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Enhancing Canadian Railway Safety: Insights from Positive Train Control (PTC) System Implementation

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SPAD

One of the persistent risks in railways is that train operators do not respond appropriately:

- to written or verbally communicated movement instructions and authorities,
- or a trackside signal indication.

PASS

Source: .shutterstock.

PASS events can lead to derailments or collisions, risking injuries and fatalities and cause property and environmental damage.

Ladbroke Grove accident, UK-1999, 31 deaths
Chatsworth train collision, US-2008, 25 deaths

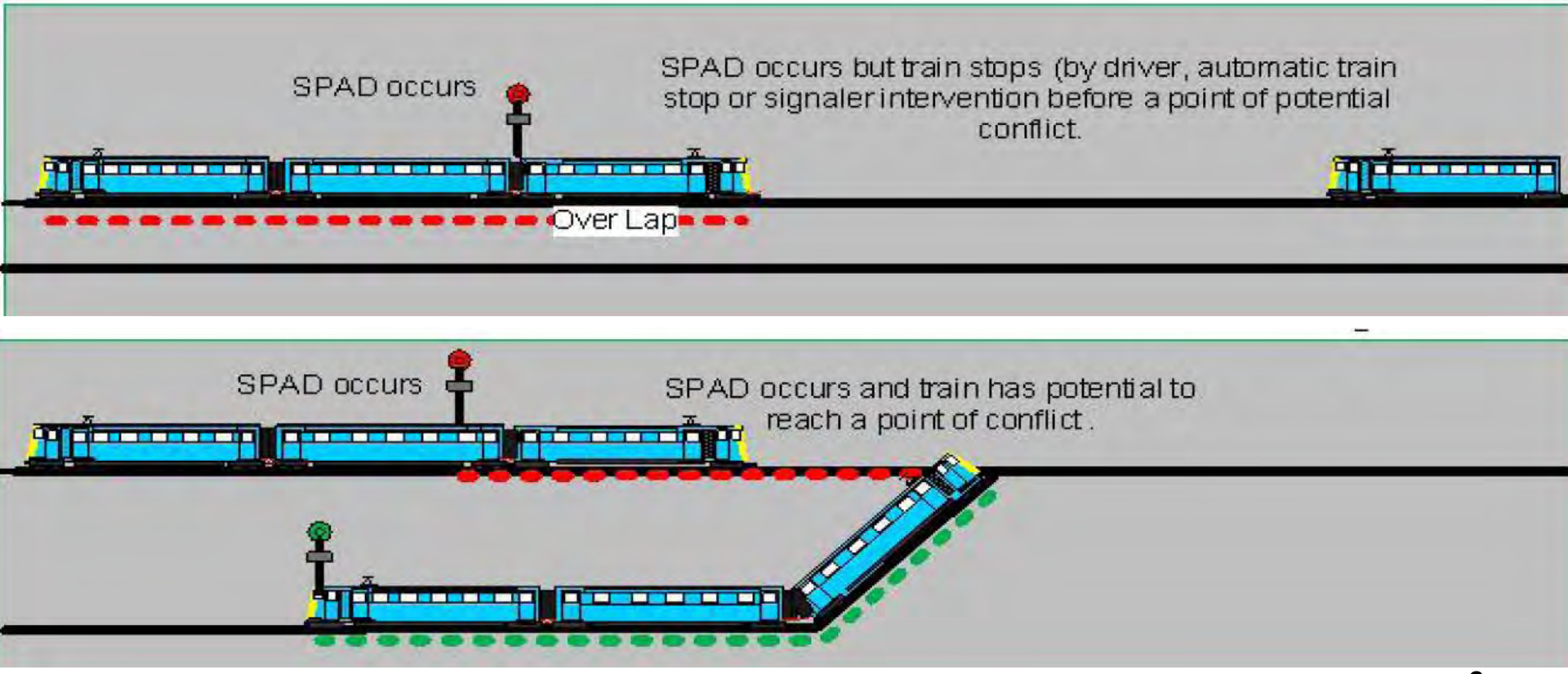


Figure 1: Examples of SPADs with varying degrees of severity RISSB (2019)

Such high-profile railway accidents have motivated the railway industry to extend their safety systems beyond signalling to incorporate protection systems that warn train operators of upcoming signals and their indications.

Chatsworth train collision occurred at 4:22:23 p.m. PDT on Friday, September 12, 2008, when a Union Pacific freight train and a Metrolink commuter train collided head-on. **The Metrolink engineer was texting while on duty. 25 people died and 135 were injured.**

In addition to providing critical alarms, modern train protection systems are now equipped with sophisticated mechanisms that can automatically stop trains if operators fail to comply with signal instructions.

Among the most prominent of these systems are the Positive Train Control (PTC) in the US, the European Train Control System (ETCS), and the Chinese Train Control System (CTCS) (Rad et al., 2021).

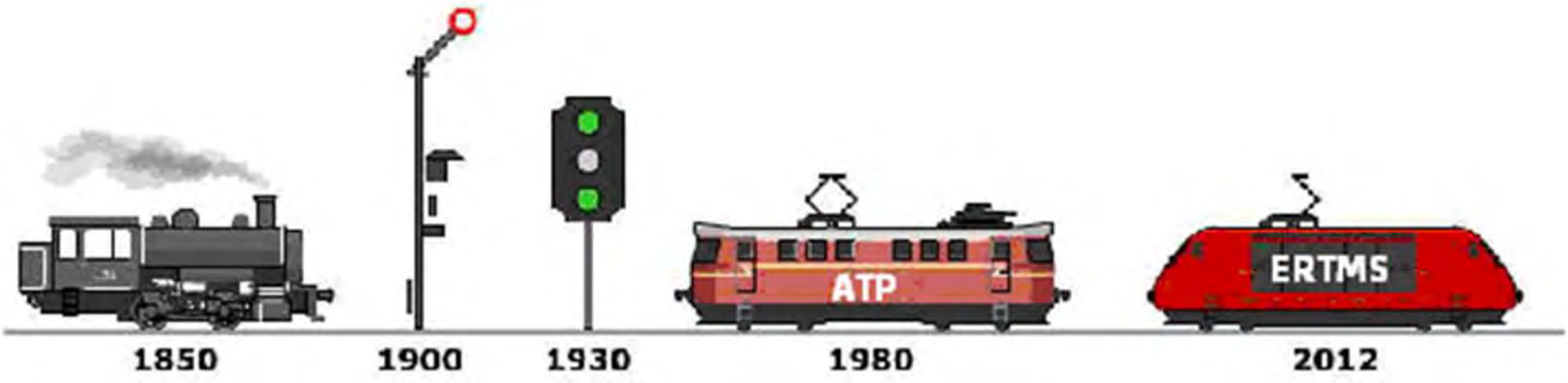
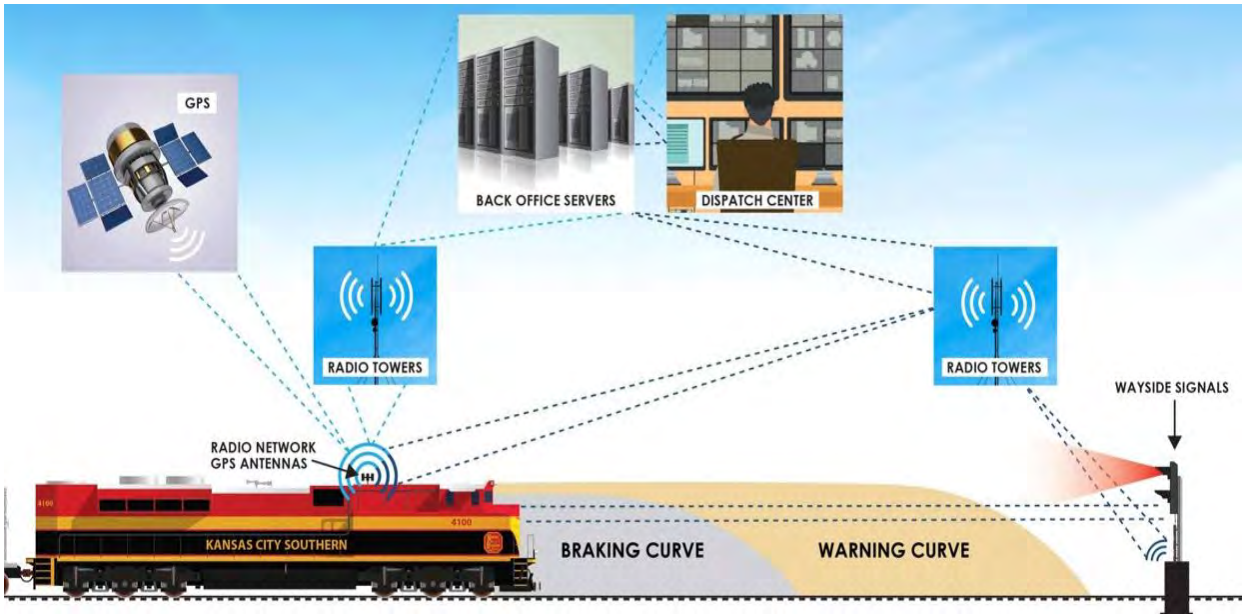


Figure 2. History of signalling systems to train protection systems in European railways (Railwaysignalling.eu, 2014).

