

# NSTSCCE

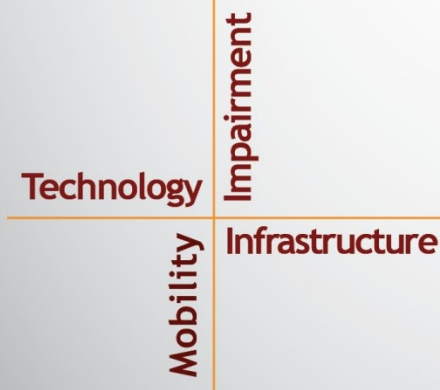
## National Surface Transportation Safety Center for Excellence

### **Pediatric Vehicular Heatstroke**

#### **Evaluation of Preventative Technologies**

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Submitted: April 6, 2021



## **ACKNOWLEDGMENTS**

The authors of this report would like to acknowledge the support of the stakeholders of the National Surface Transportation Safety Center for Excellence (NSTSCE): Tom Dingus from the Virginia Tech Transportation Institute; John Capp from General Motors Corporation; Chris Hayes from Travelers Insurance; Terri Hallquist and Nicole Michel from the Federal Motor Carrier Safety Administration; Cathy McGhee from the Virginia Department of Transportation and the Virginia Transportation Research Council; and Jane Terry from the National Safety Council.

The NSTSCE stakeholders have jointly funded this research for the purpose of developing and disseminating advanced transportation safety techniques and innovations.

The authors would also like to acknowledge Duncan Hyundai, First Team Nissan, and Shelor Subaru for allowing the research team to collect crucial data using their vehicles.

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## LIST OF ABBREVIATIONS AND SYMBOLS

CAN	Controller Area Network
GM	General Motors
NSTSCE	National Surface Transportation Safety Center for Excellence
NHTSA	National Highway Traffic Safety Administration
OBD	On-board Diagnostics
OEM	original equipment manufacturer
PVH	Pediatric Vehicular Heatstroke
RDA	Rear Door Alert (Nissan)
ROA	Rear Occupant Alert (Hyundai/Kia)
RSR	Rear Seat Reminder (GM)
RSRT	Rear Seat Reminder Technology
UROA	Ultrasonic Rear Occupant Alert (Hyundai/Kia)
VTTI	Virginia Tech Transportation Institute



## CHAPTER 1. PEDIATRIC VEHICULAR HEATSTROKE

In 2018 and 2019, pediatric vehicular heatstroke (PVH) was the leading cause of nontraffic child fatalities involving vehicles in the United States (Kids and Cars, 2019). A record high of 53 PVH fatalities were recorded in 2018, and a similar number of 52 were recorded in 2019 (Null, 2019). In response to these disturbing statistics, U.S. Senator Roger Wicker presented the HOT CARS Act in May 2019, directing the U.S. Department of Transportation to issue a rule requiring all new passenger motor vehicles weighing less than 10,000 pounds to be equipped with rear seat reminder technologies (RSRTs) that would alert, both audibly and visually, individuals inside and outside of a vehicle to the presence of an occupant in the rear seat once the vehicle is turned off (S. 1601, 2019). In June 2019, Rep. Tim Ryan introduced the HOT CARS Act of 2019 to the U.S. House of Representatives (See Appendix A. H.R. 3539). This bill is the same as that introduced to the Senate (See Appendix B. S. 1601), except that it has an additional requirement for a system to detect occupants who may have entered the vehicle independently and are unable to exit independently (H.R. 3593, 2019). Though to date neither Act has moved beyond introduction to the House and Senate, respectively, identifying an effective RSRT alert strategy is a critical step towards mandating this technology for all new vehicles meeting the requirement criteria (GovTrack.us.com, 2021).

In a previous study, the Virginia Tech Transportation Institute (VTTI) conducted an extensive literature review to better understand the circumstances under which PVH occurs, identify the available preventive technologies, and examine what is necessary for an optimized PVH-prevention solution (Glenn et al., 2019). Researchers determined that the main causes of PVH injuries and fatalities are the result of children being left unaccompanied in vehicles, both knowingly and unknowingly, as well as children gaining access to vehicles without caregiver knowledge. Available technologies designed to prevent these situations were grouped into five categories based on their primary approach:

1. **Pressure-based technology** uses pressure pads to detect the presence of an occupant and determine if an alert should be issued to the driver upon exiting the vehicle.
2. **Restraint-based technology** uses sensors that clip onto or are built into child restraints and synchronize with an attachable key fob or smartphone via Bluetooth to alert a driver if they leave the vehicle while a child restraint is still buckled.
3. **Sensor-based technology** uses various sensors and patented technology to detect an occupant's presence in the vehicle.
4. **Aftermarket vehicle-based technology** requires professional installation and issues alerts using door logic and/or other patent technology.
5. **Original equipment manufacturer (OEM) technologies** come pre-installed on a vehicle at the time of purchase and rely on the opening of a rear door prior to or during a trip as an indicator to issue an alert due to a possible occupant in the back seat (door sequencing/door logic), which may be followed up with further alerts.

The National Highway Traffic Safety Administration (NHTSA) previously evaluated a variety of aftermarket RSRTs in 2011, finding none of them to be completely reliable or consistent in their ability to detect children in the vehicle (Arbogast et al., 2012; Rudd et al., 2015). Their evaluation concluded that multiple devices on the market had syncing and connection issues that hindered their ability to work as intended. NHTSA also completed a functional assessment of

RSRTs in hope of providing guidance for companies on developing more robust reminder technologies (Rudd et al., 2015). The evaluations in this assessment were limited to applications available at the time, and hence did not include updated technologies from the authors' previous study, newer aftermarket products, or various OEM technologies that are increasingly available. These reports provide a general assessment of the available technologies at the time the evaluations were conducted, as well as recommendations for improvement. However, neither directly account for how each approach could alert caregivers across various scenarios where children are vulnerable to PVH, such as being left in a vehicle or gaining access to a vehicle without a caregiver's knowledge. Further evaluation is necessary to determine the effectiveness of these technologies in common PVH risk scenarios.

The study reported on herein builds on the previous VTTI work by taking the next appropriate step: a functional evaluation of OEM and aftermarket RSRT implementations, focusing on occupant detection methods and driver/bystander notification approaches. Using scenarios based on real-world PVH cases, this effort was a hands-on evaluation of how each RSRT implementation performed, accounting for OEM and select aftermarket RSRTs available at the time of data collection. Each implementation received ratings for reliability and effectiveness, offering opportunities to examine and discuss specific RSRT advantages and shortcomings.

## CHAPTER 2. METHODS

This section describes the RSRTs included in this evaluation, the test site location, and the developed tests based on common PVH scenarios.

### AVAILABLE RSRTS

#### Aftermarket RSRTs

VTTI acquired aftermarket RSRTs previously identified in Phase 1 that were available during data collection preparation. Table 1 describes the aftermarket RSRTs included for testing, grouped into four applicable categories: pressure-based, child restraint-based, sensor-based, and vehicle integrated. All aftermarket technologies were installed and tested in a 2008 Chevrolet Tahoe.

