940s
BC Ministry of Transportation and Infrastructure

THE EARLY YEARS

At the turn of the twentieth century, Alexander Graham Bell turned his attention to the sky to build a heavier-than-air flying machine that could carry a human in controlled, powered flight.

In 1907 he created the Aerial Experiment Association with two young Canadian engineers and two American aviation specialists, supported by funding from his wealthy wife. Less than two years later, on February 23, 1909 in Baddeck, Nova Scotia, J.A.D. McCurdy sat at the controls of the *Silver Dart* for the first powered, controlled, heavier-than-air flight in Canada. His short one-minute flight above the frozen Lake Bras d'Or heralded the dawn of Canadian aviation. With McCurdy and F.W. Baldwin, Bell went on to set up the first aircraft manufacturing firm in Canada a few months later.

The First World War encouraged numerous Canadians to become pilots, aircrew, mechanics and industry workers. During the period from 1914 to 1918, Canada built some 1,260 aircraft, mostly trainers, and saw 3,135 pilots graduate with coveted wings on their native soil. Overseas, Canadian members of the Royal Flying Corps and the Royal Naval Air Service reached the highest echelons of distinction, with three airmen winning the British Empire's ultimate gallantry award for combat, the Victoria Cross.

Canadians excelled in many fields, especially in the fighter pilot trade where four of the top 12 aces of the war came from the Dominion. Canada's first ace and later the highest-ranking Canadian in the Royal Air Force (RAF), Colonel or Group Captain Redford H. Mulock was the most experienced combat pilot, aerial leader, administrator and organizer. Becoming the chief bomber commander of the RAF in 1918, he was the only Canadian airman of the First World War to be appointed a Companion of the British Empire (CBE) for his exceptional wartime services.

Barnstorming by demobilized pilots dominated the interwar years, their cheap and thrilling flights playing a vital role in introducing younger generations to the lure of flight. Bush pilots and pioneers pushed the boundaries of aviation northward, and helped build the nation by exploring new lands, finding natural resources and stimulating the economy with commercial routes and private ventures.

Stuart Graham, operating from Lac-à-la-Tortue, Quebec in 1919 with a Curtiss HS-2L flying boat named *La Vigilance*, can be considered the father of all bush pilots. In 1929 a licensed airfield opened in Edmonton and soon became the "Gateway to the North," stretching aviation as far as the Arctic. On the ground, Canadian Flying Clubs sprung up with Calgary's being the largest aero club in Canada and (with 1,060 memberships at the end of 1929) the second largest in the British Empire. In the same year, the Calgary Glider Club claimed the nation's first glider flight. Just a year earlier, the first Canadian woman pilot, Eileen Vollick, had received her wings after she learned to fly in winter over frozen Burlington Bay on Lake Ontario. She was just over five feet tall, and needed a pillow on her seat to see over the nose of her ski-equipped fabric biplane while taking off and landing.

Canada's first experimental airmail flight was flown between Montreal and Toronto in June 1918, and the service spread rapidly between the wars. Canadian Airways, established by James Richardson of Winnipeg in 1926 as the first true national airline, was joined in 1937 by Trans-Canada Air Lines, a competitor created by Ottawa that would later become Air Canada. That same year, the Royal Canadian Mounted Police created its Air Section, heralding an era of aerial law enforcement that continues to this day. Despite all this activity, fewer than 50 aircraft were manufactured annually in Canada by 1938, while the Froebe brothers in Homewood, Manitoba engineered, built and hovered numerous times the first Canadian-designed helicopter.

WARTIME EXPANSION

The Second World War brought Canadian aviation to new heights. Prior to hostilities, the Royal Canadian Air Force (RCAF) became an independent service that could purchase hardware and supplies for its own needs. Thus, interwar rearmament brought an influx of badly needed government funding into an already depleted Canadian aircraft industry and this, in turn, revitalized aeronautical firms and skilled labour in the depths of the Great Depression. As war began, the federal government erected more than 100 new aerodromes and 107 training schools across Canada in less than four years as part of the British Commonwealth Air Training Plan, allowing 131,500 aircrew from 11 nations to be trained and sent overseas. The $1.6-billion scheme provided Canada with skilled labour and a network of sophisticated aeronautical facilities, many of which remain in operation today.

Canada's aircraft industry grew tenfold from 1939 to 1945, producing 16,000 aircraft and employing 116,000 workers, including 30,000 women. Allied-built aircraft were flown to Europe from Newfoundland, and the island served as a base for anti-submarine patrol squadrons on active duty over the North Atlantic. Edmonton became a vital centre of operations for the Alaska Route, welcoming American-built aircraft in transit to the Soviet Union via Alberta and the Yukon. On September 25, 1942 a Canadian fighter pilot, Squadron Leader Kenneth Arthur Boomer, DFC, shot down a Japanese reconnaissance float plane over the Aleutians, a unique feat in North America during the war.

Overseas, the RCAF grew to become the fourth-largest air force in the world by 1945. Participating in the British night-bomber offensive over Germany, No. 6 Group (RCAF) boasted 14 operational squadrons at its peak. With fighter squadrons over occupied Europe and transport squadrons in Burma, Canada's wings spread around the globe with a definite and pioneering impact on the anti-shipping strike tactics of the British Empire. No. 404 Squadron (RCAF) revolutionized modern warfare using unguided air-to-sea rocket projectiles against enemy vessels.

ENTERING A GOLDEN AGE

The golden age of Canadian aviation took place during the Cold War, when Canada's air assets made it a respected middle power in world affairs. Canadian-built RCAF aircraft were at the forefront of NATO strategies in Europe, culminating in a tactical nuclear capability from 1962 to 1971 with the Starfighter. Canadian peacekeepers, conceived by Lester B. Pearson, could be airlifted anywhere on

Trans-Canada Air Lines Plane on Dorval Airport Tarmac, 1964
City of Montreal

Martin Mars Flying Tanker, 2013
Struan Roberston

the planet with the Canadair North Star. The firm A.V. Roe Canada produced the C102 Jetliner, the world's second jet passenger aircraft, in 1949 and the CF-100 Canuck, one of the first true all-weather and night jet fighter interceptors, in 1952. Sadly, on February 20, 1959 the Canadian government cancelled the CF-105 Arrow interceptor project.

Nevertheless, other Canadian firms thrived. Carl Agar set landmarks in rotary aviation with Okanagan Helicopters from British Columbia, the largest helicopter operator in the world in 1955. Crop dusting, oil and gas exploration, search-and-rescue, and even leisure skiing are but a few of the areas advanced through aviation. Not to be overlooked are de Havilland Canada's short take-off and landing (STOL) aircraft such as the immortal Beaver and Otter/Twin Otter and Dash 7/8 family. In 1946, air ambulance services were born in Regina, Saskatchewan with a Noorduyn Norseman and they continue to be a fundamental part of civil aviation today. In 1967, the Canadair CL-215 water bomber appeared and changed forest fire departments forever. Canadair was eventually bought by Bombardier, which by 2007 had grown to be the world's third-largest aircraft manufacturer with 27,000 employees and an established niche in regional aircraft including the Challenger, Regional Jet and Global Express.

Canadian inventors have left behind a vital legacy including the aileron system perfected in 1908 by the Aerial Experiment Association, Wallace Turnbull's variable-pitch propeller of 1922, the 1941 anti-G flying suit of Dr. Wilbur Franks, and Air Canada's pioneering work with flight data and cockpit voice recorders (black boxes). Canada's contribution to the development of world aviation has been immense—and in return, no country has relied as much on aviation for its own growth and development.

THE FLIGHT PATH AHEAD

What else can be said after more than 100 years of Canadian aviation? In 2014, the industry has branched out to space with flying colours in SPAR Aerospace; flight simulators by CAE in Montreal dominate the market; Pratt & Whitney Canada's PT-6 and other turbine engines have an international commercial lead over their competitors; and numerous other manufacturers succeed with large military and civilian foreign contracts.

The future also seems promising for commercial aviation in general, with two national carriers eagerly and profitably competing for passengers—WestJet is branching out to Europe, while Air Canada is adding routes to its global network. Some smaller regional airlines are also growing, including Porter Airlines which is planning to expand its fleet and services.

A similar situation exists in the transport industry, with major private contracts and charter flights abounding in northern Alberta and Saskatchewan to support oil and gas development. This growth of private and commercial aviation enhances provincial economies and provides a stable and lucrative business opportunity for relatively unknown firms that specialize in serving the oil sands. High-volume employee shuttles and cargo deliveries reach astonishing levels of continuous cycles and profits in remote areas of Canada that are seldom regarded as the crucial aviation hubs they are now becoming.

DHC-8 Airplane, Jean-Lesage International Airport, Quebec City, 2010
Ministère des Transports du Québec

Ultimately, the outcomes for Canadian aviation in the twenty-first century will depend on world markets and commercial development. Many in the civilian-oriented industry are pinning their hopes on Bombardier's new CSeries jet, a narrow-body, twin-engine, medium-range airliner intended to compete with giants Airbus and Boeing. Montreal and Toronto will surely retain their strategic position as aviation centres of the nation, but Winnipeg and Calgary are quickly gaining status. The military side of the Canadian aviation industry remains firmly embedded in Canadian and American defence contracts, including the Lockheed F-35 Joint Strike Fighter program. The development of unmanned aerial vehicles, or drones, has made a giant leap in the past decade and is now reaching the civil market. Military forces around the world, government and law enforcement agencies, operators of agricultural equipment, and real estate agents are only some of the new customers in this emerging aviation market that could replace much manned flight in the coming centuries.

In summary, Canadian aviation continues to demonstrate its potential for steady, sustainable growth. Its past achievements are only the starting point for a bright and rewarding future.

TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

CANADIAN SEAWAYS: INSIDE AND OUT

CANADIAN SEAWAYS: INSIDE AND OUT

By Dany Fougères, Université du Québec à Montréal

Boats on St.John River, Fredericton, BC
City of Fredericton

Canada is a land of mountains and plains, forests and tundra. It is also a land of lakes, rivers and waterway systems. Its major rivers are rich resources in their own right, and played a key role in the European exploration of the new continent. At the dawn of the 19^{th} century, in the early days of the modern transportation era, boats were the primary mode of transport, leading the way to what some have called Canada's canal and river systems development era. One hundred and fifty years later, the mid-twentieth century saw vast improvements to Canada's transportation systems, including an undertaking of monumental proportions—the St. Lawrence Seaway. Both the early 19^{th} and mid-20^{th} centuries were times of significant economic prosperity and profound changes at the continental level, which both led to and were driven by these unprecedented enhancements to our waterway systems.

Our story begins in the eastern part of the country, where successive waves of European settlers who crossed the Atlantic put down their roots. And today, 200 years later, the key objectives remain the same: to expand westward, increase tonnage capacity and shorten travel times. The history of modern Canadian navigation is first and foremost the story of the St. Lawrence River, the most important interior navigable waterway in the northeast of the continent. All of Canada's major river systems, including British Columbia's Fraser, Manitoba's Red, Quebec's Richelieu and New Brunswick's Saint John, have developed at their own pace, and each has its own rich navigation history. Each of these stories in some way relates to the development of the St. Lawrence. Canada's navigation history is closely connected to the establishment and development of the country's ocean and inland ports.

A ROUTE TO THE GREAT LAKES

As Upper Canada's early colonists sought new development opportunities and the means to facilitate immigration and the transport of goods and merchandise from Great Britain, the need to improve access to the St. Lawrence and the Atlantic Ocean was a priority. For Lower Canada residents, notably Montréal's business class (who were mostly of British origin), improving travel to the far reaches of the new colony meant better access to growing markets and untapped natural wealth, specifically forest and agricultural resources[1]. The birth of Canada as a nation in 1867 served to bolster the development efforts put forth since the earliest days of that century. Indeed, the Canadian Confederation was in large part an economic endeavour in which the goal of improving the east-west flow of resources and products is clearly stated. In time, the completion of the trans-Canada railway would allow the transport of resources, goods and merchandise from Atlantic ports to the Pacific.

Canada was not alone in responding to these transportation challenges and capitalizing on these new opportunities, and the actions undertaken by our neighbours to the south would serve to increase the pace of development. The construction of a series of north-south and east-west canals in the state of New York would come to threaten the supremacy of the St. Lawrence route and Montréal's position at the centre of continental traffic. The race with the Americans was underway, fuelled by the fact that Western economies had been thrust into a new era of free trade by the leading economic power of the time, Great Britain. Continental geopolitics would also play a key role in the choice of the main trade

Welland Canal, lock 456
St.Lawrence Seaway Management Corporation

routes. Indeed, the memory of the not-too-distant War of 1812 between Canada and the U.S. still lingered, and many Canadian decision-makers would support the construction of a waterway from Montréal to Ottawa, and on to Kingston on the shores of Lake Ontario (by way of the soon-to-be-built Rideau Canal). Although longer that the St. Lawrence, this route was deemed safer by its proponents, as it was somewhat removed from yesterday's enemy, the Americans. However, as soon as it was established, it became clear that the St. Lawrence was destined to become the Canadian economy's principal trade route.

