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Rear Automatic Braking Feature Confirmation Test Procedure Refinement

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16. Abstract Rear automatic braking (RAB) systems are designed to detect obstacles in the path of a reversing vehicle, provide a warning to the driver, and apply the vehicle's brakes automatically to avoid striking the obstacles. This report describes an effort to investigate possible revisions to an existing research test procedure published as a draft in 2019 for assessing the pedestrian crash avoidance performance of light vehicle RAB systems. It also sought to characterize the performance of current RAB systems in detecting a variety of pedestrian and test object conditions that a reversing vehicle may encounter. Most systems available at the time this work was conducted were described in their documentation as being unable to detect pedestrians. The test procedure described in this report involved vehicle-level tests of two test scenarios: (1) Reversing Vehicle – Stationary Test Object and (2) Reversing Vehicle – Dynamic Test Object, both of which involved a straight path. Scenarios were tested with several test vehicle speeds, test object overlap percentages, and test objects, including pedestrian test mannequins of different sizes, to permit characterization of system performance. Robotic steering and pedal controllers controlled the test vehicles, which allowed for more consistent and repeatable vehicle speeds and positions as compared to previous testing. A belt propulsion system controlling pedestrian test mannequin motion provided increased consistency of motion and speed control. Four model year 2022 U.S. market passenger vehicles equipped with RAB systems were tested. Overall, testing showed RAB system performance to be generally inconsistent for three of the four test vehicles. None consistently avoided contact with pedestrian test objects.			
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List of Acronyms/Definitions

ABD	Anthony Best Dynamics
ADAS	advanced driver assistance system
AEB	automatic emergency braking
CIB	crash imminent braking
EV	electric vehicle
FARS	Fatal Analysis Reporting System
FMVSS	Federal Motor Vehicle Safety Standard
GM	General Motors
ICE	internal combustion engine
IR	infrared
NASS GES	National Automotive Sampling System General Estimates System
NCAP	New Car Assessment Program
NPRM	Notice of Proposed Rulemaking
OE	original equipment
OEM	original equipment manufacturer
OxTS	Oxford Technical Solutions
PAEB	pedestrian automatic emergency braking
PCT	playing child target
PDOV	property-damage-only vehicle
RAB	rear automatic braking
PTM	pedestrian test mannequin
RCAR	Research Council for Automotive Repairs
TTC	time-to-collision
VRU	vulnerable road user

Executive Summary

A rear automatic braking system is designed to detect obstacles in the path of a reversing vehicle, provide a warning to the driver, and apply the vehicle's brakes automatically in an attempt to avoid striking the obstacle. NHTSA has been assessing the performance of RAB technology over time and its potential for mitigating backover crashes. However, most systems available at the time this work was conducted were described in their documentation as being unable to detect pedestrians. NHTSA has also been working on development of a draft research test procedure for assessing the performance of RAB in detecting pedestrians. This report describes an investigation of possible revisions to an existing draft research test procedure for assessing the performance of vehicle RABs systems and to characterize the performance of current RAB systems in detecting pedestrians.

The existing draft research test procedure was published in 2019 and focused on pedestrian detection and avoidance. The test procedure assessed the performance of RAB in detecting a stationary pedestrian test mannequin representing a 7-year-old child positioned 20 ft behind a reversing vehicle in one of three lateral locations: at the vehicle centerline, 2 feet left of center, and 2 feet right of center. The test vehicle with transmission in reverse gear was allowed to roll on a straight path rearward without accelerator pedal application. The vehicle reversed until the RAB system either detected the test object and automatically applied the vehicle's brakes to bring the vehicle to a stop without contacting the test object or until the vehicle contacted the test object. Contact between the vehicle and test object had to be avoided for all three test object locations to pass the test.

Public comments on that test procedure suggested changes, such as incorporating a dynamic pedestrian test scenario, setting a specific, constant test vehicle backing speed, and adjusting the test procedure to accommodate for vehicles that do not roll backwards when their transmission is in neutral gear and on a level surface, such as electric vehicles. In addition, improvements in test equipment technology subsequent to the 2019 draft research test procedure release also offered potential for improved control of test conditions and test repeatability.

Research was performed to investigate possible revisions to the test procedure and to characterize the performance of current RAB systems. Testing conducted involved two types of test scenarios: (1) Reversing Vehicle – Stationary Test Object and (2) Reversing Vehicle – Dynamic Test Object. Test procedure adjustments were implemented, such as use of a robotic steering and pedal controller in the test vehicles, which helped to achieve consistent and repeatable vehicle speeds and positions. The use of a belt propulsion system for controlling pedestrian test mannequin motion provided increased consistency of motion and speed control. Scenarios were tested with a variety of test objects and test speeds to permit further characterization of RAB system performance.

Four model year 2022 RAB-equipped vehicles were tested using additional candidate test conditions as well as other conditions included for the purpose of RAB performance characterization. Several candidate dynamic pedestrian test scenario conditions were found to be viable indicators of system performance. The results of this research provide useful data to support revisions to the existing draft research test procedure for assessing RAB pedestrian detection performance.

Overall, testing showed RAB system performance to be generally inconsistent for three of the four vehicles tested. None of the vehicles were able to consistently avoid a collision with

pedestrian test objects for the dynamic test object scenarios. Tested RAB-equipped vehicles were more likely to avoid impacts for shorter test objects, as well as when tested at lower vehicle speeds. Stationary test objects were also more likely to be detected and avoided as compared to dynamic test objects. Results for the Reversing Vehicle – Stationary Test Object scenario showed two of the four vehicles were more likely to detect and provide warnings in response to a pedestrian test object, while the other two vehicles were more likely to detect and provide warnings for a non-pedestrian stationary test object. However, three out of four vehicles were more likely to avoid contact with the stationary non-pedestrian test objects when compared to the stationary pedestrian test objects. All vehicles were more likely to avoid contact with the bollard test object, as compared to the pillar.

This research provides data that can be used as a basis for updating certain aspects of the existing draft research test procedure. Stationary and dynamic pedestrian test scenario conditions were examined and found to be viable indicators of system performance and could potentially be added to a finalized updated test procedure.

Introduction

A rear automatic braking system is designed to detect one or more objects in a reversing vehicle's path, provide warnings to the driver, and automatically apply the vehicle's service brakes to help avoid striking the obstacles. Such technology may have the potential to mitigate backing crashes. NHTSA is interested in RAB technology as a potential next step in the prevention of backover crashes in which non-occupants such as pedestrians or cyclists are struck by reversing vehicles. NHTSA has been examining the performance of RAB since it was introduced in the United States in MY 2013 to assess its potential for mitigating backover crashes. However, most systems available at the time this work was conducted were described in their documentation as not having the ability to detect pedestrians. NHTSA has also been developing a draft research test procedure to assess performance of RAB in detecting pedestrians. This report describes an investigation of possible revisions to an existing draft research test procedure to assess performance of vehicle rear automatic braking systems and to characterize their performance in detecting pedestrians.

Background

A backover crash occurs when a non-occupant such as a pedestrian or cyclist is struck by a reversing vehicle. The victims of backing crashes are frequently young children and elderly people. Due to their short stature, children are difficult for drivers to detect in vehicle rear blind zones due to structural design aspects of the vehicle, such as vehicle height and length, pillar width, and rear window dimensions. Poor rear visibility contributes to the likelihood of unseen obstacles, which can include pedestrians (Mazzae et al., 2019).

Relevant Crash Statistics

In a March 2022 Notice of Request for Comments for NCAP in the Federal Register (87 FR 13452), NHTSA presented crash statistics relevant to rear automatic braking systems and other ADAS technologies. Derived target crash populations for each of the five technology categories were developed using Fatality Analysis Reporting System from 2011 to 2015 and National Automotive Sampling System General Estimates System data sets, which summarize police-reported fatal and non-fatal crashes. For a given technology category, data was compiled for each of the corresponding pre-crash scenarios to generate target crash populations surrounding the number of crashes, fatalities, non-fatal injuries, and property-damage-only vehicles. See Table 1 for a breakdown of target crash population for rear automatic braking systems.

Table 1. Summary of Target Crashes by Technology Group (Wang, 2019)

Safety Systems	Crashes	Fatalities	MAIS 1-5 Injuries	PDOVs
RAB/RvAB/RCTA ¹	148,533 (2.6%)	74 (0.2%)	35,268 (1.3%)	231,317 (3.2%)

Backover crashes where pedestrians are injured or killed by reversing vehicles (typically not on public roads), have been estimated since 2009 using Non-Traffic Surveillance system data (National Center for Statistics and Analysis, 2024). Table 2 summarizes the latest NTS backover crash estimates.

¹ Rear Automatic Braking/Reverse Automatic Braking/Rear Cross Traffic Alert.

Table 2. Number of Nonoccupants Killed or Injured in Non-Traffic Crashes Involving Backing Vehicles (NCSA, 2024)

Year	2017	2018	2019	2020	2021	5 Year Average
Fatalities	327	192	305	256	234	263
Injuries	13,362	11,019	10,825	8,019	7,157	10,076

Technology for Mitigation of Backover Crashes

Until around 2012, available backing crash countermeasures were limited to sensor-based systems designed to detect rear objects and provide warnings to the drivers, rear-facing cameras that provided drivers with images of the area behind the vehicles, and some systems that included both technologies. NHTSA has been evaluating rear object detection system performance in detecting pedestrians and other objects since the early 1990s (Mazzae et al., 2006). The evaluations have been iterative, as new original equipment and aftermarket technologies have become available. NHTSA testing of sensor-based systems to date (Mazzae et al., 2019) has found their performance in detecting small children to be poor and inconsistent.

In support of NHTSA’s response to the Kids Transportation Safety Act of 2008 (H.R.1216 - 110th Congress, 2007-2008), NHTSA conducted a research program to assess the effectiveness of technologies for mitigating backing crashes. The research included four studies (Mazzae et al., 2008; Mazzae, 2010, 2013; NHTSA, 2010) that overall found that camera-based systems providing a view of the area behind a backing vehicle were associated with the highest percentage of crashes avoided. For this reason, the December 2010 Notice of Proposed Rulemaking proposed to amend FMVSS No. 111 by adding a visual-image based countermeasure for improving rear visibility rather than a sensor-based warning system (75 FR 76186). A final rule issued on April 7, 2014, required that all vehicles under 10,000 pounds, including buses and trucks, manufactured on or after May 1, 2018, must display to a driver a rearview image showing the 10-foot wide by 20-foot long zone directly behind the vehicle (79 FR 19178).

Introduction of Rear Automatic Braking Systems into the U.S. Vehicle Fleet

The years following the addition of rearview image requirements to FMVSS No. 111 saw the introduction of rear automatic braking systems in the U.S. passenger car fleet. Rear automatic braking systems use sensors to detect objects in the vehicle’s path, provide warnings to the driver, and automatically apply the brakes to help avoid collisions when traveling in reverse gear. In MY 2013, the first rear automatic braking systems offered in the U.S. market were on some Cadillac and Infiniti models. These systems were not marketed as pedestrian detection systems; however, they may have had some ability to detect pedestrians. They used two or more sensor technologies working together to detect rear obstacles, alert the driver, and automatically initiate braking. Both vehicles were also equipped with rearview video systems.

Cadillac’s “Automatic Front and Rear Braking” was available on the 2013 ATS, XTS, and SRX, using a combination of radar and ultrasonic sensors to detect imminent crashes and provide alerts to the driver. The system was capable of automatically braking to avoid a crash or reduce impact speed and could apply the vehicle’s maximum braking capability to bring the vehicle to a stop. As noted in NHTSA’s 2019 report, *Rear Automatic Braking Feature Confirmation Test – Draft*

Test Procedure Assessment, (Mazzae et al., 2019) a September 2012 GM press release titled, *Cadillac ‘Virtual Bumpers’ Can Help Avoid Crashes*, stated the system uses:

“Radars, vision, and ultrasonic sensors ...working together to determine if a crash may be imminent.” Based on calculations, “the vehicle can automatically brake to avoid a crash or reduce impact speed, and if necessary, can apply the vehicle’s maximum braking capability.” If the driver fails to respond to the provided alerts and “a potential collision is imminent, the automatic braking is designed to apply the brakes and stop the vehicle. If the system brings the car to a stop, the electronic parking brake will hold the car in place until the driver presses the accelerator pedal.”

Infiniti’s “Backup Collision Intervention” system was available on the 2013 JX and used a combination of radar and sonar sensors to detect crossing vehicles and objects behind the vehicle, provide visual and audible warnings, and automatically apply the vehicle’s brakes momentarily to help avoid a collision. As highlighted in the following owner’s manual text (Infiniti North America, Inc., 2013), this system required that the driver had to apply pressure to the brake pedal to bring the vehicle to a stop, which differed from the operation of the Cadillac system.

“If the radar detects a vehicle approaching from the side or the sonar detects close objects in the rear, the system gives visual and audible warnings and applies the brake for a moment when the vehicle is moving backwards. After the automatic brake application, the driver must depress the brake pedal to maintain brake pressure. If the driver’s foot is on the accelerator pedal, the system pushes the accelerator upward before applying the brake.”

By 2024 most, if not all, manufacturers of U.S. market passenger cars were offering rear automatic braking systems on at least one model. The systems are referred to by names such as “Reverse Automatic Braking” or “Reverse Automatic Emergency Braking (RAEB)”. Rear automatic braking systems are also sometimes included as part of a “parking assist” system. RAB systems use sensors to detect objects behind reversing vehicles, alert the drivers of the presence of the objects via auditory, visual, haptic alerts, or a combination of these, and automatically engage the available braking system to stop the vehicles. These systems are designed to reduce the harm caused by a rear collision or assist the driver in avoiding a rear collision altogether.

Table 3 lists several RAB systems offered by U.S.-market original equipment manufacturers in 2024.

Table 3. RAB Systems in the United States With the Manufacturer-Specific System Names

OEM	RAB System Name
Audi	Maneuvering Assist
BMW	Active Park Distance Control
Chrysler (Dodge, Jeep, Ram)	ParkSense Rear Park Assist with Stop
Fisker	Rear Automatic Emergency Braking
Ford (Lincoln)	Reverse Braking Assist
General Motors (Cadillac, GMC)	Reverse Automatic Braking
Honda (Acura)	Low-Speed Braking Control
Hyundai (Genesis, Kia)	Reverse Parking Collision-Avoidance Assist
Lucid	Rear Pedestrian Collision Protection
Mazda	Smart City Brake Support Reverse
Mitsubishi	Rear Automatic Emergency Braking
Nissan (Infiniti)	Rear Automatic Braking
Porsche	Maneuvering Assist
Subaru	Reverse Automatic Braking
Tesla	Automatic Emergency Braking
Toyota (Lexus)	Parking Support Brake
Volvo (Polestar)	Rear Auto Brake

Many current RAB systems are not designed to detect pedestrians. In many cases, owner's manuals for vehicles equipped with RAB systems state that the RAB systems do not detect pedestrians, especially children and bicyclists, or animals. Many owner's manuals also state that the systems do not detect objects that are low to the ground or thin objects such as poles.

Some OEMs also offer Rear Cross Traffic Warning systems, which warn the driver of a reversing vehicle of a potential collision with an approaching vehicle that may be outside the view of the backup camera. These systems may provide automatic braking in response to rear obstacles. RCTW systems' sensing can be based on radar or wide-angle rearview cameras paired with computer vision algorithms. While these systems are not intended to detect pedestrians, there may be some capability to do so under certain conditions. As RCTW cannot be disabled separately from RAB in some vehicles, RCTW's effect on crash avoidance in a rear pedestrian scenario may not be distinguishable from RAB's performance in some cases. Table 4 is a list of several of the rear cross traffic alert systems offered by the OEMs in the U.S. market.

Table 4. Rear Cross Traffic Alert Systems in the United States

OEM	Rear Cross Traffic Alert System Name
Audi	Rear Cross Traffic Assist
Hyundai (Genesis, Kia)	Rear Cross-Traffic Collision-Avoidance Assist
Lucid	Cross Traffic Protection
Mercedes-Benz	Cross Traffic Alert
Porsche	Rear Cross Traffic Alert
Tata Motors (Jaguar, Land Rover)	Rear Traffic Braking
Volkswagen	Rear Traffic Alert

Objectives and Scope

This work investigated possible updates to an existing draft research test procedure assessing the performance of vehicle rear automatic braking systems and to characterize the performance of current RAB systems in detecting pedestrians. The existing draft research test procedure, NHTSA's *Rear Automatic Braking Feature Confirmation Test – Draft Test Procedure Assessment* (Mazzae et al., 2019), contains a single, stationary test object test scenario. Research was performed to investigate ways of updating this test procedure. A dynamic pedestrian test scenario was investigated to permit a more comprehensive assessment of RAB performance in more real-world conditions. Other relevant RAB-related test procedures such as Euro NCAP (2022) and RCAR (2017) were reviewed to consider whether any aspects of those test procedures should be included in a revised draft NHTSA RAB test procedure. Another possible change we examined included the use of set test vehicle speeds for test scenarios to improve the consistency of the test procedure and to ensure the test procedure can be performed with any U.S.-sold passenger vehicle regardless of propulsion system and transmission type. RAB performance was assessed for four MY 2022 U.S. vehicles as part of an evaluation into potential test procedure enhancements.

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Existing Test Procedures for Rear Automatic Braking

In considering revisions to the existing draft NHTSA RAB test procedure, other existing test procedures published by the Euro NCAP (2022) and the RCAR (2017) were examined to assess whether additional test scenarios from those test procedures may be beneficial to include in NHTSA's updated RAB test procedure.

NHTSA Draft Rear Automatic Braking Feature Confirmation Test Procedure (2019)

In 2019 NHTSA documented a draft research test procedure for assessing rear automatic braking system performance in a research report titled *Rear Automatic Braking Feature Confirmation Test – Draft Test Procedure Assessment* (Mazzae et al., 2019). That test procedure focused on pedestrian detection and avoidance and included a single test scenario involving a moving test vehicle reversing toward a stationary test object. The test object was a pedestrian test mannequin representing a 7-year-old child positioned 20 ft behind a reversing vehicle in one of three lateral locations, at the vehicle centerline, 2 feet left of center, and 2 feet right of center. The mannequin was oriented in a striding position as if crossing from the passenger side to the driver side of the vehicle. A test scenario trial started by the driver shifting the vehicle's transmission into reverse gear and then releasing the brake pedal allowing the vehicle to roll straight back toward the mannequin without accelerator pedal application. The test scenario is shown in Figure 1. The test trial ended either when the vehicle was stopped by automatic braking or when it struck the mannequin. The test was repeated with the child mannequin at each of the three test object positions and data was collected indicating if the system detected the presence of the object, if the vehicle stopped automatically, and if the vehicle struck the mannequin. A positive test outcome involved the vehicle stopping automatically before contacting the mannequin for each of the three test object locations.

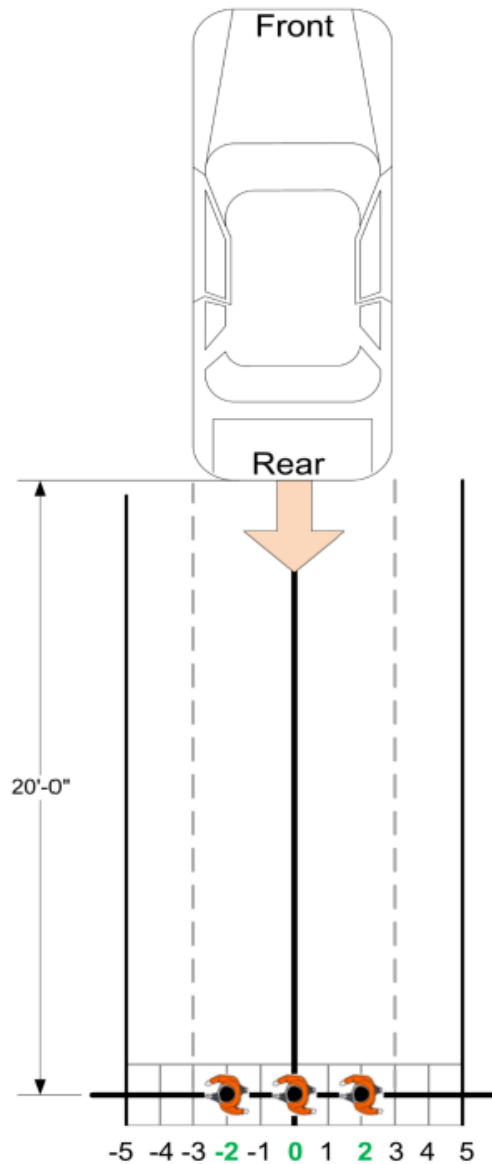


Figure 1. NHTSA RAB Draft Test Procedure Test Scenario Illustration (Mazzae et al., 2019)

The research that developed the test procedure involved testing of three different original equipment vehicle systems: “Rear Automatic Braking” on a 2014 Cadillac ATS, “Back-Up Collision Intervention” on a 2014 Infiniti Q50, and “Rear Cross Path & ParkSense Rear Park Assist” on a 2015 Chrysler 200C. As NHTSA’s focus was on protecting pedestrians in backing crashes, the goal assessed whether the test procedure was effective in evaluating the ability of a rear automatic braking feature to warn the driver of the presence of a pedestrian behind the vehicle and automatically engage the brake system to avoid striking the mannequin. The 2019 effort could not achieve a repeatable dynamic pedestrian test scenario in the timeline for the work summarized in the 2019 report, resulting in that scenario not being included in the draft research test procedure. However, testing with the stationary pedestrian test mannequin scenario found it to be repeatable and effective in evaluating the performance of a rear automatic braking

feature in detecting a child pedestrian test mannequin. Some test outcome variability was observed and may have been related to external factors such as environmental conditions.

Public feedback comments regarding the draft research test procedure included the following suggestions.

- Consider adding a dynamic pedestrian target to represent backing crash data.
- Determine a specific acceleration speed/rate until the vehicle reaches a “coasting” mode.
- Define a maximum reverse vehicle speed.
- Specify the vehicle speed that the RAB system should not be expected to be effective.
- Clarify the number of test trials.
- Include test object specifications.
- Specify the color, slope, and friction levels of the road surface.
- Clarify how manual transmissions should be treated.
- Reconsider 16 lux ambient light level specification for test conditions.
- Specify ambient light and weather conditions.

This work considered these comments in investigating revisions to the test procedure.

Euro NCAP RAB Test Procedures

The Euro NCAP *Test Protocol - AEB/LSS VRU systems, Implementation 2023, Version 4.3* (2022) includes two reversing “car-to-pedestrian” test scenarios: Car-to-Pedestrian Reverse Adult/Child Moving 50 Percent (CPRA/Cm-50) and Car-to-Pedestrian Reverse Adult/Child Stationary (CPRA/Cs). They are shown in Figure 9.

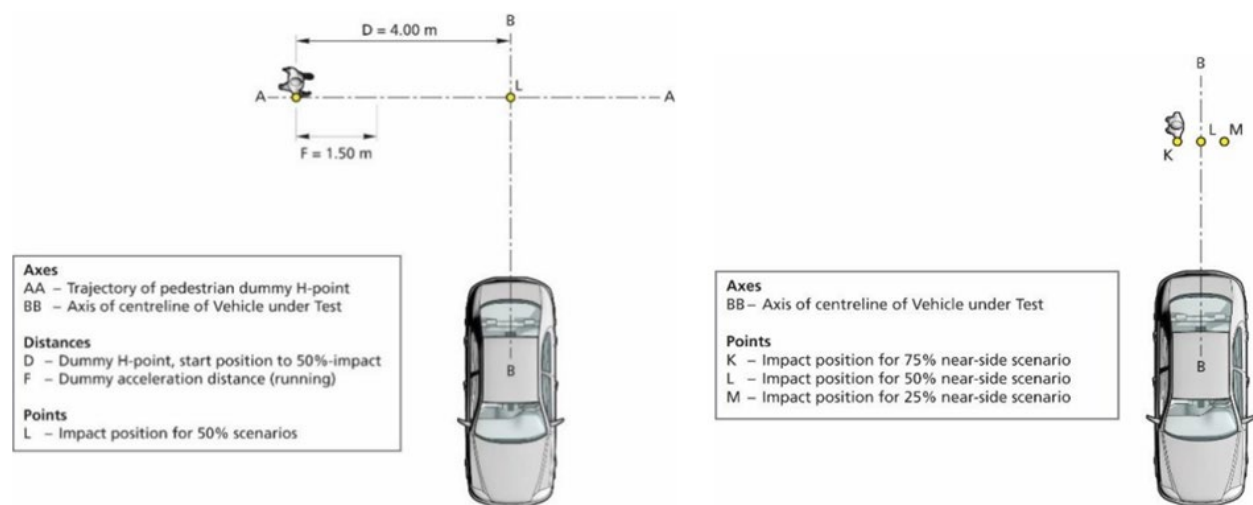


Figure 2. Euro NCAP Reverse Moving (left) and Stationary (right) Test Scenarios (Euro NCAP, 2022)

CPRA/Cm-50 involves a test vehicle traveling rearward toward an adult or child pedestrian crossing its path walking from the nearside, where the rear of the test vehicle strikes the pedestrian at 50 percent of the vehicle’s width. The mannequin is initially located 13.1 ft (4 m) from the test vehicle’s 50 percent width position, and travels at a speed of 3.1 mph (5 km/h).

CPRA/Cs involves a test vehicle traveling rearward toward an adult or child pedestrian standing still and facing sideways, where the rear of the vehicle strikes the pedestrian at 25, 50, or 75 percent of the vehicle's width.

RCAR Test Procedure

The European RCAR, “an international association of automotive research centres, owned or operated by insurers or groups of insurers” has its own RAB test procedure titled *Procedure for assessing the performance of Reverse Autonomous Emergency Braking (R-AEB) systems in rear collisions* (2017). This test procedure specifies reversing car-to-car, reversing car-to-bollard, and reversing car-to-pillar test scenarios.

The reversing car-to-bollard test has two scenarios: reversing car-to-bollard central and reversing car-to-bollard 1.3 ft (0.4 m) inbound. For the central scenario, the bollard centerline is placed at the centerline of the test vehicle. For the 1.3 ft (0.4 m) inbound scenario, the bollard is centered 1.3 ft (0.4 m) from the side of the test vehicle. These are shown in Figure 3.

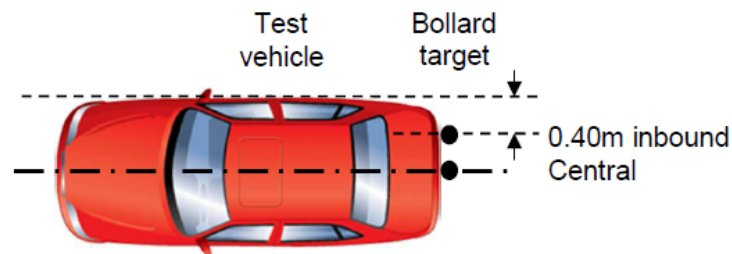


Figure 3. RCAR Reversing Car-to-Bollard Test Scenarios (RCAR, 2017)

The reversing car-to-pillar test also has two scenarios: reversing car-to-pillar central and reversing car-to-pillar 1.3 ft (0.4 m) inbound. The placement of the mannequin is identical to the reversing car-to-bollard scenarios; however, the pillar is oriented so that its faces are at a 45° angle to the centerline of the test vehicle. These are shown in Figure 4.

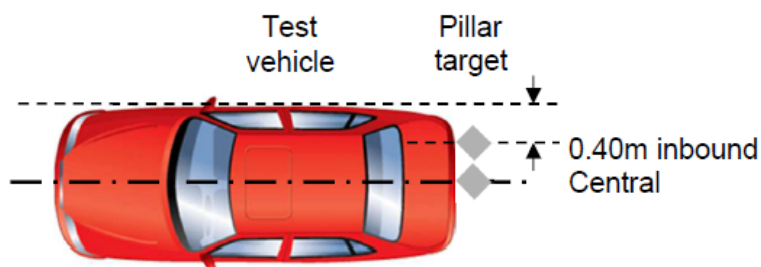


Figure 4. RCAR Reversing Car-to-Pillar Test Scenarios (RCAR, 2017)

The test scenarios are conducted with two different test vehicle starting positions: 6.6 ft (2 m) and 19.7 ft (6 m). A test vehicle speed of 1.9 mph (3 km/h) is specified for the 6.6 ft (2 m) starting position, and a test vehicle speed of 3.7 mph (6 km/h) is specified for the 19.7 ft (6 m) starting position.

Method

This section describes the method pursued for the investigation of possible revisions to the draft research test procedure and RAB performance characterization. Information outlined includes test scenario descriptions, equipment, data acquisition and instrumentation, and the data collected.

Test Procedure Revisions Investigated

Possible revisions to the test procedure that were investigated are summarized in Tables 5 and 6 along with the rationales.

Table 5. Test Procedure Possible Revisions Investigated – Test Vehicle

Test Procedure Aspect	2019 RAB Feature Confirmation Test	2024 RAB Test Procedure Refinements Investigated	Rationale
Test Scenario	Reversing Vehicle – Stationary Test Object	- Reversing Vehicle – Stationary Test Object - Reversing Vehicle – Dynamic Test Object	To investigate addition of dynamic pedestrian scenario to provide a more comprehensive performance assessment, respond to test procedure comments, and better align with Euro NCAP RAB test speeds (Euro NCAP, 2022).
Test Vehicle Speed	Idle backing speed at initial distance of 20 ft (6.1 m) from test object	- Idle backing speed at initial distance of 20 ft (6.1 m) from test object (<i>only for stationary test object</i>) 2.5 mph (4 km/h) 5 mph (8 km/h)	To increase test procedure consistency across tested vehicles and better align with Euro NCAP RAB test speeds (Euro NCAP, 2022).
Test Vehicle Speed Tolerance	N/A	± 0.5 mph (0.8 km/h)	Adjusted from the 2024 NHTSA AEB final rule (89 FR 39686, 2024) tolerance of ± 1.0 mph (1.6 km/h) (NHTSA, 2024) to account for lower test speeds.
Test Vehicle Time to Reach Steady-State	N/A	2 seconds before the test object trigger TTC	To ensure that the test vehicle and test object arrive to the impact position simultaneously.
Test Vehicle Robot Control Deactivation Time	N/A	500 ms after the test vehicle reaches a deceleration of 0.25 g (2.45 m/s ²)	To prevent any subject vehicle pedal input from influencing RAB system performance.

Table 6. Test Procedure Possible Revisions Investigated – Test Object

Test Procedure Aspect	2019 RAB Feature Confirmation Draft Test Procedure	2024 RAB Test Procedure Refinements Investigated	Reasoning for Changes
Test Object Speed	N/A	• 2 mph (3.2 km/h) • 3.1 mph (5 km/h)	To align with previous RAB research, 2024 NHTSA AEB final rule (89 FR 39686, 2024) crossing path test scenarios, and Euro NCAP CPRA/Cm-50 test scenario test object speeds (Euro NCAP, 2022).
Test Object Speed Tolerance	N/A	± 0.25 mph (0.4 km/h)	To align with the PAEB compliance test procedure in the 2024 NHTSA AEB final rule (89 FR 39686, 2024).
Test Object Percent Overlap Position	-2, 0, and 2 feet (0.61 m) from test vehicle centerline	25, 50, and 75 percent of the test vehicle's width	To align with the PAEB compliance test procedure in the 2024 NHTSA AEB final rule (89 FR 39686, 2024) and Euro NCAP AEB (2022) test procedures.
Test Object Impact Position Tolerance	N/A	± 3.2 inches (0.08 m)	Adjusted from the 2024 NHTSA AEB final rule (89 FR 39686, 2024) tolerance of ± 6 inches (0.15 m) (NHTSA, 2024).
Test Object Movement Start Distance	N/A	13.1 ft (4 m) from the test vehicle's centerline	To align with the Euro NCAP AEB (2022) test procedures.
Test Object Acceleration Distance	N/A	4.9 ft (1.5 m)	To align with the Euro NCAP AEB (2022) test procedures.

Additional details regarding how these possible test procedure revisions were examined are provided in the following sections.

Test Scenarios

Two test scenarios were included and discussed below.

Reversing Vehicle – Stationary Test Object

The Reversing Vehicle – Stationary Test Object test scenario simulates a driver performing a straight backing maneuver and an unobserved stationary obstacle is positioned behind the vehicle. Mannequins were oriented so that they faced toward the driver's side of the test vehicle, as specified in the existing draft test procedure (Mazzae et al., 2019). Details of how this scenario was taken from the existing draft test procedure (Mazzae et al., 2019) implemented as part of this testing are shown below. Figure 5 shows the test scenario layout and dimensions.

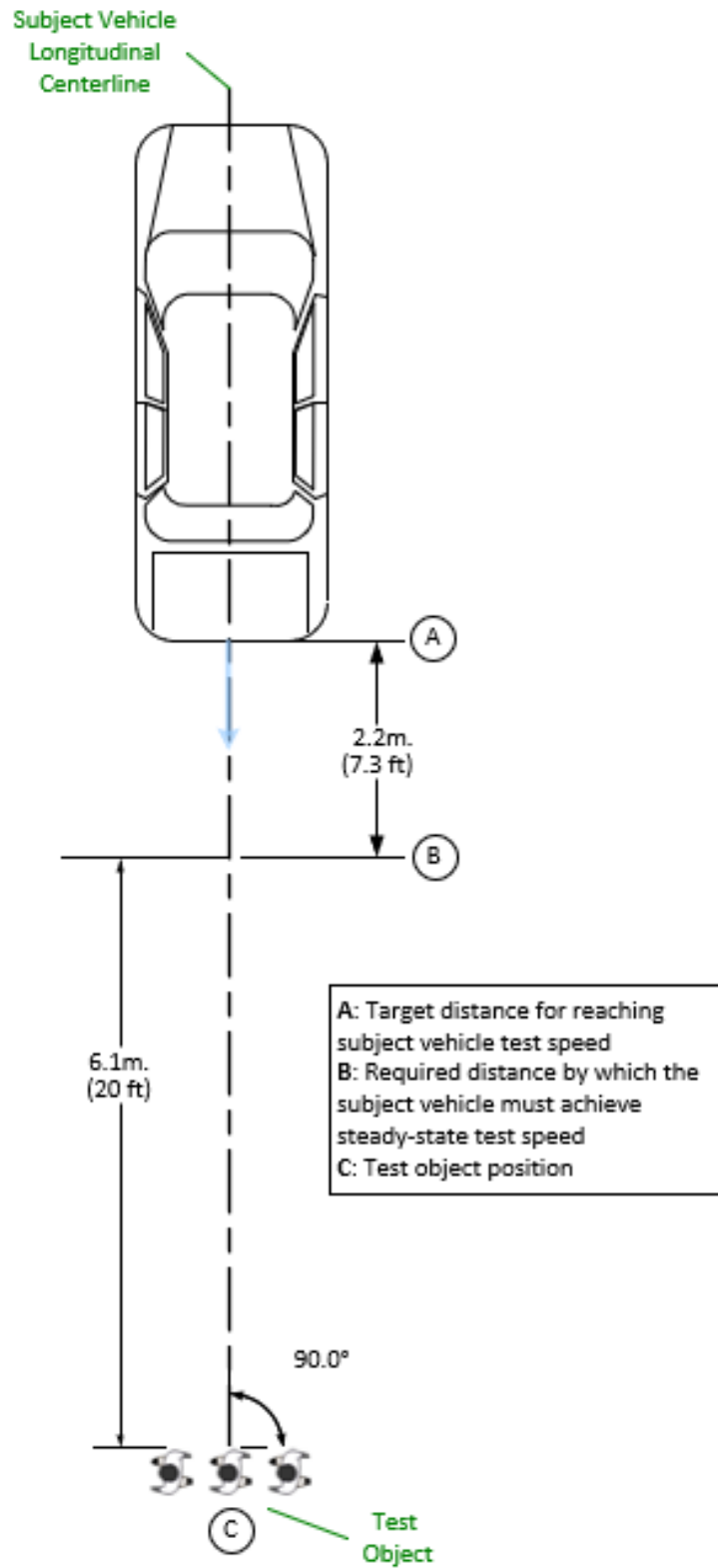


Figure 5. Reversing Vehicle – Stationary Test Object Test Scenario Layout

For idle speed tests, the vehicle was positioned 20 feet (6.1 m) away from the test object and allowed to roll backwards without brake or accelerator input from the driver. For 2.5 mph (4 km/h) and 5 mph (8 km/h) tests, the vehicle started at a distance far enough from the test object so that the test speed could be achieved and maintained at a minimum time of 2 seconds before 20 feet (6.1 m) from the test object was reached. The vehicle then continued moving rearward until the RAB system brought the vehicle to a stop or the vehicle struck the test object.

Test Object Percent Overlap – Stationary Test Object

In the original test scenario, the child mannequin was positioned in one of three lateral locations: at the vehicle centerline, 2 feet left of center, and 2 feet right of center. To better align with the PAEB approach outlined in the 2024 NHTSA AEB final rule (89 FR 39686, 2024) and Euro NCAP's *Test Protocol* (Euro NCAP, 2022), the test object positions were revised to equate to 25 percent, 50 percent, and 75 percent of the width of the vehicle, referred to as percent overlap. Vehicle width was defined as the average of the front and rear widths, referenced to the outer edges of the front and rear wheels. For stationary tests, the 25 percent position was defined as the quarter-width position closest to the passenger side of the test vehicle.

Reversing Vehicle – Dynamic Test Object

The Reversing Vehicle – Dynamic Test Object test scenario simulates a scenario where a driver is backing straight and an unobserved pedestrian moves laterally into the path on a perpendicular approach. For this test scenario, the test object started at an initial position of 13.1 ft (4 m) from the centerline of the vehicle, far enough so the test speed could be achieved and maintained at steady state for a minimum of 2 seconds before the test object began moving along its path. Once the test vehicle began moving rearward and reached steady-state speed, the test object began moving when the time-to-collision reached a specified trigger value. The test object then continued accelerating until its steady-state speed was reached, at 4.9 ft (1.5 m) along its path. After the test object reached its steady-state speed, both the vehicle and test object continued traveling along their paths at steady-state speed until the RAB system applied the brakes and stopped before striking the test object or the vehicle struck the test object.

Test Object Percent Overlap – Dynamic Test Object

Adopting the approach from the stationary object test scenario, test object locations of 25 percent, 50 percent, and 75 percent of the width of the vehicle, referred to as percentage overlap, were implemented in this testing. Vehicle width was defined as the average of the front and rear widths, referenced to the outer edges of the front and rear wheels. The trigger TTC was determined by calculating the amount of time it would take for the test object to arrive at its desired overlap position (25, 50, or 75%). Subsequently, the test object would arrive at the impact position at the same time as the vehicle if the vehicle did not slow down or come to a stop before impact.

Dynamic Pedestrian Approach Direction – Dynamic Test Object

Dynamic test object scenario trials were performed with the pedestrian test mannequin test object approaching from both sides of the vehicle, with the left side of the vehicle defined as the driver's side and the right side of the vehicle defined as the passenger side. The 25 percent and 75 percent impact positions changed based on the direction the test object was travelling, with

the 25 percent position defined as the first quarter-width position that the test object encountered. Figure 6 shows the test layout and dimensions associated with both test object directions.

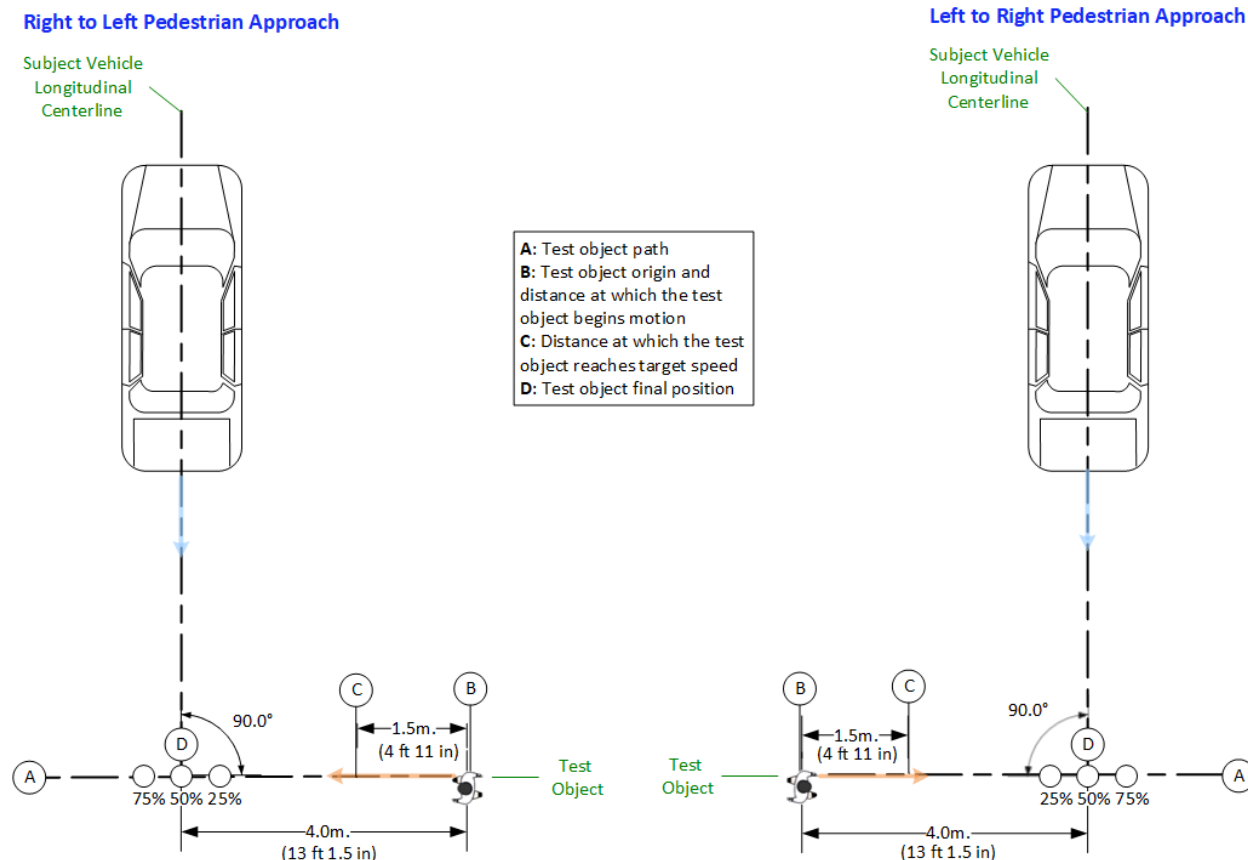


Figure 6. Reversing Vehicle – Dynamic Test Object Test Layout

Test Objects

The test scenarios were performed with pedestrian test devices and other test objects. A variety of test objects were selected to represent objects typically found in real-world backing scenarios, including pedestrians and parking lot obstacles such as shopping carts. Standardized advanced driver assistance system pedestrian test mannequins were used as human surrogate test objects. Each mannequin has a foam core, a fabric outer cover, and a polycarbonate support pole, and gives a realistic response for radar, camera, lidar, ultrasonic, and IR systems. Some were tested for research purposes only to help characterize system performance and not for potential inclusion in a revised draft research test procedure.

Table 7 shows test object details and scenario conditions of each test object. The test objects and postures marked with an asterisk were only tested for research purposes to help characterize system performance, not for inclusion in the draft research test procedure. These characterization testing trials were performed with only one test vehicle, the Jeep Grand Cherokee, due to project time constraints.

Table 7. Test Objects, Postures, and Speeds

Test Object	Test Object Model Information	Test Object Posture	Test Object Speed		
			0 mph	2 mph (3.2 km/h)	3.1 mph (5 km/h)
Adult Pedestrian Test Mannequin	4activeSystems 4activePA-adult (“adult articulated pedestrian” ²)	Standing, Walking (with articulation)	X	X	X
6- to 7-Year-Old Pedestrian Test Mannequin	4activeSystems 4activePA-child (6- to 7-year-old “child articulated pedestrian” ³)	Standing, Walking (with articulation)	X	X	X
2-Year-Old Pedestrian Test Mannequin	4activeSystems 4activePS-2year (“static pedestrian child target 2 years” ⁴)	Standing, Walking	X	X	-
		Sitting*	X	-	-
		Sitting on Bobby Car ⁵ *	X	X	X
1-Year-Old Pedestrian Test Mannequin*	4activeSystems 4activePS-1year (“static pedestrian child target 1 year” ⁶)	Standing	X	X	-
		Crawling	X	-	-
“Playing Child Target” (PCT)*	Messring “Playing Child Target (PCT)” ⁷	-	X	X	X
Bollard	Moshon Data Post (Bollard ⁸)	-	X	-	-
Pillar	Moshon Data Pillar ⁸	45° angle	X	-	-
Plastic Shopping Cart*	Carts4U All-Plastic Shopping Cart (Model #1575) ⁹	-	X	-	-
Metal Shopping Cart*	Wire Shopping Cart (Manufacturer #WMP-090L-EC) ¹⁰	-	X	-	-
Plastic Shopping Cart and Adult*	4activeSystems 4activePA-adult, Carts4U All-Plastic Shopping Cart (Model #1575)	-	X	-	-
Metal Shopping Cart and Adult*	4activeSystems 4activePA-adult, Wire Shopping Cart (Manufacturer	-	X	-	-

* Test objects and postures marked with an asterisk were only tested for research purposes.

