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Estimates of the Full Cost of Transportation in Canada

**Synthesis report prepared by
the Economic Analysis Directorate of Transport Canada
in collaboration with the Full Cost Investigation Task Force
for the Policy and Planning Support Committee of
the Council of Deputy Ministers Responsible of Transportation and Highway Safety
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Erratum :

The rail intercity passenger financial costs were understated in the August 2008 cost estimates of the Full Cost Investigation due to the fact that VIA Rail's payments to other carriers (mostly CN but also CP) for usage of the infrastructure were not included in VIA's costs. For this reason, this amount shall not be subtracted from the total financial costs in that segment. For all scenarios, the segment intercity rail passenger; total intercity passenger; total rail; and, total transportation were all underestimated by approximately $40 million. Table below shows both corrected and former values for the table (Table 3-11) for which those changes would be the most significant. For instance, total rail cost per passenger-kilometer for the intercity rail service is now estimated to be 30.9 cents as opposed to the 28.3 cents initially estimated. One would note that the sum of passenger-kilometres has been also corrected.

CORRECTED VALUES

	Financial Costs	Social Costs	Full Costs	Passenger -km	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
Unit	Billion of 2000 $			Billion	$ per passenger-km			
Rail	0.45	0.02	0.47	1.51	$0.297	$0.013	$0.309	4 %
TOTAL	47.75	10.92	58.67	327.22	$0.146	$0.033	$0.179	19 %
FORMER VALUES								
Rail	0.41	0.02	0.43	1.51	$0.271	$0.013	$0.283	4 %
TOTAL	47.71	10.92	58.63	325.55	$0.147	$0.034	$0.180	19 %

Economic Analysis
2008-10-15

Table of Contents

List of Tables

List of Figures

Executive Summary

The Full Cost Investigation project (FCI) was undertaken with a view to produce defensible estimates of the financial and social costs of transportation for Canada. It was felt that these estimates, once developed, would allow for a better understanding of the relative full costs of the different modes of transportation. The estimates represent an additional analytical tool transportation analysts can use to take into consideration a large number of impacts associated to transportation activities.

In developing the FCI estimates, a number of challenges were encountered: some pertaining to data availability and limitations, others related to methodologies, such as the methodology to use to allocate costs and to quantify and monetize impacts of transportation activities. Data availability delimited the coverage and scope of the FCI initiative. In terms of the social impacts of transportation activities, the project team had to limit itself to addressing congestion delay costs, accident costs, as well as damage caused by air pollutants, noise and greenhouse gas (GHG) emissions.

The estimates that were developed do discriminate between passenger and freight transportation as well as between local and intercity passenger movements. All estimates are for year 2000. The work was spearheaded by Transport Canada and a federal-provincial task force. Stakeholders were invited to attend five consultation sessions at which overviews of the project and progress reports were delivered. The work was conducted in a transparent and inclusive way, allowing all parties to offer views, comments and suggestions all along the project.

In order to take into account the uncertainty of some values supporting the estimates, two sets of estimates (a low and an high) have been generated in addition to the middle estimates. When all elements in scope are accounted for, the project team estimated the full costs of transportation in 2000 to range between \$ 198 billion and \$ 233 billion. Of that total, the share of infrastructure-related costs was between \$ 43 billion and \$ 55 billion. The bulk of the infrastructure costs of the country's transportation system are attributable to the infrastructure capital assets (between \$ 28.7 billion and \$ 37.6 billion), while operating costs associated to this infrastructure were between \$ 8.3 billion and \$ 8.9 billion. The remaining portion of infrastructure-related costs has to do with the estimated value of the land used by the infrastructure. The major source of transportation's financial costs is related to the vehicle assets and the operation costs of the vehicles – between \$ 145 billion and \$ 153 billion.

The social costs associated with the impacts of transportation activities in 2000 were in the order of between \$ 24.4 billion and \$ 39.5 billion. In terms of relative importance, the five social costs considered rank as: accidents, air pollution, congestion, GHG emissions and finally noise.

When assessed in terms of modes of transportation, the annual full cost of the transportation activities within the scope of the FCI range between \$ 198 billion and \$ 233 billion with road transportation alone accounting for \$ 169 to \$ 201 billion. Air

transportation is the second mode in terms of the annual full cost, followed by rail and marine transportation.

When it comes to road transportation, the share of social cost in the full cost of road transportation varied between 5 per cent for the Territories to 20 per cent for the province of Quebec. For rail transportation, Ontario had the largest share of social cost with 17 per cent of the full cost of rail transportation allocated to that province. In air transportation, Newfoundland and Labrador had the most significant share of social cost in the full cost of air transportation with 9 per cent.

For costing transportation physical assets, the perpetual inventory method was used where it was possible to do so. The approach allowed to establish the original capital asset net book value adjusted with a conversion factor to change original dollars into current (2000) dollars; the capital expenditure flows were calculated and an asset index price used; straight-line depreciation was applied, and a social opportunity cost of capital came into play to determine the full financial costs.

A methodology was developed to generate an estimated value of the land used by transportation assets and facilities. For this first set of estimates of the full costs of transportation, it can be with or without land value. Figures presented herein generally include land opportunity cost in the total.

Congestion cost estimates were developed for roads only in the FCI and it was estimated for the nine largest metropolitan areas of the country by taking into account both recurring and non-recurring congestion. For GHG emissions, after establishing the quantity of GHG emissions of each mode, a range of value of a tonne of CO_2 equivalent was used to cost out this impact of transportation activities. For air pollution costs, the approach used was more complex as it was based on three steps which started with an estimate of changes in air quality associated to transportation, followed by the monetization of the health and environmental impacts of such pollution, and finally with allocating the air pollution costs to each mode of transportation. Noise related costs were estimated using engineering and hedonic models for the establishment of the unit price to associate to noise.

An international comparison between the FCI social costs of transportation estimates and estimates from other international studies point to lower estimates of full cost of transportation in Canada. The differences may be due to methodological and scope differences and more in-depth analysis of the estimation approaches would be required before firm conclusions are drawn.

A number of areas for improvements have been identified, ranging from data-related improvements to alternate and/or refined methodological approaches. An updated set of estimates of the full cost of transportation could be used to get a sense of the changes in the demand for/supply of transportation activities and their resulting impacts on the FCI estimates.

This first set of estimates of the full cost of transportation comes with a number of caveats and limitations. Nevertheless, the estimates presented herein represent an important first step in furthering our understanding of transportation activities and of the relative costs of modal activities. Both private and public transportation decision-makers may show interest in cost elements of relative significance and for that reason may lead to some special attention on their part.

1 Introduction

1.1 COMPLEXITY OF THE TASK

The objective of the Full Cost Investigation (FCI) project, from its inception, was to assemble defensible, consistent estimates of financial and social costs of transport in Canada, primarily for use in policy analyses, and also to allow all parties a better understanding of the impacts of transportation activities.

Analytical exercises of such a complexity have to be based on sound methodologies. Clearly, it was established early on that reaching unanimity on methodologies to be adopted in the project would be a challenge. As a matter of fact, it was recognized upfront that resolving methodological issues to the satisfaction of all parties would not be possible. Consequently, it was determined that key methodological decisions made during the course of the project would be based on consistency across modes of transportation and expert advice solicited on key contentious methodological issues. Hence, to conduct the FCI, the methodological framework adopted had to allow for a sensitivity analysis around the estimates to take into account the methodological challenges and/or for a certain degree of uncertainty attached to some of the estimates. It also became clear that all estimates generated under the FCI could benefit from improved or more detailed or precise data and those methodological refinements could also improve the precision with which the cost estimates are generated. Nevertheless the results presented in this report are a good first set of estimates of the full costs of transportation.

With the FCI and its inherent approaches and methodologies, another tool has been added to the analytical toolbox of transportation analysts. Despite its limitations, this tool allows for more complete modal comparisons that account in a more comprehensive way for the costs associated with transportation activities. It is a tool that can evolve and can be improved upon in terms of its coverage. Even with its current limitations, the FCI can be useful in an era where sustainable transportation decisions are at the forefront of the public and private sector agenda.

> Due to the complexity of the task of developing estimates of the full costs of transportation, the focus was placed on the **"costs"** of transportation only. Therefore, **"benefits"** associated to transportation were out of the scope of the work done. The "benefits" of transportation are real and important to society. It would be a mistake to use the full cost estimates for decision–making purposes without factoring in the benefits generated by transportation.

1.2 OVERVIEW OF THE CONTENT OF THE REPORT

The thrust of the report is broken down into two parts. First, results of the FCI estimates and comparisons with similar work in other countries are presented, followed by further details of the FCI project, including a few suggestions for improvements.

Three chapters make up Part I of the report. Chapter 2 presents the scope of the FCI analysis; chapter 3 the results of the FCI and an analysis of them; and chapter 4 a comparison of the social cost estimates generated for the Canadian transportation system with similar work done in other countries. Part II of the report is also broken down into three chapters. Chapter 5 gives an overview on how the analytical work was conducted; Chapter 6 an overview of the methodologies applied to generate these estimates, with reference to the relevant background studies; and finally Chapter 7 provides a list of some areas for improvement. The sources of possible improvements have been identified either as the analytical work was being conducted or through views and comments provided by the various parties that were kept abreast during the development of the estimates. A set of appendices providing additional details form the last part of the report.

2 Scope of the Work Done

This chapter presents details allowing understanding the scope and the premises under which the work was conducted. First section describes the scope of the work in terms of elements covered in the FCI. The following section presents the degree of details retained for the analysis. Section 2.3 describes the implications of applying consistent approach across modes. Finally, section 2.4 covers the context of the base year choice.

2.1 ELEMENTS OF THE CANADIAN TRANSPORTATION SYSTEM COVERED

In the initial work plan of the FCI, the scope of the costs for the transportation system to be covered under the project included the following:

- With respect to financial costs:

  - Infrastructure capital costs – depreciation, opportunity costs of capital, allowance for the opportunity cost of land;
  - Infrastructure operating costs – maintenance, operation of control systems, policing;
  - Carrier/vehicle costs – all capital and operating costs of commercial transport businesses, all costs of transport incurred in-house by companies to carry their own goods, costs of personal vehicle operations;

- With respect to social costs:

  - Congestion delay costs – financial costs incurred by commercial carriers through delays, costs to private individuals of their time losses;
  - Accident costs – financial costs of accidents, monetary values of uncompensated personal losses;
  - Environmental costs – financial costs associated with damage from air pollutants, noise and climate change, monetary values of uncompensated personal losses.

One should note that some cost elements could not be distinguished from other elements to group them under the most precise retained relevant category of cost. For instance, additional cost of operating a commercial road vehicle in congestion conditions cannot be dissociated from other operating costs thus congestion per se do not include them (this avoids double-counting).

The accounting approach adopted for the FCI followed the rule of *additionality*. Starting from financial costs of fixed assets, to other financial costs and then to social costs. If a cost element was already accounted for (e.g., insurance fee of light road vehicles), it was excluded later in the accounting process to avoid double-counting it. Hence, to follow the same example, only expenses not covered by insurance have been included under the social cost labelled “accident”. More details on the scope of the FCI project are provided in Part II of the report but this approach should be kept in mind in analysing the results.

Data availability and/or resources delimited the scope of the coverage of the FCI project, and the elements of the Canadian transportation system included. At the end, for the FCI estimates, the following elements were excluded from the investigation:

- Parking;
- Pipelines;
- Non-motorized transportation (e.g., pedestrians/sidewalks, bicycles and bicycle paths);
- Off-road equipment;
- Construction equipment, including specialized vehicles used to move such equipment from one construction site to another;
- Farm equipment;
- Pleasure craft and cruise ships;
- Scenic and sightseeing activities;
- Fishing vessels;
- Foreign-flag vessels;
- International marine movements/activities;
- General aviation;
- Transportation related to military operations and facilities.

When it comes to social costs related to transportation, the scope of the coverage under the FCI did not include the costs related to the environmental consequences of many elements that could be associated at least in part to transportation, including:

- Oil and chemical spills resulting from the transportation activities;
- Fuel production to satisfy the transportation energy needs;
- Noise from vessels and marine facilities;
- Congestion of all non-road transportation activities;
- Vehicle production and disposal;
- Transportation infrastructure construction and maintenance.

2.2 SEGMENTATION OF THE TRANSPORTATION SECTORS

Hauling freight and moving people are two different activities. Likewise, the choice of mode used for commuting every day between home and the work place are not the same as the modal choice for an occasional inter-city trip. To make realistic modal comparison and to take into account the complementary role of different segments of the transportation industry, the investigation distinguished between moving freight and passengers just like it treated local and intercity movements of passengers in a distinct manner.

2.3 CHALLENGES OF ACHIEVING CONSISTENCY ACROSS MODES OF TRANSPORTATION

Since the FCI can be used to make modal comparisons, consistency across modes in the costing and allocation methodologies used to generate the cost estimates for each mode was important. Consistency across modes was a key challenge in developing the estimates in the FCI.

For each mode of transportation (with due considerations to the modal consistency objective), it was also important to understand and to factor in properly what was causing costs to vary. Some examples can help illustrate this point:

- When it comes to transportation infrastructure, costs do vary by type of structure. Part of the variations can be the result of construction standards. Capacity considerations can be addressed but usually through some incremental capacity levels, each level of capacity having its own specific cost levels, considerations and implications. For example, when it comes to roads, cost differences exist between different types of roads such as limited-access highways, interurban highways, urban expressways, rural local roads, urban arterials, and urban streets. Looking at airports, the infrastructure needs for an airport handling large jumbo jet used in international/intercontinental air services will differ from the ones of an airport handling general aviation operations. Turning to ports, differences are also driven by type and mix of traffic handled as well as by the type and nature of surface transportation access required. Size, capacity and nature of business do impact on the cost structure. The differences translate into unit cost differences specific to the nature of the operations, which in turn become subsequently important to factor in when modal comparisons are done.

- Traffic volume is another parameter that can generate some variations in costs. Traffic volume determines the level of capacity needed. “Full” costs per unit of traffic can differ with traffic volume changes. For example unit costs can come down as volume increases as long as unused capacity exists, but then they can rise as congestion delays appear. They can also increase if social costs increase in a non-linear way with traffic volume increases.

Within each mode of transport, different types/classes of vehicles are used to deliver transport services. And each type/class of vehicle within each mode has characteristics and features that are conducive to either some specific infrastructure needs, some operational cost differences or both. Such differences are of particular importance in establishing the costs related to each type/class of modal transportation vehicles. Here it is important to give some examples of modal specific transportation vehicle features conducive to cost differences:

- When it comes to road transport vehicles, trucks and private passenger vehicles do not have the same operational cost structure, as they do not have the same characteristics driving their road infrastructure needs and the wear and tear they impose on this infrastructure. Amongst trucks, different configurations and carrying capacities translate into operational cost differences. Among passenger vehicles, cars, pickups, vans and multi-purpose vehicles have also significant cost-related differences.

- With respect to air transportation, important differences exist between jet and turbo-prop aircraft. The differences may stem from the range of the aircraft, the maximum gross take-off weight, the type of fuel used, etc. These differences translate into operational cost structure differences, to type of services offered, to airport infrastructure needs (e.g., length and width of runway), to specific safety regulatory mandatory obligations, …all of which lead to some unique impact on costs.

- Turning to rail transportation, freight and passenger services use unique equipment, and rail freight operations have some specific and unique features conducive to equipment and operational differences, which in turn translate into cost differences. For instance, the differences in operating conditions of a rail car of coal in a unit train of coal and a double stack container car will generate cost differences.

- Among marine vessels, differences do exist by size of vessels, by carrying capacity as well as by the type of traffic a vessel can handle. A tanker, a container vessel, a ferry boat… are all different vessels with their own operational cost features, operational needs and port service requirements.

Turning to social costs, over and above the cost differences specific to each type/class of vehicles, some specifics pertaining to the nature of the use of transport vehicles are also important social cost determinants. For instance, the land use adjacent to where the transportation operation is taking place has to be factored in when it comes to establishing environmental damages caused by transportation activities. A residential or an industrial use of adjacent land will have different environmental damage considerations to factor in, including the number of people and structure exposed to this damage.

The factors driving variations in costs are not necessarily entirely predictable. But getting as good a handle on such variations as possible was one of the major challenges of the project. This explains why the evidence gathered was subject to the scrutiny of as many interested parties as possible to get feedback as work progressed. Decisions on methodologies to use to capture and measure such cost variations were needed and were made during the project. The collaboration of interested parties played an important role in such decision-making situations.

2.4 Base Year of the Full Cost Estimates

The work on the FCI project started in 2002-2003. The intent was to give a snapshot of the estimated full costs of Canada's transportation system for a given year. The year that was chosen was 2000. Picking a year, irrespective of the one chosen, would have its associated problems. The problems could have to do with a broad range of issues, such as:

- Data limitations specific to any given year;
- The year not being a representative one for a mode, e.g., the year chosen being just before some changes of significance were introduced that reduced costs – financial and/or social costs – of the mode;
- A year with excess demand due to an economic boom, or excess capacity due to a recession or a year when new or additional capacity may have been coming on stream.

The year 2000 was chosen knowing that irrespective of the year chosen, it would not generate unanimity. Some interested parties were bound to have some reserve on any given year chosen. This has to do with the dynamic nature of transportation activities. The needs for transportation are continuously evolving and so are the transportation services offered.

The intent for this first attempt was to develop the methodological framework and to apply it to generate estimates of the full costs of transportation for a given year. Once that was done, updating the estimates in order to have a sense of that dynamic dimension of transportation and how it impacts on its full cost over time would become possible.

The full cost estimates developed are therefore those of the year 2000 and reflect the realities prevailing that year in each mode, including the specifics of the fleet of transportation vehicles/craft in use that year.

Part I

FCI ESTIMATES RESULTS AND COMPARISONS

3 Results – Estimates of the Full Costs of Transportation in Canada

This chapter presents a summary of the cost estimates. National results were generated first, followed by provincial level ones. The cost estimates are presented as annual costs expressed in Canadian dollars for the year 2000. A short analysis of the results follows. Under the FCI, three sets of estimates have been generated: a set of low estimates and a set of high estimates, as well as a set of average estimates. The reason for generating three sets of estimates is tied to the need to conduct an analysis of the sensitivity of the estimates to some key methodological assumptions used to derive the estimates. The sensitivity analysis conducted is explained in more details in the section 3.5, while other methodological details used for the estimates are found in chapter 6. Section 3.5 provides the results of the sensitivity analysis conducted while the sub-sections of the chapter that precedes section 3.5 focus on the average estimates of the FCI.

3.1 Full Cost of Transportation - National Level Estimates

The full cost estimates of the country's transportation system are broken down into two broad categories of costs: financial costs and social costs. The cost estimates are presented at the national level first for the major modes before going into more details at modal sub-activity levels.

Table 3-1 Financial Cost Estimates by Major Mode (Billion of 2000 $)

Mode	Infrastructure			Vehicle & Carrier	Minus User charges[1]	Sector Total
	Capital	Operating	Land			
Road	28.68	4.91	6.81	128.57	12.61	156.35
Rail	2.92	1.77	0.26	4.30	0.17	9.08
Marine	0.50	0.53	0.19	1.91	0.09	3.04
Air	0.95	1.37	0.17	15.16	1.76	15.89
Total	**33.06**	**8.57**	**7.43**	**149.93**	**14.63**	**184.36**

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-1 can be considered as middle estimates, i.e., between the low and high cost estimates.
1 Transfers to infrastructure providers from users are separated to avoid counting them twice in the total costs of the sector.

Table 3-1 shows the annual cost estimates for the three main costs components associated to transportation infrastructure used in each major mode of transport. For road transportation, the infrastructure cost component includes the road network capital assets (i.e., roads and bridges); the operating costs of this road network (including patrolling, control, snow removal); and an opportunity cost for the land used by the road network. Under the "vehicle and carrier" cost component, costs associated to the road vehicles used in commercial or private application on the road network to satisfy transportation needs are shown. These costs include both the capital costs associated to the road vehicle fleet and the costs of operating that fleet. Under the header "minus user charges" are regrouped all payments made either by "vehicle" owners or made by "carriers" directly to infrastructure providers. The said costs were subtracted from the sum of the four columns in the table to remove what would have been otherwise double-counted in the financial costs of each major mode. Registration fee for road vehicles, transportation specific fuel taxes are examples of such payments that would have been double-counted if they would not have been removed from the total.

With respect to infrastructure costs, the capital cost component represents the dominant infrastructure-related cost category for road and rail transportation, the two surface transportation modes. For marine[1] and air transportation, it is rather the operating costs of infrastructure that ranks first. With the exception of road transportation, the opportunity cost of land is the smallest of the three infrastructure cost components; for road, it ranks second. For all modes, the capital and operating costs of aircraft and vessels generate costs more important than the ones related to the basic infrastructure needed for such transport services.

Table 3-2 Social Cost Estimates by Major Mode (Billion of 2000 $)

Mode	Accidents	Delay	Air pollution	GHG	Noise	Total
Road	15.78	5.17	4.73	3.68	0.22	29.59
Rail	0.30	Not covered	0.44	0.19	0.00[1]	0.93
Marine	0.06	Not covered	0.54	0.24	Not covered	0.84
Air	0.10	Not covered	0.03	0.47	0.03	0.64
Total	**16.24**	**5.17**	**5.74**	**4.58**	**0.26**	**32.00**

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-2 can be considered as middle estimates, i.e., between the low and high cost estimates.
1 Rail noise cost was estimated at less than $5 million.

With respect to social costs associated to the impacts caused by transportation activities (see Table 3-2), accidents generate more than half of transportation social costs. For congestion-delay related costs, estimates were generated only for road. This is not to be interpreted that congestion is a "road transportation" issue only. It has more to do with the lack of data to generate congestion (delay) estimates for the other modes and the fact that methodologies to measure other modal congestion are complex and data demanding. Addressing the congestion question in the other modes of transportation was beyond the resource available to come up with the first set of estimates of the full cost of transportation.

Road congestion costs are associated to time lost due to congestion to which an average value of time is applied. Congestion costs are slightly less than the damage caused by

[1] It is important to keep in mind that the coverage of the marine mode is partial.

road-related air pollution costs. Greenhouse gas emission costs are fourth in terms of relative importance of the five social costs considered. GHG costs are however the most important social cost for air transportation. Noise-related cost estimates represent the least important social costs generated by transportation activities.

3.1.1 Full Costs of Transportation – Allocation by Sub-Modal Transportation Activities

Within each mode of transportation, a distinction can be introduced between passenger and freight transportation activities. The distinction can be further refined by segmenting the activities between local and inter-city activities and by vehicle types used. Such distinctions allow to get to some key drivers of costs and to get to more refined cost estimates allowing to start thinking of comparing the full costs of transportation activities that can constitute actual alternatives to each other. Before getting to modal comparisons of costs, a breakdown of the FCI estimates was done to distinguish between freight and passenger transportation and, for passenger activities, between local and intercity movements. Such distinctions are motivated by market segmentation and modal choice considerations.

Table 3-3 Full Cost Estimates by Modal Sub-Activities (Billion of 2000 $)

Mode	Financial Costs	Social Costs	Full Costs	Social Costs / Full Costs
Intercity Passengers				
Light road vehicles	31.17	10.21	41.38	25%
Coach bus	0.86	0.05	0.91	5%
Rail	0.41	0.02	0.43	4%
Marine	0.62	0.05	0.67	7%
Air	14.65	0.58	15.24	4%
Sub-Total	47.71	10.92	58.63	19%
Local Passengers				
Light road vehicles	68.66	13.04	81.69	16%
School bus	2.82	0.13	2.95	4%
Urban bus	3.01	0.07	3.08	2%
Local rail[1]	1.94	0.01	1.95	1%
Sub-Total	76.43	13.25	89.68	15%
Freight				
Truck	49.83	4.01	53.84	7%
Rail	6.73	0.90	7.63	12%
Marine[2]	2.41	0.78	3.19	N/A
Air	1.24	0.03	1.27	3%
Sub-Total	60.21	5.72	65.94	N/A
Unallocated	0.01	2.10	2.11	N/A
Total	**184.36**	**32.00**	**216.36**	**15%**

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-3 can be considered as middle estimates, i.e., between the low and high cost estimates.
1 Subways, commuter and light rail. Totals may not add up due to rounding.
2 Partial coverage only for financial costs (financial and social costs were not estimated on the same basis).

Table 3-3 breaks down the total financial and social cost estimates by three major transportation activity types: inter-city and local passenger transportation activities and freight transportation activities. For each of these major transportation activity types, the cost estimates are further broken down by sub-activities.

For inter-city and local passenger transportation activities, light road vehicles dominate both financial and social costs of the passenger transportation activities. The relative importance of social costs is the highest for light road vehicle road activities. This relatively higher social cost share in the full cost estimates, 25 per cent of the full costs for inter-city passenger road activities, can be explained by the significantly higher absolute number of fatal accidents in road transportation than in any other mode of transportation.

Air transportation (including international air movements) represents a noticeable share of the financial costs of inter-city passenger activities. The importance of this mode for business trips and for longer haul journeys explains this important share.

For local passenger transportation, the importance of social costs of light road vehicles in their full cost estimates is in the order of 16 per cent, a share significantly higher than the ones observed for freight transportation. For local light road vehicle passenger activities, urban congestion costs represent more than $ 5 billion, hence an important share of social costs were imposed on local road users. This social cost is specific in the sense that it is borne by the transportation sector only.

For freight transportation, the relative importance of social costs in freight rail operations can be explained in part by the fact that in absolute terms the rail financial costs are relatively low which indirectly increase the relative importance of rail social costs. Because marine financial cost estimates could not cover the same level of activities than the one of social costs, it was felt that calculating the relative importance of social costs for this mode would be misleading as it would exaggerate the relative importance of social costs.

