Safety Management Plan

Automated Driving System Demonstration Grant
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Automated Driving Systems (ADS) for Rural America Overview

Iowa has a bold vision to lead the nation in improving rural roadway safety while providing significant public benefit to our communities and transportation-challenged populations like the growing older American population segment. For decades, the University of Iowa (UI) has led cutting-edge national and international research in crash avoidance and ADS research. By leveraging our previous on-road demonstrations and research, as well as financial investment through the United States Department of Transportation (USDOT), ADS for Rural America will develop and execute a demonstration project that gathers and generates a wealth of publicly available data on rural roadways. This data will help to identify risks, opportunities, and insights relevant for USDOT safety and rulemaking priorities.

The ADS for Rural America project's primary goal is to test the safe integration of ADS on our nation's on-road transportation system by focusing on rural roadways, which comprise 91% of the total public roadway mileage in the US. By conducting our demonstration in rural America, highlighting the unique challenges these roadways and environments pose, we will broaden the scope of data being collected that will result in better insights and more comprehensive safety metrics for ADS nationwide.

ADS for Rural America will take place in Eastern Iowa, a region representative of much of rural America with its variable seasons, rural roads, and roadway hazards. The project will drive in a loop from a mid-sized city (Iowa City) through rural areas and small towns, providing an example for how ADS can connect rural populations (Figure 1). With a focus on connecting rural transportation-challenged populations like the rapidly growing aging sector, ADS for Rural America will utilize a custom, mobility-friendly ADS built on a commercially available platform.

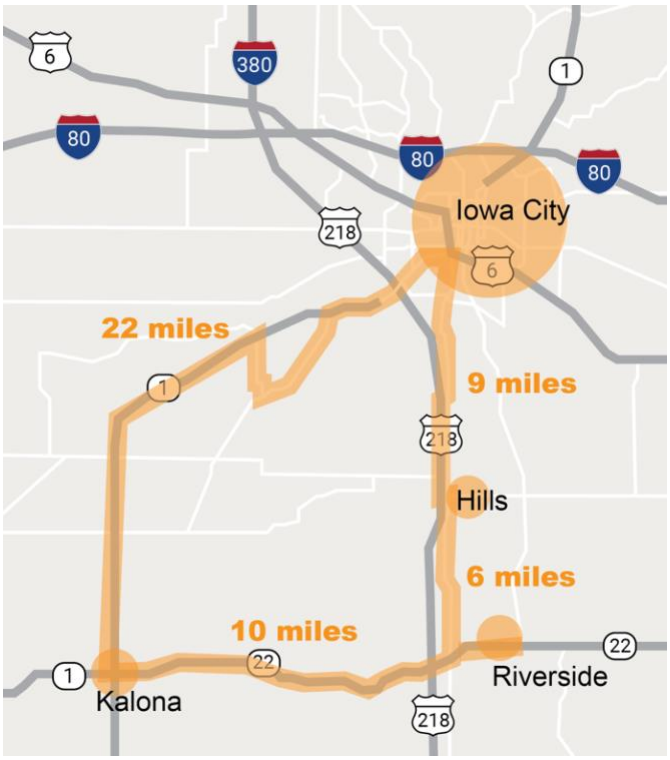

Figure 1: ADS for Rural America map

Rural roads are incredibly complex due to a variety of reasons: there are a larger variety of vehicle types, the speeds at which they travel, the types of roadways and the conditions of the lane markings and pavements. Overall, rural roadways are far more dynamic and unpredictable, which makes the safe integration of ADS onto these roadways an immensely challenging endeavor. There is a need for ADS to be tested under challenging, as well as more common conditions. It's also widely understood that there's a need to develop rich databases with more comprehensive geospatial roadway data to improve ADS' safe navigation and operation. Similar to much of the nation, ADS for Rural America provides these more

challenging conditions in which to demonstrate and record data in the operational design domains (ODD) in which ADSs are designed to operate.

ADS for Rural America consists of eight phases, with 10 drives each on the project route as shown in Figure 2.

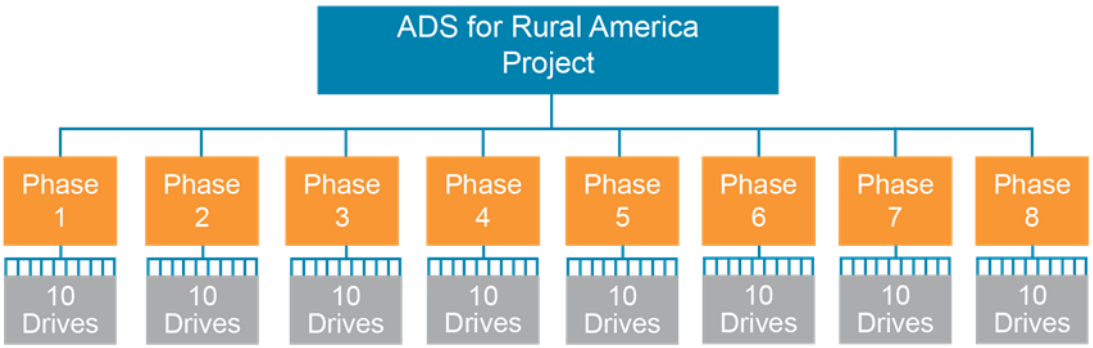

Figure 2. Project phases and drives

More automation will be introduced with each project phase to address different types of roads, intersections, driving conditions, and more that will be encountered. The defined route will be driven in its entirety for each of the project's eight phases to show how automation is increasing and to allow for comparison from one phase to the next. During each new phase, the ADS for Rural America project team will also be assessing the automation's performance and using the data collected to inform improvements in successive project phases.

Each drive will be scheduled to capture different lighting, weather, and roadway conditions to develop a dataset that will offer unique insights into the effects of these on ADS performance. Data anticipated to be collected for all phases and drives from the vehicle include:

- Automation and vehicle performance along entire route
- Automation and vehicle performance in varying weather and lighting conditions
- Automation and vehicle performance on varying road surfaces
- Safety driver and occupant physiological, emotional, and postural state
- Indexed data from sensors, video cameras (internal and external), and Light Detection and Ranging (LiDAR)

Safety is ADS for Rural America's top priority *and* the mission of the UI National Advanced Driving Simulator (NADS): To improve safety by researching the connections among drivers, motor vehicles, and road users. Safety will remain our utmost priority, as evidenced through our incorporation of a Safety Management Plan. This plan helps demonstrate our thoughtful commitment to the public that we are considering all of the aspects necessary for safe testing of these vehicles on our roadways.

The Safety Management Plan

As an on-road ADS project, we acknowledge that there will understandably be many questions from community residents, law enforcement, local public agencies, businesses, and others. Recognizing this, ADS for Rural America has developed a safety management plan that describes our approach to safely testing ADS. Our plan follows the guidance laid out by NHTSA (2016) as well as the Automated Vehicle Safety Consortium (2019) regarding the safety operator selection, training, and oversight procedures for ADS testing on public roadways.

This document provides a detailed view of the safety considerations being taken to ensure the safe testing of ADS on our public roadways. It will outline the processes and types of training for our ADS-operated vehicle, including the vehicle safety systems and features, vehicle operator requirements and their roles, basic driver training, ADS-operation training, and emergency procedures.

VEHICLE'S SAFETY FEATURES

The ADS for Rural America project will utilize a custom-built, mobility-friendly Ford Starlite Transit shuttle bus. This accessible vehicle is outfitted with a wheelchair lift, securement location, and securement system in compliance with Americans with Disabilities Act (ADA) requirements set forth in 49 CFR Part 38. The vehicle is based on a 2020 model year Ford Transit 350 HD Cutaway Cab chassis with a 138" wheelbase (Figure 3). The interior cab has two forward-facing seats, one for the safety driver and another for the co-pilot. Convenience and safety features on the vehicle include:

- Anti-lock brakes
- Brake assist with hill hold control
- 3 point integrated retractable seat belts (all seats)
- Dual front impact airbag supplemental restraint system
- Safety canopy system curtain, first row overhead airbag
- Pre-collision assist with automatic emergency braking (available in both manual and automated modes)
- Adaptive cruise control with lane centering (disabled while in automated mode)
- Front and rear camera system with split monitor
- 5 lb. fire extinguisher, 25-unit first aid kit, and reflector triangles

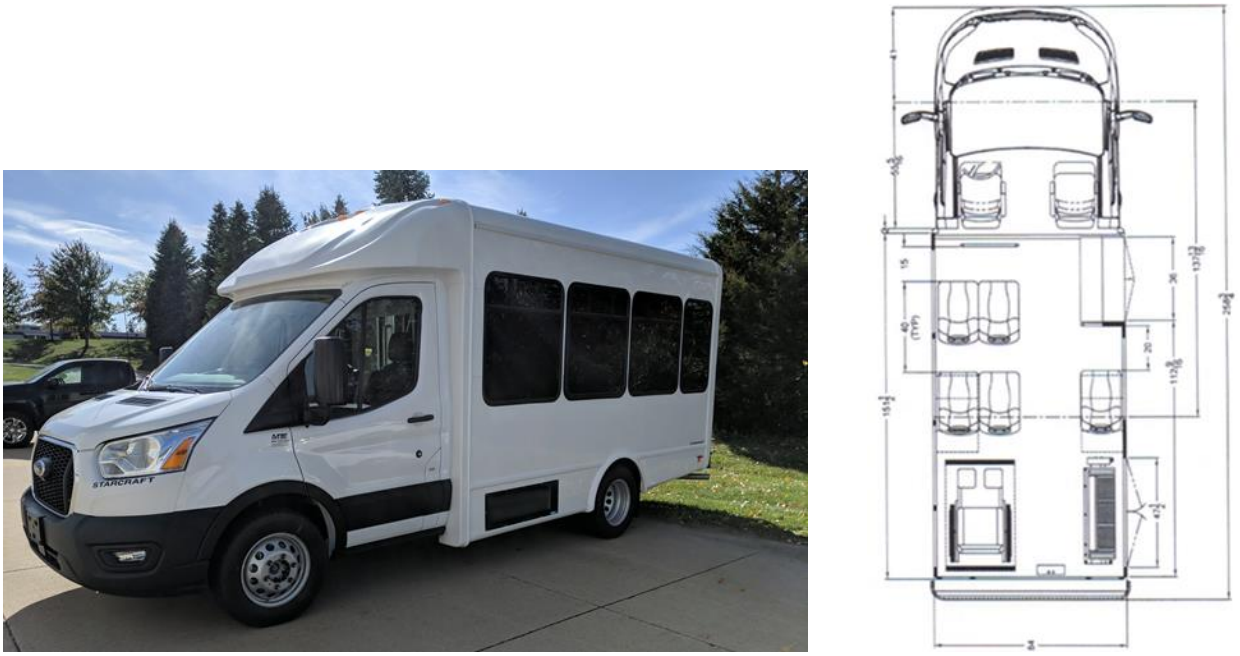

Figure 3. Driver side view of shuttle (left) and schematic view of the shuttle interior after being upfitted (right)

The vehicle was upfitted by Starcraft Bus for multiple passengers and meets ADA requirements under 49 CFR Part 38 (Figure 4). The front entry door has a stairway with handrails on either side. It is in compliance with the Federal Motor Vehicle Safety Standards (FMVSS). Equipment on the vehicle includes:

- Interlock safety system
- Dual panel rear lift door on curb side
- Braun 800# minimum wheelchair lift, 34" x 51" platform
- One set of Q-Straint (Q8101-L) deluxe retractable wheelchair/passenger restrain system with retractable lap and shoulder belt, flush mounted "L" track in floor
- Interior and exterior LED lift area lighting
- Interior ADA priority seating signage

Figure 4. Passenger side view with ADA compliant entry door and wheelchair lift (left) and passenger being unloaded using wheelchair lift (right)

In order to accommodate the higher levels of automated driving, the vehicle has been instrumented with hardware and software. This includes adding a drive-by-wire control system as well as several sensors and computing systems to understand the traffic around the vehicle and make decisions for what to do next.

- Sensors: LiDARs, cameras, and radars to "see" all around the vehicle
- Algorithms running on powerful computers to determine the traffic situation all around the vehicle and plan where to go next
- GPS antenna and highly detailed 3D maps to aid in vehicle positioning
- Precise inertial measurement systems

The operator has the ability to disable the automation and revert to full manual control at any time with a simple maneuver. Most of these maneuvers, known as "safety takeovers," would be an operator's natural reaction to roadway hazards, such as quickly turning the steering wheel or pressing on the brake pedal. A firm takeover is required when using the steering wheel or brake pedal to regain manual control of the vehicle. During this application, it may feel as though the steering or braking is holding its current position. This is expected behavior and control will be reverted back to the safety driver quickly.

The following safety takeovers will immediately disable by-wire mode:

- Pressing the E-stop button
- Pressing the brake pedal
- Pressing the accelerator pedal
- Turning the steering wheel

The ADS has been designed to detect certain, but not all, faults in vehicle control modules. These include, braking, steering, accelerating, shifting, and communication. A display will be located near the co-pilot that provides safety-related information regarding the health and status of each module and therefore the level of automation available at different points along the drive (see Figure 5). It will be the job of the co-pilot to monitor this display and communicate any issues. The safety driver should always pay attention to the vehicle and surroundings and be ready to perform a safety takeover. Additionally, before operating the vehicle, the operators should always complete a full startup procedure to ensure all control systems are properly functioning. Audible alerts will sound during faults, mode changes, and when the by-wire system E-stop is depressed. It should be noted that the by-wire systems are fail-passive. For instance, a failure in the steering "by-wire" system will not interfere with the driver's ability to manually control the vehicle. Return to automated mode will not be possible until the fault has been cleared and the safety driver and co-pilot agree that it is safe to do so.

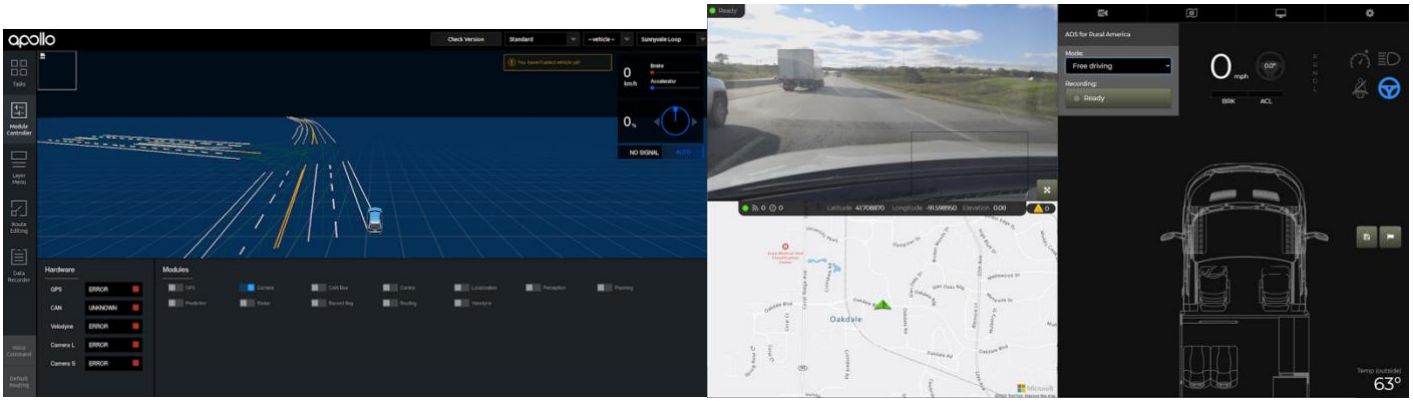

Figure 5. Draft renderings of the co-pilot safety interface; Dreamview from Apollo (top), IVy Control Panels (bottom)

THE SAFETY TEAM

Everyone on the safety team has an important role to play in making sure that ADS for Rural America is successful. The truest measure of success is the safety of our riders, our staff, and the public. To this end, we have identified several team members and specific roles and responsibilities to ensure that safety is foremost in everything we do.

Research and Data Collection Staff

The main role of the research and data collection staff is to ensure the comfort of those who are riding in the vehicle and to adhere to all procedures approved by the University of Iowa's Internal Review Board (IRB). They will be responsible for collecting questionnaire and biometric data from the passengers and will be the person they will reach out to with any questions/concerns during the drive. All research and data collection staff are IRB certified. Specific responsibilities include:

- Ensuring the safety of riders as they enter and exit the vehicle, including the operation of the wheelchair lift when necessary and wheelchair tie down
- Ensuring that all riders in the vehicle are wearing their seatbelt
- Presenting riders with all necessary information regarding the drive they will experience
- Following all IRB approved protocols including obtaining their consent for participation
- Monitoring rider health and comfort (e.g., motion sickness, need for restroom breaks, any other potential medical concerns)
- Aiding riders who need additional help using the technology necessary for data collection

All participants will have a help button on their tablet that when pushed will notify the researcher that one of the riders has a question or needs assistance.

Vehicle Instrumentation and Maintenance Personnel

The instrumentation and maintenance personnel will include members of the ADS for Rural America team as well as UI Fleet Services. They will be responsible for the health and maintenance of the vehicle. Specific responsibilities include:

- Informing the vehicle operators of any changes made to the vehicle that will impact the operational design domain of the vehicle
- Completing pre- and post-trip vehicle inspections
- Documenting any issues that arise during these inspections and how they were addressed
- Completing routine vehicle inspection and maintenance as necessary. This will be completed by UI Fleet Services.

Remote Vehicle Monitor

The remote vehicle monitor will have access to video outside of the vehicle in real time. They will be available to aid the vehicle operators in the case of an emergency. Specific responsibilities include:

- Calling emergency personnel in the case that vehicle operators are unable for some reason

- Providing assistance to the vehicle operators in the case of a vehicle breakdown (e.g., calling to arrange transfer of riders to another vehicle)
- Documenting specific interactions or issues that should be reviewed in the video/data stream

While most of the route has been measured to have solid 4G data coverage, there may be circumstances where weather or other signal interference could cause the remote data connection to the vehicle to drop for short periods of time. It's important to note that Emergency (911) cell service is continuously available and will be independent of cell service

VEHICLE OPERATORS

The importance of the vehicle operators cannot be understated: They are critical to the safe testing of ADS on public roadways. Knowledge and experience with advanced vehicle systems and their operation is an important pre-requisite for the job. Our operators are employees of the University of Iowa National Advanced Driving Simulator who have years of experience in vehicle testing and safety. They are highly trained and are dedicated to ensuring the safety of our participants, our staff, and the public. To this end, our vehicle will always be operated by a dedicated team that includes both a safety driver and a co-pilot. The roles of the operators are complimentary but there is a clear division of labor to ensure that neither is overwhelmed with the tasks necessary for safe operation and communication.

Safety Driver

The safety driver is responsible for safely responding to unexpected ADS and vehicle behaviors by taking over operational and tactical functions from the automation (e.g., braking, steering and acceleration, monitoring the environment, or response execution). Their two main duties are to (1) anticipate unexpected ADS and vehicle behaviors in a variety of operating situations and (2) control the vehicle during these situations, if they occur.

Specific responsibilities include:

- Monitor the road and the behavior of the vehicle at all times
- Keep hands on or near the steering wheel to reduce takeover response time
- Disengage the ADS at the first moment deemed appropriate, for example, if:
    - The vehicle attempts an action that would violate the rules of the road
    - The vehicle engages in an action that results in a potentially unsafe situation
- Take control of the vehicle in case of disengagement
- Drive the vehicle outside of its ODD

Co-Pilot

The main responsibility of the co-pilot is to monitor the proper operation of the ADS, including the sensors, perception, prediction, planning, and control systems, and to inform the safety driver of any irregularities. In addition, they are responsible for communicating with the safety driver to enhance the safety driver's situational awareness.

Specific responsibilities include:

- Monitoring the operation of the ADS systems (sensors, perception, prediction, planning, and control system)
- Communicating system intentions, object detection failures and system status to driver
- Troubleshooting basic system behaviors
- Identifying issues and providing feedback on system performance through trip reports. These will serve as a record for post-drive review of the video and data in order to gather further details. The trip reports will include information such as:
    - Drive date/time
    - ID of safety driver and co-pilot
    - Weather conditions (e.g., temp, precipitation, wind speed)
    - Unexpected ADS or vehicle behaviors
    - Situations of particular interest or that require further review

- Starts and stops data logging and tagging of data

VEHICLE OPERATOR REQUIREMENTS

The ADS for Rural America shuttle bus is a University of Iowa vehicle that is being used for demonstration purposes. We will comply with the University Driving Policy as applicable (https://opsmanual.uiowa.edu/administrative-financial-and-facilities-policies/risk-management-insurance-and-loss-prevention#15.7). In addition to the UI Driving policy:

- All operators must have a driving record which meets the University Driving Policy standards.
- All operators will be over the age of 25 and have an appropriate and valid US driver's license. A Class D chauffeur's license with Endorsement 3 is the license requirement for this type of vehicle.
- Operators must follow all applicable motor vehicle laws, including the following:
    - Seatbelts will be worn at all times, by all passengers of the vehicle.
    - Cell phones are not to be used or viewed by the driver when the vehicle is in motion.