² 4activeSystems GmbH, Traboch, Austria. www.4activesystems.at/4activepa

³ 4activeSystems GmbH, Traboch, Austria. www.4activesystems.at/4activepa-child

⁴ 4activeSystems GmbH, Traboch, Austria. www.4activesystems.at/4activeps-2-year

⁵ TÜV Rheinland, Cologne Germany. www.4activesystems.at/4activeps-2yo

⁶ 4activeSystems GmbH, Traboch, Austria. www.4activesystems.at/4activeps-1-year

⁷ Messring GmbH, Gilching, Germany. www.4activesystems.at/4activeps-1yo/

⁸ Moshon Data Ltd., Oxfordshire, United Kingdom. www.moshondata.com/en/reverse-aeb

⁹ Carts4U LLC, Lakewood, New Jersey. <https://carts4u.com/all-plastic-shopping-cart-model-1575>

¹⁰ W.W. Grainger, Inc., Lake Forest, Illinois. www.grainger.com/product/Wire-Shopping-Cart-300-lb-55KE09

4active Systems Articulated and Static Pedestrian Test Mannequins

Articulated (motor-driven moving legs) and static mannequins were used to represent pedestrians in testing. The mannequin has a foam core, a fabric outer cover, and a polycarbonate support pole, and provides a realistic response for radar, camera, lidar, ultrasonic, and IR systems.

The adult pedestrian test mannequin abbreviated as APTM is specified in 49 CFR part 596, subpart B, and provides a sensor representation of a 50th percentile adult male. It has a head, torso, two arms and hands, and two legs and feet. The child pedestrian test mannequin known as CPTM is also specified in 49 CFR part 596, subpart B, and provides a sensor representation of a 6- to 7-year-old child. The CPTM also has a head, torso, two arms and hands, and two legs and feet. The APTM and CPTM arms are posable but fixed and do not move. Their legs articulate using servo motors and are synchronized to the forward motion of the mannequin. Both have passive shoulder joints that do not move during testing. The APTM is 70.9 inches (1.8 m) tall and 19.7 inches (0.5 m) wide, and the CPTM is 45.4 inches (1.2 m) tall and 11.7 inches (0.3 m) wide.

The following figure shows the APTM and CPTM as tested in the stationary test scenario. The APTM is standing with its arms down by its sides and the CPTM is standing with its arms in fixed positions.



Figure 7. Articulated Adult (left) and Child (right) Mannequins (Stationary Postures)

For the dynamic scenario, the articulated mannequins' legs were programmed to move at the corresponding walking speeds for all dynamic trials. The adult PTM's arms were positioned in a striding posture as described in Annex A of ISO 19206:2-2018 (ISO, 2018), and the child mannequin's arms were positioned in its fixed positions.

The toddler pedestrian test mannequins provided sensor representations that approximate those of a 2-year-old child and a 1-year-old child. Both toddler PTMs comply with ISO Technical Standard 19206-9:2025, "Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions; Part 9: Requirements for small child

targets” per their manufacturer, 4activeSystems GmbH. The arms and legs of the toddler pedestrian test mannequins are posable, but fixed. The 2-year-old pedestrian test mannequin is 34.1 inches (0.87 m) tall and 9.1 inches (0.23 m) wide, and the 1-year-old pedestrian test mannequin is 25.9 inches (0.66 m) tall and 6.8 inches (0.17 m) wide. Both mannequins have passive neck, shoulder, hip, and knee joints that do not move during testing. The joints allow for the mannequins to be placed in different postures.

The 2-year-old PTM was tested standing with its arms down by its sides and sitting. It was also tested seated on a plastic toy car known as a “Bobby Car.”¹¹ The dimensions of the bobby car are 22.8 x 11.8 x 15 in (58 x 30 x 38 cm) (L x W x H).

The 1-year-old PTM was tested standing with its arms down by its sides, and in a crawling posture. A support pole was added to the 1-year-old PTM to allow it to stand independently.

The different toddler postures used in the static test object scenario are shown in Figure 8, from left to right: a 2-year-old standing, a 2-year-old on a Bobby Car, a 2-year-old sitting, a 1-year-old standing, and a 1-year-old crawling.



Figure 8. 1-Year-Old and 2-Year-Old Pedestrian Test Mannequins (Stationary Postures)

For the dynamic test object scenario, the 1-year-old and 2-year-old were positioned in a walking pose with striding arms, as shown in Figure 9. The walking pose for both the 1-year-old and 2-year-old pedestrian test mannequins complies with specifications in ISO 19206-9:2025 (ISO, 2025) according to manufacturer information.¹²

¹¹ SIMBA-DICKIE-Vertriebs-GmbH & Co. KG, Fürth, Germany. www.big.de/big_en/categories/ride-on-toys/big-bobby-car/classic/big-bobby-car-classic-800001303-en.html; Dimensions assembled (L x W x H): 58 x 30 x 38 cm

¹² 4activeSystems GmbH, Traboch, Austria. www.4activesystems.at/4activeps-1yo/ and www.4activesystems.at/4activeps-2yo/.



Figure 9. 1-Year-Old (left) and 2-Year-Old PTMs (right) (Walking Postures)

Pedestrian Test Object Speeds

The test object speed of 3.1 mph (5 km/h) was chosen because it is the test object speed used in the PAEB crossing path test scenarios from the 2024 NHTSA AEB final rule (89 FR 39686, 2024), as well as in the Euro NCAP (2022) CPRA/Cm-50 test scenario described in section 2.2. A test object speed of 2 mph (3.2 km/h) was also examined as a child walking speed and slower adult walking speed. The implementation of these speeds across test objects was shown in Table 1.

Test objects or test object conditions that are not dynamic in the real world were not tested as dynamic test objects. For example, seated child mannequins as well as the bollard and pillar were only tested as stationary test objects.

Toddler on Ride-On Toy

Two different test objects were used to represent a toddler playing on a ride-on toy: the 4active Systems 4activePS-2year (“static pedestrian child target 2 years”) alone and with “Bobby Car,” and the “Playing Child Target (PCT)” by Messring. These two differed in that the Bobby Car obtained from 4active for use in this test scenario was a commercially available child’s toy manufactured by BIG Spielwarenfabrik, while the Messring ride-on car was permanently coupled to the toddler mannequin and composed of similar materials to that of the mannequin.

The Messring PCT shown in Figure 10 represented a 2-year-old toddler sitting on a ride-on toy car, and is 26.8 inches (0.68 m) tall, 22.8 inches (0.58 m) long, and 14.2 inches (0.36 m) wide. The PCT is made of foam with a fabric outer cover, and provides a realistic response for radar, camera, lidar, ultrasonic, and IR systems.



Figure 10. Playing Child Target

Moshon Data Bollard and Pillar

A Moshon Data bollard and pillar were used to represent objects found in typical parking settings. The bollard is a black PVC pipe 39.4 inches (1.0 m) tall and 5 inches (0.13 m) in diameter with two white stripes around the top. The pillar is 78.7 inches (2.0 m) tall and 19.7 inches (0.5 m) long and wide, with a foam core and gray PVC cover.

For testing, the pillar was placed at a 45° angle, so a corner was facing the rear of the test vehicle, as is specified in the RCAR RAE-B test procedure (2017). The bollard is shown in Figure 11, and the pillar is shown as positioned during testing in Figure 12.



Figure 11. Moshon Data Bollard

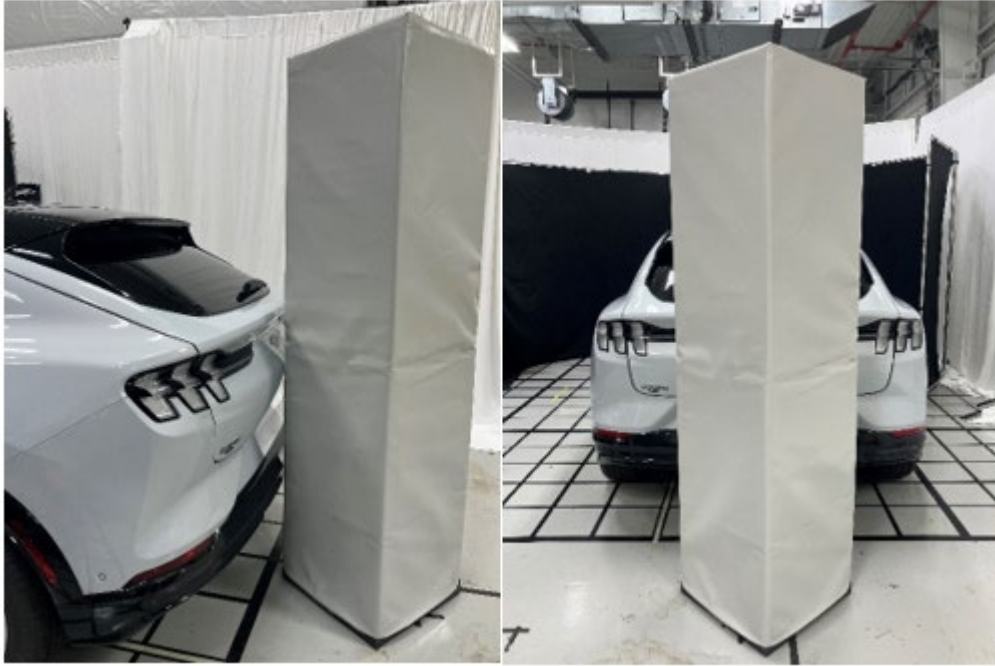


Figure 12. Moshon Data Pillar

Shopping Carts

Plastic and metal shopping carts were tested both independently and with the adult pedestrian test mannequin positioned as if it were pushing the shopping cart. The plastic shopping cart is 40.8 inches (1.04 m) tall, 37 inches (0.94 m) long, and 24.8 inches (0.63 m) wide. The metal shopping cart is 37 inches (0.94 m) tall, 32 inches (0.81 m) long, and 19 inches (0.48 m) wide. To prevent damage to the shopping carts as well as the test vehicle, radar-absorbing foam was added to the frames of the shopping carts. Both carts are shown in Figure 13, and with the 4a adult in Figure 14.



Figure 13. Plastic (left) and Metal (right) Shopping Carts



Figure 14. Plastic and Metal Shopping Carts With 4a Adult

Test Vehicle Control Equipment

Robotic vehicle controllers controlled the vehicle's motion and increased test trial repeatability. A steering robot controlled the test vehicle's path for all tests. Brake and accelerator pedal robots controlled the test vehicle's speed for the 2.5 mph (4 km/h) and 5 mph (8 km/h) tests in the Reversing Vehicle – Dynamic Test Object scenario. For tests where brake and accelerator pedal robots controlled vehicle speed, the robots were programmed to deactivate once the test vehicle reached a longitudinal deceleration threshold of 0.25 g (2.45 m/s²). The 0.25 g (2.45 m/s²) threshold has been previously defined in NHTSA's AEB testing as the peak threshold for CIB (NHTSA, 2014, 2024). This was done to avoid any potential interference with the vehicle's RAB system from the brake or accelerator pedals.

A typical configuration of robotic controller equipment in each test vehicle is shown in Figure 15, which included an Anthony Best Dynamics ¹³ SR15 Orbit steering robot and CBAR600 brake and accelerator pedal robot, along with a controller and battery pack.

¹³ Anthony Best Dynamics, also known as AB Dynamics, Bradford-on-Avon, Wiltshire, United Kingdom.



Figure 15. Steering and Pedal Robots

Test Object Motion Control Equipment

ABD's SPT20 belt propulsion system, shown in Figure 16, was used to propel the test objects for dynamic scenarios. The belt propulsion system has a drive unit powered by an ABD SR60 steering robot, a timing belt, anchoring weights, and a low-profile platform, shown in Figure 17. A horseshoe-shaped mount, shown in Figure 18, was bolted to the platform, and allowed for dynamic pedestrian test objects to be mounted onto the platform. For ease of setup and operation of the belt propulsion system, a controller, battery pack, and external 12-volt battery were installed in a support vehicle.



Figure 16. Belt Propulsion System



Figure 17. Belt Propulsion System Platform



Figure 18. Horseshoe Mount

Laptops with ABD's Robot Controller software installed controlled the steering robot, brake and accelerator robot, and belt propulsion system. ABD's Synchro system synchronized the movement and position of the test object and test vehicle for dynamic test scenarios. WLAN radios installed on the test vehicle and belt propulsion system allowed communication between the two systems.

Test Vehicle Instrumentation and Data Collected

A Dewesoft Dewe-43A PC-based data acquisition system was installed in each test vehicle to record test data from all instrumentation components. An Oxford Technical Solutions¹⁴ RT3000 inertial navigation system was used to measure test vehicle dynamics data. OxTS's RT-Range software was used to record relative position and speed data between the test vehicle and a test object. A Freewave radio was used alongside the RT3000 to provide real-time kinematic corrections. String potentiometers were installed to measure brake and accelerator pedal position independent of the pedal robot. External 12-volt batteries were used to power the test equipment.

Test equipment was arranged so that the front, rear, left, and right corner weight ratios of the loaded vehicle (with instrumentation, a driver, and a full gas tank) were within a ± 3 percent tolerance of the curb corner weight ratios. An example of an instrumented test vehicle is shown in Figure 19.

¹⁴ Oxford Technical Solutions, Oxfordshire, United Kingdom.



Figure 19. Test Vehicle Instrumentation

Table 9 shows a list of the test data collected for each test trial. Data from RT and ABD equipment was collected at a sample rate of 100 Hz. Data from the string potentiometers and microphone were collected at a sample rate of 10,000 Hz. Video data was captured at a frame rate of 30 fps.

Table 8. Data Collected and Related Instrumentation

	Test Data	Equipment
Test Object	Longitudinal and lateral position	ABD SPT20
	Speed	
	Longitudinal and lateral acceleration	
	Relative speed of test vehicle and test object	ABD Synchro
	Relative position of test vehicle and test object	
Test Vehicle	Longitudinal and lateral position	OxTS RT3000
	Speed	
	Longitudinal, lateral, and vertical acceleration	
	Roll, yaw, and pitch	
	Brake pedal and accelerator pedal position	String Potentiometers
	RAB auditory warning	Microphone

	Test Data	Equipment
Test Scenario	RAB visual warning signal (instrument panel)	Camera
	Test vehicle's rearview image (and any visual warning signals presented in this location)	
	Overhead view of bumper and area immediate behind for determination of contact with test objects	
	Full exterior view of test scenario trials	

Test Vehicle Preparation

Each test vehicle was a purchased or leased new vehicle. Each test vehicle's tires were set to the pressure values recommended by the vehicle manufacturer. The fuel tank and all other vehicle fluids were ensured to be properly filled. The vehicle's battery level was confirmed to be within normal operating range. During testing, all vehicle doors, hatches, hood, and trunk lids (as appropriate) were closed. System sensors were wiped to ensure they were free of dirt or other substances that might impact sensor performance.

The curb weight of each test vehicle was recorded, along with the curb corner weights (weight on each wheel). While the draft test procedure (Mazzae et al., 2019) specified that up to five 99.2 lb (45 kg) weights should be placed on the seat pans of the available seating positions and five 50.7 lb (23 kg) weights placed on the floorboards of the corresponding seating positions, the addition of test equipment inside the vehicle made this difficult to achieve. Instead, test equipment was arranged so that the front, rear, left, and right corner weight ratios of the loaded vehicle (with instrumentation, a driver, and a full gas tank) were within a ± 3 percent tolerance of the curb corner weight ratios. If necessary, the 99.2 lb (45 kg) and 50.7 lb (23 kg) weights were placed in available seating positions of the loaded vehicle to keep the corner weight ratios within tolerance. This method was implemented to maintain the vehicle pitch to match that of the unloaded test vehicle and to avoid changes to the height of the RAB sensors.

To achieve full brake system capability and to ensure consistent performance, the procedure defined in sections 14.1.2 and 14.1.3 of the NHTSA FMVSS No. 135 Light Vehicle Brake Systems (TP-135-01, 2005) was used to burnish new vehicle brake components.

Test Environment

Testing was conducted outdoors on a large, open paved area having a generally level surface. All tests were conducted in daylight conditions.

Prior to running test trials, preliminary testing was conducted to ensure that nothing in the test environment would elicit a response from the vehicle's rear object detection systems or reflect sensor signals.

Test Procedure

Before testing was conducted, the rear centerline of the test vehicle was aligned with the centerline of the test object, and the vehicle was reversed slowly until contact with the test object occurred to define a "zero" position. This was repeated for each test object, and the zero position was checked periodically during testing to ensure that there were no changes in position.

A test set consisted of one test trial at each test object overlap position, totaling three test trials per test set. Test sets were generally repeated three times for each permutation of test scenario, test vehicle speed, and test object speed. However, testing was stopped after one test set if the vehicle did not activate RAB and did not avoid contact with the test object for all three test trials of a test set, or if the test object sustained damage during the first test set.

For each test scenario, testing was first conducted at the lowest vehicle and test object speeds and then proceeded to higher speeds if the test vehicle avoided contact with the test object. If the vehicle did not avoid contact with the test object for all three trials in a single test set, testing was generally not continued at higher vehicle and object speeds to avoid damage to the test object or test vehicle. This was implemented to prevent unnecessary damage to the smaller pedestrian test objects. However, if the risk of damage to the test object or test vehicle was deemed to be low, testing was continued at the higher test speeds to gather the most data possible to characterize system performance.

Research Staff Roles

Two individuals were needed for testing. One individual served as the subject vehicle driver and the other was needed to manage positioning of test objects and to activate the belt propulsion system used to control motion of the test objects in the dynamic pedestrian scenario.

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RAB Systems Examined in This Report

Four MY 2022 U.S. market passenger cars equipped with RAB systems were tested for this effort. All vehicles had internal combustion engines except the 2022 Ford Mustang Mach-E electric vehicle. The following table summarizes the characteristics of the RAB systems that were tested in this effort.

Table 9. RAB Systems Tested

Vehicle Year, Make, Model, Trim	RAB System Name	Sensor Technology	Sensor Detection Range	RAB Operating Speeds	Warning Signal Modality	Ability to Hold Vehicle Stationary After Intervention	RAB Defaults to “On” After Each Ignition Cycle
2022 Cadillac XT4 Premium Luxury	Reverse Automatic Braking	Camera, Ultrasonic	Camera: 0 – 26 ft (0 – 8 m) Ultrasonic: 0 – 8 ft (0 – 2.5 m)	0.5 – 20 mph (1 – 32 km/h)	Auditory, Haptic, Visual	Yes	Yes
2022 Ford Mustang Mach-E ¹⁵	Reverse Braking Assist	Camera, Ultrasonic	Camera: Not stated Ultrasonic: 0 - 71 in (0 – 1.8 m)	1 – 7 mph (1.5 – 12 km/h)	Auditory, Visual	No	No
2022 Jeep Grand Cherokee L Limited 4x4	ParkSense Park Assist	Ultrasonic	12 in – 79 in (0.3 m - 2 m)	0 – 6 mph (0 – 9 km/h)	Auditory, Visual	No	No
2022 Subaru Outback Touring	Reverse Automatic Braking	Ultrasonic	0 – 28 in or more ¹⁶ (0 – 0.7 m or more)	1 – 9 mph (1.5 – 15 km/h)	Auditory, Visual	Yes	No

¹⁵ Testing was conducted with the Mach-E in the “Whisper” drive mode as it gave the lowest level of brake regeneration.

¹⁶ The Subaru Outback owner’s manual did not give an upper limit for detection range.

All the vehicles tested provided warnings to the driver as part of the rear automatic braking system's performance, or as part of a separate warning system. A summary of the warning systems in addition to warnings associated with the RAB systems is presented in the table below.

Table 10. Crash Avoidance Warning Characteristics of RAB Systems Tested

Vehicle Make/Model/Trim	Warning System Names	Warning Signal Modality	Sensor Technology	Sensor Detection Range	Warning Operating Speeds	Used for RAB?
2022 Cadillac XT4 Premium Luxury	Park Assist	1. Auditory/Haptic ¹⁷ 2. Visual	Ultrasonic	0 – 8 ft (0 – 2.5 m)	0 – 6 mph (0 – 9 km/h)	No
	Backing Warning	1. Auditory/Haptic ¹⁷ 2. Haptic 3. Visual	Ultrasonic	0 – 8 ft (0 – 2.5 m)	0 – 5 mph (0 – 8 km/h)	Yes
	Rear Pedestrian Alert	1. Auditory/Haptic ¹⁷ 2. Visual	Camera	0 – 26 ft (0 – 8 m)	0 – 8 mph (0 – 12 km/h)	No
2022 Ford Mustang Mach-E	Rear Parking Aid	1. Auditory 2. Visual	Ultrasonic	0 – 6 ft (0 – 1.8 m)	0 – 5 mph (0 – 8 km/h)	Yes
2022 Jeep Grand Cherokee L Limited 4x4	ParkSense Rear Park Assist	1. Auditory 2. Visual	Ultrasonic	1 – 6.5 ft (0.3 m – 2 m)	0 – 6 mph (0 – 9 km/h)	Yes
2022 Subaru Outback Touring	Sonar Audible Alarm	1. Auditory 2. Visual	Ultrasonic	0 – 2.3 ft or more ¹⁸ (0 – 0.7 m or more)	0 – 9 mph (0 – 15 km/h)	Yes

All vehicles tested in this effort were also equipped with Rear Cross Traffic Warning systems, which may have contributed to the vehicle's crash avoidance performance seen in this testing. The following table summarizes Rear Cross Traffic Warning System

¹⁷ The system gave an option for either auditory or haptic warnings.

¹⁸ The Subaru Outback owner's manual did not give an upper limit for detection range.

information for vehicles tested. Some vehicle models do not provide a means for RCTW to be turned off. As such, it is possible that RCTW may contribute to the vehicles' crash avoidance performance in some cases.

Table 11. Rear Cross Traffic Warning System Characteristics of Vehicles Tested

Vehicle Make/Model/Trim	Rear Cross Traffic Warning System?	RCTW System Name	Can Be Turned Off Separate from RAB?	Sensor Technology	Detection Limits	Operating Speeds
2022 Cadillac XT4 Premium Luxury	Yes	Rear Cross Traffic Alert (RCTA)	Yes	Radar	Objects approaching from up to 20 m (65 ft)	Not stated
2022 Ford Mustang Mach-E	Yes	Cross Traffic Alert	No	Radar	Vehicles approaching at 4 - 37 mph (6 - 60 km/h)	Not stated
2022 Jeep Grand Cherokee L Limited 4x4	Yes	Rear Cross Path (RCP)	Yes	Radar	Objects approaching at 5 mph - 20 mph (8 - 32 km/h)	Not stated
2022 Subaru Outback Touring	Yes	Rear Cross Traffic Alert (RCTA)	Yes	Radar	Not stated	Not stated

Further information about each vehicle's RAB and related warning systems are detailed in the following sections, including excerpts from the owner's manuals.

2022 Cadillac XT4

The Cadillac XT4's owner's manual (General Motors LLC, 2022) states the following regarding the "Reverse Automatic Braking" system:

"When in R (Reverse), Backing Warning alerts of rear objects at vehicle speeds greater than 8 km/h (5 mph), and RAB may automatically brake hard at speeds between 1–32 km/h (0.5–20 mph).

The Backing Warning System will beep once from the rear when an object is first detected, or pulse twice on both sides of the Safety Alert Seat. When the system detects a potential crash, beeps will be heard from the rear, or five pulses will be felt on both sides of the Safety Alert Seat. There may also be a brief, sharp application of the brakes.

When the vehicle is in R (Reverse), if the system detects the vehicle is backing too fast to avoid a crash with a detected object behind your vehicle in your path, it may automatically brake hard to a stop to help avoid or reduce the harm caused by a backing crash.

Pressing the brake pedal after the vehicle comes to a stop will release RAB. If the brake pedal is not pressed soon after the stop, the Electric Parking Brake (EPB) may be set. When it is safe, press the accelerator pedal firmly at any time to override RAB."

"Pressing the brake pedal after the vehicle comes to a stop will release RAB. If the brake pedal is not pressed soon after the stop, the Electric Parking Brake (EPB) may be set."

The owner's manual (General Motors LLC, 2022) states the following regarding pedestrian detection limitations with the "Reverse Automatic Braking" system:

"It does not detect children, pedestrians, bicyclists, animals, or objects below the bumper or that are too close or too far from the vehicle."

RAB in the Cadillac XT4 could be configured to provide an auditory signal ("beeps" per the owner's manual) or, if equipped, the Safety Alert Seat could provide a haptic warning consisting of pulses of the seat pan could be presented depending on user selection. The Cadillac XT4 had a Safety Alert Seat, and the haptic warning signal was the default warning modality for RAB warnings. For this effort, the "alert type" selected was the auditory signal to permit measurement of the auditory signal and maintain consistency across all test vehicles.

The Cadillac XT4 has three additional, separate warning systems that are active when the vehicle is in reverse gear: "Backing Warning," "Rear Pedestrian Alert," and "Park Assist." However, only the "Backing Warning" system is used in conjunction with the "Reverse Automatic Braking" system.

The "Backing Warning" system uses ultrasonic sensors and provides either auditory or haptic seat warnings. The system also may apply a haptic brake pulse consisting of a "brief, sharp application of the brakes" (General Motors LLC, 2022). The haptic brake pulse is not affected by selecting the auditory warning option. The GM owner's manual (2022) states:

“Backing Warning alerts of rear objects at vehicle speeds greater than 8 km/h (5 mph).”

“The Backing Warning System will beep once from the rear when an object is first detected, or pulse twice on both sides of the Safety Alert Seat. When the system detects a potential crash, beeps will be heard from the rear, or five pulses will be felt on both sides of the Safety Alert Seat. There may also be a brief, sharp application of the brakes.”

It also states the following regarding pedestrian detection limitations with the “Backing Warning” system:

“It does not detect children, pedestrians, bicyclists, animals, or objects below the bumper or that are too close or too far from the vehicle.”

The “Rear Pedestrian Alert” system provides visual and either auditory or haptic seat warnings when a pedestrian is detected by the rearview camera. The visual warning symbol is shown in Figure 21 along with excerpts from the GM owner’s manual (2022):

“Under certain conditions, this feature can provide alerts for a pedestrian within the system’s range directly behind the vehicle. This feature only works in R (Reverse) below 12 km/h (8 mph) and detects pedestrians up to 8m (26 ft) away during daytime driving. During nighttime driving, feature performance is very limited.”

“When a pedestrian is detected within the system’s range directly behind the vehicle, this symbol flashes amber on the infotainment display, along with two beeps from the rear, or if equipped, two pulses from both sides of the driver seat. When a pedestrian is detected close to the vehicle, the symbol flashes red on the infotainment display, along with seven beeps from the rear, or if equipped, seven pulses from both sides of the driver seat.”



*Figure 20. Cadillac XT4 “Rear Pedestrian Alert” Visual Warning Symbol
(General Motors LLC, 2022)*

The GM owner’s manual states the following regarding pedestrian detection limitations with the “Rear Pedestrian Alert” system:

“It may not detect all pedestrians if:

- The pedestrian is not directly behind the vehicle, fully visible to the Rear Vision Camera (RVC), or standing upright.
- The pedestrian is part of a group.
- The pedestrian is a child.”

The “Park Assist” system uses ultrasonic sensors and provides visual and either auditory or haptic seat warnings to the driver when objects are detected. The visual warning symbols are shown in Figure 20, and excerpts from the GM owner’s manual follow:

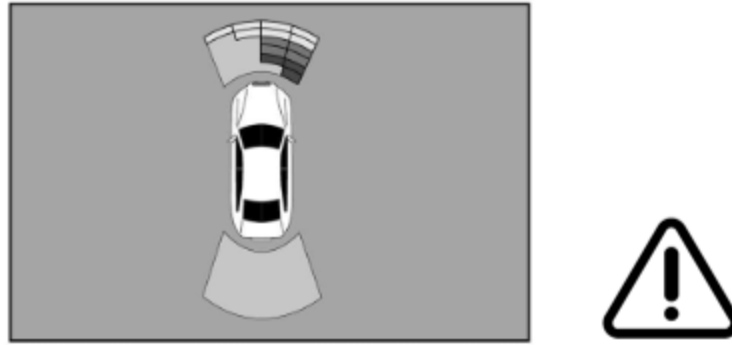


Figure 21. Cadillac XT4 Park Assist Visual Warning Symbols (General Motors LLC, 2022)

“The vehicle may have a Park Assist amphitheatre-like display on the cluster with bars that represent the estimated location of a detected object and the vehicle’s distance from the object. As a detected object becomes closer, more bars light up and change color from yellow to amber to red.”

“A warning triangle may appear on the infotainment display to show that Rear Park Assist (RPA) or Rear Cross Traffic Alert (RCTA) has detected an object. This triangle changes from amber to red and increases in size the closer the object.”

“When an object is first detected in the rear, one beep will be heard from the rear, or the driver’s seat will pulse two times, if equipped with Safety Alert Seat. When an object is very close, five beeps will sound from the front or rear (depending on the object’s location), or the driver’s seat will pulse five times.”

The GM owner’s manual states the following regarding pedestrian detection limitations with the “Park Assist” system:

“The Park Assist system does not detect children, pedestrians, bicyclists, animals, or objects located below the bumper or that are too close or too far from the vehicle.”

2022 Ford Mustang Mach-E

The Ford Mustang Mach-E’s owner’s manual (2021) states the following about its “Reverse Braking Assist” system:

“The system uses sensors on the rear of your vehicle to detect a possible collision and applies the brakes to either reduce the damage from impact, or to assist in avoiding the collision.”

“The system only applies the brakes for a short period of time when an event occurs.”

The Ford owner’s manual (2021) states the following regarding pedestrian detection limitations with the “Reverse Braking Assist” system:

“Some situations and objects prevent hazard detection. For example low or direct sunlight, inclement weather, unconventional vehicle types, and pedestrians.”

The following figure shows the warning indicator that appears “when the system applies the brakes” (Ford Motor Company, 2021).



Figure 22. Ford Mustang Mach-E Reverse Braking Assist Visual Warning Symbol (Ford Motor Company, 2021)

The Mach-E also uses the “Rear Parking Aid” system to provide warnings for its “Reverse Braking Assist” system. The “Rear Parking Aid” system uses ultrasonic sensors and provides visual and auditory warnings. A visual warning is shown in Figure 23, along with excerpts from the Ford owner’s manual:

“A warning tone sounds when your vehicle approaches an object. As your vehicle moves closer to an object, the rate of the tone increases. The warning tone continuously sounds when an object is 12 in (30 cm) or less from the rear bumper. If your vehicle remains stationary for a few seconds, the audible warning turns off. If your vehicle moves backward the tone sounds again.”

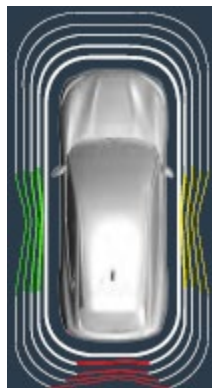


Figure 23. Ford Mustang Mach-E Rear Parking Aid Visual Warning Symbol (Ford Motor Company, 2021)

“The system provides object distance indication through the information and entertainment display.

- As the distance to the object decreases, the indicator waves and the lines move toward the vehicle icon.
- If there is no object detected, the distance indicator lines are grey.”

2022 Jeep Grand Cherokee

The Jeep Grand Cherokee owner’s manual (FCA US LLC, 2022) states the following about its “ParkSense Park Assist” system:

“The ParkSense Park Assist system provides visual and audible indications of the distance between the rear...fascia/bumper and a detected obstacle when backing up.

The vehicle brakes may be automatically applied and released when performing a reverse parking maneuver if the system detects a possible collision with an obstacle.”

Ultrasonic sensors are used to provide visual and auditory warnings through the “ParkSense Park Assist” system. The visual warning symbol is shown in Figure 24, along with excerpts from the Jeep owner’s manual (FCA US LLC, 2022):

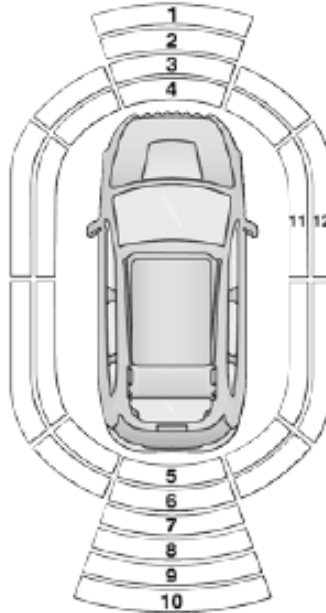


Figure 24. Jeep Grand Cherokee ParkSense Visual Warning Symbol (FCA US LLC, 2022)

“The system will indicate a detected obstacle by showing a single arc in the left and/or right front or rear regions based on the object’s distance and location relative to the vehicle.

If an object is detected in the left and/or right rear region, the display will show a single arc in the left and/or right rear region and the system will produce a tone. As the vehicle moves closer to the object, the display will show the single arc moving closer to the vehicle and the tone will change from a single $\frac{1}{2}$ second tone to slow, to fast, to continuous.

The vehicle is close to the obstacle when the instrument cluster display shows one flashing arc and sounds a continuous tone. The following chart shows the warning alert operation when the system is detecting an obstacle:”

The following table shows the detection range chart for the Jeep Grand Cherokee, as mentioned in the owner's manual:

Table 12. Jeep Grand Cherokee ParkSense Detection Range Chart and Associated Warning Signals (FCA US LLC, 2022)

ParkSense WARNING SIGNALS FOR REAR							
Rear Distance (inches/cm)	Greater than 79 in (200 cm)	79-59 in (200-150 cm)	59-47 in (150-120 cm)	47-39 in (120-100 cm)	39-25 in (100-65 cm)	25-12 in (65-30 cm)	Less than 12 inches (30 cm)
Audible Alert Chime	None	Single 0.5-s Tone	Slow	Slow	Fast	Fast	Continuous
Arcs-Left	None	None	None	None	None	6th Flashing	5th Flashing
Arcs-Center	None	10th Solid	9th Solid	8th Solid	7th Flashing	6th Flashing	5th Flashing
Arcs-Right	None	None	None	None	None	6th Flashing	5th Flashing
Radio Volume Reduced	No	Yes	Yes	Yes	Yes	Yes	Yes

2022 Subaru Outback

The Subaru Outback owner's manual (Subaru Corporation, 2021) states the following about its "Reverse Automatic Braking" system:

"Reverse Automatic Braking (RAB) is a system designed to help avoid collisions or reduce collision damage when reversing the vehicle. If a wall or an obstacle is detected in the reversing direction, the system will notify the driver with a warning sound and may activate the vehicle's brakes automatically."

"The Reverse Automatic Braking (RAB) system will operate the following 2 functions using 4 sonar sensors."

- "Sonar Audible Alarm"

"The Reverse Automatic Braking (RAB) system detects objects rearward and warns the driver by warning message on the center information display and warning beeps."

- "Automatic Braking"

"The automatic braking detects objects rearward and if there is a high risk of a collision, the system decelerates the vehicle and controls the braking to reduce damage."

"In the following cases, after the vehicle has been stopped by the Reverse Automatic Braking (RAB) system, brake control is released and the electronic parking brake operates.

- When 2 minutes pass after the vehicle is stopped
- When any door is opened"

The Subaru owner's manual (2021) states the following regarding pedestrian detection limitations with the "Reverse Automatic Braking" system:

"The system is not designed to detect people (including children), animals or other moving objects."

Visual and auditory warnings are delivered through both the "Sonar Audible Alarm" and "Automatic Braking" functions of the "Reverse Automatic Braking" system, which uses ultrasonic sensors. While both functions are part of the same system, they each can be turned off individually. The visual warning symbols and detection operating ranges are shown in the following table and figures, along with excerpts from the Subaru owner's manual (2021):

"When Reverse Automatic Braking (RAB) system is in operation, an audible warning beeps [sic] will sound in 3 levels to warn the driver of a potential collision."

Table 13. Subaru Outback Detection Range Chart (Subaru Corporation, 2021)

Alert level	Range of detected object*	Distance indicator	Alarm pattern
Long proximity alert (object detected)	28 in (70 cm) or more	Green	No warning sound
Medium proximity alert (approaching the object)	20 to 28 in (50 to 70 cm)	Yellow	Short beeps
Short proximity alert (approaching closer to the object)	12 to 20 in (30 to 50 cm)	Orange	Rapid short beeps
Closest proximity alert (too close to the object)	12 in (30 cm) or less	Red	Continuous beep

* Range of detection may vary depending on the environmental condition.

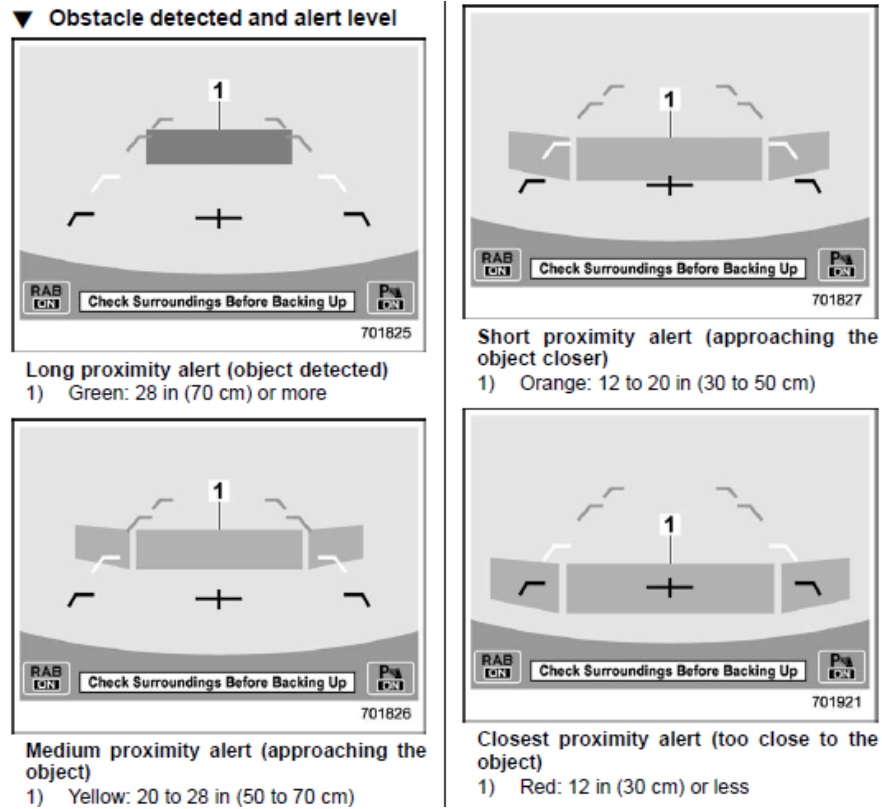


Figure 25. Subaru Outback Sonar Audible Alarm Visual Warnings
(Subaru Corporation, 2021)

“When an object is detected in the reversing direction, the range of detected object will be shown on the center information display.”

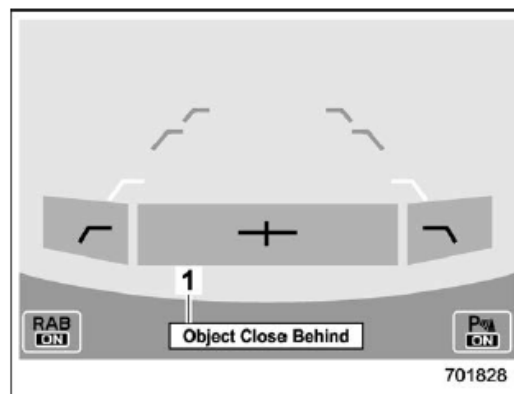


Figure 26. Subaru Outback Automatic Braking Visual Warning
(Subaru Corporation, 2021)

“If the system determine [sic] the risk of collision with the object. Short warning beeps or continuous warning beeps will sound and either strong automatic braking or torque control will be applied to prevent collision.”

Testing Notes Specific to Test Vehicle Models

Tests with the Subaru Outback and a portion of the tests with the Ford Mustang Mach-E were conducted in a different location than the rest of the vehicles. This location had the same characteristics as the primary test location, except for lane line markings located on either side of the test vehicle travel path.

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Test Results

Results from the testing of four vehicles per test scenarios and method outlined in Section 3 of this report are presented in this section.

The system response percentage tables show the percentages of trials at which auditory warnings, visual warnings, and rear automatic braking interventions occurred, as well as whether a crash was avoided. These results are separated by test object overlap position.

The system response time-to-collision and distance tables show the TTC and distance from the test object at which each of the warnings and automatic braking intervention occurred for each test trial. If a warning or automatic braking response did not occur for a test trial, “N/A” (Not Applicable) is listed instead. A TTC value of 0.0 seconds means that the vehicle’s distance from the test object had reached a value close enough to 0 that a TTC could not be reliably calculated.

The system response results for the Cadillac’s haptic brake pulse are included separately from the automatic braking results, as the brake pulse was considered a warning signal and not a rear automatic braking intervention.

Reversing Vehicle – Stationary Test Object

The results below show the system response percentages, TTCs, and distances for all vehicles with the Reversing Vehicle – Stationary Test Object scenario. The objects tested with this scenario were the adult PTM, 7-year-old PTM, 2-year-old standing mannequin, pillar, and bollard.

System Response Results by Test Object

The system response percentages of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position.

Adult PTM

The following tables show the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM. Table 14 presents these results for the Cadillac XT4.

Table 14. System Response Percentages for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Cadillac XT4

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	66%	100%	100%	100%	100%	100%
% Crashes Avoided	0%	100%	66%	33%	100%	66%	100%	100%	33%

As shown in the table above, the Cadillac’s RAB system provided warnings and automatically applied the brakes for all except one of 27 trials with the stationary adult PTM. The system

avoided a crash for all trials at the 50 percent object overlap but only avoided a crash for four out of nine of the 25 percent overlap trials five of nine trials for the 75 percent object overlap condition.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Ford Mach-E.

Table 15. System Response Percentages for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Ford Mustang Mach-E

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	66%	66%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	66%	0%	66%	100%	100%	100%	100%	100%	66%

As shown in the table above, the Ford system provided both auditory and visual warnings for all nine trials at both idle and 2.5 mph (4 km/h) speeds. For the 5 mph (8 km/h) test speed, the Ford system provided visual warnings for all nine trials but only provided auditory warnings for seven of nine trials. The Ford system automatically applied the brakes and avoided a crash for all trials at the 2.5 mph (4 km/h) vehicle speed, and the majority of the trials at the 5 mph (8 km/h) mph vehicle speed with the stationary adult PTM. However, for the idle speed trials, the system only avoided a crash for two out of three trials for both the 25 percent and 75 percent object overlaps and did not avoid a crash for any trials for the 50 percent object overlap condition.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Jeep Grand Cherokee.

Table 16. System Response Percentages for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	66%	100%	100%	100%	100%	66%	66%	66%
% Visual Warning	100%	66%	100%	100%	66%	100%	0%	0%	66%
% Automatic Braking	100%	66%	66%	100%	66%	66%	66%	33%	66%
% Crashes Avoided	66%	66%	66%	100%	66%	66%	0%	0%	33%

As shown in the table above, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for most of the trials at the idle and 2.5 mph (4 km/h) vehicle speeds with the stationary adult PTM. The system provided warnings and avoided a crash for all of the 25 percent object overlap trials at the 2.5 mph (4 km/h) vehicle speed but did not avoid a crash for all of the 25 percent and 50 percent object overlap trials at the 5 mph (8 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted at the idle vehicle speed and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 17. System Response Percentages for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Subaru Outback

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	3	3	3	0	0	0
% Auditory Warning	0%	0%	0%	0%	66%	66%	--	--	--
% Visual Warning	0%	100%	0%	33%	100%	66%	--	--	--
% Automatic Braking	0%	0%	0%	0%	33%	66%	--	--	--
% Crashes Avoided	0%	0%	0%	0%	0%	0%	--	--	--

As shown in the table above, the Subaru’s RAB system did not avoid a crash for any of the trials with the stationary adult PTM at idle or 2.5 mph (4 km/h) test speeds. For the idle vehicle speed, the system only provided a visual warning for one out of three trials and did not provide auditory warnings or automatically apply the brakes for any trial.

Overall, two RAB systems avoided more crashes with the adult PTM at the 2.5 mph (4 km/h) vehicle speed compared to the idle and 5 mph (8 km/h) speeds. However, the Cadillac avoided more crashes with the adult PTM at the 5 mph (8 km/h) vehicle speed.