Table 3-4 Financial Cost Estimates by Modal Sub-Activities (Million of 2000 $)

	Infrastructure[1]			**Vehicle & Carrier**	**Minus User charges**	**Sector Total**
	Capital	**Operating**	**Land**			
Intercity Passenger						
Light road vehicles	3,389.8	213.6	435.7	30,729.3	3,597.1	31,171.3
Coach bus	114.7	0.3	2.4	783.8	40.3	860.9
Rail	64.1	28.9	14.8	364.3	63.6	408.6
Ferry				625.9		625.9
Air	871.7	1,259.7	158.5	13,913.2	1,552.5	14,650.5
Sub-Total	4,440.3	1,502.5	611.5	46,416.4	5,253.5	47,717.2
Local Passenger						
Light road vehicles	18,122.8	632.0	5,978.5	49,997.8	6,074.4	68,656.7
School bus	477.5	0.9	21.8	2,431.9	110.2	2,822.0
Urban bus	268.5	0.5	12.2	2,791.2	61.9	3,010.6
Local rail	882.6	930.2		225.0	101.6	1,936.2
Sub-Total	19,751.4	1,563.7	6,012.5	55,445.9	6,348.1	76,425.4
Freight						
Truck	10,301.9	67.6	354.5	41,835.6	2,728.7	49,831.0
Rail	1,971.5	806.0	248.1	3,707.9		6,733.4
Marine	502.7	528.7	188.1	1,282.0	91.8	2,409.7
Air	76.9	108.6	14.1	1,242.1	204.2	1,237.6
Sub-Total	12,853.1	1,510.9	804.9	48,067.5	3,024.7	60,211.7
Total	**37,044.8**	**4,577.0**	**7,428.9**	**149,929.9**	**14,626.2**	**184,354.3**

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-4 can be considered as middle estimates, i.e., between the low and high cost estimates. 1) Some road infrastructure operating costs have been aggregated to capital to be able to perform the allocation by sub-activities.

Table 3-5 Social Cost Estimates by Modal Sub-Activities (Million of 2000 $)

	Accidents	Delay	Air pollution	GHG	Noise	Total
Intercity Passenger						
Light road vehicles	8,767.8	0.0	650.1	791.6	0.0	10,209.5
Coach bus	21.1	0.0	16.4	8.9	0.0	46.3
Rail	8.1	0.0	7.6	3.3	0.1	19.1
Ferry	16.0	0.0	46.2	0.0	0.0	62.3
Air	90.5	0.0	28.5	448.3	17.5	584.8
Sub-Total	8,903.5	0.0	748.9	1,252.0	17.6	10,921.9
Local Passenger						
Light road vehicles	5,482.4	5,172.9	923.7	1,458.6	0.0	13,037.5
School bus	40.8	0.0	55.6	31.9	0.0	128.3
Urban bus	17.0	0.0	31.3	22.9	0.0	71.2
Local rail	0.0	0.0	7.6	3.3	0.1	11.0
Sub-Total	5,540.2	5,172.9	10,18.2	1,516.7	0.1	13,248.0
Freight						
Truck	1,453.0	0.0	1,194.8	1,362.1	0.0	4,009.9
Rail	287.7	0.0	428.5	180.4	1.1	897.7
Marine	47.2	0.0	492.5	242.5	0.0	782.1
Air	8.1	0.0	1.6	23.9	0.0	33.6
Sub-Total	1,796.0	0.0	2,117.4	1,808.9	1.1	5,723.4
Unallocated	0.0	0.0	1,860.0	0.0	241.8	2,101.8
Total	**16,239.6**	**5,172.9**	**5,744.5**	**4,577.6**	**260.5**	**31,995.1**

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-5 can be considered as middle estimates, i.e., between the low and high cost estimates.

Tables 3-4 and 3-5 give a more detailed breakdown of the financial and social cost estimates respectively for the same three major transportation activity types: inter-city and local passenger transportation activities and freight transportation activities. The detailed cost components for financial costs and for social costs reported in the Tables 3-4 and 3-5 allow a better understanding at the sub-activity and sub-cost component levels of the financial and social differences reported at a more aggregate level in Table 3-3. One would note that some cost elements have not been allocated at that level of details, thus the sum of the figures presented for the major modes in Table 3-1 and in Table 3-2 could be greater than the totals in Table 3-3 to Table 3-5.

3.2 Full Cost of Transportation - Provincial-Territorial Level Estimates

When the FCI project was launched, it was decided that national level estimates of the full costs of transportation would not be informative enough. It was important to generate estimates at the provincial-territorial level as well. To achieve this goal, efforts were made upfront to generate as much as possible estimates directly at the provincial and territorial level, and when it was not possible to do so, it meant using an allocation approach to breakdown national estimates by provinces and territories. This section of the chapter gives an overview at the provincial-territorial level of the FCI results. However, it is important to flag that some cost elements measurable only at the national level were difficult to allocate at the provincial level due to data limitations. Thus the sum of provincial figures could be smaller than the national figure for specific cost items. Some methodologies, good for estimating national level costs, had weaknesses at the provincial level. These limitations are flagged somehow in subsequent sections of the report.

Table 3-6 Full Cost Estimates for Road Transportation by Province (Billion of 2000 $)

	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
NL	2.325	0.308	2.634	12%
PE	0.634	0.116	0.750	15%
NS	4.493	0.590	5.083	12%
NB	3.823	0.599	4.422	14%
QC	28.309	7.266	35.575	20%
ON	59.161	10.020	69.181	14%
MB	6.184	0.960	7.144	13%
SK	8.440	0.968	9.409	10%
AB	22.817	3.163	25.980	12%
BC	17.354	3.678	21.032	17%
TR	1.446	0.069	1.515	5%
Unallocated	1.367	1.847	3.214	57%
TOTAL	156.352	29.586	185.938	16%

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-6 can be considered as middle estimates, i.e., between the low and high cost estimates.

Table 3-6 gives an overview of the full costs of road transportation – financial and social costs – allocated to provinces and territories. This includes infrastructure financial costs, vehicle and carrier costs as well as social costs. The noise costs and the air pollution costs caused by paved road dust ($PM_{2.5}$) are excluded from the costs reported in that table as they could be measured at the national level but could not be allocated by provinces and territories. The share of the FCI road transportation costs of each provinces and territories follow more or less the relative importance of the respective population of the different jurisdictions. Exceptions are found with Prairies provinces - Manitoba, Saskatchewan and

Alberta - as well as with the Territories, and the explanation has to do with the fact that their road transportation costs account for a greater share than their population in 2000. At the national level, social costs associated with road transportation represented a proportion of 16 per cent of the full costs of the mode. This relative importance of social costs did vary by province. The lowest share was observed with the territories (5 per cent), while the highest one was observed for the province of Quebec with 20 per cent. For Quebec, this higher share of social costs in the total costs associated with road transportation appears to be driven by a share for financial costs (18 per cent of the national total) inferior to its share of the total national population (24 per cent of the country's population in 2000) as well as a share of social costs (26 per cent of the allocated national total) superior to its share of national population.

Table 3-7 gives an overview of the allocation of the FCI rail cost estimates by provinces and territories. Ontario has almost a third of the allocated rail financial costs but 51 per cent of rail social costs. The share of British Columbia is 22 per cent for allocated financial costs and 14 per cent of social costs. Quebec has 11 per cent of financial costs and 14 per cent of social costs. The Prairies provinces have a 30 per cent share of rail allocated financial costs and 18 per cent of social costs. Comparing the two surface major modes, the proportion of social costs in the full cost is slightly less for rail than for road (9% instead of 16%). **Social costs by province are mainly driven by the location of accidents with fatalities.** The small number of such incidents allocated to rail is tied to a higher variance of the importance of social cost over the full cost observed by province.

Table 3-7 Full Cost Estimates for Rail Transportation by Province (Billion of 2000 $)

	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
NL	0.084	0.003	0.086	3 %
PE	0.000	0.000	0.000	
NS	0.070	0.007	0.077	9 %
NB	0.138	0.013	0.151	9 %
QC	0.794	0.132	0.926	14 %
ON	2.387	0.475	2.862	17 %
MB	0.526	0.033	0.559	6 %
SK	0.830	0.041	0.871	5 %
AB	0.890	0.094	0.984	10 %
BC	1.662	0.129	1.791	7 %
TR	0.009	0.000	0.009	1 %
Unallocated	1.689	0.002	1.691	0 %
TOTAL	9.078	0.929	10.007	9 %

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-7 can be considered as middle estimates, i.e., between the low and high cost estimates.

The approach used to do the provincial allocation of marine transportation costs is explained in section 5.1. It has already been said that the coverage of the marine sector could only be partial and therefore the allocation of the national marine cost estimates was done on this partial cost coverage. Because of the nature of the marine transportation industry operations, this partial coverage has an impact on the relative importance of provincial share of marine transportation cost estimates. It was felt that it would not be appropriate to report a ratio of Social Costs over Full Costs due the partial coverage of the financial costs for the marine sector. The figures reported in Table 3-8 are preliminary in nature. British Columbia with more than $ 1.1 billion has more than one third of the total costs, followed by Quebec with $ 0.8 billion. The other provinces with a significant share of the marine costs are Ontario ($ 0.4 billion), Nova Scotia and Newfoundland and Labrador (with $ 0.2 billion each).

Table 3-8 Full Cost Estimates for Marine Transportation by Province (Billion of 2000 $)

	Financial Costs	Social Costs	Full Costs
NL	0.178	0.027	0.206
PE	0.035	0.003	0.038
NS	0.153	0.040	0.193
NB	0.058	0.025	0.083
QC	0.466	0.303	0.768
ON	0.225	0.174	0.399
MB	0.001	0.000	0.001
SK	0.002	0.000	0.002
AB	0.003	0.000	0.003
BC	0.874	0.247	1.121
TR	0.000	0.008	0.008
Unallocated	1.042	0.017	1.059
TOTAL	3.037	0.844	3.882

Note that the ratio of Social Cost over Full Costs is not appropriate for the marine sector due to the partial coverage of the financial costs.

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-8 can be considered as middle estimates, i.e., between the low and high cost estimates.

Table 3-9 presents the provincial results of the air mode and complete the section on provincial results. Ontario has more than one third of the air sector costs with $ 6.3 billion. British Columbia has close to a quarter of the total air mode costs with $ 3.6 billion followed by Alberta ($ 2.4 billion) and Quebec ($ 2.2 billion). The air sector is also significant for the other provinces. Compared to the other major modes (i.e., road, rail and marine), the importance of social cost is generally smaller and the variance of their importance among provinces is lower.

Table 3-9 Full Cost Estimates for Air Transportation by Province (Billion of 2000 $)

	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
NL	0.210	0.021	0.231	9%
PE	0.038	0.000	0.039	1%
NS	0.512	0.015	0.526	3%
NB	0.150	0.006	0.156	4%
QC	2.116	0.084	2.200	4%
ON	6.091	0.165	6.256	3%
MB	0.545	0.018	0.564	3%
SK	0.300	0.006	0.306	2%
AB	2.335	0.073	2.408	3%
BC	3.452	0.147	3.599	4%
TR	0.046	0.021	0.068	32%
Unallocated	0.093	0.080	0.172	46%
TOTAL	15.888	0.636	16.524	4%

The estimates have been generated using a sensitivity analysis to test the nature of the changes to the estimates generated by varying some of the key parameters used to generate the estimates. The figures reported in Table 3-9 can be considered as middle estimates, i.e., between the low and high cost estimates.

3.3 Full Cost Over Activity Measures – National Level Results

Table 3-10 allows performing a quick comparison of sub-activities for local movement of passengers by introducing a measure of activity (production). For local movements, since average distance travelled estimations are not available for all sub-activities, only the number of passenger-trip is considered. One would note that typical distances vary among the sub-activities and this introduces a bias in the comparison.

Table 3-10 Full Cost Estimates and Activity Level – Passenger Local

Local Passenger	Financial Costs	Social Costs	Full Costs	Passenger Trips	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
Unit	Billion of 2000 $			Billion	$ per passenger-trip			
Light road vehicles	68.66	13.04	81.69	12.31	$5.58	$1.06	$6.64	16 %
School bus	2.82	0.13	2.95	0.52	$5.40	$0.25	$5.65	4 %
Urban bus	3.01	0.07	3.08	1.02	$2.96	$0.07	$3.03	2 %
Local rail	1.94	0.01	1.95	0.47	$4.15	$0.02	$4.17	1 %
TOTAL	76.43	13.25	89.67	14.31	$5.34	$0.93	$6.26	15 %

In Canada, personal light road vehicles delivered the vast majority of passenger local movements: 12.3 billion of passenger-trips over a total of 14.2 billion or almost 85%. This mode is by far the more expensive from financial and social points of view. One would note that almost all parking costs are not included in these estimates[2].

Table 3-11 presents a similar comparison than the previous table but for the segment passenger intercity. One would note that the activity is measured by passenger-kilometres (the number of passengers multiplied by the distance travelled).

Table 3-11 Full Cost Estimates and Activity Level – Passenger Intercity

	Financial Costs	Social Costs	Full Costs	Passenger -km	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
Unit	Billion of 2000 $			Billion	$ per passenger-km			
Light road vehicles	31.17	10.21	41.38	209.91	$0.148	$0.049	$0.197	25 %
Coach bus	0.86	0.05	0.91	9.97	$0.086	$0.005	$0.091	5 %
Rail	0.41	0.02	0.43	1.51	$0.271	$0.013	$0.283	4 %
Ferry	0.62	0.05	0.67	0.92	$0.677	$0.054	$0.731	7 %
Air	14.65	0.58	15.24	104.92	$0.140	$0.006	$0.145	4 %
TOTAL	47.71	10.92	58.63	325.55	$0.147	$0.034	$0.180	19 %

With almost 210 billion of passenger-km delivered in the year 2000, light road vehicles generated almost two thirds of the intercity passenger-km at an average financial cost per unit very close to the national average for all modes (14.8 cents compare to 14.7 cents). The air mode followed with almost a third of the market share with a slightly lower average unit financial cost of 14 cents. Per passenger-km, these two modes generated very different social costs of respectively 4.9 cents for light vehicles and 0.6 cents for aircrafts. Rail and buses generated both a similar percentage of social cost over the total cost, but rail costs are more than twice the costs generated by buses on intercity trips per passenger-km for both financial and social costs.

Table 3-12 completes the set of comparisons by looking at freight activities. The tonne-kilometre is used as a measure of activity. Each of these modes has its niche for which the other modes are not competing. Almost all the feeding and delivering are performed by the trucking industry (either private or for-hire). Rail performs the vast majority of bulk low unit value commodity shipments, especially on long distances. Marine has its share of the low unit value bulk traffic, but only when navigation season and route allow it. Finally, airfreight traffic has its share of high valued goods. These different core businesses have an impact on national average presented in Table 3-12 and thus results

[2] Only parking costs that were paid directly by users are part of the light vehicles operating costs. See Ray Barton (2006) FCI Report R9 (The list of FCI reports is available in the appendix).

should be interpreted with care. Marine is not included in the comparison because of its financial costs partial coverage.

Table 3-12 Full Cost Estimates and Activity Level – Freight

	Financial Costs	Social Costs	Full Costs	Tonne-km	Financial Costs	Social Costs	Full Costs	Social costs / Full costs
Unit	Billion of 2000 $			Billion	$ per tonne-km			
Truck	49.83	4.01	53.84	244.97	$0.203	$0.016	$0.220	7 %
Rail	6.73	0.90	7.63	322.44	$0.021	$0.003	$0.024	12 %
Air	1.24	0.03	1.27	2.04	$0.607	$0.016	$0.623	3 %
TOTAL	60.21	5.72	65.94	569.46	$0.106	$0.010	$0.116	9 %

The Full Costs Total includes the marine mode.

Rail generated the majority of freight traffic in the year 2000 with 322 billion of tonnes-km or approximately 57% of the traffic (excluding the marine mode). Trucking with 245 billion of tonnes-km followed it. Air mode generated less than 1% of the freight traffic. Average unit financial costs were very different for air at 61 cents, trucking at 20 cents and rail at 2 cents per tonne-km. Average social costs per tonne-kilometre were similar for trucking and air modes at 1.6 cents but were lower for rail with approximately a third of a cent.

3.4 FULL COST OF TRANSPORTATION ESTIMATES - MODAL COMPARISONS

This section deals with specific markets that have been identified by the federal-provincial FCI Task Force as having potential modal competitive forces at play. With the FCI estimates, it is possible to look at the costs and estimate them at the level of these specific markets. Some of the comparisons presented below are limited to financial costs and others include social costs. What is important to flag is that we are talking of economic cost, costs concepts that are different from the ones coming into play in the establishment of prices. So these comparisons are about FCI cost estimates, NOT modal price differences. Actual pricing can involve different allocation methods, more adapted to commercial realities and beyond the scope of allocating costs for the FCI.

3.4.1 Full Cost of Transportation Estimates – Urban Transportation

Every day, users of transportation services make modal choice decisions and in their decisions, several aspects are considered. For instance, choosing a mode over another one for commuting between home and the work place has financial impacts but the decision has also impacts on social costs associated to the satisfaction of this transportation need. For an individual, it is a decision needed at least over 400 times during any given year – twice a day, once to get to work and once to return home from work, for over 200 working days per year. In this section, modal choice decisions are compared for a number of cities in Canada. Since in the largest metropolitan areas, commuter train services are also offered, this modal choice option is included in the comparison with light road vehicles for longer distance journeys. To make the comparison as complete as possible, the parking costs for personal vehicles are taken into account. The inclusion of parking costs is done despite the fact that a large portion of workers is provided with an access to parking facilities by their employers (and employers do not always cost recover the parking costs from their employees). The inclusion of parking costs allows testing the sensitivity of the modal comparison with and without this cost element into the analysis.

In Table 3-13, the average provincial light vehicle unit costs on a local trip[3] were multiplied by the average distance from the residences to city centres in each city[4]. This distance has been increased by 50% to compare light vehicle costs with commuter rail. These simulations do NOT represent the actual average observed on urban transit trips. Authorities in charge of these services estimate the average distance at a lower level than the ones simulated in Table 3-13.

Table 3-13 Financial Cost Estimates of Local Passenger Transportation Services for Selected Urban Centres for Given Distances ($/ Passenger)

Cities	Distance one way (km)	Car Average*	Car with parking	Urban Transit
Halifax	11.1	$7.50	$20.00	N/A
Montreal	15.6	$9.38	$23.38	$7.77
Montreal LD	23.4	$13.82	$27.82	$11.45
Ottawa	12.1	$7.50	$24.50	$9.40
Toronto	20.4	$12.39	$28.39	$13.73
Toronto LD	30.6	$18.40	$34.40	$15.46
Winnipeg	8	$5.99	$15.99	$6.31
Regina	5.3	$4.84	$11.09	$3.51
Edmonton	12.6	$8.18	$18.18	$11.30
Calgary	10.4	$6.88	$20.63	$5.16
Vancouver	16	$10.14	$23.14	$11.69
Vancouver LD	24	$14.92	$27.92	$16.88
Victoria	8.2	$5.48	$15.48	$6.79

Note that light vehicles are assumed to have single occupancy.

LD means long distance that is 50% more than normal distance.

Table 3-13 shows the importance that could take parking costs in the total costs of using a light vehicle to commute. Most Canadians do not face the full costs of parking. Since parking charges could be significant and the modal choice for those who have to pay it could be different. However, modal choice is much more complex than just comparing

[3] Local trips are the residual of total minus intercity trips defined as trip of 25 km and more on road with speed limits of 80 km/h or more. Fuel efficiency are lower than average on local trips.
[4] Calculated from the 2001 Census information by Statistics Canada Cat. No. 89-613-MIE (June 2005)

unit costs. A comprehensive analysis of relative benefits would need to be completed to explain modal choice. For the cities of Montreal, Toronto and Vancouver, commuter train costs are compared to light vehicle costs used on longer distance (times 1.5) than the average distance used for the bus comparison. In all cases without the cost of parking, financial cost per passengers would be comparable only for single occupancy light vehicle. If parking costs were included in the total costs analysis, the occupancy would have to be approximately two persons by personal vehicle to have comparable cost to the public service per person (assuming all light vehicle users would share the cost equally).

Table 3-14 Full Cost Estimates of Local Passenger Transportation Services for Selected Urban Centres for Given Distances ($/ Passenger)

Cities	Car Average*	Car with parking	Urban Transit (Low)	Urban Transit (High)
Halifax	$7.90	$20.40	N/A	N/A
Montreal	$23.19	$37.19	$7.99	$8.15
Montreal LD	$34.54	$48.54	$11.71	$11.71
Ottawa	$11.58	$28.58	$9.56	$9.68
Toronto	$24.58	$40.58	$14.00	$14.19
Toronto LD	$36.68	$52.68	$15.57	$15.62
Winnipeg	$13.39	$23.39	$6.47	$6.47
Regina	$5.15	$11.40	$4.04	$4.04
Edmonton	$8.98	$18.98	$12.27	$12.87
Calgary	$7.54	$21.29	$5.96	$6.46
Vancouver	$24.96	$37.96	$12.11	$12.14
Vancouver LD	$37.15	$50.15	$17.01	$17.02
Victoria	$5.99	$15.99	$7.00	$7.02

Table 3-14 shows the full cost of different modal choices for local displacement in urban areas. The differences between figures shown in Table 3-13 and figures in Table 3-14 are the social costs. Congestion delays that were estimated to totalize $5.17 billion in the year 2000, are the main cost element for individual light vehicle usage in all major cities. Since adding social costs to financial costs reverses the order of modes in many cities (urban transit and commuter rail become cheaper), this is an indication that charging full cost of modal choice could have an impact on that decision if relative price plays a role in that decision. This raises the interest of further research in that area since many other factors are likely to influence the decision making process of commuters.

3.4.2 Modal Cost Comparisons - Intercity Passenger Transportation Services

Intercity passenger transportation is dominated by the use of light road vehicles, but for some specific type of intercity journeys - mainly the longer haul journeys - air transportation plays a more important role. Scheduled intercity buses and intercity passenger train services are the other modal choice options available to passengers. Table 3-15 provides financial costs on a per passenger basis for a selected number of city-pairs and for a number of modal service options available to the travelling public.

For these modal comparisons of intercity transportation service options, one key parameter to keep in mind which does have an impact on the relative importance of each modal option costs, is the occupancy ratio. This point is flagged in the section on the sensitivity analysis. What is reported here, with the exception of inter-city bus services, is the financial costs estimated with the basic fundamental characteristics used to derive for each modal sub-activity the financial cost estimates. So different occupancy ratios would generate different cost results[5].

The comparison shows that intercity bus services have the lowest financial cost estimates on a per passenger basis of the three passenger surface transportation service options. When it comes to comparing rail and air transportation intercity services, the relative differences between the two modal options depend highly of the markets considered.

Table 3-15 presents the results of specific origin-destination pair financial cost estimates per passenger for light road vehicles, coach buses (low and high occupancy); passenger rail; and aircraft. Table 3-16 presents for the same city pairs the full costs by adding to the financial costs the social cost estimates. Comparing these two tables allow to make a few observations. The rank of each mode is not affected by the addition of the social cost. In other words, the most expensive mode from the financial point of view stays the most expensive one from the full cost perspective and therefore the following analysis is valid for both financial and full costs. Road modes increase their costs generally smoothly with distances while the air mode costs increase even more slowly. Thus, on longer distances the air mode becomes cheaper compared to other modes. Passenger rail is the most expensive mode for all selected city pairs; but for Montréal-Toronto, the volume of traffic as well as the number of cars per train make its average cost comparable to the ones of air transportation. Intercity bus, even with low occupancy rates, generates less cost per passenger for all city pairs but for the very long distances trip (Toronto-Vancouver).

[5] Due to the uncertainty of actual occupancy ratios for buses, a range of ratios have been used in the comparisons.

Table 3-15 Financial Costs per Passenger of Intercity Transportation Services for Selected City Pairs by Mode ($/ Passenger)

		Financial Costs per Passenger				
		Light Road Vehicle	Coach Bus		Rail	Air
Origin	Destination		Low Occupancy	High Occupancy		
Montréal	Ottawa	$30.99	$12.07	$11.03	$110.89	$98.04
Calgary	Edmonton	$46.13	$24.46	$16.81	n/a	$105.78
Regina	Saskatoon	$43.69	$22.39	$15.39	n/a	$121.29
Toronto	Sarnia	$46.22	$23.61	$16.23	n/a	$148.35
Vancouver	Victoria	$61.23	$18.12	$12.94	n/ap.	$71.04
Fredericton	Halifax	$61.28	$34.58	$23.77	n/a	n/a
Montréal	Toronto	$86.52	$25.69	$23.81	$122.58	$155.65
Moncton	Montréal	$147.26	$81.19	$55.82	$335.00	$172.97
Quebec City	Windsor	$183.09	$95.41	$65.59	n/a	n/a
Edmonton	Vancouver	$212.13	$110.08	$75.68	$402.67	n/a
Halifax	St John's	$226.37	$115.13	$79.15	n/a	$162.80
Toronto	Regina	$458.61	$232.00	$159.50	n/a	$293.77
Saskatoon	Halifax	$716.88	$372.24	$255.92	n/a	n/a
Toronto	Vancouver	$759.72	$383.68	$263.78	n/a	$351.02
Winnipeg	Churchill	n/ap.	n/ap.	n/ap.	$1,343.63	$260.52

Note: n/ap. Means 'not applicable' because the service is not available for this specific route and mode. The n/a means that 'not available' because the cost assessment was not produced for the FCI.

Table 3-16 Full Costs of Intercity Passenger Transportation Services for Selected City Pairs by Mode ($/ Passenger)

		Full Costs per Passenger				
Origin	Destination	Light Road Vehicle	Coach Bus		Rail	Air
			Low Occupancy	High Occupancy		
Montréal	Ottawa	$40.44	$12.76	$11.68	$112.37	$98.92
Calgary	Edmonton	$58.61	$24.89	$17.24	n/a	$107.67
Regina	Saskatoon	$55.69	$25.08	$17.97	n/a	$123.14
Toronto	Sarnia	$57.80	$24.59	$17.14	n/a	$149.33
Vancouver	Victoria	$64.73	$19.16	$13.92	n/ap.	$71.41
Fredericton	Halifax	$81.31	$35.98	$25.08	n/a	n/a
Montréal	Toronto	$109.13	$27.49	$25.49	$128.12	$158.59
Moncton	Montréal	$198.79	$83.69	$58.15	$341.10	$184.93
Quebec City	Windsor	$235.20	$99.34	$69.25	n/a	n/a
Edmonton	Vancouver	$273.77	$124.04	$88.88	$447.96	n/a
Halifax	St John's	$292.28	$119.37	$82.73	n/a	$179.15
Toronto	Regina	$578.18	$242.03	$169.17	n/a	$305.91
Saskatoon	Halifax	$920.26	$388.62	$271.27	n/a	n/av
Toronto	Vancouver	$966.45	$412.50	$291.29	n/a	$367.88
Winnipeg	Churchill	n/ap.	n/ap.	n/ap.	$1,365.93	$271.03

Note: n/ap. Means 'not applicable' because the service is not available for this specific route and mode. The n/a means that 'not available' because the cost assessment was not produced for the FCI.

