NOTES TO CHAPTER 6: RAIL INFRASTRUCTURE ISSUES

1. Running Rights and Joint Track Usage

This section provides a more extended discussion of existing arrangements under which one railway company uses another railway company's track, as a supplement to the subsection of Chapter 6 in Volume 1 entitled "Improving Access to Rail Tracks."

1.1 GENERAL

Running rights and joint operations have a long history both in Canada and elsewhere, and are considered by some to be residual customs from early railway development in England. Today, sharing sections of track owned by another railway company is both common and beneficial. Running rights and joint operations not only provide railway companies with access to another company's lines, but can also provide alternative transportation services for railway customers. In Canada, with its difficult geography, such alternatives are very important — when a railway's track is temporarily closed through accident or for major maintenance, trains are routinely routed over a competitor's line.

In some instances, the sharing of facilities is brought about by the need to connect two pieces of track. At the root of this sharing is a desire to avoid unnecessary duplication of railway facilities. Running rights can permit a railway company without its own track to operate successfully. Although it does have small track holdings, VIA Rail essentially operates in this way.

There is a technical difference between running rights and joint operations (or joint track usage). A railway company may have the right to operate trains over the tracks of another railway without any reciprocal (running rights) privilege for the second railway. Joint operations (joint track usage) involve railways sharing facilities in order to improve service or to avoid the duplication of facilities. In Canada, situations range from the example of one railway operating trains for a few hundred feet using another's tracks in order to connect to its own track (running rights), to the proposal that CN and CP jointly use track in the Fraser River canyon. This proposal was made (but never implemented) 10 years ago[1] when double digit traffic growth was forecast.

Running rights and joint track usage complicate the technical operation of a railway. This is most obvious where freight and passenger services are combined. The problem is largely one of operating logic (and perhaps union agreements, where crews are paid on the basis of distance rather than time). Passenger trains accelerate faster and generally operate at faster speeds than freight trains. Also they are usually given higher priority. Problems with scheduling and signalling, especially road crossing protection, can be encountered.

In Canada at the moment, perhaps the most complex operational situation exists between Hamilton and Toronto, where one double-track line serves CN, CP, VIA Rail and GO Transit. This example falls somewhere between the simple running rights example and the Fraser River canyon example, and could be considered joint operations, since the construction of duplicate facilities has been avoided.

1.2 LEGISLATION AND REGULATION

1.2.1 Canada

Legislation concerning access to trackage of another company has been in the *Railway Act* for many years[2] and remained largely unchanged from the 1919 Act until the proclamation of the *National Transportation Act, 1987* (NTA, 1987).[3] When the NTA, 1987 was drafted, most of the provisions concerning the use of facilities belonging to another railway were taken from the *Railway Act* (section 134) and placed in Part III, Division I of the NTA, 1987, which only deals with freight (see Annex 1). Previously, section 134 of the *Railway Act* had applied to both freight and passenger rail; however, section 94 of the *Railway Act* (1970) remains intact (renumbered section 98) and provides for running rights or joint track usage if the directors of the respective companies agree.[4] The regulatory body's power to order a railway to permit a passenger operator on its lines appears to have been removed, since section 98 (formerly 94) merely provides for agreement by the respective carriers.

The NTA, 1987, section 148 provides for mandatory running rights. Reviewing how it has been applied (for freight) is instructive. The National Transportation Agency recently granted an organization that owns no track (known as MOQ Rail[5]) the status of a railway company under section 11 of the *Railway Act* as amended in 1987. The requirement for this status is similar to that for freight motor vehicle undertakings — a certification of fitness. In May 1990, MOQ Rail applied to operate under the provisions of the NTA, 1987, section 148, over CN lines between Moncton, New Brunswick, and Windsor, Ontario. Tests for a prototype operation (prior to certification under the *Railway Safety Act*) were planned; however, MOQ's application was withdrawn when CN purchased 50% of the company.

1.2.2 United States

In the United States, if Amtrak can demonstrate the need to operate over a section of line and can demonstrate that the line is inadequate for passenger operations, the Interstate Commerce Commission (ICC) can require the owning railroad to sell the line to Amtrak for an amount set by the ICC under the provisions of the *Rail Passenger Services Act of 1970* (45 USC 562(d)). As of early 1992, a case was pending before the U.S. Supreme Court that challenged the ICC's enforced sale to Amtrak of a line owned by Guildford Transportation, which owns and operates the Boston and Maine and the Maine Central Railroads. In this instance, Amtrak upgraded the line and then sold it to one of Guildford's competitors.

When Amtrak was established, several lines in the northeastern United States were conveyed to it, while in other areas, it operated over shared facilities. For example, Amtrak at one time operated through the Detroit to Windsor tunnel without paying for the use of the facilities and ran over the Canada Southern (then controlled by

ConRail) across southern Ontario to Niagara Falls. It picked up and carried Canadian passengers between Canadian points and did not pay for the use of the Canada Southern line. It neither sought nor received formal authority from the Canadian Transport Commission to operate on that route. Furthermore, the tunnel was a subsidiary of the Canada Southern, a Canadian company. Amtrak subsequently terminated the service and CP and CN purchased the Canada Southern, the tunnel and the railway bridge at Niagara Falls.

With respect to freight operations in the United States, the ICC has often ordered joint facility usage, especially in yards, when mergers have taken place. Running rights and access to yard facilities have been ordered to ensure that a railroad can connect its various segments of track, and that it can reach connecting carriers.

1.3 COMPENSATION

Canadian statutes are silent on the matter of compensation. There are several accepted methods of compensating a railway for the use of its facilities, and these are largely determined by the type of usage made and the privileges accorded to the user railway. There does not appear to be any impediment to two parties developing their own method of compensation based on the nature of the agreement.

In the simplest example — of using a very short stretch of track — the compensation normally consists of installing and paying for the connection(s) and sharing the maintenance costs of the short section of track. In other circumstances, if the host railway only permits the user to run over its line without picking up or delivering freight or passenger traffic, compensation normally consists of what is known as wheelage — that is, a fixed amount per car or locomotive that runs over the line. If the user is allowed to solicit business along the host line, compensation may be a percentage of the revenue generated by the user railway (for example, CP's arrangements for running over CN lines between Port Colborne and Welland).

2. Benefits and Costs of Greater Specialization in Track Use for Freight and Passenger Services on the Toronto–Ottawa–Montreal Track Network — A Preliminary Analysis

The subsection of Chapter 6 in Volume 1 entitled "Should a Separate Rail Track Agency be Public or Private?" notes the possibility of rationalizing track use in the Toronto–Ottawa–Montreal triangle. Chapter 18 notes that faster service on some passenger rail routes might be an element of development of some viable rail services. One suggestion presented to the Royal Commission was that dedicating one of the existing Toronto to Montreal rail lines to passenger rail might allow significant improvements in train speed, especially if accompanied by some track upgrading. The Royal Commission did not attempt any thorough evaluation of this suggestion — such an evaluation is the task of managers of passenger rail operations who, under the Royal Commission's framework, would have the main responsibility for judging whether such initiatives might be commercially viable. Some preliminary analysis, however, was carried out that may be of interest to those concerned with passenger rail possibilities.

This note considers the potential for the three class-1 railways — CN, CP and VIA Rail — to reorganize their infrastructure to deliver better rail services, and to do so more efficiently, through consolidating freight operations on one of the main line systems and dedicating the other to passenger service or, more likely, optimizing it to the requirements of passenger service. Any such change would require line upgrading and there could also be regulatory requirements to overcome.

2.1 General Concept

Achieving a substantial degree of specialization of the intercity track in the Toronto–Ottawa–Montreal triangle in either freight or passenger operations might require a single track authority. This note, however, does not concern itself with such possible institutional reform, but rather explores cost aspects of greater specialization in track use that would be relevant whatever the institutional arrangements.

From the passenger service point of view, potential benefits would arise out of:

(a) redistribution of the freight traffic on the existing lines so as to provide one Toronto to Montreal route that could be "optimized" for intermediate speed passenger operations; and

(b) any further arrangements that would help minimize the extent to which competing freight and passenger traffic were at odds.

The concept, as examined here, is not necessarily designed to result in one of the two principal rail rights-of-way becoming a "passenger-only" line, with all of the freight being shifted to the other line. The creation of a passenger-only track — especially using the present CN's Lakeshore route — could result in significant freight access problems and harm to local industry. Rather, the focus is on a system where one route would be optimized for, and carry, the passenger traffic and the other optimized for, and carry, most of the freight.

2.2 REQUIREMENTS FOR A UNIFIED SYSTEM OF TRACK

To achieve a workable collective or separated track operation, a blend of technical and operational changes would be necessary.

On the technical side, the CN and CP Toronto to Montreal tracks would need to be connected in four or more locations to allow reasonably convenient access from the northern, predominantly freight track (the present CP mainline) to freight yards and shippers to the south (on the present CN line). There would need to be fully automated, interlocked crossovers that allowed movement between the tracks at reasonable speeds. There are many points where such crossovers could be located. (See subsection 2.3.)

The second major technical change would be a requirement for an integrated signal, train control, and dispatching system for the two tracks, which could be tied into the individual CN and CP systems at each end. The integrated control system should not present insurmountable difficulties, especially since both railways have shown serious interest in the implementation of Advanced Train Control Systems (ATCS).

Other issues needing resolution would include redefining crew districts and seniority systems to reflect the different routing some of the freight trains may take, plus training freight train crews for the additional route. Both railways have successfully negotiated such issues in the past as a result of other structural changes in the railway system. It would also be necessary to develop some changes in the way liability for accidents is assessed. Again, CN, CP and VIA Rail have operated with running rights over parts of other railway systems and have developed methods of dealing with the issue.

Another issue that must be addressed is the capacity of the one route — in this discussion, the CP track — to efficiently handle the additional freight traffic displaced from the other route. In general, the capacity appears to exist, but there could be degradation of express-train trip times — which both CN and CP may find unacceptable for market reasons. Additional siding capacity would be needed on the single-track section between Toronto and Smiths Falls. Without simulation of the train configurations and dispatch times, it is difficult to predict the extent of the additional capacity requirements.

2.3 FREIGHT ACCESS

The development of satisfactory freight access from the present CP mainline to the present CN Lakeshore track seems possible at the cost of investing in new connections. Freight access is not as much of an issue on other segments of the "triangle." VIA Rail is the only user of, and has purchased, the Smiths Falls to Ottawa segment of the track. Between Brockville and Smiths Falls there is presently very little freight traffic, and this is unlikely to interfere with the passenger trains. On this segment, most passenger delays are due to the transition between the two routes at Smiths Falls. Thus, greater specialization of track use, in itself, could not be expected to be of any significant benefit to the passenger system; a by-pass or new connecting tracks would be required to make any noticeable improvement. (This has not been included in the notional cost estimates that appear later.)

On the Ottawa to Montreal route (CN's Alexandria Subdivision), there is little opportunity to provide alternative freight access for local traffic. The line also carries Ottawa to Montreal freight trains and some freight trains between western Canada and Montreal. There is alternative routing from the Lakeshore track to Ottawa via the CP Prescott Subdivision, and traffic from western Canada can be rerouted via CP's mainline through Smiths Falls.[6]

It should also be noted that VIA Rail presently owns most of CP's old M and O Subdivision right-of-way that runs from Ottawa to Dorion. The track has been removed from this route. While this would be a straight and direct route for passenger service, it would require new track at substantial cost.

2.4 BENEFITS OF REDUCED FREIGHT INTERFERENCE

It is sometimes suggested that reducing the number of freight trains on the Lakeshore track could create a significant benefit in improved passenger trip times since there would be less interference between freight and passenger trains. This is not likely to be the case. First, much of the CN freight traffic is scheduled at night and other times when there are no passenger trains, and some daytime freight trains do not operate on an express schedule, instead waiting for the passenger trains. Second, the Lakeshore route is a full double-track system with a significant siding capacity, which reduces freight and passenger interference.

In overall terms, our investigations suggest that there is little freight interference delay built into VIA Rail's present express-train times between Toronto and Montreal. If anything, there may be more interference between individual passenger trains at station stops.[7] Other potential interference between the freight and passenger systems is more incidental and can be eliminated or reduced without restricting the number of freight trains.[8] On average, reducing freight-passenger interference by restricting the number of freight trains on the Lakeshore route could only shorten the passenger-trip time by a few minutes — because mainly through-freight (which interferes little) could be shifted to the CP route, and the present level of way-freight activity (which interferes more) would continue.

Of more benefit may be the potential for greater schedule flexibility (arrival and departure times) that might be gained through reducing the number of freight trains on the Lakeshore route. However, this type of freight and passenger interference often takes place in urban areas and at other points where geography limits the potential for reducing the number of freight trains. For example, eastbound CN freight access from the Montreal yard over the Victoria Bridge to the Maritimes appears to be one of the governing factors in the scheduling of passenger trains into and out of Montreal's Central Station. Given the importance of the timeliness of these trains to the Halifax container terminals, competing against Montreal and U.S. rivals, there is only limited flexibility here.

2.5 BENEFITS OF HIGHER SPEED LIMITS

Given the present demands on the transportation system, greater potential benefits from the creation of a "passenger-optimized" Toronto to Montreal route may result from raising the passenger train speed limit. At present, with a mix of freight and passenger trains — operating over level crossings at quite different speeds — the passenger train speed limit is 95 mph (153 km/h). Steps that might be taken to improve passenger train trip times include adjusting crossing signal timings to safely allow higher speed operation through grade crossings, and resetting curve super-elevations more in line with passenger train speeds.

How much and what type of freight remains on the passenger-optimized line will be important. Assuming that higher speed operation through grade crossings is considered reasonable — Amtrak allows 110 mph (177 km/h) operation through grade crossings in the Northeast Corridor — it would be necessary to reset all of the grade-crossing protection circuits to provide the necessary warning time at higher speeds. Presuming some freight traffic is to be retained, it would be advantageous to provide some form of "smart" grade-crossing circuits that would detect the difference in train speeds and provide the appropriate warning time. (Imposing a long wait on motorists for a slow freight train undermines crossing signal credibility, and encourages motorists to take risks.) The technology for smart grade crossings is available, but its installation could be expensive.

Resetting curves would allow passenger trains to negotiate them at a higher speed, but curves cannot be fully optimized for passenger service if freight traffic is to be continued. While there are curves on the Lakeshore route, it is not overly curvaceous. Thus, the potential gains in trip time will be limited. On the other hand, if one were prepared to wait, the cost of resetting curves would be modest, since much of this work could be carried out as part of the routine and scheduled track maintenance programs.

In terms of the signal system itself — for protecting following and opposing train movements — preliminary investigations do not suggest that much additional investment would be required to allow higher passenger train speeds within the range that is being considered. It appears that present block lengths and stopping distance allowances would be sufficient to allow 105 mph (170 km/h) or higher operation in many of the non-urban areas of the Lakeshore route.

How much time could be gained on a Toronto to Montreal trip? VIA Rail's present best trip time with an F-40 locomotive and four LRC cars is 4 h 10 min with an intermediate stop only at Dorval. For every 5 mph (8 km/h) gain in the average achievable speed in the non-urban areas (roughly Pickering to Dorval), approximately 10 minutes could be taken off the trip time. A 20-minute improvement in trip time might be achievable — perhaps a bit more — without substantial investment (more than estimated in subsection 2.6). In addition, there appear to be other modest investments that would result in a savings of trip time. What is not at all clear is how much of the overall time savings may be achievable within the present context, and how much might require the shifting of freight traffic.

An important issue in improving train speeds on the Lakeshore route that is often overlooked is the capabilities of the rolling stock itself. The LRC locomotive has been tested to speeds as fast as 125 mph (200 km/h), although neither CN nor VIA Rail would want to operate such a heavy locomotive at that speed. The newer F-40s have been cleared to operate at 95 mph (153 km/h). It is not known how much more speed can be gained from this equipment. What is clear is, however, that going to much higher speeds would require the shortening of the trains or adding a second locomotive. Under present circumstances, the addition of even one car to a four-car LRC-powered train would result in a noticeable performance degradation if run to VIA Rail's fastest schedule. The potential need for more powerful locomotives, or for a second locomotive unit, will have to be included in any analysis of the gains from increased speed. In many cases, the second locomotive may already be available in the present (or projected) fleet to handle peak train sizes; it simply is not used on days when demand dictates a shorter train.

2.6 NOTIONAL CAPITAL COSTS FOR AN INTEGRATED SYSTEM

In terms of infrastructure investment, costs of a general order of $60 million would be required to interconnect the two systems substantially to allow ease in rerouting intercity freight trains and faster passenger-train operation. The following are the types of investment required:

Table 6(2)-1
COST OF INVESTMENTS FOR AN INTEGRATED SYSTEM

Investment	Notional cost
Provision of interconnections between CN and CP main track	$15 million to $20 million
Provision of new signal interlockings and consequent changes	$15 million to $25 million
Alteration of grade-crossing circuits (Lakeshore)	$10 million to $20 million
Improvements to CP main track	about $5 million
Total	**$45 million to $70 million**

2.7 NOTIONAL TRACK OPERATING AND MAINTENANCE COSTS

An examination of VIA Rail's cost data indicates that approximately $15 million is paid annually to CN and CP (mostly CN) for use of the track between Toronto, Ottawa and Montreal as defined in the subject network. This figure is higher than that paid under the basis of estimated system-average variable unit cost, which was used in the past for determining compensation to the freight railways for passenger train use. It reflects an acceptance of the propositions that:

- the passenger service constitutes a substantial component of the traffic between Toronto and Montreal, and accounts for costs that would not be avoidable under most Canadian passenger-rail circumstances;
- for track for which VIA Rail is sole user, it must pay the total (not just the variable) cost;
- the costs of maintaining a track for higher than average speed passenger operations are higher than average; and
- incentive payments for service can be effective where regulatory compulsion fails.

CN's and CP's total cost,[9] not including corporate overhead, of maintaining and operating track in this network is about $75 million per year. (This amount includes the cost of train dispatching; the area includes the links to Ottawa.)

2.8 ATTRIBUTION OF COST

Shifting the proportions of freight and passenger to concentrate freight on the CP line would result in a larger proportion of the present CN track costs being attributed to the passenger system, especially that portion of the costs independent of traffic levels. Routine rail replacement and other maintenance requirements for the track specialized for passenger use can be expected to decrease simply because of the decreased traffic levels.[10] At the same time, higher passenger speeds would cause increased unit costs from:

- increased track damage due to dynamic loads; and
- tighter track (line, level and gauge) tolerances.

Presumably the track would be priced on the basis of the value of the service provided; traffic that could not cover its marginal cost would not be accepted. Estimates of service value and marginal cost are far beyond the scope of this very preliminary exploration; however, two cost allocation possibilities — essentially limits within which true causality should fall — are shown in Table 6(2)-2.

Table 6(2)-2
ALLOCATION OF NOTIONAL TRACK OPERATING COSTS

	Proportion of traffic		Allocated cost	
Allocation	**Tonne-km (%)**	**Train-km (%)**	**Tonne-km ($ million)**	**Train-km ($million)**
Passenger	11	40	8	30
Freight	87	57	65	43
Commuter	2	3	2	2

Table 6(2)-2 does not include any charges for administration of a track operating authority or for necessary capital investment. Nor are GO Transit's track ownership or maintenance costs considered. It will be seen that annual operating costs allocated to passenger rail could well exceed current VIA Rail payments for track use by $5 million to $10 million. In addition, some portion of the roughly $60 million in one-time capital costs should be attributed to the passenger rail service. Track specialization, and the modest investment in track upgrading for passenger-only use, might improve the time of the faster Toronto to Montreal train from 4 h 10 min to about 3 h 30 min.

ENDNOTES

1. This proposal considered joint CN and CP operations in the Fraser Canyon with westbound trains using CN tracks and eastbound trains using CP tracks. De Leuw Cather Canada Ltd., *Joint Track Usage Study: Kamloops–Mission B.C.,* November 1985.

2. An early reference to *running rights* appears in the *Railways Clauses Consolidation Act,* (8 Vict. c.20) of 1845 (British). Much Canadian railway legislation was patterned on this statute.

3. The running rights provisions in the *Railway Act* and the NTA, 1987 only apply to federally incorporated railways (this includes U.S. railroads connecting into Canada). The National Transportation Agency can order a federal railway to permit a connection with a provincially incorporated railway.

4. Recommendation by the National Transportation Agency and sanction by the Governor in Council are also required.

5. MOQ Rail is developing a prototype operation using highway type trailers fitted with both highway type wheels and steel rail type wheels. The motive power would be provided by highway style cabs. The trailer concept has similarities to the successful RoadRailer system operated by Triple Crown (a subsidiary of Norfolk Southern) in the United States. The motive power is a new departure.

6. Such a scheme for trains to and from western Canada has been discussed for many years and may have benefits for CN and CP independently of any passenger system benefit.

7. For example, four passenger trains stop at Kingston during a half-hour period on weekday mornings. Often, one or more of these trains must wait for one of the other passenger trains to clear the station.

8. For example, at Brockville, additional delay is sometimes incurred because there is direct foot access to only one track, and there is no physical barrier between the two main tracks. Providing a passenger underpass or overpass, and building a fence between the tracks would eliminate some of the problems here.

9. Operating cost and sustaining capital.

10. The counterpart to much of this savings would be increased replacement and maintenance requirements for the CP track to which the freight traffic would be shifted.

ANNEX 1

THE *NATIONAL TRANSPORTATION ACT, 1987*

Provisions of the *National Transportation Act, 1987* (NTA, 1987) dealing with running rights and joint track usage are under the title Railway Freight.

- Section 148 authorizes the National Transportation Agency to direct one railway company to provide access to another and to set the required amount of compensation the user must pay. The Agency may exercise this power where the two companies cannot reach an agreement and rail access is deemed to be in the public interest.
- Section 149 authorizes the Governor in Council, after specified process, to order common use of a railway right-of-way and fix the amount of compensation to be paid for that common use.

Presumably such provisions apply solely to freight. There is no obvious reason why they should not also be made applicable to passenger rail.

Subsection 174(6) provides that when a railway line is transferred from one railway company to another, the selling railway is relieved of its obligations related to the operation of that line under the NTA, 1987 or any other Act of Parliament. However, when VIA Rail has an existing operation on a line sold by a federal company to another company (either federal or provincial), the line remains under federal jurisdiction. The acquiring company inherits all the obligations of the selling company, including those under the *Canada Labour Code,* for example, the selling railway's collective agreements.

If a line with VIA Rail service transferred from one company to another is then abandoned, or VIA Rail service is discontinued, the line is no longer deemed to be a work for the general advantage of Canada and may be transferred out of federal jurisdiction.

NOTES TO CHAPTER 7: ENVIRONMENTAL EFFECTS OF INTERCITY PASSENGER TRANSPORTATION

1. Introduction

The Royal Commission's considerations of environmental issues were aided by two pieces of contracted research. The first is by VHB Research & Consulting Inc., "Environmental Damage from Transportation," published in Volume 4 of this report,[1] which summarizes the nature and effects of environmental damage, and provides estimates of air pollutant emissions by intercity passenger mode in Canada. It also considers the practicality of methods of assessing the social costs of environmental damage, and offers some estimates of the costs of air pollution per mode. In view of its availability in Volume 4, only the briefest summary of the effects will be provided in these notes.

The second piece is by William A. Sims, "Externality Pricing," which is distributed as RR-07 in the series of reports prepared for the Royal Commission.[2] It reviews the theoretical case for direct pricing of such externalities as environmental damage, from the economic literature. The policy issues in charging for environmental damage, or otherwise approaching damage mitigation through economic incentives/ disincentives, are also reviewed thoroughly in a Government of Canada paper that became available during the Commission's deliberations, *Economic Instruments for Environmental Protection*.[3]

1.1 MAIN ENVIRONMENTAL EFFECTS

The environmental effects of passenger transportation that are of main policy concern are:

- air pollution;
- global warming; and
- noise.

Another important environmental effect is the disruption of local communities by transport infrastructure and traffic.

These effects all cause harm to natural ecosystems or to people or communities, but harm that is outside our normal system of markets. Thus, it is unpriced, failing to appear as a cost to the transport carrier or passenger. These effects also all differ spatially, seasonally and by time of day. A pricing system that incorporated these "externalities" in decisions about infrastructure investment and use would (at least to some extent) reduce the extent of transportation, and cause shifts toward those modes of travel, locations and times that would cause less environmental damage.

Most of what follows in these notes refers to air pollution and global warming because those are the effects for which most information is available. It is anticipated that a policy framework dealing with these effects should also apply to noise and community disruption; some relevant policy aspects of the damage are mentioned below.

2. Emissions from Engines and Vehicles

2.1 EMISSIONS OF MAIN CONCERN[4]

2.1.1 Volatile Organic Compounds

Volatile organic compounds (VOCs) include the volatile hydrocarbons of unburned fuel in exhaust gases, or evaporated from engines and gas tanks (and filling stations). These are of concern primarily because of their contribution to the formation of low-level ozone (discussed later). About 40% of all VOCs from non-natural (man-made) sources originates from transportation.

2.1.2 Nitrogen Oxides

Oxides of nitrogen (NO_x) are fuel combustion by-products, formed particularly at high engine temperatures, and, therefore, disproportionately by diesel engines. Nitrogen dioxide (NO_2) is of concern because it can cause harm to health and damage to vegetation, and it reduces urban visibility (forming the brown haze on hot days in large cities). Through chemical conversion, NO_x also contributes to the formation of ozone and of nitric acid, a component of acid rain. Transportation is responsible for about 60% of all non-natural NO_x emissions.

The most important, and complex, role of transportation NO_x is in the formation of ozone. This gas is important to the environment in two very different ways. More familiar to the public is the "ozone layer" in the high atmosphere, which acts as a reflective screen against solar ultraviolet radiation, preventing harmful amounts of radiation from reaching the Earth's surface, where they would add to global warming and increase skin cancer. The concern is that this layer is being depleted through artificial disruption of natural processes.

Quite the opposite concern is expressed when ozone exists in the atmosphere close to ground level, where its effects are harmful rather than beneficial. Low-level ozone is formed from chemical conversion of NO_x in sunlight, with VOCs aiding the reactions. Non-natural emissions are partially responsible, including those from transportation. This "low-level" ozone can be transported downwind, but breaks down through further chemical processes within hours or days. Concentrations increase over cities with high NO_x and VOCs emissions, particularly in summer, in "episodes" that last a few days. Effects can be felt over regions encompassing groups of cities arranged along the direction of the prevailing air currents, and over the intervening rural areas.

Ozone concentrations are greatest in three regions of Canada: the Lower Fraser Valley of British Columbia; the "corridor" between Windsor, Ontario, and Quebec City, Quebec; and in the area of Saint John, New Brunswick. Ozone originating from adjacent U.S. industrial areas is largely responsible for the concentrations in the latter region, and contributes substantially to concentrations in southern Ontario and Quebec.

Potential harmful effects of low-level ozone include respiratory problems and damage to foliage of crops and trees. Furthermore, ozone in the lower atmosphere itself acts as a "greenhouse gas," absorbing heat radiated from the Earth and adding to global warming.

The low-level ozone is effectively unconnected to the high-level "ozone layer," so the Earth faces simultaneously an excess of ozone in the lower atmosphere and depletion in the upper atmosphere.

The contribution of transportation NO_x to ozone formation, as well as its effects, depends on the altitude at which the emissions occur. As the great bulk are at ground level (from motor vehicles, trains and ships), the main potential problem is the direct damage ozone causes to people and foliage.

Aircraft emissions, however, present different problems. There is increasing evidence that NO_x emitted by aircraft in the high troposphere (at the cruising altitude of modern jets) is particularly potent at producing ozone.[5] That ozone is unlikely to reach people and crops at ground level, but might be adding substantially to global warming. Furthermore, supersonic aircraft operate at much higher altitudes, close to, or even within, the "ozone layer." Paradoxically, their emissions of NO_x at those altitudes do not create ozone, but actually contribute to its depletion. At present, there are very few such aircraft operations, but if the supersonic fleet were to expand greatly, control of their NO_x emissions might become a priority.

2.1.3 Carbon Monoxide

Carbon monoxide (CO) is a combustion by-product with potentially serious health effects. About 60% of total non-natural emissions are from transportation, and 75% of transportation emissions come from passenger cars, pick-up trucks and vans.

2.1.4 Particulates

Particulates are solid materials in engine exhaust, consisting of about 75% carbon (soot) and 25% "polycyclic aromatic hydrocarbons," which potentially cause cancer. Transportation sources account for only about 1.3% of total non-natural particulate emissions, but a larger portion of the very small particles that are considered more problematic (those less than one hundredth of a millimetre in diameter). Very small particles are emitted more by diesel engines than by gasoline engines or turbines.

2.1.5 Sulphur Dioxide

Sulphur dioxide (SO_2) is a by-product of burning fossil fuels containing sulphur. It is of concern for its potential direct health effects and also its conversion to form sulphuric acid, the predominant acid in acid rain. Emissions depend on the amount of sulphur in fuels (including how much is removed from oil during refining). The sulphur content of diesel is higher than that of gasoline and aviation fuel, and is greater for marine diesel than for diesel used in motor vehicles or trains. Transportation contributes only about 2.2% of total non-natural emissions in Canada, of which one third is from marine engines. Non-ferrous smelting and thermal power generation provide the bulk of emissions.

2.1.6 Chlorofluorocarbons

Chlorofluorocarbons (CFCs) are used as blowing agents, coolants in air conditioning systems and refrigeration in all transport modes, and in foam padding and seats. CFCs are of concern for their destruction of the ozone layer. Motor-vehicle air conditioners have recently contributed about 25% of Canadian CFC emissions; the remainder comes largely from commercial refrigeration and air conditioning. Replacement chemicals are expected to be introduced rapidly in accordance with Canada's announced goal to eliminate CFC use by 1997. (This goal is discussed later in this chapter.)

2.1.7 Carbon Dioxide

Carbon dioxide (CO_2) is a by-product of combustion of any carbon-based fuel (such as oil, coal or wood), and is of concern as the major contributor to the "greenhouse effect" of global warming. Unlike VOCs, NO_x and CO, which can be controlled by exhaust-treatment techniques, CO_2 remains unchanged, and therefore varies directly with the amount of fuel used. About one quarter of total non-natural emissions are from transportation, the bulk of the remainder being from power generation, industrial energy use and space heating. CO_2 is released naturally by all plants and animals as a consequence of energy production (as when the body processes food carbohydrates and oxygen into energy, creating waste products of carbon dioxide and water vapour); CO_2 is also the result of natural decaying or burning of vegetation, and of volcanic activity.

