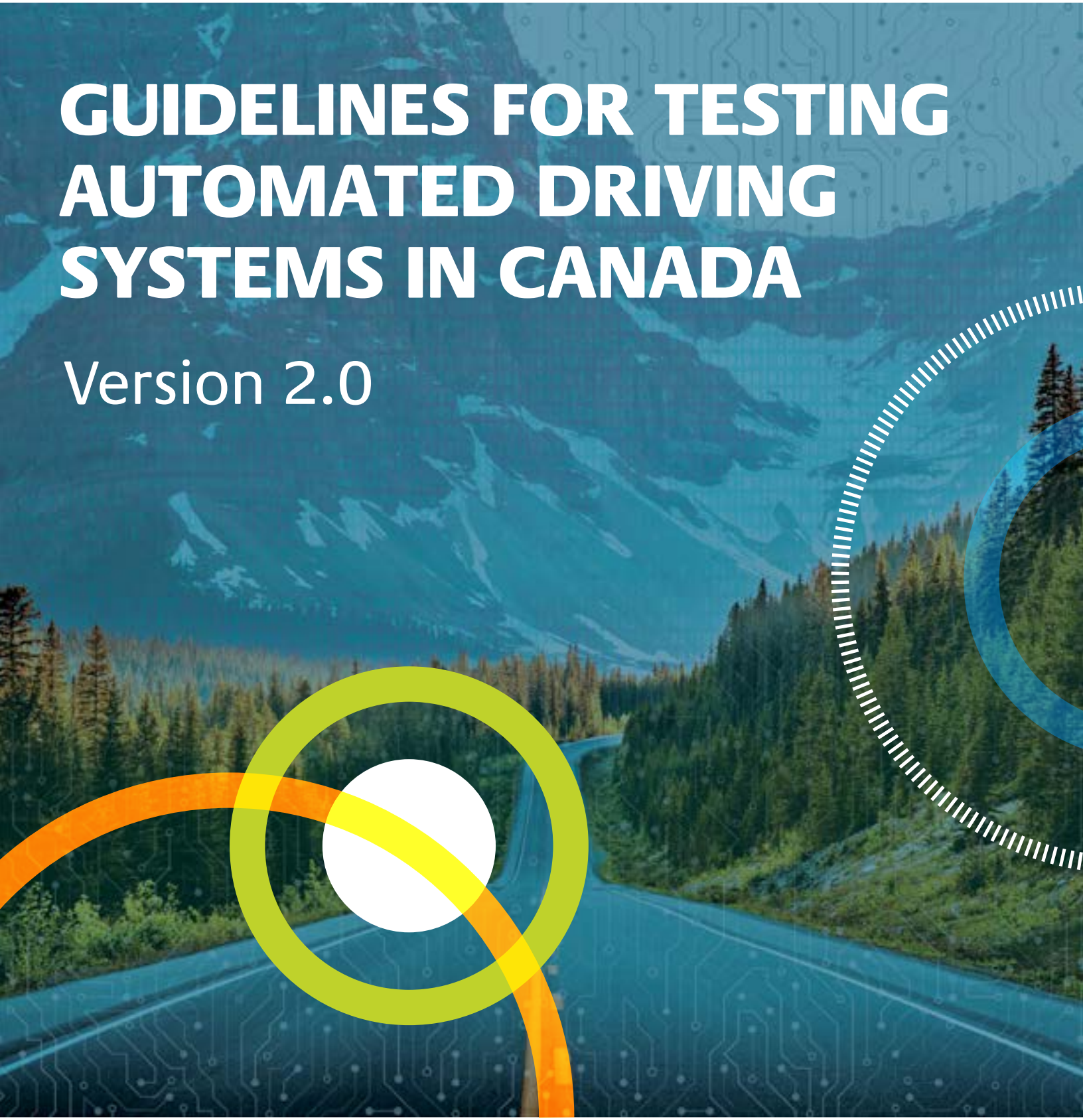
Transport Canada Transports Canada

GUIDELINES FOR TESTING AUTOMATED DRIVING SYSTEMS IN CANADA

Version 2.0



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MESSAGE FROM THE MINISTER OF TRANSPORT

It is my great pleasure to introduce *Guidelines for Testing Automated Driving Systems in Canada Version 2.0*. This document replaces Transport Canada's earlier document, *Testing Highly Automated Vehicles in Canada: Guidelines for Trial Organizations*, published in 2018. These updated guidelines incorporate new best practices and technical standards that have been developed by the international community as testing of automated driving systems continues to expand around the world, including within Canada.

Motor vehicles continue to play a vital role in the lives of Canadians by connecting communities, businesses and families across one of the world's largest roadway networks.

Today, with the introduction of automated vehicles, we are witnessing a pivotal shift in motor vehicle technology that will transform many aspects of Canadian life. Automated vehicles have the potential to improve the efficiency of Canada's transportation system, as well as increase mobility choices, offer environmental benefits and create new economic opportunities for Canadians.

Most importantly, these vehicles hold the promise of safer roads for Canadians. In 2018, 1,922 people lost their lives in motor vehicle collisions in Canada. It is our goal that automated vehicles, in time, and in concert with other safety measures, will help us to drastically reduce this number.

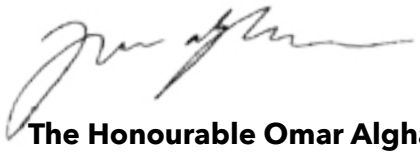
Public confidence in these new vehicle technologies will be key to their successful adoption. Trials conducted to date in Canada have provided an opportunity for many Canadians to see this technology operate first-hand. For us to enjoy the benefits of automated vehicles, we will need to continue to test them on our roadways, in our communities, and in our diverse Canadian climates.

As testing activities continue to grow in Canada, close collaboration will be required between all orders of government, automated vehicle developers, road safety stakeholders and international partners to ensure Canada can maximize the potential safety benefits of these vehicle technologies, while also promoting innovation.

These guidelines will help to ensure that trials are conducted in a safe and secure manner, according to a baseline of nationally consistent safety practices. This document further clarifies the roles and responsibilities of each order of government in facilitating these tests, and will serve to promote Canada as a leading destination for research and development of automated vehicles.

As automated driving systems continue to evolve, Transport Canada will continue to update this document, as well as its other guidance and tools to support the ongoing safety of Canadian road users.

I would like to thank the member jurisdictions of the Canadian Council of Motor Transport Administrators, and the many stakeholders that were involved in the development of these guidelines. In keeping with our Transportation 2030 strategic plan, the Government of Canada will continue to work with key partners to ensure Canadian road users benefit from this transformative technology in the years to come.



The Honourable Omar Alghabra, P.C., M.P.
Minister of Transport

INTRODUCTION

The development of automated vehicle technologies shows great potential to enhance the safety, mobility and productivity of Canadians.

In order to achieve the many positive outcomes promised by these technologies, it is essential that all orders of government, industry, and Canada's diverse road safety stakeholders work together to ensure that automated vehicles are safe for use in Canada. This process necessarily involves testing new technologies in the various real-world environments and conditions that may be encountered across Canada.

Guidelines for Testing Automated Driving Systems in Canada: Version 2.0 (referred to hereafter as the Testing Guidelines) establishes a baseline of nationally consistent best practices to direct the safe conduct of trials involving vehicles equipped with automated driving systems (ADS).[1] These guidelines were developed in consultation with provincial and territorial representatives of the Canadian Council for Motor Transport Administrators (CCMTA).

Version 2.0 of the Testing Guidelines replaces the previous version of this document published by Transport Canada in 2018. Updates have been made to safety practices based on lessons learned from domestic and international testing activities. Additional guidance is provided on assessing the safety of test vehicles, route selection, safety drivers and remote operations, and passenger safety, among others. An annex with best practices specific to testing automated shuttles has also been added.

Other changes include updated information pertaining to the Government of Canada's administrative procedures for importing test vehicles such as amendments to the *Motor Vehicle Safety Act* (MVSA) and the *Motor Vehicle Safety Regulations* (MVSR). Additional information is also provided on duties and taxes on imported vehicles, compliance with technical standards and licensing requirements for wireless technologies, and engagement with first responders and law enforcement.

Version 2.0 of the Testing Guidelines also takes into account other guidance issued by Transport Canada since 2018 including *Canada's Safety Framework for Automated and Connected Vehicles*, the *Safety Assessment for Automated Driving Systems in Canada*, *Canada's Vehicle Cyber Security Guidance*, and the *Canadian Jurisdictional Guidelines for the Safe Testing and Deployment of Vehicles Equipped with Automated Driving Systems* published by the Canadian Council of Motor Transportation Administrators (CCMTA), as well as guidance and other publications issued by various ADS developers.

1 The term Automated Driving System is used specifically to describe a level 3, 4, or 5 driving automation system. See full definition in the Definitions section. An overview of the levels of driving automation can be found on the Levels of Driving Automation infographic at the end of the document.

PURPOSE

This document seeks to clarify for trial organizations the various roles and responsibilities of federal, provincial and territorial, as well as municipal governments in approving and facilitating trials of ADS-equipped vehicles. These guidelines also establish safety best practices that trial organizations should follow when conducting research and development testing of ADS-equipped vehicles in Canada.[2]

Provincial and territorial jurisdictions remain responsible for approving requests from trial organizations, based on their respective laws and regulations, and building upon these best practices as they deem necessary. Provinces and territories are encouraged to consult the *Canadian Jurisdictional Guidelines for the Safe Testing and Deployment of Vehicles Equipped with Automated Driving Systems* (*referred to hereafter as the* CCMTA Jurisdictional Guidelines), in conjunction with this document, to inform the development of their testing and deployment policies and regulations.

SCOPE OF THE GUIDELINES

The Testing Guidelines apply to any organization that is conducting research and development trials of ADS-equipped vehicles[3] in Canada (SAE levels 3 - 5). These guidelines are intended to apply to temporary trials of ADS-equipped vehicles, not their permanent market deployment – the requirements for which will be developed by federal, provincial, and territorial jurisdictions as ADS equipped vehicles continue to mature and evolve (see definitions of "deployment" and "testing" in the *Other Terms section* respectively). For additional information on how Transport Canada is adapting its safety regime to support the longer-term deployment of new vehicle technologies, please refer to *Canada's Safety Framework for Connected and Automated Vehicles*.

This document primarily focuses on operational safety practices for on-road testing. However, Transport Canada recognizes that safety and security considerations (including cyber security considerations) are closely intertwined and apply to the entire vehicle technology life cycle (i.e. both product research and development as well as deployment phases). As such, it is very important that trial organizations assess cyber security risks associated with the test vehicle, as well as supporting physical and digital infrastructure. In May 2020, Transport Canada published *Canada's Vehicle Cyber Security Guidance* (Cyber Guidance), which provides a set of technology-neutral guiding principles to support industry in strengthening cyber security throughout the vehicle lifecycle and, where appropriate, in the supporting vehicle infrastructure. Trial organizations are strongly encouraged to consult the Cyber Guidance and Canada's Vehicle Cyber Security Assessment Tool (VCAT) to assess the cyber security performance and resilience of their vehicles and vehicle components, as well as relevant international standards and best practices outlined in Annex C.[4] In close collaboration with stakeholders, Transport Canada continues to develop a suite of non-regulatory tools to help stakeholders manage cyber security risks in vehicles and the enabling road transportation system. Trial organizations should regularly consult Transport Canada's website for relevant updates.

2 In the case of a discrepancy between these Guidelines and any applicable federal, provincial or territorial laws, the laws will prevail.

3 These guidelines may apply to all on-road motor vehicle types. However, it is at the discretion of the provinces and territories to determine what types of vehicles may be tested in their jurisdictions.

4 The level of cyber security risk may vary depending on a number of factors including (but not limited to): the location and duration of the trial, the number of vehicles being tested, and the public profile of the testing activities (e.g. if the trial includes carrying members of the public on board as passengers etc.).

STRUCTURE OF THE DOCUMENT

This document contains four chapters that focus on government approval processes as well as safety issues trial organization should consider before, during and after trial activities.

> The first chapter describes the approvals trial organizations are required to seek from various government entities prior to conducting testing.

> Chapter two explores pre-trial safety considerations including: assessing the safety of the test vehicle, route selection/operating environment, the establishment of safety management strategies, the use of safety drivers, public communication and awareness and engagement with first responders and law enforcement.

> Chapter three covers safety considerations that should be managed throughout the trial, including: applying a graduated approach to testing, adapting safety management strategies, incident and emergency response, safety driver responsibilities during testing, the safe management of remote operations, conducting trials without a safety driver present, safe interactions with other road users, trials with passengers and regular reporting and information sharing.

> Finally, the fourth chapter includes brief recommendations on final reporting as well as information on exporting, destroying, or donating test vehicles following the completion of trials.

> A summary of the trial guideline recommendations as well as definitions for terms used throughout the document can be found at the end of chapter four.

> There are also appendices at the end of the document that include recommended best practices specific to automated shuttle testing, a contact list of provincial transportation authorities, and an inventory of international standards resources.

CHAPTER 1: ENGAGEMENT WITH GOVERNMENT AGENCIES

The first chapter of this document details the responsibilities of each level of government in Canada and the approvals trial organizations must seek prior to conducting testing. In Canada, road safety is a shared responsibility between federal, provincial and territorial governments. Transport Canada, under the *Motor Vehicle Safety Act* (MVSA), establishes safety regulations for the manufacture and importation of motor vehicles, as well as designated motor vehicle equipment, and the shipment of newly manufactured vehicles and equipment across provincial and territorial boundaries. The objective of these regulations is to reduce the risk of death, injury, and damage to property and the environment.

Provinces and territories are responsible for the licensing of drivers, vehicle registration and insurance, as well as laws and regulations regarding vehicle maintenance and the safe operation of vehicles on public roads. As such, provinces and territories are also responsible for approving and overseeing trials of automated vehicles that take place within their jurisdiction.

Within provinces and territories, municipal governments, to varying degrees, are responsible for: the enactment and enforcement of by-laws concerning vehicle movement; the use of local infrastructure; and, the provision of public transportation in their respective jurisdictions. Trial organizations are encouraged to engage municipal authorities, in conjunction with the relevant provincial and territorial road transportation agency, to ensure local traffic and infrastructure considerations are addressed.

Notwithstanding these distinct roles and responsibilities, all levels of government are encouraged to work together to share information and to foster learning among each other and with trial organizations, to facilitate the safe testing and eventual deployment of these technologies on Canadian roads. Transport Canada will continue to work with trial organizations and other jurisdictions to support these learning opportunities and collaborations moving forward.

1.1 TRIAL ORGANIZATION'S RESPONSIBILITIES

The responsibility for ensuring the safe and orderly conduct of trials rests with the trial organization. Trial organizations must comply with all federal, provincial and territorial laws and regulations that apply to their testing activities, and maintain awareness of any changes to these laws and regulations.