Additionally, all operators must complete basic training on the vehicle operations as well as training specific to the ADS. All training will be completed without passengers. Once training is complete, staff from the UI will act as passengers to ensure all procedures are vetted before actual passengers are recruited from the community.

Basic Driver Training

Basic driver training will begin in the classroom before moving to a closed course (e.g., parking lot or abandoned airport runway), to a 2-mile loop around NADS and then finally on the public roadways identified along the specific route to be driven for the demonstration. The basic driver training classes will concentrate on general understanding of manual vehicle handling and dynamics and will be provided by the University of Iowa's Cambus Services (training materials can be found in Appendix A).

The classes will cover the following topics:

1. The importance of vehicle familiarity and pre- and post-trip vehicle inspection (vehicle inspection details as well as the vehicle inspection report template can be found in Appendices B and C)
2. Vehicle maneuver techniques
    - Turning, steering, braking, stopping distance, following distance, etc.
    - Clearance
    - Use of mirrors
    - Hills
    - Railroad tracks
    - Traffic circles
    - Entering/exiting highways
3. Vehicle handling under special conditions
    - Rain, snow, night driving
4. Making safe stops
5. Elderly riders and riders with disabilities
    - ADA requirements
        - Maintenance of accessibility features
        - Keeping vehicle lifts in operative condition
        - Lift and securement use
    - Boarding/alighting riders
6. Defensive driving

Additional training specific to the ADA compliant paratransit equipment on our vehicle will include:

1. Wheelchair and passenger securement (see Appendix D)
2. Wheelchair lift operation (see Appendix E)

ADS Training

ADS training will begin in the classroom before moving to a closed course (e.g., parking lot or abandoned airport runway), to a 2-mile loop around NADS and then finally on the public roadways identified along the specific route to be driven for the demonstration. This training will be provided by AutonomouStuff and will take place at their facility upon receipt of the vehicle, when the vehicle arrives at the University of Iowa, and again at the beginning of each new phase. An overview of the training provided is described below. Training materials can be found in Appendix F.

- Classroom training will focus on the types of sensors that will be used, their role in the automation, and the strengths and limitations associated with each sensor. This will provide the operator with information that can help inform their decision making and calibrate their trust in the system. Effective communication strategies will also be discussed, including key items to be included in trip notes, as well as best practices for communication between the safety driver and co-pilot regarding important environmental situations and critical system statuses to ensure readiness and safe operation.
- During closed course training the operator will learn to conduct the ADS specific pre- and post-trip protocols (Appendix G) and complete an ADS inspection report (Appendix H). The protocols will include visual inspection of sensors, in-cabin system checks, and ADS health reports. They will also be introduced to system operations, including the human-machine interface. The operator will gain practice in a safe environment engaging and disengaging the automation and will learn to recognize when the ADS is or is not engaged. This will limit confusion regarding responsibility of the dynamic driving task. Operators will also be trained on identifying failures and responding to unexpected disengagement initiated by the ADS as well as the E-stop button in order to prepare and train them for quickly resuming control. They will also practice responding to environmental hazards, including exercises performing evasive maneuvers.
- On-road training will be supervised by engineers from AutonomouStuff or UI team members who have successfully completed both basic and ADS training. The training will begin as either a ride along or as the co-pilot so that the person being trained can observe the safety driver and the in-vehicle communications. The skills of the person being trained will be verified by experienced personnel under increasingly complex driving environments, until they are proficient driving the entire ADS for Rural America route.

Periodic Re-evaluation and Training

Basic driving training will be revisited throughout the project in order to practice skills that may not be commonly used (e.g., evasive maneuvers). In addition, ADS operation training will occur before every phase of the project as the systems in the vehicle are modified or upgraded. From one phase to the next the ODD of the vehicle may change, and it is imperative that the operators are aware of all system parameters and limitations.

ON-ROAD TESTING PROTOCOLS

We have identified specific procedures in order to ensure the safety of those in the vehicle as well as other road users we encounter along the route. These will include emergency procedures and safety team protocols, pre-trip protocols, in-trip protocols, and post-trip protocols. Each of these will be discussed in detail in the sections below.

Emergency Procedures

Under any circumstances, if the safety driver does not feel comfortable driving the vehicle, testing will be cancelled. Additionally, there may be instances when testing will take place without passengers/riders in the vehicle.

Inclement Weather Policy

- We will not operate when schools along our route are closed due to weather (e.g., snow, ice, fog).
- We may operate without passengers when schools along our route are closed due to extreme temperatures.
- When school buses are allowed to travel on hard surfaces only, we will not drive the gravel portion of our route.
- We will ensure that the location where we are picking up/dropping off has been cleared of snow or ice.

Tornado Safety Procedures

All tornado watches will be closely monitored. If the radar indicates weather that has the potential for producing a tornado is heading in the direction of our route, we will not operate. We **will not** operate if there is a tornado warning in effect anywhere along the route. However, if a warning should occur while en-route, these procedures are to be followed:

- Seek a safe area if there is a tornado warning for the county you are traveling in. If a tornado warning is sounded, you should seek shelter at the closest safe area. Inform any passengers/staff to seek shelter and assist those needing assistance to a tornado safe shelter. The following locations are stops along the route and considered to be **TORNADO SAFE SHELTERS**:
    - Iowa City Marketplace
    - Riverside Casino
    - Hills Community Center
    - Kalona Public Library
- If driving in open country, drive at a right angle away from the tornado's path.
- If the vehicle is caught out in the open as a tornado is approaching, passengers/staff should seek shelter in a nearby depression, such as a ditch, culvert, or ravine. Direct people to protect their head and stay low to the ground, lying face down with hands over their head.

Fire

In the event of a fire on the vehicle, the safety driver should pull over as quickly as possible and set the brakes, open the doors, activate the flashers, and shut off the engine. The research staff will assess the situation, checking for injuries and begin evacuation of riders. The co-pilot will contact emergency personnel. If it is safe to do so, operators will use a fire extinguisher to put out the flame. Make sure that all staff and riders are kept a safe distance from the vehicle and wait for help to arrive. To prevent a fire on the bus:

- Perform a complete pre-trip inspection, including checking the fire extinguisher.
- While en-route, check your equipment, including tires, for signs of heat.
- Monitor your instrument panel for signs of trouble.

Mechanical Breakdowns

If the vehicle has mechanical issues during the drive, the safety driver will stop the vehicle in a safe location, activate the flashers, and position the emergency triangles. The operators will then check for danger, fire, smoke, and leaks such as fuel leaks. All displays will be examined in order to check for possible causes. The operators will contact staff at NADS who will determine the appropriate actions, including the transport of riders to the appropriate drop-off location. Riders will be kept informed of the situation as information becomes available. When it is safe to do so, the ADS-equipped vehicle will be transported to NADS for inspection and maintenance. Safety checks and additional testing will be completed before any drives with riders will resume.

Violations/Citations

- Drivers are required to promptly report any moving violations or citations to Omar Ahmad (project manager) and Dan McGehee (director, NADS). This information must be immediately forwarded to University of Iowa Fleet Services.
- Instances of hit and run or vandalism of the vehicle should be reported immediately to the police or University of Iowa Public Safety.

Crashes

- Driver's first responsibility is to call 911 and ensure the health and safety of all passengers, with the help of other UI staff on board.
- Drivers are required to report crashes as soon as possible to the UI project manager (Omar Ahmad). The UI project manager will then follow the crisis communication plan found in Appendix I. This will include contacting NADS director (Dan McGehee), NADS head of communications (Kristine Roggentien), and UI Head of Fleet Services (Mike Wilson). The

UI project manager will also notify the Federal Transit Administration (FTA) project manager (Steve Mortensen) and the Federal Highway Administration (FHWA) co-manager (John Gibson). See Appendix I for more details.

Note: The crisis communication plan will be used in case of a crash, fire, vehicle breakdown, medical emergency on board, or other incidents for which the project manager determines it is necessary.

- A Vehicle Accident Report form (Appendix J) must be completed and sent to UI Risk Management.

Medical Emergencies

If there is a medical emergency, the ADS research staff will respond in the following way:

- Stop the vehicle in a safe location, off the side of the roadway, making sure that it will be accessible to emergency responders if necessary.
- Determine if the rider needs medical attention. If you suspect medical assistance may be necessary, call 911.
    - Know WHERE you are. This is probably the most important information you can provide as a 911 caller, so use the in-vehicle display to identify street names, addresses, landmarks, or cross streets.
    - Stay calm. When you are on the phone with 911, try not to panic. Answer ALL of the 911 operator's questions so they can get the right services to your location as quickly as possible.
    - NEVER hang up unless instructed to do so.
- Make the person comfortable and reassure them that medical assistance is on the way.
- Administer first aid if needed.
- Notify the UI project manager to initiate the crisis communication plan.

At least one of the operators on board the ADS-equipped vehicle will be certified in first aid and CPR by the American Heart Association.

Safety Equipment

The vehicle will have the following safety equipment on board. All staff will be informed of the equipment's location and trained on its use.

- 25-unit first aid kit
    - Gauze pads – ANSI 3" x 3" 4/unit
    - Strips – plastic – ANSI 1" x 3" 16/unit
    - Antibiotic cream – ANSI 1g 10/unit
    - Antiseptic BZK towelettes – ANSI 5" x 7" 10/unit
    - Burn cream – ANSI 1g 6/unit
    - Triangular bandage – O/W – ANSI 40" x 40" x 56"
    - Absorbent compress – ANSI 32 sq."
    - Strips – heavy weight woven fingertip
    - Strips – heavy weight woven knuckle Non-stick pad 2" x 3"
    - Gloves – Nitrile – ANSI large 1/pair
    - Tape – ANSI 1/2" x 2 1/2 yd.
    - Cold pack – junior 5" x 7"
    - PVP iodine swab crushable
    - Insect sting wipe-ups 1" x 2"
    - Eye wash 1 oz
    - First aid facts guide card
- Automated external defibrillator (AED)
- 5 lb. fire extinguisher
- Reflector triangles
- Cell phone and list of emergency contacts

COVID-19 and Precautions

Note: These will be revisited as we get closer to the actual demonstration. COVID-19 is a very fluid situation, and the precautions may be tightened or relaxed based on the state of knowledge at that time. What is described below is what is currently being recommended for all naturalistic driving studies (as of March 2021).

The following precautions will be taken to minimize the potential for the spread of COVID-19:

- All participants/riders will be contacted 2 days prior to their appointment to review COVID symptoms and potential exposure.
- Prior to entering the vehicle, all human subjects' temperature will be taken with a non-touch thermometer, and health questions will be asked.
- Masks will be worn by everyone who enters the vehicle. The researcher who will have direct contact with participants/riders will also wear a face shield.
    - This is also in adherence to the Center for Disease Control's (CDC) federal mask requirement for transit systems based on President Joseph R. Biden's Executive Order 13998, issued January 21, 2021. The TSA has extended the face mask requirement for all transportation networks, including public transportation, through September 13, 2021. https://www.transit.dot.gov/coronavirus
- All staff and participants/riders will be required to use hand sanitizer upon entering and exiting the vehicle.
- Participants will be limited to three per drive, and they will be seated 6 feet apart.
- Windows will be cracked to allow sufficient air flow inside the vehicle.
- HEPA air filters will be installed in this vehicle.
- Vehicle interior (seats, seat belts, windows, doors, railings, etc.) will be cleaned with appropriate disinfectant before and after each drive.
- All tablets touched by staff or participants will be cleaned with appropriate disinfectant before and after each drive.

These procedures have been recommended by an expert in the field of epidemiology at the University of Iowa Hospitals and Clinics and approved by our UI IRB.

SAFETY TEAM PROTOCOLS

Pre-trip Protocols

- Pre-drive preparation
    - Ensure that the test vehicle has the proper paperwork and documentation (e.g., license, registration, insurance), as well as emergency protocols and emergency contact information in the case of an emergency.
- Conduct a pre-trip briefing
    - Any updates to the safety driver or co-pilot procedures will be discussed.
    - A list of significant changes and/or updates to the hardware and software will be generated. The functional impact of the updates, as well as the limitations of the ADS will be generated for the team and discussed during the pre-trip briefing.
    - Any anomalies along the route (e.g., construction, road closures), current road conditions, and the weather forecast will be discussed.
- Conduct all pre-trip inspections (vehicle and ADS-specific):
    - Visually inspect the vehicle (e.g., tires, windshield, lights)
    - Check the condition of the ADS hardware (e.g., sensors are operational and scratch free, firmly mounted, and clean)

In-trip Protocols

- No more than one drive will be completed per day to prevent fatigue and vigilance decrements.
- Personal electronic devices cannot be used by the safety driver.
- Personal electronic devices cannot be used by the co-pilot. However, they are not prohibited from operating electronic equipment necessary to monitor and operate the AV technology.
- Communication between the safety driver and co-pilot should be limited to topics related to safe operation of the vehicle.
- Eating and smoking are not permitted by the safety driver, co-pilot, or anyone else on board the vehicle.
- The safety driver should not operate the vehicle if they are under the influence of alcohol or drugs, including prescription medicines that may impact their ability to operate a vehicle.
- The safety driver and co-pilot should eliminate distractions from noise (e.g., radio).

Post-trip Protocols

- Conduct a post-trip briefing:
    - On-board personnel should communicate to the rest of the team any ADS issues, system performance, and anomalies.
    - Discussion of any newly experienced events (e.g., edge and corner cases, near misses). These need to be documented, flagged in the data, and reviewed.
    - Discuss any takeover events that were unexpected and ensure that these are documented.
- Conduct a post-trip inspection.
    - Shut down of all systems occurred as expected.
    - Data download occurred as expected.
    - There are no signs of damage to sensors or other equipment.

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PART 37 - TRANSPORTATION SERVICES FOR INDIVIDUALS WITH DISABILITIES (ADA) Authority:42 U.S.C. 12101-12213; 49 U.S.C. 322. Source:56 FR 45621, Sept. 6, 1991 (https://ecfr.io/Title-49/Part-37)

PART 38 - AMERICANS WITH DISABILITIES ACT (ADA) ACCESSIBILITY SPECIFICATIONS FOR TRANSPORTATION VEHICLES Authority:42 U.S.C. 12101-12213; 49 U.S.C. 322. Source:56 FR 45756, Sept. 6, 1991, (https://ecfr.io/Title-49/Part-38)

Appendix A: Basic Driver Training

The goal of this program is to teach you good defensive driving habits. By the end of training, you must demonstrate competence in:

- Inspecting the vehicle
- Adjusting and using your mirrors
- Starting, steering, accelerating, and braking
- Maintaining proper following distance
- Passing
- Negotiating curves
- Maneuvering through intersections
- Special driving circumstances

INSPECTIONS

Before beginning your trip, you will need to properly inspect your bus. There are many reasons a professional operator must inspect the vehicle. These reasons include:

- Safety – Inspect your bus to know it's safe;
- Legal Requirements – Federal and state laws require inspections;
- Familiarization – Inspection provides a way to become familiar with the controls.

Vehicle inspection should be an ongoing process. The inspection begins before setting out on your route. However, it should continue during and at the end of your day.

While en-route, you should use your senses to check for problems. Listen for odd noises and notice any unusual smells. Keep an eye on your lights and gauges.

Don't forget to fill out the vehicle inspection report, adding any problems noted during, or at the end of, your trip.

General Inspection Method

Do the inspection the same way each time so you will be less likely to forget any of the steps.

Step 1: Approach the vehicle; notice the general condition of the body; check to see if the bus is leaning.

Step 2: Check the engine compartment for oil, fuel, and coolant leaks. Check the belts and wiring for obvious defects.

Step 3: Start the engine and listen for unusual noises. Check the dash lights and gauges. (Make sure no mechanics are working on vehicle first). Turn on the headlights, four-way flashers, and interior lights. Check the condition of the driver's controls.

Step 4: Walk around the vehicle and check the headlights, clearance lights, brake lights, and turn signals. Check tires for tread depth (4/32 in the front, 2/32 in the rear – no recaps or retreads on the front tires). Cycle wheelchair lift.

Step 5: Check the passenger compartment to see if the seats are clean and secure. Check the floor for cleanliness and for any slipping hazards. Check the stairwell lights and check the steps for cleanliness. Verify that all wheelchair securement system components are present.

Step 6: Check the brake system (if applicable).

STARTING AND SHIFTING

It is very important to become completely familiar with the operation of each control in the driver's compartment. The more familiar you are with the controls, the more you will be able to concentrate on:

- Driving the bus
- Reacting to emergencies

Bus starting procedures include

1. Turning on the master switch to “day run” position
2. Pushing the starter button
3. Warming up the engine

STEERING

Push-Pull Method

Use this method for making minor corrections in the direction of travel:

- Pull the wheel down with one hand while pushing up with the other.

Hand-Over-Hand Method

Use this method for making turns and maneuvering around curves:

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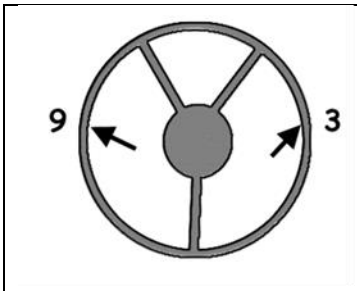
<td> 
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Start with your hands at the 3 and 9 o’clock positions on the steering wheel.
Lean forward and with one hand grasp the outside of the steering wheel at the 10 o’clock position.
Then lean back pulling the wheel down.
Repeat as needed to complete your maneuver.

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Caution

- Never hook your thumbs under the steering wheel. If the wheel snaps back, it could break your thumbs.
- Do not wear jewelry that may catch on your clothing while driving the bus.

ACCELERATING

Procedure for Accelerating

1. Accelerate during the first third of the block.
2. Maintain speed in the second third of the block.
3. Prepare to stop in the final third of the block.

Being prepared to stop at intersections helps to prevent:

1. Riders being thrown to the floor and injured by abrupt stops
2. Vehicles rear-ending the bus
3. Excessive wear on the brake system

Prepare to stop for:

1. Traffic lights turning yellow then red
2. Pedestrians crossing the street
3. Stop signs
4. Other vehicles crossing the intersection

STOPPING DISTANCE

Stopping distance is the distance it takes the bus to stop after you first see a hazard until the time that the vehicle comes to a stop.

Stopping distance factors:

- Perception distance is the distance a vehicle travels from the time you see a hazard (or stop sign) until your brain recognizes the object (usually about ¾ of a second).
- Reaction distance is the distance traveled from the time your brain tells your foot to press on the brake, until the time your foot actually depresses the brake pedal (usually about ¾ of a second).
- Brake lag is the time it takes for the air to travel from the storage tank to the brake chambers (usually between ½ and ¾ of a second). (only in air brake equipped vehicles)
- Braking distance is the distance traveled from the time you touch the brake until the bus actually stops.

Effects on Stopping Distance

Stopping distance is made up of three components: the vehicle, the operator, and road conditions.

Vehicle	**Operator**	**Road Conditions**
Equipment type	Illness	Rain
Weight	Emotions	Snowy or icy
	Stress	Gravel, sand, or wet leaves
	Fatigue	Oil

Caution: Wet roads can double stopping distance, so reduce your speed about one-third. On packed snow, reduce your speed by half. On ice, reduce your speed to a crawl.

FOLLOWING DISTANCE

Following distance is the distance you should maintain between your vehicle and another vehicle to allow for a safe stop.

At speeds under 40 mph, use the "1,000 and 4" rule to establish your following distance:

1. Note when the vehicle ahead passes a point (telephone pole, bridge, sign, etc.)
2. Begin counting "one thousand and one… one thousand and two."
3. Your vehicle should not pass that same point before you count to "one thousand and four." If you do, you are following too closely and should drop back.

At speeds over 40 mph add 1 second to determine your following distance.

Caution: Allow the same following distance for a bicycle, motorcycle, or moped as you do for other vehicles.

Stopping Behind Other Vehicles

- Keep following distance in mind when stopping behind another vehicle.
- Allow 10 feet between your paratransit vehicle and a vehicle that is stopped ahead.
- When the vehicle moves forward, allow five feet to open before moving your vehicle forward.

These techniques allow you to establish a safe following distance and allow sufficient room to maneuver around the vehicle if it should stall or stop.