To transform the St. Lawrence into a major waterway linking the Atlantic Ocean and the Great Lakes, major physical obstacles would need to be overcome, including the fast-moving waters of the Sainte-Marie Narrows and the Lachine Rapids, on Montréal's doorstep. The upriver trip from Lachine to Kingston, at the time the largest city on Lake Ontario, included numerous obstacles. A channel was built to navigate the treacherous passage between Lac Saint-Louis and Lac Saint-François, and the section of the St. Lawrence between Cornwall and Kingston was considerably narrower and included many obstructions and shoals. Around 1800, the trip from Montréal to Kingston took seven days. Downriver from Montréal, those navigating the inbound trip from the Atlantic Ocean needed to contend with frequently difficult wind, current and tide conditions, up to Quebec City, where the St. Lawrence narrows abruptly. Past Quebec City, the upstream currents were more amenable along the shoreline up to Lac Saint-Pierre, approaching Trois-Rivières. The shoals of Lac Saint-Pierre were the last major obstruction before Montréal.

The development of a trade route along the St. Lawrence would prove to be a colossal undertaking. Early on, however, the endeavour would be made more appealing by major technological advances in ship design, including the advent of the steam-powered vessel (around 1810-1820), followed in the mid-1800s by the introduction of the propeller-driven motor replacing the paddle-wheel, and later by the steel-hulled vessel. The 1850s marked the beginning of transatlantic steamship travel. Its main promoter was Sir Hugh Allan, owner of the *Allan Line*, whose steamships made the Montréal to Liverpool crossing on a 15-day schedule, which represented a one-half to two-thirds reduction in crossing time. Steam travel from Montréal upstream was gradually introduced in the 1840s with the use of "Durham Boats" (flat-bottomed vessels). It should be noted that although these important technological advances in vessel design were a powerful force in the modernization and growth of Canadian navigation (as was the case throughout the world), it was all made possible by the development of a major navigable waterway.

In January 1805, a government committee was established to identify ways to improve inland navigation. Later, in 1815, the colonial authorities allocated public funds in the amount of £25,000 for the construction of a first major endeavour, the Lachine Canal[2]. Following unsuccessful attempts by private developers, government authorities took over the construction project in 1821 and the canal opened in 1825. Following the completion of the Lachine Canal project, a series of additional improvements were required all the way downstream to Kingston. These works, completed in 1846 at a total cost of £1,390,000, included the dredging of a channel, construction of the Beauharnois Canal and another canal in Cornwall. The Soulanges Canal was built from 1893 to 1899 on the north shore of the St. Lawrence, in replacement of the Beauharnois Canal. In 1932, the Beauharnois Canal reopened and the Soulanges Canal is abandoned.

Port of Quebec
Ministère des Transports du Québec

Port of Montreal
Ville de Montréal

THE 1950S AND THE ST. LAWRENCE SEAWAY

As was the case 100 years before, the transformations undergone by the St. Lawrence in the mid-20th century were a reflection of changing national circumstances, a new international context and vast improvements in naval construction and navigation. In the 1950s, the St. Lawrence River would become the St. Lawrence Seaway, because of its incomparable scale and its international component, given the involvement of the United States. By that time, the Lachine Canal no longer played the central role it had in the previous century[3].

The St. Lawrence Seaway Project was initiated in 1954, following three years of discussions between Canadian and American authorities. Despite the opposition of certain interest groups involved in ground transportation, the Canadian and United States governments jointly assumed the roles of project promoters and developers. Government involvement was not a new development, as public authorities had played a key role in the major initiatives of the 19th century, including the construction of canals and the later development of the national railway. In the post-war years, government involvement would be supported by a newly dominant ideological doctrine based on the welfare state and economic interventionism. In addition, the economic context was at that time conducive to the project: the era of mass consumption was beginning in earnest, the manufacturing sector was expanding, automobile production was targeting the masses and Canadian agricultural products were in high demand abroad. In addition, raw materials (e.g. iron and petroleum products) were needed to fuel the unprecedented growth of iron and steel industries in the American Midwest. The St. Lawrence Seaway was perfectly positioned to play a key role in that era of economic growth and expansion.

The St. Lawrence Seaway construction project was completed and officially opened in 1959[4]. The total cost was in the order of $470 million, a colossal sum at the time. It was a massive undertaking. In Montréal, bridges were heightened to add vertical clearance, lands upstream of Lac Saint-Louis and Lac Saint-François were flooded and entire villages expropriated, numerous dam structures were built to maintain water levels, channels dredged and locks built. Since the day it opened, the Seaway has continued to adapt in response to evolving navigation needs (as evidenced by extensive dredging works conducted in 2004 to deepen the shipping channels) and has kept up with advances in information technology, including the 2003 implementation of the Automatic Identification System (AIS) for vessels. In the 1980s, the volume of cargo transported on the Seaway surpassed one billion tonnes[5].

PORTS – VITAL COMPONENTS OF CANADA'S MARITIME TRANSPORTATION SYSTEM

Just like the waterways, the history of Canada's ports followed an east-to-west progression. The simple jetties put down in the 16th and 17th centuries would soon be replaced with permanent structures. However, the first major wave of large-scale port infrastructure development would occur in the 19th century with the construction of ports in Montréal, Quebec City and Halifax, with the addition of a port in Vancouver later in the century. These were followed in the 20th century with the construction of high-tonnage ports in remote locations, such as Baie-Comeau and Sept-Îles on the north shore of the St. Lawrence.

Asian freighter in Port Metro Vancouver, BC
British Columbia Transportation and Infrastructure

In 1867, Confederation confirmed what was already occurring under colonial rule: the senior level of government would assume responsibility for ports and navigable waterways. From 1936 to 1983, the Ministry of Transport would administer Canada's ports through the National Harbours Board (NHB). To the seven ports (Halifax, Saint-John, Chicoutimi, Québec, Trois-Rivières, Montréal and Vancouver) originally included in the NHB's initial mandate, six other ports and two grain elevators would be added over the years. In 1983, the Canada Ports Corporation Act (CPCA) would institute the Canada Ports Corporation (CPC) in replacement of the NHB. Over the years, the NHB and later the CPC would administer over 500 ports, in total or in part[6].

As of 1995, the federal government's new maritime policy would see it progressively withdraw from the direct operation of Canadian ports. This policy also divided Canada's ports into three distinct categories, including the Canada Port Authorities (CPAs), regional and local ports, and remote ports. The Canadian Port Authorities remain the most important component of Canada's port and harbour system: In 2011, the 18 Canadian Port Authorities handled 61 percent of Canada's total port traffic[7].

To this day, the St. Lawrence Seaway remains Canada's most important commercial waterway. However, the epicentre of Canada's port and marine transportation system has shifted westward with the emergence of the Port of Vancouver. Although the Port of Montréal remained Canada's busiest at the turn of the century, it would be gradually overtaken by Vancouver. In 2008, the ports of Vancouver, Fraser and Fraser North amalgamated into a new entity under the name Port Metro Vancouver.

CONCLUSION

The demographic, technical and scientific revolutions that drove the industrialization that characterized the 19th century led to the development of modern transportation in Canada. Nearly 200 years later, at the dawn of the 21st century, new forces, including the telecommunications revolution and environmental and energy-related uncertainties, are guiding a new age in Canadian transportation. In the 19th century, the transportation system was built around ships and waterways. Later, our land-based roadway and railway networks tended to follow waterway systems or connect to them in the most effective way. Today, although marine transportation is essentially confined to certain segments of the transportation chain, it remains of key importance in a new multimodal era.

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TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

THE TRANS-CANADA HIGHWAY: CONNECTING CANADIANS

THE TRANS-CANADA HIGHWAY: CONNECTING CANADIANS

By Donaldson MacLeod, PhD, P.Eng

INTRODUCTION

This sign is familiar to every motorist on Canada's highways. The Trans-Canada Highway runs from coast to coast, and includes rural two-lane highways, rural and urban multi-lane highways, major downtown streets (as in St. John's, NL and Calgary, AB) and urban freeways (such as the Metropolitan Autoroute in Montreal, QC), as well as major ferry crossings to Vancouver Island and Newfoundland.

The original Trans-Canada Highway, completed in 1971, ran some 7,821 kilometres from St. John's, NL to Nanaimo, BC. It was the longest continuous highway in the world. There have been numerous additions to the system, but this chapter deals mainly with the original Trans-Canada Highway. Much of the information is taken from the final report on the *Trans-Canada Highway Act*[1].

BEFORE THE HIGHWAY

Today, travelling from coast to coast in Canada on a high-standard highway is taken for granted – but it wasn't always so.

The first crossing by automobile was in 1912, when Thomas Wilby travelled from Halifax, NS to Victoria, BC in two months, making large portions of the trip with his automobile strapped onto a railcar or on a deck of a steamer.

In 1925, photographer Ed Flickenger marked the 21st anniversary of the founding of Ford Canada by driving a new Model T from Halifax, NS to Vancouver, BC. Between September 8 and October 17 he traveled 7,715 km without leaving Canada. At times, he had to cross rivers and valleys that were not yet bridged for traffic, use roads so narrow that brush and trees scraped the edge of the car, and struggle through axle-deep gumbo on the prairies and wagon roads in the Rockies. On 14 occasions the right-of-way was cleared for him. This accomplishment still did not qualify him for the honour of being the first person to travel on rubber from coast to coast — for some 1,345 km where there were no roads, Flickenger substituted flanged wheels and used the transcontinental railway. But it remained a major accomplishment that stood for many years.

The first complete crossing by automobile was in 1946. Brigadier R. A. Macfarlane drove a new Chevrolet from Louisburg, NS to Victoria, BC in nine days, only a few months after the last link connecting the highway systems of eastern and western Canada had been completed in northern Ontario. This crossing, plus the post-war boom and the rapid growth in the number of automobiles, led to the passing of the *Trans-Canada Highway Act* in 1949. The dream of crossing Canada by automobile was at last changing from a dream to reality[1].

THE TRANS-CANADA HIGHWAY ACT

An Act to Encourage and to Assist in the Construction of a Trans-Canada Highway, or the *Trans-Canada Highway Act* as it is more commonly known, was enacted on December 10, 1949. The original Act was to be in effect for seven years with $150 million in federal contributions paid to the provinces covering up to half the cost of construction. Subsequent amendments extended the Act to December 31, 1970 and increased federal payments to $825 million.

Highway 40, 1960s
Ministère des Transports du Québec

The Act called for the federal government to share costs equally with provinces, except in the National Parks where the highway would be the full responsibility of the federal government. This was significant, as some of the most difficult terrain was to be found in the western National Parks. A subsequent amendment in 1956 took “cognisance” of the great variation in construction costs by providing an additional 40 percent to each province. Agreements were signed on April 25, 1950 with British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Prince Edward Island. Additional agreements were signed with New Brunswick on May 27, 1950, Newfoundland on June 27, 1950, Nova Scotia on May 15, 1952, and Quebec on October 27, 1960.

Administration of the Act was initially the responsibility of the Department of Resources and Development, but was transferred to the Department of Public Works in September, 1953. Construction of the Trans-Canada Highway was carried out by provinces except in the National Parks where Public Works was responsible. All designs, tender calls, contract awards and construction were subject to review by federal authorities, and arrangements were made for federal inspection of the work as it proceeded. The final federal investment totalled $825 million to the provinces plus $76.6 million for sections of the highway in National Parks. Including provincial costs, the total cost of the highway was $1.4 billion in 1971 dollars.

Design Element	Desirable Standard	Minimum Standard
Right-of-way	100 feet	66 feet in densely populated areas
Pavement	24 feet wide maximum, bituminous hot mix with graded aggregate, 3 inches thick	22 feet
Shoulders	10 feet	5 feet where required by terrain and/or economy
Obstructions	Distance between edge of pavement and obstruction shall be 1 foot less than width of shoulders	
Base, sub-base and drainage	Shall be constructed in such a manner that combined they will produce a roadway having a load-bearing capacity for a repeating axle load of 18,000 pounds	
Curvature	3 degrees	6 degrees
Gradient	6 percent	7 or 8 percent for short distances
Sight distance	600 feet for a 6-inch object height and 4.5-foot eye height	
Bridges	Loading H20-S16 with overhead clearance of 14.5 feet. Width: full pavement and shoulder width if less than 30 feet long, 27 feet wide plus 1.5-foot wide curbs on each side if 30 to 100 feet long, 24 feet wide plus 1.5-foot curbs on each side if more than 100 feet long	

Figure 1. Trans-Canada Highway Standards

CONSTRUCTION ACHIEVEMENTS

Building the Trans-Canada Highway through Glacier Park
British Columbia Transportation and Infrastructure

Tunneling the Trans-Canada Highway, Kicking Horse Canyon and Rogers Pass
British Columbia Transportation and Infrastructure

A major objective of the government, set in 1956, was to have all ten provinces connected by a paved road by the time of Canada's centennial in 1967. In 1955, much of the roadway designated as Trans-Canada Highway was gravel. While half of the highway remained gravel at the time of its official opening in 1962, by 1967 most of the highway had been paved.