In the event that a province or territory chooses to impose additional or separate requirements from those outlined in these guidelines, the requirements imposed by that jurisdiction will prevail and must be followed by the trial organization. Contact information for each provincial and territorial jurisdiction is provided in Annex B.

A table outlining responsibilities of each order of government can be found in table 1. A simplified checklist of key steps that trial organizations should follow when seeking to obtain authorization to conduct a trial in Canada can be found in table 2.

1.2 FEDERAL GOVERNMENT DEPARTMENTS

This section provides an overview of federal requirements that may apply when testing ADS equipped vehicles in Canada.

1.2.1 TRANSPORT CANADA

Transport Canada's overarching approach to automated vehicle safety is outlined in *Canada's Safety Framework for Connected and Automated Vehicles*. The pages that follow provide greater detail on federal requirements trial organizations must follow when seeking to test ADS equipped vehicles in Canada. Additional information on Canada's approach to automated vehicle safety can be found at: canada.ca/automatedvehicles. Questions or other inquiries can also be sent to: tc.avcv-vcva.tc@tc.gc.ca

The overarching legislation that outlines Transport Canada's authorities, as well as safety obligations of companies and manufacturers is the *Motor Vehicle Safety Act* (MVSA). The MVSA was amended in 2018 to strengthen the Minister of Transport's enforcement and compliance authorities and afford greater flexibility to keep pace with emerging technologies in the automotive industry, including emerging automated vehicle technologies.

Under the MVSA, Transport Canada establishes safety regulations that apply to the importation of motor vehicles and designated motor vehicle equipment, and the shipment of newly manufactured motor vehicles and designated equipment across provincial and territorial boundaries. Standards included within the regulations are primarily performance-based, rather than design-based, and set out a minimum threshold level of safety to reduce the risk of death, injury and damage to property and the environment.

TRANSPORT CANADA IMPORTATION REQUIREMENTS

Trial Organizations seeking to import a vehicle into Canada should refer to Transport Canada's Importing a Vehicle webpage for information on requirements that may apply to their specific situation.

It should be noted that Section 7(1)(a) of the MVSA allows persons or companies to temporarily import a vehicle that does not comply with the *Canada Motor Vehicle Safety Standards* (CMVSS) requirements (and/or other obligations outlined in Section 5 and 6 of the MVSA), if the vehicle will be used for certain special purposes, including: exhibition, demonstration, evaluation or testing. Temporary importation can occur for a period up to one year or longer, as authorized.

Prior to temporarily importing a vehicle for testing, Canadian trial organizations must address the requirements of Section 11.3(1) of the *Motor Vehicle Safety Regulations* (MVSR) by completing and submitting to Transport Canada, a Declaration of Vehicles Imported Temporarily for Special Purposes (herein referred to as the Declaration) via the Temporary Vehicle Importation System Online Application.

If the information provided in the Declaration is accurate and complete, the temporary importation of the non-compliant vehicle will be permitted on a case-by-case basis for the purpose stated by the applicant. Transport Canada officials may pose additional questions to the applicant to validate that a program has been established for the stated purpose of the temporary importation (e.g. evidence of a test plan, etc.). When the Declaration expires, the temporarily imported vehicle must either be exported from the country or destroyed. In some cases, a vehicle imported temporarily for special purposes may be donated to a public museum or an educational institution, provided that the recipient ensures that the vehicle will not be driven or drawn on public roads as per the requirements of Section 11.4 of the MVSR.

Organizations that are already operating in Canada under an active Declaration who wish to continue testing must contact Transport Canada to discuss options prior to the expiry date of their Declaration.

For questions related to temporarily importing a test vehicle, trial organizations can contact Transport Canada:

> by telephone: 1-800-333-0371 (toll-free); 1-613-998-8616 (outside North America) or

> by email: TVIS-SITV@tc.gc.ca

CONDUCTING INTERPROVINCIAL TRIALS

The MVSA prohibits a company from shipping from one province to another, or delivering to any person for the purpose of being so shipped, any vehicle of a prescribed class manufactured in Canada unless it has a national safety mark (NSM) applied to it.

Section 5.1 of the MVSR provides a means for a vehicle manufactured in Canada that does not have a NSM applied to it to be shipped from one province to another for the purpose of exhibition, demonstration, and evaluation or testing. A declaration must be filed with the Minister and must include prescribed information outlined in subsection 5.1(2) of the regulation, including whether and when the vehicle will be returned to the province of origin or destroyed after the trial/demonstration.

1.2.2 CANADIAN TRANSPORTATION AGENCY

The Canadian Transportation Agency (CTA) is an independent, quasi-judicial tribunal and regulator. Its mandate is to protect the fundamental human rights of persons with disabilities to accessible transportation services. The *Canadian Transportation Act* (CTA) provides the Agency with powers to protect and advance the fundamental right of persons with disabilities to an accessible federal transportation network.

The Accessible Transportation for Persons with Disabilities Regulations (ATPDR) falls under the jurisdiction of the Agency and came into effect on July 25, 2020. The ATPDR provides a set of clear, consistent, specific and legally binding accessibility requirements for many transportation service providers. The ATPDR applies to large carriers and terminals in modes of transport under federal jurisdiction.[5] Trial organizations should consult these regulations if they are planning a trial to determine whether their services would fall within the scope of the regulations.[6] The CTA also creates other regulations, codes of practice and guidelines for accessibility. Trial organizations may wish to consult these resources when conducting a trial. The CTA has a number of resources, including a series of guides related to accessible transportation, which explain the obligations of transportation service providers and the rights of persons with disabilities. These resources can be found here.

1.2.3 INNOVATION SCIENCE AND ECONOMIC DEVELOPMENT CANADA (ISED)

ISED is responsible for setting and enforcing compliance with technical standards and licensing requirements related to wireless technologies integrated in vehicles and roadside infrastructure. These standards and licensing requirements are set to minimize harmful interference to radio communication services and to ensure that Canadians are not overexposed to radiofrequency fields from wireless technologies. ISED has various requirements that a trial organization must adhere to when using wireless communication technology to facilitate testing.

If a trial organization is conducting tests that incorporate the use of wireless technologies to test connectivity capabilities with other vehicles and infrastructure, the trial organization must ensure that their activities comply with all certification and licensing requirements, including procedures administered by ISED. For more information, please visit ISED's Developmental License Playbook as well as The Internet of Things Toolkit for Small and Medium Businesses.

5 Please note that the CTA will have guidance material for small Transportation Service Providers before the end of 2021. This guidance will serve a base for the development of regulations in 2022.

6 The ATPDR applies to bus services that travel between 2+ provinces and from Canada to the US.

Trial organizations are also encouraged to notify the relevant provincial and territorial authorities of trials involving connected vehicle technologies to determine if any additional approvals may be required (e.g. for installation of sensors on local infrastructure).

1.2.4 OFFICE OF THE PRIVACY COMMISSIONER OF CANADA

Oversight responsibilities for federal privacy legislation fall under the Office of the Privacy Commissioner. Currently, the Personal Information Protection and Electronic Documents Act (PIPEDA)[7] governs how private sector organizations collect, use and disclose personal information during the course of commercial activities in Canada. The PIPEDA provides a framework with both robust privacy protections and the flexibility to support businesses' legitimate needs to access personal information.[8]

1.2.5 CANADA BORDER SERVICES AGENCY (CBSA)

CBSA is responsible for facilitating the flow of legitimate travellers and trade including the collection of duties and taxes on all goods entering Canada, even those imported temporarily. If an ADS equipped vehicle is imported from another country, it is subject to applicable duties and taxes (including the goods and services tax/harmonized sales tax (GST/HST)) on its full value. If the vehicle is considered to be cargo and not a conveyance (i.e., the vehicle is not bringing passengers across the border) it may be eligible for customs duty and GST/HST relief under tariff item No. 9993.00.00 depending on the circumstances of the importation. Vehicles imported temporarily under tariff item No. 9993.00.00 may remain in Canada for a maximum of up to 18 months, as indicated on Form E29B.

If the vehicle or vehicle components are written off during or after testing, any remains must be exported or destroyed under CBSA supervision. The officer certifying the destruction will complete a Form E15. Otherwise, the CBSA will consider the goods to have been permanently imported and they will be subject to full customs duties and taxes, including the GST/HST, and any other government department requirements as at the time of importation.[9]

For additional information please contact the CBSA Business Information Service:

- Calls within Canada (Toll-free): 1-800-461-9999
- Calls outside Canada (Long distance charges apply): 1-204-983-3500 and 1-506-636-5064
- TTY within Canada: 1-866-335-3237

1.3 PROVINCIAL AND TERRITORIAL GOVERNMENTS

Provincial and territorial road safety administrators are responsible for the licensing of drivers, vehicle registration and insurance, vehicle and equipment maintenance as well as laws and regulations regarding the safe operation of vehicles on public roads. Some provinces and territories may have accessibility legislation or standards that trial organizations may need to consider if they will be carrying passengers.

Provinces and territories are also responsible for approving and overseeing trials of ADS equipped vehicles that take place within their jurisdiction. Transport Canada remains available to provide assistance to trial organizations and/or provincial and territorial road safety administrators, in particular, to share best practices and information on strategies to manage safety that have been used in other contexts.

7 Currently, the provinces of Alberta, British Columbia, and Quebec have enacted "substantially similar" laws to PIPEDA. In many circumstances, the provincial law applies instead of the federal law. Trial organizations should consult the privacy legislation enacted in these jurisdictions in addition to PIPEDA. It is possible that more than one privacy law could apply to an organization. When more than one law applies, organizations must comply with both.

8 To note: at the time of the publication of this guidance document efforts are underway by the Parliament of Canada to consider new privacy legislation. Trial organizations are encouraged to consult www.priv.gc.ca for up to date information on privacy legislation in Canada.

9 To note: the importation forms referenced above may be subject to change.

Prior to conducting testing, a trial organization must ensure that it has obtained the appropriate authorizations from the province or territory where the tests will be conducted, as applicable, including any required permits/approvals/authorizations, or other requirements that may be specified by the jurisdiction as part of their trial approval processes. It is important that trial organizations interested in testing ADS equipped vehicles on public roads engage with provincial and territorial road safety administrators early in the trial planning process. In some cases, authorizations may require additional consultations with, and/or approvals from the municipalities involved.

Unless otherwise specified by the province or territory, trial organizations must ensure that they comply with all applicable legislation such as existing vehicle registration, driver licensing, insurance requirements and road safety rules established by the jurisdiction in which the trial takes place. Trial organizations must ensure that they have adequate liability insurance, in the form and manner required by the provincial or territorial authority and based on the level of risk and the type of testing being conducted.

Jurisdictions should also include provisions for suspension or revocation of any permit to test on public roads if trial organizations violate permit conditions as part of the application processes. They may also impose penalties should the trial organization continue to operate or test in violation of the suspension or revocation order. Trial organizations will be held responsible for violations of existing traffic laws subject to existing legal processes.

Questions pertaining to provincial and territorial requirements for conducting trials can be directed to the contacts listed in Annex B.

1.4 MUNICIPALITIES

Constitutionally, municipal governments in Canada fall under the authority of provinces and territories. Nevertheless, in many jurisdictions municipalities exercise responsibility over some aspects of local transportation. Some of these responsibilities include:

> enacting and enforcing bylaws for local roadways and parking;

> the use of local infrastructure;

> enforcing traffic laws and regulations;

> advocating for and accommodating testing of new vehicle technologies;

> adapting infrastructure; and

> managing passenger transportation (including public transit and taxis).

Trial organizations are strongly encouraged to engage municipal authorities including local traffic engineers, in conjunction with the relevant provincial and territorial road transport agency, to ensure local traffic and infrastructure considerations are addressed and that local law enforcement and emergency response personnel are appropriately informed of testing activities.

Local engagement is important to ensure that trials are conducted with the needs of local residents in mind. Residents should be made aware of whether test vehicles will operate in spaces occupied by other road users. Consultations with local transit agencies, community organizations, and residents can help shape trial planning and ensure that strategies to manage safety reflect local contexts. As recommended in the CCMTA Jurisdictional Guidelines, municipal governments should be engaged throughout ADS testing activities.

TABLE 1: SUMMARY OF FEDERAL, PROVINCIAL AND TERRITORIAL, AND MUNICIPAL RESPONSIBILITIES

FEDERAL RESPONSIBILITIES[10]

Transport Canada:

- Regulating and enforcing compliance with safety standards for manufactured and imported vehicles (including the import of trial vehicles) as well as motor vehicle equipment (tires and child car seats)
- Investigating and managing the recall and remedy of non-compliances and safety-related motor vehicle defects
- Motor vehicle safety research
- Public education on motor vehicle safety issues

Canadian Transportation Agency:

- Regulating and enforcing accessibility requirements for all modes of federally-regulated transportation (including bus carriers that provide a service for the transportation of passengers between two or more provinces and from a point of origin in Canada to a point of destination in a foreign country)

Innovation, Science and Economic Development Canada (ISED):

- Regulating and enforcing compliance with technical standards and licensing requirements related to wireless technologies integrated in vehicles and roadside infrastructure (for trials involving the testing of connected vehicle technology)

Office of the Privacy Commissioner of Canada:

- Enforcing federal private sector privacy law, which provides rules for how organizations may collect, use, and disclose personal information in commercial activities

Canada Border Services Agency (CBSA)

- Administering legislation that governs the admissibility of people and goods, plants and animals into and out of Canada
- Collecting applicable duties and taxes on imported goods
- Interdicting illegal goods entering or leaving the country

PROVINCIAL/ TERRITORIAL RESPONSIBILITIES

- Approving on-road testing of ADS equipped vehicles
- Driver Licensing
- Vehicle Registration
- Enacting and enforcing traffic laws and regulations (including trials)
- Conducting safety inspections
- Regulating motor vehicle insurance and liability
- Public education on motor vehicle safety issues
- Adapting infrastructure to support CAV deployment
- Enacting and enforcing accessibility legislation and regulations for provincially/ territorially regulated public transportation and other mobility services
- Some provinces (BC, AB, QC) have private sector privacy laws that supersede the federal privacy law in respect of commercial activities within a province

MUNICIPAL RESPONSIBILITIES[11]

- Enacting and enforcing by-laws
- Enforcing traffic laws and regulations
- Advocating for and accommodating testing
- Adapting infrastructure to support CAV deployment
- Managing passenger transportation (including public transit and taxi cabs)
- Parking
- Traffic management and
- Public education on motor vehicle safety issues

10 These are the principle federal authorities relating to road safety. Other laws and regulations outside of this scope may apply to trial vehicles, depending on the technologies and equipment incorporated. Trial organizations are responsible for determining which laws apply to their specific vehicles.