2.2 AMOUNTS OF EMISSIONS BY INTERCITY MODES

Emissions by mode, in grams per unit of fuel used, were obtained from the VHB study for the Royal Commission, reproduced in Volume 4 of this report.[6] Estimates are provided of energy use by mode in megajoules per passenger-kilometre, and of emissions in grams per passenger-kilometre of CO_2, SO_2, NO_x, non-methane hydrocarbons (VOCs), particulates and CO. For intercity passenger travel, and the attempts to cost and price the environmental damage, it is assumed that the crucial emissions are those of CO_2, NO_x and VOCs, so the estimates that follow are confined to those.

The estimates of emissions for passenger cars were modified to combine estimates for cars and light trucks, based on light truck emissions of NO_x and VOCs being 20% greater per vehicle-kilometre than car emissions. (This value was derived from weighted national averages of the information in Tables 5 and 6 of the VHB report.) Highway fuel consumption, and therefore CO_2 emissions, are estimated to be 33% higher per vehicle-kilometre for light trucks (12 L/100 km versus 9 L/100 km). The combined results appear as estimates for "cars" in the tables.

The estimates of average fuel consumption by mode were also modified by the Royal Commission staff, as discussed in the Notes to Chapter 3. The VHB estimates of emissions by mode have been converted first to grams per megajoule (g/MJ) of fuel, represented in Table 7(2)-1.

Table 7(2)-1
Ratios of Emissions to Energy Use (g/MJ)

Mode	CO_2	NO_x	VOCs
Bus	70.8	0.915 to 0.962	0.106 to 0.135
Car	73.8	0.388 to 0.482	0.488 to 0.599
Train	70.7	1.428 to 1.442	0.069 to 0.195
Airplane	70.8	0.045 to 0.174	0.030 to 0.037
Ferry	81.6	0.091 to 0.120	0.009 to 0.012

These are multiplied by estimated system-wide average consumption of MJ of energy, obtained from Royal Commission staff estimates of average fuel use, as in Table 7(2)-2.

Table 7(2)-2
System-Wide Average Fuel Use by Mode

Mode	Energy/Fuel (MJ/L)	Amount travelled/ Fuel (pass-km/L)	Energy/Amount travelled (MJ/pass-km)
Bus	38.68	57.8	0.67
Car	34.66	18.6	1.86
Train	38.68	23.4	1.65
Plane	37.68	9.7	3.88
Ferry[a]	38.68	5.2	7.39

a. See endnote 7.

Then multiplying g/MJ by MJ/pass-km gives grams of emissions per passenger-kilometre by mode, as in Table 7(2)-3.

Table 7(2)-3
Estimated Emissions per Passenger-Kilometre (g/pass-km)

Mode	CO_2	NO_x	VOCs
Bus	51.7	0.500 to 0.860	0.070 to 0.100
Car	125.5	0.659 to 0.819	0.829 to 1.019
Train	116.9	2.361 to 2.385	0.115 to 0.323
Plane	274.9	0.175 to 0.676	0.116 to 1.144
Ferry	603.0	0.672 to 0.887	0.067 to 0.089

2.3 SUMMARY OF KNOWLEDGE OF EFFECTS[8]

2.3.1 Health

The federal government has established National Ambient Air Quality Objectives (NAAQOs)[9] for the major pollutants, specifying levels that are the maximum "acceptable," intended to provide adequate well-being and personal comfort. Measurements of pollutants are taken continually by Environment Canada at numerous sites across the country. Interpretation of the results shows that, while there are some potential health problems posed by high local concentrations of CO, NO_2 and diesel particulates, none of these is found routinely in concentrations that violate the National Ambient Air Quality Objectives.[10]

A much greater concern is the exposure of people to low-level ozone. Canada's NAAQOs for a one-hour exposure to ozone is exceeded occasionally in most large cities, and regularly so in the Lower Fraser Valley of British Columbia, southern Ontario, the area of Quebec between Montreal and Quebec City, and southeastern New Brunswick.[11] There is evidence that ozone at these concentrations causes breathing difficulties, particularly among asthmatics (5% of the population). Periods of high ozone have also been linked with increases in hospital admissions and use of medication for respiratory problems.[12]

2.3.2 Materials

Acid rain can affect building stone and mortar; NO_2, nitric acid and ozone can affect paints; NO_2 and ozone can affect fabrics; SO_2, NO_2 and nitric acid can affect metals. But the laboratory demonstrations of these effects are conducted using concentrations far higher than exist in Canada. The VHB research report for the Royal Commission concludes there is "no evidence that existing levels in the Canadian environment adversely affect materials."[13]

2.3.3 Forest Resources

Substantial effects of acid rain on germination and survival of tree seedlings are seen only at levels of acidity higher than found in Canadian rainfall, and no definitive trends in responses of forests to ozone have been found.

2.3.4 Crops

Effects of ozone in damaging foliage, and therefore crop yields, are well established, with resulting reductions in annual crop values estimated for Ontario at $15 million to $23 million in 1984.[14] NO_2 and acid precipitation at Canadian levels are not thought to cause substantial damage to crops.

2.3.5 Fish

NO_x deposited as acid rain has adverse effects on life in eastern Canadian lakes. Approximately 150,000 lakes are being damaged, more than 14,000 of which have been described by Environment Canada as "acidified."[15]

2.4 GLOBAL WARMING

Scientific concern has increased that non-natural additions of certain gases to the atmosphere increase the atmosphere's retention of radiated heat in a "greenhouse effect" that raises average global surface temperatures. Research has not produced definitive findings on the extent and effects of such warming, so an Intergovernmental Panel on Climate Change was established in 1988, under the United Nations Environment Programme. This panel of scientists reviewed the scientific evidence, concluding:

> We are certain of the following:
>
> - There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.
> - Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse

gases: carbon dioxide, methane, chlorofluorocarbons and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface.[16]

The panel predicts that, if no control measures are taken, global mean temperature will rise above pre-industrial levels by more than 2°C by 2050 and 4°C before 2100. Among the important effects, thermal expansion of the oceans and melting ice would raise global mean sea level by about 6 cm per decade.

The Canadian Climate Program Board has predicted that the potential effects in Canada would include:

- a shift of climatic zones several hundred kilometres northward over the next 50 years, significant degradation of permafrost, changes to ecosystems and wildlife habitat at so fast a rate that some species may be unable to survive, disruption to northern indigenous people, and threats to northern buildings and pipelines;
- increased drought risks, especially in the Prairies;
- increased probabilities of forest fire and insect and disease attacks;
- adverse effects on human health from more frequent and intense heat waves in cities, and the northward spread of tropical diseases; and
- an increase in soil erosion, changes to coastal ecology, damage to wetlands and important fisheries, and substantial costs for coastal protection due to rising sea levels.

The Board also suggests there is some potential for northward expansion of agricultural crops where soils permit.[17]

Descriptions of potential global effects are provided in a recent U.S. National Academy of Sciences study.[18] To date, estimates of the costs that would be imposed by the predicted effects have not been made for Canada, and are rare worldwide. Predictions of the effects by sector of activity in the United States lead Nordhaus[19] to suggest that identifiable costs would be equivalent to about one quarter of 1% of national income, and his judgement is that including unmeasured effects and uncertainty puts the upper limit at 2% of national income.

3. Current and Announced Control Strategy for Air Pollution

3.1 VEHICLE EMISSION STANDARDS

Control of transportation air pollutants is mostly by federal regulation of limits for emissions from new vehicles, and is essentially limited to road vehicles. Aircraft jet engines are subject to limits set by the International Civil Aviation Organization, to which all Canadian engines conform, even though the standards have no legal force in Canada. No regulations exist for locomotive engines. Ships are subject only to a federal smoke limit, which is a remnant of the coal-fired steamship era.

Motor-vehicle exhaust emissions are controlled by regulations for new vehicle performance under the federal *Motor Vehicle Safety Act*, administered by Transport Canada. The standards were tightened substantially for new cars in 1986 and new trucks in 1988, essentially to be equal to U.S. standards. Those standards in the United States have since been made even more stringent, and plans have been announced by Environment Canada and Transport Canada to "harmonize" with those shortly.[20] Thereafter it is the intention to maintain equivalence with the United States, thus continuing to have the most stringent standards in the world. Those plans also include examining the feasibility of regulating emissions released by aircraft, ships and trains.

Emissions through the lifetimes of motor vehicles are regulated to some extent through the new vehicle standards, which specify performance to be met over a designated vehicle lifetime. Nevertheless, emissions can increase over lifetime through poor maintenance or tampering with emission control equipment. Provincial programs of compulsory periodic emissions testing are proposed in the NO_x/VOCs Management Plan for the "ozone non-attainment areas" of southern British Columbia and the Windsor to Quebec City corridor (see description of the Plan, which follows). British Columbia introduced a testing program for cars and light trucks in the lower mainland in September 1992.

3.2 ANNOUNCED NATIONAL OZONE CONTROL STRATEGY

3.2.1 Multinational Goals

NO_x: Under the NO_x Protocol of 1988, Canada and 24 other countries are committed to freezing national NO_x emissions at 1987 levels. Canada's strategy is contained in the NO_x/VOCs Management Plan.

VOCs: By a similar international agreement signed in November 1991, Canada will by 1999 freeze VOCs at 1988 levels, and reduce them by 30% in two areas designated under the agreement as "tropospheric ozone management areas": the Lower Fraser Valley and the Windsor to Quebec City corridor.

3.2.2 NO_x/VOCs Management Plan

Recognizing ozone as the prime air pollution problem in Canada, the Canadian Council of Ministers of the Environment (CCME) adopted, in November 1990, a Management Plan for NO_x/VOCs.[21] The Plan includes a number of new nation-wide regulations, which in the transport sector involve further tightening of motor-vehicle emission standards starting in 1996. In addition, the Plan designates the three Canadian regions that frequently exceed ozone NAAQOs as "ozone non-attainment areas": the Lower Fraser Valley, the Windsor to Quebec City corridor, and the Saint John area. For these, separate targets for NO_x and VOCs reductions are being negotiated with the provinces concerned, and the plan envisages adopting special local control measures. The list being considered initially includes, for the transport sector:

- more rigorous speed-limit enforcement in summer;
- motor-vehicle inspections and anti-tampering laws;
- reduction in summer gasoline volatility; and
- evaporative loss controls at refuelling stations.

The plan includes forecasts to 2005 of expected changes in emissions, based on economic and population growth estimates, National Energy Board (NEB) estimates of energy demand by sector of activity, and demand growth estimates and input fuel mixes for electricity generation provided by provincial power utilities. For road transportation, it includes forecasts of vehicle sales provided by the Motor Vehicle Manufacturers Association, together with NEB estimates of total vehicle fleet size and use (assuming constant annual kilometres per vehicle).[22]

Effects of the Plan were predicted as changes in these forecasts. Some details of the main sources of NO_x and VOCs are shown in Tables 7(2)-4 and 7(2)-5, together with predictions for 2005 with and without the impacts of the new Plan. It can be seen that emissions of both NO_x and VOCs were predicted to increase by about 6% from 1985 to 2005 in the absence of the Plan, as growth in the use of stationary sources outweighed the very substantial continuing reductions in transport sources resulting from already-established motor-vehicle standards. The Plan expects NO_x levels to decrease until 1995 due to a sharp decline in emissions from light and heavy vehicles. This will result from increasing numbers of vehicles equipped with emission controls that meet recent standards, combined with modest reductions in rail emissions. These transportation reductions outweigh increases in emissions from other sectors until about 1995. Thereafter, the increases in motor-vehicle use are expected to offset remaining reductions in average fleet emissions per vehicle-kilometre, so that total national emissions first flatten and then begin to rise slowly as emissions continue to grow in other sectors.

Table 7(2)-4

Nitrogen Oxides Emissions and Projections to 2005

Source	1985 (kt)	Proportion of total (%)	2005 base case (kt)	Change from 1985 (%)	2005 with plan[a] (kt)	Change from 1985 (%)
Transport						
Road						
Cars, light trucks	453	24.0	238	−47	169	−63
Heavy trucks	285	15.1	260	−9	235	−18
Off-road	261	13.8	346	+33	338	+30
Subtotal road	999	52.9	845	−15	742	−26
Air	33	1.8	42	+27	42	+27
Water	15	0.8	19	+24	19	+24
Rail	132	7.0	113	−15	113	−15
All transport	**1,180**	**62.5**	**1,018**	**−14**	**916**	**−22**
Stationary sources						
Power generation	248	13.1	352	+42	230	−7
Natural gas industry	159	8.4	205	+29	202	+27
Indust./comm. fuel use	145	7.7	207	+43	141	−3
Residential fuel use	41	2.2	37	−11	33	−20
Industrial processes	89	4.7	140	+57	129	+45
Other	25	1.3	36	+44	37	+48
All stationary sources	**707**	**37.5**	**977**	**+38**	**772**	**+9**
TOTAL	**1,887**	**100.0**	**1,995**	**+6**	**1,687**	**−11**

Source: Canadian Council of Ministers of the Environment, *Management Plan for Nitrogen Oxides and Volatile Organic Compounds, Phase I,* November 1990.

a. After implementation of the measures currently outlined in the NO_x/VOCs Management Plan.

Table 7(2)-5

Volatile Organic Compounds Emissions, and Projections to 2005

Source	1985 (kt)	Proportion of total (%)	2005 base case (kt)	Change from 1985 (%)	2005 with plan[a] (kt)	Change from 1985 (%)
Transport						
Road						
Cars, light trucks	557	31.2	350	–37	262	–53
Heavy trucks	54	3.0	48	–11	48	–11
Off-road	90	5.0	109	+22	109	+22
Subtotal road	700	39.3	507	–28	419	–40
Air	10	0.6	13	+30	13	+30
Water	28	1.6	32	+13	32	+13
Rail	7	0.4	6	–15	6	–15
All transport	**745**	**41.8**	**558**	**–25**	**469**	**–37**
Stationary sources						
Solvent use	502	28.2	603	+20	431	–14
Industrial processes	152	8.5	239	+57	173	+14
Fuelwood combustion	108	6.0	133	+23	133	+23
Slash burning	80	4.5	129	+60	129	+60
Gas distribution	109	6.1	124	+14	67	–39
Industrial fuel use	50	2.8	64	+29	60	+21
Other	36	2.0	42	+17	42	+17
All stationary sources	**1,037**	**58.2**	**1,334**	**+29**	**1,034**	**(no change)**
TOTAL	**1,782**	**100**	**1,892**	**+6**	**1,504**	**–16**

Source: Canadian Council of Ministers of the Environment, *Management Plan for Nitrogen Oxides and Volatile Organic Compounds, Phase I,* November 1990.

a. After implementation of the measures currently outlined in the NO_x/VOCs Management Plan.

For VOCs, a rapid decline in emissions is also expected from motor vehicles in the short term, outweighing increases in other sectors. Motor vehicles, however, contribute a smaller proportion of total VOCs emissions than total NO_x emissions, and their reductions are expected to be overtaken earlier than 1995 by persistent increases in VOCs from non-transportation sources.

Adopting proposals identified in the national Plan would reduce total NO_x emissions in 2005 by about 11%, and VOCs emissions by 16% over recent levels. The Plan also envisages tightened objectives and extended programs in the future, particularly in the non-attainment areas.

The CCME forecasts that implementing the Plan will substantially reduce peak ozone concentrations and periods exceeding the maximum acceptable NAAQO. In 2005, the annual hours in excess of the latter standard would be halved in the Lower Fraser Valley and Saint John area, and reduced by 20% to 40% in the Windsor to Quebec City corridor, east of Toronto.[23] The improvements are expected to be even greater when combined with announced control programs in the United States. The CCME expects implementation of the amendments to the U.S. *Clean Air Act* to reduce NO_x emissions by 30% and VOCs emissions by 40% to 50% in those regions of importance to Canadian ozone concentrations (the U.S. Eastern Seaboard, the area south and west of lakes Erie and Ontario, and the Seattle area). This reduction will bring important additional reductions in periods exceeding the maximum acceptable NAAQO for ozone in southwest Nova Scotia and throughout the Windsor to Quebec City corridor, particularly to the west of Toronto.[24]

4. Global Warming and Canada's Proposed Actions[25]

4.1 GREENHOUSE GAS EMISSIONS IN CANADA

Minor transport contributions to global warming arise from CFCs in automobile air conditioners and methane from natural gas distribution. Low-level ozone, to which transport emissions of NO_x and VOCs contribute, also adds to the greenhouse effect. All such contributions are dwarfed by transport emissions of CO_2 from burning carbon fuels.

4.1.1 Carbon Dioxide

Emissions of CO_2 in 1990, and projections for the years 2000 and 2010, are shown in Table 7(2)-6. It will be seen that transport accounts for about 25% of the Canadian total of some 520 Mt, with road vehicles alone responsible for about four fifths of the transport contribution, or 20% of the total.

Table 7(2)-6
CARBON DIOXIDE EMISSION PROJECTIONS 1990–2010[a]

Source	1990 (Mt)	Proportion of total (%)	2000 (Mt)	Change from 1990 (%)	2010 (Mt)	Change from 1990 (%)
Transport						
Road						
Cars, light trucks	67	12.9	70	+4		
Heavy trucks	41	7.9	46	+12		
Subtotal road	108	20.8	116	+7		
Air	14	2.9	16	+18		
Water	5	1.0	6	+10		
Rail	3	0.6	4	+15		
All transport	**132**	**25.5**	**141**	**+7**	**150[b]**	**+15**
Stationary sources						
Residential	57	11.0	57	(no change)	57	(no change)
Commercial	27	5.2	30	+11	32	+20
Industrial	133	25.7	159	+20	200	+50
Producer consumption	77	14.9	93	+20	107	+40
Power generation	92	17.8	108	+17	130	+40
Total	**518**	**100**	**590**	**+14**	**675**	**+30**

Source: National Energy Board, and Transport Canada; distributions within transport sector interpolated from Transport Canada estimates for 1987 and 2005.

a. One tonne of carbon dioxide contains 0.2727 tonnes of carbon.
b. Modal breakdown not available for 2010.

The projections are made by the National Energy Board (NEB),[26] using historical relationships among CO_2, national output, population growth and energy prices. Central assumptions are that gross domestic product (GDP) will grow at 2.3% per annum, the number of households at about 1.4% per annum, and the car stock at about 1.5% per annum, while the price of crude oil increases from US$20/barrel in 1990 to US$27/barrel in 2010 (in constant 1990 dollars). Growth in energy use overall and in CO_2 are expected to be at lower rates over the next 20 years than during the last two decades, which will continue the substantial downward trend in emissions per unit of GDP.

The table shows that NEB's base-case forecast for 2000 is for total CO_2 to increase by 14% from 1990, to about 590 Mt. The overall growth predicted for transport sources to 2000 is about the same as for all other sources, but within transport the contributions of heavy trucks and aircraft increase faster than those of the other vehicle types.

By 2010, the base-case forecast is for emissions to increase by about 30% over 1990 levels to 675 Mt. The greatest increases are in industrial uses (50% over 1990 levels) and power generation and producer consumption (40%). Growth is expected to be only about 15% in the transport sector, and negligible in residential energy use.

4.2 CANADA'S GOALS ON GLOBAL WARMING

4.2.1 CFCs

With the protocol signed in 1987 in Montreal, Canada committed to a 50% reduction of CFCs by 2000. At the London Conference of June 1990, all original signatories agreed to increase the target to 100% phase-out by 2000, while Canada and 12 other countries declared they would eliminate CFCs by 1997. The prime motivation for CFC control is protection of the stratospheric ozone layer, but CFCs are also the most potent of the greenhouse gases per unit of weight.

4.2.2 CO_2

At the May 1990, UN Conference in Bergen, Norway, Canada committed to stabilize greenhouse gas emissions, other than CFCs, at 1990 levels by 2000. The CCME describes this as "a national target which does not pertain to specific regions or sectors." Canada is also committed to the UN Framework Convention on Climate Change, completed in May 1992, and signed by the Prime Minister at the UN Conference on Environment and Development in Rio de Janeiro in

June 1992.[27] That convention is less specific in its goals. Its objective reads in part (Article 2):

> The ultimate objective . . . is to achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Its "commitments" in Article 4 include:

> Each of [the developed country] Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the present decade to earlier levels of anthropogenic emissions and other greenhouse gases . . . would contribute to such modification. . . .

and:

> In order to promote progress to this end, each of these Parties shall communicate, within six months of entry into force of the Convention for it and periodically thereafter, . . . detailed information on its policies and measures . . . as well as on its resulting projected anthropogenic emissions . . . with the aim or returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases. . . .

As illustrated by Table 7(2)-6, the goal of stabilization by 2000 at 1990 levels would require reductions in national CO_2 emissions by 14% from the NEB base-case forecast — in addition to the improvements in motor-vehicle fuel consumption and residential conservation already included in that forecast.

4.3 CO_2 REDUCTION MEASURES: TRANSPORTATION FUEL CONSERVATION

Federal fuel consumption policy has been limited to road vehicles, specifically cars, pick-up trucks and vans. In 1976, the government agreed with motor-vehicle manufacturers that the U.S. standards for fuel consumption of new vehicles would be met in Canada on a voluntary basis. These standards involve average fuel consumption targets being met separately for cars and "light trucks," averaged across each manufacturer's sales. With the agreements being renewed periodically, this has meant that Canada has essentially achieved fuel consumption improvements matching those under the U.S. mandatory standards. (In fact, Canadian fuel consumption has been slightly better in recent years, as Canadians have, on average, bought slightly lighter and smaller-engined vehicles than Americans.)

Extensive action has been taken by provincial and municipal governments to achieve greater fuel efficiency in transport. The 1970s and 1980s saw the introduction of a great variety of measures to encourage the use of public transport and discourage the use of private cars, including expansions of public transit networks and greater subsidization of their use; "park-and-ride" facilities; incentives for car-pooling; and traffic control and parking restrictions to limit use of private cars. In addition, incentives have been offered for using propane or compressed natural gas (conversion grants and lower excise taxes on the fuels), and many provinces and municipalities have converted some of their own vehicles to use these alternative fuels.

The federal government expects that substantial improvements in new motor-vehicle fuel consumption will continue to be made by manufacturers in the coming decades. *Canada's Green Plan*[28] includes reconsideration of mandatory federal standards. A radical tightening of U.S. fuel efficiency standards is also under consideration (to an average of 40 miles per U.S. gallon for cars). In Canadian terms, this equates to 5.9 L/100 km — compared with the current voluntary standard for new vehicles of 8.6 L/100 km, and the average consumption of cars in use of about 12 L/100 km. Such improvements are feasible through a combination of increased engine efficiency and reduction in vehicle weight.[29]

It can also be anticipated that development of alternative fuels for motor vehicles will help to limit the use of gasoline and diesel fuel. Of the alternatives available in the immediate future, compressed natural gas offers the potential of up to a 20% reduction in CO_2 per unit of distance (over the whole cycle of production and use), while methanol offers less than 5% if produced from natural gas, and up to 100% if produced from biomass.[30] Some experts suggest that, in the long term, a transport system fuelled by electricity (produced without carbon fuels, by using hydro-electric, nuclear or solar energy) or fuelled by hydrogen will develop.[31] Such fuels would emit almost none of the pollutants and greenhouse gases. However, the prospects of this system developing on a large scale within the next 30 years or so remain very remote,[32] and the carbon-fuelled internal combustion engine will likely survive with little change for at least that period. In the interim, air pollutant and CO_2 emissions should be reduced substantially as vehicle fuel consumption improves, and it is likely also that greater use will be made of such alternative fuels as methanol, propane and natural gas, offering further reductions.

4.4 POTENTIAL CO_2 REDUCTION MEASURES

CCME has announced some initial steps toward setting sectoral goals, but has not yet agreed on programs. Its *National Action Strategy on Global Warming* suggests specific measures that might be pursued, including:

- replacing the use of fossil fuel in generating electricity by using nuclear, hydro-electric, wind, solar or tidal power;

- obtaining more efficient generation from fossil fuels, for example, by using "clean coal" technology or cogeneration;
- investing in conservation rather than generating capacity;
- applying "marginal cost and peak-load pricing" of electricity;
- increasing the use of mass transit, through restricting car access to city cores, raising parking fees, or charging urban highway tolls;
- improving traffic flows and reducing traffic densities through urban signal coordination, and so on; and
- promoting staggered working hours and working at home.[33]

The U.S. National Academy of Sciences study also includes an assessment of potential mitigation technologies.[34] Its conclusion is that decisions should be guided by the overall cost-effectiveness of the options, and it recommends that a substantial list of currently available technologies be adopted. The study concludes that this action could reduce U.S. greenhouse gas emissions by 10% to 40%, at relatively low costs or even at net savings.[35] It further states that options requiring great expense are not justified. It recommends moving toward "full-cost pricing" of energy.

5. Potential Role of Economic Instruments

Recent discussions of strategies for environmental protection, in Canada and elsewhere, give great prominence to the potential of applying pricing or using other market mechanisms (referred to more generally as "economic instruments") instead of, or in support of, regulations.[36] As well as specific pricing proposals, the CCME Strategy on CO_2 emphasizes the potential role for more general economic instruments such as carbon taxes or a carbon emissions trading system.[37] The *Green Plan* frequently mentions the potential for economic instruments, and recommends their development.[38]

Also, under the NO_x/VOC Management Plan, consideration is being given to introducing emissions trading programs within one non-attainment area, the Lower Fraser Valley.[39]

The main economic instruments of relevance are emissions charges and tradeable emissions permits.

5.1 EMISSIONS CHARGES[40]

5.1.1 Description

The most elegant form of emissions charging system would add the social costs imposed by the emissions to the price of any activity that produced them.[41] Those activities would then only be undertaken if participants obtained benefits that outweighed the social costs, and participants would also invest in controls that were cheaper than the alternative charges. Economists predict that, unless the type of environmental damage is so severe that it must be entirely eradicated, charging for its costs would be more efficient than regulating its reduction because charging would automatically lead to the least-cost pattern of abatement. To achieve the same result through regulation, the regulator would need to differentiate regulated limits for each class of polluters on the basis of the relative costs for pollution reduction. This would be complex, and regulators are unlikely to have the required information.

Furthermore, the social costs of damage could be incorporated into "benefit-cost" analyses of proposed system investments, to give appropriate weight to environmental concerns in comparisons of investments among modes (and between transport and other activities).

Thus, the simple prescription for achieving an efficient level of damage mitigation is to identify the costs imposed by the environmental damage that are attributable to each mode, and to incorporate them in user-charges.

5.1.2 Can Damage Costs be Estimated?

Many would counter that it is not possible to estimate costs for many aspects of damage, as does Environment Canada in its discussion paper on economic instruments.[42] The difficulties of determining costs have defeated most attempts to date, beyond some simple valuations of damages to materials or crops, when the damage is unequivocal and a market price can be referred to for its value. Two problems, respectively of science and economics, have proven intractable:

- identifying the damage caused by a unit of transport (passenger-kilometres/trip/mode); for example, by determining the extent to which people, plants and animals are harmed by transport emissions, noise or community disruption; and
- attributing money values to the damage.

It seems likely that scientific techniques will improve, though the medium-term prospects for improvements are limited, especially for quantification of the health effects. Some economists believe that there has been great progress recently in attributing money values for damage through such techniques as asking individuals what they would pay in hypothetical trading situations for improvements in environmental conditions.[43] When structured carefully, these experiments are impressive, and a growing body of social scientists finds them credible. While it might be credible, however, to use resulting values in cost-benefit analyses of control measures (in which analytical techniques can overcome experimental uncertainty), the hypothetical nature of these values would pose very substantial problems of public credibility if attempts were made to base prices on them.

It is also possible in some cases to estimate the costs of cleaning up environmental damage, which might provide a proxy for the social cost of the damage itself, and a basis for charging the polluters. In Europe, some public agencies charge companies for the treatment costs of chemical discharges into waterways.[44] It has been suggested that the principle might be applicable to global warming damage, estimating the costs to mitigate flood damage from rising sea levels, for example (and possibly basing charges for CO_2 emissions on them). The principle, however, is by no means applicable to all types of environmental damage, as some types are completely irreversible (for example, the loss of a species), while for others, including air pollution, there are no clean-up options.

Problems of valuing noise damage are arguably less difficult than those for air pollution, because the sources and effects are easier to measure — particularly in the case of aircraft noise — and also because individual behaviour to avoid or accommodate noise is easier to measure. Nevertheless, considerable ingenuity is still required to infer values for noise, for example, from the effects of noise on house prices.[45]

5.1.3 Alternative Bases for Setting Emissions Charges

Costs to achieve pollution reduction targets: When national or international targets for pollution reduction are accepted, predictions of average reactions of transport users to changes in prices may indicate the level of emission charge that needs to be imposed to reach the goal. For example, it should be possible to examine the national NO_x goal and to infer the emissions surcharge on gasoline that would be needed to achieve the required reduction in that sector. It should also be possible to extend the analysis to consider what combinations of surcharges on the various fuels or engines might be needed throughout the transportation sector, and to do the same for all other sectors, in order to design a broad strategy.

While such an inferential procedure does not directly use the information available on the extent and value of environmental damage, this information will likely be assessed by policy makers in setting the national goals. The charges inferred to meet the goals would then also be based implicitly on that information.

Such inference of charges required to meet goals is the focus of much recent discussion of carbon taxes. Predictions of the reactions of industry and the public to such taxes in the United States have suggested that carbon taxes might need to be between about US$100/t and US$400/t of carbon to reach the Toronto Conference goal of 20% reduction in CO_2 by 2005.[46] Similar modelling in Canada has suggested that achieving the extra 15% reduction in CO_2 needed to meet the national stabilization goal in 2000 would necessitate a tax of about $120/t of carbon. This would amount to 7.7¢/L of gasoline, and 9¢/L of diesel fuel.

The appropriate goal for CO_2 reduction remains the subject of great debate, and of international negotiations.[47] Some economists reject the proposals for carbon taxing on the scale required to stabilize CO_2 emissions at 1990 levels, or to meet the Toronto Conference goal of a 20% reduction, arguing that it is not necessary at present to adopt an arbitrary goal that is expensive to meet. The U.S. studies mentioned earlier suggest that the annual costs of achieving the Toronto goal through carbon taxing would range from about 1% to 3% of gross national product. It can be argued that efforts might, at present, be better directed at defining more clearly the nature of the effects of global warming, and therefore the magnitude of the benefits to be gained from its control, and also at developing means to reduce emissions more cheaply in future.[48] Proponents of this view suggest that a modest carbon tax be introduced in the interim in order to steer behaviour toward conservation and substitution of energy use.

Resolving these differing judgements of the appropriate levels of charges requires enhanced understanding of the nature and costs of global warming, further objective analysis of the cost-effectiveness of control options, and careful modelling of producers' and consumers' reactions to charges in all relevant sectors of the economy.