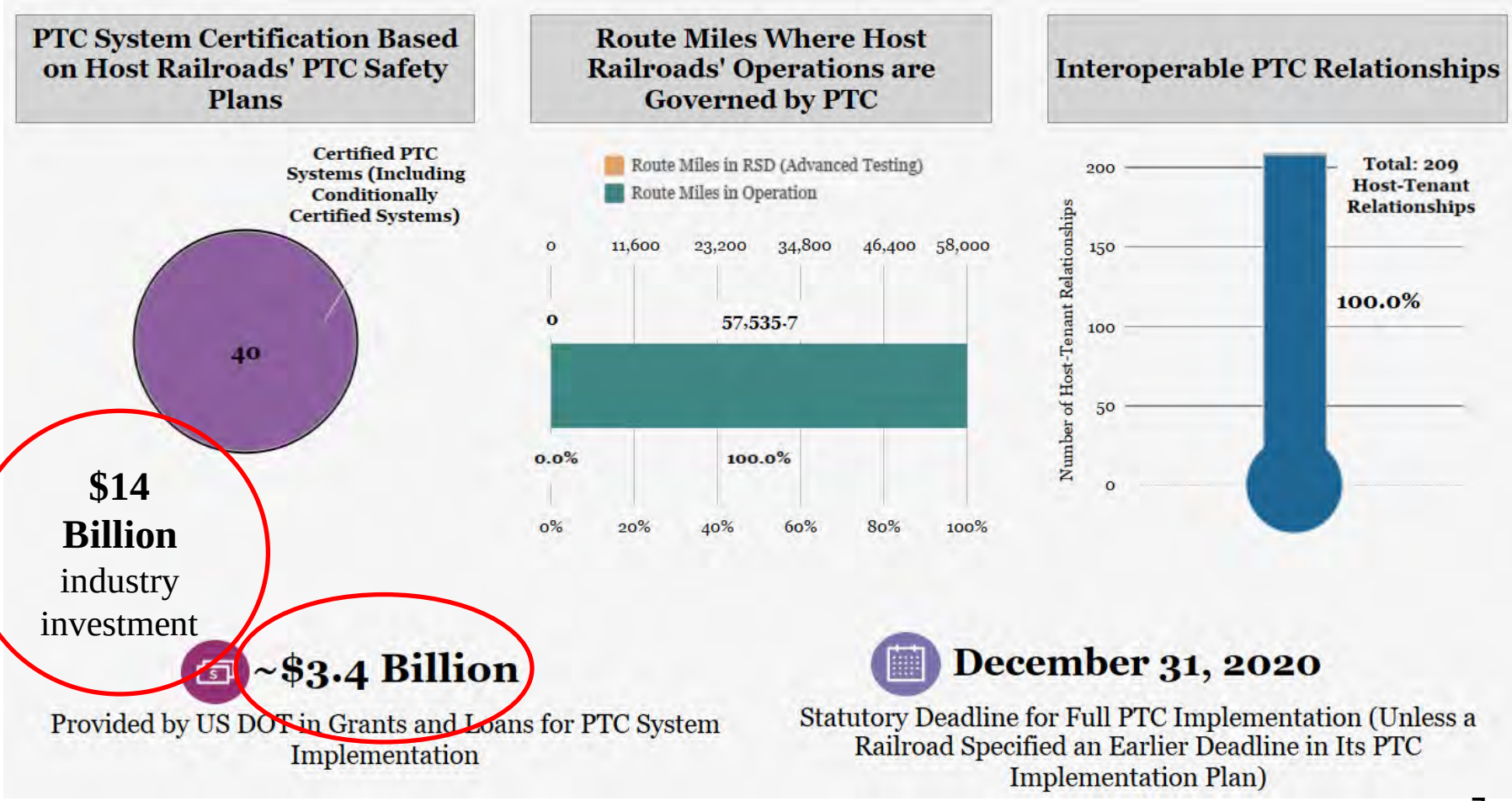
PTC systems are designed to automatically stop or slow down a train before certain types of accidents occur, including those caused by human error related to signal interpretation and train speed control.

Positive Train Control (PTC) systems are designed to prevent:

- train-to-train collisions,
- over-speed derailments,
- incursions into established work zones, and
- movements of trains through switches left in the wrong position.



on December 29, 2020, FRA announced that PTC technology is in operation on all required freight and passenger railroad route miles.



Source: FRA

Progressing Towards the Enhanced Train Control (ETC) system in Canada

PASS events feature prominently on the Transport Safety Board (TSB) of Canada's watchlist as a critical safety concern within the nation's transportation system.

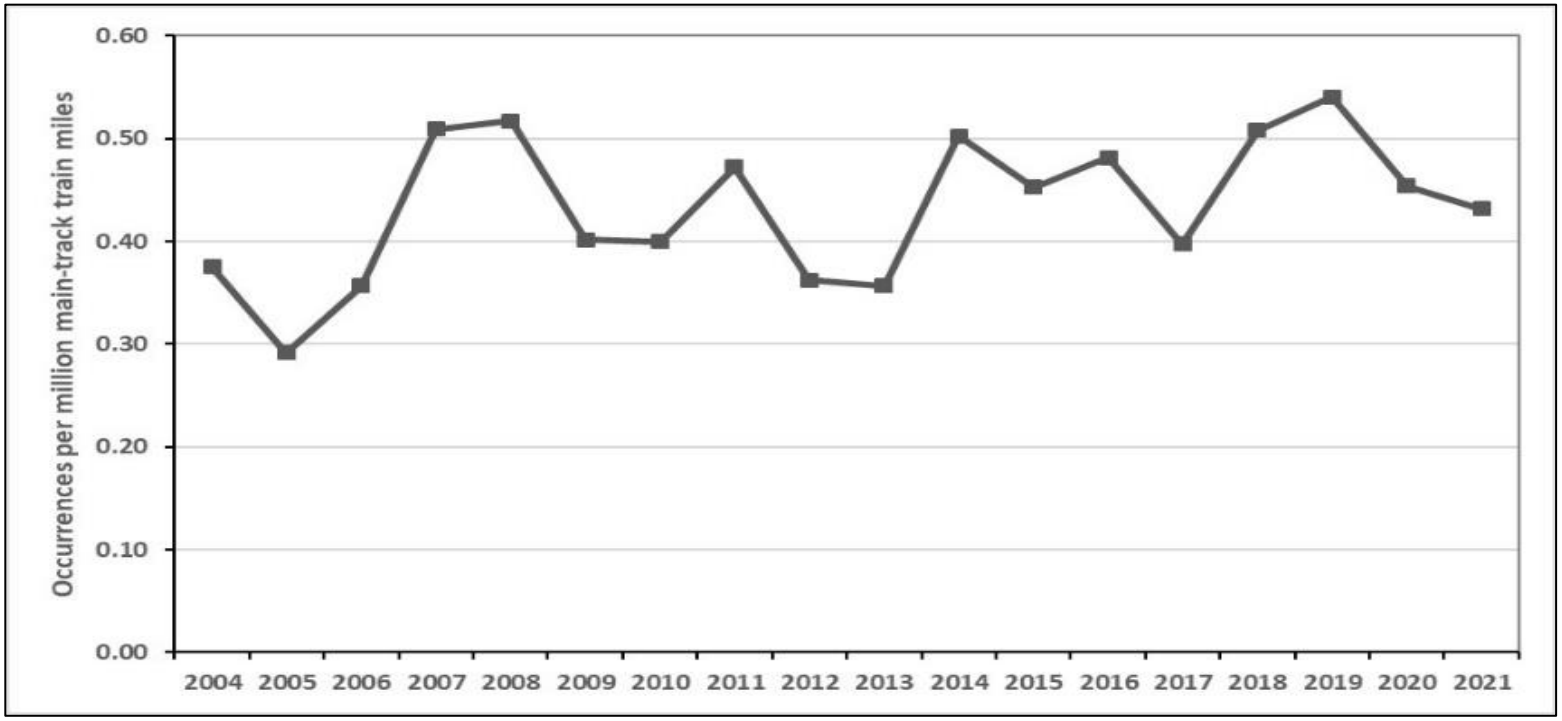


Figure 3. Rail transportation occurrences involving missed signals per million main-track train miles, 2004 to 2021 (Source: TSB)

From 2004 to 2021, the TSB recorded an annual average of **35** occurrences, equating to approximately **0.43** incidents per million main-track train miles, where train crews in Canada failed to respond correctly to trackside signal indications (TSB, 2022).

