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Used Fuel Transportation System – Transportation Collision Mitigation Report

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NWMO Used Fuel Transportation System Transportation Collision Data & Mitigation Assessment

Transportation Collision Mitigation Report

October 2023

Revision		Prepared	Checked/Approved
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Signature in the above signatory box confirms that the parties have read, understood, and are committed to comply with the NTS Quality Plan requirements on behalf of their respective organisation, and that NTS and DRS hereby agree to provide all relevant requested documentation during an audit, should one be required by NWMO or its programme reviewers.

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AMENDMENT RECORD

#	Date	Details of Amendment
1	**-**	Original publication of Table of Contents
2	**May 17, 2023**	85% report
3	**July 13, 2023**	90% (Draft Report) incorporating comments and requests at 85% report review.
4	**Aug 31, 2023**	Draft report submission incorporating comments from NWMO and including executive summary.
5	**Oct 10, 2023**	Amendments throughout in response to AECOM and NWMO commentary.
6	**Oct 27, 2023**	Final Submission

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List of Acronyms and Abbreviations

ACC	Adaptive Cruise Control
ACT	Accident Conditions of Transport
ACNS	AECOM Canada Nuclear Services
ADAS	Advanced Driver Assistance Systems
AECL	Atomic Energy of Canada Limited
APM	Adaptive Phased Management
AWS	Automatic Warning System
BSI	British Standards Institution
CANUTEC	Canadian Transport Emergency Centre
CCMTA	Canadian Council of Motor Transport Administrators
CDM	Construction Design and Management
CDP	Competency Development Plan
CMS	Competency Management System
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
COSHH	Controlled Substances Hazardous to Health
CTA	Canadian Trucking Alliance
CVSA	Commercial Vehicle Safety Alliance
DGR	Deep Geological Repository
DRS	Direct Rail Services
DSD	Deadman's Switch Device
ECM	Entities in Charge of Maintenance
ECTS	European Train Control System
GPS	Global Positioning System
GSM-R	Global System for Mobile Communications-Railway
HGV	Heavy Goods Vehicle
IAEA	International Atomic Energy Agency

ISO	International Organization for Standardization
LGV	Large Goods Vehicle
LKA	Lane Keeping Assist
M&TE	Measurement and Test Equipment
MOD	Ministry of Defence (UK)
MTO	Ministry of Transport Ontario
NCT	Normal Conditions of Transport
NDA	Nuclear Decommissioning Authority
NSC	National Safety Code Standard
NSR	Nuclear Security Regulations
NTS	Nuclear Transport Solutions
NWMO	Nuclear Waste Management Organization
OTDR	On Train Data Recorder / Event Recorder
PPE	Personal Protective Equipment
PPM	Planned Preventative Maintenance
PTNSR	Packaging and Transport of Nuclear Substances Regulations
RACI	Responsible, Accountable, Consulted, Informed
SAE	Society of Automotive Engineers
SPAD	Signal Passed at Danger
SPM	Safety Performance Monitoring Reporting
STS	Secured Transportation Services
TCC	Transportation Command Centre
TPWS	Train Protection Warning System
TSB	Transportation Safety Board of Canada
TSP	Transportation Security Plan
VMI	Vehicle Maintenance Instruction
VIBT	Vehicle Inspection and Brake Test

Terms and Definitions

Collision	An unexpected and unintentional event that results in damage or injury. For this report, the event involves a large truck or train, resulting in subsequent “collision” and “non-collision” events.
Collision with a fixed object	Encompasses collisions with fixed objects, such as bridges, structures, trees, guide rails, rocks, ditches, etc.
Collision with a non-fixed object	Encompasses collisions with moving objects, such as another vehicle, trains, animals, pedestrians, cyclists, etc.
Heavy Goods Vehicle	A transport truck/trailer with a gross combined weight of 3,500 kg, including cargo (European Union), also known as a large goods vehicle (LGV).
Motor Vehicle Accident	A motor vehicle accident is an accident that involves a collision with another motor vehicle(s) (as defined in Canadian Nuclear Safety Commission Data).
Train Accident (Collision)	Train accident is an event in which the involved train collides with other objects (e.g., other trains, vehicles, fixed objects, lifeforms), derails, catches fire or explodes (as defined in Transportation Safety Board Data).
Train Derailment	Any instance where one or more wheels of rolling stock have come off the normal running surface of the rail, including occurrences where there are no injuries and no damage to track or equipment.
Type B Package	Type B packages are used to transport materials with high levels of radioactivity, such as used nuclear fuel, high-level radioactive waste, or high-radiation sources. These packages are typically large and heavy, designed and tested to provide adequate containment and shielding when subjected to normal conditions of transport and under hypothetical accident conditions set forth in regulations (i.e., pass stringent impact, drop, and puncture tests, an engulfing fire test, and immersion in water). In Canada, these packages are certified by CNSC.
Used Nuclear Fuel	Used fuel assemblies removed from a reactor after several years of use. The fuel is a solid material in the form of ceramic pellets contained within tubes made of corrosion-resistant zircaloy.

Executive Summary

The Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of Canada's used nuclear fuel. NWMO's plan calls for used nuclear fuel to be safely contained and isolated in a deep geological repository (DGR), consistent with international practice. Currently, two candidate communities are being considered to host the DGR. One is in the Wabigoon Lake Ojibway Nation-Ignace area in Northwestern Ontario, and the second is in the Saugeen Ojibway Nation-South Bruce area in Southern Ontario. A final decision regarding the site for the DGR is expected by the end of 2024.

The transportation of used nuclear fuel from interim storage facilities located in Ontario, Quebec, and New Brunswick to the centralized DGR location will be required.[1] However, while there is a strong international track record regarding the shipment of radioactive materials, these shipments understandably raise concerns and queries from the public and interested parties regarding potential incidents or collisions during transport.

In 2022, NWMO commissioned a study aimed at gathering, analysing and assessing available collision data relevant to the modes (road and rail) and types of conveyances proposed to transport used fuel to the DGR in Type B Packages[2]. This study, the Transportation Collision Data Analysis Report [1], conducted statistical analysis on types of collisions, severities, and potential causal factors in order to quantify transport collision probabilities with the intent that the collision probabilities, patterns, and trends identified therein would be used as input to future analyses.

In turn, this report aims to utilize the information developed previously, in combination with the first-hand operational experience provided by Nuclear Transport Solutions (NTS) in collaboration with Secured Transport Services (STS), to provide insights and inform the discussion into mitigation measures associated with safety during transport of used nuclear fuel.

As part of the United Kingdom’s Nuclear Decommissioning Authority, NTS is responsible for safely transporting nuclear materials between Nuclear Decommissioning Authority (NDA) sites, primarily by rail and ship, as well as providing key operational solutions on both UK and international radioactive material transport. STS has extensive experience in transporting radioactive materials in North America, backed by decades of experience, including over 200 nuclear road transport operations in Canada.

This report intends to provide an overview of key findings from the Transportation Collision Data Analysis Report with regard to the most probable types of collisions that conveyances meant to transport used nuclear fuel may encounter during both road and rail shipping operations. Leveraging the operational experience of both NTS and STS, this report then provides an overview of road and rail operations and identifies potential mitigation measures that can be implemented by the NWMO in their used fuel transportation program.

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[1] Used fuel from Whiteshell Laboratories (Manitoba) is anticipated to be consolidated at Canadian Nuclear Laboratories (Ontario) prior to the start of NWMO transportation operations.
[2] Type B packages are among the most protective and transport highly radioactive materials where the content exceeds a prescribed threshold value. They provide containment and a high level of shielding against radiation. They are designed, tested, and certified to ensure they withstand expected incident conditions such as drops, fires, and immersion in water. Type B packages are commonly used to transport used nuclear fuel by road, rail, and water modes of transport.

Furthermore, this report provides insights into the aspects of nuclear material transportation that differentiate it from commercial road and rail shipments with regard to overall safety and security, as well as incident response. This includes, but is not limited to:

- Route Planning/Reconnaissance
- Driver Training
- Advanced Driver Assistance Systems
- Vehicle Maintenance and Inspection
- Driver Condition / Fitness for Duty
- Adverse Weather Considerations
- Road Surface Conditions
- Train Safety Features
- Informed Decision Making
- Emergency Response
- Incident Drills and Exercises
- Transportation Command Center
- Human Performance Programs
- Risk Management
- Audits
- Asset Maintenance and Inspections
- Personnel and Operational Safety
- Supplier and Contract Management

1 Introduction

1.1 Background

The Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of Canada's used nuclear fuel. Canada's plan for managing used nuclear fuel is known as Adaptive Phased Management (APM). It consists of isolating and containing used nuclear fuel in a Deep Geological Repository (DGR) using a multiple barrier system in a robust host geology.

Canada's used nuclear fuel is currently safely stored on an interim basis in licensed facilities at reactor sites in Ontario, Québec, and New Brunswick, as well as at Atomic Energy of Canada Limited's (AECL) nuclear research laboratories in Ontario and Manitoba. Managing all of Canada's used nuclear fuel in a single repository location will require the transport of used nuclear fuel from these interim storage facilities to the centralized DGR location.

NWMO is currently in the process of identifying a willing and informed host community and region for the APM DGR. The Township of Ignace and Wabigoon Lake Ojibway Nation in Northwestern Ontario and the Municipality of South Bruce and Saugeen Ojibway Nation in Southern Ontario are potential host areas for the project. Site selection is currently expected to occur in late 2024. The interim storage sites and candidate DGR sites are outlined in **Figure 1**.

Figure 1 Overview of Existing Interim Storage and Candidate DGR Sites

NWMO's responsibility in used nuclear fuel management includes designing and developing a transportation system for the safe and secure delivery of used fuel from current interim storage facilities to the DGR. Current plans are to begin operation of a repository facility no sooner than 2043. Once a facility is constructed and licensed, used fuel will be transported from the existing interim storage sites to the repository by road and/or by rail.

The objective of this report is to take the key findings from the Transportation Collision Data Analysis Report and identify potential mitigating measures that can be implemented by NWMO in their used fuel transportation program to reduce the likelihood of transportation collisions with consideration of the types of modes and conveyances being studied by NWMO.

The information in this report is presented to provide potential mitigations to prevent accidental collisions or derailment scenarios for NWMO's program of transport.

1.1.1 Radioactive Material Transportation

The transportation of radioactive materials in Canada is governed by jointly by the Canadian Nuclear Safety Commission (CNSC) and Transport Canada under several pieces of legislation, including but not limited to the Transportation of Dangerous Goods Act (S.C. 1992, c. 34), the Packaging and Transport of Nuclear Substances Regulations (PTNSR) (SOR/2015-145) [2], the Nuclear Safety and Control Act (S.C. 1997, c.9) [3], and the Nuclear Security Regulations (NSR) (SOR/2000-209) [4].

Under the framework set out by the above-noted legislation, radioactive materials are defined as Class 7 Dangerous Goods and can be further categorized according to their specific properties pertaining to the type and level of ionizing radiation that may be applicable. Thousands of shipments of radioactive materials are safely carried out within Canada annually by various industries, including power production, surveying, and nuclear medicine.

Drawing from the International Atomic Energy Agency's Regulations for the Safe Transport of Radioactive Materials (IAEA, SSR-6) [5], Canada's PTNSR sets out requirements for the types of packages that must be used to transport various categories of radioactive materials.

This includes the content characteristics and the safety-related performance of packages during Normal Conditions of Transport (NCT) and Accident Conditions of Transport (ACT). Different categories of packages may be required depending on the nature and form of the content. These include but are not limited to, the three types summarised in **Table 1**.

Table 1 Categories of Transportation Packages

Type IP Packages	Type A Packages	Type B Packages
These packages are utilized for shipping materials considered to pose a low risk or hazard due to the nature and level of the contents (low specific activity or surface contamination). They provide a basic level of protection and shielding and must withstand normal transport conditions, among other requirements. Common contents include surface-contaminated clothing or PPE.	These packages are designed for the transport of moderately radioactive materials. They provide a higher level of protection compared to Type IP packages. They are rated to contain levels of ionizing radiation below a given threshold value (known as an A2 value) which varies depending on the nature of the contents. Common contents found in Type A packages include radiopharmaceuticals and other industrial materials.	**These packages are among the most protective and transport highly radioactive materials where the content exceeds a prescribed threshold value.** **They provide containment and a high level of shielding against radiation. They are designed, tested, and certified to ensure they withstand expected incident conditions.** **Type B packages are commonly used to transport used nuclear fuel.**

Note: The A_2 value is the maximum amount of radioactivity of a specific radioisotope measured in terabecquerel (TBq) than can be transported in a Type A package for normal form materials like most radioactive waste. In other words, the amount of radioactivity they contain is limited by regulations and in the event of a release, these limits ensure that the risk from radiation/contamination is managed.

<u>Safety of Type B Transport Packages for Used Nuclear Fuel</u>

The basic philosophy behind the Canadian transport regulations is that safety heavily relies on the design of the transport package. Used fuel packages, or Type B packages are designed, tested, and certified to retain their contents during normal operations and in the event of a credible accident. Under the regulations, the package design must meet a series of rigorous impact, fire, and water immersion tests:

- Two drop tests: 1) a 9 meter drop onto an unyielding surface and 2) a 1 metre drop onto a steel bar at least 20 centimeters long; conducted in the sequence and orientation that would result in the most damage to the package.
- Following the drop tests, a fire test on the same specimen which the package is subjected to a fully engulfing fire of 800^{O}C for 30 minutes.
- Immersion test where the cask is then subjected to conditions equivalent to 15 metre submersion for 8 hours. For casks designed for the more highly radioactive materials there is an enhanced immersion test of 200 metres for 1 hour.

These tests ensure that packages can withstand accidents involving crashes, fires, or submergence under water that can realistically be envisioned.