11 Authorities in these areas may vary depending on the size of the municipality and the powers accorded to it by the provincial or territorial government. Trial organizations should consult with the provincial/territorial road transport agency to determine what municipal approvals may be required.

TABLE 2: PATHWAY TO APPROVAL – A CHECKLIST FOR TRIAL/TESTING APPLICANTS

This checklist captures key steps a trial organization should take to seek approvals to conduct testing of automated driving systems in Canada.[12] Please refer to Annex B for federal, provincial, and territorial authorities' contact information.

#1. CONTACT TRANSPORT CANADA TO START THE AUTHORIZATION PROCESS[13]

Transport Canada officials will:

> arrange a meeting with the applicant to discuss testing plans (i.e. vehicle technology, trial proposal)
> provide the applicant with additional information/updates on safety considerations that may not be captured in this document
> provide information on potential funding and research partnership opportunities that the applicant could access to support testing

#2. CONTACT PROVINCIAL/TERRITORIAL GOVERNMENT(S)

Provincial/territorial authorities will provide the applicant with the required authorization and specific information regarding their jurisdiction's application process and any safety conditions that may apply, as well as obligations for licensing and registration, insurance and other requirements as applicable

#3. ENGAGE WITH LOCAL AUTHORITIES AND FIRST RESPONDERS AS REQUIRED BY PROVINCIAL/TERRITORIAL AUTHORITIES

Trial organizations can request the contact details of local authorities from the province/territory in which testing is occurring

#4. PUBLISH A VOLUNTARY SAFETY ASSESSMENT OR SUBMIT A VOLUNTARY SAFETY ASSESSMENT REPORT TO TRANSPORT CANADA AND THE PROVINCIAL/TERRITORIAL GOVERNMENT (SEE SECTION 2.1 FOR FURTHER INFORMATION)

Transport Canada officials and/or Provincial/Territorial officials may follow up with the applicant to discuss specific safety requirements

Trial organizations are strongly encouraged to make a version of their safety assessment available to the public to promote public education and awareness

#5. PREPARE AND SUBMIT (AS REQUIRED) A SAFETY MANAGEMENT PLAN TO THE AUTHORIZING PROVINCIAL/TERRITORIAL GOVERNMENT (SEE SECTION 2.3 FOR FURTHER INFORMATION).

Safety Management Plan requirements may vary depending on the jurisdiction in which testing is occurring and the type of testing being conducted. A province/territory may request amendments or apply conditions on testing after reviewing the safety management plan

Some jurisdictions may require additional documentation, such as a signed declaration confirming that particular safety requirements have been met or previous testing has been conducted

#6. OBTAIN ALL NECESSARY APPROVALS FROM THE AUTHORIZING PROVINCIAL/TERRITORIAL GOVERNMENT(S) TO CONDUCT TESTING IN THEIR JURISDICTION(S)

Provincial and territorial jurisdictions remain responsible for approving requests from trial organizations, based on their respective laws and regulations, and building upon these best practices as they deem necessary

#7. ENSURE ALL TRANSPORT CANADA REQUIREMENTS ARE FOLLOWED WHEN IMPORTING A TEST VEHICLE INTO CANADA OR WHEN PLANNING TO CONDUCT AN INTERPROVINCIAL TRIAL (SEE SECTION 1.2.1 FOR FURTHER INFORMATION)

Trial Organizations seeking to import a vehicle into Canada should refer to Transport Canada's Importing a Vehicle webpage for information on requirements that may apply to their specific situation

#8. CONTACT CANADA BORDER SERVICE AGENCY (CBSA) TO VERIFY IF ANY DUTIES OR TAXES MUST BE PAID WHEN IMPORTING A TEST VEHICLE INTO CANADA. SEE SECTION 1.2.5 FOR FURTHER INFORMATION

CBSA is responsible for facilitating the flow of legitimate travellers and trade including the collection of duties and taxes on all goods entering Canada, even those imported temporarily

#9. ENSURE COMPLIANCE WITH ALL LICENSING REQUIREMENTS ESTABLISHED BY INNOVATION SCIENCE AND ECONOMIC DEVELOPMENT CANADA (ISED) WHEN CONDUCTING TRIALS INVOLVING WIRELESS TECHNOLOGIES (SEE SECTION 1.2.3 FOR FURTHER INFORMATION)

Standards and licensing requirements as well as contact information for ISED regional offices can be found at: https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/home

12 This checklist is not exhaustive and is provided to aid a trial organization navigate the application process. It is the responsibility of the applicant to ensure understanding of, and compliance with, all relevant federal, provincial/territorial, and municipal laws.

13 The order of step #1 and step #2 may vary. If a trial organization is seeking to import a vehicle into Canada for testing purposes it is recommended that they contact Transport Canada first. Trial organizations should always seek to engage both levels of government to ensure compliance with relevant requirements.

CHAPTER 2: PRE-TRIAL CONSIDERATIONS

The second chapter of this document explores safety considerations that should be reviewed and considered prior to commencing testing. Topics addressed in this chapter include assessing the safety of the test vehicles, ensuring that appropriate test routes are chosen, development of safety management plans, the use of safety drivers, establishing public communication plans to inform members of the community and other road users of testing activities and ensuring that local law enforcement and emergency response personnel are appropriately informed about trial operations.

2.1 ASSESSING THE SAFETY OF THE TEST VEHICLE

Prior to commencing a trial on public roads in Canada, trial organizations should ensure that the safety of all test vehicles has been sufficiently validated through previous testing in a controlled environment (e.g. closed roads, parking lots, or test tracks), on-road in another jurisdiction, and/or through other validation mechanisms (i.e. computer simulations).[14] Tests should consider the various environmental, road, and traffic conditions that can reasonably be expected to be encountered within the geographical area and timeframe for the planned trial.

Trial organizations testing vehicles equipped with SAE level 3 to 5 ADS should review the safety of their test vehicles and develop safety assessment reports using the *Safety Assessment for Automated Driving Systems in Canada*.[15] The Safety Assessment tool provides a non-exhaustive list of factors for industry to consider as they review the safety and security of ADS equipped vehicles, focusing on considerations related to automation. Trial organizations are strongly encouraged to submit a safety assessment report to Transport Canada and the authorizing provincial or territorial jurisdiction, and are also encouraged to make a version of their report available to the public to promote public education and awareness.

The safety assessment report will define the capabilities and limitations of the test vehicle and should inform the identification of appropriate testing environments and safety management plans to be respected throughout the trial (see further discussion in Chapter 3).

14 TC encourages organizations to share results of previous testing or other methods that organizations have taken to validate the safety of their vehicle's ADS. For example, some organizations may wish to share reports that outline the results of previous trials in other jurisdictions.

15 Safety assessment reports should always be developed by the ADS developer. In instances where the trial organization is not the ADS developer, the trial organization should request a safety assessment report from the ADS developer.

The 13 safety outcomes for ADS equipped vehicles identified in Transport Canada's Safety Assessment tool are outlined in the Application Process Checklist below:

1 ADS LEVEL OF AUTOMATION AND INTENDED USE

The ADS features' level(s) of automation is/are clearly defined based on the levels of automation found in the SAE J3016 standard, as this will determine what behaviors are expected of drivers/users. Some vehicles may be capable of operating at different levels of automation in different modes.

2 OPERATIONAL DESIGN DOMAIN

The ADS(s) has/have a clearly defined Operational Design Domain (ODD). Domain constraints are known, and the vehicle will respond safely and predictably when the ODD is exceeded.

3 OBJECT EVENT DETECTION AND RESPONSE

The vehicle has object event detection and response (OEDR) capabilities adapted to its ODD that enable safe and appropriate actions to be taken when subjected to day-to-day traffic conditions, as well as unexpected events.

4 INTERNATIONAL STANDARDS AND BEST PRACTICES

Where they apply, and as much as possible, the vehicle and ADS comply with relevant standards and best practices, such as those developed by SAE International and the International Organization for Standardization (ISO).

5 TESTING AND VALIDATION

Safety risks were considered throughout the development of the vehicle and the ADS technologies. Sufficient pre-deployment testing has been conducted and validation methods have been employed to verify performance, safety of the intended functionality, occupant safety, and failure handlings. Validation and verification have been used to ensure safe integration and operation of the vehicle and ADS features in day-to-day traffic and in response to unexpected events and various weather conditions.

6 SAFETY SYSTEMS

The vehicle is equipped with safety systems with appropriate redundancies that continuously monitor system performance, perform fault detection, hazard analysis, signal any malfunctions, and ultimately take corrective actions or revert to a minimal risk condition when needed.

7 HUMAN-MACHINE INTERFACE AND ACCESSIBILITY OF CONTROLS

Vehicle controls are accessible to users (i.e. intuitive/easy to understand). The vehicle can communicate critical messages to passengers, taking into account relevant accessibility factors, needs of different occupants, and the intended use of the vehicle.

8 PUBLIC EDUCATION AND AWARENESS

Concrete actions have been taken to ensure awareness of the capabilities and limitations of the ADS features of the vehicle, as well as the vehicle's safe fallback conditions. Drivers/users are aware of what is expected of them in relation to the dynamic driving task under different conditions and of the vehicle and ADS features maintenance requirements. Drivers/users will be informed of any changes in these expectations that arise following a system update.

9 USER PROTECTIONS DURING COLLISIONS OR SYSTEM FAILURES

The vehicle is equipped with adequate active and passive safety features to protect occupants and other road users, and mitigate injuries and damages in the event of a collision or system failure. The vehicle will be brought to a safe state following a collision or system failure, and will convey safety critical information to passengers, first responders, and emergency services.

10 CYBER SECURITY

Adequate design and mitigation strategies have been developed to protect the ADS-equipped vehicle from cyber security threats. Programs, plans, and/or operating procedures have been established to manage cyber events. Consideration should also be given to how these events are communicated to other stakeholders, including government agencies, to prevent similar events in the future. Trial organizations should also consider additional cyber security best practices found within *Canada's Vehicle Cyber Security Guidance* and consult Canada's Vehicle Cyber Security Assessment Tool (VCAT), as well as other international standards and best practices.

11 SYSTEM UPDATES AND AFTER-MARKET REPAIRS/MODIFICATIONS

In the event of a system update or after-market repair or modification, measures are in place to verify all vehicle systems continue to operate safely, and as intended.

12 USER PRIVACY

Measures are put in place by the trial organizations to ensure that the privacy and protection of personal information collected, used, and disclosed is in accordance with the requirements under federal and provincial or territorial legislation.

13 COLLABORATION WITH GOVERNMENT AGENCIES AND LAW ENFORCEMENT

In the event of a collision or other incident, data collected by vehicles and their ADS features should be shared with federal, provincial or territorial, and municipal law enforcement and government agencies to support investigations, including defect and collision investigations.

2.2 ROUTE SELECTION/ OPERATING ENVIRONMENTS

It is critical that trial organizations select trial routes and/or operating environments that reflect the technical capabilities and limitations of test vehicles. It is always important to consider the ADS's operational design domain (ODD) and object and event detection and response (OEDR) capacities when selecting a route or operating environment. It is also important that trial organizations ensure that appropriate infrastructure is available and that any necessary modifications are made, if applicable, with the consent of the relevant jurisdiction (e.g. painting or repainting road markings, installing signage etc.). Roles and responsibilities for these modifications should be discussed and agreed upon with the municipality and/or province/territory. Trial organizations should also consider how testing will impact existing road users and the safe flow of traffic and discuss these issues with the relevant authorizing jurisdiction. Trial organizations should monitor the route or operating environment during testing for any changes that could affect safety (i.e. potholes, construction).

This section outlines safety considerations for two different types of testing environments. The testing environments described below are not exhaustive, but reflect many of the different types of trials that have been conducted in Canada to date.

2.2.1 RESTRICTED ACCESS ENVIRONMENTS

Restricted access environments are test routes where access by other vehicles is controlled. This could include dedicated test tracks, parking lots, and pathways through public parks or private campuses, or a dedicated lane separated from other traffic by a physical barrier (segregated lane), among others.

Testing in restricted access environments provides an opportunity for trial organizations to test various aspects of ADS in controlled conditions, including the vehicle's capabilities and limitations. Restricted access environments can limit interactions between the test vehicle and other vehicles, though it may still encounter other vehicles travelling at lower speeds (e.g. in parking lots or campuses) or other road users such as pedestrians and cyclists.

Restricted access environments may still present unique challenges and potential safety risks that should be considered during testing. This may include unique road types and conditions (e.g. road surfaces, steep road grades, etc.), unique objects that may be encountered on the route (e.g. wildlife), or road user behaviours that may be distinct to that particular operating environment. Existing infrastructure along the selected route should also be evaluated to ensure it is suitable for the testing activities. When evaluating a restricted environment test route, trial organizations may need to consider infrastructure modifications or other measures to address site-specific challenges based on an assessment by qualified professionals before conducting testing.

SEGREGATED LANES

As stated in the definition above, restricted access environments may include test routes on public roads if the test vehicle is operating in a designated lane, separated from other traffic by physical barriers that prevent interactions between the test vehicle and other vehicles. Segregated lanes can be a useful testing route, as they can be used to introduce complexity and a more dynamic environment for the ADS while still limiting direct interactions with other vehicles. When considering test routes with segregated lanes, trial organizations will have to ensure the chosen physical barriers are compatible with the ADS sensing systems and do not interfere with the vehicle's localization and OEDR capabilities.

Often, segregated lanes are integrated to the rest of the roadway at intersections where the test vehicle may encounter other road users and vehicles. Analysis should be conducted to ensure the ADS can operate safely through the intersection and that the route can accommodate all road users, including pedestrians and cyclists. Pre-trial testing should be conducted to ensure the ADS can safely react to vulnerable road users, including pedestrians and cyclists.

2.2.2 MIXED TRAFFIC

Mixed traffic test routes are those where the test vehicle is operated on public roads and fully integrated with existing traffic.[16]

For new types of test vehicles, mixed traffic environments pose the highest risks to safety because of the exposure to other traffic and road-users, including cyclists, pedestrians, and other vehicles. While in many cases, the test vehicle may be equipped with collision mitigation features (e.g. emergency braking), operating in mixed traffic presents the risk of being involved in a collision with other vehicles. Even if the ADS is operating optimally in mixed traffic, test vehicles are at risk of exposure to unsafe driving behaviours of other road users. As some test vehicles could have novel configurations and may not conform to the MVSR or CMVSS, their crashworthiness may be unproven.

The safety implications of mixed traffic test proposals must be thoroughly assessed and trial organizations should adopt appropriate risk management strategies to support safe operations in the selected environment.