One would note that for very long journeys, using surface modes involve using commercial facilities to rest and eat that would inflate the cost of a trip compare to aircraft that provide a faster service. These costs were not considered in the above analysis. Of course, many travellers could also perceive travelling time as an important cost. However, for the FCI, shorter travelling time was considered being a benefit and was therefore not assessed in this phase of the investigation.

3.4.3 Modal Cost Comparisons of Freight Transportation Services

When it comes to the transportation of freight, modes are in competition on some segments of the Canadian transportation system for some particular traffic conducive to the use of more than one mode of transportation. Some city pairs have been identified over which some given commodity traffic needs to be transported and more than one mode can be used to satisfy such transportation needs. City-pairs were identified in order to use the FCI estimates to compare the full costs of the different modes on these selected origin-destination pairs. Results are shown in $ per tonne and were estimated on different distance bands to take into account the different operating reality of the compared modes.

Table 3-17 Financial Cost Comparison of Freight Modes for Selected Origin-Destination Pairs ($ per tonne)

FREIGHT			Financial Costs $ per metric tonne			
Origin	**Destination**	**Commodity**	**Truck**	**Rail**	**Marine**	**Air**
Trois-Rivières	Delson	Lumber	$11.38	N/A	N/AP.	N/AP.
St-Romuald	Montréal	Petroleum products	$20.15	$5.61	N/A	N/A
Vancouver	Victoria	General Cargo	$23.26	N/AP.	N/A	$302.72
Montreal	Toronto	Expressway	$24.35	$14.33	N/A	N/A
Montreal	Toronto	Marine containers	$25.63	$9.07	N/A	N/A
Hamilton	Montreal	General Cargo	$26.26	N/A	N/A	$816.00
Windsor	Toronto	Salt	$31.19	$9.27	$10.64	N/A
Moncton	Montreal	General Cargo	$33.36	N/A	N/A	$854.32
Montreal	Detroit	Marine containers	$38.70	$21.85	N/A	N/A
Moncton	Toronto	Containers	$78.55	$25.91	N/A	N/A
Halifax	Toronto	Containers	$90.55	$21.71	N/A	N/A
Hamilton	Winnipeg	General Cargo	$101.51	N/A	N/A	$1,397.59
Brandon	Thunder Bay	Grain	$105.97	$13.02	N/AP.	N/A
Prince-George	Vancouver	Lumber	$141.16	N/A	N/A	N/A
Thunder Bay	Port Colborne	Grain	$178.60	N/A	$20.58	N/A
Thunder Bay	Montréal	Grain	$198.42	N/A	$35.10	N/A
Thunder Bay	Québec	Grain	$222.38	$21.38	$32.94	N/A
Vancouver	Toronto	Containers	$227.02	$63.86	N/A	N/A
Vancouver	Toronto	Marine containers	$230.63	$70.01	N/A	N/A
Saskatoon	North Vancouver	Grain	$239.38	$27.65	N/AP.	N/A
Hamilton	Vancouver	General Cargo	$255.21	N/A	N/A	$2,560.46

Table 3-18 Full Cost Comparisons of Freight Modes for Selected Origin-Destination Pairs ($ per tonne)

FREIGHT			Full Costs per Tonne			
Origin	Destination		Truck	Rail	Marine	Air
Trois-Rivières	Delson	Lumber	$19.05	N/A	N/AP.	N/AP.
St-Romuald	Montréal	Petroleum products	$31.80	$6.82	N/A	N/A
Vancouver	Victoria	General Cargo	$24.44	N/AP.	N/A	$303.70
Montréal	Toronto	Expressway	$33.16	$15.52	N/A	N/A
Montréal	Toronto	Marine containers	$34.44	$10.26	N/A	N/A
Hamilton	Montreal	General Cargo	$36.07	N/A	N/A	$824.29
Windsor	Toronto	Salt	$41.61	$10.23	$11.55	N/A
Moncton	Montreal	General Cargo	$64.56	N/A	N/A	$865.35
Montreal	Detroit	Marine containers	$52.00	$23.76	N/A	N/A
Moncton	Toronto	Containers	$119.07	$29.72	N/A	N/A
Halifax	Toronto	Containers	$135.08	$25.97	N/A	N/A
Hamilton	Winnipeg	General Cargo	$130.57	N/A	N/A	$1,420.68
Brandon	Thunder Bay	Grain	$131.50	$14.78	N/AP.	N/A
Prince-George	Vancouver	Lumber	$161.51	N/A	N/A	N/A
Thunder Bay	Port Colborne	Grain	$221.05	N/A	$21.99	N/A
Thunder Bay	Montréal	Grain	$229.24	N/A	$38.76	N/A
Thunder Bay	Québec	Grain	$283.01	$29.03	$36.81	N/A
Vancouver	Toronto	Containers	$302.51	$70.58	N/A	N/A
Vancouver	Toronto	Marine containers	$306.11	$76.73	N/A	N/A
Saskatoon	North Vancouver	Grain	$310.11	$36.06	N/AP.	N/A
Hamilton	Vancouver	General Cargo	$333.06	N/A	N/A	$2,597.31

Table 3-17 shows the estimated financial costs for specific city pairs for different modes: Trucking, Rail, Marine and Air. Trucking estimates have been generated using the Ash-Barton model built for the FCI[6] while the other mode financial cost estimates have been generated in different studies[7].

3.5 Full Cost Estimates of Transportation - Sensitivity Analysis

The different methodologies that, together, make up the approach used to generate the estimated full costs of transportation, can be used to test the sensitivity of the said estimates.

3.5.1 With and Without Land

The transportation infrastructure that supports the Canadian transportation systems uses land. For the land dedicated to transportation infrastructure, in a context of the FCI project, a unit value (by square meter) across various spatial physical location of this land was developed. Such a task represented a challenge of importance.

[6] See Ash-Barton model in FCI report R12 as well as results in FCI Report R16 (see exact reference for FCI Reports in appendix A-3). Ferry cost estimates are included.
[7] See for Rail FCI Report r2, for Marine FCI Report M2 and for Air FCI Report A3.

The valuation of "transportation land" was done with the intent to develop a more comprehensive analysis of the full costs of transportation. For many, "transportation land" is considered a sunk cost and should be ignored in economic analysis. This reflects the conventional treatment of publicly owned land where it is not included in public transportation agency financial accounts. This would not be the case in relation to a project requiring the acquisition of land. Economists argue that "transportation land" has an opportunity cost and its value should be considered in economic analysis. Land used by transportation infrastructure could have been used for alternative purpose and this represents therefore an opportunity cost for society. If a given land access level could be obtained by using less land, this would reduce transportation cost. Another argument often used when it comes to putting a value to "transportation land", is the strong correlation between access and value of a piece of land: transportation infrastructure proximity increases both. Given that the relative use of land by the different modes of transportation varies, not considering the value of "transportation land" may lead to different decisions than with it. Canada has a low density of population, but it is a highly urbanized population. Land value is more significant in urban areas and a lot of travel activity takes place in urban setting.

The opportunity cost of land used by transportation infrastructure was estimated and added as a stand-alone cost element in the FCI estimates. Because it is a stand-alone cost element, it is possible to develop financial cost estimates for each mode with and without a value of the land used by each mode.

3.5.2 Social Opportunity Cost of Capital

Transportation is a sector like many others that uses physical capital assets. Without capital assets, transportation activities would not be possible. Transportation investment decisions tied to physical capital assets are made by both the public and private sectors as both are involved in the transportation sector. The opportunity cost of capital is one of the factors considered in transportation investment decisions. Different methodologies can be used to measure this opportunity cost of capital and they have been and continue to be the subject of much discussion and debate.

The FCI did not attempt to solve the conceptual and empirical questions related to the cost of capital. The decision on the conceptual and practical approach to use for the establishment of capital charges was related back to the objective of measuring the full societal costs of transportation activities under the FCI project. This meant coming up with an estimate of the sacrifices society as a whole makes in freeing up resources for the investment needed to sustain Canada's transportation system. Such an estimate is based on the calculated risk-adjusted social opportunity cost of capital (SOCC). Such a social discount rate approach is defensible for estimating the sacrifices associated with transportation investment. It is adjusted up or down to take into account the different degrees of systematic risk associated with different transport assets. Using a reasonable range of savings retention coefficient and a real pre-tax private investment return between 8 per cent and 10 per cent result in an estimated range for the SOCC between 6.5 per cent and 8.7 per cent. A value of 7.3 per cent for the SOCC was used, derived from a reasonable mid-range saving retention coefficient and a 9 per cent pre-tax return on investment as well as an assumed breakdown of the required resources for transportation investment of 50 per cent from displaced private investment, 10 per cent from displaced private consumption and 40 per cent from foreign sources. A risk adjustment to this SOCC gave a range of 6.0 per cent to 8.6 per cent to conduct a sensitivity analysis around the SOCC[8].

3.5.3 Other Variables Used to Conduct Sensitivity Analysis

Police forces used to enforce road regulations and to take care of road accidents were difficult to estimate. From an initial percentage range of between 10 per cent and 60 per cent of the total police force costs to be allocated to police road-related interventions (e.g., road regulation enforcement and road accident investigations), the range was narrowed to between 10 per cent and 20 per cent following the result of a survey of municipalities conducted in 2006. Adding/subtracting a share of 10-percentage points of the total police force costs to the enforcement of road regulations add/subtract an annual sum of $ 610 million to the said road costs elements.

A sensitivity analysis using a range of estimates was also conducted around social cost elements. Human consequences of transportation accidents and of air pollution were monetized using a range of values for a (statistical) life. The low value of a (statistical) life used was $ 3.05 million, while the high value used was $ 5.05 million, with a mid-range value of $ 4.05 million. Other human consequences of transportation accidents were also scaled according to a comparable proportional range (see Table 3-19). For greenhouse gas emissions, the value used per tonne of CO_2 equivalent ranged between $ 18.67 and $ 37.38 per tonne of CO_2, with a mid value of $ 29.03. Road congestion thresholds were used to start to associate delays to a congestion situation. The high end of the congestion delay estimate was associated to an observed travel speed of 50 per cent or less of the free flow of traffic, i.e., the maximum speed allowed on the road. At the other extreme of the estimated range of the congestion delay was a travel speed of 70 per cent or less of the free flow of traffic, while a 60 per cent threshold was used for the mid scenario of the congestion cost estimates.

The sensitivity analysis has been applied by generating a set of results with the low cost estimates and the high cost estimates. Clearly, besides the parameters identified around which the sensitivity analysis was structured, there are other potential sources of variance of the FCI estimates and, depending on the use to be made of the FCI estimates, they should be considered as well. For instance, in passenger transportation activities, the passenger occupancy ratio in transportation vehicles, and empty-haul return trip for freight movements should receive proper attention in modal comparison applications of the FCI estimates. Within the same category of vehicles (e.g., light road vehicle), variances have also been noted that may in some case impact on the relative importance of unit cost differences observed among modes.

[8] A more comprehensive discussion is available in Brean et al. (2005) FCI Report T4.

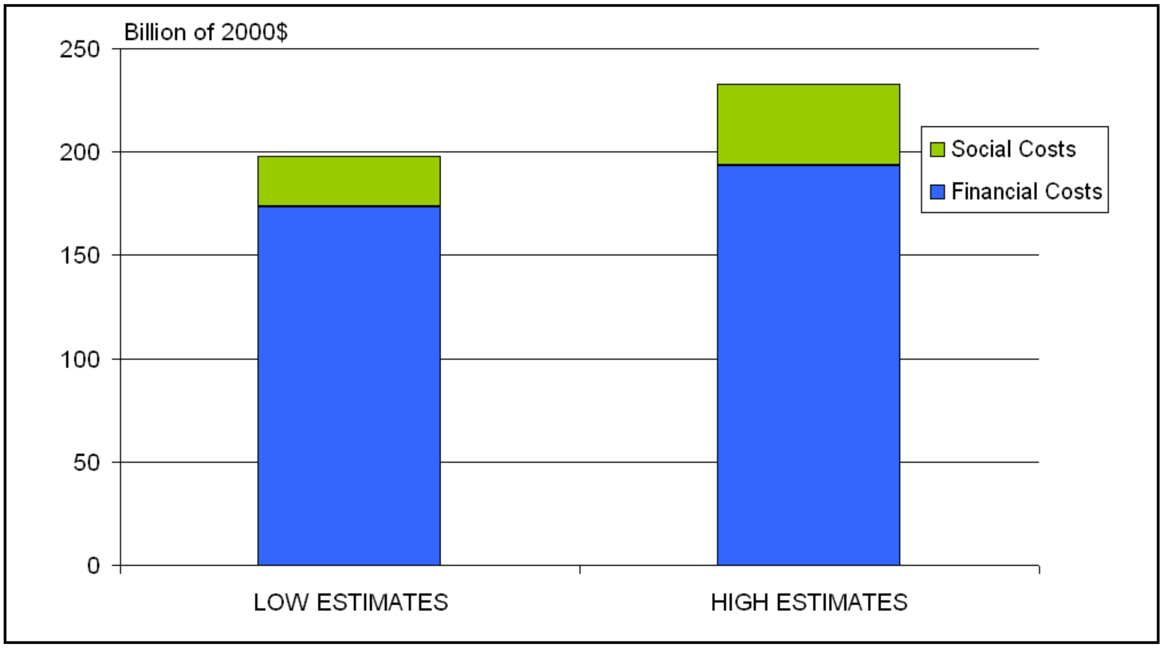
Table 3-19 Values of Human Consequences for FCI Estimates (2000 $)[9]

		Disability		Non-disabling injury		
	Fatal	Total	Partial	Major	Minor	Minimal
Base case	4,050,000	259,627	129,813	23,275	4,674	249
Low Scenario	3,050,000	195,521	97,761	17,528	3,520	188
High Scenario	5,050,000	323,732	161,866	29,022	5,828	311

Source: TNS Findings January 11, 2007

3.5.4 FCI Estimates and Sensitivity Analysis

Figure 3-1 Overview of the sensitivity analysis applied to the estimates of the Full Costs of transportation.



[9] The FCI Task Force decided to use the same set of values for human consequences of transportation accidents across the whole country. See for instance FCI Report T8.

Table 3-20 Financial Cost Estimates by Major Mode– Low Estimates (Billion of 2000 $)

	Infrastructure			Vehicle & Carrier	Minus User charges[1]	Sector Total
Mode	**Capital**	**Operating**	**Land**			
Road	24.82	4.60	5.59	124.10	12.61	**146.50**
Rail	2.55	1.77	0.22	4.24	0.17	**8.60**
Marine	0.46	0.53	0.15	1.89	0.09	**2.78**
Air	0.86	1.37	0.14	15.03	1.76	**15.65**
Total	**28.69**	**8.26**	**6.10**	**145.26**	**14.63**	**173.53**

1) Transfers to infrastructure providers from users are separated to avoid counting them twice in the total costs of the sector.

Table 3-21 Financial Cost Estimates by Major Mode - High Estimates (Billion of 2000 $)

	Infrastructure			Vehicle & Carrier	Minus User charges[1]	Sector Total
Mode	**Capital**	**Operating**	**Land**			
Road	32.70	5.21	8.02	131.01	12.61	**164.33**
Rail	3.29	1.77	0.31	4.36	0.17	**9.56**
Marine	0.55	0.53	0.22	1.93	0.09	**3.14**
Air	1.04	1.37	0.20	15.28	1.76	**16.13**
Total	**37.59**	**8.87**	**8.75**	**152.57**	**14.63**	**193.15**

1) Transfers to infrastructure providers from users are separated to avoid counting them twice in the total costs of the sector.

Overall, the sensitivity analysis conducted around the financial cost estimates showed that the variability of the estimates to the parameters used to conduct the sensitivity analysis generated total financial cost differences of about 10 per cent between the low and the high estimates. Some elements of the financial costs showed even more variability under the sensitivity analysis conducted. The capital cost of transport infrastructure showed a difference of close to 29 per cent between the low and high estimates. At the other extreme can be found “vehicle and carrier” costs with a difference of 5 per cent between the low and the high estimates.

Table 3-22 Social Cost Estimates by Major Mode - Low Estimates (Billion of 2000 $)

Mode	Accidents	Congestion Delay	Air pollution	GHG	Noise	Total
Road	12.42	4.01	3.60	2.45	0.22	**22.70**
Rail	0.22	Not covered	0.33	0.13	0.00[1]	**0.68**
Marine	0.05	Not covered	0.40	0.16	Not covered	**0.61**
Air	0.07	Not covered	0.02	0.31	0.03	**0.45**
Total	**12.76**	**4.01**	**4.35**	**3.06**	**0.26**	**24.44**

Note: (1) rail noise costs were estimated to be less than $5 million

Table 3-23 Social Cost by Major Mode - High Estimates (Billion of 2000 $)

Mode	Accidents	Congestion Delay	Air pollution	GHG	Noise	Total
Road	19.19	6.31	5.83	4.90	0.22	**36.46**
Rail	0.37	Not covered	0.56	0.25	0.00[1]	**1.18**
Marine	0.08	Not covered	0.67	0.32	Not covered	**1.07**
Air	0.12	Not covered	0.04	0.63	0.03	**0.82**
Total	**19.76**	**6.31**	**7.10**	**6.10**	**0.26**	**39.53**

Note: (1) rail noise costs were estimated to be less than $5 million

Overall, the sensitivity analysis conducted around the social cost estimates showed a greater degree of variability than the one observed with the financial cost estimates - a difference of more than 60 per cent between the low and the high estimates. The highest difference in percentage appears to be for the greenhouse gas emission costs where the high estimates are twice the low estimates. This reflects the level of uncertainty still prevailing around the impacts caused by GHG emissions. One would note thought that the absence of a variance for the noise-related costs does not mean that there is no uncertainty regarding these estimates. On the contrary, the level of uncertainty is high with this social cost element but coming up with parameters to conduct a sensitivity analysis around the estimates of the noise costs would not have been based on rigorous enough grounds. However, the noise-related total costs have been estimated under a very conservative approach to reflect the grounds that could be used to establish it. The noise cost estimates are low and have less of an impact on an overall sensitivity analysis for the total social costs.

Table 3-24 Results of the Full Cost Estimates Sensitivity Analysis by Major Mode (Billion of 2000 $)

	Low Estimates			High Estimates		
Mode	Financial Costs	Social Costs	Full Costs	Financial Costs	Social Costs	Full Costs
Road[1]	146.50	22.70	169.20	164.33	36.46	200.78
Rail	8.60	0.68	9.28	9.56	1.18	10.73
Marine[2]	2.78	0.61	3.39	3.14	1.07	4.21
Air	15.65	0.45	16.09	16.13	0.82	16.96
Total	**173.53**	**24.44**	**197.97**	**193.15**	**39.53**	**232.68**

1) Including paved road dust PM 2.5, see FCI Report T9 for more details.
2) Partial coverage

Financial costs increase mainly because the social opportunity cost of capital rate is 8.6 per cent with the high scenario instead of 6 per cent for the low scenario. Social cost differences are driven more by the unit cost used for the value of a statistical life (a range between $3.05 and $5.05 million) and the range of values used for the cost of a tonne of CO_2 equivalent.

3.5.5 Light Road Vehicles and Sensitivity of Cost Estimates

In the case of light road vehicles, the financial cost sensitivity was tested with respect to vehicle class and vehicle vintage for low and high estimates. The cost per kilometre differs by vehicle size, and the intensity of use varies by vehicle class. For example, the cost per kilometre of a compact car is about **two thirds** of the cost per kilometre of a SUV vehicle, yet SUVs, on average, are driven more intensively.

Table 3-25 Sensitivity Analysis for Light Road Vehicles Cost, by Vehicle Class

Vehicle Class	Average Km per vehicle	Low Estimates		High Estimates	
		Annual Cost per Vehicle	Average Cost per km	Annual Cost per Vehicle	Average Cost per km
Two-seaters	14,150	3,707	0.25	3,906	0.26
Subcompact	16,651	4,025	0.23	4,190	0.24
Compact	17,101	4,217	**0.24**	4,403	0.25
Midsize	16,523	4,575	0.26	4,790	0.28
Full size	16,311	5,084	0.30	5,321	0.31
Station wagon	15,625	3,912	0.25	4,051	0.26
Minivan	20,484	6,290	0.30	6,626	0.32
Passenger Van	18,838	5,792	0.31	5,983	0.32
Cargo van	18,250	4,852	0.26	5,038	0.27
SUVs	20,033	7,589	**0.37**	7,975	0.38
Pickups	18,112	5,388	0.30	5,612	0.31
Weighted average	17,562	4,944	0.27	5,166	0.28

It is important to note that the number of passenger(s) within a vehicle does have a significant impact on the costs related to the use of the vehicle per passenger-km.

Costs per kilometre and costs per vehicle are particularly sensitive to vehicle vintage. As the vehicle age increases, both the costs per kilometre, and costs per vehicle drop considerably, a decrease in costs driven by a decrease in depreciation and in other fixed costs that more than offset the increase in fuel and other operating costs.

Table 3-26 Sensitivity Analysis for Light Road Vehicle Costs, by Vehicle Vintage Classes

Vehicle Vintage (Years)	Average Km per vehicle	Low Estimates		High Estimates	
		Cost per Vehicle	Cost per km	Cost per Vehicle	Cost per km
0 to 2	23,130	7,831	0.34	8,360	0.36
3 to 5	21,547	6,538	0.30	6,854	0.32
6 to 8	18,592	4,895	0.26	5,059	0.27
9 to 11	14,623	3,509	0.24	3,607	0.25
12 to 14	12,839	2,920	0.23	2,977	0.23
15+	9,545	2,066	0.22	2,103	0.23
Weighted average	17,562	4,944	0.27	5,166	0.28

4 International Comparisons

Every country has somewhat unique transportation needs and challenges, dictated by the nature and type of economic activities, its own geography and topography and its size. The FCI estimates for the Canadian transportation system represent one of the first social cost estimates for Canada[10] but similar projects have been done in other countries. This section provides a short comparison analysis with similar studies done elsewhere. The focus of the comparison is on social costs of transportation only. Social costs have been at the centre of some recent analytical work by foreign public authorities and international organizations. Clearly, the methodologies used to generate estimates of social costs can differ and the differences can be significant. A comparison of the FCI social cost estimates with the ones tabulated in other countries does have some limitations due to methodological differences. To be truly comprehensive, a review of foreign studies would compare methodologies, explain the differences observed and infer implications for the estimated social costs.

To have a sense of the relative importance of social costs, it is common practice to express them as a percentage share of a country's Gross Domestic Product (GDP). GDP is a good indicator of a country's economic activities. In 2000, Canada's GDP was about 985 billion of current dollars.

The basis for the comparison that is presented here is mainly sourced from a study by André de Palma and Néjia Zaouali ["*Monétarisation des externalités de transport: un état de l'art*" (2007-04-05)], which reviewed studies conducted in various countries. Each bar in the bar charts of this section represents a specific study or a specific country. The FCI results are presented last, on the right end of the bar charts.

4.1 ACCIDENT COSTS

The Value of a Statistical Life (VSL) is the key driver of the transportation accident costs estimated in the FCI. The willingness-to-pay method has been used to estimate that VSL and for the FCI, a range between 3.05 and 5.05 million Canadian dollars was used. Other methods, such as the willingness-to-accept or the present value of future earnings, could have been used and would have generated a different value, either higher or lower. INFRAS used 1.5 million € (approximately 2.14 million Canadian dollars) as a VSL for Western Europe in its March 2004 study[11].

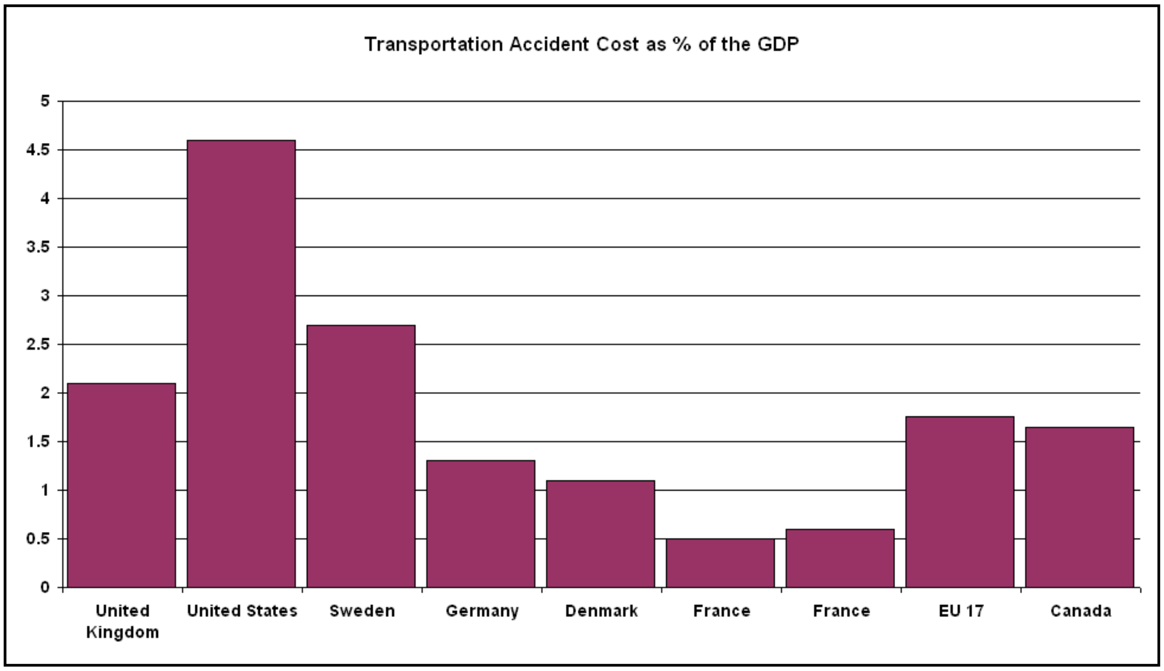
Figure 4-1 below shows the results of several studies on different countries although some studies targeted the same country (e.g., France). The high transportation accident cost in the United States can be explained in part by the higher rate of transportation accident related death observed in that country (more than 15 per 100,000 inhabitants

[10] See for instance DIRECTIONS : The Final Report of the Royal Commission on National Passenger Transportation (1992)

[11] Maibach, Markus et al. (INFRAS-IWW) External Costs of Transport: Accident, Environmental and Congestion Costs in Western Europe. Zurich & Karlsruhe, October 2004

compared to about 10 per 100,000 for Canada). Part of the relative differences across countries could be due to other methodological differences across studies (e.g., inclusion or exclusion of insurance costs).