1.1.2 Type B Transportation Packages and Conveyances

NWMO is currently assessing several conveyance options for transporting various Type B transport packages from interim storage sites to the APM DGR. Types of conveyances being considered include the:

- Truck tractor (see **Figure 2**)
- Rail consist (see **Figure 3** for an image of the rail consists and **Figure 4** for an image of the 8-axle DSC-TP railcar)
- Heavy haul truck (super-load truck)[3]

A heavy haul truck was scoped out of NWMO Transportation Collision Data Analysis Report [1] due to a lack of databases containing collision information on these types of conveyances, therefore the focus of that report was on truck tractors and rail consists. This assumption was carried forward into this report.

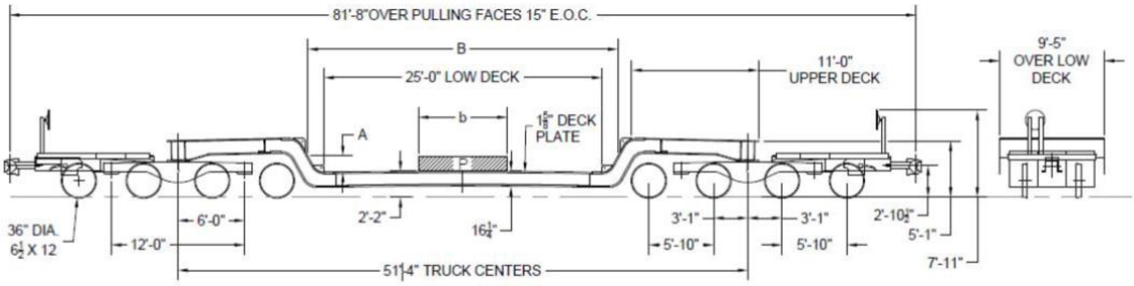
Depending on the final mode chosen and the storage method utilized at the interim storage sites, these conveyances may transport various Type B transportation packages (i.e., the Used Fuel Transportation Package, the Dry Storage Container Transportation Package, the Basket Transportation Package).

Figure 2 An Illustration of Road Conveyance with Used Fuel Transportation Package (top) and Basket Transportation Package (bottom)

[3] Heavy haul truck has been scoped out of this report because there were no databases containing collision information on these types of conveyances, therefore the focus of this report is on truck tractors and rail consists.

Figure 3 An illustration of Dry Storage Container Transportation Packages and Supporting Rail Consist

Figure 4 An illustration of the 8-axle Dry Storage Container Transportation Package Railcar



1.2 Objective of the Report

The Transportation Collision Mitigation Report was prepared by Nuclear Transport Solutions (NTS) for NWMO's use in addressing the specific needs of the project and their business. This report is based on available information at the time of preparation.

The purpose of this report is to leverage the statistical analysis and assessment of the accident data developed in the Transportation Collision Data Analysis Report [1] to identify potential collision mitigation methods that can be implemented within NWMO's transportation program (including conveyance, equipment inspection, maintenance, and operational and administrative controls).

To meet the overall project objectives, the scope of work has been organized into three distinct and integrated Work Packages which focus on the following:

- Work Package # I: Collection and analysis of existing relevant collision data,
- Work Package # II: Development of event trees and collision probabilities, and,
- Work Package # III: Identification & assessment of mitigation measures that can reduce risks.

The Transportation Collision Data Analysis Report [1] addresses Work Package #I and Work Package # II; analysing historical collision conditions to quantify collision probabilities which may apply to road and rail conveyances which are being considered by NWMO for transporting Type B Packages. **Section 1.4** provides a summary of key conclusions of the Transportation Collision Data Analysis Report [1] which were used to inform this report.

This report encompasses the work completed in Work Package # III. The objective of this report is to take the key findings from the previous work packages and identify potential mitigating measures that can be implemented by NWMO in the used fuel transportation program to reduce the likelihood of a transportation accident with consideration to the types of modes and conveyances being studied by NWMO.

Nuclear Transport Solutions (NTS) worked in collaboration with AECOM Canada Nuclear Services (ACNS) to complete this third work package regarding transportation operational considerations for the safe transport of used fuel in Canada.

NTS is a wholly owned subsidiary of the United Kingdom's Nuclear Decommissioning Authority (NDA), with extensive and proven expertise in irradiated fuel management and nuclear material transportation. This report draws upon direct operational experience in strategic assessments and feasibility studies relating to irradiated fuel management and transportation.

In partnership with Secured Transportation Services (STS), NTS draws from its decades of nuclear transport experience to develop this report. A robust approach to a used fuel transportation system is proposed by mapping operational experience to the outcomes identified with the Transportation Collision Data Analysis Report [1].

1.3 Content Overview

This report encompasses the work completed in Work Package # III as described above.

Section 2: Transport Overview	A high-level overview of the transport context, safety, design requirements, and testing of Type B packages.
Section 3: Road Operations	Comparison of conventional trucking to nuclear transport highlighting safety considerations. This section covers key elements of safe nuclear transport by road.
Section 4: Rail Operations	Discussion of key rail safety features, as informed by historical and operational experience.
Section 5: Emergency Response and Transport Security Considerations	Overview of the incident/emergency response and transport security arrangements that accompany safe nuclear transport operations.
Section 6: Human Performance Approach	Overview of management factors which comprise key programme elements associated with fitness for duty, performance programs, competency management and recruitment.
Section 7: Key Management Aspects	Discussion of the key organizational and management factors that culminate to form a safe operating environment for nuclear transport.
Section 8: Conclusions	A summary encompassing conclusions and recommendations of each section of the transport mitigation report.

1.4 Summary of Transportation Collison Data Analysis Report

As described in **Section 1.2**, this report leveraged the statistical analysis and assessment developed in the Transportation Collision Data Analysis Report [1] which collected and analysed Canadian transport collision datasets from 2010-2019 to identify the highest probability of accident scenarios (e.g., collision with fixed or non-fixed objects for road operations, collision leading to derailment for rail operations).

The nuclear transport industry is limited in probabilistic studies due to a lack of collision data for conveyances carrying Type B packages compared to conventional commercial transport operations or even transports of other classes of dangerous goods. While this can be interpreted as a properly functioning regulatory regime influencing operational safety, the distinct challenges for transporting nuclear material must still be considered in operational planning and preparation regardless of data availability.

Table 2 gives an overview of the scenario rankings found in the previous work packages [1]. These scenarios encompass the most probable collision types and objects struck following the advent of a collision taking place. A full listing of collision scenarios is available in the preceding work packages report [1]; see sections 9.1.2 for truck collisions and 9.2.2 for train collisions therein.

Table 2: Summary of scenario rankings from previous work packages.

Short-List of Ranking (Truck Tractor)		
Collision Type	**Object Struck**	**Rank**
Collision with a non-fixed object	Other moving vehicles (light damage to vehicle)	1
Collision with a non-fixed object	Other moving vehicles (severe/moderate damage to vehicle)	2
Non-collision	Other non-collision e.g., skidding/sliding or running off-road (severe/moderate damage to vehicle)	3
Collision with a fixed object	Other fixed objects e.g., tree, culvert, guide rail (severe/moderate damage to vehicle)	4
Collision with a fixed object	Other fixed object (light damage to vehicle)	5
Short-List of Ranking (Train)		
Derailment Scenario	**Collision Scenario**	**Rank**
Derailment	Non-main-track derailment (conventional shipment)	1
Remains on rail	Other objects e.g., abandoned vehicle, track unit (conventional shipment)	2
Derailment	Main-track train derailment (conventional shipment)	3
Remains on rail	Life form (conventional shipment)	4
Derailment	Non-main-track train derailment (dangerous goods)	5

The Transportation Collision Data Analysis Report [1] further breaks down observed collision scenarios per their probability of occurrence, associated vehicle damage severity (as applicable). It then goes on to analyse causal factors and emerging themes of interest for certain scenarios.

As part of this report, NTS and STS leverage decades of experience in the transport of nuclear material by road (STS has conducted over 200 nuclear road transport operations in Canada). This experience is used to provide guidance as it relates to mitigation measures associated with noted collision scenarios as well as other risks registered by both carriers. Similarly, NTS works to mitigate wider risks associated with rail transport, influenced by decades of operational experience and the UK's national rail safety group, including:

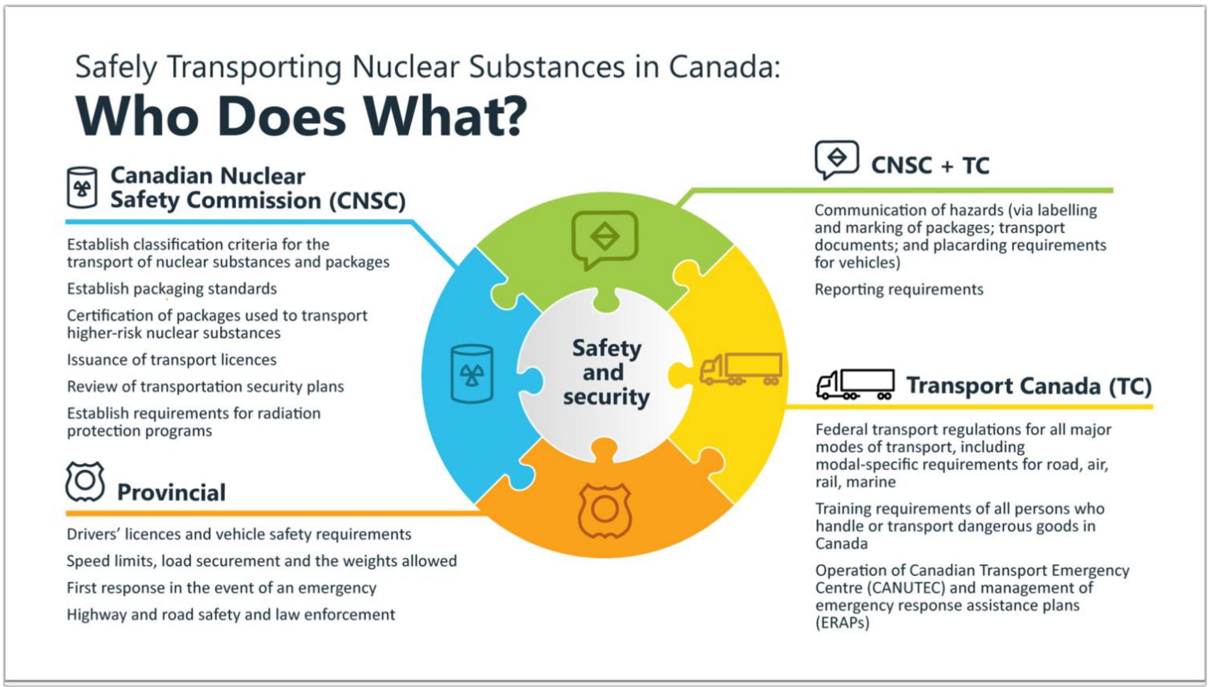
- Wagon Condition on the network
- Road Risk
- Workplace H&S Arrangements
- Safety Critical Communications
- Signal Passed at Danger (SPAD) Reduction
- Fatigue
- Trespass & Security
- Health & Wellbeing
- Common safe systems of Work

This report provides operational insight into mitigation measures that are in place for the identified transport accident scenarios while also providing a holistic view of the wider mitigating factors associated with nuclear transport operations.

2 Transport Overview

Canada has a robust regulatory framework governing the transport of nuclear material, as outlined within **Section 1.1.1**, which is overseen by the CNSC, Transport Canada and provinces. The transport safety requirements of the IAEA SSR-6 [5] are adopted through the CNSC's PTNSR [2], with the PTNSR serving to establish the safety requirements for the packaging and transport of nuclear substances. **Figure 5** provides an overview of the responsibilities associated with the safety and security of transporting nuclear substances in Canada.

Figure 5 Overview of shared regulatory oversight for transport of nuclear substances in Canada [6]



Transport Canada utilizes the Transportation of Dangerous Goods Regulations [7] to set transport requirements for the movement of radioactive material. In tandem, these regulations create a robust framework that must be complied with when packaging and transporting nuclear material in Canada.

When considering the transport of Type B packages (see **Table 1**), stringent testing requirements are required to ensure that transport safety is built into the design of the package. NCT testing sees packages undergo a water spray test, free drop test, stacking test and penetration test.

To ensure the robustness of Type B packages, ACT testing extends the requirements to demonstrate robustness in conditions deemed to be credible severe accident conditions; these include:

Mechanical Testing

Three different drop tests in an order such that, on completion of the mechanical testing, the package will have suffered the maximum damage prior to the thermal testing that follows. The drops include:

(a) 9m drop test to suffer the maximum damage.

(b) 1m drop onto punch bar rigidly mounted perpendicular to the target.

(c) Dynamic crush test created by positioning the package in a manner that causes maximum damage from the drop of a 500kg mass from 9m.

Thermal Testing

The package is held under conditions of an ambient temperature of 38 ºC and subjected to:

(a) 30 minutes of a fully engulfing flame, at an average temperature of 800 ºC

(b) Exposure back to an ambient temperature of 38 ºC

Water Immersion Test

The package is fully immersed under at least 15m of water for a period of no less than 8 hours in a manner that would cause maximum damage. For some sub-categories of Type B packages, an enhanced water test is required consisting of full immersion under at least 200m of water for no less than 1 hour.

Any package that can successfully maintain integrity throughout the ACT is, by design, developed to withstand transport accidents deemed credible and severe, and is inherently robust.

In developing mitigation measures for transport accidents, acknowledging the testing requirements and subsequent safety conscious design for Type B packages allows for a commensurate, yet robust approach to transport safety. Beyond this, data availability for transport accidents involving Type B packages is very limited as incidents involving these package types are particularly uncommon, with an event involving any form of radiological release being extremely rare. It is noted that the previous work packages have drawn from wider data sets of involving other heavy vehicles to obtain viable data sets.

3 Road Operations

Section 3 provides an overview of the key risks associated with the carriage of dangerous goods with a focus on class 7 radioactive material, comprising the factors that increase the likelihood of a collision with a fixed and non-fixed object, which have been identified as the most probable collision scenario within NWMO Transportation Collision Data Analysis Report [1] for road operations.