TSB recommended the implementation of additional physical safety defences to ensure that signal indications governing operating speed and operating limits are consistently recognized and followed (TSB, 2022).

The analysis revealed that many past events could have been prevented by an additional physical safety defence, which is called the Enhanced Train Control (ETC) system:

80 rail incidents between 1990 to 2021 (TSB, 2022).

Nearly 6% of rail incidents between 2007 and 2016 (CaRRL, 2018).

In response to

- recommendations from the Transport Safety Board (TSB)

and

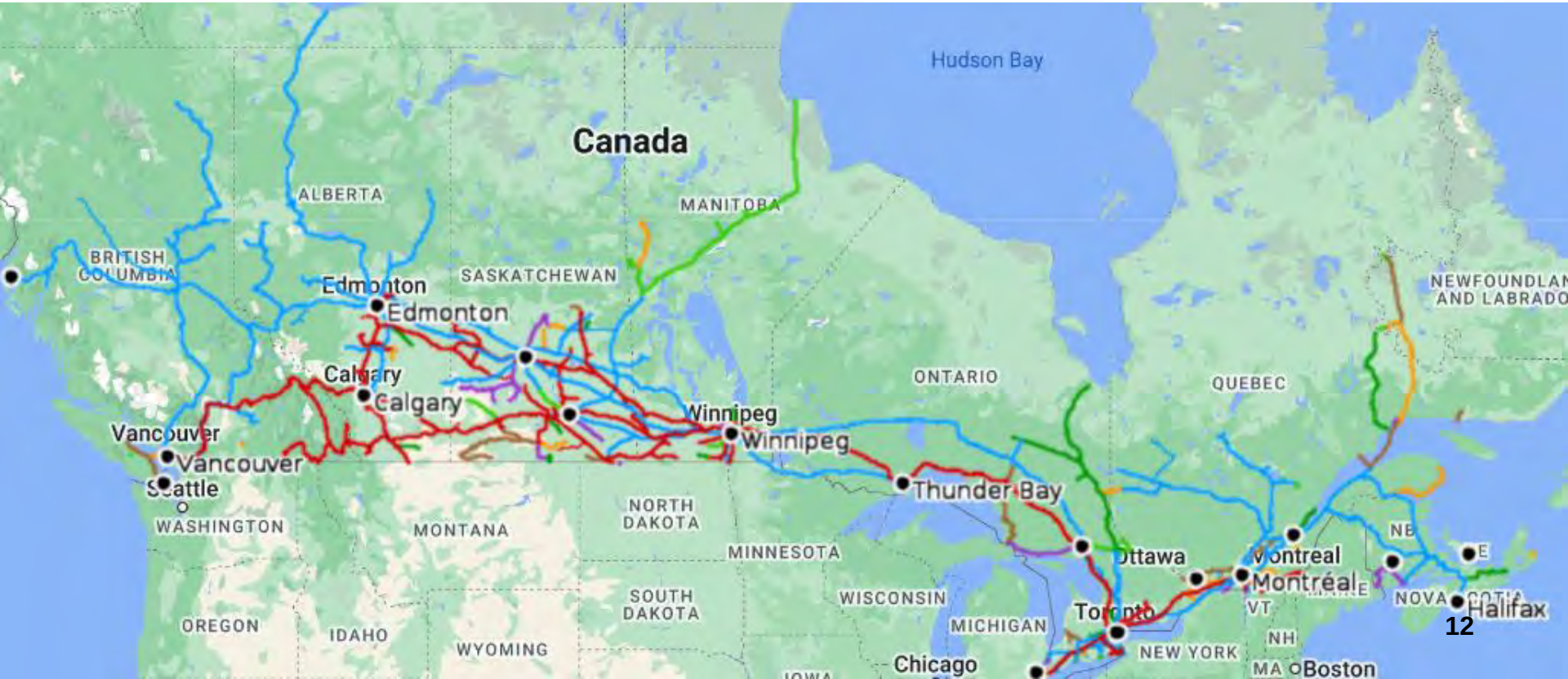
- the 2018 Railway Safety Act Review,

Canadian rail operators are implementing the **Enhanced Train Control (ETC)** system, **a variation of the US's Positive Train Control (PTC)**, to improve safety across their passenger and freight networks (RAC, 2022, TCWG, 2018).

Transport Canada has introduced a corridor-specific, risk-based approach for ETC implementation.

Under this framework, the complexity and cost of the ETC system increase in accordance with the risk level of each specific corridor (TC, 2019).

Source: RAC Canadian Rail Atlas



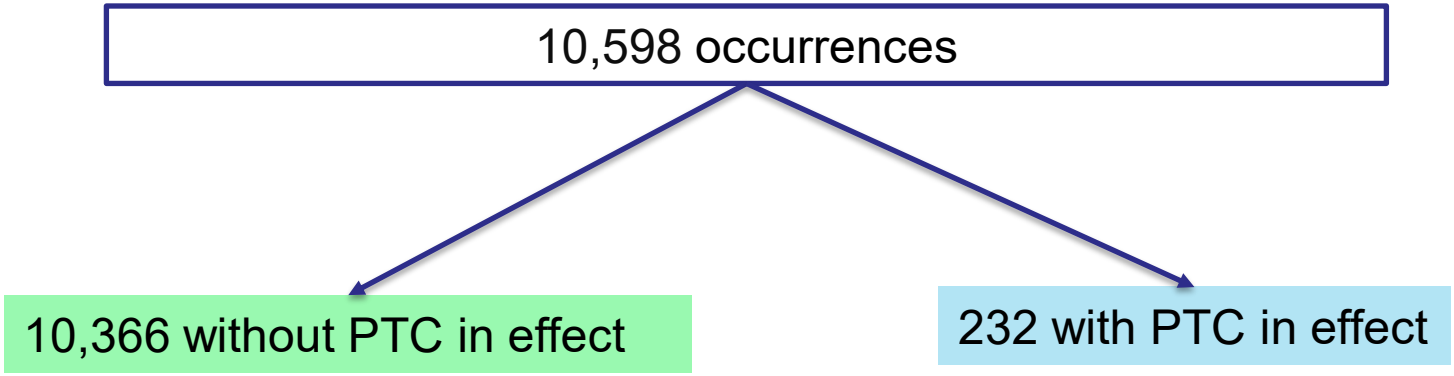
Four-tiered ETC

Table 1. High-level hierarchy of ETC systems (CaRRL, 2018).

ETC Level 1	ETC Level 2	ETC Level 3	ETC Level 4
Crew assist and monitoring	Crew assist and enforcement	Vital enforcement	Vital enforcement
Locomotive equipment only	Locomotive equipment and selective trackside buildouts	Locomotive equipment and full trackside buildouts	Locomotive equipment and trackside equipment
Overlay	Overlay	Overlay	Full replacement
Crew warnings	Non-vital enforcement	Vital enforcement	Vital enforcement
Basic onboard display	Improved display	Full display	Full display