Figure 4-1 International Comparison of Transportation Accident Costs

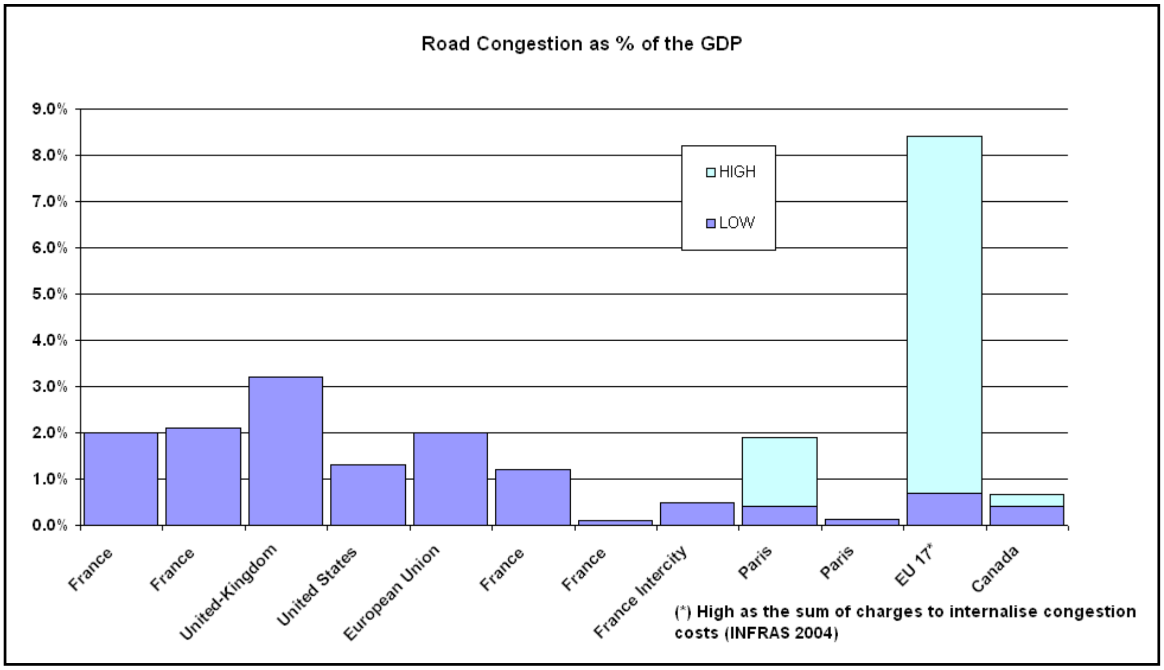


4.2 CONGESTION COSTS

Road congestion is another social cost element for which a number of methodologies are in use to generate cost estimates. That explains at least in part the differences in results for the same entity (e.g., France). As illustrated in Figure 4-2, Canada's FCI congestion cost estimates are lower than the ones generated in studies conducted in other countries.

The results labelled EU 17 that have been produced by INFRAS-IWW used a different concept for the 'high estimates'. Rather than a cost per se, the high estimate correspond to the revenues that would have been generated if road pricing were imposed in Europe to manage the congestion problem. Depending on the demand price elasticity, revenue generated estimates could be greater than the actual cost of congestion.

Figure 4-2 International Comparison of Road Congestion Costs



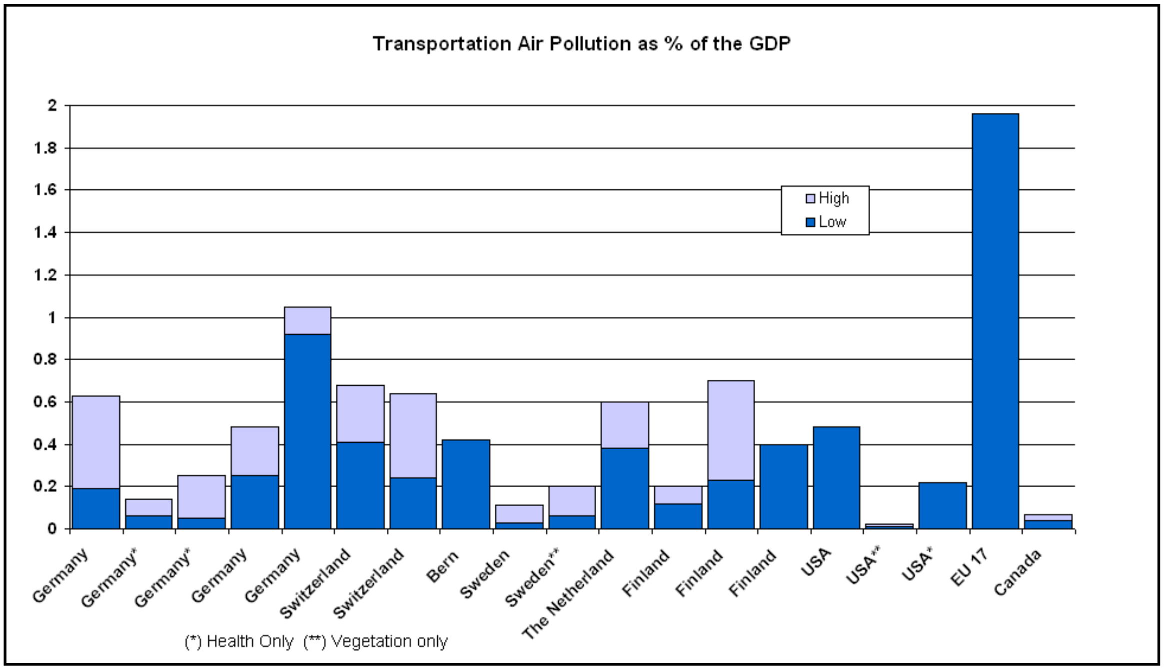
4.3 AIR POLLUTION COSTS

As it can be seen in Figure 4-3, the costs of air pollution from transportation activities, as estimated in the FCI, represent a smaller share of Canada's GDP in comparison to those developed through studies conducted for other countries. Knowing that the bulk of the costs are tied to human health degradation, the smaller size of the population that faces the consequences of lower air quality due to transportation may explain in part this difference. Given the complexity of estimating such impacts, a more in-depth comparison of the methodologies used to come up with the estimates would be needed to better understand and explain the noted differences.

It is noticeable that studies with high and low estimates have greater variability between their low and high estimates than what came out of Canada's estimates. This may be linked to a range of approaches rather than uncertainties of specific parameters.

Canada's cost estimates are more on the low side compared to most of the other studies. This could be explained in part by the lower density of the Canadian population. It could be assumed that a tonne of a pollutant affects more people where the population density is higher. One would note that average population density reaches more than 125 inhabitants per squared kilometre in Europe (EU-15 and EU-25) while it is about 3 inhabitants per squared kilometre in Canada.

Figure 4-3 International Comparison of Air Pollution Costs

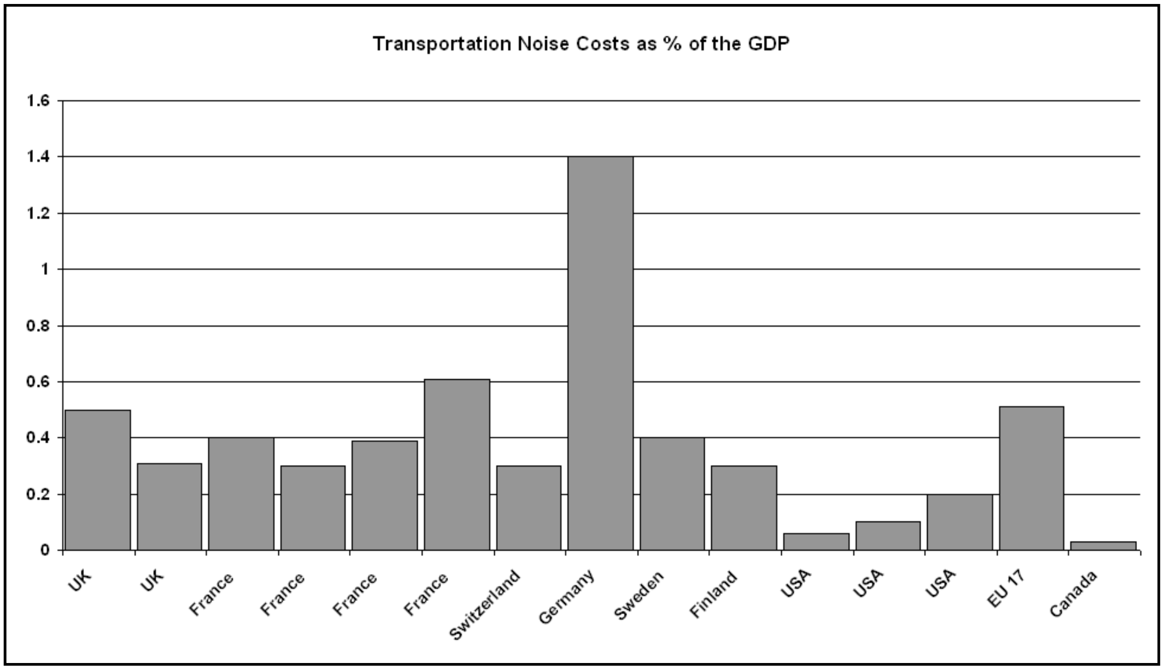


The results for climate change (not shown) are truly dependent on the unit cost ($ per tonne of CO_2 equivalent) chosen. In a recent study, INFRAS-IWW used two scenarios, the low scenario had a unit price of 20 €, the high scenario had a unit price of 140 € (seven times more). In the FCI, the range used for the unit cost of a tonne of CO_2 equivalent was less significant, with a unit cost of about 15 € for the low scenario and 30 € for the high scenario.

4.4 NOISE COSTS

There are a number of methodologies that can be used to develop estimates of transportation noise-related costs, each one possibly yielding different estimates. This can explain in part the differences observed in the relative importance of noise costs. Without getting into the methodological differences, Figure 4-4 shows a comparison of the FCI results for Canada with studies done in other countries. Canada's estimates of noise costs are much lower than those estimated for other countries. Population density differences may explain in part the observed differences. The partial coverage of the FCI noise estimates may also be another source of explaination. FCI noise estimates should be considered with caution given the early stage of the research in Canada regarding this social cost element.

Figure 4-4 International Comparison of Noise Costs



4.5 CONCLUSION OF THE INTERNATIONAL COMPARISON

Overall the social cost estimates developed in the context of the FCI, when compared with similar cost estimates in other countries, represent, generally speaking, a lower share of the country's GDP than what seems to be experienced in other countries. This does not necessarily mean that the FCI underestimated the actual social costs of transportation. More effort and time at examining the subtle differences in methodologies and approaches used throughout these studies would be needed to understand the noted differences: hence more work would be needed on the noted differences before any conclusions on the comparability of the work done in Canada to measure transportation social costs with the ones in other countries can be drawn.

Part II

SCOPE, WORK PLAN, GOVERNANCE METHODOLOGICAL DETAILS AREAS FOR IMPROVEMENTS

5 How the Work Was Conducted

The FCI project was conducted under a formal governance structure and a very "inclusive" approach. Understanding the structure and the approach under which the work was conducted is critical to develop an appreciation of the rigour and transparency with which the project was conducted from inception to closure. This section of the report describes how the analytical work of the FCI was undertaken. More specifically, it gives an overview of the work plan established for the project and the "governance" structure put in place to overlook at the work done.

5.1 WORK PLAN AND SCOPE

The complexity and challenges inherent to the project were recognized right from the outset, particularly in terms of its data requirements. The work plan, as developed, defined the objectives, the scope and the phases under which the work was to be conducted. (The approved work plan is posted on Transport Canada's website.) The **objective** of the FCI project was to develop estimates of full economic and social costs of each major transportation mode, with a differentiation of the costs between passenger and freight transportation activities and between types of vehicles or craft.

The **scope** of the project was the Canadian transportation system and covered both the commercial and private transportation infrastructure/activities. This scope was delimited largely by data access/limitation considerations. Each mode of transportation (road, rail, marine and air) presented its own data-related challenges. The scope covered for each mode is summarized below.

ROAD

For *road transportation*, initially, the intent was to estimate financial costs of all light road vehicles (defined as vehicles of less than 4.5 tonnes using the Canadian road system in the year 2000). Costs were differentiated according to 11 vehicle classes: two-seaters, sub-compact, compact, midsize, and full size cars; station wagons; minivans, passenger vans, and cargo vans; SUVs; and pickups.

The cost estimates were further differentiated by each province and two territories (for Nunavut, unit costs were estimated based on Northwest territories data); as well as by six vehicle vintage categories.

An estimate of the financial costs of U.S.-domiciled light road vehicles using the Canadian road network in the year 2000 and an estimate of the volume of activities of Canadian vehicles on the United States road network were needed to have a precise coverage of activities on the Canadian road network. It was assumed that the activities on the US road network by Canadian light road passenger vehicles were equivalent to the ones on the Canadian road network by the US light road passenger vehicles. With such an assumption, total Canadian vehicle activities were used to estimate the activities on the Canadian road network.

The operational unit cost estimates for light road vehicles did come up with an estimate related to the use of the unpaved portion of the Canadian road network.

For the FCI project, it was assumed that light road vehicle trips in excess of 25 kilometres on roads with a posted speed limit of 80 km/h or more were associated to intercity activity, while other trips were treated as local trips. Provincial allocation of light road vehicle cost was based on the province of registry of the vehicles.

For commercial road vehicles, all possible combinations of 17 power units and 21 trailer units defined the vehicle classes for which an estimate of costs per vehicle-kilometre was developed. Representative combinations were chosen for each of the four groups of trucks (i.e., straight trucks between 4.5 t and 15 t; straight trucks weighting more than 15 t; tractor and one trailer; and tractor with two trailers). For buses, five distinct categories were considered: urban transit buses; school buses; intercity-scheduled; charter; and others.

As for light road vehicles, the activities of Canadian commercial vehicles in the United States, and the activities in Canada of commercial vehicles registered in the U.S. had to be estimated. The estimates did not show a balance thus Canadian trucking activities in the USA have been deducted while US trucking activities in Canada have been added to obtain the level of activities in Canada.

The commercial road vehicle cost estimates were further refined for the same geographical regions as the ones used for light road vehicle cost estimation. Further refinements of heavy vehicle unit costs were made by distinguishing operation scenarios such as low or high annual kilometres per year, road surface type driven on, vehicle age, national domicile of carrier, trip characteristics such as average trip distance, number of trips per day, and number of working days per year.

Road infrastructure costs were estimated using a National Road Network geographic information system to match unit cost estimates for fourteen classes of road in fourteen geographic regions. Road infrastructure costs were allocated among three classes of vehicle - light vehicles; buses; and trucks -fourteen functional classes of road and by province and territory. It took into account the density of the traffic in each of these categories of road and the intensity of use.

The challenge was to have heavy road vehicle activity level measurements for each class of vehicle type. The estimate of activity level by province was generated using different sources of information (i.e., provincial International Fuel Tax Agreement databases, the 1999 National Roadside Survey and the Canadian Vehicle Survey)[12].

[12] See Transport Canada 2007 - FCI Report R16 for more details.

RAIL

For *rail transportation*, the FCI cost estimates included the Canadian operations of rail carriers in Canada, the ones of Class I rail carriers (CN, CP and Via Rail) and those of over 40 short line and regional rail carriers across the country.

The rail sector is unique in the sense that (in most cases) rail carriers own and maintain their rail infrastructure. With other modes, a clear distinction (in most cases) between owners of infrastructure and users exist.

For the purpose of calculating the capital costs, the rail assets consist of two main large asset categories: rail equipment and rail roadway and structures. The capital base was calculated using the current value of historical capital expenditures, less depreciation. The asset life used was 30 years for equipment and 50 years for roadway and structures.

Capital spending records were available for the larger railways but for other companies (non-Class I railways), some assumptions had to be made to estimate as accurately as possible their asset base in year 2000.

On the revenue side, revenues for rail transportation are (in nearly all cases) available by category thereby allowing a clear distinction between freight and passenger revenues, and other sources of revenues. Freight revenues come from services provided to shippers and clients while passenger revenues come from passenger rail services.

With a limited number of Class I rail carriers and quality data available, the task was fairly straightforward when it came to rail freight transportation. However, for the more than forty regional and short line carriers in the rail freight business, their interaction (interlining) with Class I carriers definitely added a degree of complexity to the task and made for a somewhat more challenging exercise. Provincial allocation of train costs was based on fuel consumption, while tracks location was used to allocate infrastructure and land costs.

Other railway carriers besides VIA Rail provide rail passenger services on specific intercity segments (sometimes on behalf of VIA Rail). In the case of CN and CPR passenger revenues, they come from their assets supporting the delivery of some rail passenger services that required in turn the allocation of a portion of their costs (albeit small) to the rail passenger segment of the industry. To do this allocation, the portion of costs allocated to the passenger business was assumed equivalent to the proportion of the company's passenger revenues relative to their total revenue base. It should be noted that heritage railways and seasonal/tourist operations were not within the scope of the FCI, while streetcar/tramway services and commuter rail were within that scope but were primarily dealt with in the urban transit portion of the FCI.

With respect to passenger rail infrastructure, VIA Rail owns very little of the network it operates rail passenger services having to pay CN and CPR for use of their tracks. The FCI captured these transfers as well in a way that acknowledged these as an expense for

VIA Rail and a revenue for the other two Class I carriers, to avoid the issue of double-counting.

MARINE

For *marine transportation*, the complexity of the industry added to the challenge. A large number of Canadian-based terminals and ships are owned and operated by companies whose main activities are not related to transportation. Their bookkeeping approaches favour a consolidated approach that does not permit to isolate costs and revenues by transportation assets owned and operated. There is also the challenge that many ships/vessels sailing within the Canadian waters and using the port system are foreign-flag vessels and the companies owning and operating them do not file financial data with the Canadian government.

Estimates developed in the FCI account for the St. Lawrence Seaway[13], the nineteen Canada Port Authorities[14], five major ferry operators[15], nine inland ferry services[16,17], Transport Canada's marine assets and Marine Safety programs, the four pilotage authorities[18] and the Canadian Coast Guard services[19] offered to the commercial marine industry. The coverage possible did not allow for a detailed coverage of some of these entities, nor did it allow for a comprehensive and uniform treatment of these entities. Consequently, the importance of the marine transportation sector is underestimated as no financial and operational information could be found on a large number of entities.

The scope initially envisioned for the marine sector was broader than the one that could be achieved under the FCI. The intent was to cover all water carriers (freight and passenger, domestic as well as foreign-flag carriers) sailing into Canadian waters, all commercial marine facilities (including private ports and terminals), and international movements and activities. However no detailed financial information (i.e., capital assets values, operating costs and revenues) could be found on some of these entities and could not be included under the FCI or were covered but not in as much details as required by the project. For the same reasons, international activities or movements could not be covered. Fishing, recreational (including scenic and sightseeing tours) and military activities, and related infrastructure and craft were outside the scope.

[13] Excluding the two locks located in the United States.
[14] Hamilton became a CPA in 2001 and was thus included in the computation.
[15] BC Ferries, La Société des Traversiers du Québec, Marine Atlantic, Northumberland Ferries and C.T.M.A. Traversier Ltée.
[16] Inland ferry services are intra-provincial services provided by or on behalf of provincial governments, to connect the provincial road system and carrying automotive vehicles, rail cars or goods across a river or other body of water, usually travelling back and forth on a regular schedule.
[17] Inland ferry services operated by or on behalf of the provincial governments of Alberta, British Columbia, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Saskatchewan and the Albion Ferry (Translink) in British Columbia.
[18] Atlantic pilotage authority, Laurentian pilotage authority, Great Lakes pilotage authority and Pacific pilotage authority.
[19] Icebreaking, Vessel Traffic Services and Short Range Aids to Navigation.

The coverage of the marine sector is based on publicly available financial information on the marine transport industry and infrastructure and the following statements allow a better understanding of the partial coverage of the sector:

- Canadian Port Authorities (CPAs) ports could be covered. In 2000, the tonnage handled at Canadian ports totalled 402.8 million metric tonnes, of which 56 per cent were handled at the nineteen CPAs. The remaining tonnage was handled at some of Transport Canada port facilities but mostly at other privately owned terminals and port facilities for which no financial information could be found. The estimates derived herein do not comprise the later set of facilities.

- More than 107 thousand vessel transits were recorded at Canadian ports and 4,185 through the St. Lawrence Seaway System. While on the domestic market, Canadian-registered vessels carried the bulk of the cargo loaded at Canadian ports, on the international markets, they accounted for 19 per cent of all the flows from and to Canada in 2000[20]. The lack of publicly available financial information on Canadian and foreign-flag ship operators did not allow to come up with estimates of the infrastructure and operating costs for these operators.

- Five major Canadian ferry operators were covered; they carried 28.4 million passengers and 13.9 million vehicles in 2000 (accounting for respectively 74 per cent and 69 per cent of all passengers and vehicles carried by Canadian ferry operators in 2000). Inland ferry services operated by or on behalf of provincial governments, carried approximately 8.7 million passengers and 3.5 million vehicles.

- In 2000, 790 international cruise ship dockages were recorded at Canadian ports, 47 per cent of them at ports in British Columbia. With no financial information on the operators, they could not be included in the FCI estimates.

Estimates of the capital stock and the operating costs (and revenues) on the marine sector are developed for the major transportation networks. The marine capital stock consists of building construction, engineering construction (such as wharves and berthing structures), machinery and equipment, as well as the vessels. The value of the marine capital assets has been calculated using the Perpetual Inventory Method (PIM) with the original capital assets net book values, adjusted by a conversion factor to convert original dollars into current dollars; estimated capital asset useful lives; calculated capital expenditure flows; marine assets index prices; and straight-line depreciation.

In the development of the marine capital stock, the following main fixed asset classes were used: berthing structure and dredging; boats and ships; buildings; channels, canals and locks; machinery and equipment; remedial works; road and surfaces; and wharfs and terminals.

[20] This includes the Canada-US where Canadian ships had a large market share and deep sea shipping where Canadian ships carried less than 1% of the tonnage.

The provincial allocation of the capital and operating cost (and revenue) estimates was done according to the physical location of the facilities (for ports, terminals and the Seaway); the main province of operation for multi-user services (for pilotage and Canadian Coast Guard services); or by province of origin or destination of traffic.

The national estimates developed for the marine sector have been allocated over the 10 provinces as no financial information could be found on the marine facilities and operations in the Territories. Due to data limitations, no provincial estimates could be reported for freight carriers.

AIR

For *air transportation*, the FCI work undertaken allowed to estimate the air transport costs of Canadian air carriers, Canadian airports and Nav Canada. In addition, some smaller services such as those borne by the Civil Aviation group within Transport Canada were also included. Costs related to general aviation and military air services were not included.

The asset base was calculated using the current value of historical capital expenditures, less depreciation. Depreciation was calculated using the straight-line approach, with asset lives assumed to vary according to the type of structure or asset. For most airport assets, this generally ranged from 25 to 40 years. For air navigation systems equipment, the assumed asset life was 12 years. Other asset lives (such as carrier assets, computer equipment and baggage systems) were estimated using information from individual airport authorities' financial statements, and were generally much shorter. Because the level of information available for air carriers varied greatly, it was assumed that the air carrier assets were made-up mostly of aircraft, for which a 20 year asset life was used (which presents a compromise between the 17 year asset life employed by Statistics Canada and the 20 to 25 year asset life generally used by air carriers for financial reporting purposes). Leased assets, which account for a significant proportion of aircraft, were not included in the asset base, due to the difficulty in measuring the value of leased assets. Instead, the lease expenses were included in capital costs in place of the deprecation and cost of capital of those assets. As a result, the cost of capital and depreciation rates implicitly used for these leased assets would be the rates incurred (such as the interest rate in the lease) as a result of the terms of the leases, and would not fluctuate with the FCI cost of capital rate scenarios.

Revenue figures for NAS airports were derived entirely from airport authority financial statements. A small portion (2 per cent) of both revenues and costs were removed in order to account for a portion that would be attributed to general aviation activity. For the most part, airport revenues were made up of terminal and landing fees, airport improvement fees, rentals and concessions (including parking). Air carrier revenues consisted of passenger ticket and cargo revenues. Nav Canada revenues were also obtained from their annual reports.

Funds from Nav Canada's rate stabilization account, which are recognized as revenues in the annual reports, were not included in annual revenues. This rate stabilization account is made-up of Nav Canada revenues from previous years. During years in which there is a strong demand for their services, Nav Canada contributes to the rate stabilization account. In years of soft demand, the funds from the rate stabilization account are used to ensure that Nav Canada remains in a break-even position (displacing the need to raise prices). The need for this account arises from Nav Canada's obligation to remain in a break-even but also not-for-profit position, as well as the desire for price-stability. However, because funds used from the account (a net reduction in the stabilization account) do not represent revenues collected from carriers in that year, they are not included in revenues for our purposes. Furthermore, in years where existed a net contribution to the rate stabilization account, those revenues would be included (in contrast to the treatment in Nav Canada's financial statements, where contributions to the account are not included in total revenues).

Actual revenues and operating costs of non-NAS airports, although largely not available on an individual basis, were estimated. Airports in this group handled approximately 6 to 7 per cent of annual passenger traffic over the 2000 to 2002 period. Estimates were made by applying average revenues and costs per passenger to the total passenger traffic handled by those airports. Average passenger revenues and costs from the non-NAS airports group were obtained from a study on these airports conducted by Transport Canada. The study surveyed airports in this group, which accounted for over 2 million enplaned-deplaned passengers in 2000. This provided a reasonable estimate of total revenues and operating costs of these airports on an aggregate basis.