2.3 DEVELOPING A SAFETY MANAGEMENT PLAN

Testing of ADS can vary significantly depending on the system's capabilities and the local environment where testing will take place. Each trial program will therefore present unique safety risks that will need to be appropriately managed. A safety management plan should be established and documented (e.g. in the form of standard operating procedures) based on a risk assessment of the testing environment, to ensure the safety of trial operations and consistent adherence by all trial participants.

The safety management plan should outline all necessary safety procedures for trial personnel to follow during the trial. This may include steps to follow at the start of a test (e.g. verifying that systems initiate properly, doing a vehicle walk-around, etc.), during vehicle operations (e.g. monitoring system performance, responding to display prompts, etc.), and at the end of the test (e.g. how to do a proper system shut down, any maintenance/cleaning requirements, data downloads, vehicle charging/fueling, etc.).

Safety management plans should also include procedures to ensure the roadworthiness of test vehicles throughout the trial. This may include procedures documenting routine maintenance (e.g. cleaning of sensors, etc.), system calibration, and hardware or software updates, among others, required to maintain safe operations. Trial organizations should ensure that software updates are only executed by the ADS developer or trusted actors, and that they are appropriately tested and validated prior to being deployed.

To note: some provinces and territories may require the preparation and submission of safety management plans as part of their approval process for a trial and may request amendments to the plan or apply conditions on testing activities based on this review. Some jurisdictions may also require trial organizations to provide a signed declaration confirming that particular safety requirements have been met (e.g. prior safety validation testing to confirm the ODD etc.).

Jurisdictions are encouraged to consult technical experts from Transport Canada as part of their review of safety management plans to promote collaboration and information sharing on these continuously evolving technologies.

16 For the purpose of this document, designated lanes that are not separated from other traffic by physical barriers are considered mixed-traffic environments because there is a risk that other vehicles may enter the lane and interact with the vehicle.

2.4 TRIALS WITH SAFETY DRIVERS

Trial organizations are responsible for ensuring that all safety drivers are properly trained and licensed to operate the ADS equipped vehicle. Safety drivers should be familiar with the vehicle's technology, understand the vehicle's ODD, including any operational constraints (such as adverse weather), and respect the host jurisdiction's rules of the road at all times. Safety drivers must also be informed of and observe any additional safety requirements imposed by the authorising jurisdiction. Prior to approving the trial, the provincial or territorial road safety administration may require trial organizations to provide records of driver training for verification. In some cases jurisdictions may also require background checks for safety drivers.

2.4.1 TRAINING

Trial organizations should ensure safety drivers receive appropriate training to operate the test vehicle safely throughout testing activities. Trial organizations may be required to provide the authorizing jurisdiction with an overview of the safety driver training program. Safety driver training should be developed by the ADS developer and reflect the state of development of the test vehicle, the type of vehicle being tested, and the operating environment.

Some ADS equipped vehicles feature new designs and control configurations. As a result, safety drivers should be trained to properly use these control systems. It is important that driver controls are intuitive and accessible to ensure the safe and comfortable operation of the vehicle, especially when an intervention from the safety driver is required.

Trial organizations should also consider industry best practices developed for trial personnel such as the following document published by the SAE International Automated Vehicle Safety Consortium (AVSC): *AVSC Best Practice for In-Vehicle Fallback Test Driver Selection, Training, and Oversight Procedures for Automated Vehicles under Test*.

2.5 PUBLIC COMMUNICATION AND AWARENESS

Depending on the type of testing being conducted, trial organizations may be directed by the provincial or territorial road transportation administration to develop a communications plan to inform the public and other road users of trials on public roads. Communication plans may include information on where testing will be conducted, the test vehicle's capabilities and limitations, as well as instructions on how other road users can expect to interact with the test vehicle throughout the trial. Information can be disseminated through various means such as social media, incorporating signs along the test route, holding community forums, etc.

In some instances, provincial and territorial road transportation agencies may choose to develop their own communication plans to notify the public of trials on public roads. Taking a proactive approach to public communication and awareness that promotes safe interactions with test vehicles may help to increase positive public perception and acceptance of trials involving ADS equipped vehicles and vehicle automation more broadly.

2.6 ENGAGING LOCAL FIRST RESPONDERS AND LAW ENFORCEMENT

First responders and law enforcement should be briefed on local trials to ensure that they are aware and prepared to respond to collisions or other incidences that may occur. Briefs should include specific information on how law enforcement and first responders can safely interact with the ADS equipped vehicle. Other information may include dates and locations of trial activities.

When responding to incidents involving ADS equipped vehicles, first responders may be required to take additional safety precautions depending on the type of vehicle being tested. It is important that law enforcement and first responders are aware of the operational characteristics of the ADS equipped vehicle being tested and be provided with the knowledge and tools necessary to safely manage a serious incident to reduce the risk of potential harms.

Hazards first responders may encounter when dealing with test vehicles may include, but are not be limited to: silent operation, self-initiated or remote ignition, high voltage, and unexpected movement. Furthermore, some tools used by first responders (e.g. hydraulic rescue tools) may not work effectively on all ADS equipped vehicles, depending on their components and build materials. Trial organizations should also consider industry best practices developed for interacting with first responders such as the following document published by AVSC: *AVSC Best Practice for First Responder Interactions with Fleet-Managed Automated Driving System-Dedicated Vehicles (ADS-DVs)*.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CHAPTER 3: TEST CONSIDERATIONS

This chapter presents safety issues that should be considered and revisited throughout the trial process. Topics discussed in this section focus on the application of a graduated approach to testing, adapting safety management strategies during trial operations, safety driver responsibilities, remote driving, and incident response plans. The final sections of this chapter explore additional safety factors to address when test plans include public participation as well as reporting and information sharing considerations.

3.1 APPLYING A GRADUATED APPROACH TO TESTING

As new vehicle technologies are developed, it is important that trial organizations adopt a graduated approach to testing. This refers to the gradual introduction of complexity and risk when testing an ADS. An illustrative example of this might include beginning testing in a restricted operating environment such as a closed track before moving to more complex environments and/or operations.

The graduated approach to testing allows trial organizations to safely assess the capabilities and limitations of their test vehicles/systems and make necessary adaptations as complexity and new risks are introduced. The use of the term *graduated approach* does not mean that the ADS permanently "graduates" from one testing method/stage to another. Rather, this term recognizes that ADS development is an iterative, cyclical process. For example, even if a trial organization has reached a point where they are testing on public roads, they may determine that it is useful and prudent in some cases to continue track or simulation testing to examine unforeseen edge cases[17] or other issues observed during on-road trials. In other cases, trial organizations may determine that it is appropriate to safely validate any system updates (for example, significant changes to automation capabilities) through track and or/simulation testing before returning to on-road trials.

3.2 ADAPTING SAFETY MANAGEMENT STRATEGIES DURING TRIAL OPERATIONS

Applying a graduated approach to testing can also provide an opportunity to review and modify the trial's safety management strategy in response to observations made during the different phases of testing. As the trial progresses, the trial organization may discover new risks and challenges that were not identified during the planning phases of the project. For example, the trial organization may discover unforeseen hazards, system performance challenges or note other important safety observations that were not considered during the initial development of the safety management plan.

17 An edge case is a rare situation that still requires specific design attention for it to be dealt with by the ADS in a reasonable and safe way. The quantification of "rare" is relative, and generally refers to situations or conditions that will occur often enough to pose a foreseeable safety risk during ADS operations. Edge cases may vary across different automated driving systems. Some illustrative examples of edge cases may include unique road signage or an unexpected animal type encountered on a roadway.

The trial organization should hold regular meetings with relevant personnel involved in testing activities to discuss any issues that have arisen during testing and develop new safety protocols as required. Regular information sharing among personnel is important when trials are conducted by multiple teams working on the same ADS. Trial personnel should be informed of any over-the-air updates performed to the vehicle's software. If a manufacturer changes the ODD or other aspects of the ADS, trial personnel should be informed and, where necessary, trained on any changes to the ADS capabilities/functions.

The trial organization may also consider implementing go/no-go decisions throughout various stages of the project where the trial cannot proceed to the next phase of the testing until specific safety management objectives have been met.

Trial organizations may also wish to consider seeking feedback from passengers and other road users throughout the trial to inform their test operations (where applicable).

3.3 INCIDENT AND EMERGENCY RESPONSE PLANS & PROCEDURES

In addition to routine safety management strategies, trial organizations should develop and maintain incident and emergency response plans in consultation with local first responders based on a risk assessment of their trial activities. For example, incident and emergency response plans should be considered, as appropriate, for collisions and other emergency situations (e.g. health emergency involving a passenger) or where a security event (including cybersecurity incident) occurs. As previously noted, trial organizations may wish to consult the following document: *AVSC Best Practice for First Responder Interactions with Fleet-Managed Automated Driving System-Dedicated Vehicles (ADS-DVs)*, which provides best practices on developing an interaction plan with first responders.

Incident and emergency response plans should include documented protocols with clear roles, instructions and task priorities that the trial organization will follow as well as specific guidance for first responders. Protocols for the trial organization may include:

- instructions on how to contact local law enforcement and emergency personnel;
- how to comply with incident and collision reporting requirements established by the provincial or territorial road safety administration;
- how to notify other project partners (e.g. Transport Canada, municipal authorities, etc.);
- how to retrieve data from various systems within the test vehicle (when it is safe to do so, as appropriate);
- how to assess maintenance requirements and perform safety checks prior to putting the vehicle back in service; and
- any approvals that must be sought before testing can resume after an incident.

Specific guidance for first responders may include:

- how to ensure the ADS is disabled;
- how to open the doors manually or otherwise access the vehicle interior
- information on the safe management of fires (including on fire suppressants, chemical/ battery fires); and
- how to identify hazardous components such as live electrical wires.

For trials involving passengers, organizations should also consider procedures for addressing incidents that may prevent completion of the vehicle's planned trip, such as loss of battery power. These procedures should consider how passenger safety will be maintained and how transportation of passengers to a safe location/ final destination will be addressed (e.g. transfer to another vehicle).

3.3.1 COLLISION REPORTING

While trial organizations should always maintain robust safety management plans throughout testing, incidents can occur. Trial organizations should report any collision or incident requiring an emergency response to relevant government authorities.

When warranted, a collision report will be compiled by the trial organization with the assistance of local law enforcement. In some cases, Transport Canada collision investigation teams may also be available to contribute technical expertise to support the development of the collision report. Trial organizations may be requested to provide collision investigators with access to the test vehicle and to data collected from various vehicle sub-systems to facilitate understanding of how the collision occurred. Safety drivers and other trial personnel should cooperate fully to aid such investigations.

In the event of a collision causing bodily injury or death, the trial organization should submit a preliminary report to the provincial or territorial road transportation administrator that provided the permit within 24 hours of the collision (or as otherwise required under provincial law or regulations) and immediately postpone trial activities involving any of the persons or vehicles involved until further direction is provided.

3.4 SAFETY DRIVER ROLES AND RESPONSIBILITIES DURING TESTING

Safety drivers can intervene and assume manual control of the test vehicle in the event that the ADS does not function as intended or exceeds its ODD requiring assistance to achieve a minimal risk condition and/or continue its journey safely.

The safety driver must monitor the driving environment and assume the dynamic driving task when prompted by the ADS or as required to ensure the safe operation of the vehicle. Safety drivers should be familiar with the jurisdiction's road rules and ensure that the test vehicle adheres to these rules. Trial organizations should also take measures to minimize safety driver distractions such as restricting the use of personal electronic devices to ensure the safety driver is ready to intervene in a timely manner if required. Trial organizations may include the use of driver monitoring systems.

Trial organizations should also take steps to avoid automation bias and driver fatigue. Automation bias refers to a specific class of errors people tend to make when working with and or monitoring highly automated systems. Automation bias can cause drivers to make errors due to an over-reliance on the system. For example, drivers may commit errors if a device fails to detect a problem and the driver does not notice because they are not appropriately monitoring the environment. The risk for automation bias can increase as the trial progresses and safety drivers become more confident in the ADS' capabilities. Automation bias may also be exacerbated if the trial route is monotonous and lacking complexity.

Evidence from studies of fatigue in transportation shows that the nature of the driving task has an impact on a driver's vigilance and level of alertness. A monotonous driving environment has been shown to decrease driver's alertness and vigilance and contribute to slower reaction times.[18] If a driver is required to engage in a monotonous task for a prolonged period of time, they may experience drowsiness and risk falling asleep at the wheel. The trial organization should consider implementing mitigation strategies to prevent automation bias and fatigue, which could include allowing safety drivers to take frequent breaks,[19] having them perform regular tasks to maintain their attention and vigilance, using driver monitoring technology and/or adding a co-driver.

It is recommended that safety drivers follow the Canadian hours of service requirements for commercial motor vehicle operators to help manage fatigue or follow more stringent hours of service as required by the trial organization.

18 Thiffault, P., & Bergeron, J. (2003).

19 See SAE's 2021 version of "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems J3016. To note: This standard is subject to ongoing revision.

3.5 SAFETY CONSIDERATIONS FOR REMOTE DRIVERS AND OTHER REMOTE SUPPORT ACTIVITIES

Currently, some ADS developers and technology firms are working to develop systems that provide varying degrees of remote support to test vehicles, and in some cases, allow a remote driver to take over the dynamic driving task from an ADS-equipped vehicle. It is envisioned that in some cases, remote support may be used to overcome certain limitations of ADS technologies as they continue to be refined and developed. For example, a remote assistant (discussed below) may provide information or guidance to the ADS-equipped vehicle when it encounters a rare or particularly complex scenario it has not been designed to navigate.

3.5.1 DISTINGUISHING REMOTE DRIVING FROM OTHER REMOTE SUPPORT ACTIVITIES

A remote driver as defined by SAE J3016 (for full definition, see the Definitions section) may include a driver who is able to operate the vehicle and is either:

- within the vehicle but not in a position to manually operate controls;
- outside of the test vehicle, but within line of sight of it; or
- outside and beyond the line of sight of the test vehicle.

It is important to note that SAE J3016 differentiates between a remote driver who undertakes all or some aspects of the dynamic driving task or DDT and a "driverless operation dispatcher" who makes strategic driving decisions, such as directing a vehicle to a particular location to carry out a particular service. Finally, the standard also identifies a "remote assistant" as someone who provides information or advice to the ADS-equipped vehicle to facilitate trip continuation.

Other support functions may also be carried out remotely, such as monitoring the operation of a vehicle and communicating with passengers and/or first responders in the event of a collision or other event. The table below provides some examples of different types of remote support for ADS-equipped test vehicles.

While different types of remote support for test vehicles may accelerate the development of automated driving systems and facilitate new use-cases and business models, appropriate precautions need to be taken to ensure risks associated with this type of testing are safely managed. Risks will vary significantly depending on the specific remote support tasks involved.