Costs of damage implicit in previous regulatory decisions: Adoption by government of environmental damage regulations involves either explicit or implicit acceptance of its cost-effectiveness, in costs per unit of damage prevented. It can be inferred that the government believes the cost of the regulation per unit of damage prevented to be somewhat less than the social costs the damage would impose (otherwise they would prefer the damage). By extension, it could be argued that the implied unit cost of the regulation provides a minimum social cost to be used as a basis for setting charges for remaining emissions. This has been the argument used in Sweden, where a parliamentary agency endorsed the use as emissions charges of values per unit of emissions implicit in a previous decision to impose a motor-vehicle equipment regulation.[49]

An analogous inference could be made in Canada from the 1987 motor-vehicle emission standards, for example, that the cost per tonne of NO_x reduction was about $2,000.[50] If this is a reasonable charge for remaining NO_x emissions, it would imply a surcharge of about 0.12 cents per kilometre for cars, or 1 cent per litre of gasoline, and 0.74 cents per kilometre for heavy trucks, or about 1.2 cents per litre of diesel. Such charges should, of course, be extended logically beyond the transport sector.

5.2. TRADEABLE EMISSIONS PERMITS

5.2.1 Description[51]

The essence of a permit system is that the total amount of allowable emissions is determined in advance by the regulatory agency. Permits are then issued (donated or sold) only up to that limit, and they can be traded among emitters of pollution. The system is intended to introduce some flexibility compared with the customary regulatory procedure in which the emissions of every company are specified by the regulator. Under the permit system, if there are substantial differences in costs of meeting the standards among companies, one with high costs can effectively choose to pay a low-cost company to reduce emissions instead, by the device of buying the latter's permits. If the high-cost company pays a price for the permits lower than its own costs of abatement but higher than those of the low-cost company, both companies are better off by the trade, as is the economy as a whole. The regulator's goal of the specified emissions limit is achieved, but at a lower cost than if the companies were required to abate equally.

If each company faces the same cost structure, there will be no trades, and if there are substantial costs in organizing trades, they might wipe out the potential gains. Alternatively, the scheme might be frustrated by low-cost firms refusing to trade, in order to gain a competitive advantage, or by high-cost firms choosing not to buy permits, to avoid public censure. In any of these cases, a permit scheme reverts to being a customary regulation. Therefore, permit schemes will, at worst, impose the same costs as regulations, and offer the prospect of achieving emissions reductions more cost-effectively.

5.2.2 Potential Relevance of Tradeable Permits to Transportation Emissions

No workable system of tradeable permits for individual transport vehicles has been designed. The flexibility of vehicle use, and therefore the unpredictability of their emissions in any specified time period, makes it difficult to envisage a permit system that is not also an administrative nightmare. For example, consider the case of NO_x emissions, which arise from many different types of processes, with major differences in the costs of abatement (for example, between pulp mills, power plants, passenger cars and diesel trucks). Cost-effectiveness comparisons show it could be cheaper for car drivers to pay for NO_x reductions in pulp mills than to obtain the equivalent reduction by buying Californian engine controls (or being forced to do so by a regulation).[52] But to address this with a permit system would require issuing and then monitoring trades in large numbers of permits for the very small amounts individuals would need (for example, an estimated vehicle-year's emissions or a vehicle-lifetime's emissions).

Alternatively, permits could be issued to vehicle manufacturers for their whole production fleet, allowing them to trade with other sources.[53] This would require manufacturers to take responsibility for the lifetime use of vehicles, so the requirements for monitoring by the regulatory agency (or the manufacturers) would still be stringent.

There would seem to be greater potential to design trading schemes that involved rail or air carriers, with fewer participants, and more predictable and monitorable emissions, but the payoff would not be great due to the relatively small total contributions of these modes to total emissions.

Some less ambitious variants of tradeable permits might be more feasible, and preferable to simple customary regulation in allowing more flexibility and lower compliance costs. An example might be to allow trading at least within an individual company. Rather than setting targets for each unit of production, a company-wide target would be set, and the company could meet the target however it pleased. Such corporate targets are the chosen means of regulating motor-vehicle fuel consumption, where the manufacturer meets a sales-weighted average consumption across all models, but, conspicuously, not for motor-vehicle emissions standards, in which each model must meet the same standard (in grams per kilometre). The government could obtain the same aggregate performance from each manufacturer with a corporate average emission rate, while allowing manufacturers the flexibility to achieve this at lowest cost by focussing on models in which abatement is cheaper (avoiding expensive re-design of old models, for example). Furthermore, if the target is expressed this way as an average emission rate (rather than total emissions from the vehicles concerned, with all the attendant problems of controlling vehicles over their lifetime), it becomes more reasonable to consider trading of those emissions rights among manufacturers. Companies producing predominantly cleaner (smaller) cars would sell their rights to those producing more-polluting (larger) ones.

5.3 EQUITY ISSUES IN ECONOMIC INSTRUMENTS

Environmental damage from transportation is arguably largely unfair, in that those harmed are usually not responsible, and are usually not compensated for damage. Furthermore, to the extent that regulations are inefficient through requiring the same emissions reduction (and its costs) to be borne by all, when the effects differ by location, those who do not travel in sensitive areas are unfairly penalized. Emissions charges that forced polluters to pay, and were differentiated by amounts of damage, would be fairer.

Emission charges, however, that were consistent across the modes — the same for each unit of pollutant — might pose some thorny equity questions. Current evidence suggests emissions are higher per passenger-kilometre by train than by car (discussed later in this chapter); therefore, charges per passenger would be higher for rail passengers than car passengers. It would be argued that such charges were regressive. Also, of course, the higher emissions for trains reflect current equipment and load factors, which rail passengers would be quick to claim were beyond their responsibility.

The equity implications of extending emissions charges to urban transportation would also be important. Charging car users for their emissions, through surcharges on gasoline taxes or registration fees, would be characterized as tax hikes, and viewed with suspicion because of their possibly regressive effects. In the case of poorer residents of our largest cities, if they were forced by circumstance to drive older, more-polluting cars, they would face surcharges higher than those in the surrounding areas, and higher than the average, and yet they would also be subject to the worst of the city environment themselves.

Similarly, introducing a carbon tax for CO_2 control would raise the question of its incidence by income group, and also by province or region, as its implications for electricity pricing became clear.

Finally, the emissions permit trading systems would have some equity implications, in apparently allowing permit buyers to meet lower pollution limits than permit sellers. (In other words, vehicle manufacturers might buy permits rather than reduce emissions in larger vehicles or older designs.) This might be perceived as unfair (though a strong counter-argument would be that such permit buyers are meeting the same standards, but choosing to do so by paying for emission reduction to be gained more cheaply elsewhere).

5.3.1 Uses of Revenues from Charges/Permits

As the charges would be payments for the social costs of environmental damage, Chapter 7 of Volume 1 of this report recommends that they should be paid to the government(s), rather than to the owners of the infrastructure (if separate agencies), and should not be used for system development. Charges might be used to pay for cleaning up the damage, in the limited cases where that is possible, or for compensating victims of damage, in the cases where they might be identifiable (which seems remote in the case of most air pollutants or for global warming). The remainder would probably constitute large amounts of new revenue to governments. There seems no compelling argument for earmarking these revenues for general use in environmental programs outside transport (as some environmental advocates have proposed).

6. Illustrations of the Possible Costs of Damage from Emissions and of the Potential Magnitude of Emissions Charges

Attempts are made later to illustrate the possible magnitude of costs of damage for each of the intercity passenger modes on a comparable basis. The system-wide averages per passenger-kilometre are provided, as are totals for two sample trips. It is supposed that the estimated damage costs could provide a basis for setting charges by mode.

The detailed design of environmental charges would be a complex effort, because the transfers of money involved on a national scale are potentially very large. The Royal Commission has not attempted the task, because the effects of possible charges on all damage sources would need to be predicted and judged, and these sources extend considerably beyond the transportation sector. This task should be undertaken by the departments of federal, provincial and territorial governments responsible for transport, environment, energy and finance.

All sources of environmental damage should be considered, possibly including disruption of social activities and other forms of "disamenity" experienced by those in proximity to transport facilities, as well as the more obvious forms of discharges and pollution. For the present, some hypothetical possibilities of charges are offered here based only on the damage from emissions of CO_2, NO_x and VOCs, together with aircraft noise, to illustrate the potential magnitude of surcharges, and how they might differ by mode. These are obviously not the only sources of environmental damage, but are possibly the most important, and are also those on which some scant information on possible costs is available.

Other components of emissions have been purposefully ignored. Carbon monoxide and particulate emissions are assumed irrelevant for intercity trips, as their damage is essentially urban, and SO_2 emissions from transportation are assumed to be so small a proportion of total national SO_2 emissions as to be negligible. These assumptions might prove incorrect when detailed design of potential charges was undertaken.

6.1 AVERAGE COSTS OF ENVIRONMENTAL DAMAGE FROM AIR POLLUTANTS AND CO_2 BY MODE

There are no convincing estimates of the average costs of environmental damage from CO_2, NO_x and VOCs. In preparing the Royal Commission's estimates of comprehensive costs by mode, it has therefore been assumed that the charges necessary to achieve nationally declared goals for these emissions reflect the social value placed on preventing the damage. For CO_2, reviews were made of estimates in the United States and Canada of the prices that would be necessary to stabilize total CO_2 emissions from all sources at 1990 levels in 2000. In Canada, modelling has suggested that the necessary price is about \$120/t of carbon, which is equivalent to \$32.70/t of CO_2, or 3.27¢/kg (in 1991 dollars). This is used here as an estimate of the environmental damage from CO_2.

For NO_x and VOCs, no similar modelling appears to have been undertaken of the charges that might be sufficient to meet Canada's announced goals. At present, therefore, the charges can only be guessed to illustrate the costs and potential charges if the Royal Commission's recommendations are implemented. The task of making reliable estimates (or estimating damage losses from these emissions in some other manner) would be an initial priority in implementing the proposals.

The guesswork is guided by the NO_x/VOCs Management Plan, which produced some (very rough) estimates of the cost-effectiveness of a number of its proposed policies, in cost per tonne of emission prevented.[54] Measures considered acceptable in the Plan — various technological controls and limitations on activities — have an upper limit of cost of about \$3,000 per tonne of either emission prevented (in 1989 prices). These measures in total are not sufficient to achieve Canada's recently announced goals for NO_x and VOCs reductions, so it can be deduced that to succeed in achieving them would require measures costing more than \$3,000 per tonne. An initial guess is that such measures might cost \$5,000 per tonne (in 1991 prices). (It is noted that measures are under consideration in the United States that would cost several times this amount per tonne of VOCs prevented.)[55] Then it can be suggested that the goals could alternatively be achieved through setting a price of that same amount of \$5,000 per tonne, from rough reasoning that such a price would induce manufacturers and consumers to take advantage of all possible control measures and behavioural changes that cost less than $5,000 per tonne. In support of these prices, it should be noted that the prices introduced in Sweden for NO_x and VOCs emissions amount apparently to about US$7,150 per tonne of NO_x and about US$3,550 per tonne of VOCs.[56]

Whether the prices for NO_x and VOCs should be equal in Canada should also be addressed in implementing the Royal Commission's proposals. For the present, it should be noted that the question of the relative contributions of the two types of emissions to low-level ozone formation in Canada's ozone-sensitive regions has not been definitively answered, though the NO_x/VOCs Management Plan suggests pursuing both NO_x and VOCs reductions with equal urgency. The Plan also implicitly endorses an equal value for damage in proposing the adoption of measures with the same upper limit on cost-effectiveness per tonne. For illustrative purposes, the value of $5,000 per tonne ($5 per kilogram) is used in the Royal Commission's costing for both NO_x and VOCs.

It must also be decided whether the damage costs and any prices that emerge from these costings apply equally throughout Canada. It is clear from Environment Canada and CCME decisions that the effects of low-level ozone are considered much worse within the three ozone-sensitive regions now designated as requiring special attention — the Lower Fraser Valley, Windsor to Quebec City corridor and southeastern New Brunswick. It is assumed for illustrative purposes that the costs of damage arise from emissions of NO_x and VOCs only in those regions. Estimates must therefore be made of the proportions of total emissions by mode that arise within the sensitive regions. From the Canadian Travel Survey for 1988, it was reported that about 70% of the car-kilometres in long-distance trips were driven within the provinces of British Columbia, Ontario, Quebec and New Brunswick. It is guessed that the proportion of that travel, and its fuel and emissions, within the ozone-sensitive regions was around 70%, so about 50% (70% of 70%) of national intercity car traffic was within those regions. The damage cost of $5,000 per tonne of NO_x and VOCs is therefore applied to 50% of the average national emissions by car per passenger-kilometre. Similarly, the proportions of bus and train fuel use and emissions within the sensitive regions are guessed to also be 50%, while that of aviation emissions is guessed at 20%. (The average NO_x and VOCs emissions from aircraft are low relative to the other modes and also relative to aircraft CO_2 emissions, so the margin of error in the final estimate of the damage costs for aircraft is relatively unimportant.) For ferries, it is assumed that none of the emissions are within the sensitive regions (which ignores ferry contributions to problems in southern British Columbia and around Saint John, New Brunswick).

Furthermore, the focus must be on those periods when the emissions are most damaging. Concentrations of ozone exceeding the maximum acceptable NAAQO occur primarily in the summer months, in episodes lasting a few hours or days. It is assumed that charging $5,000 per tonne for NO_x and VOCs only during the summer season would prompt adoption of measures that achieve the goals. Costs are therefore counted only for the emissions in that season. Monthly counts from the Canadian observation stations of episodes in which ozone exceeds the maximum acceptable NAAQO show that they are concentrated in the months of May to August.[57] The target season for ozone charges is therefore defined as May to August. Within those four months, it is assumed (based roughly on fuel sales by month) that emissions in each mode account for 40% of the annual total.

Finally, applying the above values of $32.70 per tonne of CO_2, and $5,000 per tonne of NO_x or VOCs within the ozone-sensitive regions, to 40% (summertime proportion) of the emissions per passenger-kilometre by mode in Table 7(2)-3, the following system-wide average costs of emissions per passenger-kilometre by mode are obtained (and used in the system-wide average costing in Volume 1, Chapter 3 of this report).

Table 7(2)-7
ESTIMATED COSTS OF SYSTEM-WIDE, YEAR-ROUND EMISSIONS PER PASSENGER-KILOMETRE (1991 CENTS PER PASSENGER-KILOMETRE)

Mode	CO_2	NO_x/VOCs	Combined
Bus	0.169	0.077	0.246
Car	0.410	0.166	0.577
Train	0.382	0.259	0.642
Airplane	0.899	0.022	0.921
Ferry	1.972	0.000	1.972

6.2 ILLUSTRATION OF POTENTIAL MAGNITUDE OF EMISSIONS CHARGES FOR SAMPLE ROUTES

The examples used in Volume 1, Chapter 7 are for the trips from Toronto to Montreal and Saskatoon to Halifax. To estimate the environmental damage, the first step is to estimate the amounts of emissions by mode for each of the trips. The emissions per unit of fuel energy used in each mode are expected to remain as shown in Table 7(2)-1, but the emissions per passenger-kilometre are expected to differ from the system-wide averages shown in Table 7(2)-3 because equipment and load factors vary by route for the public modes, and so, therefore, do the amounts of fuel used per passenger-kilometre. Royal Commission staff estimates of the amount of fuel required per passenger-trip (consistent with the vehicle/carrier costing elsewhere in this report) are shown in Table 7(2)-8.

Table 7(2)-8
FUEL USE PER PASSENGER-TRIP BY MODE, FOR SAMPLE ROUTES (LITRES/PASSENGER-TRIP)

Mode	Toronto to Montreal	Saskatoon to Halifax
Bus	5.9	67
Car	28.9	240
Train	15.0	283
Airplane	40.8	219

Multiplying the energy used in megajoules per passenger-kilometre (using values from Table 7(2)-2) by the ratios of emissions to energy use by mode (in Table 7(2)-1) provides measures of the emissions of CO_2, NO_x and VOCs per passenger-kilometre. These values are shown in Table 7(2)-9, for the two sample routes. (This table appears in a slightly different form in Chapter 7 of Volume 1 as Table 7-1.)

Table 7(2)-9
Emissions per Passenger-Kilometre (grams)

Toronto to Montreal							
					If all seats filled		
	Car	Bus	Train	Airplane	Bus	Train	Airplane
CO	5.20	0.18	0.34	0.17	0.14	0.21	0.11
VOCs	0.94	0.05	0.14	0.10	0.04	0.09	0.07
NO_x	0.75	0.40	1.54	0.34	0.31	0.96	0.23
CO_2	128.0	30.0	76.0	220.0	23.0	47.0	148.0
Load factor		0.77	0.62	0.675	1.00	1.00	1.00
Saskatoon to Halifax							
					If all seats filled		
	Car	Bus	Train	Airplane	Bus	Train	Airplane
CO	5.20	0.24	0.77	0.13	0.14	0.54	0.09
VOCs	0.94	0.07	0.32	0.08	0.04	0.23	0.05
NO_x	0.75	0.54	3.52	0.26	0.31	2.46	0.17
CO_2	128.0	41.0	173.0	167.0	23.0	121.0	113.0
Load factor		0.57	0.7	0.675	1.00	1.00	1.00

Sources: Emissions per unit fuel from VHB Research & Consulting, "Environmental Damage from Transportation." Fuel consumption per pass-km estimated by Royal Commission staff.

As noted, the emissions rates depend on the assumed load factors of the public modes, shown for each route in the final row of Table 7(2)-9. To show the importance of the load factors, the table also shows the potential emissions per passenger-kilometre if all seats were filled. No load factor for cars is shown, but the assumed car occupancy of about 1.8 implies a load factor of only 35%. Filling all car seats could then potentially reduce car emissions per passenger-kilometre by about 65%.

To estimate the damage costs, and potential emissions charges to recuperate them, the total emissions per passenger-trip are estimated, as shown in Table 7(2)-10. The table indicates the trip distances by mode, and total emissions of CO_2, NO_x and VOCs per passenger-trip. However, as discussed, the emissions of the ozone precursors, NO_x and VOCs, are assumed to produce damage only when released in the ozone non-attainment areas. The table therefore indicates the distance by each mode that is assumed to take place within such areas. For the Toronto to Montreal trip, all of the surface routes are within the Windsor to Quebec City corridor, while for the Saskatoon to Halifax trip, only those parts of the trip within that ozone non-attainment area and the one in southeastern New Brunswick are included.

Table 7(2)-10
Emissions per Passenger-Trip (grams)

Toronto to Montreal							
	km	km in ozone-sensitive areas	Total emissions			In sensitive regions	
			CO_2	NO_x	VOCs	NO_x	VOCs
Car	539	539	68,933	406	508	406	508
Bus	539	539	16,243	215	28	215	28
Train	540	540	41,027	833	77	833	77
Airplane	496	340	108,902	169	52	116	35
Saskatoon to Halifax							
	km	km in ozone-sensitive areas	Total emissions			In sensitive regions	
			CO_2	NO_x	VOCs	NO_x	VOCs
Car	4,485	650	573,586	3,380	4,225	490	612
Bus	4,485	650	183,522	2,431	312	352	45
Train	4,468	400	774,859	15,724	1,449	1,408	130
Airplane	3,500	559	585,081	906	277	145	44

Sources: Emissions per unit fuel from VHB Research & Consulting, "Environmental Damage from Transportation." Fuel consumption per pass-km and route distances estimated by Royal Commission staff.

For the airplane trips, it is assumed that the emissions at cruising height are too high to contribute to low-level ozone concentrations. An estimate of the emissions that do contribute to low-level ozone is obtained using the constant term from the fuel consumption equation used in the air carrier costing model. Approximately 35 L per aircraft trip is constant over a trip of any distance, contributing to low-level ozone through climbing, descending, taxiing and idling. The figures in Table 7(2)-10 for airplane-trip "kilometres in ozone-sensitive zones" are obtained by expressing 35 L as a proportion of total fuel used per passenger-trip, and multiplying this by total trip distance.

The illustrative emissions charges are then obtained by multiplying the CO_2 emissions in Table 7(2)-10 by 3.27¢/kg, and the NO_x and VOCs emissions in the sensitive regions by $5/kg. The results are shown in Table 7(2)-11, which appears (with rounded values) as Tables 7-2 and 7-3 in Volume 1, Chapter 7.

Table 7(2)-11
ILLUSTRATIVE EMISSIONS CHARGES (DOLLARS PER PERSON-TRIP)

Toronto to Montreal				
	Winter	Summer		
	CO_2 charge	CO_2 charge	NO_x/VOCs charge	Total charge
Car	2.25	2.25	4.57	6.82
Bus	0.53	0.53	1.21	1.75
Train	1.34	1.34	4.55	5.89
Airplane	3.56	3.56	0.76	4.32
Saskatoon to Halifax				
	Winter	Summer		
	CO_2 charge	CO_2 charge	NO_x/VOCs charge	Total charge
Car	18.76	18.76	5.51	24.27
Bus	6.00	6.00	1.99	7.99
Train	25.34	25.34	7.69	33.03
Airplane	19.13	19.13	0.94	20.08

Source: Royal Commission staff estimates. See text.

6.3 ESTIMATES OF ENERGY USE AND EMISSIONS BY HIGH-SPEED RAIL

The estimates of possible emission charges for high-speed trains in Volume 1, Chapter 7 of the report are based on the following analysis.

6.3.1 Energy Use

Estimates of the energy requirement for a service like the "train à grande vitesse" (TGV), operating in the Windsor to Quebec City corridor (at 300 km/h), are available as follows:

The power required from the electricity grid into the rail system is estimated by Lake et al. as:[58]

- 0.083 kilowatt-hours (kWh) per passenger-kilometre,
- where 1.0 kWh equals 3.6 MJ.

In other words, the service would require 300 kJ of energy per passenger-kilometre.[59]

Khan's report[60] quotes Johnson et al.[61] for an estimate of the power required from the electricity grid as:

- 275 kJ/seat-kilometre.

The estimated average train occupancy on the proposed Toronto to Montreal route is:

- 75%.

This means that:

- 370 kJ of energy per passenger-kilometre would be used.

Khan also considers the source of the electricity. He estimates that the combined electricity output of Ontario and Quebec is provided approximately 55% by hydro-electricity plants and 45% by thermal (including nuclear) plants. He suggests that of the "primary" fuel used for the thermal plants, 3.6% is required to process and transport the fuel to generating plants, and up to 70% is lost in the generation process. For either thermal or hydro-electricity, he suggests 15% of power supplied by the plants is lost in transmission and delivery within the rail system. In sum, he estimates that, on average in the two provinces, only 55% of "primary" energy (electricity from the hydro plants, or initial fuel for thermal plants) reaches the trains. Therefore he suggests that the 275 kJ/seat-kilometre in "secondary" energy requires (275/0.55 =) 500 kJ/seat-kilometre in "primary" energy. Using his 75% average train occupancy, this equals an energy requirement of 670 kJ/per passenger-kilometre.

The report of the Ontario/Quebec Rapid Train Task Force[62] quotes estimates made by Ontario's Ministry of Transportation of "overall energy efficiency" of current modes and future options for high-speed rail and magnetic levitation (maglev) trains, including the following kilowatt-hours per passenger-kilometre for the 300 km/h TGV Atlantique or ICE in a Windsor to Quebec City corridor service.[63] The final column converts these to kilojoules per passenger-kilometre.

	kWh/pass-km	kJ/pass-km
Windsor to Toronto	0.10–0.12	360–430
Toronto to Montreal	0.09–0.11	320–400
Montreal to Quebec City	0.11–0.13	400–470

It is not clear whether these estimates refer to "secondary" or "primary" power requirements, but it seems likely they are the power requirements of the rail system from the electricity grid.

6.3.2 Synthesis

These estimates lie in the range of 300 to 470 kJ/pass-km for all of the corridor services. For the Toronto to Montreal route, the estimates are 300 kJ/passenger-kilometre from Lake et al., 370 kJ/pass-km from Khan, and the range of 320 to 400 kJ/pass-km from the Ontario/ Quebec Rapid Train Task Force. An approximate mean of this range, for the purpose of showing the possible magnitudes of energy and emissions from high-speed trains relative to current modes, is 350 kJ/passenger-kilometre.

To the extent that the electricity was provided from fossil-fuel-fired plants, a conversion from "secondary" energy requirements to "primary" requirements is necessary, along the lines suggested by Khan. Khan's estimates of the average losses of energy in generation, however, are probably too pessimistic in their assumption that about 75% of Ontario's power comes from thermal stations with average conversion efficiency of 30%. For the present main purpose of comparing emissions from high-speed trains with those from other modes, the prime interest is in the amount of fossil fuel that might be used to generate the electricity. The conversion efficiency is only of relevance to the extent that the high-speed rail system would be supplied from fossil-fuel-fired plants. The current contribution of such plants in Ontario and Quebec is shown in Table 7(2)-12.

Table 7(2)-12
Sources of Electric Power Generation in Ontario and Quebec, 1991

Source	Ontario		Quebec	
	(GWh)	(%)	(GWh)	(%)
Hydro	37,441	26.6	137,867	97.1
Conventional steam	31,483	22.4	264	0.2
Nuclear	70,773	50.3	3,910	2.7
Other	1,001	0.7	(negligible)	
Total	**140,698**	**100.0**	**142,041**	**100.0**

Source: Statistics Canada, Catalogue No. 57-001.

The "conventional steam" plants and the "other" plants in Ontario are fired by fossil fuels. Of the combined total for the two provinces, therefore, these provided some 11.6% of electricity generated in 1991. This proportion can be expected to decrease in the future, if plans are implemented in Quebec to increase its hydro-electric output and in Ontario to increase its nuclear output.[64]

The extent to which a high-speed rail system would in practice draw on the fossil-fuel-fired plants would depend on the production conditions at the time its demands were made. For certain trains at peak electricity demand times, it is possible that all of the marginal power used would be generated by the fossil-fuel-fired plants, while for others at off-peak times the marginal power would come entirely from hydro-electric or nuclear plants. For a simple illustration of the potential emissions, no attempt is made to predict the exact outcome, but the simple assumption is made that a high-speed rail system at the end of the current decade would draw from the electricity grids of Ontario and Quebec in an average manner. It could then be expected to receive about 10% of its electricity from fossil fuels. Recognizing that losses in generation in fossil-fuel-fired plants amount to 50% to 70% of total energy input, the "primary" fuel requirement to those generation stations can be estimated conservatively to be of the order of double the above rate per passenger-kilometre, or about 700 kJ/pass-km. The illustrations of potential emissions from high-speed rail that follow use these average assumptions: 10% of the electricity required for the trains is generated using fossil fuels, at an average energy intensity of 700 kJ/pass-km.[65]

6.3.3 Emissions

For comparisons with the environmental costs of other modes, all of the environmental impacts expected from each should be strictly accounted for. Due to the uncertainties of damage cost estimation, the cost analyses by mode are limited to those effects expected to be of most importance from intercity passenger transportation: the emissions of CO_2, NO_x and VOCs. When considering the case of high-speed rail, only costs for emissions of CO_2 and air pollutants are shown, so only the fossil-fuel-fired portion of the electricity used is relevant. No costs are added for the other potentially important categories of environmental effects from hydro-electricity plants and nuclear generating stations.

The emissions of interest and importance from fossil-fuel-fired plants are CO_2, NO_x and also SO_2. Sulphur dioxide is important because it damages health by aggravating respiratory complaints such as asthma and bronchitis, and because of its major contribution to acid rain. While SO_2 is produced in all combustion processes, the amounts created from fuel use by current intercity passenger transportation are considered sufficiently small, and their emissions sufficiently remote from sensitive populations, that no cost was assigned to them in the cost analyses in the earlier sections. However, the SO_2 from fossil-fuel-fired electricity plants is of sufficient importance that an attempt should be made to assign a cost to it, as has been done with NO_x and VOCs.

Table 7(2)-13 shows the main components of the cost analysis:

Column 1 illustrates the emissions per unit of energy used in these plants:

- Emissions of CO_2 can be estimated from the carbon content of coal (assuming Canadian bituminous coal is used in power plants) as 92.1 g/MJ.[66]
- Emissions of NO_x and SO_2 can be estimated from average rates forecast by Ontario Hydro for 1996 to 2000,[67] of 1.612 g/kWh of NO_x, and 4.0 g/kWh of SO_2. These convert to 0.448 g/MJ of NO_x and 1.11 g/MJ of SO_2.

Column 2 shows the estimated energy requirement from fossil-fuel-fired plants of 700 kJ per passenger-kilometre.

Column 3 lists the grams of emissions per passenger-kilometre, which is the product of the previous two columns.

Column 4 shows the estimated costs per tonne of emissions. The amounts for CO_2 and NO_x are as used throughout this environmental cost analysis, from amounts assumed to be necessary to meet national goals, of $120 per tonne carbon, or $32.70 per tonne CO_2, and $5,000 per tonne NO_x, when emitted in summer. The estimated cost of SO_2 is obtained from the report by VHB for the Royal Commission,[68] derived in turn from a review of cost estimates by Ottinger et al.[69] The cost is quoted as $5.29/kg in 1989 prices, which is inflated to 1991 prices, and converted to an estimate of $6,000 per tonne.

Column 5 estimates the costs in cents per passenger-kilometre, obtained as the product of columns 3 and 4.

Table 7(2)-13
Costs of Emissions from Fossil-Fuel-Fired Electricity Plants, for High-Speed Rail (1991 prices)

	g/MJ	kJ/pass-km	g/pass-km		Cost ($/tonne)	Cost (¢/pass-km)
CO_2	92.10	700	64.50		33	0.21
NO_x	0.45	700	0.31	summer	5,000	0.16
				other seasons	0	0.00
SO_2	1.11	700	0.78		6,000	0.47
Total					**summer**	**0.84**
					other seasons	**0.68**
					average	**0.74**[a]

a. Assuming summer emissions are 40% of the annual total.

The emissions costs are thus estimated to range between zero, when the electricity is generated from non-fossil sources, to about 0.73 cents per passenger-kilometre when the electricity is entirely from fossil fuel. Then it remains to estimate average costs per passenger-kilometre for electricity used in high-speed rail, given the proportion of the power to be provided by fossil-fuel-fired plants. As noted earlier, the assumption is made that this proportion will, on average, be the same as the contribution of fossil-fuel-fired plants to total electricity generated in Ontario and Quebec: about 10%. The final estimated costs of the emissions from high-speed rail are therefore approximately

(10% of 0.84¢ =) 0.08¢/pass-km in summer, and 0.07¢/pass-km in the rest of the year. A rounded estimate of the year-round average, with about 40% of fuel use in summer, would be 0.07¢/pass-km.

6.4 ESTIMATES OF AIRCRAFT NOISE COSTS

Costs for aircraft noise are included in the system-wide costs and costs for sample routes in Chapters 3 and 18 of Volume 1 of this report, based on the following information.