WORK PLAN

The **work plan** adopted had broken down the work in five phases:

1. The first phase was about estimating the financial costs of infrastructure and vehicles/craft by mode of transportation at the national level.
2. The second phase was about estimating the same financial costs of infrastructure and vehicles/craft by mode of transportation but at the provincial/territorial level.
3. Under the third phase, the work to be conducted was to establish estimates of infrastructure costs by type of vehicle/craft, differentiating between passenger and freight as well as network characteristics.
4. Phase four was about estimating the social costs of the impacts of transportation service activities. The challenges under that phase had to do with the need to quantify the said impacts and to come up with a monetary valuation of the quantified impacts.
5. In the last phase of the work, the plan was to generate estimates of the full costs of transportation allowing to compare modes of transportation for activities where real modal competition can take place.

This ambitious work plan needed "data" to be implemented. It was proposed to provinces and territories. In a subsequent sub-section, the "governance" approach adopted to conduct the work will be explained in more details.

5.1.1 Data and the FCI Project

Some transportation data is filed in confidence with Transport Canada. It should be noted however that the intent was to generate estimates of the full costs of transportation and to make such estimates publicly available.

Hence, the vast majority of data used in the FCI project came from existing data and information publicly available. There were some exceptions: for instance, a survey was conducted on a sample of Canadian municipalities and some stakeholders volunteered data. The survey with municipalities was conducted by Transport Canada with the collaboration of the Federation of Canadian Municipalities to get a better understanding of municipal road funding practices as well as costs associated with municipal road policing and regulation enforcement.

The other data-related challenges of importance had to do with the scope of modal data availability in relation to the scope of the intended modal coverage of the FCI; the proposed modal comparison which had to be considered upfront in data gathering tasks; the importance of modal consistency and comparability; the use of methodology (ies) to circumvent modal data shortfalls.

5.1.2 Diversity of Expertise Needed to do the FCI

Reference has already been made to “methodologies”. Beside data, methodologies in the FCI framework were of paramount importance, and were also at the forefront of the list of challenges with such a project. Complex methodological work was required in all phases of the project.

Partnerships with other Transport Canada services and other federal departments, as well as consultations with specialists from provincial ministries were done to obtain expert advice on approaches for many of the cost estimate calculations needed in the context of the FCI.

For methodological work requiring very specific expertise, external consultants and expertise were called upon. The work carried by such parties was always conducted under the scrutiny of partner experts that steered the work contracted out (experts from within TC, other federal department(s), provincial ministries, and/or transport sectors).

All in all, the FCI sponsored a total of nineteen expert studies[21] to deal with complex methodological work in support of this investigation.

[21] The list of FCI Reports conducted in the context of the FCI can be found in Appendix A-3. All studies are posted on Transport Canada’s website and can be accessed at the following web address: www.tc.gc.ca

5.2 Governance of the FCI work - Transparency

5.2.1 FCI Federal-Provincial Task Force

Figure 5-1 presents the governance structure put in place in support of the FCI project under the leadership of Transport Canada.

The Council of Deputy Ministers Responsible for Transportation and Highway Safety (Council of DMs) adopted the project in its work plan. The Council of DMs then tasked the Policy and Planning Support Committee (PPSC), a committee of federal-provincial-territorial Assistant Deputy Ministers (ADMs), with the responsibility to overlook the FCI project. To that effect, a federal-provincial FCI task force was created, chaired by Transport Canada. The Chair of the FCI federal-provincial task force reported to PPSC and to the Council of DMs on progress achieved. PPSC authorized the public release of study reports completed and reviewed by the FCI federal-provincial task force and the organization of information sessions with stakeholders on the project.

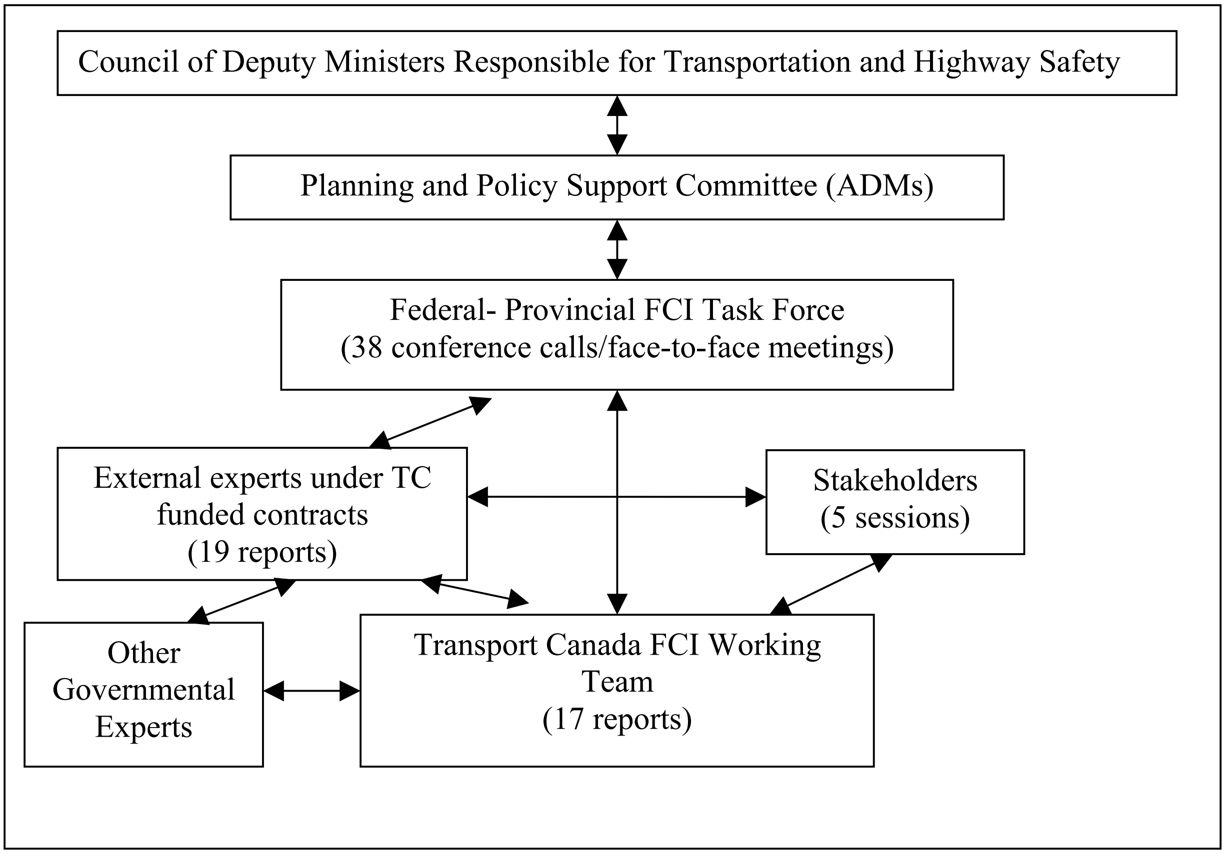
Between January 15th, 2004 and June 15th, 2007, 38 conference call/face-to-face meetings of the FCI task force took place.

With respect to the expert studies mentioned above, a steering committee was established to oversee each study done, irrespective of whether the study would be carried out by experts hired by Transport Canada or done by Transport Canada officials. The composition of such steering committees was driven by the specifics of the work to be done; it varied, as it was important to have the most appropriate 'expertise' to steer each study. On many research studies, industry was represented as well as provinces, not to mention experts from either other groups within Transport Canada or other federal departments. Steering committees overlooked at the progress of the work conducted in relation to the terms of reference approved by the FCI Task Force. The Task Force approved the final version of each study conducted, which was then submitted to PPSC's scrutiny before being released publicly.

During the course of the FCI project, five information sessions were held with industry stakeholders[22]. At these sessions, associations (e.g., transportation, labour, environmental, shipper) were presented with details and progress on the project. The sessions informed but also gave an opportunity to express views, to offer comments and suggestions. Many stakeholders took advantage of studies being posted on the web to have a closer look at details and formally bring their views and comments to the attention of the project team.

[22] The material used for these information sessions has been posted on the Transport Canada website.

Figure 5-1 Governance of the Full Cost Investigation



5.2.2 Acknowledgement of Contribution of Provincial Officials and Stakeholders

The FCI has benefited from the support and collaboration of provinces, stakeholders representing the industry (e.g. shippers, carriers, etc.) and transportation infrastructure and service providers. Their contribution to the FCI over the whole project was important and very valuable. The contribution took many different forms: provision of comments; facilitation of access to information needed for the project; active participation as a member of a steering committee formed for a specialized study conducted; participation in the validation of preliminary results; etc.

The adoption of such a governance approach for the conduct of the project allowed transparency and permitted to receive views and comments all along the duration of the project, allowing to have throughout all the phases of the work rigour at the forefront of the FCI estimates generated.

6 Details on the Full Cost Investigation Approach

This chapter of the report presents some details on the methodologies used to derive the FCI estimates presented in Part I of the report. It is an overview only. Readers are invited to consult for more information the different expert studies which were instrumental in developing the estimates. These studies are accessible on Transport Canada's website, a list of which has been appended to the report. The chapter first deals with financial costs, followed by social costs.

- ***FINANCIAL COSTS***

Financial costs consist of three sets of cost elements: physical asset costs, operating costs and the opportunity cost of land occupied by transportation infrastructure.

6.1 APPROACHES USED TO COST OUT THE USE OF TRANSPORTATION PHYSICAL ASSETS

Under the FCI project three categories of physical assets were distinguished:

1. Transportation infrastructure;
2. Transportation equipment to provide services to infrastructure users; and
3. Transportation equipment used by infrastructure users

Under the scope of the FCI project, a broad range of transportation physical assets were included: public roads and bridges; rail tracks, marshall yards, rail traffic control equipment; wharfs, ports, a portion of the Coast Guard vessels and icebreakers, navigation aids; registered airports, and NAV Canada equipment. The FCI also included private road vehicles, buses, trucks, locomotives and rail cars, ships, vessels, ferry boats and aircraft.

For physical assets that have a useful life of more than one year, there was a need to establish their annual costs through a method taking into account the year in which occurred the expenses (investment) and the actual consumption of the physical asset capital. For the FCI, the perpetual inventory method (PIM) was the method adopted to establish such annual costs. This method requires an historical time series of capital expenses, accounted for in real terms, by category of assets. The specific expected useful life of each category of assets defines the annual depreciation rate. The PIM allows to generate an estimate of the capital stock for each year.

The total annual capital costs for any given category of physical transportation asset are estimated by summing the annual depreciation of the stock of the said physical asset and the product of the Social Opportunity Cost of Capital (SOCC) rate applied to the capital stock obtained through the PIM approach.

One of the challenges associated with this approach is the availability of time series information on annual expenses over a period of time long enough to cover the life of all assets. Moreover, for assets with a long life expectancy, relevant price indices need to be applied to obtain a real term capital stock measurement for each capital asset with a specific and different useful life.

The PIM approach could not be applied to all physical transportation assets within the scope of the FCI project. Most of the exceptions came from data availability issues that imposed the use of an alternative (but as much as possible equivalent) approach. The transportation physical assets for which the PIM approach could not be used are listed below.

Railways infrastructure: rail capital expenses time series information was available starting with the year 1986. However, an estimate of the initial value of the rail capital stock in 1986 could be derived from a previous Transport Canada rail study. If depreciation rates used prior to 1986 were greater (lower) than the one used under the PIM approach, this would lead to an underestimation (overestimation) of the capital costs in the year 2000.

Road infrastructure: capital expenses were not available by functional class of roads. Hence, an approach equivalent to the PIM had to be applied. The Equivalent Uniform Annual Cost (EUAC)[23] approach on a sixty-year time period was applied to the following level of detail/distinction:

1. 14 regions – all 10 provinces, one combined "territory"; Quebec, Ontario and British Columbia each subdivided in 2 regions.
2. Provincial versus municipal ownership of roads;
3. Urban versus rural design of roads; and
4. Four functional classes of roads: freeway, arterial, collector and local.

The resulting estimates of a unit cost per kilometre of lane formed a 196-cell matrix. Each cell of the matrix corresponds to a specific unit cost. This unit cost was then multiplied by its corresponding road length estimates established by Transport Canada from the national road network[24] to generate the estimated annual cost per functional class of road.

Light road vehicles: capital costs of light road vehicles were estimated[25] according to the following level of detail/differentiation:

1. 12 regions; (10 provinces, Yukon and Northwest Territories)
2. 11 classes of light road vehicles;
3. 1 or 4 models in each class of light road vehicles; and
4. 6 age groups of the light road vehicles in the fleet.

[23] See: Applied Research Associates, 2008 – FCI Report R8.
[24] See: Paolo Mazza, 2006 – FCI Report T11.
[25] See: Barton et al. (2006a) – FCI Report R9.

This yielded a matrix with 2,112 unit cost cells. The "red book[26]" was used to calculate the capital stock and the annual depreciation. The total costs of operating the light road vehicle fleet could be established by using these unit costs and applying to them the intensity of use derived from the data of the Canadian Vehicle Survey[27].

Commercial road vehicles: capital costs were estimated[28] at the following level of detail, according to the following distinction:

1. 12 regions; (10 provinces, Yukon and Northwest Territories)
2. 17 types of power units (i.e., 5 types of buses, 3 types of tractors and 9 types of straight trucks);
3. 21 types of trailers; and
4. 4 age groups.

The total cost estimates for commercial road vehicles were arrived at by multiplying each unit cost cell generated and an estimated specific activity level, and then summing everything up.

6.2 VEHICLE/CARRIER OPERATING COSTS

Annual reports of carriers as well as Statistics Canada's financial expenditure information on Canadian transportation firms were the basic data sources used to generate the operating cost estimates for carriers in the air and rail modes.

For ferry services, the financial information was retrieved from corporate annual reports, public accounts or was provided by provinces.

For marine transportation, almost all of Canada's international shipping service needs are handled by foreign firms and they do not have to report financial information on their operations to/from Canada.

Attempts to obtain the proper coverage of financial information needed for the FCI project from marine carriers proved to be unsuccessful. Consequently, the scope of the coverage of the marine transportation mode was limited to a sample of 17 filing Canadian marine freight carriers and the operating expenses coverage of this mode was only partial, limiting the use of FCI estimates for this mode.

Private road vehicles are important both in terms of its relative importance in the total road vehicle fleet but also in the total volume of activity on the country's road network. For road vehicles, unit cost estimates had to be combined with information on activity (measured in vehicle-kilometre traveled (VKT) per year). The Canadian Vehicle Survey database as well as the National Roadside Survey database of 1999 were the two main

[26] The red book presents each month a range of estimated market values for used light vehicles in Canada by model and vintage url: http://www.canadianredbook.com/default2.asp .
[27] See Transport Canada (2007) – FCI Report R14.
[28] Barton et al. (2006b) – FCI Report R12.

data sources used for generating activity level measurements needed to generate the operating cost estimates[29].

6.3 COST OF LAND USED BY TRANSPORTATION INFRASTRUCTURE

A geographic information system approach was adopted to arrive at an estimate of the opportunity cost of land occupied by transportation infrastructure in Canada. Unit costs of land were measured in dollar per square metre and were estimated by Census division area based on their use (farm, industrial, commercial and residential)[30]. Transport Canada calculated and mapped the surface occupied by the road network including the right-of-way; by the rail network including the right-of-way and marshall yards; by airports and by Canada Port Authorities. From the mapped surface occupied, it was possible to calculate the surface occupied with a clear distinction of the “use” of the areas where the land was physically located. This physical location determined the “dollar per square meter” of the land occupied from which the cost of land occupied by transportation infrastructure could be derived.

For sake of consistency among modes, the same approach has been applied to generate the estimates of the opportunity cost of land to all modes without taking into account the probability of using the land for an alternative purpose. In some cases, the legal status of a given piece of land would prevent an alternative use for a century making the hypothetical alternative use actually impossible. The calculated opportunity cost of land may not be suitable for the determination of a charge for the use of the land due to legal restrictions placed on the current use of the land. However, the presence of a legal restriction does not itself eliminate the economic cost of the land use, rather, it may only impact the decision of who ought to absorb that cost. In other cases, the reduction of access of changing the purpose of a land occupied by a transportation infrastructure would be such that the probability of changing the purpose of the land would be almost zero. Hence, the interpretation of the cost estimated herein should be limited to the Full Cost Investigation context.

6.3.1 Opportunity Cost and the Value of Land in the Full-Cost Investigation

The concept of opportunity cost and its application to the cost of land in the FCI project is tied to one of the key goals of the project, i.e., to determine the full financial costs, regardless of whether or not a monetary transaction takes place.

A significant portion of land is used by transportation infrastructure. However, land may not always have an original cost[31]. Furthermore, land very seldom depreciates, having a tendency instead to appreciate over time, due to the increase in demand and its fixed supply (even in instances where land does depreciate in value, for reasons of decreased demand, regulatory factors, rather than a loss in efficiency or service life as for

[29] Transport Canada (2007) – FCI Report R16
[30] Woudsma (2006) – FCI Report T6.
[31] While there have been cash transactions for the purpose of transferring ownership of the land from one party to another, there was actually no cost of ‘building’ the land in the first place.

technical/physical capital assets). However, this does not mean that there is no cost associated with the use of the land. An opportunity cost of using land exists, if there is a possible alternative use of this land.

Without making a judgment concerning who should be deriving the benefits or bearing the costs of the land use, this value is considered by some as a cost of production in the foregone opportunity of its use, costs that have resulted from the efforts of human beings. This distinction leads to the question of who should bear the rewards of the increased land value.

Some view land as a form of capital when considering the individual, but not to society as a whole.[32] Others maintain that the attempt to distinguish land from other forms of property is futile.[33]

There is an efficiency loss arising when the opportunity cost of land is not included, since land may have various alternate uses. When land or other capital is not apportioned properly, a smaller income results.[34]

In the literature, arguments are found supporting either the inclusion or the exclusion of the opportunity cost of land within a FCI framework. This is a somewhat distinct question from the issue of who should capture the returns to the land. If the cost of land is ignored, it is possible that an efficiency loss would occur in the form of a reduction of total welfare (or forgone opportunity of increased welfare), as the land may not be employed in its most productive use (and those who are willing to pay the most in order to use the land would not be guaranteed this use). When it comes to transportation, ignoring the cost of land introduces a bias against the modes that use land less intensively or will discourage a more efficient land use in general (an argument that does have some practical and real limits). This opportunity cost would be prevalent regardless of the outcome or judgment on who should derive the benefits of the profits resulting from the employment of land, whether it is the land-owner, the consumer of the resulting products or society as a whole.

The sensitivity analysis around the value of land allows for a better understanding of the importance of land in the full costs of transportation. The opportunity cost of land was determined by using a percentage (actually a range of 6 to 8.6 per cent, the SOCC rate) applied to the current (net) value of assets tied up by transportation activities. The current value is determined by the lesser of the net replacement cost or the discounted present value of expected future cash flows from the assets. The former measure has not been used in the FCI because if the latter figure was lower, it would imply a non-viable asset, creating another type of methodological issue. Note that because it is the current value with which the project is concerned, the original investment values were of no relevance, as the intent was to arrive at a reasonable estimate of what the current value would be.

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[32] Francis Edgeworth (1925), collected Papers Relating to the Political Economy.
[33] American Journal of Economics and Sociology (Dec. 2002), *Land as a factor of production*, p. 2.
[34] Clark, Chapter XXII.14

Land has some unique features that must be accounted for. Land cannot be reproduced in the same way other assets can. For land, the discounted present value of expected future cash flows becomes the base estimate. Land does not depreciate. Therefore the cash flows are perpetual and it is therefore possible to use the simple annuity formula[35] (when real expected cash flows are constant and payments are infinite) in order to determine the current value of land.

Technically, the cash flows would not be constant from year-to-year. If cash flows are growing at a rate close to the general rate of inflation, then the use of a real discount rate (as it is the case with the FCI since assets are valued at replacement cost) implies that factoring growth would not be necessary.

The expected cash flows and cost of capital would be determined by the best alternative use of land. If the current use cannot generate a return equal to its cost of capital on a given value of land, there is a misallocation of resources. If the current use is returning something more than its cost of capital, that value determined by the alternative use generates an economic surplus. Note that if one use of land is subject to a lower cost of capital than another, perhaps due to greater certainty of cash flows, then it could result in a higher value of land despite yielding smaller expected cash flows. In order to arrive at the actual land value estimates, data based upon market values of land were collected and used to arrive at the estimates presented in the Woudsma's study.

This valuation assumes that the land can be employed in an alternative use at the immediate cessation of the current activity. For example, land used today for an airport can be made available for residential occupation tomorrow. Clearly significant investments and time would be required to convert the land to alternate uses.

What is required to remove the current infrastructure and redevelop the land was substantiated from Woudsma's estimates in order to arrive at a net value of land in its alternative use.

Furthermore, it was necessary to account for the period over which the land would not generate any returns because it would be tied up in the redevelopment activity.

It was this net value that needed to be considered in the land value base used for the opportunity cost of the current transportation use of the land. It is very sensitive to the estimates used for the redevelopment costs and lag period. Doing such calculations within the time frame under which the FCI estimates had to be developed was unrealistic. Rather, a systematic method of discounting the gross values was employed in order to provide a reasonable estimation. A discount factor of 20 per cent for the gross urban land value estimate, 33 per cent for the gross value for land intended for industrial use, and of 50 per cent for the gross value for farmland were recommended[36] and used.

[35] This formula is used in order to discount constant future cash flows to a present value.
[36] Hirshhorn (2003) – FCI Report T1.

Woudsma's land value estimates are based on three categories of land: rural, urban and Census Metropolitan Area (CMA). Rural land was subjected to the farmland discount. Urban land was based upon residential land value estimates and was subjected to the residential discount factor. The CMA land category was based on a mix of urban, commercial and industrial uses, and a discount factor reflecting a weighted average of the three discount factors was used. For commercial land uses, it was assumed that development costs would fall somewhere between residential and industrial uses and a discount factor of 25 per cent of the gross value was used.

If the net current value of land increases due to an increase in the cost of replacing it, this is measured as an increase in the opportunity cost, rather than some form of supranormal profits.

Using an opportunity cost of land is more consistent with the core methodologies adopted under the FCI project. A point not discussed yet in favour of not considering the value of land in the FCI is the strong interaction between the presence of transportation infrastructure, the pending increased access to land and the resulting higher value of land in general. However, this is a reality observed also with most fixed technical capital, such as office building, other commercial development such as retail space, public infrastructure or residential housing: they all have a positive effect on land values.

Evaluating land based on a scenario calling for the removal of all transportation infrastructure is not an option as the value of land would come down significantly. The approach needed to be one measuring the value of land as reflected by marginal or incremental changes.

Finally, land used by one type of transportation infrastructure could be used for another type of transportation infrastructure. For example, the best alternative use of some portions of land occupied by road infrastructure could be in the form of light rail, which would preserve access to the surrounding land.

It was determined based on expert views and views of those that contributed to the discussion that the FCI estimates should include the cost of land to be methodologically consistent. While land is unique in that it does not depreciate and therefore does not have to be replaced, in terms of the actual opportunity cost there is little need to distinguish it from technical capital within the FCI.

- ***SOCIAL COSTS***

6.4 THE SOCIAL COST CONCEPT

When it comes to transportation, social costs refer to the costs imposed on society from transportation activities; costs that are not however the object of direct financial transactions. For instance, if the health impact on individuals affected by air pollution caused by transportation are not factored in the costs of transportation service providers, then society, somehow, must absorb the said costs. So such costs would be a "social" cost. The general approach is to quantify the impacts of transportation activities, monetize them and finally allocate these costs to the sub-activities of transportation responsible for them.

Under the FCI project, five social costs were considered: accidents; road congestion; air pollution; greenhouse gas emissions (climate change); and noise. An overview of how the five social cost category estimates have been generated follows.

6.4.1 Accident-Related Costs

To estimate and then allocate accident costs, a multi-step approach was applied. In order to quantify and monetize the cost elements associated to accidents for all transportation modes, results from a joint study by the Ministry of Transportation of Ontario (MTO) and Transport Canada (TC), were used as a basis for the calculations. To generate the final estimates, the following steps were undertaken:

1. The first step was to gather the quantitative raw data on the number of casualties and fatalities in road, rail, air and marine modes of transportation as well as on property damages caused by modal accidents in the year 2000.
2. The second step involved the development of monetary unit values to be applied to accidents with a differentiation between values associated to human deaths, human injuries, and property damage.
3. Under the third step, the adjusted quantities obtained in step 1 for the road mode were combined with the respective monetary unit values developed under step 2 in order to estimate the total costs associated with road accidents.
4. The fourth step involved the calculation of the average unit costs for road accidents by elements such as death, major injury, minor injury and so on. Table 3-19 in Section 3.5.3 reported on the values of a statistical life used in the FCI as well as on the values of injuries ensuing from accidents. The costs related to accidents with human consequences represents the major part of these average costs. These average unit costs include cost items such as ambulance transportation, first aid, hospitalization and so on.
5. The relevant road accident average costs obtained from step 4, combined with the quantitative information on accidents in other modes gathered in step 1, were used to calculate the gross total accident costs for the rail, air, and marine modes.
6. The last step was the allocation of the modal accident costs by province and by sub-modal activity (e.g., freight vs. passenger). For road accidents, for example, the potential 127 combinations for seven groups of road users[37] were taken into account for the allocation of road accident cost estimates out of the number of vehicles involved in each combination by province and three levels of accident seriousness (fatal, with injuries, property damage only)[38].

[37] The seven type of road users are: pedestrians and bicycles; light duty vehicles; freight vehicles; school buses; urban transit vehicles; intercity buses; and others (excluded from the FCI). See FCI Report T8 as listed in Appendix A-3 for details.