The final report on the *Trans-Canada Highway Act* identified three other major challenges that were overcome during the project:

- **Muskeg, gumbo and rock –** One particularly difficult section was the 265-km stretch along the shore of Lake Superior from Wawa to Sault Ste. Marie, ON. There, muskegs could be up to 15 m deep, and thousands of tons of blast rock had to be transported in to make a solid base. Similar conditions were found elsewhere in northern Ontario and Newfoundland. Sticky, heavy "gumbo" clays across the prairies were treacherous when wet, and major rockwork was required through the Fraser and Kicking Horse Canyons. Just as one example, a 14.5-km stretch between Golden and Field, BC required moving more than 2 million tons of rock and another 2 million tons of earth.
- **Rogers Pass –** The 45-km Trans-Canada Highway section through Glacier National Park averages 8.5 metres of snow each year (receiving almost 17 m of snow in 1953-1954), and is lined by snow-laden peaks that produce numerous avalanches. However, routinely closing the highway to avoid avalanche risks or clear snow was not an acceptable approach; with snow-clearing equipment but without avalanche-control devices, it was estimated that the road would be closed to traffic for 75 days between November and May in a normal winter. The Avalanche Research Group was created by the Department of Public Works in 1953 to locate potential avalanche zones, recommend practical defence mechanisms and to develop an avalanche forecasting system. Many of this group's effective innovations that are still in use today include concrete snow sheds that permit avalanches to pass over the highway, and gun emplacements where Canadian Army personnel fire mortar shells into known trigger zones to create smaller avalanches and prevent more massive ones. Other mechanisms to break up or divert avalanches before they reached the highway include earth diversion dams that change the direction of the avalanche and/or reduce snowshed length, benches dug into the mountainside to catch snow slides and hold them, and cone-shaped hills that act as breaking obstacles. While these technologies have not completely eliminated road closures due to avalanches, such closures tend to be few and of short duration.
- **Louis-Hippolyte Lafontaine Bridge-Tunnel –** One of the more complex engineering feats was the design and construction of the 1.9-km combined bridge-tunnel crossing of the St. Lawrence River at the east end of Montreal. Pre-stressed sections of the tunnel were constructed on land, floated into position and sunk in a prepared trench on the riverbed. The cost of the bridge-tunnel was $85 million in 1971 dollars.

OFFICIAL OPENING

This great Canadian accomplishment was celebrated twice in 1962: first by a provincial event on July 30, and then by the federal government on September 3. British Columbia's Premier W.A.C. Bennett skipped the second event because he wanted more federal construction money and had officially opened the road through the pass himself a month earlier at a nearby spot, calling it B.C. Highway No. 1 and never once mentioning Canada.

The federal opening ceremony was at Rogers Pass, with a backdrop of the snow-covered peaks of Glacier National Park (see Figure 2). The site was not far from the historic location at Craigellachie, BC where Sir Donald Smith drove the transcontinental railway's last spike in 1885. The significance of both ceremonies was not that the routes were physically completed, but that formidable gaps had been closed. The routes were open for use after overcoming great obstacles to construction[1].

Figure 2. Prime Minister John Diefenbaker and representatives from all ten provinces attend the opening ceremonies at Rogers Pass in Glacier National Park on September 3, 1962[2]

ADDITIONS SINCE THE *TRANS-CANADA HIGHWAY ACT*

Figure 3 shows the original Trans-Canada Highway, and Figure 4 depicts the current highway including major additions since 1971. These include a section in Ontario from Ottawa through Pembroke and Sudbury to Sault Ste. Marie, an alternative route in northern Ontario through Kapuskasing and Hearst, and the Yellowhead Highway from Winnipeg to British Columbia's Haida Gwaii (formerly the Queen Charlotte Islands). Other route additions have included Highway 417 in Ontario, and the Confederation Bridge between New Brunswick and Prince Edward Island. About 12,800 km of road are now classified as Trans-Canada Highway.

While there have been improvements to the highway to serve higher traffic volumes and speeds, the fact that much of the Trans-Canada Highway follows the original route is testimony to the work of the original engineers.


Opening Ceremony of First Completed Section of the Trans-Canada Highway. Regina, August 21, 1957
Saskatchewan Archives Board

THE FUTURE OF THE TRANS-CANADA HIGHWAY

With the completion of a 36-km, four-lane section from Edmunston, NB to Rivière-du-Loup, QC, the Trans-Canada Highway will effectively be four-laned from New Glasgow, NS to just west of Ottawa, ON and from Winnipeg, MB to Glacier National Park at the border between Alberta and British Columbia.

The future will undoubtedly see more four-lane additions to the highway. During the tenure of Prime Minister Jean Chrétien in the 1990s and early 2000s, a project to construct a four-lane highway from coast to coast was not successful because many sections had lower traffic volumes than other roads and provinces had other priorities. For example, the Trans-Canada Highway did not go through Ontario's Greater Golden Horseshoe, and many north-south routes in the Prairies also faced competing priorities. A fixed link between Vancouver Island and the mainland has also been studied, but there are no immediate plans for such a crossing as it is difficult to justify economically.

The Trans-Canada Highway will undoubtedly continue to promote tourism and economic development across our country.

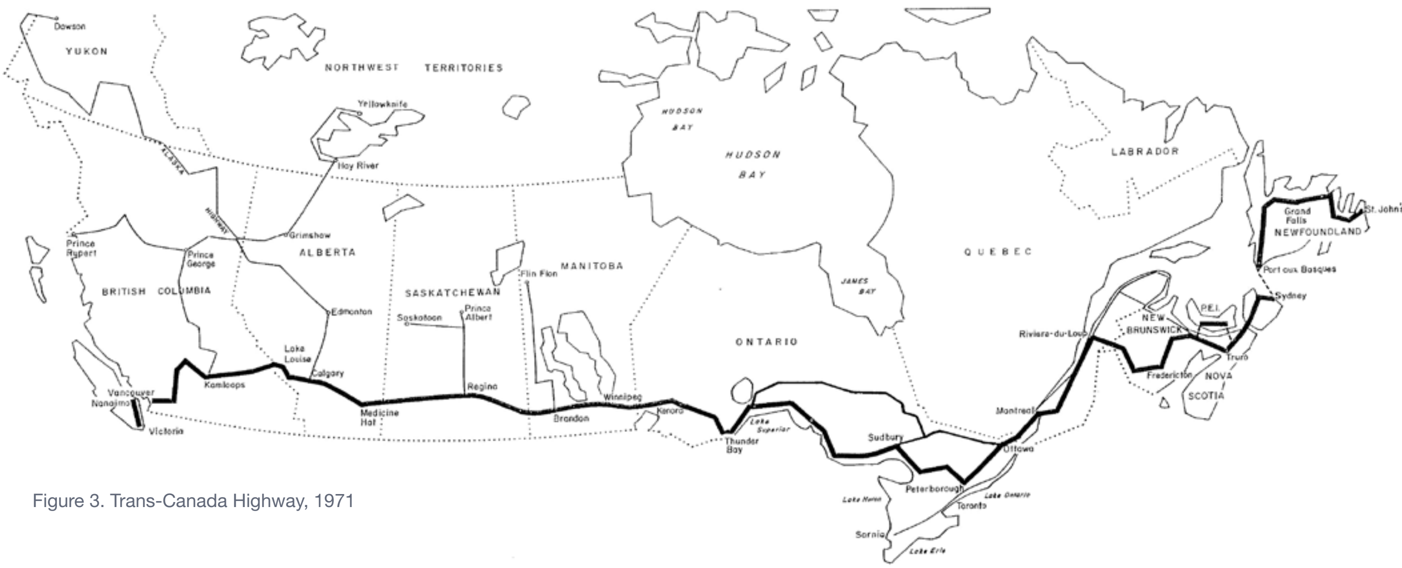

Figure 3. Trans-Canada Highway, 1971

Figure 4. Trans-Canada Highway, 2013[3]

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TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

MODERN HIGHWAYS: LIFEBLOOD OF THE NATION

MODERN HIGHWAYS: LIFEBLOOD OF THE NATION

By Katie MacDonald, Max Mantha and Johanna Hoyt, EllisDon Civil Ltd.

THE IMPORTANCE OF HIGHWAYS

As a massive and dispersed nation, Canada requires strong linkages for social and economic connection. Great distances between major population centres, manufacturing areas and international markets have made safe and efficient transportation essential to the country's prosperity. In 2011, 56 percent of Canada-U.S. trade and 35 percent of Canada's worldwide trade was carried on roads[1]. Canada's highway system is a priority for governments and industry associations, and Canadians are rightly proud of it.

Canada's leadership in highways is rooted in the construction of the Trans-Canada Highway in the mid-1900s. The nation's highway network is now the third-longest in the world, behind only the United States and China[2]. Canada's 38,000-km National Highway System, established in 1988 by the Council of Ministers Responsible for Transportation and Highway Safety, includes key national and regional highways that support interprovincial and international trade and travel. Its core, feeder and northern/remote routes connect capital cities, major provincial population and commercial centres, gateways to the United States, and hubs for other transportation modes (see Figure 1)[3].

Figure 1. National Highway System
Transport Canada

Figure 2. Highway 401 at Keele Street, Toronto, in 1958 (at top, four lanes) and 2009 (at bottom, 16 lanes) illustrates the growth in Canadians' car use and the need for highways. Traffic congestion was an issue that governments were dealing with as early as the 1950s.

THE EVOLUTION OF HIGHWAY DESIGN AND CONSTRUCTION

Canada's safe, smooth highways are the result of good geometric and structural design, appropriate materials and quality construction. Design and construction standards are the responsibility of provinces, with support from the federal government. Collaboration and information sharing between provinces, research agencies, universities, industry and American peers benefit the system as a whole. Across Canada there is a commitment to research, development and technological innovation that will optimize our highway system.

Current road design and construction have seen many advancements since the early days of road building. In the early 1800s, plank roads (thick wood planks on longitudinal stringers) and macadam roads (layers of compacted broken stones) were common. By the late 1800s, asphalt pavement started to be used, typically as a two-inch top spread over a stone or concrete base[4]. Government intervention and investment in roads increased over the 1900s as the automobile was introduced and became more popular, spurring new construction and advancing standards for geometric design, structures, material selection, intelligent transportation systems (ITS) and environmental considerations.

Geometric design considerations for highways include traffic speeds and volumes, level of service objectives, sight distance requirements, and criteria governing lane widths, alignment, super-elevation and grading. The design of modern highways includes a surface course of hot-mix asphalt (HMA) or Portland cement concrete (PCC), which provides a smooth surface and transfers loads to the wearing course (base and sub-base layers) consisting of gravel, crushed stone or stabilized soil constructed over a compacted, natural soil subgrade. The concrete for Canada's first concrete pavement highway (the Toronto-Hamilton Highway, in 1917) was mixed on-site, moved by wheelbarrows and laid and finished manually. HMA pavements became popular after the 1960s and dominated the market for decades[5]. Today, both HMA and PCC roads are constructed across the country, with concrete typically being used for highways subject to higher traffic loading.

Flexible pavement – The use of HMA as a surface layer advanced significantly with the development of the "superior performing asphalt pavement system" (Superpave). This mix design method, one of the key results of the United States Strategic Highway Research Program (SHRP) in the 1990s, incorporates better evaluation of the asphalt binder and aggregate selection as well as traffic loading and climate considerations[6]. The introduction of these requirements into the Canadian market, as well as the desire for cost-effectiveness and sustainability, led to new types of asphalt pavements such as performance graded (PG) asphalt cements with polymer modifiers, and mixes with 20 to 30 percent recycled components (e.g. tires or asphalt shingles)[7]. The materials and thickness of each layer of a flexible pavement, as well as the traffic loads and environmental conditions, determine the expected service life.

