

Study of Large Truck Accident Statistics in Canada

To Support Radioactive Material Transport Regulations

Ingenuity.
Imagination.
Insight.

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Background and Motivation

Why is this study needed?

- 760,000 radioactive material shipments/year in Canada
- 900,000 packages transported annually
- 97% of radioactive activity transported in Type B packages
- Radioactive transport accidents are extremely rare
- General large truck accident data used as a surrogate for probabilistic assessment

Regulatory and Study Context

- Transport regulated by the **Canadian Nuclear Safety Commission (CNSC)**
- Safety relies on robust package design supported by quality assurance and transport regulations
- 2019: Feasibility study confirmed sufficient Canadian truck accident data for event tree analysis
- 2024 (This Study): Refined the event tree, analyzed accident causes, and developed an Ontario-specific event tree for comparison with Canada-wide data

Key Challenge

- Very few radioactive transport accidents are available for direct statistical analysis.

Large truck accident statistics provide a practical basis for probabilistic safety assessment of radioactive material transportation.

Approach

- Collected Canada & Ontario truck accident data (2011–2020)
 - Assessed contributing factors
 - Screened and consolidated accident data
 - Refined the Canadian event tree structure
 - Calculated branch and scenario probabilities
 - Developed event trees for Canada and Ontario
 - Compared results to identify similarities and differences
- A refined probabilistic event tree methodology was developed using Canadian large truck accident data.

Accident Data Collection

Data Source

- Transport Canada National Collision Database (NCDB)
- Police-reported large truck accidents across Canada
- Accident data collected for 2011–2020

Data Selection

- Included Canada-wide and Ontario-specific accident records
- Additional detailed data obtained directly from Transport Canada
- Focused on large trucks (>4,536 kg) relevant to Type B package transport
- 2020 data retained as COVID-19 had minimal impact on the overall results

Analysis of Contributing Factors

- Focused on driver- or vehicle-related accident causes
- Environmental factors (e.g., weather, animals, road conditions) were excluded
- Contributing factors grouped into:
 - Alcohol and drugs
 - Disobeying traffic controls/rules
 - Other drivers' behaviors
 - Vehicle issues

Year	Canada			Ontario		
	Total	For Analysis of Contributing Factors	For Event Tree Creation	Total	For Analysis of Contributing Factors	For Event Tree Creation
2011	45,364	15,609	14,294	13,768	6,789	8,557
2012	41,492	14,718	11,950	13,397	6,644	8,298
2013	43,410	15,406	12,861	14,641	7,158	9,172
2014	43,679	16,352	13,548	15,716	7,769	10,004
2015	41,572	15,561	12,852	14,432	7,100	9,250
2016	39,466	14,310	12,708	13,501	6,753	8,928
2017	41,851	13,924	12,962	13,706	6,787	9,285
2018	43,077	14,217	13,300	14,203	6,249	9,596
2019	41,669	13,384	13,206	15,432	6,665	10,084
2020	32,080	10,348	10,337	10,829	4,789	7,301
Average	41,366	14,383	12,802	13,962	6,670	9,048

Event Tree Development

- Excluded accidents with no vehicle damage
 - Refined the event tree using NCDB accident parameters
 - Three-node event tree developed:
 - **Accident Type**
 - Hit moving object
 - Hit non-moving object
 - Non-collision
 - **Accident Category**
 - Relevant categories for each accident type
 - **Vehicle Damage Severity**
 - Demolished
 - Severe
 - Moderate/Light (*combined*)
- **Only accidents with vehicle damage were considered representative of potential transport package damage.**