**Table 1. Aftermarket RSRT descriptions.**

Product	Type	Approach	Notification
Sense A Life*	Pressure-Based	Weight pad and optical sensor.	Optical sensor issues an auditory alert if the driver walks away while weight remains on the weight pad.
Elepho eClip <a href="https://elepho.com/">https://elepho.com/</a>	Sensor-Based	Clip that can attach to the child's car seat harness (or anywhere in the vehicle).	Clip connects to a Smartphone app, issuing an alert if the phone is at least 25' away from the buckled clip.
Childminder SoftClip <a href="https://www.babyalert.info/">https://www.babyalert.info/</a>	Child Restraint-based	Key fob-linked restraint harness clip that replaces the pre-existing harness clip.	Key fob issues an alert if the phone is at least 15' away from a buckled harness clip.
Sensor Safe <a href="https://cybex-online.com/en-us/sensorsafe">https://cybex-online.com/en-us/sensorsafe</a>	Child Restraint-based	Car seat equipped with a sensor in the restraint harness clip that connects to a device plugged into the vehicle's On-board Diagnostics 2 (OBD2) port.	System issues an auditory, visual, and haptic alert to the driver's smartphone via the system's application if the driver walks away while the car seat is still buckled.
Ride N Remind <a href="http://ridenremind.com/">http://ridenremind.com/</a>	Vehicle Integrated	Senses when the rear door has been opened and closed before or while the engine is on.	Issues an auditory alert from under the dashboard if the driver turns off the vehicle and an additional auditory alert (vehicle horn) if driver does not open rear door and push an installed button.
* No website available at time of publication. Product currently unavailable.			

## Vehicle-based RSRTs (OEM)

OEMs offering vehicles equipped with RSRTs as of model year 2020 included GM, Subaru, Toyota, Nissan, Hyundai, and Kia (also part of the Hyundai Motor Group). VTTI researchers acquired a representative vehicle with RSRT from all companies except for Kia. In most cases, vehicles were borrowed from local dealerships for a few hours in order to complete the required testing (see Appendix C for phone script). The research team confirmed with an OEM representative (personal communication, February 27, 2020) that both the Hyundai and Kia RSRT have the same operational logic, and therefore only one vehicle was required to represent both manufacturers). Descriptions of the vehicle makes and models included for testing are shown in Table 2.

**Table 2. OEM RSRT descriptions.**

<b>Year, Make, Model, &amp; Trim</b>	<b>Feature Name</b>	<b>Approach</b>	<b>Notification</b>	<b>Availability for Testing</b>
2017 GMC Acadia SLT-2	RSR	Senses when rear door is opened and closed before the engine starts or while it is running.	Issues an auditory and visual alert to the driver's seating location when driver turns off the vehicle.	VTTI fleet vehicle
2020 Subaru Ascent Touring	RSR	Senses when rear door is opened and closed before the engine starts or while it is running.	Issues an audio and visual alert to the driver's seating location when driver turns off the vehicle.	Via Shelor Subaru
2020 Toyota Highlander XLE	RSR	Senses when rear door is opened and closed before the engine starts or while it is running.	Issues an audio and visual alert to the driver's seating location when driver turns off the vehicle.	Via Shelor Toyota
2020 Nissan Rogue SV	Rear Door Alert (RDA)	Senses when rear door is opened and closed before the engine starts or while it is running.	Issues a visual alert to the driver's seating location when driver opens and closes driver door.  Issues an audio alert (vehicle horn) if vehicle is locked when driver does not open a rear door after visual alert is issued.	Via First Team Nissan
2020 Hyundai Palisade SE (Representing Kia as well)	Rear Occupant Alert (ROA)	Senses when rear door is opened and closed before the engine starts or while it is running.	Issues an auditory and visual alert to the driver's seating location when driver opens driver door.	Via Duncan Hyundai

Year, Make, Model, & Trim	Feature Name	Approach	Notification	Availability for Testing
	Ultrasonic Rear Occupant Alert (UROA)	Senses movement in armed and locked vehicle for up to 24 hours following engine cut off.	Issues an auditory, visual and haptic alert to driver and/or bystanders once movement is detected.	

\* Phone script used to obtain vehicle for testing.

## TESTING AREA

Scenarios that involved static testing took place at VTTI’s campus in Blacksburg, Virginia, in both a propriety garage and in an outside parking area closed off to the public (Figure 1). Researchers used public roads in the New River Valley area for scenarios that required a dynamic component (e.g., testing using the navigation system). While weather was not an inhibitor, all testing was performed during clear and low-wind conditions.



**Figure 1. Photo. Testing area.**

## EVALUATION STRATEGY

### Scenarios

The research team developed 24 scenarios to encompass the three main PVH scenarios: (1) child unknowingly left in the vehicle (i.e., forgotten), (2) child knowingly left in the vehicle, and (3) child gained entry without caregiver knowledge. Scenarios were developed and categorized into one of these three main PVH scenarios based on news reports and caregiver testimonials about children who were injured or who died due to PVH (see Appendix D for a sample of reports and testimonials). Researchers attempted to simulate caregivers’ known and possible behaviors during these scenarios. However, it is important to note that if a caregiver wants to intentionally

leave a child in the car, they can continue to ignore or dismiss alerts as they wish no matter how these alerts are delivered. Regardless, these are scenarios that need to be taken into consideration with systems designed to prevent PVH.

The first 16 scenarios were designed based on situations in which a caregiver unknowingly or knowingly left a child in a vehicle. These scenarios included four main types, each with four different caregiver means of exit.

1. Driving directly to a destination with no mid-trip stops.
  - a. This scenario simulated situations in which caregivers drove directly to a destination (i.e., work) without dropping their child off at a childcare provider as intended.
2. Driving to a destination with a mid-trip stop, during which the engine remains on and a rear door opens.
  - a. This scenario simulated situations in which caregivers had multiple occupants in the rear seating—for instance, one small child and another child or adult who exited the vehicle independently (i.e., at school, work, or childcare provider) before the final destination.
3. Driving to a final destination with a mid-trip stop during which the engine is turned off and the driver door is opened and closed twice.
  - a. This scenario simulated situations in which caregivers refueled their vehicle mid-trip while a child remained in the rear of the vehicle.
4. Driving to a destination with a mid-trip stop during which the engine remains on and both the driver and rear doors are opened and closed.
  - a. This scenario simulated situations in which caregivers may have had two children in the rear of the vehicle, neither of whom were unable to exit independently—for instance, one child was dropped off at an intermediate destination before arriving at the final destination.

Each scenario ended in one of four ways: with the accessory mode on or off and with the vehicle locked or unlocked. These conditions were chosen as the main variations in ways that a caregiver might leave their vehicle once reaching a destination. Accessory mode may be used by a caregiver in order to keep music playing, devices such as television screens powered, or the fan blowing while they leave their children in the vehicle knowingly. Both locked and unlocked conditions for each scenario were included, as some PVH incident reports of children gaining access to vehicles state that the vehicle was not locked. Furthermore, not all drivers are in the habit of locking their vehicles once parked. Table 3 provides a full breakdown of each of the 16 scenarios ( $4 \times 2 \times 2$ ).