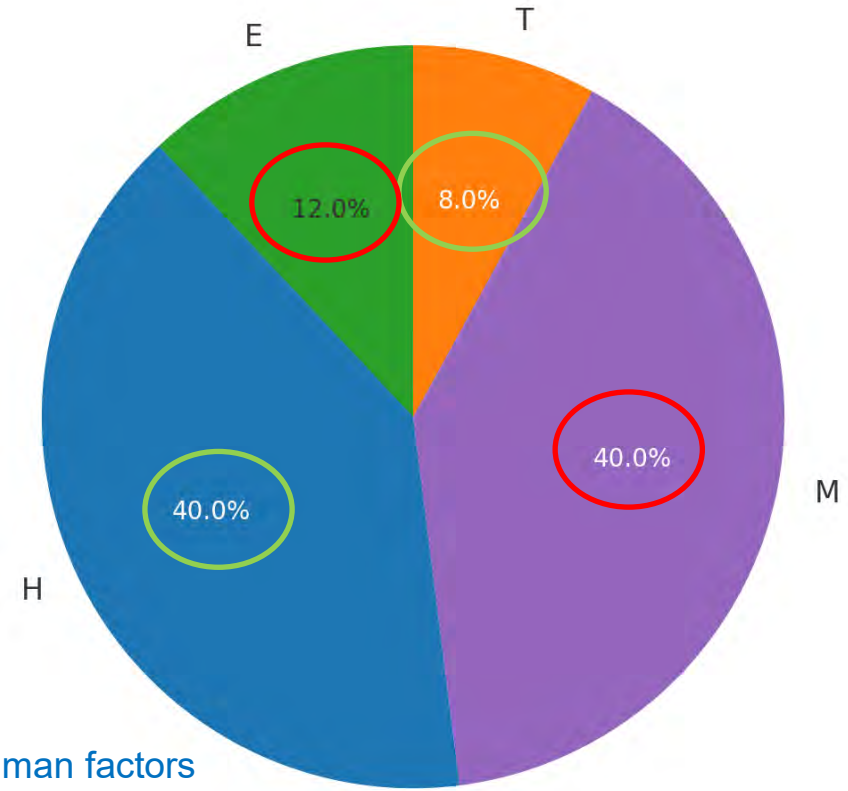
Analyzing US PTC implementation for insights into ETC effectiveness despite limited early data

Federal Railroad Administration (FRA) Accident/Incident Data from 2018 to 2022



Cause group of Incidents **without** PTC

Cause group of Incidents **with** PTC



H: Train operation - human factors
T: Track, roadbed and structures
E: Mechanical and electrical failures
S: Signal and communication
M: Miscellaneous causes not otherwise listed

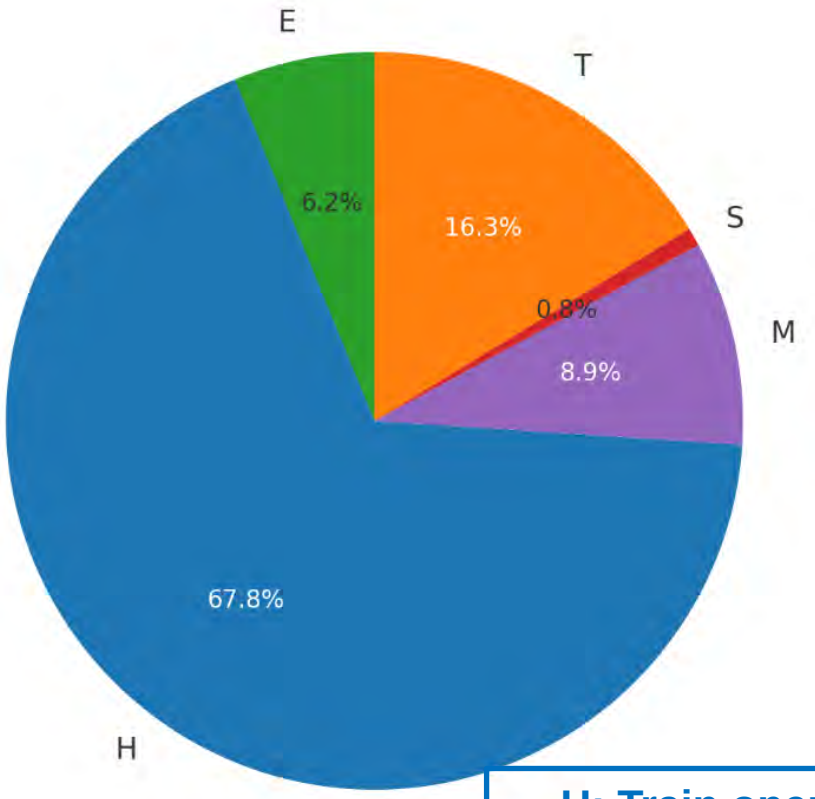
Figure 4. Group causes of incidents with and without PTC

Shift in the Nature of Incidents

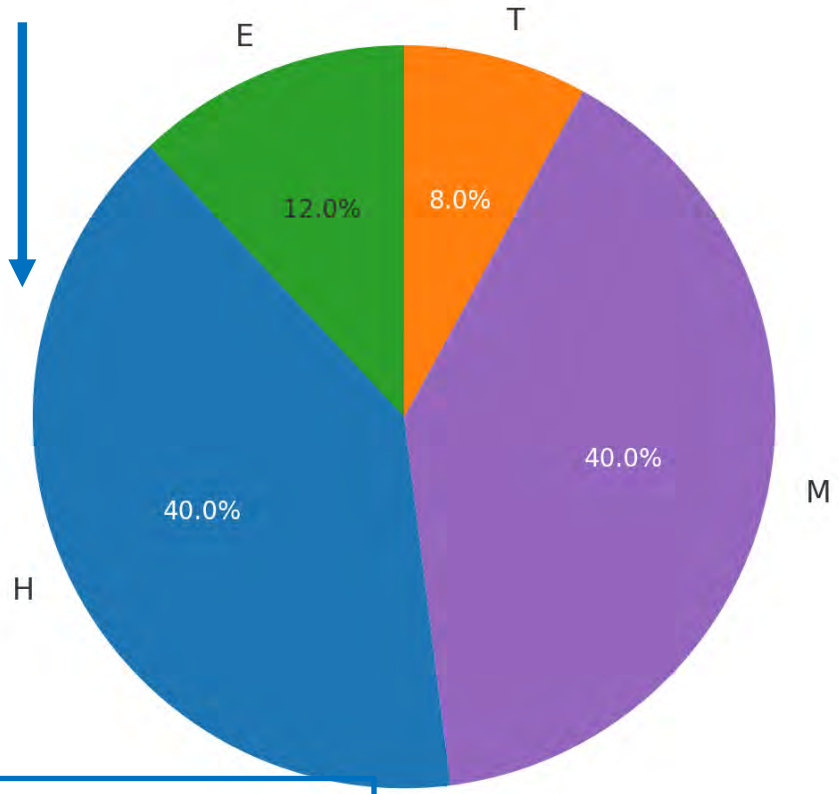
The implementation of PTC seems to shift the nature of incidents from those potentially caused by human error or oversight to those involving Mechanical and electrical failures.

This shift might indicate areas where further improvements in technology, training, or infrastructure could enhance safety further.