Event Tree Development

Screening and consolidation of parameters for event tree branches

Category	Value in National Collision Database	Comments
Train	Hit train	Relevant for this study and kept separate due to the context of radioactive material transport.
Other moving vehicle	Hit motor vehicle	Relevant for this study and combined.
	Hit streetcar	
Other moving object	Hit other moving object	Relevant for this study and combined.
	Hit pedestrian	
	Hit cyclist	
	Hit animal	
Structure	Hit building	Relevant for this study and combined.
	Other non-road structure	
	Other road structure	
Ground feature	Hit ditch	Relevant for this study and combined.
	Hit rock/embankment	
Other non-moving object	Hit parked vehicle	Relevant for this study and combined.
	Hit non-fixed object	
	Hit culvert	
	Hit tree	
	Hit utility pole	
	Hit curb	
	Hit sign post	
	Hit traffic barrier	
Fire/explosion	Other fixed object	Relevant for this study and kept separate due to the context of radioactive material transport.
	Fire/explosion	
Other non-collision	Other non-collision event	Relevant for this study and combined.
	Skid/spun	
	Ran off road	
	Rolled	
	Jack-knife	
	Load spill	
	Load shift	
None	Submersion	Screened out since no information is included for use in the event trees.
	Not applicable	
	Other	
	Unknown	

Event Tree Development

Event tree for road traffic accidents involving large trucks in Canada

Accident	Accident Type	Category	Vehicle Damage Severity		Probability
Large truck accident 1	Hit moving object 0.770	Train 0.001	Demolished	0.433	3.29E-04
			Severe	0.337	2.56E-04
			Moderate/light	0.231	1.75E-04
		Other moving vehicle 0.923	Demolished	0.024	1.74E-02
			Severe	0.075	5.33E-02
			Moderate/light	0.901	6.40E-01
		Other moving object 0.076	Demolished	0.016	9.06E-04
			Severe	0.128	7.43E-03
			Moderate/light	0.857	4.98E-02
		Structure 0.124	Demolished	0.085	1.09E-03
			Severe	0.206	2.64E-03
			Moderate/light	0.709	9.09E-03
	Hit non-moving object 0.104	Ground feature 0.267	Demolished	0.214	5.92E-03
			Severe	0.339	9.39E-03
			Moderate/light	0.446	1.24E-02
		Other non-moving object 0.609	Demolished	0.090	5.68E-03
			Severe	0.162	1.02E-02
			Moderate/light	0.747	4.71E-02
	Non-collision 0.126	Fire/explosion 0.021	Demolished	0.579	1.52E-03
			Severe	0.170	4.47E-04
			Moderate/light	0.250	6.58E-04
		Other non-collision 0.979	Demolished	0.237	2.93E-02
			Severe	0.256	3.17E-02
			Moderate/light	0.508	6.29E-02

Event Tree Development

Event tree for road traffic accidents involving large trucks in Ontario

Accident	Accident Type	Category	Vehicle Damage Severity		Probability
Large truck accident 1	Hit moving object 0.818	Train 0.0003	Demolished	0.544	1.30E-04
			Severe	0.222	5.29E-05
			Moderate/light	0.233	5.55E-05
		Other moving vehicle 0.945	Demolished	0.018	1.40E-02
			Severe	0.059	4.56E-02
			Moderate/light	0.923	7.13E-01
		Other moving object 0.055	Demolished	0.016	7.28E-04
			Severe	0.137	6.14E-03
			Moderate/light	0.847	3.79E-02
		Structure 0.113	Demolished	0.051	4.52E-04
			Severe	0.191	1.69E-03
			Moderate/light	0.758	6.69E-03
	Hit non-moving object 0.078	Ground feature 0.120	Demolished	0.147	1.37E-03
			Severe	0.263	2.46E-03
			Moderate/light	0.590	5.53E-03
		Other non-moving object 0.767	Demolished	0.059	3.52E-03
			Severe	0.127	7.63E-03
			Moderate/light	0.814	4.89E-02
	Non-collision 0.104	Fire/explosion 0.022	Demolished	0.485	1.12E-03
			Severe	0.188	4.34E-04
			Moderate/light	0.327	7.55E-04
		Other non-collision 0.978	Demolished	0.124	1.26E-02
			Severe	0.262	2.67E-02
			Moderate/light	0.614	6.25E-02