Remote driving is likely to pose the greatest risk to safety. The risk profile of remote driving may vary significantly depending on a variety of factors, including but not limited to:

- the vehicle's operating speed;
- the operating environment (e.g. restricted access or mixed traffic environment); and
- whether remote driving will be conducted within or beyond line of sight of the vehicle.

The following section details a variety of safety risks associated with remote support for test vehicles that will need to be carefully managed by any trial organization seeking to conduct such activities, particularly when engaging in remote driving.

TABLE 3: OVERVIEW OF HUMAN AND ADS ROLES IN VARIOUS TYPES OF REMOTE SUPPORT APPLICATIONS[20]

DRIVERLESS OPERATION DISPATCHER	REMOTE MONITOR[21]	REMOTE ASSISTANT	DIRECT LINE-OF-SIGHT	BEYOND LINE-OF-SIGHT
Roles of the remote dispatcher may include directing a vehicle to a particular destination and making other strategic driving decisions such as planning and selecting routes. **In this case the ADS performs the entire DDT.**	Roles of the remote monitor may include continuous monitoring of passenger safety and security, communicating with passengers to address any questions or concerns, and providing support or requesting emergency responders in response to a safety or security event. **In this case the ADS performs the entire DDT.**	Roles may include periodic assistance with manoeuvre planning. For example, providing information and advice to the vehicle on navigating through an intersection or deviating around a roadway obstruction it has encountered. **In this case the ADS performs all aspects of the DDT with periodic assistance on manoeuvre planning from the remote assistant.**	A remote driver may perform some or all aspects of the DDT from on-board (e.g. low speed shuttle) or a nearby location overlooking the vehicle. This may be for a temporary or prolonged period of time. **During these periods, the ADS does not perform those aspects of the DDT that are assumed by the remote driver.**	The remote driver performs some or all aspects of the DDT without a direct field of view of the vehicle and its environment. This may be for a temporary or prolonged period of time. **During these periods, the ADS does not perform those aspects of the DDT that are assumed by the remote driver.** **Important:** Testing of this type of remote operation should not be pursued with passengers and/or on public roads unless sufficient evidence can be provided to the authorizing jurisdiction that all potential safety risks can be appropriately managed.

20 These applications are not mutually exclusive. A remotely located individual could provide various support functions during test vehicle operations.

21 Although this is not a remote support role explicitly defined in J3016, such activities are described in J3016 section 3.13 under "Fleet support (functions)".

3.5.2 POTENTIAL CHALLENGES ASSOCIATED WITH REMOTE SUPPORT ACTIVITIES

There is limited evidence currently available to establish specific guidelines related to remote support for test vehicles. Transport Canada will continue to engage with international partners to understand emerging use cases and associated safety risks and update these testing guidelines as appropriate. Some potential safety risks that may require management when engaging in remote support, particularly when it involves a remote driver undertaking aspects of the DDT, include, but are not necessarily limited to the following:

COMMUNICATION FAILURES

- **Signal loss or interruption:** For remote support to work effectively, a communication link must be maintained with the test vehicle. If a connection is lost or interrupted this could pose significant risks particularly if a remote driver is required to control the DDT at a given moment and they are unable to do so.
- **Signal latency:** signal latency could impact the timely receipt of information by the remote driver, as well as the timely actuation of the remote driver instructions by the ADS. This can pose a serious risk if the remote driver/ADS is required to react immediately to avoid a collision.

HUMAN FACTORS CONSIDERATIONS

- **Automation bias:** Remote drivers may also be susceptible to automation bias**.** Automation bias refers to a specific class of errors people tend to make when working with highly automated aids (e.g., computers) and the human actor is required to monitor the system. See section 3.4 for an earlier discussion on automation bias.
- **Task-induced fatigue:** Passive fatigue can occur when an individual must engage in a monotonous task for extended periods of time.[22] Task-induced fatigue can affect the remote driver's ability to take over the vehicle's DDT or respond to an incident in a timely manner. Automation bias may also be exacerbated by task induced fatigue if the task of monitoring the vehicle(s) is monotonous and lacking complexity.
- **Distraction:** If a remote driver becomes distracted, they may not be able to respond in a timely or effective manner if they are required to intervene and take control of the vehicle's DDT. Consideration should be given to the remote driver's work environment and how different sources of distraction can be managed.
- **Awareness of the operating environment:** A remote driver will be dependent on the vehicle's sensors and effective human-machine-interfaces to observe and respond to the driving environment. If information provided to the remote driver is insufficient for any reason, they may fail to notice a change in their operating environment. This could greatly impede the remote driver's ability to conduct a safe maneuver when they are required to intervene.[23] Physical detachment from the vehicle and its surroundings may limit the remote driver's sensitivity to potential hazards and as a result, may have a decreased sense of urgency to react to potential safety risks.[24]
- **Information/task overload:** Conversely, there a risk that a remote driver may become overwhelmed with information from multiple sensors and ADS subsystems. This risk may be further compounded if a remote driver is given responsibility for more than one remote vehicle (as envisioned by some technology developers). Information overload could cause a remote driver to miss important cues, including take over-requests. In some cases, information overload may also lead to an over-reliance on the ADS and to automation bias.[25] Information overload could also exacerbate problems such as confusion related to the status of the vehicle's automation features (e.g. mode confusion).

22 Zeller, R., Williamson, A., & Friswell, R. (2020).

23 Galpin, Adam, Underwood, Geoffrey, & Crundall, David. (2009).

24 Human Factors Challenges of Remote Support and Control: A Position Paper. Submitted by Human Factors in International Regulations for Automated Driving Systems (HF-IRADS).

25 Galpin, Adam, Underwood, Geoffrey, & Crundall, David. (2009) and Ibid.

Further research is needed to understand the full extent of these and other potential safety risks when using remote operators, particularly when undertaking aspects of the DDT. At the time of this document's development, Transport Canada notes that much of the testing of ADS systems with some type of remote DDT support appears to involve use cases where the vehicle is operating at low speeds and/or in restricted access environments (such as a closed worksite).

It is conceivable that some trial organizations may envision other, higher risk use cases for remote driving (for example, beyond line of site of the test vehicle, in mixed traffic at highways speeds). It is Transport Canada's assessment that, at present, there is insufficient evidence to support the safe conduct of remote driving use cases such as this, given the aforementioned safety risks and the lack of evidence available to date that they can be appropriately managed.

Recognizing, however, that technology and safety evidence will continue to evolve, trial organizations wishing to include any aspects of remote driving should ensure that the tasks assigned are: appropriate for safe and effective human performance; are appropriate for the intended operating environment; and that the technology has been appropriately validated for use in these environments through previous testing. Trial organizations should be prepared to provide sufficient evidence of this testing to authorizing jurisdictions when seeking approval to conduct such trials. The vehicle should revert to a minimal risk condition if there is a fault/failure or the remote driver does not provide appropriate and timely input. It is also recommended that the vehicle be equipped with appropriate collision avoidance systems.

3.6 SAFETY CONSIDERATIONS FOR CONDUCTING TRIALS WITHOUT A SAFETY DRIVER

Trial organizations may seek to test level 4 and/or level 5 ADS-dedicated vehicles without a safety driver. In this case the trial organization should take a graduated approach to testing to ensure the vehicle is able to perform all aspects of the DDT, within the designated ODD. Trial organizations must consult the requirements of the jurisdiction in which they are operating and seek appropriate authorization when conducting trials without a safety driver present.

If the trial organization envisions carrying passengers during testing they may also need to consider additional measures to ensure passenger safety (e.g. enhanced audio/visual announcements) and find alternative ways of providing passenger services usually performed by a transit or safety driver (e.g. assisting passengers with accessibility needs, first aid, security concerns etc.).

The vehicle should always be supervised when in operation and be fitted with a two-way communication link with personnel overseeing the trial to provide continuous information on the vehicle's location and to monitor its status. This link should also allow two-way communication between these personnel and any passengers if the vehicle experiences any failures that would endanger the safety of the vehicle's passengers or other road users, or otherwise prevent the vehicle from functioning as intended, while operating without a driver.

Finally, the vehicle should be equipped with a warning system that alerts personnel monitoring the trial when the automated system disengages or an automated system failure occurs. The vehicle should be capable of reverting to a minimal risk condition and there should be appropriate redundancies to perform these tasks in instances where the ADS disengages or an ADS failure occurs.

3.7 SAFE INTERACTIONS WITH OTHER ROAD USERS

The conspicuity of the vehicle and how the vehicle communicates its intent to other road users are other important factors that can help reduce the risk of collisions. Depending on the intended use case of the vehicle, trial organizations may want to consider appropriate measures to ensure that test vehicles can be seen and heard by other road users and communicate its intended movements in a clear manner (e.g. appropriate visual and/or auditory cues, etc.). Transport Canada will continue to monitor international research on road user interactions with test vehicles and may update the testing guidelines based on best practices that are observed.

3.8 TRIALS WITH PASSENGERS

Depending on the type of vehicle being tested, trial organizations may wish to conduct testing with members of the public on board as passengers. Testing ADS equipped vehicles with passengers can introduce additional complexity and safety and security risks that need to be appropriately managed. Passengers should only be permitted to ride in the trial vehicle after extensive safety validation of the vehicle in its intended ODD. An assessment of passenger-related safety and security risks should also be conducted with relevant measures incorporated into the trial organization's safety management plan as appropriate.

3.8.1 USER PROTECTIONS

Some test vehicles may have unique configurations and may use novel fabrication methods and materials that do not conform to existing occupant protection, crash avoidance, and crashworthiness standards set out in the MVSR and CMVSS. When considering novel configurations and fabrication methods for their test vehicles, manufacturers should ensure that risks to occupant protection, crash worthiness and crash avoidance are appropriately validated, based on the ODD of the test vehicle and the types of vehicles/road users that may be encountered during operations. Where appropriate, organizations may also consider additional procedures to further manage risks to occupants and vulnerable road users during on-road testing activities (e.g. limiting testing to restricted access environments, reducing speed limits for all vehicles along the test route, etc.).

3.8.2 ACCESSIBILITY OF TEST VEHICLES

Depending on the intended user of the vehicle, it will be important that critical safety messages, interfaces and controls designed to inform or be used by passengers take into account the diverse needs of the Canadian public.

To support accessibility, interfaces and controls should follow principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use.[26] Interfaces and controls should be easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level, so that all passengers can safely enjoy their ride. For example, in a public transit setting, passengers should be able to easily book a ride, understand how to make stop requests, open doors, initiate emergency stops, operate emergency exits, and request assistance. Consideration should also be given to the broader accessibility needs of all users with disabilities.[27]

Some illustrative examples of accessibility features for persons who have low vision, or are blind, include high resolution screens, high contrast markings to identify key features (e.g. seating, steps), enhanced audio/visual announcements as well as the incorporation of braille on passenger operated interfaces.

26 Detailed information on universal design and guidelines can be found here.

27 Disability definition as per the *Accessible Canada Act* : disability means any impairment, including a physical, mental, intellectual, cognitive, learning, communication or sensory impairment – or a functional limitation – whether permanent, temporary or episodic in nature, or evident or not, that, in interaction with a barrier, hinders a person's full and equal participation in society."

Other accessibility considerations include allotting adequate space for mobility aids, service dogs, and support person. If a vehicle is equipped with a ramp it is also important to consider the vehicle's route and associated infrastructure (such as curb heights) to ensure the ramp can be deployed safely. When conducting trials involving passengers, trial organizations should ensure they are compliant with federal as well as relevant provincial or territorial accessibility regulations where applicable.

Manufacturers are encouraged to consult widely with persons with disabilities to gain a better understanding of the types of human-machine interfaces and accessibility features their vehicles should incorporate to best serve the diverse needs of the Canadian population.

3.8.3 PRIVACY AND OCCUPANT MONITORING

During trials, it is possible that personal data may be gathered from passengers and other road users who interact with the vehicle. Data may be gathered through a variety of means, such as through the vehicle's sensors, or through information provided directly by the passengers as part of the trial process (e.g. online reservations, filling out surveys, waivers). Trial organizations should take steps to securely store and protect any personal information that is collected and establish measures to respond to a privacy breach.

All businesses operating in Canada must comply with the privacy laws that govern the collection, use, and disclosure of personal information. In the private sector context, the federal Personal Information Protection and Electronic Documents Act (PIPEDA) applies to commercial activities that cross provincial or national borders or that take place wholly within in a province that has not enact legislation that is "substantially similar" to the federal law.[28] Under PIPEDA, organizations generally must obtain an individual's meaningful consent before processing their personal information. In doing so, the trial organization will place emphasis on the following key elements: what personal information is being collected; with whom personal information is being shared; the purpose of collecting, using, or disclosing the personal information; and the risk of harm and other consequences. Trial organizations should ensure they keep themselves informed of any changes in federal privacy legislation.

When transporting passengers, the trial organization should take reasonable steps to safeguard passengers from assault, abuse or harassment. Internal monitoring systems can further support passenger security (where applicable). As with some of today's unpiloted transit systems, passengers may be able to contact remote monitors who can provide assistance including contacting appropriate authorities to manage problematic passenger behaviour in real-time. It is important to balance privacy considerations with passenger protection. The type of monitoring being undertaken should be adapted to the type of vehicle being tested. For example, passengers have different expectations of privacy if they are riding in a personal vehicle compared to a public transit type vehicle.

3.9 REGULAR REPORTING AND INFORMATION SHARING

Supporting the safe development of ADS trials is an ongoing learning experience for both policy makers and trial organizations. To help facilitate a collaborative working relationship and information sharing, trial organizations are encouraged (or in some cases may be required) to periodically engage with provincial or territorial road transportation agencies to provide updates on testing activities.

In some cases, regular reporting requirements may include sharing data from testing activities. In their final reports trial organizations are encouraged to provide information on operational

28 Currently, the provinces of Alberta, British Columbia, and Quebec have enacted "substantially similar" laws. To note: at the time of the publication of this guidance document efforts are underway by parliament to consider new privacy legislation. Trial organizations are encouraged to consult www.priv.gc.ca for up to date information on privacy legislation in Canada.

issues experienced during the trial such as issues related to unplanned disengagements of the ADS or specific challenges faced during testing.[29] Provincial or territorial road safety administrators are encouraged to share trial reports with Transport Canada officials to inform the development of future safety policies. Trial organizations are also encouraged to allow Transport Canada and provincial or territorial road transportation agencies to observe trials in person and to provide advance notice of trials that will be open to the general public.

Transparency from industry and government is critical to the safe deployment of automated vehicles. As automated vehicle technology evolves, the public will be looking to both industry and government to ensure their systems are safe and trustworthy. Trial organizations should consider sharing data with researchers and the public to help advance collective knowledge of the current state of ADS testing and deployment and increase public trust.