Cause group of Incidents **without** PTC



Cause group of Incidents **with** PTC



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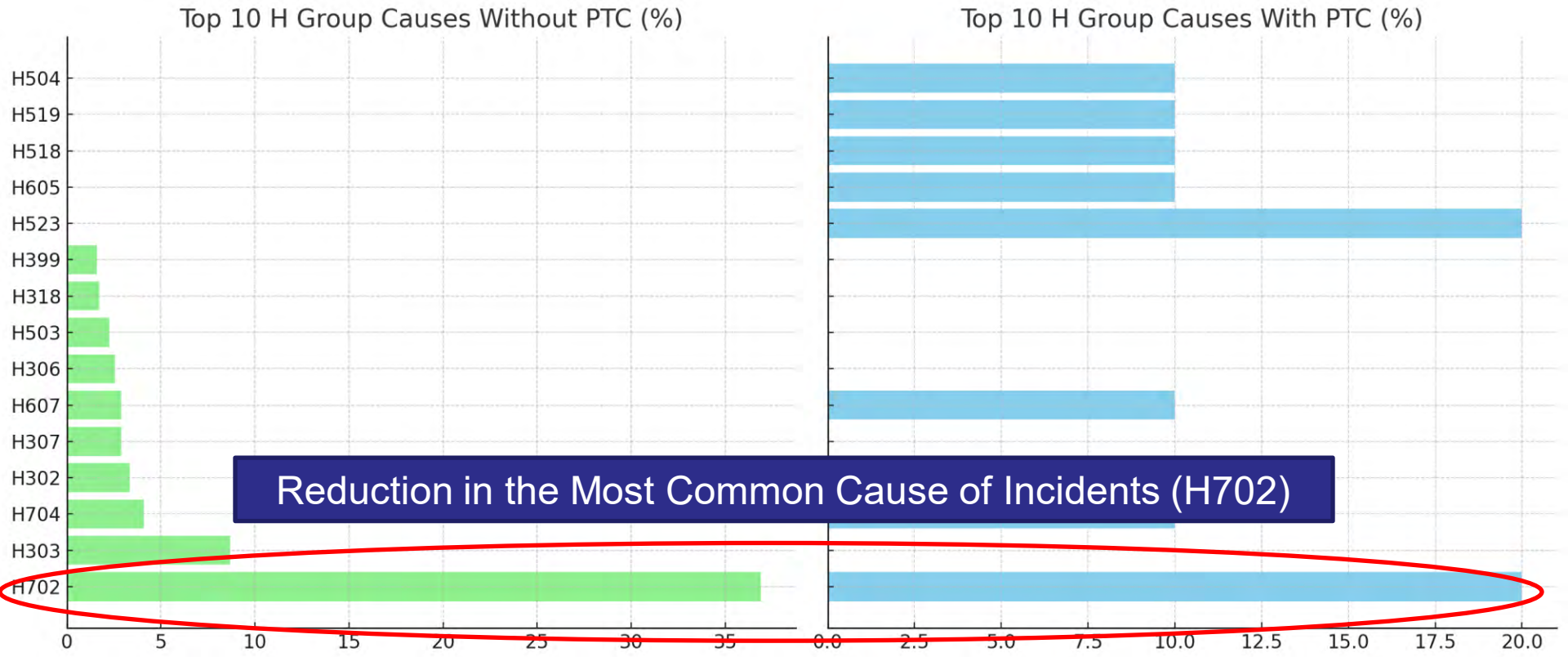
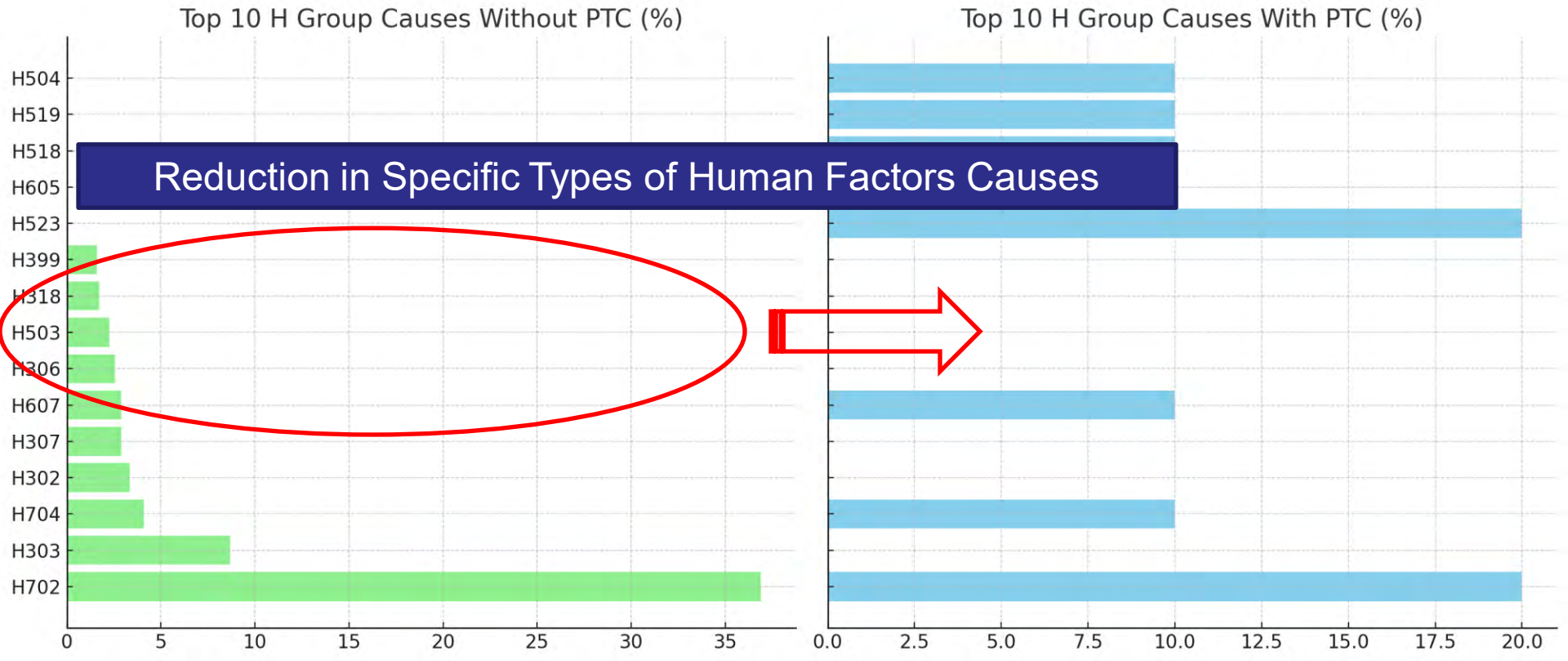
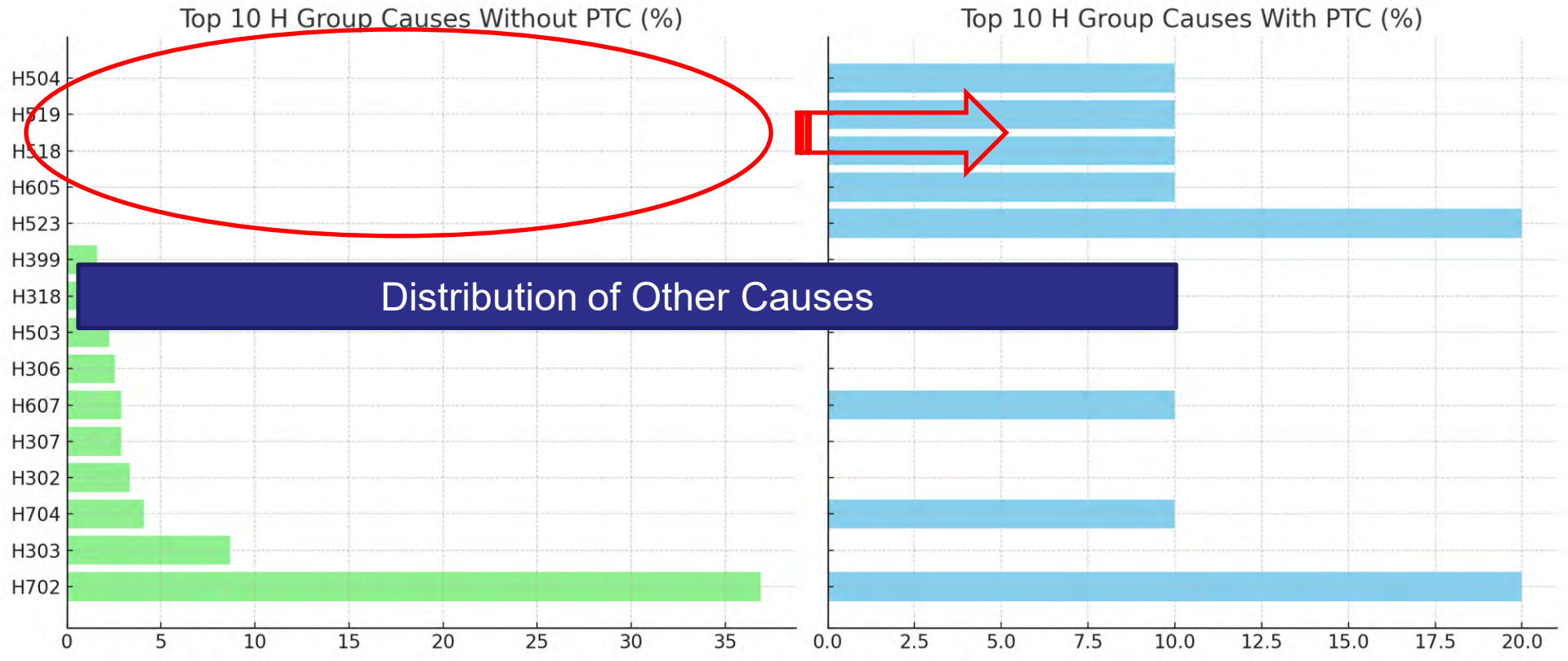


Figure 5. Top 10 H (Train operation - human factors) group causes with and without PTC