Heavy Traffic

To maintain your following distance in heavy traffic:

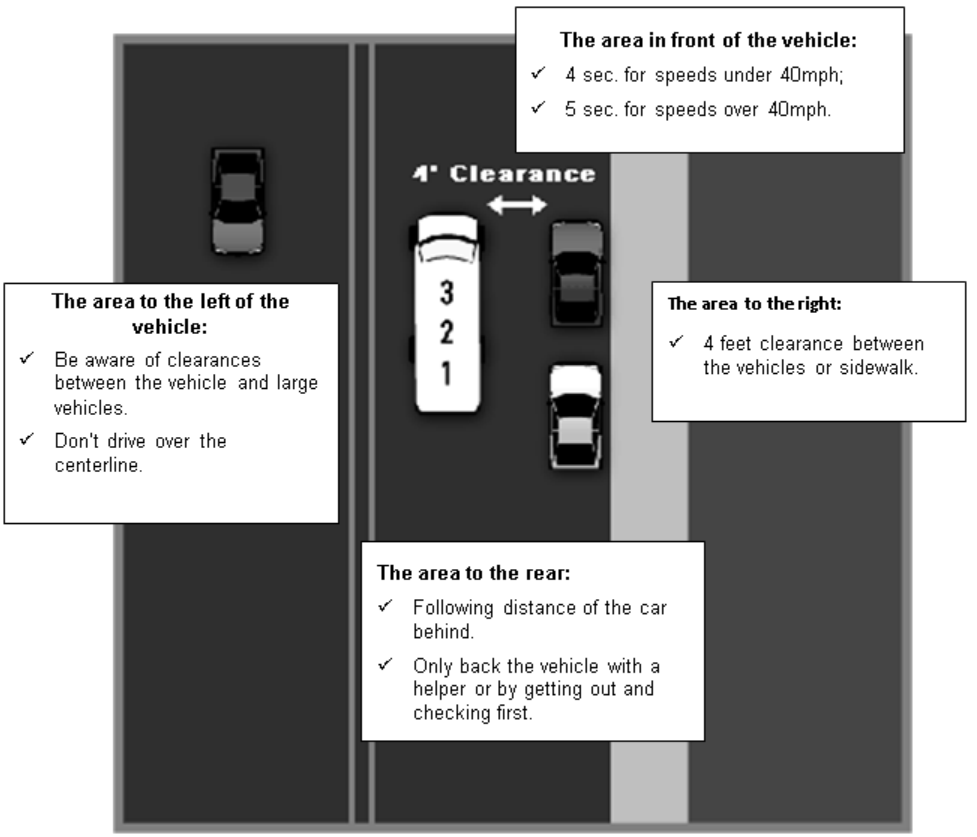
- Drop back as much as possible.
- Drive slowly if necessary.
- Drive more cautiously.

Caution: Be especially cautious around cyclists.

CLEARANCES

Know the height of the vehicle when it's empty. Do not assume heights posted on bridges, etc., are correct. When in doubt, stop the vehicle and check for clearance.

The clearance under the vehicle is less when the bus is fully loaded. Drive over tracks and dips slowly to prevent scraping. Don't hesitate to stop and check your clearance.



MIRRORS

For proper mirror adjustment, **remember to adjust your seat first.**

Special situations require more than regular mirror checks. These include:

- Lane changes
- Turns
- Merges
- Reduced clearances

Within turns, check your mirrors to make sure the rear corner of your vehicle will not hit anything.

When merging, use your mirrors to make sure the gap in traffic is large enough for you to enter.

Surveying the Road

Be particularly aware of:

- Traffic signs and signals
- Pedestrians, joggers

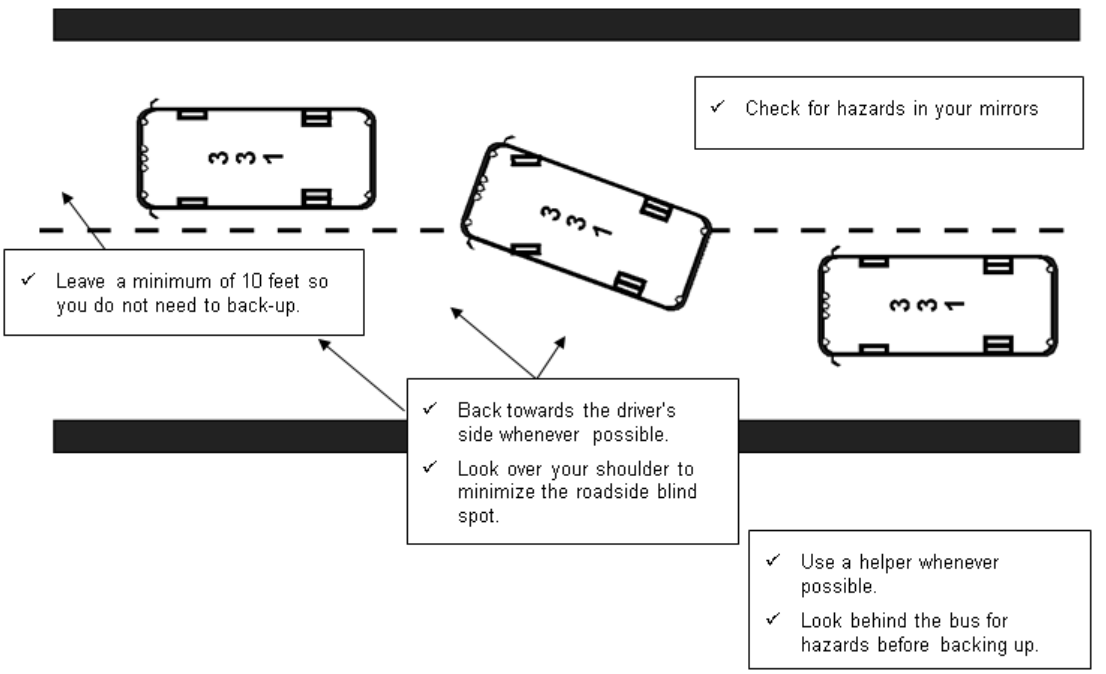
- Other vehicles, including bicycles and motorcycles
- Obstacles, such as construction, traffic islands, or branches in the road
- Animals

To properly survey the road, follow these steps.

1. Look in the left mirror.
2. Look in the inside mirror.
3. Look in the right mirror.
4. Look straight ahead.
5. Keep your eyes moving and repeat this pattern every five to ten seconds.

Learn and know the limits of your mirrors (where the blind spots are).

BACKING THE BUS



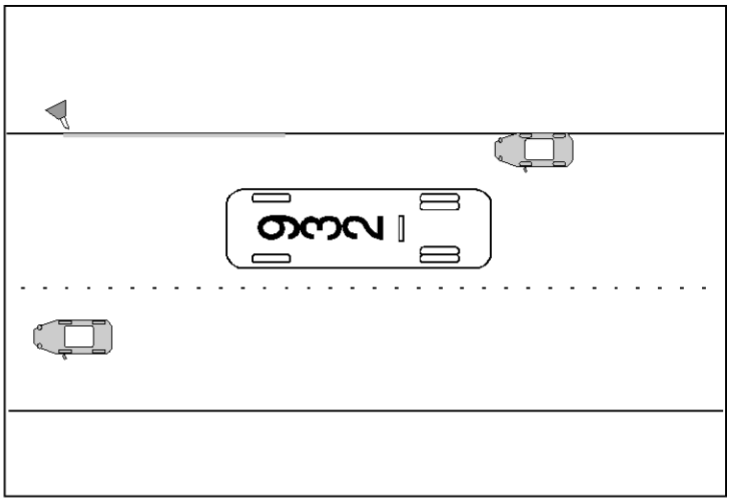
When backing the bus:

- Avoid backing the bus whenever possible. When it is necessary to back out of a parking space into the roadway, we will use a spotter. Drivers will also be trained to crack the window to listen and pull out slowly.
- Look at your path of travel before you begin moving the bus, both visually and using the back-up camera.
- Activate your four-way hazard lights.
- If your back-up alarm is not working, use continuous short beeps of your horn.

SHARING THE ROAD

Precautions.

- ✓ Leave yourself an escape route
- ✓ Other drivers may turn in front of the paratransit vehicle
- ✓ Watch for strong winds when passing other vehicles
- ✓ Beware of pedestrians on sidewalk
- ✓ You should not go over the centerline
- ✓ Leave 4 feet between the bus and the curb or parked cars.



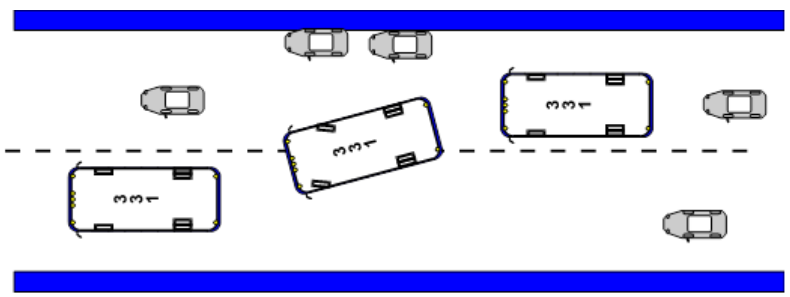
You should normally drive in the right lane because it:

- ✓ Allows you to make fewer lane changes when making vehicle stops.
- ✓ Prevents cars from passing the paratransit vehicle on the right.

Pull up or drop back to be sure other drivers can see you. Leaving room will give you an escape route.

Lane Changes

Every time you change lanes you increase your chances of having a collision.



Precautions

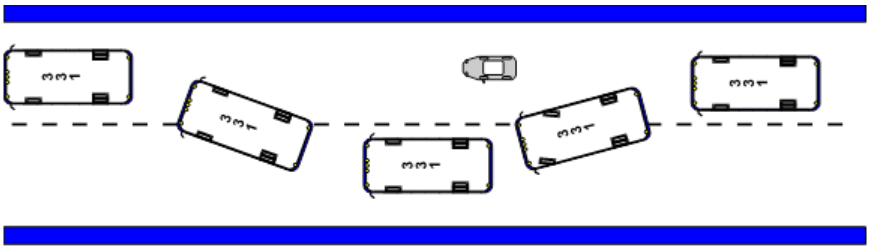
- ✓ Cars in your lane may stop for turns or delivery.
- ✓ Cars behind your vehicle may speed up to pass.
- ✓ Cars in blind areas may try to pass your vehicle.

Lane Changing Steps

1. Activate your turn signals.
2. Check for traffic in the next lane, behind and in front of the paratransit vehicle.
3. Move smoothly into the next lane.
4. Cancel your turn signal.
5. Maintain safe following distance.

Caution: Make lane changes smoothly to allow other cars time to react to the movement of the vehicle.

Passing Stopped Vehicles



Caution:

- ✓ Never turn in before the rear axle of the vehicle passes the car.

Do not leave too much space between you and the car before turning back in. If you leave too much room, cars may try to pass you on the right.

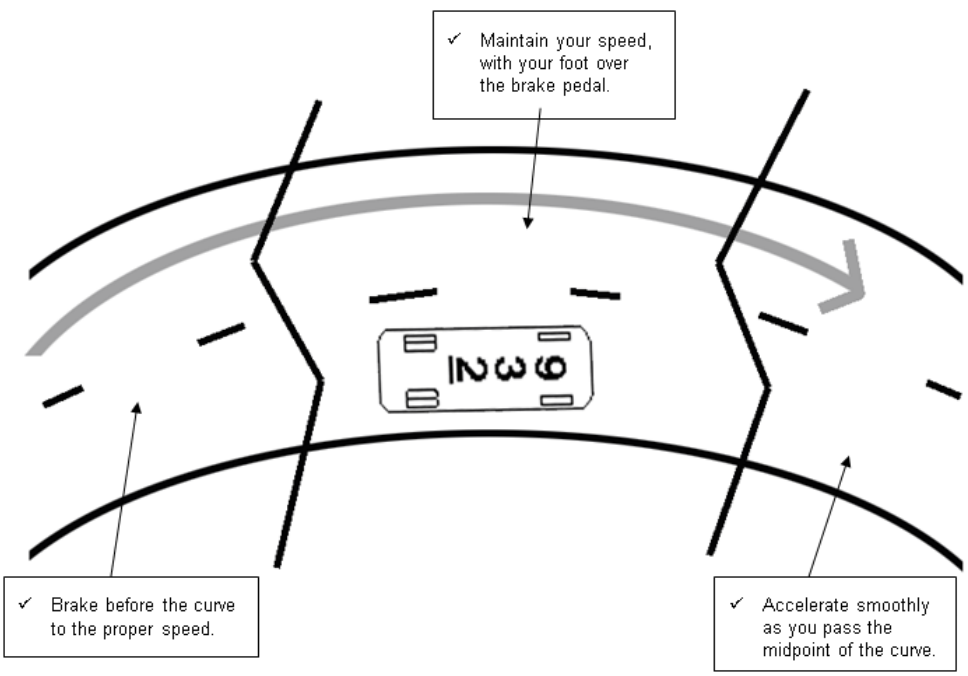
Passing Steps

- ✓ Check mirrors and activate turn signal;
- ✓ Move into the left lane;
- ✓ Pass the vehicle;
- ✓ Signal right;
- ✓ Move to the right only when you can see in your mirror, that you are clear of, and safely ahead of the passed vehicle

Caution: Treat cyclists as another vehicle. Give them the same—or more—side clearance and following distance.

ROAD GEOMETRY

Curves



Brake on the straight portion of the road. If you brake hard on the curved portion you could go into a skid.

Hills

Factors that affect vehicle speed when driving on hills are:

- Steeper grades
- Longer grades
- Heavier loads

- Road conditions and weather

As a general rule, go down the hill no faster than the vehicle will go up the hill.

Use a steady, even pressure on the brake to maintain the speed of the vehicle.

Narrow Streets

Any street that does not have a minimum of 3 feet on both sides of the vehicle should be considered a narrow street.

Caution:

- If you meet a car coming in the other direction, stop and check for clearance.
- Never drive over 15 miles per hour.
- If necessary, ask the other driver to back up.

Traffic Circles

The traffic circle is a type of intersection that frequently contributes to collisions.

Points to remember about traffic circles:

- Vehicles in the circle have the right-of-way.
- Continue around the circle if you cannot exit safely.
- Be aware of drivers in or near the circle who seem lost or confused.

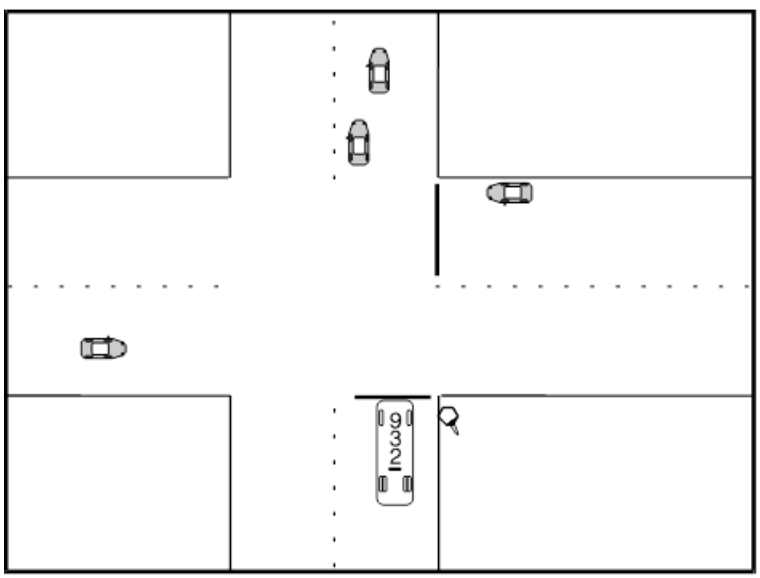
Parking Lots

Parking lots present a variety of hazards that can come at you from all directions.

Watch for:

- Drivers speeding up to cut you off to get parking spaces
- Drivers rolling through stops
- Drivers entering through the exits
- Pedestrians walking between cars or down the rows
- Drivers backing up without warning

INTERSECTIONS



Intersection Rules

- ✓ The vehicle that makes a complete stop at a four way stop first should proceed first.
- ✓ When two vehicles arrive at the same time the vehicle on the right goes first.
- ✓ Always give the right-of-way to pedestrians.
- ✓ Never insist on the right-of-way.

Procedure:

1. Check to the left first.
2. Check to the right.

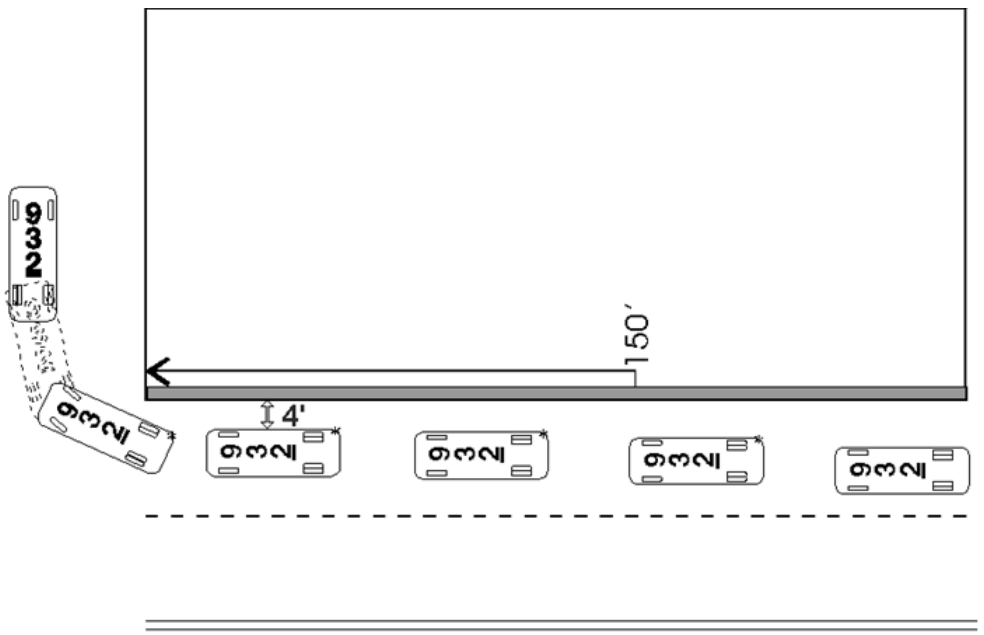
3. Check to the left again.
4. Proceed cautiously with your bus under control.
5. Remember safety first! Never sacrifice safety for your schedule.

Check for room across the intersection before proceeding.

Right Turn

Procedure:

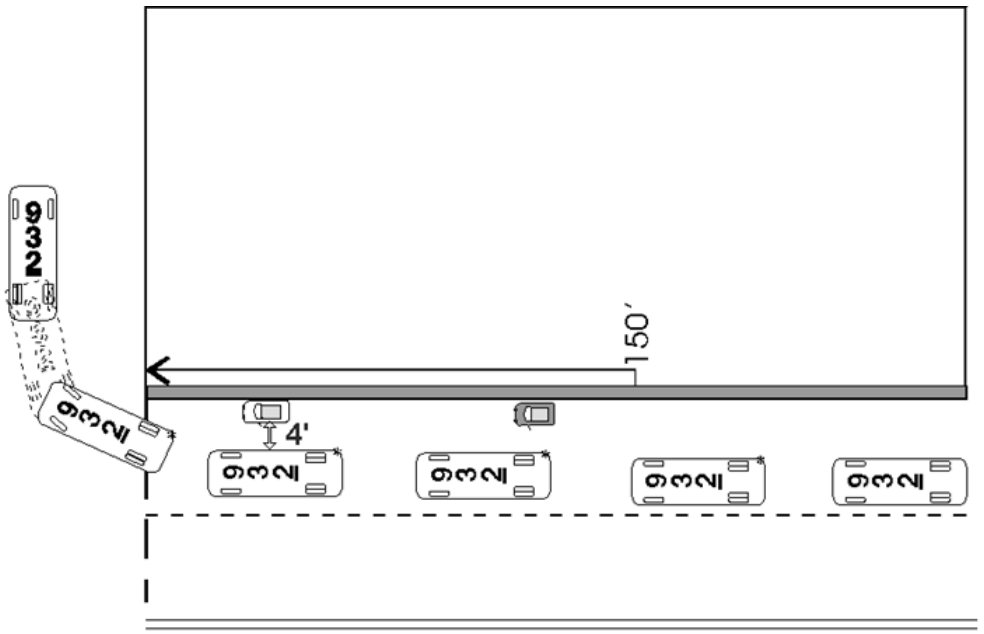
1. Activate your turn signal 150 feet from the intersection.
2. Align the vehicle parallel to, and 4 feet from, the curb.
3. Stop behind the limit line and move forward as needed to check for hazards.
4. Check your mirrors.
5. Make the turn at no more than 5 mph.
6. Start to straighten out when the right front corner is 4 feet from curb.



Right Turn With Cars On Same Street Forty Feet Or Less From Corner

Procedure:

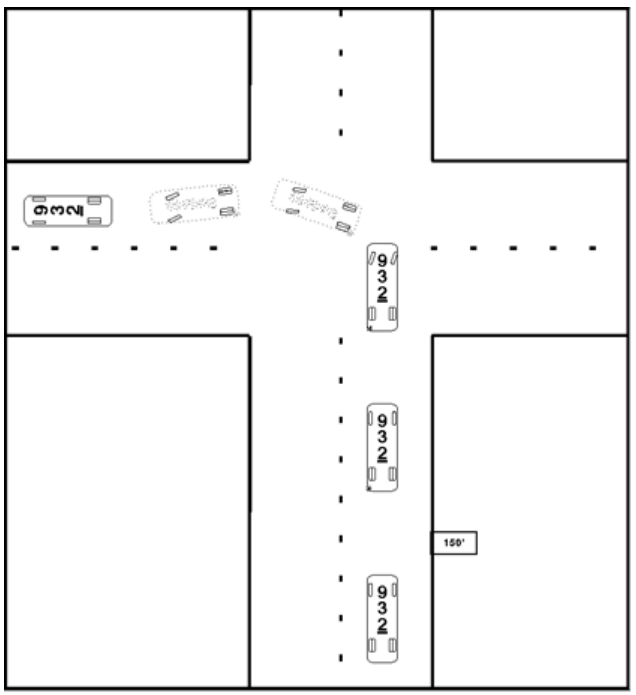
1. Signal 150 feet from the intersection.
2. Align vehicle parallel to and 4 feet from the car.
3. Stop behind the limit line and move forward as needed to check for hazards.
4. Check your mirrors.
5. Make the turn at no more than 5 mph.
6. Start to straighten out when the right front corner is 4 feet from curb.