**Table 3. Child left knowingly/unknowingly scenario conditions.**

Scenario		Accessory Mode Status	Doors Lock Status
1	Driving directly to a destination with no mid-trip stops. Once parked, driver turns ignition off and exits.	Accessory Mode On	Doors Locked
2			Doors Unlocked
3		Accessory Mode Off	Doors Locked
4			Doors Unlocked
5	Driving to a destination with a mid-trip stop during which the engine remains on and a rear door opens.	Accessory Mode On	Doors Locked
6			Doors Unlocked
7		Accessory Mode Off	Doors Locked
8			Doors Unlocked
9	Driving to a destination with a mid-trip stop during which the engine is turned off and the driver door is opened and closed twice.	Accessory Mode On	Doors Locked
10			Doors Unlocked
11		Accessory Mode Off	Doors Locked
12			Doors Unlocked
13	Driving to a destination with a mid-trip stop during which the engine remains on and both the driver and rear doors are opened and closed.	Accessory Mode On	Doors Locked
14			Doors Unlocked
15		Accessory Mode Off	Doors Locked
16			Doors Unlocked

Additional scenarios were included to represent situations in which a child gains access to a vehicle, either locked or unlocked, independently and without caregiver knowledge. Testing simulated either the door being completely shut or only partially latched due to the required skill and strength, and the vehicle being either locked from the inside or unlocked. Accounting for each of these combinations resulted in eight additional scenarios. In terms of locking and unlocking, testing assumed that the vehicle had a key fob per current trends. Table 4 provides a full breakdown of each of the 8 scenarios ( $2 \times 2 \times 2$ ).

**Table 4. Child gains access scenario conditions.**

Initial Door Lock Status	Door Closed Status	Final Door Lock Status
Doors Locked	Doors Completely Closed	Doors Locked
		Doors Unlocked
	Door Partially Latched	Doors Locked
		Doors Unlocked
Doors Unlocked	Doors Completely Closed	Doors Locked
		Doors Unlocked
	Door Partially Latched	Doors Locked
		Doors Unlocked

Researchers also tested whether notifications associated with leaving a fuel door, hood, trunk, sunroof, or window open interfered with RSR alert delivery in any way. Moreover, testing was conducted for conditions during which navigation, music, and telephone via Bluetooth were in use to observe if there was an impact on RSR alert delivery. Evaluating performance across this full set of scenarios took approximately 1 hour for each implementation.



## CHAPTER 3. RESULTS

### PRESSURE-BASED SYSTEM

#### Sense A Life

##### *System Overview*

The Sense A Life system uses a pressure-based approach consisting of two sensors. A weight-sensing pad is placed under the car seat padding, and a sensor device is mounted on the side of the driver's seat (Figure 2). If the system senses weight on the pad when the driver opens the door, the device mounted to the driver's seat issues an audio alert. For these tests, the sensor was placed under a Cybex Sirona M child seat that was obtained for this research to test the Sensor Safe 2.0 technology.



**Figure 2. Photo. Sense A Life system.**

Sense A Life provides a single level auditory alert, relying on the combined information from both sensors to determine whether an alert is warranted. It does not require any batteries; however, the sensor device mounted on the side of the driver's seat requires charging via a USB charger. This sensor did not arrive fully charged and initially required over 7 hours for a complete charge.

##### *How System Is Armed*

The Sense A Life feature issues a “system activated” auditory prompt via the device attached to the driver's seat once the pad senses added weight (Figure 2). For research purposes, a 15-lb ball was used to simulate the weight of a 4- to 5-month old infant (Center for Disease Control and Prevention, 2000; Figure 3). The entire system is armed (i.e., ready to issue an alert if conditions are met) once weight is placed on the sensing pad and the driver's door has been closed for 1 minute. If the driver's door opens up before the minute has passed, the system is not armed and an alert will not be issued. However, if the door is closed again for 1 minute, the system is fully armed.



**Figure 3. Photo. Sense A Life pad in car seat with 15-lb ball.**

### ***Alert Approach***

Once the system is armed, the following audible alert is issued three times if the driver's door is opened after at least 1 minute has passed with weight on the pad.

- 1) Level 1:
  - a. An auditory alert of "Occupant detected in car seat, please remove child from seat" repeated three times.

Sense A Life does not have an option to manually disarm or dismiss the audio alert before it is issued. The system will alert the driver each time the driver door is opened when conditions are met. After the system issues the auditory alert, it is automatically disarmed until the aforementioned conditions are met again.

### ***System Performance Across Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** As shown in Figure 5, the Sense a Life alert system provided an alert at the final destination in all conditions under which a child would be knowingly or unknowingly left unattended in a vehicle as long as the system was still successfully armed (e.g., the weight had not shifted off the pad; see Challenges and Inconsistencies section below). Additionally, Sense a Life issued an alert at each midway stop in which a driver stepped out of the car (i.e., getting gas or helping another child out of car). Sense a Life remained armed through these mid-way stops and issued the alert again at the final destination.

**Table 5. Sense A Life alert issued in unknowingly/knownly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stop mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** Per Table 6, the Sense a Life system did not issue an alert for any scenario in which a child independently gained access to a vehicle. The Sense A Life system is not designed for such a scenario, as the child must be on the weight pad for the system to work as intended. A child who gains access would need to sit on the pad and have opened and closed the driver door, which is unlikely. However, even if a child did perform these actions and sit in their car seat after gaining access to the vehicle, the audio alert is issued only in the general vicinity of the car and would be unlikely to alert a caretaker located inside a house, for example.

**Table 6. Sense A Life alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: "✓" denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

**Competing Alerts and Activities**

Because this is an aftermarket approach, none of the pre-existing vehicle features competed with the Sense A Life system’s general operation, as shown in Table 7.

**Table 7. Sense A Life alert issued without conflict from other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued</i>									

**Challenges and Inconsistencies**

The Sense A Life alert system requires caretaker buy-in to purchase, install, and ensure that the system is properly charged and armed for each trip. As researchers were testing this system, a

number of potential annoyances were noted. Even though the system is stated to only need a pound and a half of pressure (ABC News, 2019), the 15-lb weight researchers used had to be positioned in a particular way in order to activate the system. Merely placing a weight on the pad did not always arm that part of the system, necessitating the potential adjustment of the weight simulating the child before the system was armed. Though the weight used in place of a child was not distributed as a child's body weight would be, researchers believe that this sensing difficulty could still be an issue with a real child and testing with real children of varying weights and different car seats would provide more insight into this issue. In addition, this system was only tested with one forward-facing car seat. It is possible that varying car seat manufacturers and seating positions may affect results, though no information on this was available from the manufacturer at time of publication. It is important to note that, while the system notified a user that it was armed upon sensing weight, no further notifications were provided if the system was disarmed at any point due to removal of the weight, which could just be a child moving around in their seat. Caregivers could become frustrated if they have to readjust a child's position multiple times to arm the system. Testing also revealed that the alert would sometimes still go off, even with no weight on the pad. Operationally, no visual or audio signals exist to notify the user that the device has a low battery. The system does not provide solutions to drivers for any gained access scenarios.

### ***Overall System Assessment***

The Sense a Life's weight sensor was inconsistent, as the system's decision on whether to arm depended on the weight distribution on the pad. The audio feedback letting the driver know when the system was armed was useful in determining correct weight distribution. However, an alert saying the system is deactivated would be useful to notify drivers if the system disarms due to a child shifting or moving off the pad. Because the system is not integrated with the vehicle, there were no competing systems when issuing an alert. However, lack of integration also means no possible suppression of loud music or an active phone call to increase the likelihood of the system gaining a driver's attention.

## **CHILD-RESTRAINT-BASED SYSTEMS**

### **Child Minder SoftClip**

#### ***System Overview***

The SoftClip system consists of a clip that replaces the pre-existing safety harness clip in a child restraint system and a key fob that is intended to remain with the driver (e.g., attached to their key chain, etc.; Figure 4). The basic system logic is that the key fob attachment issues an alert if the distance between the fob and a secured harness is greater than 15 ft.