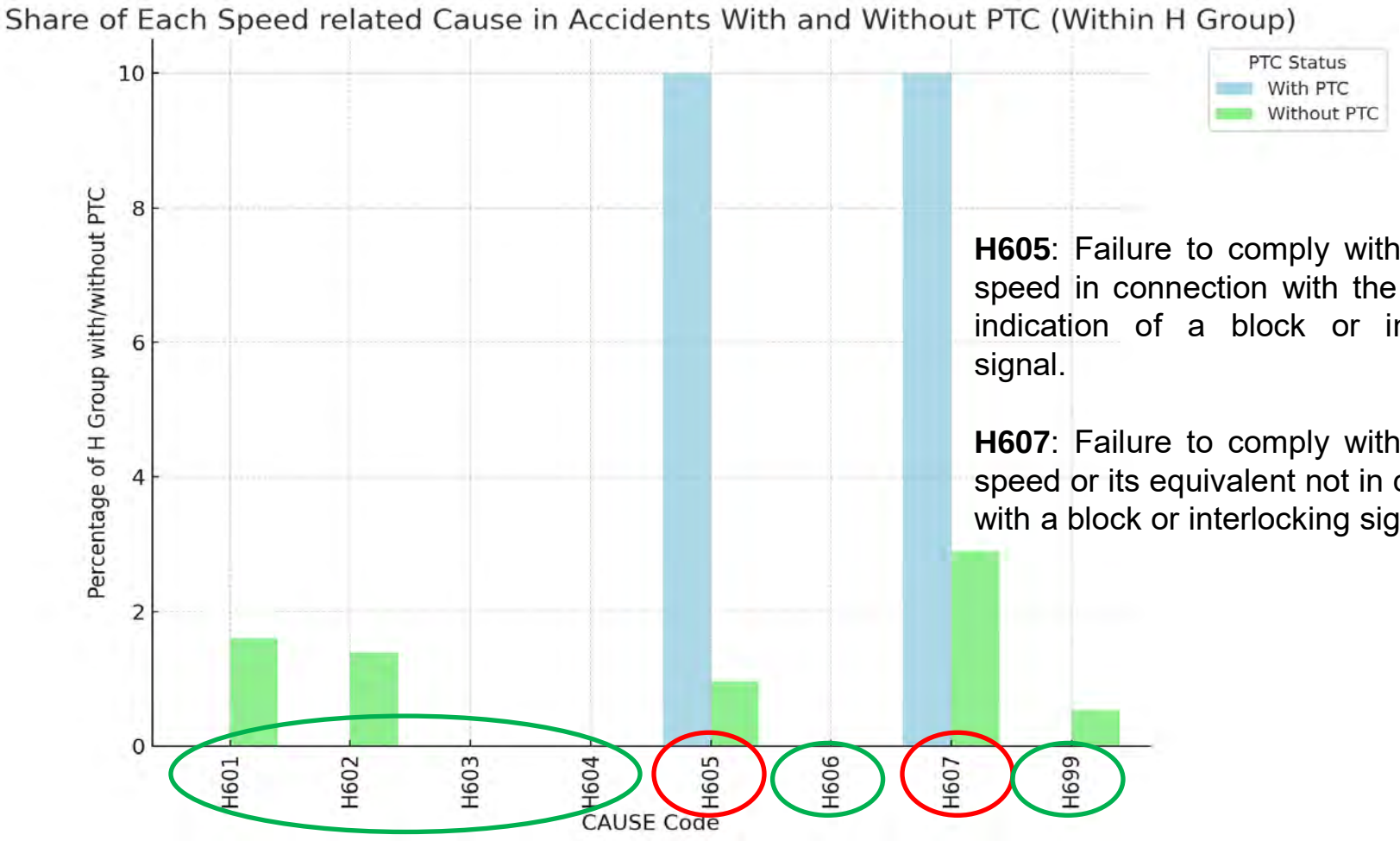

Top 10 H Group Causes Without PTC (%)
Top 10 H Group Causes With PTC (%)
Reduction in Specific Types of Human Factors Causes
H504
H519
H518
H605
H523
H399
H318
H503
H306
H607
H307
H302
H704
H303
H702
0
5
10
15
20
25
30
35
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0



H519: Dynamic brake, too rapid adjustment
H518: Dynamic brake, excessive, and
H523: Throttle (power), too rapid adjustment

Human factors causes related to <u>Speed</u>:

H601: Coupling **speed excessive**
H602: Switching movement, **excessive speed**
H603: Train on main track inside yard limits, **excessive speed**
H604: Train outside yard limits, in block signal or interlocking territory, **excessive speed**
H605: **Failure to comply with restricted speed** in connection with the restrictive indication of a block or interlocking signal.
H606: Train outside yard limits in non block territory, **excessive speed**
H607: **Failure to comply with restricted speed** or its equivalent not in connection with a block or interlocking signal.
H699: Speed, other (Provide detailed description in narrative)



H605: Failure to comply with restricted speed in connection with the restrictive indication of a block or interlocking signal.

H607: Failure to comply with restricted speed or its equivalent not in connection with a block or interlocking signal.

Figure 6. Speed-related H group causes with and without PTC

Human factors causes related to <u>Passing a Stop Signal (PASS):</u>

H220: Fixed signal (other than automatic block or interlocking signal), **failure to comply**.

H221: Automatic block or interlocking signal displaying a stop indication - **failure to comply**.

H605: Failure to comply with restricted speed in connection with the restrictive indication of a block or interlocking signal.