The Canadian Strategic Highway Research Program (C-SHRP) was formed in 1987 by the same council responsible for the development of the National Highway System, with the objective of improving the performance, durability, cost-effectiveness and safety of Canadian highways. As part of this program, the Canadian Long-Term Pavement Performance Program (C-LTPP) studied cost-effective pavement rehabilitation procedures with the goal of increasing pavement life for Canadian highways. Through the implementation of test sections, C-LTPP focused on asphalt-concrete overlays constructed over an existing asphalt pavement with granular base course, compared to alternative strategies such as variable overlay thickness, hot and cold-mix recycling, milling or the inclusion of performance-enhancing additives[8]. Test sections were geographically spread across every province to ensure that various local factors, such as traffic loading, the environment and subgrade type, were considered. These studies and continued research help to advance pavement design and maintenance.

Figure 3. Asphalt paving on Highway 63 twinning north of Wandering River, Alberta in 2012
Alberta Transportation

Rigid pavement – PCC is used in the construction of rigid pavement slabs that are classified as jointed plain, jointed reinforced or continuously reinforced, based on their use of joints and/or reinforcing steel to control cracking and transfer loads[9]. The use of concrete versus asphalt has generated much debate and research; the driving factors are the expected traffic loading and the cost of maintenance and rehabilitation, which are compared using life-cycle cost analysis[10].

Figure 4. Concrete pavement on Highway 401 in 2010
Ontario Ministry of Transportation

Bridges – Canadian roads and highways include more than an estimated 80,000 bridges[11]. Although timber trusses can still be seen on older bridges, the primary construction material of Canadian bridges is reinforced concrete, especially for long span superstructures, followed by steel. Many different bridge designs are used across the country, although most bridge decks are constructed of concrete, with concrete or steel girders. The Canadian Precast Concrete Institute (CPCI) and the Canadian Institute of Steel Construction (CISC) have been leaders in promoting quality, certified construction in Canada.

Figure 5. Highway 407 bridge over the Humber River, Toronto. After being erected the precast concrete girders, pretensioned for handling, were continuously post-tensioned from abutment to abutment for structural efficiency
Canadian Precast Concrete Institute

Canada's cold climate and reliance on de-icing salts have resulted in research and advancements in durable construction materials and effective rehabilitation methods. Innovations used in Canadian bridge design includes epoxy coated rebar, carbon fibre, silica fume, corrosion inhibitors, stainless steel rebar, chloride extraction and re-alkalization, and high performance concrete (HPC). HPC is a concrete technology introduced in the late 1990s, and since then ultra-high performance concrete (UHPC) has been developed and used in other countries. UHPC provides very high strength and very low permeability, and therefore structural efficiency, durability and cost-effectiveness that is being reviewed in relation to the *Canadian Highway Bridge Design Code*[12].

Minimizing environmental impacts – Canadian highways traverse many natural habitats. During the design of a new route or the widening of an existing route, provincial and federal environmental agencies provide input, and qualified biologists participate in design reviews. Habitat protection measures are incorporated in the design; for example, British Columbia has more than 350 km of wildlife fencing to separate and protect wildlife[13]. During construction, contractors are required to have environmental management plans and control measures in place, and construction is only permitted in environmental windows to (for example) protect fish spawning and bird nesting.

MODERN HIGHWAY MAINTENANCE OPERATIONS

Highway maintenance is integral to safety after initial construction, and involves seasonal work such as snow removal or grass cutting as well as the regular assessment and improvement of road conditions through pothole repair, resurfacing and guardrail replacement. As with highway construction, the responsibility for highway maintenance falls to provinces and territories.

Canada's harsh winters and beautiful summers put stresses on our roads that exceed those of more constant climates. Our weather conditions require equipment, labour and materials for winter snow clearing, salting and sanding, and for summer roadside mowing and brush clearing. In addition, freeze-thaw cycles necessitate regular spring and summer maintenance of cracks and potholes. Canada's vast landscape also requires more specialized efforts, from avalanche safety in the Rocky Mountains to monitoring the impact of salt water on steel bridge structures, such as the Canso Causeway that connects Cape Breton to mainland Nova Scotia.

Road maintenance can involve a number of delivery models, from individual agencies' own equipment and staff to area maintenance contracts (AMCs) with third parties. In Ontario, a move to shift risk from the Ministry of Transportation to third parties during the 1990s and early 2000s saw an almost complete transformation from Ministry-operated maintenance to AMCs. In-house labour and management moved from the Ministry's employ to that of third-party contractors and suppliers[14].

No matter which model is used to deliver services, the regular assessment and maintenance of capital transportation assets are important to preserving the investments Canadians have made in their road networks.

ALTERNATIVE FINANCING AND PROCUREMENT (AFP)

Across Canada, the continued use of traditional bid-build models is being complemented by the growing use of innovative, alternative contracting models to build and maintain new highways. Governments are seeking to maximize value for money on each project, and to spur improvements in design, construction, asset management, maintenance, rehabilitation and operations. In response, highway industry participants are innovating, evolving and in some cases seeking independent financing to deliver large highway projects. There are over 46 AFP and public-private partnership (PPP) transportation projects being procured, built or operated in Canada today, with a combined value of more than $28 billion[15].

The real value of AFP is in the transfer of risk from provinces to the private sector. This transfer leverages the experience of designers, contractors, financiers, maintainers and operators to produce projects that meet high client expectations and deliver the greatest value for money. Alignment of partners on both sides of the transaction is critical, and must be harnessed by experienced owners, performance-based specifications and warranties. For projects that fit an alternative model, the end goal is efficient design and construction along with a committed maintenance and operations partner who can meet requirements at the lowest possible cost.

> "Public private partnerships achieve the best value for taxpayers by ensuring that large infrastructure projects are delivered in the most cost-effective and timely manner. Commonly known as P3s, public-private partnerships involve the private sector and governments. Typically, the private sector will assume a major share of the risks in terms of financing and construction. The private sector also typically takes charge of maintaining the project once it's constructed."
>
> *www.infrastructure.gc.ca/plan/ppp-eng.html*

With the emerging use of AFP models, Canada has become a world leader in highway construction and operation. World-class teams are competing to build, rehabilitate and operate Canada's highways. Our national experience is continuously leveraged to develop new means and methods of highway delivery (e.g. tolling systems and infrastructure, intelligent transportation systems, precast concrete uses, traffic management systems). We can be proud of our progress, but we must maintain a focus on innovation to ensure that Canada continues to have one of the safest and most reliable highway networks in the world.

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BRIDGES AND TUNNELS: LINKING COMMUNITIES

TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

BRIDGES AND TUNNELS: LINKING COMMUNITIES

By Mike Lau, Dillon Consulting Limited

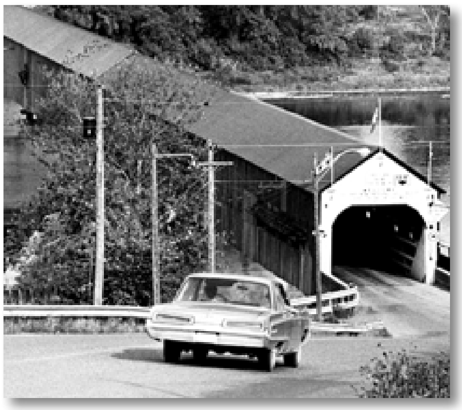

Figure 1. Hartland Covered Bridge, Hartland, NB[2]
Provincial Archives of New Brunswick, Richard Harrington Fund

Figure 2. Kinsol Trestle Bridge, Cowichan Valley, BC, 2006[3]
Cowichan Valley Museum & Archives

INTRODUCTION

Bridges and tunnels provide a link between countries, cities, towns and neighbourhoods for trains, trucks, buses, cars, pedestrians and cyclists. They can greatly impact social connections, boost the growth of businesses and help users accomplish everyday tasks. Conversely, their absence can have negative effects on access and mobility, with high economic costs and adverse environmental impacts.

Canada is a vast country with many lakes, rivers and mountain ranges that necessitate the construction of bridges and tunnels. There are roughly 80,000 bridges in Canada. More than 32,500 are managed by provincial and territorial transportation agencies, with the largest number of these in Alberta with 13,900, followed by Quebec with 9,000. Tunnels are many fewer in number, with most located in British Columbia, Ontario and Quebec.

Canada has seen spectacular displays of bridge engineering as well as some extraordinary failures. With computer-assisted design, advancements in construction materials and continuous research and development, today's bridges are vastly different from those of Canada's pioneer bridge designers, many years ago.

A LOOK BACK

Bridges have always been vital to transportation in Canada because of the numerous waterways to be crossed by roads and railways. Logs cut from local forests had to suffice for stream crossings on primitive trails before the advent of truss design in the early 1800s. In winter, the frozen surfaces of rivers and lakes provided safe crossing once the ice had reached sufficient thickness, and ice bridges are still used to access remote northern communities.

Covered bridges – Covered bridges, still seen on secondary roads in eastern Canada, were used during early bridge building. There were at least 1,000 in Quebec and 400 in New Brunswick, but there are now fewer than 200 in each province. Special efforts have been made in New Brunswick for their preservation, with one example being the Hartland Covered Bridge National Historic Site (see Figure 1).

Timber bridges – The use of timber for bridge construction in Canada has continued to the present day. Some of the most notable examples are the great timber trestle bridges used in early railway construction in the west, which have largely been replaced by steel structures.

Figure 2 shows one of the most dramatic trestle bridges in the world, British Columbia's Kinsol Trestle, which connected Victoria to Nootka Sound in 1920. The dilapidated structure was abandoned in 1980, but was subsequently rehabilitated and reopened to the public in 2011.

Steel bridges – Wrought iron bridge spans were used for a brief period in bridge construction, but were overtaken by steel by the end of the 1800s. The Royal Alexandra Interprovincial Bridge over the Ottawa River was the fourth-longest cantilever span in the world when it was inaugurated in 1901, and the steel truss structure is still in heavy use. The Jacques Cartier Bridge, built to connect Montreal and Longueuil, Quebec in 1929, is another fine cantilever structure. The Quebec Bridge, farther down the St. Lawrence River, is Canada's most famous bridge; part of the National Transcontinental Railway, it was intended to be the longest steel cantilever bridge in the world. During construction it failed twice, both in 1907 and again in 1916 (see Figure 3), with tragic loss of life. The completed bridge (see Figure 4) finally opened in 1919. A royal commission studied the accident and issued a final report that benefited bridge design around the world.

Figure 3. Collapse of the Quebec Bridge, QC, 1916[4]
Library and Archives Canada

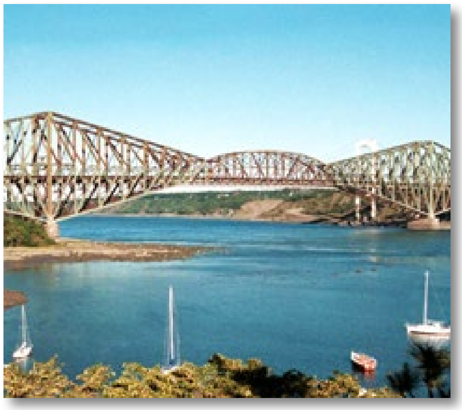

Figure 4. Quebec Bridge
Ministère des Transports du Québec

Suspension bridges – The Pierre Laporte Bridge, a suspension bridge for road traffic, now runs parallel to the Quebec Bridge. It is one of a small number of graceful structures found at strategic spots in Canada, including the Lions Gate Bridge in Vancouver (Figure 5), the international Thousand Islands Bridge over the St. Lawrence River, and the Angus L. Macdonald and A. Murray MacKay suspension bridges connecting Halifax and Dartmouth, Nova Scotia.

Figure 5. Lions Gate Bridge, Vancouver, BC[5]
British Columbia Transportation and Infrastructure

Reinforced concrete bridges – Reinforced concrete was first used in bridge construction in the early 1900s, with one example being Ottawa's Hurdman Bridge in 1906. Today, most small highway bridges are made of reinforced concrete, with an increasing use of prefabricated units. Some fairly large bridges have been constructed with this versatile material, such as the multi-span arched Broadway Bridge across the South Saskatchewan River in Saskatoon (see Figure 6) and the earlier University Bridge, both of which add to the distinctive appearance of this prairie city's central area. Perhaps most impressive is the Confederation Bridge (see Figure 7), opened in 1997 and stretching nearly 13 km across the Northumberland Strait to link Prince Edward Island and New Brunswick.

Figure 6. Broadway Bridge by night, Saskatoon, SK, 2006[6]
Jay Van Doornum

Figure 7. Confederation Bridge crossing Northumberland Strait[7]
Strait Crossing Bridge Ltd.

Figure 8. Modular panel bridge in northern Manitoba, 2013
Dillon Consulting Ltd.

Bridges in remote communities – Many remote First Nations communities in northern Canada are accessible by a network of winter roads that cross frozen lakes and rivers. Constructing bridges at key river locations can extend use of the surrounding winter road by more than two months. Modular bridge systems (see Figure 8) are often used due to the access and construction equipment limitations of remote sites, and this type of construction can provide significant employment and training opportunities for residents of First Nations communities.