7-Year-Old PTM

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Cadillac XT4.

Table 18. System Response Percentages for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Cadillac XT4

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	66%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	100%	100%	100%	33%	100%	100%	66%	66%	100%

As shown in the table above, the Cadillac’s RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the idle vehicle speed with the stationary 7-year-old PTM, except for one trial where a visual warning was not presented. At the 2.5 mph (4 km/h) and 5 mph (8 km/h) vehicle speeds, the system avoided a crash for all of the 75 percent

object overlap trials and avoided a crash for 8 out of 12 trials at the 25 percent and 50 percent object overlaps.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Ford Mach-E.

Table 19. System Response Percentages for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Ford Mustang Mach-E

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	66%	33%	100%	100%	100%	100%	100%	33%
% Visual Warning	100%	66%	33%	100%	100%	100%	100%	100%	33%
% Automatic Braking	100%	66%	33%	100%	100%	100%	100%	100%	33%
% Crashes Avoided	100%	33%	33%	100%	100%	100%	100%	100%	33%

As shown in the table above, the Ford system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 2.5 mph (4 km/h) speed with the stationary 7-year-old PTM. The system also provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 25 percent object overlap for idle and 5 mph (8 km/h) test speeds. However, fewer crashes were avoided for idle speed trials at 50 percent and 75 percent overlap and 5 mph (8 km/h) trials at the 75 percent overlap condition.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Jeep Grand Cherokee. Although the RAB system was able to avoid crashes with the test object at lower vehicle speeds, there were concerns about damage to the test object so testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 20. System Response Percentages for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	100%	100%	100%	100%	66%	100%	--	--	--
% Visual Warning	66%	66%	66%	100%	33%	100%	--	--	--
% Automatic Braking	100%	100%	66%	100%	66%	66%	--	--	--
% Crashes Avoided	66%	100%	66%	66%	33%	33%	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings for a majority of test trials, automatically applied the brakes for eight of nine trials, and avoided a crash for seven out of nine trials at the idle vehicle speed with the stationary 7-year-old PTM. The system provided auditory and visual warnings for seven of nine trials and avoided a crash for four out of nine trials at the 2.5 mph (4 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted at the 2.5 mph (4 km/h) vehicle speed and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 21. System Response Percentages for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Subaru Outback

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	1	1	1	0	0	0
% Auditory Warning	66%	0%	33%	0%	0%	0%	--	--	--
% Visual Warning	33%	0%	33%	0%	0%	0%	--	--	--
% Automatic Braking	0%	0%	0%	0%	0%	0%	--	--	--
% Crashes Avoided	0%	0%	0%	0%	0%	0%	--	--	--

As shown in the table above, the Subaru’s RAB system did not automatically apply the brakes for any trial with the stationary 7-year-old PTM and only provided both auditory and visual warnings for two of nine trials at the idle vehicle speed. The system did not provide warnings or automatically apply the brakes for any trial at the 2.5 mph (4 km/h) vehicle speed.

Overall, for the stationary 7-year-old PTM test trials, more crashes were avoided at the 2.5 mph (4 km/h) and idle vehicle speeds compared to the 5 mph (8 km/h) speed.

2-Year-Old PTM Standing

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Cadillac XT4.

Table 22. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Cadillac XT4

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	66%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	100%	66%	100%	100%	100%	100%	100%	100%	100%

As shown in the table above, the Cadillac’s RAB system provided at least one mode of warning and automatically applied the brakes for all trials with the stationary standing 2-year-old PTM. The system also avoided a crash for all but one trial, an idle speed trial at 50 percent overlap.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Ford Mach-E.

Table 23. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Ford Mustang Mach-E

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	66%	100%	100%	66%	0%	66%	66%
% Visual Warning	100%	100%	66%	100%	100%	66%	0%	33%	66%
% Automatic Braking	100%	100%	66%	100%	100%	66%	0%	33%	66%
% Crashes Avoided	100%	100%	66%	100%	100%	33%	0%	0%	66%

As shown in the table above, the Ford system provided warnings, automatically applied the brakes, and avoided a crash for all the 25 percent and 50 percent object overlap trials at the idle and 2.5 mph (4 km/h) vehicle speeds with the stationary standing 2-year-old PTM. However, the system did not provide a warning, automatically apply the brakes, or avoid a crash for any of the 25 percent object overlap trials at the 5 mph (8 km/h) vehicle speed. The Ford system provided warnings at all test speeds for the 75 percent overlap condition in 66 percent of trials and avoided a crash in 66 percent of trials for idle and 5 mph (8 km/h). The Ford system only avoided a crash in one of three trials at 2.5 mph (4 km/h) for the 75 percent overlap condition with the stationary standing 2-year-old PTM.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 24. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	100%	33%	100%	66%	66%	100%	--	--	--
% Visual Warning	100%	33%	66%	66%	66%	100%	--	--	--
% Automatic Braking	100%	33%	66%	66%	33%	100%	--	--	--
% Crashes Avoided	66%	33%	33%	33%	0%	100%	--	--	--

As shown in the table above, the Jeep’s RAB system provided warnings and automatically applied the brakes for all idle speed trials at 25 percent overlap, and all trials with the 75 percent overlap at the 2.5 mph (4 km/h) vehicle speed. Warning presentation was seen for fewer trials at the idle speed 50 percent and 75 percent overlap conditions and 2.5 mph (4 km/h) trials at the 25 percent and 50 percent overlap conditions. The system avoided a crash for three of six trials at the 25 percent overlap condition and four of six trials at the 75 percent overlap condition with the

stationary standing 2-year-old PTM but only avoided a crash for one out of six trials at the 50 percent object overlap.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Subaru Outback. Due to observed instances of contact with the test object, only one test trial at each test object overlap was conducted at the 2.5 mph (4 km/h) and idle vehicle speeds and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 25. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Subaru Outback

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	1	1	1	0	0	0
% Auditory Warning	100%	0%	0%	0%	0%	0%	--	--	--
% Visual Warning	100%	0%	0%	0%	0%	0%	--	--	--
% Automatic Braking	0%	0%	0%	0%	0%	0%	--	--	--
% Crashes Avoided	0%	0%	0%	0%	0%	0%	--	--	--

As shown in the table above, the Subaru's RAB system did not tend to provide warnings and did not automatically apply the brakes or avoid a crash for any trial conducted with the stationary standing 2-year-old PTM.

Overall, for the 2-year-old standing mannequin test trials, vehicles were more likely to impact when it was located at the 50 percent overlap compared to the 25 percent and 75 percent object overlaps.

Pillar

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Cadillac XT4.

Table 26. System Response Percentages for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Cadillac XT4

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	33%	33%	100%	100%	66%	100%	0%	33%	0%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	100%	100%	100%	100%	100%	100%	100%	100%	100%

The Cadillac's RAB system consistently provided auditory warnings and automatic braking and avoided a crash for all trials with the pillar but did not provide a visual warning for 13 of 27 trials.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Ford Mach-E.

Table 27. System Response Percentages for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Ford Mustang Mach-E

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	66%	66%	66%	100%	100%	100%	0%	66%	0%
% Visual Warning	0%	0%	33%	66%	100%	100%	0%	0%	0%
% Automatic Braking	0%	0%	0%	0%	66%	0%	0%	0%	0%
% Crashes Avoided	0%	0%	0%	0%	0%	0%	0%	0%	0%

As shown in the table above, the Ford system provided auditory warnings in 17 or 27 trials and visual warnings in nine of 27 trials with the pillar test object. The system provided auditory warnings for all trials at the 2.5 mph (4 km/h) vehicle speed. However, the Ford system only provided automatic braking in two of 27 trials and avoided no crashes with the pillar.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding contact with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 28. System Response Percentages for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	33%	33%	66%	100%	100%	100%	--	--	--
% Visual Warning	33%	0%	33%	100%	100%	100%	--	--	--
% Automatic Braking	0%	0%	33%	100%	33%	100%	--	--	--
% Crashes Avoided	0%	0%	33%	66%	0%	33%	--	--	--

As shown in the table above, the Jeep’s RAB system provided auditory and visual warnings for all trials at the 2.5 mph (4 km/h) vehicle speed but provided significantly fewer warnings for idle speed trials. The system avoided no crashes for trials at 50 percent object overlap and avoided crashes in a third of trials at 75 percent overlap for both idle and 2.5 mph (4 km/h) test speeds. For the idle vehicle speed, the vehicle contacted the pillar in eight out of nine trials.

The following table shows results for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Subaru Outback.

Table 29. System Response Percentages for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Subaru Outback

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	66%	100%	100%	100%	100%	66%	66%	66%
% Visual Warning	100%	66%	100%	100%	100%	100%	66%	33%	66%
% Automatic Braking	100%	33%	100%	100%	100%	100%	33%	0%	33%
% Crashes Avoided	100%	0%	33%	66%	66%	100%	0%	0%	0%

As shown in the table above, the Subaru's RAB system provided warnings and automatically applied the brakes for all pillar trials at the 2.5 mph (4 km/h) vehicle speed and avoided crashes in seven of nine of those trials. For idle speed, the system presented auditory and visual warnings for all trials at 25 percent and 75 percent overlap and avoided crashes in seven of nine of those trials. Performance was poorer and avoided no crashes for the idle speed 50 percent overlap trials and all 5 mph (8 km/h) vehicle speed trials.

Overall, for the pillar test trials, vehicles were more likely to impact the pillar when it was located at the 50 percent object overlap. However, system performance was generally inconsistent.

Bollard

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Cadillac XT4.

Table 30. System Response Percentages for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Cadillac XT4

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	100%	100%	100%	100%	100%	100%	100%	100%	100%

As shown in the table above, the Cadillac's RAB system provided both auditory and visual warnings, automatically applied the brakes, and avoided a crash for all trials with the bollard.

The following table on the next page shows results for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Ford Mach-E.

Table 31. System Response Percentages for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Ford Mustang Mach-E

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	66%	100%	100%	100%	100%	100%	66%	100%
% Crashes Avoided	100%	66%	33%	100%	100%	100%	33%	0%	0%

As shown in the table above, the Ford system consistently provided auditory and visual warnings for all trials with the bollard. The Ford system provided automatic braking consistently all 2.5 mph (4 km/h) trials and all 25 percent and 75 percent overlap conditions at idle and 5 mph (8 km/h) test speeds. For the 50 percent overlap condition, the system automatically applied the brakes in two of three trials for idle and 5 mph (8 km/h) test speeds. The Ford system avoided crashes for all bollard trials at the 2.5 mph (4 km/h) vehicle speed. However, crashes were only avoided in six of nine idle speed trials and one of nine trials at the 5 mph (8 km/h) vehicle speed.

The following table results for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Jeep Grand Cherokee.

Table 32. System Response Percentages for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	66%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	66%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	66%	100%
% Crashes Avoided	100%	100%	100%	100%	100%	100%	100%	66%	100%

As shown in the table above, the Jeep's RAB system provided both auditory and visual warnings, automatically applied the brakes, and avoided a crash for all but one trial with the bollard.

The following table on the next page shows results for the Reversing Vehicle – Stationary Test Object scenario results for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Subaru Outback.

Table 33. System Response Percentages for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Subaru Outback

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	66%	100%	100%	100%	66%	33%	100%
% Visual Warning	100%	100%	66%	100%	100%	100%	66%	33%	100%
% Automatic Braking	100%	100%	66%	100%	100%	100%	66%	33%	66%
% Crashes Avoided	100%	100%	66%	100%	100%	100%	0%	33%	0%

As shown in the table above, the Subaru’s RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 2.5 mph (4 km/h) vehicle speed and all but one trial at the idle vehicle speed with the bollard. However, the system only avoided a crash for one out of nine trials at the 5 mph (8 km/h) vehicle speed.

Overall, for the bollard test trials, RAB-equipped vehicles tested were able to provide warnings, automatically apply the brakes, and avoid a crash for the majority of trials.

System Response TTCs and Distances by Test Object

The system response TTCs and distances of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position.

Adult PTM

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Cadillac XT4.

Table 34. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Cadillac XT4

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC s at Auditory Warning Onset	Set 1	5.61	5.69	5.42	5.00	4.92	4.86	3.01	2.96	2.97
	Set 2	5.38	5.51	5.41	4.88	4.50	4.78	2.92	2.83	3.17
	Set 3	5.76	5.85	5.16	4.88	5.38	4.93	2.87	2.93	2.94
Distance (in) at Auditory Warning Onset	Set 1	195.76	196.31	193.56	220.47	216.20	213.20	266.79	262.09	262.95
	Set 2	192.92	194.83	193.33	214.25	198.15	210.19	258.36	251.14	280.44
	Set 3	196.92	197.93	190.63	214.39	236.17	216.97	254.04	259.10	259.41
TTC (s) at Visual Warning Onset	Set 1	5.18	5.28	5.04	4.85	4.80	4.70	2.88	2.82	2.81
	Set 2	4.95	5.15	5.04	4.72	4.36	4.63	2.76	2.70	3.02
	Set 3	5.34	5.39	4.78	4.73	5.24	4.78	2.72	2.81	2.77
Distance (in) at Visual Warning Onset	Set 1	190.43	191.38	188.62	213.78	210.79	206.77	255.00	250.24	249.13
	Set 2	187.28	190.28	188.54	207.76	191.18	203.66	244.17	239.17	267.01
	Set 3	191.93	192.87	185.39	207.87	230.12	210.24	240.98	248.15	245.20
TTC (s) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	1.43	1.41	1.37
	Set 2	--	--	--	--	--	--	1.36	1.38	1.38
	Set 3	--	--	--	--	--	--	1.47	1.43	1.45
Distance (in) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	126.30	124.29	120.26
	Set 2	--	--	--	--	--	--	120.17	121.85	121.90
	Set 3	--	--	--	--	--	--	129.52	125.79	127.05
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.18	0.31	0.22	N/A	0.30	0.09	0.26	0.24	0.21
	Set 2	0.12	0.29	0.20	0.12	0.30	0.25	0.19	0.25	0.21
	Set 3	0.17	0.26	0.26	0.07	0.36	0.26	0.25	0.27	0.21
Distance (in) at Subject Vehicle Braking Onset	Set 1	13.18	22.80	16.51	N/A	13.40	3.85	21.64	20.30	18.11
	Set 2	9.24	21.26	14.41	5.42	13.14	10.91	16.07	21.20	17.17
	Set 3	12.63	19.23	19.54	3.26	15.93	11.46	21.05	23.25	18.18

As shown in the table above, the Cadillac’s RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at the same vehicle speed with the stationary adult PTM. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Ford Mach-E.

Table 35. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Ford Mustang Mach-E

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.24	0.66	0.66	1.08	1.37	1.28	N/A	0.33	0.55
	Set 2	0.00	0.59	0.26	1.35	0.93	1.29	0.32	N/A	0.60
	Set 3	0.41	0.60	0.29	1.29	1.33	1.41	0.34	0.00	0.51
Distance (in) at Auditory Warning Onset	Set 1	14.75	41.20	41.46	48.72	62.62	57.78	N/A	18.46	49.11
	Set 2	10.65	37.51	8.14	62.69	43.74	59.00	21.40	N/A	53.35
	Set 3	26.13	37.74	6.75	59.31	59.60	63.62	11.82	9.12	45.56
TTC (s) at Visual Warning Onset	Set 1	0.20	0.47	0.51	0.85	1.19	1.13	0.41	0.42	0.39
	Set 2	0.72	0.41	0.28	1.22	0.75	1.09	0.38	0.52	0.45
	Set 3	0.34	0.39	0.29	1.10	1.13	1.22	0.38	0.37	0.28
Distance (in) at Visual Warning Onset	Set 1	10.87	29.76	32.40	38.15	54.49	51.14	34.45	35.91	32.36
	Set 2	44.17	26.26	15.20	56.73	35.47	49.84	31.73	43.31	38.27
	Set 3	18.98	25.08	16.57	50.71	50.71	54.88	31.38	29.57	25.04
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.29	0.35	0.32	0.53	0.48	0.53	0.46	0.46	0.46
	Set 2	0.43	0.12	0.37	0.46	0.49	0.51	0.45	0.58	0.50
	Set 3	0.41	0.05	0.36	0.39	0.45	0.58	0.45	0.44	0.21
Distance (in) at Subject Vehicle Braking Onset	Set 1	18.48	22.19	20.44	23.48	21.66	23.80	40.23	40.31	41.01
	Set 2	26.45	8.04	23.25	21.16	22.60	22.78	39.69	50.90	44.49
	Set 3	26.13	3.02	22.91	17.93	19.96	25.90	39.42	38.86	18.87

As shown in the table above, the Ford system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary adult PTM. However, the system automatically applied the brakes at a TTC of approximately 0.5 seconds for 16 out of 18 trials at the 2.5 mph (4 km/h) and 5 mph (8 km/h) vehicle speeds. The system generally provided auditory warnings earlier than visual warnings, with the exception of trials at the 5 mph (8 km/h) vehicle speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Jeep Grand Cherokee.

Table 36. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.07	0.45	0.59	1.00	0.67	1.51	0.06	0.08	0.48
	Set 2	0.67	0.71	0.55	1.18	0.07	0.87	0.07	N/A	N/A
	Set 3	0.67	N/A	0.59	0.33	0.79	0.27	N/A	0.01	0.14
Distance (in) at Auditory Warning Onset	Set 1	4.53	30.81	39.22	46.35	31.34	68.86	5.71	7.24	40.66
	Set 2	44.26	46.36	36.81	50.02	3.49	40.92	6.60	N/A	N/A
	Set 3	44.45	N/A	42.24	15.38	33.68	12.60	N/A	0.92	12.06
TTC (s) at Visual Warning Onset	Set 1	0.09	0.51	0.73	1.02	0.37	1.53	N/A	N/A	0.39
	Set 2	0.71	0.75	0.57	1.22	N/A	0.93	N/A	N/A	N/A
	Set 3	0.70	N/A	0.65	0.24	0.65	0.18	N/A	N/A	0.02
Distance (in) at Visual Warning Onset	Set 1	6.14	34.61	47.48	46.97	18.31	69.80	N/A	N/A	31.34
	Set 2	46.46	48.43	38.15	51.50	N/A	43.70	N/A	N/A	N/A
	Set 3	46.18	N/A	46.46	11.02	27.76	8.62	N/A	N/A	1.85
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.11	0.33	0.39	0.37	0.37	0.36	0.00	0.00	0.43
	Set 2	0.41	0.39	0.41	0.41	N/A	0.42	0.00	N/A	N/A
	Set 3	0.38	N/A	N/A	0.23	0.38	N/A	N/A	N/A	0.06
Distance (in) at Subject Vehicle Braking Onset	Set 1	8.01	22.56	26.36	17.80	17.89	17.25	0.48	0.22	36.41
	Set 2	28.15	26.31	27.36	17.97	N/A	20.52	0.49	N/A	N/A
	Set 3	25.64	N/A	N/A	9.83	17.10	N/A	N/A	N/A	5.02

As shown in the table above, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary adult PTM. The system generally provided auditory and visual warnings at similar TTCs.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the adult PTM for the Subaru Outback. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted at the idle vehicle speed and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 37. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Adult PTM, 2022 Subaru Outback

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		1	1	1	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	N/A	0.11	N/A	--	--	--
	Set 2	--	--	--	N/A	0.01	0.17	--	--	--
	Set 3	--	--	--	N/A	N/A	0.21	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	N/A	5.05	N/A	--	--	--
	Set 2	--	--	--	N/A	0.59	7.58	--	--	--
	Set 3	--	--	--	N/A	N/A	9.37	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.63	N/A	0.88	1.18	N/A	--	--	--
	Set 2	--	--	--	N/A	0.05	0.13	--	--	--
	Set 3	--	--	--	N/A	1.16	0.43	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	43.74	N/A	38.74	51.46	N/A	--	--	--
	Set 2	--	--	--	N/A	2.36	5.98	--	--	--
	Set 3	--	--	--	N/A	51.38	18.82	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	0.03	N/A	--	--	--
	Set 2	--	--	--	N/A	0.65	0.09	--	--	--
	Set 3	--	--	--	N/A	N/A	0.15	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	1.50	N/A	--	--	--
	Set 2	--	--	--	N/A	N/A	4.00	--	--	--
	Set 3	--	--	--	N/A	N/A	6.73	--	--	--

As shown in the table above, the Subaru's RAB system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary adult PTM. If the system provided warnings or automatically applied the brakes, it was often right before a crash or as a crash occurred.

Overall, the stationary adult PTM test trials tested vehicles' RAB warning and automatic braking occurrence timings were inconsistent for trials at the same conditions, with the exception of the Cadillac. Auditory warnings were generally presented before visual warnings for the stationary adult PTM test trials.

7-Year-Old Pedestrian Test Mannequin

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Cadillac XT4.

Table 38. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Cadillac XT4

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.40	1.32	0.23	3.98	2.03	2.05	2.47	2.32	2.45
	Set 2	1.43	1.42	1.41	2.04	2.02	2.05	2.41	2.43	2.40
	Set 3	1.42	1.38	1.40	2.45	1.94	2.02	2.40	2.40	2.47
Distance (in) at Auditory Warning Onset	Set 1	86.18	82.51	16.69	175.06	89.24	89.66	218.36	204.25	215.80
	Set 2	87.78	87.44	86.89	90.15	89.16	90.22	212.86	214.43	211.85
	Set 3	87.60	85.86	86.76	107.51	85.74	88.86	212.42	212.30	217.66
TTC (s) at Visual Warning Onset	Set 1	1.19	1.05	N/A	3.85	1.87	1.91	1.00	0.98	1.00
	Set 2	1.25	1.20	1.19	1.90	1.83	1.91	1.02	1.01	0.63
	Set 3	1.18	1.17	1.20	2.30	1.84	1.88	2.10	1.01	1.06
Distance (in) at Visual Warning Onset	Set 1	75.59	70.63	N/A	169.45	82.28	83.54	75.00	74.25	74.80
	Set 2	79.09	76.54	76.10	83.43	80.63	84.13	74.92	74.61	49.45
	Set 3	75.08	75.08	76.73	100.98	80.98	82.60	185.12	75.16	78.11
TTC (s) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	1.41	1.37	1.36
	Set 2	--	--	--	--	--	--	1.32	1.34	1.35
	Set 3	--	--	--	--	--	--	1.38	1.36	1.34
Distance (in) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	123.84	120.55	119.71
	Set 2	--	--	--	--	--	--	116.17	118.19	118.49
	Set 3	--	--	--	--	--	--	121.59	119.90	117.35
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.18	0.25	0.21	0.13	0.29	0.14	0.25	0.27	0.22
	Set 2	0.16	0.28	0.20	0.05	0.35	0.17	0.15	0.20	0.23
	Set 3	0.20	0.25	0.22	0.01	0.30	0.17	0.17	0.26	0.20
Distance (in) at Subject Vehicle Braking Onset	Set 1	13.41	18.47	15.23	5.80	12.39	5.65	20.73	22.53	18.53
	Set 2	12.03	20.40	14.91	2.45	14.82	7.36	12.14	16.65	18.65
	Set 3	14.98	18.63	16.36	0.66	12.88	7.28	14.34	21.35	16.55

As shown in the table above, the Cadillac’s RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at a given vehicle speed backing toward the stationary 7-year-old PTM. The system generally provided the auditory warning earlier than the haptic brake pulse warning and provided the visual warning after the auditory and haptic warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Ford Mach-E.

Table 39. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Ford Mustang Mach-E

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.62	0.32	0.29	1.26	1.13	0.39	0.57	0.50	N/A
	Set 2	0.74	N/A	N/A	1.18	1.09	1.03	0.41	0.36	N/A
	Set 3	0.24	0.17	N/A	1.29	1.25	1.44	0.41	0.47	0.40
Distance (in) at Auditory Warning Onset	Set 1	38.46	19.92	8.35	56.90	52.88	17.02	50.90	43.98	N/A
	Set 2	46.09	N/A	N/A	56.00	48.11	47.30	35.16	31.40	N/A
	Set 3	13.96	10.26	N/A	57.72	56.39	62.65	35.10	9.06	8.95
TTC (s) at Visual Warning Onset	Set 1	0.42	0.24	0.29	1.07	0.98	0.37	0.42	0.34	N/A
	Set 2	0.56	N/A	N/A	1.03	0.95	0.89	0.37	0.30	N/A
	Set 3	0.21	0.14	N/A	1.09	1.07	1.23	0.40	0.40	0.37
Distance (in) at Visual Warning Onset	Set 1	26.57	13.58	15.71	48.19	45.98	14.76	35.67	24.84	N/A
	Set 2	35.28	N/A	N/A	48.98	42.01	40.79	30.39	24.06	N/A
	Set 3	11.22	7.80	N/A	48.74	48.27	53.94	33.74	34.25	30.16
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.39	0.32	0.38	0.52	0.39	0.42	0.48	0.46	N/A
	Set 2	0.41	N/A	N/A	0.42	0.41	0.51	0.43	0.38	N/A
	Set 3	0.31	0.22	N/A	0.48	0.48	0.45	0.47	0.44	0.45
Distance (in) at Subject Vehicle Braking Onset	Set 1	24.56	20.58	23.71	23.07	18.28	19.74	42.06	40.47	N/A
	Set 2	25.90	N/A	N/A	19.81	17.87	22.85	37.76	33.21	N/A
	Set 3	19.50	13.97	N/A	21.27	21.55	20.17	41.20	38.87	39.69

As shown in the table above, the Ford system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and vehicle speed, when backing toward the stationary 7-year-old PTM. The system generally provided auditory warnings earlier than visual warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 40. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.52	0.59	0.05	0.71	N/A	0.15	--	--	--
	Set 2	0.25	0.36	0.41	0.10	0.07	0.42	--	--	--
	Set 3	0.50	1.05	0.41	0.77	0.67	0.05	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	34.86	38.54	3.28	30.62	N/A	7.80	--	--	--
	Set 2	17.31	24.80	27.37	4.87	3.41	19.34	--	--	--
	Set 3	33.83	63.70	27.70	32.71	28.63	2.33	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.66	N/A	0.73	N/A	0.04	--	--	--
	Set 2	0.16	N/A	0.50	0.01	N/A	0.44	--	--	--
	Set 3	0.46	1.17	0.32	0.79	0.68	0.00	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	42.40	N/A	31.42	N/A	1.77	--	--	--
	Set 2	10.87	N/A	10.55	0.51	N/A	20.00	--	--	--
	Set 3	30.91	69.41	21.97	33.54	29.17	1.02	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.44	0.40	N/A	0.26	N/A	0.05	--	--	--
	Set 2	0.18	0.28	0.32	0.01	N/A	0.33	--	--	--
	Set 3	0.41	0.41	0.33	0.32	0.28	N/A	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	29.39	26.53	N/A	12.67	N/A	2.64	--	--	--
	Set 2	12.39	19.28	21.39	0.29	N/A	15.62	--	--	--
	Set 3	27.72	27.40	22.27	14.56	13.11	N/A	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings and automatically applied the brakes at different TTCs for sets of trials with the stationary 7-year-old PTM. The system automatically applied the brakes at similar TTCs for the idle vehicle speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 7-year-old PTM for the Subaru Outback. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted at the 2.5 mph (4 km/h) vehicle speed and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 41. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 7-Year-Old PTM, 2022 Subaru Outback

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.10	N/A	0.00	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	0.12	N/A	N/A	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	6.90	N/A	0.08	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	0.22	N/A	N/A	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.05	N/A	0.69	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	N/A	N/A	N/A	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	3.50	N/A	47.01	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	N/A	N/A	N/A	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	N/A	N/A	N/A	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	N/A	N/A	N/A	--	--	--	--	--	--
	Set 3	N/A	N/A	N/A	--	--	--	--	--	--

As shown in the table above, the Subaru's RAB system provided warnings and automatically applied the brakes at different TTCs for sets of trials with the stationary 7-year-old PTM. If the system did provide warnings or automatically apply the brakes, it was often right before a crash or as a crash occurred.

Overall, for the stationary 7-year-old PTM test trials, the timing of warnings and automatic braking varied between vehicles. Auditory warnings were generally presented before visual warnings.

2-Year-Old PTM Standing

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Cadillac XT4.

Table 42. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Cadillac XT4

Test Vehicle Speed		Idle				2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%		25%	50%	75%	25%	50%	75%
N		3	3	3		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.34	1.41	1.46		5.12	2.07	3.31	3.06	3.05	2.43
	Set 2	1.38	1.54	1.38		2.09	4.79	4.73	2.30	2.44	2.45
	Set 3	1.41	1.36	1.48		2.00	4.74	2.02	2.43	2.46	2.46
Distance (in) at Auditory Warning Onset	Set 1	83.16	87.84	89.67		225.96	91.05	145.17	270.15	270.00	215.19
	Set 2	85.95	94.07	86.73		92.48	210.77	208.17	203.68	215.47	215.90
	Set 3	87.67	85.40	91.16		88.18	209.08	88.63	213.72	216.92	216.59
TTC (s) at Visual Warning Onset	Set 1	1.10	1.19	1.25		4.98	1.92	3.14	2.91	2.90	0.47
	Set 2	1.17	1.32	1.21		1.95	4.63	4.58	2.16	2.23	0.14
	Set 3	1.23	1.16	1.25		1.85	4.59	1.84	1.93	N/A	0.18
Distance (in) at Visual Warning Onset	Set 1	70.94	76.14	79.25		219.96	84.45	138.39	257.83	257.44	37.83
	Set 2	75.43	83.19	78.03		85.91	203.66	201.22	190.98	196.26	7.76
	Set 3	78.31	75.24	79.45		81.30	202.76	80.83	170.31	N/A	4.61
TTC (s) at Haptic Brake Pulse Onset	Set 1	--	--	--		--	--	--	1.42	1.39	1.39
	Set 2	--	--	--		--	--	--	1.47	1.36	1.40
	Set 3	--	--	--		--	--	--	1.41	1.42	1.41
Distance (in) at Haptic Brake Pulse Onset	Set 1	--	--	--		--	--	--	125.15	122.07	122.21
	Set 2	--	--	--		--	--	--	129.32	119.32	122.75
	Set 3	--	--	--		--	--	--	123.67	124.16	123.24
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.20	0.20	0.26		0.26	0.34	0.31	0.26	0.27	0.27
	Set 2	0.21	0.30	0.22		0.24	0.33	0.24	0.26	0.26	0.26
	Set 3	0.25	0.27	0.29		0.24	0.35	0.26	0.23	0.27	0.27
Distance (in) at Subject Vehicle Braking Onset	Set 1	14.92	14.65	18.99		11.36	15.06	13.39	21.85	22.58	22.23
	Set 2	15.52	21.89	16.55		10.73	14.39	10.88	22.07	21.97	22.03
	Set 3	18.48	20.16	21.31		10.62	15.45	11.66	19.47	22.78	22.95

As shown in the table above, the Cadillac’s RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at the same vehicle speed with the stationary standing 2-year-old PTM. At the 2.5 mph (4 km/h) vehicle speed, the system provided warnings at TTCs of approximately 2.0 seconds for half of the trials and provided warnings at TTCs of approximately 5.0 seconds for the other half of the trials. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Ford Mach-E.

Table 43. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Ford Mustang Mach-E

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.84	0.52	0.37	1.35	1.27	1.33	N/A	N/A	0.53
	Set 2	0.89	0.84	0.48	1.29	1.21	N/A	N/A	0.16	0.32
	Set 3	0.86	0.88	N/A	1.29	0.96	0.20	N/A	0.02	N/A
Distance (in) at Auditory Warning Onset	Set 1	51.57	33.24	23.12	60.01	55.19	57.65	N/A	N/A	46.34
	Set 2	54.24	51.85	30.80	57.58	52.21	N/A	N/A	14.60	26.85
	Set 3	52.79	53.96	N/A	56.93	40.82	8.71	N/A	1.74	N/A
TTC (s) at Visual Warning Onset	Set 1	0.68	0.38	0.33	1.15	1.13	1.18	N/A	N/A	0.35
	Set 2	0.70	0.68	0.36	1.07	1.04	N/A	N/A	0.10	0.29
	Set 3	0.71	0.74	N/A	1.11	0.77	0.12	N/A	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	42.28	23.27	18.86	50.83	49.45	51.34	N/A	N/A	27.99
	Set 2	43.19	42.60	20.28	48.11	45.28	N/A	N/A	8.86	24.02
	Set 3	44.13	45.83	N/A	49.21	33.23	4.33	N/A	N/A	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.39	0.41	0.40	0.47	0.43	0.43	N/A	N/A	0.43
	Set 2	0.42	0.35	0.43	0.41	0.45	N/A	N/A	0.17	0.36
	Set 3	0.43	0.43	N/A	0.49	0.28	0.24	N/A	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	24.19	26.23	25.60	20.71	18.46	18.67	N/A	N/A	37.57
	Set 2	26.17	22.16	26.98	18.21	19.53	N/A	N/A	15.50	31.17
	Set 3	27.20	27.04	N/A	21.65	11.96	10.48	N/A	N/A	N/A

As shown in the table above, the Ford system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at a given vehicle speed with the stationary standing 2-year-old PTM. The system automatically applied the brakes at a TTC of approximately 0.4 seconds for 14 out of 18 trials at the 2.5 mph (4 km/h) and idle vehicle speeds.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 44. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.12	N/A	0.01	N/A	0.06	1.62	--	--	--
	Set 2	1.05	N/A	0.08	0.22	0.21	0.72	--	--	--
	Set 3	0.26	1.10	1.10	0.82	N/A	1.11	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	8.13	N/A	0.42	N/A	2.86	67.71	--	--	--
	Set 2	65.28	N/A	5.66	10.84	9.80	29.57	--	--	--
	Set 3	17.83	67.46	67.61	34.53	N/A	44.72	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.00	N/A	N/A	N/A	0.00	1.64	--	--	--
	Set 2	1.08	N/A	0.00	0.12	0.14	0.73	--	--	--
	Set 3	0.15	1.11	1.13	0.81	N/A	1.12	--	--	--
Distance (in) at Visual Warning Onset	Set 1	0.16	N/A	N/A	N/A	1.85	68.43	--	--	--
	Set 2	66.46	N/A	0.28	5.16	6.34	29.72	--	--	--
	Set 3	9.65	68.23	69.45	34.13	N/A	45.31	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.03	N/A	N/A	N/A	N/A	0.26	--	--	--
	Set 2	0.32	N/A	0.00	0.13	0.13	0.33	--	--	--
	Set 3	0.17	0.33	0.39	0.34	N/A	0.30	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	1.81	N/A	N/A	N/A	N/A	12.33	--	--	--
	Set 2	21.82	N/A	0.02	6.01	6.01	14.51	--	--	--
	Set 3	11.58	22.40	26.47	15.89	N/A	13.49	--	--	--

As shown in the table above, the Jeep’s RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary standing 2-year-old PTM. The system generally provided the auditory warning earlier than the visual warning for all trials.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a standing posture for the Subaru Outback. Due to the RAB system’s inconsistency avoiding crashes with the test object, only one test trial at each test object overlap was conducted at the 2.5 mph (4 km/h) and idle vehicle speeds and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 45. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Standing, 2022 Subaru Outback

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		1	1	1	1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.27	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	18.93	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.64	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	42.91	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--

As shown in the table above, the Subaru's RAB system provided the visual warning earlier than the auditory warning for the trial where warnings occurred with the stationary standing 2-year-old PTM.

Overall, for the four vehicles tested, timing consistency of warnings and automatic braking varied between vehicles when backing toward the 2-year-old PTM standing. Auditory warnings were generally presented before visual warnings.

Pillar

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Cadillac XT4.

Table 46. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Cadillac XT4

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.65	1.46	1.47	0.64	2.12	2.12	2.51	2.46	2.50
	Set 2	0.30	0.31	1.48	0.54	0.42	2.11	2.45	2.53	2.52
	Set 3	0.30	0.34	1.52	2.10	1.95	2.08	2.30	2.51	2.25
Distance (in) at Auditory Warning Onset	Set 1	44.71	90.02	89.80	28.39	93.35	93.41	221.98	216.69	220.81
	Set 2	22.14	22.98	90.78	23.71	18.36	92.61	216.27	222.47	222.50
	Set 3	22.12	25.28	92.73	92.62	85.52	91.86	202.90	221.22	197.88
TTC (s) at Visual Warning Onset	Set 1	0.42	1.24	1.26	0.49	1.96	1.95	N/A	N/A	N/A
	Set 2	N/A	N/A	1.27	0.38	N/A	1.93	N/A	1.84	N/A
	Set 3	N/A	N/A	1.29	1.92	1.80	1.95	N/A	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	29.92	79.21	79.25	21.73	86.14	86.06	N/A	N/A	N/A
	Set 2	N/A	N/A	80.51	16.85	N/A	84.96	N/A	161.81	N/A
	Set 3	N/A	N/A	81.38	84.65	79.06	85.87	N/A	N/A	N/A
TTC (s) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	1.40	1.38	1.42
	Set 2	--	--	--	--	--	--	1.44	1.48	1.42
	Set 3	--	--	--	--	--	--	1.44	1.46	1.44
Distance (in) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	122.58	121.57	124.52
	Set 2	--	--	--	--	--	--	126.33	129.01	124.42
	Set 3	--	--	--	--	--	--	126.13	127.88	126.70
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.27	0.29	0.29	0.25	0.44	0.28	0.29	0.31	0.24
	Set 2	0.26	0.28	0.29	0.30	0.41	0.31	0.22	0.31	0.26
	Set 3	0.26	0.30	0.27	0.30	0.42	0.30	0.29	0.28	0.25
Distance (in) at Subject Vehicle Braking Onset	Set 1	19.78	21.46	21.05	11.02	19.17	12.19	23.87	26.21	20.01
	Set 2	19.21	20.78	21.08	13.12	17.93	13.67	18.84	26.58	22.23
	Set 3	19.17	22.36	20.10	12.98	18.39	13.16	24.36	23.59	21.22

As shown in the table above, the Cadillac's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at the same vehicle speed with the pillar. The system automatically applied the brakes at a TTC of approximately 0.3 seconds for all trials, except for the 50 percent object overlap trials at the 2.5 mph (4 km/h) vehicle speed, where the TTC was approximately 0.4 seconds. The system generally provided the auditory warning earlier than the haptic brake pulse warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Ford Mach-E.

Table 47. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Ford Mustang Mach-E

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.05	N/A	0.28	0.27	0.44	0.19	N/A	0.05	N/A
	Set 2	0.04	0.02	0.03	0.15	0.59	0.48	N/A	0.04	N/A
	Set 3	N/A	0.08	N/A	0.07	0.54	0.40	N/A	N/A	N/A
Distance (in) at Auditory Warning Onset	Set 1	3.27	N/A	18.01	11.98	20.41	8.54	N/A	4.70	N/A
	Set 2	2.80	1.14	1.92	6.88	26.52	21.78	N/A	3.80	N/A
	Set 3	N/A	5.42	N/A	3.46	24.16	17.82	N/A	N/A	N/A
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	0.07	0.03	0.29	0.02	N/A	N/A	N/A
	Set 2	N/A	N/A	N/A	0.03	0.39	0.31	N/A	N/A	N/A
	Set 3	N/A	N/A	N/A	N/A	0.41	0.19	N/A	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	4.25	1.18	13.27	0.71	N/A	N/A	N/A
	Set 2	N/A	N/A	N/A	1.54	17.64	13.94	N/A	N/A	N/A
	Set 3	N/A	N/A	N/A	N/A	18.27	8.46	N/A	N/A	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	0.15	N/A	N/A	N/A	N/A
	Set 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Set 3	N/A	N/A	N/A	N/A	0.11	N/A	N/A	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	N/A	6.61	N/A	N/A	N/A	N/A
	Set 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Set 3	N/A	N/A	N/A	N/A	4.72	N/A	N/A	N/A	N/A

As shown in the table above, the Ford system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the pillar. At the 2.5 mph (4 km/h) vehicle speed, the system generally provided warnings and automatically applied the brakes at similar TTCs for the 50 percent object overlap trials. The system generally presented the auditory warnings earlier than the visual warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 48. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.63	N/A	0.44	0.45	0.17	0.27	--	--	--
	Set 2	N/A	N/A	N/A	0.44	0.16	0.57	--	--	--
	Set 3	N/A	0.07	0.03	0.80	0.17	0.32	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	41.81	N/A	29.98	20.07	8.26	12.75	--	--	--
	Set 2	N/A	N/A	N/A	19.66	7.73	24.06	--	--	--
	Set 3	N/A	4.71	2.15	34.30	8.43	14.51	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.64	N/A	0.40	0.49	0.21	0.32	--	--	--
	Set 2	N/A	N/A	N/A	0.37	0.18	0.65	--	--	--
	Set 3	N/A	N/A	N/A	0.81	0.17	0.33	--	--	--
Distance (in) at Visual Warning Onset	Set 1	42.13	N/A	27.36	21.65	10.16	14.69	--	--	--
	Set 2	N/A	N/A	N/A	16.34	8.54	26.81	--	--	--
	Set 3	N/A	N/A	N/A	35.08	8.31	14.80	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	0.37	0.11	N/A	0.00	--	--	--
	Set 2	N/A	N/A	N/A	0.37	0.01	0.03	--	--	--
	Set 3	N/A	N/A	N/A	0.34	N/A	0.33	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	25.21	5.36	N/A	0.41	--	--	--
	Set 2	N/A	N/A	N/A	16.50	0.65	1.32	--	--	--
	Set 3	N/A	N/A	N/A	15.97	N/A	15.38	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the pillar. The system generally presented the visual warnings earlier than the auditory warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the pillar for the Subaru Outback.

Table 49. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Pillar, 2022 Subaru Outback

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.59	N/A	0.20	0.23	1.02	0.57	0.44	N/A	0.42
	Set 2	0.62	0.21	0.61	1.00	1.03	0.96	0.15	0.01	0.05
	Set 3	0.53	0.07	0.22	1.00	0.11	0.93	N/A	0.07	N/A
Distance (in) at Auditory Warning Onset	Set 1	39.61	N/A	13.53	10.37	45.01	25.82	38.76	N/A	35.99
	Set 2	41.70	14.25	40.22	44.11	45.40	41.76	13.03	0.82	4.67
	Set 3	35.88	4.58	15.19	44.16	4.76	42.14	N/A	6.00	N/A
TTC (s) at Visual Warning Onset	Set 1	0.73	N/A	0.18	1.20	1.22	1.07	0.47	N/A	0.52
	Set 2	0.74	0.70	0.68	1.21	1.19	1.14	0.09	N/A	0.18
	Set 3	0.67	0.69	0.70	1.19	0.08	1.08	N/A	0.53	N/A
Distance (in) at Visual Warning Onset	Set 1	48.50	N/A	12.28	52.48	53.74	47.83	41.10	N/A	44.96
	Set 2	48.98	46.14	44.80	53.11	52.17	49.65	7.83	N/A	15.83
	Set 3	45.28	45.98	46.10	52.28	3.35	49.29	N/A	46.46	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.47	N/A	0.11	0.15	0.53	0.50	0.32	N/A	0.29
	Set 2	0.53	0.11	0.43	0.58	0.57	0.56	N/A	N/A	N/A
	Set 3	0.41	N/A	0.11	0.57	0.03	0.58	N/A	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	31.50	N/A	7.47	6.39	22.92	22.20	28.25	N/A	24.81
	Set 2	35.64	7.31	28.21	25.52	25.10	24.63	N/A	N/A	N/A
	Set 3	28.33	N/A	7.63	25.42	1.17	25.45	N/A	N/A	N/A

As shown in the table above, the Subaru's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials at the 2.5 mph (4 km/h) vehicle speed with the pillar. The system generally provided visual warnings earlier than auditory warnings.

Overall, for the pillar test object stationary test trials, timing consistency of warnings and automatic braking varied between vehicles. The order in which warnings were presented also varied between vehicles.

Bollard

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Cadillac XT4.