Left Turns

Procedure:

1. Activate your turn signal 150 feet from the intersection.
2. Enter the correct lane no less than 100 feet before the intersection.
3. Stop behind the limit line and move forward as needed to check for hazards.
4. Check your mirrors.
5. Make sure you have reached the center of the intersection before you start the left turn. If you turn too soon, the left side of your vehicle may hit another vehicle because of off tracking.
6. When clear, begin the left turn.
7. Make the turn at no more than 5 mph.
8. Start to straighten out when the right front corner is 4 feet from the curb.



RAILROAD CROSSINGS FOR BUSES

Buses are required to stop for all railroad crossings unless one of the following conditions exists:

- The tracks are marked “Exempt.”
- The tracks run alongside and down the street.
- There is a traffic officer or flag person directing traffic.
- The tracks are controlled by a traffic signal light.

Procedure:

1. Activate the emergency flashers.
2. Stop between 15-50 feet before the tracks.
3. Open the front door to improve your ability to see and hear any trains.
4. Listen and look in both directions.
5. Make sure there is no traffic ahead which may prevent you from completely crossing the tracks.
6. Close the door and cross the tracks.

Caution:

- Never shift gears when crossing tracks.
- Never pass on the tracks.
- Never stop on the tracks.

If your vehicle is not considered a bus, the proper procedure for approaching a railroad cross is:

- Always approach the crossings at a reasonable speed.
- Be prepared to stop if you have to.
- Be especially alert when you are following buses or trucks, which may have to make a mandatory stop.

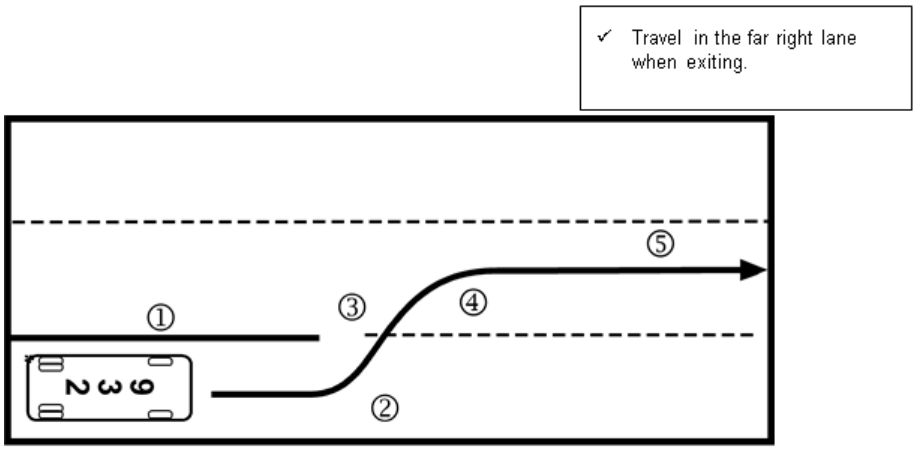
Do not proceed until you can do so safely.

STEPS FOR ENTERING THE EXPRESSWAY

Merging onto the Expressway

Procedure:

1. Activate turn signal 150 feet before merging onto the expressway.
2. In the acceleration lane, adjust your speed to the flow of traffic.
3. Use your mirrors (and turn your head) to check for traffic.
4. Merge smoothly into traffic.
5. Maintain following distance.



Lane Changing on Expressway

Lane changes are the most dangerous moves you can make on an expressway.

Procedure:

1. Check for following distance between your vehicle and the vehicle in front.
2. Check for space before moving into another lane.
3. Signal your movements.
4. Gradually steer the vehicle over until it is positioned in the new lane.
5. Re-check your mirror and blind spots, complete the lane change.
6. Turn off your turn signals when the vehicle is completely in the other lane.

Do not reduce your speed when changing lanes.

Steps for Exiting the Expressway

Procedure:

1. Move to the right lane early.
2. Signal 250 feet from the exit.
3. Maintain your speed until you enter the deceleration lane.
4. Brake to the deceleration lane speed.
5. If you miss your exit, continue on the expressway to the next exit. Do not try to back up on the expressway. And never make any sudden lane changes.

Caution: Speed limits posted on off-ramps are for cars. Your vehicle may need to go slower.

VEHICLE HANDING UNDER SPECIAL CONDITIONS

Night Driving

More than half of all traffic collisions happen at night.

- Do not “over-drive your headlights.” You should be able to stop within your area of visibility.
- If a car comes toward you with its high beams on, focus your vision along the right edge of the roadway.

Procedure:

1. Headlights should be used one half hour before sunset until one half hour after sunrise (never drive with just your parking lights).
2. Dim your headlights 500 feet from an oncoming car, or at 300 feet if you are following a car.
3. Never over-drive your headlights.

4. Be sure your windshield is clean.
5. Use your high beams (when legal) on open country roads to increase your visibility.

Smoke and Fog

Procedure:

1. Drive with your low-beam headlights.
2. Reduce your speed.
3. Increase your following distance.
4. Be prepared to make sudden stops for stalled or stopped vehicles.

Glare

Be prepared for glare in the early morning and late afternoon.

Tips for dealing with glare:

- Check the operation of your sun visor during the pre-trip inspection.
- Use a sun visor and sunglasses.
- Reduce your speed.
- Increase your following distance.

Rain

The first rain after an extended dry period is usually the most dangerous.

- Use defroster equipment to keep your windshield clean.
- Be careful with road spray when passing or following other vehicles.
- Check wiper blades for signs of wear during trip.
- Check tires for proper tread and air pressure (could cause skids).
- Increase your following distance by two or three times.
- Avoid braking hard to prevent skids.
- Watch for stalled vehicles.

Do not drive through deep water. If you are unsure of the depth of the water, do not go through the water! Observe other vehicles going through the water to help determine its depth.

Winter Driving

Winter driving hazards:

- Drivers who haven't adjusted to road conditions
- Visibility problems
- Traction problems
- Encountering snow removal equipment

Tips for driving in snow:

- Turn on your headlights.
- Start slowly; release the accelerator if the wheels begin to spin.
- Double your following distance.
- Make sure to check your equipment prior to driving your vehicle.

Check the operation of the:

- Defroster
- Windshield wipers
- Headlights

- Tires

Other drivers:

- Give them extra following distance.
- Concede the right-of-way.
- Slow down and let them pass.
- Make your movements slower than normal.

Visibility:

- Inspect the windshield wipers.
- Turn on the headlights and interior lights.
- Reduce your speed.

Poor traction—use extreme caution under the following conditions:

- When the temperature is below freezing
- When the temperature warms up, but there are still shaded areas on the road
- When approaching bridges

If you encounter snow removal equipment:

- Reduce your speed.
- Allow for more stopping distance.
- Watch for sudden movement of the equipment.
- Be alert for snow drifts.
- Pass only when it is safe.

Skids and Hydroplaning

These situations occur when your tires lose traction with the road. This happens when there is a sudden change in direction or from hard braking.

To prevent skids and hydroplaning:

- Use smoother accelerating and braking.
- Avoid quick movements.
- Check tire tread (2/32 rear and 4/32 front minimum) and tire pressure.

Caution: If you start to lose traction – do not brake hard!

ELDERLY AND DISABLED RIDERS

Guidelines for Assisting Customers who are Aging:

- Assistance that is needed will vary greatly from person to person. The important thing is to recognize what particular needs an individual may have.
- Many elderly people have less strength, speed, or coordination than they did when they were younger. These changes can affect their balance, which puts them more at risk for falls. Falls are more dangerous to these individuals due to their brittle bones.
- Arthritis and other age-related physical conditions could worsen their balance and mobility problems.
- Offer help in boarding the vehicle and in getting to their seat.
- Be patient with these customers as it may take them longer than others to move into or about the vehicle.
- If the senior asks for, or accepts your help, offer your arm for them to take hold of. Do not move too fast.
- If the rider refuses assistance, stand nearby when the customer is getting on or off the vehicle. Position yourself so you can catch the person's arm if they begin to fall. Do not try to catch the person from behind as you may become injured in the process.

- Watch for extremes of temperature (cold and hot) on the vehicle. Seniors are more susceptible to the harmful effects of temperature extremes.

Guidelines for Assisting Customers who use Wheelchairs for Mobility

- A person treats their wheelchair as an extension of their body; never touch a person's wheelchair without asking their permission.
- Be aware of hazards on the path of travel when assisting a person who uses a wheelchair (obstacles, cracks, curbs, etc.)
- Maintain normal eye contact.
- Try to position yourself at their level if you will be talking to them for a long period of time.

ADA REQUIREMENTS

Maintenance of Accessibility Features

- Maintain in operative condition vehicle accessibility features including, but not limited to:
  - Lifts and other means of access to vehicles
  - Securement devices
  - Signage
  - Communications systems for persons with vision/hearing impairments
- Repair promptly accessibility features that are damaged or out of order

Keeping Vehicle Lifts in Operative Condition

- Establish a system of regular and frequent maintenance checks of lifts.
- Ensure reporting, by the most immediate means available, any failure of a lift to operate in service.
- Ensure the lift is repaired before the vehicle returns to service.

Lift and Securement Use

- Transport all wheelchairs meeting the definition contained in 49 CFR 37.3 (this includes mobility scooters).
- Provide and use a wheelchair securement system.
  - Wheelchairs that cannot be secured to personnel's satisfaction must still be transported
- Where necessary or upon request, assist with the use of securements, ramps, and lifts.
- Permit customers with disabilities who do not use wheelchairs, including standees, to use the lift or ramp.

SERVICE STOPS

A service stop is when the operator stops the vehicle to board or alight passengers.

Procedures for simple boarding zone:

1. Activate your turn signal 150 feet before the boarding zone.
2. Angle the bus so that you will be able to stop parallel to the curb.
3. Stop in a safe location, parallel and 6 to 12 inches away from the curb (18-20 inches is ideal for wheelchairs).

Make sure the vehicle is parallel to the curb and that you can see clearly down the street.

Boarding and Alighting

Boarding/alighting areas – without curbing:

- Check your mirrors.
- Check for hazards.
- Stop in a safe place.
- Take into consideration the space required to deploy the lift or ramp.
- Take into consideration the safest path of travel for the customer.

Lift Operation

The operation of each lift may differ. Make sure you are qualified on each type of lift.

The proper method for using the lift is:

- Select a flat, open area giving consideration to the crown of the roadway.
- Make sure there is a clear path that will allow the customer to get to or away from the platform.
- Never deploy the lift where trees, poles, hydrants, walls, etc., could jeopardize the safety of the customers or cause possible damage to the lift.
- Ask if the customer has used a lift before. If the customer has not, briefly explain the procedure.
- Caution all other persons to remain clear of the lift while it is in operation.
- Board or alight the customer in accordance with company policy and procedures.
- Assist the customer away from the platform or complete the boarding procedure.
- Properly stow the lift.

When in operation, the lift will activate the interlock mechanism.

Interlock Mechanism

Many vehicles have a safety feature referred to as the interlock. When the door control is in the open position a brake is applied.

The interlock is activated by an electrical solenoid and is subject to failure. Never park the bus using the interlock.

The interlock is not a full brake application.

The throttle is deactivated when the interlock is on.

Caution:

- Never use the interlock to park the vehicle.
- Never use the interlock to hold the vehicle at stop lights.
- Never open the door before the vehicle comes to a complete stop.

Departing

Procedures to follow when pulling away from boarding/alighting area:

1. Make sure everyone is clear of the doors.
2. Close the doors completely.
3. Make sure customers are safe and secure.
4. Signal when you are ready to leave the stop.
5. Check traffic, mirrors, blind spots, pedestrians, traffic signs, and lights.
6. Take your foot off the brake.
7. Merge gradually and smoothly into traffic.

DEFENSIVE DRIVING

Defensive driving is being continually alert to possible hazards around your bus and taking action to avoid those hazards.

Defensive driving is expecting the unexpected. Simply knowing how to maneuver your vehicle is NOT enough to prevent collisions.

Examples of collisions:

- Non-Preventable – If a rock hits your bus, it is not your fault; there is nothing you can do to keep it from happening.
- Preventable – These are collision situations in which operators have enough control that they are able to take defensive action and keep a collision from happening.

Common Characteristics of the Defensive Driver

Knowledge

- Knows the traffic laws
- Knows how to avoid a collision
- Knows how to recognize hazards
- Knows how to respond correctly and in time
- Knows the limitations of the equipment

Alertness

- Is aware of how physical and mental conditions affect driving
- Gives driving 100% of their attention
- Stays alert to traffic situations by routinely checking mirrors

Foresight

- Inspects the vehicle before driving
- Anticipates and prepares for hazards
- Sizes up traffic situations as far ahead as possible

Judgment

- Looks for alternatives in any traffic situation
- Does not make risky maneuvers
- Passes when safe

Skill

- Operates the vehicle properly and safely
- Makes turns, passes, etc., legally and safely

If you see any of the following road hazards, slow down and be very careful:

• Driving too near the edge • Children • Objects in the road • Cell phones • Dangerous objects • Conversations • Oncoming vehicles • Workers near roadways • Parked vehicles • Street vendors • Highways • Vehicle maintenance • Blocked vision • Collision sites	• Blind intersections or alleys • Shopping areas • Delivery trucks • Confused drivers • Stopped vehicles • Slow moving vehicles • Road construction • Turn signals • Construction vehicles • Impatient drivers • Pedestrians and bicyclists • Fatigued drivers • Distracted people

Defensive driving tools include:

• Brakes • Lights • Steering wheel • Defroster • Windshield wipers	• Mirrors • Accelerator • Horn • You

Actions:

- Survey the area around the bus.
- Assume and prepare for the worst.
- Maintain the safety zone.

THE OPERATOR

Fatigue/Drowsiness

There are many factors that can cause you to be less alert than you should be. Some of them include:

- Lack of sleep
- Illness
- Over-the-counter medications
- Alcohol and illegal drugs
- Personal problems
- Unnecessary conversation
- Inattention

Effects of fatigue include:

- Increased reaction times from the average of ¾ second
- Decreased ability to think clearly
- Increased irritability

You should assess whether any of these are currently impacting your ability to drive safely and do not drive if you feel this is the case.

Alcohol

Drinking alcohol, whether it's wine, beer, or hard liquor is a common activity in our society.

Drinking alcohol and then driving is a very serious problem. People who drink alcohol are involved in traffic collisions resulting in over 20,000 deaths every year.

Drugs

A drug is any chemical that when taken into the body, affects your physiological processes.

Prescriptions Drugs

Drugs can be essential medical tools, but they can significantly impact your driving ability especially when used illegally or improperly. Even over-the-counter medications can hinder your ability to drive. Be sure you know the potential effects of any drug before you take it. Ask your doctor or pharmacist about your ability to drive on the drug. Find out if taking the drug will affect your reaction time, concentration level, or eye/hand coordination. And then find out how long these effects will last.

Also, be sure that you are abiding by your company's drug policy. If you have any questions, ask your supervisor or instructor.

Appendix B: Vehicle Inspection

PRE-TRIP INSPECTION

Do the inspection the same way each time so you will be less likely to forget any of the steps. Use the memory aids in Figures 6 and 7 to help ensure that each item in the box is checked.

Step 1: Approach the vehicle and take notice of the general condition of the body; check to see if the bus is leaning.

Step 2: Check the engine compartment for oil, fuel, and coolant leaks. Check the belts and wiring for obvious defects. Check fluid levels: oil, washer fluid, antifreeze, battery fluid covers, power steering, transmission, brake, refrigerant, and others from the A/C system.

Step 3: Start the engine and listen for unusual noises. Check the dash lights and gauges. Turn on the headlights, four-way flashers, and interior lights. Check the condition of the driver's controls.

Step 4: Walk around the vehicle and check the headlights, brake lights, and turn signals.

Step 5: Check tires for the following:

- Tread depth: should be even from wall to wall and should not be below wear bars. Depth should be 4/32 inch on steering axle and 2/32 inch on all other axles. Check each tire for minimum wear at the location of greatest wear.
- Sidewall cuts: bulges or knots may indicate cord separation, leaving the tire in poor condition.
- Punctures: check for nails or other objects in the tires. Even if they don't leak immediately, a flat can still occur.
- Valve stems: flex the stem slightly from side to side and listen for leaking air. Wheel rim welds: check for cracks or dents.
- Inflation: check visually and with a pressure gauge or mallet.
- Leaks: check wheels to ensure there is no leaked oil or brake fuel.
- Wheel lug nuts: check to ensure they are tight (rust may indicate a loose nut). None should be missing.

Step 6: Check the passenger compartment to see if the seats are clean and secure. Check the floor for cleanliness and for any slipping hazards. Special care should be taken to ensure the following:

- Passenger seating area: ensure each seat is secured to the floor and is not damaged. Ensure seatbelts work and the floor is clean and dry. Check for suspicious objects, light bulbs, tampering, or those that may have been left by maintenance.
- Driver area: ensure you have a fire extinguisher, first aid seatbelt cutter (within reach of your seated position), three triangle reflectors or flares, flashlight, and jack handle. Check that the emergency equipment is in place and that your seatbelt functions. Adjust your seat and mirrors; check all gauges as well as for signs of tampering.
- Lights, brakes, and stairwell: ensure your lights and brakes function properly and that the doors open and close.
- Lift and lift door: ensure the door opens and closes and that the light comes on when door is open. Ensure lift controls are in good shape and that the backup manual lift handle is in place. Check that the lift cycles down/up, unfolds, and folds properly. Check securement devices. Check that no hydraulic fluid is leaking and there are no signs of tampering.
- Mobility device securement: ensure that an adequate number of securement devices and seatbelts are available to secure all wheelchair and other mobility device positions, and check that they all function correctly and are not torn or frayed. Properly store securement devices and make sure securement tracks are clean and free of debris.