**Figure 4. Photo. ChildMinder SoftClip (source: Amazon.com, n.d.,b).**

The SoftClip System provides a single level auditory alert, relying on the status of the harness clip (buckled or unbuckled) and the distance between the key fob and the harness clip ( $> 15$  ft = alert) to determine whether an alert is warranted. Both units require a CR-2450 battery, which is included in the original packaging and is expected to last one year (Baby Alert International, 2016).

### ***How System Is Armed***

The system is armed when the user secures the clip once a child is in the restraint and the center button on the key fob is depressed until it beeps (typically after a few seconds).

### ***Alert Approach***

Once the system is armed, an alert is issued as follows within 8 seconds if the key fob is at least 15 ft away from the buckled harness clip (Baby Alert International, 2016).

- 1) Level 1:
  - a. A continuous beep auditory alert is issued via the key fob.

The SoftClip system has an option to manually “snooze,” but not dismiss or disarm, the alert without unbuckling the restraint clip. A caregiver can snooze the alert by pressing the center button on the key fob; however, the alert will resume after less than 20 seconds of silence if the key fob remains more than 15 ft away from the buckled restraint clip. If the key fob moves back within 15 ft from the buckled restraint clip, the alert will stop but the system remains armed. If a caregiver unbuckles the clip, it is presumed the child has been removed from the vehicle and the system is therefore disarmed.

### ***System Performance Across Scenarios***

For measuring distances, researchers used a Rolatape model 112. Researchers used the Cybex Sirona M car seat for testing though this system is designed for use with any car seat.

**Child Knowingly or Unknowingly Left in Vehicle:** As shown in Table 8, the SoftClip issued an alert in all conditions under which a child would be knowingly or unknowingly left unattended in a vehicle. For scenarios such as dropping off another child mid-route, or stopping

to get gas, etc., there were no additional alerts if the key fob remained within 15 ft of the buckled restraint clip. In addition, the system remained armed until the final destination without needing reactivation.

**Table 8. Child Minder Softclip alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** Per Table 9, the SoftClip did not issue an alert for any scenario in which a child independently gained access to a vehicle. The SoftClip system is not designed for this type of scenario due to its need to be armed every use by buckling the restraint clip and pressing the center button on the key fob. Even if a child did perform these actions after gaining access to a vehicle, no alert would be issued, as the audio alert is issued only to the key fob once it is 15 ft from the buckled restraint clip, and would presumably stay with the child in the vehicle in this scenario.

**Table 9. Child Minder Softclip alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: "✓" denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

### Competing Alerts and Activities

Because this is an aftermarket approach, none of the pre-existing vehicle features competed with the SoftClip general operation, as noted in Table 10.

**Table 10. Child Minder Softclip alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued without conflict</i>									



### ***Challenges and Inconsistencies***

Like the other aftermarket systems, the Child Minder SoftClip system requires caretaker buy-in to first purchase, ensure the batteries are working, and arm the system for each trip. This system requires pressing a button on the key fob, which is a step beyond merely placing a child in the car seat and driving to arm the system. This step can easily be overlooked as not necessary for particular trips and hence the system may not be used consistently. In addition, no alert was issued if the system was disarmed at any point due to the unbuckling of the restraint clip while driving (for example if a child were to unbuckle themselves). According to a sales representative for SoftClip, in this scenario, both the clip and fob would beep four times and then be disarmed (Personal Communication with Baby Alert International Sales Representative, 2020), with no alert issued at the final destination.

In order to function as designed, the system works on the assumption that the key fob will remain with the driver; however, if the driver forgets to bring the key fob with them, the alert will never go off. In addition, the key fob alert is fairly quiet, as loud as someone talking quietly, and may be easily muffled if placed in a full bag or purse. There is no additional alert if the key fob alert does not get the driver's attention. The manufacturer suggests that no more than one key fob device be armed at a time to prevent errors in the system (Baby Alert, 2019). The SoftClip and/or Key Ring will provide an auditory (beep) and visual (flashing LEDs) warning upon activation when a low battery is detected (Baby Alert International, 2016). Notably, during these evaluations, the SoftClip began beeping intermittently whether the clip was buckled or unbuckled. The batteries were removed from both the key fob and the chest clip in order to reset the system as suggested by the manufacturer, but the device continued to perform inconsistently.

### ***Overall System Assessment***

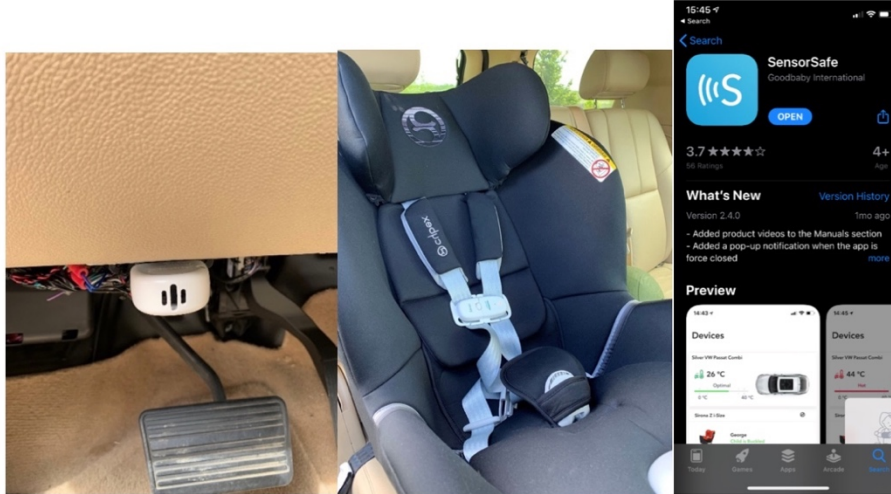
The Child Minder SoftClip system reduces unnecessary alerts by issuing them only if the key fob is over 15 ft away from a buckled restraint clip. This feature could minimize nuisance (i.e., false) alerts, which may desensitize the caregiver to the system. Because the system is not integrated with the vehicle, there are no competing systems when giving the alert. However, loud music or phone calls are not detected, and thus the system cannot interrupt any audio to increase the likelihood of gaining a driver's attention in cases where the SoftClip audio alert may be muffled or inaudible. However, the beeping from the key fob continues until action is taken and would presumably continue once the music or phone call is terminated, though if the alert is muffled enough, it might remain undetected for hours.

## **Sensor Safe 2.0**

### ***System Overview***

The Sensor Safe 2.0 system also uses a child-restraint-based approach consisting of the Cybex Sirona M child car seat, an integrated monitoring restraint clip, a wireless receiver that plugs into the vehicle's OBD port, and the Sensor Safe smartphone/watch application (Figure 5). The smartphone/watch application, which the user must download for the level 2 and level 3 alerts, supports both Apple and Android operating systems. An audio alert is issued from the OBD receiver upon turning the ignition off following a drive during which the restraint clip is buckled. The phone app provides access to multiple alert types, such as when a child might unbuckle the

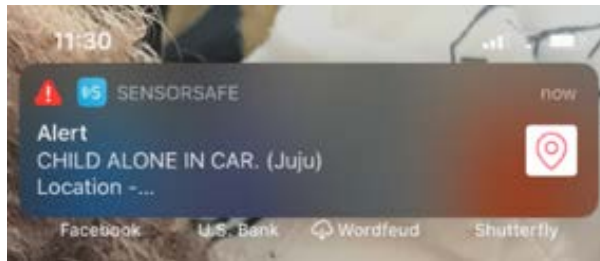
chest clip during the trip, when the temperature is too warm or too cold for a child, or if a child has been left in a vehicle (based on the restraint clip still being fastened). The clip requires a BR 2032 battery in the harness, which is included with purchase, and issues a warning if fastening the clip with a low battery.