Table 50. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Cadillac XT4

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.49	1.47	1.55	2.18	2.13	2.09	2.45	2.43	2.45
	Set 2	1.50	1.41	1.47	2.09	2.05	2.09	2.48	2.44	2.53
	Set 3	1.54	1.44	1.51	2.01	2.11	2.09	2.49	2.49	2.53
Distance (in) at Auditory Warning Onset	Set 1	91.01	88.88	92.23	94.13	91.58	91.38	216.83	215.55	216.80
	Set 2	91.58	87.02	89.97	92.01	90.17	92.12	219.88	216.19	223.45
	Set 3	92.94	88.81	91.41	88.80	92.95	92.04	220.09	220.00	223.57
TTC (s) at Visual Warning Onset	Set 1	1.25	1.20	1.30	1.95	2.00	1.92	1.06	1.00	1.00
	Set 2	1.29	1.17	1.18	1.93	1.85	1.93	1.05	1.10	1.06
	Set 3	1.31	1.18	1.32	1.88	1.95	1.93	1.00	1.02	0.97
Distance (in) at Visual Warning Onset	Set 1	79.17	75.31	80.31	84.25	85.71	83.50	78.82	75.28	74.61
	Set 2	81.42	75.16	75.47	84.92	81.30	85.20	79.21	81.50	79.53
	Set 3	81.89	75.51	82.24	82.91	85.67	84.80	75.87	77.32	74.41
TTC (s) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	1.40	1.43	1.33
	Set 2	--	--	--	--	--	--	1.44	1.41	1.44
	Set 3	--	--	--	--	--	--	1.44	1.44	1.48
Distance (in) at Haptic Brake Pulse Onset	Set 1	--	--	--	--	--	--	123.17	125.35	117.15
	Set 2	--	--	--	--	--	--	126.79	124.10	126.52
	Set 3	--	--	--	--	--	--	126.50	126.36	129.81
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.37	0.34	0.35	0.32	0.37	0.26	0.21	0.29	0.31
	Set 2	0.35	0.29	0.24	0.28	0.35	0.25	0.22	0.27	0.28
	Set 3	0.24	0.23	0.24	0.15	0.51	0.33	0.25	0.33	0.32
Distance (in) at Subject Vehicle Braking Onset	Set 1	26.73	23.91	24.82	12.19	15.84	11.49	18.20	24.24	25.82
	Set 2	25.55	21.01	17.41	12.16	15.48	10.82	18.70	22.81	22.90
	Set 3	17.84	17.28	16.21	6.50	22.20	14.44	20.91	27.22	27.25

As shown in the table above, the Cadillac's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials with the same vehicle speed with the bollard. The system automatically applied the brakes at a TTC range from 0.2 or 0.3 seconds for 25 out of 27 trials. The system generally provided the auditory warning earlier than the haptic brake pulse warning and provided the visual warning after the auditory and haptic warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Ford Mach-E.

Table 51. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Ford Mustang Mach-E

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.90	0.83	0.71	0.47	0.85	0.66	0.03	0.57	0.26
	Set 2	0.55	0.83	0.30	0.80	0.94	0.77	0.58	0.18	0.49
	Set 3	0.46	0.42	0.67	0.63	0.93	0.77	0.40	0.53	0.38
Distance (in) at Auditory Warning Onset	Set 1	55.79	51.89	44.84	21.47	39.13	29.49	2.28	50.72	22.90
	Set 2	34.48	51.75	19.31	36.19	41.66	34.51	51.56	16.18	43.40
	Set 3	29.54	26.62	42.50	28.49	41.96	34.44	35.88	47.34	33.51
TTC (s) at Visual Warning Onset	Set 1	0.72	0.68	0.53	0.41	0.69	0.52	0.12	0.38	0.18
	Set 2	0.38	0.68	0.13	0.63	0.78	0.65	0.37	0.07	0.25
	Set 3	0.31	0.37	0.46	0.47	0.71	0.58	0.20	0.34	0.17
Distance (in) at Visual Warning Onset	Set 1	45.39	42.64	34.02	16.02	31.69	23.19	10.20	33.94	15.79
	Set 2	23.03	42.52	7.52	28.62	34.80	29.33	31.93	6.02	21.54
	Set 3	18.27	21.30	29.61	21.14	32.20	25.79	16.50	30.16	14.84
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.42	0.39	0.18	0.47	0.36	0.50	0.19	0.16	0.24
	Set 2	0.42	N/A	0.20	0.50	0.46	0.51	0.38	N/A	0.26
	Set 3	0.37	0.42	0.41	0.47	0.50	0.55	0.26	0.19	0.18
Distance (in) at Subject Vehicle Braking Onset	Set 1	26.88	24.64	11.54	21.01	16.08	21.89	16.48	14.39	21.13
	Set 2	26.23	N/A	12.89	22.22	20.20	22.88	33.84	N/A	22.92
	Set 3	23.75	26.62	26.00	20.81	22.55	24.21	22.57	17.05	15.71

As shown in the table above, the Ford system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the bollard. The system automatically applied the brakes at a TTC of approximately 0.4 seconds for 6 out of nine trials at the idle vehicle speed and automatically applied the brakes at a TTC of approximately 0.5 seconds for eight out of nine trials at the 2.5 mph (4 km/h) vehicle speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Jeep Grand Cherokee.

Table 52. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.70	0.76	0.50	1.13	1.20	1.15	0.49	0.49	0.45
	Set 2	0.72	0.77	0.68	1.23	1.24	1.23	0.47	0.46	0.48
	Set 3	0.74	0.69	0.73	1.22	1.25	1.16	0.49	N/A	0.40
Distance (in) at Auditory Warning Onset	Set 1	45.52	49.22	34.27	48.68	50.09	47.71	41.93	42.40	37.85
	Set 2	46.99	51.44	45.84	51.58	51.76	51.18	40.73	39.80	41.77
	Set 3	49.09	47.82	47.66	50.39	50.89	48.07	42.69	N/A	35.19
TTC (s) at Visual Warning Onset	Set 1	0.72	0.75	0.54	1.13	1.21	1.17	0.50	0.52	0.47
	Set 2	0.74	0.76	0.69	1.24	1.25	1.25	0.43	0.43	0.49
	Set 3	0.76	0.72	0.75	1.25	1.28	1.19	0.41	N/A	0.31
Distance (in) at Visual Warning Onset	Set 1	46.38	48.54	36.81	48.74	50.51	48.54	43.27	44.37	39.69
	Set 2	48.46	50.83	46.34	51.97	52.13	51.77	37.28	36.85	42.32
	Set 3	50.35	49.72	48.54	51.65	52.13	49.33	34.37	N/A	25.98
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.38	0.39	0.38	0.35	0.34	0.34	0.42	0.40	0.40
	Set 2	0.40	0.42	0.40	0.37	0.34	0.36	0.41	0.40	0.41
	Set 3	0.42	0.42	0.39	0.37	0.34	0.32	0.43	N/A	0.33
Distance (in) at Subject Vehicle Braking Onset	Set 1	25.58	26.43	26.60	16.31	15.41	15.58	35.87	34.67	33.61
	Set 2	27.54	29.51	27.86	17.05	15.47	16.39	35.49	34.58	35.74
	Set 3	28.66	30.11	26.91	16.79	15.65	14.96	36.68	N/A	29.08

As shown in the table above, the Jeep's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at the same vehicle speed with the bollard. The system generally provided warnings at a distance from 40 to 50 inches for all vehicle speeds and automatically applied the brakes at a TTC of approximately 0.4 seconds for all vehicle speeds.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the bollard for the Subaru Outback.

Table 53. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Bollard, 2022 Subaru Outback

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.61	0.65	N/A	1.02	1.05	1.01	N/A	0.48	0.08
	Set 2	0.61	0.64	0.67	1.01	1.09	1.03	0.21	N/A	0.24
	Set 3	0.63	0.65	0.60	1.04	1.07	0.98	0.24	N/A	0.03
Distance (in) at Auditory Warning Onset	Set 1	41.69	44.57	N/A	44.52	45.76	43.84	N/A	41.85	7.05
	Set 2	42.84	44.31	44.10	44.15	47.58	44.96	18.22	N/A	21.16
	Set 3	42.68	43.21	39.35	45.50	46.73	42.95	20.84	N/A	2.75
TTC (s) at Visual Warning Onset	Set 1	0.73	0.77	N/A	1.18	1.19	1.19	N/A	0.59	0.55
	Set 2	0.70	0.71	0.84	1.21	1.24	1.19	0.57	N/A	0.56
	Set 3	0.78	0.74	0.71	1.19	1.22	1.21	0.57	N/A	0.56
Distance (in) at Visual Warning Onset	Set 1	49.41	52.48	N/A	51.14	51.77	51.61	N/A	51.65	48.46
	Set 2	48.62	48.50	54.06	53.07	53.82	51.65	50.24	N/A	49.13
	Set 3	51.89	48.74	46.22	52.17	53.11	53.19	50.55	N/A	49.17
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.47	0.50	N/A	0.50	0.56	0.57	N/A	0.38	0.00
	Set 2	0.51	0.49	0.52	0.57	0.59	0.53	0.09	N/A	0.13
	Set 3	0.53	0.52	0.51	0.56	0.56	0.59	0.10	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	32.05	34.18	N/A	21.80	24.34	24.75	N/A	33.11	0.03
	Set 2	35.89	33.83	34.16	24.85	25.38	23.19	7.64	N/A	11.46
	Set 3	35.84	34.51	33.41	24.82	24.04	25.52	8.50	N/A	N/A

As shown in the table above, the Subaru's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for all trials at the same vehicle speed with the bollard, with the exception of the 5 mph (8 km/h) vehicle speed. The system automatically applied the brakes at a TTC of approximately 0.5 seconds for 17 out of 18 trials at the idle and 2.5 mph (4 km/h) vehicle speeds.

Overall, for the bollard test trials, the timing of warnings and automatic braking was generally consistent for trials at the same conditions. The order in which warnings were presented varied between vehicles.

Reversing Vehicle – Dynamic Test Object

The results below show the system response percentages, TTCs, and distances for all vehicles with the Reversing Vehicle – Dynamic Test Object scenario. The objects tested with this scenario are the adult PTM, 7-year-old PTM, and 2-year-old PTM, traveling in the right to left and left to right directions.

System Response Percentages by Test Object

The system response percentages of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position. The tables are separated by test object travel direction.

Adult PTM Walking

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left for the Cadillac XT4.

Table 54. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	0%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	0%	33%	100%	0%	0%	100%	0%	100%	100%	0%	66%	100%

As shown in the table above, the Cadillac's RAB system consistently provided auditory and visual warnings for all trials with the adult PTM traveling in the right to left direction. However, the system did not avoid a crash for any of the 25 percent object overlap trials. The system avoided a crash in 11 of 18 trials at the 5 mph (8 km/h) vehicle speed and seven of 18 trials at 2.5 mph (4 km/h).

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right for the Cadillac XT4.

Table 55. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	0%	100%	100%	100%	100%	100%	66%	100%	100%
% Crashes Avoided	0%	100%	100%	0%	100%	100%	100%	100%	100%	33%	100%	100%

As shown in the table above, the Cadillac's RAB system consistently provided both auditory and visual warnings for all trials with the adult PTM traveling in the left to right direction. The system automatically applied the brakes in nearly all trials, with automatic braking absent for only the 25 percent overlap at 2.5 mph (4 km/h) condition and one of three trials for the 25 percent overlap at 5 mph (8 km/h). The Cadillac RAB system avoided a crash for all dynamic adult pedestrian traveling left to right trials at the 5 mph (8 km/h) vehicle speed and 2 mph (3.2 km/h) test object speed combination. However, the system did not avoid a crash for any of the 25 percent object overlap trials at the 2.5 mph (4 km/h) vehicle speed with the adult PTM traveling in the left to right direction. The Cadillac RAB system avoided a crash for 16 out of 18 trials at the 5 mph (8 km/h) vehicle speed compared to 12 out of 18 trials at the 2.5 mph (4 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left for the Ford Mach-E. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 56. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0	0	0	0
% Auditory Warning	66%	100%	100%	0%	100%	100%	--	--	--	--	--	--
% Visual Warning	0%	100%	100%	0%	0%	66%	--	--	--	--	--	--
% Automatic Braking	33%	100%	100%	33%	33%	33%	--	--	--	--	--	--
% Crashes Avoided	0%	100%	100%	0%	0%	33%	--	--	--	--	--	--

As shown in the table above, the Ford RAB system provided a warning, automatically applied the brakes, and avoided a crash for all trials at the 2 mph (3.2 km/h) test object speed at the 50 percent and 75 percent object overlap conditions. For trials of the 2.5 mph (4 km/h) test vehicle speed at the 25 percent object overlap condition, no crashes were avoided. Crash avoidance performance was also poor for the 2.5 mph (4 km/h) test vehicle speed and 3.1 mph (5 km/h) object speed combination for 50% and 75 percent overlap conditions, in which the system only avoided a crash for one out of six trials.

The following table on the next page shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right for the Ford Mach-E. Due to damage to the test object during testing, only one test trial at each test object overlap was conducted with the 5 mph (8 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted with the 5 mph (8 km/h) vehicle speed and 3.1 mph (5 km/h) object speed combination.

Table 57. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	1	1	1	0	0	0
% Auditory Warning	0%	66%	100%	0%	0%	66%	0%	100%	0%	--	--	--
% Visual Warning	33%	66%	100%	0%	0%	66%	100%	100%	0%	--	--	--
% Automatic Braking	66%	66%	66%	66%	100%	100%	100%	100%	0%	--	--	--
% Crashes Avoided	0%	33%	66%	0%	0%	100%	0%	100%	0%	--	--	--

As shown in the table above, the Ford RAB system provided both auditory and visual warnings for only four of 21 trials performed with the adult PTM traveling in the left to right direction. The system did not avoid a crash for any of the 25 percent object overlap trials performed with the adult PTM traveling in the left to right direction. The system automatically applied the brakes for 16 of 21 trials but only avoided a crash for seven of 21 trials.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left for the Jeep Grand Cherokee.

Table 58. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	33%	100%	100%	100%	66%	66%	33%	100%	66%
% Visual Warning	66%	100%	100%	0%	66%	100%	33%	33%	66%	0%	66%	66%
% Automatic Braking	66%	100%	100%	33%	66%	100%	66%	66%	66%	33%	66%	66%
% Crashes Avoided	0%	100%	100%	0%	66%	100%	0%	0%	0%	0%	0%	33%

As shown in the table above, the Jeep's RAB system provided auditory warnings in 29 of 36 trials and visual warnings in only 21 of 36 trials for trials with the adult PTM traveling in the right to left direction. The system did not avoid a crash for any of the trials at the 25 percent overlap for both test vehicle speeds. At the 2.5 mph (4 km/h) vehicle speed, the system avoided a crash for all of the trials with the 75 percent object overlap and five of six trials at 50 percent overlap. The system only avoided a crash for one out of 18 trials at the 5 mph (8 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right for the Jeep Grand Cherokee.

Table 59. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	66%	100%	100%	100%	100%	66%	66%	100%	100%
% Visual Warning	100%	100%	100%	66%	100%	100%	66%	100%	66%	66%	100%	100%
% Automatic Braking	100%	100%	100%	66%	100%	100%	100%	100%	66%	66%	100%	100%
% Crashes Avoided	100%	100%	100%	0%	100%	100%	0%	100%	66%	0%	33%	100%

As shown in the table above, the Jeep’s RAB system provided warnings, automatically applied the brakes, and avoided a crash for all the trials with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination with the adult PTM traveling in the left to right direction. However, the system did not avoid a crash for any of the trials with the 25 percent object overlap at any other speed combination.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 60. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0	0	0	0
% Auditory Warning	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Visual Warning	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--	--	--	--

As shown in the table above, the Subaru’s RAB system did not provide warnings, automatically apply the brakes, or avoid a crash for any trial with the adult PTM traveling in the right to left direction.

The following table on the next page shows results for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at

lower vehicle speeds, only one test trial at each test object overlap condition was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination and testing was not conducted at higher speeds.

Table 61. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0	0	0	0
% Auditory Warning	0%	100%	100%	--	--	--	--	--	--	--	--	--
% Visual Warning	0%	100%	100%	--	--	--	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--	--	--	--

As shown in the table above, the Subaru's RAB system provided auditory and visual warnings for two out of three trials at the 2.5 mph (4 km/h) test speed. However, the system did not automatically apply the brakes or avoid a crash for any trial when backing toward the adult PTM traveling in the left to right direction.

Overall, for the dynamic adult PTM test trials, tested RAB systems avoided more crashes at lower vehicle and object speeds. Performance based on the test object direction of travel was not consistent between vehicles. However, the Jeep was more likely to impact the test object when the test object direction of travel was right to left.

7-Year-Old PTM Walking

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left for the Cadillac XT4.

Table 62. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	0%	100%	100%	0%	100%	100%	100%	100%	100%	66%	100%	100%
% Crashes Avoided	0%	66%	100%	0%	0%	100%	33%	100%	100%	0%	100%	100%

As shown in the table above, the Cadillac RAB system consistently provided auditory and visual warnings for all trials with the 7-year-old PTM traveling in the right to left direction. The system automatically applied the brakes for 17 of 18 trials. However, the system did not avoid a crash in

11 of 12 trials at the 25 percent object overlap condition. For the 2.5 mph (4 km/h) test vehicle speed and 50 percent overlap condition, the Cadillac system avoided crashes in only two of six trials.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right for the Cadillac XT4.

Table 63. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Automatic Braking	33%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	0%	100%	100%	0%	33%	100%	100%	100%	100%	0%	100%	100%

As shown in the table above, the Cadillac’s RAB system consistently provided auditory and visual warnings in all trials with 7-year-old PTM traveling in the left to right direction. The system automatically applied the brakes in all trials and avoided a crash in all trials at the 5 mph (8 km/h) vehicle speed except for the 25 percent overlap 2 mph test object speed condition. The system did not avoid a crash for nine out of 12 trials at the 25 percent object overlap trials with 7-year-old PTM traveling in the left to right direction.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left for the Ford Mach-E.

Table 64. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	33%	100%	100%	0%	100%	100%	33%	100%	100%	0%	33%	100%
% Visual Warning	0%	100%	100%	0%	100%	100%	66%	100%	100%	0%	100%	100%
% Automatic Braking	33%	100%	100%	66%	100%	100%	100%	100%	100%	66%	100%	100%
% Crashes Avoided	0%	100%	100%	0%	66%	100%	0%	33%	66%	0%	0%	66%

As shown in the table above, the Ford RAB system provided both auditory and visual warnings in 22 of 24 trials for 50 percent and 75 percent overlap conditions at both test vehicle speeds for the 7-year-old PTM traveling in the right to left direction, but did not consistently provide warnings and did not avoid a crash for all of the trials at the 25 percent overlap condition. The system avoided a crash for 11 of 18 trials at the 2.5 mph (4 km/h) vehicle speed and five of 18 trials at the 5 mph (8 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right for the Ford Mach-E.

Table 65. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	33%	100%	100%	0%	33%	100%	0%	100%	100%	0%	0%	33%
% Visual Warning	33%	100%	100%	0%	66%	66%	0%	66%	100%	0%	0%	33%
% Automatic Braking	100%	100%	100%	33%	100%	100%	66%	66%	100%	0%	66%	33%
% Crashes Avoided	33%	100%	100%	0%	66%	66%	0%	33%	66%	0%	0%	0%

As shown in the table above, the Ford RAB system showed inconsistent presentation of warnings and crash avoidance response for trials with the 7-year-old PTM traveling in the left to right direction. The system avoided no crashes for trials of the 5 mph (8 km/h) vehicle speed and 3.1 mph (5 km/h) object speed combination. The RAB system avoided a crash in only one out of 12 trials at the 25 percent object overlap condition.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left for the Jeep Grand Cherokee.

Table 66. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	66%	66%	33%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	0%	33%	66%	0%	100%	66%
% Automatic Braking	100%	100%	100%	100%	100%	100%	66%	33%	33%	0%	100%	100%
% Crashes Avoided	33%	100%	100%	0%	100%	100%	0%	0%	33%	0%	66%	0%

As shown in the table above, the Jeep's RAB system provided auditory and visual warnings and automatically applied the brakes in all 2.5 mph (4 km/h) trials with the 7-year-old PTM traveling in the right to left direction. It also avoided crashes for all trials at the 50 percent and 75 percent overlaps at the 2.5 mph (4 km/h) vehicle speed. However, the system's performance was more variable at the 5 mph (8 km/h) test vehicle speed and did not avoid a crash for 11 out of 12 trials at the 25 percent object overlap across all vehicle speeds.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right for the Jeep Grand Cherokee.

Table 67. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	66%	100%	100%	100%	100%	100%	66%	100%	100%
% Visual Warning	100%	100%	100%	0%	100%	100%	66%	100%	100%	0%	66%	100%
% Automatic Braking	100%	100%	100%	33%	100%	100%	100%	66%	100%	66%	100%	100%
% Crashes Avoided	66%	100%	100%	0%	100%	100%	0%	66%	33%	0%	66%	66%

As shown in the table above, the Jeep’s RAB system provided both auditory and visual warnings for 17 of 18 trials at 2 mph (3.2 km/h) test object speed and 11 of 18 trials at the 3.1 mph (5 km/h) test object speed with the 7-year-old PTM traveling in the left to right direction. The Jeep’s RAB system avoided a crash for 19 out of 24 trials at the 50 percent and 75 percent object overlaps across all vehicle speeds, when backing toward. However, the Jeep’s RAB system did not avoid a crash for 10 out of 12 trials at the 25 percent object overlap across all vehicle speeds.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 68. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0	0	0	0
% Auditory Warning	0%	100%	100%	--	--	--	--	--	--	--	--	--
% Visual Warning	0%	100%	100%	--	--	--	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--	--	--	--

As shown in the table above, while Subaru’s RAB system provided warnings for two out of three trials performed, it did not automatically apply the brakes or avoid a crash for any trial when backing toward the 7-year-old PTM traveling in the right to left direction.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 69. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0	0	0	0
% Auditory Warning	0%	100%	0%	--	--	--	--	--	--	--	--	--
% Visual Warning	0%	100%	0%	--	--	--	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--	--	--	--

As shown in the table above, the Subaru’s RAB system provided warnings for one out of three trials but did not automatically apply the brakes or avoid a crash for any trial when backing toward the 7-year-old PTM traveling in the left to right direction.

Overall, for the dynamic 7-year-old PTM test trials, RAB systems avoided more crashes at lower vehicle and test object speeds. Performance based on the test object direction of travel was not consistent between vehicles.

2-Year-Old PTM Walking

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left for the Cadillac XT4.

Table 70. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%
% Automatic Braking	0%	100%	100%	100%	100%	100%
% Crashes Avoided	0%	100%	100%	100%	100%	100%

As shown in the table above, the Cadillac’s RAB system provided warnings for all trials of the 2-year-old PTM traveling in the right to left direction. The system automatically applied the brakes

and avoided a crash for 15 out of 18 trials. The three trials in which the system did not automatically apply the brakes and avoid a crash were for the 25 percent test object overlap at the 2.5 mph (4 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right for the Cadillac XT4.

Table 71. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2022 Cadillac XT4

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%
% Crashes Avoided	0%	100%	100%	100%	66%	100%

As shown in the table above, the Cadillac’s RAB system consistently provided visual and auditory warnings and automatic braking for all 18 trials with the 2-year-old PTM traveling in the left to right direction. However, crashes were only avoided for 14 of 18 trials. No crashes were avoided for the 25 percent object overlap condition at the 2.5 mph (4 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left for the Ford Mach-E.

Table 72. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	33%	33%	100%	33%	100%	100%
% Visual Warning	0%	66%	100%	66%	100%	100%
% Automatic Braking	0%	66%	100%	66%	100%	100%
% Crashes Avoided	0%	66%	100%	66%	100%	100%

As shown in the table above, for trials involving 2-year-old PTM traveling in the right to left direction, the Ford RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials of the 75 percent object overlap condition and the 50 percent overlap condition at 5 mph (8 km/h). For the 25 percent overlap condition at 2.5 mph (4 km/h), the system only provided an auditory warning in one of three trials and did not attempt braking nor avoid a crash in any of the 3 trials. The system avoided a crash for five out of nine trials at the 2.5 mph (4 km/h) vehicle speed and eight out of nine trials at the 5 mph (8 km/h) vehicle speed.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right for the Ford Mach-E.

Table 73. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2022 Ford Mustang Mach-E

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	0%	0%	100%	0%	33%	100%
% Visual Warning	0%	100%	100%	33%	66%	100%
% Automatic Braking	33%	100%	100%	66%	66%	100%
% Crashes Avoided	0%	100%	100%	0%	33%	100%

As shown in the table above for test trials involving the 2-year-old PTM traveling in the left to right direction, the Ford system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 75 percent object overlap position. However, the system did not avoid a crash for all trials at the 25 percent object overlap position. The system avoided a crash for 6 out of nine trials at the 2.5 mph (4 km/h) vehicle speed and avoided a crash for four out of nine trials at the 5 mph (8 km/h) vehicle speed.

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left for the Jeep Grand Cherokee.

Table 74. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	66%	100%	100%	33%	66%	33%
% Visual Warning	33%	100%	100%	0%	66%	33%
% Automatic Braking	33%	100%	100%	0%	66%	33%
% Crashes Avoided	33%	100%	100%	0%	66%	0%

As shown in the table above for test trials involving the 2-year-old PTM traveling in the right to left direction, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for all the trials with the 50 percent and 75 percent object overlaps at the 2.5 mph (4 km/h) vehicle speed. The system avoided crashes in only two out of nine trials at the 5 mph (8 km/h) vehicle speed, in which both trials where a crash was avoided were at the 50 percent object overlap.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 75. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3
% Auditory Warning	100%	100%	66%	--	--	--
% Visual Warning	33%	66%	66%	--	--	--
% Automatic Braking	66%	100%	66%	--	--	--
% Crashes Avoided	0%	33%	66%	--	--	--

As shown in the table above for test trials involving the 2-year-old PTM traveling in the left to right direction at 2.5 mph (4 km/h) test vehicle speed, the Jeep’s RAB system provides auditory warnings in eight or nine trials and visual warnings in five of nine trials. The system automatically applied the brakes for seven out of nine trials and avoided a crash in three of nine test trials conducted. The system did not avoid a crash for any trial at the 25 percent object overlap condition.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left for the Subaru Outback. Due to damage to the test object during testing, only two test trials were conducted at the 25 percent test object overlap and only one test trial was conducted at the 50 percent, and 75 percent test object overlaps for the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed test combination. Testing was not conducted at any other speeds.

Table 76. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	2	1	1	0	0	0
% Auditory Warning	0%	100%	100%	--	--	--
% Visual Warning	0%	100%	100%	--	--	--
% Automatic Braking	0%	0%	100%	--	--	--
% Crashes Avoided	0%	0%	100%	--	--	--

As shown in the table above for test trials involving the 2-year-old PTM traveling in the right to left direction for the 2.5 mph (4 km/h) test vehicle speed, the Subaru’s RAB system provided both auditory and visual warnings and automatically applied the brakes for both trials at the 50 percent and 75 percent overlap conditions, but had no response in the 25 percent overlap

condition. The system provided warnings, automatically applied the brakes, and avoided a crash for the one trial at the 75 percent overlap, but did not avoid a crash for the 25 percent and 50 percent overlap conditions.

The following table shows results for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right for the Subaru Outback. Due to damage to the test object during testing, only one test trial was conducted.

Table 77. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2022 Subaru Outback

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	1	0	0	0	0	0
% Auditory Warning	100%	--	--	--	--	--
% Visual Warning	0%	--	--	--	--	--
% Automatic Braking	0%	--	--	--	--	--
% Crashes Avoided	0%	--	--	--	--	--

As shown in the table above, the Subaru’s RAB system only provided an auditory warning for the one trial conducted when backing toward the 2-year-old PTM traveling in the left to right direction.

Overall, for the dynamic 2-year-old PTM test trials, the Subaru RAB system performance was inconsistent across all vehicle speeds, object speeds, and object directions of travel when backing toward the. However, the Ford and Cadillac avoided more crashes at the 5 mph (8 km/h) vehicle speed, 2 mph (3.2 km/h) object speed, and right to left direction of travel test combination when compared to other conditions.

System Response TTCs and Distances by Test Object

The system response TTCs and distances of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position. The tables are separated by test object travel direction.

Adult PTM Walking

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 78. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.03	2.53	2.94	0.95	1.35	1.69
	Set 2	2.07	2.63	2.93	1.00	1.32	1.72
	Set 3	2.07	2.50	3.03	1.17	1.58	1.65
Distance (in) at Auditory Warning Onset	Set 1	88.83	110.97	129.29	42.10	59.60	74.15
	Set 2	90.95	115.43	128.83	44.16	58.51	75.62
	Set 3	91.12	109.74	133.49	51.69	69.24	72.48
TTC (s) at Visual Warning Onset	Set 1	1.87	2.39	2.82	0.83	1.22	1.59
	Set 2	1.95	2.51	2.81	0.89	1.19	1.61
	Set 3	1.97	2.40	2.92	1.07	1.46	1.52
Distance (in) at Visual Warning Onset	Set 1	82.13	104.88	124.06	36.65	53.62	69.88
	Set 2	85.47	110.31	123.66	39.21	52.40	70.63
	Set 3	86.57	105.28	128.39	47.17	64.29	66.81
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.15	0.38	N/A	0.09	0.27
	Set 2	N/A	0.19	0.37	N/A	0.11	0.27
	Set 3	N/A	0.23	0.35	N/A	0.14	0.28
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	6.48	16.92	N/A	3.93	11.82
	Set 2	N/A	8.18	16.19	N/A	4.73	11.73
	Set 3	N/A	10.09	15.26	N/A	6.13	12.36

As shown in the table above, the Cadillac's RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed, when backing at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the right to left direction. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Cadillac XT4.

Table 79. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.20	2.61	2.81	1.34	1.57	1.82
	Set 2	2.33	2.57	3.21	1.28	1.41	1.78
	Set 3	2.24	2.56	2.85	1.12	1.39	1.84
Distance (in) at Auditory Warning Onset	Set 1	194.37	229.56	247.98	118.31	138.60	159.95
	Set 2	205.25	226.80	282.25	112.49	124.50	156.58
	Set 3	197.62	225.36	250.74	98.65	122.19	161.60
TTC (s) at Visual Warning Onset	Set 1	2.09	2.49	2.69	1.21	1.45	1.69
	Set 2	2.20	2.44	3.09	1.15	1.27	1.65
	Set 3	2.09	2.43	2.74	1.00	1.28	1.71
Distance (in) at Visual Warning Onset	Set 1	184.13	219.65	236.89	106.97	127.83	148.62
	Set 2	193.66	215.00	271.77	101.38	112.17	145.59
	Set 3	184.17	214.33	241.42	87.68	112.72	150.39
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.85	1.25	N/A	N/A	N/A
	Set 2	N/A	0.74	1.20	N/A	N/A	0.61
	Set 3	N/A	0.71	1.24	N/A	N/A	0.60
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	74.19	108.89	N/A	N/A	N/A
	Set 2	N/A	64.54	104.84	N/A	N/A	53.78
	Set 3	N/A	62.61	108.27	N/A	N/A	52.70
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.16	0.24	0.23	0.00	0.18	0.29
	Set 2	0.21	0.23	0.26	0.03	0.27	0.24
	Set 3	0.17	0.26	0.22	0.08	0.28	0.32
Distance (in) at Subject Vehicle Braking Onset	Set 1	13.81	18.30	19.15	0.59	16.13	25.53
	Set 2	18.04	17.41	21.00	2.27	23.29	15.53
	Set 3	14.72	19.50	18.12	7.11	24.55	22.89

For test trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the adult PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 80. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.02	2.58	3.02	1.07	1.44	1.85
	Set 2	2.04	2.51	2.89	1.33	1.55	1.92
	Set 3	1.97	2.56	3.02	1.27	1.89	1.93
Distance (in) at Auditory Warning Onset	Set 1	88.28	113.26	132.63	47.09	63.38	81.48
	Set 2	90.14	110.53	126.93	58.71	68.09	84.65
	Set 3	86.66	112.38	132.43	56.18	83.16	84.71
TTC (s) at Visual Warning Onset	Set 1	1.93	2.47	2.88	0.94	1.32	1.71
	Set 2	1.94	2.38	2.80	1.20	1.40	1.80
	Set 3	1.82	2.44	2.90	1.15	1.73	1.78
Distance (in) at Visual Warning Onset	Set 1	84.45	108.39	126.18	41.61	58.11	75.31
	Set 2	85.55	105.12	122.68	52.91	61.73	79.37
	Set 3	80.24	107.01	127.09	50.63	76.02	78.15
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.12	0.20	0.41	N/A	0.15	0.26
	Set 2	0.08	0.24	0.30	N/A	0.18	0.32
	Set 3	0.04	0.21	0.25	N/A	0.17	0.34
Distance (in) at Subject Vehicle Braking Onset	Set 1	5.45	8.80	17.98	N/A	6.61	11.51
	Set 2	3.49	10.22	12.99	N/A	7.85	13.98
	Set 3	1.64	9.25	10.81	N/A	7.25	14.86

For test trials in which the Cadillac reversed at a speed of 2.5 mph toward the adult PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Cadillac XT4.

Table 81. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.37	2.63	2.95	1.44	1.54	1.83
	Set 2	2.29	2.69	2.85	1.26	1.61	1.90
	Set 3	2.29	2.65	3.04	1.27	1.59	1.78
Distance (in) at Auditory Warning Onset	Set 1	209.04	231.44	260.73	126.49	135.40	161.25
	Set 2	201.74	237.23	251.34	110.47	142.09	167.38
	Set 3	201.32	234.14	268.26	111.79	140.33	156.85
TTC (s) at Visual Warning Onset	Set 1	2.25	2.48	2.83	1.28	1.42	1.68
	Set 2	2.16	2.53	2.74	1.11	1.47	1.75
	Set 3	2.17	2.51	2.90	1.13	1.47	1.67
Distance (in) at Visual Warning Onset	Set 1	198.39	218.27	249.69	112.40	125.04	148.31
	Set 2	190.59	223.23	241.10	97.36	129.49	154.25
	Set 3	190.71	221.42	256.38	99.88	129.69	146.85
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.83	1.33	N/A	N/A	0.66
	Set 2	N/A	0.94	1.29	N/A	N/A	0.7
	Set 3	N/A	0.82	1.26	N/A	N/A	0.71
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	72.75	116.34	N/A	N/A	58
	Set 2	N/A	82.73	112.98	N/A	N/A	60.73
	Set 3	N/A	72.12	110.64	N/A	N/A	62.7
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.25	0.19	0.23	0.13	0.22	0.29
	Set 2	0.23	0.26	0.26	N/A	0.20	0.33
	Set 3	0.23	0.26	0.24	0.19	0.23	0.25
Distance (in) at Subject Vehicle Braking Onset	Set 1	21.82	14.36	19.08	11.71	19.12	21.26
	Set 2	20.39	20.04	21.32	N/A	18.02	24.25
	Set 3	20.18	19.75	19.56	16.67	20.37	19.15

As shown in the table above for test trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the adult PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E. Due to damage to the test object while attempting testing at the 5 mph (8 km/h) vehicle speed with the adult PTM traveling left to right, testing was not conducted with the Ford March-E at the 5 mph (8 km/h) vehicle speed with the adult PTM traveling right to left.

Table 82. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.34	0.47	N/A	0.07	0.49
	Set 2	0.04	0.74	0.75	N/A	0.01	0.10
	Set 3	0.01	0.30	0.45	N/A	0.96	0.46
Distance (in) at Auditory Warning Onset	Set 1	N/A	14.29	20.97	N/A	3.08	21.17
	Set 2	1.53	31.57	34.81	N/A	0.42	4.43
	Set 3	0.33	12.44	19.35	N/A	41.85	20.54
TTC (s) at Visual Warning Onset	Set 1	N/A	0.30	0.43	N/A	N/A	0.29
	Set 2	N/A	0.54	0.58	N/A	N/A	N/A
	Set 3	N/A	0.28	0.30	N/A	N/A	0.32
Distance (in) at Visual Warning Onset	Set 1	N/A	10.24	15.24	N/A	N/A	12.56
	Set 2	N/A	22.72	26.93	N/A	N/A	N/A
	Set 3	N/A	10.67	13.03	N/A	N/A	14.45
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.05	0.36	0.47	N/A	0.06	0.00
	Set 2	N/A	0.41	0.46	0.06	N/A	N/A
	Set 3	N/A	0.36	0.22	N/A	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	2.32	15.54	20.50	N/A	2.65	0.01
	Set 2	N/A	17.12	21.23	2.42	N/A	N/A
	Set 3	N/A	16.93	9.43	N/A	N/A	N/A

For test trials in which the Ford reversed at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E.

Table 83. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.17	0.45	N/A	N/A	0.23
	Set 2	N/A	N/A	0.25	N/A	N/A	N/A
	Set 3	N/A	0.01	0.22	N/A	N/A	0.23
Distance (in) at Auditory Warning Onset	Set 1	N/A	7.58	19.76	N/A	N/A	8.85
	Set 2	N/A	N/A	10.82	N/A	N/A	N/A
	Set 3	N/A	0.54	9.56	N/A	N/A	9.88
TTC (s) at Visual Warning Onset	Set 1	0.02	0.02	0.28	N/A	N/A	0.21
	Set 2	N/A	0.35	0.05	N/A	N/A	N/A
	Set 3	N/A	N/A	0.18	N/A	N/A	0.04
Distance (in) at Visual Warning Onset	Set 1	0.83	0.92	10.20	N/A	N/A	6.89
	Set 2	N/A	10.67	2.05	N/A	N/A	N/A
	Set 3	N/A	N/A	6.81	N/A	N/A	1.57
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.14	N/A	0.35	N/A	0.10	0.29
	Set 2	N/A	0.41	N/A	0.00	0.05	0.11
	Set 3	0.01	0.08	0.27	0.02	0.04	0.08
Distance (in) at Subject Vehicle Braking Onset	Set 1	6.25	N/A	15.39	N/A	4.24	12.49
	Set 2	N/A	17.89	N/A	0.18	2.09	5.16
	Set 3	0.33	3.54	12.73	0.72	1.78	3.70

As shown in the table above for test trials involving the Ford reversing at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally started automatically applying the brakes before providing a warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Ford Mach-E. Due to damage to the test object during testing, only one test trial at each test object overlap was conducted at the 2 mph (3.2 km/h) object speed, and testing was not conducted at the 3.1 mph (5 km/h) object speed.

Table 84. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.35	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	27.21	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.13	0.37	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	10.71	30.28	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.22	0.44	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	19.73	37.90	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--

As shown in the table above for trials involving the Ford reversing at a speed of 5 mph (8 km/h) toward the adult PTM traveling in the left to right direction, the RAB system provided warnings and automatically applied the brakes at different TTCs for the two trials where at least one mode of warning and automatic braking occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 85. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.15	0.33	0.45	0.05	0.37	0.27
	Set 2	0.15	0.35	0.18	N/A	0.03	0.28
	Set 3	0.08	0.33	0.54	N/A	0.28	0.22
Distance (in) at Auditory Warning Onset	Set 1	6.54	14.30	17.05	2.17	15.22	11.33
	Set 2	6.47	14.91	7.79	N/A	1.13	12.31
	Set 3	3.27	14.28	23.32	N/A	6.15	9.64
TTC (s) at Visual Warning Onset	Set 1	0.24	0.32	0.44	N/A	0.13	0.18
	Set 2	0.19	0.27	0.09	N/A	0.29	0.21
	Set 3	N/A	0.25	0.54	N/A	N/A	0.12
Distance (in) at Visual Warning Onset	Set 1	10.51	13.78	17.60	N/A	10.20	6.65
	Set 2	8.11	9.57	3.43	N/A	10.39	8.74
	Set 3	N/A	10.43	23.23	N/A	N/A	4.69
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.09	0.27	0.45	0.00	0.30	0.18
	Set 2	0.11	0.29	0.12	N/A	N/A	0.23
	Set 3	0.01	0.27	0.08	N/A	0.27	0.17
Distance (in) at Subject Vehicle Braking Onset	Set 1	0.15	0.33	18.64	0.05	0.37	0.27
	Set 2	0.15	0.35	5.15	N/A	0.03	0.28
	Set 3	0.08	0.33	3.31	N/A	0.28	0.22

As shown in the table above for test trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. However, at the 50 percent object overlap with the 2 mph (3.2 km/h) object speed, the system provided warnings and automatically applied the brakes at an approximate TTC of 0.3 seconds for all trials.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 86. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.14	N/A	0.28	0.06	0.17	N/A
	Set 2	0.05	0.12	0.36	N/A	0.04	0.34
	Set 3	0.09	0.24	N/A	N/A	0.19	0.29
Distance (in) at Auditory Warning Onset	Set 1	12.04	N/A	24.46	4.95	13.84	N/A
	Set 2	4.55	10.11	30.52	N/A	3.01	28.30
	Set 3	7.58	20.30	N/A	N/A	15.91	24.70
TTC (s) at Visual Warning Onset	Set 1	0.01	N/A	0.15	N/A	0.09	N/A
	Set 2	N/A	N/A	0.25	N/A	N/A	0.22
	Set 3	N/A	0.13	N/A	N/A	0.20	0.19
Distance (in) at Visual Warning Onset	Set 1	1.14	N/A	11.77	N/A	7.17	N/A
	Set 2	N/A	N/A	19.13	N/A	N/A	15.71
	Set 3	N/A	10.20	N/A	N/A	16.73	15.59
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.07	N/A	0.21	0.00	0.11	N/A
	Set 2	N/A	0.05	0.30	N/A	N/A	0.28
	Set 3	0.03	0.17	N/A	N/A	0.12	0.23
Distance (in) at Subject Vehicle Braking Onset	Set 1	5.97	N/A	17.57	0.10	9.62	N/A
	Set 2	N/A	4.13	25.48	N/A	N/A	23.30
	Set 3	2.42	14.40	N/A	N/A	10.04	19.62

As shown in the table above for test trials in which the Jeep reversed at a speed of 5 mph (8 km/h) toward the adult PTM traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 87. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.20	0.56	1.49	N/A	0.30	0.56
	Set 2	0.27	0.55	0.96	0.13	0.25	0.44
	Set 3	0.34	0.79	0.61	0.14	0.28	0.44
Distance (in) at Auditory Warning Onset	Set 1	8.50	23.35	65.38	N/A	12.34	24.09
	Set 2	11.37	22.59	43.21	5.61	9.29	18.46
	Set 3	14.41	33.01	27.26	5.77	11.75	18.38
TTC (s) at Visual Warning Onset	Set 1	0.09	0.56	1.47	N/A	0.31	0.52
	Set 2	0.18	0.52	0.98	0.14	0.25	0.38
	Set 3	0.26	0.79	0.63	0.04	0.27	0.36
Distance (in) at Visual Warning Onset	Set 1	3.11	23.31	64.57	N/A	12.83	22.32
	Set 2	7.01	21.34	44.25	5.79	9.41	13.27
	Set 3	10.59	32.91	28.07	1.61	11.50	12.80
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.14	0.34	0.41	N/A	0.25	0.34
	Set 2	0.21	0.29	0.37	0.06	0.27	0.38
	Set 3	0.27	0.24	0.38	0.08	0.16	0.37
Distance (in) at Subject Vehicle Braking Onset	Set 1	5.99	14.14	18.02	N/A	10.26	14.68
	Set 2	8.80	12.16	16.61	2.66	10.86	15.94
	Set 3	11.41	9.99	16.99	3.29	6.59	15.42

As shown in the table above for test trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 88. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.28	0.46	0.32	0.18	0.43	0.42
	Set 2	0.11	0.32	0.38	N/A	0.19	0.38
	Set 3	0.24	0.35	N/A	0.12	0.05	0.48
Distance (in) at Auditory Warning Onset	Set 1	23.89	39.81	24.35	15.08	36.08	35.68
	Set 2	9.65	26.68	32.73	N/A	16.49	32.92
	Set 3	18.37	29.15	N/A	9.81	3.77	40.94
TTC (s) at Visual Warning Onset	Set 1	0.18	0.36	0.34	0.08	0.34	0.45
	Set 2	N/A	0.45	0.40	N/A	0.06	0.28
	Set 3	0.27	0.25	N/A	0.10	0.04	0.50
Distance (in) at Visual Warning Onset	Set 1	14.96	29.21	28.82	6.89	27.17	38.43
	Set 2	N/A	38.07	34.33	N/A	4.84	22.48
	Set 3	22.56	20.12	N/A	7.99	3.07	42.72
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.22	0.40	0.37	0.12	0.38	0.39
	Set 2	0.05	0.26	0.37	N/A	0.12	0.32
	Set 3	0.30	0.29	N/A	0.16	0.08	0.40
Distance (in) at Subject Vehicle Braking Onset	Set 1	18.75	33.77	31.74	9.94	31.84	33.12
	Set 2	4.46	21.62	31.87	N/A	10.46	26.92
	Set 3	25.67	24.06	N/A	13.99	7.14	33.30

As shown in the table above for test trials involving the Jeep reversing at a speed of 5 mph (8 km/h) toward the adult PTM traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning, except for all but one of the 75 percent overlap trials.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 89. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--

As shown in the table above, the Subaru's RAB system did not provide warnings or automatically apply the brakes for any trial when backing at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the right to left direction.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the adult PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 90. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Adult PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.29	0.31	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	13.13	13.73	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.21	0.23	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	9.21	10.04	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--

As shown in the table above for test trials in which the Subaru reversed at a speed of 2.5 mph (4 km/h) toward the adult PTM traveling in the left to right direction, the RAB system provided auditory warnings at a TTC of approximately 0.3 seconds and provided visual warnings at a TTC of approximately 0.2 seconds for the two out of three trials where warnings were provided.