Estimates of the costs of noise at Toronto and Vancouver airports are obtained from Gillen and Levesque.[70] The authors infer values of noise nuisance from those airports, and estimate noise costs for various models of aircraft. Their findings imply that there are substantially greater costs for "Stage 2" aircraft than for those with "Stage 3" noise controls. For example, the cost per movement for a B767-200 is $89 at Lester B. Pearson International Airport in Toronto compared with $123 for a B737-200 and $138 for a DC9-30. The costs are somewhat different at Vancouver from those at Pearson, and no simple averages for all types of aircraft are presented. For purposes of illustration, however, only orders of magnitude are necessary, and it is apparent from the tables that the cost per seat-movement is somewhat above $1.00 for the older aircraft, and below $0.50 for the newer models. Taking average occupancies into account, it will be assumed that it is reasonable to represent noise costs at these two airports as $1.00 per person-movement, in round figures (a figure somewhat higher than the source tables would suggest).

Then it is assumed that similar noise costs hold at Montreal's Dorval Airport, but that noise costs are otherwise negligible at Canadian airports. (This is not realistic but possibly counters the overstatement of costs at the main airports.) These three major airports account for 60% of total enplaned/deplaned passengers in Canada (including international passengers). It is therefore assumed that noise costs are, in very rounded figures, closer to $0.50 per passenger-movement nation-wide, or $1.00 per passenger-trip. This cost is included in the estimates of system-average environmental damage costs in Volume 1, Chapter 3 of this report, and for the costs of the sample routes, the costs are assumed to occur only at the major three airports, as $1.00 per passenger-movement.

Endnotes

1. VHB Research & Consulting, "Environmental Damage from Transportation," in Volume 4 of this report.

2. William A. Sims, "Externality Pricing," a report prepared for the Royal Commission on National Passenger Transportation, RR-07, Oct. 1991.

3. Government of Canada, *Economic Instruments for Environmental Protection.* Cat. No. En21-119/1992/E (Ottawa: Supply and Services Canada, 1992).

4. The following is drawn from the report by VHB Research & Consulting, "Environmental Damage," section 4.2, and from Transport Canada/Environment Canada, *A Plan to Identify and Assess Emission Reduction Opportunities from Transportation, Industrial Engines and Motor Fuels,* Report TP 9773 (Ottawa: Transport Canada, May 1989).

5. See C. Johnson, J. Henshaw and G. McInnes, "Impact of Aircraft and Surface Emissions of Nitrogen Oxides on Tropospheric Ozone and Global Warming," *Nature* 355 (Jan. 1992), pp. 69–71; and M. Barrett, *Aircraft Pollution, Environmental Impacts and Future Solutions,* World Wildlife Fund, Aug. 1991.

6. VHB Research & Consulting, "Environmental Damage," Table 4.

7. The estimate of pass-km per litre for ferries might be underestimated as fuel use is allocated between passenger and freight traffic according to deck space used, with no allowance for any effect of vehicle loads on fuel consumption. If weight were the only determinant, passengers and their vehicles would be responsible for much less fuel use, and the estimate of pass-km per litre in the table might rise by 50% or so. Information on vehicle loads is not available, but it is believed that they are of only minor additional importance to fuel consumption once use of deck space is allowed for.

8. This section is drawn particularly from VHB Research & Consulting, "Environmental Damage," Section 4.2.5.

9. For definitions of NAAQOs see Environment Canada, Inventory Management Division, Conservation and Protection, *National Urban Air Quality Trends 1978-1987,* Report EPS 7/UP/3 (Ottawa, May 1990), p. 6.

10. Ibid., Sections 4, 3 and 6.

11. Ibid., Section 5.

12. A summary of health effects is contained in D. V. Bates, "Adverse Health Effects of Automobile Emissions," unpublished paper presented to the Royal Commission on National Passenger Transportation Technical Seminar on Transportation and the Environment, Sept. 1991.

13. VHB Research & Consulting, "Environmental Damage."

14. Ontario Ministry of the Environment, *Ozone Effects on Crops in Ontario and Related Monetary Values,* Report ARB-13-84 (Toronto, 1984).

15. Transport Canada/Environment Canada, *A Plan to Identify,* p. 10.

16. Intergovernmental Panel on Climate Change, *Policy Makers Summary of the Scientific Assessment of Climate Change: Report to the IPCC from Working Group I*, United Nations Environment Programme, June 1990.

17. Predictions excerpted from Canadian Council of Ministers of the Environment (CCME), *National Action Strategy on Global Warming*, Nov. 1990, p. 4.

18. U.S. National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Policy Implications of Greenhouse Warming* (Washington, D.C.: National Academy Press, 1991).

19. W. D. Nordhaus, "To Slow or Not to Slow: The Economics of the Greenhouse Effect," (New Haven, CT: Yale University, Feb. 1990) (mimeograph); or see W. D. Nordhaus, "A Sketch of the Economics of the Greenhouse Effect," *American Economic Review Papers and Proceedings of the 103rd Annual Meeting*, May 1991, pp. 146-150.

20. See Transport Canada/Environment Canada, *A Plan to Identify*, for descriptions of proposals.

21. CCME, *Management Plan for Nitrogen Oxides (NO_x and Volatile Organic Compounds (VOCs), Phase I*, CCME-EPC/TRE-31E, Nov. 1990.

22. Ibid., Appendix A.

23. Ibid., Table 20, p. 153.

24. Ibid., pp. 148–52.

25. The following notes rely heavily on CCME, *National Action Strategy on Global Warming.*

26. National Energy Board, *Canadian Energy Supply and Demand 1990–2010*, Cat. No. NE23-15/1991 (Ottawa: Supply and Services Canada, 1991).

27. United Nations, *Framework Convention on Climate Change* (New York, N.Y.: UN, May 1992).

28. Environment Canada, *Canada's Green Plan for a Healthy Environment*, Cat. No. En21-94/1990 (Ottawa: Supply and Services Canada, 1990).

29. See P. Reilly-Roe, "Assessment of Transportation Energy Technologies to 2020," Transportation Energy Division, Energy, Mines and Resources Canada, 1991 (unpublished mimeograph); and V. C. Battista, D. Boucher and E. R. Welbourne, "A Preliminary Review of Options for Reducing Emissions of Carbon Dioxide from Motor Vehicles," Technical Memorandum TMVS 9101, unpublished, Road Safety Directorate, Transport Canada, Jan. 1991.

30. Battista et al., "A Preliminary Review," pp. 34–40. The report suggests methanol from biomass would have essentially no net CO_2 emissions as it would initially fix atmospheric CO_2 and subsequently release it.

31. See R. F. Webb, "Alternative Fuels: Prospects and Effects," unpublished paper presented to the Royal Commission on National Passenger Transportation Technical Seminar on Transportation and the Environment, Sept. 1991.

32. We note that some U.S. states, starting with California, intend to require that manufacturers begin to supply vehicles with very low emissions (which initially means electric vehicles) within this decade.

33. CCME, *National Action Strategy on Global Warming.*

34. U.S. National Academy of Sciences, *Policy Implications*; and *Policy Implications of Greenhouse Warming, Report of the Mitigation Panel* (Washington, D.C.: National Academy Press, 1991).

35. The report's suggestion that consumers are uninformed or irrational in failing to adopt such cost-reducing technologies as compact fluorescent lightbulbs is challenged in W. D. Montgomery, *The Cost of Controlling Carbon Dioxide Emissions, Final Report*, Report CRA 858.00 (Washington, D.C.: Charles River Associates Incorporated, Dec. 1991). Montgomery suggests the alternative interpretation that consumers' rejection of such technology demonstrates that the NAS analysis understates the private costs or overstates the private benefits.

36. See for example, Environment Canada, *Economic Instruments for Environmental Protection*; Organisation for Economic Co-operation and Development (OECD), *Economic Instruments for Environmental Protection* (Paris: OECD, 1989); and more generally W. J. Baumol and W. E. Oates, *The Theory of Environmental Policy*, 2nd ed. (Cambridge, U.K.: Cambridge University Press, 1988).

37. CCME, *National Action Strategy on Global Warming*, section 8.2.1.

38. Environment Canada: *Canada's Green Plan*, pp. 156–8.

39. CCME, Emission Trading Working Group, *Emission Trading, A Discussion Paper*, CCME, May 1992.

40. For a detailed discussion see Sims, "Externality Pricing."

41. Strictly prices would need to be equal everywhere to social marginal cost.

42. Environment Canada, *Economic Instruments for Environmental Protection.*

43. See in particular: D. W. Pearce and A. Markyanda, *Environmental Policy Benefits: Monetary Valuation* (Paris: OECD, 1989); D. W. Pearce and R. K. Turner, *Economics of Natural Resources and the Environment* (Baltimore, MD: Johns Hopkins University Press, 1990); and VHB Research & Consulting, *Environmental Damage*, Sections 3.3 and 7.

44. OECD, *Economic Instruments*, Chapters 3 and 4.

45. See for example, D. W. Gillen and T. J. Levesque, *The Management of Airport Noise*, Report TP 10118 (Ottawa: Transport Canada, Transportation Development Centre, July 1990); and D. W. Gillen and T. J. Levesque, "Measuring the Noise Costs of Alternative Runway Expansion at LBPIA Using Residential Housing Markets," report prepared for Transport Canada, Major Crown Projects, Apr. 1991.

46. See J. A. Edmunds and J. M. Reilly, "Global Energy and CO_2 to the Year 2050," *The Energy Journal* 4 (1983), pp. 21–47; A. S. Manne and R. G. Richels, "Global CO_2 Emission Reductions: The Impact of Rising Energy Costs," *The Energy Journal* 12, 1 (1991), pp. 87–107; W. D. Nordhaus, "The Cost of Slowing Climate Change: a Survey," *The Energy Journal* 12, 1 (1991), pp. 37–65; D. W. Jorgensen and P. J. Wilcoxen, "The Cost of Controlling U.S. Carbon Dioxide Emissions," in *Proceedings of the Workshop on Economic/Energy/Environmental Modelling for Climate Policy Analysis*, eds. D. O. Wood and Y. Kaya (Cambridge, Mass.: MIT Center for Energy Policy Research, Jan. 1991); and U.S. Congressional Budget Office, *Carbon Charges as a Response to Global Warming: The Effects of Taxing Fossil Fuels* (Washington, D.C.: CBO, August 1990). For summaries and interpretations, see W. R. Cline, "Economic Models of Carbon Reduction Costs: An Analytical Survey," Harvard University Institute for International Economics, June 1991 (mimeograph); and Montgomery, *The Cost of Controlling.*

47. See M. Grubb, *The Greenhouse Effect: Negotiating Targets* (London, U.K.: Royal Institute of International Affairs, 1989).

48. Montgomery, *The Cost of Controlling.*

49. L. Hansson, "Air Pollution Fees and Taxes in Sweden," paper presented to 70th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 1991.

50. J. J. Lawson, *Analysis of the Effects of Proposed Revisions to Light Motor Vehicle Emission Standards*, Report TP 6684 (Ottawa: Transport Canada, Road Safety Directorate, June 1985).

51. See T. H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (Washington, D.C.: Resources for the Future Inc., 1985); and discussions in Sims, "Externality Pricing"; Environment Canada, *Economic Instruments for Environmental Protection*; and A. J. Krupnick, "Vehicle Emissions, Urban Air Quality, and Clean Air Policy," discussion paper QE91-15 (Washington, D.C.: Resources for the Future, July 1991).

52. See Lawson, *Analysis of the Effects* and other comparisons of cost-effectiveness of control options in Krupnick, "Vehicle Emissions."

53. As proposed in B. K. Stevens, "A Tradeable Vehicle and Fuel Credits Program," paper presented to the (U.S.) Western Economic Association International Conference, 1991.

54. CCME, *Management Plan for Nitrogen Oxides and Volatile Organic Compounds, Phase I*, Tables 24 and 25, pp. 168–9.

55. Krupnick, "Vehicle Emissions," Table 2, p. 20.

56. Oral presentation by Lars Hansson, "Political problems of implementing emission and congestion pricing in Sweden," Session 198, Transportation Research Board 71st Annual Meeting, Washington, D.C., Jan. 1992.

57. From information provided to the Commission by Mr. T. Dann, Head Air Toxics Section, Technology Development Branch, Conservation and Protection, Environment Canada, Ottawa, dated May 25, 1992. Average "total station episode-days" by month during 1987-1989 were as follows (where an episode is one or more hours with ozone concentration greater than 81 ppb):

Month	Episode-Days
April	6
May	103
June	222
July	311
August	166
September	32
October	10

58. R. W. Lake et al., *Alternative to Air: A Feasible Concept for the Toronto–Ottawa–Montreal Corridor* (Kingston: Queen's University, CIGGT, 1980).

59. It can also be deduced from the report that reaching peak speed of 300 km/h rather than 260 km/h, a 15% increase in speed, requires 25% more energy.

60. A. M. Khan, *Energy and Environmental Factors in Intercity Passenger Transportation,* Report TP 10198 (Ottawa: Economic Analysis Division, Transport Canada, 1990).

61. L. R. Johnson et al., *Maglev Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System,* Argonne National Laboratory Report ANL/CNSV-67, Apr. 1989.

62. Dessau Inc., *A Review of the Environmental Impact of Investment in High-Speed Rail in the Ontario-Quebec Corridor: Final Report,* Ontario/Quebec Rapid Train Task Force (Aug. 1990).

63. This report also provides a range of estimates of energy use for a 200km/h service (British Rail HST, Amtrak Turboliner, or PCH Turboliner), of 220 kJ/pass-km to 400 kJ/pass-km.

64. See Ontario Hydro, *Submission to the National Energy Board, in the matter of an application by Ontario Hydro for export permits pursuant to Division II of the Act, Volume 4, Social Cost Studies* (Toronto: Ontario Hydro, Oct. 1990).

65. Some further support for this estimate is provided by T. Lynch, "Maglev and High Speed Rail System Environmental Energy and Economic Benefit Evaluation in Florida: A Comparative Analysis," in *Magnetic Levitation Technology and Transportation Strategies,* Report SP-834 (Warrendale, P.A.: Society of Automotive Engineers, Aug. 1990). This suggested the TGV-type train would use about 250 kJ/pass-km in "net" energy, or 750 kJ/pass-km in "gross" energy from thermal stations.

66. From A. P. Jaques, *National Inventory of Sources and Emissions of Carbon Dioxide (1987),* Report EPS 5/AP/2 (Ottawa: Environment Canada, 1987), Table S.3. This average might understate average emissions from coal plants, as lignite is used to some extent in Ontario generating plants, with a CO_2 emission rate of 108.4 g/MJ.

67. Ontario Hydro, *Submission to,* Table 3.3, p. 3–27.

68. VHB Research & Consulting Inc., "Environmental Damage," Table 17, p. 55.

69. R. L. Ottinger, D. R. Wooley, N. A. Robinson, D. R. Hodas and S. E. Babb, *Environmental Costs of Electricity* (New York, NY: Oceana Publications, Inc., 1990).

70. Gillen and Levesque, *The Management*, see especially Tables 6-3 and 6-4, p. 188.

NOTES TO CHAPTER 8: TRANSPORTATION SAFETY — ESTIMATION OF ACCIDENT RISKS AND COSTS

Introduction

The issues of transport safety were considered by the research staff of the Royal Commission, rather than through contracted research. The following notes are therefore more detailed than those supported by reports from contracted research.

1. Summary of Transport Safety

The history of transport safety shows that deaths, injuries and property damage have increased as traffic has grown. For example, there were 521 deaths in rail and road transport in 1921 and 4,060 deaths in 1990, while injuries and property damage increased faster still. The increase in accidents and casualties[1] over the long term, however, has been much less than the increase in traffic. The number of road fatalities grew quickly in the early days of motorization, but since 1930 it has only tripled, while the number of vehicles has increased 14-fold. It can be concluded that the "risks"[2] of accidents and casualties per vehicle-kilometre and per passenger-kilometre (pass-km) have fallen substantially. Recently, the improvement has been even more impressive. Since 1973, risks of death and serious injury have fallen faster than traffic has grown, so that the numbers of persons killed or seriously injured annually have fallen.

Within those transportation totals, it appears that risks have continued to decrease in passenger aviation and in trucking since deregulation. To the extent that deregulation has caused an increase in the use of smaller aircraft, some elevation of risks might be expected, but the reduction in risks from diverting traffic from road to air is likely to be much larger. In trucking, both the increase in truck traffic stimulated by deregulation and traffic diversion from rail are likely to increase truck accidents and the risks to other road users from trucks. There has been a strong downward trend in road accident risks, however, and improvements in vehicle and road technology, and in driver behaviour suggest that this will continue.

1.1 RELATIVE RISKS IN THE PASSENGER MODES

Table 8(2)-1 (which repeats Table 8-9 from Volume 1 of this report), provides two main safety indicators for comparisons among the passenger transportation modes. The first is the total numbers of persons killed in passenger operations — whether passengers, crew or bystanders — per billion pass-km. This indicator is referred to in Volume 1 as the "fatality rate in passenger operations." The importance of this indicator emerges when considering major changes in the extent of those operations, or major shifts among the modes, as it indicates how the total number of transportation-related deaths might change. The second indicator is the number of passengers killed per billion pass-km, referred to in Volume 1 as the "passenger fatality rate." This is the main indicator of the relative safety of passengers using the different modes, and is therefore of most interest to the travelling public.

Table 8(2)-1 illustrates these two fatality rates for the ground transportation modes and for three groups of air carriers. The following discussion describes those rates and considers possible trends for each mode.

Table 8(2)-1
Fatality Rates[a] per Billion Intercity Passenger-Kilometre by Mode

Mode	Passenger fatality rate[b]	Fatality rate in passenger operations[c]
Air — Level 1 carriers[d]	0.05	0.05
Air — Level 2 carriers[d]	0.7	1.0
Air — Level 3 to 6 carriers[d]	14.0	28.0
Train	0.8	13.8
Bus	0.0–1.0	2.0
Ferry	0.2	0.5
Car	10.0	13.0

a. Based on the 1980s as a whole, or recent years in 1980s.
b. Includes only passengers killed.
c. Includes passengers, crew and bystanders killed during passenger operations.
d. Includes all Canadian-registed carrier opeartions, domestic and international.

The many qualifications to these estimates follow. Important among them are that the traffic estimates are very rough for road transport, and that while all estimates are recent, they are not necessarily current. (The aviation and rail estimates are averaged over the last decade, for example, while the bus estimates are derived from accidents over a more limited period.) More importantly, the estimates are system-wide averages, and the trips — particularly their lengths — differ substantially by mode.

Within each mode, it is probable that risks are lower for longer trips. This is certainly the case for air travel, in which the risk falls with increasing stage length because of the dominance of the risks of landing and take-off, and because longer trips tend to be made in more reliable aircraft. It is probably also the case with rail travel, because longer trips are usually made over better-quality track (fewer grade crossings, in particular), and with bus travel, because the roads used are likely to be of better quality (divided highways, for example). For private motor-vehicle travel, better-quality roads will also be used on longer trips and, perhaps more importantly, the trips are more likely to be made in daylight, by experienced and unimpaired drivers using larger vehicles.

The qualifications on these estimates are particularly important in considering the effects of traffic shifting from one mode to another. For example, Table 8(2)-1 shows that shifting traffic from private motor vehicles to aircraft could save nearly one fatality for each 75 million pass-km, or that shifting 1% of highway car traffic to airplanes could prevent 27 deaths.[3] The true effects would probably be much less spectacular because the length of the trips that shifted would probably have a lower fatality rate than the road average, but would probably sustain a higher fatality rate than the air average.[4]

2. Summaries of Safety by Mode

Each of the modes is summarized here, focussing on passenger safety. Then, some aspects of heavy truck safety are considered, and finally a brief summary of developments in road safety is provided.

2.1 AVIATION SAFETY

Statistics on aviation accidents are available from the Transportation Safety Board, together with estimates of hours flown by type of operation. Statistics Canada provides estimates of pass-km for air carriers. The relevant figures and derived estimates of aviation risks for the years 1981 to 1990 are shown in Tables 8(2)-2 to 8(2)-8. Table 8(2)-3 shows that 1,176 people died in aviation accidents during the decade; approximately half in private-flying and half in commercial operations. Of 607 killed in commercial aviation, only 68 flew with Level 1 or 2 carriers; the remainder flew with smaller carriers.

Aviation accidents and fatalities are so rare that they vary substantially year to year, making estimation of accident rates per unit of traffic uncertain. Those rates may be calculated for each year per 100,000 flying hours, which is the industry measure common to all types of traffic. As shown in Tables 8(2)-4 and 8(2)-6, even the annual rate for total aviation fatalities fluctuates substantially, and annual rates for the separate types of traffic fluctuate more than this. For Level 1 and 2 carriers, the single accidents in 1983 and 1989 (Cincinnati and Dryden) changed the annual fatality rates dramatically. To compare these services with the other types of traffic, it is necessary to average the rates over the entire decade (or another long period). Table 8(2)-6 shows that between 1981 and 1990 the rate of fatalities per 100,000 hours for private aviation was more than double the rate for all commercial aviation. For Level 1 and 2 carriers combined, the fatality rate was only one fifth of that for other levels of carriers, and Level 1 carriers had about one twentieth of the fatality rate of Level 2 carriers.

Given that smaller aircraft have slower operating speeds, the disparity in the rates of fatalities per kilometre flown would appear even greater between private and commercial services, and within the commercial services, between levels of carrier. Unfortunately, kilometres flown are not available for private aviation.

The comparisons rates of fatalities per pass-km among the various types of carrier, and how these rates change over time are of particular interest to the Royal Commission. Published data do not distinguish passengers from other fatalities (such as crew and others), so the major indicator that can be calculated is the "fatality rate in passenger operations." Tables 8(2)-7 and 8(2)-8 offer the relevant data. Again, to smooth the annual fluctuations, comparison is best made over the entire decade. Over the decade, Level 1 carriers provided about 95% of all pass-km by commercial carriers, with a fatality rate of 0.048 per billion pass-km, in other words, only one death every 20 billion pass-km. For Level 2 carriers, the rate was 1.0 fatality per billion pass-km (heavily influenced by the single Dryden crash), while for other levels of carriers the rate was as high as 28 deaths per billion pass-km, but their share was only 3.5% of all commercial pass-km.[5] For Levels 1 and 2 combined (the two national carriers, main feeders and charter operators), the fatality rate was 0.13 deaths per billion pass-km, one death every 7.7 billion pass-km.

Within those broader rates of fatalities in passenger operations, the passenger fatality rate can be distinguished using unpublished information provided by the Transportation Safety Board, which separates deaths of passengers from those of crew and others.[6] Figures obtained are aggregated over the decade 1981 to 1990, and show the following:

Class of carrier	Deaths of passengers	Deaths of others
Level 1	23	0
Level 2	34	11
Levels 3 to 6	270	269
All	327	280

Aviation Safety Indicators, 1981 to 1990

Table 8(2)-2
Aviation Operating Hours

Year	Hours of operation in year (thousands)						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	661	147	1,853	2,662	1,332	126	4,119
1982	621	110	1,612	2,343	1,212	133	3,689
1983	588	111	1,474	2,173	1,150	124	3,447
1984	611	114	1,452	2,176	1,027	119	3,322
1985	660	154	1,390	2,204	934	118	3,256
1986	690	172	1,441	2,303	764	105	3,173
1987	705	182	1,533	2,421	800	100	3,321
1988	759	384	1,456	2,600	800	100	3,500
1989	677	405	1,618	2,700	800	100	3,600
1990	690	641	1,369	2,700	800	100	3,600
All	6,662	2,421	15,199	24,282	9,619	1,126	35,027

Sources: Canadian Aviation Safety Board and Transportation Safety Board.

Table 8(2)-3
Aviation Fatalities

Year	Number of fatalities in year						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	0	6	79	85	85	2	172
1982	0	0	73	73	49	1	123
1983	23	4	41	68	78	2	148
1984	0	0	62	62	58	0	120
1985	0	0	42	42	29	0	71
1986	0	0	48	48	61	4	113
1987	0	0	44	44	52	1	97
1988	0	4	50	54	40	1	95
1989	0	31	53	84	64	2	150
1990	0	0	47	47	40	0	87
All	23	45	539	607	556	13	1,176

Sources: Canadian Aviation Safety Board and Transportation Safety Board.

Table 8(2)-4
AVIATION FATALITY RATES PER 100,000 OPERATING HOURS

Year	Fatality rates per 100,000 hours						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	0.00	4.08	4.26	3.19	6.38	1.59	4.18
1982	0.00	0.00	4.53	3.12	4.04	0.75	3.33
1983	3.91	3.60	2.78	3.13	6.78	1.61	4.29
1984	0.00	0.00	4.27	2.85	5.65	0.00	3.61
1985	0.00	0.00	3.02	1.91	3.10	0.00	2.18
1986	0.00	0.00	3.33	2.08	7.98	3.80	3.56
1987	0.00	0.00	2.87	1.82	6.50	1.00	2.92
1988	0.00	1.04	3.43	2.08	5.00	1.00	2.71
1989	0.00	7.65	3.28	3.11	8.00	2.00	4.17
1990	0.00	0.00	3.43	1.74	5.00	0.00	2.42
All	0.35	1.86	3.55	2.50	5.78	1.15	3.36

Source: Calculated from data in Tables 8(2)-2 and 8(2)-3.

Table 8(2)-5
AVIATION FATAL ACCIDENTS

Year	Number of fatal accidents in year						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	0	1	39	40	47	1	88
1982	0	0	32	32	29	1	62
1983	1	1	17	19	43	1	63
1984	0	0	27	27	31	0	58
1985	0	0	18	18	22	0	40
1986	0	0	29	29	35	1	65
1987	0	0	23	23	29	1	53
1988	0	2	23	25	24	1	50
1989	0	3	21	24	34	1	59
1990	0	0	22	22	24	0	46
All	1	7	251	259	318	7	584

Source: Canadian Aviation Safety Board and Transportation Safety Board.

Table 8(2)-6

AVIATION FATAL ACCIDENT RATES PER 100,000 OPERATING HOURS

Year	Fatal accident rates per 100,000 hours						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	0.000	0.679	2.104	1.503	3.529	0.794	2.136
1982	0.000	0.000	1.985	1.366	2.392	0.751	1.681
1983	0.170	0.900	1.153	0.874	3.739	0.806	1.828
1984	0.000	0.000	1.859	1.241	3.018	0.000	1.746
1985	0.000	0.000	1.295	0.817	2.355	0.000	1.228
1986	0.000	0.000	2.013	1.259	4.580	0.949	2.049
1987	0.000	0.000	1.500	0.950	3.625	1.000	1.596
1988	0.000	0.521	1.579	0.962	3.000	1.000	1.429
1989	0.000	0.741	1.298	0.889	4.250	1.000	1.639
1990	0.000	0.000	1.607	0.815	3.000	0.000	1.278
All	0.015	0.289	1.651	1.067	3.306	0.622	1.667

Source: Calculated from data in Tables 8(2)-2 and 8(2)-5.

Table 8(2)-7

AVIATION PASSENGER-KILOMETRES

Year	Pass-km in year (millions)						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	45,300	395	383	46,078	not available	not available	not applicable
1982	42,855	597	750	44,202			
1983	41,895	737	783	43,415			
1984	44,690	1,262	904	46,856			
1985	47,181	1,819	967	49,967			
1986	47,788	2,779	2,517	53,084			
1987	48,266	4,787	2,311	55,364			
1988	54,121	7,491	2,248	63,860			
1989	53,049	10,115	4,961	68,125			
1990	50,125	15,883	3,393	69,401			
All	475,270	45,865	19,217	540,352			

Sources: For unit toll services: Statistics Canada, *Aviation in Canada*, Catalogue No. 51-501, Dec. 1986, and *Canadian Civil Aviation*, Catalogue No. 51-206. For charter services: private communication from Statistics Canada, Aviation Statistics Centre.

Table 8(2)-8
Aviation Fatality Rates per Billion Passenger-Kilometres

Year	Fatalities per billion pass-km						
	Level 1 carriers	Level 2 carriers	Other carriers	All commercial	Private	Govt.	Total
1981	0.000	15.190	206.266	1.845	not available	not available	not applicable
1982	0.000	0.000	97.333	1.652			
1983	0.549	5.427	52.363	1.566			
1984	0.000	0.000	68.584	1.323			
1985	0.000	0.000	43.433	0.841			
1986	0.000	0.000	19.070	0.904			
1987	0.000	0.000	19.039	0.795			
1988	0.000	0.534	22.242	0.846			
1989	0.000	3.065	10.683	1.233			
1990	0.000	0.000	13.852	0.677			
All	0.048	0.981	28.048	1.123			

Source: Calculated from data in Tables 8(2)-3 and 8(2)-7.

Dividing these figures by the pass-km travelled by carriers of each level (given in Table 8(2)-7) results in passenger fatality rates per billion pass-km as follows:

Class of carrier	Fatalities per billion pass-km
Level 1	0.048
Level 2	0.741
Levels 3 to 6	14.050
All levels	0.605

While these rates represent the decade's experience, it must be emphasized that the rates for Level 1 and 2 carriers are the result of an extremely small number of crashes, and may change radically in a short period due to the large numbers of passengers potentially involved in single events. At the time of writing, it is known that a single crash of a Level 2 carrier's aircraft in 1991 has changed the 10-year average radically.[7] This event has not been included in the intermodal comparisons in the Royal Commission's report, in consequence of a decision to standardize information by using the most recent decade (1981 to 1990) for which data are currently available in most of the modes.

2.1.1 How is Passenger Aviation Safety Changing over Time?

From the information in Tables 8(2)-2 to 8(2)-8, it appears that the fatal accident rates and fatality rates per pass-km for all commercial operations have improved over the decade. Examining the rates by level of carrier, however, shows that the trend was determined essentially by the experience of the smaller carriers. The infrequency of crashes among Level 1 and 2 carriers makes it impossible to determine whether their safety has improved over the period, or to make a confident estimate of the expected fatality rates for those carriers in the immediate future.

For greater confidence, we can look to safety experience in the United States, which has similar aircraft and operating conditions, but much larger numbers of operations and pass-km. We have no reason to believe Canadian carriers have worse safety records than their U.S. counterparts (and some evidence that Canadian safety records are better). In the United States, we can see a 30-year trend of reductions in accidents and fatalities per billion pass-km.[8]

2.1.2 What Has Been the Effect of Airline Deregulation on Safety?

The effect of Canadian deregulation in stimulating Level 1 and 2 carriers' traffic can be seen in Tables 8(2)-2 and 8(2)-7. No effect on aviation fatalities can be discerned, because of the uncertainty in estimating fatality rates in the short term. The hypothesis that deregulation would reduce profitability and lead to cuts in safety was tested to some extent in a recent Canadian study.[9] While the study found some intriguing evidence that spending by carriers on maintenance is associated with lower rates of accidents (broadly defined), it found no relationship between the profitability of carriers and their overall accident experience.