H821: Automatic cab signal, **failure to comply.**

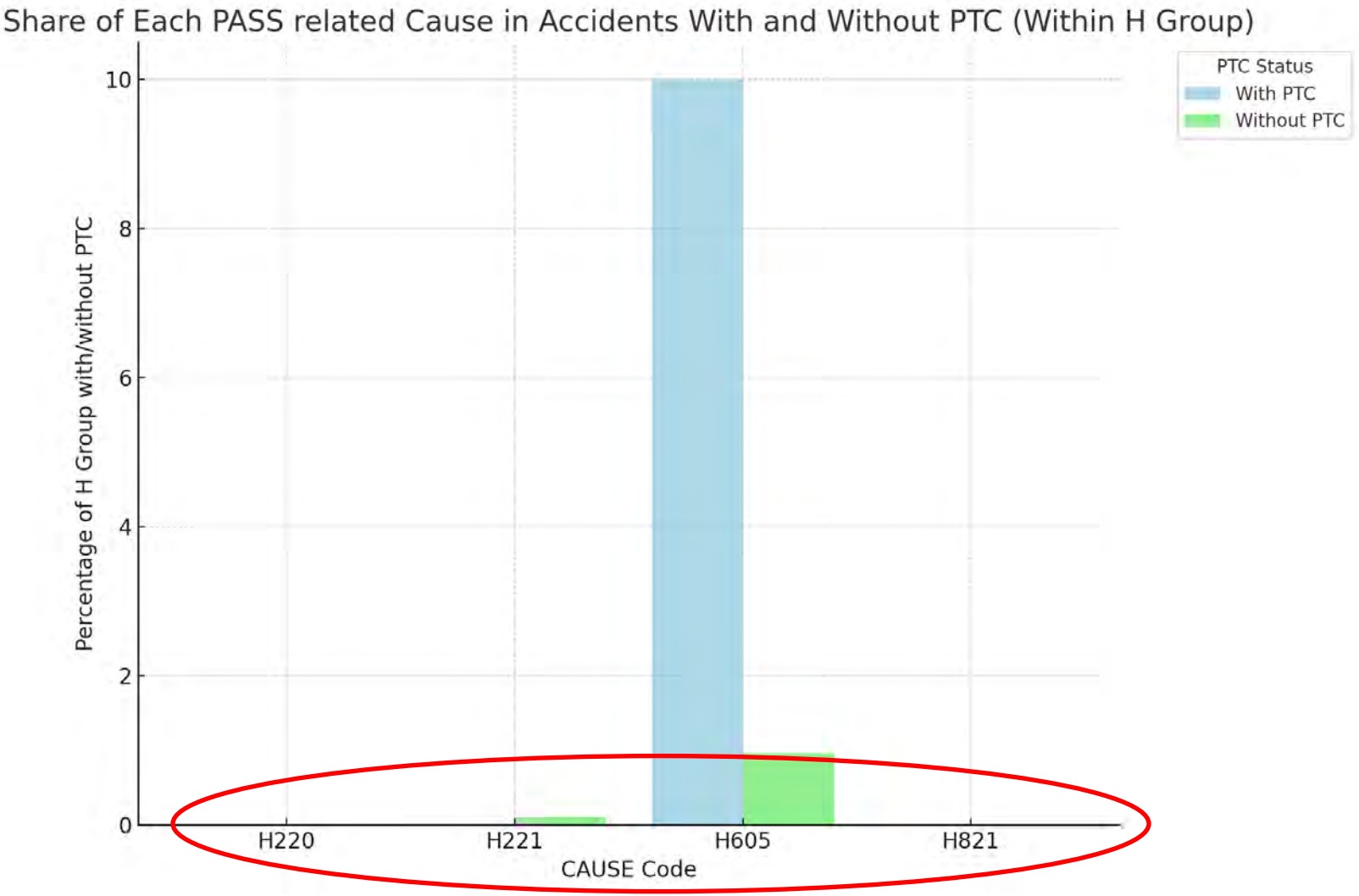
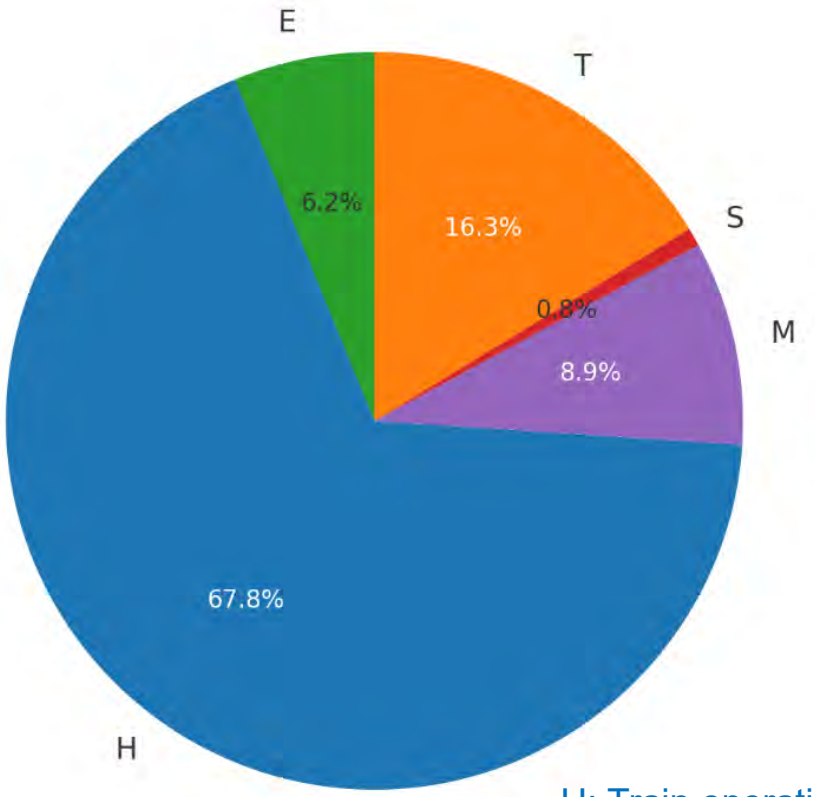
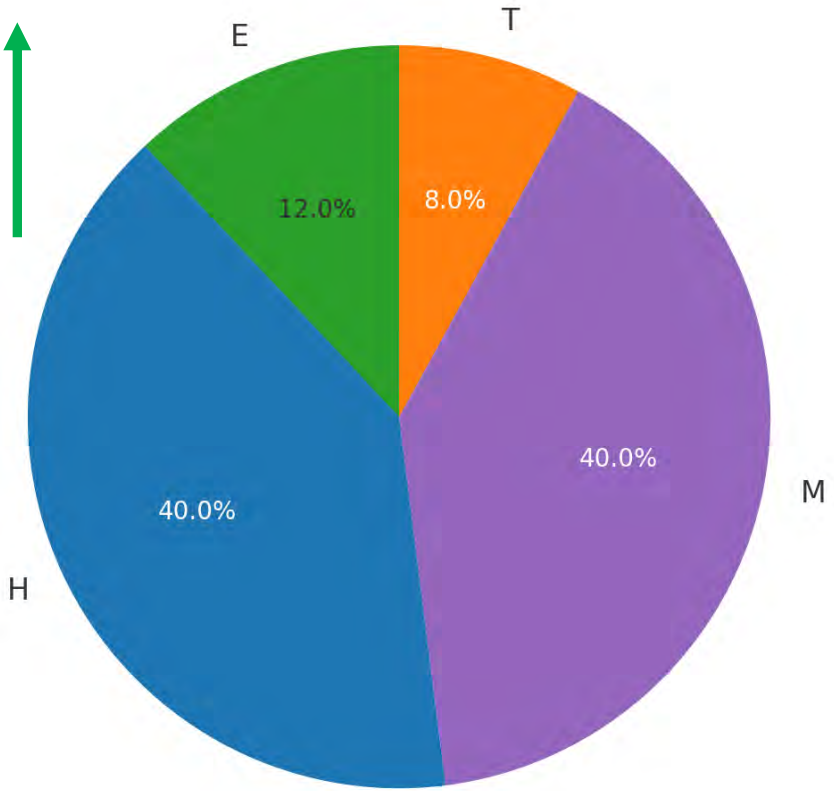


Figure 7. PASS-related H group causes with and without PTC.

Cause group of Incidents **without** PTC



Cause group of Incidents **with** PTC



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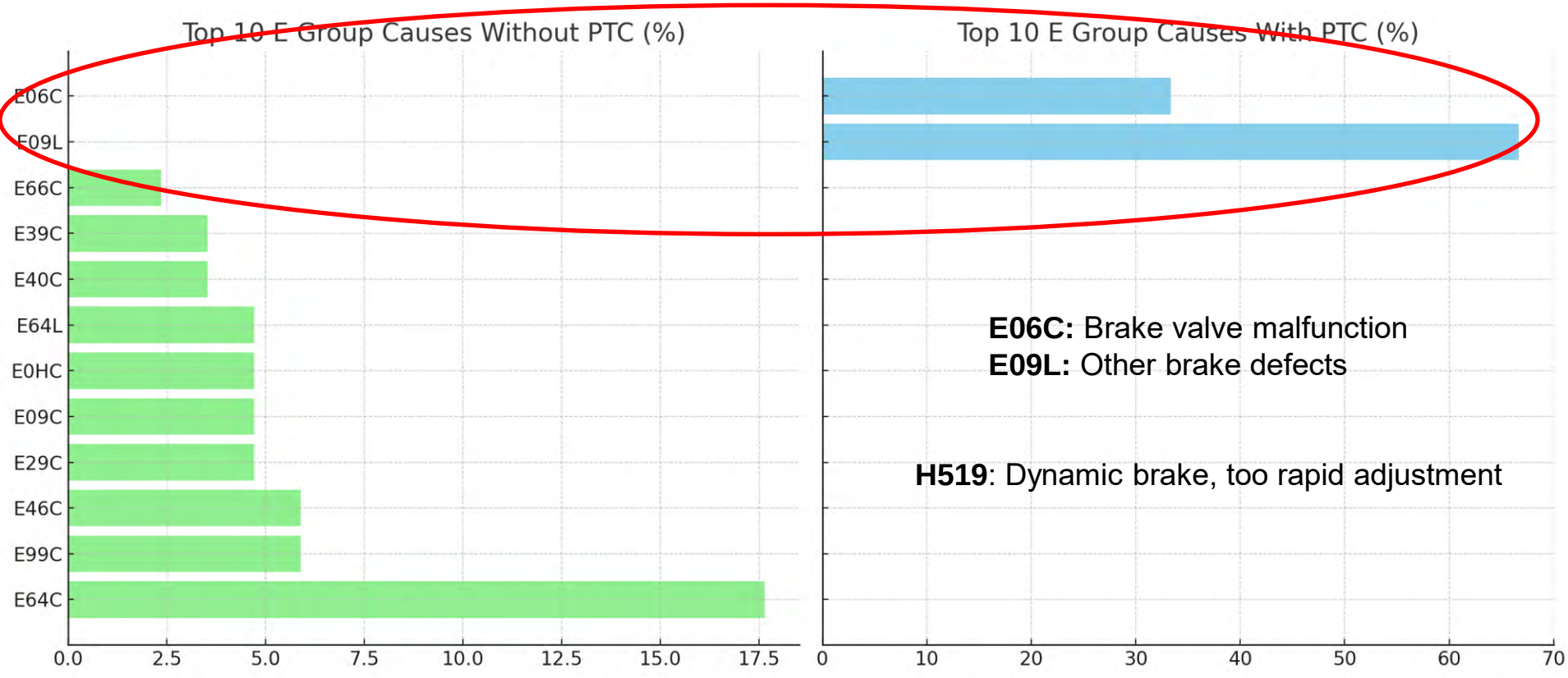
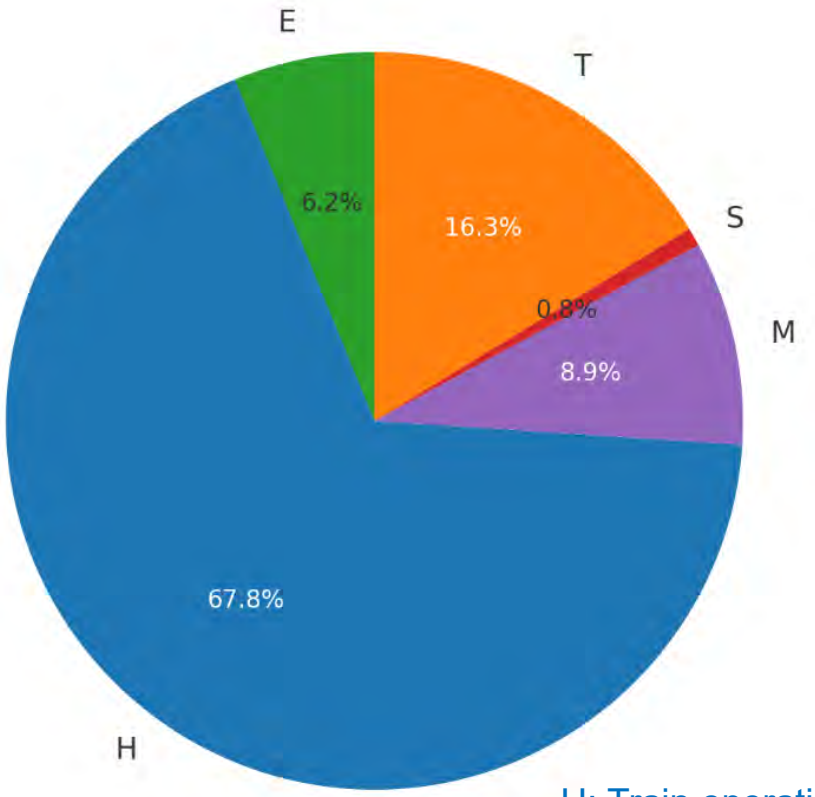
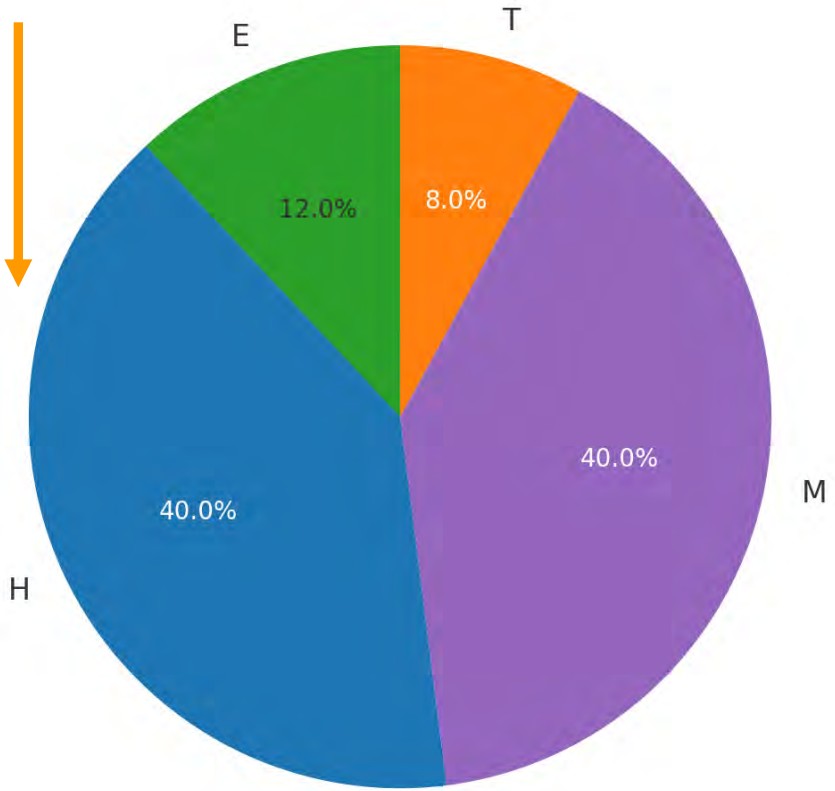