Overall, for the dynamic adult PTM test trials, warning and automatic braking occurrence timings were inconsistent for trials at the same conditions, with the exception of the Cadillac. Auditory warnings were generally presented before visual warnings.

7-Year-Old PTM Walking

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 91. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.82	2.25	2.66	0.98	1.27	1.57
	Set 2	1.85	2.27	2.78	0.88	1.37	1.65
	Set 3	1.80	2.09	2.76	0.95	1.26	1.68
Distance (in) at Auditory Warning Onset	Set 1	80.10	99.14	116.93	43.14	56.15	69.28
	Set 2	81.68	100.39	122.64	38.63	60.48	72.55
	Set 3	79.28	92.96	120.75	41.96	55.86	73.96
TTC (s) at Visual Warning Onset	Set 1	1.69	2.13	2.53	0.86	1.15	1.44
	Set 2	1.73	2.14	2.65	0.74	1.23	1.54
	Set 3	1.68	1.95	2.63	0.83	1.12	1.54
Distance (in) at Visual Warning Onset	Set 1	74.37	93.66	111.18	37.87	50.75	63.46
	Set 2	76.14	94.49	116.61	32.48	53.94	67.72
	Set 3	73.78	86.34	115.20	36.50	49.49	67.72
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.11	0.36	N/A	0.09	0.24
	Set 2	N/A	0.16	0.38	N/A	0.06	0.30
	Set 3	N/A	0.08	0.35	N/A	0.05	0.27
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	4.85	15.78	N/A	3.79	10.62
	Set 2	N/A	6.94	16.44	N/A	2.44	13.06
	Set 3	N/A	3.59	15.25	N/A	2.32	11.71

As shown in the table above for test trials in which the Cadillac reverse at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Cadillac XT4.

Table 92. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.99	2.27	2.84	1.10	1.43	1.79
	Set 2	2.04	2.34	2.71	1.14	1.43	1.79
	Set 3	1.87	2.42	2.62	1.10	1.48	1.75
Distance (in) at Auditory Warning Onset	Set 1	174.74	199.88	251.02	97.22	125.66	157.35
	Set 2	180.17	206.29	239.70	100.52	126.31	157.58
	Set 3	164.82	213.59	231.03	97.18	130.75	153.92
TTC (s) at Visual Warning Onset	Set 1	1.87	2.14	2.69	0.95	1.30	1.66
	Set 2	1.89	2.23	2.60	1.00	1.30	1.65
	Set 3	1.74	2.32	2.49	0.97	1.34	1.63
Distance (in) at Visual Warning Onset	Set 1	165.12	188.31	237.80	83.90	114.88	146.46
	Set 2	167.09	196.10	229.33	88.19	114.41	145.63
	Set 3	153.19	203.98	219.80	85.59	118.03	143.46
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.68	1.18	N/A	N/A	0.59
	Set 2	N/A	0.75	1.2	N/A	N/A	N/A
	Set 3	N/A	0.65	1.19	N/A	N/A	0.64
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	59.8	103.42	N/A	N/A	52.27
	Set 2	N/A	65.21	105.33	N/A	N/A	N/A
	Set 3	N/A	57.02	103.87	N/A	N/A	56.04
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.12	0.22	0.35	0.00	0.21	0.34
	Set 2	0.18	0.25	0.30	0.09	0.22	0.31
	Set 3	0.12	0.23	0.23	N/A	0.22	0.31
Distance (in) at Subject Vehicle Braking Onset	Set 1	10.18	15.92	27.56	0.39	18.86	24.22
	Set 2	16.00	18.55	24.48	7.88	19.74	27.26
	Set 3	10.61	17.23	19.36	N/A	19.51	19.69

As shown in the table above for test trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 93. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.80	2.24	2.79	1.01	1.34	1.64
	Set 2	1.85	2.35	2.77	0.91	1.24	1.58
	Set 3	1.87	2.32	2.71	0.95	1.43	1.63
Distance (in) at Auditory Warning Onset	Set 1	79.21	98.10	122.34	44.57	59.34	72.03
	Set 2	81.67	103.36	121.71	40.05	54.73	69.41
	Set 3	82.52	102.00	118.73	41.91	63.16	71.75
TTC (s) at Visual Warning Onset	Set 1	1.66	2.09	2.65	0.90	1.21	1.50
	Set 2	1.73	2.24	2.66	0.76	1.10	1.43
	Set 3	1.74	2.19	2.56	0.83	1.31	1.49
Distance (in) at Visual Warning Onset	Set 1	73.11	91.65	116.61	40.04	53.50	66.02
	Set 2	76.54	98.46	116.89	33.74	48.46	63.27
	Set 3	76.65	96.38	112.32	36.57	57.80	65.79
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.00	0.26	0.31	N/A	0.12	0.00
	Set 2	N/A	0.25	0.38	N/A	0.06	0.28
	Set 3	N/A	0.22	0.30	N/A	0.14	0.26
Distance (in) at Subject Vehicle Braking Onset	Set 1	0.19	11.29	13.40	N/A	5.39	0.10
	Set 2	N/A	10.73	16.43	N/A	2.79	12.36
	Set 3	N/A	9.72	13.17	N/A	6.19	11.24

As shown in the table above for test trials in which the Cadillac reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Cadillac XT4.

Table 94. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.02	2.48	3.10	1.14	1.55	1.87
	Set 2	2.14	2.28	2.93	1.25	1.46	1.83
	Set 3	2.02	2.43	2.85	1.32	1.51	1.86
Distance (in) at Auditory Warning Onset	Set 1	177.62	218.40	273.70	100.70	136.38	164.41
	Set 2	188.82	201.20	258.24	109.80	129.12	160.97
	Set 3	178.34	214.27	251.36	115.89	133.17	163.89
TTC (s) at Visual Warning Onset	Set 1	1.88	2.35	2.96	1.00	1.40	1.74
	Set 2	2.01	2.15	2.79	1.10	1.33	1.70
	Set 3	1.91	2.24	2.73	1.19	1.41	1.74
Distance (in) at Visual Warning Onset	Set 1	165.71	207.32	261.34	88.31	123.31	153.03
	Set 2	176.89	189.69	246.18	97.05	116.93	149.49
	Set 3	167.68	199.84	243.94	105.12	123.98	153.15
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.85	1.36	N/A	N/A	0.69
	Set 2	N/A	0.86	1.3	N/A	N/A	0.65
	Set 3	N/A	0.82	1.35	N/A	N/A	0.7
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	74.93	119.05	N/A	N/A	60.64
	Set 2	N/A	75.68	114.3	N/A	N/A	57.23
	Set 3	N/A	71.66	118.02	N/A	N/A	61.69
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.22	0.27	0.21	0.05	0.26	0.27
	Set 2	0.25	0.26	0.26	0.00	0.24	0.28
	Set 3	0.26	0.33	0.26	0.00	0.21	0.28
Distance (in) at Subject Vehicle Braking Onset	Set 1	19.13	20.88	17.89	4.63	22.41	20.24
	Set 2	21.89	19.83	21.74	0.41	21.49	18.76
	Set 3	22.74	25.00	21.50	0.54	18.17	21.04

As shown in the table above for trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E.

Table 95. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.44	0.59	N/A	0.11	0.42
	Set 2	N/A	0.00	0.52	N/A	0.19	0.43
	Set 3	0.03	0.32	0.54	N/A	0.19	0.24
Distance (in) at Auditory Warning Onset	Set 1	N/A	18.60	25.75	N/A	4.13	15.09
	Set 2	N/A	8.78	23.66	N/A	6.73	14.80
	Set 3	1.21	10.56	24.34	N/A	7.05	7.77
TTC (s) at Visual Warning Onset	Set 1	N/A	0.42	0.47	N/A	0.12	0.42
	Set 2	N/A	0.35	0.41	N/A	0.19	0.43
	Set 3	N/A	0.33	0.44	N/A	0.15	0.26
Distance (in) at Visual Warning Onset	Set 1	N/A	16.14	17.64	N/A	4.49	15.51
	Set 2	N/A	12.91	15.98	N/A	7.09	14.45
	Set 3	N/A	12.13	15.94	N/A	4.84	9.96
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.48	0.51	0.00	0.22	0.47
	Set 2	N/A	0.42	0.47	N/A	0.27	0.48
	Set 3	0.10	0.39	0.49	0.00	0.26	0.35
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	20.75	22.25	0.15	9.91	20.82
	Set 2	N/A	18.64	20.96	N/A	12.09	20.75
	Set 3	4.49	17.30	21.61	0.03	11.15	16.49

As shown in the table above for trials in which the Ford reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed. The system generally provided the auditory warning earlier than the visual warning at the 2 mph (3.2 km/h) object speed and generally provided the warnings at similar TTCs at the 3.1 mph (5 km/h) object speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Ford Mach-E.

Table 96. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.03	0.23	0.38	N/A	N/A	0.25
	Set 2	N/A	0.28	0.39	N/A	N/A	0.23
	Set 3	N/A	0.22	0.54	N/A	0.17	0.13
Distance (in) at Auditory Warning Onset	Set 1	1.75	20.02	33.44	N/A	N/A	18.82
	Set 2	N/A	19.94	34.11	N/A	N/A	17.01
	Set 3	N/A	16.39	47.77	N/A	11.72	9.16
TTC (s) at Visual Warning Onset	Set 1	0.12	0.19	0.30	N/A	0.02	0.29
	Set 2	0.01	0.35	0.26	N/A	0.14	0.30
	Set 3	N/A	0.24	0.36	N/A	0.24	0.22
Distance (in) at Visual Warning Onset	Set 1	9.72	16.02	24.84	N/A	1.26	23.50
	Set 2	0.71	29.13	21.14	N/A	11.38	24.88
	Set 3	N/A	19.57	30.94	N/A	19.09	18.27
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.20	0.25	0.35	0.06	0.09	0.36
	Set 2	0.09	0.41	0.33	N/A	0.12	0.36
	Set 3	0.04	0.33	0.40	0.01	0.32	0.29
Distance (in) at Subject Vehicle Braking Onset	Set 1	17.74	21.71	30.83	5.02	7.46	31.23
	Set 2	7.87	36.02	28.75	N/A	9.38	31.69
	Set 3	3.78	28.75	35.45	0.87	27.86	25.63

As shown in the table above for trials in which the Ford reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning at the 2 mph (3.2 km/h) object speed and generally provided the visual warning earlier than the auditory warning at the 3.1 mph (5 km/h) object speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E.

Table 97. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.33	0.56	0.37	N/A	0.08	0.38
	Set 2	N/A	0.30	0.38	N/A	N/A	0.08
	Set 3	N/A	0.67	0.36	N/A	N/A	0.21
Distance (in) at Auditory Warning Onset	Set 1	8.89	15.63	16.07	N/A	3.71	16.43
	Set 2	N/A	10.24	15.98	N/A	N/A	3.54
	Set 3	N/A	13.53	11.52	N/A	N/A	8.81
TTC (s) at Visual Warning Onset	Set 1	0.32	0.51	0.34	N/A	N/A	0.30
	Set 2	N/A	0.31	0.36	N/A	0.35	N/A
	Set 3	N/A	0.49	0.35	N/A	0.16	0.11
Distance (in) at Visual Warning Onset	Set 1	11.57	17.68	12.28	N/A	N/A	9.96
	Set 2	N/A	11.61	13.11	N/A	12.64	N/A
	Set 3	N/A	16.02	13.03	N/A	6.46	3.90
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.38	0.53	0.40	N/A	0.04	0.37
	Set 2	0.02	0.37	0.42	N/A	0.41	0.05
	Set 3	0.06	0.51	0.42	0.07	0.23	0.22
Distance (in) at Subject Vehicle Braking Onset	Set 1	16.08	22.10	17.84	N/A	1.93	15.56
	Set 2	0.88	15.76	18.53	N/A	17.51	2.15
	Set 3	2.68	21.61	19.30	3.21	10.25	9.67

As shown in the table above for trials in which the Ford reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. However, the system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the 75 percent object overlap at the 2 mph (3.2 km/h) object speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Ford Mach-E.

Table 98. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.01	0.37	N/A	N/A	N/A
	Set 2	N/A	0.21	0.40	N/A	N/A	N/A
	Set 3	N/A	0.00	0.17	N/A	N/A	0.05
Distance (in) at Auditory Warning Onset	Set 1	N/A	0.82	32.40	N/A	N/A	N/A
	Set 2	N/A	5.56	35.51	N/A	N/A	N/A
	Set 3	N/A	0.36	13.78	N/A	N/A	4.30
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	0.32	N/A	N/A	0.09
	Set 2	N/A	0.33	0.29	N/A	N/A	N/A
	Set 3	N/A	0.07	0.19	N/A	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	27.09	N/A	N/A	7.64
	Set 2	N/A	27.95	23.58	N/A	N/A	N/A
	Set 3	N/A	6.14	15.98	N/A	N/A	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.06	N/A	0.39	N/A	0.01	0.16
	Set 2	0.01	0.39	0.39	N/A	N/A	N/A
	Set 3	N/A	0.15	0.25	N/A	0.04	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	5.65	N/A	35.09	N/A	0.60	14.36
	Set 2	0.82	34.84	34.61	N/A	N/A	N/A
	Set 3	N/A	13.70	22.47	N/A	3.49	N/A

As shown in the table above for trials in which the Ford reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system automatically applied the brakes before providing a warning for all but one trial where both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 99. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.14	0.38	0.40	0.13	0.25	0.48
	Set 2	0.11	0.82	0.96	0.08	0.30	0.40
	Set 3	0.22	0.92	0.83	0.11	0.24	0.51
Distance (in) at Auditory Warning Onset	Set 1	5.94	15.97	16.36	5.97	11.35	21.50
	Set 2	4.57	34.11	39.02	3.42	12.98	17.75
	Set 3	9.05	38.20	34.70	4.75	10.86	23.17
TTC (s) at Visual Warning Onset	Set 1	0.05	0.30	0.32	0.01	0.24	0.52
	Set 2	0.01	0.87	1.00	0.02	0.20	0.33
	Set 3	0.23	0.96	0.84	0.09	0.19	0.51
Distance (in) at Visual Warning Onset	Set 1	1.81	10.98	12.20	0.51	11.02	22.99
	Set 2	0.51	35.98	40.63	0.98	7.28	13.03
	Set 3	9.33	39.65	34.80	3.86	8.35	23.35
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.07	0.32	0.33	0.07	0.13	0.31
	Set 2	0.05	0.35	0.38	0.04	0.23	0.34
	Set 3	0.13	0.31	0.34	0.06	0.19	0.29
Distance (in) at Subject Vehicle Braking Onset	Set 1	3.06	13.41	13.49	3.27	5.88	13.92
	Set 2	2.05	14.72	15.09	1.57	9.91	15.10
	Set 3	5.32	12.71	14.34	2.51	8.22	13.14

As shown in the table above for trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the right to left direction, the Jeep's RAB system generally provided warnings at different TTCs across sets of trials. The system generally automatically applied the brakes at similar TTCs for trials with the same object overlap and object speed.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 100. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.08	0.19	0.32	N/A	0.33	0.27
	Set 2	0.05	0.01	N/A	N/A	0.35	0.19
	Set 3	0.03	N/A	0.19	0.02	0.32	0.06
Distance (in) at Auditory Warning Onset	Set 1	7.13	16.00	27.76	N/A	28.93	23.68
	Set 2	4.42	0.60	N/A	N/A	30.16	16.73
	Set 3	2.42	N/A	16.89	2.20	28.20	5.36
TTC (s) at Visual Warning Onset	Set 1	N/A	0.09	0.22	N/A	0.23	0.17
	Set 2	N/A	N/A	N/A	N/A	0.26	0.11
	Set 3	N/A	N/A	0.12	N/A	0.22	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	7.44	18.39	N/A	18.62	14.13
	Set 2	N/A	N/A	N/A	N/A	21.26	8.78
	Set 3	N/A	N/A	10.24	N/A	17.91	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.01	0.12	0.26	N/A	0.26	0.21
	Set 2	0.00	N/A	N/A	N/A	0.28	0.14
	Set 3	N/A	N/A	N/A	N/A	0.27	0.00
Distance (in) at Subject Vehicle Braking Onset	Set 1	0.99	10.01	22.56	N/A	22.86	18.48
	Set 2	0.82	N/A	N/A	N/A	24.09	11.60
	Set 3	N/A	N/A	N/A	N/A	23.02	0.12

As shown in the table above for trials in which the Jeep reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. However, at the 50 percent object overlap with the 3.1 mph (5 km/h) object speed, the system provided warnings and automatically applied the brakes at a TTC range of 0.2 – 0.3 seconds for all trials.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 101. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.28	0.74	0.44	N/A	0.26	0.46
	Set 2	0.21	0.49	0.62	0.10	0.22	0.21
	Set 3	0.09	0.39	0.45	0.03	0.30	0.38
Distance (in) at Auditory Warning Onset	Set 1	12.82	33.44	20.02	N/A	12.11	20.38
	Set 2	9.42	21.93	27.39	4.39	10.10	9.63
	Set 3	4.21	17.68	19.87	1.37	13.84	17.37
TTC (s) at Visual Warning Onset	Set 1	0.20	0.75	0.39	N/A	0.17	0.39
	Set 2	0.10	0.47	0.60	N/A	0.11	0.13
	Set 3	N/A	0.39	0.44	N/A	0.22	0.33
Distance (in) at Visual Warning Onset	Set 1	8.15	33.54	17.83	N/A	6.81	15.16
	Set 2	3.66	21.02	26.54	N/A	4.41	5.51
	Set 3	N/A	17.64	19.45	N/A	9.80	15.24
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.23	0.27	0.38	N/A	0.21	0.39
	Set 2	0.15	0.23	0.35	0.03	0.15	0.15
	Set 3	0.03	0.31	0.40	N/A	0.24	0.33
Distance (in) at Subject Vehicle Braking Onset	Set 1	10.56	12.18	16.87	N/A	9.35	17.28
	Set 2	6.71	10.31	15.43	1.29	6.93	6.87
	Set 3	1.50	14.06	17.26	N/A	11.09	15.04

As shown in the table above for trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 102. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.11	0.33	0.27	N/A	0.34	0.38
	Set 2	0.12	0.46	0.33	0.06	0.39	0.36
	Set 3	0.15	0.15	0.38	0.11	0.10	0.43
Distance (in) at Auditory Warning Onset	Set 1	10.00	25.76	23.26	N/A	29.34	32.46
	Set 2	10.82	39.92	27.62	5.50	34.25	29.56
	Set 3	13.39	13.45	32.77	9.41	8.83	37.04
TTC (s) at Visual Warning Onset	Set 1	N/A	0.44	0.19	N/A	0.24	0.38
	Set 2	0.01	0.47	0.32	N/A	0.29	0.37
	Set 3	0.04	0.16	0.38	N/A	N/A	0.42
Distance (in) at Visual Warning Onset	Set 1	N/A	38.15	16.54	N/A	21.30	31.46
	Set 2	0.98	41.30	26.65	N/A	23.98	31.54
	Set 3	2.76	13.74	32.76	N/A	N/A	36.14
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.04	0.38	0.21	N/A	0.27	0.41
	Set 2	0.07	0.40	0.32	0.01	0.31	0.39
	Set 3	0.09	N/A	0.00	0.05	0.04	0.36
Distance (in) at Subject Vehicle Braking Onset	Set 1	3.89	33.22	18.03	N/A	23.25	35.02
	Set 2	6.48	34.68	26.78	1.13	27.28	33.80
	Set 3	8.07	N/A	0.34	4.17	3.59	30.98

As shown in the table above for trials in which the Jeep reversed at a speed of 5 mph (8 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided auditory warnings and visual warnings at similar TTCs if both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 103. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.21	0.17	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	9.35	7.32	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.36	0.07	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	16.02	2.87	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--

As shown in the table above for trials in which the Subaru reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the right to left direction, the RAB system provided warnings at different TTCs for the two trials where warnings occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 7-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, only one test trial at each test object overlap was conducted with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination, and testing was not conducted at higher speeds.

Table 104. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 7-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.26	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	11.46	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.31	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	13.70	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--

As shown in the table above for trials in which the Subaru reversed at a speed of 2.5 mph (4 km/h) toward the 7-year-old PTM traveling in the left to right direction, the RAB system provided a visual warning earlier than an auditory warning.

Overall, for the dynamic 7-year-old PTM test trials, warning and automatic braking occurrence timings were inconsistent for trials at the same conditions, with the exception of the Cadillac. Auditory warnings were generally presented before visual warnings.

2-Year-Old PTM Walking

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 105. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.90	2.27	2.82
	Set 2	1.90	2.30	2.72
	Set 3	1.95	2.32	2.87
Distance (in) at Auditory Warning Onset	Set 1	83.47	100.35	123.66
	Set 2	83.97	101.05	119.19
	Set 3	86.11	101.86	125.26
TTC (s) at Visual Warning Onset	Set 1	1.79	2.15	2.69
	Set 2	1.76	2.19	2.59
	Set 3	1.83	2.16	2.73
Distance (in) at Visual Warning Onset	Set 1	78.58	95.00	117.99
	Set 2	77.56	96.14	113.46
	Set 3	80.67	94.88	119.21
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.18	0.30
	Set 2	N/A	0.15	0.20
	Set 3	N/A	0.14	0.17
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	7.88	12.99
	Set 2	N/A	6.45	8.53
	Set 3	N/A	5.99	7.60

As shown in the table above for test trials involving the Cadillac reversing at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in a right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 106. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.14	2.61	2.92
	Set 2	2.09	2.38	2.91
	Set 3	2.06	2.50	3.18
Distance (in) at Auditory Warning Onset	Set 1	188.61	230.68	256.98
	Set 2	184.34	209.88	257.29
	Set 3	181.02	221.06	280.20
TTC (s) at Visual Warning Onset	Set 1	2.02	2.47	2.76
	Set 2	1.97	2.27	2.77
	Set 3	1.93	2.37	3.08
Distance (in) at Visual Warning Onset	Set 1	177.72	217.64	243.58
	Set 2	173.27	200.28	244.13
	Set 3	170.04	208.78	271.34
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.65	1.21
	Set 2	N/A	N/A	1.2
	Set 3	N/A	0.68	1.23
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	56.89	105.77
	Set 2	N/A	N/A	105.43
	Set 3	N/A	60.03	107.64
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.20	0.26	0.18
	Set 2	0.18	0.23	0.25
	Set 3	0.17	0.16	0.23
Distance (in) at Subject Vehicle Braking Onset	Set 1	17.21	19.32	14.53
	Set 2	15.41	19.88	20.59
	Set 3	14.97	12.52	19.17

As shown in the table above for test trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Cadillac XT4.

Table 107. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	1.87	2.47	2.88
	Set 2	1.89	2.38	2.83
	Set 3	1.86	2.38	2.93
Distance (in) at Auditory Warning Onset	Set 1	82.25	108.68	126.21
	Set 2	82.73	104.75	123.61
	Set 3	81.87	104.59	128.52
TTC (s) at Visual Warning Onset	Set 1	1.72	2.35	2.73
	Set 2	1.77	2.25	2.68
	Set 3	1.74	2.27	2.79
Distance (in) at Visual Warning Onset	Set 1	75.79	103.50	119.41
	Set 2	77.56	99.06	117.44
	Set 3	76.65	99.80	122.13
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.07	0.23	0.25
	Set 2	0.12	0.28	0.19
	Set 3	0.05	0.20	0.25
Distance (in) at Subject Vehicle Braking Onset	Set 1	3.00	9.87	10.97
	Set 2	5.33	12.37	8.49
	Set 3	2.19	8.84	11.15

As shown in the table above for test trials in which the Cadillac reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Cadillac XT4.

Table 108. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Cadillac XT4

Test Vehicle Speed		5 mph (8 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	2.20	2.89	3.07
	Set 2	2.12	2.67	3.03
	Set 3	2.19	2.76	2.96
Distance (in) at Auditory Warning Onset	Set 1	194.25	255.23	270.73
	Set 2	186.88	235.41	267.86
	Set 3	192.89	243.72	261.27
TTC (s) at Visual Warning Onset	Set 1	2.08	2.76	2.94
	Set 2	1.98	2.53	2.91
	Set 3	2.07	2.64	2.83
Distance (in) at Visual Warning Onset	Set 1	183.31	244.13	258.70
	Set 2	174.29	222.83	257.56
	Set 3	181.73	233.23	249.49
TTC (s) at Haptic Brake Pulse Onset	Set 1	N/A	0.86	1.31
	Set 2	N/A	0.84	1.46
	Set 3	N/A	0.95	1.41
Distance (in) at Haptic Brake Pulse Onset	Set 1	N/A	76	114.6
	Set 2	N/A	73.98	128.05
	Set 3	N/A	83.28	123.01
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.25	0.22	0.20
	Set 2	0.27	0.28	0.29
	Set 3	0.28	0.28	0.26
Distance (in) at Subject Vehicle Braking Onset	Set 1	21.92	16.96	17.09
	Set 2	23.87	21.31	24.87
	Set 3	25.08	21.40	21.73

As shown in the table above for test trials in which the Cadillac reversed at a speed of 5 mph (8 km/h) toward the 2-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the auditory warning earlier than the visual warning and provided the haptic brake pulse warning after the auditory and visual warnings.

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E.

Table 109. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	0.23
	Set 2	N/A	0.45	0.48
	Set 3	0.00	N/A	0.55
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	9.13
	Set 2	N/A	14.06	21.42
	Set 3	0.22	N/A	24.73
TTC (s) at Visual Warning Onset	Set 1	N/A	0.48	0.25
	Set 2	N/A	0.43	0.40
	Set 3	N/A	N/A	0.42
Distance (in) at Visual Warning Onset	Set 1	N/A	17.32	10.47
	Set 2	N/A	15.91	16.65
	Set 3	N/A	N/A	18.86
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.51	0.32
	Set 2	N/A	0.48	0.44
	Set 3	N/A	N/A	0.41
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	22.18	14.80
	Set 2	N/A	20.63	19.22
	Set 3	N/A	N/A	18.03

As shown in the table above for test trials in which the Ford reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system automatically applied the brakes before providing a warning for three out of 5 trials where both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Ford Mach-E.

Table 110. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		5 mph (8 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.23	0.00	0.31
	Set 2	N/A	0.57	0.38
	Set 3	N/A	0.36	0.41
Distance (in) at Auditory Warning Onset	Set 1	5.09	16.80	27.04
	Set 2	N/A	17.88	34.11
	Set 3	N/A	20.54	36.25
TTC (s) at Visual Warning Onset	Set 1	0.31	0.46	0.26
	Set 2	0.28	0.48	0.32
	Set 3	N/A	0.41	0.28
Distance (in) at Visual Warning Onset	Set 1	25.75	37.52	22.13
	Set 2	22.83	41.61	26.06
	Set 3	N/A	32.83	23.07
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.39	0.52	0.33
	Set 2	0.35	0.51	0.40
	Set 3	N/A	0.47	0.34
Distance (in) at Subject Vehicle Braking Onset	Set 1	34.34	46.41	29.68
	Set 2	31.00	45.47	35.88
	Set 3	N/A	40.85	30.02

As shown in the table above for test trials in which the Ford reversed at a speed of 5 mph (8 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the visual warning earlier than the auditory warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Ford Mach-E.

Table 111. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	0.49
	Set 2	N/A	N/A	0.51
	Set 3	N/A	N/A	0.69
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	21.11
	Set 2	N/A	N/A	21.69
	Set 3	N/A	N/A	29.47
TTC (s) at Visual Warning Onset	Set 1	N/A	0.32	0.41
	Set 2	N/A	0.33	0.38
	Set 3	N/A	0.33	0.49
Distance (in) at Visual Warning Onset	Set 1	N/A	11.69	13.11
	Set 2	N/A	11.77	13.46
	Set 3	N/A	11.97	20.94
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.38	0.45
	Set 2	0.08	0.39	0.42
	Set 3	N/A	0.39	0.46
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	16.90	19.38
	Set 2	3.39	16.59	17.87
	Set 3	N/A	17.10	19.28

As shown in the table above for test trials in which the Ford reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the left to right direction, the Ford system generally provided visual warnings and automatically applied the brakes at similar TTCs for trials with the same object overlap. The system generally provided the visual warning earlier than the auditory warning for trials where both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 5 mph (8 km/h) vehicle speed for the Ford Mach-E.

Table 112. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Ford Mustang Mach-E

Test Vehicle Speed		5 mph (8 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	0.26
	Set 2	N/A	N/A	0.30
	Set 3	N/A	0.18	0.48
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	22.72
	Set 2	N/A	N/A	20.96
	Set 3	N/A	13.39	42.27
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	0.21
	Set 2	0.09	0.04	0.38
	Set 3	N/A	0.25	0.36
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	17.36
	Set 2	7.48	2.95	32.60
	Set 3	N/A	21.26	29.25
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.03	N/A	0.29
	Set 2	0.18	0.12	0.43
	Set 3	N/A	0.33	0.43
Distance (in) at Subject Vehicle Braking Onset	Set 1	2.74	N/A	25.36
	Set 2	15.66	10.28	38.99
	Set 3	N/A	29.01	37.86

As shown in the table above for test trials in which the Ford reversed at a speed of 5 mph (8 km/h) toward the 2-year-old PTM traveling in the left to right direction, the system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system automatically applied the brakes earlier than it provided a warning for trials where both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 113. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.03	0.35	0.12
	Set 2	N/A	0.55	0.06
	Set 3	0.25	0.16	0.96
Distance (in) at Auditory Warning Onset	Set 1	1.51	15.91	5.67
	Set 2	N/A	25.00	2.16
	Set 3	11.34	7.31	43.09
TTC (s) at Visual Warning Onset	Set 1	N/A	0.27	0.05
	Set 2	N/A	0.56	0.11
	Set 3	0.16	0.08	0.95
Distance (in) at Visual Warning Onset	Set 1	N/A	10.98	2.01
	Set 2	N/A	25.43	4.92
	Set 3	7.05	3.27	43.03
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.30	0.05
	Set 2	N/A	0.35	0.13
	Set 3	0.20	0.10	0.40
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	13.62	1.91
	Set 2	N/A	15.90	5.78
	Set 3	9.01	4.66	18.04

As shown in the table above for test trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials, when backing. The system provided the auditory warning earlier than the visual warning for most trials.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 114. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.40	N/A
	Set 2	N/A	0.42	0.39
	Set 3	0.02	N/A	N/A
Distance (in) at Auditory Warning Onset	Set 1	N/A	35.15	N/A
	Set 2	N/A	36.46	34.27
	Set 3	2.19	N/A	N/A
TTC (s) at Visual Warning Onset	Set 1	N/A	0.37	N/A
	Set 2	N/A	0.42	0.30
	Set 3	N/A	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	32.17	N/A
	Set 2	N/A	36.93	25.71
	Set 3	N/A	N/A	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.34	N/A
	Set 2	N/A	0.33	0.32
	Set 3	N/A	N/A	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	29.91	N/A
	Set 2	N/A	28.63	28.14
	Set 3	N/A	N/A	N/A

As shown in the table above for test trials in which the Jeep reversed at a speed of 5 mph (8 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system provided warnings and automatically applied the brakes at a TTC range of 0.3 – 0.4 seconds for 50 percent overlap trials where both warnings and automatic braking occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 115. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.04	0.08	N/A
	Set 2	0.15	0.18	0.26
	Set 3	0.08	0.40	0.28
Distance (in) at Auditory Warning Onset	Set 1	1.60	3.58	N/A
	Set 2	6.93	8.12	11.69
	Set 3	3.73	17.51	12.97
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	N/A
	Set 2	0.06	0.10	0.17
	Set 3	N/A	0.32	0.18
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	N/A
	Set 2	2.32	4.53	6.69
	Set 3	N/A	12.40	7.56
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.03	N/A
	Set 2	0.08	0.12	0.21
	Set 3	0.02	0.34	0.21
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	1.34	N/A
	Set 2	3.74	5.33	9.43
	Set 3	1.05	14.87	9.74

As shown in the table above for test trials in which the Jeep reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the left to right direction, the RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials. The system generally provided the auditory warning earlier than the visual warning.

Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, testing with the 2-year-old PTM traveling left to right with the 5 mph (8 km/h) vehicle speed was not conducted with the Jeep Grand Cherokee.

The following table on the next page shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to damage to the test object during testing, only two test trials were conducted at the 25 percent test object overlap and only one test trial was conducted at the 50 percent and 75 percent test object overlaps for the 2.5 mph (4 km/h) vehicle speed and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 116. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		2	1	1
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.14	0.59
	Set 2	N/A	--	--
	Set 3	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	6.19	26.10
	Set 2	N/A	--	--
	Set 3	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	0.11	0.60
	Set 2	N/A	--	--
	Set 3	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	4.84	26.54
	Set 2	N/A	--	--
	Set 3	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	0.53
	Set 2	N/A	--	--
	Set 3	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	23.03
	Set 2	N/A	--	--
	Set 3	--	--	--

As shown in the table above for test trials in which the Subaru reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the right to left direction, the RAB system provided warnings at different TTCs for the two trials where warnings occurred.

The following table on the next page shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Subaru Outback. Due to damage to the test object during testing, only one test trial was conducted and testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 117. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Subaru Outback

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		1	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.02	--	--
	Set 2	--	--	--
	Set 3	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	0.76	--	--
	Set 2	--	--	--
	Set 3	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	--	--
	Set 2	--	--	--
	Set 3	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	--	--
	Set 2	--	--	--
	Set 3	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	--	--
	Set 2	--	--	--
	Set 3	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	--	--
	Set 2	--	--	--
	Set 3	--	--	--

As shown in the table above for test trials in which the Subaru reversed at a speed of 2.5 mph (4 km/h) toward the 2-year-old PTM traveling in the left to right direction, the Subaru only provided an auditory warning for the one trial conducted.

Overall, for the dynamic 2-year-old PTM test trials, timing consistency of warnings and automatic braking varied between vehicles. The order in which warnings were presented also varied between vehicles.

Additional RAB Characterization Testing - Jeep Grand Cherokee Test

Certain test objects were only tested with the Jeep Grand Cherokee as the test matrix was cut short for the other vehicles due to schedule constraints. The system response percentages, TTCs, and distances for these test objects are shown in the tables below.

Reversing Vehicle – Stationary Test Object

The following results show the system response percentages, TTCs, and distances for the additional objects tested with the Reversing Vehicle – Stationary Test Object scenario for the

Jeep Grand Cherokee. The objects tested in this scenario were the 1-year-old standing mannequin, Playing Child Target, 2-year-old PTM seated on the Bobby Car, 2-year-old seated mannequin, 1-year-old crawling mannequin, plastic shopping cart, metal shopping cart, plastic shopping cart with the adult PTM, and the metal shopping cart with the adult PTM.

System Response Results by Test Object

The system response percentages of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position.

1-Year-Old PTM Standing

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 1-year-old PTM positioned in a standing posture for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 118. System Response Percentages for Reversing Vehicle – Stationary Test Object, 1-year-old Mannequin Standing, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	33%	66%	66%	100%	33%	100%	--	--	--
% Visual Warning	33%	66%	66%	66%	33%	100%	--	--	--
% Automatic Braking	33%	66%	66%	100%	33%	100%	--	--	--
% Crashes Avoided	0%	33%	66%	0%	0%	100%	--	--	--

As shown in the table above for test trials involving the stationary standing 1-year-old PTM, the Jeep’s RAB system provided warnings, automatically applied the brakes, and avoided a crash for 5 out of six trials at the 75 percent object overlap. The system avoided a crash in one of three trials at the 50 percent overlap condition and did not avoid a crash for any of the 25 percent overlap trials.

Playing Child Target

The following table on the next page shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the Playing Child Target for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at the 5 mph (8 km/h) vehicle speed, only one test trial at each test object overlap was conducted.

Table 119. System Response Percentages for Reversing Vehicle – Stationary Test Object, Playing Child Target, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	1	1	1
% Auditory Warning	66%	100%	100%	100%	100%	100%	0%	100%	0%
% Visual Warning	66%	100%	100%	100%	100%	100%	0%	0%	0%
% Automatic Braking	66%	100%	100%	100%	66%	100%	0%	0%	0%
% Crashes Avoided	66%	100%	66%	100%	66%	100%	0%	0%	0%

As shown in the table above for test trials involving the stationary Playing Child Target, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for all of the 50 percent test object overlap trials at the idle vehicle speed, and all of the 25 percent and 75 percent test object overlap trials at the 2.5 mph (4 km/h) vehicle speed. At the 5 mph (8 km/h) vehicle speed, the system only provided an auditory warning for one trial and did not provide visual warnings or automatically apply the brakes for any trial.

2-Year-Old PTM on Bobby Car

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM seated on the Bobby Car for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 120. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM on Bobby Car, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	100%	100%	100%	100%	100%	100%	--	--	--
% Visual Warning	100%	100%	66%	100%	66%	100%	--	--	--
% Automatic Braking	66%	100%	66%	100%	100%	100%	--	--	--
% Crashes Avoided	66%	33%	66%	66%	0%	66%	--	--	--

As shown in the table above for test trials involving the stationary 2-year-old PTM seated on the Bobby Car, the Jeep's RAB system provided warnings and automatically applied the brakes for most trials but avoided crash for only five of nine trials at idle speed and four of 9 at 2.5 mph (4 km/h).

2-Year-Old PTM Seated

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a seated posture for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object, only one test trial at each test object overlap was conducted for one vehicle speed.

Table 121. System Response Percentages for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Seated, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0
% Auditory Warning	0%	0%	0%	--	--	--	--	--	--
% Visual Warning	0%	0%	0%	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--

As shown in the table above for test trials involving the stationary seated 2-year-old PTM, the Jeep’s RAB system did not provide warnings, automatically apply the brakes, or avoid a crash with the test object for any trial.

1-Year-Old PTM Crawling

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the 1-year-old PTM positioned in a crawling posture for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in providing warnings and avoiding crashes with the test object, only one test trial at each test object overlap was conducted for one vehicle speed.

Table 122. System Response Percentages for Reversing Vehicle – Stationary Test Object, 1-Year-Old PTM Crawling, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	1	1	1	0	0	0	0	0	0
% Auditory Warning	0%	0%	0%	--	--	--	--	--	--
% Visual Warning	0%	0%	0%	--	--	--	--	--	--
% Automatic Braking	0%	0%	0%	--	--	--	--	--	--
% Crashes Avoided	0%	0%	0%	--	--	--	--	--	--

As shown in the table above for test trials involving the stationary crawling 1-year-old PTM, the Jeep’s RAB system did not provide warnings, automatically apply the brakes, or avoid a crash with the test object for any trial.

Plastic Shopping Cart With Adult PTM

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the plastic shopping cart positioned with the adult PTM for the Jeep Grand Cherokee.

Table 123. System Response Percentages for Reversing Vehicle – Stationary Test Object, Plastic Shopping Cart With Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	66%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Crashes Avoided	100%	100%	100%	100%	100%	100%	66%	100%	66%

As shown in the table above for test trials involving the stationary plastic shopping cart and adult PTM, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the idle and 2.5 mph (4 km/h) vehicle speeds. The system avoided a crash for seven out of nine trials at the 5 mph (8 km/h) vehicle speed.

Metal Shopping Cart With Adult PTM

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the metal shopping cart positioned with the adult PTM for the Jeep Grand Cherokee.

Table 124. System Response Percentages for Reversing Vehicle – Stationary Test Object, Metal Shopping Cart With Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	100%	100%	66%
% Visual Warning	100%	100%	100%	100%	100%	100%	100%	100%	66%
% Automatic Braking	100%	100%	100%	100%	100%	100%	100%	100%	66%
% Crashes Avoided	66%	66%	100%	100%	100%	100%	100%	66%	66%

As shown in the table above for test trials involving the stationary metal shopping cart and adult PTM, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 2.5 mph (4 km/h) vehicle speed. The system avoided a crash for seven out of nine trials for both the idle and 5 mph (8 km/h) vehicle speeds.

Plastic Shopping Cart

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the plastic shopping cart for the Jeep Grand Cherokee.

Table 125. System Response Percentages for Reversing Vehicle – Stationary Test Object, Plastic Shopping Cart, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	66%	100%	100%
% Visual Warning	100%	100%	100%	100%	100%	100%	66%	66%	100%
% Automatic Braking	100%	100%	100%	100%	100%	100%	66%	66%	100%
% Crashes Avoided	100%	100%	66%	100%	100%	100%	66%	66%	100%

As shown in the table above for test trials involving the stationary plastic shopping cart, the Jeep's RAB system provided warnings, automatically applied the brakes, and avoided a crash for all trials at the 2.5 mph (4 km/h) vehicle speed. The system avoided a crash for eight out of nine trials for the idle vehicle speed and avoided a crash for seven out of nine trials for the 5 mph (8 km/h) vehicle speed.

Metal Shopping Cart

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Stationary Test Object scenario with the metal shopping cart for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 126. System Response Percentages for Reversing Vehicle – Stationary Test Object, Metal Shopping Cart, 2022 Jeep Grand Cherokee

Test Vehicle Speed	Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	0	0	0
% Auditory Warning	33%	33%	33%	100%	100%	100%	--	--	--
% Visual Warning	0%	0%	0%	100%	66%	66%	--	--	--
% Automatic Braking	0%	0%	33%	100%	66%	100%	--	--	--
% Crashes Avoided	0%	0%	0%	33%	66%	0%	--	--	--

As shown in the table above for test trials involving the stationary metal shopping cart, the Jeep's RAB system automatically applied the brakes for eight out of nine trials and avoided a crash in three of nine trials at the 2.5 mph (4 km/h) vehicle speed. However, the system did not avoid a crash for any trials at the idle vehicle speed.

System Response TTCs and Distances by Test Object

The system response TTCs and distances of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position.

1-Year-Old PTM Standing

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 1-year-old PTM positioned in a standing posture for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 127. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 1-Year-Old PTM Standing, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.12	0.80	1.03	0.55	N/A	0.67	--	--	--
	Set 2	N/A	0.25	0.23	8.57	N/A	0.59	--	--	--
	Set 3	N/A	N/A	N/A	0.08	0.11	0.41	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	8.31	51.22	62.82	23.91	N/A	27.94	--	--	--
	Set 2	N/A	17.27	15.92	0.10	N/A	25.87	--	--	--
	Set 3	N/A	N/A	N/A	3.96	5.41	18.69	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.05	0.80	1.07	0.58	N/A	0.67	--	--	--
	Set 2	N/A	0.15	0.16	0.07	N/A	0.64	--	--	--
	Set 3	N/A	N/A	N/A	N/A	0.00	0.37	--	--	--
Distance (in) at Visual Warning Onset	Set 1	3.82	51.06	64.53	24.88	N/A	27.72	--	--	--
	Set 2	N/A	10.20	10.87	0.18	N/A	27.36	--	--	--
	Set 3	N/A	N/A	N/A	N/A	0.04	17.13	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.04	0.34	0.32	0.22	N/A	0.29	--	--	--
	Set 2	N/A	0.17	0.16	4.72	N/A	0.26	--	--	--
	Set 3	N/A	N/A	N/A	0.00	0.03	0.33	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	2.61	23.20	21.29	10.15	N/A	13.18	--	--	--
	Set 2	N/A	11.72	11.06	6.31	N/A	12.14	--	--	--
	Set 3	N/A	N/A	N/A	0.17	1.31	15.00	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings and automatically applied the brakes at different TTCs across sets of trials, when backing toward the stationary 1-year-old standing mannequin. The system generally provided warnings earlier for the idle vehicle speed when compared to the 2.5 mph (4 km/h) vehicle speed.

Playing Child Target

The following table shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the Playing Child Target for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at the 5 mph (8 km/h) vehicle speed, only one test trial at each test object overlap was conducted.

Table 128. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Playing Child Target, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	1	1	1
TTC (s) at Auditory Warning Onset	Set 1	0.59	0.73	0.09	1.11	1.74	1.07	N/A	0.04	N/A
	Set 2	N/A	0.61	1.15	0.84	1.14	1.12	--	--	--
	Set 3	1.12	1.06	0.76	0.79	0.28	0.25	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	0.99	46.93	6.62	47.07	69.58	45.63	N/A	3.43	N/A
	Set 2	N/A	40.09	69.98	34.21	47.05	46.71	--	--	--
	Set 3	68.62	65.85	49.12	32.79	12.72	11.70	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.73	0.76	0.01	1.13	1.81	1.13	N/A	N/A	N/A
	Set 2	N/A	0.62	1.15	0.60	1.15	1.14	--	--	--
	Set 3	1.11	1.07	0.77	0.61	0.22	0.14	--	--	--
Distance (in) at Visual Warning Onset	Set 1	47.40	48.50	0.47	47.91	72.56	48.15	N/A	N/A	N/A
	Set 2	N/A	41.10	70.24	25.16	47.40	47.64	--	--	--
	Set 3	67.99	66.18	50.08	25.83	9.84	6.26	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.40	0.38	0.02	0.34	N/A	0.32	N/A	N/A	N/A
	Set 2	N/A	0.39	0.40	0.38	0.33	0.31	--	--	--
	Set 3	0.32	0.34	0.39	0.32	0.19	0.16	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	25.55	25.74	1.60	15.81	N/A	15.11	N/A	N/A	N/A
	Set 2	N/A	26.59	27.27	16.61	14.69	13.97	--	--	--
	Set 3	21.81	23.21	26.42	14.25	8.63	7.41	--	--	--

As shown in the table above, the Jeep’s RAB system provided warnings at different TTCs across sets of trials with the stationary Playing Child Target. The system automatically applied the brakes at a TTC range of 0.3 – 0.4 seconds for 13 out of 18 trials at the idle and 2.5 mph (4 km/h) vehicle speeds.