29 While these reports would not necessarily require trial organizations to share commercially sensitive and/or proprietary information, appropriate measures to protect trial organization data will be implemented where necessary. These measures would be informed by existing procedures that Transport Canada has established with manufacturers to facilitate defect and collision investigations, as well as other research activities.

CHAPTER 4: POST-TEST CONSIDERATIONS

The final chapter of this document addresses factors trial organizations will have to consider after concluding their testing activities, including reporting trial results and the export or disposal of test vehicles and their components. If test vehicles are imported temporarily, they may need to either be exported, destroyed or donated once testing is completed.

4.1 FINAL REPORTING ON TRIAL OUTCOMES

Trial organizations are encouraged to share best practices and lessons learned with respect to the conduct of trials and to provide feedback to relevant federal, provincial and territorial authorities regarding the regulatory requirements and permit procedures they have been required to follow.

Trial organizations are also encouraged to publish end-of-trial report(s) on research and trial outcomes, to help advance collective knowledge of the current state of ADS testing and deployment. As ADS technologies continue to evolve, the sharing of test results can support the development of domestic and international safety requirements for ADS technologies and may contribute to the eventual safe deployment of automated vehicles on Canada's roads.

4.2 EXPORT, DISPOSAL OR DONATION OF TEST VEHICLES

Test vehicles imported using a Declaration of Vehicles Imported Temporarily for Special Purposes must either be exported from the country or destroyed under the supervision of a CBSA agent upon the expiration of the Declaration and evidence of such provided to Transport Canada. In the event that the vehicle is destroyed, the trial organization should ensure they dispose of any hazardous waste such as batteries and electronic components in the appropriate manner as mandated by the jurisdiction where testing is taking place. In some cases, a vehicle imported temporarily for special purposes may be donated to a public museum or an educational institution, provided that the recipient ensures that the vehicle will not be driven or drawn on public roads. Trial organizations may contact Transport Canada using the contact information in Section 1.2.1 for further information.

SUMMARY OF RECOMMENDATIONS FOR TRIAL SAFETY

BELOW IS A HIGH LEVEL SUMMARY OF KEY SAFETY BEST PRACTICES COVERED IN EARLIER SECTIONS OF THIS DOCUMENT:

- Ensure compliance with all applicable federal, provincial and territorial laws and regulations and maintain awareness of any changes to these laws and regulations. See checklist of key authorization steps to follow in Table 2.

- Ensure that the safety of test vehicles has been sufficiently validated through previous testing. Trial organizations, specifically the ADS developer, should evaluate and document the safety of the test vehicle using Transport Canada's Safety Assessment tool.

- Review and assess the cyber security of the test vehicle using Canada's Vehicle Cyber Security Guidance, Canada's Vehicle Cyber Security Assessment Tool, and other international best practices.

- Choose a route that is appropriate for the test vehicle based on its ODD, OEDR, and other technical limitations.

- Identify and document routine safety management strategies (e.g. standard operating procedures) to ensure safe operations throughout the trial.

- Ensure safety drivers are appropriately licensed, adequately trained.

- Develop appropriate communication plans to inform other road users of testing being conducted (where applicable).

- Engage with local first responders and law enforcement before commencing testing activities to ensure that they are aware and prepared to respond to potential incidents.

- Take a graduated, iterative approach to testing, progressively introducing new complexity and/or risk as the safety of the test vehicle is proven.

- Adapt safety management strategies as necessary as new risks and challenges are identified throughout the trial and ensuring that safety critical information is shared among all relevant trial personnel.

- Develop incident response plans in consultation with local first responders.

- Ensure that safety drivers carry out their duties safely and remain attentive during trial operations, incorporating measures to manage fatigue and to prevent driver distraction (if applicable).

- Manage any safety risks associated with remote operation (where applicable).

- If conducting testing without the use of a safety driver present in the vehicle the trial organization should ensure the test vehicle is able to operate safely (e.g. the vehicle should be able to revert to a minimal risk condition) and be outfitted with a two-way communication link.

- Ensure that test vehicles can be seen and heard by other road users and communicate its intended movements in a clear manner (where applicable).

- Manage additional risks posed by the transportation of passengers during trials (where applicable).

- Provide routine reports or updates to authorizing jurisdictions throughout the trial (as required).

- Consider publishing a public report of trial or research outcomes.

- Exporting, destroying or donating the test vehicle as required by the MVSA (where applicable).

ANNEX A: BEST PRACTICES FOR AUTOMATED SHUTTLE TESTING IN CANADA

WHAT ARE AUTOMATED SHUTTLES?

A broad variety of automated shuttle concepts have emerged in recent years, some of which are produced by companies who are new entrants to the motor vehicle sector. While the specifications of each vehicle are unique to the manufacturer, typical characteristics include electric powertrains, the capacity to carry approximately 4 to 12 passengers, operational speed ranges of about 5 to 25 km/h, and maximum speeds that may reach up to 60km/h.[30] Most automated shuttles are eventually intended to operate without a driver within a limited operational design domain (ODD), subject to further testing.

Automated shuttles have a number of potential future use cases. Some companies have marketed their automated shuttles as a first/last mile solution to bridge gaps in underserved areas for public transit users. Other use-cases envisioned for automated shuttles include more controlled driving environments such as university campuses, large parking facilities, shopping districts or at airports to transport passengers between terminals.[31]

Automated shuttle trials and demonstrations have been conducted in Canada in various cities including Ottawa, Montreal, Calgary, Edmonton, and Vancouver, among others. Canada is a desirable testing environment for many reasons, including significant seasonable variability observed in many regions of the country. Trials in Canada have mirrored similar projects underway in other countries and regions, including in the United States, Australia, Singapore, the United Kingdom and Europe.

While the technology continues to improve, automated shuttles remain test vehicles capable of operating in specific environments with limited complexity. As such, the safety of automated shuttle trials should be appropriately managed to reduce risks for passengers and other road users.

AUTOMATED SHUTTLE SAFETY

Transport Canada recognizes the value in promoting safe experimentation and trials of automated shuttles to inform safety practices and foster innovation in the context of the ongoing development of these vehicles. However, it is imperative that organizations conducting tests work within the limits of existing technologies, and always maintain safety as their top priority.

Testing automated shuttles presents unique safety considerations due in large part to three characteristics observed in many shuttle trials to date in Canada:

1) Vehicle design: Because the automated shuttle's design is often a novel configuration that may not conform to a prescribed vehicle class in the *Motor Vehicle Safety Regulations*, many vehicles may not comply with associated standards related to occupant protection, crash avoidance and crashworthiness defined in the *Canada Motor Vehicle Safety Standards* (CMVSS).

30 This definition reflects general characteristics of test vehicles observed in the context of trials in North America. Automated shuttles are not a specific class of vehicle defined in Transport Canada's Motor *Vehicle Safety Regulations*.

31 US Department of Transportation (2018).

2) Types of organizations conducting testing: Many shuttle manufacturers are marketing their vehicles and partnering with other entities such as municipalities and transportation companies to lead testing operations in different locations across Canada. Close collaboration between trial organizations, shuttle manufacturers and other stakeholders involved in the trial is required to ensure the safety of all stakeholders involved in testing activities, as the vehicles and their automated driving systems continue to evolve. Organizations conducting shuttle trials need to have a strong understanding of the vehicle's capabilities and limitations to ensure that the shuttle is suitable for the environment where it will operate, and plan or adapt operations accordingly.

3) Inclusion of members of the public in testing activities: In numerous automated shuttle trials and demonstrations, members of the public are invited to ride in the vehicles as passengers so companies can promote public acceptance of automated technologies, gauge consumer reactions to the vehicle, and test the viability of use cases and potential business models.

Transport Canada supports a technology-neutral approach to automated vehicle safety as much as possible. However, the department also firmly believes in documenting safety best practices that can help to inform future testing of these specific vehicle types in Canada, taking into account some of the unique safety considerations described above and lessons learned from shuttle trials to date.

Building on the guidance outlined in previous sections of this document, this annex provides trial organizations with additional best practices that are specific to automated shuttles testing. Transport Canada reiterates some recommendations found earlier in this document that may be of particular relevance when testing these vehicle types.

These best practices were developed based on a review of international publications, interviews with various organizations involved in shuttle testing to date in Canada, as well as stakeholder feedback received from shuttle developers and other parties in response to informal consultations conducted by Transport Canada in Summer/Fall 2020. The shuttle annex begins with considerations for understanding the shuttle's capabilities and limitations, followed by best practices when determining a route for the shuttle. Other topics discussed include shuttle maintenance, weather, considerations for a safety driver including when removing an onboard operator, passenger displays and controls, user protections as well as engagement with municipal governments and first responders.

UNDERSTANDING THE SHUTTLE'S CAPABILITIES AND LIMITATIONS

- ✓ Trial organizations should ensure they have an in-depth understanding of the shuttle's functionality, including its capabilities and limitations.
- ✓ Trial organizations should understand what conditions the shuttle has been tested in previously, what lessons were learned, how the technology was adapted, and any challenges it faced.
- ✓ Pre-trial testing should demonstrate that the shuttle vehicle has the ability to engage in safe driving behaviour in its intended operating environment such as being able to safely navigate amongst other road traffic, including vulnerable road users (e.g. cyclists, pedestrians), safely avoiding stationary obstacles along its path, and safely achieving a minimum risk condition when required.
- ✓ Shuttle manufacturers should be able to provide all trial organization participants and the authorizing jurisdiction with a detailed definition of the automated shuttle's ODD(s), as well as documented testing used to validate each ODD including:
  - Road types on which the automated driving system can operate safely;
  - Geographic areas;
  - Speed range; and
  - Environmental conditions (daytime/nighttime, weather, etc.).

- ✓ When the limits of an automated shuttle's ODD are exceeded (for example, due to a change in weather conditions), the shuttle should be able to revert to a minimal risk condition (a safe state to reduce the risk of a collision when a given trip cannot or should not be completed). The minimal risk condition should be clearly communicated to the trial organization by the manufacturer.
- ✓ Shuttle manufacturers should provide a safety assessment report to organisations seeking to obtain shuttles for trial purposes as well as to the jurisdiction responsible for authorizing the trial. See Section 2.1.
- ✓ Prior to obtaining a shuttle, trial organizations should attend demonstration events offered by the manufacturer where possible.
- ✓ Trial organizations should ensure that the appropriate security safeguards are in place to protect the shuttle vehicle and infrastructure. Organizations can refer to Transport Canada's Vehicle Cyber Security Guidance, which provides best practices on managing cyber security risks and protecting the entire vehicle ecosystem with safeguards, and should consider conducting a vehicle cyber security assessment using Canada's Vehicle Cyber Security Assessment Tool.
- ✓ Trial organizations and the respective jurisdiction(s) should be informed of any over-the-air updates performed to the vehicle's software. If a manufacturer changes the ODD or other aspects of the ADS, trial organizations should be informed and where necessary, trained on any changes to the automated shuttle's capabilities.
- ✓ Manufacturers must notify the trial organization and respective jurisdiction(s) of any defects with the system or the vehicle that are discovered after the vehicle is procured and work with the trial organization to rectify these issues.
- ✓ Trial organizations should collaborate closely with the shuttle manufacturer and local jurisdiction throughout the trial to address and manage challenges as they arise.
- ✓ Trial organizations should reference ISO 22737 which includes various requirements for low-speed automated driving (LSAD) systems such as standards for performance requirements and test procedures, which may be relevant for validating the safety of the test vehicle.

ROUTE SELECTION AND PLANNING

All test routes

- ✓ Confirmation should be received from the manufacturer that the automated shuttle's ODD and OEDR is appropriate for the route where it will be operating. The automated shuttle should be able to perceive and react appropriately to road-users and other objects it may encounter.
- ✓ Manufacturers should provide adequate evidence of prior testing to demonstrate these capabilities, which could be based on a combination of methodologies (e.g. track testing, simulation or previous on road tests).
- ✓ Manufacturers should inform the trial organization of factors that might impact the vehicle's navigation and localization so that they can plan routes and their maintenance accordingly (e.g. clearing snow buildup or foliage that may block signage or other objects required for localization).
- ✓ Crashworthiness of the automated shuttle should also be discussed with the manufacturer, including what crash tests have been conducted to date, and what types of passive and active safety features[32] have been incorporated into the vehicle to protect occupants. Crashworthiness will inform the type of route where the shuttle should operate.

32 Active safety features intervene to prevent or mitigate collisions (e.g. electronic stability control and lane departure warning systems). Passive safety features are designed to protect vehicle occupants during a collision (e.g. seatbelts and crumple zones).

- ✓ Members of the public should only be invited to ride the shuttle once the safety of the route and chosen operating environment has been validated as part of the graduated approach to testing described in Section 3.1. Frequent[33] pre-departure safety checks of the shuttle should be conducted by trained personnel, in accordance with the safety management plan to ensure the vehicle is operating as intended.
- ✓ The proposed route should provide adequate space for the shuttle to safely pull over to pick-up/drop-off passengers along the route.
- ✓ Stops along the shuttle's route should be accessible for all passengers.
- ✓ The trial organization should conduct frequent checks of the route for major hazards, obstacles and the condition of signs along the route (including shuttle stops and lane markings as applicable). All relevant trial personnel should be made aware of any safety related observations that arise.
- ✓ Trial organizations should be aware of the various factors that could impact the automated shuttle's battery life and plan routes and schedules accordingly to ensure safe and reliable transportation for passengers.
- ✓ Ensure other road-users (e.g. pedestrians, cyclists, drivers) are aware of the trial and of their expected behaviour when the shuttle is operating, including right-of-way at intersections or designated crossings as described above or using other intersection design methods.

Restricted access environments (see description in section 2.2.1)

- ✓ Trial organizations should assess the suitability of the trial route and its infrastructure to ensure the safe operation of the shuttle, in consultation with relevant technical experts as needed. Some illustrative examples based on previous trial experiences include:
  - verifying that infrastructure such as footbridges along the route can support the weight of the vehicle;
  - ensuring that gravel or other unpaved pathways do not create excessive dust that may interfere with the vehicle's sensors;
  - ensuring the shuttle can operate safely through the intersection and the route can accommodate all road users, including pedestrians and cyclists; and
  - verifying that route grades are not too steep for the vehicle to safely operate.
- ✓ Where applicable, trial routes that use segregated lanes may benefit from physical barriers and/or appropriate signs to ensure the route is reserved for exclusive use by the automated shuttle. Physical barriers should be compatible with the automated shuttle's sensing systems, and should not interfere with the vehicle's localization and OEDR capabilities.
- ✓ Consider adding supplementary infrastructure at crossings or intersections with Vehicle-to-infrastructure (V2I) connectivity or other appropriate redundant sensor inputs to ensure the shuttle can safely navigate the environment. Trial organizations should ensure that infrastructure modifications made to the test route do not pose any negative safety impacts for other road users, including vulnerable road users.