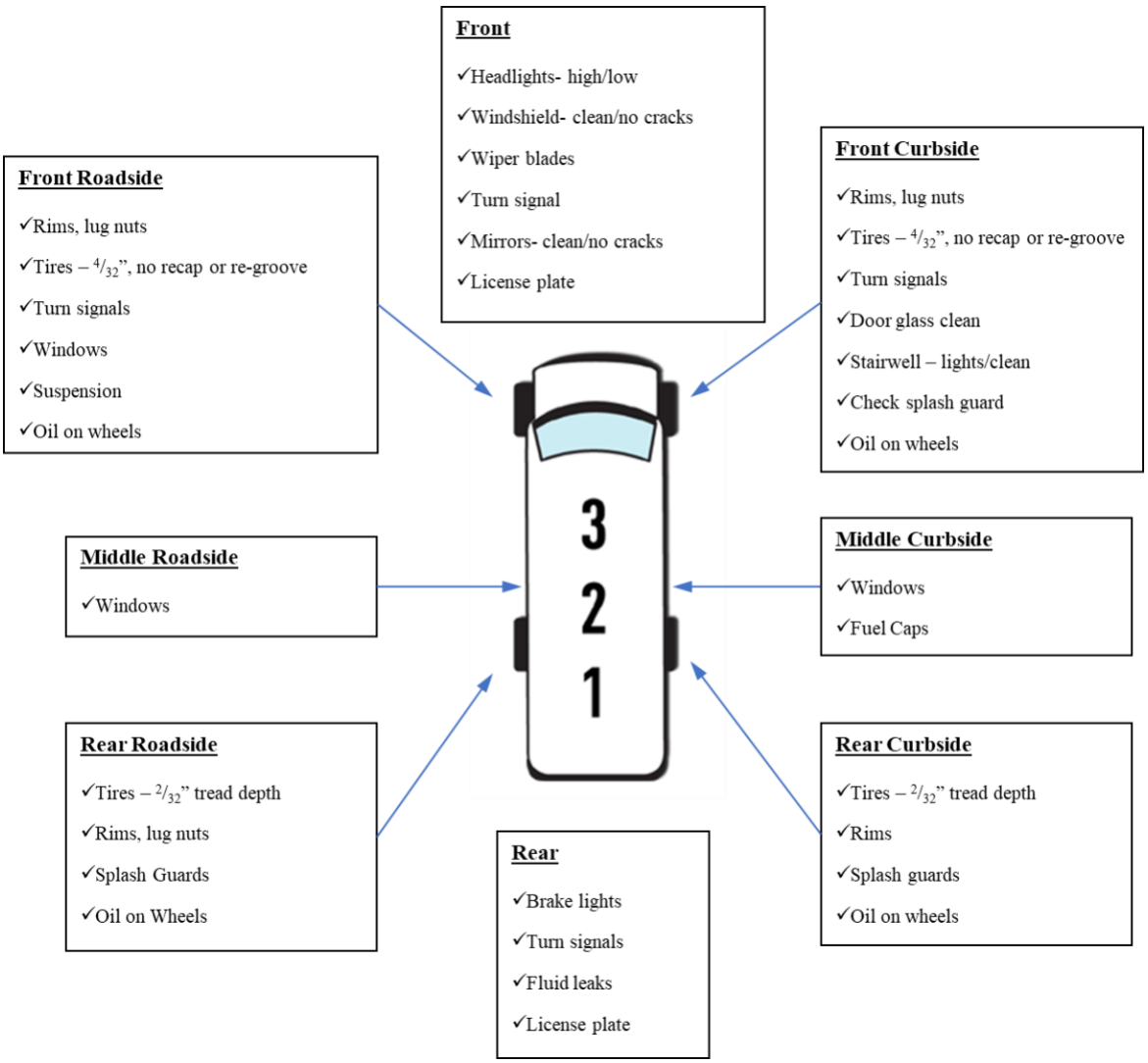


Figure 6. Memory aid for checking the outside of the vehicle

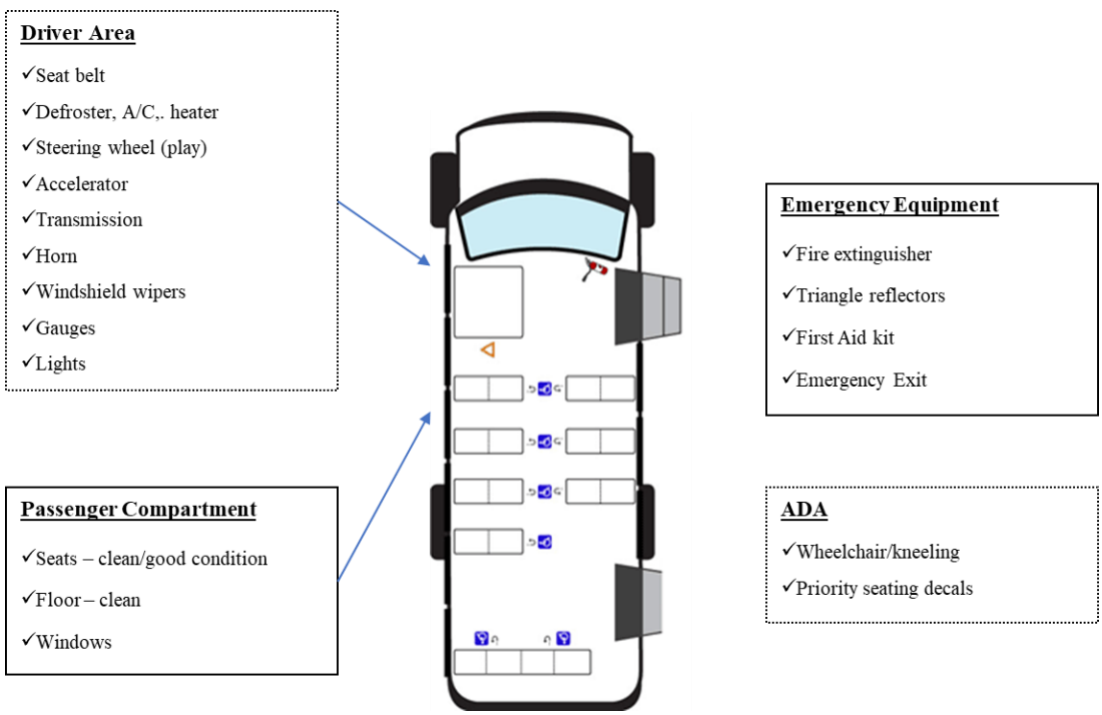


Figure 7. Memory aid for checking the inside of the vehicle

Step 7: Once the vehicle has been visually inspected inside and out, the safety driver will take the vehicle for a short drive. At this time the driver will:

- Listen for odd noises
- Note any unusual smells
- Watch lights and gauges

Step 8: Complete a vehicle inspection report.

POST-TRIP INSPECTION

The following items should be reviewed when a drive is complete:

- Parking brake should be set and secure.
- No passenger's personal property should be on the bus.
- All windows and hatches should be closed.
- No signs of damage or vandalism are apparent inside or outside the vehicle. You should also report any noncritical defects that you observed during the drive to ensure that the vehicle is in proper working order for the next demonstration drive.

Appendix C: Vehicle Inspection Report

Indicate that the item has been inspected with a check ✓

		✓	Notes
Safety Belt	The safety belts are securely mounted, adjusted and latched properly, and are not ripped or frayed.		
Emergency Equipment	• There are three red reflective triangles. • There is a properly charged and rated fire extinguisher. • The fire extinguisher is Type ABC, puts out all fires, and is mounted securely. • The first aid kit and AED are in the vehicle. • The study cell phone and list of emergency contacts is in the vehicle. • There are blankets and safety vests in the vehicle.		
Safe Start	• The engine has started safely. • The ABS light came on and then turned off, showing that the anti-lock braking system is working properly.		
Temperature Gauge	The temperature gauge is working and shows the temperature is in normal operating range of 160-190° Fahrenheit.		
Oil Pressure Gauge	The oil pressure gauge is working and indicates the pressure is in normal operating range, greater than 15 psi.		
Voltmeter	• The voltmeter indicates the alternator is charging. • There are no warning lights or alarms associated with these gauges.		
Light Indicators	• The left turn signal is working. • The right turn signal is working. • The hazards/4-way flashers are working. • The high beam headlights are working.		
Horn	The horn is working.		
Steering Play	The steering wheel has no more than 2 inches of play before the front left wheel moves.		
Heater/Defroster	Set defrost control to floor fan. Turn the fan on and off. (Place hand over floor vent so you can feel the air.)		

	• The floor fan is working properly. Set defrost control to defrost. Turn the fan on and off. (Place and over the defrost vent so you can feel the air.) • The defrost is working properly.		
Mirrors/Windshield	• Mirrors are clean and adjusted properly from inside. • The windshield is clean; it has no stickers, no obstructions, and no damage to the glass.		
Wipers/Washers	• The wiper arms and blades are secure, not damaged, not dry-rotted, and operate smoothly. • Windshield washers operate correctly.		

TESTING THE BRAKES – REQUIRED

		✓	**Notes**
Parking Brake Check	With the parking brake engaged, I shift into drive. I gently press the accelerator pedal. The bus does not move, so my parking brake is functioning properly.		

PASSENGER ITEMS – REQUIRED

		✓	**Notes**
Passenger Entry/Lift	• Entry doors operate smoothly and close securely from the inside. • Handrails are secure and step lights are working. • The ADA ramp has no leaking, damaged, or missing parts. • Check the ramp for proper operation. Cycle the ramp out and in. The ramp is fully retracted and latched securely.		
Emergency Exits	All major windows and the rear doors, act as emergency exits. • The emergency exits have no damage, operate smoothly, and close securely from the inside. Demonstrate the ability to operate one of the major windows as emergency exit by pulling the		

	red handle down and pushing the window out to open.		
Seating	Seat frames have no damage and are firmly secured to the floor. Seat cushions are firmly secured to the seat frames.		

ENGINE COMPARTMENT

		✓	Notes
Fluids	Check fluid levels: oil, washer fluid, antifreeze, battery fluid covers, power steering, transmission, brake, refrigerant, and others from the A/C system		
Belts	Check the belts and wiring for obvious defects.		
Hoses/Lines	Hoses and lines are in good condition and have no leaks. There are no puddles on the ground or dripping fluids on the underside of the engine and transmission.		

LIGHTS/REFLECTORS

		✓	Notes
Front of Vehicle	All lights are clean and functional • 4 clear headlights: 2 high beams, 2 low beams • 2 amber turn signal/hazard lights • 2 amber reflectors		

FRONT/REAR WHEELS

		✓	Notes
Tires	• Tread depth is at least four-thirty-seconds (4/32) of an inch. The tread is evenly worn and not damaged. • There are no cuts or other damage to the tread or sidewall. • Air valve cap and stem are not missing, broken, or damaged. • The tire is properly inflated to approximately 110 psi. Check the Tire Pressure Monitoring System (TMPS) that		

	displays tire pressure and gives a dashboard warning if out of range.		
Rims	Rims are not damaged or bent and have no welding repairs.		
Lug Nuts	• All lug nuts are present, not cracked or distorted, and show no signs of looseness such as rust trails or shiny threads. • Bolt holes are not cracked or distorted.		
Splash Guards/ Mud Flaps	Splash guards and mud flaps are not damaged and are mounted securely.		

FUEL AREA/UNDER/SIDE

		✓	**Notes**
Fuel Tank	• Fuel tank is secure, and the cap is tight. • There are no leaks from the tank or lines.		
Exhaust System	• Exhaust system has no damage and no signs of leaks such as rust or carbon soot. • System is connected tightly and mounted securely.		

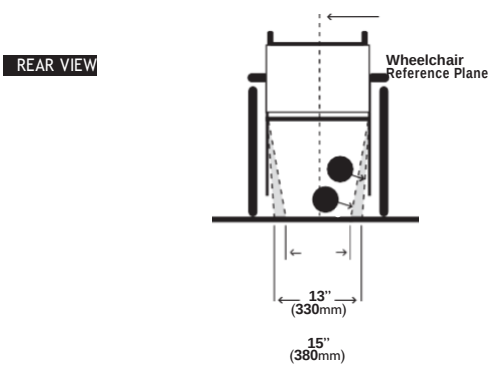
Appendix D: Wheelchair and Passenger Securement

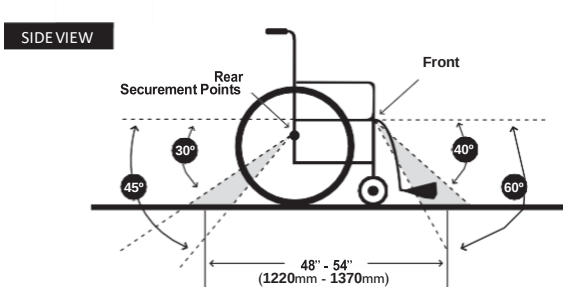
SECURING WHEELCHAIR

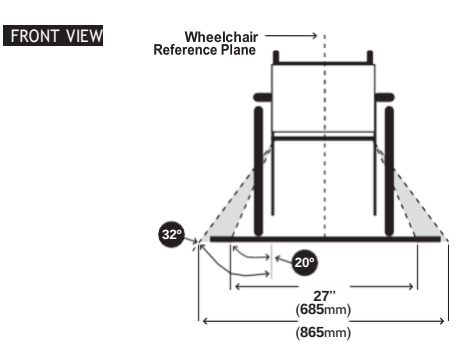
1. Ask passenger to center wheelchair facing forward in Securement Zone and if possible to enable wheel locks (or power off electric chair) (**A**).

2. Attach 4 Retractors into Floor Anchorage points and lock them in place, with an approximate distance of 48" to 54" between the front and rear Retractors (**B**).

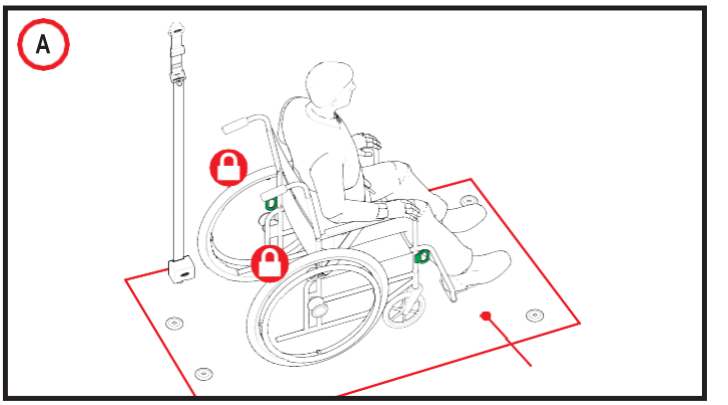
3. Completely pull out each Webbing and attach J-Hooks to compliant WC19 Chair Securement Points near seat level (**C**) (or solid frame members) at an approximate 45-degree side angle. If securement system attachment points are not readily observable, consult with rider.

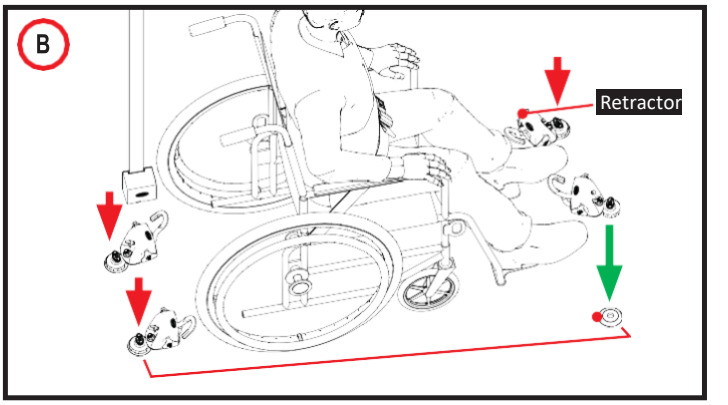


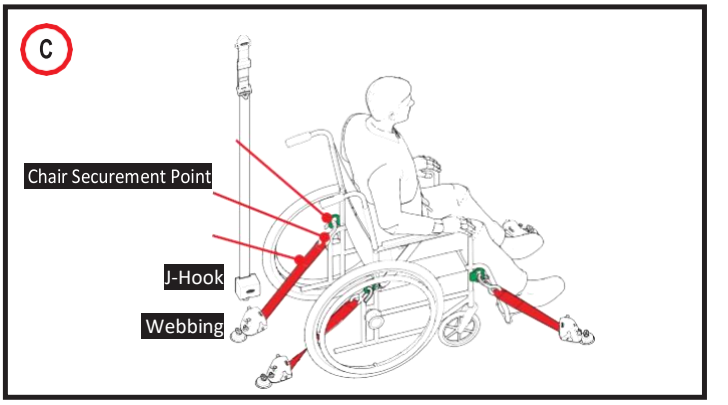


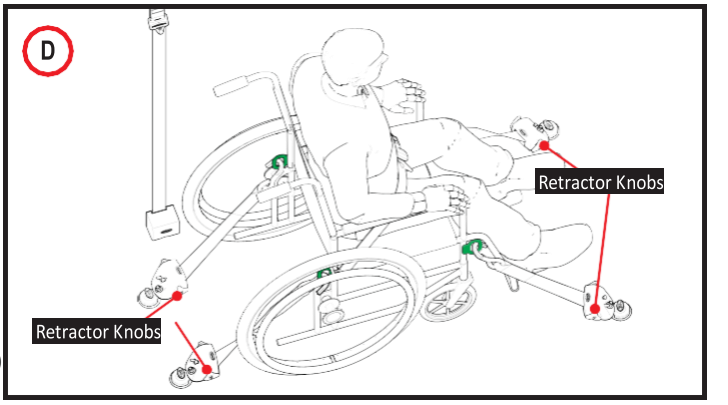


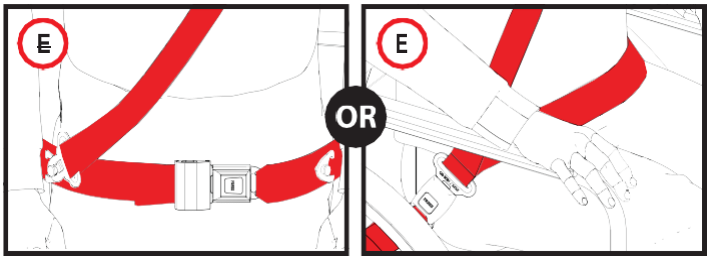
Keep loose articles of clothing away from retractors.



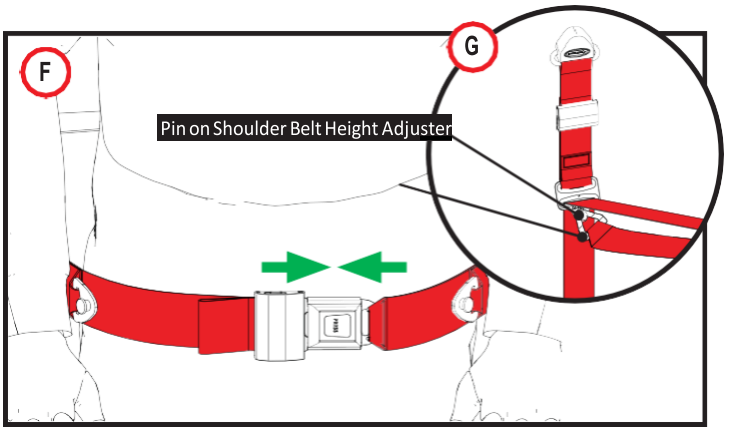








Compliant Shoulder and Pelvic (Lap) Belt Restraint (E) must go across occupant's shoulder and pelvis (hips), and not be worn twisted or held away from the occupant's body by wheelchair components. We do not recommend only using a pelvic belt restraint because it will compromise the performance of the system.

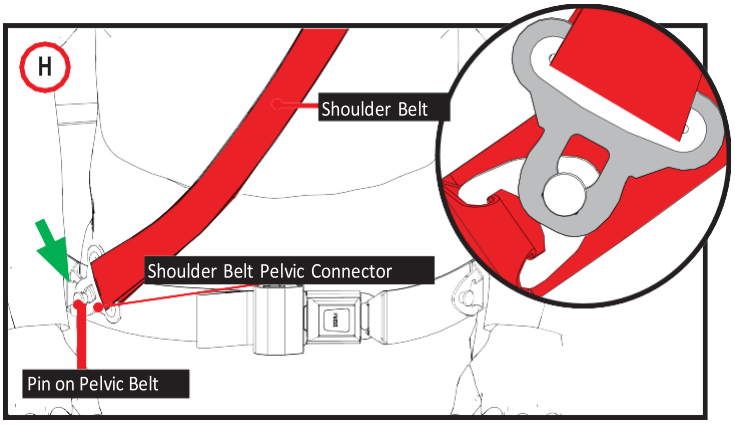


4. **WC19 Wheelchair:** (If the chair does not come with a compliant pelvic (lap) belt follow steps 9-12.) Make sure chair's Pelvic Belt is buckled over occupant's hips (**F**).

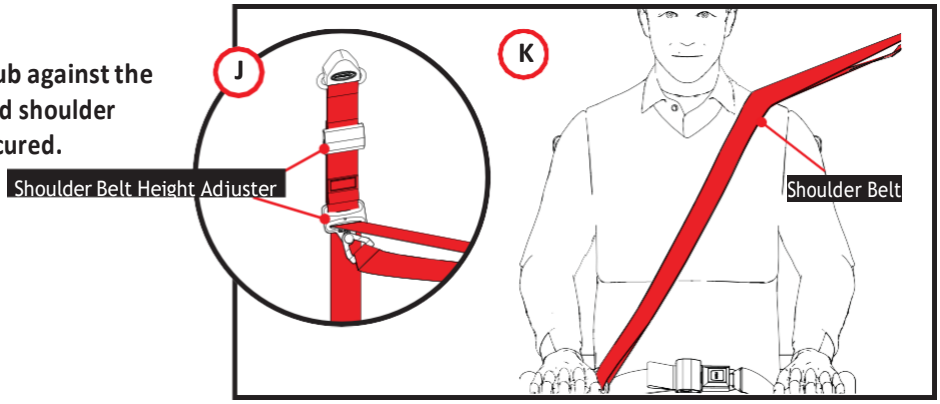
5. Attach Shoulder Belt Pin Connector to Pin located on Shoulder Belt Height Adjuster (**G**).

6. Pull Shoulder Belt over occupant's chest and attach Shoulder Belt Pelvic Connector to Pin on Compliant WC19 Pelvic Belt (**H**).

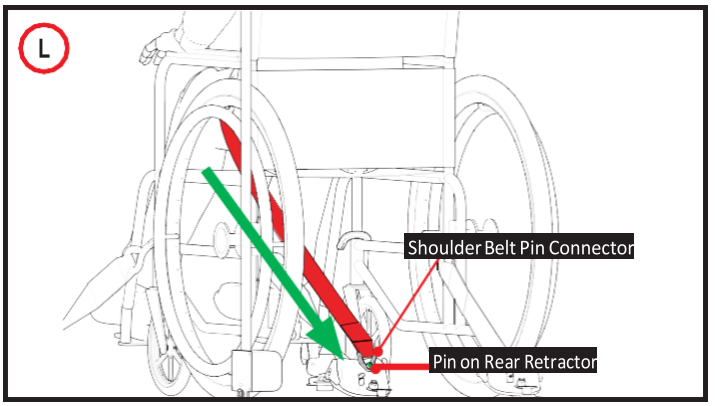
7. Adjust Shoulder Belt Height (**J**) so that Shoulder Belt rests on shoulder. After the occupant and vehicle are secured, the occupant is ready for transportation.



Make sure Shoulder Belt does not rub against the occupant's neck (K). Never use lap and shoulder belt unless wheelchair is properly secured.