2-Year-Old PTM on Bobby Car

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM seated on the Bobby Car for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 129. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM on Bobby Car, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.14	0.41	0.27	0.24	0.17	0.18	--	--	--
	Set 2	0.55	0.31	0.07	1.06	0.15	1.17	--	--	--
	Set 3	0.70	0.69	0.64	1.15	0.11	0.84	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	9.69	28.68	18.48	11.74	8.65	8.38	--	--	--
	Set 2	37.25	21.35	2.64	45.48	7.55	49.65	--	--	--
	Set 3	46.04	45.15	42.37	48.63	5.79	35.27	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.05	0.45	0.20	0.13	0.08	0.05	--	--	--
	Set 2	0.60	0.32	N/A	1.09	0.04	1.17	--	--	--
	Set 3	0.76	0.70	0.70	1.17	N/A	0.87	--	--	--
Distance (in) at Visual Warning Onset	Set 1	3.39	31.14	13.43	6.14	3.82	2.13	--	--	--
	Set 2	39.96	22.44	N/A	46.77	2.01	49.72	--	--	--
	Set 3	49.21	46.14	45.63	49.61	N/A	36.73	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.06	0.18	0.19	0.13	0.08	0.10	--	--	--
	Set 2	0.37	0.18	N/A	0.35	0.07	0.32	--	--	--
	Set 3	0.42	0.37	0.37	0.19	0.02	0.29	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	4.06	12.95	12.94	5.90	4.06	4.61	--	--	--
	Set 2	25.63	12.91	N/A	16.00	3.46	15.16	--	--	--
	Set 3	27.93	25.02	24.89	9.32	1.22	13.45	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary 2-year-old PTM seated on the Bobby Car. The system generally provided warnings earlier for the 2.5 mph (4 km/h) vehicle speed and automatically applied the brakes earlier for the idle vehicle speed.

2-Year-Old PTM Seated

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 2-year-old PTM positioned in a seated posture for the Jeep Grand Cherokee. Due to the RAB system not providing warnings and crashing with the test object in all trials, only one test trial at each test object overlap was conducted for one vehicle speed.

Table 130. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 2-Year-Old PTM Seated, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--

As shown in the table above, the Jeep's RAB system did not provide warnings or automatically apply the brakes for any trial with the stationary seated 2-year-old PTM.

1-Year-Old PTM Crawling

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the 1-year-old PTM positioned in a crawling posture for the Jeep Grand Cherokee. Due to the RAB system not providing warnings and tendency to contact the test object, only one test trial at each test object overlap was conducted for one vehicle speed.

Table 131. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, 1-Year-Old PTM Crawling, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		1	1	1	0	0	0	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--	--	--	--
	Set 3	--	--	--	--	--	--	--	--	--

As shown in the table above, the Jeep's RAB system did not provide warnings or automatically apply the brakes for any trial with the stationary crawling 1-year-old PTM.

Plastic Shopping Cart With Adult PTM

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the plastic shopping cart positioned with the adult PTM for the Jeep Grand Cherokee.

Table 132. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Plastic Shopping Cart With Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.80	0.51	0.48	1.30	1.50	1.02	0.47	0.42	0.21
	Set 2	1.07	0.70	0.44	1.44	1.18	0.93	0.20	0.44	0.28
	Set 3	0.94	0.94	0.50	1.30	1.02	0.44	0.45	0.43	0.42
Distance (in) at Auditory Warning Onset	Set 1	51.31	33.76	32.06	54.95	63.49	43.78	40.81	36.45	18.17
	Set 2	66.01	45.06	29.87	62.12	48.31	38.69	16.82	38.11	17.10
	Set 3	59.04	59.63	33.47	56.35	43.53	20.39	38.98	37.39	35.47
TTC (s) at Visual Warning Onset	Set 1	0.81	0.53	0.49	1.31	1.52	1.04	0.60	0.39	N/A
	Set 2	1.10	0.72	0.33	1.48	1.23	0.96	0.10	0.42	0.33
	Set 3	0.96	0.66	0.45	1.32	1.06	0.45	0.36	0.34	0.40
Distance (in) at Visual Warning Onset	Set 1	51.85	35.00	32.32	55.47	64.09	44.61	51.34	33.90	N/A
	Set 2	67.32	46.34	21.69	63.98	50.00	39.96	8.31	35.83	27.48
	Set 3	59.88	43.46	30.55	57.40	45.16	21.02	29.69	28.82	34.17
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.45	0.42	0.36	0.34	0.31	0.27	0.41	0.37	0.15
	Set 2	0.48	0.46	0.35	0.30	0.32	0.31	0.13	0.38	0.36
	Set 3	0.50	0.50	0.42	0.29	0.28	0.27	0.39	0.36	0.35
Distance (in) at Subject Vehicle Braking Onset	Set 1	30.25	27.71	24.00	15.57	14.19	12.96	34.79	32.15	12.87
	Set 2	31.82	30.49	23.77	13.80	14.28	14.05	10.80	32.09	30.87
	Set 3	33.25	33.45	28.08	13.77	13.22	13.23	33.73	30.50	29.50

As shown in the table above, the Jeep’s RAB system generally provided warnings at different TTCs across sets of trials with the stationary plastic shopping cart and adult PTM. The system automatically applied the brakes at a TTC of approximately 0.3 seconds for all trials at the 2.5 mph (4 km/h) vehicle speed.

Metal Shopping Cart With Adult PTM

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the metal shopping cart positioned with the adult PTM for the Jeep Grand Cherokee.

Table 133. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Metal Shopping Cart With Adult PTM, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.49	0.74	0.62	0.74	0.66	0.31	0.41	0.13	0.33
	Set 2	0.32	0.51	0.50	0.33	0.74	0.42	0.38	0.35	0.40
	Set 3	0.65	0.17	0.58	0.80	0.82	0.66	0.35	0.38	N/A
Distance (in) at Auditory Warning Onset	Set 1	33.13	48.04	40.79	31.40	28.89	15.05	34.92	11.13	28.70
	Set 2	22.23	33.98	34.40	15.42	31.90	19.83	31.95	29.80	34.16
	Set 3	42.71	11.80	38.55	33.34	35.16	28.83	29.68	32.43	N/A
TTC (s) at Visual Warning Onset	Set 1	0.43	0.77	0.66	0.82	0.68	0.34	0.43	0.24	0.23
	Set 2	0.33	0.50	0.46	0.40	0.87	0.50	0.34	0.19	0.44
	Set 3	0.67	0.18	0.63	0.89	0.87	0.75	0.21	0.30	N/A
Distance (in) at Visual Warning Onset	Set 1	29.45	49.49	42.95	34.92	29.61	15.98	37.17	20.12	19.41
	Set 2	22.91	33.39	31.42	18.11	37.76	22.91	28.70	15.43	37.32
	Set 3	43.82	12.68	41.34	37.13	37.09	32.76	17.64	25.47	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.40	0.35	0.33	0.28	0.29	0.24	0.34	0.06	0.26
	Set 2	0.22	0.42	0.41	0.25	0.25	0.21	0.32	0.22	0.32
	Set 3	0.36	0.04	0.41	0.27	0.22	0.23	0.24	0.31	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	27.04	23.98	22.68	13.36	13.67	11.70	28.89	5.07	22.64
	Set 2	15.19	28.55	28.19	11.65	12.12	10.22	26.88	18.78	27.35
	Set 3	24.64	2.55	27.17	12.59	10.60	11.11	20.33	26.49	N/A

As shown in the table above, the Jeep's RAB system generally provided warnings at different TTCs across sets of trials with the stationary metal shopping cart and adult PTM. The system automatically applied the brakes at a TTC of approximately 0.25 seconds for all trials at the 2.5 mph (4 km/h) vehicle speed.

Plastic Shopping Cart

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the plastic shopping cart for the Jeep Grand Cherokee.

Table 134. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Plastic Shopping Cart, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.81	0.88	0.75	1.18	0.99	0.91	0.48	0.46	0.45
	Set 2	0.87	0.73	0.59	1.63	1.17	1.23	0.45	0.46	0.47
	Set 3	0.92	0.98	0.24	0.97	1.58	0.39	N/A	0.04	0.47
Distance (in) at Auditory Warning Onset	Set 1	51.49	55.73	48.19	50.23	41.83	39.29	41.67	38.67	38.50
	Set 2	55.27	51.36	38.84	68.08	49.78	51.50	38.48	39.43	40.15
	Set 3	57.93	60.42	17.02	40.91	68.12	18.44	N/A	3.19	39.52
TTC (s) at Visual Warning Onset	Set 1	0.86	0.89	0.74	1.24	1.01	0.93	0.41	0.50	0.48
	Set 2	0.93	0.75	0.59	1.68	1.16	1.28	0.49	0.38	0.49
	Set 3	0.96	1.00	0.17	0.99	1.62	0.42	N/A	N/A	0.42
Distance (in) at Visual Warning Onset	Set 1	54.13	55.94	47.72	52.48	42.80	39.88	34.49	42.68	41.34
	Set 2	58.19	52.72	39.06	70.31	49.65	53.62	41.73	31.34	41.69
	Set 3	59.76	61.85	12.17	42.01	69.61	19.49	N/A	N/A	35.12
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.36	0.38	0.35	0.29	0.35	0.35	0.42	0.41	0.39
	Set 2	0.38	0.38	0.37	0.29	0.33	0.26	0.39	0.40	0.40
	Set 3	0.36	0.35	0.15	0.29	0.31	0.30	N/A	N/A	0.42
Distance (in) at Subject Vehicle Braking Onset	Set 1	24.32	25.67	23.66	13.84	15.87	16.24	35.63	34.45	33.38
	Set 2	25.56	28.19	24.75	13.39	15.58	12.17	33.37	33.51	34.22
	Set 3	24.56	23.28	10.68	13.76	14.79	14.18	N/A	N/A	35.31

As shown in the table above, the Jeep's RAB system generally provided warnings at different TTCs across sets of trials with the stationary plastic shopping cart. However, the system automatically applied the brakes at a TTC range of approximately 0.3 - 0.4 seconds for 24 out of 27 trials.

Metal Shopping Cart

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Stationary Test Object scenario with the metal shopping cart for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 135. System Response TTCs and Distances for Reversing Vehicle – Stationary Test Object, Metal Shopping Cart, 2022 Jeep Grand Cherokee

Test Vehicle Speed		Idle			2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.01	N/A	N/A	0.48	0.05	0.24	--	--	--
	Set 2	N/A	N/A	N/A	0.16	0.26	0.11	--	--	--
	Set 3	N/A	0.07	N/A	0.48	0.38	0.11	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	0.84	N/A	N/A	8.98	2.72	12.21	--	--	--
	Set 2	N/A	N/A	N/A	21.92	12.91	5.85	--	--	--
	Set 3	N/A	5.10	N/A	8.20	18.11	5.84	--	--	--
TTC (s) at Visual Warning Onset	Set 1	N/A	N/A	N/A	0.08	N/A	0.13	--	--	--
	Set 2	N/A	N/A	N/A	0.48	0.16	N/A	--	--	--
	Set 3	N/A	N/A	N/A	0.06	0.30	0.01	--	--	--
Distance (in) at Visual Warning Onset	Set 1	N/A	N/A	N/A	3.90	N/A	6.34	--	--	--
	Set 2	N/A	N/A	N/A	21.89	7.52	N/A	--	--	--
	Set 3	N/A	N/A	N/A	2.95	14.13	0.28	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	0.09	N/A	0.14	--	--	--
	Set 2	N/A	N/A	N/A	0.35	0.17	0.02	--	--	--
	Set 3	N/A	N/A	N/A	0.08	0.29	0.02	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	N/A	N/A	4.55	N/A	7.13	--	--	--
	Set 2	N/A	N/A	N/A	16.37	8.39	1.17	--	--	--
	Set 3	N/A	N/A	N/A	4.17	13.84	1.15	--	--	--

As shown in the table above, the Jeep's RAB system provided warnings and automatically applied the brakes at different TTCs across sets of trials with the stationary metal shopping cart.

Reversing Vehicle – Dynamic Test Object

The following results show the system response percentages, TTCs, and distances for the additional objects tested with the Reversing Vehicle – Dynamic Test Object scenario for the Jeep Grand Cherokee. The objects tested in this scenario were the 1-year-old standing mannequin, Playing Child Target, and the 2-year-old PTM seated on the Bobby Car, traveling in the right to left and left to right directions.

System Response Results by Test Object

The system response percentages of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position. The tables are separated by test object travel direction.

1-Year-Old PTM Walking

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 1-year-old PTM traveling right to left for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 136. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 1-Year-Old PTM, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	0	0	0
% Auditory Warning	66%	100%	33%	--	--	--
% Visual Warning	0%	100%	0%	--	--	--
% Automatic Braking	66%	100%	0%	--	--	--
% Crashes Avoided	0%	33%	0%	--	--	--

As shown in the table above for test trials involving the 1-year-old PTM traveling in the right to left direction, the Jeep’s RAB system provided warnings and automatically applied the brakes for all three trials at the 50 percent object overlap yet only avoided a crash for one of nine trials overall at the 2.5 mph (4 km/h) test vehicle speed.

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 1-year-old PTM traveling left to right for the Jeep Grand Cherokee. Due to the RAB system’s inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 137. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 1-Year-Old PTM, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)			5 mph (8 km/h)		
Test Object Speed	2 mph (3.2 km/h)					
Test Object Overlap	25%	50%	75%	25%	50%	75%
N	3	3	3	0	0	0
% Auditory Warning	66%	100%	100%	--	--	--
% Visual Warning	66%	33%	0%	--	--	--
% Automatic Braking	66%	100%	100%	--	--	--
% Crashes Avoided	33%	33%	33%	--	--	--

As shown in the table above for test trials involving the 1-year-old PTM traveling in the left to right direction, the Jeep’s RAB system automatically applied the brakes for eight out of nine

trials at the 2.5 mph (4 km/h) test vehicle speed but only avoided a crash in one of three trials at each overlap condition.

Playing Child Target Dynamic

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling right to left for the Jeep Grand Cherokee.

Table 138. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	33%	100%	100%	100%	100%	66%	0%	66%	100%
% Visual Warning	100%	100%	100%	0%	66%	100%	66%	66%	66%	0%	33%	100%
% Automatic Braking	100%	100%	100%	0%	100%	100%	66%	66%	66%	0%	66%	100%
% Crashes Avoided	66%	100%	100%	0%	66%	100%	0%	33%	66%	0%	0%	66%

As shown in the table above for test trial results for the Playing Child Target traveling in the right to left direction, the Jeep's RAB system provided warnings and automatic braking for all trials with the 2.5 mph (4 km/h) vehicle speed and 2 mph (3.2 km/h) object speed combination. For the Playing Child Target traveling at 3.1 mph (5 km/h) with 25 percent overlap, the Jeep's RAB system provided an auditory warning in one trial but otherwise did not respond to this test object at either test vehicle speed. The system provided auditory and visual warnings and braked automatically in all trials at 2 mph (3.2 km/h) test object speed and 2.5 mph (4 km/h) test vehicle speed while avoiding a crash in all but one of the nine trials. Overall, for the 5 mph (9 km/h) test vehicle speed, the Jeep's RAB system avoided a crash with the dynamic Playing Child Target crash in five of 18 trials.

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling left to right for the Jeep Grand Cherokee.

Table 139. System Response Percentages for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	3	3	3
% Auditory Warning	100%	100%	100%	100%	100%	100%	33%	100%	100%	0%	100%	100%
% Visual Warning	33%	100%	100%	0%	100%	100%	33%	66%	33%	0%	100%	100%
% Automatic Braking	33%	100%	66%	66%	100%	100%	33%	100%	66%	0%	100%	100%

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
% Crashes Avoided	0%	100%	66%	0%	33%	100%	0%	33%	33%	0%	66%	100%

As shown in the table above for test trial results for the Playing Child Target traveling in the left to right direction, the Jeep's RAB system provided auditory warnings for all 18 trials at 2.5 mph (4 km/h) test vehicle speed and 13 of 18 trials at 5 mph (8 km/h) test vehicle speed. The Jeep's RAB system provided visual warnings for 23 of 36 trials for the Playing Child Target traveling in the left to right direction. The system avoided no crashes for trials at the 25 percent overlap condition. The system provided warnings, automatically applied the brakes, and avoided a crash for all tests with the 75 percent overlap condition at the 3.1 mph (5 km/h) object speed.

2-Year-Old PTM on Bobby Car Dynamic

The following table shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling right to left for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower vehicle speeds, testing was not conducted at the 5 mph (8 km/h) vehicle speed and 3.1 mph (5 km/h) object speed combination.

Table 140. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Right to Left, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	0	0	0
% Auditory Warning	66%	100%	66%	0%	100%	100%	100%	100%	66%	--	--	--
% Visual Warning	66%	100%	66%	0%	66%	100%	66%	66%	66%	--	--	--
% Automatic Braking	66%	100%	66%	0%	100%	100%	66%	100%	66%	--	--	--
% Crashes Avoided	33%	66%	66%	0%	0%	100%	0%	0%	66%	--	--	--

As shown in the table above for trials involving the 2-year-old PTM seated on the Bobby Car traveling in the right to left direction, the Jeep's RAB system had a variable response to the test object conditions with no obvious pattern of results by test object overlap condition. The system avoided a crash in seven out of nine trials at the 75 percent overlap position. Overall, for the 2-year-old PTM seated on the Bobby Car traveling in the right to left direction, the Jeep's RAB system avoided a crash in 10 of 27 trials conducted.

The following table on the next page shows the percentages of test trials at which auditory warnings, visual warnings, and rear automatic braking occurred, as well as if a crash was avoided, for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling left to right for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower

vehicle speeds, testing was not conducted at the 5 mph (8 km/h) vehicle speed and 3.1 mph (5 km/h) object speed combination.

Table 141. System Response Percentages for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Left to Right, 2022 Jeep Grand Cherokee

Test Vehicle Speed	2.5 mph (4 km/h)						5 mph (8 km/h)					
Test Object Speed	2 mph (3.2 km/h)			3.1 mph (5 km/h)			2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
N	3	3	3	3	3	3	3	3	3	0	0	0
% Auditory Warning	33%	66%	100%	0%	66%	100%	33%	66%	100%	--	--	--
% Visual Warning	33%	66%	66%	0%	33%	100%	--*	--*	--*	--	--	--
% Automatic Braking	33%	66%	100%	0%	66%	100%	33%	66%	66%	--	--	--
% Crashes Avoided	0%	0%	100%	0%	0%	100%	0%	0%	66%	--	--	--

*Only [one] trial for each of the test object overlap positions had usable visual warning data.

As shown in the table above for test trials involving the 2-year-old PTM seated on the Bobby Car traveling in the left to right direction, the Jeep's RAB system avoided a crash for eight of nine trials at the 75 percent overlap conditions but avoided no crashes for the 25 percent and 50 percent overlap conditions.

System Response TTCs and Distances by Test Object

The system response TTCs and distances of auditory warnings, visual warnings, automatic braking, and crashes avoided are presented based on test object overlap position. The tables are separated by test object travel direction.

1-Year-Old PTM Walking

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 1-year-old PTM traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 142. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 1-Year-Old PTM, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.06	0.14	0.04
	Set 2	0.08	0.28	N/A
	Set 3	N/A	0.14	N/A
Distance (in) at Auditory Warning Onset	Set 1	2.90	6.05	1.90
	Set 2	3.65	12.58	N/A
	Set 3	N/A	6.21	N/A
TTC (s) at Visual Warning Onset	Set 1	N/A	0.02	N/A
	Set 2	N/A	0.21	N/A
	Set 3	N/A	0.02	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	0.91	N/A
	Set 2	N/A	9.13	N/A
	Set 3	N/A	0.63	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.00	0.09	N/A
	Set 2	0.02	0.22	N/A
	Set 3	N/A	0.08	N/A
Distance (in) at Subject Vehicle Braking Onset	Set 1	0.21	3.81	N/A
	Set 2	0.98	9.89	N/A
	Set 3	N/A	3.52	N/A

As shown in the table above, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials, when backing at a speed of 2.5 mph (4 km/h) toward the 1-year-old PTM traveling in the right to left direction. The system provided auditory warnings earlier than visual warnings for trials in which both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 1-year-old PTM traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in avoiding crashes with the test object at lower vehicle speeds, testing at the 5 mph (8 km/h) vehicle speed was not conducted.

Table 143. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 1-Year-Old PTM, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)		
Test Object Speed		2 mph (3.2 km/h)		
Test Object Overlap		25%	50%	75%
N		3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.23	0.05
	Set 2	0.22	0.10	0.05
	Set 3	0.16	0.08	0.10
Distance (in) at Auditory Warning Onset	Set 1	N/A	10.65	2.42
	Set 2	9.76	4.46	2.39
	Set 3	7.15	3.40	4.38
TTC (s) at Visual Warning Onset	Set 1	N/A	0.15	N/A
	Set 2	0.12	N/A	N/A
	Set 3	0.08	N/A	N/A
Distance (in) at Visual Warning Onset	Set 1	N/A	6.54	N/A
	Set 2	4.96	N/A	N/A
	Set 3	3.66	N/A	N/A
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.18	0.00
	Set 2	0.16	0.04	0.00
	Set 3	0.10	0.01	0.04
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	7.89	0.21
	Set 2	7.06	1.70	0.36
	Set 3	4.46	0.29	1.62

As shown in the table above for test trials involving the 1-year-old PTM traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials for a backing speed of 2.5 mph (4 km/h). The system provided the auditory warning earlier than the visual warning for all trials where both occurred.

Playing Child Target

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 144. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.19	0.49	0.82	N/A	0.31	0.44
	Set 2	0.21	0.47	0.91	N/A	0.24	0.38
	Set 3	0.24	0.68	0.88	0.04	0.11	0.28
Distance (in) at Auditory Warning Onset	Set 1	8.44	22.02	36.70	N/A	13.82	19.53
	Set 2	9.74	20.70	39.41	N/A	10.82	17.10
	Set 3	10.73	30.11	39.24	1.72	4.77	12.31
TTC (s) at Visual Warning Onset	Set 1	0.05	0.48	0.83	N/A	0.23	0.42
	Set 2	0.14	0.46	0.93	N/A	0.15	0.34
	Set 3	0.16	0.71	0.91	N/A	N/A	0.21
Distance (in) at Visual Warning Onset	Set 1	2.01	21.57	37.28	N/A	9.72	18.70
	Set 2	5.59	20.12	40.28	N/A	5.67	15.47
	Set 3	5.91	31.18	40.59	N/A	N/A	8.43
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.13	0.35	0.35	N/A	0.24	0.28
	Set 2	0.17	0.26	0.37	N/A	0.19	0.31
	Set 3	0.20	0.23	0.38	N/A	0.06	0.21
Distance (in) at Subject Vehicle Braking Onset	Set 1	5.75	15.68	15.64	N/A	10.70	12.41
	Set 2	7.47	11.45	15.98	N/A	8.59	13.95
	Set 3	8.52	10.06	16.53	N/A	2.52	8.37

As shown in the table above for test trials involving the Playing Child Target traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a reversing speed of 2.5 mph (4 km/h). However, the system generally provided warnings and automatically applied the brakes at similar TTCs for the 25 percent and 75 percent object overlap trials at the 2 mph (3.2 km/h) object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 145. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.24	0.35	0.29	N/A	0.11	0.46
	Set 2	0.02	0.17	0.33	N/A	N/A	0.24
	Set 3	0.23	0.03	N/A	N/A	0.15	0.47
Distance (in) at Auditory Warning Onset	Set 1	20.91	30.34	25.01	N/A	9.34	39.97
	Set 2	1.79	15.14	28.82	N/A	N/A	20.95
	Set 3	19.77	2.62	N/A	N/A	13.26	40.33
TTC (s) at Visual Warning Onset	Set 1	0.14	0.27	0.18	N/A	N/A	0.39
	Set 2	N/A	0.03	0.22	N/A	N/A	0.16
	Set 3	0.07	N/A	N/A	N/A	0.18	0.44
Distance (in) at Visual Warning Onset	Set 1	11.06	23.07	14.80	N/A	N/A	33.46
	Set 2	N/A	2.60	18.66	N/A	N/A	14.21
	Set 3	5.71	N/A	N/A	N/A	15.16	37.68
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.18	0.30	0.24	N/A	0.05	0.39
	Set 2	N/A	0.11	0.27	N/A	N/A	0.18
	Set 3	0.16	N/A	N/A	N/A	0.05	0.41
Distance (in) at Subject Vehicle Braking Onset	Set 1	15.70	25.94	20.64	N/A	4.11	33.91
	Set 2	N/A	9.84	23.54	N/A	N/A	15.69
	Set 3	13.67	N/A	N/A	N/A	4.65	35.14

As shown in the table above for test trials involving the Playing Child Target traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 5 mph (8 km/h). The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 146. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.14	0.51	0.14	0.11	0.16	0.43
	Set 2	0.03	0.25	0.88	0.01	0.18	0.19
	Set 3	0.04	0.53	0.84	0.05	0.22	0.27
Distance (in) at Auditory Warning Onset	Set 1	6.21	22.96	6.49	4.91	7.06	19.86
	Set 2	1.26	11.64	38.85	0.53	8.14	8.66
	Set 3	1.87	23.93	37.89	2.15	10.13	12.13
TTC (s) at Visual Warning Onset	Set 1	0.02	0.52	0.03	N/A	0.15	0.44
	Set 2	N/A	0.17	0.86	N/A	0.06	0.09
	Set 3	N/A	0.53	0.83	N/A	0.11	0.18
Distance (in) at Visual Warning Onset	Set 1	0.83	23.46	0.98	N/A	6.73	20.04
	Set 2	N/A	7.17	38.11	N/A	2.13	3.39
	Set 3	N/A	24.02	37.24	N/A	4.09	6.61
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.09	0.31	0.10	0.04	0.11	0.28
	Set 2	N/A	0.20	N/A	N/A	0.13	0.13
	Set 3	N/A	0.29	0.34	0.00	0.17	0.23
Distance (in) at Subject Vehicle Braking Onset	Set 1	3.97	13.87	4.25	1.79	4.78	12.95
	Set 2	N/A	8.90	N/A	N/A	5.85	5.97
	Set 3	N/A	13.01	15.45	0.08	7.85	9.93

As shown in the table above for test trials involving the Playing Child Target traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 2.5 mph (4 km/h). The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the Playing Child Target traveling left to right and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 147. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, Playing Child Target, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.46	0.46	N/A	0.34	0.20
	Set 2	N/A	0.05	0.04	N/A	0.18	0.46
	Set 3	0.28	0.09	0.02	N/A	0.38	0.46
Distance (in) at Auditory Warning Onset	Set 1	N/A	40.53	40.53	N/A	29.98	9.06
	Set 2	N/A	4.59	3.14	N/A	15.78	40.08
	Set 3	24.36	6.48	1.41	N/A	32.74	40.84
TTC (s) at Visual Warning Onset	Set 1	N/A	0.38	0.39	N/A	0.26	0.26
	Set 2	N/A	N/A	N/A	N/A	0.07	0.38
	Set 3	0.22	0.09	N/A	N/A	0.28	0.36
Distance (in) at Visual Warning Onset	Set 1	N/A	31.93	33.46	N/A	22.40	20.35
	Set 2	N/A	N/A	N/A	N/A	5.98	32.64
	Set 3	19.41	6.65	N/A	N/A	22.95	29.02
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.41	0.40	N/A	0.29	0.31
	Set 2	N/A	0.00	0.00	N/A	0.13	0.40
	Set 3	0.23	0.18	N/A	N/A	0.33	0.41
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	35.34	35.25	N/A	25.55	27.30
	Set 2	N/A	0.24	0.35	N/A	11.41	34.88
	Set 3	19.95	15.51	N/A	N/A	28.40	35.56

As shown in the table above for test trials involving the Playing Child Target traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 5 mph (8 km/h). The system generally provided the auditory warning earlier than the visual warning.

2-Year-Old PTM on Bobby Car

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling right to left and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 148. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Right to Left, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	0.20	0.35	N/A	N/A	0.16	0.38
	Set 2	0.19	0.24	0.64	N/A	0.16	0.17
	Set 3	N/A	0.21	0.60	N/A	0.12	0.42
Distance (in) at Auditory Warning Onset	Set 1	9.32	15.79	N/A	N/A	7.30	17.63
	Set 2	8.80	11.20	29.05	N/A	7.20	7.63
	Set 3	N/A	9.38	27.08	N/A	5.39	19.40
TTC (s) at Visual Warning Onset	Set 1	0.14	0.28	N/A	N/A	0.03	0.31
	Set 2	0.09	0.16	0.62	N/A	0.08	0.06
	Set 3	N/A	0.10	0.60	N/A	N/A	0.39
Distance (in) at Visual Warning Onset	Set 1	6.22	10.04	N/A	N/A	1.30	11.81
	Set 2	2.95	6.26	27.80	N/A	3.31	2.36
	Set 3	N/A	3.35	26.85	N/A	N/A	17.83
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.15	0.30	N/A	N/A	0.10	0.34
	Set 2	0.14	0.19	0.36	N/A	0.10	0.11
	Set 3	N/A	0.16	0.35	N/A	0.07	0.37
Distance (in) at Subject Vehicle Braking Onset	Set 1	6.61	13.51	N/A	N/A	4.57	15.33
	Set 2	6.47	8.88	16.30	N/A	4.53	4.87
	Set 3	N/A	7.15	15.86	N/A	3.17	17.08

As shown in the table above for test trials involving the 2-year-old PTM seated on the Bobby Car traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 2.5 mph (4 km/h). However, the system generally provided warnings and automatically applied the brakes at similar TTCs for the 50 percent object overlap trials at the 3.1 mph (5 km/h) object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling right to left and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower speeds, testing was not conducted at the 3.1 mph (5 km/h) object speed.

Table 149. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Right to Left, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	0.20	0.05	N/A	--	--	--
	Set 2	0.20	0.10	0.47	--	--	--
	Set 3	0.01	0.29	0.47	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	17.77	4.17	N/A	--	--	--
	Set 2	17.47	8.57	41.16	--	--	--
	Set 3	0.98	25.53	41.24	--	--	--
TTC (s) at Visual Warning Onset	Set 1	0.11	N/A	N/A	--	--	--
	Set 2	0.09	0.01	0.44	--	--	--
	Set 3	N/A	0.19	0.49	--	--	--
Distance (in) at Visual Warning Onset	Set 1	9.09	N/A	N/A	--	--	--
	Set 2	7.20	0.63	37.95	--	--	--
	Set 3	N/A	15.08	42.36	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	0.16	0.00	N/A	--	--	--
	Set 2	0.15	0.05	0.41	--	--	--
	Set 3	N/A	0.24	0.41	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	13.45	0.16	N/A	--	--	--
	Set 2	13.14	4.19	35.92	--	--	--
	Set 3	N/A	20.36	35.14	--	--	--

As shown in the table above for test trials involving the 2-year-old PTM seated on the Bobby Car traveling in the right to left direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 5 mph (8 km/h). However, the system generally provided warnings and automatically applied the brakes at similar TTCs for the 25% and 75% object overlap trials at the 2 mph (3.2 km/h) object speed. The system generally provided the auditory warning earlier than the visual warning.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling left to right and the 2.5 mph (4 km/h) vehicle speed for the Jeep Grand Cherokee.

Table 150. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Left to Right, 2.5 mph (4 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		2.5 mph (4 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	3	3	3
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.15	0.19	N/A	N/A	0.20
	Set 2	0.10	0.19	0.12	N/A	0.05	0.38
	Set 3	N/A	0.08	0.74	N/A	0.19	0.45
Distance (in) at Auditory Warning Onset	Set 1	N/A	6.86	8.78	N/A	N/A	9.16
	Set 2	4.64	8.35	5.54	N/A	2.33	17.11
	Set 3	N/A	3.51	33.41	N/A	8.73	20.30
TTC (s) at Visual Warning Onset	Set 1	N/A	0.05	0.08	N/A	N/A	0.10
	Set 2	0.02	0.09	N/A	N/A	N/A	0.31
	Set 3	N/A	N/A	0.70	N/A	0.07	0.38
Distance (in) at Visual Warning Onset	Set 1	N/A	1.89	2.68	N/A	N/A	3.74
	Set 2	0.63	3.46	N/A	N/A	N/A	12.60
	Set 3	N/A	N/A	31.77	N/A	2.72	16.22
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.11	0.14	N/A	N/A	0.14
	Set 2	0.05	0.13	0.06	N/A	0.00	0.33
	Set 3	N/A	N/A	0.29	N/A	0.13	0.40
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	5.10	6.46	N/A	N/A	6.44
	Set 2	1.98	5.69	2.79	N/A	0.35	14.82
	Set 3	N/A	N/A	13.33	N/A	5.97	18.02

As shown in the table above for test trials involving the 2-year-old PTM seated on the Bobby Car traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 2.5 mph (4 km/h). The system generally provided the auditory warning earlier than the visual warning for trials where both occurred.

The following table on the next page shows the TTCs and distances at which auditory warnings, visual warnings, and rear automatic braking occurred for each test trial for the Reversing Vehicle – Dynamic Test Object scenario with the 2-year-old PTM seated on the Bobby Car traveling left to right and the 5 mph (8 km/h) vehicle speed for the Jeep Grand Cherokee. Due to the RAB system's inconsistency in providing warnings and avoiding crashes with the test object at lower speeds, testing was not conducted at the 3.1 mph (5 km/h) object speed.

Table 151. System Response TTCs and Distances for Reversing Vehicle – Dynamic Test Object, 2-Year-Old PTM on Bobby Car, Left to Right, 5 mph (8 km/h) Test Vehicle Speed, 2022 Jeep Grand Cherokee

Test Vehicle Speed		5 mph (8 km/h)					
Test Object Speed		2 mph (3.2 km/h)			3.1 mph (5 km/h)		
Test Object Overlap		25%	50%	75%	25%	50%	75%
N		3	3	3	0	0	0
TTC (s) at Auditory Warning Onset	Set 1	N/A	0.10	0.07	--	--	--
	Set 2	N/A	0.06	0.45	--	--	--
	Set 3	0.24	N/A	0.46	--	--	--
Distance (in) at Auditory Warning Onset	Set 1	N/A	8.68	5.76	--	--	--
	Set 2	N/A	5.10	40.18	--	--	--
	Set 3	21.19	N/A	39.83	--	--	--
TTC (s) at Visual Warning Onset*	Set 1	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	0.11	N/A	0.38	--	--	--
Distance (in) at Visual Warning Onset	Set 1	--	--	--	--	--	--
	Set 2	--	--	--	--	--	--
	Set 3	8.03	N/A	32.44	--	--	--
TTC (s) at Subject Vehicle Braking Onset	Set 1	N/A	0.05	N/A	--	--	--
	Set 2	N/A	0.01	0.40	--	--	--
	Set 3	0.18	N/A	0.41	--	--	--
Distance (in) at Subject Vehicle Braking Onset	Set 1	N/A	4.27	N/A	--	--	--
	Set 2	N/A	0.72	34.84	--	--	--
	Set 3	15.93	N/A	35.44	--	--	--

*Only [one] trial for each of the three test object overlap positions had usable visual warning data.

As shown in the table above for test trials involving the 2-year-old PTM seated on the Bobby Car traveling in the left to right direction, the Jeep's RAB system generally provided warnings and automatically applied the brakes at different TTCs across sets of trials at a backing speed of 5 mph (8 km/h). The system generally provided the auditory warning earlier than the visual warning for trials where both occurred.

Discussion

Investigation of Possible Test Procedure Revisions

As stated previously, the purpose of this work was to investigate possible revisions to an existing draft research test procedure for assessing the performance of vehicle rear automatic braking systems and to characterize the performance of current RAB systems in detecting pedestrians. The following sections discuss observations about test scenarios, test procedure considerations, and RAB performance.

RAB Test Scenarios

This effort examined a Reversing Vehicle — Dynamic Test Object scenario as a means of allowing the test procedure to address dynamic pedestrian scenarios. While prior NHTSA research conducted several years ago encountered problems in achieving repeatable dynamic pedestrian test object motion, the use of a motorized test object propulsion system in this effort enabled consistent and repeatable test object speeds and paths to be achieved for a variety of pedestrian test objects. While testing the dynamic scenario with an idle backing vehicle speed was not conducted in this effort, the scenario was able to be effectively conducted with constant test vehicle speeds and test object speeds.

As mentioned in Sections 3, a review of other relevant RAB test procedures was conducted for possible inclusion in the revised draft procedure. The Euro NCAP “Car-to-Pedestrian Reverse Adult/Child” moving scenario (2022) was found to be relevant, and aspects of the scenario were adapted to create the Reversing Vehicle — Dynamic Test Object scenario, as stated in Table 6. The RCAR “reversing car-to-bollard” and “reversing car-to-pillar” scenarios (NHTSA, 2005) were found to be applicable as well, and the test objects from those scenarios were tested in the Reversing Vehicle — Stationary Test Object scenario. The RCAR “reversing car-to-car” scenario was not evaluated in this testing effort. Examination of these other test procedures provided information about additional test procedure conditions that could be considered for inclusion in a revised draft research test procedure.

Based on this effort, revisions to the draft research test procedure can be determined to potentially include additional test vehicle conditions, test object conditions, and related test performance criteria as appropriate.

Test Scenario Validity

Specific repeatability testing of the test procedure was not performed in this effort. However, test results were reviewed to ensure that the vehicle and object position and speed tolerances specified in Table 12 were consistently met.

Robotic steering and pedal controllers were implemented to allow consistent test vehicle backing speeds and test vehicle position. The steering controller robot was able to consistently steer the vehicle along the test path with a maximum lateral deviation of ± 2 inches (0.05 m). While the laser method used in the 2019 draft test procedure assessment (Mazzae et al., 2019) to control test vehicle position allowed for a maximum vehicle path lateral deviation of ± 1 inch (0.03 m), the laser was difficult to see outdoors in this effort, and the steering robot maximum lateral deviation of ± 2 inches (0.05 m) was found to be consistent and acceptable. The accelerator and

brake pedal robots were able to control the test vehicle speed consistently and repeatedly within 0.3 mph (0.5 km/h) of the desired test speed for all test vehicles.

The figure below is a histogram of the maximum test vehicle lateral deviations for all test trials. The lateral deviation was measured as the difference between the vehicle's lateral position as controlled by the steering robot and the lateral coordinates of the programmed test path.

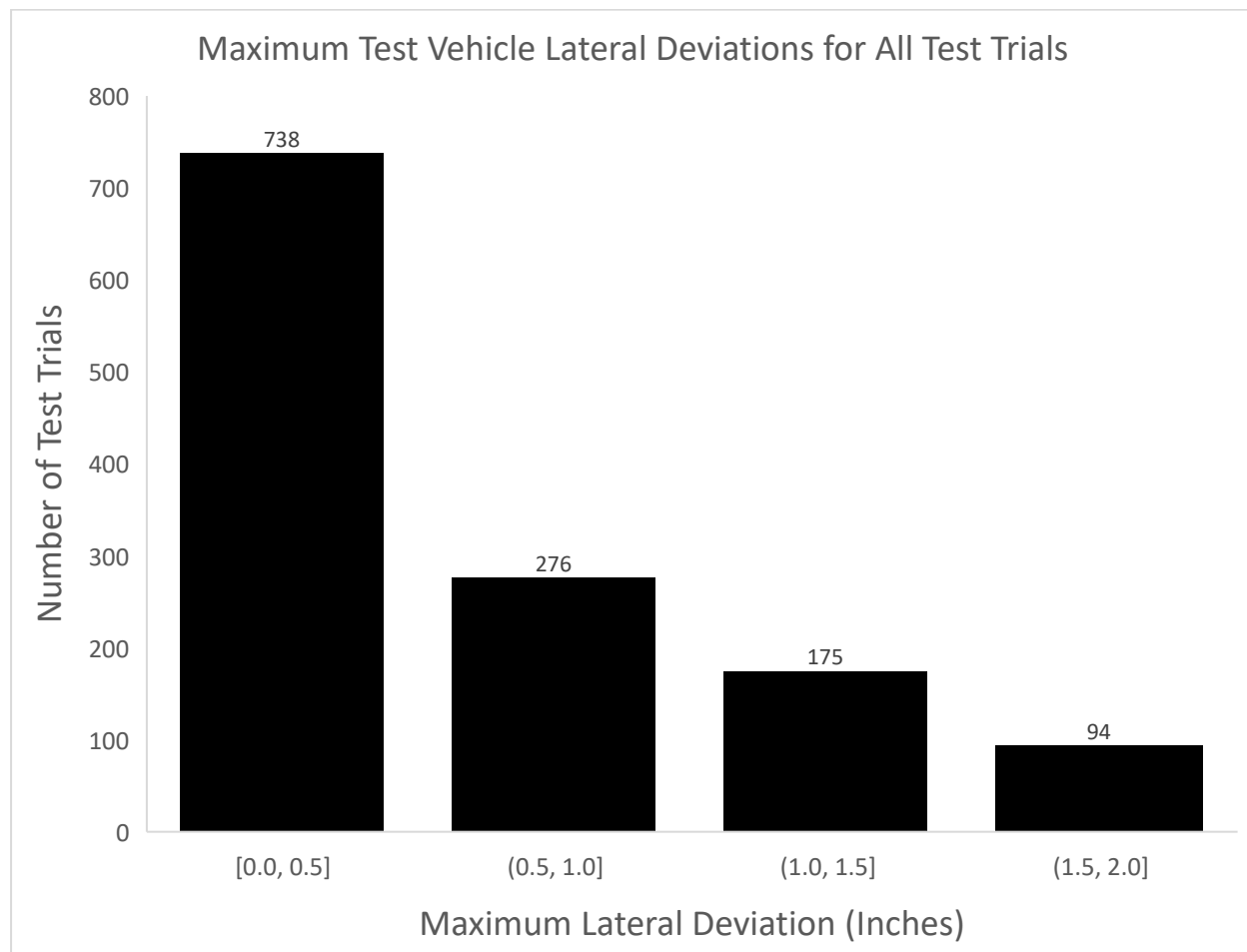


Figure 27. Histogram of Maximum Test Vehicle Lateral Deviations

As shown in the graph, the maximum lateral deviation for the majority of the test trials was from 0 to 0.5 inches (1.3 cm). Overall, the steering robot facilitated repeatable test paths.

The SPT20 belt propulsion system used to propel the dynamic test objects was able to consistently provide accurate object speeds and positions, with a maximum speed deviation of ± 0.1 mph (0.2 km/h) and a maximum position deviation of ± 0.8 in (2 cm).

Compatibility of the Test Procedure With All Vehicle Types

Both vehicles with internal combustion engines and electric vehicles were tested with the revised test procedure. While the original draft research test procedure's approach of allowing the test vehicle to roll rearward without accelerator pedal application was stated to be incompatible with electric vehicles, the electric-powered Ford Mustang Mach-E did roll rearward when positioned

on a level surface. As such, testing was not conducted with an electric vehicle that did not roll backwards.

A vehicle with a manual transmission was not tested as the majority of vehicle models for sale in the U.S. market that are offered with manual transmissions also have automatic transmission versions that could be tested per the draft research test procedure.

RAB System Performance

RAB system performance results were found to be generally inconsistent across sets of trials for three of the four test vehicles. As shown in the system response percentage tables, warnings and automatic braking are often only presented for one or two out of the three test trials at each test object overlap position. No system consistently avoided contact with test objects across all test speeds and scenarios; however, the Cadillac XT4's RAB system avoided with test objects more than the other systems tested. The Cadillac was the only vehicle that avoided contact with a test object for all trials across all test speeds, doing so with the stationary bollard and pillar.

Test Speeds

The following figures show the percentage of crashes avoided by vehicle speed and object speed for all test vehicles.