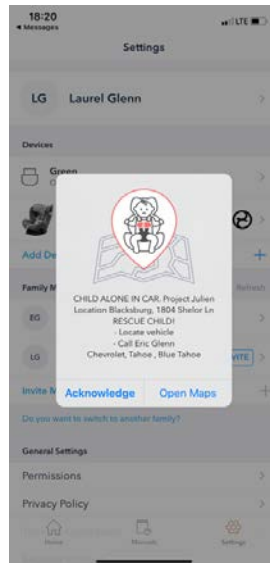
**Figure 5. Photos. Sensor Safe OBD receiver, integrated car seat restraint clip, and application.**

Sensor Safe provides up to three levels of alerts, relying on the combined information of the vehicle state from the OBD receiver and the restraint clip to determine if an alert is warranted. The user must have a smartphone with the application in order to receive the second or third level alerts. The system issues both an in-vehicle auditory alert and an optional visual, auditory, and haptic alert issued to a driver's smartphone/watch via the Sensor Safe application. Additionally, users can designate an emergency contact who will receive an email alert.

- 1) Level 1:
  - a. An auditory musical series of 13 chimes is issued once the engine is turned off. The series of chimes can repeat two times.
- 2) Level 2:
  - a. A visual, auditory, and haptic alert issued to a driver's smartphone/watch via the Sensor Safe application. The auditory alert is a spoken alert stating, "Child in Car" (Figure 6).
- 3) Level 3:
  - a. An alert is sent to the designated emergency contact via the Sensor Safe application. Alert includes information on the last known location of the vehicle and vehicle description if this feature is enabled (Figure 7).



**Figure 6. Photo. Sensor Safe level 2 visual notification.**



**Figure 7. Photo. Sensor Safe level 3 visual notification.**

The app is not required for users to receive the level 1 in-vehicle alert. However, it must be open or at least running in the background in order to receive the level 2 and 3 alerts.

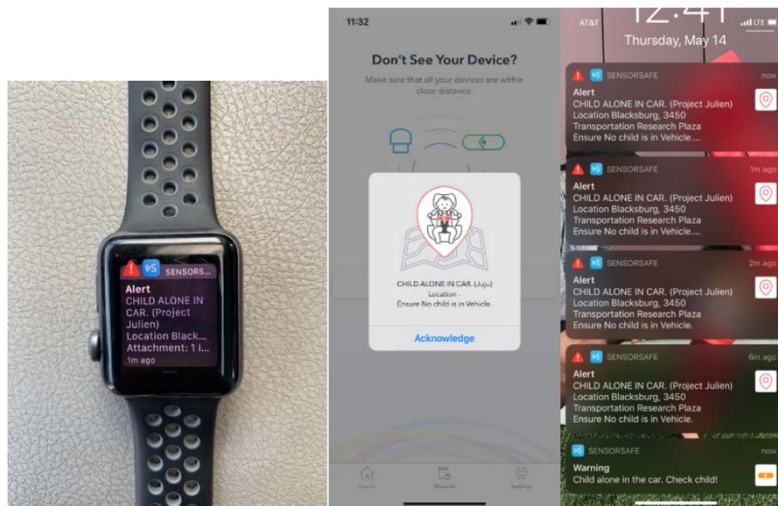
### ***How System Is Armed***

To initially set up and arm the Sensor Safe 2.0 system, the driver must first download the Sensor Safe application to their smartphone and “Add a device,” during which the restraint clip must be buckled, the wireless receiver must be plugged into the OBD-port, and the vehicle must be running. Though this application is not required for the level 1 alert, it is required for this initial setup. Information about the vehicle, such as manufacturer, model, year, exterior color, standard vs. hybrid, electric, or vehicle with start stop technology must be entered into the application’s settings. The wireless receiver plugs into the vehicle’s OBD port and monitors vehicle actions in order to determine when an alert should be issued.

The Sensor Safe system is armed once the restraint clip is buckled and the vehicle travels at more than 5 mph. The level 2 alert is armed at the same time as the level 1 alert when the application is opened in the vehicle associated with the system (vehicle that has the wireless receiver plugged into the OBD). Once the engine is turned off, the system issues a musical chime alert. If the restraint clip remains buckled and the driver either remains in their vehicle for approximately 4

minutes with the ignition off or exits their vehicle with their app running in the background (researchers measured within approximately 35 ft), the system issues the level 2 alert. If the level 2 alert has gone off for 4 minutes without any intervention, the system then notifies the emergency contact via a push notification (level 3 alert).

There is no option to manually disarm or dismiss the first level of the Sensor Safe alert system. The second level of this alert system can be dismissed by ignoring the phone alerts or by selecting “Acknowledge” in the app. However, the same visual, audio, and haptic alerts will continue to be issued every 5 minutes until the harness associated with the system is unbuckled. (Figure 8). The level 3 alert has no manual disarm or dismiss option before issuing the alert, which will only be issued if no prior disarming of the system has taken place.



**Figure 8. Photo. Sensor Safe application alerts on watch and driver’s phone.**

### ***System Performance Across Scenarios***

For testing, researchers used an iPhone XS and iPhone 11 as the mobile app devices. For measuring distances, researchers used a Rolatape model 112.

**Child Knowingly or Unknowingly Left in Vehicle:** As shown in Table 11, the Sensor Safe 2.0 monitor system issued alerts at the final destination in all conditions under which a child would be knowingly or unknowingly left unattended in a vehicle. Additionally, if there were any stops prior to the final destination, the system would also issue the level 1 alert at each midway stop where a driver stepped out of the car (i.e., getting gas, helping another child out of car, etc.). The level 2 and 3 alerts were not issued during any conditions with mid-way stops provided that the driver did not walk away from the vehicle with the smartphone. Importantly, the Sensor Safe system remained armed through these mid-way stops and issued an alert again at the final destination.

**Table 11. The Sensor Safe 2.0 alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening with vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening with vehicle in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** Per Table 12, Sensor Safe 2.0 did not issue an alert in any situation in which a child independently gained access to a vehicle. The Sensor Safe 2.0 system is not designed for such scenarios, as it needs to be armed for every use by buckling the restraint clip and driving the vehicle at a speed of at least 5 mph.

**Table 12. Sensor Safe 2.0 monitor system alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: “✓” denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

**Competing Alerts and Activities**

Because this is an aftermarket approach, none of the pre-existing vehicle features competed with Sensor Safe’s general operation, as seen in Table 13. The research team did not experience any impacts from the device reading the vehicle Controller Area Network (CAN). However, it is important to note that users should be aware of the potential issues aftermarket OBD port plug-in devices can cause to their vehicle’s system along with disclaimers from OEMs on unapproved aftermarket devices. Researchers also tested what would occur with the level 2 alert system if the driver was using other applications—such as music, navigation, or social media—on the phone while walking away from the vehicle. Under all circumstances, the full level 2 alert, including visual, audible and haptic alerts, interrupted any other phone applications.