This section draws upon the established experience of nuclear road transport operations of STS and NTS management experience of road operations, to provide insight on best practice for safety.

3.1 High Level Comparison of Operating Conditions for Conventional and Nuclear Transports

It is recognized that many questions and concerns are raised regarding the transportation of used nuclear fuel based on the general public's understanding of the commercial trucking industry. For example, the Transportation Collision Data Analysis Report [1] Section 6.2.1.1 identified that collisions with non-fixed objects (such as other moving vehicles) was the leading collision type by sequence of events, followed by collisions with fixed objects.

However, the road transport of nuclear materials in Canada occurs in a **very different environment** from conventional trucking, in part due to the many additional safety requirements and enhanced training requirements:

- Truck drivers for nuclear shipments are not under pressure to achieve tight profit-driven delivery schedules, deadlines, or similar constraints requiring long hours at the wheel. The contingent risks of "driver error, speeding, and cutting corners" are often mitigated by the presence of security escorts, a higher standard of training and experience, operational controls, and a tighter regulatory environment than that which generally exists for standard commercial trucking – which is unconstrained by these factors.
- Transport of Category II nuclear material in Canada has a regulatory requirement that the shipment is conducted by qualified drivers with strict licenses and certifications for the transport and packages set out within the PTNSR [2] while adhering to wider transport regulatory requirements.
- Nuclear transport drivers are expected to ensure that they are implementing the Transportation Security Plan (TSP), performing routine communications check calls, logging calls received, etc.
- Operations typically see sensors attached to packages for vibration and drop detection and issue an alert to initiate the appropriate response.
- Drivers are also expected to meet the pre-identified transportation schedule which derives from the need for regulatory compliance for safety and security. As such, safety and security requirements take precedence over any time pressures that could be born of financial gain (as may be seen in commercial road operations). In practice this could see designated security checkpoints factored in and a detailed notification matrix developed to ensure communication of scheduling to operational support teams.

For all nuclear transport operations overseen by STS in Canada, assurances are provided that the truck drivers deployed are qualified, experienced, adequately rested, and familiar with the route plan, the TSP, the cargo vehicle and cargo, and the regulatory guidelines. These are all considered key elements in conducting nuclear road transport operations.

While it is not appropriate to say that equipment failure, stress, fatigue, or other general transportation environmental variables could not also occur for nuclear transports, it is important to note that the statistical probability of such risks must consider the ***significant differences*** between the nuclear transport operations and the standard commercial operations. Data derived from the standard commercial transportation industry would show a higher rate of collisions than would be applicable to the nuclear transportation industry.

Therefore, in comparison with the conditions for standard commercial trucking noted above, road transport of nuclear material in Canada is conducted under a rigorous regulatory framework.

3.2 Potential Causes and Mitigation Measures Associated with Truck-Tractor Collisions

As identified within the NWMO Transportation Collision Data Analysis Report [1], Table 11 details leading contributing factors associated with conventional truck-tractor collisions. The identified categories of contributing factors fall into 4 groups across the data analysed by the previous work packages, which are:

- Driver action
- Driver condition
- Weather condition
- Road surface condition

By leveraging the findings in [5], this section considers additional contributing factors (such as mechanical failures) and identifies relevant mitigating measures which can be incorporated in NWMO transportation program for road shipments. **Table 3** provides a mapping of the discussion as it relates to contributing factors and relevant potential mitigating measures for truck-tractor collisions.

Table 3: Truck-Tractor Collisions - Potential Causes and Mitigation Measures

Topic	Potential Causes	Potential Mitigation Measures
Driver Action (**Section 3.3**)	Potential Causes (**Section 3.3.1**)	Mitigation Measures (**Section 3.3.2**) • Route Planning and Route Reconnaissance • Driver Training • Advanced Driver Assistance Systems (ADAS) • Speed Reduction
Mechanical Failures (**Section 3.4**)	Potential Causes (**Section 3.4.1**)	Mitigation Measures (**Section 3.4.2**) • Vehicle Maintenance • Vehicle Inspection • Securing Loads
Driver Condition (**Section 3.5**)	Potential Causes (**Section 3.5.1**)	Mitigation Measures (**Section 3.5.2**) • Driver Fatigue • Driver Health • Driver Impairment • Inattentive Driving
Adverse Weather Conditions (**Section 3.6**)	Potential Causes (**Section 3.6.1**)	Mitigation Measures (**Section 3.6.2**) • Monitoring Weather Conditions
Road Surface Conditions (**Section 3.7**)	Potential Causes (**Section 3.7.1**)	Mitigation Measures (**Section 3.7.2**) • Monitoring Weather Conditions • Route Planning and Route Reconnaissance • Monitoring of Road Conditions from TCC

3.3 Driver Action

3.3.1 Potential Causes

As identified within the previous work packages [1], driver action, i.e., reckless driving and driver error, is the leading cause of conventional truck-tractor collisions.

- A driver may mishandle traffic or road conditions if unfamiliar with the highway.
- Any driver who does not pay attention to traffic or road conditions or follow highway traffic laws is at risk of causing an accident.
- Distracted driving (for example, driving while texting or talking on the phone) is a hazardous practice that puts drivers and other travellers in danger.

3.3.2 Potential Mitigation Measures

Potential mitigating measures related to reckless driving and driver error are described below and include route planning and route reconnaissance; driver training; Advanced Driver Assistance Systems (ADAS); and speed reduction, where appropriate.

Route Planning and Route Reconnaissance

Given that the transportation of dangerous goods by road requires careful planning and preparation, route planning is a vital element of the preparation process. Such a plan must be cognisant of the specific hazards associated with the dangerous goods in transport.

Route requirements for nuclear material are specifically designed to use prescribed roadways whenever possible and avoid unsuitable, narrow, or poorly maintained roads.

Industry best practices for developing a route plan for the carriage of dangerous goods by road are as follows:

- Identify the Route Restrictions - This includes identifying any restrictions on certain roads or highways, such as weight or size restrictions, and any associated time restrictions. Route planning should take specific note of road surfaces, seasonal variances and implications when cross-referenced with the transport arrangements proposed.
- Identify the Potential Hazards - Steep inclines, sharp curves, low bridges, and narrow roads could all be considered potential hazards on a road route.
- Consider the Transport Vehicle - This includes considering the size and weight of the vehicle, as well as the type of cargo being transported.
- Consider Emergency Response Procedures - Emergency response procedures should also be considered when developing a route plan for the carriage of dangerous goods by road. This includes identifying emergency response teams and procedures along the route and ensuring that all necessary contact information is readily available.

Unfamiliarity with the highway can be an issue early in a campaign or during a one-time shipment leading to driver error. However, this can be mitigated by developing detailed turn-by-turn directions for the drivers and security escorts via the route plan. This practice is enhanced by conducting “Route Reconnaissance”, another best practice in which a proposed route for transport of nuclear materials is driven in advance to check for low overpasses, narrow bridges or tunnels, steep grades, tight corners, bridges that have weight restrictions, and refuelling plazas large enough to accommodate nuclear transportation vehicles that also offer easy ingress and egress. This allows the Transportation Command Centre (TCC, see **Section 5.2**) to relay any specific hazards or guidance directly to the drivers and other operational support teams.

Driver Training

One of the most effective measures to reduce risks associated with reckless driving or driver error is training. Driver training should cover defensive driving techniques, safe loading and unloading practices, and emergency response procedures. In addition, it should also address the specific hazards associated with the dangerous goods being transported.

Industry best practices for driver training include a combination of classroom instruction and practical experience. In Canada, Transport Canada provides guidance on the legislation covering driver training courses for the transportation of dangerous goods [8]. The courses are accredited by Transport Canada and cover a range of topics, including the transportation of dangerous goods regulations, the properties of dangerous goods, and emergency response procedures. These courses are delivered by experienced instructors and provide participants with hands-on training in a range of scenarios.

In addition to formal driver training courses, ongoing education and training elements are critical components of driver training. Drivers should receive regular updates on changes to regulations governing the transportation of dangerous goods, as well as ongoing education on best practices for safe driving.

Operationally, drivers are expected to conduct routine communications such as check-calls which are typically streamlined by using a single button press to transmit “all is well” messages to the TCC to minimise distraction while communicating driver condition. This helps to further reduce the hazards of distracted driving.

Having security escort personnel accompanying the truck-tractor also acts to forestall careless or reckless behaviour as an additional layer of assurance. While accidents caused by other drivers are a possibility, nuclear transport operational protocols are designed to reduce the probability of any nuclear material transport driver behaving carelessly or recklessly at any time.

Advanced Driver Assistance Systems (ADAS)

ADAS are a collection of electronic systems and features designed to enhance vehicle safety and driver comfort by automating or enhancing certain driving tasks. These systems use various sensors, cameras, and onboard computing to provide real-time feedback and assistance to the driver, helping to prevent accidents and improve overall driving efficiency.

ADAS are increasingly being adopted by commercial goods vehicles in Canada to improve safety, efficiency, and overall driving experience. Some common ADAS technologies employed include adaptive cruise control, automatic emergency braking, lane departure warning, blind spot detection, and traffic sign recognition.

ADAS technologies can be categorized into five levels based on their degree of automation, as defined by the Society of Automotive Engineers (SAE) International [9].

Level 0	No Automation: The driver is fully responsible for all driving tasks without vehicle assistance. ADAS features in this level may include basic warnings and alerts, such as parking sensors, but do not actively control the vehicle.
Level 1	Driver Assistance: In this level, the vehicle can assist with either steering or acceleration/braking, but not both simultaneously. The driver remains in control of the vehicle and is responsible for all other driving tasks. Examples of Level 1 systems include Adaptive Cruise Control (ACC) and Lane Keeping Assist (LKA).
Level 2	Partial Automation: The vehicle can control both steering and acceleration/braking simultaneously under certain conditions, but the driver is still required to monitor the environment and take over control when needed. Examples of Level 2 systems include Tesla’s Autopilot and Volvo’s Pilot Assist.
Level 3	Conditional Automation: In this level, the vehicle can handle all aspects of driving under specific conditions, such as highway driving, but the driver must be ready to take over control when the system requires it. An example of Level 3 automation is Audi’s Traffic Jam Pilot.
Level 4	High Automation: The vehicle can handle all driving tasks without human intervention within a specific operational domain (such as geofenced areas or dedicated lanes). However, a human driver may still take over control when desired. Examples of Level 4 systems are currently being tested by companies like Waymo and Cruise.

Level 5	Full Automation, where the vehicle can handle all driving tasks under all conditions without any human intervention. However, this level is not considered part of ADAS, as it represents a fully autonomous vehicle that does not require any driver assistance.

Transport Canada frequently promotes the use of ADAS in commercial vehicles to reduce accidents and improve road safety. In 2019 the Canadian Council of Motor Transport Administrators (CCMTA) released a report on the impact of ADAS on commercial vehicles, discussing their benefits, challenges, and recommendations for implementing such systems [10]. Further, the Canadian Trucking Alliance (CTA) has been advocating for ADAS adoption in the trucking industry. The CTA Blue Ribbon Task Force on the Driver Shortage published a report suggesting that adopting ADAS technologies can help address the driver shortage in the industry by making the job more attractive to potential drivers [11].

The following summary provides information on five key components of ADAS:

Duress Button	A duress button, also known as a panic button, is designed to help drivers in emergency situations. When pressed, it immediately sends a distress signal to a monitoring centre (the Transportation Command Centre (TCC) described in **Section 5.2**) or designated authorities. This feature is particularly useful in cases such as security events or medical emergencies. The signal can be transmitted via cellular networks or other communication technologies.
GPS Tracking System	Global Positioning System (GPS) tracking systems enable real-time location monitoring of vehicles, which can be crucial for fleet management, stolen vehicle recovery, and general navigation purposes. These systems use a combination of satellites and cellular networks to provide accurate and up-to-date positioning data. With the integration of ADAS, GPS tracking can also facilitate features like geofencing (creating virtual boundaries) and route optimization.
Anti-Theft Features	ADAS offers various anti-theft features to enhance vehicle security. These include immobilizers, which prevent unauthorized vehicle operation by disabling the engine or fuel system; alarms, which deter theft attempts through loud audible alerts; and remote monitoring and control systems, which allow owners to track their vehicles, lock/unlock doors, and even shut down engines remotely.
Event Recorders	Event recorders, also known as black boxes or crash data recorders, are devices that capture, and store data related to vehicle performance and driver behaviour. In the event of an accident, these recorders can provide valuable information for accident reconstruction and insurance claims. They typically collect data such as vehicle speed, braking activity, steering inputs, and impact forces.
Real-Time Metrics	Real-time metrics involve the collection and analysis of data from various sensors and systems within the vehicle. This data can include information about vehicle performance, driver behaviour, traffic conditions, and environmental factors. By analysing real-time metrics, ADAS can provide valuable insights to improve safety, optimize fuel efficiency, and enhance the overall driving experience.

Speed Reduction

Speed reduction is widely considered amongst the most easily implemented and effective traffic accident mitigation measures available; however, it is not mandated for nuclear transport operations. Reducing transport speeds has been shown in numerous studies to facilitate safety by increasing reaction time for drivers and generally reducing the distance required to execute emergency stops.

Drivers must also consider that slowing down the speed of nuclear transport vehicles will also slow down the speed of vehicles behind them and make it more difficult for other drivers to get around the slow-moving cargo vehicles. Therefore, drivers must use their own judgement in slowing, particularly in areas that have limited passing options for other vehicles, reinforcing the importance of high-level driver training.

3.4 Mechanical Failures

3.4.1 Potential Causes

Commercial truck-tractors accumulate wear and tear as they are driven through challenging weather and road conditions. If these risks are not carefully monitored, mechanical failures may occur, such as tire blowouts and engine trouble.

Truck-tractors can also create a serious hazard by incorrectly parking on the side of the road while attending to mechanical issues. Ill-maintained lighting standards and reflective markings can make a truck or its trailer difficult to be seen, placing the truck at risk of being hit by passing vehicles.