Figure 28 shows the percentage of crashes avoided for each vehicle at each test vehicle speed for the Reversing Vehicle – Stationary Test Object scenario, and Figure 29 shows the percentage of crashes avoided for each vehicle at each test vehicle speed for the Reversing Vehicle – Dynamic Test Object scenario. Results are averaged across all test objects and test object overlaps. Stationary test object scenario trial results summarized across all test objects show the Cadillac performed consistently at approximately 90 percent crashes avoided across all test vehicle speeds, while the other three systems each avoided more crashes at the 2.5 mph (4 km/h) test vehicle speed than at the idle or 5 mph (8 km/h) speeds. Results of dynamic test object trials summarized across all test objects show the Cadillac avoided more crashes at 5 mph (8 km/h) than at the slower speed of 2.5 mph (4 km/h), while the other three vehicles avoided more crashes at the slowed speed.

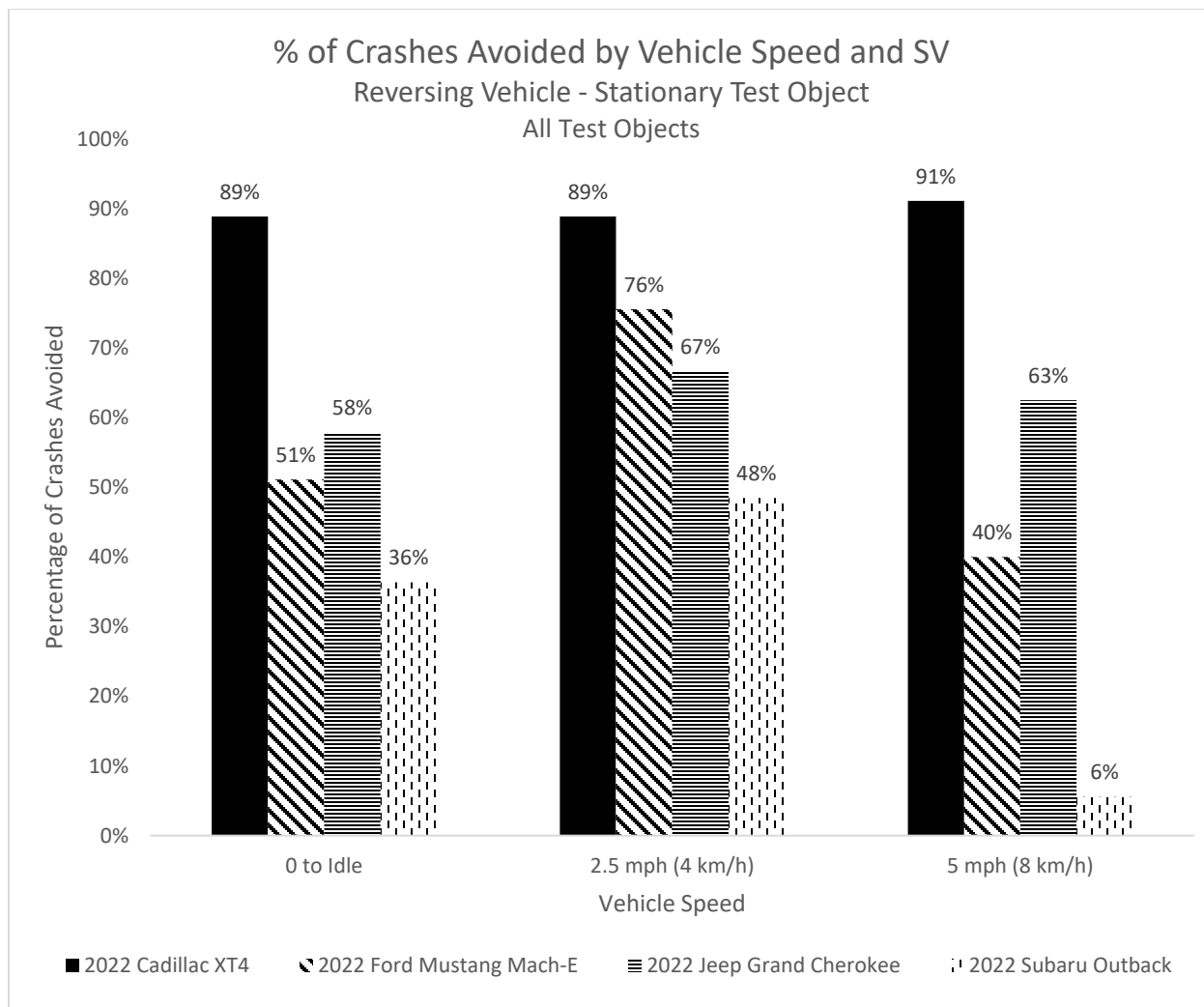


Figure 28. Percentage of Crashes Avoided by Vehicle Speed, Reversing Vehicle – Stationary Test Object, All Test Objects

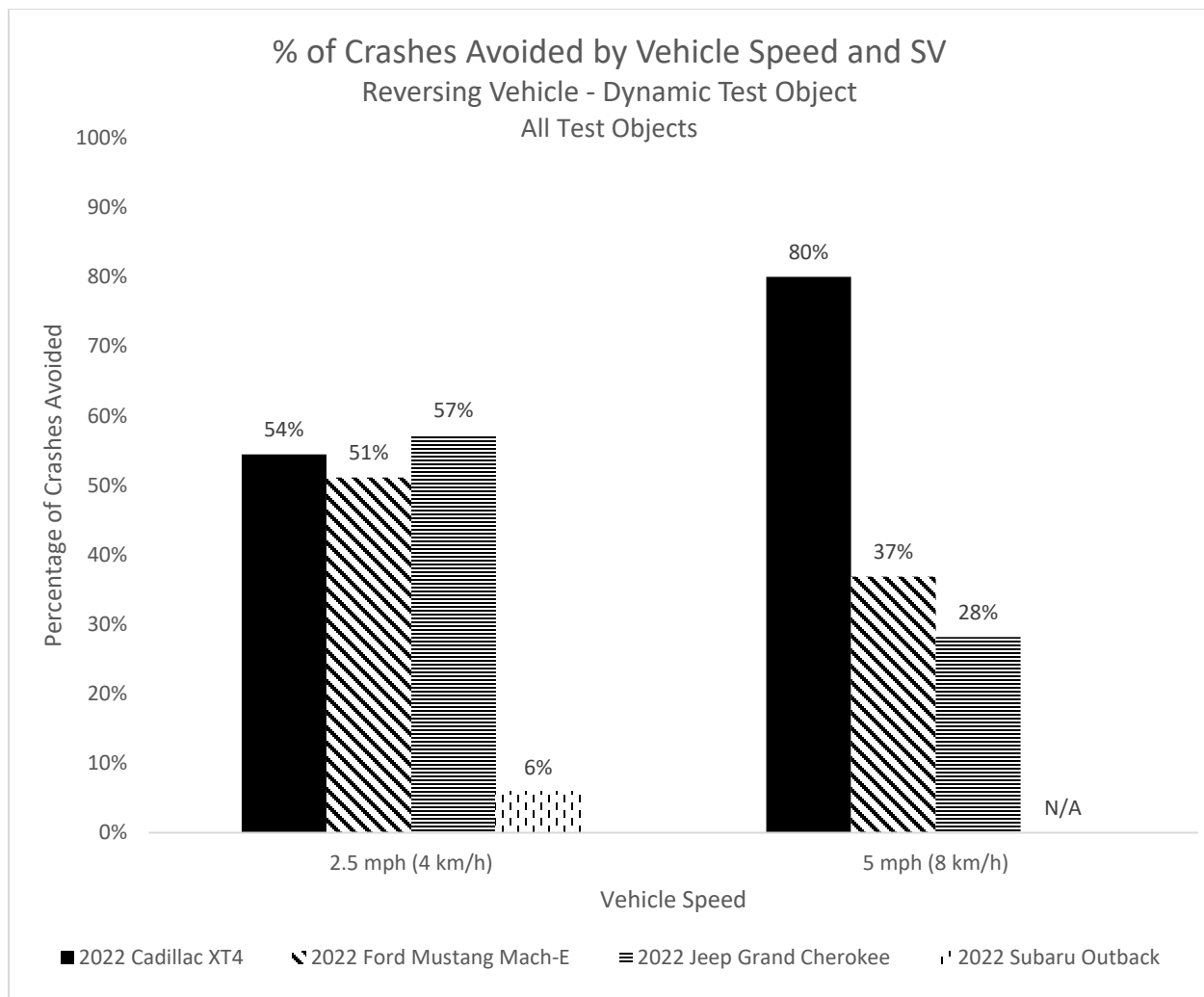


Figure 29. Percentage of Crashes Avoided by Vehicle Speed, Reversing Vehicle – Dynamic Test Object, All Test Objects

Figures 30 and 31 show the percentage of crashes avoided for each vehicle at each test speed for the adult and 2-year-old PTMs. Figure 30 shows the percentages for the stationary scenario and Figure 31 shows percentages for the dynamic scenario. Stationary test object scenario trial results summarized for the adult and standing 2-year-old pedestrian test mannequins show the Cadillac avoided more crashes as test vehicle speed increased whereas the Ford and Jeep showed better crash avoidance at the 2.5 mph (4 km/h) test vehicle speed. The Subaru did not avoid crashes with the stationary adult and standing 2-year-old PTMs. Dynamic test object scenario trial results summarized for the stationary adult and walking 2-year-old pedestrian test mannequins show more crashes avoided at the 5 mph (8 km/h) test vehicle speed for the Cadillac and Ford, while the Jeep and Subaru avoided more crashes at the slower speed.

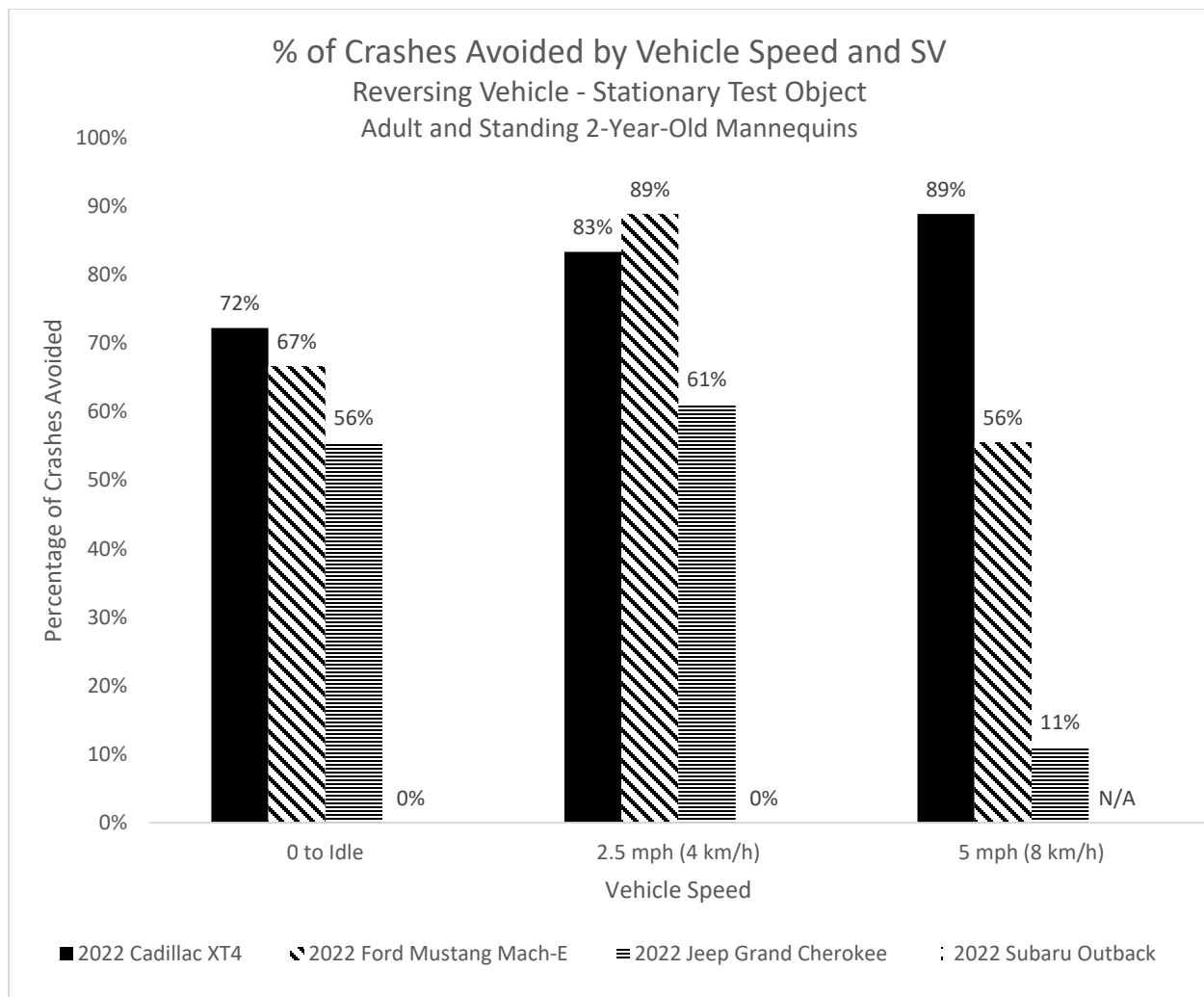


Figure 30. Percentage of Crashes Avoided by Vehicle Speed, Reversing Vehicle – Stationary Test Object, Adult and Standing 2-Year-Old PTMs

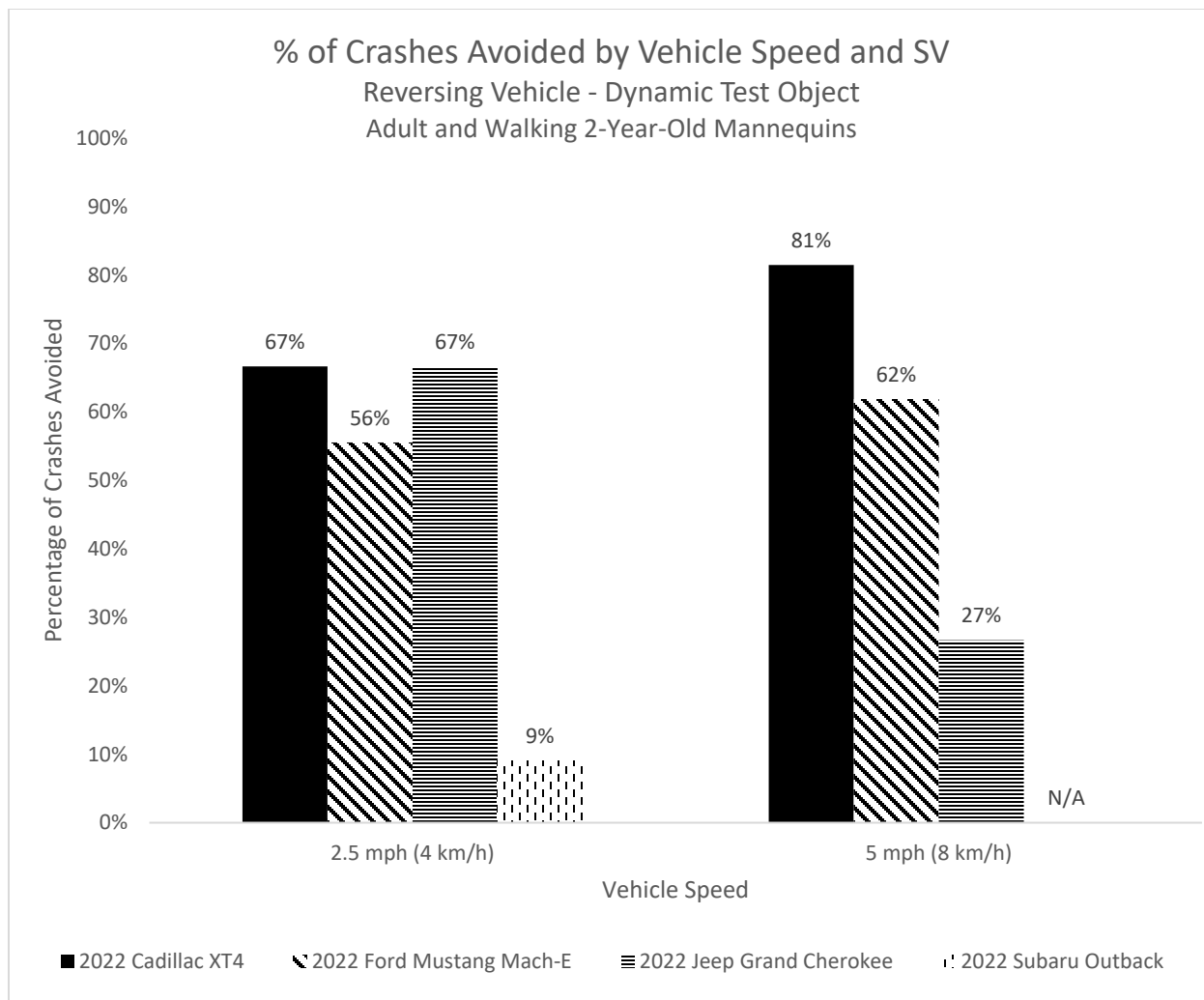


Figure 31. Percentage of Crashes Avoided by Vehicle Speed, Reversing Vehicle – Dynamic Test Object, Adult and 2-Year-Old PTMs

The following figure on the next page shows the percentage of crashes avoided for each vehicle at each test object speed for the Reversing Vehicle – Dynamic Test Object scenario. All dynamic test objects, test object overlaps, and test vehicle speeds are represented in the figure. This figure shows that when considering performance summarized across all test objects, tested vehicles were more likely to avoid contact with the test object when the test object was traveling at a lower speed, except for the Jeep, which had similar performance across the two test object speeds.

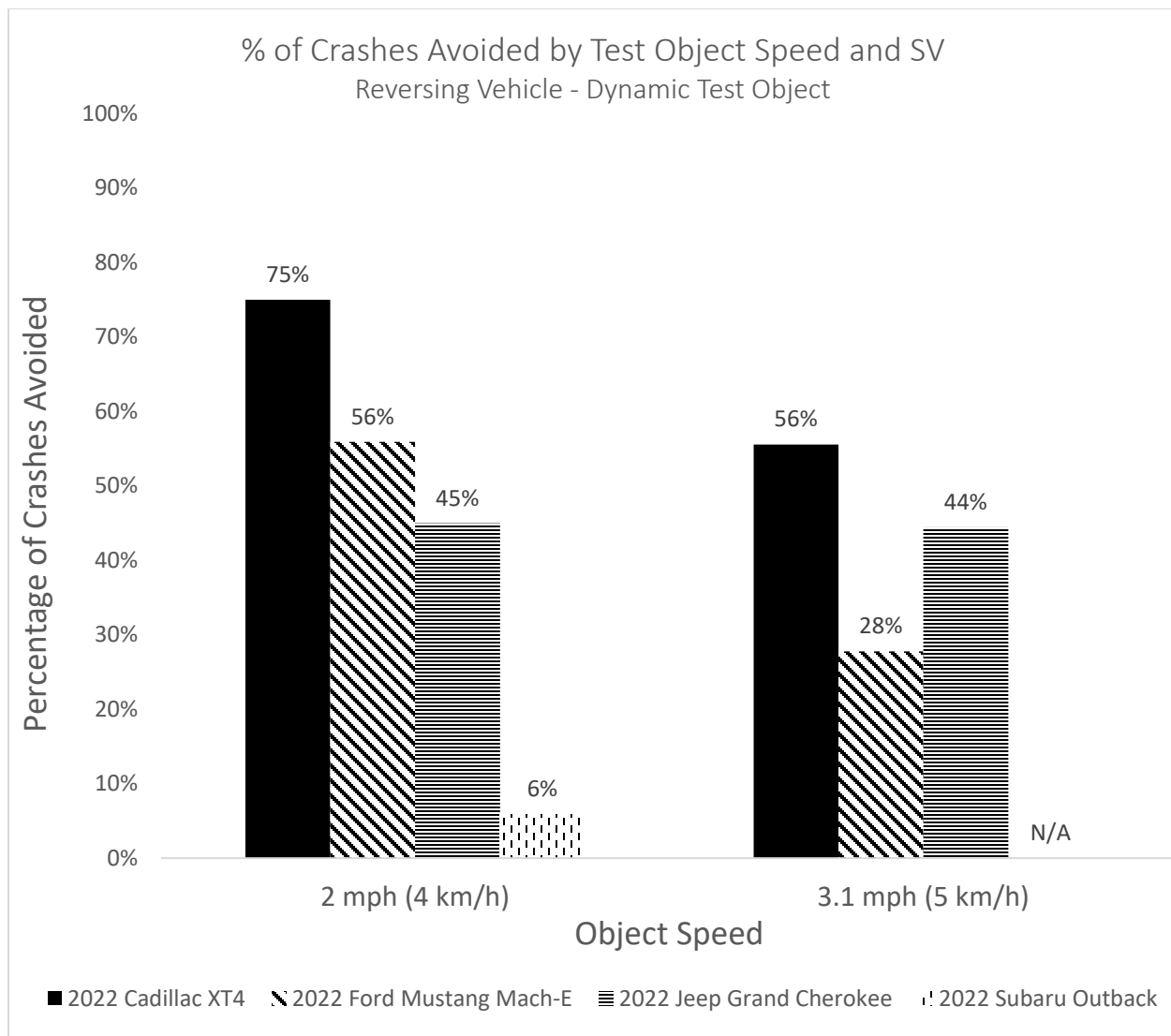


Figure 32. Percentage of Crashes Avoided by Object Speed

Generally, vehicles were more likely to avoid crashes in test trials with lower test vehicle and test object speeds. As shown in Figures 28 and 29, the Cadillac avoided more crashes at the 5 mph (8 km/h) test vehicle speed than at the 2.5 mph (4 km/h) test vehicle speed. The other three test vehicles were often able to avoid contact with test objects for all trials at the 2.5 mph (4 km/h) test vehicle speed but were not able to avoid contact at the idle and 5 mph (8 km/h) test vehicle speeds. As shown in Figure 32, when considering performance summarized across all test objects, most tested vehicles were more likely to avoid contact with the test object when the test object was traveling at a lower speed.

Test Objects

The figures below show the percentage of crashes avoided of the adult, 7-year-old, and 2-year-old PTMs for all test vehicles.

Figure 33 shows the percentage of crashes avoided for each vehicle by mannequin test object for the Reversing Vehicle – Stationary Test Object scenario. The test objects represented are the adult, 7-year-old, and standing 2-year-old PTMs, as those were the mannequin test objects that were tested with all vehicles. Results are averaged across all test object overlaps. These results show that the Cadillac's percentage of crashes avoided increased with decreasing size of stationary pedestrian, while the Ford and Jeep avoided somewhat fewer crashes with the smallest pedestrian. The Subaru did not detect these stationary pedestrian conditions.

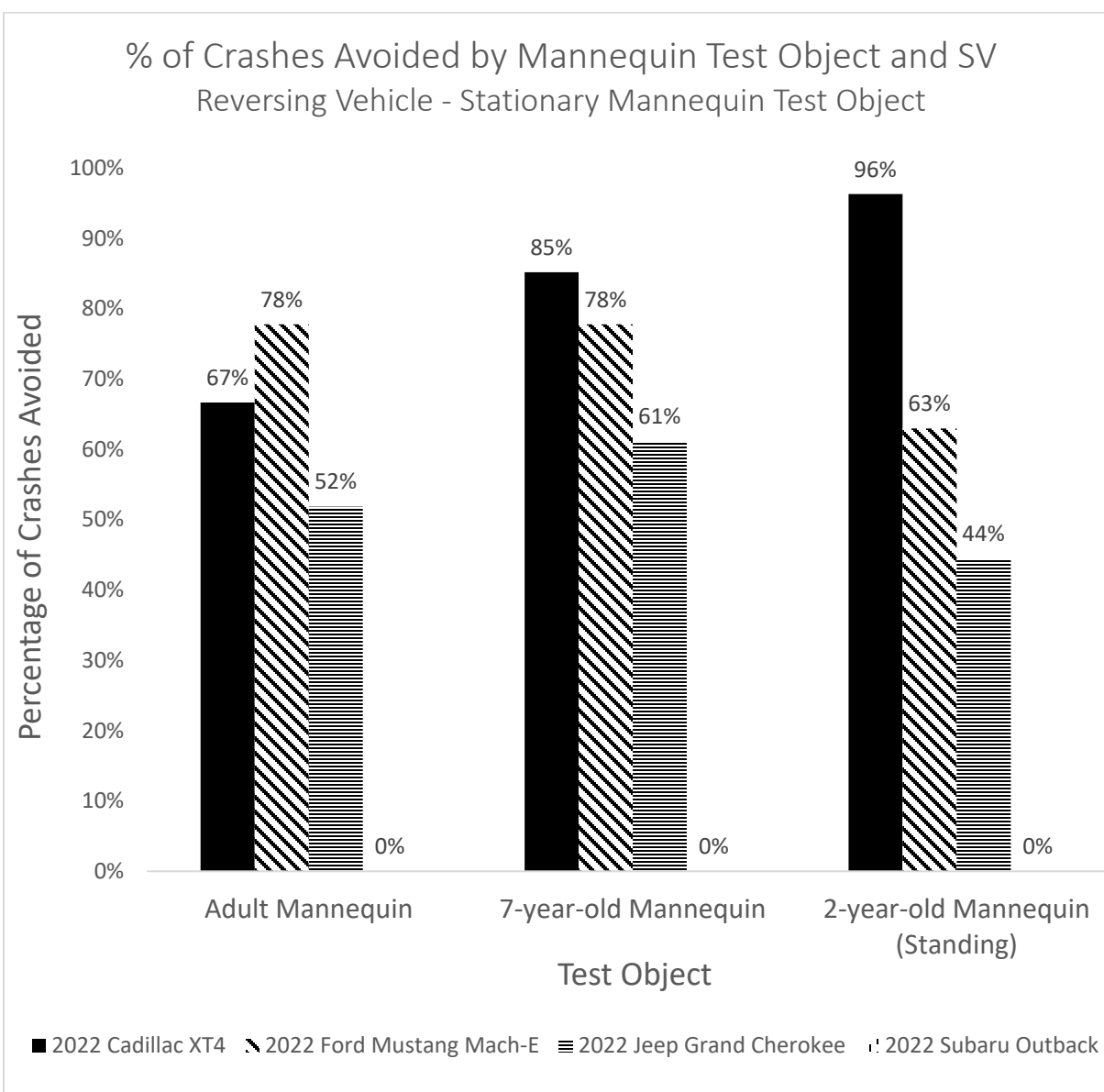


Figure 33. Percentage of Crashes Avoided by Mannequin Test Object, Reversing Vehicle – Stationary Test Object

Figure 34 shows the percentage of crashes avoided for each vehicle by mannequin test object for the Reversing Vehicle – Dynamic Test Object scenario. Results are averaged for all dynamic test objects, test object overlaps, and test vehicle speeds. These results again show that the Cadillac’s percentage of crashes avoided increased with decreasing size of pedestrian, this time for the dynamic pedestrian scenario, while the Ford and Jeep avoided somewhat fewer crashes with the smallest pedestrian. The Subaru did not detect these stationary pedestrian conditions.

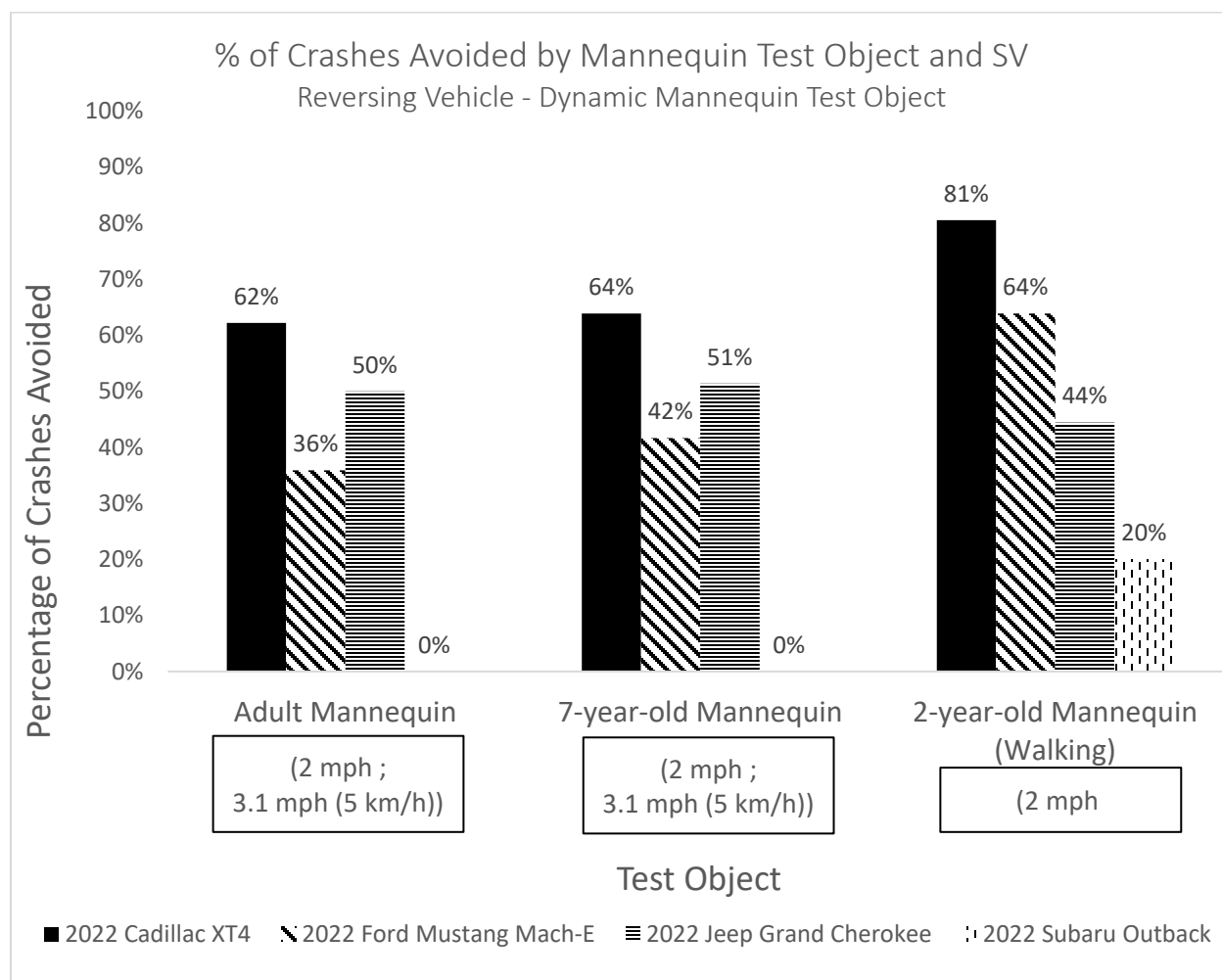


Figure 34. Percentage of Crashes Avoided by Mannequin Test Object, Reversing Vehicle – Dynamic Test Object

As shown in Figures 33 and 34, the pedestrian test objects were more likely to be detected and avoided in the Reversing Vehicle — Stationary Test Object scenario when compared to the Reversing Vehicle — Dynamic Test Object scenario. All four vehicles were also more likely to detect and/or avoid the 7-year-old and 2-year-old test objects when compared to the adult test object, especially with the Reversing Vehicle — Dynamic Test Object scenario.

The Cadillac XT4 performed well with pedestrian test objects, which could be due to the vehicle’s use of a camera sensor for obstacle detection and its “Rear Pedestrian Alert” system.

On the other hand, the Subaru Outback performed poorly with pedestrian test objects, as it only avoided a collision with a pedestrian test object once across both the stationary and dynamic scenarios.

The following figure shows the percentage of crashes avoided with the stationary pillar and bollard test objects for all vehicles. All test vehicle speeds, and test object overlaps are represented in the figure.

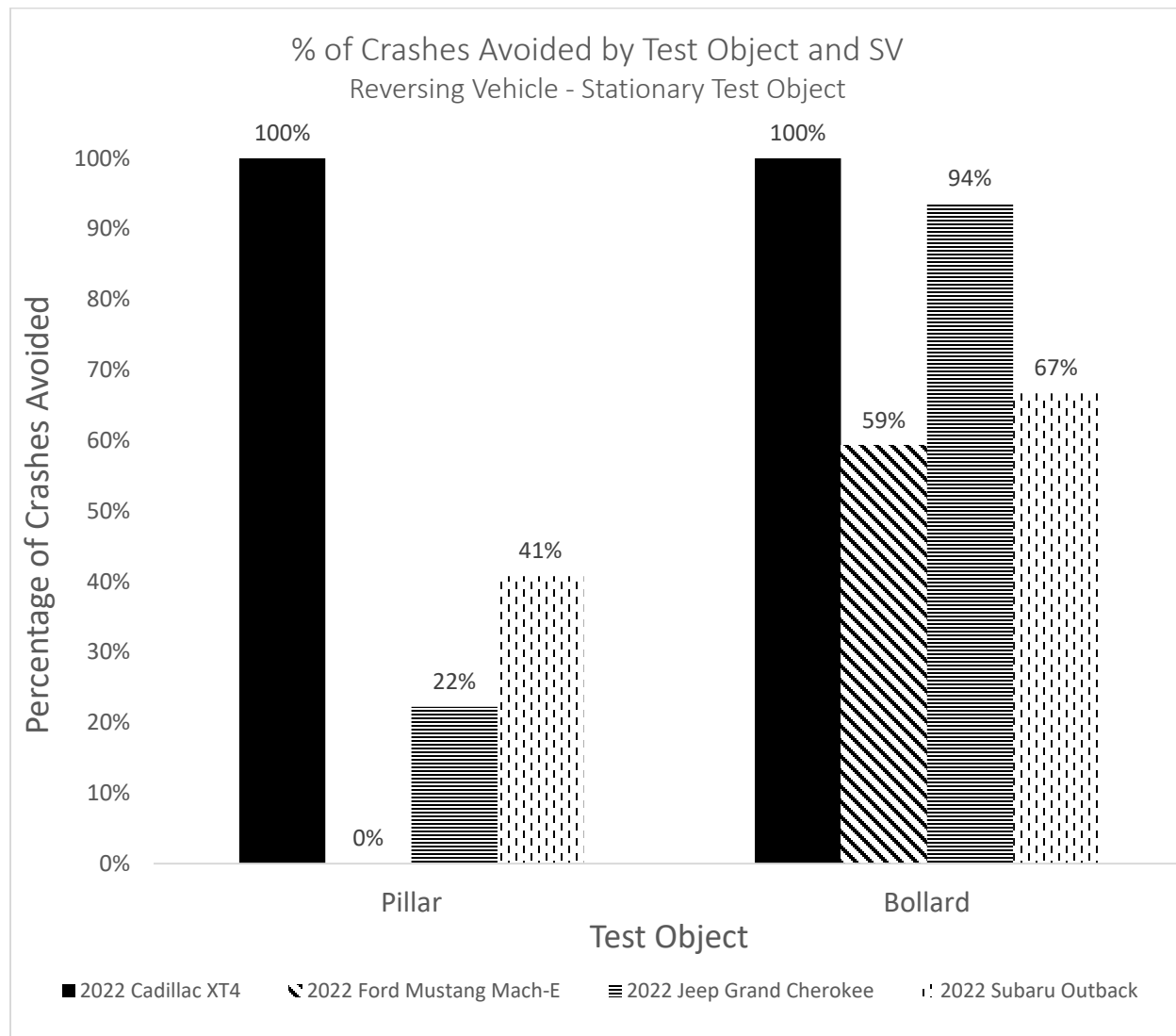


Figure 35. Percentage of Crashes Avoided for Pillar and Bollard, Reversing Vehicle – Stationary Test Object

Performance results with the pillar and bollard differed. Generally, vehicles were more likely to contact the pillar when compared to the bollard. The Ford's RAB system did not avoid a crash with the pillar for all test trials but was able to avoid a crash 59 percent of the time with the bollard. The bollard was also the test object that was the most often avoided for the Jeep and Subaru. However, the Cadillac was able to avoid a crash for all trials with both the pillar and the bollard.

Test Object Overlap Percentages

Figures 36 and 37 show the percentages of crashes avoided of all test objects organized by test object overlap position, for all test vehicles. Figure 36 shows data from the Reversing Vehicle – Stationary Test Object scenario, and Figure 37 shows data from the Reversing Vehicle – Dynamic Test Object scenario. Results are averaged for all test vehicle and test object speeds.

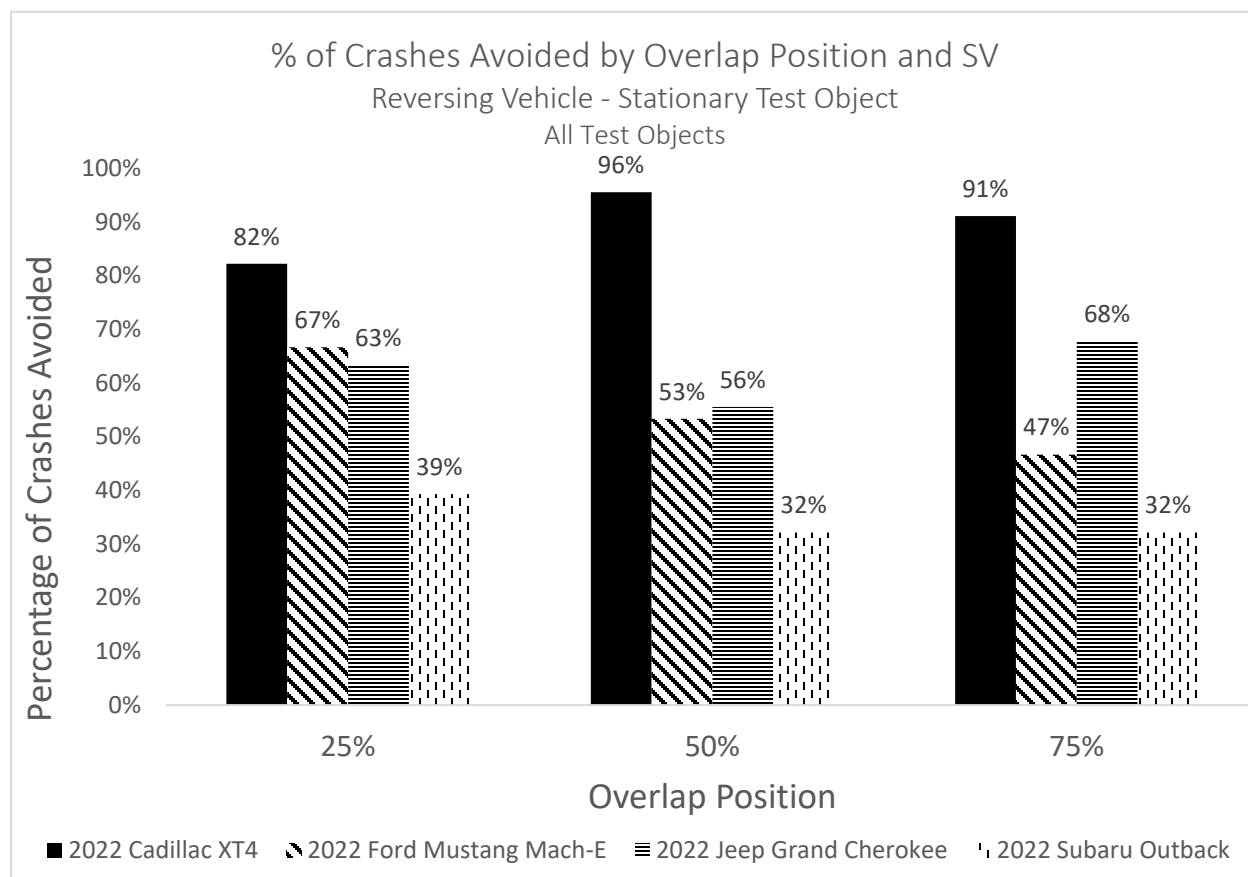


Figure 36. Percentage of Crashes Avoided by Overlap Position, Reversing Vehicle – Stationary Test Object, All Test Objects

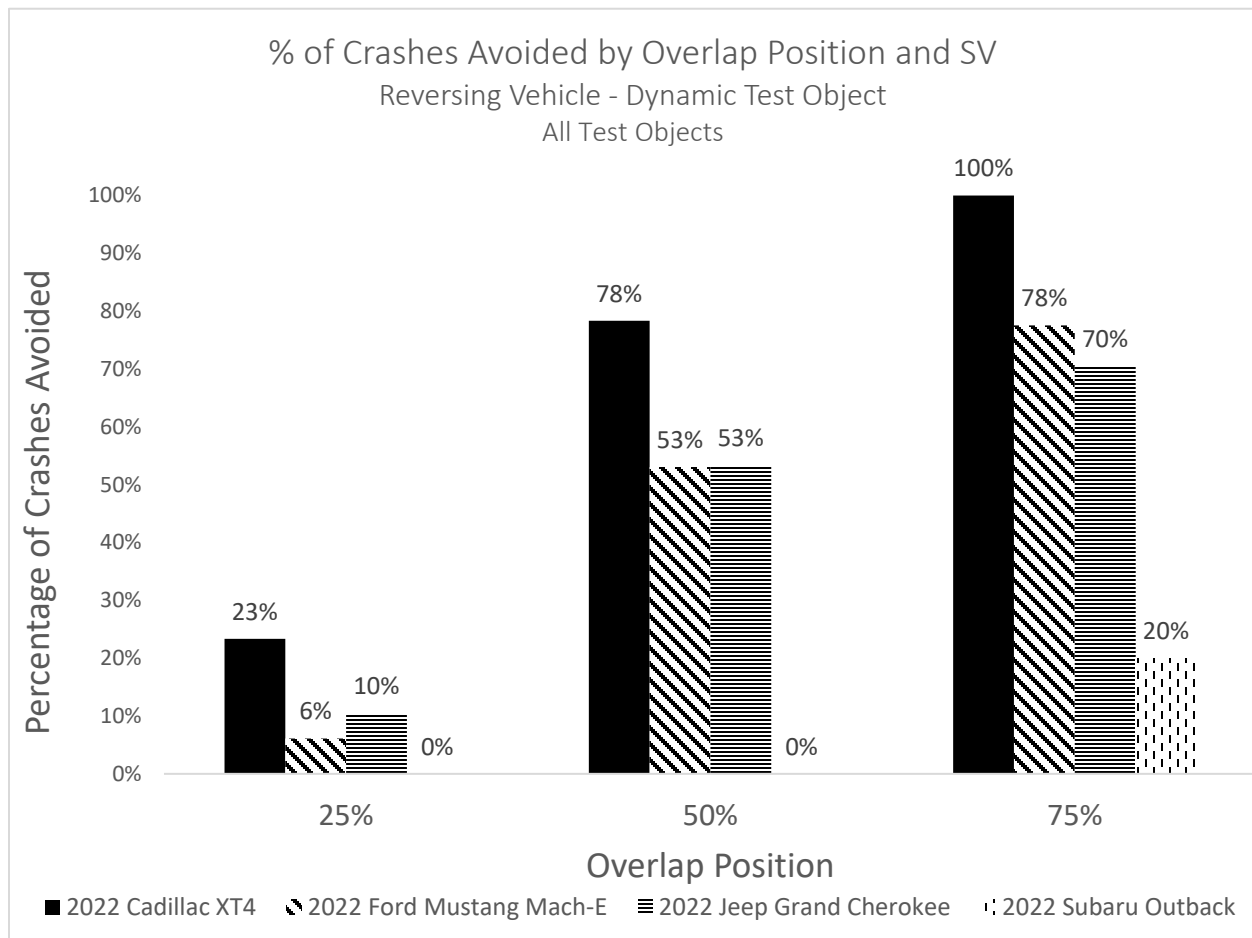


Figure 37. Percentage of Crashes Avoided by Overlap Position, Reversing Vehicle – Dynamic Test Object, All Test Objects

Figures 38 and 39 show the percentage of crashes avoided by overlap position for each vehicle with the adult and 2-year-old PTMs. Figure 38 shows the percentages for the Reversing Vehicle – Stationary Test Object scenario and Figure 39 shows the percentages for the Reversing Vehicle – Dynamic Test Object scenario. Results are averaged across all test speeds.