**Table 13. Sensor Safe 2.0 Monitor System alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued without conflict</i>									

***Challenges and Inconsistencies***

This Sensor Safe 2.0 alert system requires caretaker buy-in to first purchase this system. Hybrid drivers will also need to order an additional adapter that can adjust to the ignition OFF/ON sequence of a hybrid, which they may not realize until they purchase the original system and begin setup. Furthermore, the driver must remember to open the application every time they drive or, at a minimum, leave the application running on their smartphone if they want to make use of the level 2 and level 3 alerts. The system assumes that the caretaker owns a smartphone/watch to download the app and complete setup procedures. The manual for Sensor Safe 2.0 states that the level 1 auditory alert should go off 2 seconds after the engine is shut off. However, during testing, researchers experienced trials where the level 1 alert usually did not sound until approximately 30 seconds after the engine was turned off. If a driver is in a hurry, they may be out of their vehicle and on their way well before the alert is issued, rendering this alert level ineffective. In addition, the level 1 alert was occasionally issued during normal driving behavior without turning off the engine. Lastly, the system can easily be moved into another vehicle without properly configuring it to the new vehicle. While the system works without any immediate issues and could be useful to two-car families that want to make the switch between vehicles, this could lead to problems if the vehicles have different powertrains (hybrids, electric vehicles) or in cases where the emergency contact is alerted and a search is undertaken for the vehicle assigned to the system instead of the vehicle it is actually installed in. The system does not provide solutions to drivers for any gained access scenarios.

***Overall System Assessment***

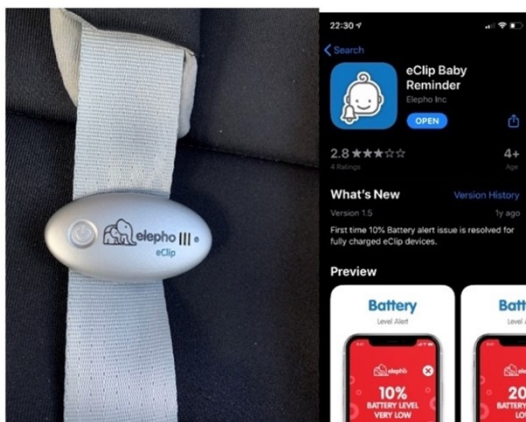
The level 1 alert is attention grabbing for a driver, but not loud enough to potentially wake a sleeping child, which is beneficial to caregivers. The alert chimes are harmonious rather than harsh. The non-issuance of the level 2 alert when the driver is still close by (presumed by the proximity of the phone to the wireless receiver) is also appropriate for any mid-way stops which could otherwise lead to a nuisance alert. With an adult nearby, it is presumed that there is no immediate danger to the child. The level 3 alert of contacting other family members or an emergency contact with the GPS coordinates of the vehicle via the phone app is beneficial. However, an actual phone call to emergency contacts if the alert is not acknowledged after a designated amount of time could also be helpful..

## SENSOR-BASED

### Elepho eClip

#### *System Overview*

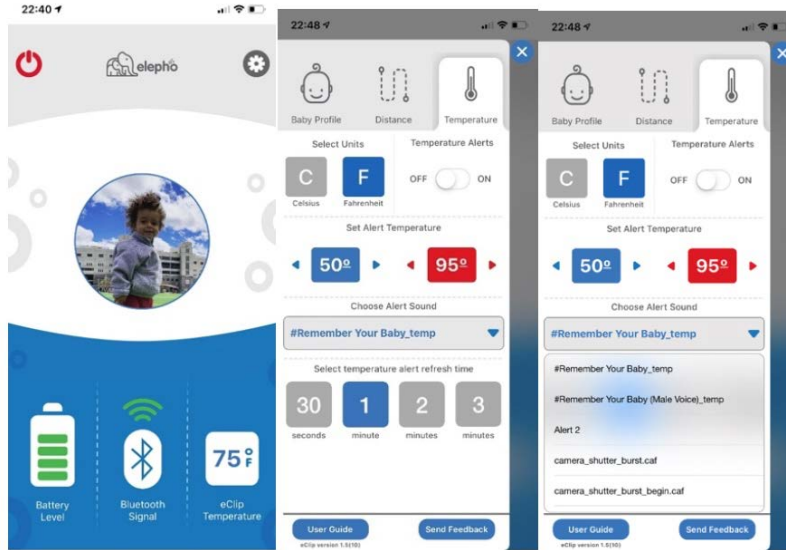
The Elepho eClip system uses Bluetooth technology to sense the distance between the eClip device and a caregiver's smartphone to determine whether or not a child may have been left in a vehicle (Figure 9). The eClip may be placed wherever is most suitable for the caregiver; the manufacturer suggests a car seat strap, diaper bag, or adult seatbelt strap as appropriate locations. When the caregiver's mobile phone is approximately 25 ft from the eClip, the Bluetooth signal is lost and audio, visual, and haptic alerts are issued to the caregiver via their phone.



**Figure 9. Photo. Elepho eClip on child restraint strap and application.**

The Elepho eClip provides a single-level auditory, visual, and haptic alert delivered to a caregiver's phone, relying on the presence of a Bluetooth connection between the smartphone and the eClip to determine whether an alert is warranted. The eClip application must be downloaded onto the driver's Apple or Android smartphone. The application can be personalized with the name and picture of the child the system is being used to monitor. Also customizable are the type of audio alert that is given, frequency of both distance and temperature alerts, and the thresholds for issuing maximum and minimum temperature alerts (Figure 10). The Elepho eClip requires a CR-2032 battery, which did not come with the system, and requires replacement approximately every 6 months (Elepho, n.d.). The app comes equipped with a battery level monitor, which notifies the caretaker when the battery needs to be replaced (Figure 10).

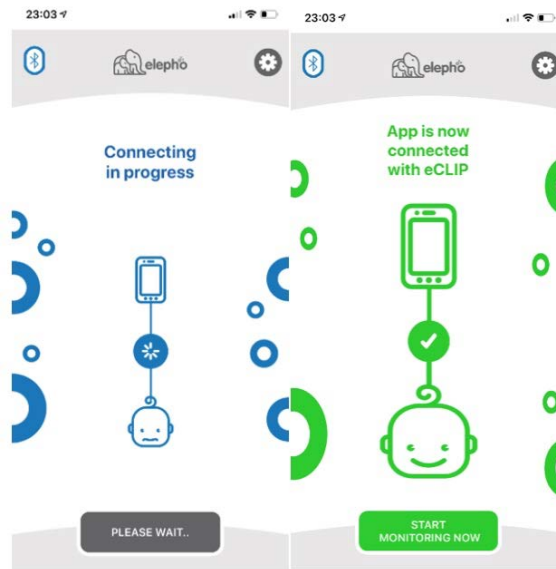




**Figure 10. Photo. Elepho eClip application and customization options.**

### *How System Is Armed*

The eClip must be turned on by pressing the “on” button located on the front of the clip for 3 seconds. The application must also be opened on a device within 6 ft of the eClip to connect via Bluetooth. The app will show “connecting in progress” in blue before turning green with a message “App is now connected with eCLIP” (Figure 11).