Mixed traffic on public roads[34]

- ✓ Confirmation should be received from the manufacturer that the automated shuttle's ODD and OEDR is appropriate for mixed traffic scenarios. The automated shuttle should be able to perceive and react appropriately to road-users and other objects it may encounter. Manufacturers should provide adequate evidence of prior testing to demonstrate these capabilities, which could be based on a combination of methodologies (e.g. track testing, simulation or previous on road tests).

33 Frequent means on a daily basis or as necessary based on the risk assessment conducted by the trial organization.

34 For the purpose of this document, designated lanes that are not separated from other traffic by physical barriers are considered mixed-traffic environments because there is a risk that other vehicles may enter the lane and interact with the shuttle.

- ✓ In instances where an authorizing jurisdiction permits a shuttle trial to occur on a public road in mixed traffic, additional measures to manage safety risks associated with potential collisions with other vehicles and road users should be considered. A non-exhaustive list of strategies to manage safety that could be considered (where appropriate and applicable) include:
    - ✓ Operating the shuttle on low speed roadways only and/or reducing the speed of all road traffic along a shuttle route, where appropriate.
    - ✓ Limiting occupancy to seated passengers only. Seat-belts should also be installed and used at all times while the shuttle is operating in mixed traffic on public roads.
    - ✓ Ensuring the proposed route provides adequate space for the shuttle to safely pull over to pick-up/drop-off passengers along the route and merge safely back into traffic.
    - ✓ Choosing routes that have low-traffic density.
    - ✓ Informing other road-users (pedestrians, cyclists, other drivers, etc.) about the trial and how they should behave when the shuttle is operating (including right-of-way). This could include:
        - Having other vehicles yield right of way to the shuttle when the shuttle is merging back into traffic, (similar to transit buses in many jurisdictions); and
        - Affixing appropriate signage to the shuttle to convey the need to yield.
    - ✓ Assessing the shuttle's potential impact on traffic flow and other road user behaviour when selecting routes. Risks observed in other trials include unsafe driving behaviour by other vehicles attempting to overtake the slower moving shuttlxOther behaviours include pedestrians stepping out in front of the shuttle to test its ability to detect them and stop. Such risks should be monitored to inform changes to the route where necessary and where appropriate, to engage local law enforcement.
    - ✓ Consideration could be given initially to limiting the hours of operation of the automated shuttle to off-peak times, until the automated shuttle can reliably navigate its programmed route without interrupting regular traffic flows.

SHUTTLE SAFETY MAINTENANCE

- ✓ Trial organizations should understand maintenance requirements the shuttle may need throughout testing, and manage operations accordingly.
- ✓ Trial organizations should ensure sensors are cleaned and maintained to ensure the ongoing safe operation of the vehicle.
- ✓ Some manufacturers may periodically update the automated shuttle software through over-the-air updates. Trial organizations should be informed when the updates will take place and have a clear understanding of the types of connections (Wifi, etc.) that need to be maintained to ensure the updates are completed in full. Updates should never be performed while the vehicle is operating. Once the shuttle's automated driving system is updated, it is recommended that the safe operation of the test vehicle be validated by undertaking a graduated approach to testing as described by Transport Canada in Section 3.1.

WEATHER CONSIDERATIONS

- ✓ Members of the public should only be allowed to ride the automated shuttles in weather conditions that are proven to be safe for shuttle operation, validated through previous testing. Trials of automated shuttles in adverse weather that test the limits of the vehicle's ODD should be conducted first in closed track environments and without passengers.

- ✓ Trial organization should continuously monitor weather conditions to ensure that it is safe for the vehicle to continue to operate.
- ✓ Safety drivers should understand what weather conditions may interfere with the automated shuttle's sensors and exercise increased vigilance when they occur.
- ✓ Trial organizations should understand and manage safety risks that could arise as a result of the automated shuttle operating in varying seasonal conditions. For example, high-definition mapping exercises may need to be repeated as seasons change to support ongoing localization and navigation functions, and avoid unexpected stops due to changes along the shuttle's route, such as snowbanks and altered vegetation.

TRIALS WITH AN ON-BOARD SAFETY DRIVER

- ✓ Measures should be incorporated to minimize safety driver distraction, including interactions with passengers during the vehicle's operation. It may be prudent to have an on-board attendant who can address any passenger questions/concerns and promote rider acceptance and familiarity with the shuttle during early stages of testing.
- ✓ In some cases, trial organizations may consider using pre-recorded safety messages/videos and signage to provide key safety messaging to reduce the need for safety driver interaction with passengers and the risk of distraction.
- ✓ Trial organizations should incorporate appropriate measures to manage safety drivers' performance, including their vulnerability to automation bias and their levels of alertness and fatigue which may be exacerbated if the trial route is monotonous and lacking complexity.
- ✓ The safety driver must ensure that they always have a clear line of sight when operating the shuttle (e.g. ensuring that the driver's view is not obstructed by standing passengers).

SAFETY DRIVER TRAINING AND HMI

- ✓ Trial organizations should facilitate appropriate training on the shuttle's control system, including emergency manoeuvres and fault injection training[35] based on programs developed by the manufacturer or ADS developer.
- ✓ For automated shuttles with unconventional vehicle controls, safety drivers should be provided training opportunities that include operating the vehicle on closed-roads or test tracks prior to being allowed to operate the shuttle in more complex environments and carry passengers.
- ✓ Safety drivers should be made aware of what is expected of them in relation to the dynamic driving task under different conditions and of the shuttle's features and maintenance requirements. Safety drivers should be trained to recognize when the vehicle is operating as intended and when they are required to intervene. Safety drivers should also be informed of any changes in these expectations that arise following a system/hardware update.
- ✓ For trials that include passengers, it is recommended that safety drivers or on-board attendants receive standard first aid training.
- ✓ The trial organization should review safety practices for local transit operators and consider their relevance to safety drivers for shuttle testing.

35 Fault injection training is used to assess the performance of a system under exceptional conditions, and can help avoid designer and tester blind spots when testing exceptional condition responses. This involves not only simulating objects for primary sensor inputs, but also inserting exceptional conditions to test the robustness of the system (e.g., inserting invalid data into maps).

CONSIDERATIONS PRIOR TO REMOVING ONBOARD SAFETY DRIVERS

- ✓ Trial organizations considering operations without a safety driver will need to consult the requirements of the jurisdiction in which they are operating.
- ✓ Trial organizations should ensure they have conducted sufficient testing through a graduated approach before permitting passenger on board a shuttle without a safety driver.
- ✓ Trial organizations may need to consider measures to ensure passenger safety (e.g. enhanced audio/visual announcements) and find alternative ways of providing passenger services usually performed by a transit or safety driver (e.g. assisting passengers with accessibility needs, first aid, security concerns etc).

PASSENGER DISPLAYS AND CONTROLS

- ✓ Trial organizations should procure shuttles that are accessible by the broader Canadian public including people with varying accessibility needs, as per the definition of disability in the *Accessible Canada Act*.[36]
- ✓ The Canadian Standards Association D409 Standard - Motor Vehicles for the Transportation of Persons with Physical Disabilities can be consulted to inform considerations for shuttle accessibility.
- ✓ Trial organizations are encouraged to consult the report published by the Canadian National Institute for the Blind (CNIB): Advance Connectivity and Automation in the Transportation System: Understanding the Impact of Connected and Automated Vehicles for Pedestrians who are Blind or Partially Sighted for examples of strategies to address accessibility needs of persons who are blind or partially sighted.
- ✓ Passenger controls, including controls for opening the doors and requesting stops, should be intuitive and designed for maximum usability.
- ✓ Trial organizations are encouraged to consult *AVSC Best Practice for Passenger-Initiated Emergency Trip Interruption* for aspects of passenger-initiated emergency features.
- ✓ If a malfunction occurs that renders the shuttle inoperable measures should be established to ensure all passengers, including those with accessibility needs, can exit the shuttle safely and be taken to their intended destination.

USER PROTECTIONS

- ✓ Shuttles should be designed with appropriate crash compatibility, occupant protections, and crashworthiness adapted to the vehicle's ODD, given the potential for interactions with vulnerable road users and other vehicle types in some operating environments.
- ✓ Shuttle interiors should be designed to optimize occupant protection and include safety features such as seatbelts, securement systems for wheel chairs, hand-holds, etc., including signage reminding customers to use these features.
- ✓ Trial organizations should ensure the shuttle has safety systems and/or procedures which allow first responders to immobilize or otherwise disable the vehicle post-crash, to prevent movement or reactivation of the vehicle.
- ✓ The shuttle should convey safety critical information to passengers, first responders, and emergency services.
- ✓ Protocols and/or systems should be in place that allow communication between the safety driver/passengers with remote monitors/ emergency services.

36 Disability definition as per the *Accessible Canada Act* : disability means any impairment, including a physical, mental, intellectual, cognitive, learning, communication or sensory impairment – or a functional limitation – whether permanent, temporary or episodic in nature, or evident or not, that, in interaction with a barrier, hinders a person's full and equal participation in society.

- ✓ Passengers should be able to exit the shuttle by manually opening the doors, windows, or other emergency exits in case of an emergency or malfunction of the shuttle.
- ✓ Shuttles should include appropriate safety equipment. This may include a first aid kit, fire extinguisher, safety hammer, etc.
- ✓ Passengers should not be permitted to board the shuttle with bulky/unsecured items such as bicycles, which could harm other passengers in the event of a sudden stop.
- ✓ Trial organizations should promote passenger safety by providing instructions where appropriate. This may include instructions to:
  - Avoid obstructing the safety driver's outward view;
  - Avoid distracting the safety driver, including saving questions until the shuttle is stopped;
  - Remain seated and fasten seatbelts during the shuttle's operation; as well as,
  - Directions on securing mobility aids.

ENGAGEMENT WITH MUNICIPAL GOVERNMENTS

- ✓ Trial organizations should collaborate with the municipality as well as local transit agencies to ensure the vehicle being tested can meet identified transportation needs within their communities, and that local factors are considered and addressed in safety management planning.
- ✓ The trial organization and municipality/test site owner should establish a clear understanding of who is responsible for the maintenance and modifications of the shuttle's route as required (e.g. snow clearing, tree trimming) and the installation of infrastructure such as signage or roadside units (V2I), which may be required to assist with the shuttle's safe localization and navigation.

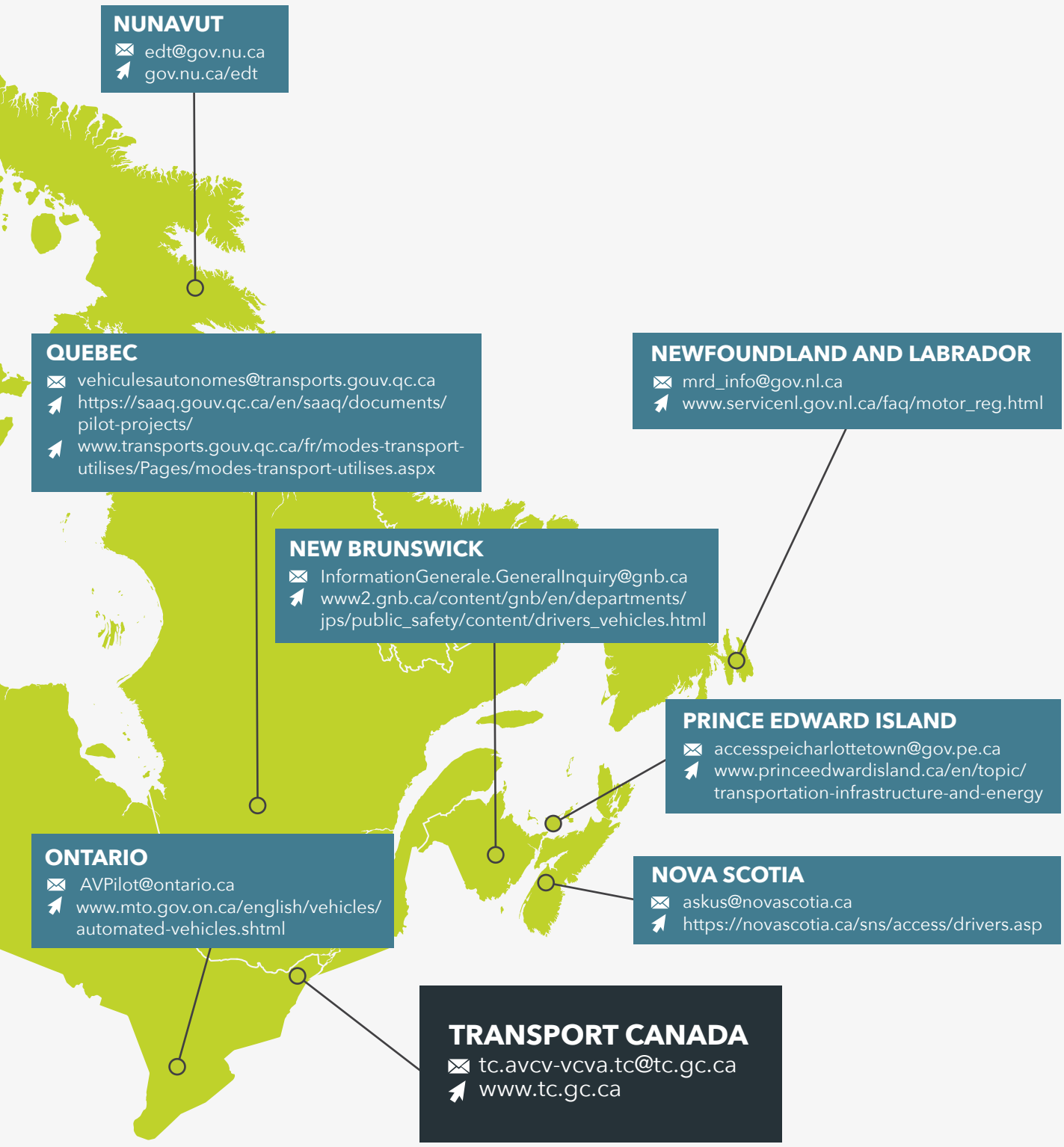
ENGAGEMENT WITH LAW ENFORCEMENT AND FIRST RESPONDERS

- ✓ Shuttles should be appropriately labeled for first responder/law enforcement safety in the event of a collision (e.g. high voltage areas should be clearly identified).
- ✓ A shuttle operating in mixed traffic on public roads should have the ability to pull over in response to an approaching first responder vehicle or if requested by law enforcement.

CONCLUSION

Automated shuttles are an important innovation that have garnered the attention of many transportation organizations and authorities across Canada and around the world. As automated shuttles and their use cases continue to evolve, so too will the best practices associated with testing these vehicles. Transport Canada is available to meet with trial organizations to discuss their plans for a shuttle project in Canada and to discuss other best practices/lessons learned since the publication of this document.