3.4.2 Potential Mitigation Measures

The risk of mechanical error places significant importance on the application of proper vehicle maintenance, inspection and load securing methods. Mitigation approaches from best practice and operational experience are as follows.

Vehicle Maintenance

Commercial cargo vehicles must comply with various Canadian standards and stay in good working order through regular maintenance. Commercial carriers are legally required to have an effective maintenance and inspection program. Additionally, trucks with a licensed mass of more than 11,794 kg must complete trip inspection reports and carry a schedule as set out under National Safety Code Standard 13 (NSC-13) [12].

The PTNSR stipulate that carriers must implement and maintain work procedures to ensure compliance with the Regulations and keep a record documenting those procedures [2]. Nuclear transport cargo trucks routinely undergo more in-depth inspections as part of established best practice to ensure they are unlikely to break down en route.

Vehicle maintenance is critical to ensuring road safety and preventing incidents during transportation. In Canada, the Canadian Council of Motor Transport Administrators (CCMTA) has established guidelines and standards for Heavy Goods Vehicles (HGV) maintenance. The CCMTA's National Safety Code Standard 11 requires all commercial vehicles to undergo regular safety inspections, which include checking the brakes, steering, suspension, and tires, among other components [13].

The Commercial Vehicle Safety Alliance (CVSA) inspection levels are not referenced within the CCMTA's National Safety Code Standard 11 but are considered industry best practices and are typically required by provincial authorities.

Vehicle Inspection

Regular driver walk-around checks are widely considered best practice to identify any visible defects or issues with the vehicle before starting a journey. These checks include examining the condition of the vehicle's tires, lights, and mirrors and checking for any leaks or damage to the bodywork. By adhering to the guidelines of the CCMTA, HGV operators in Canada can ensure the safety and roadworthiness of their vehicles. Some key items of a vehicle maintenance plan are as follows:

Daily Inspections - A daily inspection will occur before the vehicle is driven. This includes checking the engine oil level, transmission fluid level, coolant level, brake fluid level, and windshield washer fluid level. The driver will also inspect the tires for damage or wear and check the brakes for proper operation. Any issues will be addressed immediately before the vehicle is driven.

Regular Servicing - Regular servicing is essential for ensuring the vehicle's safe operation. The vehicle should be serviced according to the manufacturer's recommendations, including regular oil changes, filter replacements, and fluid changes. The timing of these services will depend on the manufacturer's guidelines, but generally, they should be carried out every 16,000-24,000 kilometers.

Brake Inspection - Brakes are one of the most critical components of a heavy goods vehicle, and regular inspection is essential to ensure their proper operation. Brakes should be inspected every 6 months or 40,000 kilometers, whichever comes first. This inspection should include checking the brake pads, shoes, drums, rotors, and hydraulic system for proper operation. Any issues should be addressed immediately.

Suspension Inspection - The suspension system is also a critical component of a heavy goods vehicle, and regular inspection is essential to ensure its proper operation. The suspension system should be inspected periodically per the manufacturer's instructions. This inspection should include checking the shocks, springs, and bushings for proper operation. Any issues should be addressed immediately.

Electrical System Inspection - HGVs rely on complex electrical systems to operate safely and efficiently. Proper maintenance and inspections of these systems are crucial to ensure that HGVs are roadworthy and safe.

Cooling System Inspection - The cooling system is another critical component of a heavy goods vehicle, and regular inspection is essential to ensure its proper operation. The cooling system should be inspected every 6 months or 40,000 kilometers, whichever comes first. This inspection should include checking the radiator, hoses, thermostat, and water pump for proper operation. Any issues should be addressed immediately.

Truck-tractors used for nuclear material transport tend to be relatively new and are carefully inspected before each deployment during a separate process for mechanical and electrical readiness for duty.

The CVSA provides eight levels of inspections ranging from the Level I Inspection, which evaluates both the driver and vehicle, to inspection levels with a more specific area of focus, such as Level VI for radioactive materials and Level VIII for electronic inspections.

Truck tires are inspected to ensure they are new, near new, or within wear guidelines set by the CVSA. From STS' operational experience, all road shipments originating from Canadian Nuclear Laboratories (CNL) destined for the US, transported through Ontario were subject to a CVSA Level VI inspection. These inspections were performed by Ministry of Transport Ontario (MTO) personnel and derived from a contractual requirement with the carrier [14].

Securing Loads

Nuclear material is transported in specially designed and licensed packages. These packages are robust and weigh many tons. Because these packages are so specialized and heavy, they require specific cargo securement fixtures, which are part of the package license/certificate. Special cargo fixtures ensure that the packages are properly secured to the conveyance as part of compliance with national regulations.

Commercial trucks often carry heavy loads of cargo or materials. Failure to properly secure the load can cause it to fall off the truck and hit other vehicles or create a barrier if left on the road. Catastrophic injuries or fatalities can quickly happen if other vehicles encounter fallen loads or hazardous materials left behind by a truck [15].

In contrast to standard commercial truck transports, vehicles used for nuclear transport are inspected carefully before every deployment including load securing methodology. For past STS-controlled nuclear transport operations, vehicles and drivers underwent an independent rigorous pre-inspection by a qualified mechanic and a formal CVSA inspection. The "pre-inspections" were designed to find and repair any issues before the provincial inspection to ensure that no schedule delays would impact planned transports including the securing of loads.

3.5 Driver Condition

3.5.1 Potential Causes

Driver conditions (fatigue, health, impairment, and inattentive driving) are common causes of commercial trucking accidents. Potential mitigation measures are discussed below.

3.5.2 Potential Mitigation Measures

Driver Fatigue

Driver fatigue is another common cause associated with commercial truck-tractor incidents. In June 2021, amendments to the Commercial Vehicle Drivers Hours of Service Regulations [16] came into effect mandating no driver to accumulate more than 13 hours driving time in a day and electronic logging devices for federally regulated motor carriers. These updates are intended to help more accurately track drivers' work/rest hours and reduce the risk of fatigue.

Unlike truck drivers in standard commercial road transport, truck drivers engaged in nuclear material transportation are not under pressure to achieve tight profit-driven delivery schedules, deadlines, or similar constraints requiring long hours at the wheel. The contingent risks of "driver error, speeding, and cutting corners" are often mitigated by the presence of security escorts, a higher standard of training and experience, and a tighter regulatory environment than that which generally exists for standard commercial trucking – which is unconstrained by these factors.

In comparison to commercial trucking conditions described above, best practice sees road transport of nuclear material conducted by a team of drivers for long-duration routes. The working recommendation is that two drivers – a primary driver and a co-driver – are assigned to each nuclear transport vehicle in rotating shifts so that driver fatigue is managed during the transport operation. Additionally, pre-departure inspections examine the driver's logs to ensure they have had sufficient rest to adequately meet all requirements during available duty hours.

The CNSC requires licensees to implement and maintain human performance programmes. Licensees typically perform a risk-informed analysis to identify safety-sensitive positions that will be subject to these requirements. REGDOC-2.2.4, Fitness for Duty: Managing Worker Fatigue [17] specifies requirements and gives guidance for managing worker fatigue.

Driver Health

Drivers may schedule routine physical examinations to reduce the likelihood of heart attacks, strokes, or enroute medical emergencies caused by health problems such as diabetes, kidney disease, or other long-term debilitating conditions. By reducing the chance of a driver suffering a medical condition during a transport, the likelihood of an accident occurring during a medical emergency is reduced. Notably, the release of, or requirement for, submittal of personal medical information may be unlawful in many legal jurisdictions, both in Canada and the US.

Driver Impairment

Impairment is also a major factor that can increase the risk of road accidents, as drivers under the influence of drugs or alcohol lack the coherence to suitably control a vehicle. Nuclear material transport drivers should participate in a continuous drug and alcohol screening process to maintain their government-issued security clearances. This greatly reduces the likelihood of driver impairment due to the influence of drugs or alcohol. Employers must make the decision to implement drug and alcohol testing for their employees. Within nuclear regulation, the CNSC's REGDOC-2.2.4, Fitness for Duty, Volume II: Managing Alcohol and Drug Use [18] establishes requirements and guidance for managing workers fitness for duty with respect to drug and alcohol use. The intention of the document is for high-security sites as defined within the NSR [4] with requirements and guidance being applicable to workers with "safety critical" or "safety-sensitive" positions defined within. Notably, dangerous goods drivers are not defined within this document, but a risk-based analysis of the role would suitably inform the requirement.

Human performance is a contributor to the safe and secure transport of radioactive material. Implementing a fitness for duty program could provide assurance that drivers or others in operational roles have the capacity and are free of any impairment that could hinder their ability to competently and safely perform duties so that they do not pose a safety or security risk.

Fitness for duty assessments could include, but are not limited to, medical assessments, psychological assessments, occupational fitness assessments, alcohol, and drug testing.

The NTS fitness for duty program includes drug and alcohol testing, fatigue management policy and driver terms and conditions designed to aid fitness for duty (see **Section 4.1**).

Inattentive Driving

Best practices for nuclear transportation typically see two drivers (or a driver plus security escort) being present in the cargo truck cab, to ensure attentive driving and increase the ability to respond to operational complexities. For example, ensuring both a driver and co-driver are awake and alert in the truck cab at all times facilitates communications and response protocols both under routine circumstances and under duress. Two drivers will allow most emergencies to be handled while still ensuring control of the cargo vehicle itself. Additionally, the use of escort personnel may serve a similar function in maintaining control of cargo during any emergencies while having secure communication links to the relevant response arrangements.

Operationally, routine communications such as check-calls are typically streamlined by using a single button press to transmit “all is well” messages to the TCC to minimize any distraction potential. This helps to further reduce the hazards of distracted driving. Having security escort personnel accompanying the truck also acts to forestall careless or reckless behaviour as an additional layer of assurance. While accidents caused by other drivers are a possibility, nuclear transport operational protocols are designed to reduce the probability of any nuclear material transport driver behaving inattentively at any time.

3.6 Adverse Weather Conditions Considerations

3.6.1 Potential Causes

Section 6.2.1.4 of the previous work package [1] illustrates that most collisions involving truck-tractors and heavy vehicles in different provinces occurred during “clear” weather conditions. This is expected to be due to most transports taking place during clear conditions, however the potential impacts of adverse weather must remain a pertinent planning consideration.

High winds, difficult terrain, narrow highways, icy roads, and heavy rain or snowfall all pose different risks to commercial vehicle drivers. Truck drivers can cause collisions if they lose control when driving in dangerous weather. [15]

3.6.2 Potential Mitigation Measures

Monitoring Weather Conditions

Inclement weather is always a possibility within Canada, especially during the winter months. A series of pre-shipment weather checks can mitigate this. Under unexpected dangerous weather or storms, it is considered standard protocol to notify the shipper, law enforcement authorities, and regulators so that a “go/no go” decision can be made to delay the shipment or proceed, with the possible need to shelter in a safe harbour enroute.

Based on STS experience operating within Canada, out of more than 200 nuclear material transport operations carried out over a three-year period, only one has encountered circumstances that forced a cancellation. This was because of Hurricane Dorian forcing a shipment headed to the Buffalo port of entry to turn around. The decision was made to pause further shipments for a week while bridges along the route were assessed.

3.7 Road Surface Conditions

3.7.1 Potential Causes

As identified within the previous work packages [1], adverse road surface conditions could lead to truck collisions as they relate to loose snow, slush, ice, mud, sand, gravel and/or spills.

3.7.2 Potential Mitigation Measures

As noted in previous sections, route planning and route reconnaissance (see **Section 3.3.2**) and monitoring the impacts from inclement weather (see **Section 3.6.2**) are some measures that can be implemented to mitigate impacts from adverse road conditions. Furthermore, ongoing monitoring of traffic and road conditions by the TCC with feedback to the driver, can help provide valuable information to the drivers regarding hazardous road surface conditions during transport. Ongoing assessment of the transport will provide decision makers (TCC) with the information required to take action to mitigate the risks associated with poor road surface conditions, by means such as re-routing or rescheduling transports if necessary.

4 Rail Operations

Previous work packages discussed rail collisions within Section 6.2.2.3 [1], identifying the frequency and percentage of collisions under defined derailment scenarios. Data was separated for collisions in which rail vehicle remains on track and those in which a derailment occurs, with derailment defined as any instance where one or more wheels of rolling stock have come off the normal running surface of the rail, including occurrences where there are no injuries and no damage to the track or equipment. Notably, 63% of collisions from rail source data (the Transportation Safety Board of Canada (TSB) data dictionary [19]) within the Transportation Collision Data Analysis Report [1] involved a derailment.

As described therein (in Section 6.3.2 [1]), train operators' actions and conditions were not recorded in the TSB dataset for collisions. In addition, environmental conditions, including weather, surface, and lighting conditions were only available for a small fraction of train collisions in Canada. In the absence of such detailed information, the contributing factors for train collisions could not be identified. However, over several decades, rail assets have been developed and engineered through the implementation of electrical and mechanical systems to remove factors that could lead to collision or derailment due to human error. Detailed below are several key safety systems and factors that are mandated and incorporated in NTS' rail assets and can be considered best practice for mitigations associated with causes of derailment which include: rail operator fitness for duty; driver training; train safety features, rail conveyance and equipment testing, inspection and maintenance, informed decision-making, and route planning.

Examples of NTS owned rail wagon assets are included in **Appendix A**.

4.1 Rail Operator Fitness for Duty

Driver assessment should occur on a regular basis. For example, NTS rail procedures require a full medical examination every 3 years for drivers under the age of 55 and annually once aged 55 and over. In addition, NTS operates drugs and alcohol screening supported by the organization's Drugs and Alcohol Policy.

A robust fatigue management policy is essential to ensure all drivers are driving fully alert and rested. The fatigue management policy is supported by continuous fatigue monitoring, which is a complex formula accounting for the previous and current weeks' work, while also incorporating hours worked, start and end of shift times, continuous shifts worked and degree of movement in hours between the start of shifts.