**Figure 11. Photo. Elepho eClip connection.**

After this initial pairing, merely launching the application will arm the system without additional driver input. The application must be launched for every drive to arm the system. Once the system is armed, an alert is issued as follows once the Bluetooth connection between the eClip

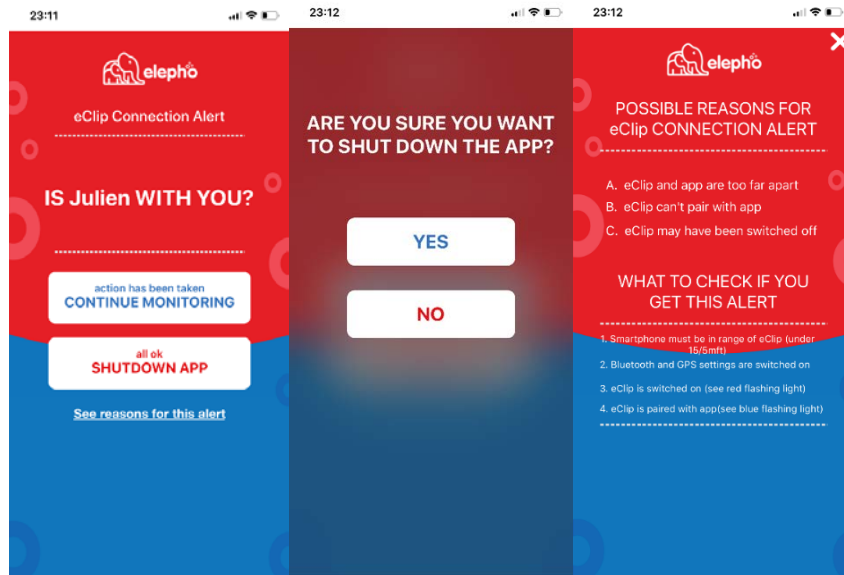


and the caregiver’s mobile phone is lost. Elepho indicates that this alert occurs once the mobile phone is approximately 25 ft away from the eClip.

1) Level 1:

A visual alert on the caregiver’s phone asks if the caregiver has the child with them and prompts the user to respond with “action has been taken CONTINUE MONITORING” or “ALL OK SHUTDOWN APP” (Figure 12).

- i. Selecting ALL OK SHUTDOWN APP will prompt the app to send a confirmation question to the caretaker: “ARE YOU SURE YOU WANT TO SHUT DOWN THE APP, YES OR NO” (Figure 12).
  - ii. There is also a “See reasons for this alert” hyperlink that the caretaker can select that will give possible reason for the alert along with actions to take if the alert is issued (Figure 12).
- b. An audio alert of the user’s choosing with the default audio as “eClip connection alert. Have you taken your child out of the car?”
- c. A vibration of the phone.



**Figure 12. Photo. Elepho eClip alert with options.**

The volume level of the alert is automatically set to the maximum volume regardless of the actual phone settings. Elepho warns that if the device goes into a sleep mode or if the screen is turned off, the user may not receive any alerts; however, during this evaluation, the alert was still issued when the screen was turned off. The issued audio alert continues despite hitting the phone’s volume or lock button.

The Elepho eClip system has the option to manually disarm or dismiss the alert before it is issued by shutting down the eClip app on the smartphone. In addition, after the alert is issued, the caretaker has the ability to disarm the system without returning to the vehicle. The visual alert is accompanied by a choice on the mobile application to continue monitoring or to shut down the application. If the user chooses to shut down the application, they are asked once more if they are

sure and are prompted to respond “YES” or “NO” (Figure 12). The system is then disarmed until a caregiver arms it for the next desired trip.

***System Performance Across Scenarios***

For testing, researchers attached the eClip to the child car seat strap of the Cybex Sirona M car seat and used an iPhone XS as the device for the mobile application. For measuring distances, researchers used a Rolatape model 112.

**Child Knowingly or Unknowingly Left in Vehicle:** As shown in Table 14, the Elepho eClip system alerted the research team at the final destination in all conditions under which a child would be knowingly or unknowingly left in a vehicle. Researchers noted that though Bluetooth connection may be lost around 25 ft, there was a delay in the alert being sent to the device. Researchers measured distances of over 150 ft from the driver side door of the vehicle before receiving an alert while walking at a typical pace.

**Table 14. Elepho eClip alert issued in unknowingly/knownly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** Per Table 15, the Elepho eClip system did not issue an alert for any scenario in which a child independently gained access to a vehicle. The Elepho eClip system is not designed for such a scenario, as it needs to be armed each time it is used.

**Table 15. Elepho eClip alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: “✓” denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

***Competing Alerts and Activities***

Because this is an aftermarket approach, none of the pre-existing vehicle features competed with the Elepho eClip’s general operation. Researchers tested for potential interruption of the alert

should the caregiver be using other applications—such as music, navigation, or social media—on the phone while walking away from the eClip. When using navigation or social media, the full range of alerts, including visual, auditory and haptic, was issued to the user. However, when listening to music, only a vibration and visual alert appeared on the device. Regardless, some part of the alert was successfully issued under all circumstances, as shown in Table 16.

**Table 16. Elepho eClip alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued without conflict</i>									

### ***Challenges and Inconsistencies***

The Elepho eClip system requires caretaker buy-in to first purchase, download, and install the phone app, and also to ensure the system is properly armed for each trip and that the phone is charged. It also relies on a battery within the clip. The system does not provide solutions to drivers for any gained access scenarios.

### ***Overall System Assessment***

The Elepho eClip system relies on Bluetooth connectivity, which means that the caregiver must have a smartphone with these capabilities. There is no part of the system that functions without the presence of a smartphone, and only one phone can be connected to the eClip at a time. This can limit the customer base for this system to only those who have a compatible device. The eClip can be disarmed without any physical action taking place at the vehicle. This could be an advantage to caregivers who knowingly leave their child in the vehicle with another adult and do not need to actually return to the vehicle to check on the child. However, if a caregiver has already distanced themselves by up to 150 ft, possibly having entered a building, they may decide to continue their outing, leaving the child in the vehicle with the thought that their task will only take a few minutes, and subsequently dismissing the alert from a distance. As reflected in stories of PVH incidents, the caregiver could then lose track of time while the child remains in the vehicle or could forget the child is there altogether. The app is extremely intuitive and customizable. The ability to make the alert more personal by adding the child’s picture and name can make the alert more salient. Being able to control the frequency and type of audio alert expressed is also helpful in situations where the parent may not want bystanders to know they left their child in the vehicle by announcing that exact message as the alert.

## AFTERMARKET VEHICLE INTEGRATED TECHNOLOGY

### Ride N Remind System

#### *System Overview*

The Ride N Remind System is an integrated implementation that is based on the detection of a rear door opening and closing relative to shutting the ignition off. The Ride N Remind system issues an audio alert upon turning the ignition off after a rear door opens and closes.

Ride N Remind's manufacturer recommends professional installation of the product. For this evaluation, hardware engineers from VTTI's Center for Technology Development installed the system in a 2008 Chevrolet Tahoe per the included instructions. This implementation comes with two buttons that are installed in the C-pillars of the passenger side door frames (Figure 13) and the Ride N Remind system box that is installed into the Body Control Module, which then reads whether a rear door has been opened and if the engine was running and has since been turned off. Installation can vary based on the vehicle and which engine circuit was used. The triggering information for the alert could be the engine being turned off, keys being removed from the vehicle (if keys are present), or any other vehicle status such as "ON" even while the engine is off. To support this evaluation, the system was installed using the vehicle "on" status and key removal as the trigger information for issuing the alert. As an integrated system, Ride N Remind uses the vehicle's energy supply instead of relying on chargeable or disposable batteries.