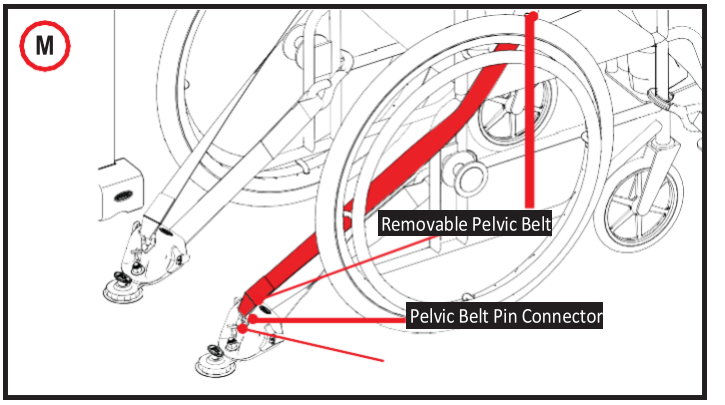


8. **Non WC19 Wheelchairs:** Attach Shoulder Belt Pin Connector to Pin on Rear Retractor closest to wall (**L**).

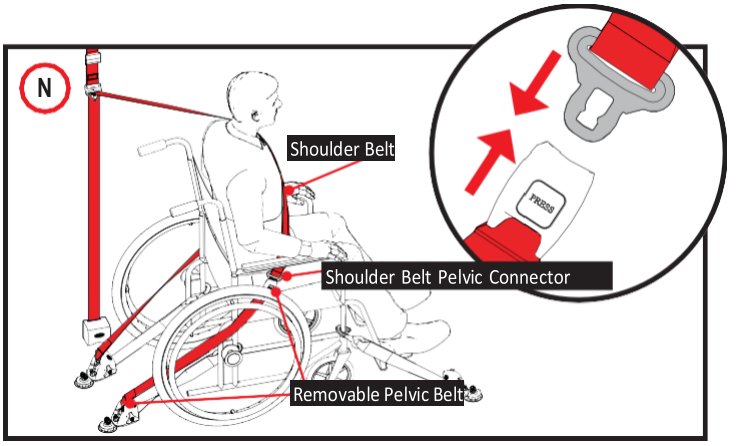


Occupant Restraint (Shoulder and Pelvic Belt) MUST not be held away from the occupant's body by wheelchair components.

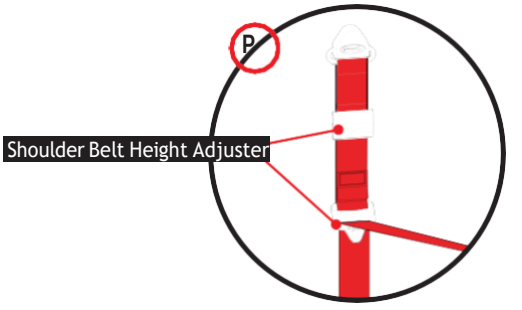
9. Attach the Pelvic Belt Pin Connector to Pin on Rear Retractor closest to the aisle (**M**).



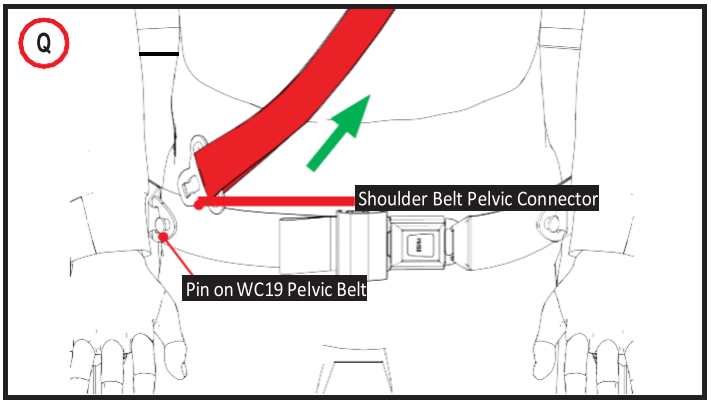
10. Pull the Shoulder Belt over occupant's chest and buckle Shoulder Belt Pelvic Connector to Removable Pelvic Belt (**N**).



11. Adjust Shoulder Belt Height (**P**) so that Shoulder Belt rests on shoulder. After the occupant and vehicle are secured, the occupant is ready for transportation.



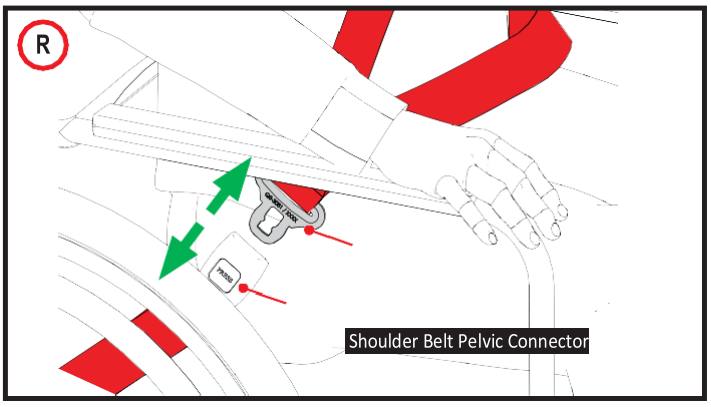
12. **WC19 Wheelchair:** (If chair does not come with a pelvic belt follow steps 14-17.) Detach Shoulder Belt Pelvic Connector from Pin on WC19 Pelvic Belt (**Q**) and return Shoulder Belt to storage position.



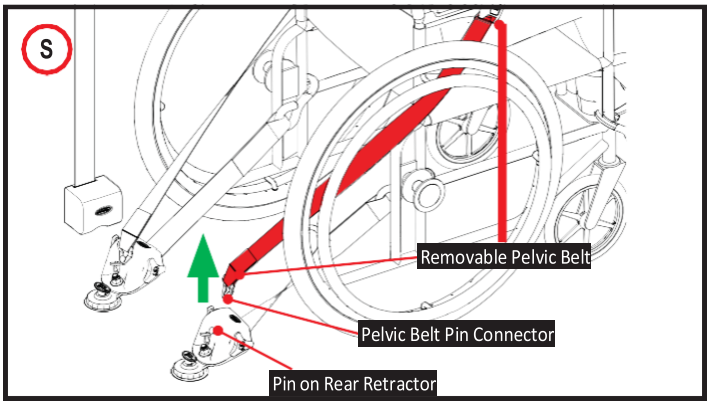
13. **Non WC19 Wheelchairs:** Unbuckle Shoulder Belt Pelvic Connector from Removable Pelvic Belt (**R**).

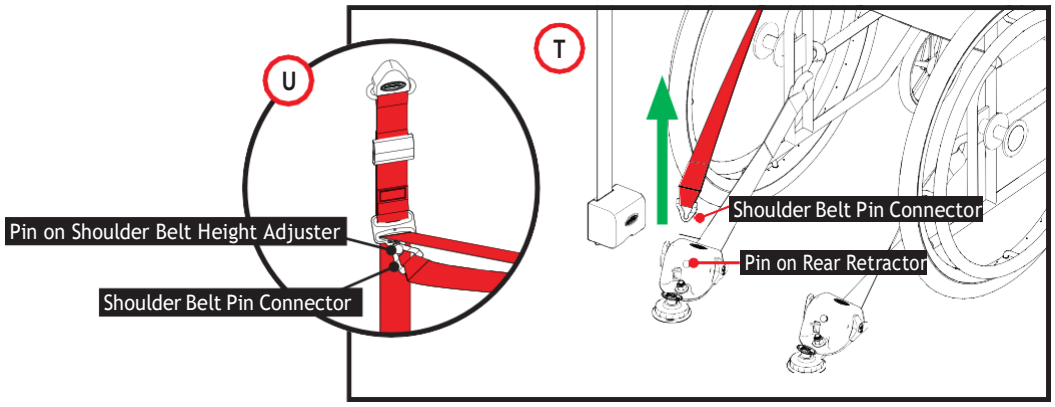
14. Detach Pelvic Belt Pin Connector from Pin on Rear Retractor closest to aisle (**S**). Place Removable Pelvic Belt in storage.

15. Detach Shoulder Belt Pin Connector from Pin on Rear Retractor closest to wall (**T**).



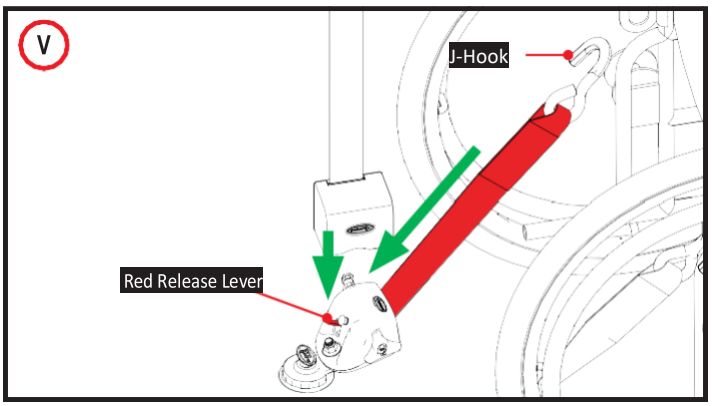
16. Attach Shoulder Belt Pin Connector to Pin on Shoulder Belt Height Adjuster (**U**) and return Shoulder Belt to storage position.





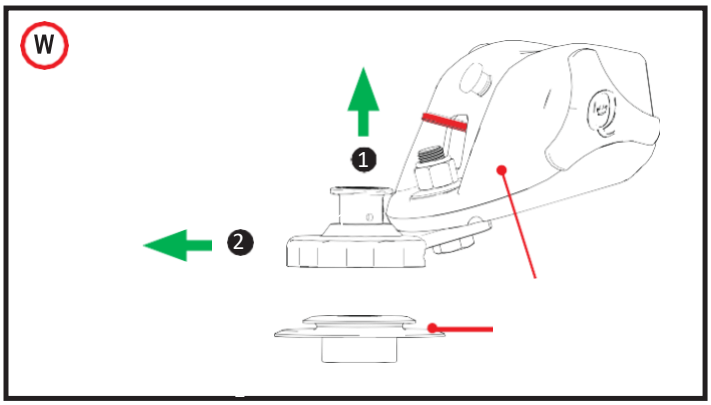
17. Press Red Release Levers on Retractors, detach J-Hooks from wheelchair frame and slowly return them to retractors (**V**).

Keep loose articles of clothing away from retractors.

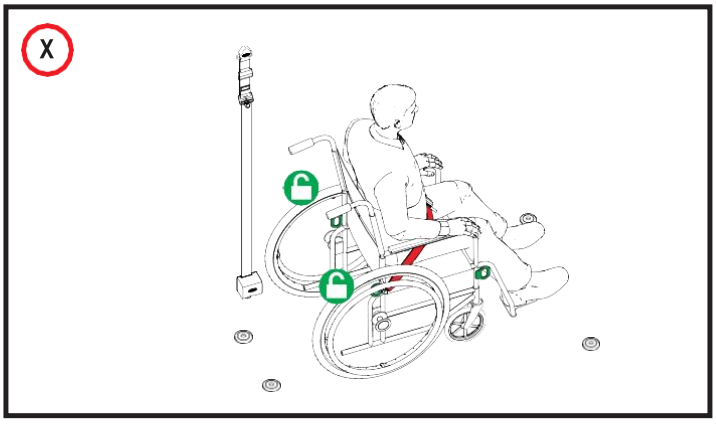


18. Remove Retractors from Floor Anchorage points (**W**) andplace in storage.

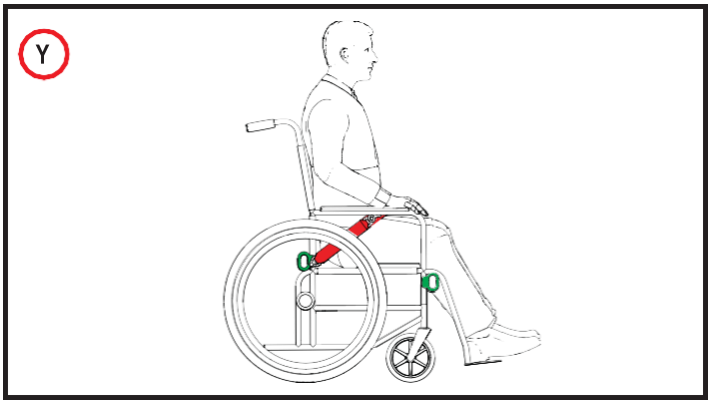
Shown is the Slide'n Click anchorage system. Pull the lever (1) and slide (2) to remove (W).



19. Advise Rider to unlock wheelchair brakes (or power on electric chair) (**X**).



20. Wheelchair occupant is ready to exit vehicle (**Y**).



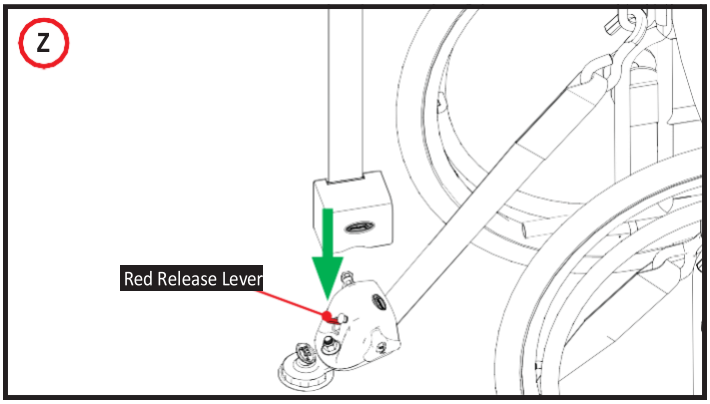
EMERGENCY RELEASE

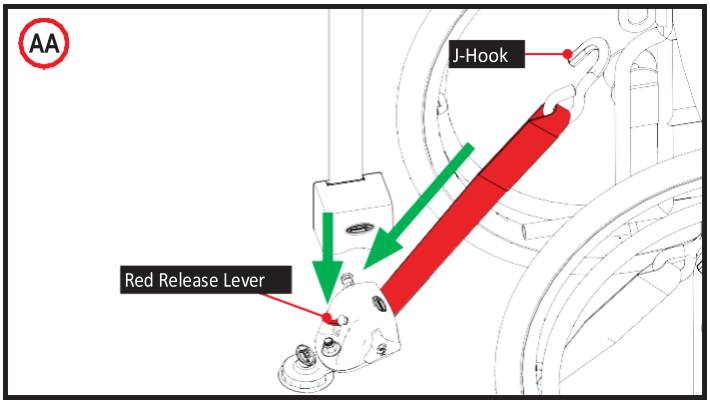
First, release Occupant Restraint (Shoulder and Pelvic Belt). If Occupant Restraint System does not release occupant, in an emergency cut webbings at an angle.

1. Press and hold the Red Release Lever on each retractor to release the webbing (Z).

2. Detach J-Hooks from wheelchair and slowly return webbing to retractors (AA)

If retractors do not release the webbing, in an emergency cut the front and rear webbings at an angle.





Note: The full owner's manual will be located inside the vehicle and is available for review upon request.

Appendix E: Wheelchair Lift Operation

Before lift operation, park the vehicle on a level surface, away from vehicular traffic. Place the vehicle transmission in "Park" and engage the parking brake. Vehicle engine must be running.

LIFT OPERATING INSTRUCTIONS

Open door(s) and secure.

To Unfold Platform:

Stand clear and press the UNFOLD switch until the platform stops (reaches floor level – unfolds fully). Release switch. In event platform does not unfold, press FOLD switch to release Lift-Tite™ latches.

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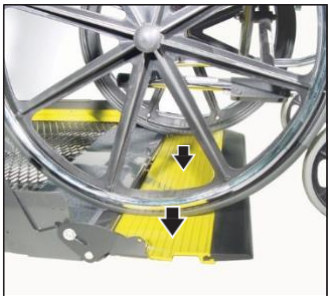
To Unload Passenger:

1. Load passenger onto platform and lock wheelchair brakes.

Note: Passenger must be positioned fully inside yellow boundaries, outer barrier must be UP and outer barrier latches must be engaged.

2. Press DOWN switch until the entire platform reaches ground level and the outer barrier unfolds fully (ramp position). Release switch.

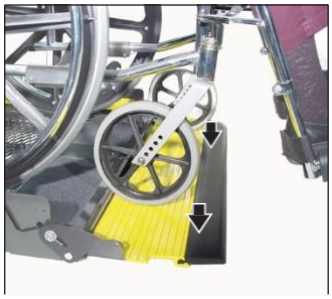
3. Unlock wheelchair brakes and unload passenger from platform.

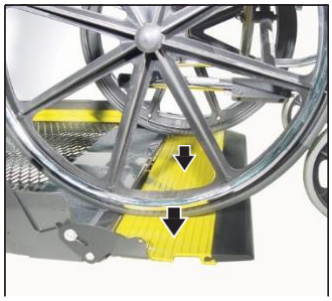


Note: Outer barrier must be fully unfolded (ramp position) until the entire wheelchair (or standee) has crossed the outer barrier.

To Load Passenger:

1. Ensure that the outer barrier is fully unfolded (ramp position) until the entire wheelchair (or standee) has crossed the outer barrier. Load passenger onto platform and lock wheelchair brakes.





Note: Passenger must be positioned fully inside yellow boundaries.

2. Press UP switch to fold outer barrier UP fully (vertical) and raise the platform to floor level. Release switch.

3. Unlock wheelchair brakes and unload passenger from platform.

To Fold Platform:

Press FOLD switch until platform stops (fully folded) and release switch.

Close door(s).

NHTSA OPERATIONS CHECKLIST

The following operations have been verified upon installation. This operational checklist can be used at any time to verify the lift is fully functional.

Verified	Vehicle movement is prevented unless the lift door is closed, ensuring the lift is stowed.
	Lift operation shall be prevented unless the vehicle is stopped and vehicle movement is prevented.
	The platform will not fold/stow if occupied.
	The inner roll stop will not raise if occupied.
	The outer barrier will not raise if occupied.
	Verify platform lighting when lift is deployed and pendant illumination when lift is powered.
	A visual and audible warning will activate if the threshold area is occupied when the platform is at least one inch below floor level.
	Platform movement is prohibited beyond the position where the inner roll stop is fully deployed (up).
	Platform movement shall be interrupted unless the outer barrier is deployed (up).

***WARNING**

Discontinue lift use immediately if any lift or vehicle interlock does not operate properly. Failure to do so may result in serious bodily injury and/or property damage.

Note: The full owner's manual will be located inside the vehicle and is available for review upon request.

Appendix F: ADS Training

The goal of this program is to teach you about the systems the vehicle will be using in automated driving mode. By the end of training you must demonstrate and understanding of:

- ADS technology on the vehicle and its purpose
- ADS system functionality and limitations
- Initiating automation
- Transitions between automated and manual modes
- The in-vehicle displays for the safety driver and co-pilot
- Communication best practices
- Pre- and post-trip protocols

ADS TECHNOLOGY

The following computing modules and sensors will be used by the vehicle to both enable the automation and capture data. It is important that the operators have a general understanding of what each does and how they interact.

Controller Area Network (CANBUS) Module

The CANBUS module will implement the Platform Actuation & Control Module (PACMod) CAN communication protocol which will then establish bidirectional communication between the software stack and the vehicle. The commands from the CANBUS module include throttle percentage, brake percentage, steering angle, as well as steering rate. The feedback from the PACMod system include the same, as well as wheel speeds, and other information that may be useful to additional features in future phases. Communication from the computer to the vehicle and radars is done using a PCIe ESDcan 401 interface card. The communication to this card is handled by the CANBUS module.

Control Module

The control module uses the driving path and target speed output from the planning module to calculate control actions for the vehicle. For example, using different lateral controllers to minimize error or optimize lateral control over a series of future waypoints, steering angle and velocity calculations are made. These values are then passed as inputs to the AutonomouStuff SSC library, which returns throttle, brake, and steering values to then pass to the CANBUS module, which are then passed to the PACMod Drive-By-Wire system.

Planning Module

The planning module uses the HD map, the current lane, obstacles in the path, vehicle speed, current location, among other data, to calculate a reference line and path of waypoints in which to follow, dynamically recalculating this on a regular cycle. If obstacles are in the way, alternate paths are evaluated and calculated, and can include maneuvers such as lane changes, weaving, slowing down, or stopping and waiting. The planning module has a large number of defined scenarios meant to handle intersection interactions, traffic lights, open space, and more, including lane changes, adaptive cruise type actions, and more. This module is one of the more complex software modules of the entire system.

Perception Module

The perception module receives sensor data from one or more LiDARs, one or more radars, and one or more cameras in order to understand the environment around the vehicle. Point cloud data from LiDARs spaced in strategic locations around the vehicle are transformed and merged into one point cloud which is then processed in the perception stack, using the Nvidia GPU to do object detection using inference in a Convolutional Neural Network (CNN). Data from the radars are used to improve object detection accuracy and velocity estimation, in addition to detections of other vehicles at farther distances. The two forward facing cameras are used for traffic light detection and state monitoring. V2V and V2I communications are anticipated to be received and handled in the perception module in later phases of the project.

Prediction Module

The prediction module uses information output from the perception module to estimate and predict future positions of obstacles. In particular, the module is concerned with obstacles that have a trajectory that will intersect with the path of the vehicle. Such obstacles are tracked from frame to frame and their future possible positions are predicted. For example, an object at an intersection detected as another vehicle, waiting to turn, may be predicted by the system to either turn left, turn right, or go straight. Which of those three possible outcomes actually occurs is not known until the vehicle moves, but predicting the options available allows for more advanced scenarios to be handled in the planning module.