[38] Deaths of intrusive have all been allocated to rail while it could be argued that some of these deaths should have been allocated to other cause than transportation. If only 50% of these deaths would be

6.4.2 Congestion-Related Costs

A research conducted for the FCI has estimated the costs of non-recurrent congestion in Canada's nine largest metropolitan areas[39]. The methodology used built upon the one used in an earlier Transport Canada study on *The Costs of Urban Congestion in Canada* that had focussed on recurrent congestion. A modified version of the Buffer Index, a methodology used to measure travel time reliability, was applied to the average peak hour volumes and speeds as modeled for the various urban areas. The "Buffer Index" is using historical data of travel times for a particular route. The "buffer" time is the extra time needed to arrive on schedule for 95 per cent of travellers' trips. The Buffer Index calls for the use of vehicle-kilometres travelled to weigh the travel time but speeds were used to weigh travel times. The Buffer Index approach was used for two reasons: a literature review demonstrated its extensive use allowing for comparisons with similar work elsewhere, and it can be applied to model-based estimates of traffic volume and speeds. Using travel time data provided by some of the urban authorities, the consultant developed average Modified Buffer Index values (a simple average of 127 per cent for expressways and 134 per cent for arterials) from which, estimates of the costs of non-recurrent congestion were developed for the nine urban areas, for the three impacts calculated in *The Costs of Urban Congestion in Canada* study: delay, wasted fuel and greenhouse gas emissions. Note that only delay costs were retained for the FCI since the other cost elements related to congestion and affecting commercial road transport activities (e.g. additional hours of work paid to truck drivers) were already accounted for in the financial and social costs (but could not be isolated).

The key findings related to congestion are as follows:

- Non-recurrent and recurrent costs are approximately equal, with the non-recurrent costs representing 51 per cent at a threshold travel speed 50 per cent or less of the free flow traffic and recurrent costs representing 53 per cent at a threshold travel speed 70 per cent or less of free flow traffic. In other words, it is important to cost out both recurrent and non-recurrent congestion.
- The total costs of delay ranged from $4.4 billion, at the 50 per cent threshold, to $6.7 billion annually (70 per cent). These costs must be considered as conservative estimates of the costs of congestion.

Finally, although the modified Buffer Index is a suitable approach, it is important to note that further research is required in order to develop a methodology applicable to existing engineering and modeling tools of road traffic.

allocated to rail, that would reduce the social cost of that mode between $ 83 million and $ 137 million depending on the scenario.

[39] iTRANS (2006) – FCI Report R13.

6.4.3 GHG Emission Costs

A methodology was also required to assess the costs of greenhouse gas emissions (GHG) associated from transportation activities. GHG emissions data came from the Office of Energy Efficiency of Natural Resources Canada and were converted in tonnes of CO_2 equivalent. In the context of the FCI, GHG emissions needed to be converted into "costs" and there is more than one way of doing this: an approach based on abatement costs, one using carbon prices on carbon markets. The latter was adopted for the FCI[40].

Since Canada does not have a formal carbon market, the unit price of carbon on the *European Carbon Exchange*[41] was used to assess the unit value of a tonne of GHG emissions (CO_2 equivalent) from transportation activities in Canada. Such a unit value would correspond to the marginal unit cost of a tonne of CO_2 under a target of emission reductions equal to the optimal level of emissions, i.e., the global marginal damage per tonne of CO_2 equivalent would be equal to the marginal cost of abatement. Under the *Kyoto Protocol*[42], the creation of market mechanisms called the Kyoto Mechanisms identified the marginal cost of GHG abatement[43].

A lower and upper limit to define the unit cost of a tonne of CO_2 equivalent in Canada were deemed appropriate, rather than a single figure. This approach explicitly accounted for the risk associated to the instability of the carbon price on the European carbon market. Risk is a major determinant of price. The limits chosen to assess the GHG costs from transportation activities in Canada were 15 € and 30 € per tonne of CO_2 equivalent.

These carbon prices were in nominal Euro (€) on the *European Carbon Exchange* for the year 2006. They had to be converted in Canadian dollars for the year 2000. In 2000 Canadian dollars, it gave a range of $18.67 to $37.38 per tonne of CO_2 equivalent. Total costs of GHG emissions of each mode were then calculated by multiplying tonnes of modal GHG by this range of unit price of a tonne of CO_2.

[40] See FCI Report T10. Note that the coverage has been modified to include half of GHG emissions for international bunker (air and marine) since the publication of that FCI Report.
[41] Data on transaction volume and on price of carbon on *the European Carbon Exchange* is available at: www.europeanclimateexchange.com
[42] United Nations Framework Convention on Climate Change "Reporting Requirements", 2004.
[43] The European Union created a tradable permit system for carbon that imposes emission limits on large industrial sectors and a carbon exchange that indicates the carbon price even prior to the first commitment period (2008-2012). The European Union's Emissions Trading Scheme (EU ETS) is considered the largest and most robust carbon trading scheme (while also having the highest carbon prices) and hence largely drives the price of project credits. The EU ETS tradable carbon instrument is referred to as European Allowance (EUA) and is denominated in a tonne of CO_2 equivalent.

6.4.4 Air pollution costs

The complexity of the methodology used to generate air pollution estimates makes the summary presented herein longer than the other social costs. A study[44] was conducted to estimate the social costs related to air pollution caused by transportation activities, to allocate the said costs by transport mode and by province, and to estimate average costs per unit of air pollution. To develop the estimates of the total costs of transport-caused air pollution in Canada in the year 2000, a three-step approach was used (Figure 6-2 gives an overview of that process):

Step 1. Estimation of changes in air quality using scenarios with and without transport emissions

The first step in the analysis was to isolate and determine the incremental air quality impacts attributable solely to transportation emissions. The baseline emissions inventory used to evaluate the air quality impact of transportation emissions came from *Environment Canada's* Criteria Air Contaminant Emission Inventory, 2000. This inventory has all emissions (with the ones generated by transportation) of volatile organic compounds (VOCs), nitrogen oxides (NO_X), particulate matter ($PM_{2.5}$), and sulphur oxides (SO_2) in Canada in the year 2000. Air pollutant emissions alter ambient air quality either directly, as in the case of particulate matters, or through the secondary formation of PM and ozone as in the case of NO_x, SO_2, and VOCs.

Two emission scenarios were then developed from this emission inventory for the year 2000 to isolate transport emissions:

- a scenario isolating all transportation emissions but excluding paved road dust (transport emissions *without* paved road dust),
- a scenario isolating all transportation emissions and including paved road dust (transport emissions *with* paved road dust).

The two transportation emission scenarios were used in the Reduced Form Source-Receptor Tool (ReFSoRT)[45] model to determine changes in ambient air quality attributable only to transport at the census division level.

[44] Evaluation of Total Costs of Air pollution due to transportation in Canada by Marbek Resource Consultants and RWDI Inc, March 2007 for Transport Canada. FCI Report T9. The study benefited greatly from the direct participation of representatives of Health Canada (Dr. David Steib) and of Environment Canada (Timothy Folkins) on the steering committee.

[45] ReFSoRT was developed by RWDI in collaboration with *Environment Canada* and was used to determine the changes in ambient air quality attributable to year 2000 transport emissions at the census division level.

Step 2. Use the air pollution estimates caused by transportation to estimate and monetize health and environmental impacts

Three types of impact resulting from transportation-induced air pollution were assessed in the process to determine the total costs of transport-related emissions in Canada in the year 2000:

- *Human health impacts*, in terms of changes in mortality and morbidity due to changes in ambient air quality from transport-related emissions;

- *Impacts on agriculture crops* in terms of changes in crop productivity and yield due to the level of ozone attributable to transport emissions; and,

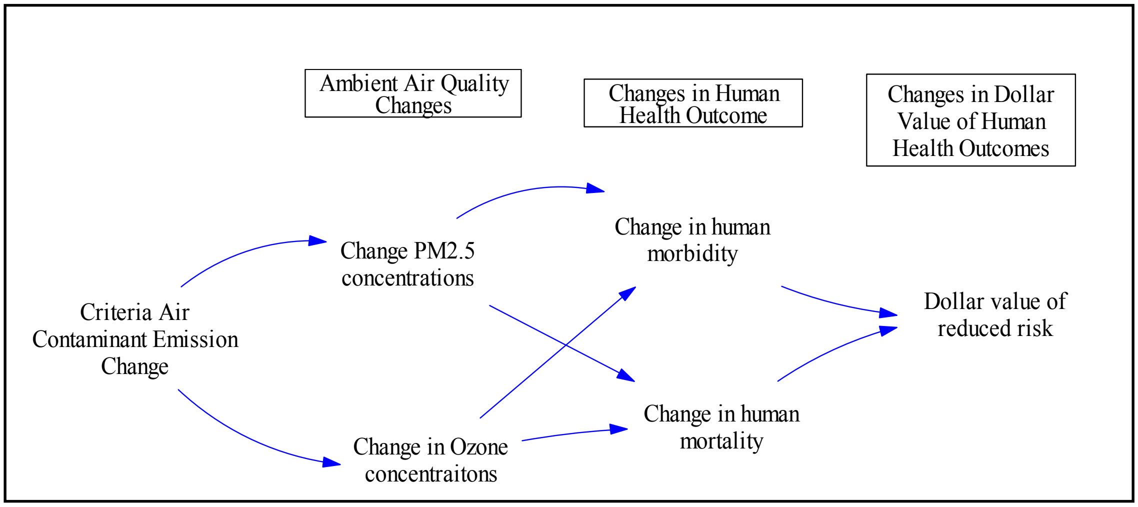
- *Visibility*[46] *impacts* coming from particulate emissions from transport-related activities reducing the view for individuals.

The impacts of transportation on air quality and the health and environmental receptors were converted in dollar terms and aggregated in order to derive the total cost of transport emissions in 2000.

In order to measure the incremental impact of transport-related air pollution, a damage function approach (see Figure 6-1) was used for identifying, quantifying and monetizing the total costs of transport-related emissions in Canada in 2000. The approach linked emissions criteria air contaminants and their precursors to quantified changes in ambient air quality such as ozone and $PM_{2.5}$. This change in ambient air concentrations was then associated with changes in health and crop yield and visibility outcomes which can also be expressed in dollar values. This method therefore translated the three main transport-related impacts – on health, crop yield and visibility - into monetary estimates for the determination of the total costs of transport-related emissions in 2000.

[46] It is to be noted that due to data limitations, transport-related air pollution impacts on forestry were not assessed in this study. Estimations of visibility impacts were not originally in scope of the FCI but are provided since data and methods were readily available.

Figure 6-1 Damage Function Approach Used to Determine Health Impacts of Transport-Related Emissions



Source: Marbek Evaluation of Total Cost of Air Pollution Due to Transportation in Canada (2007), p.7. FCI Report T9.

The concentration changes in the ambient air quality from ReFSoRT, by census division, were used as inputs into other models: one health model and two environmental valuation models as follows:

- Health Canada's valuation model developed to assess health endpoints, called the Air Quality Benefits Assessment Tool (AQBAT), or the AQBAT model, was used to estimate changes in 10 morbidity and mortality health endpoints related to ambient air quality changes;
- Environment Canada's *Value of Ozone Impacts on Canadian Crops Estimator* (VOICCE) model was used to estimate changes in production yield for 10 different crops that are sensitive to ambient ozone; and,
- Environment Canada's *Visibility Impacts Estimator of Welfare* (VIEW) model was used to link changes in $PM_{2.5}$ concentrations to improvements in visibility.

For health, human mortality outcomes were valued according to the willingness-to-pay of individuals to avoid mortality risk or willingness to accept compensation to incur greater mortality risks. Morbidity outcomes are based on a combination of willingness to pay and cost of illness metrics. For crops, the value of the lost production indicated the costs attributable to transport emission while it was the individuals' preference for reduced haze and increased visibility that formed the basis for monetary value of the visibility impact. Details on the specific information used to derive this monetized estimate of transportation air pollution impacts can be found in the Marbek study listed in Appendix A-3.

Step 3. Allocation of total costs by transportation mode, activity and province

The aggregated monetized air quality impacts caused by transportation on the health and environmental receptors, had then to be allocated by mode and by province. Figure 6-3 illustrates this allocation process.

The assignment of the costs of emissions to the various modes was performed as follows:

1. For each census division, the economic impact of each pollutant was further disaggregated to the respective emission source;
2. Each province's share of emission impacts was the sum of its contribution to upwind impacts and local impacts;
3. The ReFSoRT emissions by mode of transportation were by province;
4. The transportation emission impacts were split between freight and passenger activities for each mode. Air pollution costs calculated for health, visibility and agricultural endpoints associated with transportation emissions were allocated to each of the 18 modal/modal activity distinctions factored in the FCI. The costs estimated represent the cause (emissions from transport) and not the effect (costs incurred at endpoints).

All these calculations allowed to derive an allocation of the total transportation air pollution costs to each mode by transport activity level for use in the FCI.

For the FCI estimates, the average unit costs per tonne of pollutant emitted that resulted from the estimates were the following: \$12,600 for $PM_{2.5}$ \$13,900 for $PM_{2.5}$ including paved road dust, \$3,960 for SO_2 , \$3,580 for NO_X and \$436 for VOC.

Table 6-1 National Allocation of Air Pollution costs to Transport Canada Modes

Mode	Costs (000's)
Intercity Passengers	
Light road vehicles	$550,655
Coach bus	$16,420
Rail	$7,650
Marine	$46,200
Air	$28,500
Total	$649,425
Local Passengers	
Light road vehicles	$1,022,645
School bus	$50,379
Urban bus	$36,481
Local Rail	$7,650
Total	$1,117,155
Freight	
Truck	$1,197,200
Rail	$428,000
Marine	$492,000
Air	$1,580
Total	$2,118,780
All Transport Canada Modes	**$3,885,360**
Paved Road Dust	**$1,860,000**
Total Canada	**$5,745,360**

Note: From the initial CAC costs allocation in Appendix C of the "Evaluation of Total Cost of Air Pollution due to Transportation in Canada" report, total light vehicles costs were disaggregated by local and intercity movements in a ratio of 0.65/0.35; urban and school buses costs were disaggregated in a ratio of 0.42/0.58; rail passenger costs were allocated on a 50/50 basis between local and intercity movements.

As shown in Table 6-1, total annual costs of air pollution caused by transportation activities in Canada for the year 2000 are estimated at $ 3.9 billion without paved road dust and $ 5.7 billion with paved road dust. Just the health-related impacts, their estimated costs (without paved road dust) ranged between $ 2.8 billion and $ 4.8 billion. By including paved road dust, health impacts were estimated to be between $ 4.2 billion and $ 6.9 billion.

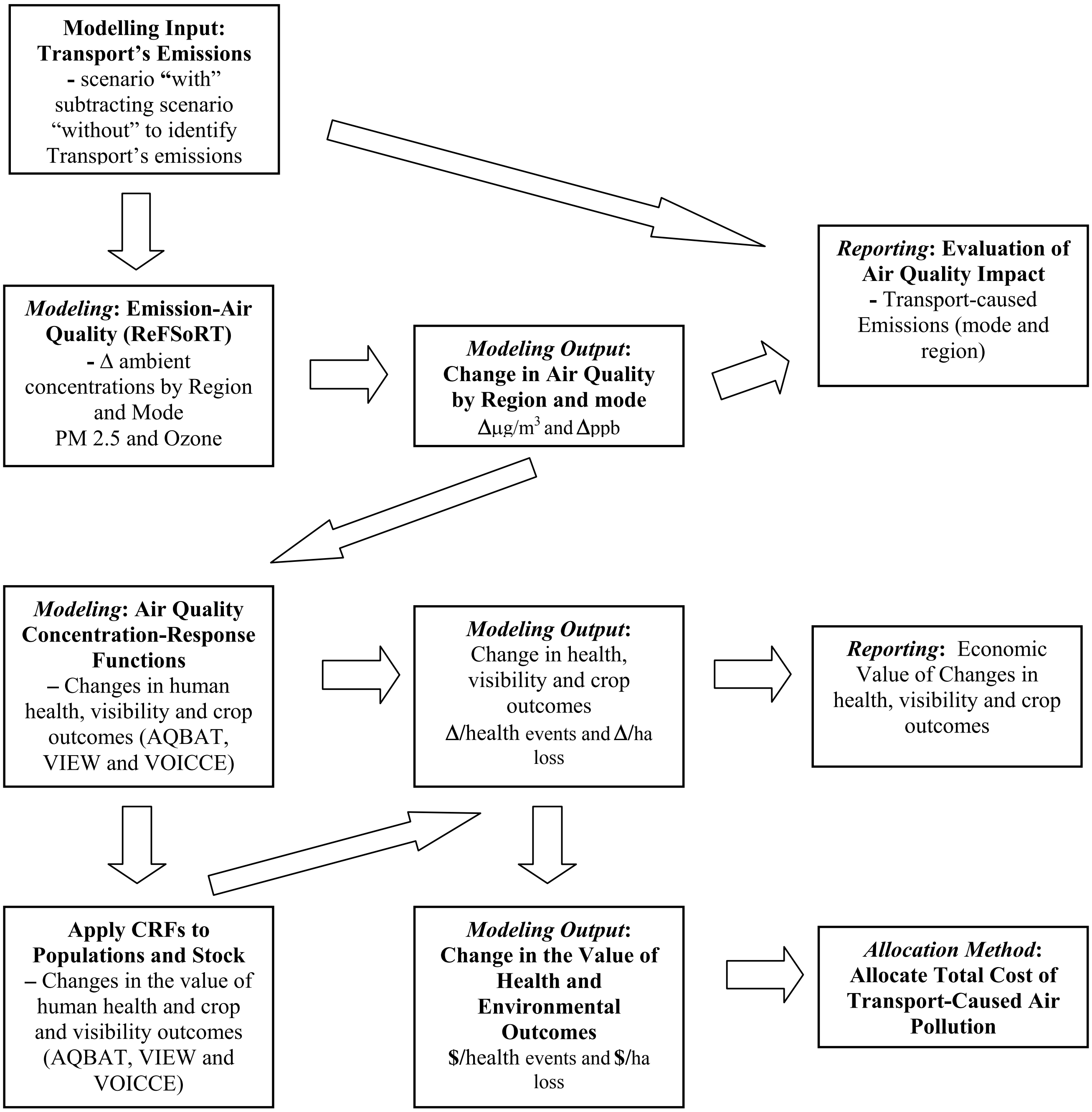
Visibility impact estimates were of the order of $ 62.2 million and $ 165 million when paved road dust emissions are excluded and included respectively. Agricultural yield loss represents $ 35.9 million.

Paved road dust represents about 32 per cent of total air pollution costs (ranging between $1.5 billion to $2.3 billion). The totals with all estimates include unpaved road dust, but this element cannot be allocated by sub-activity.

Health impacts represent approximately 97 per cent of total costs of transport-caused air pollution costs while visibility and agricultural impacts accounted for less than 3 per cent.

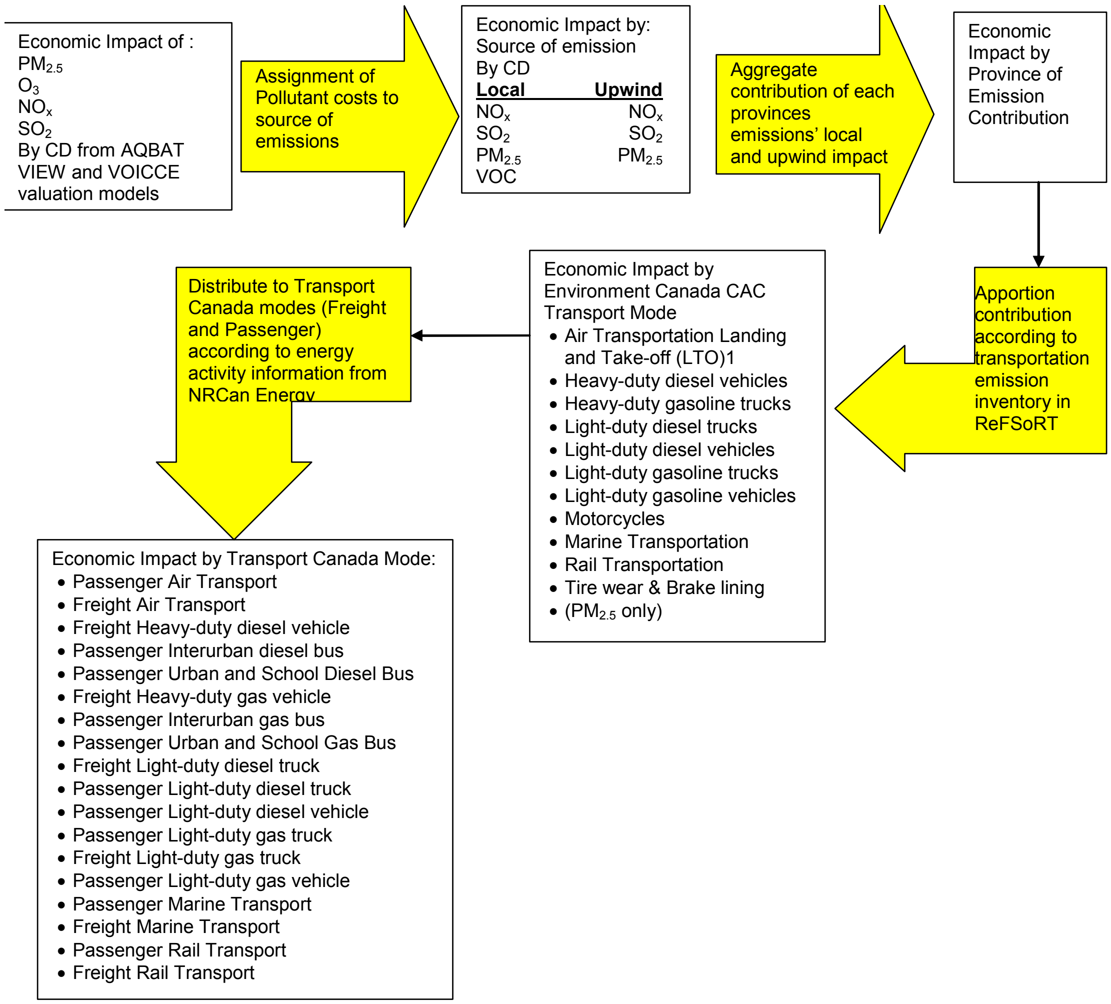
Freight heavy-duty diesel vehicle and passenger light-duty gas account for 52 per cent of the total estimated air pollution costs of transportation. Freight marine and rail transportation, as well as passenger light-duty gas trucks are also major contributors to transportation air pollution costs.

Figure 6-2 Overview of Modelling and Analysis Approach Used to Develop Air Pollution Costs of Transportation in the FCI



Source: Marbek Evaluation of Total Cost of Air Pollution Due to Transportation in Canada (2007), p. 10. FCI Report T9.

Figure 6-3 Steps Followed to Attribute Air Pollution Costs to Transport Modes.



Source: Marbek Evaluation of Total Cost of Air Pollution Due to Transportation in Canada (2007), p. 52. FCI Report T9.

6.4.5 Noise-related costs

As for each of the other social costs of transportation activities within the scope of the FCI, costs related to noise made by transportation required some methodological work in order to calculate such costs. The noise costs calculated provide measures of total annual aggregated costs by mode for Canada and by province for some modes[47].

To calculate the costs of noise requires a measure of noise levels generated, a threshold noise level at which noise starts to incur "costs" and a unit price to associate to noise: 'quantification and monetization of noise'.

The quantification of noise is based on engineering models while the price placed on noise came from various sources and is based on hedonic models (air transportation) or a mix of hedonic and stated preference studies (auto, truck, train).

Noise rates per type of transportation activities were translated into economic damage costs. The price of noise was established by considering total residential property damaged costs in a pre-defined vicinity of a modeled transportation activity. Marginal costs of noise calculations required considerations of the changes in the cost of noise with level and mix of traffic. Another degree of complexity in relation to transportation-related noise is that a transportation activity noise can be continuous or punctual. To account fully for all these dimensions, detailed data would have been required and available data only permitted a partial coverage of transportation noise-related costs.

For the noise-related costs, figures reported are potentially low for rail operations, uncertain for road transportation due to information on traffic flow not available at the proper level of detail, and potentially low for air due to noise data shortfalls. For air transportation, the airports included in the airport sample used represent approximately 60 per cent of total flight operations in Canada. Marginal cost calculations were provided for road; they were calculated for air using a regression model using a limited number of observations which made the estimated value not as robust as it should be; and marginal cost could not be calculated for rail. Marginal and average costs of rail noise become relatively close to each other when there is more than nine trains per hour.

6.5 ALLOCATION OF COSTS IN THE FCI

In the FCI work, allocation was an omnipresent task. When it came to a need to allocate some costs, methodological options were some times available. Needless to say, allocation questions were at the heart of the FCI and have been the object of discussions[48]. Since one of the ultimate goals of the FCI is to compare the full costs of different modes on selected itineraries, rigour within the limits prescribed by data availability was a key allocation decision factor. Rigour and consistency, driven by data availability considerations, delineated the achievable level of allocation accuracy.

[47] See: Gillen (2007) – FCI Report T7.
[48] See: Transport Canada's Allocation Options (2006) – FCI Report T5.

Allocation was needed to break down aggregated costs by sector, by geographic region, by user group, by type of vehicle, and by service.

Allocation methods have to be fair (i.e., not create some modal distortion), efficient and applicable. One of the key drivers of allocation approach decisions was the existence or not of causal relationships within and between the costs generated by each transportation activity. Allocation needs were also indirectly imposed by data gaps or limitations on activities, in which case they aimed to get around the data limitation by using methodologies to refine further the level of details of available cost information based on known and established causal relationships between activities and costs. Costs common to multiple transportation activities un-attributable from known causal relationships make up a significant proportion of total costs and yet had to be allocated to the different activities.

The review of options satisfying simultaneously the principles of equity, efficiency and applicability lead to proposed allocation methods in each mode. The methods differed slightly from mode to mode, mainly as a result of modal differences in data limitations, but tried to sustain as much as possible the principle of compatibility across mode. Proposed methods were submitted to the scrutiny of the federal-provincial FCI task force and of stakeholders, leading to discussions and sometimes needs to adapt/modify proposed methods as needed before applying them to derive actual cost estimates.

The option of carrying out sensitivity analysis in the event of accuracy concerns was used to add confidence in the allocation done and the resulting relative costs derived from the process, particularly on allocation matters having to do with data on relative levels of modal activity.