We can turn again to the United States, which has much larger numbers of flights and pass-km, for evidence of the safety effect of deregulation. Several experts have concluded that U.S. deregulation has not led to a degradation of safety.[10] Since deregulation in 1978, accident rates have followed the downward trend established in the regulated period. Moore shows that, during the period 1979 to 1986, total air carrier accidents, fatal accidents and fatalities all declined by over 40% compared with the period 1971 to 1978, and the rates per flight hour declined even more.[11] Oster and Zorn compare the period 1979 to 1985 with 1970 to 1978, and conclude that for all U.S. domestic scheduled services, fatal accidents per million aircraft departures more than halved from 0.46 to 0.22, while passenger fatalities per million passenger enplanements fell from 0.42 to 0.30.[12]

There had been concern that deregulation would switch traffic from major carriers to commuter carriers, and that the latter had worse safety records. Comparing the same periods, however, showed only slightly greater growth in flight hours for air taxis and commuter airlines than for scheduled large jet air carriers (29.8% versus 26.1%).[13] More importantly, passenger safety was shown to improve more for smaller carriers than for larger carriers. Oster and Zorn show that on domestic scheduled services, fatalities per million passengers remained essentially unchanged among trunk carriers, and also among the 20 largest commuter carriers, but fell by over 60% among the smaller commuter carriers.[14] They explain that much of the reduction resulted from a change in average stage length among the commuter carriers. The records of commuter carriers per pass-km reflect their shorter average stage lengths, and the fact that rates of accidents and deaths fall with increased stage length because the risks are much lower when cruising compared with landing or taking off. (This also partially explains the apparently higher fatality rates of Canadian Level 2 carriers compared with Level 1, and of Levels 3–6 carriers compared with Level 2.) The switch to commuter lines following deregulation was part of the hub-and-spoke development, which actually reduced the number of stops on a typical passenger's flight, thereby substantially improving the commuter carriers' safety.[15]

Overall, researchers reach the cautious conclusion that, although the increase in commuter traffic possibly raised average risks per pass-km compared with what might have occurred without deregulation, air safety continued to improve.

Furthermore, commentators note that, to the extent that aviation deregulation diverted traffic from road to air travel, the safety of that traffic improved substantially (see notes on road passenger risks). A study by Bylow and Savage uses a model of highway travel demand to estimate the reduction in road travel as a result of airline deregulation, and then uses U.S. rural highway fatality rates per vehicle-kilometre to estimate the reduction in highway deaths. The authors suggest that highway deaths were reduced by 3,000 over the period 1978 to 1988, dwarfing estimates of the effects of deregulation in raising the risk of air fatalities.[16]

2.2 RAIL SAFETY

Major indicators of rail safety are provided in Tables 8(2)-9 to 8(2)-12. Table 8(2)-9 first shows deaths arising from all rail operations, most of which transport freight, of course. Over the decade to 1990, there was a total of 1,255 deaths. Half occurred in grade crossing accidents, and nearly all were occupants of the motor vehicles struck. Another 40% were persons struck by trains, either employees, or persons walking on tracks, including suicides. Only 54 deaths (less than 5% of the total) came from collisions or derailments, and 24 of these occurred in a single crash in 1986 at Hinton, Alberta.

The annual total of fatalities declined fairly steadily through the decade. Table 8(2)-10 shows that train-kilometres also declined, but less than fatalities, so the overall fatality rate per train-kilometre declined slightly over the period. Among the accident types, deaths in collisions and derailments are so rare that annual rates per train-kilometre are too unstable to show trends. Little change over time can be discerned in the death rate of persons struck by trains, but some improvement does seem to have occurred in the rate of deaths from grade crossing accidents.

Table 8(2)-9
Fatalities in Rail Accidents, 1981 to 1990

Year	Fatalities by type of incident					
	Main-track collisions/ derailments	Other collisions/ derailments	Grade crossing accidents	Persons struck on track	Other	Total
1981	3	2	82	62	4	153
1982	0	4	77	57	7	145
1983	6	2	60	52	6	126
1984	1	0	70	51	2	124
1985	0	4	58	61	5	128
1986	24	0	47	44	3	118
1987	0	1	50	53	2	106
1988	2	0	58	49	2	111
1989	0	5	85	49	2	141
1990	0	0	47	53	3	103
All	36	18	634	531	36	1,255

Source: Transportation Safety Board.

Table 8(2)-10
Fatality Rates in Rail Accidents, 1981 to 1990

Year	Train-km (m)	Fatalities per million train-km by type of incident					
		Main-track collisions/ derail-ments	Other collisions/ derail-ments	Grade crossing accidents	Persons struck on track	Other	Total
1981	131.9	0.023	0.015	0.622	0.470	0.030	1.160
1982	113.3	0.000	0.035	0.680	0.503	0.062	1.280
1983	116.8	0.051	0.017	0.514	0.445	0.051	1.079
1984	124.5	0.008	0.000	0.562	0.410	0.016	0.996
1985	121.3	0.000	0.033	0.478	0.503	0.041	1.055
1986	120.8	0.199	0.000	0.389	0.364	0.025	0.977
1987	122.8	0.000	0.008	0.407	0.432	0.016	0.863
1988	125.7	0.016	0.000	0.462	0.390	0.016	0.883
1989	119.9	0.000	0.042	0.709	0.409	0.017	1.176
1990	112.8	0.000	0.000	0.417	0.470	0.027	0.913
All	1,209.8	0.030	0.015	0.524	0.439	0.030	1.037

Sources: Train-kilometres from Transportation Safety Board; fatality rates computed by Royal Commission staff from train-kilometres plus data in Table 8(2)-9.

Table 8(2)-11
FATALITIES IN RAIL PASSENGER OPERATIONS, 1981 TO 1990

Year	Fatalities by type of victim				
	Passengers	Crew	Victims at crossings	Trespassers	Total
1981	0	0	17	14	31
1982	0	0	17	14	31
1983	4	1	10	17	32
1984	0	0	21	9	30
1985	0	0	21	16	37
1986	16	7	18	16	57
1987	0	0	12	11	23
1988	0	0	12	7	19
1989	0	0	27	15	42
1990	0	0	19	14	33
All	20	8	174	133	335

Source: Personal communication between Transportation Safety Board staff and Royal Commission staff.

Table 8(2)-12
FATALITY RATES IN RAIL PASSENGER OPERATIONS, 1981 TO 1990

Year	Intercity pass-km (millions)	Fatality rates per billion intercity pass-km				
		Passengers	Crew	Victims at crossings	Trespassers	Total
1981	2,844	0.000	0.000	5.977	4.923	10.900
1982	2,267	0.000	0.000	7.499	6.176	13.674
1983	2,545	1.572	0.393	3.929	6.680	12.574
1984	2,515	0.000	0.000	8.350	3.579	11.928
1985	2,622	0.000	0.000	8.009	6.102	14.111
1986	2,390	6.695	2.929	7.531	6.695	23.849
1987	2,236	0.000	0.000	5.367	4.919	10.286
1988	2,418	0.000	0.000	4.963	2.895	7.858
1989	2,798	0.000	0.000	9.650	5.361	15.011
1990	1,473	0.000	0.000	12.895	9.501	22.396
All	24,108	0.830	0.332	7.217	5.517	13.896

Sources: Intercity pass-km from Statistics Canada, *Railway Transport: Part IV, Operating and Traffic Statistics*, Catalogue No. 52-210, to 1981, and unpublished data thereafter, with interpolation for 1990 from VIA Rail annual report; fatality rates calculated by Royal Commission staff from pass-km plus data from Table 8(2)-11.

The safety of passenger rail operations is portrayed in Tables 8(2)-11 and 8(2)-12 (provided by the Transportation Safety Board from unpublished tabulations). Passenger fatalities averaged about two per year, but there were no deaths in eight of the years, and 16 deaths in 1986 in the single crash at Hinton. Over the decade, passenger operations also resulted in eight crew deaths, 174 deaths at grade crossings, and the deaths of 133 trespassers.

Table 8(2)-12 shows that pass-km on intercity rail services fluctuated somewhat during much of the decade, but then dropped by nearly half in 1990, following the major cuts in VIA Rail services. The same Statistics Canada source shows that commuter pass-km rose over the period, comprising 13% of total pass-km in 1981, and 19% in 1988. The fatality rates in Table 8(2)-12 (and in Chapter 8 of Volume 1 of this report) are expressed relative to pass-km for intercity services, while the fatality estimates in Table 8(2)-11 include deaths occurring in commuter services. The fatality rates are therefore somewhat overstated. Table 8(2)-12 first shows the passenger fatality rate for the decade, averaging 0.83 deaths per billion intercity pass-km. It then shows fatality rates for each of the types of non-passenger, and finally totals the overall fatality rate in passenger operations, which averaged 13.9 over the period. It can be seen that the annual passenger fatality rate per pass-km is subject to major, erratic variation because of variability in the frequency of deaths, and therefore no trend can be recognized. The annual total fatality rate in passenger operations is less variable, but shows no trend over this relatively short period.

2.3 INTERCITY BUS SAFETY

Statistics describing the safety of intercity bus operations are very sparse. Provinces and territories are responsible for their own road accident reporting systems, and none routinely reports the total numbers of casualties cross-referenced to the types of vehicles involved in the accidents. Only five jurisdictions (Saskatchewan, Manitoba, Ontario, Nova Scotia and Newfoundland) have distinguished intercity buses from transit buses in their police report forms and computer systems. All jurisdictions recently agreed to report annually to the Canadian Council of Motor Transport Administrators the number of victims killed and injured in intercity buses as part of the effort to monitor the impact of deregulation and the National Safety Code. Their agreement, however, has not been implemented.

Table 8(2)-13 presents a special tabulation from Transport Canada's provincial and territorial computer files showing victims killed and injured in accidents involving intercity buses in the five provinces listed.[17] The table combines the numbers for the three years from 1985 to 1987, showing a total of seven deaths and 265 injuries in these accidents. Of these, no bus occupants were killed, and 27 bus drivers and 73 bus passengers were injured. All seven deaths, and 135 of the other 165 injured, were occupants of other vehicles, which were nearly all cars or light trucks. Only four of the bus occupants and 17 of the other victims were injured severely enough to require hospitalization.

Table 8(2)-13
Intercity Bus Accident Victims, Five Provinces,[a] 1985 to 1987

Victim type	Severity of Injury[b]			
	Minimal	Minor	Major	Fatal
Bus driver	16	10	1	0
Bus passenger	51	19	3	0
Occupant of other vehicle	74	47	14	7
Motorcyclist	2	3	0	0
Bicyclist	2	5	0	0
Pedestrian	5	10	3	0
All	150	94	21	7

Source: Personal communication between staff of Transport Canada and Royal Commission staff.

a. Saskatchewan, Manitoba, Ontario, Nova Scotia and Newfoundland.

b. Minimal — no treatment required;
Minor — treated but not admitted to hospital;
Major — admitted to hospital.

This tabulation can offer no indication of trends over time, and suggests that the annual numbers would be too small to allow trends to be recognized easily even if a long series were available. It is possible only to speculate about trends, but it is relevant that the majority of victims in these accidents were in cars and light trucks, and it is known that the accident rates and "crashworthiness" of those vehicles (the ability of occupants to survive crashes) have improved over time. Improvement will likely continue as accident avoidance capabilities are developed (for example, through anti-lock braking systems, hazard detection systems, and the vehicle guidance aspects of "intelligent vehicle-highway systems"), crashworthiness is improved (through air bags and enhanced side-impact protection) and seat belts are used more consistently.

No estimates of the death and injury rates per intercity bus vehicle-kilometre and pass-km can be made confidently from the information available, particularly as we have no estimates of pass-km travelled in the five provinces concerned. Making the very heroic assumption that the ratio of intercity bus casualties to total road casualties in these five provinces is the same in other jurisdictions, it is possible to estimate total casualties in intercity bus accidents for the three years from 1985 to 1987 as approximately 17 fatalities and 500 injured. Total national traffic in intercity bus services in 1991 is estimated by Royal Commission staff as 3.3 billion pass-km. If traffic was at that same level during 1985 to 1987, the total for the three years would have been 9.9 billion pass-km, and the average risk of fatalities in passenger operations for the period would therefore have been 1.7 deaths per billion pass-km. Due to the uncertainty in both the number of deaths and the traffic estimates, this fatality rate is rounded in Chapter 8 of Volume 1 of this report as 2.0 deaths per billion pass-km.

From the information available, none of the victims during these three years was a bus occupant, so the estimated bus passenger fatality risk would be zero — clearly incorrect as a representation of the long-term risk. To provide some indication of the likely risk, in order to make intermodal comparisons in Volume 1 of this report, it is guessed that passenger fatalities constitute less than half the total fatalities in bus operations. Noting that passengers constituted 73 of the total of 265 injured victims, the true bus passenger risk would lie somewhere between 0 and 1.0 deaths per billion pass-km.

2.4 FERRY SAFETY

Statistics from the Transportation Safety Board (unpublished tabulation) on passenger deaths on ferries are summarized in Table 8(2)-14. These relate to all ferries in Canada, not just the longer services on which the Royal Commission has focussed in Volume 1.[18] The table distinguishes the latter "intercity" ferries from those relating to "river or harbour crossings," showing that six passengers died on intercity ferries during the decade to 1990, of a total of 20 passenger deaths on all ferries.

Table 8(2)-14
PASSENGER DEATHS IN ACCIDENTS ABOARD FERRIES

Year	Intercity ferries	River/harbour crossings	Total
1981	1	3	4
1982	1	3	4
1983	0	1	1
1984	0	3	3
1985	1	1	2
1986	2	0	2
1987	0	0	0
1988	1	0	1
1989	0	0	0
1990	0	3	3
All	6	14	20

Source: Personal communication between Transportation Safety Board staff and Royal Commission staff.

Fatalities in ferry passenger operations should also include deaths of crew and any other non-passengers. Other unpublished statistics from the Transportation Safety Board show that there were a total of 26 deaths aboard or involving ferries during the decade.[19] From this it can be deduced that six of those who died were not passengers. The proportion of those non-passenger deaths occurring in the inter-city services is not known, but, if similar to the proportion among passenger fatalities, would mean that two of the six were in intercity services. The total number of deaths in intercity passenger ferry operations during the decade is therefore estimated at eight.

To assess risks associated with ferry transport, these rough estimates of fatalities are converted to annual averages. Passenger fatalities amounted to about 0.6 per year during the decade, and total fatalities in passenger operations to about 0.8 per year. Passenger-kilometres are not available in traffic records for the whole decade, but have been estimated, in the Notes to Chapter 3 of this report, for all the intercity ferries, at about 830 million pass-km in 1990. Assuming that the average annual fatalities for the decade were constant,[20] estimated risks for passenger deaths are 0.7 deaths per billion pass-km, and for fatalities in passenger operations about 1.0 deaths per billion pass-km.

2.5 PRIVATE MOTOR-VEHICLE SAFETY IN INTERCITY TRAVEL

The aggregate risks associated with intercity passenger travel by private motor vehicles (cars, vans and light trucks) can be roughly estimated as follows. Transport Canada statistics of motor-vehicle traffic accidents provide the number of fatalities on roads with speed limits greater than 60 km/h — including highways and local rural roads. In 1989 there were 2,808 such fatalities, constituting 65% of total motor vehicle fatalities for the year.[21] The Royal Commission's estimate of total highway passenger-vehicle traffic for the year was 210 billion pass-km. Comparing the two gives a fatality rate of 13 per billion pass-km, or one fatality for every 80 million pass-km. In addition, we can estimate the rate of persons injured (of all severities) as 440 per billion pass-km.

The passenger fatality rate in road use is interpreted differently than in the public transport modes because there is no important distinction between private vehicle passengers and "crew." Private vehicle operators are nearly always travellers themselves (professional drivers being rare exceptions), and so should be included in the calculation of a passenger fatality rate. This rate differs considerably from the fatality rate in passenger operations, because private-vehicle occupants (drivers and other occupants) constitute about 80% of the total fatalities. The remainder are pedestrians, motorcyclists, bicyclists or occupants of vehicles of other types (heavy trucks, mobile equipment, and so on). In 1989 the passenger fatality rate was about 10 per billion pass-km.

2.6 HEAVY TRUCK SAFETY

As in the intercity bus case, information on truck safety has not been routinely available due to the failure of the provinces and territories to tabulate their records of accident victims by vehicle type. Limited information has become available recently as a result of the agreement through the Canadian Council of Motor Transport Administrators to monitor the effects of the National Safety Code. (This information provides the input to Transport Canada's annual report to Parliament on "Commercial Vehicle Safety in Canada," required under the *National Transportation Act, 1987.*) The information is limited particularly because it provides no details on the number of accident victims. Instead, it merely indicates the number of accidents of each severity in which heavy trucks were involved. These numbers are provided for the years 1986 to 1988 in Table 8(2)-15.

Traffic data comparable with the accident information in Table 8(2)-15 are not available. National compilations of the numbers of vehicles registered do not even distinguish heavy trucks from light trucks (that is, pickups and small vans, which probably outnumber heavy trucks by 10 times). No vehicle-kilometre information exists beyond that obtained for part of the heavy truck fleet from Statistics Canada's surveys of major carriers and partial surveys of private trucking. For some provinces, it is possible to estimate that heavy trucks account for about 3% of vehicles registered. By extrapolation, one can roughly estimate that they account for 9% of total vehicle-kilometres by road.[22] In contrast, the table shows that trucks were involved in slightly less than 3% of non-fatal injury accidents in each of the three years, but in about 9% of all fatal accidents. It seems likely that trucks are substantially under-involved in accidents relative to their vehicle-kilometres travelled — that is, they are less likely to crash per vehicle-kilometre than cars — but when accidents occur the greater weight of the trucks makes the consequences more severe.[23]

Table 8(2)-15
Heavy Truck Involvements in Accidents, 1986 to 1988

Fatal accidents						
	Year 1986		Year 1987		Year 1988	
Vehicle type	**Number**	**%**	**Number**	**%**	**Number**	**%**
Straight truck	141	2.6	190	3.3	195	3.5
Tractor-trailer	319	5.8	344	5.9	327	5.8
Pickup/van	918	16.7	940	16.2	988	17.6
Automobile	3,200	58.3	3,581	61.6	3,497	62.2
Other	913	16.6	760	13.1	616	11.0
Total	**5,491**	**100.0**	**5,815**	**100.0**	**5,623**	**100.0**

Injury accidents						
	Year 1986		Year 1987		Year 1988	
Vehicle type	**Number**	**%**	**Number**	**%**	**Number**	**%**
Straight truck	4,848	1.5	4,886	1.4	5,461	1.6
Tractor-trailer	3,986	1.2	4,289	1.3	4,151	1.2
Pickup/van	38,780	12.0	42,044	12.3	43,624	13.0
Automobile	235,819	73.1	255,312	74.7	251,018	75.0
Other	39,163	12.1	35,473	10.4	30,597	9.1
Total	**322,596**	**100.0**	**342,004**	**100.0**	**334,851**	**100.0**

Source: Personal communication between staff of Transport Canada and Royal Commission staff.

Just how severe is shown in Table 8(2)-16, which compares injuries sustained by the truck occupants with those of the other victims in these accidents. From a large sample of heavy truck accidents analyzed by Transport Canada staff,[24] the table shows that a total of 90 truck occupants were killed and 4,078 injured. About half of these were single-vehicle accidents. Non-truck victims accounted for 392 deaths and 6,806 injuries. Sixty-seven of those killed were pedestrians, bicyclists or motorcyclists — the most vulnerable road users — and the other 324 were occupants of cars or light trucks. Accidents involving cars or light trucks illustrate the disproportion in risks faced by the light and heavy vehicle occupants: the accidents produced 27 times as many deaths in light vehicles as in heavy trucks (324:12), and 4.6 times as many injuries.

Table 8(2)-16

Heavy Truck Occupant Casualties (sample 1984 to 1986)

Traffic unit	Victims in truck		Victims not in truck	
	Killed	**Injured**	**Killed**	**Injured**
Pedestrian	0	0	40	188
Bicycle	0	0	11	79
Motorcycle	0	2	17	128
Car/light truck	12	1,380	324	6,411
Straight truck	10	349	—	—
Tractor-trailer	15	561	—	—
No other unit	53	1,786	—	—
Total	**90**	**4,078**	**392**	**6,806**

Source: E.R. Welbourne and P. Gutoskie, "Heavy truck accidents, casualties and countermeasures," *Proceedings of the Canadian Multidisciplinary Road Safety Conference VI* (Fredericton, N.B.: University of New Brunswick, 1989) pp. 183–93.

2.6.1 Effects of Increasing Truck Sizes

Canada allows substantially larger and heavier trucks to use its highways routinely than does the United States, particularly since the signing of a Memorandum of Understanding among provinces and territories in September 1989.[25] This agreement followed extensive review of the issue of the safety of various trucks, and original work (by the National Research Council, through TAC) on the stability of heavy truck configurations. Evidence on the safety of different classes of truck from over-the-road experience is confounded by differences in operating conditions. Studies find lower accident involvement rates for combination trucks (various tractor and trailer configurations) than for the lighter and shorter straight trucks, and lower rates for double-trailer combinations than for single trailers.[26] It is clear that the larger, heavier trucks operate in more favourable conditions, in particular on major rural highways that have lower accident rates for all traffic, and probably operate with more experienced and capable drivers. Comparing trucks under similar conditions, the U.S. Transportation Research Board finds that the accident and fatality rates of trucks increase with gross weight and dimensions, but by much less than the carrying capacity.[27] This suggests that transferring loads to larger trucks, and therefore using fewer trucks for a given tonnage of freight, improves safety per tonne-kilometre.

2.6.2 Effects on Safety of Trucking Deregulation

Table 8(2)-15 can also be examined for evidence of trends in the three years, the latter two of which followed deregulation of trucking. The numbers concerned are small, but do seem to indicate that the accident involvement of heavy trucks increased after 1986, relative to all other vehicles. This is more pronounced for fatal accidents than non-fatal, and appears confined to "straight trucks" rather than tractor-trailer combinations. No traffic information is available, however, to explain whether this represents an increase in the fatal accident rate per vehicle-kilometre, an increase in vehicle-kilometres, or any change in operating conditions.

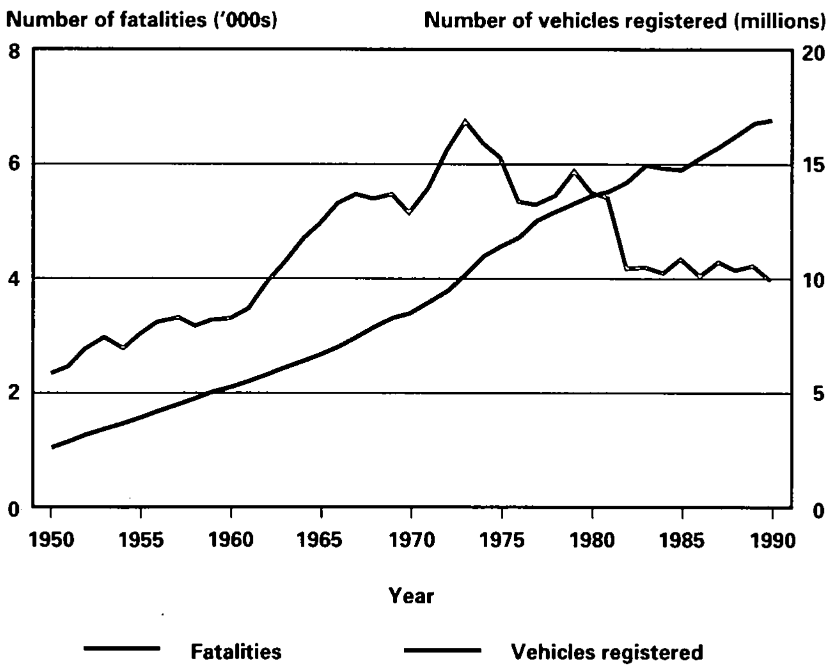
Evidence from the United States, which has many more trucks and accidents, allows more precise assessments. The conclusions of a seminar held in 1987 were that truck safety has continued to improve during the period since deregulation (a reduction from 64 fatal accidents per billion vehicle-kilometres in 1978, to an average of 54 between 1983 and 1985).[28] The U.S. Department of Transportation concluded more recently that, from 1977 to 1988, the rate of fatal crash involvements for single-unit trucks fell by one third, and the rate for combination trucks by 40%, while the rate for passenger vehicles declined by 25%.[29]

2.7 OVERALL TRENDS IN ROAD SAFETY[30]

The trends in road traffic and safety from 1950 to 1990 are illustrated in Chart 8(2)-1 by two main indicators: the size of the motor vehicle fleet and the number of road accident fatalities. (Consistent estimates of vehicle-kilometres are not available.) Road traffic has grown almost without interruption since the invention of the motor vehicle. Since 1950, the vehicle fleet has become six times as large. The chart shows that deaths have increased with traffic, but not consistently. The number of deaths grew until 1973, and fell since then, but with substantial perturbations in the trend. Fatalities approximately trebled between 1950 and 1973, from 2,272 to 6,706. During this 24-year period, a total of 98,196 people died in road accidents.

Extrapolation of the simple trend observed prior to the year 1973 suggested that a further 230,000 would die in road accidents between then and the end of the century; and that over 130,000 would die between 1973 and 1990. In fact, the trend in fatalities changed quite abruptly after 1973. Since then, the annual toll has fallen almost every year. In 1990, it was 3,957, which was 40% lower than in 1973,

Chart 8(2)-1
Trends in Road Traffic and Safety, 1950 to 1990



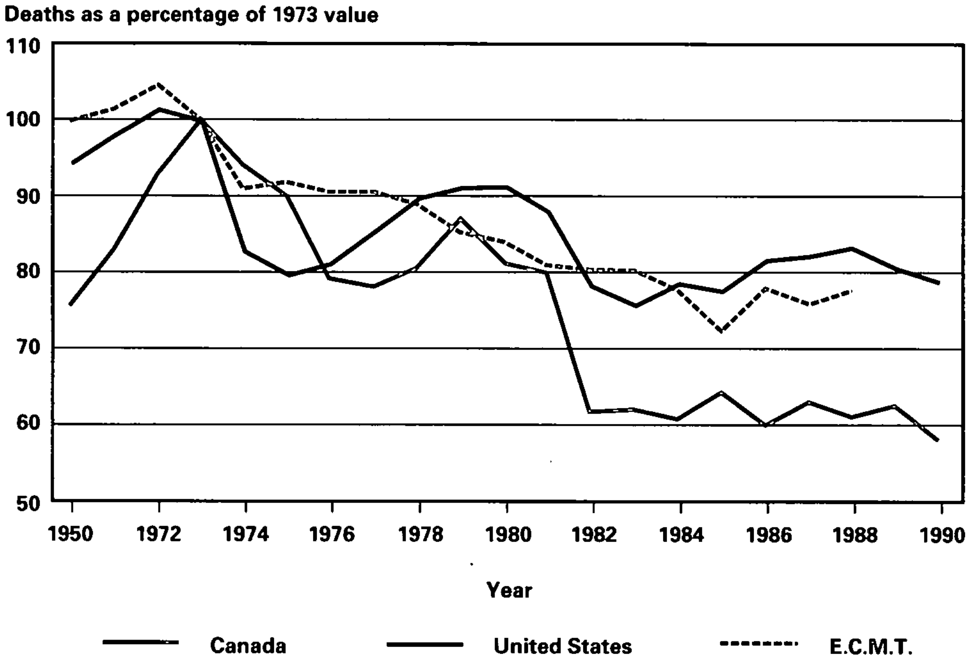
and lower than in any year since 1962. For the period 1974 to 1990, the total deaths were 82,619, but this was one third lower than was predicted from the trend prior to 1973.

The trend to 1973 was of a long-term decline in the average rate of fatalities per vehicle as the vehicle fleet grew. There were, however, substantial fluctuations in that trend, including some sustained periods, such as 1961 to 1966 and 1970 to 1973, when fatalities grew faster than the vehicle fleet and faster than total traffic. Such periods can be shown (in other developed countries as well as Canada) to coincide with spurts in economic growth.[31]

Since 1973, the decline in the average fatality rate has been much sharper, and rose only in 1979 and 1985. While the rate of deaths per 10,000 vehicles fell from 8.7 to 6.6 in the 23 years between 1950 and 1973, it then fell by more than two thirds to 2.3 in the next 17 years to 1990. The sharpest reductions in the fatality rate occurred in 1974 and 1982, which were years of depressed economic activity. But strong economic growth between those years brought no more than a slight increase in deaths in 1979, and sustained growth from 1982 to 1989 produced no increase. It seems safe to conclude that a fundamental improvement in safety — a change in the underlying relationship of fatalities to traffic — has occurred since 1973.

Chart 8(2)-2 supports this conclusion with simple comparisons of trends in Canada with those in other developed countries. The chart shows fatalities represented by indices, with 1973 levels set to 100, for Canada, the United States, and a combined group of 19 countries of the European Conference of Ministers of Transport (ECMT). It is clear that there has been a much greater proportional reduction in fatalities in Canada than in these other countries since 1973, particularly since 1981.

Chart 8(2)-2
INDEX OF FATALITIES, 1973=100



Some major aspects of these improvements are summarized below.

(i) Deaths by type of road user: Driver fatalities have remained almost constant over the past couple of decades, and now amount to about 1,900 annually; while those of passengers have fallen to about 1,100 per year reflecting reductions in vehicle occupancies with increased motorization. Pedestrian deaths have shown the largest reduction, and there are less than half as many deaths (600) as 20 years ago. Motorcyclist deaths increased until about 1983, but have since declined by 40% to about 250 per year; and bicyclist deaths have remained relatively constant, at about 100 deaths a year.

(ii) Deaths by age-group: Assessing the period from 1957 to 1987 shows:

- Age-group 0 to 4 contributes only about 2% of deaths; the fatality rate per capita is less than one third of the average for all groups and has fallen faster than the average; the population of the group fell by 9%.

- Age-group 5 to 14 contributes about 6% of all deaths; the fatality rate per capita is less than half the average; population of the group declined 21% in the period.
- Age-group 15 to 24 contributes nearly 30% of all deaths — a remarkable over-representation; the fatality risk per capita is two and a half times that of the average of the other age-groups, but has recently fallen faster than the average; the population is larger than in 1970, but has contracted since 1980.
- Age-group 25 to 64 contributes 50% of all deaths; the fatality rate per capita fell overall by 40% over 20 years; the population grew by about 50%.
- Age-group 65 and over contributes nearly 15% of total deaths; the rate of fatalities per capita is slightly higher than the average for all age-groups and is falling faster than the average over the period; but growth in the population of the age-group is stronger than the reduction in its fatality rate per capita, so the absolute number of deaths in the group is rising.