For NTS, all planned base driver rosters are checked against a fatigue index (see **Figure 6**) to ensure that acceptable parameters are not exceeded on a planned basis. If a driver triggers a certain threshold on the fatigue index due to additional or extended working, the policy will address this with several potential interventions.

Figure 6 NTS Fatigue Index Calculator example

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company
Location
Shift ID
Date
Mode: Fatigue | Defaults | Reset Index | Calculate Index

Assessor
Display schedule
Display charts
© Crown Copyright 2005
Version 2.3
About

Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
1	03:00	09:00	Default	Default	6h	Fully Rested	6h	0.1	2.6	1.6	**4.3**
3	12:00	22:00	Default	Default	10h	2d 3h	5h 20m	1.0	0.7	1.0	**2.7**
4	10:00	15:15	Default	Default	5h 15m	12h	5h 19m	1.6	0.4	0.1	**2.1**
5	03:15	11:50	Default	Default	8h 35m	12h	5h 58m	2.3	2.5	2.4	**7.0**
6	13:30	21:25	Default	Default	7h 55m	1d 1h 40m	6h 18m	3.6	0.7	0.6	**4.8**
7	14:45	22:00	Default	Default	7h 15m	17h 20m	6h 26m	3.5	0.9	0.8	**5.1**
9	03:15	13:15	Default	Default	10h	1d 5h 15m	6h 7m	4.0	2.5	2.9	**9.1**
10	03:15	13:15	Default	Default	10h	14h	6h 30m	11.9	2.5	2.9	**16.6**
11	03:15	13:15	Default	Default	10h	14h	6h 49m	17.5	2.5	2.9	**21.9**
12	02:50	11:21	Default	Default	8h 31m	13h 35m	6h 58m	21.0	3.0	2.9	**25.7**
13	03:00	09:00	Default	Default	6h	15h 39m	6h 53m	23.5	2.6	1.6	**26.8**
14	22:50	09:50	Default	Default	11h	1d 13h 50m	6h 42m	15.0	12.7	13.5	**37.2**

It is important that fatigue awareness and management training is carried out for all safety-critical workers as a minimum. This includes a pre-shift self-checklist for drivers to complete to assess their fitness for duty prior to arriving at work.

Driver's terms and conditions also play a vital role in ensuring drivers' fatigue is managed correctly. These terms and conditions may address the following key areas:

1. Salaried payment with no material incentive to work above planned hours on a regular basis.
2. Minimum rest between shifts (e.g.,12 hours for NTS rail)
3. Maximum planned shift length (e.g.,12 hours, with no driving into the 11th hour for NTS rail)
4. Maximum amendments to planned start times.
5. Continuous driving time limit (e.g., 5 hours for NTS rail)
6. Authorized diagrams of routing for each shift
7. Regular breaks at authorized and equipped break facilities incorporated into each shift.

4.2 Driver Training

As with road transports, driver training for relevant traincrew is one of the most effective measures to mitigate accidents on the railway. On appointment, individual training needs analysis is undertaken to determine the specific training required before they can carry out unsupervised train driving duties. This will typically consist of the following key components and take approximately 1 year to complete based on no previous train driving experience.

Induction & Cab Experience (two weeks) – The induction and cab experience process provides an initial introduction to the company and covers all key policies, non-technical skills, and initial nuclear industry awareness training.

This is followed by a period of cab experience for new recruits who have never driven trains before, which involves them accompanying existing NTS train services. Nuclear services are not utilised for this purpose.

Rules Training (eight weeks) – New recruits are then required to study all current railway rules and sit through an examination, which they must successfully pass to continue training.

Traction Training (one week per locomotive type) – On successfully completing Rules Training, new recruits will then commence traction training on designated types of locomotives the company operates. This training will include classroom, static and practical training.

Practical Train Handling (twenty weeks) – Trainee drivers must then complete a minimum of 225 hours practical full train driving under qualified mentor supervision. At the end of this process, they will receive a full driving assessment to determine whether they are competent to drive.

Route Knowledge (three weeks per route)- Trainee drivers will then be assigned a minimum of 2 core routes to learn. Route learning is completed through a combination of classroom (route risk assessment, maps, and video) and practical experience. This element will be completed over a planned, predetermined continuous period before a route assessment takes place, which will take the form of a question paper and as required, a practical assessment. Once qualified, any further route learning required will be undertaken, assessed, and signed off following the same process.

Post Qualification (two years) – Once qualified, the driver will be assigned to a further 2-year post-qualification phase where they will receive a greater number of assessments to ensure they are working with the correct skill and knowledge.

4.3 Train Safety Features

4.3.1 Train Protection Warning System (TPWS)

The purpose of the TPWS is to automatically activate the train brakes through detection from the locomotive in the event of excessive speed being detected on the approach to signals or when a SPAD. SPAD is referred to as passing a stop signal in Canada and refers to a train passing a stop signal when not allowed to do so.

TPWS installed on locomotives need to be compatible with installed infrastructure equipment throughout the chosen rail network to operate safely and effectively.

TPWS will only trigger in the event of an incident, so it is important to test the system to ensure reliability. During the locomotives' maintenance, depots utilize handheld signal generators to emit sequences of signals to the locomotive antennas.

The simulated signals demonstrate that the locomotive brakes deploy in the event of both overspeed and SPADs. Typical locomotives used for nuclear material transport carry out an automated self-test on each startup to prove system functionality. Asset managers such as NTS are expected to conduct more in-depth depot checks on each locomotive at a minimum of every six months.

4.3.2 Automatic Warning System (AWS)

The AWS is installed to provide train drivers with an audible warning and visual reminder that they are approaching a signal at caution. Failure to acknowledge an approaching caution signal would result in automatic application of the locomotive's brakes. The AWS is connected to a visual and audible display in the drivers' cab.

If the signal being approached displays a restrictive aspect (red, yellow, or double yellow), the AWS will sound a continuous horn. The driver then has approximately 2 seconds to cancel the warning by pressing and releasing the AWS/TPWS acknowledgement button. On cancelling the warning, the horn then stops, and the visual indicator changes to a pattern of black and yellow spokes, which persists until the next AWS magnet and reminds the driver of the restrictive aspect.

As a fail-safe mechanism, the AWS will not be cancelled if the driver fails to cancel the warning in time or if the driver collapses onto the button or keeps it held down. The emergency brake will apply and bring the train to a stand.

To ensure function of the AWS, maintenance depots periodically simulate the magnetic fields of the infrastructure to conduct testing and maintenance. These sequences then prove that systems on the locomotives are operating correctly.

4.3.3 On Train Data Recorder / Event Recorder (OTDR)

An OTDR, also known as an event recorder or black box, is an important safety feature on locomotives as it records a variety of data related to the train's operation. This data can be used to investigate accidents and near-misses, among other incident types, to determine their cause and prevent them from happening in the future.

The OTDR records information such as train speed, brake status, throttle position, horn and bell usage, and other important parameters. This data can be used to reconstruct the sequence of events leading up to an incident and determine the cause. Safety experts can identify trends and patterns indicating potential safety issues by analysing this data.

In addition, the data recorder can be used to monitor the performance of the train and its crew. For example, if the data recorder shows that a train has been consistently exceeding speed limits, steps can be taken to address the issue and prevent accidents from occurring.

Overall, an on-train data recorder is an important preventative safety tool that can be used to ensure the continued safe operation of the train. By providing valuable data that can be used to improve safety practices, the data recorder helps to protect assets and traincrew.

Data recorders at NTS have a functional check every three months to ensure they operate correctly.

4.3.4 Deadman's Switch Device (DSD) Vigilance System

DSD vigilance is a critical safety feature on locomotives that ensures the driver is alert and responsive while operating the train. In simple terms, the DSD system requires drivers to acknowledge their presence and attentiveness by pressing a button or pedal at regular intervals. If the driver fails to respond to the audible warning, the system will automatically apply the emergency brakes, stopping the train.

Testing the DSD vigilance system is essential to ensure the system is in good working order and can maintain the safety of train operations. Regular testing and maintenance of the DSD system can help prevent accidents, injuries, and fatalities. NTS tests the DSD & Vigilance operation on every locomotive every three months.

4.4 Rail Conveyance and Equipment Testing, Inspection and Maintenance

4.4.1 Rail Assets

To ensure the safety of rail assets and reduce the likelihood of derailment, the rail conveyance and equipment must be tested, inspected, maintained, and managed effectively.

- Each asset needs to be maintained in accordance with an approved maintenance plan.
- Each maintenance plan needs to be updated in the event of changes to an asset.
- Internal and external assurance of maintenance carried out on the vehicles needs to be conducted.
- Safety critical components must be identified, procured, and tracked in line with approved robust processes.
- The safety systems on an asset must be in place, in good working order and tested regularly.
- Maintenance staff working on rail vehicles should be assessed as competent.

4.4.2 Rail Conveyance and Equipment Testing, Inspection and Maintenance Frequencies

The maintenance of a rail asset is derived by adopting a combination of both best practices and component manufacturer recommendations. Testing, inspection, and maintenance intervals are defined by either elapsed time or on a usage basis measured in track kilometers. An evaluation of the predicted annual mileage is made, and then an alignment is done between the 2 variables where possible. These recommendations are reviewed and are grouped to form exams with tasks to adopt these into a Vehicle Maintenance Instruction (VMI). **Appendix B** details a list of job codes within the VMI, these codes are linked to the relevant test procedures for each assets specific testing, maintenance, and inspection requirements. VMIs are established and utilised to define and undertake maintenance for each rail vehicle type (locomotives and rail wagons), wider maintenance requirements for transport packages are the responsibility of the owner and do not sit within the remit of the NTS VMI for rail operations.

4.4.3 Refinement of a Rail Maintenance Plan

Based on NTS' experience, the following factors outlined below are considered those that would lead to a vehicle maintenance instruction (VMI) being refined.

Routine Review - On a 12-month basis, a review will incorporate any minor corrections noted on the VMI at that time. This review will also incorporate any relevant information that may have come from specialized maintenance bulletins produced within those 12 months.

Safety Performance Monitoring Reporting (SPM) - SPM is captured monthly for each asset type. The report investigates trends in defects of safety-related components and mileage of vehicles and captures key information concerning critically defined maintenance periodicities. The SPM report would also incorporate national-level reports of defective components that are picked up externally.

Modifications to Vehicle Structure or Components - Any modifications that have been carried out to the vehicle need to go through a formal engineering change process. The engineering change process is used to validate that the changes made do not add any additional risk to the operation of the vehicle on the rail network and that the modification complies with all applicable standards.

Changes of Equipment from that Captured within the Original VMI - If a component is replaced for a similar component with the same functionality from a different supplier, this needs to be assessed formally through the engineering change process.

Change in Vehicle Duty Cycle or Environment - As noted above, the vehicle duty cycle plays an important part in the maintenance regimen for a rail asset. In some cases, infrequent use can be as damaging to a vehicle as frequent use. Competent engineers need to assess a change in predicted use, with the effect on the maintenance cycle assessed and adjusted accordingly. Consideration should also be given to any potential change in operating environment for the vehicle.

4.5 Informed Decision-Making

There may be situations which require a decision to be made before a shipment. This may be a security alert at the departing location and/or receipting location or sudden unavailability of the infrastructure (e.g., tracks or cranes). A risk-based approach should be followed, with the health and safety of all personnel involved taking priority in decision-making.

The risk appetite of the operations should be well understood by the operational leads of the business. Should some form of concern be raised prior to transport, the operational support team should convene to agree on whether or not to go ahead with the shipment based upon pre-determined criteria for the decision making, set by the carriers and communicated to the transport teams.

4.5.1 The Impact of Weather

As with road operations, weather forms an element of planning for rail operations. Weather conditions can impact transport operations: prior to the transport taking place; during the transport; and sometimes after the transport has concluded. At all times, the health, well-being, and overall safety of personnel involved is a primary consideration, and if at any point a transport operation needs to be paused due to adverse weather conditions, then a decision must be made to do so.

For example, NTS utilizes UK Met Office weather forecasts, and the dedicated NTS 24/7 control room is responsible for monitoring warnings and reacting to applicable inclement weather warnings. The control room team is signed up to receive automated messages of all-weather warnings. In Canada, agencies such as Environment Canada provide periodic weather data that can be used to support operational preparations.

Within the weather escalation process, the following risk factors need to be considered:

- Location – where is the weather warning situated?
- Direction of travel – is the weather front moving? Which direction and where will it end up?
- Timings – how long is the warning in place? When will the weather front hit that area?
- Staff – Are staff currently in that location? Are staff currently travelling to and from that location? Are staff planned to be in that location during the weather warning?
- Transport operations – are any transport operations taking place in that location? Are there any transport operations being affected already? Are there any transport operations which will be affected imminently? Are there any transport operations likely to be impacted upon in the future?
- Equipment/assets – are there any other pieces of equipment/assets that could be impacted?

4.6 Rail Route Planning

Route planning for rail operations is typically more constrained than that of planning for road due to the limited path (track) options. However, route planning is still a key part of planning for nuclear transport operations by rail. Some key considerations are as follows:

Train Weight, Length and Gauging Characteristics - In selecting the safest and most practicable rail route, the locomotive and wagon's specific design characteristics and the railway infrastructure's specific constraints need to be reviewed. This review ensures at the outset that the route has the capability to accommodate the weight, length and gauging of the nuclear rail movement.

Track/lineside Condition and Signalling Arrangements - Where possible, the route should contain the most up-to-date track and signalling arrangements, which can be checked with the infrastructure provider. Defect and repair records are available from the provider, together with any relevant upgrade work. Further consideration should be given to significant infrastructure items such as level crossings and stations, where there is an increased risk of public interface.

Route Resilience & Performance and Incident History - A resilience assessment can be carried out on the route to highlight potential areas of weakness or higher risk. For example, a route very close to the coast could be prone to flooding or landslides. Performance information is also typically available to aid in determining the reliability of a route and enable an evaluation of the likelihood of disruption to rail movements on that route. Alternative diversionary options should also be assessed to enable alternative routes to be utilized where possible if the original route is unavailable.