Results

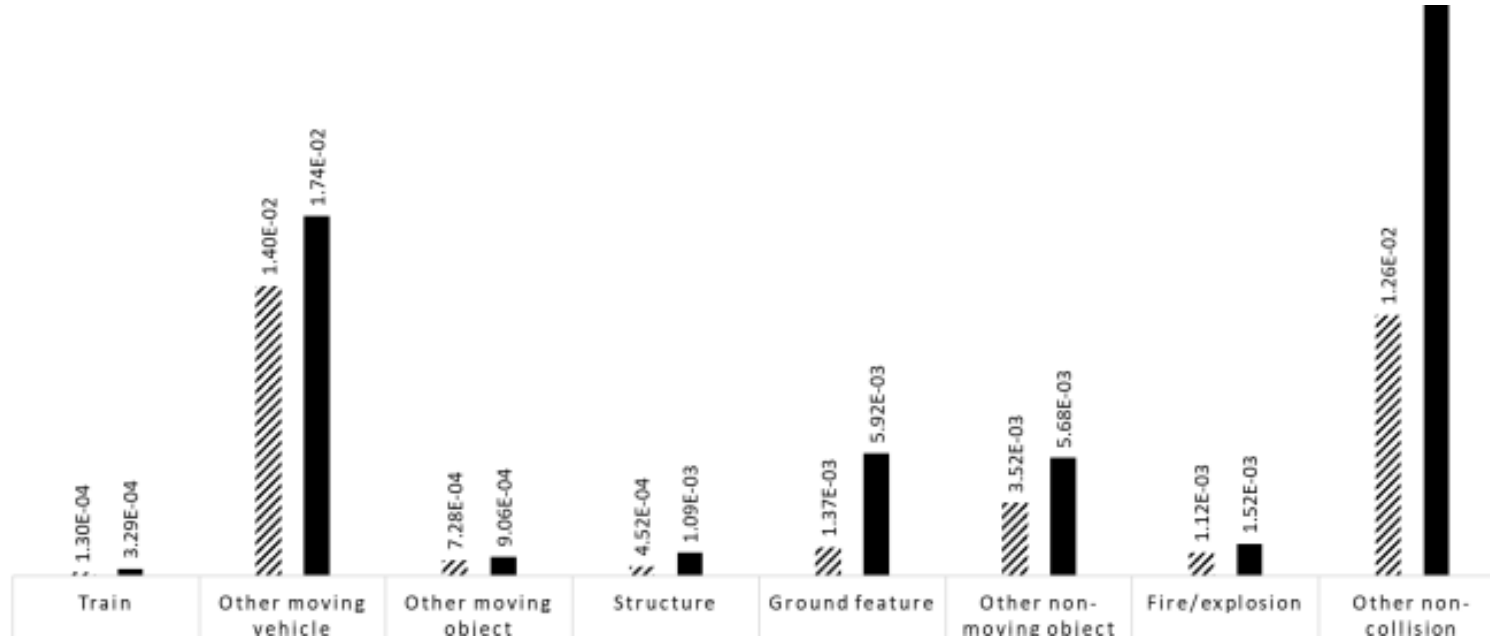
Comparison of Canada and Ontario Accident Probabilities

- Compared event tree probabilities for Canada and Ontario
- Focused on demolished vehicle scenarios, representing the highest potential challenge to transport package integrity
- Ontario showed a lower probability of demolished truck accidents than Canada overall
- In Canada, the most likely demolished vehicle scenario was non-collision events, such as:
 - Run-off-road
 - Rollover
 - Jack-knifing
- Fire and explosion events remained relatively uncommon
- Ontario experiences fewer high-severity truck accidents than the Canadian average, while non-collision events remain the dominant severe accident scenario.