ANNEX B: CONTACTS PAGE



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www.transports.gouv.qc.ca/fr/modes-transport-utilises/Pages/modes-transport-utilises.aspx

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ANNEX C: INTERNATIONAL STANDARDS RESOURCES

ISO 26262 Functional Safety Standard: is an automotive-specific international standard that focuses on safety components, including an automotive safety lifecycle, an automotive specific risk-based approach for safety assurance, and requirements for validation and confirmation measures.

ISO/PAS 21448 Road Vehicles – Safety of the Intended Functionality (SOTIF): provides further guidance on applicable design, verification and validation measures to achieve the absence of unreasonable risk due to hazards resulting from functional insufficiencies of the intended functionality or by foreseeable misuse.

ISO 24089 Road vehicles – Software update engineering: currently at the Committee Draft stage and is planned to be published in late 2022

J3018 Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automate Driving Systems: Published by SAE International this document provides safety-relevant guidelines for testing automated vehicles in mixed traffic environments and on public roads.

SAE J3061 Cybersecurity Guidebook for Cyber-Physical Vehicle Systems establishes a set of high-level guiding principles for Cybersecurity as it relates to cyber-physical vehicle systems.

ISO/SAE 21434 Road vehicles – Cybersecurity engineering (document is an unapproved DRAFT of a proposed SAE International Standard) specifies requirements for cybersecurity risk management regarding engineering for concept, development, production, operation, maintenance, and decommissioning for road vehicle electrical and electronic (E/E) systems, including their components and interfaces.

ISO 22737 - Intelligent transport systems – Low-speed automated driving (LSAD) systems for predefined routes – Performance requirements, system requirements and performance test procedures specifies requirements for the operational design domain, system requirements, minimum performance requirements, and performance test procedures that may be relevant for validating the safety of low-speed automated driving (LSAD) systems for operation on predefined routes.

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DEFINITIONS

The following definitions were sourced from SAE International's *Surface Vehicle Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*, J3016 (2021) and were reprinted with SAE International's permission.[37] This document can be accessed for free from the SAE International website at: https://www.sae.org/

ADS-dedicated vehicle (ADS-DV): An ADS-equipped vehicle designed for driverless operation under routine/normal operating conditions during all trips within its given ODD (if any).

NOTE: In contrast to previous versions of this document, which specified that an ADS-DV was limited to Levels 4 and 5, this revised definition of an ADS-DV also allows for the possibility of a Level 3 ADS-DV if the remote fallback-ready user can be receptive to both ADS-issued requests to intervene and to evident DDT performance-relevant system failures in the vehicle. Once either of these conditions occurs, the remote fallback-ready user begins to perform the DDT fallback in (virtually) real time using wireless means.

Automated Driving System (ADS): The hardware and software that are collectively capable of performing the entire Dynamic Driving Task (DDT) on a sustained basis, regardless of whether it is limited to a specific Operational Design Domain (ODD); this term is used specifically to describe a level 3, 4, or 5 driving automation system.

Dispatch (In Driverless Operation): To place an ADS-equipped vehicle into service in driverless operation by engaging the ADS.

NOTE 1: The term "dispatch," as used outside of the context of ADS-equipped vehicles, is generally understood to mean sending a particular vehicle to a particular pick-up or drop-off location for purposes of providing a transportation service. In the context of ADS-equipped vehicles, and as used herein, this term includes software-enabled dispatch of multiple ADS-equipped vehicles in driverless operation that may complete multiple trips involving pick-up and drop-off of passengers or goods throughout a day or other pre-defined period of service, and which may involve multiple agents performing various tasks related to the dispatch function. In order to highlight this specialized use of the term dispatch, the term is modified and conditioned by the stipulation that it refers exclusively to dispatching vehicles in driverless operation.

(Driverless Operation) Dispatching Entity: An entity that dispatches an ADS-equipped vehicle(s) in driverless operation. NOTE: The functions carried out by a dispatching entity may be divided among one or several agents, depending on the usage specification for the ADS-equipped vehicle(s) in question.

(Dispatching Entity) Driverless Operation Dispatcher: A user(s) who dispatches an ADS-equipped vehicle(s) in driverless operation.

NOTE: A dispatcher(s) may also perform other fleet operations functions.

Driverless Operation (Of an ADS-Equipped Vehicle): On-road operation of an ADS-equipped vehicle that is unoccupied, or in which on-board users are not drivers or in-vehicle fallback-ready users.

37 Definitions are subject to change as the SAE periodically revises their taxonomy and definitions related to driving automation systems. Definitions in this document may be updated periodically to reflect changes to the J3016 standard.

Dynamic Driving Task (DDT): All of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints, and including without limitation, the following subtasks:

1. Lateral vehicle motion control via steering (operational);
2. Longitudinal vehicle motion control via acceleration and deceleration (operational);
3. Monitoring the driving environment via object and event detection, recognition, classification, and response preparation (operational and tactical)
4. Object and event response execution (operational and tactical);
5. Maneuver planning (tactical); and
6. Enhancing conspicuity via lighting, sounding the horn, signaling and gesturing, etc. (tactical).

Dynamic Driving Task (DDT) Fallback: The response by the user to either perform the DDT or achieve a minimal risk condition (1) after occurrence of a DDT performance-relevant system failure(s), or (2) upon operational design domain (ODD) exit, or the response by an ADS to achieve minimal risk condition, given the same circumstances.

(Human) Driver: A user who performs in real-time part or all of the DDT and/or DDT fallback for a particular vehicle.

NOTE: This definition of "driver" does not include a robotic test device designed to exercise steering, braking, and acceleration during certain dynamic test maneuvers.

(Human) User: A general term referencing the human role in driving automation.

NOTE 1: The following five terms (1 - driver, 2 - passenger, 3 - DDT fallback-ready user, 4 - driverless operation dispatcher, and 5 - remote assistant) describe categories of (human) users.

NOTE 2: These human categories define roles that do not overlap and may be performed in varying sequences during a given trip.

Minimal Risk Condition: A stable, stopped condition to which a user or an ADS may bring a vehicle after performing the DDT fallback in order to reduce the risk of a crash when a given trip cannot or should not be continued.

Object and Event Detection and Response (OEDR): The subtasks of the DDT that include monitoring the driving environment (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the DDT and/or DDT fallback).

Operate (a motor vehicle): collectively, the activities performed by a (human) driver (with or without support from one or more level 1 or 2 driving automation features) or by an ADS (level 3–5) to perform the entire DDT for a given vehicle.

Operational Design Domain (ODD): Operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.

Passenger: A user in a vehicle who has no role in the operation of that vehicle.

Remote Assistance: Event-driven provision, by a remotely located human, of information or advice to an ADS-equipped vehicle in driverless operation in order to facilitate trip continuation when the ADS encounters a situation it cannot manage.

NOTE 1: Remote assistance does not include real-time DDT or fallback performance by a remote driver. Rather, the ADS performs the complete DDT and/or fallback, even when assisted by a remotely located human.

NOTE 2: Remote assistance may include providing an ADS with revised goals and/or tasks.

NOTE 3: The remote assistance function does not include providing strategic instruction regarding selection of destinations or trip initiation timing (i.e., dispatch functions), even if the same person performs both remote assistance and dispatching functions.

EXAMPLE 1: A Level 4 ADS-DV encounters an unannounced area of road construction within its ODD. The ADS-DV communicates to a remotely located human that it is unable to proceed around the construction. The remotely located human provides a new pathway for the vehicle to follow around the construction zone that allows the ADS-DV to automatically proceed and complete its trip.

Remote Assistant: A human(s) who provides remote assistance to an ADS-equipped vehicle in driverless operation.

NOTE: A remote assistant(s) may also perform other fleet operations functions.

Remote Driver: A driver who is not seated in a position to manually exercise in-vehicle braking, accelerating, steering, and transmission gear selection input devices (if any) but is able to operate the vehicle.

NOTE 1: A remote driver can include a user who is within the vehicle, within line of sight of the vehicle, or beyond line of sight of the vehicle.

NOTE 2: A remote driver is not the same as a driverless operation dispatcher, although a driverless operation dispatcher may become a remote driver if they have the means to operate the vehicle remotely.

NOTE 3: A remote driver does not include a person who merely creates driving-relevant conditions that are sensed by, or communicated to, the ADS (e.g., a police officer who announces over a loudspeaker that a particular stop sign should be ignored; another driver who flashes their head lamps to encourage overtaking; or a pedestrian using a dedicated short range communication (DSRC) system to announce their presence).

EXAMPLE 1: A level 2 automated parking feature allows the remote driver to exit the vehicle near an intended parking space and to cause the vehicle to move into the parking space automatically by pressing and holding a special button on the key fob, while they are monitoring the driving environment to ensure that no one and nothing enters the vehicle pathway during the parking maneuver. If, during the maneuver, a dog enters the pathway of the vehicle, the remote driver releases the button on the key fob in order to cause the vehicle to stop automatically. (Note that the remote driver in this level 2 example completes the OEDR subtask of the DDT during the parking maneuver.)

EXAMPLE 2: Identical situation to Example 1, except that the remote driver is sitting in the back seat, rather than standing outside the vehicle.

EXAMPLE 3: A level 4 closed campus delivery vehicle that has experienced a DDT performance-relevant system failure, which forced it to resort to a minimal risk condition by parking on the side of a campus roadway, is returned to its designated marshalling yard by a remote driver who is able to operate the vehicle using wireless means.

Remote Driving: Real-time performance of part or all of the DDT and/or DDT fallback (including, real-time braking, steering, acceleration, and transmission shifting), by a remote driver.

NOTE: The remote driver performs or completes the OEDR and has the authority to overrule the ADS for purposes of lateral and longitudinal vehicle motion control.

Request to Intervene: An alert provided by a Level 3 ADS to a fallback-ready user indicating that s/he should promptly perform the DDT fallback, which may entail resuming manual operation of the vehicle (i.e., becoming a driver again), or achieving a minimal risk condition if the vehicle is not operable.

NOTE: As previously noted in this document, it may be possible for a passenger in a Level 4 or 5 ADS-operated vehicle to also resume manual operation of the vehicle under certain conditions, provided that the vehicle and feature are designed for this (e.g., a dual-mode vehicle or a conventional vehicle with a Level 4 sub-trip feature). However, even when alerted by the ADS to take over vehicle operation, a passenger of such a vehicle is not required to do so to ensure competent operation, as Level 4 and 5 ADS features/vehicles are capable of automatically achieving a minimal risk condition when necessary. Thus, such an alert to a passenger of a Level 4 or 5 ADS-operated vehicle is not a "request to intervene" as defined herein for Level 3 ADS-equipped vehicles.

OTHER TERMS

In some instances, this document uses additional terms not included in the SAE's *Taxonomy and Definitions (J3016)* to supplement key concepts and to ensure accessibility of the text for non-technical audiences.

Connected Vehicles and Automated Vehicles: An automated vehicle uses a combination of sensors, controllers and onboard computers, along with sophisticated software to control at least some aspects of the dynamic driving task (for example, steering, braking and acceleration, and checking and monitoring the driving environment). There are six levels of driving automation defined by the SAE International (see p. 49). Connected vehicles use different types of wireless communications technologies to communicate with their surroundings. Connected vehicles may be able to communicate with: passengers (e.g. through mobile devices or onboard infotainment); with other vehicles and road users; with the surrounding transportation infrastructure (such as roadways and traffic lights); and through internet based applications. It is possible that connected vehicle technologies may eventually support and complement automated vehicle technologies, by allowing automated vehicles to coordinate their movements more efficiently on the road and improve overall traffic flows.

Deployment: the operation of a market-ready ADS equipped vehicle compliant with the MVSR, including Canada Motor Vehicle Safety Standards (CMVSS) applicable to its prescribed class (unless an exemption has granted). This could include ADS equipped vehicles manufactured for the purpose of sale or permanent importation, or the management of a fleet of ADS equipped vehicles in the context of transit, taxi or ride-sharing operations.

Disengagement (of the ADS): a deactivation of the automated mode when a failure of the ADS is detected or when the safe operation of the vehicle requires that the driver or remote driver assume immediate operation of the vehicle or, in the case of ADS-dedicated vehicles, that the ADS system be deactivated for the safety of the vehicle, its occupants, or other road users.

Heavy Vehicle: There is no definition of a heavy vehicle in the MVSR. However, trial organizations may need to consider and include additional mitigation factors in their safety management plan to address any additional risks posed if they test larger vehicles such as transport trucks. This may include consideration of network access, community consultation and engagement.

Serious Incident: Any reportable collision involving a trial vehicle (that meets the jurisdiction's reporting threshold for collisions); a contravention of a traffic law that compromises safety, such as unsafely exceeding the speed limit or a red light violation, where a passenger, driver or other road user is injured; or, a scenario where safety is otherwise compromised.

Testing: The temporary operation of an ADS equipped vehicle or new vehicle technology for the purpose of evaluation, demonstration or exhibition. Testing must be approved by the respective provincial or territorial government and may include limitations on the environment/route where testing may occur.

Trial Organization: a company or organization seeking to test ADS-equipped vehicles in Canada. Trial organizations can include but are not limited to: original equipment manufacturers, technology companies, academic or research institutions, and manufacturers of parts, systems, equipment or components of ADS equipped vehicles.

LEVELS OF DRIVING AUTOMATION

LEVEL 0

NO AUTOMATION
The human driver performs all aspects of the dynamic driving task.

LEVEL 1

DRIVER ASSISTANCE
The vehicle's driver assistance features support the driver with **either** steering **or** acceleration/deceleration **under specific conditions**. The human driver is expected to perform all remaining aspects of the dynamic driving task, including monitoring and responding to the driving environment.

LEVEL 2

PARTIAL AUTOMATION
The vehicle's driver assistance features support the driver with **both** steering **and** acceleration/deceleration **under specific conditions**. The human driver is still expected to perform all remaining aspects of the dynamic driving task, including monitoring and responding to the driving environment.

LEVEL 3

CONDITIONAL AUTOMATION
The vehicle's automated driving system (ADS) features perform all aspects of the dynamic driving task, including monitoring and responding to the driving environment, **under specific conditions**. The human driver must **be alert and ready** to perform the dynamic driving task when the system requests the human driver to intervene.

LEVEL 4

HIGH AUTOMATION
The ADS-equipped vehicle performs all aspects of the dynamic driving task, including monitoring and responding to the driving environment, **under specific conditions**. The vehicle is designed to respond safely without human action to all situations, including when it reaches the limits of its operating environment.

LEVEL 5

FULL AUTOMATION
The ADS-equipped vehicle performs all aspects of the dynamic driving task, including monitoring and responding to the driving environment, **in all conditions**.