A review of incident history can also be undertaken to identify safety performance on the route and key trends in safety risks. This may serve to identify if a particular route has a significantly better safety record than another and influence route decisions.

Route Access - Another factor that should be considered is the train movements' ability to gain access to the route on a planned basis. Assessment of the time effectiveness of a route can ensure that train services are on a public network for a minimal amount of time. The route should enable the train to operate without stopping, to accommodate other traffic, and to minimize the potential for tampering while standing out on the network.

Effective route planning is achieved through balance of identified risks and understanding the various decision-making influences on the transport. Best practice sees safety, security and operational logistics working together to undertake an appropriate route selection process. A route risk assessment should be completed when undertaking the route evaluation and selection process. This will provide a comprehensive document detailing the identified risks. This will enable specific mitigations to be identified, actioned, and recorded (e.g., a speed restriction due to a poorly sighted signal). Further, the document forms a key part of traincrew route learning, where it will inform those learning or refreshing the route with key information that they must learn and understand. The risk assessment document can ultimately form part of the route learning evaluation process before a train crew member is officially signed off as competent to drive that route.

Any updates to the route that create new key information or key risks must be captured in a formal review process. A review process can be instigated by notified changes to the infrastructure, observations, or hazard reports the traincrew generates as they operate the route.

An example of a current route risk assessment is included in **Appendix C** – Route Risk Assessment Sellafield to Carlisle , which details the UK line that carries a significant level of nuclear rail traffic.

5 Emergency Response and Transport Security Considerations

5.1 Emergency Response

5.1.1 Overview

Radioactive materials present a range of potential hazards during transport, and the purpose of regulation and effective emergency response arrangements is to protect persons, property and the environment from hazards posed by radioactive material during transport. In the event of a transport emergency involving radioactive material in Canada, the consignor and carrier must have measures in place to respond to an emergency involving the transport of the material.

NWMO will provide an emergency response plan to Canadian regulatory agencies to demonstrate that appropriate emergency measures as in place and that information is available to public response agencies. The purpose of the emergency response plan is to ensure coordination among NWMO, provincial and local first responders as well as federal agencies.

Additionally, for Category II security nuclear transports, a suitable contingency plan in the event of a security incident included within the TSP will also be expected to meet the requirements of the NSR as part of the licence requirements to transport nuclear materials [4].

These plans provide information to ensure coordination among federal, provincial, and local first responders, should an incident take place. Emergency Management Plans contain contingency plans for various off-normal situations and include step-by-step procedures that tell drivers exactly what to do in the event of incidents.

Appendix D provides typical key roles and responsibilities associated with incident response.

5.1.2 Drills and Exercises

Exercises generally have three main purposes which are to validate plans, develop staff competencies/practice roles, and to test well established procedures. Exercising all emergency response arrangements is essential to identify learning opportunities which can improve processes and prevent repeat issues from occurring.

Exercises can take various forms, including live exercises or table-top exercises, and can include a single organisation or involve multiple agencies.

All emergency exercises are scenarios based around a plausible incident; examples of scenarios could include the following:

- Protester activity
- Derailment of nuclear services involving emergency services
- Crane failure during lifting operations

- Security incident on a rail service or road shipments
- Road traffic collision on a highway/freeway/road

Emergency plans are exercised through simulated situations. These situations are designed to evaluate the effectiveness of the response organization's emergency plans, procedures, and capabilities by identifying problems or gaps that can be resolved prior to a real emergency. They also identify good practices to be reinforced and provide opportunities for organizations and personnel to test their capabilities to respond to a particular component of a plan.

5.1.3 Incident Reporting

Robust communications capability between all involved parties connected through the TCC enables timely incident response and reporting. Communications should be routinely tested, with suitable redundancies and contingencies in place ahead of operations taking place.

For transport operations within Canada, the CNSC have a 24/7 duty officer telephone line for reporting in the event of an emergency involving a nuclear facility or radioactive materials. The CNSC's role in an emergency is to monitor and evaluate the actions while providing technical advice to federal and provincial response authorities. The CNSC will also inform government and the public regarding its assessment of the situation. Any event involving the loss or damage of nuclear material or the threat of theft, smuggling, vandalism, or terrorist activity involving nuclear material, is reportable to the CNSC.

5.1.4 Incident Support

In addition to the CNSC, Transport Canada operates the Canadian Transport Emergency Centre (CANUTEC) [20] is a national advisory service that helps emergency responders handle dangerous goods emergencies on a 24/7 basis. Staff include bilingual scientists in chemistry or related fields and are trained emergency response. CANUTEC's emergency response advisors provide immediate advice on actions to take and to avoid during a dangerous goods emergency.

5.2 Transportation Command Centre (TCC)

The purpose of the Transportation Command Centre (TCC) is to act as a centralised point of contact for the carrier to coordinate normal transport conditions, as well as accident or incident conditions during a transport. The role of the TCC is to stand up and coordinate response at a tactical level, liaising with all relevant response organizations. The TCC should have attendance from, or communications links to, involved multi-agencies (e.g., carrier, response force, emergency services, consignor, consignee etc.).

5.3 Transport Security

Transport security requires a bespoke approach to that of a licensed nuclear facility. Section 5 of the NSR [4] sets the requirements to obtain a license to transport Category I, II or III nuclear material within Canada and is aligned to international security recommendations and conventions communicated by the IAEA. Part B of REGDOC-2.12.3: Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material [21] provides information and guidance on how to comply with the security measures for transport of nuclear material, as set out within the NSR.

5.3.1 Escorts

For security escort arrangements, REGDOC-2.12.3 [21] states that any transport of Category II material "should be accompanied by one or more escorts". Security escorts are required to maintain constant surveillance of the cargo by travelling in either an accompanying vehicle or in the cargo carrying vehicle. Security escorts will also typically hold secure communications links to the relevant response forces along the planned route and the TCC.

5.3.2 Transportation Security Plans

The NSR details that any application for a license to transport Category I, II or III nuclear material in Canada shall contain (in addition to the requirements set out within the PTNSR), a written Transportation Security Plan (TSP) including:

- Name, quantity, radiation levels and physical and chemical characteristics of the material in transport
- Suitable threat assessment
- Conveyance description
- Proposed security arrangements for the transport
- Communications arrangements for the transport
- Response force arrangements
- The planned route
- Any alternate / contingency routing arrangements

The TSP is a key operational document that is securely passed to the necessary parties prior to any transport operation taking place. Periodic exercising of arrangements established within transportation security plans is also a common requirement for carriers of nuclear material.

6 Human Performance Approach – NTS Rail

The following section outlines NTS' approach to human performance for rail operations. Some elements of human performance are cross cutting and practices identified herein (competency management and recruitment) can be applied to wider nuclear transport operations (i.e., different modes of transport or various radioactive material transport programs); however, all details are derived from the operational activity of Direct Rail Services (DRS), the rail organization operated by NTS.

6.1 Human Performance Program

6.1.1 Competency Management

Traincrew

A qualified train driver will undergo a planned competency assessment cycle that details at least two practical (or locomotive) download assessments for each specific competency within a 2-year cycle, as discussed within **Section 4.2**. At the end of each 2-year cycle, the driver will re-sit their railway rules exam and must pass this exam and all assessments to maintain their driving competency. This process is formally documented and recorded in a Competency Management System (CMS), which is subject to annual internal and external assurance audits. The CMS system also maintains accurate train driver route and traction competency records.

If a driver is involved in an incident and is deemed to have development requirements following the incident investigation, they may be placed on a formal Competency Development Plan (CDP). The CDP will detail several additional measures to support the required development, such as an increased number of assessments in the 2-year period, a particular focus on non-technical skills or refreshing a route. These plans are formally documented, reviewed, and signed off as complete when the driver successfully completes them.

Engineering Staff

NTS has an internal engineering training manager who delivers training using a network of approved suppliers to train engineers on various aspects of rail vehicle asset maintenance. It is a minimum requirement that any full-time engineer has a certified, recognized qualification in a mechanical or electrical engineering discipline and has gained experience using these skills in a real-world environment before being assessed as competent on DRS rail vehicles. Initial assessments are carried out using a mix of on-the-job show-and-tell evidence and classroom-based examinations.

NTS engineering teams have certified assessors who maintain a continual check on continued competencies. Competencies are assessed based on a schedule or where there is a reason to call into doubt an engineer's competence through an observed error. At the point of re-assessment, the engineer must be able to demonstrate continued competence to an approved assessor, where they must provide evidence of work carried out over the previous 24 months and by way of a further practical assessment if deemed necessary.

Anyone failing to meet the competency requirements will no longer be able to carry out duties on the asset in question.

6.1.2 Traincrew Recruitment

Traincrew recruitment is considered a multi-level process. Typically, Traincrew can be recruited through the following mechanisms:

1) New entrants to the industry
2) Qualified drivers from another train operating company
3) Existing employees progressing from non-driving positions.

To be considered for a driving position, an individual must successfully pass several industry-standard psychometric tests, attend a panel interview, pass an industry-standard medical examination, and obtain the necessary level of security clearance.

7 Key Management Aspects – NTS Rail

The following section outlines NTS's management approach for rail operations. Some of the management methods are cross cutting and practices identified herein can be applied to wider nuclear transport operations (i.e., different modes of transport or various radioactive material transport programs); however, all details are derived from the operational activity of Direct Rail Services (DRS), the rail organization operated by NTS.

7.1 Organization

While legal responsibilities are assigned to roles within the organization, NTS's experience is that the most effective way to manage safety is to enable the transport operations and engineering teams to take ownership and accountability for transportation safety. It is important to recognize this accountability in organizational design to ensure there is a sufficiently skilled and trained resource to effectively carry out all the work associated with the safety of rail transport operations.

Notably, the most effective approach to safety management (across all levels of the business) is delivered when the operational division that is assigned ownership and responsibility has the tools, capability and resources required to execute their work. For large and complex organizations, a Responsible, Accountable, Consulted, Informed (RACI) matrix for key tasks can be implemented. Ensuring these elements are clearly defined, and the necessary training, equipment, and resources are in place to support those identified as responsible and accountable will enhance the safety capability of the organization.

Delivering training and safety engagement takes considerable time and resources, both in terms of those delivering and those being trained. Therefore, the organization must recognize the time required and plan its resource levels and rosters accordingly, so these key activities can occur with regularity and timeliness.

7.2 Risk Management

A robust risk management plan underpins the approach to safely transporting nuclear material. The purpose of such a system ensures continued safe operations, while maintaining public confidence in the ability to conduct such transports.

At NTS, internal monitoring is conducted against three key areas:

1. Proactive inspections
2. Internal audit and assurance plan
3. Incident investigation data

Each element of findings, whether positive, minor, or major non-conformances, are assigned an immediate and root cause criterion. The latest information is then transposed into the risk bowtie to support the status of controls and actions as a red, amber, or green format representing the status of the actions (red: incomplete, amber: ongoing and green: complete).

In managing strategic transport risk, NTS utilizes a risk "bowtie" methodology. The risk bowtie method is a visual representation of the impacts of a hazard, the risk it represents, the associated conceivable consequences and the controls that should be put in place.

This process must be closely aligned with the overall business risk appetite while drawing upon all influencing areas across the organization to populate the template and develop a suitable risk profile properly. A template of the NTS Strategic Risk for derailment can be found in **Appendix E.** Risk bowties are periodically visited and revised to ensure that actions and controls are being captured and risks appropriately managed. This is overseen by the risk owners and fed into the relevant governance levels throughout the business.

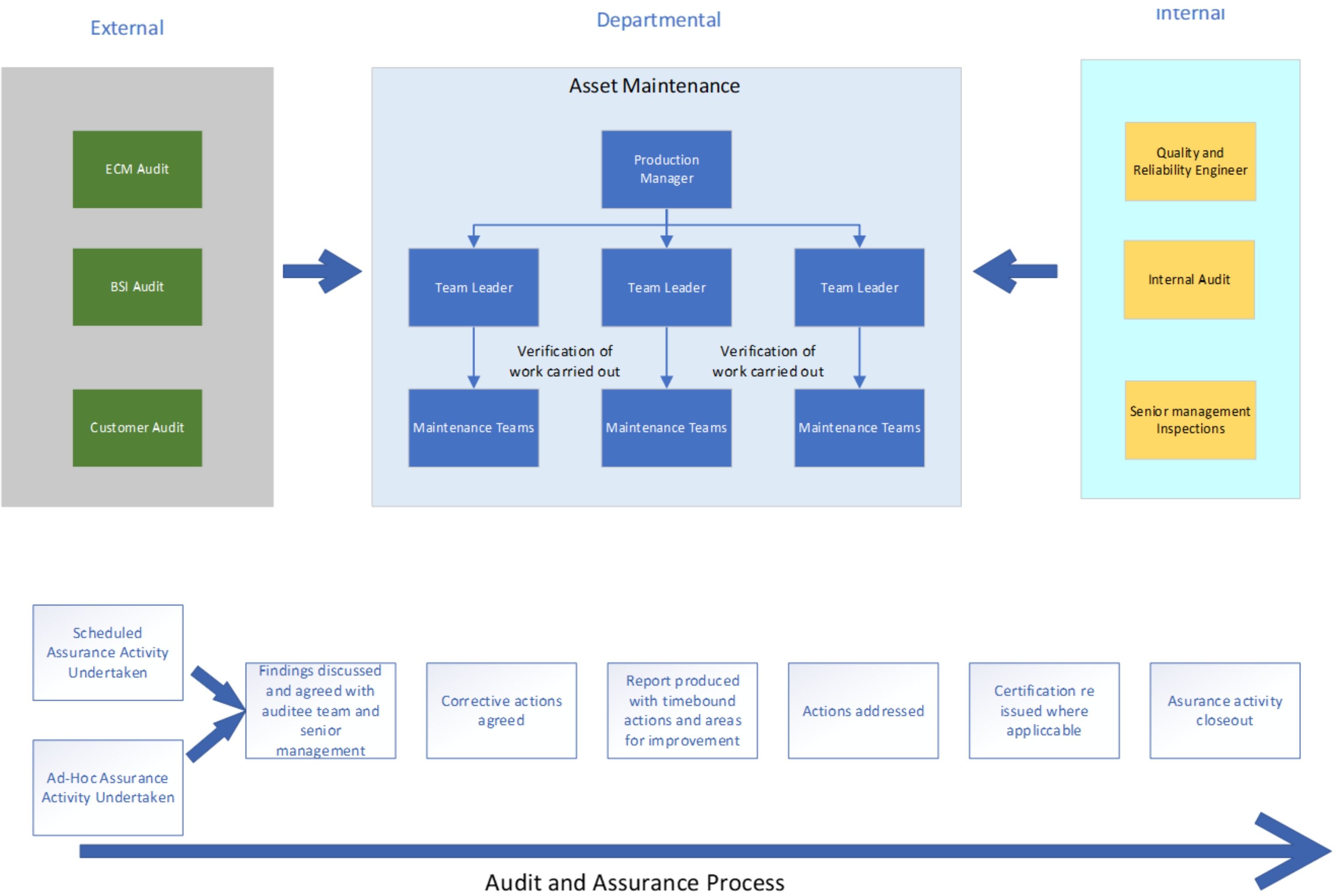
7.3 Performance Management in Engineering Maintenance