The road infrastructure represents an important cost element of Canada's transportation system. It is made up of a variety of types of roads, each with its particular functionality and cost of construction and operation; it is used by a range of users, each with different needs, with different cost implications and different levels of quality of service requirements. One of the allocation issues tied to roads that had to be addressed under the FCI, was the allocation of road wear associated to traffic and the one associated with climate[49]. It is well known that temperature; frost and thaw action as well as moisture are factors that can cause certain types of road pavement deterioration. These factors can also intensify pavement deterioration caused by heavy vehicles.

[49] Doré et al. (2005) – FCI Report R6.

Table 6-2 Road Wear due to Traffic

Road Deterioration due to Traffic				
Highway Classification	**Fine Grained Soil**			**Coarse**
	Wet freeze		**Dry freeze**	**Average Conditions**
	High Frost	**Low Frost**	**High Frost**	
Major Highways	**65%**	**70%**	**50%**	**80%**
Other Highways	**60%**	**65%**	**45%**	**70%**
Local Roads	**55%**	**60%**	**45%**	**60%**
Municipal Roads	**55%**	**60%**	**45%**	**60%**

Source: Doré *et al.* [2005]

Table 6-2 summarizes the results of a study conducted to assess the relative damage caused by traffic and by climate, using traffic damage indices applicable to Canadian conditions for two soil types (fine, coarse), applied and factored in across the country's road network.

The link between road wear and costs of road rehabilitation is straightforward. Cost elements related to the road infrastructure were the object of scrutiny[50] in the context of needs for the development of methodologies to allocate road infrastructure costs by type of users (light passenger vehicles, buses and trucks). The challenge was to take into account five classes of heavy vehicle configurations for the allocation. The road cost allocation had to go to the same level of details as the one used for the road unit cost study differentiation by geographical location, jurisdiction, road design features and functional class of roads. The results of this allocation are summarized in Figure 6-4 for Canada as well as by province in Table 6-3. Note that opportunity costs of land are not included in this table but have been included in Table 6-4.

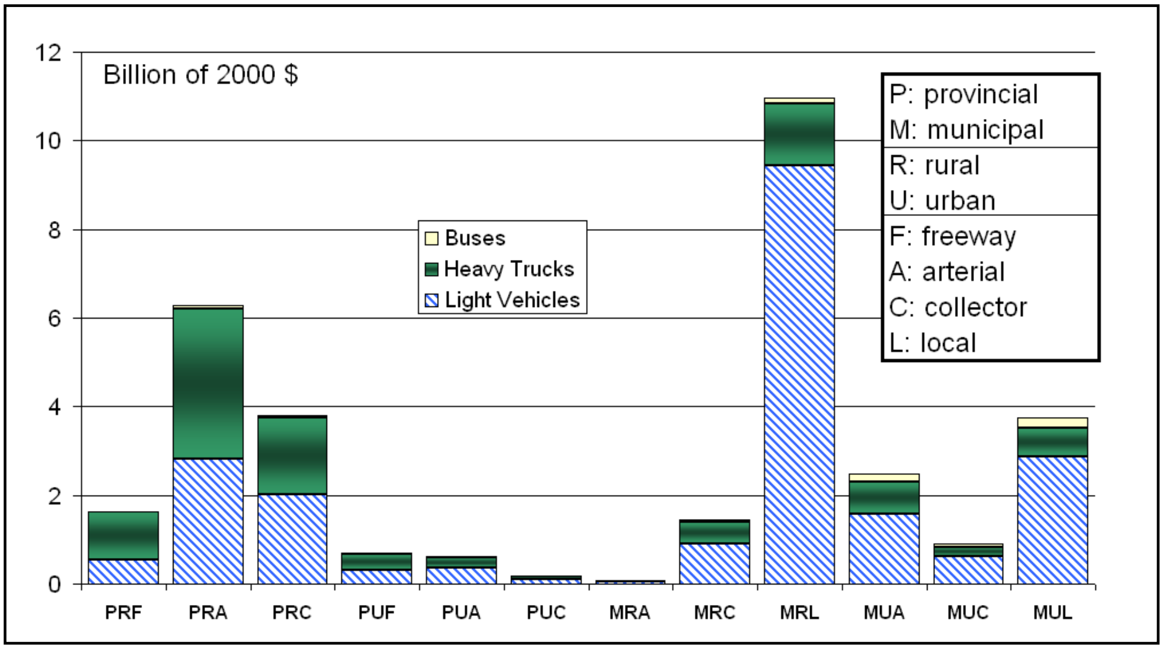
The volume of traffic varies by functional class of roads. Such variations lead to road user unit cost per VKT that could vary significantly by class of roads, depending on the cost allocation methodology used[51].

Although less important in terms of total costs, many other elements of costs had to be allocated for the FCI and Table 6-5 summarizes the method applied for each case.

Cost allocation in the context of the FCI and cost recovery are two different concepts. Major refinements to the FCI transportation cost estimates would have to be completed before one could think of using them to develop policies of recovering from users transportation funding requirements or managing transportation demand by setting prices that reflect also social costs of transportation.

[50] See Applied Research Associates (2007) – FCI Report R14.
[51] See: Transport Canada (2006) – FCI Report T5 for a more detailed discussion on allocation.

Figure 6-4 Road Annual Cost Middle Estimates by Class of Roads



Note: Opportunity costs of land used by road right-of-way are not included in this figure.

Table 6-3 and Table 6-4 show annual cost estimates by class of road and by province that are grouped as provincial or municipal. These results should be analysed with caution. Road funding is complex in Canada and evolved on an on-going basis. For instance, some provinces transferred to municipalities the responsibility of maintaining roads that were built by them. In terms of funding, many infrastructure projects have involved federal; provincial and local government spending. Hence, matching cost and funding by level of government would have required a much more complex analysis than the analysis of the data presented in these tables.

Table 6-3 Road Infrastructure Annual Cost Estimates (Excluding Land Opportunity Costs) by Class of Road by Province (Million of 2000 $)

	PRF	PRA	PRC	PUF	PUA	PUC	MRA	MRC	MRL	MUA	MUC	MUL	TOTAL
NL	30.8	135.0	262.2	13.0	5.9	18.0	0.0	0.0	163.2	55.9	14.6	55.2	754.0
PEI	0.0	22.0	122.5	0.0	3.6	2.1	0.0	0.0	28.5	2.7	1.8	14.8	197.9
NS	95.8	360.6	216.7	22.8	35.3	15.4	0.0	0.0	341.4	74.4	23.4	113.0	1,298.8
NB	90.5	128.5	328.0	21.8	9.2	34.0	0.0	0.0	276.9	38.8	18.4	91.8	1,037.8
QC	312.7	792.9	586.2	283.9	204.4	88.8	0.0	0.0	1,759.9	551.2	204.9	954.8	5,739.8
ON	427.3	1,140.3	458.9	256.0	131.1	0.0	49.6	1,442.0	2,230.7	1,261.7	436.7	1,454.8	9,289.2
MB	97.4	493.8	450.7	4.3	43.8	10.3	0.0	0.0	632.0	46.1	21.2	124.8	1,924.3
SK	104.9	487.5	365.2	7.1	22.1	4.6	46.9	105.2	1,485.9	37.5	20.4	91.7	2,779.1
AB	315.0	812.2	884.6	78.7	42.6	14.4	0.0	0.0	3,104.6	181.4	91.8	496.3	6,021.7
BC	295.7	1,805.0	200.1	59.8	166.5	18.2	0.0	0.0	1,224.6	419.0	163.4	608.0	4,960.1
TR	0.0	611.8	211.6	0.0	4.9	0.5	0.0	0.0	136.0	9.7	3.0	14.7	992.1
Canada	1,770.2	6,789.7	4,086.8	747.4	669.3	206.1	96.5	1,547.3	11,383.6	2,678.3	999.7	4,020.0	34,994.8

NL	4%	18%	35%	2%	1%	2%	0%	0%	22%	7%	2%	7%	100%
PEI	0%	11%	62%	0%	2%	1%	0%	0%	14%	1%	1%	8%	100%
NS	7%	28%	17%	2%	3%	1%	0%	0%	26%	6%	2%	9%	100%
NB	9%	12%	32%	2%	1%	3%	0%	0%	27%	4%	2%	9%	100%
QC	5%	14%	10%	5%	4%	2%	0%	0%	31%	10%	4%	17%	100%
ON	5%	12%	5%	3%	1%	0%	1%	16%	24%	14%	5%	16%	100%
MB	5%	26%	23%	0%	2%	1%	0%	0%	33%	2%	1%	6%	100%
SK	4%	18%	13%	0%	1%	0%	2%	4%	53%	1%	1%	3%	100%
AB	5%	13%	15%	1%	1%	0%	0%	0%	52%	3%	2%	8%	100%
BC	6%	36%	4%	1%	3%	0%	0%	0%	25%	8%	3%	12%	100%
TR	0%	62%	21%	0%	0%	0%	0%	0%	14%	1%	0%	1%	100%
Canada	5%	19%	12%	2%	2%	1%	0%	4%	33%	8%	3%	11%	100%

Table 6-4 Road Infrastructure Annual Cost Estimates Including Land Opportunity Costs by Class of Road by Province (Million of 2000 $)

	PRF	PRA	PRC	PUF	PUA	PUC	MRA	MRC	MRL	MUA	MUC	MUL	TOTAL
NL	34.9	137.3	273.9	15.5	6.5	21.4	0.0	0.0	177.2	55.9	14.6	55.2	792.5
PEI	0.0	22.8	126.6	0.0	4.6	2.7	0.0	0.0	30.1	2.7	1.8	14.8	206.1
NS	100.6	371.3	225.9	26.9	40.7	19.0	0.0	0.0	361.9	74.4	23.4	113.0	1,357.3
NB	94.1	132.1	336.2	25.7	10.4	39.8	0.0	0.0	287.6	38.8	18.4	91.8	1,074.8
QC	334.2	821.8	606.9	331.4	233.3	99.8	0.0	0.0	1,845.6	551.2	204.9	954.8	5,983.9
ON	508.3	1,205.9	462.8	358.7	158.9	0.0	58.2	1,817.8	2,820.8	1,261.7	436.7	1,454.8	10,544.5
MB	490.3	441.9	33.7	353.3	115.6	0.0	38.5	1,773.0	2,106.7	1,099.3	392.4	1,320.9	8,165.7
SK	17.9	764.0	429.1	5.4	43.3	0.0	19.7	44.8	714.1	162.4	44.3	133.9	2,378.9
AB	106.9	506.4	468.3	5.0	53.7	13.3	0.0	0.0	689.0	46.1	21.2	124.8	2,034.6
BC	329.6	1,865.9	206.6	82.9	201.7	25.9	0.0	0.0	1,423.2	419.0	163.4	608.0	5,326.1
TR	380.0	890.5	977.9	111.8	53.3	18.4	0.0	0.0	3,639.7	181.4	91.8	496.3	6,841.3
Canada	2,396.9	7,160.1	4,148.0	1,316.5	921.9	240.3	116.3	3,635.6	14,095.8	3,892.8	1,413.0	5,368.3	44,705.5

NL	4%	17%	35%	2%	1%	3%	0%	0%	22%	7%	2%	7%	100%
PEI	0%	11%	61%	0%	2%	1%	0%	0%	15%	1%	1%	7%	100%
NS	7%	27%	17%	2%	3%	1%	0%	0%	27%	5%	2%	8%	100%
NB	9%	12%	31%	2%	1%	4%	0%	0%	27%	4%	2%	9%	100%
QC	6%	14%	10%	6%	4%	2%	0%	0%	31%	9%	3%	16%	100%
ON	5%	11%	4%	3%	2%	0%	1%	17%	27%	12%	4%	14%	100%
MB	6%	5%	0%	4%	1%	0%	0%	22%	26%	13%	5%	16%	100%
SK	1%	32%	18%	0%	2%	0%	1%	2%	30%	7%	2%	6%	100%
AB	5%	25%	23%	0%	3%	1%	0%	0%	34%	2%	1%	6%	100%
BC	6%	35%	4%	2%	4%	0%	0%	0%	27%	8%	3%	11%	100%
TR	6%	13%	14%	2%	1%	0%	0%	0%	53%	3%	1%	7%	100%
Canada	5%	16%	9%	3%	2%	1%	0%	8%	32%	9%	3%	12%	100%

Table 6-5 Allocation applications

Element	Allocation needed between:	Allocation Approach
Light Road Vehicles Costs	Intercity and local activities	VKT of trip > 25 km and on road with speed limit > 80 km/h = intercity
Rail marketing Costs	Rail equipment and infrastructure	Allocated to equipment
Rail other overhead costs		Based on share of all other costs
Rail vehicle costs	Provinces	Based on fuel consumption
Rail infrastructure costs	Freight and passenger activities	Share of revenues provided by passenger activities in total revenues of freight operators
Coast Guard costs	Commercial vessels and others	Methodology used by CCG
Marine tied services	Provinces	Location of activities
Ferry costs	Freight and passenger activities	Types of road traffic on PRA
Air carrier costs	Provinces and territories	Number of passenger enplaned and deplaned in each province
Road accident costs	7 different types of users of road infrastructure	Number of vehicles involved in each of the 127 combinations of type of accident by province and 3 levels of severity
Level crossing accident costs	Rail and road users	Split equally between the two
Air pollution costs	Provinces and Territories	Source of emissions at the Census Division level
Air pollution costs	Sub-modal transportation activities	Adapted Office of Energy Efficiency's allocation approach

6.6 Treatment of Taxation in the FCI

Taxes and charges are elements found in the cost structure of firms. When it comes to transportation, and more specifically of an investigation of the full costs of transportation for the country's transportation system as a whole, the fact that both the public and private sectors are key transport stakeholders force to devote special attention to taxation in the FCI. Charges are also special as within the same mode of transportation, a charge can be levied by a stakeholder and paid by another, yet the two play essential roles in the provision of modal transportation services. For instance, airport landing fees are levied by airports from operators of air services, who in turn have to recover these landing fees through their fares/rates asked from users.

Transportation carriers pay taxes and/or charges for the use of transport infrastructure. In turn, infrastructure providers may also pay taxes or other fees. These taxes and charges are costs to those entities that generally need to be recuperated through charges to users. The question from a conceptual and methodological point of view in the context of the FCI is whether they are true economic costs, whether they represent consumption or use of a resource. It is for such reason that, these tax/charge/fee payments were distinguished from other cost categories in the FCI.

A parallel can be drawn between the issue of the treatment of taxation, charges and fees and the problem of double-counting when aggregating accounts for GDP estimates: the income of one firm can be an expenditure for another, or said differently, the input of one firm may be the output of another. When it comes to the objectives of the FCI, one purpose is to uncover the costs of an activity associated with an activity-specific tax and/or fee. There was, however, no attempt to do this for general taxes as it would not have been feasible to do so.

Returning to the air service example, if all of the costs of the air carriers, airports and other air infrastructure providers were simply aggregated, many of the actual costs would be double-counted. Air carriers include in their costs, charges for landing and terminal fees paid to airports. However, the actual costs of producing these services are included in the airports' accounts. Therefore, these costs would be counted twice if a simple aggregation of air carriers and airport costs was done. Furthermore, revenues would also be double-counted by doing a similar aggregation on the revenue side. Air carriers' revenues come predominately from the sale of passenger tickets, while airports obtain their revenues (to a large extent) from the air carriers. Summing these totals would overstate the total value of the services provided.

When calculating the GDP of a given country, a number of different methods can be used to avoid double-counting. One method counts only the revenues obtained from the sale of final goods (goods that are consumed rather than used as an input for the production of another good). Another method is to sum the value-added (value of outputs minus the value of inputs) of all firms or industries. Whichever method is used, the final result is the same (although discrepancies due to data issues do occur).

In the context of the FCI, a similar approach to the expenditure method (sum of the sale of final goods) to calculating GDP would be to identify and count only revenues collected from the final user of the services. This would provide us with the total revenues of that sector. In the air transport example, this would mainly include all revenues collected from passengers (cargo services would be included as well). Thus, revenues from passenger tickets (collected by air carriers), Airport Improvement Fees and airport commercial revenues (both collected by airports) would be aggregated in order to provide total revenues. In order to estimate total costs, the actual costs faced by the carriers and airports in order to offer their respective services would be summed up, but payments between air carriers and airports (such as the landing and terminal fees) would not be part of the calculation as the costs of these services are already accounted for in the airports' income statements.

6.6.1 Taxes

Activity-specific taxes (such as excise fuel taxes) are somewhat unique from the transfers made between carriers and infrastructure providers. On the revenue side, the expenditure-based approach can be retained to account for them. For example, governments collect jet fuel taxes from air carriers, not from the air passengers. Therefore, there is no need to add them to the revenues' total for the industry as they would already be included in the price of the tickets sold by the air carriers. On the cost side, the fuel taxes appear on the cost accounts of the air carriers but would appear on the revenue side of governments. Treating the taxes in a way similar to the transfers between carriers and airports, the cost faced by governments related to the actual service provided, rather than the revenues from the fuel tax itself, would be included. In this case, the cost of any government services provided to the industry would be included (though there are now very few directly provided by the government to the air sector).

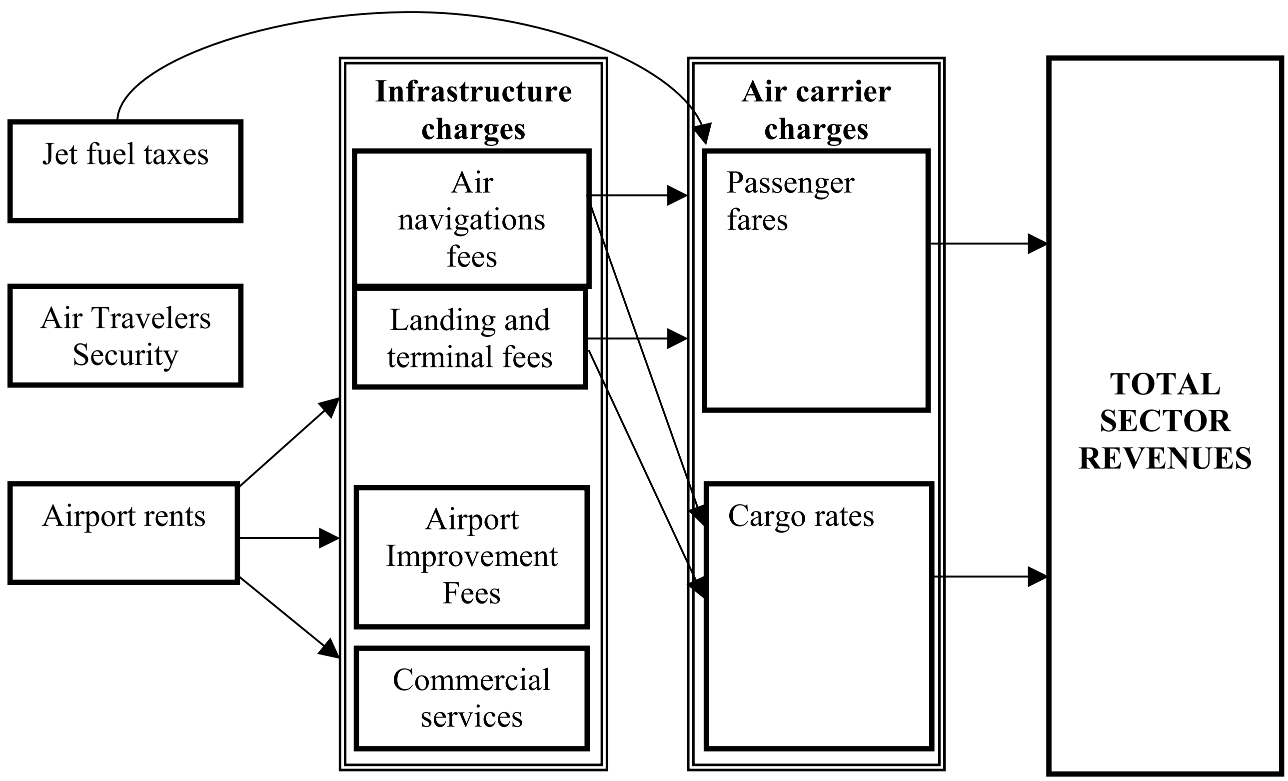
However, general taxes are not removed from the cost accounts of the transportation modes as it is assumed that they are part of a necessary societal cost and do not discriminate between modes or between transportation and other activities. This is not an issue of arbitrarily including or not including certain costs. Rather, it is an issue of replacing a tax or fee (a payment) with the economic cost of the service that is related to that specific tax or fee. As mentioned, this would not be a feasible task to perform for general taxes. So for the FCI, it was assumed that the services associated with the collection of those taxes were equal to the taxes collected in order to finance them.

An example in the general cost category is the corporate income tax. The FCI accounts include a pre-tax cost of capital charge in order to account for the level of corporate income tax. Furthermore, general sale taxes are not removed from the accounts as they are levied on most final consumption goods.

Excises taxes on fuel are included in the activity-specific category since they are, for the most part, transportation-specific. Furthermore, the excise taxes vary by mode and province. If these taxes are raised or lowered for one specific mode, it may have an effect on consumption patterns and certainly increases or decreases the cost burden for the carriers or users. However, it does not reflect an actual increase or decrease in resources consumed related to the level of activity. It is for this reason that they were not included in the economic costs under the FCI.

Figure 6-5 uses the air transport sector to illustrate how taxes, charges and fees in relation to the revenues and costs of the sector were accounted for in the FCI.

Figure 6-5. Illustration of Air Transport Sector Revenues



6.6.2 Differences in Activity-Specific Taxes Between Modes

The activity-specific taxes affect the cost accounts in yet another way. It has already been mentioned that jet fuel taxes are collected from air carriers (not the final user) and therefore requires no adjustment on the revenue side. However, in the road mode, private automobile users pay the fuel tax directly when they purchase fuel for their own consumption. For this reason, the revenues from that excise tax are included in the total revenues for that mode. On the cost side, the actual costs of any services provided to road users by governments are included. These include construction of the infrastructure, maintenance of roads, snow removal, etc.

Taxes paid by the two modes were treated differently because of the commercial nature of the air industry versus the private-use nature of the personal automobile. If road users only traveled in a way similar to air travelers, by using taxis instead of driving their own vehicles, all of the fuel taxes would be paid for by taxi operators and then passed on to the road user. In that case, no revenue adjustment would be required (as the taxi revenues would cover total revenues for the mode)[52]. Conversely, if all air travellers owned and operated their own airplanes, the air mode would require similar treatment as the road mode.

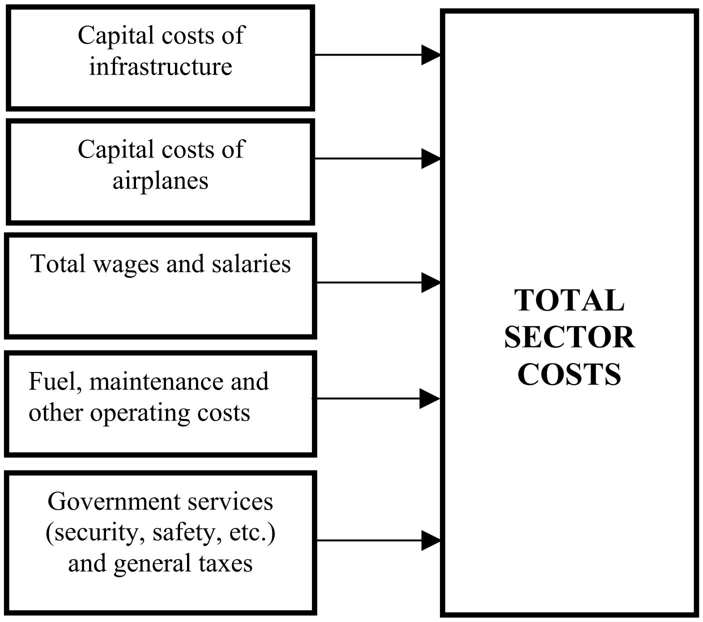
In the rail mode, there is virtually no distinction between carriers and infrastructure providers (at least on the rail freight side). Since the rail carriers build and maintain their own infrastructure (the track), no explicit charge for the use of the rail infrastructure appears in the accounts between rail carriers and rail infrastructure providers[53]. This would be somewhat similar to the air carriers building and operating the airports, if this was the case, it would eliminate the need to distinguish between carrier and airport revenues since there would be no transfers from carriers to airports and all revenues would be collected directly from air passengers. However, the results in terms of total revenues and costs would remain the same as long as the same approach is retained.

The treatment of taxes and charges/fees varied by mode and by type of charges in the FCI. The need for such a differential treatment came from the fact that they are levied in a variety of ways. In general, only revenues from charges levied directly from users (the passenger or shipper in the case of freight) were added to total revenues for the mode. Those charged to carriers who in turn then passed them on to the users through their fares/rates were not counted, in order to avoid double counting.

Furthermore, the activity-specific taxes and the transfers were not included on the cost side of the accounts. Only costs representing the consumption or use of a resource were considered to be true economic costs. It was therefore necessary to determine what the cost of producing the actual service was and distinguish that from the charge or tax levied in order to finance those costs.

[52] Note that road taxis have not been included in the FCI due to their relatively small share of total traffic and data issues.
[53] Exceptions include those cases where a carrier operates on the track owned by another and makes payments in exchange for this privilege.

Figure 6-6: Illustration of Air Transport Sector Costs



7 Areas for Improvements of the Estimates of the Full Costs of Transportation

The work conducted in the FCI allowed for the development of a first set of estimates of the full costs – financial and social costs – of transportation in Canada. Through the life of the project, a number of challenges surfaced and the discussions that ensued with respect to the potential solutions to these challenges and means of addressing the scope limitations, have allowed the project team to identify areas where improvements could be made in the future. Comments received during the course of the work also proved to be useful in identifying other possible sources of improvements.

This chapter exposes some potential improvements, noting that all cannot be addressed in a straightforward manner nor can solutions, in some cases, be easily implemented. Some would require a great deal of 'investment' in data collection effort to bridge data gaps.

7.1 Improvements at the Modal Level

7.1.1 Road Transportation

Road Infrastructure Network

Even by using a detailed approach with 196 cells differentiating road segments by functional class and their environment, improvements in the estimates of the road infrastructure costs could be achieved by increasing the number of road classes, in particular at the local level, where unit costs can vary greatly by type of road. The relative importance of the length of the lower classes of roads is so important in the overall road network of Canada, compared to the high-end part of the network, that any mistake in the unit cost for these roads may have an important impact on the accuracy of the total cost of the entire network.