2.7.1 Effects of Safety Measures

These trends show that the decline of fatalities in Canada can be explained partially through demographic changes, but mostly remains unexplained. The information available on the effectiveness of programs in road improvement, vehicle performance regulation, or road user education and control, however, is surprisingly poor. The complex relationships among contributing factors, and the poverty of data describing them, have meant that efforts at modelling and explaining the processes have not been very successful. Gaudry's modelling of relationships between social factors and accidents in Quebec is unusual in allowing recognition of the influences of a number of the factors with some statistical confidence.[32] But the introduction of safety measures is rarely immediate enough or sufficiently widespread so that the effects could be assessed accurately even with such a model.

Furthermore, an intriguing aspect of the overall trends is that, in one way, they appear simple to describe: that is, in the long-term decline in the fatality rate per vehicle (or vehicle-kilometre). Researchers have shown in a number of countries that a simple curve describes how the fatality rate declines as the level of motorization (vehicles per capita) grows.[33] They further suggest that the relationships are very similar in many countries — in other words, that different countries have very similar fatalities per vehicle at the same level of motorization. Although this generalization is attractive, it would worry safety programmers because it suggests that safety programs are a waste of time and that improvement over time is inexorable with increasing motorization.

The notion of such a simple determination of the fatality rate is countered by evidence that there are important changes in the relationship over time in any country, and among countries.[34] A substantially different interpretation of the change in the fatality rate over time has recently emerged, particularly from researchers at the Institute for Road Safety Research in The Netherlands.[35] They suggest that the trend in the fatality rate can best be described by a very simple relationship derived from mathematical "learning theory." This they interpret to mean that the phenomenon of a declining fatality rate results from "social learning" about safety — a growing understanding by all involved of the means of controlling motorization. The part played by all the various safety programs still remains conjectural — these researchers suggest that the progressive implementation of safety measures has been part of social learning, but have no specific evidence for their effects.

Such evidence should have accumulated from evaluations of specific safety measures using laboratory experiments, or careful observations of the effects of measures that have been implemented. Unfortunately, it has proven difficult to predict from laboratory experiments how safety measures will be received when implemented (for example, how drivers will react to changes in road markings, or to improvements in vehicle performance). In particular, it has been found that road users adapt their behaviour to changes in equipment or controls, and often in a way that reduces the intended safety gain.[36] One hypothesis has held that adaptation is intended to keep risks constant,[37] while other empirical evidence shows that the extent of adaptation is unpredictable.[38]

To identify the effects specific to a safety measure, evaluations of its implementation attempt to control for changes in traffic and other extraneous factors. Unfortunately, most evaluations are controlled poorly, and many evaluations are subject to upward biases in their estimates of safety improvements,[39] so all claims for the effects of preventative measures should be viewed with great suspicion.

In sum, there are not many measures that safety researchers would agree have been demonstrated to be effective. The list would probably include:

- a number of major highway improvements (generally for capacity expansion purposes), including grade separation, straight and flat alignments, and paved shoulders;
- guardrails, crash barriers and edge-linings;
- minor improvements on roads at "black spots," for example, to sight-lines, surface conditions, traffic signs and controls;[40]
- a number of U.S. and Canadian motor vehicle performance standards, particularly those for crashworthiness, including standards for deflecting steering columns, side door beams, windshields, door locks, seat belts and air bags;[41]
- seat-belt use laws and their enforcement;[42] and
- random breath testing to enforce laws against drunk-driving.[43]

The list would probably not include some very popular remedies, such as motor vehicle inspection,[44] high-school driver education,[45] and most public information campaigns.[46]

2.7.2 Possible Future Trends

Some of the trends noted earlier can be expected to continue. One of the major changes noted was the disproportionate reduction in pedestrian and passenger fatalities. The reduction in pedestrian fatalities should slow because the changes were proportionately so large, and because underlying contributors, such as the decline in the child population and school consolidation, have slowed. Passenger fatalities could continue to drop relative to driver fatalities if the vehicle fleet continues to grow faster than the population, because vehicle occupancies could be expected to continue to fall.

The effects of future demographic trends must also be factored into the predictions. The contraction of the youngest age-group appears to have ceased, and the child population can be expected to be more stable in the immediate future. The group 25 to 64, with an aggregate fatality rate that is close to the average, will continue to provide the bulk of total population growth. The oldest age-group, over 64, will also continue to grow fastest, exerting an upward pressure on average fatality rates. For the next decade or so, this will be more than offset by the continuing contraction in the young adult group aged 15 to 24, with its very disproportionate risks.

Overall, none of these effects seems likely to be very dominant in changing the fatality rate from its current level. The main determinant of the change in fatalities will continue to be the change in the traffic. As represented by the size of the vehicle fleet, total traffic seems likely to follow its historical growth at a faster rate than the population.

Fatality rates, however, can probably be expected to continue to fall over time. It seems likely that driving activity will increase more in conditions with lower risks (more urban than rural driving, for example, and at slower speeds because of congestion), and among drivers with lower than average risk, as driving activity continues to broaden demographically (involving more women and older people). Reductions should be reinforced by the lagged effects of recent safety measures, and by the impacts of anticipated new measures. It can be expected that air bags will be introduced in all cars and light trucks, and that further vehicle standards will be introduced to improve crashworthiness (especially in side impacts) and crash avoidance (for example, through anti-lock brakes and hazards warning, or even automatic hazards avoidance). It can also be expected that highway safety will be improved by paving shoulders, removing roadside obstacles, and constructing further grade-separated highways.

In the longer term, the introduction of Intelligent Vehicle-Highway Systems holds the prospect of extraordinary improvements in safety (as well as traffic capacity). Once two-way vehicle communication systems are established for navigation (which will likely be broadly available in congested cities within 20 years), the development of vehicle control systems is likely to proceed swiftly, offering the possibility of vehicle queue control. Combined with the development of enhanced on-board vehicle control systems, and, ultimately, autonomous systems, these seem capable of greatly reducing crashes.

3. Values of Accident Losses

3.1 ESTIMATES OF LOSS COSTS IN ACCIDENTS IN CANADA

Most of the work to estimate accident losses has been done in relation to road safety.[47] A number of different cost items might be distinguished:

- damage to vehicles and other property;
- health care for victims;
- lost employment and other "work efforts" of victims;
- time and efforts of police and other emergency services;
- pain, suffering or mental anguish suffered by victims and others;
- lost home, family or community services of victims;

- legal and court proceedings to establish fault, compensation, and so on;
- administration of insurance claims; and
- efforts of family or friends in attending victims.

With a little ingenuity, the list can be extended considerably to include a number of other losses and irritations that affect the victim, the family, employer and social contacts, and that require social resources to correct.

Most of the items on the list would be difficult to identify and estimate, and some might be impossible to measure. The "subjective" costs of victims' pain and suffering obviously present the most problems, but a number of other items, such as losses of services in the home or other family and community services, are normally unpaid and are difficult to assess monetarily.

Transport Canada has attempted to estimate values for all of these losses, and show that three major items dominate (in this order): property damage, lost work, and health care costs. Costs of property damage are estimated from insurance company claims records, with allowances for unclaimed damage. Costs of lost work are estimated from durations of disability and average expectations of lifetime income, with allowance for unpaid efforts at alternative market rates. Health care costs are estimated primarily from payment records from the provincially owned motor-vehicle insurance administrations in Quebec and British Columbia.

Estimates of the losses (rounded) are shown in Tables 8(2)-17 to 8(2)-21, as total amounts for the year 1990, as averages per accident by severity, and as averages per victim by severity (the average accident including more than one victim, plus property damage).

Table 8(2)-17
ESTIMATED VALUES OF TOTAL LOSSES IN ROAD ACCIDENTS, 1990

Type of loss	Amount ($ billion)
Property damage	5.0
Lost work	3.5
Health care	0.5
Total	**9.0**

Source: J.J. Lawson, *The Valuation of Transport Safety*, updated by author to 1990.

Table 8(2)-18
ESTIMATED LOSSES PER ACCIDENT, 1990

Severity of accident	Loss per accident ($)
Fatal	400,000
Injury	25,000
Damage only	5,000

Source: Lawson, *The Valuation of Transport Safety*, updated by author to 1990.

Table 8(2)-19
ESTIMATED LOSSES PER VICTIM, 1990

Severity of injury	Loss per victim ($)
Fatal	330,000
Non-fatal	10,000

Source: Lawson, *The Valuation of Transport Safety*, updated by author to 1990.

Table 8(2)-20
ESTIMATED LOSSES PER ACCIDENT BY TYPE OF LOSS, 1990

Class of accident	Health care ($)	Work loss ($)	Property damage ($)	Total ($)	Number of accidents
Fatal	(few)	400,000	10,000	400,000	3,340
Injury	2,000–3,000	12,000	10,000	25,000	178,854
Damage only	nil	nil	5,000	5,000	650,000

Source: Lawson, *The Valuation of Transport Safety*, updated by author to 1990.

Table 8(2)-21
ESTIMATED TOTAL LOSSES IN ALL ROAD ACCIDENTS BY TYPE OF LOSS, 1990
(BILLIONS OF DOLLARS)

Class of accident	Health care	Work loss	Property damage	Total
Fatal	(few)	1.4	(few)	1.4
Injury	0.5	2.1	1.8	4.4
Damage only	nil	nil	3.2	3.2
Total	**0.5**	**3.5**	**5.0**	**9.0**

Source: Lawson, *The Valuation of Transport Safety*, updated by author to 1990.

3.2 HEALTH CARE LOSSES: WHO PAYS?

Surprisingly little information is available on the extent and costs of health care for victims of transportation accidents, partly because the health care system is more concerned with recording diagnoses and treatments than causes of ill-health, and partly because hospitals and provincial medical insurance schemes do not attribute treatment costs to individual victims, but average their costs per day and charge victims for the number of days treated.

The values in the tables come from Quebec and British Columbia, where the provincial motor-vehicle insurance agency reimburses the department of health for treatment of road accident victims. In both provinces, the agreed amount in each year is a lump sum estimated by the department of health as the costs it incurred.

The amounts in 1990 were about $1,250 per reported road accident victim in British Columbia, and about $2,500 per reported victim in Quebec.[48] Adjusting for a higher average severity of injury to victims in Quebec, the national average is estimated to be $1,500 to $2,000 per reported victim. In 1990, the total would be rounded up to about $500 million for the 263,000 reported victims. Note that this average per reported victim is much lower than the individual costs of treatment for those who received health care, because about 35% of all reported victims received no medical treatment, another 55% received only out-patient treatment, and only about 10% were admitted to hospital.

Of the total of about $500 million, the Quebec and British Columbia insurance corporations — through their policy-holders — paid nearly $200 million. In Ontario, since the introduction of "no-fault" motor-vehicle insurance in 1990, the entire amount has been paid from provincial medical insurance budgets — and that probably amounted to between $200 million and $220 million in 1990. (Previously, the provincial health agency was able to recuperate the costs of health care from vehicle insurance companies when their clients were found responsible, and operated a bulk payment agreement by which the companies paid a flat rate of 2.5% of liability insurance premiums to cover those health care costs.)

In Saskatchewan, the provincially owned motor-vehicle insurance corporation is held liable by the provincial health insurance systems for the health care costs of victims who are negligent in accidents, but those are a small minority of victims. (In Saskatchewan, the payment this year amounts to about $3 million.[49]) The rest of the cost is borne by provincial health insurance. In the remaining provinces, the private vehicle insurance companies can be held responsible for the health care costs of those found at fault (as used to be the case in Ontario). This must be done case by case, however, and so reimbursement is not pursued systematically — probably most often when costs are higher and negligence is more firmly established.

In summary, it seems probable that for road accident victims roughly as much as $300 million of health care costs are borne annually by health insurance plans, and about $200 million by motor vehicle owners (essentially only in Quebec and British Columbia).

For other modes, no information is available whether provincial health care authorities recover health care costs. It seems less likely that recovery would be achieved for these modes, because the assignment of responsibility is probably less formal than is the case with road accidents (where police normally determine responsibility, and fault-finding procedures are well established in insurance legislation or by customary practice). Therefore, it seems probable that health care systems and the people who pay for them meet all the costs of care for accident victims in these other modes. However, there are also many fewer casualties compared with those in road accidents. The total health care costs, in 1990, for road casualties (urban as well as interurban) related to 3,957 fatalities and 263,000 injuries. Comprehensive and comparable records of the number of injured victims in the other modes are not available, but their total annual number is likely much less than 1,000. The largest number would be in bus accidents, which subsection 2.3 suggests were about 170 annually from 1985 to 1987. The next largest group would be victims of train accidents. Transportation Safety Board records show that the ratio of injured victims to fatalities from 1981 to 1990 was fewer than five to one, in which case the annual number in accidents involving passenger trains and excluding grade crossing accident victims (counted as road accident victims) would be fewer than 80. For accidents involving aviation, in which about 60 people died annually during the decade, it seems likely that the ratio of injured to killed is very low (because aviation accidents are so severe). Finally, ferry accidents are so rare that fewer than one person was killed annually in the decade, and the number of injured was likely to be fewer than 10 per year.[50] Health care costs for all injured victims in the public modes would then have been less than $2 million in 1990, if costs per victim were the same as for road accident victims.

3.3 ALTERNATIVE VALUATIONS OF ACCIDENT LOSSES, FROM "WILLINGNESS TO PAY"

Academics have debated the appropriate "value of life" for a century or more. Most of the argument has centred on the value of improvements in safety brought by public investments. The predominant view among economists is currently that intangible benefits in benefit-cost analysis should be given money values based on what the beneficiaries would be willing to pay for them. The view of specialist, safety economists is also that the benefit from a safety improvement is the risk reduction gained by the population at risk, and that its value is whatever people would be willing to pay for the psychological satisfaction they gain.

From this viewpoint, the value of avoiding accidents and their consequences need bear no direct relationship to the costs of sustaining those consequences. Rather than valuing safety by adding up the costs of people dying, it proposes that we add up what the population at risk is willing to pay to reduce the specified chance of dying.

Researchers have considered the following sources:

- insurance premiums paid by individuals;
- court awards of compensation to accident victims;
- values of safety implied by previous government decisions;
- premiums received by workers in risky jobs;
- amounts paid by consumers for safety devices; and
- amounts individuals say they would pay for hypothetical risk reductions.

The first three sources are inappropriate for appraising safety improvements. Insurance premiums address only risks of personal financial losses, and cannot incorporate loss of a victim's own life or physical suffering. Court awards are circumscribed by law and precedent, and tend to be paid in unrepresentative circumstances, in which negligence can be shown, and/or losses are large. Values implied by previous government decisions reveal what hindsight shows the government to have accepted, when rarely was the trade-off explicit, and shows major inconsistencies.

The other three potential sources are cases where individuals trade money for safety, and are considered to be legitimate approaches to finding "willingness to pay" for safety. Worldwide, only about 40 of these empirical studies have been undertaken.[51] It is very difficult to find credible situations in which safety is traded for money in an identifiable way — when the change in risk that is being purchased, and the amount of money involved, are obvious to both the purchaser and the researcher.

Most of these studies compare wage premiums paid for job risks. In these studies, the researcher normally has only some broad estimates of average risks existing in various industries, and must assume that each worker recognizes and trades precisely those risks in deciding where to work. That seems implausible, as does the presumption in the studies that the risk premiums are unaffected by bargaining conditions such as trade union power.

In studies of consumer purchases of safety devices, it is even more difficult to determine what risk reduction consumers believe they are obtaining. Researchers seldom find it possible even to obtain an objective estimate of the risk reduction involved. Such studies are, consequently, extraordinarily rare. The favoured alternative approach is to consider situations in which travellers trade time for safety, and to infer a value for safety from an assumed money value for their time. These add the complications of the great uncertainties in determining values of time to those of revealing the nature of the traded risk.[52]

Finally, the survey approach, asking people the values they would pay for hypothetical risk reductions, manages to avoid the problems of recognizing the risk changes involved, as these are specified in the questions. It faces the criticism, however, that hypothetical responses might relate only poorly to behaviour, and it introduces a number of specific problems in respondents' ability to understand and manipulate small numerical risks.

The behavioural studies we reviewed provide estimates for the value of avoiding a death ranging from less than $200,000 to more than $50 million. The view of some economists[53] is that the best of these can be judged to centre on about $1 million to $3 million, and that such values should be used in benefit-cost analysis. The view of others[54] is that the results of the studies do not allow a confident finding of a central value, or schedule of values of different risks. They also believe there is currently no substitute for either using minimum values based on material losses (Tables 8(2)-17 to 8(2)-21), or obtaining a political judgement of the values of safety to use in benefit-cost analysis, based on the relative priority to be given to safety among other objectives of government action.

3.4 CURRENT PRACTICE AT TRANSPORT CANADA

The policy on valuing safety at Transport Canada has undergone a radical change, with adoption in 1992 of a single value for a death avoided of $1.5 million, in 1991 dollars. Recent practice differed substantially among different parts of the Department, with values in 1989 dollars varying from $310,000 in road safety evaluations to as high as $2.9 million in some aviation investment evaluations. The differences were not created by income differences in the victims (by mode), but resulted from different interpretations of the literature on willingness-to-pay valuations. The position taken for road safety evaluations was that willingness-to-pay research had not provided convincing estimates, so the value used was a minimum estimate based on material losses, while the value used in aviation evaluations reflected a judgement that some of the willingness-to-pay research provided defensible values.

The current position of Transport Canada's Economic Evaluation Branch is that a single value should be used throughout the Department, and that $1.5 million is appropriate.

3.5 RECENT FOREIGN PRACTICE

Values for transport safety are used routinely in many countries, particularly in road investment analysis. Recent official values of transport safety were as follows:

	Approximate $ Can., 1989
United States:	
Federal Highway Administration (FHWA)[55]	2,400,000
Federal Aviation Administration (FAA)[56]	2,500,000
Department of Transportation (DOT) General Counsel[57]	1,600,000
United Kingdom[58]	1,000,000
Australia[59]	480,000
Germany[60]	850,000
Finland[61]	950,000
France[62]	350,000
Sweden[63]	950,000

Values for road safety in most of the countries have been based on the measurable money losses, due to an admitted inability to reveal values in any other way. This is true in Australia, Germany, France, and, until recently, the United Kingdom. As these losses consist mainly of the earnings expected to be lost over a lifetime, most of the differences among the countries arise through differences in wage rates and discount rates. (Canada's Road Safety values were lower than most because of a higher discount rate.)

The value shown for the United Kingdom was the result of an explicit ministerial decision to nearly double the previous value because it gave insufficient priority in road improvement decisions to safety compared with saving time and operating costs, and therefore favoured proposals that increased road traffic volumes or speeds at the expense of safety.[64] The value has subsequently been argued to represent a reasonable median value from the willingness-to-pay research.[65]

The value shown for the U.S. DOT General Counsel also reflects a political decision in 1986 on the minimum value to be defended in public by that department. It is now superseded at FHWA and FAA by the higher values recently proposed by those agencies, on the basis of a consultant's assessment that the research evidence converges to those values.

ENDNOTES

1. The term "casualty" refers to either death or injury.

2. "Risk" is used to refer to a **rate** of accidents or casualties per unit of traffic (for example, vehicles, veh-km or pass-km).

3. Total car/light-truck highway traffic is estimated at 210 billion pass-km in 1991. Transferring 1% of that, or 2.1 billion pass-km, with an average risk of 13 deaths per billion pass-km would save about 27 road deaths, while if it achieved the average risk for Levels 1 and 2 air carriers combined, of 0.13 deaths per billion pass-km, expected aviation deaths would rise by only 0.27.

4. A particularly interesting recent comparison of risks between road and air suggests that a typical U.S. business traveller who is sober, in a large car, in daylight, on limited-access highways faces a **lower** risk than on a scheduled flight for distances up to 1 000 km! (L. Evans, M.C. Frick and R.C. Schwing, "Is it safer to fly or drive?," *Risk Analysis* 10(2) (1990), pp. 239–246).

5. Passenger-kilometres reported by Statistics Canada are for carriers of Levels 1 to 4, so this 3.5% share actually represents carriers of Levels 3 and 4, rather than 3 to 6. However, it is expected that the passenger traffic carried by Levels 5 and 6 is so small as to be almost negligible in the total for Levels 3 to 6, and in the estimation of fatality rates per pass-km for this class of carriers. In support of that contention, it can be noted that prior to 1981, Statistics Canada reported pass-km for Level 5 carriers on unit toll services, and that, in 1980, those carriers provided less than 0.7% of the pass-km reported on services by carriers of Levels 3 and 4, and that the proportion had declined substantially since 1976 (Statistics Canada, *Air Carrier Operations in Canada*, Catalogue No. 51-002, 1975–1981 issues, Table 1 or 1.2).

6. Personal communication between a Transportation Safety Board official and Royal Commission staff.

7. The crash of a Nationair aircraft in Jeddah in 1991, which claimed 261 lives, will substantially change the long-term fatality rates estimated for Canadian carriers as a whole, and that for the Level 2 carriers quite dramatically. The 10-year average passenger fatality rate per billion pass-km for Level 2 carriers will rise from 0.7 to about 4.6, and the combined rate for Levels 1 and 2 from about 0.1 to 0.6.

8. U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970*, Series Q, Air Transportation (Washington D.C.: 1976) and *Statistical Abstract of the United States* (Washington, D.C.: 1970 to 1990).

9. G. Dionne, R. Gagné and C. Vanasse, *A Statistical Analysis of Airline Accidents in Canada 1976-87* (Montreal: Univ. of Montreal, Centre for Research on Transportation, May 1991).

10. For summaries see: D.L. Golbe and L. Lazarus, "Summary and Policy Implications for Air," *Transportation Deregulation and Safety, Conference Proceedings* (Northwestern University Transportation Center, June 1987), pp. 513–17; L.N. Moses and I. Savage, "Summary and Policy Implications, The Airline Industry," in *Transportation Safety in an Age of Deregulation*, eds. L.N. Moses and I. Savage (New York: Oxford University Press, 1989), pp. 308–320; L.N. Moses, and I. Savage, "Aviation Deregulation and Safety: Theory and Evidence," *Journal of Transport Economics and Policy*, May 1990, pp. 171–88.

11. T.G. Moore, "The myth of deregulation's negative effect on safety," in *Transportation Safety in an Age of Deregulation*, eds. L.N. Moses and I. Savage, pp. 8–27.

12. C.V. Oster, and C.K. Zorn, "Is it still safe to fly?," in *Transportation Safety in an Age of Deregulation*, pp. 129–152.

13. Moore "The Myth Of," Table 2.1, p. 14.

14. Oster and Zorn, "Is it still safe to fly?," Table 10.3.

15. See Oster and Zorn "Is it still safe to fly?," Table 10.4; and R.J. Gordon, "Productivity in the Transportation Sector," *NBER Working Paper No. 3815* (Cambridge, Mass.: National Bureau of Economic Research, August 1991).

16. L.F. Bylow and I. Savage, "The Effect of Airline Deregulation on Automobile Fatalities," *Accident Analysis and Prevention* 23 (5), (1991), pp. 443-52.

17. Problems of interpretation mean that it is possible that some intercity bus accidents and their victims were not identified.

18. As noted in Volume 1, Chapter 13, these ferries comprise the marine ferries on the west and east coasts, together with the crossings of the St. Lawrence tidal estuary in Quebec, and the Tobermory-South Baymouth service in Lake Huron.

19. Personal communication from Transportation Safety Board staff to Royal Commission staff, Dec. 2, 1991.

20. It is not possible from the available evidence to observe whether the annual fatalities were changing through the decade. Ferry traffic (measured by number of passengers carried) grew substantially through the decade, but no equivalent growth in fatalities can be seen in Table 8(2)-14.

21. P. Gutoskie, *Road Accident Statistics in Canada — 1989*, Report TP 10812, Road Safety Directorate (Ottawa: Transport Canada, March 1991), Table A14. The subsequent publication for 1990 records the number of "rural" fatalities as 2,654 (TP 11230, Jan. 1992).

22. Royal Commission staff estimate, based on 420,000 heavy trucks assumed in use in 1989, and kilometres per vehicle as estimated in F. Nix, M. Boucher and B. Hutchinson, "Road Costs," in Volume 4 of this report.

23. Note that Nix et al. estimate that heavy trucks travel some 2.5 times as many kilometres per vehicle per year as cars and light trucks (44,000 compared with 17,600), in which case their rate of fatal accident involvement per vehicle-kilometre can be inferred to be only 40% of that for cars and light trucks (or 1 ÷ 2.5).

24. E.R. Welbourne and P. Gutoskie "Heavy Truck Accidents, Casualties and Countermeasures," *Proceedings of the Canadian Multidisciplinary Road Safety Conference VI*, (Fredericton, N.B.: University of New Brunswick, 1989), pp. 183–93.

25. Transportation Association of Canada, Interjurisdictional Committee on Vehicle Weights and Dimensions, *Summary of Weight and Dimension Regulations for Interprovincial Operations, Resulting from the Memorandum of Understanding on Interprovincial Weights and Dimensions* (Ottawa: TAC, Sept. 1989).

26. See, for example, G. Sparks et al., *The Safety Experience of Large Trucks in Saskatchewan* (Saskatchewan Highways and Transportation, Spring 1988).

27. Transportation Research Board, "Twin Trailer Trucks," *Special Report 211* (Washington, D.C.: National Research Council 1986).

28. R.P. Schweitzer, "The Myth of Economic Deregulation and Safety in the U.S. Motor Carrier Industry," *Transportation Deregulation and Safety* (Northwestern Univ. Transportation Center, June 1987), pp. 693–710.

29. U.S. DOT, National Highway Traffic Safety Administration, "A Summary of Fatal and Nonfatal Crashes Involving Medium and Heavy Trucks in 1988," draft report, February 1990.

30. Much of the following description is derived from J.J. Lawson, *Long Term Trends in Road Safety*, Report TP 9417 (Ottawa: Transport Canada, July 1988).

31. Traffic in vehicle-kilometres is estimated in Canada only approximately from fuel sales. Evidence from countries with more direct measures of vehicle-kilometres confirms that fatalities grew faster than traffic in these periods; see European Conference of Ministers of Transport, *Statistical Report on Road Accidents*, Paris, annual.

32. M. Gaudry, "DRAG, un modèle de la Demande Routière, des Accidents et de leur Gravité, appliqué au Québec de 1956 à 1982," Publication #359, (Montreal: Univ. of Montreal, Centre for Research on Transportation; Univ. of Montreal, October 1984).

33. See, for example, (in chronological order) R.J. Smeed, "Some Statistical Aspects of Road Safety Research," *J Royal Stat. Soc.*, A(1) (1949), pp. 1–34; J.G.U. Adams, *Risk and Freedom: the Record of Road Safety Regulations* (Cardiff: Transport Publishing Projects, 1985); J.G.U. Adams, "Smeed's Law: Some Further Thoughts," *Traffic Engineering and Control* 28(2) (Feb. 1987), pp. 70–73; and J. Broughton, "Predictive Models of Road Accident Fatalities," *Traffic Engineering and Control* 29 (May 1988), pp. 296–300.

34. See, for example, D.C. Andreassen, "Linking Deaths with Vehicles and Population," *Traffic Engineering and Control* 26(11), Nov 1985, pp. 547–9.

35. S. Oppe, M.J. Koornstra and R. Roszbach, "Macroscopic Models for Traffic Safety," *International Symposium of Traffic Safety Theory and Research Methods, Session 5*, (Leidschendam, The Netherlands: Institute for Road Safety Research (SWOV), April 1988); S. Oppe, "The Development of Traffic and Traffic Safety in Six Developed Countries," *Accident Analysis and Prevention* 23(5) (1991) pp. 401–412; S. Oppe, "Development of Traffic and Traffic Safety: Global Trends and Incidental Fluctuations," *Accident Analysis and Prevention* 23(5) (1991) pp. 413–422.

36. For a specific example, see K. Rumar, U. Berggrund, P. Jernberg and U. Ytterbom, "Driver Reaction to a Technical Safety Measure — Studded Tyres," *Human Factors*, 18 (1976), pp. 443–54; for a recent major summarization of the issues, see Organisation for Economic Co-operation and Development, Road Transport Research, *Behavioural Adaptation to Changes in the Road Transport System* (Paris: OECD, 1990).

37. G.S. Wilde, "The Theory of Risk Homeostasis: Implications for Safety and Health," *Risk Analysis* 2 (1982), pp. 209–25.

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40. See summary of research in P.J. Cooper, *Benefit/Cost Assessment of Some Major Traffic Accident Countermeasures in British Columbia* (Vancouver: Insurance Corporation of British Columbia, Jan. 1985).

41. See summary in R.W. Crandall et al., *Regulating the Automobile* (Washington: The Brookings Institution, 1986).

42. See summary in U.S. Department of Transportation, National Highway Traffic Safety Administration, *Effectiveness of Safety Belt Use Laws: A Multinational Examination*, Report DOT HS 807018 (Washington, D.C.: DOT, Oct. 1986).

43. See, for example, Australia, Federal Office of Road Safety, *Drink Driving Controls in Australia* (Canberra: Dept. of Transport, Aug. 1986).

44. See U.S. Department of Transportation, National Highway Traffic Safety Administration, *Study of the Effectiveness of State Motor Vehicle Inspection Programs, Final Report*, Report HS 807468 (Washington, D.C.: DOT, Sept. 1989).

45. See J.R. Stock et al., *Evaluation of Safe Performance Secondary School Driver Education Curriculum Demonstration Project, Final Report* (Springfield, VA: National Technical Information Services, 1983).

46. Organisation for Economic Co-operation and Development, *Road Research Programme: Road Safety Campaigns: Design and Evaluation* (Paris: OECD, Dec. 1971).

47. For a review of recent literature, see J.J. Lawson, *The Valuation of Transport Safety*, Report TP 10569 (Ottawa: Transport Canada, Economic Evaluation Branch, May 1989), on which much of the following discussion is based.

48. Total payments for the year were obtained through personal communication with staff of the Insurance Corporation of British Columbia and Société de l'Assurance Automobile du Québec, and totals were divided by number of reported victims to obtain the above averages. Total payment in Quebec was reported for 1985 in B. Bordeleau, *Évaluation des coûts de l'insécurité routière au Québec* (Quebec: Régie de l'assurance automobile du Québec, Dec. 1988), p. 43.

49. Personal communication with staff of SGI Corp.

50. Transportation Safety Board, *Annual Report 1990* (Ottawa: Supply and Services Canada, 1991), records (Table A-2) some 1,132 injured and 168 killed in all accidents involving Canadian commercial vessels (including accidents aboard ships), during 1981–1990, a ratio of 6.7 injured to each death.