Figure 9. Detroit-Windsor tunnel during construction[8]
Library of congress, Detroit Publishing Co.

Tunnels – Major tunnels in Canada include the St. Clair Tunnel, Fraser Canyon Highway Tunnels, and Louis-Hippolyte Lafontaine Bridge-Tunnel. Another tunnel of historical importance is the Detroit-Windsor Tunnel, built using a tunnel-boring machine (see Figure 9). In June 1919, Windsor's Mayor Edward Blake Winter requested Ottawa to construct a tunnel as a memorial to soldiers lost in World War I. In 1926, a New York architecture firm predicted that a tunnel would be not only feasible but profitable, and in 1928 construction began on both sides of the river. The 1.57-kilometre long Detroit-Windsor Tunnel opened one year ahead of schedule in November 1930, an engineering feat unparalleled at the time.

GUIDANCE FOR BRIDGE DESIGN

The Canadian Standards Association (CSA) published the first edition of the *Design of Highway Bridges Code* in 1922, and subsequently updated it several times (the last in 1988). In 2000, the CSA published the new *Canadian Highway Bridge Code*, CAN/CSA S6-00 (updated in 2006, with another edition pending), which superseded the previous CSA code and amalgamated it with the Ontario Ministry of Transportation's *Ontario Highway Bridge Design Code*, OHBDC-91-01. Not all Canadian provinces and territories use the *Canadian Highway Bridge Design Code*; the Province of Manitoba uses the *Load Resistance Factor Design Bridge Design Specifications* of the American Association of State Highway and Transportation Officials.

More than 40 percent of Canada's current bridges were built more than 50 years ago, and many of them need strengthening, rehabilitation or replacement. In 2006, under the auspices of TAC's Structures Standing Committee, the *Guide for Bridge Repair and Rehabilitation* was published to provide basic managerial information for agencies and individuals responsible for maintaining bridges. In 2001, the Bridge Hydraulic Committee and Structures Standing Committee published the second edition of *Guide to Bridge Hydraulics* to help engineers prevent bridge damage and failure from floods and erosion.

RECENT INNOVATIONS IN BRIDGE CONSTRUCTION

Increased traffic and urban congestion, combined with a short summer construction season, demand out-of-box thinking to accelerate bridge rehabilitation and replacement projects. Traffic control can represent up to 30 percent of bridge construction budgets, and the costs of user delays can be substantial in heavy traffic areas. Prefabricated bridge systems offer significant benefits in the face of these challenges. By shifting the bulk of construction to a remote site outside the right-of-way, they can increase constructability, reduce traffic and environmental impacts, and improve safety by minimizing the need for lane narrowings, closures and detours. They can both increase quality and reduce costs, especially in situations where sophisticated techniques would otherwise be needed for cast-in-place elements, such as long water crossings or multi-level interchanges.

To quickly replace bridge components (particularly decks) during limited or overnight road closures, full-depth waffle deck panel systems made of ultra-high performance concrete (UHPC) have been developed. UHPC extends the useful life of the bridge deck by protecting against chlorides, freeze-thaw effects, salt scaling, abrasion, accidental impact, fatigue and overload. Waffle panel bridge decks enable faster construction and longer spans by using materials efficiently and reducing weight, and they can be applied in both new construction and rehabilitation projects.

Monitoring programs are essential to the continuous evaluation of new materials and technologies for bridge construction and rehabilitation. Several types of sensors have been developed for integration with new materials such as fibre-reinforced polymer composite; these sensors enable short-term monitoring of the bridge's dynamic behaviour under traffic loading, as well as longer-term performance monitoring. For existing steel infrastructure, the goal of monitoring is to detect the onset of corrosion and its rate of proliferation.

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TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

PUBLIC TRANSPORTATION: MOVING THE MASSES

PUBLIC TRANSPORTATION: MOVING THE MASSES

By John Hubbell, HDR Corporation

INTRODUCTION

Canadians have enjoyed many forms of public transportation since the ferry service between Halifax and Dartmouth began in 1752. However, the modern history of transit from 1914 to 2014 is really the story of Canada's shift from a rural to an urban society, with growing cities and evolving transportation technologies.

In 1914, 45 percent of Canada's eight million people lived in urban areas; there were 41 centres with a population exceeding 10,000, and just two cities with more than 100,000 people. Today, Canada's population of 36 million is 81 percent urban; there are 147 centres of more than 10,000 people, and 31 cities exceeding 100,000. Canada transitioned from a rural to urban nation in 1921, and this created a positive environment for the development of public transportation (see Figure 1).

Over the last century, the dominant form of public transportation has changed from electric streetcars (which usually shared the road with horses and motor cars) to motor buses. Private transportation has also changed significantly and while very few Canadians had access to an automobile then, most do today.

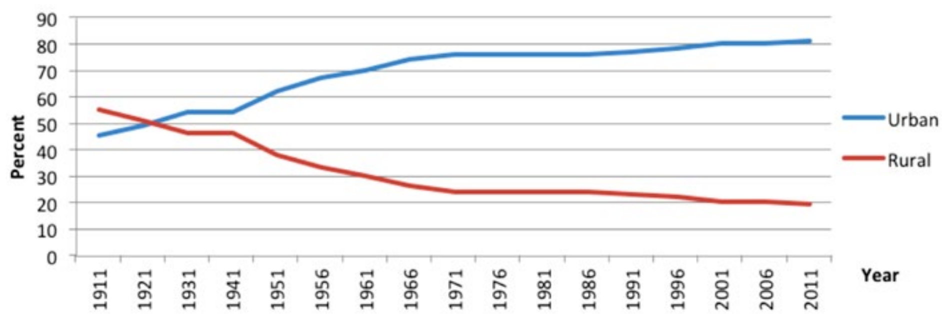
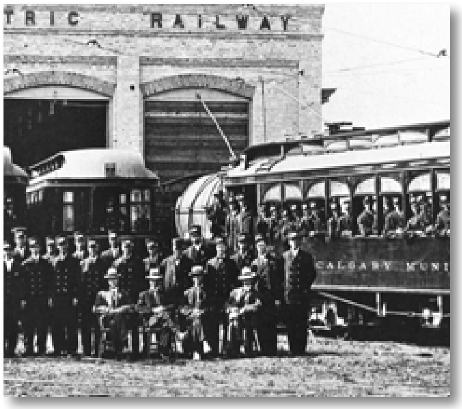


Figure 1. Urban and rural proportions of Canada's population, 1911-2011
(source: Statistics Canada)

THE ROLE OF PUBLIC TRANSPORTATION

Public transportation responds to the social, economic and environmental issues inherent in the development of towns and cities. Transit is not a business developed in isolation—rather, it helps solve some problems that arise when large numbers of people live in urban concentrations.

While the most common forms of public transportation have shifted over the last 100 years, transit's social, economic and environmental roles have remained relatively constant. It still has a social role in transporting people who may not be able to transport themselves due to distance, medical or physical limitations. It still has an economic role in allowing people to access jobs and participate in the economic activities of the community, and in lowering the cost of urban travel for both individuals and municipalities. And it still has an environmental role in lessening the impacts of urban travel on air, land and water.



Trolleys, Victoria Park, Calgary, AB, 1910
City of Calgary

Construction of Montreal Metro, 1960s
City of Montreal

Smaller urban centres are generally accessible by walking; however, public transportation becomes more of a necessity as populations grow and trips lengthen. For example, Canada's four largest cities (Toronto, Montreal, Vancouver and Calgary) have dense, economically intense central cores that are only possible due to the large proportion of workers commuting downtown by transit. The shares of overall travel by transit in Toronto (22 percent), Montreal (24 percent), Vancouver (21 percent) and Calgary (18 percent) only tell part of the story. When one looks at downtown commuting only, those shares rise dramatically–for example, to 70 percent in Toronto and 50 percent in Calgary. The urban form of these cities would change dramatically if all travel was by private auto.

Average per-capita usage of public transportation does vary considerably with the size of a community, with larger cities exhibiting much stronger ridership. For example, small urban centres with less than 50,000 people average 15 annual transit trips per capita; mid-sized centres with 150,000 to 400,000 people average 44 annual transit trips per capita; and very large centres with more than 2,000,000 people average 164 annual transit trips per capita.

The environmental benefits of public transportation are as important today as when electric streetcars were seen as a way to save cities from being buried in manure from horses, the dominant transportation mode of the time. Today, electricity is the motive power for subways, light rail and streetcar lines, whereas diesel engines power most buses, commuter rail engines and ferries. The development of hybrid and natural gas engine technologies, and the electrification of commuter rail, both offer the prospect of further reducing transit emissions.

KEY PUBLIC TRANSPORTATION MILESTONES IN CANADA

1752	Ferry from Halifax to Dartmouth is the first scheduled transit service in Canada
1849	Toronto implements the first scheduled horse-drawn omnibus service
1861	Toronto implements the first horse-drawn street railway
1882	Montreal implements commuter rail service
1886	Windsor implements the first urban electric streetcar service
1887	St. Catharines implements the first interurban electric railway
1904	Montreal introduces motor bus service
1914	49 Canadian cities have electric streetcar services
1922	Windsor and Toronto introduce rubber-tired electric trolley coaches
1954	Toronto Subway begins service
1966	Montreal Metro begins service
1967	GO Transit commuter rail begins service in Toronto
1977	Vancouver SeaBus begins service across Burrard Inlet
1978	Edmonton LRT is the first modern “new start” LRT system in North America
1981	Calgary CTrain begins service
1983	Ottawa Transitway begins service

SeaBus Passenger Ferry, Vancouver, 2009
South Coast British Columbia Transportation Authority (TransLink)

First Streetcar Run, Windsor, ON, 1886
Bernie Drouillard

Hurdman Bus Transit Station, Ottawa, 1985
MMM Group Limited

1985	Vancouver SkyTrain becomes the first unmanned automated people-mover
1991	St. Albert is the first Canadian city to operate low-floor and articulated buses
1995	West Coast Express commuter rail begins service
2001	Calgary's CTrain becomes the first wind-powered light rail line in the world
2001	Ottawa O-Train diesel-powered light rail line begins service
2009	SkyTrain's Canada Line begins service

PUBLIC TRANSPORTATION MODES IN CANADA

In 1914, electric streetcars carried most public transportation trips. Of today's three billion annual passenger trips, 63 percent are made by bus, 23 percent by heavy rail, 8 percent by light rail, 3 percent by streetcar, 2 percent by commuter rail, and 0.3 percent by ferry.

- **Ferries –** The first scheduled public transportation service in Canada was the passenger ferry operating between Halifax and Dartmouth, which began in 1752 and still operates today. Other urban ferries operate between Quebec City and Lévis, and between downtown Toronto and the Toronto Islands. However, the most active transit ferry today is from downtown Vancouver to the Lonsdale Quay across the Burrard Inlet via the SeaBus, a four-engine catamaran that began operating in 1977.

- **Streetcars –** The first streetcar services in Canada were horse-drawn rail cars. Electric streetcars were introduced in Windsor in 1886, and by 1914 they were operating in 49 Canadian cities. With the outward expansion of cities and the refinement of the motor bus in the 1950s, most streetcar services were replaced with bus routes. Today, only the Toronto Transit Commission (TTC) provides electric streetcar service, with 249 streetcars operating on 11 routes in central Toronto.

- **Motor bus –** Motor buses were introduced in Montreal in 1904, followed by Calgary in 1907, Leamington in 1910, Brantford in 1916 and Winnipeg in 1918. They were common by the 1930s, but only became the dominant transit mode in the 1950s. The most common urban buses today are the diesel-powered 12-metre low-floor standard bus and the 18.5-metre low-floor articulated bus. A variety of other buses under nine metres in length provide community shuttle functions in communities across Canada. In total, there are more than 16,000 urban buses in Canada and they carry more than 63 percent of all public transportation trips.

- **Electric trolley bus –** Rubber-tired, electric-powered "trackless trolleys" with double overhead wires and twin-pole pickups were first introduced in Windsor and Toronto in 1922. At least 16 Canadian cities were operating trolley buses by the late 1940s; however, diesel buses replaced most trolley operations by 1975. Edmonton operated trolley buses until 2009, and now only Vancouver operates trolleys with a fleet of 262 vehicles on 13 routes.

- **Subway –** There are two heavy rail subway operations in Canada. Toronto's service began in 1954, followed by Montreal's in 1966. Both systems have been highly successful and today they carry 23 percent of all transit trips in Canada. The TTC subway has three lines and 64 stations, and is 62 km long. The rubber-tired Montreal Metro has four lines and 68 stations, and is 65 km long.