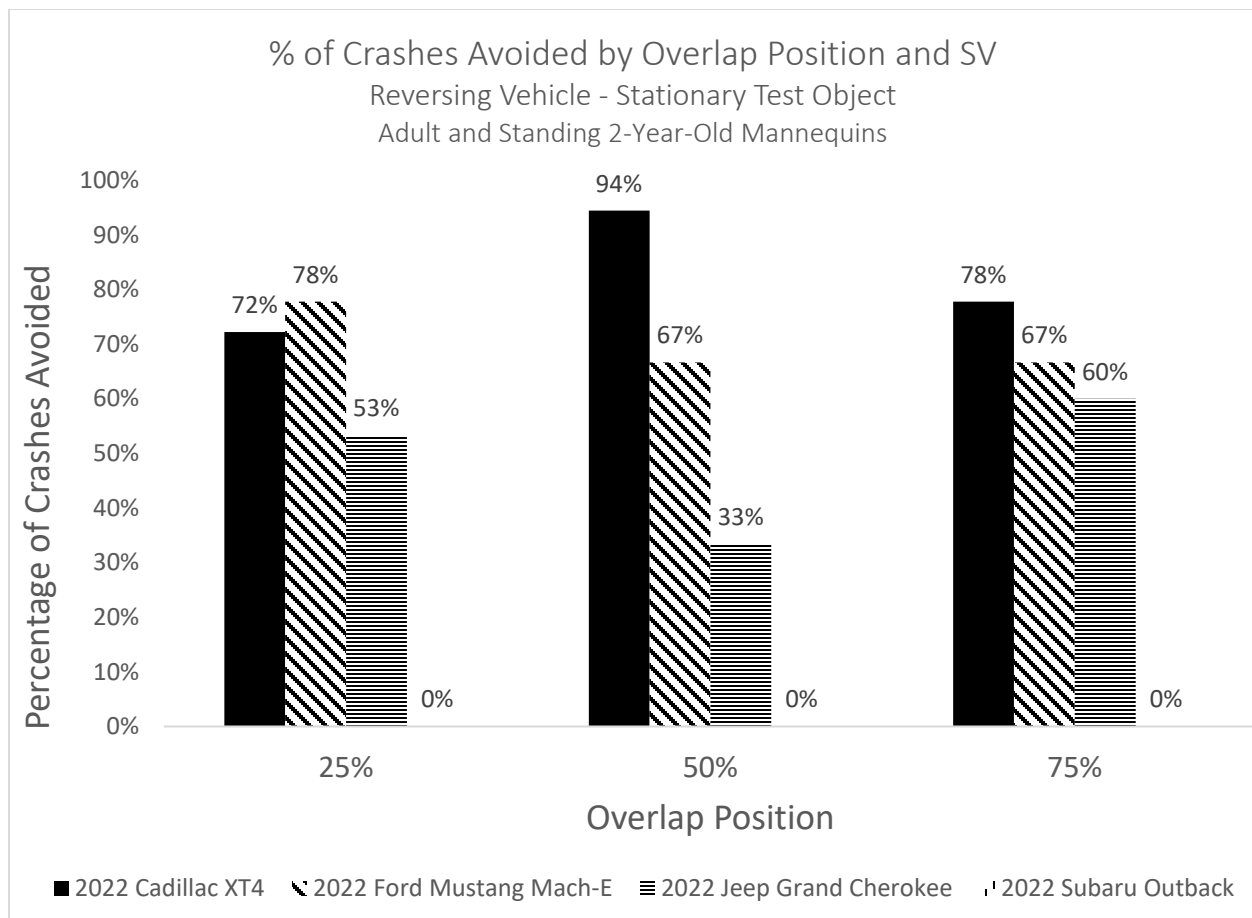


Figure 38. Percentage of Crashes Avoided by Overlap Position, Reversing Vehicle – Stationary Test Object, Adult and Standing 2-Year-Old PTMs

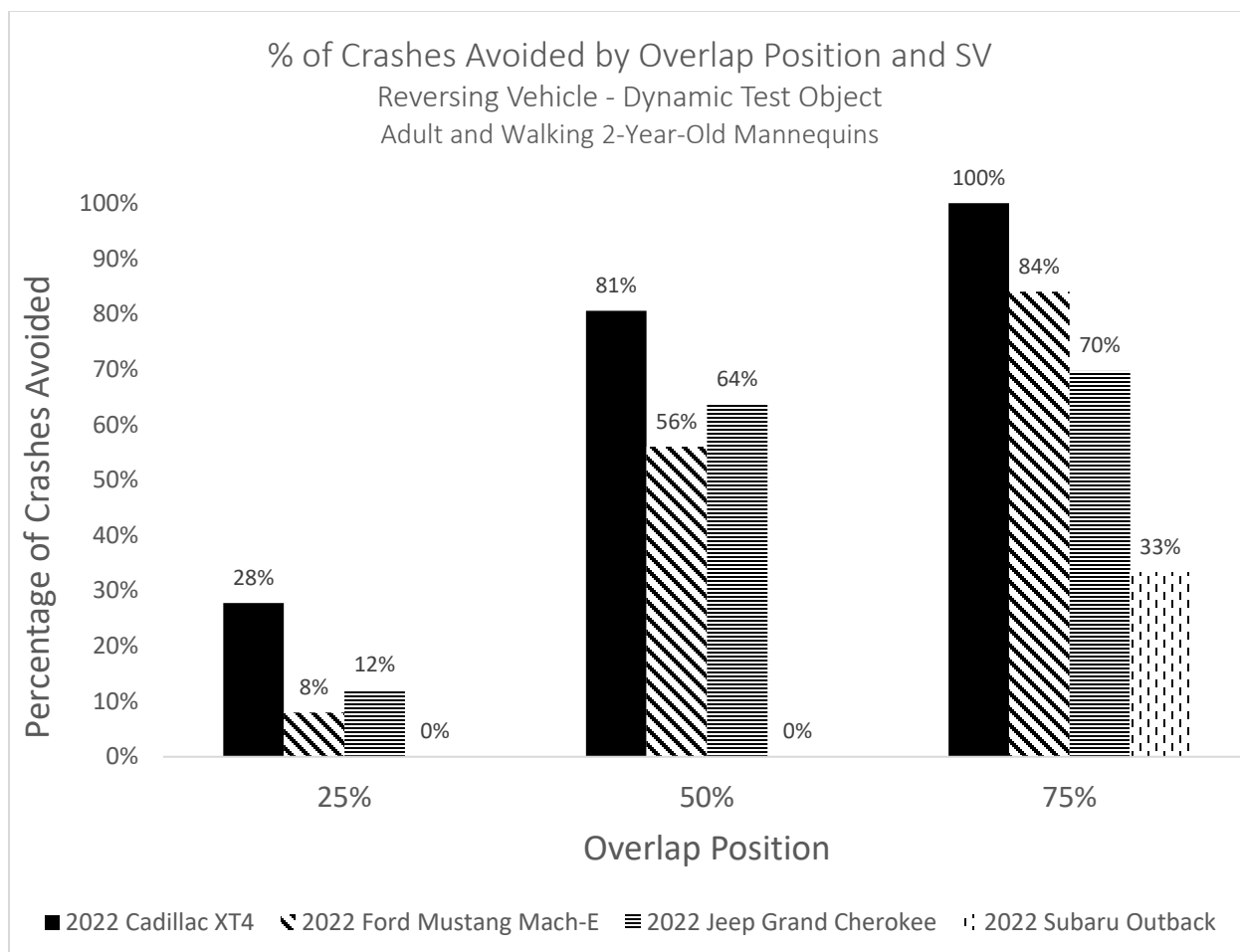


Figure 39. Percentage of Crashes Avoided by Overlap Position, Reversing Vehicle – Dynamic Test Object, Adult and Walking 2-Year-Old PTMs

As shown in the graphs above, there does not appear to be any trends or correlation between test object overlap position and RAB system performance for the stationary test scenario. For the dynamic test scenario, system performance was significantly worse for all vehicles with the 25 percent test object overlap position, which was expected as the vehicle had less time to detect the object moving into its travel path. System performance followed this trend for the other overlap positions, with more crashes avoided at the 50 percent overlap position and the most crashes avoided at the 75 percent overlap position. The Cadillac XT4’s RAB system avoided all crashes at the 75 percent overlap position for the dynamic test scenario.

Additional Testing of 2-Year-Old and 1-Year-Old PTMs in Alternative Postures

Tests were conducted with the 2-year-old PTM in a seated posture and the 1-year-old PTM in a crawling posture for the Jeep Grand Cherokee. The Jeep did not provide warnings or automatically apply the brakes for either of these conditions.

Test Object Approach Direction

For the Reversing Vehicle – Dynamic Test Object test scenario, slight differences were observed in system performance based on the direction of test object approach.

The figure below shows the averaged percentage of crashes avoided for each test speed combination, based on the test object's direction of travel. All test vehicles and test object overlaps are represented in the graph.

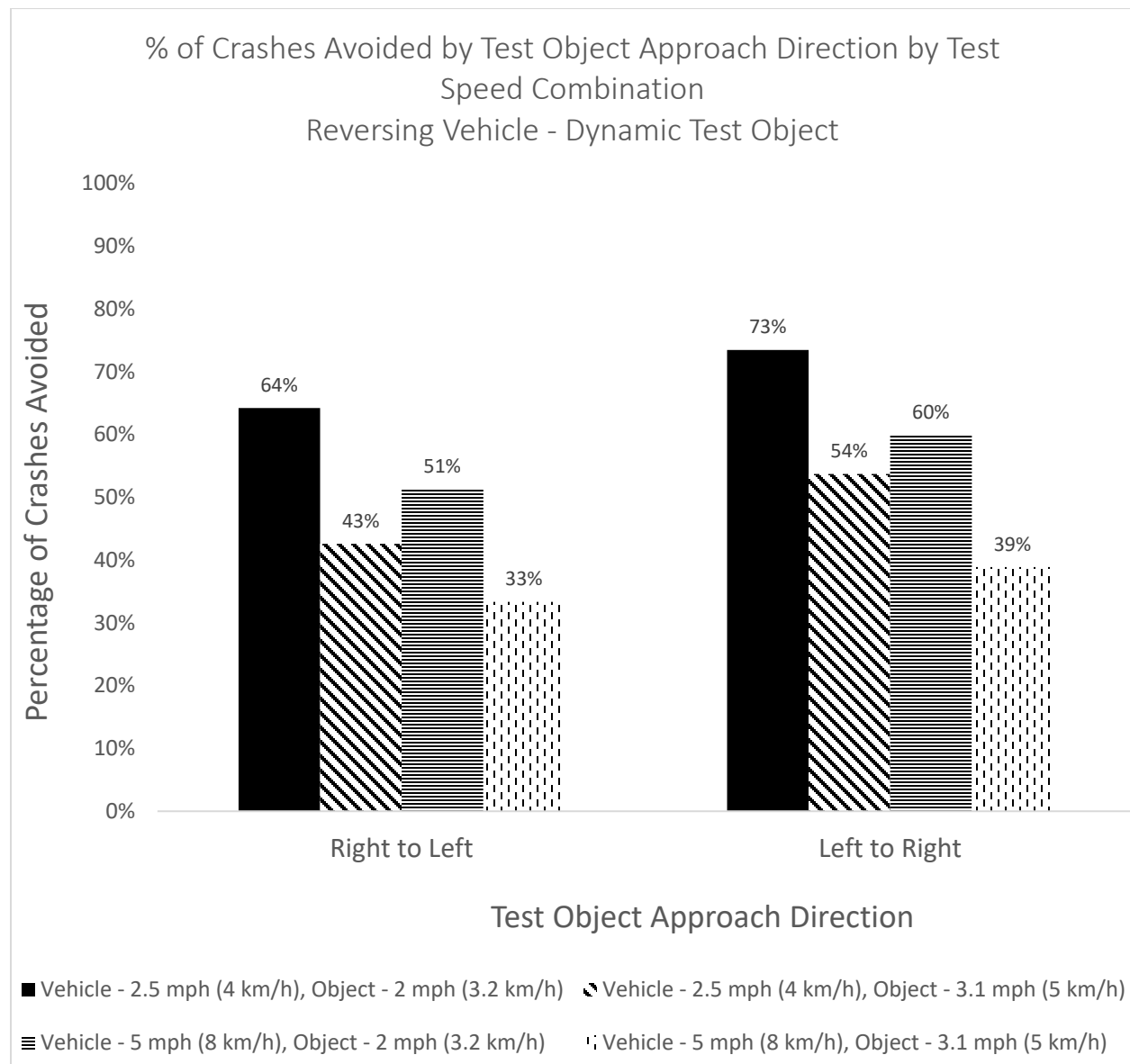


Figure 40. Percentage of Crashes Avoided by Test Object Approach Direction, Based on Test Speed Combination

The results show that vehicles were slightly more likely to avoid a crash when the test object was traveling in the left to right direction for each of the test speed combinations.

The following figure shows the averaged percentage of crashes avoided for the adult, 7-year-old, and 2-year-old PTMs based on the test object's direction of travel.

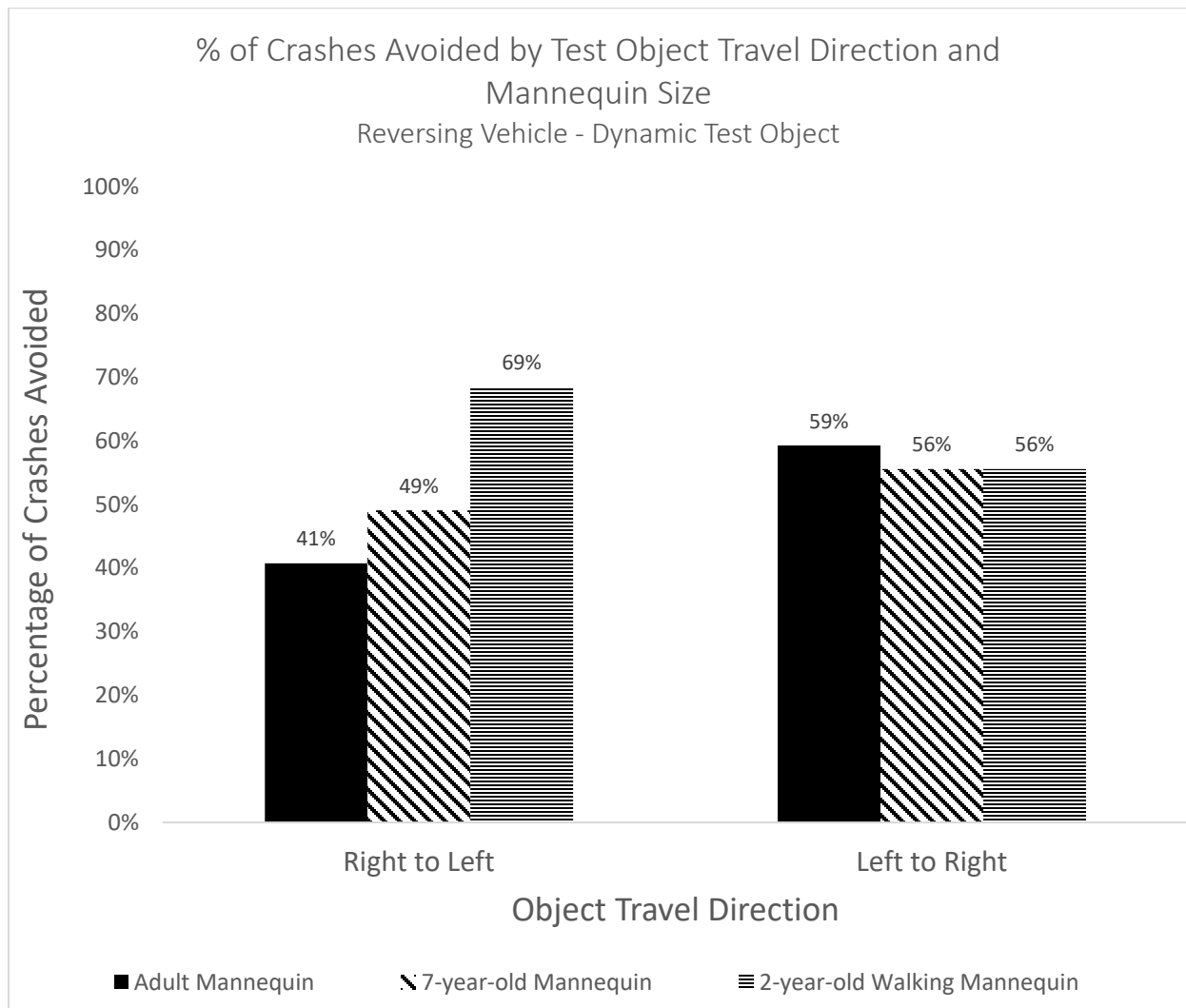


Figure 41. Percentage of Crashes Avoided by Test Object Approach Direction, Based on Mannequin Size

Vehicles were more likely to avoid a crash when the adult and 7-year-old PTMs traveled in a left to right direction. However, vehicles were more likely to avoid a crash when the 2-year-old walking mannequin traveled from right to left.

The following figure shows the percentages of crashes avoided for each test object speed in the dynamic test scenario, based on the test object approach direction. Results were averaged across all test trials.

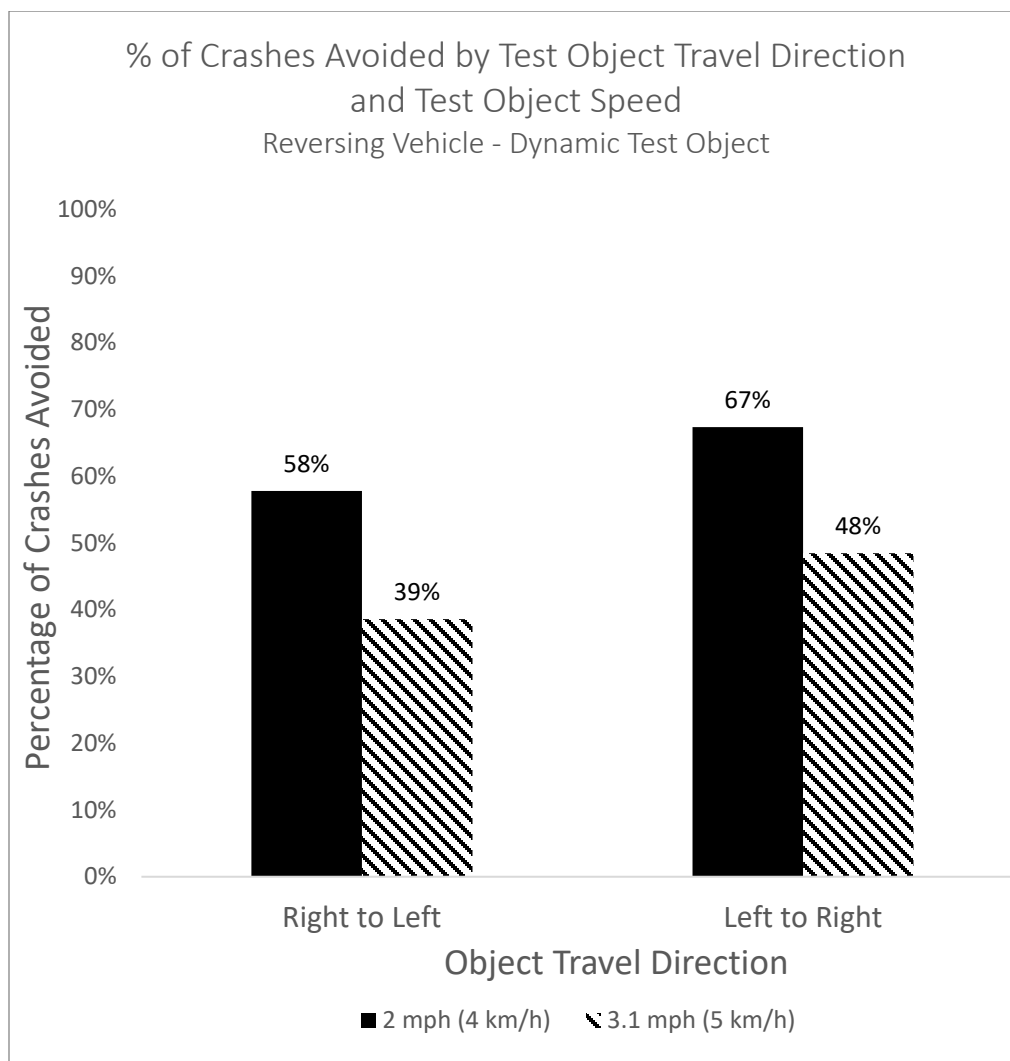


Figure 42. Percentage of Crashes Avoided by Test Object Approach Direction, Based on Test Object Speed

As shown in the figure above, vehicles were more likely to avoid contact with a test object when the test object was traveling at the 2 mph (4 km/h) speed in the right to left direction. However, vehicles were slightly more likely to avoid contact with a test object that traveled at the 3.1 mph (5 km/h) speed in the left to right direction.

Figure 43 shows the percentage of crashes avoided for tests with the dynamic adult PTM traveling at 3.1 mph (5 km/h) at the 50 percent test object overlap. Figure 44 shows the percentage of crashes avoided for tests with the dynamic walking 2-year-old PTM traveling at 2 mph (3.2 km/h) at the 50 percent test object overlap. Results are averaged across all overlap positions.

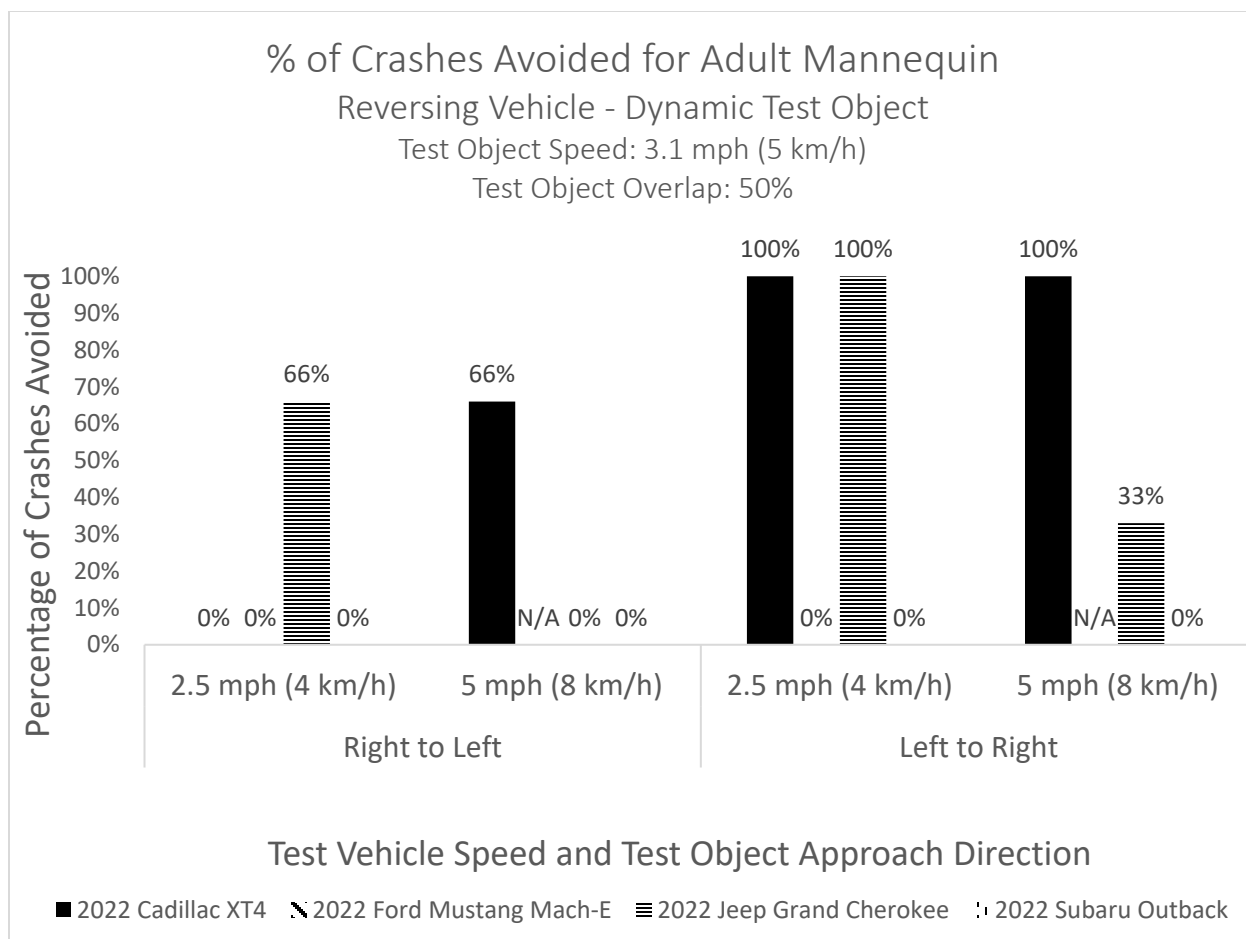


Figure 43. Percentage of Crashes Avoided by Test Object Approach Direction – Dynamic Adult PTM, 5 km/h Object Speed, 50 percent Overlap Position

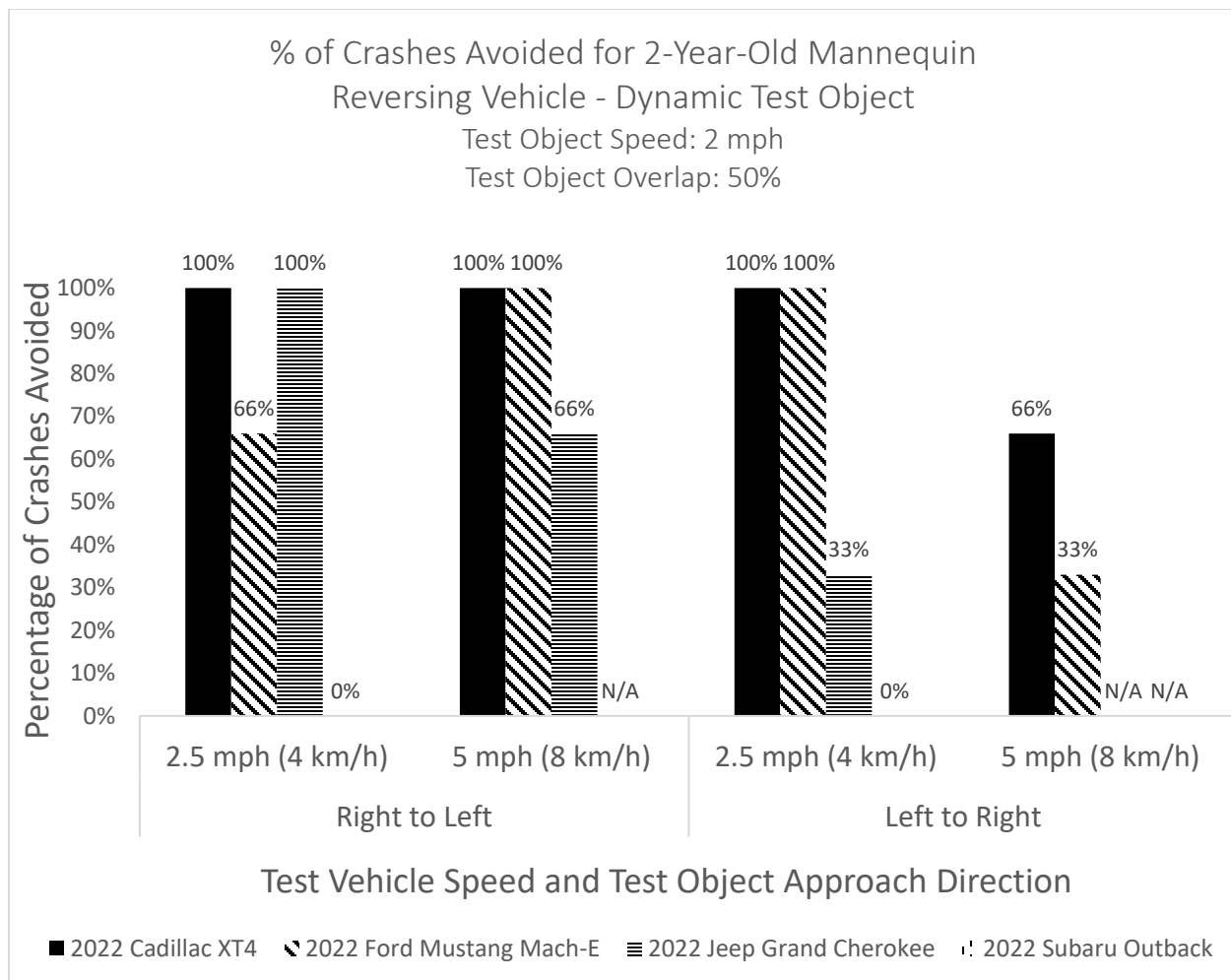


Figure 44. Percentage of Crashes Avoided by Test Object Approach Direction – Dynamic 2-Year-Old PTM, 5 km/h Object Speed, 50% Overlap Position

As shown in the figures above, none of the vehicles tested in this effort were able to avoid a crash for the test conditions that were specified in each respective figure. However, the Cadillac avoided a crash for all but one test with the 2-year-old PTM and the test conditions specified in Figure 44. While RAB performance differed based on test object approach direction and speeds of the test vehicle and test object, assessing performance as a function of test object approach direction, the reason for this curious performance difference is not known.

Rear Automatic Braking Hold Time

Tests were also run to determine how long the vehicles' RAB systems would hold the vehicle at a standstill after bringing the vehicle to a stop, with the values reported in the table below. There are no time values for the Cadillac and Subaru, as their RAB systems automatically apply the parking brake if driver input is not detected after the vehicle is stopped by automatic braking.

Table 152. Automatic Braking Hold Times

Vehicle	Automatic Braking Hold Time (s)
2022 Cadillac XT4	Until driver depresses accelerator pedal
2022 Ford Mustang Mach-E	2.0
2022 Jeep Grand Cherokee	1.0
2022 Subaru Outback	Until driver depresses accelerator pedal

Auditory and Visual Warning Characteristics

Auditory and visual warning information was recorded for all tests. The table below shows the frequencies associated with the auditory warning from each test vehicle.

Table 153. Auditory Warning Characteristics

Vehicle	Fundamental Frequency (Hz)	Secondary Frequency (Hz)	Tempo
2022 Cadillac XT4	750	N/A	Increased as the vehicle approached the test object
2022 Ford Mustang Mach-E	750	N/A	
2022 Jeep Grand Cherokee	688	N/A	
	788	N/A	
2022 Subaru Outback	800	2400	

The Cadillac XT4 and Ford Mustang Mach-E both had auditory warnings that had a fundamental frequency of 750 Hz. The Jeep Grand Cherokee had two separate auditory warnings, with the initial warning used to indicate that an object was detected, and the second warning occurring shortly after the first and used to indicate that RAB intervention was imminent or had occurred. The two auditory warnings presented had different fundamental frequencies. The Subaru Outback's auditory warning consisted of two frequencies presented simultaneously: a fundamental frequency of 800 Hz and a secondary frequency of 2400 Hz. It was observed for all vehicles tested that the tempo of the auditory warnings increased as the test vehicle approached the test object. The changes in tempo differed for each test vehicle but were not calculated for this testing effort.

The following table on the next page shows the visual warning characteristics for each test vehicle, including warning location, the approximate dimensions of the warning, and the primary color of the warning. Pictures of the visual warnings are also shown in the following figures, in the order that they are listed in the table. All of the test vehicles presented visual warnings; however, the order in which the warnings were presented was often inconsistent, especially with warnings that were presented in several locations.

Table 154. RAB Visual Warning Characteristics

Vehicle	Warning System	Warning Location	Dimensions (Width x Height)	Color
2022 Cadillac XT4	Park Assist	Instrument Panel	0.625" x 1" (1.59 cm x 2.54 cm)	Yellow, Red
		Center Stack Display	0.5" x 0.5" (1.27 cm x 1.27 cm)	Yellow, Red
	Rear Pedestrian Alert	Center Stack Display	0.5" x 0.5" (1.27 cm x 1.27 cm)	Yellow, Red
2022 Ford Mustang Mach-E	Reverse Braking Assist	Center Stack Display	1" x 2.5" (2.54 cm x 6.35 cm)	Green, Orange, Red
		Instrument Panel	3" x 1.75" (7.62 cm x 4.45 cm)	Red
2022 Jeep Grand Cherokee	ParkSense Park Assist	Instrument Panel	1.5" x 1.5" (3.81 cm x 3.81 cm)	Yellow
				Red
2022 Subaru Outback	Sonar Audible Alarm	Center Stack Display	1.375" x 0.75" (3.49 cm x 1.91 cm)	Green, Yellow, Orange, Red
	Automatic Braking	Center Stack Display	1.375" x 0.75" (3.49 cm x 1.91 cm)	Green, Yellow, Orange, Red
		Instrument Panel	2" x 2" (5.08 cm x 5.08 cm)	Red and Yellow



Figure 45. Cadillac XT4 Visual Warnings

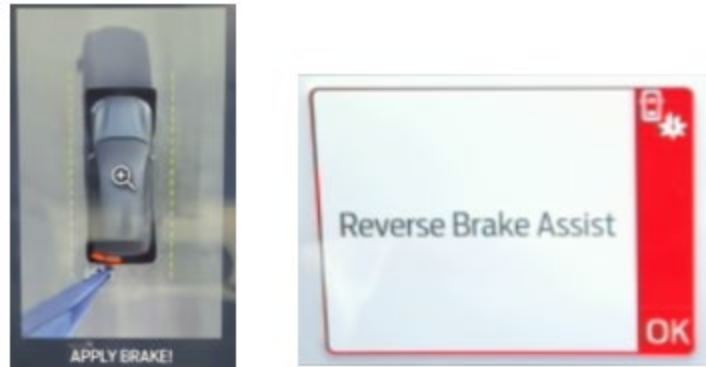


Figure 46. Ford Mustang Mach-E Visual Warnings



Figure 47. Jeep Grand Cherokee Visual Warnings



Figure 48. Subaru Outback Visual Warnings

For test trials where RAB occurred, audible and visual warnings were usually present as well. The onset of the warnings and the order in which they were presented were generally inconsistent, but it was found that if both warnings were presented, they were usually simultaneous or close to simultaneous.

False Positives

False positive testing was not conducted in this effort. However, some OEMs have published technical service bulletins regarding the false positive system activations.

A 2020 Ford technical service bulletin (2020) titled *Reverse Braking Assist Perceived As Too Sensitive Detecting Objects – Built On Or Before 23-July-2020* says that some vehicles “may inadvertently activate the reverse braking assist system while backing up”. Ford says that the cause of the inadvertent activations “may be due to the software in the image processing module B (IPMB).”

A 2024 General Motors technical service bulletin (2024) titled *Information on Unwanted Rear Automatic Braking (RAB)* describes a similar issue, saying that “some customers may comment that the rear automatic braking may brake unwantedly, usually when reversing out of a garage or driveway.” General Motors says that “the cause of the condition may be due to the design sensitivity with the rear virtual bumper.”

Test Vehicle Average Backing Speeds

As each vehicle has a different idle backing speed, the tested vehicles' average idle backing speeds at 20 feet (6.1 m) were measured for test trials in which automatic braking did not occur. The results are shown in the table below. There did not appear to be any correlation between average idle backing speed and system performance for the vehicles tested, as the Cadillac had the highest average idle backing speed and was the test vehicle that avoided contact with test objects in the most cases.

Due to the average idle backing speeds of all test vehicles falling in between the two tested vehicle speeds of 2.5 mph (4 km/h) and 5 mph (8 km/h), the test vehicle's the brakes were applied as needed for test trials at the 2.5 mph (4 km/h) vehicle speed to assist in maintaining the test speed. The brakes were not applied for test trials at the 5 mph (8 km/h) vehicle speed.

Table 155. Average Backing Speeds Without Accelerator Application

Vehicle	Average Idle Backing Speed
2022 Cadillac XT4	4.25 mph (6.84 km/h)
2022 Ford Mustang Mach-E	3.73 mph (6.0 km/h)
2022 Jeep Grand Cherokee	4.14 mph (6.66 km/h)
2022 Subaru Outback	4.11 mph (6.61 km/h)

Rearview Image Presentation Time Lag

During testing, it was visually observed that there was a time lag in the presentation of the vehicle's rearview image. This lag was detected both by the test driver during test conduct and comparing the time synchronized video data views of the vehicle's rearview image to the video captured from the overhead data acquisition camera. This lag was observed for every test vehicle with the magnitude of the lag times being different for each vehicle. Exact lag times were not recorded in this testing effort. This time lag is not related to the FMVSS No. 111 specification for rearview image response time.

Rear Cross Traffic Warning Systems

Testing was conducted with the rear cross traffic warning systems on for all vehicles, as for some tested vehicles those systems were not able to be deactivated separately from the RAB system. Rear cross-traffic warning systems tend to use radar that, if active during an RAB test trial, could positively affect the trial outcome.

Dynamic tests were conducted with the Subaru to see if there were differences in crash avoidance performance when the rear cross traffic warning system was activated, and when the system was deactivated. The RAB system was activated for these tests. It was concluded that activating the rear cross traffic warning system did not have an effect on crash avoidance results for this testing effort.

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Summary

This report describes an effort to investigate possible revisions to an existing draft research test procedure for assessing the performance of vehicle rear automatic braking systems and to characterize the performance of current RAB systems in detecting pedestrians.

The dynamic test object scenarios implemented in this effort were able to demonstrate RAB system performance and assess RAB systems' ability to stop the vehicle before striking a stationary or moving test object for both pedestrian and non-pedestrian test objects. The implementation of driving robots in both test scenarios was effective for achieving consistent and repeatable vehicle speeds and positions, and the additional vehicle speeds tested with the robots provided useful data on RAB system performance limitations.

Overall, testing showed RAB system performance to be generally inconsistent for three of the four vehicles tested. None of the vehicles were able to consistently avoid a collision with pedestrian test objects for the dynamic test object scenarios and only one system was able to do so for two test objects for the stationary test scenario. Tested RAB-equipped vehicles were more likely to avoid impacts for shorter test objects, as well as when tested at lower vehicle speeds. Stationary test objects were also more likely to be detected and avoided as compared to dynamic test objects. Results for the Reversing Vehicle – Stationary Test Object scenario showed two of the four vehicles were more likely to detect and provide warnings in response to a pedestrian test object, while the other two vehicles were more likely to detect and provide warnings for a non-pedestrian stationary test object. However, three out of four vehicles were more likely to avoid contact with the stationary non-pedestrian test objects when compared to the stationary pedestrian test objects. All vehicles were more likely to avoid contact with the bollard test object, as compared to the pillar.

This research provides data and information that could be used as a basis for updating the existing draft research test procedure for assessment of RAB performance in detecting and avoiding pedestrians. Stationary and dynamic pedestrian test scenario conditions were examined and found to be viable indicators of system performance and could potentially be added to an updated test procedure.

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References

- 49 CFR 571.111. Standard [FMVSS] No. 111, Rear Visibility, October 1, 2024. www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571/subpart-B/section-571.111
- 75 FR 76186, Notice of Proposed Rulemaking, Rear Visibility; Federal Motor Vehicle Safety Standard, Rearview Mirrors; Federal Motor Vehicle Safety Standard, Low-Speed Vehicles; Phase-in Reporting Requirements, March 2, 2011. www.federalregister.gov/documents/2011/03/02/2011-4737/rear-visibility-federal-motor-vehicle-safety-standard-rearview-mirrors-federal-motor-vehicle-safety
- 87 FR 13452, Notice of Proposed Rulemaking, Federal Motor Vehicle Safety Standards, New Car Assessment Program, March 9, 2022. www.govinfo.gov/content/pkg/FR-2022-03-09/html/2022-04894.htm
- 89 FR 39686, Final Rule, Federal Motor Vehicle Safety Standards, Automatic Emergency Braking Systems for Light Vehicles, May 9, 2024. www.govinfo.gov/app/details/FR-2024-05-09/2024-09054
- European New Car Assessment Programme. (2022, November). *Test Protocol – AEB/LSS VRU Systems, Implementation 2023, Version 4.3*. https://cdn.euroncap.com/cars/assets/euro_ncap_lss_test_protocol_v43_f2ddd5f6d6.pdf
- FCA US LLC. (2022). *2022 Grand Cherokee/Grand Cherokee L owner’s manual*, 3rd Edition. https://vehicleinfo.mopar.com/assets/publications/en-us/Jeep/2022/Grand_Cherokee_L/P138164_22_WL_OM_EN_USC_DIGITAL.pdf?_gl=1*1vk9qbu*_gcl_au*ODMyNTU0Njk5LjE2ODQ3NjMyOTk
- Ford Motor Company. (2020). *Reverse braking assist perceived as too sensitive detecting objects - Built on or before 23-July-2020* (20-2291). <https://static.nhtsa.gov/odi/tsbs/2020/MC-10179156-0001.pdf>
- Ford Motor Company. (2021). *Ford Mustang Mach-E owner's manual 2022* (Part Number: 202109 20210913121328). www.fordservicecontent.com/Ford_Content/Catalog/owner_information/2022-Ford-Mustang-Mach-E-Owners-Manual_version-1_om_EN-US_10_2021.pdf
- General Motors LLC. (2022). *2022 Cadillac XT4 owner’s manual* (Part No. 84683981 B). www.cadillac.com/bypass/pcf/gma-content-api/resources/sites/GMA/content/staging/MANUALS/5000/MA5479/en_US/4.0/22_CA_D_XT4_OM_en_US_U_84683981B_2022JAN14_2P.pdf
- General Motors LLC. (2024). *Information on unwanted rear automatic braking (RAB)* (Service Bulletin No. 24-NA-048). <https://static.nhtsa.gov/odi/tsbs/2024/MC-10251915-0001.pdf>
- H.R.1216, 110th Congress (2007-2008): K.T. Safety Act of 2007, February 28, 2008. www.congress.gov/bill/110th-congress/house-bill/1216 [Also known as the Cameron Gulbransen Kids Transportation Safety Act of 2007.]
- Infiniti North America, Inc. (n.a.). *2013 Infiniti JX owner’s manual*. www.infinitiusa.com/content/dam/Infiniti/US/manuals_guides/jx/2013/2013-infiniti-jx35-owner-manual.pdf

- International Standards Organization. (2025). *ISO Technical Standard 19206-9:2025, Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions; Part 9: Requirements for small child targets*.
- Mazzae, E. N. (2011, September). *Drivers' use of rearview video and sensor-based backing aid systems in a non-laboratory setting* (Report No. DOT HS 811 512). National Highway Traffic Safety Administration. www.nhtsa.gov/sites/nhtsa.gov/files/811512.pdf
- Mazzae, E. N. (2013, May). *Rearview video system use by drivers of a sedan in an unexpected obstacle event* (unnumbered NHTSA report). National Highway Traffic Safety Administration. [Docket submission. Docket No. NHTSA–2010–0162–0253 in Regulations.gov]. https://downloads.regulations.gov/NHTSA-2010-0162-0253/attachment_1.pdf
- Mazzae, E. N., Baldwin, G. H. S., & Andrella, A. T. (2019, July). *Rear automatic braking feature confirmation test - Draft test procedure assessment*. (Report No. DOT HS 812 766). National Highway Traffic Safety Administration.
- Mazzae, E. N., Barickman, F. S., Baldwin, G. H. S., & Ranney, T. A. (2008). *On-road study of drivers' use of rearview video systems* (ORSDURVS) (Report No. DOT HS 811 024). National Highway Traffic Safety Administration. https://rosap.ntl.bts.gov/view/dot/63329/dot_63329_DS1.pdf
- Mazzae, E. N., & Garrott, W. R. (2006, September). *Experimental evaluation of the performance of available backover prevention technologies*. (Report No. DOT HS 810 634). National Highway Traffic Safety Administration.
- National Center for Statistics and Analysis. (2024, April). *Non-Traffic Surveillance: Fatality and injury statistics in non-traffic crashes in 2021* (Report No. DOT HS 813 539). National Highway Traffic Safety Administration. <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813539.pdf>
- National Highway Traffic Safety Administration. (2005, December 2). *Laboratory test procedure or FMVSS 135, Light vehicle brake systems* (Test No. TP-135-01). www.nhtsa.gov/sites/nhtsa.dot.gov/files/tp-135-01.pdf
- NHTSA. (2014, August). *Automatic emergency braking system (AEB) research report* (unnumbered NHTSA report. www.regulations.gov/document/NHTSA-2012-0057-0037
- Research Council for Automobile Repairs. (2017, January). *Procedure for assessing the performance of reverse autonomous emergency braking (R-AEB) systems in rear collisions*. <https://mail.rcar.org/Papers/MemberPapers/Reverse%20AutoBrake%20Test%20Procedure.pdf>
- Subaru Corporation. (2021). *2022MY Outback owner's manual*. https://cdn.subarunet.com/stis/doc/ownerManual/MSA5M2204A_STIS-Opt.pdf
- Wang, J.-S. (2019, March). *Target crash population for crash avoidance technologies in passenger vehicles* (Report No. DOT HS 812 653). National Highway Traffic Safety Administration. <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812653>

Appendix A: Test Vehicle Images

2022 Cadillac XT4



Figure 49. The 2022 Cadillac XT4 Rear View

2022 Ford Mustang Mach-E



Figure 50. The 2022 Ford Mustang Mach-E Rear View

2022 Jeep Grand Cherokee



Figure 51. The 2022 Jeep Grand Cherokee Rear View

2022 Subaru Outback



Figure 52. The 2022 Subaru Outback Rear View

DOT HS 813 830
October 2026



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**



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