51. A number of which are reviewed in some detail in Lawson, *The Valuation of Transport Safety*, on which the following assessment is based.

52. For summaries of efforts to estimate the value of time, see Lawson, JJ, *The Value of Travel Time for Use in Economic Evaluations of Transport Investment: An Assessment of the Research Findings*, Report TP 10569 (Ottawa: Transport Canada, Economic Evaluation Branch, March 1989); or W.G. Waters II, *The Value of Time Savings for the Evaluation of Highway Investments in British Columbia* (Vancouver: University of British Columbia Centre for Transportation Studies, 1992).

53. Prominently Miller; see, for example, T.R. Miller, S. Luchter and C.P. Brinkman, "Crash Costs and Safety Policy," *Accident Analysis and Prevention* 21(4) (1989), pp. 303–16.

54. For example, Lawson, *The Valuation of Transport Safety.*

55. U.S. Department of Transportation, Federal Highway Administration, *Technical Advisory T 7570.1: Motor Vehicle Accident Costs* (Washington, D.C.: DOT, June 30, 1988).

56. Personal communication with staff of U.S. Dept. of Transportation, Federal Aviation Administration.

57. Memorandum from General Counsel, Office of the Secretary, U.S. Dept. of Transportation, to "Regulation Council Members," on the subject of "Value of a Life," dated April 10, 1986.

58. U.K. Dept. of Transport, *Values for Journey Time Savings and Accident Prevention* (London: Dept. of Transport, 1987).

59. L.A. Steadman and R.J. Bryan, *Costs of road accidents in Australia*, Occasional Paper 91 (Canberra: Bureau of Transport and Communications Economics, 1988).

60. R. Krupp, *Extent, Severity and Economic Costs of Permanent Injuries Caused in Road Accidents* (Bergisch Gladbach: Bundesanstalt für Strassenwesen, May 1984), updated by personal communication from Dr. Krupp.

61. N. Halla, A. Tevajarvi, *User Costs in Road Traffic 1988* (Helsinki, Finland: Roads and Waterways Administration, April 1988).

62. H. Duval, *La valeur monétaire d'une vie humaine*, Cahier d'Étude 58 (Arceuil: Organisme national de sécurité routière, March 1983).

63. Vagverket, Serviceavdelning Planering och Projectering: *Objektanalys 18. Effektkatalog Vag- och gatuinvesteringar* (Borlange, Sweden: Vagverket (Swedish Road Administration), July 1986).

64. Quoted in "Values Placed on Road Deaths," *Traffic Engineering and Control* 29 (July/Aug. 1988), p. 423.

65. M.Q. Dalvi, *The Value of Life and Safety: A Search for a Consensus Estimate* (London: Dept. of Transport, 1988).

NOTES TO CHAPTER 9: LEGISLATION, REGULATIONS AND RELATED DEVELOPMENTS AFFECTING PEOPLE WITH TRANSPORTATION-RELEVANT DISABILITIES

Introduction

These notes provide background information on the accessibility of transportation to people with disabilities. The topics covered include:

1. the current legislative base;
2. National Transportation Agency orders and regulations;
3. major events, studies and inquiries; and
4. a comparison of U.S. and Canadian legislation and regulations designed to improve transportation accessibility.

1. Legislative Base

Early in Chapter 9, Volume 1, the current situation relating to Canadians with transportation-relevant disabilities is described. One key to understanding this situation is a knowledge of the legislation that provides the principles to be observed in improving access to transportation services for travellers with disabilities. This section quotes these legislative provisions and briefly describes how they interrelate.

1.1. THE *NATIONAL TRANSPORTATION ACT, 1987*

The *National Transportation Act, 1987*[1] (NTA, 1987) applies to all federally regulated modes of transportation. For passenger services this includes all air, most rail, and some bus and marine services. Paragraph 3(1)(g) of the Act provides that:

> each carrier or mode of transportation, so far as practicable, carries traffic to or from any point in Canada under fares, rates and conditions that do not constitute . . . an undue obstacle to the mobility of persons, including those persons who are disabled. . . .

The NTA, 1987 also provides direction to the National Transportation Agency concerning its specific role in improving access to transportation services for people with disabilities. This direction took effect through the July 1988 amendments to the Act that read as follows:

63.1(1) The [National Transportation] Agency may, with the approval of the Governor in Council, make regulations for the purpose of eliminating undue obstacles in the transportation network governed by this Act to the mobility of disabled persons, including regulations respecting

(a) the design, construction or modification of, and the posting of signs on, in or around, means of transportation and related facilities and premises, including equipment used in them;

(b) the training of personnel employed at or in those facilities or premises or by carriers;

(c) tariffs, rates, fares, charges and terms and conditions of carriage applicable in respect of the transportation of disabled persons or services incidental thereto; and

(d) the communication of information to disabled persons.

(2) Regulations made under subsection (1) incorporating standards or enactments by reference may incorporate them as amended from time to time.

(3) The Agency may, with the approval of the Governor in Council, make orders exempting specified persons, means of transportation, services or related facilities and premises from the application of regulations made under subsection (1).

63.2 The Agency and the Canadian Human Rights Commission shall co-ordinate their activities in relation to the transportation of disabled persons in order to foster complementary policies and practices and to avoid jurisdictional conflicts.

63.3(1) The Agency may, of its own motion or on application, inquire into a matter in relation to which a regulation could be made under subsection 63.1(1), regardless of whether such a regulation has been made, in order to determine whether there is an undue obstacle to the mobility of disabled persons.

(2) Where the Agency is satisfied that regulations made under subsection 63.1(1) that are applicable in relation to a matter have been complied with or have not been contravened, the Agency shall determine that there is no undue obstacle to the mobility of disabled persons.

(3) On determining that there is an undue obstacle to the mobility of disabled persons, the Agency may order the taking of appropriate corrective measures, or the payment of compensation for any expense incurred by a disabled person arising out of the undue obstacle, or both.

On June 18, 1992, an omnibus Bill (C-78) was passed by Parliament. It amended six Acts, including section 3 of the NTA, 1987. The words "accessible" and "persons with disabilities" were added to the introductory statement of section 3, which is the key statement of general policy in the Act. The statement now reads as follows:

> It is hereby declared that a safe, economic, efficient, and adequate network of viable and effective transportation services <u>accessible to persons with disabilities</u> . . . is essential to serve the transportation needs of shippers and travellers, <u>including persons with disabilities</u>. . . . [addition underlined]

1.2 THE *CANADIAN CHARTER OF RIGHTS AND FREEDOMS* AND THE *CANADIAN HUMAN RIGHTS ACT*

Section 63.2 of the NTA, 1987, directs the National Transportation Agency to coordinate its efforts on behalf of persons with disabilities with the efforts of the Canadian Human Rights Commission. In questions relating to persons with disabilities, the judicial system, including the Canadian Human Rights Commission, is influenced by the equity provisions of the *Canadian Charter of Rights and Freedoms*[2] and the *Canadian Human Rights Act*.[3] The key section of the Charter reads:

> *Equality Rights*
>
> 15.(1) Every individual is equal before and under the law and has the right to the equal protection and equal benefit of the law without discrimination and, in particular, without discrimination based on race, national or ethnic origin, colour, religion, sex, age or mental or physical disability.
>
> (2) Subsection (1) does not preclude any law, program or activity that has as its object the amelioration of conditions of disadvantaged individuals or groups including those that are disadvantaged because of race, national or ethnic origin, colour, religion, sex, age or mental or physical disability.

The key sections of the *Canadian Human Rights Act* stipulate:

> *General*
>
> 3.(1) For all purposes of this Act, race, national or ethnic origin, colour, religion, age, sex, marital status, family status, disability and conviction for which a pardon has been granted are prohibited grounds of discrimination.
>
> (2) Where the ground of discrimination is pregnancy or child-birth, the discrimination shall be deemed to be on the ground of sex.

Discriminatory Practices

5. It is a discriminatory practice in the provision of goods, services, facilities or accommodation customarily available to the general public

   (a) to deny, or to deny access to, any such good, service, facility or accommodation to any individual, or

   (b) to differentiate adversely in relation to any individual,

   on a prohibited ground of discrimination.

1.3 HOW THE SYSTEM WORKS

Although subsection 63.3(1) of the NTA, 1987 gives the National Transportation Agency the power to initiate inquiries into matters that relate to a regulation or a potential regulation, until recently the Agency normally limited its activities to the investigation of possible undue obstacles. In these cases, an individual had to have experienced an unsatisfactory situation before registering a complaint.

Under the *Canadian Charter of Rights and Freedoms* and the *Canadian Human Rights Act*, a traveller with a disability must have attempted to travel and been denied access in order to have a case. As pointed out in Chapter 9 of Volume 1 of this report, it is not sufficient to know that one would be refused access to a mode of transportation — a person must have been denied access before having recourse to the Canadian Human Rights Commission.

2. National Transportation Agency Orders and Regulations

This section outlines the key initiatives undertaken by the National Transportation Agency to improve the accessibility of transportation for people with disabilities. Since the NTA, 1987 was amended in July 1988, the Agency has resolved over 50 complaints about possible undue obstacles and has initiated four inquiries.

2.1 ORDERS AND DECISIONS

In response to complaints lodged with the National Transportation Agency, the Agency issued several orders and decisions to improve accessibility. For example:

- Canadian Partner (Ontario Express Ltd.) was ordered to reverse its policy of refusing to carry certain persons with disabilities on small aircraft (September 1990).
- Air Canada was instructed to make wheelchairs available on all aircraft that are equipped to store them and to assist those people who require help in using the nearest on-board washroom (July 1991).
- McIntosh Limousine Service at Lester B. Pearson International Airport in Toronto was ordered to provide transportation to all passengers with disabilities and to inform all of its drivers of this policy (August 1991).
- In June 1991, Air Canada and Canadian Airlines International were ordered to provide a reasonable number of copies of their safety briefing material in both braille and large print, in addition to the personal safety briefing provided to passengers with visual disabilities, effective August 1, 1992. The carriers were further required to show why they should not also provide safety information on audio cassettes. The Agency accepted the carriers' arguments that it is not operationally possible to provide such information on audio cassettes at this time.

2.2 REGULATIONS

On March 21, 1992, the National Transportation Agency published proposed regulations regarding transportation access for persons with disabilities in the *Canada Gazette, Part I*. The final regulations are proposed to become effective one year after they have been published in the *Canada Gazette, Part II.* As of July 31, 1992, they had not been published in Part II. The proposed regulations comprise two components:

- amendments to the *Air Transportation Regulations* "to regulate the domestic carriage of persons with disabilities in aircraft of 30 or more passenger seats relating to services to be provided to persons with disabilities;" and
- Personnel Training Regulations for the Assistance of Disabled Persons, which would apply to personnel in the transportation network governed by the *National Transportation Act, 1987* (all domestic air, rail, marine passenger carriers and Newfoundland's Roadcruiser bus service).

2.2.1 *Air Transportation Regulations* — Amendment

The proposed amendments to the *Air Transportation Regulations* specify, step by step, the kinds of assistance that must be provided to travellers with disabilities from the time they register at the check-in counter until they enter the general public area after retrieving checked baggage. The amendments also specify the way to handle special aids, such as wheelchairs, that are required for the mobility and well-being of a traveller.

Although these regulations in general apply to aircraft with 30 or more passenger seats, if an aircraft has fewer than 60 passenger seats, and its design prevents carrying an electric or manually operated wheelchair or three-wheel scooter, the air carrier is not required to carry the special aid. The air carrier, however, must advise the traveller about transportation arrangements that are available for the aid.

Where there is a conflict between the proposed regulations and any safety regulations made under the *Aeronautics Act*, the latter prevail.

The description of the proposed regulations indicates that they address areas agreed upon by organizations representing people with disabilities and air carriers. An important feature of the regulations is the guarantee of uniformity of services throughout the country for travellers with disabilities.

The description also acknowledges that the largest impact upon carriers will be on the small and medium-sized operators (about 25 in Canada) that will need to establish comprehensive programs for responding to people with disabilities. The regulations, however, do not require alterations to transportation equipment. Because the amendments apply only to procedures, the description states that "it is not anticipated that carriers will incur additional operating expenses."

The National Transportation Agency also noted in its general description of the regulations that the original set of proposals sent to interested parties in July 1988 "also referred to special air fares for the assistants of passengers with disabilities, and for additional seats required to accommodate a disability. The section on special air fares has been removed to permit further consultation."

In Chapter 9 of Volume 1 of this report, the Royal Commission recommends that:

> When the National Transportation Agency or the carrier concludes that, for safety reasons, an attendant is needed during a trip to assist an individual with a disability, the attendant's fare be borne by the carrier. Otherwise, the traveller should bear the cost. To ensure consistency, carriers should coordinate their policies in this area.
> (Recommendation 9.8)

Section 154 of the Agency's proposed regulations states that "an air carrier shall accept the determination made by or on behalf of a person that the person does not require any extraordinary service during a flight." "Extraordinary service" is defined as "any service related to a disability that is not required by [the proposed regulations] to be provided by an air carrier or any service that is not normally provided by an air carrier."

2.2.2 Personnel Training Regulations

This set of regulations applies to personnel employed by carriers in all modes of transportation and by owners, operators and lessees of passenger transportation networks governed by the Act, every operator of a terminal, including personnel, and agents who provide transportation-related services such as security, parking, car rentals, baggage handling and, in the case of air travel, ground transportation from the terminals. Exempt from the regulations are small air carriers whose gross annual revenues are less than $250,000 or whose operations are limited solely to serving the needs of a lodge operation, and owners, operators or lessees of air terminals where less than 10,000 passengers were enplaned and deplaned during the preceding year.

The definition of "carrier" used in the proposed regulations restricts the application of the regulations to Canadian citizens or permanent residents and governments in Canada or their agents. It also applies to any entity that is controlled in fact by Canadians having at least 75 percent of the voting interests, and that operates a passenger transportation service within and from Canada.

As with the amendments to the *Air Transportation Regulations*, the Agency is aiming for uniform training standards across the country so travellers with disabilities will know what to expect during any Canadian trip. Essentially, the training of carrier personnel is to be at a level appropriate for the requirements of their jobs and should emphasize:

(a) knowledge of the policies and procedures of the carrier and operator with respect to a person with a disability, including relevant regulatory requirements;

(b) recognizing those disabilities most likely to need special services, and knowing the responsibilities on the part of the carrier and operator in relation to those disabilities, such as the level of assistance, methods of communication, and aids or devices generally required by a person with a disability; and

(c) acquiring the necessary skills to assist a person with a disability, by knowing the role of the assistant as well as the needs of a person travelling with a service-animal, including the role and the needs of that animal.

In addition, applicable carrier personnel are to be trained in the areas of providing physical assistance to passengers with disabilities and handling mobility aids (including disassembling and assembling) and special equipment.

Carriers and terminal operators are required to file a description of their training programs, in a form set out in the schedule included in the regulations. This description must be filed with the Agency when the regulations come into force, that is, one year after their publication in Part II of the *Canada Gazette.*

Because the Agency's proposed training regulations are not yet in effect, the Royal Commission recommends in Chapter 9 of Volume 1 that:

> Carriers ensure that personnel who are in a position to assist travellers with disabilities be trained to deal with such passengers with sensitivity and understanding.
> (Recommendation 9.9)

2.3 OTHER PROPOSED REGULATORY INITIATIVES OF THE AGENCY[4]

2.3.1 Special Air Fare Policy

At the same time that the Agency prepared the proposed revisions to the *Air Transportation Regulations* discussed earlier, it also developed a special air fare policy. The regulations relating to this policy for aircraft with 30 or more seats have been separated from the other air regulations, and additional consultations are being held with the Air Transport Association of Canada, and with groups representing people with disabilities. It should be noted, however, that in approving draft regulations the Agency has determined that it is an undue obstacle to the mobility of people with disabilities to charge for the seat used by an attendant needed to provide services additional to those provided by the carrier, or to charge for additional seating that is needed to accommodate the passenger because of a disability. The current expectation is that the proposed regulations on special fares will be submitted to the Minister of Transport in autumn 1992.

2.3.2 Terms and Conditions of Carriage in Small Aircraft

Agency staff is currently completing an inquiry report into the manner in which carriers operating small aircraft serve people with disabilities. The report is expected to make recommendations on proposed regulations and will be provided to the industry for comment. The regulations will be for small aircraft (under 30 seats) and will cover services, fares for attendants, and fares for additional seats required to accommodate a passenger because of a disability. The Agency is expected to submit the regulations to the Minister early in 1993.

2.3.3 Terms and Conditions of Carriage in Other Federal Modes of Transportation

These proposed regulations will standardize the services provided to passengers with disabilities in modes of transportation (other than air) that are under federal jurisdiction. The proposals are being developed in consultation with an advisory committee representing people with disabilities, industry and federal government departments, including Transport Canada. The regulations are expected to be submitted to the Minister late in 1992.

2.3.4 Multimodal Equipment Accessibility

The proposed regulations will cover accessibility features in transportation equipment for all modes of transportation under federal jurisdiction. As for regulations concerning the terms and conditions of carriage, these proposals are being developed in consultation with an advisory committee representing all of the relevant parties. Two inquiries — one on ferries, the other on extra-provincial motor coaches — are currently under way and their results will be taken into consideration in the redrafting of the equipment standards. When these standards are amended, they will be distributed to the advisory committee members for comment before being submitted for Agency approval. The proposed regulations (with the exception of ones dealing with extra-provincial motor coaches) will be submitted to the Minister of Transport at the end of 1992.

2.3.5 Communication of Information to People with Disabilities

This initiative is expected to standardize, in all transportation modes under federal jurisdiction, the way information is provided to people with sensory or cognitive impairments. Agency personnel are currently developing draft regulations for consideration within the Agency. It is expected that these will be submitted to the Minister of Transport during the summer of 1993.

2.3.6 Accessibility of Transportation Facilities (Terminals)

Agency staff are currently considering draft standards developed by Transport Canada, as well as the Canadian Standards Association Barrier-Free Design Standards, to determine how they can be incorporated into a regulatory proposal covering terminals in all modes under federal jurisdiction. It is expected that the proposal will be submitted to the Minister of Transport during the fall of 1993.

3. Major Events, Studies and Inquiries

The following section presents further details on major developments relating to transportation accessibility.

3.1 INDEPENDENCE '92

This major international conference was held in Vancouver from April 22 to 25, 1992. Its theme was "Self-Determination by Persons with Disabilities." The conference included an exposition whose centrepiece was "Independence Street," featuring an accessible bus as well as buildings and sidewalks that were designed to be very accessible. The conference concluded the United Nations Decade of Disabled Persons, giving people with disabilities and their representatives the opportunity to celebrate the accomplishments of the past decade and prepare for future initiatives.

3.2 CANADA COACH LINES DEMONSTRATION PROJECT[5]

A major demonstration project of accessible intercity busing commenced in October 1989 in the Kitchener to Niagara Falls corridor in Ontario. Although some experience in providing intercity accessible bus transportation had been gained in Newfoundland since 1985, an additional demonstration project was required to assess the demand for accessible intercity bus service and to collect information concerning the economics of such a service.

Canada Coach Lines (CCL) was the only bus company that expressed an interest in offering such a service and, therefore, was awarded a contract by Transport Canada for the demonstration project.

The service is scheduled to continue for three years. It operates in a 180-kilometre corridor from Kitchener to Cambridge, Hamilton, St. Catharines and Niagara Falls serving a population of approximately 900,000. Within this corridor, more than 13,600 people with disabilities had registered to use the local para-transit service. These registrants made up the minimum potential market for the demonstration project.

All scheduled services within the corridor are provided by accessible buses that have the capacity to carry two passengers in wheelchairs. Although not a requirement, passengers are encouraged to reserve their trips in advance to ensure that space is available. Reservations can be made from anywhere in the corridor by means of a toll-free number.

3.2.1 Key Results of the First 21 Months

Users: When surveyed, travellers with disabilities who used the intercity bus expressed a high level of satisfaction with the service. All users stated that they would continue to use the service. Two thirds said that they had taken more intercity trips because the service was available and a quarter said that they would not have travelled otherwise.

The total usage of the service, however, was very low. During the first 21 months, only 242 trips were made by people with disabilities, an average 12 trips per month. Only 41 people used the service, and two of these made 47 percent of all the trips. Thus, only about 0.3 percent of the potential market took advantage of the service, and the trips made by people with disabilities represented only approximately 0.04 percent of the total trips taken.

Operations: The accessible service has had little effect on CCL's operations. Because the number of disabled travellers has been relatively low, the additional effort required to book reservations and to coordinate transfers and other activities has not placed a significant burden on the operations staff. During the first 21 months, there were only 13 incidents that affected the operation of the service and none of these was major.

CCL Personnel: Canada Coach Lines developed a one-day training program for the personnel who would be serving passengers with disabilities. In a September 1990 survey of drivers and dispatchers, 90 percent stated that they believed they had been adequately trained. Four drivers indicated that they had experienced some difficulty in understanding some passengers' speech, which might suggest that future training should include techniques for dealing with the problem.

Vehicles: During the first 21 months, the lifts on the buses malfunctioned 26 times — resulting in minor delays, but all passengers were carried safely. It was found that the accessible buses require a higher level of maintenance than similar non-accessible buses. This is due mainly to the specialized equipment, especially the lift, as well as to increased brake wear, apparently caused by the weight of the lift and additional equipment. During the first year of the demonstration, maintenance costs averaged 7 cents per kilometre for the accessible coaches, compared with 2.5 cents for the non-accessible coaches. However, maintenance costs were highest during the first six months and have since decreased.

Marketing: When the demonstration project was initiated, major promotional efforts were made to inform potential customers of the existence of the service. Despite these activities, the service has not achieved a high level of market penetration. Brochures distributed through consumer organizations and local para-transit services appear to be the most effective way to inform potential users about the service.

Financial Data: During the first 21 months, the total cost of the demonstration was $338,800, of which $240,000 came from Transport Canada, $1,250 came from travellers with disabilities, and the remainder from Canada Coach Lines. Transport Canada paid for the lifts, the Washington transfer chairs and a portion of the marketing costs. CCL covered the toll-free telephone line, the personnel training costs, maintenance, and a portion of the marketing costs.

3.2.2 Supplementary Comments

In their submissions to the Royal Commission, some groups representing people with disabilities criticized the choice of location for the demonstration project, suggesting that Toronto should have been included. While use by people with disabilities has not been very high, Transport Canada has indicated that the route used for the demonstration is fairly representative of many routes in Canada. In addition, Canada Coach Lines is not licensed to operate into or out of Toronto.

3.3 INTERIM REPORT OF THE INQUIRY INTO LEVEL OF ACCESSIBILITY OF FERRY SERVICES

On March 19, 1991, the National Transportation Agency appointed three of its officers to "inquire into . . . whether the equipment and services offered by ferry companies under federal jurisdiction constitute undue obstacles to the mobility of persons with disabilities and make recommendations for the removal of such undue obstacles as they may discover."[6] These officers contacted major associations of, and for, people with disabilities, ferry operators, and provincial and federal governments. They met with representatives of many of these organizations and inquired into difficulties in gaining access to the vessels, accessibility to services on vessels, the awareness and training of ferry personnel, aspects of carriers' fare policies governing travellers with disabilities and the costs of providing accessibility. The inquiry officers also made their own examinations of some frequently used services.

Among the ferry services visited were BC Ferries (Canada's largest ferry operator but provincially regulated since it operates within British Columbia), Marine Atlantic Inc., Northumberland Ferries Limited, Société des traversiers du Québec and Coopérative de transport maritime et aérien (CTMA). The inquiry team also held discussions with providers of provincial services in Newfoundland and British Columbia.

The inquiry reached the following conclusions[7] in its interim report dated January 17, 1992:

1. Overall, carriers are making efforts to improve accessibility; Marine Atlantic especially is making efforts and in doing so benefits from its on-going consultations with an Advisory Accessibility Committee.
2. There are no national standards across Canada and the inquiry officers believe that inconsistencies in levels of accessibility pose obstacles to the mobility of persons with disabilities.

3. Since Northumberland Ferries Ltd. is reliant upon the federal government, through Transport Canada, for its operations, the inquiry officers believe that its operations should reflect the policy of the federal government. Transport Canada is a participating Department in the National Strategy for the Integration of Persons with Disabilities, whose purpose is to encourage industry to develop and use equipment that will advance accessibility of transportation.

The inquiry's interim report was circulated to interested parties, and comments were received and analyzed. The Agency has noted the findings in their Final Report, which will also be distributed to interested parties. That part of the report dealing with proposed regulations will be incorporated into the Agency's regulation development program.

3.4 INQUIRY INTO CANADIAN MOTOR COACH SERVICES

This inquiry, entitled "The Road to Accessibility," is examining the level and adequacy of accessible services currently available on extra-provincial motor coaches. The inquiry is also to determine if it is appropriate to set a national standard for services, and the financial implications of doing this. Public hearings are being conducted throughout the country and it is expected that a report will be presented to the Minister of Transport early in 1993.

3.5 INQUIRY INTO GROUND SERVICES AT AIRPORTS

In response to a request from the Canadian Paraplegic Association, the Agency is inquiring into whether the equipment and services offered by automobile rental agencies, taxis, limousines and airport shuttle buses operating at or from Canadian airports present undue obstacles to the mobility of people with disabilities. At the time of writing, it is expected that the inquiry will be completed in the summer of 1992.

3.6 INQUIRY INTO THE POLICIES OF CANADIAN AIR CARRIERS

This inquiry into the policies, standards and practices of all Canadian air carriers with respect to transporting people with disabilities was conducted in two parts. The first part dealt with operators of large aircraft (30 seats or more) and has been circulated to interested parties; the second dealt with the accessibility of smaller aircraft (fewer than 30 seats) and should be circulated to interested parties in late 1992.

4. A Canada–United States Comparison

Chapter 9 of Volume 1 describes the frustration and progress that has occurred in relation to access to transportation for people with disabilities. It specifically mentions the *Americans with Disabilities Act of 1990*, a major event in the United States. This section describes the U.S. legislation and compares it with the situation in Canada.

Canada has not been alone in becoming more aware of the needs of people with disabilities. As is noted in Volume 1, Chapter 9, there has been frustration in Canada at the lack of progress in addressing these needs, including increasing access to transportation services. On the other hand, there has been progress in all passenger modes and it would be inaccurate to underrate the importance of the improvements that have occurred. The bus mode appears to have improved most slowly and, therefore, it is especially positive that the National Transportation Agency embarked on a major inquiry into accessibility within this mode.

In Canada, progress toward increased accessibility has been uneven. This is also the case in other countries that the Royal Commission examined. The example of the United States has been of particular interest to Canadian organizations of and for persons with disabilities, because of the passage of the *Americans with Disabilities Act of 1990*, which applies to the rail and bus modes, and the *Code of Federal Regulations* pursuant to the *Air Carrier Access Act of 1986*, which applies to the air mode. Some Canadian organizations would argue that this legislation places the United States well ahead of Canada in its treatment of people with disabilities. The provisions in the Code and the Act are very comprehensive. In addition, the Act provides for new regulations regarding standards to be met. The following provides a summary of some of the major provisions.

4.1 AIR MODE

The *Code of Federal Regulations* puts into practice the *Air Carrier Access Act of 1986*, which states that, when providing air transportation, no air carrier may discriminate against any otherwise qualified person because of a disability.

The Act and the Regulations specify in considerable detail how aircraft and their interiors must be configured to make seats and washrooms accessible; how airport facilities should be designed; when an air carrier is required to provide transportation to a person with a disability and to provide the services that make the trip feasible (such as oxygen); how aircraft boarding and seat selection are to be performed; when and how personal equipment such as wheelchairs and other aids are to be stowed; how information must be provided to travellers with disabilities; and what special services must be available to people with hearing impairments.

The key provisions on arrangements for attendants accompanying travellers with disabilities are as follows:

- A carrier may require that an attendant accompany a person with a disability in specific circumstances for the safety of the passenger (for example, if a mental disability or severe hearing and sight disabilities prevent the passenger from understanding the safety briefing).
- If the carrier determines that a passenger must travel with an attendant, but the passenger believes that he or she is capable of travelling independently, the carrier shall not charge for transporting the attendant.

- If the carrier determines that an attendant is necessary but an extra seat is not available on the flight on which the traveller has a confirmed reservation, then the traveller with the disability shall be eligible for denied-boarding compensation.

As described earlier in Section 2 of these Notes, the National Transportation Agency has proposed regulations regarding accessible transportation, which will become effective one year after the date of their publication in the *Canada Gazette, Part II*. At the time of writing, the publication in Part II had not occurred. One important consideration to organizations of, and for, persons with disabilities relates to fares for attendants. This issue has not been covered in the regulations the Agency has promulgated to date. The Royal Commission's recommendation concerning attendants is similar to the U.S. requirement already in place.

In the United States, if the physical limitations of an aircraft with less than 30 passenger seats preclude the use of existing models of lifts, boarding chairs or other feasible devices to enplane a person with a disability, air-carrier personnel are not required to carry that person onto the aircraft by hand. In Canada, the currently proposed amendments to the regulations do not pertain to aircraft with fewer than 30 seats. Consequently, there are no regulations available at present to compare with those in the United States. A specific National Transportation Agency decision, however, suggests a direction for the Canadian situation. For example, the Agency ordered Canadian Partner (Ontario Express Ltd.) to make its transportation system accessible to persons with disabilities. This case involved a Jetstream 31 aircraft, which has 19 seats. In response, Canadian Partner is exploring, with manufacturers, the development of a device that will allow access to aircraft in a dignified manner by passengers requiring assistance. However, until a suitable device is available, passengers requiring assistance in ascending and descending stairs on the Jetstream 31 will be manually lifted by Canadian Partner crew. Training in various lifting techniques will be provided to the personnel involved.

In Canada, as described earlier, the National Transportation Agency has proposed regulations for domestic air carriers using aircraft with 30 or more seats. At the present time, Air Canada and Canadian Airlines International each have various special services, not currently required by regulation, to assist travellers with disabilities. These special services are similar to some of the provisions found in the *Code of Federal Regulations* for U.S. air carriers and include:

- advance seat selection;
- a toll-free line available in Canada for those with a Telecommunications Device for the Deaf (TDD);
- reduced fares for attendants on flights within North America;[8]
- transportation of wheelchairs free of charge in the cargo compartment and the provision of special packing for wet-cell battery packs used on motorized chairs;
- for in-flight use, airline-provided wheelchairs on all airplanes except DC-9s and Boeing 747 combis (Air Canada) and Boeing 737s and DC-10s (Canadian Airlines International);
- on all Boeing 727s, 767s and 747s (Canadian Airlines International only for the latter), Airbus A310s and A320s, and DC-10s,[9] washrooms that are accessible to passengers in wheelchairs;
- on all aircraft, except Air Canada's Boeing 747 combis and some 727s, retractable arm rests on selected aisle seats to ease the transfer of travellers from wheelchairs to their seats;
- oxygen "Medipaks," for passengers with respiratory problems, available at an extra charge with advance notice (72 hours for Air Canada and 24 hours for Canadian Airlines International);
- provision for guide dogs accompanying passengers with a visual or hearing impairment in the passenger cabin, except on flights to the United Kingdom and New Zealand, due to animal quarantine regulations in those countries;

- a variety of specially prepared meals when advised 24 hours in advance;
- individual on-board safety briefings; and
- a special facility at Lester B. Pearson International Airport with full-time airline staff offering assistance to passengers needing boarding assistance (Air Canada at Terminal 2 and Canadian Airlines International at Terminal 3).