SkyTrain, Vancouver, 2010
South Coast British Columbia Transportation Authority (TransLink)

- **Commuter rail –** There have been commuter rail services in Montreal since at least 1882 and in Toronto since 1892. There are now three commuter rail systems in Canada: GO Transit in Toronto, the Agence métropolitaine de transport (AMT) in Montreal, and West Coast Express in Vancouver. Montreal operates both electric and diesel trains on five lines with over 200 km of track. GO Transit's service launched in 1967 and includes seven lines, more than 450 km of track and 63 stations. West Coast Express began service in 1995, and runs 69 km from Waterfront Station in downtown Vancouver eastward to the District of Mission. The two busiest rail stations in Canada are Toronto's Union Station and Montreal's Central Station.

- **Light rail transit –** Light rail transit (LRT) emerged in the mid-1970s when cities sought an intermediate-capacity rail mode to fill the gap between streetcars and heavy rail. In 1978, Edmonton opened North America's first "new start" LRT line which is now 21 km long with 15 stations and a significant amount of underground right-of-way. Calgary's CTrain system opened in 1981 and has grown to include two lines with four legs radiating outward from the downtown core, 53 km of largely at-grade alignment, and 44 stations. The service has more than 300,000 daily boardings, making it the most successful "new start" LRT system in North America. Ottawa's O-Train launched in 2001 with five stations along 8 km of existing rail line, and is unique in that it operates diesel-powered cars rather than the electric systems of both Edmonton and Calgary. Calgary's CTrain was the first rail system in the world to source all required electricity from windmills.

- **Advanced light rail transit –** The SkyTrain service in Vancouver and the Scarborough RT do not fall into either LRT or heavy rail categories, and have been described as advanced light rail (or rapid) transit (ALRT). SkyTrain opened in 1985 with a fully automated service on a mostly elevated guideway. Its three lines are almost 69 km long and have 47 stations. The Scarborough RT also opened in 1985 and is a manned system operating on 6.4 km of mostly elevated guideway with six stations.

- **Funiculars –** There have been at least nine inclined railway operations in Canada, but by 1914 only those in Hamilton, Port Stanley, Montreal, Niagara Falls, Quebec City and Bell Island were operating. The single remaining funicular is in Quebec City.

PUBLIC TRANSPORTATION TODAY

Today there are over 100 transit systems in Canada, carrying more than 3 billion passengers annually. They have more than 53,000 employees and operate about 16,000 buses, 1,600 heavy rail vehicles, 800 commuter rail vehicles, 600 LRT and ALRT vehicles, 250 streetcars, 6 ferries and one funicular. They provide 1.2 billion vehicle-kilometres of service, with direct operating expenses of more than $7 billion and operating revenues of $4 billion. Governments across Canada continue to invest in expanded operations and capital assets, and transit ridership is increasing faster than population growth.

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SMALL MUNICIPALITIES: BENEFICIARIES OF INNOVATION

TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

SMALL MUNICIPALITIES: BENEFICIARIES OF INNOVATION

By Rod Sanderson, City of Chilliwack

Downtown Fredericton, NB
City of Fredericton

Canada's rural and small municipalities were settled mainly to produce and export commodities. Over the past century, as these communities have faced important challenges and evolved, so have their transportation needs. Innovations in transportation have helped them address challenges and contributed to their growth and development—whether by railway, boat, horses or gravel roads in times past, to today's reliance on cars, trucks, airplanes and paved roads.

Despite dealing with narrow choices in transportation modes or limited road and rail networks, residents in rural and small communities have increasingly been connected to each other and to larger urban areas. The case of the city of Chilliwack, BC highlights these challenges and the responses of transportation authorities.

INNOVATIONS IN TRANSPORTATION MODES AND INFRASTRUCTURE

Railways – From the mid 1800s to the late 1930s, railways were the major transportation innovation supporting the development of rural and small municipalities. They dominated Canadian transportation during that era, particularly in western Canada where the Canadian Pacific Railway enabled the settlement of numerous municipalities from Manitoba to British Columbia. The transcontinental railway and its secondary lines allowed people to travel great distances, and connected smaller municipalities to urban areas. The westward expansion of railway lines enabled the connection of settler communities and farmers to major cities such as Winnipeg, Saskatoon and Edmonton. Furthermore, railways played a major role in western Canada's rapid population growth by connecting branch lines in less populated areas to main lines. Electric railways also proved useful to rural and small communities in the early 1900s, and while they never completely fulfilled the hopes of many communities, they did connect many suburban areas and enable short runs between towns poorly served by the railway.[1]

Waterways – Throughout the late 1800s and much of the 1900s, federal and provincial governments undertook major public works to improve Canadian waterways. Canal construction and improvement were a major benefit to smaller communities. The two major waterway projects undertaken in Canada during the 20th century—the fourth Welland canal (1913-1932) and the St. Lawrence Seaway (1954-1959)—had a profound impact on rural areas across the country. By providing a faster route to the Atlantic Ocean, these projects accelerated grain exports and trade. In Atlantic Canada, the construction of the 1.2-km long Canso canal in the mid-1950s, combined with the Canso Causeway, connected the communities on Cape Breton Island to Nova Scotia's mainland while also proving to be a commercial success.

Bridges – Developments in bridge construction also played an important role in the growth of many rural and small communities. Wood, iron and steel bridges dominated at the end of the 1800s and early 1900s, while concrete and reinforced concrete gained prominence after the World War I, in part due to the scarcity and high cost of steel. Many rural municipalities across Canada built reinforced concrete bridges, such as the Ashburnham bridge in Peterborough, ON, completed in 1920. Pre-stressed concrete became very popular for bridges after

World War II, and one of the first (in 1953) was the Ross Creek Bridge in Medicine Hat, AB. Aluminum was thought to be the material of the future, but prohibitive costs limited their construction to the arched Arvida Bridge in Quebec.

The final twinning of the Trans-Canada Highway (Highway 1) was completed between Moosomin and Wapella in 2008.
Saskatchewan Archives Board

Helicopters are deployed to sling goods across the river, 2013
Government of North West Territories

Roadways – In terms of transportation infrastructure, better roads have had the most important and long-lasting impact on quality of life in smaller communities over the past century. The end of statute labour (in Prince Edward Island in 1877 and in other provinces by the early 1900s), forced municipalities and provincial governments to take over road construction and maintenance while the federal government provided supplementary funding. Roads improved slowly at first, but more quickly during the 1930s and afterward. In Prince Edward Island, Nova Scotia and New Brunswick, for example, this process led to networks connecting almost every town and village and facilitating the movement of goods and people.[2]

Pavement has been one of the most important advances for smaller communities over the years. Until the mid-1930s, roads outside urban areas were generally made of dirt, macadam or gravel, and sharp turns and high crowns were additional obstacles. Proper drainage improved gravel roads to some extent, but paved roads proved to be the real game-changer. Asphalt became the road surfacing material of choice, reducing air and noise pollution while improving traffic safety.

The expansion of interregional roadways also contributed to the evolution of smaller municipalities. The Trans-Canada Highway and provincial routes such as Alberta's Provincial Highway 2, connecting Grande Prairie to the United States border, link numerous smaller communities to each other and to larger metropolitan areas, thereby improving access to city services for rural residents. Moreover, they broaden access to economic generators (such as tourist sites, ports, industrial and natural resource areas) and support the vitality of rural regions. An important outcome of these roadways has been the permanent or seasonal urbanization of some rural areas.

Cars – In combination with better roadways, cars had easily the greatest impact on rural lifestyles over the last century. In a process that took more than three decades, cars gradually replaced horses, buggies and carriages. Until the late 1930s, horses and carriages were very much present in rural communities, even while cars were transforming urban areas. Since the mid-1950s, cars have been the dominant mode of transportation in rural and smaller communities. Reliable alternatives do not exist in most rural areas, and transportation access remains tied to the availability of personal vehicles.

Aviation – Since 1950, aviation has played a complementary but important role in the growth of rural and small communities, especially in the north. In remote communities unreachable by road or rail, airplanes are used to carry passengers and goods. In northern Saskatchewan, the Ministry of Highways and Infrastructure operates 17 airports. In Nunavut, planes carried over 80% of visitors from other provinces, territories and abroad in 2008.[3]

Public transportation – Automobile dependency and low population density present real challenges to public transit in smaller and rural communities, where residents have limited choices for getting around. Nevertheless, over the years many smaller communities have developed public transit systems: among Canada's 300 municipalities with 10,000 to 50,000 people outside metropolitan areas, 36 have developed a public transit system. Many others offer public transit solutions to their residents through intermunicipal or provincial partnerships.[4]

CASE STUDY: THE STORY OF TRANSPORTATION IN CHILLIWACK, BC

Chilliwack is located in the Upper Fraser Valley, about 100 km east of Vancouver. After the town's incorporation in 1873, steamboats and trains were the main modes of transportation while a wagon road paralleling the Fraser River from New Westminster to Yale ran through the area where the City of Chilliwack now stands. That portion of the route crossed many waterways and at times of high water the soft road became impassable, leading to the eventual construction of a superior route on higher ground.

The early economy of Chilliwack was dominated by agriculture, timber and transportation by land and on the Fraser River. To maximize the usefulness of fertile land, the communities organized and built the Vedder Canal to drain Sumas Lake. In addition to drainage purposes, the canal featured in the rowing competition of the 1954 British Empire and Commonwealth Games.

Downtown sidewalk construction, Chilliwack, BC
City of Chilliwack

The Trans-Canada Highway also played a major role in Chilliwack's development. The divided four-lane facility now bisects the city, has seven grade-separated interchanges, and carries about 30,000 vehicles daily including a large volume of commercial trucks. The community's remaining 640 kilometres of local, collector and arterial roads feature about 50 traffic signals and one roundabout. The community now has two bridge crossings of the Chilliwack River, one near the historic crossing to the south and one across the Vedder Canal to the neighboring community of Abbotsford.

Grading street, Chilliwack, BC
City of Chilliwack

The demand for transit in Chilliwack and Abbotsford has grown as their populations increase and gradually age. The communities have funded local transit service for decades, and are about to launch a connecting transit system that will allow riders to access Metro Vancouver to the west. The proposed Fraser Valley Express will serve work, medical, educational and other personal travel, and will connect to TransLink's Carvolth Transit Exchange in suburban Langley, where riders can access fast bus service to the SkyTrain system. This service will be especially important to students of the University of the Fraser Valley in Chilliwack, Abbotsford and Mission, who will be able to travel to classes and activities at all three campuses without needing a car. Mobile telephone applications and electronic travel cards will help attract new riders, and to reduce emissions the diesel bus fleet will be converted to compressed natural gas.

Chilliwack's emerging challenges revolve around two key issues: funding and prioritization of works to reduce congestion, improve safety and add active transportation facilities; and efforts to ensure harmonious sharing of public roads by different users.

THE WAY FORWARD

Over Canada's first century and a half, rural and small communities such as Chilliwack have experienced numerous transportation challenges. Dirt roads have given way to paved roads, while cars and public transit have replaced horse-drawn buggies. Going forward, rural and smaller communities will continue to face emerging financial and environmental challenges—and there is no doubt that innovation will continue to be a part of the solution.

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TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

ROAD SAFETY: SAVING LIVES

ROAD SAFETY: SAVING LIVES

By Gerry Forbes, Intus Road Safety Engineering Inc.

INTRODUCTION: THE EARLY YEARS OF THE AUTOMOBILE

When the automobile debuted in Canada in the late 1800s, the associated excitement and novelty seemed to overshadow any danger or risk that accompanied these machines. Then on June 24,1866, Father Antoine Belcourt, a parish priest in Prince Edward Island, lost control of his steam-powered automobile at a parish picnic, ran off the road, went through a fence, and rolled over. This is regarded as the first recorded traffic accident in Canada[1], and while not much was made of the incident at the time (there were no injuries) it is a noteworthy milestone in the evolution of road safety in Canada.

In the late 1800s and early 1900s, motorists were a small group of affluent citizens whose principal concern was creating and maintaining “good roads”. Canadian roads were built for pedestrians and equestrians, and were not passable by thin-tired automobiles after a rainstorm or winter thaw. So the focus at this time was on passable roads, and there was comparatively little concern for the safety of the motorists. In fact, the main safety concern generated by the automobile was the peril that motorized vehicles presented to other road users. In all regions where automobiles started to appear, there was an insurgence by some who thought that the loud and fast-moving automobiles endangered pedestrians and scared horses.

The principal traffic safety concern of the early 1900s was automobile speed, and the solutions were mainly legislative. Maximum speed limits of about 10 mph (16 km/h) were introduced for automobiles, about the speed achievable by a team of horses. Some communities also legislated measures such as having to bring the automobile to a full stop when meeting an equestrian, and/ or having the motorist disembark the vehicle and lead a frightened horse past by hand. Prince Edward Island exhibited the most extreme response, banning all automobiles from the island in 1908 because Islanders thought the automobile to be a public nuisance based on reports of numerous accidents and spooked horses[2].