Figure 8. Top 10 E (Mechanical and electrical failures) group causes with and without PTC

Cause group of Incidents **without** PTC



Cause group of Incidents **with** PTC



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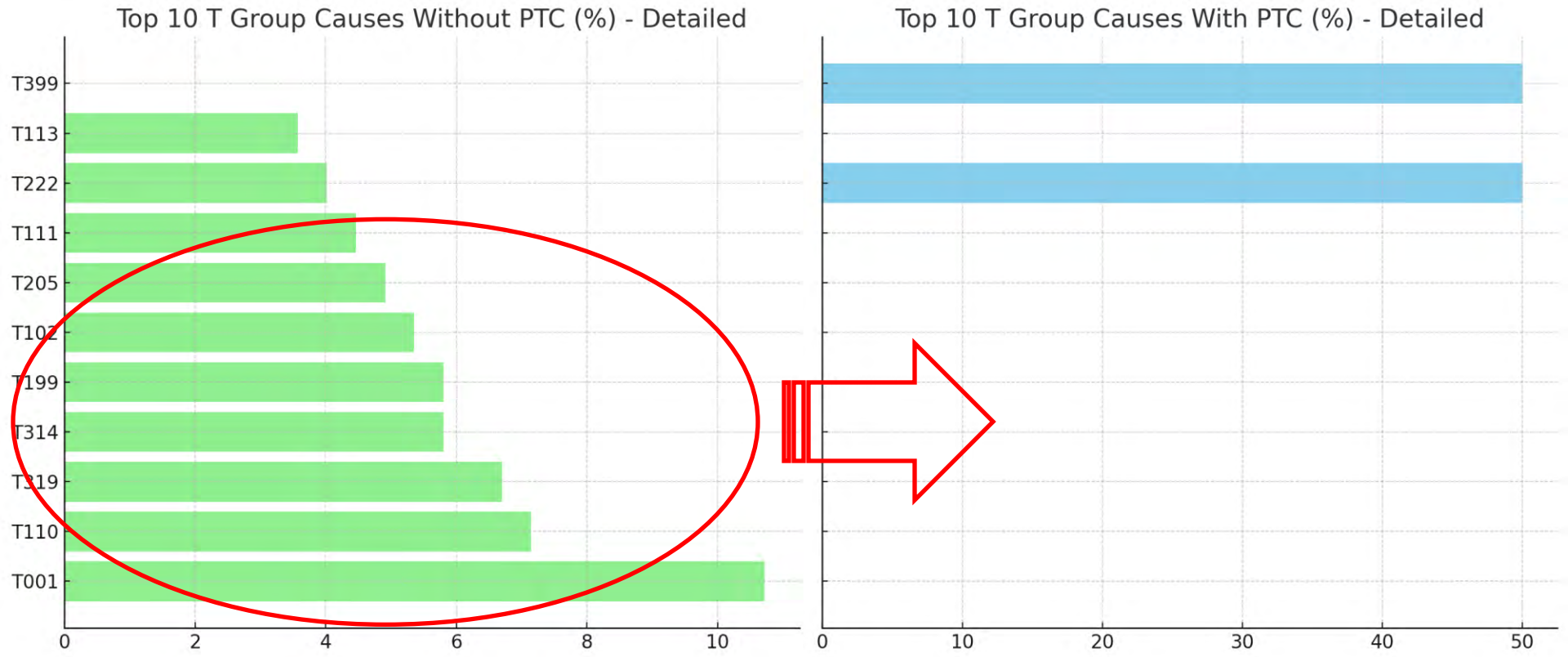

Figure 9. Top 10 T (Track, roadbed and structures) group causes with and without PTC

Conclusion:

- Our analysis has provided valuable insights into the impact of Positive Train Control (PTC) on railway safety, highlighting both successes and areas for further examination.

- While PTC has shown promising results in mitigating certain types of incidents, such as those attributed to human factors, we have observed a shift in accident causation toward mechanical and electrical failures.

- This shift underscores the ongoing challenges associated with ensuring effective braking and addressing technical issues within the railway infrastructure.

- Our analysis has shown an increase in the share of Miscellaneous causes post-PTC implementation, necessitating further analysis to understand whether this increase is solely due to a shift in accident types and causes or if new issues have arisen as a result of PTC implementation.

- It's essential to recognize that this is an ongoing research endeavor, requiring continued collaboration and exploration.

- Understanding the underlying causes of accidents, especially those expected to be eliminated by the train control system, will be crucial for enhancing railway safety in the future.

- Further analysis, including a deeper dive into accident reports and narratives, is needed to comprehensively evaluate the effectiveness of PTC.

Thank You!

Questions or Comments?

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Acknowledgments

CN

Transport Canada

Transports Canada

NSERC
CRSNG

ALBERTA INNOVATES

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