The purpose of assurance in engineering maintenance is to ensure that maintenance activities are performed consistently and that the equipment or systems being maintained remain safe, reliable, and available. Assurance is an essential part of maintenance management, as it provides a systematic and proactive approach to identifying potential issues and risks and ensures that appropriate measures are taken to mitigate them. Assurance in engineering maintenance involves a range of activities, including:

- Compliance with regulatory requirements and industry standards.
- Implementation of best practices and procedures for maintenance activities.
- Use of appropriate tools and technologies to support maintenance activities.
- Training and development of maintenance personnel.
- Monitoring and measurement of maintenance performance.
- Continuous improvement of maintenance processes and systems.

Figure 7**,** provides a visual overview of these activities conducted within NTS.

Figure 7 Audit and assurance process



Assurance activities can be categorized under three levels; External, Internal and Departmental, all of which can be both planned and ad hoc. Planned audits are scheduled on a recurring basis. Typically, these are annually for Internal and External and daily for departmental-level checks and verifications. Ad hoc audits usually arise from a concern raised, and this may be an incorrect procedure being followed, a concerning trend or a result of another investigation (failure of asset, accident/incident).

7.3.1 External Audits

External assurance activities are carried out by organizations with no direct link to the delivery of maintenance, providing an independent review of activities undertaken by the maintenance teams.

Entities in Charge of Maintenance (ECM) Audit - Annual audits by an approved ECM certification body to ensure that NTS is meeting their requirements under the ECM regulations in the delivery of maintenance of assets. This audit looks at all aspects of engineering and, with regards to maintenance, will focus on key areas such as competence management, management of calibrated tooling, use of the asset management system and critical component tracking.

The British Standards Institution (BSI) Audit – NTS holds certification against various International Organization for Standardization (ISO) to which the BSI conduct periodic audits against to verify alignment or certification and provide confidence to our stakeholders and customers. These ISO standards include elements such as business continuity, health and safety and management systems.

Customer Audit - NTS maintains leased assets and assets operated by other rail operators. Leasing companies and customers conduct annual audits on NTS and their maintenance practices, including competence, Measurement and Test Equipment (M&TE) to ensure that NTS maintain the defined standards.

7.3.2 Internal Audits

Internal assurance is defined as assurance activities carried out by anyone within the organization or parent organization but not within the department or function carrying out the maintenance work.

Quality and Reliability Engineer - The engineer audits the work carried out by the maintenance team, with a focus on fleet reliability. This work can lead to discussions about the competence of engineers, trends in faults or component failures, proposals for improvement in working practices, proposals for modifications to the fleet and suggested training requirements for anyone involved in asset reliability or safety.

Internal Audit - Internal audit teams are independent of the maintenance department. The teams provide an independent review and assess a wide range of maintenance-related activities from procurement and storage of components and materials, inspections of lifting equipment, the validity of risk and Controlled Substances Hazardous to Health (COSHH) assessments and to ensure proper procedures are followed. Any findings from these audits are escalated to senior management, and remedies are implemented as appropriate.

Senior Management Inspections - Regular senior management inspections are carried out throughout the year. On average these will occur monthly at each maintenance location. The senior management visits focus on traditional health and safety issues, such as housekeeping, working at heights, use of Personal Protective Equipment (PPE), first aid & fire arrangements, provision of spill kits and management of COSHH substances.

7.3.3 Departmental Assurance

Within each maintenance location, there is a hierarchy of engineers, team leaders and production managers. When engineers carry out work, this is captured and signed off within an asset management system.

The work is then peer-reviewed by a team leader or production manager before release.

On occasion, a team leader or production manager will carry out physical checks of the work performed to ensure it meets an acceptable standard and to ensure that the individual has complied with the instructions given when carrying out the work. Any issues noted at any point throughout the process will lead to additional vehicle checks being made and performance discussions being held with individuals.

7.4 Personnel and Operational Safety Interface

7.4.1 Hazard Reporting

The drive to the most positive, consistent safety culture is underpinned by the highest levels of hazard reporting, in which potential incidents or actual hazards are being identified, reported, and actioned by colleagues throughout the business.

The ability to identify at-risk behaviours and near misses through a hazard reporting system enables the business to understand, in greater detail and at a greater pace, key trends and issues that can be addressed before they become incidents of increasing severity.

The feedback and action tracking associated with a successful system is key to ensuring timely, informed decisions, with actions being implemented to eliminate the risk. In addition, positive feedback loops are essential in encouraging greater reporting so that colleagues are fully aware that their reports add value to the safety of the business.

7.4.2 Safety Observations

Using unannounced safety observations can provide vital information about the levels of safety performance and culture in the business. Setting the management team with clear targets to perform such observations with defined tasks and locations to observe gathers a unique level of data on the reality of the safety performance within the business. Announced observations are also a useful tool to ensure consistent safety performance while not increasing the stress on staff that may be associated with unannounced observations.

7.4.3 Safety Engagement

Safety Leadership Tours

Conducting a programme of safety leadership tours from the Executive team and wider teams throughout the organization helps to drive a positive safety culture throughout the organization.

Tours should be documented, with any observations being built into the established hazard reporting system to ensure one central location for all safety improvement opportunities. These tours take place across various locations with the focus being to demonstrate the levels of safety in place at each respective site, ensuring that the importance of safety is fully embedded throughout all levels of the organization. Tours are typically hosted by local site staff and include representatives from leadership across the organization.

Learning Briefs

Incident learning briefs are also an effective tool for safety-focused engagement. The purpose of this briefing format is to capture the pertinent learning from any safety event or incident, to raise the level of safety awareness to the relevant teams. These briefs should be developed and issued after every safety event or incident to ensure that awareness, lessons learned, and actions are clearly communicated to all relevant teams.

Safety Briefs

Driver safety briefs held on a quarterly basis are also an excellent vehicle for safety engagement, where group discussion and ideas sharing are proven to enhance the overall approach to safety and safety performance. Safety briefs will typically last for several hours, and drivers will not be rostered to other work on the day. A regular format would include:

- Safety performance update
- Incident review – key learnings
- Rule book and standards updates
- Seasonal safety theme
- Safety hot focus topic
- Desktop/practical exercise
- Open discussion

As an example, NTS delivers over 700 safety briefs annually to ensure each driver receives 4 briefings per year. While this is a time-intensive task, these are very positively received, and when a workforce is often relatively solitary with drivers starting at a variety of times, the ability to bring a number together for collective learning and discussion is effective. Increasing additional safety briefs per annum in 2022-23 has contributed to the reduction in operational safety incidents year on year from 32 in 2021-22 to 11 incidents in 2022-23 at NTS.

7.5 Supplier and Contract Management

7.5.1 Procurement of Safety Critical Components

NTS categorizes all suppliers to afford the appropriate selection and assurance practices. The 5 supplier categories used by NTS are:

- Safety Critical Service
- Safety Critical Product
- Business Essential
- Construction and Maintenance Services
- General

Safety Critical Service - A service which can import risk on the UK mainline railway. Examples could include the procurement of track, structures, rail vehicles, component, systems, telecommunications, signalling equipment, modifications, maintenance services, other engineering activities, hire of labour, consultancy, and technical advice.

Some illustrative examples of key activities NTS classifies as 'Safety Critical Services' are as follows (note: this list is not exhaustive):

- Vehicle Overhauls
- Vehicle Exams
- Technical Consultancy
- Wheelset Overhauls
- Vehicle Lease
- Vehicle Procurement
- Bearing Overhauls
- Brake Equipment Overhauls
- Labourers
- Vehicle Modifications
- Vehicle Repairs

Safety Critical Product - Safety-critical products are defined as any product capable of importing risk to controlled rail infrastructure (such as procurement of track, rail vehicles, locomotive and wagon components, e.g., brake equipment, window wiper systems, wheelsets, TPWS equipment, brake blocks, lighting etc.). Examples of products NTS defines as safety critical are as follows (note: this list is not exhaustive):

- Brake Components
- Brake Equipment (distributer, valves etc.)
- Brake Blocks
- Vehicle Windows
- Vehicle Window Wipers
- Wheelsets (all components – pans, tyres, centres, axle, axle boxes, suspension tubes)
- Bearings (axle box, suspension tube)
- Hoses (flexible)
- Vehicle Safety Systems e.g., TPWS, AWS, Global System for Mobile Communications – Railway (GSM-R), European Train Control System (ECTS)

Business Essential - Business essential products are defined by NTS as any product or service where there are limited technical alternatives available or for which very few commercially attractive alternative suppliers are known and whose products/services are essential for business continuity. Business essential examples are as follows (note: this list is not exhaustive):

- Occupational Health Services
- Plant Hire
- Fuel Suppliers
- Cleaning Services
- Security Services
- Consultancy/Training Services

Construction and Maintenance Services - Any product or service which is procured to support general maintenance and development of NTS building infrastructure (including Construction Design and Management (CDM) duty holders) is considered as construction and maintenance services. Examples are as follows (note: this list is not exhaustive):

- Principal Contractor
- General builders work
- Gas
- Plumbing
- Civil Engineering Works
- Electrical
- Air conditioning
- Joinery Works
- Window Cleaning

General - Any product or service which is procured to support general business activity and is considered of low risk to business practices ongoing. NTS examples are as follows (note: this list is not exhaustive):

- PPE
- Lease vehicle providers
- Laundry Services
- Consumables (fasteners and fixings)
- Stationary
- Water bottle suppliers

7.5.2 Tracking of Safety Critical Components

Tracking of safety-critical components is done by serial number, using dedicated asset management software. Each component is registered against an asset when fitted and then tracked on the asset until removed through fault, recall or scheduled expiry date.

Key safety critical components to be tracked include:

- Axles (serial number, date of manufacture and last non-destructive ultrasonic test date)
- Axle Bearings (serial number, date of manufacture, date fitted to axles, date of last overhaul)
- Air Brake Distributors (serial number, date of manufacture or fitment and expiry date)
- Air Brake Hoses (serial number and expiry date tracked)
- AWS & TPWS Components (serial number and expiry date)

The purpose of tracking these components is to ensure no asset is in service with components operating outside their safe designed parameters.

8 Conclusion

This report identifies potential mitigating measures that can be implemented in the NWMO used fuel transportation program to reduce the likelihood of transportation accidents, with consideration to the types of modes and conveyances being considered by NWMO.

This report drew upon the conclusions found within NWMO Transportation Collision Data Analysis Report [1] to identify potential mitigation measures associated with a collision with a fixed or non-fixed object for road operations, and derailment for rail operations.

Transport operations in conventional commercial trucking in Canada are not subject to the additional stringent requirements in place for nuclear transport operations. As such, the experience of NTS and STS has been leveraged to provide insight into mitigating functions of an operational nuclear transport organization.

- **Section 3** provides insight into road-specific operational practices that should be considered to reduce the likelihood of transportation collisions with fixed or non-fixed objects.
- **Section 4** has highlighted the rail-specific operational mitigations that can be associated with a collision leading to derailment. While some inclusions are cross-cutting (i.e., applicable to both road and rail), the different challenges associated with each mode of transport should be noted, as this influences the differing approaches from the carrier organization.

Driver training and competency are highlighted across both road and rail operations as a fundamental element of collision mitigation, and this is true for transport risks beyond those identified within the initial work packages. Significant time and cost should be afforded to properly develop drivers to be suitably qualified for nuclear transport operations.

Vehicle maintenance and inspection for both road and rail vehicles is also a crucial element, with the different approaches for each mode detailed within this report. Establishing engineering and operational functions that can suitably carry out these crucial activities is also fundamental to mitigating transport collisions.

Similarly, route planning is an important element of the planning phase of any nuclear transport operation. The factors associated with road transport are not completely aligned with those in rail transport. However, the broad approach is similar in nature.

Organizational measures that underpin the operational undertaking of the company have also been discussed. The risk appetite of the organization should be communicated through thorough risk management processes and ultimately influence how transport operations are conducted.

Monitoring performance and auditing at multiple levels ensure that the organization's safety remains to a high standard and follows established best practices. One such measure is an incident response capability for either safety or security response arrangements. Although discussed at a high level, it is important to note that wider arrangements and considerations exist in this area to conduct transport operations safely and securely.

The submission of this report is intended to provide insight into important elements associated with transportation collision mitigation for a nuclear transport programme, drawing upon decades of operational experience to do so. These mitigation measures ensure continued safe operations vital to the nuclear fuel cycle, and this report intends to provide information to support those operations.