Routing Module

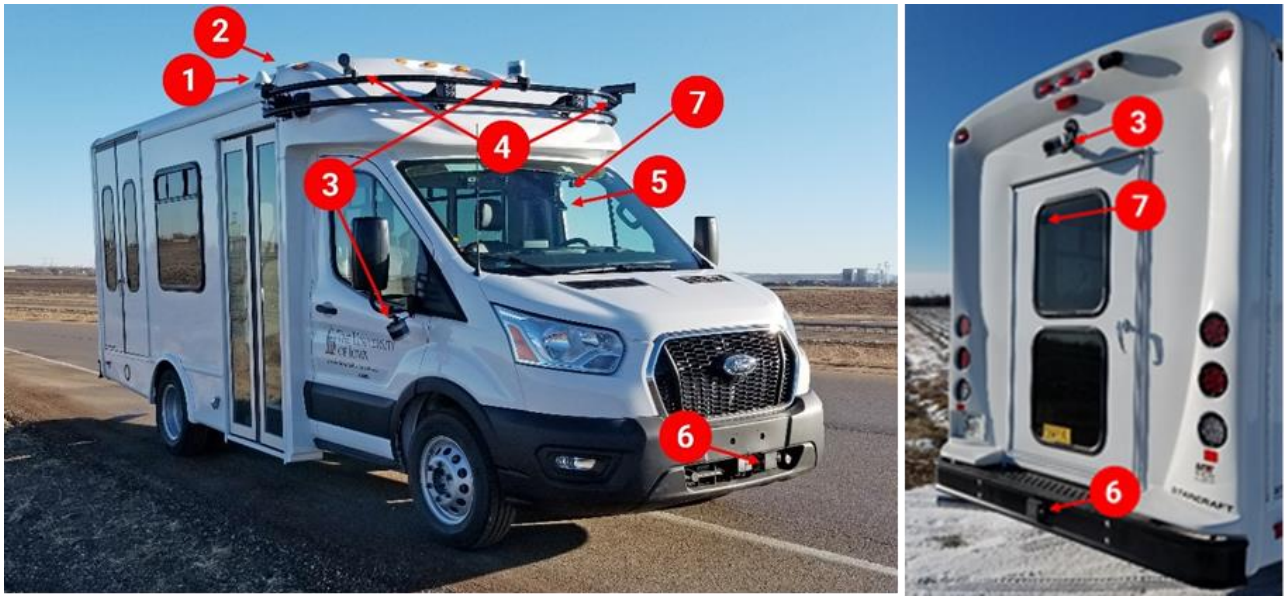
The routing module utilizes the map, current vehicle position, and requested destination point or points to calculate a path of travel. This path is the preliminary route that will take the vehicle from the current point to a new point within the constraints of the loaded HD map.

Localization Module

The localization module handles the connection to the NovAtel GNSS receiver and outputs vehicle localization data and vehicle pose data which is used by most other modules in one way or another. On initialization, the module connects over the in-vehicle network to the NovAtel receiver and subscribes to LOG messages that include fused position and IMU data. This data is then used to calculate the rates of acceleration in all axes, velocities in all axes, as well as pose of the vehicle.

Sensor Driver Modules

Sensor drivers in Apollo are separate for the LiDARs, radars, and cameras. It is anticipated that a V2X adapter is utilized for the purpose of integrating V2V and V2I data into the autonomy stack. For each LiDAR, a separate instance of the driver will be running, and publishing data to a differently named topic. The same approach will apply also for the radars and cameras.



Location and Description of Sensors (LiDARs, radars, and cameras) and Other Instrumentation

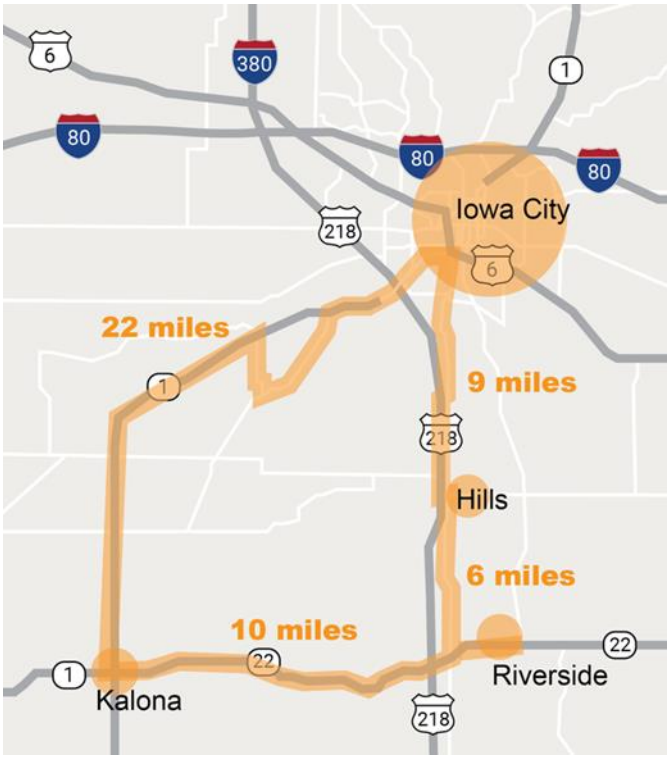
1. Cohda Wireless MK5 On-Board Unit (OBU) antenna: Vehicle-to-Infrastructure (V2I) communication, e.g., traffic lights
2. NovAtel GPS antenna: Positioning
3. Velodyne LiDARs: Perception of surrounding area
4. Leopard Imaging 1080p WDR USB 3.0 cameras with 1x25mm and 3x12mm lens with waterproof housings: Perception of surrounding area

5. Mobileye 630 collision avoidance system (interior): Lane marking and road sign detection
6. Continental ARS 408 long range radars: Perception of surrounding area
7. Logitech 930 webcam video cameras: Video capture

ADS FUNCTIONALITY

Expectations and Challenges

Over the course of the project additional automation will be introduced with each project phase to address different types of roads, intersections, driving conditions, and more that will be encountered. The defined route will be driven in its entirety for each of the project's eight phases to show how automation is increasing and to allow for comparison from one phase to the next. During each new phase, the ADS for Rural America project team will also be assessing the automation's performance and using the data collected to inform improvements in successive project phases.



ADS for Rural America Route

Phase 1 – Controlled Access Divided Highway/Interstate

Functionality Expected:

The vehicle will navigate along controlled-access highways. The vehicle will maintain lateral and longitudinal position via automation that utilizes on-board sensors and a high-definition (HD) map of the route. This HD map is being created specifically for this project and will be updated twice (if needed) during the data collection to capture changes along the route due to construction or maintenance.

Potential challenges:

- Responding to mixed traffic which will include heavy trucks, wide loads, and slow-moving vehicles
- Responding to merging vehicles or cut-ins
- Reaction to unexpected events

Phase 2 – Two-lane Undivided Highway

Additional functionality expected:

The vehicle will navigate along two-lane undivided highways maintaining lateral and longitudinal position via automation. The safety driver will assume control over parts of the route where the vehicle doesn't have protected right of way (such as intersections).

Potential challenges:

- Oncoming vehicles encroaching in lane
- Vehicles or vulnerable road users (VRUs) on the shoulder encroaching in lane (e.g., joggers, cyclists, or slow-moving road users like horse and buggies)
- Roads with a wider variety of vehicle types, speeds, and shapes
- Unexpected events (animals on roadway)
- Traffic entering the roadway from driveways or intersections

Phase 3 – Connected Vehicles on Two-lane Highways

Additional functionality expected:

The vehicle will demonstrate its ability to interact with other vehicles (i.e., school buses) on 2-lane rural highways. During the drives, on-board telemetry processors located on the buses will provide location and speed information to our vehicle, enabling it to slow down and/or stop even without direct line of sight.

Potential challenges: These should be similar to Phase 2.

Phase 4 – Roads through Cities and Towns

Additional functionality expected:

The vehicle will navigate more urban roadways, through cities and towns. We will instrument four intersections with transmitters to provide information about the traffic signal state to the vehicle. The vehicle will demonstrate its ability to interact with infrastructure.

Potential challenges:

- Higher traffic densities across multiple lanes of traffic
- Pedestrians and cyclists crossing the roadway
- Controlled intersections with traffic signals with and without connected infrastructure capability
- Interactions at uncontrolled intersections
- Blind intersections/corners
- Speed limit variations

Phase 5 – On- and Off-Ramps

Additional functionality expected:

The vehicle will navigate highway on and off-ramps along the project route.

Potential challenges:

- Vehicles merging onto or exiting highways at varying speeds
- Vehicles displaying varying lane positions and spacing from other vehicles
- High rate of curvature of on/off ramps

Phase 6 – Unmarked Road

Additional functionality expected:

The vehicle will navigate roadways without any lane markings, including unpaved, gravel roads.

Potential challenges:

- Exposure to oncoming vehicles that seem directly in path
- Adopting a line of travel not informed by lane markings and changes depending on if there is any oncoming traffic
- Interaction with oncoming vehicles
- Narrow lanes
- Soft/narrow of missing shoulders
- No centerline

Phase 7 – Navigating Parking Areas

Additional functionality expected:

The vehicle will navigate in two on-street parking areas and in two parking lots, performing some parking maneuvers.

Potential challenges:

- Slow speed maneuvering in tight spaces
- Interactions with pedestrians crossing in unanticipated places
- Interactions with other vehicles where right of way may not be apparent

Phase 8 – Full Loop

Additional functionality expected:

This phase offers an opportunity to address some of those challenges in the previous phases and collect more data on a highly automated vehicle across the entire route.

Potential challenges:

These will include all of those mentioned for the previous phases. The timing of each phase will also present challenges as those phases that occur during winter driving conditions will include: snow and ice-covered roadways and higher exposure to poor lane markings and potholes due to worsening road pavement conditions over winter.

ADS Limitations

It is important for the safety driver to understand that the functionality of the vehicle can and will change based on several important roadway and environmental conditions. In winter, snow and ice buildup on some sensors can degrade their performance. On windy summer days, dust and sand can sometimes get into the sensors also degrade the performance. Even bug splatter can affect the ability of sensors to operate as they are intended. The safety driver should always be extra cautious and ready for takeover when the following conditions are present:

Roadway conditions

- Hills and curves that limit sight distance
- Poor lane markings
- Snow and ice-covered roadways
- Faded or hidden traffic signs
- Potholes

Environmental conditions

- Lack of roadway lighting

- Glare
- Fog, rain, snow

INITIATING AUTOMATION

Automation can be activated and deactivated using a button on the steering wheel. Once activated, the vehicle will control steering, throttle control, and braking.

TRANSFERRING BETWEEN AUTOMATED AND MANUAL MODE

Voluntary Takeovers

The automation can be deactivated by pressing a button on the steering wheel.

Safety Takeovers

The PACMod 3.0 System responds to certain operator actions by disabling by-wire mode and reverting to full manual control. Most of these maneuvers, known as “safety takeovers,” would be an operator’s natural reaction to roadway hazards, such as quickly turning the steering wheel or pressing on the brake pedal. The PACMod 3.0 System also automatically restores full manual control when it detects certain faults in the by-wire controls or stock vehicle components.

The following safety takeovers will immediately disable by-wire mode:

- Pressing the E-stop button
- Pressing the brake pedal
- Pressing the accelerator pedal
- Turning the steering wheel

Note: A firm takeover is required when using the steering wheel to regain manual control of the vehicle. During this application, it may feel as though the steering is holding its current position. This is expected behavior and will release very quickly.

SAFETY DRIVER AND CO-PILOT INFORMATION DISPLAYS

The job of the safety driver is to monitor the roadway and be prepared to take control of the vehicle from the automation when necessary. Therefore, the information presented to them is limited to only that necessary for safe operation of the vehicle. The co-pilot is responsible for monitoring the health of the automation, ensuring that data collection is taking place and to note any anomalies that may need further review. Therefore, the information displays that were designed for this project are very different and are based on the specific roles of each individual.

Safety Driver Display

The safety driver display (Figure 8) will be located to the left of the steering wheel, near the A pillar, but not to interfere with vision out the forward view or to the driver-side mirror. It is a touchscreen; however, all interactions with it will be done prior to the drive. There should be no need for the driver to touch it while the vehicle is in motion.

Figure 8. Safety driver interface location (left); safety driver interface (right)

The interface will:

- Provide situational awareness to safety driver
- Provide auditory and visual feedback regarding automation engagement/disengagement
- Be the HMI for V2V alerts

Information to be provided on the display will include:

- The status of the automation (i.e., manual mode or automated mode)
- A map of the route and the vehicle location on that route
- Speed limits along the route
- Outside temperature
- Road temperature
- Lane position
- Headway information

Co-Pilot Display

The co-pilot display will be located on the far-right side of the vehicle, near the A pillar, and will not interfere with the safety driver's ability to see out the passenger-side mirror (Figure 9). It is a touchscreen; however, the co-pilot will be able to interact with it using a wireless keyboard as well. The co-pilot will have the ability to switch between Dreamview (default view and the main HMI for Apollo) and the IVy control panel, developed by NADS (Figures 10 and 11).

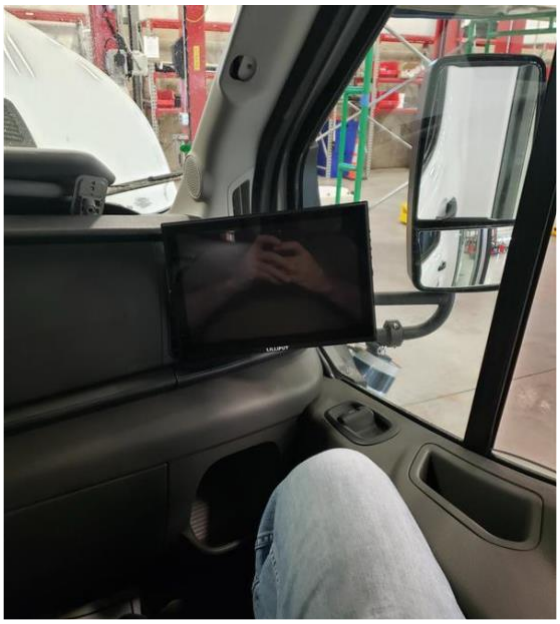


Figure 9. Co-pilot interface location

Dreamview is a web application that visualizes the current output of relevant autonomous driving modules, e.g., planning trajectory, car localization, chassis status, etc. It provides human-machine interface for users to view hardware status, turn on/off of modules, and start the autonomous driving car. It also provides debugging tools, such as PnC Monitor to efficiently track module issues.

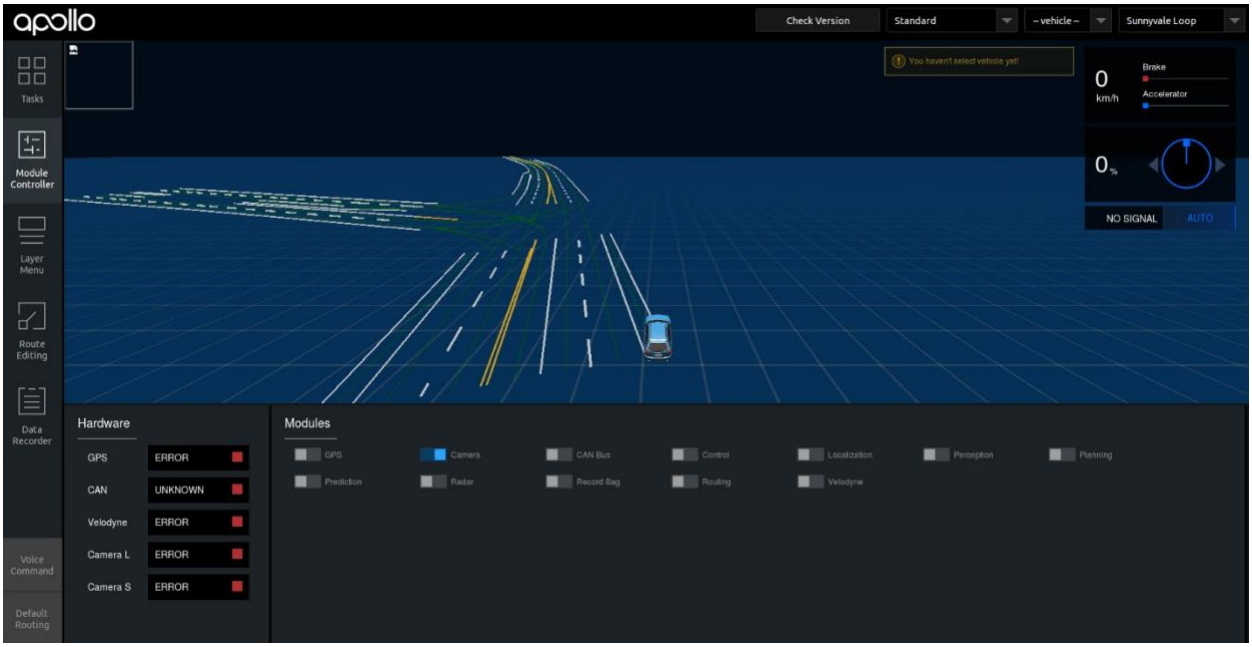


Figure 10. Dreamview interface

IVy was developed to provide the co-pilot with information relevant to the drive (e.g., speed, route, road conditions). It also allows the co-pilot to set the parameters for, and start/stop the ADS recordings.

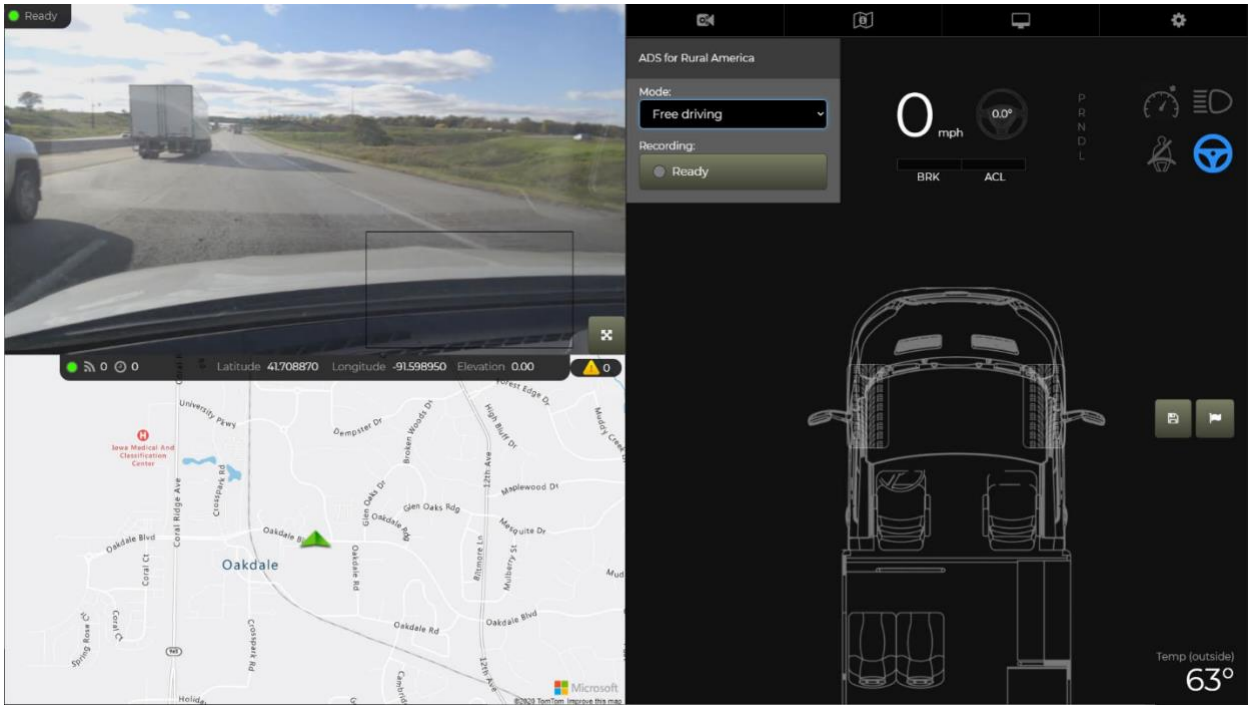


Figure 11. IVy Interface

COMMUNICATION BEST PRACTICES

Communication Between Safety Driver and Co-Pilot

The AVSC recommends a two-person crew comprised of a safety driver and a co-pilot during testing and evaluation of automated vehicle technologies. Having this two-person team allows the safety driver to focus on safety while ensuring that all systems and environmental factors are monitored. Due to the role they both play in the safe operation of the vehicle, it is necessary that there be efficient, clear, and concise communication. A clear division of labor on-board the vehicle will facilitate communication and minimize duplication of efforts. However, it is important that both members of the team understand that it is imperative that they voice any and all concerns as soon as they are aware of them.