4.2 SURFACE MODES

The *Americans with Disabilities Act of 1990* provides the criteria to determine if discrimination under the Act has occurred in providing transportation services to people with disabilities. Separate criteria are set out for:

- public entities such as bus, rail, or any other conveyance (other than aircraft or intercity or commuter rail) that provide the general public with general or special service (including charter service) on a regular and continuing system;
- operators of commuter rail transportation and intercity rail transportation (the latter being Amtrak); and
- private entities offering travel or transportation services. (These services include transportation by bus, rail, or any other conveyance, other than by aircraft, that provides the general public with service, including charter, on a regular and continuing basis.)

For the most part, there are differences between new and existing equipment and facilities. Generally speaking, new equipment must be accessible to travellers with disabilities. Private entities, however, operating purchased or leased vehicles with a seating capacity of fewer than 16 passengers face more relaxed requirements. Existing equipment and facilities must be fully accessible by specified deadlines.

One controversial area relating to the application of the Act and Regulations concerns over-the-road buses.[10] To deal with these issues, the Office of Technology Assessment has undertaken a study to determine:

- the access needs of individuals with disabilities to over-the-road buses and over-the-road bus service; and
- through consideration of all forms of boarding options, the most cost-effective methods for providing access to over-the-road buses and over-the-road bus service to individuals with disabilities, particularly individuals who use wheelchairs.

The study, including any options for legislative action, is to be submitted to the President and Congress by July 1993.

In Canada, for the surface modes, the major event related to accessibility is the proposed National Transportation Agency regulations relating to the training of carrier personnel to assist travellers with disabilities. As mentioned earlier in these Notes to Chapter 9, the Agency is in the process of preparing regulations concerning the terms and conditions for transporting persons with disabilities using federally regulated modes other than air (which has already received some attention). Regulations covering the accessibility features of transportation equipment in all modes of transportation under federal jurisdiction are also being prepared, as are regulations to standardize the communication of information to persons with sensory or cognitive impairments.

ENDNOTES

1. *National Transportation Act, 1987.* R.S.C. 1985, c.28 (3rd Supp.).

2. *Canadian Charter of Rights and Freedoms.* R.S.C. 1985, Appendix II, No. 44.

3. *Canadian Human Rights Act.* R.S.C. 1985, c.H-6 (2nd Supplement).

4. National Transportation Agency of Canada, *Accessible Transportation Services for Persons with Disabilities.* A Staff Report to the National Transportation Act Review Commission, May 1992.

5. *Canada Coach Lines Accessible Intercity Bus Service Demonstration, Preliminary Results* prepared by Transport Canada, Policy and Coordination, Transportation Development Centre, October 1991. Information on the total ridership, potential market of persons with disabilities and allocation of costs between Transport Canada and Canada Coach Lines was obtained from Transport Canada officials.

6. Kenneth A. Mozersky, Anne M. Hampel and Paul Lacoste, *Interim Report of the Inquiry into Level of Accessibility of Ferry Services* (Ottawa: National Transportation Agency of Canada, January 17, 1992.)

7. Ibid., p. 12.

8. The attendant's fare is 50 percent of the applicable fare (whether full or discount) at the time.

9. The DC-10 washrooms could be considered "not fully" accessible since the door to the washroom cannot be closed. Entry to the washroom is facilitated by a bar and a privacy screen, and the latter conceals the Washington chair and doorway while the washroom is in use. Canadian Airlines International, however, is phasing out its DC-10 aircraft.

10. An "over-the-road" bus is defined in the United States as one that has an elevated passenger deck located over a baggage compartment.

NOTES TO CHAPTER 18: CHANGES IN COSTS TO 2000 S-Q AND 2000 D CASES — METHODOLOGY AND ESTIMATES

Introduction

Chapter 18 of Volume 1 describes the changes in costs by mode to be expected during the decade from 1991 to 2000 under *Status Quo* (S-Q) and *Directions* (D) conditions. The chapter describes the changes forecast using four trips as illustrations:

- Saskatoon to Halifax
- Toronto to Montreal
- Winnipeg to Churchill
- Halifax to St. John's

Subsequently, the system-wide changes to be expected in each mode are summarized when the total estimated costs for 2000 S-Q and 2000 D are presented in Tables 18-5 and 18-6 of Volume 1.

These notes will reverse this order, describing first the system-wide changes to be expected in each mode, and then offering some details for each of the sample trips where these differ from the system-average changes.

In general, the percentages of change cited here for various factors that differ from 1991 to 2000 S-Q, or between 2000 S-Q and 2000 D, are used in developing our illustrative estimates. They do not always match percentage changes that can be calculated from the tables in Chapter 18. The percentage changes implicit in those tables may differ because rounded numbers and sums of rounded numbers were used in the tables.

1. Changes Expected from 1991 to 2000 S-Q

1.1 CHANGES IN TRAFFIC BY MODE

Simple assumptions are made that, in the absence of the policy changes recommended by the Royal Commission, intercity traffic by mode in passenger-kilometres would grow between 1991 and 2000 by:

- Car 30%
- Bus no change
- Airplane (domestic) 30%
- Train no change
- Ferry 30%

These are not intended to be accurate forecasts, but merely illustrative of the possibilities, in order to allow the implications of the Royal Commission's recommendations to be explored. Their realism can be judged in light of the following observations about recent changes in traffic by mode:

- On Ontario highways, traffic increased between 1980 and 1989 by 36% measured in vehicle-kilometres by all classes of vehicle (separate estimates for car traffic being unavailable).[1]
- Passenger-kilometres on intercity buses are not available, but between 1980 and 1989, total bus-kilometres on intercity unit toll services fell by 16%, while total passengers carried fell by 47%.[2] It is noted, however, that part of the decline is attributable to the reclassification of GO Transit bus services from intercity to urban transit.
- Passenger-kilometres on domestic unit-toll air carrier services increased by 13% between 1981 and 1990, and by 32% between 1983 and 1990.[3]

- Revenue passenger-kilometres on intercity train services declined 3% between 1980 and 1989, and then, on VIA Rail services (87% of the 1989 total), almost halved in 1990.[4]
- The number of passengers carried on intercity ferries increased between 1980 and 1988 by 39% (46% on west coast ferries and 10.5% on east coast ferries).[5]

1.2 CHANGES IN COSTS BY MODE BETWEEN 1991 AND 2000 S-Q

1.2.1 Car

The 2000 S-Q case differs from the 1991 case in allowing for some improvements in vehicle fuel consumption, emissions and safety. Fuel efficiency and CO_2 emissions are expected by Environment Canada and the National Energy Board to improve by about 13% per vehicle (fleet average) by the year 2000.[6] In the cost estimates, the fuel component of vehicle/carrier costs is therefore reduced by 13% in 2000 S-Q, and the CO_2 component of environmental damage costs is reduced by 13%.

The Canadian Council of Ministers of the Environment, through adoption of its Management Plan, intends that NO_x and VOCs emissions will fall by about 40%, including the effects of announced vehicle emission standards and a number of specific programs in the "ozone-sensitive areas."[7] The NO_x/VOCs component of environmental damage costs is therefore reduced by 40% in 2000 S-Q.

Safety is predicted to continue to improve in terms of fatality rates per vehicle and per passenger-kilometre; recent trends have been strongly downward, but the longer term reduction is somewhat slower. On the other hand, the frequency of less-severe accidents and their damage costs continue to increase. An expectation that the reduction in deaths will predominate in the cost equations is represented by a reduction of 10% in the cost per passenger-kilometre.

The fuel tax component of special taxes/fees is assumed to be unchanged per passenger-kilometre, despite the reduction in fuel consumption noted earlier. It is expected in the status quo option that governments would adjust tax rates upward to offset reductions in tax revenue per passenger-kilometre (their practice over the last 15 years having been to increase tax rates more than needed to offset reductions in fuel consumption per vehicle-kilometre).

Together, these changes would reduce average car costs per passenger-kilometre by about 4% by the year 2000.

1.2.2 Bus

The illustrative figures for the bus mode, projected to 2000 but presuming no change from the present regime of provincially regulated regional monopolies, reflect an expectation that, without major policy change, there will be little improvement in costs in this mode. Only the cost of accidents is projected to fall by 10% per vehicle-kilometre and per passenger-kilometre compared with 1991 — reflecting a continuing trend toward safer travel by improving vehicle technology and improving infrastructure and control systems.

This portrayal of 2000 S-Q bus costs could prove optimistic if the current decline in the use of this mode continues; however, for the system total and for the sample routes selected, continued deterioration has not been assumed.

1.2.3 Airplane

The carrier component of air travel costs is expected to continue to fall through 2000 as the older aircraft of existing fleets are replaced by newer airplanes that are fuel efficient, require fewer people in the flight crews, and have lower maintenance costs. New aircraft will reduce the cost of most Canadian domestic air operations. Aging DC-9s, Boeing 727s and early models of the B-737 are being replaced by a new generation of aircraft. These are quieter, can be operated by a cockpit crew of two (instead of three), and are much more economical on fuel.[8]

In some instances, the newer aircraft can accommodate twice the passenger load at the same fuel consumption. For airplanes, such as the Airbus A320 (which is replacing the B-727-200), the same number of passengers are transported at a 40% fuel saving (approximately 150 people in the "all-economy" configuration). A reliable picture of the maintenance costs for the newer aircraft will have to wait until they have aged, but substantial savings are indicated. The following estimated savings were developed using published U.S. airlines' data.[9]

SAVINGS: A320 over B-727-200	
Crew	10%
Fuel	40%
Maintenance	20%

For illustrative purposes, and based on the above, the air operations cost models were projected to 2000 by adjusting fuel and labour costs. The aggregate effect was cost reductions, for system-average vehicle/carrier costs in the sample routes, of 11.5% to 13.5%. For the system average, the projected 1991 to 2000 cost reduction is approximately 12%. With cleaner engines and this fuel saving, an emissions reduction of 15% was estimated.

Air traffic has, with intermittent corrections, grown steadily over the years. It is reasonable to assume that such growth would generally continue. Transport Canada staff (from their Passenger Origin-Destination Model) provided Royal Commission staff with forecasts of air traffic origin-destination from 1989 to the year 2000.

The model forecasts indicate a growth in domestic airline traffic of 37% from 1989 to 2000. This amounts to approximately 30% for 1991 to 2000.

Although the traffic increase that is forecast would affect the economics of flying, particularly between lower density city pairs, it is not expected to have any important impact on the system-average load factors (presumed to be 67.5% for jet and 56% for commuter turboprop) used in the carrier cost presentation. On the other hand, the impact on the average unit cost for under-utilized airports would be considerable — presuming that traffic increases are not matched with even more investment.

Aviation infrastructure spending is expected to grow much less than traffic, indicating that costs per passenger-kilometre will fall. Costs at Toronto and Vancouver airports are the exceptions; it is assumed that expansion costs at these airports would preclude economies in per-passenger costs. Otherwise, marginal costs for Calgary, Edmonton, Winnipeg, Ottawa, Montreal and Halifax are assumed to be 50% of 1991 average levels, and at smaller airports, zero. Presuming a system-average growth in airport activity (domestic and international combined) of 42% from 1989 to 2000,[10] average airport costs per passenger-kilometre would fall by 17% at the six airports listed earlier, and by 30% at smaller airports.

Air navigation services costs per passenger-kilometre are projected to fall system-wide by an average of 25% by the year 2000. Total land costs remain unchanged, but are averaged over a 30% greater volume of passenger-kilometres. Average costs attributable to land, therefore, fall by about 23% per passenger-kilometre. Overall, infrastructure costs fall by about 22%.

Improvements in average fuel consumption (as mentioned earlier) will continue as older models of aircraft retire and are replaced by more efficient versions. An improvement of 15% between 1991 and 2000 is assumed, producing an equivalent reduction in CO_2 and air pollutant emissions damage. In addition, environmental costs are projected to fall as noise costs are presumed to halve, following more extensive adoption of "Stage III" aircraft.

Aircraft fuel tax per passenger-kilometre is projected to decline by 15%, in line with fuel consumption. For cars, where fuel taxes are the main source of government revenue, it is assumed that governments would adjust road fuel tax rates per litre upward to offset declining consumption. For air, no change in fuel tax rates is assumed. Had the assumption been the same as that made for cars, the difference in total costs in the 2000 S-Q case would have been relatively minor.

Airplane accident costs per passenger-kilometre are presumed unchanged.

In sum, domestic air travel costs per passenger-kilometre are projected to fall by about 15% from 1991 to 2000.

1.2.4 Train

Improvements in VIA Rail's cost-recovery performance were generally projected, but assumed to be restricted to its higher potential services. For the sample routes considered, no changes in cost and revenue levels were assumed in cost levels prevailing for Winnipeg to Churchill, or the Montreal to Halifax segment of the hypothetical Saskatoon to Halifax rail journey. For the Saskatoon to Toronto link, a large improvement in average passenger revenue was projected — reflecting an increased emphasis on higher-quality and higher-priced, tourist-focussed transcontinental service. Also included are more-modest increases in per passenger infrastructure and train costs — allowance for the net effects of lower passenger-kilometres per car-kilometre, adjusted in the case of train costs for predicted operating economies.

Projected changes for the Toronto to Montreal sample route are more substantial — in keeping with VIA Rail's plans for a faster service using improved equipment, which will garner higher revenues. Per-passenger vehicle/carrier costs are projected to fall from $124 to $106, revenue to improve by $4 and infrastructure charges to increase (by $2) due to higher speeds.

No change is expected in environmental, accident or special tax/fee costs per passenger-kilometre. The projected reductions in vehicle/carrier costs are sufficient to reduce train costs per passenger-kilometre overall by about 4% between 1991 and 2000.

1.2.5 Ferry

No change is anticipated in the costs per passenger-kilometre of any of the ferry services. However, system-average vehicle/carrier costs would fall slightly as growth is expected to be more vigorous among the west coast services (40% growth in passenger-kilometres, compared with 10% on east coast services), and those west coast services have much lower costs per passenger-kilometre.

Overall, ferry costs per passenger-kilometre are projected to fall by about 3% between 1991 and 2000.

2. Changes Expected from 2000 S-Q to 2000 D

2.1 CAR

The year 2000 D case essentially involves:

- A large shift in the burden of the infrastructure costs from taxpayers to users;
- Introduction of payments by users for the environmental damage costs to users, offsetting costs borne by others; and
- A transfer to users of that portion of accident costs hitherto borne by others.

Accident cost changes are a simple transfer. We do not assume any further improvement, although the change in responsibility for cost might well be an incentive for improvement. The infrastructure cost changes and environmental cost changes are more complex, and will be described further.

The analysis of 1991 system-average costs suggested that, within car infrastructure costs, the costs of "control" were matched by registration fees, but the remaining costs of the "way" (including capital charges and land costs, as well as pavement wear and maintenance costs) were approximately double the revenues received by governments from special fuel taxes. Infrastructure cost recovery could be achieved by doubling the fuel tax rate. Implementing the Royal Commission's recommendations, however, should lead to the application of more rigorous criteria to expenditure decisions on the road network, slowing expansion relative to traffic growth.

To illustrate the possible consequences, infrastructure costs are assumed to be about 5% lower in the 2000 D case. Presuming that the fuel tax (the dominant element of the 2000 S-Q special transportation tax/fee) was the means of collecting the infrastructure charge, it would only need to be increased by about 90% to cover the comprehensive costs throughout the road network.

It is expected that, at least for the next decade or so, road infrastructure charges would be applied (through fuel taxes) at the same rate network-wide, rather than differing by link. The new average charges would therefore produce large surpluses over costs on the links with dense traffic, particularly expressway-standard highways. The surpluses would be needed to cross subsidize less-travelled routes that continued to under-recover. This is evident in the illustrations for sample routes, all of which (except Winnipeg to Churchill, which has no continuous road link) are on major highway routes, with sufficient road traffic to show surpluses on the new infrastructure charges in the 2000 D case.

The net cost increase to users under the 2000 D scenario from infrastructure, environmental and accident charges, less special taxes, would not add dramatically to fully allocated average costs per trip. As of 2000, it would constitute an 8% increment to the average cost per passenger-kilometre, or per trip. The increment would be, however, a larger portion of the "out-of-pocket" costs perceived by motorists, and would amount to a large percentage increase in the effective cost of fuel consumption. This might be expected to cause appreciable changes of travel behaviour and especially in the type of vehicle purchased. In the 2000 D illustrations, it is assumed that these reactions will produce another 10% reduction in both fuel consumption and emissions.

Overall, car costs per passenger-kilometre fall by about 2%. It should be noted, however, that demand for road travel will also be somewhat dampened through travelling less and switching modes, which is not represented in the tables.

2.2 BUS

Regulatory reform, to allow entry to the intercity scheduled bus industry on the basis of "fit, willing and able" criteria, would open the bus industry to competition, and give operators greater commercial freedom. This could induce cost efficiencies and the removal by carriers of internal cross subsidies among routes. Potential efficiencies are illustrated by a 15% reduction in vehicle-carrier costs of the bus services once carriers are free to adjust equipment, schedules and fares to the market, and to withdraw from services where patronage is insufficient.

The analysis of 1991 costs suggested that public infrastructure costs — the allocated costs of the road system, including capital charges and land costs—are almost balanced by the "special taxes/ fees" from buses. Infrastructure costs per bus-kilometre would fall very slightly (about 5%) along with the overall improvement in road infrastructure spending described in the section earlier on car costs. The new infrastructure charges per bus-kilometre would be introduced at levels only slightly higher than those taxes and fees that they replaced. Adjusting for the improvement in average load factor, infrastructure charges per passenger-kilometre would fall further.

User charges would also be instituted for environmental damage costs, transferring the costs from the general public to bus users. These environmental charges would induce bus fuel consumption improvements and emissions reductions, reinforcing reductions arising through more stringent regulations. The scope for additional improvement in bus emissions per vehicle-kilometre appears large relative to that for cars. Compounding this, with a load factor improvement projected for the 2000 D scenario, a reduction of 30% would be a reasonable expectation.

Overall, operating efficiencies and the removal of cross subsidies would mean that costs borne by users would fall by about 11%, even after imposition of the new user-charges. The average full cost of a passenger-kilometre of bus travel would fall by about 15% from the 2000 S-Q scenario.

Bus costs used for the route-specific illustrations are not estimates of actual costs for the routes in question. They are based on adjusting the system-average costs developed (see Notes to Chapter 3 in this volume) for factors specific to the route type. In some cases what they portray may not be accurate. For example, the costs illustrated in the 1991 and 2000 S-Q cases for Halifax to St. John's are not actual costs of the service provided by CN Roadcruiser, but generic costs for similar services provided privately elsewhere. The actual costs are probably substantially higher. For the Newfoundland service, the expectation is that privatization and/or contracting for operation of subsidized services might well reduce costs proportionally more than shown in Table 18-4, which is based on expected changes in system-average costs.

2.3 AIRPLANE

No further changes in air carrier unit costs, except for infrastructure and environmental charges, have been assumed to result from the 2000 D scenario.

Applying the disciplines of full cost recovery and user-sensitive management to airport and air traffic control investment and management should result in infrastructure cost reductions. Actual economies from eliminating excess costs would vary widely by site. Cost saving potential in airports is represented by a reduction of 10% in costs per passenger at Toronto and Vancouver airports, 25% at medium-sized airports, and 35% at smaller airports. Special circumstances are illustrated for the Winnipeg to Churchill example, discussed later.

The illustrative cost reduction presumed to be achieved from public utility style management of air navigation services is 25%. Improvement might well exceed that, as illustrated by the success of the Airways Corporation of New Zealand.[11] Infrastructure costs therefore fall by about 18% on average. Carriers and passengers would be charged directly for these infrastructure costs, but with the exception that the smaller airports[12] would retain transitional subsidies, estimated at $40 million in total in 2000.

The federal fuel excise tax would be eliminated, replaced by a charge for environmental damage. This would induce some additional reduction in aircraft emissions through improved technology or operating practices, illustrated as a reduction of 5% in environmental costs per passenger-kilometre.

Overall, air travel costs per passenger-kilometre fall by about 5% compared with 2000 S-Q. User costs per passenger-kilometre increase by about 10%.

2.4 TRAIN

Different effects of the 2000 D scenario on rail carrier and infrastructure cost, and consequent changes in service offerings, are illustrated for the Toronto to Montreal and Saskatoon to Halifax examples, and in subsection 2.6 for the Winnipeg to Churchill example.

The 2000 D scenario illustrates a possible niche for rail on the Toronto to Montreal route. One hypothetical niche could, of course, be a Toronto to Montreal high-speed rail system; however, even if a decision to proceed were taken on the completion of present studies, the system would not be operative until well after 2000. The niche for rail assumed under the 2000 S-Q scenario involves a system that is more expensive to the user — much more expensive. In part, this would be due directly to full commercial cost recovery. Also, with its prices rising, the only possible approach would seem to be for rail travel to seek a market by moving "up scale."

Part of the projected price rise to an average Toronto to Montreal fare of $119 by 2000 (still supplemented by a transition subsidy of $21) is attributable to improved speed, comfort and service. It is possible that travellers would be unwilling to pay 22 cents per kilometre (24 cents per kilometre standardized to air distance, rising to 28 cents over about three years as the VIA Rail subsidy completely disappeared in 2003), even for an improved rail service, and the mode would fail to survive in an open market. Such a rail operation would, however, provide a markedly improved service, and fill a niche closer to air travel than to bus travel. It would cost less than 75% (rising to 87% as transitional subsidies are phased out) of the price of air travel, be more comfortable, and require only marginally more — or in some cases less — travel time, depending on exact origins and destinations within the metropolitan regions. The time disadvantage of rail is further diminished if time spent less conveniently (that is, time in taxis or terminals) is weighted more heavily relative to time spent comfortably aboard the train or airplane.

Saskatoon to Halifax by rail would cost the user more than four times the air price, or $1,556 for a trip with three changes of trains and with average accommodation, when the transition process is complete early in the next century. (Declining subsidies would mean that the trip would cost $1,271, or more than three times the price of air, in 2000.) Anyone choosing such a trip at this cost would doubtless want better-than-average accommodation, and would have to pay substantially more. The system-total reduction of rail passenger-kilometres for the 2000 D scenario by half (to 0.7 billion passenger-kilometres) recognizes the likely major effect of increasing costs on rail patronage. Remaining rail service would probably be concentrated on higher-volume routes and some tourist services.

Because the potential for fuel consumption and emissions reductions appears large, especially as part of a process of concentrating services on higher-volume routes, it is illustrated by a 20% reduction in environmental damage costs per passenger-kilometre.

2.5 FERRY

Major changes would be introduced to ferry financing, through a phase-down of subsidies over a 10-year period. In the illustrative case it is assumed that, by 2000, this would apply even to the ferry services that are "constitutional" obligations, and that the subsidy would, by 2000, be only about one quarter of its 1991 level. This stimulus, together with the introduction of other management incentives to efficiency (including the ability to contract services in publicly owned ships, and the institution of an advisory panel of users on services and fares), would be expected to reduce costs. In the illustration, it is assumed that costs fall by 20% per passenger-kilometre on the east coast services and by 5% on west coast services (for which average costs per passenger-kilometre are already substantially lower).

Introducing direct charges for environmental damage would prompt reductions in fuel consumption and emissions of about 20%.

There is also scope for reduction in the average costs of the publicly provided infrastructure. Full cost recovery by Transport Canada, together with the creation of a users' advisory body on investments, services and charges, should stimulate efficiencies in provision of the services. This is represented in the illustration by a reduction of 10% in the infrastructure cost per passenger-kilometre.

In summary, costs to users per passenger-kilometre rise by about 40%, while overall comprehensive costs per passenger-kilometre fall by about 9%.

2.6 CHURCHILL TO WINNIPEG: AN ILLUSTRATION OF CHANGE

The town of Churchill has approximately 1,200 residents and no road access. Expenditures by "taxpayers" to maintain existing passenger transportation to and from Churchill are very large per trip, and relative to the total population of the area served. A $19.5-million passenger-rail subsidy in 1990 equalled over $16,000 per resident of Churchill; the airport subsidy amounted to another $8,000 — slightly less if the population served using Churchill Airport as an intermediate point is considered. These are large amounts relative to benefits to the residents. Under the 2000 D scenario, air and rail connections would still be provided but at much lower cost to taxpayers.

2.6.1 Air

Churchill Airport accounts for a total annual cost attributable to commercial aviation of $9,524,000. Of this, $3,951,000 and $1,368,000 would be required to cover airfield and terminal capital investments respectively. Operating costs, excluding depreciation but including Transport Canada overhead, were $4,234,000 in 1990-91. Thompson, Manitoba, however, has a lower comparable total annual cost (including cost of capital) and lower operating costs, of $2,832,000 and $977,000 respectively — and Thompson handles similar aircraft and three times the passenger traffic of Churchill. Other comparisons with airports handling similar commercial traffic also confirmed that Churchill is over-built for the commercial aviation traffic it handles.

Although some of the airport facilities might be justified on the basis of military use or other benefits, it would seem reasonable to run an airport at Churchill for about 100 to 150 passengers daily at an operating and maintenance cost of the order of $800,000 annually, or $23 per passenger. Under the 2000 D scenario this would occur.

Presuming that the over-building were written off, it remained to estimate necessary sustaining capital. Here, as will be the case with any specific site, the question of the necessity of providing a full-service jet facility arose; a facility for turboprop aircraft was presumed adequate, at an estimated (sustaining) capital charge of $500,000 annually. Thus, including the charge for using Winnipeg, a total airport cost per passenger of $37 would seem reasonable. To this is added $6 for air navigation services, for a total infrastructure cost of $43. The total is still a substantial increase over the $25 that the average passenger would pay under the 2000 S-Q scenario. For illustrative purposes, a transitional subsidy of $9 is shown, with the average passenger paying $34.

2.6.2 Rail

Table 18-3 in Volume 1 illustrates, for Churchill to Winnipeg travel, an important aspect of the Royal Commission's recommendations for rail in more remote circumstances — Recommendation 12.5b, that "any subsidized remote access service (regardless of mode) be designed to take passengers out to and bring them in from the closest convenient point where transfer can be made to a commercial unsubsidized carrier." Rail travel (the average of fares for upper and lower berths) from Winnipeg to Churchill presently costs the traveller $229, and would continue to do so under the 2000 S-Q scenario. This is insufficient even to cover the allocated $280 cost for the use of CN's track. Most of the total cost (including a $41 credit for the excess of attributable fuel taxes over the normal sales tax[13]) of $2,978 per passenger is paid by the taxpayer. No improvement in this cost recovery is predicted unless there is a major change in the service offered.

2.6.3 Intermodal

There is bus service to Gillam, 265 km to the south of Churchill. The illustrative table for 2000 D shows a bus-train service that would provide transportation to Churchill at a total cost of $179. A mixed passenger and freight train with basic coach and baggage service was assumed to be used.[14] This would lack the comforts of the present sleeper service with meal and beverage amenities, but the distance and time involved would be much less. Analogous to the situation for the air mode earlier, a transition subsidy is illustrated — in this case $40.

ENDNOTES

1. Ontario Ministry of Transportation, *Provincial Highways Traffic Volumes 1989* (Toronto: Ministry of Transportation, July 1991).

2. Statistics Canada, *Passenger Bus and Urban Transit Statistics,* Catalogue No. 53-215, Annual.

3. Statistics Canada, *Air Carrier Operations in Canada,* Catalogue No. 51-002, October–December issues, 1981–1987, and *Canadian Civil Aviation,* Catalogue No. 51-206, 1988–1990 issues.

4. Statistics Canada, *Railway Transport: Part IV, Operating and Traffic Statistics,* Catalogue No. 52-210, 1980 and 1981 issues; unpublished data provided in personal communication by Statistics Canada for 1982–1989; VIA Rail traffic in 1990 from VIA Rail Canada, *Annual Report.*

5. Unpublished data provided in personal communication by Statistics Canada, together with data from Société des Traversiers du Québec, *Annual Reports,* 1980–1988.

6. National Energy Board, *Canadian Energy Supply and Demand 1990–2010,* Catalogue No. NE 23-15/1991 (Ottawa: Supply and Services Canada, June 1991). Table 4-12 shows total car stock and truck stock fuel efficiencies improving between 1989 and 2000 by 1.5 percent per annum and 1.4 percent per annum respectively; 1.4 percent per annum for 9 years 1991–2000 would be an improvement of about 13 percent.

7. CCME, *Management Plan for Nitrogen Oxides and Volatile Organic Compounds, Phase I,* CCME, Nov. 1990. The National Energy Board in *Canadian Energy Supply and Demand, 1990–2010,* Tables 11-2 and 11-3, expects NO_x emissions between 1990 and 2000 to fall by about 50% in cars, 38% among gasoline-fuelled light trucks and 20% among diesel-fuelled light trucks, and VOCs emissions over the same period to fall by 40% to 45% among cars and gasoline-fuelled light trucks, and 30% among diesel-fuelled light trucks.

8. State-of-the-art new aircraft are also expensive; however, this does not have as large a bearing on total cost as does the operating cost side. The financial costs — depreciation and cost of capital — associated with even a relatively young fleet would rarely exceed 10 percent of an airline's total costs.

9. *Air Transport World,* several issues — 1989 to 1991.

10. Growth of 30 percent is assumed for 1991 to 2000.

11. See: "ATC turns a profit" and "New ATC Network Comes in on Target," *Jane's Airport Review,* March 1992, p. 10 and pp. 26–29.

12. The smaller airports are those designated as level 4 and 5 in the airport cost analysis: see "Notes to Chapter 3" in this volume.

13. The Manitoba and Saskatchewan early-1991 provincial fuel taxes of 13.6 cents and 15 cents per litre of fuel used for rail travel within these provinces were used. This substantially exceeds their 9 cent and 10 cent per litre taxes on automobile gasoline. (It is noted that Manitoba raised its tax on gasoline to 10.5 cents per litre in May 1991.)

14. Neglecting the Crown corporation status of the logical operator — CN Rail — some financial support or alternative persuasion might be necessary if the carrier were to be convinced to initiate such a service (where potential profits are small and financial risk substantial).