As automobile travel in Canada slowly increased over the first part of the 20^{th} century, governments continued to be concerned with upgrading roads to make them passable by motorized traffic in all weather conditions, and expanding the network. The safety of travel by automobile still received comparatively little attention, except for attempts to harmonize the

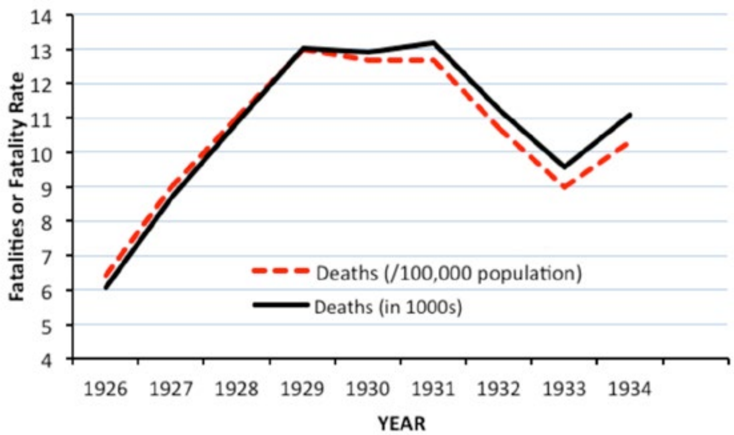

Figure 1. Canadian deaths from motor vehicle accidents[3]

Width Separation, Saskatchewan, Trans-Canada Highway
Saskatchewan Archives Board

Early Road Construction, 1937
Newfoundland and Labrador Transportation and Works

rules of the road across the country. For example, up to the mid-1920s Canadian provinces that were originally settled by the French (i.e. Quebec and Ontario) permitted driving on the right side of the road, and provinces settled by the English (i.e. British Columbia and the Maritimes) permitted driving on the left side of the road. By 1924, all Canadian provinces settled on a right-side driving environment.

Motor vehicle accident statistics from the 1920s and 1930s show the steady decline of road safety in Canada, and demonstrate that the situation was not being addressed.

THE FIRST REAL ADVANCES

It was not until the 1930s that road safety became a noticeable national concern for government, road builders and engineers. While the primary responsibility for road safety was still believed to rest with the road user, it was recognized that "much can be done by the highway engineer and road builder to anticipate mistakes in driving and walking, and to guard against their having serious consequences."[4] Following on that theme, the Canadian Good Roads Association (CGRA, the predecessor organization of TAC) identified the highway situation as "not good" because of the mismatch between automobile technology and infrastructure – Canada had automobiles capable of achieving 80 mph on infrastructure where only 35 mph was safely attainable. They proposed a new paradigm for road construction: following the shortest route rather than the easiest route, maximum curvatures of three degrees, a minimum sight distance of 800 to 1000 feet, and a maximum gradient of five percent. Clearly, the safety offered by the design of a road was recognized and beginning to take on some prominence.

It was during this era that Canadian engineers started to make some significant advances in designing and delivering safer road infrastructure. Two examples follow:

- In 1930, the concept of using a line to mark the centre of a paved road was developed in response to run-off-road accidents on a section of road that experienced recurrent foggy conditions. An Ontario engineer placed white dots every 300 feet (91 metres) along the centre of the road to help guide motorists. This marking system was the precursor to the directional dividing line, which remains an important traffic control device for road safety.
- The first superhighway was constructed in Canada. The Queen Elizabeth Way between Toronto and Hamilton was the first divided intercity highway in North America, used a grade-separated interchange at the intersection with Highway 10, and featured the longest stretch of consistent illumination in the world. The interchange and 30-foot median width were ground-breaking features in Canada, and harbingers of a profound effort to better integrate crash minimization considerations into road design.

PROGRESS ACCELERATES

The next major advancement in Canadian road safety as it relates to road infrastructure came almost 20 years later. At the end of World War II, increasing prosperity brought an explosive increase in automobile ownership and travel by road, and it became obvious that much of Canada's main road system was inadequate to meet the needs of modern motor vehicles. It was the mid-1950s when the CGRA publicly identified that road safety in Canada was deteriorating, and that loss of life

Roundabout, Kitchener-Waterloo, ON
GHD and Regional Municipality of Waterloo

King Road Grade Separation, Jack Structure, Burlington, 2011
Hatch Mott MacDonald

and property had grown to such proportions that only national action could reduce the loss. To that end, the CGRA and other national organizations convened the first National Conference on Highway Safety in May 1955.

This multidisciplinary conference was a watershed moment for highway designers, traffic engineers and others associated with highway safety. It resulted in specific recommendations from the engineering community including: uniform Canadian standards for highway design, construction and maintenance so that geometric design would help provide safe traffic conditions; a Canadian manual of uniform traffic control devices to bring about uniformity in roadway signs, markings and signals; and courses in traffic engineering at Canadian universities. All of these recommendations came to fruition:

- In 1956, the University of Alberta established Canada's first post-graduate civil engineering program concentrating on highway engineering.
- In 1959, the first edition of the *Manual of Uniform Traffic Control Devices for Canada* was developed. Its important advances included standardizing the red octagonal shape of the stop sign (as stop signs on Ontario highways were square and white until about 1955).
- In 1963, the CGRA released the *Geometric Design Standards for Canadian Roads*, the first manual providing national guidance on road design.

The documents and programs that were put in place as a result of this conference are the foundation of Canada's current design standards and guidelines for highway design and traffic control.

MODERN DEVELOPMENTS

From the early 1960s to the present, Canadian engineers and road builders have continued to improve infrastructure and design guidelines to benefit Canadians. Notable examples include:

- **Ontario tall wall traffic barrier –** Developed in 1968 by the Ontario government, this barrier is a taller version of the concrete Jersey barrier seen on most high-speed multilane highways. The Ontario tall wall contains vehicles with higher centres of gravity, and also does a better job blocking headlight glare from taller vehicles going the other way.
- **Modern roundabouts –** The first modern roundabout in Canada opened in Saint-Laurent, QC in 1998. An update on the old traffic circles and rotaries of the 1940s and 1950s, the modern roundabout better manages speed at intersections, and efficiently assigns right-of-way leading to significant reductions in crash occurrence and severity.
- **Red light cameras –** Introduced in British Columbia in 1998, red light cameras have been used to reduce injury-producing angle collisions at busy signalized intersections across the country.

The contribution of safer roads to saving lives on Canadian highways is undeniable. By one account, it has been estimated that road engineering improvements prevented about 11,000 deaths and 500,000 injuries between 1979 and 2000, with

Metal Crash Barrier Installation
British Columbia Transportation and Infrastructure

Car Safety Testing
PMG Technologies

most of the savings resulting from divided highways, intersection channelization, clear zone widening, breakaway devices, energy-absorbing barrier end treatments, protected left-turn phases, rigid barriers and horizontal curve flattening.

In more recent times, Canada's multi-sectoral focus on road safety has been emphasized through development and adoption of a national road safety vision, which aspires to make Canada's roads the safest in the world. The current version of the document, *Road Safety Strategy 2015*, includes a framework of best practices that each jurisdiction can adopt or adapt to address its specific road safety challenges, including 95 infrastructure-based measures that have been vetted and advanced by TAC standing committees. The strategy also promotes a coordinated and holistic "safe systems" approach to crash reduction that targets road users, vehicles and infrastructure. The safe systems concept effectively brings together all stakeholders by recognizing the interdependencies that exist among these elements.

A LOOK AHEAD

As Canada's road safety community moves into the future, it faces important and exciting prospects as well as some persistent long-term issues.

Arguably, the single most important challenge—which has persisted since the invention of the automobile—is managing speed. Speed is both beneficial and detrimental to society, and that is why opinions differ on what speeds are appropriate. Nonetheless, the human body was not designed to travel faster than it can on foot, and crash frequency and severity both increase with speed. So while we have mitigated the impacts of speed by providing better occupant protection in vehicles and more forgiving roadsides, engineers still struggle with getting road users to travel at the right speed for the road and traffic conditions. The safe systems approach to road safety, combined with the emerging concept of self-explaining roads, holds promise in this regard.

One exciting prospect for improving the safety of Canada's roads is the arrival of self-driving cars and autonomous vehicles. Since human error is a contributing factor in the vast majority of motor vehicle collisions, removing the human from the driving equation could yield significant safety benefits. This is a rapidly developing field and one that the Canadian engineering community must address in a timely manner to minimize complications and maximize benefits. Several jurisdictions in the United States have already passed legislation permitting driverless cars on their road systems, and the time for dealing with this in Canada is probably closer than we think.

As Canada continues its journey towards a road system that is the safest in the world, it is important to reflect on past achievements and to remember that what engineers and road builders do is important. This is often masked by the fact that infrastructure improvements that contribute significantly to improved road safety often occur through shifts in road design and traffic engineering. Unlike legislative or regulatory changes (e.g. those requiring seatbelts or air bags) the evolution of road design is gradual and largely unnoticed by the general public. However, when one stops to consider the facts, it is clear that road design matters because safer roads save lives.

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[1] The Belcourt accident occurred before Confederation. The first post-Confederation motor vehicle accident occurred in Quebec in August, 1867 when Henry Seth Taylor (riding the first automobile to be built in Canada) attempted to descend a steep hill, went out of control and crashed at the bottom.

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[2] This law was modified (e.g. allowing automobile traffic on some days) before finally being lifted in 1919. P.E.I. Auto Ban, www.gov.pe.ca/cornerstore/htmlsite/autoban.htm, accessed on October 18, 2013.

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SUSTAINABLE TRANSPORTATION: NEW KID ON THE BLOCK

TRANSPORTATION IN CANADA

TRANSFORMING THE FABRIC OF OUR LAND

SUSTAINABLE TRANSPORTATION: NEW KID ON THE BLOCK

By Todd Litman, Victoria Transport Policy Institute

Montreal Subway Construction
City of Montreal

Arch
City of Calgary

INTRODUCTION: A NEW PARADIGM FOR TRANSPORTATION PLANNING

There is growing interest in the concept of sustainable transportation. *Sustainability* is a set of overarching principles that balance long-term economic, social and environmental goals (Figure 1). *Sustainability planning* emphasizes the integrated nature of human activities and the need to coordinate different sectors, jurisdictions and groups. It provides guidance to ensure that individual decisions balance economic, social and environmental objectives, taking into account indirect, distant and long-term impacts. This is a significant change from conventional planning which assigns narrowly defined problems to organizations with limited responsibilities; for example, transportation agencies tackle traffic congestion, environmental agencies fight pollution emissions, public health agencies support fitness and health, and local governments set parking requirements. This type of planning can result in agencies rationally implementing solutions to their own concerns that exacerbate other problems facing society, and tends to undervalue strategies that provide more modest but multiple benefits.

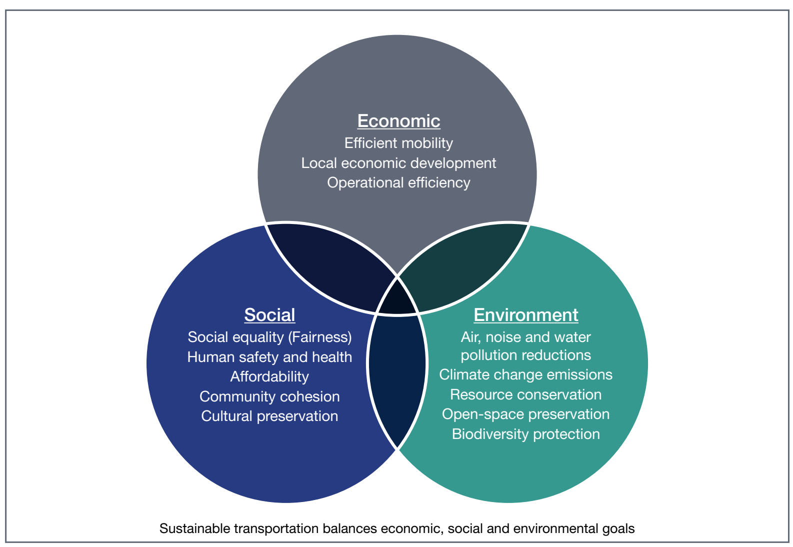

Figure 1. Scope of sustainable transport[1]

Sustainable transportation planning represents a paradigm shift, that is, a fundamental change in the way problems are defined and potential solutions evaluated. Figure 2 summarizes this new paradigm. The old paradigm evaluated transport system performance based primarily on automobile travel conditions, using indicators such as roadway level of service and average traffic speeds. The new paradigm applies more comprehensive, multimodal evaluation that considers a wider range of objectives, impacts and transportation system improvement options. Sustainable transportation planning creates new opportunities for collaboration, for example between transportation, economic development, health agencies and environmental agencies to support innovative solutions to transport problems such as urban redevelopment, safe routes to schools, and parking management.