The safety driver will be responsible for:

- Informing the co-pilot of any unexpected vehicle behavior
- Notifying the co-pilot prior to trip start/end and confirming data recording start/stop

The co-pilot will be responsible for:

- Informing the safety driver of Important environmental situations (e.g., weather alerts, road surface temperatures, objects in the road)
- Notifying the safety driver of important system statuses (e.g., the health of various sensors or modules)
- Notifying the remote operator of any mechanical issues pertaining to the vehicle or the wheelchair lift
- Contacting 911 in the case of an emergency (e.g., collision or medical situation on-board)
- Taking notes during the trip regarding any unexpected vehicle behavior reported by the safety driver, situations that should be identified in the data or reviewed on video, maintenance issues that are identified, or system challenges that need to be addressed by other members of the ADS for Rural America team (UI or AutonomouStuff)

All conversations that are un-related to safely operating the vehicle should be kept to a minimum. Cell phone use is not allowed unless it is to contact the remote operator or emergency services.

Pre- and Post-Trip Protocols

These protocols will include visual inspection of sensors, in-cabin system checks, and ADS health reports (see Appendix G for details regarding the ADS inspection process and Appendix H for the ADS Inspection Report).

Pre-Trip Inspection

Do the inspection the same way each time so you will be less likely to forget any of the steps.

Step 1: Inspect all sensors and equipment for damage or occlusion from dirt or debris.

Step 2: Perform an in-cabin systems check. Ensure that all displays and interfaces are operational.

Step 3: Check in-vehicle cameras.

Step 4: Test the by-wire mode.

Step 5: Take the vehicle for a short drive on the local test route (i.e., 2-mile loop around NADS) to ensure that all systems are working, including the data recording feature.

Step 6: Complete an ADS Inspection Report.

Post-Trip Inspection

The following items should be done upon completion of each demonstration drive:

- Shut down of all systems occurred as expected.
- Data download occurred as expected.
- There are no signs of damage to sensors or other equipment.
- Request that the vehicle is washed if it appears that sensors or other equipment appears dirty.
- Report any noncritical defects that you observed during the drive to ensure that the vehicle is in proper working order for the next demonstration drive.

Appendix G: ADS Inspection

PRE-TRIP INSPECTION

Do the inspection the same way each time so you will be less likely to forget any of the steps. Use the labeled diagram below to help ensure that each sensor is checked (Figure 12).

Step 1: Before beginning your trip, you will need to properly inspect the ADS equipment, including all sensors on the vehicle. Make sure that they are correctly positioned and are not dirty, blocked, or damaged. Start at the front of the vehicle and work your way all the way around. It may be necessary to use a step ladder to view the antennae at the top of the vehicle.

Figure 12. Location and description of sensors (LiDARs, radars, and cameras) and other instrumentation

1. Cohda Wireless MK5 On-Board Unit (OBU) antenna
2. NovAtel GPS antenna
3. Velodyne LiDARs
4. Leopard Imaging 1080p WDR USB 3.0 cameras
5. Mobileye 630 collision avoidance system (interior)
6. Continental ARS 408 long range radars
7. Logitech 930 webcam video camera

Step 2: Perform an in-cabin systems check. Ensure that all displays and interfaces power up and display the appropriate information. This includes the safety driver display, the co-pilot display, as well as the central information display and all passenger HMI (see Figure 13, left).

Step 3: Check all in-vehicle cameras to ensure that they have not been moved or bumped. The passenger video views/angles can be checked by looking at the video recorder—it will be showing live views of the four connected cameras (see Figure 13, right). Going to record (from standby) can also be verified by indicators on the recorder.

Front and rear-view cameras can be checked by looking at the safety driver, co-pilot, or remote displays. These will also give a live representation of a subset of all of the diagnostic data information being recorded.

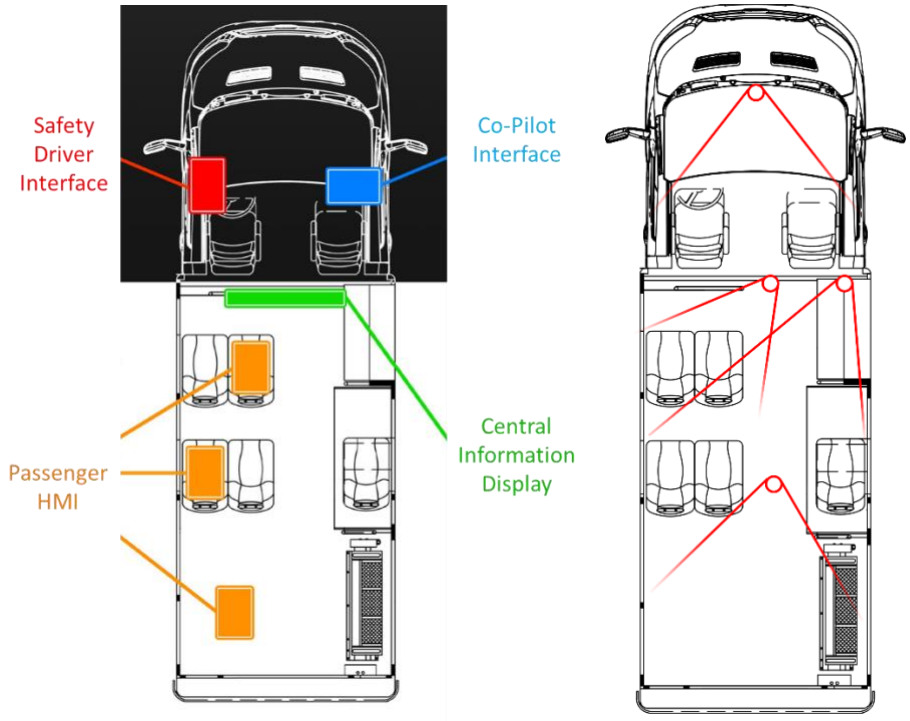


Figure 13. Location of all displays and interfaces (left); location of all in-vehicle cameras (right)

Step 4: Test the by-wire mode

Operators should always complete a full startup procedure to ensure all control systems are properly functioning. Audible alerts will sound during faults, mode changes, and when the by-wire system E-stop is depressed.

1. Apply E-stop.
2. Turn vehicle ignition on. Ensure mode indication LEDs show red. A three second audible alarm is given upon vehicle startup.
3. Apply vehicle parking brake and hold the normal vehicle brake.
4. Manually push each one of the E-shifter gear selection buttons. Ensure the gear shifter successfully achieves each position.
5. Return the vehicle gear to park. Confirm the vehicle parking brake is still applied. Release the foot brake.
6. Release the E-stop. Ensure the LEDs turn green.
7. Launch PACMod By-Wire Controller software.
8. Enable by-wire mode.
9. Test the steering takeover to ensure system returns to manual mode. Return to by-wire mode.
10. Test the brake takeover to ensure system returns to manual mode. Return to by-wire mode.
11. Test the accelerator takeover to ensure the system returns to manual mode. Return to by-wire mode.
12. Apply steering commands with the by-wire controller, ensure the system responds.
13. Apply the by-wire brake, release the park brake, shift into drive, test by-wire control of throttle and braking.
14. Stop the vehicle and shift by-wire through each of the gears.
15. Command the horn, hazard lights, headlights, and turn signals. Ensure the system responds accordingly.
16. The vehicle is now ready for by-wire control.

Step 5: Take the vehicle for a short drive on the local test route (i.e., 2-mile loop around NADS) to ensure that all systems are working, including the data recording feature. Overall recording status will be visible on both the safety driver and co-pilot displays. Doing a short recording check might be useful.

Step 6: Don’t forget to fill out the ADS inspection report (Appendix H), adding any problems noted during, or at the end of, your trip.

Appendix H: ADS Inspection Report

Indicate that the item has been inspected with a check ✓

		✓	Notes
Sensors	Velodyne LiDARs		
	Leopard Imaging 1080p WDR USB 3.0 cameras		
	Continental ARS 408 long range radars		
	Logitech 930 webcam video camera		
Antennae	Cohda Wireless MK5 On-Board Unit (OBU) antenna		
	NovAtel GPS Antenna		
Equipment	Mobileye 630 collision avoidance system (interior)		
In-Vehicle Displays	Safety driver interface		
	Co-pilot interface		
	Central information display		
	Rider/passenger interface		
In-Vehicle Cameras	Safety driver camera		
	In-cabin cameras		
By-Wire Mode	Mode indication LEDs are functioning		
	Audible alert at engine start up and at mode change		

	Test steering takeover		
	Test braking takeover		
	Test accelerator takeover		
	Test by-wire command of steering, throttle, and braking		
	Test by-wire command of the horn, hazard lights, headlights, and turn signals		

Appendix I: Crisis Communication Plan

A “crisis” involving the vehicle, or its inhabitants may include but is not limited to:

- a vehicle crash,
- vehicle breakdown, or
- medical emergency of someone on board.

After first calling 911 and ensuring the safety of the staff and riders, operators are required to report any crises as soon as possible to Omar Ahmad (project manager). Omar will be responsible for immediately contacting Dan McGehee (director, NADS), Kristine Roggentien (NADS, head of communications), and, when there is damage to the vehicle, Mike Wilson (UI Fleet Services). Within 24 hours of the incident, Omar will notify Steve Mortensen (FTA project manager) and John Gibson (FHWA co-manager) via email and phone.

Once Kristine has been notified, she will begin to contact and work with the following to prepare an internal summary of the incident and any further media statements as needed (please see the ADS for Rural America Media Relations Plan for additional details):

- UI Office of the General Counsel
- UI Media Relations
- UI Risk Management
- FTA Office of Communications and Congressional Affairs (Valerie Berton) and FTA Office of Chief Counsel via FTA project manager, Steve Mortensen

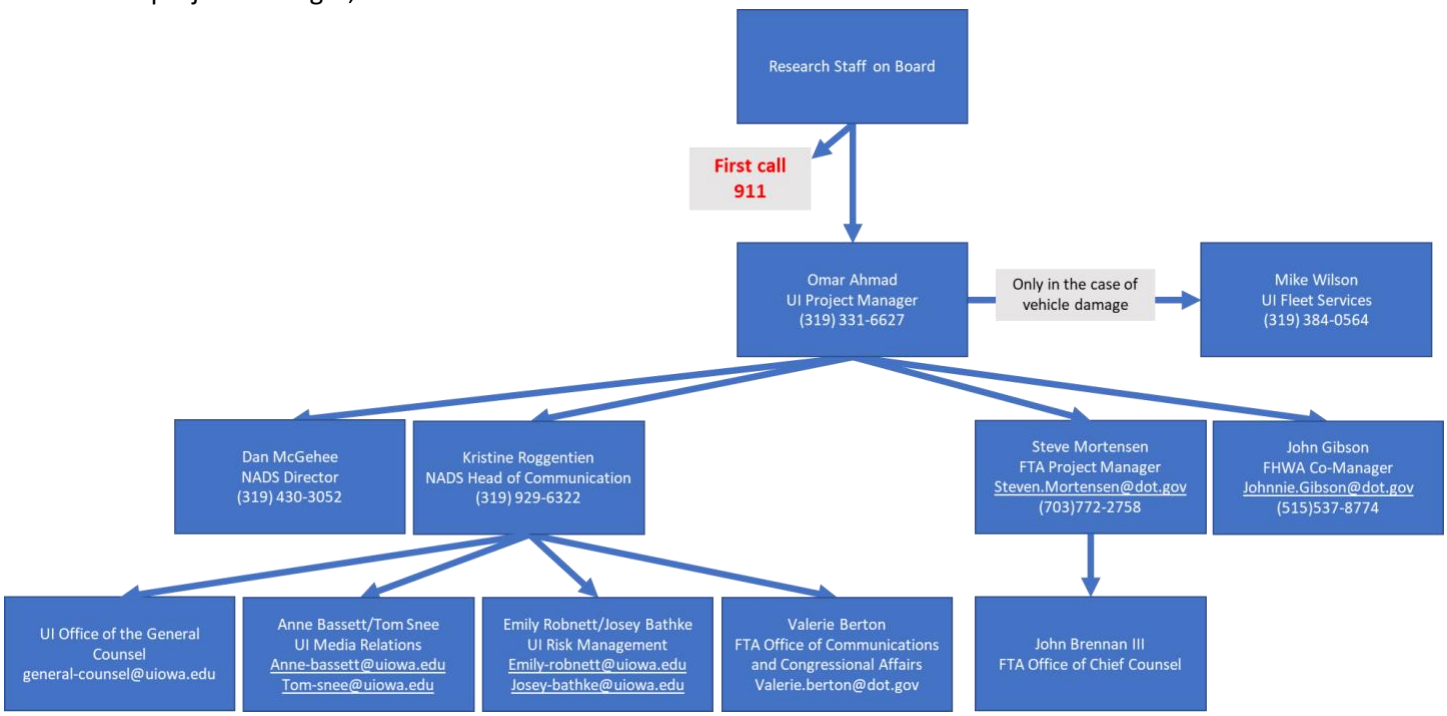


Figure 14: Crisis communication plan and contact tree

Appendix J: Accident Report

REGENT INSTITUTIONS
BOARD OF REGENTS, STATE OF IOWA
VEHICLE ACCIDENT REPORT

Vehicle Accident Reporting Procedures

1. **STOP** - Do not leave the scene of the accident.

2. Render aid or assistance to the injured (Section 321.263, Code of Iowa).

3. Notify the nearest law enforcement agency immediately if the accident involves a fatality, injury, or property damage. If the accident occurs on campus, please contact the Department of Public Safety at your institution:

Iowa State University	The University of Iowa	The University of Northern Iowa
(515) 294-4428	(319) 335-5022	(319) 273-2712

4. Do not admit fault and do not attempt to settle your own claim.

5. If the accident involves another party, complete the Accident Information Exchange.

6. Be sure to obtain names, addresses, and phone numbers of any passengers or witnesses.

7. Complete the Vehicle Accident Report form. Answer all questions.

8. Return the completed form to:

Iowa State University	The University of Iowa	The University of Northern Iowa
Transportation Services	Risk Management	Transportation Services
919 Haber Road	430 Plaza Centre One	Facilities Management
Ames, IA 50011	Iowa City, IA 52242	Cedar Falls, IA 50614

9. Notify your supervisor.

If you have questions, please call Risk Management

Iowa State University	The University of Iowa	The University of Northern
Office of Risk Management	Risk Management	Risk Management
1700 Administrative Services Building	430 Plaza Centre One	3219 Hudson Rd
2221 Wanda Daley Drive	Iowa City, IA 52242	Cedar Falls, IA 50614-0197
Ames, IA 50011	Ph: (319) 335-0010	Ph: (319) 273-3189
Ph: (515) 294-7711	Email: risk-management@uiowa.edu	Email: safety@uni.edu
Email: claims@iastate.edu		

Board of Regents, State of Iowa
ACCIDENT INFORMATION EXCHANGE

Regents Driver: Please complete the bottom half of this form and give to the other party. Have the other party complete the top half of this form and give to you.

Other Vehicle Information

Driver's Name _____

Street Address _____ City, State, Zip _____

Driver License No./State _____ Date of Birth _____

Work Phone No. _____ Home Phone No. _____

Owner's Name _____

Street Address. _____ City, State, Zip _____

Name of Insurance Company _____ Policy No. _____

Address of Insurance Company _____ City, State, Zip _____

Type of Vehicle (Pass. Car, Truck, etc.) _____ Mileage _____

Year, Make, Model, License Plate No. _____

Names and Addresses of Passengers/Witnesses _____

Regent Driver/Vehicle Information

Names _____ Work Phone _____

Driver License No./State _____ Date of Birth _____

Type of Vehicle (Pass. Car, Truck, etc.) _____ Mileage _____

Year, Make, Model _____ License Plate No. _____

Owner's Name _____

Street Address _____ City, State, Zip _____

Board of Regents' institutions are agencies of the State of Iowa and are self-insured for motor vehicle liability.

If you have any questions, please contact:

Iowa State University
Office of Risk Management
1700 Administrative Services Building
2221 Wanda Daley Drive
Ames, IA 50011
Ph: (515) 294-7711
Email: claims@iastate.edu

The University of Iowa
Risk Management
430 Plaza Centre One
Iowa City, IA 52242
Ph: (319) 335-0010
Email: risk-management@uiowa.edu

The University of Northern Iowa
Risk Management
3219 Hudson Rd
Cedar Falls, IA 50614-0197
Ph: (319) 273-3189
Email: safety@uni.edu

VEHICLE ACCIDENT REPORT
Board of Regents, State of Iowa

Do Not Write In This Box Fleet File No.

Regents Institution: ☐ Iowa State University ☐ University of Iowa ☐ University of Northern Iowa
☐ Iowa School for the Deaf ☐ Iowa Braille and Sight Saving School

TIME AND LOCATION OF ACCIDENT

Accident Date (Mo/Day/Year)	Day of Week	Time ☐ AM ☐ PM	Number of Vehicles

City	State	At (Street Address, Intersection, Highway, or Parking Lot Name/Number) ☐ On Campus ☐ Off Campus

Were the police notified? ☐ Yes ☐ No	Police Department/Agency	Investigating Officer	Case No.

Were charges filed? ☐ Yes ☐ No	Against whom?	Describe violation (attach copy of the charge)

NO. 1 (REGENTS VEHICLE)

UI Driver/Reporter (Last, First, MI)	Date of Birth	Leased vehicle ☐ Yes ☐ No	Valet Driver ☐ Yes ☐ No	Driver License No./State

Home Address	City/State/Zip	Home Phone#

Work Phone #	Department	Job Title	No. of Occupants

License Plate Number	VIN	State of Reg.	Vehicle Year, Make, Model

Damage Estimate $	Describe Vehicle Damage

NO. 2 (OTHER VEHICLE)

Driver's Name (Last, First, MI)	Date of Birth	Leased vehicle ☐ Yes ☐ No	Valet Driver ☐ Yes ☐ No	Driver License No./State

Street Address	City/State/Zip	Home Phone#	Work Phone#

Type of Vehicle	Make	Model	Year	License Plate No.	State of Registration	No. of Occupants

Owner's Name	Street Address	City/State/Zip	Phone Number

Insurance Company Name/Agent's Name	Address and Phone Number

Damage Estimate $	Describe Vehicle Damage

PROPERTY DAMAGED OTHER THAN VEHICLE *(Fence, utility pole, etc.)*

Owner's Name	Street Address	City/State/Zip	Phone Number

Property Damage

INJURED PERSONS *(Attach additional sheets if necessary)*

Contact information (Name, Address, Phone Number)	Describe Injuries	
		Treated at scene Yes ☐ No ☐ Taken to ER Yes ☐ No ☐
		Treated at scene Yes ☐ No ☐ Taken to ER Yes ☐ No ☐

PASSENGER IN REGENTS VEHICLE *(Attach additional sheets if necessary)*
Contact information (Name, Address, Phone Number, Email)

WITNESS *(Attach additional sheets if necessary)*
Contact information (Name, Address, Phone Number, Email)

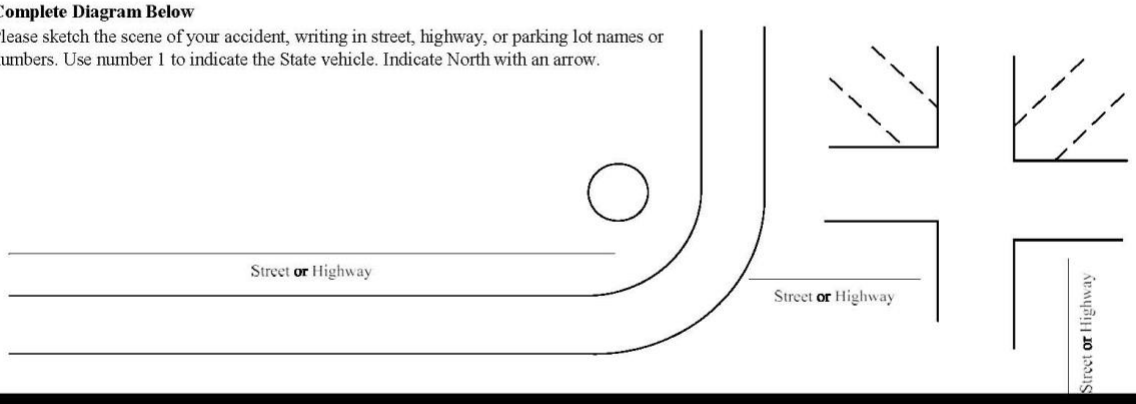
ACCIDENT INFORMATION		
Did you signal a turn? ☐ Yes ☐ No	If yes, by... ☐ Signal Light ☐ Hand Signal	Which direction? ☐ Left ☐ Right
Was your seatbelt fastened? ☐ Yes ☐ No	Speed before accident?	
Were headlights and taillights burning? ☐ Yes ☐ No	Were safety warning lights burning? ☐ Yes ☐ No	

ACCIDENT DESCRIPTION

Accident (Please note any contributing factors, e.g. weather, road construction, etc.)

Complete Diagram Below

Please sketch the scene of your accident, writing in street, highway, or parking lot names or numbers. Use number 1 to indicate the State vehicle. Indicate North with an arrow.



Signature Date

Print Name

Contact Information/Email or Cell Phone

Supervisor/Department Head Date

Print Name

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