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Appendix A – NTS Rail Vehicles and Capabilities

NTS operates several bespoke nuclear rail assets. Each asset is designed for a specific purpose; to abide by all rail standards and meet any necessary nuclear package transport approvals. The following information outlines the three key nuclear rail assets operated and maintained by NTS.

FNA-D

The FNA-D was designed and built in 2014 as a replacement for the former (now expired) FNA wagon. It is restricted in use and is certified to convey used nuclear fuel in flasks on the UK rail network. It is also restricted to travel at a maximum speed of 95 km/h in empty and laden conditions. NTS operates and maintains a fleet of forty (40) FNA-D wagons on the UK rail infrastructure.

KUA

The KUA is designed to carry nuclear fuel for the UK Ministry of Defence (MOD). The wagon operates at a maximum of 95 km/h and has a double bogie design at each end of the vehicle to enable the gross laden weight of 149 T (tonnes) to be shared across 8 axles. NTS operates and maintains two (2) of these vehicles.

KXA-C

The KXA-C is designed to carry nuclear fuel in various specified flasks for onward international shipment by vessel. The wagon operates at a maximum of 95 km/h and has a double bogie design at each end of the vehicle to enable the maximum gross laden weight of 180 T load to be shared across 8 axles. NTS operates and maintains six (6) of these vehicles.

Appendix B – NTS Rail Maintenance Task and Periodicity

Event	Periodicity
Planned Preventative Maintenance (PPM)	6 monthly
Vehicle Inspection and Brake Test (VIBT)	12 monthly
OVERHAUL A	8 Yearly
OVERHAUL B	16 Yearly

Job No	Task	PPM	VIBT	Overhaul A	Overhaul B
B*01	Air Brake Equipment Inspect	X	X	X	X
BB01	Examine Brake Blocks	X	X	X	X
BH01	Bogie Mounted Handbrake Inspect	X	X	X	X
BM01	Bogie Brake Rigging Inspect	X	X		
BM02	Bogie Brake Rigging Gauge			X	X
BZ01	PPM Air Brake Test	X			
BZ02	VIBT Air Brake Test		X	X	X
BX01	Brake Equipment Overhaul A			X	
BX02	Brake Equipment Overhaul B				X
C*01	Bodywork & Canopy Examine	X	X	X	X
CN01	Signs & Markings	X	X	X	X
U*01	Underframe Inspect	X	X	X	X
UA01	Axleboxes / Cartridge Bearings Inspect	X	X	X	X
UB01	Buffers Inspect	X	X	X	X
UC01	Drawbar / Drawgear Inspect	X	X		
UC02	Drawbar / Drawgear Gauge			X	X
UC03	Coupling Inspect	X			
UC04	Coupling Gauge		X	X	X
UF01	Bogies Inspect	X	X		
UF02	Bogies Dismantle & Inspect			X	X
UN01	Wheelset Ultrasonic Axle Test		X	X	X
UW01	Wheels & Axles Inspect	X	X	X	X

Appendix C – Route Risk Assessment Sellafield to Carlisle

From:		**Route Reference**	**Route Assessment Date**
To:			
Assessed by		**Issue Number:**	

Hazard/Risk		**Location & Detail**
A	Signals which have been the subject of multiple Signal Passed at Danger (SPAD) incidents, particularly where the potential consequences of a SPAD are severe, including the reasons why the signals have been passed at danger.	
B	Signal gantries with a history of SPADs or there is potential to misread signals intended for adjacent lines (reading across).	
C	Signals beyond the signal immediately applicable to the movement which become visible to drivers before, or with similar intensity to, the applicable signal (reading).	.
D	Signals that are known to be affected by bright sunlight at times of the day or year (both main and shunting signals).	
E	Signals which are positioned on the right-hand side of the running line in the direction of travel and considered a risk (both main and shunting signals).	
F	Locations where braking distances between signals are inconsistent.	
G	Locations where the signal aspect sequence changes from four to three aspects.	
H	Start and finish points of bi-directional working.	
I	Stations where the signal is not in view from the station stopping point, with potential for starting against the signal at danger.	
J	Stations where the normal stopping point is adjacent to the signal with potential for starting against the signal at danger.	
K	Risks associated with trains not stopping at designated stopping points within a station platform.	

Hazard/Risk		Location & Detail
L	Potential distractions on approach to a signal, such as a neutral section.	
M	Locations or routes with a mixture of colour light and semaphore signalling.	
N	Locations or routes not fitted with Automatic Warning System (AWS), including termination and commencement points of AWS and AWS gaps.	
O	Low adhesion due to seasonal factors (including weather and leaf fall).	
P	Possibility of unexpected low adhesion conditions at level crossings and the consequential risk of wheel slide, particularly where hazards are located beyond the crossing (for example, high risk signals or stations with permissive working or bay platforms).	
Q	The effects of driving over the route in darkness compared with driving during the daytime.	
R	Lighting on platforms, in tunnels or adjacent streets which may affect the identification of braking points and sighting of signals.	
S	Locations that may cause distraction, such as depots and yards.	
T	Locations where bi-directional, reversible or multi track lines do not run parallel to each other.	
U	Locations where there is a significant reduction in line speed.	
V	Gradients that have the potential to affect safe train operations.	
W	Communication black spots.	
X	Complex signalling or track layouts.	
Y	Frequency Staff will work over a route once completed.	
Z	Locations that are fitted with overhead line equipment and the limits of electric traction movements.	

Appendix D – Incident Response - Roles and Responsibilities

The following roles are typical to an incident management structure. Generic responsibilities are also described below.

Role	Responsibilities
Executive	Ensure that the incident management structure conforms to the requirements of any internal processes and measures the performance.
Director responsible for incident management arrangements	Has the overall responsibility for the performance of the incident management structure to support company resilience arrangements
Senior manager responsible for incident management arrangements	To lead, develop and embed resilience arrangements, inclusive of emergency preparedness and response, crisis management and business continuity in line with its business, customer, and regulatory requirements. To carry out verification of the competency management system for the incident management structure.
Senior manager responsible for learning and development	To engage with the senior manager responsible for incident management arrangements to ensure that all competency-based training needs are addressed, and any training requests are validated and budgeted.
Manager responsible for documenting incident management arrangements	Responsible for delivering an effective and holistic major incident plan inclusive of all transport requirements, including the management of relevant plans and processes, including maintenance, reviewing and ongoing testing through exercising with partners. Ensures that all transport operations are fully compliant with requirements stipulated within relevant national and international legislation and regulatory frameworks.
Business Continuity Manager	To lead the creation, training, exercising, reviewing, and assessing business continuity processes/plans.
Resilience Officer	Supports the Resilience Team by supporting the delivery of an effective, timely and holistic corporate incident management and business continuity management provision inclusive of all business requirements.
Strategic Commander (Strategic/Gold)	To provide strategic leadership and set the strategic aim and objectives by considering the following: • Political factors • Economic or financial factors • Social factors • Technical factors

Role	Responsibilities
	• Environmental factors • Ethical factors • Legal or regulatory factors • Organizational factors • Safety • Security • Recovery
Tactical Commander (Tactical/Silver)	To invoke resilience arrangements and coordinate/manage the organizational response to a transport-related incident.
Operational Commander (Operational/Bronze)	To respond to resilience arrangements and coordinate operational resources to support the overall incident and provide engineering and operational, technical advice where needed. To act as the operational lead at the scene of a transport-related incident and manage the operational response for the organisation. This means acting as a liaison with the emergency services and the business to ensure an effective response and support function.
Duty Media Officer	To ascertain key media requirements and work with internal and external parties to provide media, communications and reputational management expertise, advice, and release media information/statements.
Duty Security and Resilience Advisor	To provide security and resilience advice and guidance and liaise/provide relevant information to key parties.
Licensing Advisor	To provide information and advice on transport packages and regulations.
Incident Support Officer	To support and assist the incident management structure in logging key decisions and actions and providing general support throughout the incident response.

Appendix E – NTS Strategic Risk Template – Derailment

NTS Strategic Risk Dashboard

Classification	OFFICIAL
Strategic Objective	All - cross cutting
Business Line	Rail
Executive Owner	Claire Peers
Risk Manager	Craig Hutchison
Handling Strategy	
Control Rating	
Driving Impact	
Last Update	

RISK DESCRIPTION

Major safety or environmental incident caused by Rail operations resulting in a derailment on the mainline network causing multiple fatalities, significant media coverage, legal action or loss of business. The cause of the incident as a result of deficiencies in maintenance, operational controls or infrastructure failures

Early Warning Indicators (EWIs)

LINKED TO (Cause/Conseq. & No) / DESCRIPTION			Trend	CURRENT
Cause		Performance - leading & lagging indicators	Increasing	High 10
Cause		Culture surveys, employee engagement	unquantified	High 15
Cause		Internal & external audit findings	unchanged	High 5
Cause		Lessons learned - external incidents & internal	unchanged	High 15
Cause		Assurance reviews	unchanged	High 10
Cause		Organisation change	unchanged	High 10

Impact:	1 Very Unlikely <5%	2 Unlikely 6-20%	3 Possible 21-50%	4 Likely 51-79%	5 Almost Certain >80%
5 Critical	High 5	High 10	High 15	Extreme 20	Extreme 25
4 Severe	Moderate 4	Moderate 8	High 12	Extreme 16	Extreme 20
3 Major	Low 3	Moderate 6	Moderate 9	High 12	High 15
2 Moderate	Very Low 2	Low 4	Moderate 6	Moderate 8	High 10
1 Marginal	Very Low 1	Very Low 2	Low 3	Low 4	Moderate 5

Likelihood

Key Causes

	Causes – Description	Linked Controls
1	Failure of NTS maintenance	1, 2, 3, 6
2	Failure of 3rd Party Maintenance	1, 4
3	Trespassers or vandalism	5, 8, 9, 10
4	Defective track	5, 9, 10
5	Weather conditions	3, 5
6	Line blockage or previous incident	3, 5
7	Collision with a stationary object on the track	3, 5, 9, 10
8	Human error from drivers or fitters	3, 6, 7
9	Human error from signalers or others working on track	3, 5
10		
11		
12		
13		
14		

Risk Impact Category	Rating	Risk Appetite
Safety	High 10	Approaching
Environmental	High 10	Approaching
Legal	High 10	Approaching
Reputation	High 10	Approaching
Delivery	High 10	Approaching
Security	High 5	Well Within
Financial : DRS	High 10	Approaching
Financial : INS	Low 1	Well Within

Key Impacts

	Consequences – Description	Linked Controls
1	Multiple fatality event	1 to 10
2	loss of containment of cargo or fuel	1 to 10
3	damage to infrastructure	1 to 10
4	loss of rolling stock	1 to 10
5	inability to provide a customer service or line blockage preventing others delivering a service	1 to 10
6	regulator involvement	1 to 10
7	legal action	1 to 10
8		
9		
10		
11		
12		
13		
14		

Overall Risk Summary

Rail operations on the network are where the significant HSE risks are likely to occur associated with operations. Industry forums, license's to operate and some industry best practice are all in place across NTS. However incidents within NTS or its supply chain have occurred in the last 3 years which were precursors to a significant event Whilst processes are in place to minimize and mitigate these risks they can not be eliminated.

VH = Very High
H = High
M = Medium
L = Low

Existing Control: Causes					Improvement Actions							
No	Description	Owner	Opinion	Basis on Opinion	No.	Description	Owner	Priority	Date: Baseline	Date: Revised	% Complete	Status
1	Vehicle design and manufacture standards including inspection and testing with authorization to operate on UK network	Engineering		External Audit								
2	Maximo maintenance plans in place and Prom 018, P0313, PROM053	Engineering		External Audit		Improvement to Maximo System as part of the modernisation programme Improved ECM internal audits as part of the IAP		High	8.03.24		20	On Track
3	Competence Management Procedures P0418, PROM044, PROM029	Operations		External Audit		Improvements to CMS as part of the modernization programmed Improved CMS internal audits as part of the IAP		High	8.03.24		25	On Track
4	Supplier and 3rd Party management procedures including acceptance, engagement, inspections, audits and LFE	Commercial & Operations		Internal Audit		Improved supplier approval process as part of commercial transformation programmed Contract Managers and CMP in place as part of commercial transformation programmed Improved inspections and audits of the	CMS & KL	Very High	8.03.24		20	On Track
5	NWR engagement via communications, meetings and infrastructure inspections	Operations & H&S		Self-Assessment								
6	In process checks in engineering and operations pre and post departure or event	Engineering & Operations		External Audit		Compliance managers as part of the modernization programmed	OS & RB	Medium	9.09.24		10	On Track
7	Work planning, medicals and fatigue management	Operations & HR		Self-Assessn		Workplan controls and processes being improved as part of modernization	OS	Medium	8.03.24			On Track
8	SSOW in place such as CSMW & RA	Engineering &		Internal Aud		Full review and oversight of the assessments in place required - action to be addressed	OS	Medium				
9	Security assessments for our locations & Industry work on tresspass reduction	Engineering &		External Aud		Security improvement plan in place	TB, RB, OS	Medium	8.03.24			On Track
10	Transport security assessments	Security		External Aud								

Existing Control: Impacts					Improvement Actions							
No	Description	Owner	Opinion	Basis on Opinion	No.	Description	Owner	Priority	Date: Baseline	Date: Revised	% Complete	Status
1	Close call reporting P0302 & P0701	OS		Self-Assessment		Improve reporting and action culture in Rail - plan to be developed	JN	Medium				
2	Emergency Response P0422, P0944, PROM065, PROM047	Security		Self Assessment								
3	On call arrangements PROM093, PROM065	Security		Self-Assessment								
4	Gotcha data, HABD information from NWR and industry on events	HSEQ				Improve the oversight of the industry data - plan to be developed	CP	Medium				
5	Investigation processes to identify root cause and set suitable actions to prevent reoccurrence	HSEQ										
6	Return to service checks P0704, P032	Engineering		Self-Assessment								
7												
8												
9												
10												