	Old paradigm	New paradigm
Definition of *transportation*	Movement of people and goods, particularly automobile travel	Ability to obtain goods, services and activities
Modes considered	Automobile, truck and transit	Multiple modes and transport services
Performance indicators	Vehicle travel speeds, roadway level of service, cost per person km	Quality of transport options, proximity of destinations, per capita transport costs
Planning goals	Increase vehicle travel speed and affordability	Improve overall accessibility and transport system efficiency
Favoured transport improvements	Roadway and parking facility expansions, vehicle improvements	Multimodal improvements, transportation demand management, smart growth policies

Figure 2. Transport planning paradigms[2]

York Spadina Subway Extension, 2008-2016, Toronto
Hatch Mott MacDonald

Bike Path
City of Calgary

Because it expands the range of impacts considered in the planning process, the new paradigm helps identify win-win strategies, that is, solutions to one problem that also help achieve other planning objectives, such as congestion reduction strategies that also reduce parking problems, safety risks and emissions while improving physical fitness, and transport options for people who do not drive.

Current demographic and economic trends are increasing the value of creating a more efficient and diverse transportation system; aging population, rising fuel prices, increasing urbanization, increasing health and environmental concerns, new technologies, and changing consumer preferences are causing automobile travel to peak, and are increasing demand for alternative modes.

Sustainable transportation planning tends to increase support for resource-efficient modes such as walking, cycling and public transit, and for demand management strategies such as mobility pricing and smart growth, since those strategies can achieve a diverse range of economic, social and environmental objectives.[3] These tend to reflect basic market principles including consumer sovereignty (ensuring that transport system users have diverse options available, so they can choose the combination that best meets their needs), efficient pricing (users pay for roads, parking, fuel and insurance based, as much as possible, on the actual costs they impose) and least-cost planning (transport planning decisions are based on cost efficiency, considering all impacts, with demand management solutions given equal consideration as capacity expansion).

PROGRESS AND CHALLENGE IN CANADA

Canada has been a global leader in sustainable transportation theory and analysis:

- TAC has supported progress toward more sustainable transportation. For example, its briefings *New Vision for Urban Transportation* (1996, Figure 4) and *Strategies for Sustainable Transportation Planning* (2007) recommended advanced specific principles and planning practices to create more sustainable transportation systems.
- The federal government helped establish the Centre for Sustainable Transportation (CST) in 1996, with a mission to “work proactively in achieving the sustainable transportation of persons and goods in Canada.” In cooperation with various other organizations including Transport Canada, the National

Round Table on the Environment and the Economy, and industry groups such as the Railway Association of Canada and the Canadian Urban Transportation Association, the CST developed sustainable transportation theory and planning practices.[4] Transport Canada commissioned the CST to develop a functional definition of sustainable transportation, and after considerable research and consultation they developed the definition in Figure 3. Versions of this definition have been adopted by many organizations around the world, including the European Council of Ministers of Transport, and the Transportation Research Board's Sustainable Transportation Indicators Subcommittee.

- Transport Canada has conducted programs such as the Urban Transportation Showcase Program and Moving On Sustainable Transportation, which increased awareness and supported new tools for sustainable transportation.

A sustainable transportation system is one that:
• Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
• Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
• Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

Figure 3. CST's definition of sustainable transportation (2005)

1. Plan for increased densities and more mixed land use.
2. Promote walking as the preferred mode for person trips.
3. Increase opportunities for cycling as an optional mode of travel.
4. Provide higher quality transit service to increase its attractiveness relative to the private auto.
5. Create an environment in which automobiles can play a more balanced role.
6. Plan parking supply and price to be in balance with walking, cycling, transit and auto priorities.
7. Improve the efficiency of the urban goods distribution systems.
8. Promote inter-modal and inter-line connections.
9. Promote new technologies which improve urban mobility and help protect the environment.
10. Optimize the use of existing transportation systems to move people and goods.
11. Design and operate transportation systems which can be used by the physically challenged.
12. Ensure that urban transportation decisions protect and enhance the environment.
13. Create better ways to pay for future urban transportation systems.

Figure 4. Key elements of TAC's *A New Vision for Urban Transportation* (1996)

Vancouver Sky Train, Millenium Line
MMM Group Limited

Segregated Bicycle Lanes, Laurier Avenue, Ottawa
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There are still challenges facing widespread progress toward more sustainable transportation planning in Canada. Unique among peer nations, our constitutional arrangement means that the federal government has little policy involvement in urban transportation. As a nation, we are comparatively weak in collecting and disseminating the basic data required for comprehensive transport system performance evaluation, such as statistics on vehicle travel, fuel consumption, consumer expenditures on transportation, pollution emissions, and population. Although local and regional jurisdictions conduct travel surveys, there is no standardization of the data collected that would facilitate comparisons between jurisdictions.

Despite these obstacles, sustainability principles are being adopted by many transportation agencies, particularly at the regional and local levels. Although the motivations and details vary, the general direction is consistent. Canadian transport agencies and the professionals who work with them increasingly apply more comprehensive and multimodal planning, sometimes in the name of sustainability but often because they seek the most cost-effective and beneficial transport system improvements. Most Canadian jurisdictions, including suburban and rural communities, are implementing some projects and programs that help achieve sustainability objectives—such as walking and cycling programs, public transport improvements and smart growth—although virtually none are implementing all of the projects that would be justified if sustainable transportation principles were fully applied[5,6].

APPLYING SUSTAINABLE TRANSPORTATION PLANNING

Canada's experience implementing sustainable transportation indicates both its potential value, and the barriers it faces. Most transportation professionals understand the importance of applying comprehensive, multimodal analysis, and the potential benefits of policies and plans that support more diverse and resource-efficient transportation systems. They also realize that sustainable transportation planning requires overcoming substantial practical and political obstacles. Professional organizations such as TAC, the Canadian Institute of Transportation Engineers and the Canadian Institute of Planners, along with provincial, regional and local planning agencies, have the responsibility to reconcile day-to-day decisions with our aspirations for more sustainable transportation[2,7].

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EXTENDING SUCCESS: THE FUTURE AND OUR TRIPLE BOTTOM LINE

TRANSPORTATION IN CANADA
TRANSFORMING THE FABRIC OF OUR LAND

EXTENDING SUCCESS: THE FUTURE AND OUR TRIPLE BOTTOM LINE

By Peter Wallis, Van Horne Institute

York-Spadina subway extension, Toronto, ON
Hatch Mott MacDonald

In 1882, William Cornelius Van Horne declared that the Canadian Pacific Railway, in its stretch across the Prairies, would build 500 miles of track in a single year[1]. If this goal seemed unimaginable at the time, it is unlikely that Van Horne or any of his contemporaries could imagine the Canadian transport landscape as it is today. Canada now boasts over 72,000 kilometres of rail tracks, one million kilometres of roadways, 10 major airports, two leading airlines and more than 400 million tonnes of freight traffic each year. We continue to imagine the unimaginable, including an extensive high-speed rail network, more pipelines to transport Canadian oil, and transit systems to minimize the need for personal cars.

In retrospect, we can say that the history of Canadian transport has been one of success. Each year, we move more goods and more people and contribute significantly to one of the world's best economies. Despite challenges such as a vast geography and rising oil prices, we can examine our bottom line and reflect proudly on our accomplishments.

Yet, it seems this moment may be short-lived. While we score well in traditional measures of success—greater passenger and freight movement, reduced transit times, streamlined processes, economic growth—those criteria are about to change. The definition of success is expanding beyond profits to include both people and the planet. It seems that, as an industry, we can no longer be satisfied by our financial bottom line. We must now acknowledge our social and environmental bottom lines as well.

Globally, the concept of triple bottom line (TBL) accounting—measuring social and environmental indicators on top of economic performance—is becoming mainstream. Companies, governments and organizations are no longer expected to be only financially sustainable, but to sustain society and the planet as well. From a transport perspective, people and the planet have the potential to be as significant to the sector as profit has always been.

DEFINING TBL: WHERE ARE WE NOW?

As an industry, we are still finding our way to fully define and measure sustainable transport practices and the triple bottom line. In the past, TAC helped promote the Centre for Sustainable Transportation's definition of sustainable transportation that is clearly aligned with the "three Ps" of profit, people and planet:

Sustainable transportation:

1. Allows individuals and societies to meet their access needs safely and in a manner consistent with human and ecosystem health, and with equity between generations
2. Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy
3. Limits emissions and waste within the planet's ability to absorb them, minimises consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimises the use of land and the production of noise[2]

Confederation Bridge
Strait Crossing Bridge Ltd.

The Centre was also one of the few global organizations to develop a TBL measurement tool for transport[3]. It included 14 sustainable transport performance indicators, each of which declines with a stronger triple bottom line:

- Energy use for transport
- Greenhouse gas emission levels (particularly carbon dioxide)
- Other transport emissions (e.g. carbon monoxide, sulphur dioxide, nitrogen oxides, volatile organic compounds)
- Safety (i.e. injuries and fatalities)
- Movement of people
- Movement of freight
- Travel by cars and planes
- Personal vehicle movement
- Urban land use (i.e. minimize land use, avoid urban sprawl)
- Length of paved roads
- Household spending
- Relative transit costs (i.e. ratio of public transit fares to gasoline prices)
- Energy intensity
- Emissions intensity

These indicators, however, are far from achieving universal acceptance. As definitive measurement tools they remain imperfect, with environmental, social and financial bottom lines sometimes coming into conflict. For example, earlier in this book Stéphane Guevremont outlines the potential for economic sustainability of air transport in Canada and describes the growth of private aircrafts and charter planes in Canada's oilfields as economic contributors—and yet air transport contributes to Canada's greenhouse gas emissions. As well, Rod Sanderson notes that an increase in cars and roads in smaller Canadian communities can support healthy rural societies and economies, while according to these indicators it is in the interest of sustainability to reduce the number of cars and roads.

Rather than viewing these challenges as barriers to TBL accounting for transportation, we can use them as a call for balance with the understanding that supporting the economy, environment and society in the short term may not always be a win-win-win proposition. However, in the long run all three bottom lines are likely to align. A healthy society and environment lead to productive workers and greater outputs. Maintaining natural resources means they are available for future integration into the Canadian economy. Even on a corporate level, companies that implement sustainability practices are finding social and environmental efforts help their financial results.

MEASURING UP: WHERE DO WE STAND?

Similar to Van Horne's development of the railroad, we still have a long length of track to lay in the area of sustainable transportation. Traditionally, our bottom lines have been out of balance, with short-term economic goals outweighing longer-term social and environmental ones. While we have seen much discussion of sustainability since the 1970s, rhetoric has exceeded action[4]. Specifically, when considering the aforementioned performance indicators, in only a few areas are we moving forward rather than back. Technology is allowing for greater efficiency in emissions intensity, and Jonathan Regehr tells us that truck exhaust has become much cleaner—yet we are emitting more greenhouse gases and using more energy for freight transport than ever before. Another example is that, despite efforts to improve public transit systems, road networks and personal vehicle use continue to grow.

SAFETY FIRST: A CASE FOR HOPE

A poor TBL report card does not mean that we are destined to fail, either as an industry or as a nation. The potential for internalizing TBL principles is demonstrated in the way we have absorbed transportation safety practices into our consciousness over the past two centuries. Safety may not immediately come to mind when we think of TBL, but preventing injury and loss of life is a major contributor to our social bottom line. As Gerry Forbes explains, there was a time when motor safety was of little concern. It took things getting worse—with an increase in accidents in the 1920s and 1930s—before they got better, and it was decades before Canada developed the exemplary transportation safety record it maintains today.

Perhaps this is where we are with other TBL indicators such as transport emissions, public transit prices, urban land use and road development. Only recently have we started to see the dramatic long-term consequences of financial decisions that fail to promote environmental and social well-being. We could argue that a paradigm shift is taking place, possibly faster than the one that occurred towards safety. This is beginning to show, as Todd Litman points out, with transportation planners enabling walking, cycling and public transit ahead of car usage. The result, as noted by John Hubbell, is that transit ridership is increasing faster than population.

How long a paradigm shift towards full TBL accounting will take is still unknown. Can we imagine a transportation sector in which the environmental and social consequences of our decisions weigh as heavily on us as financial outcomes? If we had asked Van Horne in his time, he would likely have said, "Why not?" After all, it was Van Horne who shared with us his belief that, "Nothing is too small to know, and nothing is too big to attempt[5]."

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