Accident Type	Category	Vehicle Damage Severity	Probability	
			Canada	Ontario
Hit moving object	Train	Total	7.60E-04	2.38E-04
		Demolished	3.29E-04	1.30E-04
		Severe	2.56E-04	5.29E-05
		Moderate/light	1.75E-04	5.55E-05
	Other moving vehicle	Total	7.11E-01	7.73E-01
		Demolished	1.74E-02	1.40E-02
		Severe	5.33E-02	4.56E-02
		Moderate/light	6.40E-01	7.13E-01
	Other moving object	Total	5.82E-02	4.48E-02
		Demolished	9.06E-04	7.28E-04
		Severe	7.43E-03	6.14E-03
		Moderate/light	4.98E-02	3.79E-02
Hit non-moving object	Structure	Total	1.28E-02	8.82E-03
		Demolished	1.09E-03	4.52E-04
		Severe	2.64E-03	1.69E-03
		Moderate/light	9.09E-03	6.69E-03
	Ground feature	Total	2.77E-02	9.36E-03
		Demolished	5.92E-03	1.37E-03
		Severe	9.39E-03	2.46E-03
		Moderate/light	1.24E-02	5.53E-03
	Other non-moving object	Total	6.30E-02	6.00E-02
		Demolished	5.68E-03	3.52E-03
		Severe	1.02E-02	7.63E-03
		Moderate/light	4.71E-02	4.89E-02
Non-collision	Fire/explosion	Total	2.63E-03	2.31E-03
		Demolished	1.52E-03	1.12E-03
		Severe	4.47E-04	4.34E-04
		Moderate/light	6.58E-04	7.55E-04
	Other non-collision	Total	1.24E-01	1.02E-01
		Demolished	2.93E-02	1.26E-02
		Severe	3.17E-02	2.67E-02
		Moderate/light	6.29E-02	6.25E-02

Results

Comparison of large truck accidents resulting in a demolished vehicle



Results

Comparison of groups of contributing factors

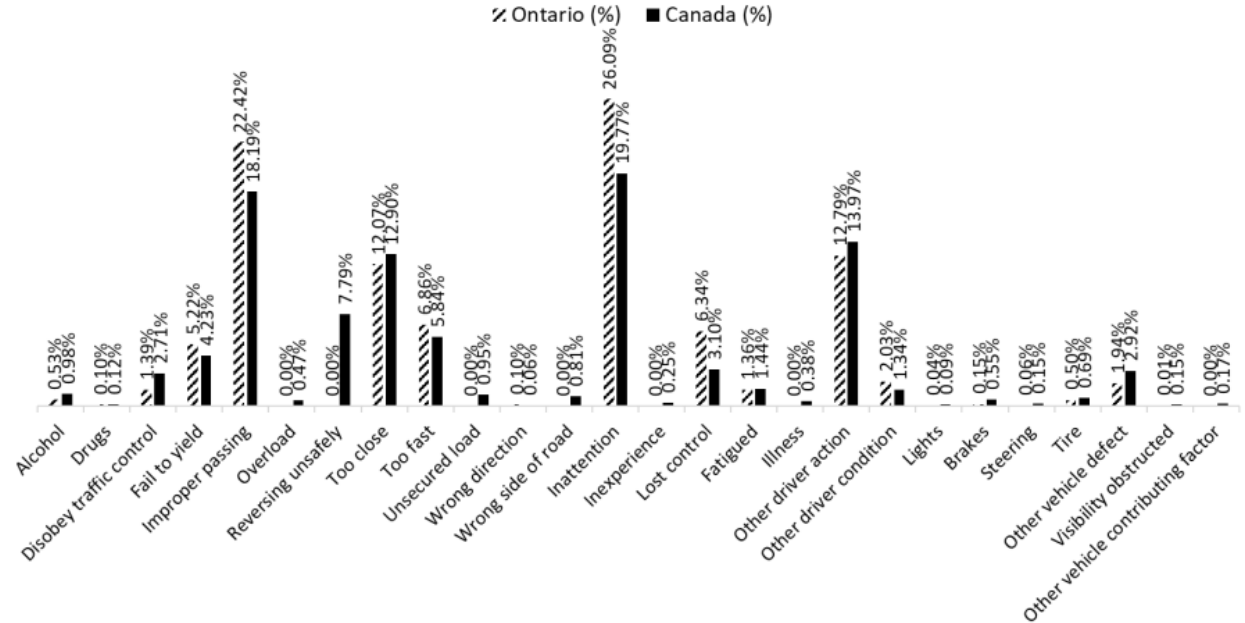
Driver-related factors were the primary contributor to large truck accidents in both Canada and Ontario (2011–2020).