It is necessary to pay close attention to the comparability of various highway construction and maintenance costs. There is an absence of a common accounting policy among highway infrastructure suppliers, from the provincial level down through the regional authorities and municipalities, which makes any and all comparison risky. Updating the data, based on common accounting methodology with regards to construction and maintenance costs, would improve the reliability of any future estimate of highway infrastructure cost.

Road cost allocation among the different types of road users could be improved upon by having more precise activity level measurements by the different vehicle categories on the different classes of roads. Improving the road traffic data gathering on the entire road network would prove to be particularly helpful to refine the allocation of road infrastructure costs to the different road users.

Light Road Vehicles

The study could benefit from a precise estimation of the intensity of use by Canadian vehicles of the United States road network. In other words, the proportion of Canadian road vehicle use of the US road network was not known. What was available was only a total average estimate by road vehicle type in a given year, not broken down between a use on the Canadian road network and a use on other countries' network (which would be mainly the US road network). Therefore the estimates presented do potentially include the use of the American road network by Canadian vehicles, and do not include the use of the Canadian road network by American vehicles. The use of the American road network by Canadians can not be measured out of available data sources such as the International Travel Survey because it does not provide detailed records of visitors to specific locations.

The significance of the impact of such a shortfall could be marginal if on both sides of the border the uses of the foreign road network are comparable; the other country's road network was comparable. But if the volume of same-day or one-night-or-more visits from each side of the border was different, then better data on intensity of use of the American road network by Canadians, and intensity of use of the Canadian road network by Americans would improve the accuracy of the estimates.

The Canadian Vehicle Survey (CVS) is not the best source of road activity level information as it does not provide information on the type of road surface used. The Canadian Vehicle Survey does not provide information on the province where the trip took place forcing to assume that the province of registry of the vehicle was also the province where the trip took place. The estimation of the use of unpaved roads in the network could also be improved upon.

Commercial Road Vehicles

With the Canadian Vehicle Survey, the activity measure by vehicle class had to be limited to four types of trucks and four types of buses. Activity level data for a wider range of truck configurations would help improve the estimates.

Data on intensity of use by specific segments of the road network, per province, had to be estimated and therefore any road activity data improvements at such a level of detail would increase the degree of precision of the road-related estimates.

Data on geographical location of travel (rather than the 'home base' of the vehicle – i.e., the jurisdiction the vehicle is registered with) was only partially available through the National Roadside Survey. Should more precise travel data become available, significant improvements in the measurement of urban freight transport activities would ensue.

For the bus industry, data on the size of the bus fleet and on the intensity of its use by trip purpose would also be a source of improvements. Better coverage of the bus industry activity level data by the characteristics of the different industry segments such as intercity, shuttle, charter or transit services would also permit to improve the allocation of road infrastructure costs for this segment of the road vehicle fleet.

7.1.2 Rail

For the most part, data related to the Class I rail carriers was good. However, regional and short line carrier data was not as robust. Capital costs for the latter had to be estimated and there were gaps in the operating cost data for these rail carriers as well. Data improvements on this segment of the rail industry would improve the overall rail cost estimates.

The allocation of rail costs between freight and passenger services could also be improved upon with a more thorough analysis of the drivers of the costs of these two services.

7.1.3 Marine

The scope of coverage of the marine transportation mode was limited by data availability[54]. The scope initially envisioned was to include all water carriers (freight and passenger, domestic as well as foreign-flag carriers) sailing into Canadian waters, all commercial marine facilities (including private ports and terminals[55]), and international movements or activities.

Congestion at ports and noise emitted by vessels and at marine facilities are other elements that could not be covered under the FCI. The valuation of land occupied by marine facilities is another area where improvement would need to be made.

Provided more information could be made available, the coverage of the marine sector could be improved (expanded) to include the elements that could not be covered by the investigation or covered in as much detail as initially envisioned.

7.1.4 Air

General aviation activity was not included within the scope of the air transport costs estimates. An estimate of these costs would improve the overall picture of aviation activity. However, some data limitations would have to be overcome to do so.

While an estimate for the cost of small airports was included, this estimate could be improved upon with better data. This would require a more comprehensive survey of the small airport operations or a new source of information on smaller airports

[54] Financial (i.e., capital assets values, operating costs and revenues) and operational information.
[55] Including marine facilities and assets owned and operated by companies whose main activities are not related to transportation (e.g. mining companies).

The allocation of costs between passenger and cargo activities was performed in a systematic way due to the prevalence of joint and common costs between the two types of activity. More detailed data on the 'drivers' of these two cost categories at both the infrastructure and carrier level could improve the accuracy of the allocation of the costs.

Provincial allocation, in particular on the cargo side, could also be revisited as the current method employed had to work around data limitations that could be circumvented by better data on air cargo operations to permit more detailed methods of allocation.

7.1.5 Social Costs

Social costs, including accident and air emissions, have been allocated by type of road users to distinguish between freight and passenger, and between public and private vehicles among passengers. Improved activity level data would allow applying further details to distinguish light road vehicles among themselves. Given the importance of the relative differences in unit costs observed among light road vehicles, calculating social costs by sub-groups of light vehicles could lead to improved estimates.

Air pollution costs have been allocated by using provincial-level unit costs to specific origin-destination pairs. Although this is more accurate than using national averages, this simple approach masked the complexity of the relationship between the actual location of the emissions from transportation activities and their environmental and health damages. Unit costs could be calculated at a more precise physical location of the areas where transportation activities take place. That would require more complete transportation activity information, something that may be costly, not to say unaffordable.

Congestion cost estimates have been limited to the major urban centres where most of the road congestion is observed. Moreover, the estimates account only for the time lost by light vehicle drivers. A better estimate would include an assessment of the value of time of all road users, including the urban bus passengers and the car passengers. More focused studies could also be conducted on the impact of high-occupancy reserved lanes as a congestion mitigation measure. The role of the intermodal interactions on congestion has been ignored as well as the impact of the variety of road vehicles in the urban traffic at peak hours. More research is required to refine the estimates of this aspect of the transportation social costs.

Congestion costs experienced by commercial road freight carriers were not isolated as they were in essence, captured in the financial costs of the industry (in the form for example of incremental labour costs). Apportioning these costs with more precision would be a demanding task requiring numerous assumptions.

On congestion again, note was made that a portion of congestion experienced on roads may also be caused (perhaps more so in major urban areas that anywhere else) by the interaction of road and rail. With longer trains, major urban areas with limited grade separation may face additional road congestion delays caused by rail operations. An area for improvement would be to try to isolate and quantify that road-rail type of congestion and address the allocation challenge this poses.

7.2 Improvements to the Methodology(ies) Used to Develop the Estimates

Noise generated by transportation activities is not well measured. Methodologies to measure noise levels for all modes in urban areas with some accuracy would be an area for improvements. The methodological work needed in relation to noise would have to allow for a clear delineation between transportation-induced noise and noise generated by other activities. This is a real challenge, especially in those areas where a mix of activities takes place.

Congestion was addressed only for road transportation. An area of improvement may be to look at methodologies that could potentially be used to get a measure of the level of congestion experienced in other modes.

It might be worthwhile to explore how the methodology used to allocate costs between passenger and freight traffic in air and bus transportation can be improved, if at all.

When looked at from the perspective of the different players involved in modal activities and from a cost and revenue perspective as well, the FCI estimates can be used to assess whether the users cover all the financial costs associated with the level of infrastructure being provided to the providers/users of transportation of services.

7.3 Base Year

7.3.1 Updating the Estimates

Using a more recent year to establish a revised set of FCI cost estimates could prove useful in more than one way. A number of changes in the composition of vehicle fleets (across all modes) have occurred since 2000 and such changes have had impacts on emission rates and would have had an influence on the relative costs across modes but also within modes between different transportation elements. Performing an update of the estimates would also allow for a better understanding of the differences that may be experienced in each of the cost elements over time. This would significantly enrich the explanatory power of the FCI. Producing the FCI estimates for a more recent year and comparing a more recent set of estimates with those developed for year 2000 would be instrumental in addressing that need.

Appendices

A-1 List of Officials on the Task Force

Full Cost Investigation Task Force

Chair: Roger Roy
Transport Canada

Membership:

Transport Canada	Bruno Jacques	
British Columbia	Jim Hester	Brenda Janke
Alberta	*Information only*	
Saskatchewan	Andrew Liu	Wayne Gienow
Manitoba	Amar Chadha	Jake Kosior
Ontario	Alan Stillar, Strategic Policy Branch, Ministry of Transportation	Ryan Bailey
Québec	Évangéline Lévesque	Éric Genest-Laplante
New Brunswick	Susi Derrah	
Nova Scotia	Jane Fraser	Greg Penny
Prince Edward Island	*Information only*	
Newfoundland and Labrador	Kevin Antle	John Byrne
Yukon	*Information only*	
Northwest Territories	*Information only*	
Nunavut	*Information only*	

A-2 List of Transport Canada Officials Involved in the FCI Working Team

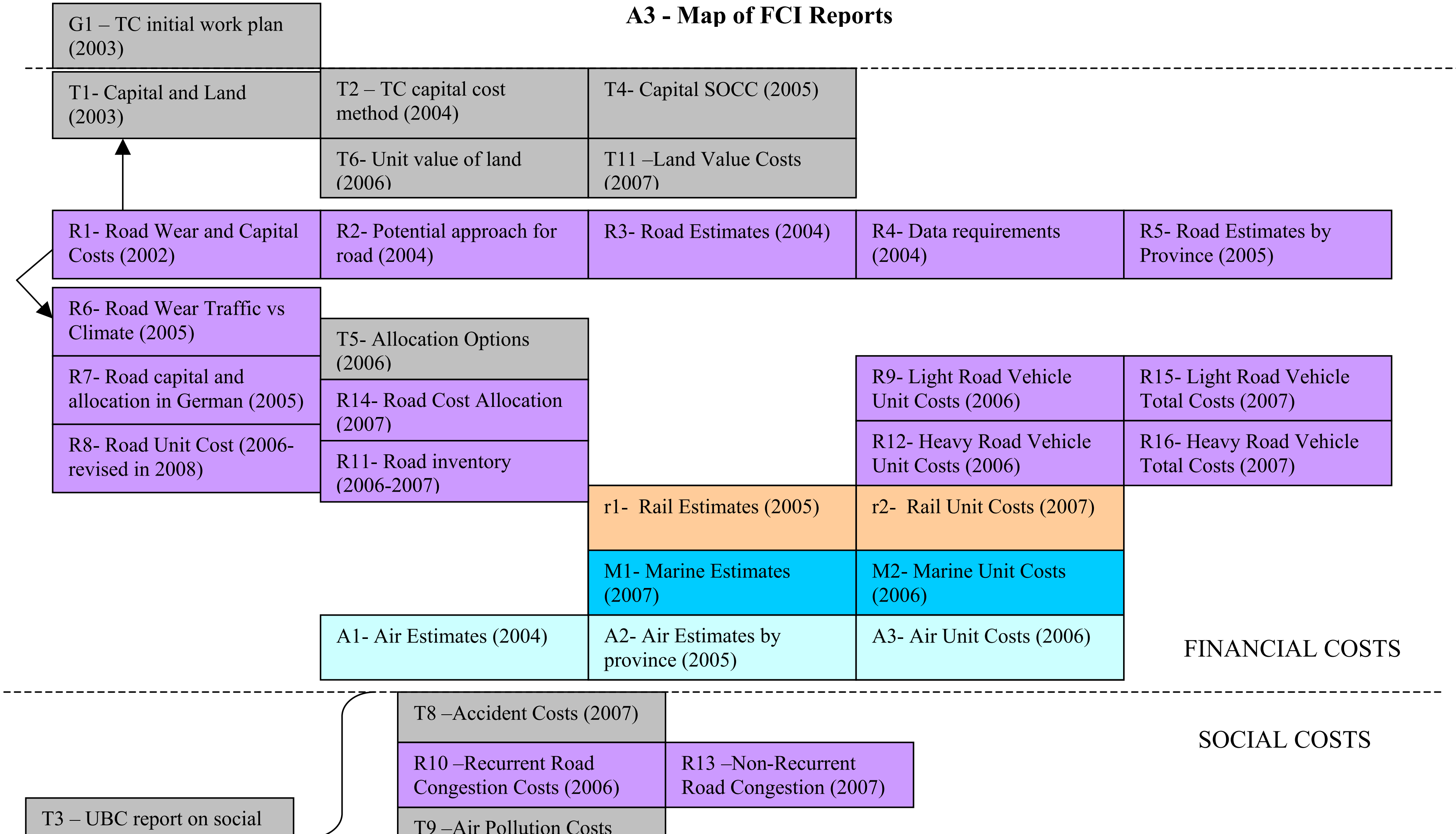
Officers

Roger Roy, John Lawson, Bruno Jacques, Jean-Pierre Roy, Richard Thivierge, Jeff Harris, Sylvie Mallet, Vijay Gill, Christian Beauregard, Franziska Borer Blindenbacher, Rosy Anne Amourdon, Ana Julia Yanes Faya, Eugène Karangwa, Muna Goran, Allan Krisciunas, David Kowalski, Joe Kruger, Dan O'Shea

Students

Alina Kotov, Nicholas Gray, Anne Chau, Yves Morrissette, Jason Blom, Patricia Foster, Jean-Philippe Roy, Jennifer Vieno, Daniel Blondin, Paolo Mazza, Frédérik Bélanger, Jay Crone, Nathalie Olds, Gregory Schreiber

A3 - Map of FCI Reports



Note: This map of **FCI Reports** is a visual aid that could help to identify clusters of reports. Reports on the same subject are located on the same row. Reports that precede others are located to the left. The exact reference could be found in the list of FCI background reports that is provided in annex A-3. All reports are available on: www.tc.gc.ca/pol under The Full Cost Investigation.

A-3 List of FCI Reports

The document entitled **Full Costing Investigation: Work Plan and Status Report-** completed in May 2005 updated the 2003 FCI initial work plan. The technical reports are often only available in the language chosen by the authors when those are consultants not working for government. Only a summary is available in the other official language in such a case and these technical reports are identified with an asterisk (*).

Research Projects Related to More than one Mode (transmodal)

T1. Concepts and practical values of land costs and capital charges for a "Full-Cost Accounting" of transport infrastructure in Canada - The study analyzes issues involved in measuring the costs of infrastructure land and capital within the context of the more general context of the measurement of transport services costs including the costs of publicly funded infrastructure.

- Contractor: Ronald Hirshhorn
- Completion date: December 2003

T2. Methodological options for estimation of infrastructure capital costs in FCI project – code TP 14485E, study by Transport Canada to discuss the opportunity cost of capital rate, the method of depreciation and the value of land.

- Completion date: July 2004

T3. Towards Estimating the Social and Environmental Costs of Transportation in Canada* - Literature review completed by the University of British Columbia on a number of "social costs": accidents; delays due to congestion; air pollution; climate change; noise. The report suggests methodologies to assess these specific social costs for all modes.

- Authors: Anming Zhang (Project Director), Anthony E. Boardman, David Gillen and W.G. Waters II
- Completion date: August 2004

T4. Treatment of Private and Public Charges for Capital in a "Full-Cost Accounting" of Transportation* - The paper reviewed the theory around the use of social opportunity cost of capital (SOCC). This paper is the source from which the narrowing of the range of SOCC to use for all parts of the FCI. The range was 5% to 10% and it is now 6% to 8.6%.

- Contractors: Donald Brean, David Burgess, Ronald Hirshhorn, Joseph Schulman
- Completion date: March 2005

T5. Allocation Options - The paper reviews allocation methods to apply to cost elements of the transportation system that serve more than one type of users. Preferred allocation methods have to be based on causal links between activities and costs and they would take into account data availability.

- Completion date: March 2006

T6. Unit Land Value* - The study developed a methodology to estimate the land unit value occupied by transportation infrastructure as well as a database of these estimates ($ per m^2) using a Geographic Information System coding.

- Contractors: Dr. Clarence Woudsma (University of Waterloo), Todd Litman (Victoria Transport Policy Institute), Glen Weisbrod (Economic Development Research)
- Completion date: June 2006

T7. Noise Costs* - The study estimates the total and marginal costs of noise based on the residential property depreciation. The scope of the study includes major modes: road, rail and air.

- Contractor: David Gillen (UBC)
- Completion date: March 2007

T8. Accident Costs - The study estimates the costs of accidents, mainly human life losses and injuries, using the willingness-to-pay approach and thus the value of statistical life. Basis for the monetary unit values will probably be the Ontario Study 2007 (ongoing). The allocation of costs per mode and activities will be covered. The study scope includes all major modes: road, rail, marine and air.

- Completion date: March 2007

T9. Air Pollution Costs* - The study estimates the costs of air pollution based on difference between air quality with and without pollutant emissions from the transportation activities. The study scope includes all major modes: road, rail, marine and air.

- Contractors: David Sawyer, Seton Stiebert (MARBEK), Michael Lepage, Colin Welburn (RWDI)
- Completion date: March 2007

T10. Greenhouse gas Costs - The study estimates the costs of greenhouse gases based on emissions taken from the National inventory. The unit values are a range of abatement values ($/ t CO_2 equivalent) as observed on the European Carbon Market. The study scope includes all major modes: road, rail, marine and air.

- Completion date: December 2006

T11. Land Value – The study uses estimates of opportunity costs of land occupied by transportation infrastructures in Canada by province and by major modes: road, rail, marine and air.

- Completion date: Airports and rail completed in December 2006, roads and ports in February 2007 (post road inventory revision)

RESEARCH PROJECTS RELATED TO THE ROAD MODE

R1. The Estimation of Road Wear and Capital Costs – The study investigates the costs related to road wear and road capital costs.

- Contractor: Ronald Hirshhorn
- Completion date: March 2002

R2. A possible approach to developing the financial costs of road transportation in Canada – Study by Transport Canada TP 14482E - This technical paper suggests a possible approach to the determination at the national level of the annual financial costs and revenues related to road transportation. The suggested approach is based on a review of publicly available financial, fleet and activity data.

- Completion date: March 2004

R3. Interim Estimates of the Financial Costs and Revenues Associated with the Provision of Road Infrastructure in Canada, 2000 – Transport Canada study coded TP 14490 E, it estimates the financial costs of road infrastructure in Canada, as compared to the revenues derived from road related charges and taxes.

- Completion date: November 2004

R4. Data requirements for road cost / revenue comparisons – Transport Canada study coded TP 14483 E, it assumes that inter-modal comparisons involve vehicles/crafts that can realistically compete and that it will be necessary to estimate costs by region, province, type of geometry/quality, and broken down by ownership (provincial, municipal, federal).

- Completion date: July 2004

R5. Interim Estimates of the Financial Costs and Revenues Associated with the Provision of Road Infrastructure in Canada, 2000 – Transport Canada study coded TP 14490 E, it estimates the financial costs of road infrastructure in Canada, as compared to the revenues derived from road related charges and taxes.

- Completion date: April 2005

R6. Estimation of the relationships of Road deterioration to Traffic and Weather in Canada* –the project reviews the existing literature on the contribution of climate and traffic to wear of pavements. The study also reviews the existing design practices and available data in Canada, as well as including a number of performance simulations for estimation. The results will be used for allocating cost between light and heavy vehicles (ref. R13).

- Contractors: Pr. Guy Doré (Université Laval), Philippe Drouin, Pascale Pierre, Pierre Desrochers (BPR)
- Completion date: May 2005

R7. Study of Methods of Road Capital Cost Estimation and Allocation by Class of User in Austria, Germany and Switzerland* –(TP14494) the technical report explains methodologies and data used by government authorities in the three German speaking European countries (Austria, Germany and Switzerland) to estimate road infrastructure costs, by functional class of road, and allocate them by type of vehicle or user.

- Completion date: March 2005

R8. Estimation of the Representative Annualized Capital and Maintenance Costs of Roads by Functional Class* – Estimation of the annualized unit costs by functional class of road for the Canadian road infrastructure. The study also estimates traffic volumes on the road network.

- Contractors: David Hein, Jerry Hajek, D.J. Swan, Applied Research Associates, Inc. (ARA)
- Completion date: March 2006 – Revised in August 2008

R9. Estimation of Costs of Cars and Light Trucks Use per Vehicle-Kilometre in Canada* – The study estimates the unit costs per vehicle kilometre of Canadian owned cars and light trucks use in the year 2000 including: capital costs of depreciation of the vehicle, financing costs of vehicle purchase, fuel costs, and other costs.

- Contractors: Ray Barton Associates Ltd, the Victoria Public Policy Institute and Dr. Kouros Mohammadian (University of Illinois).
- Completion date: March 2006

R10. Costs of Congestion in Canada's Transportation Sector – This investigation of congestion delays and their costs was completed for Transport Canada's Environmental Affairs Directorate; separate from the FCI, but potentially of considerable use to it. The report considers definitions and measurements of urban road congestion, recommending a particular definition and applying it to a number of Canadian cities, with the aid of those cities' planning models.

- Contractors: David Kriger, M. Baker (iTRANS), Gilles Joubert (ADEC)
- Completion date: March 2005

R11. National Road Inventory by Functional Class - The study classifies the Canadian road infrastructure for each province or territory, for each level of jurisdiction, by road design features, and by functional class of road. Based on a geographic information system (GIS) approach, the study allowed to assess the road length by functional class that corresponds to the unit cost study (R8).

- Contractors: Allan Krisciunas, Paolo Mazza, Greg Schreiber
- Completion date: August 2006 (revised in January 2007)

R12. Heavy Road Vehicles Unit Operating Costs*
This study estimates operating and capital costs per vehicle-kilometre for typical heavy road vehicles (18 trucks and 4 buses) in Canada.

- Contractors: Ray Barton and Associates and Lloyd Ash
- Completion date: December 2006

R13. Non-recurrent road congestion costs*
iTRANS Consulting Inc. conducted a study on the non-recurrent aspect of congestion. The study estimates the costs of non-recurrent road congestion in 9 large urban areas, contributing to the Phase 4 estimates in the FCI. The study reveals the development and application of methods to estimate non-recurrent congestion and its costs, relative to and based upon the estimate of recurrent congestion and its costs from *The Cost of Urban Congestion in Canada (2006)*. The study also provides a critical assessment of the method, its application and recommendations for further research, data collection, etc.

- Contractors: David Kriger, M. Baker (iTRANS)
- Completion date: December 2006

R14. Estimation of road cost allocation between Light Vehicles and Heavy Vehicles in Canada* - The study allocates total costs required to build and maintain road infrastructure in Canada between light vehicles and heavy vehicles. In addition the costs allocated to heavy vehicles had to be allocated between trucks and buses. The results of the project will be used to compare the total financial and social costs of transport incurred by all major transportation modes: road, rail and air transportation in Canada. (see ref. to R6).

- Contractors: David Hein, Jerry Hajek, D.J. Swan (Applied Research Associates)
- Completion date: February 2007

R15. Estimation of Total Costs of Cars and Light Trucks Use in Canada – The study estimates the total costs of Canadian owned cars and light trucks use in the year 2000. The study takes the unit costs per vehicle per kilometre from the Ray Barton, *et al*. March 2006 study, and multiplies it by the total number of vehicles and intensity of use in kilometres taken from the Canadian Vehicle Survey.

- Completion date: January 2007

R16. Estimating the Total Cost of Commercial Road Vehicles and Urban Transit – The study estimates the total costs of trucks and buses use as well as public urban transit in the year 2000 in Canada. The study takes the unit costs per vehicle per kilometre from the Ray Barton, *et al*. December 2006 study, and multiplies it by the total number of vehicles and intensity of use in kilometres taken from the Canadian Vehicle Survey and other sources. Urban transit costs are estimates using also the Canadian Urban Transit Association database.

- Completion date: July 2007

RESEARCH PROJECTS RELATED TO THE RAIL MODE

r1. Preliminary Estimates of the Financial Costs and Revenues of Rail Transportation in Canada in 2000 - The paper presents the national estimates of costs for the rail sector. This includes a breakdown between freight and passenger services. The report focuses on the year 2000 but contains information on the 1998 to 2002 period.

- Completion date: May 2005

r2. Trains unit operating costs* - The study develops a cost structure of train operation using the FCI approach standardized for all modes. The model developed for the study will allow modal comparison for specific origin-destination shipments.

- Contractors: Don McKnight, Joseph Schulman, Jim Best
- Completion date: March 2007

RESEARCH PROJECTS RELATED TO THE MARINE MODE

M1. Financial Costs and Revenues of Marine Transportation in Canada in 2000 - The report will summarize Phases 1 and 2 estimates for the marine mode**.**

- Completion date: December 2006

M2. Ship unit operating costs* - The study on ship unit cost will provide estimates of the cost of moving grain or salt on four designated routes on the St. Lawrence Seaway (between Ontario and Quebec). The objective is to estimate the cost for Canadian marine carriers on specific domestic routes.

- Contractor: Maritime Innovation
- Completion date: December 2006

RESEARCH PROJECTS RELATED TO THE AIR MODE

A1. Financial Costs and Revenues of Air Transportation in Canada –The report summarizes Phase 1 estimates. The air infrastructure as defined by this study consists mainly of airport assets as well as other assets required for the operation of air services, such as air navigation systems provided by Nav Canada. In addition, Canadian-based air carriers' revenues and costs are included in order to provide a more complete view of total air transportation costs.

- Completion date: November 2004

A2. Financial Costs and Revenues of Air Transportation in Canada –(TP 14488E). This paper provides estimates for the financial costs and revenues of air transportation. It follows the November 3, 2004 draft report entitled "Financial Costs and Revenues of the Air Infrastructure." The air infrastructure as defined here consists mainly of airport assets as well as other assets required for the operation of air services, such as air navigation systems.

- Completion date: April 2005

A3. Aircraft unit operating costs* – The objective of the study is to provide estimates of the marginal operating costs of aviation activity for the purpose of contributing to the Phase 5 estimates in the FCI. The estimates may also be used in order to refine Phase 3 data, in particular for freight transportation where data is limited. The estimates vary by aircraft type, configuration and route. These variables have been selected primarily for their relevance in terms of modal comparisons.

- Contractors: Richard Fisher; Suzanne Moreau, Martin Headland (Moncrieff Management)
- Completion date: December 2006

Additional Bibliography

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