Group	Vehicle Damage Severity	Canada	Ontario
Alcohol and drugs	Demolished	0.23%	0.08%
	Severe	0.12%	0.11%
	Moderate/light	0.24%	0.31%
	No visible/unknown/not provided	0.52%	0.12%
Disobeying traffic controls/rules	Demolished	1.28%	0.88%
	Severe	2.02%	2.66%
	Moderate/light	16.49%	27.74%
	No visible/unknown/not provided	34.16%	16.78%
Other driver behaviours	Demolished	2.46%	2.11%
	Severe	3.06%	4.11%
	Moderate/light	14.44%	23.75%
	No visible/unknown/not provided	20.27%	18.65%
Vehicle issues	Demolished	0.24%	0.14%
	Severe	0.30%	0.22%
	Moderate/light	0.94%	1.07%
	No visible/unknown/not provided	3.23%	1.27%

Results

Comparison of driver- and vehicle-related factors that contribute to large truck accidents

- Driver inattention was the most common contributing factor
- Improper passing was another major cause of accidents
- Following too closely and other driver behaviours were also significant contributors
- Alcohol and drug-related accidents accounted for only a small fraction of cases



Key Findings

- Canada and Ontario accident trends were broadly consistent, with Ontario accounting for the majority of screened accidents.
 - Most accidents resulted in moderate or light vehicle damage; demolished vehicles were uncommon.
 - Ontario had fewer demolished truck accidents than the Canadian average, likely due to lower urban traffic speeds.
 - Driver-related factors dominated large truck accidents in both regions.
 - Driver inattention and improper passing were the leading contributing factors.
 - Alcohol and drug-related accidents represented only a very small proportion of cases.
- **Human factors—not vehicle failures or impairment—were the primary contributors to large truck accidents, while severe vehicle damage remained relatively rare.**

Conclusions

- ✓ **Probabilistic event tree analysis** provides a valuable complement to radioactive material transport safety assessments.
 - ✓ **General large truck accident data** offers a practical and **conservative surrogate** for radioactive material transport.
 - ✓ **Driver-related factors** are the dominant contributors, highlighting the importance of **driver training and regulatory controls**.
 - ✓ Actual accident probabilities for radioactive material transport are expected to be **lower** due to **stricter operational and regulatory requirements**.
- **The developed methodology strengthens risk-informed decision-making and supports future improvements in the safety of radioactive material transportation.**

References

1. Lloyd's Register Applied Technology Group, *Radioactive Material Transport Probabilistic Risk Assessment – Large Truck Accidents on Canadian Roadways*, Technical Report #TR-18-58 (212685), Research report RSP-660.1 prepared for the Canadian Nuclear Safety Commission, September 2019.
2. Vysus Group, *A Study on Large Truck Accident Statistics in Canada and Ontario*, report NUC0500054_R01 prepared for the Canadian Nuclear Safety Commission, April 23, 2024.
3. NCDB online at: <http://wwwapps2.tc.gc.ca/saf-sec-sur/7/ncdb-bndc/p.aspx?c=100-0-0&l=en>.



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Thank you