**Figure 13. Photo. Ride N Remind buttons in C-pillars.**

#### *How System Is Armed*

The Ride N Remind system arms if the rear door is opened for a minimum of 3 seconds within 15 minutes of the engine turning on or while the engine is already running, issuing an auditory chime to acknowledge that the system is armed. Once the system is armed, an alert is issued as follows after the ignition is turned off or keys are removed per the aforementioned installation method.

- 1) Level 1:
  - a. An auditory chime that begins once engine is turned off or keys are removed from the ignition.
- 2) Level 2:
  - a. An auditory alert of a series of honks from the vehicle's horn.

The Ride N Remind system does not have an option to manually disarm or dismiss the level 1 audio alert before it is issued. The system will issue the level 1 alert each time conditions are met after the engine is turned off or the key is removed. The level 2 alert can be disarmed before it is issued; however, the driver must open the rear door and press the installed button on the C-pillar within 40 seconds of the ignition off or keys removed (per method of installation) in order to dismiss the level 2 alert. If the driver does not open the rear door and press the button within 40 seconds, the system issues the level 2 alert.

The system can be disarmed after the level 1 or level 2 alert by opening the rear door and pressing the installed button in the C-pillar. Notably, pressing the button while the rear door is closed and the windows are rolled down will not disarm the system, as the rear door must be opened. If the driver opens the rear door, leaves it open, but does not press the button, the system will delay issuing the level 2 alert for 10 minutes. The level 2 alert will still sound within 40 seconds if the driver closes the door before the 10-minute grace period. A driver can also press the button five consecutive times to temporarily disarm the system for 3 hours. The system will automatically arm again the next time conditions are met.

### ***How Alerts Performed Under Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** As shown in Table 17, the Ride N Remind issued the level 1 and level 2 alerts at the final destination for all intentional and unintentional leaving scenarios, except for the scenarios involving a stop mid-drive with the ignition off. In these scenarios, the level 2 alert was issued mid-trip but not at the final destination. In addition, for any scenario in which the vehicle was placed in accessory mode with the keys remaining in the ignition, the system merely gave a brief auditory “chirp” and no further alerts were given. It is important to note that this situation is unique to how researchers installed this system for testing, as it is the most likely situation for a driver forgetting their child in the vehicle. The installer for this research said that this scenario could be changed so that an alert is issued once the engine is off versus once the keys are removed from the ignition. Researchers counted the audio chirp as an alert for these results; however, the level 2 alert was never issued in scenarios where keys were left in the ignition (accessory mode). Researchers also added the step of removing keys whenever the engine was turned off when testing the Ride N Remind to ensure similar results should this system be installed with the ignition off status being the condition required to issue the alert. The Ride N Remind system did not issue level 2 alerts during mid-way trips with rear doors opening and closing, but the level 1 brief auditory chirp was given during these events.

**Table 17. Ride N Remind alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** Per Table 18, the Ride N Remind system did not issue an alert for any scenario in which a child would independently gain access to a vehicle. The Ride N Remind is not designed for such a scenario, as the ignition needs to be turned on in order to fully arm the system.

**Table 18. Ride N Remind alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: “✓” denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

***Competing Alerts and Activities***

None of the pre-existing vehicle features competed with Ride N Remind’s general operation even though it was integrated into the vehicle (Table 19).

**Table 19. Ride N Remind alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued without conflict</i>									

***Challenges and Inconsistencies***

The Ride N Remind alert system requires caretaker buy-in to first purchase and then have the system professionally installed. Installation cost can range from \$100 to \$200 depending on the shop (Amazon, n.d., b), however, buyers may attempt to forgo the recommendation for professional installation and install the system themselves. The manner of system installation will determine how the system ultimately operates and issues alerts—specifically, which engine

signal is tapped into to define the condition to issue the alert (i.e., ignition off vs. keys removed). If this system is installed in a push start vehicle, there is a true ignition off signal, as opposed to a key start vehicle, which can have multiple options for ignition off. The driver could accidentally disarm the system for 3 hours by pushing the C-pillar button five consecutive times in a rush to disarm the system before the horn alert activates. This system will need to be explained to everyone driving the vehicle, as it may issue the alert to unsuspecting drivers who have opened and closed the rear door for a purpose other than placing a child in the rear seat and may become startled and/or confused when the horn begins to sound loudly if the system is not disarmed. Caretakers may also get irritated that there is no way to disarm the system from the driver's seat to prevent the chimes from waking a sleeping child. The system does not provide solutions to drivers for any gained access scenarios.

### ***Overall System Assessment***

As noted, the Ride N Remind system can function differently based on how the system is installed. Depending on the manner of installation, a caregiver could simply leave the key in the ignition and leave the child in the car knowingly without an alert going off. For example, if a child is sleeping, and the caregiver does not want to disturb the child, they could leave them in the vehicle while running errands without any alerts, possibly putting them at risk of PVH. However, this feature can also be beneficial, as it allows a caregiver to avoid causing the system to issue an alert if the child is asleep and they want the child to remain sleeping. The Ride N Remind company states: "When filling up for gas, turn off the engine but leave ignition switch in the on position. When left this way for only a few minutes, no harm will be caused to the car battery and this will allow you to avoid having to deactivate the chime."

Following the manufacturer-suggested steps, it is also possible that, depending on the method of installation and vehicle configuration, the system would remain armed until the final destination during a stop mid-drive, unlike in the current study. In addition, since the rear door needs to be open for at least 3 seconds in order to arm the alert system, these suggested steps would cut back on alerts for situations in which people may just be quickly placing items in the back of the car, which would not merit a critical reminder. If a driver were to receive too many reminders for unnecessary items, they may consider the system a nuisance.

The level 2 alert of the car horn can get not only the driver's attention but of that of any bystanders that may be able to take action. However, a horn alert to a bystander does not clearly indicate what the problem with a vehicle may be (theft, keys left in vehicle, or unaccompanied child) and hence may not actually invoke a call to action.

### **ACTIVE OEM TECHNOLOGY**

The following OEM technologies are presented in order of increasing technology complexity. While each implementation has limitations, it is important to note that these systems have been voluntarily implemented by the reflected OEMs in an attempt to create a technology that can help save children from PVH. As of this writing, many OEMs still do not offer a solution. Developing a robust system to detect children unattended in a vehicle while minimizing nuisance alerts is a difficult task; however, these OEMs have put effort into the first steps to address PVH. Importantly, implementations are continuously evolving, with broader availability and increased capabilities offered with each new model year.

## General Motors RSR

### *System Overview*

GM was the first vehicle manufacturer to address the PVH problem with a RSR technology in some of their 2017 vehicles (White, R., 2016), and also offers the broadest coverage across their vehicle lineup. The GM RSR system uses door logic to determine whether to issue an alert to a driver. The system issues an alert when a rear door has been opened up to 10 minutes before the engine is turned on or while the engine is already running and is then turned off.

GM's RSR system provides a single-level auditory and visual alert relying on the combined information of the rear door opening and engine status to determine whether issuing an alert is warranted. The feature can be turned off through the vehicle settings. See Table 20 for a list of GM models with RSR technology. GM plans to make RSR standard on nearly all of their four-door vehicles by 2022 (Olsen, 2019). The vehicle included in this study was a 2017 GMC Acadia (Figure 14).

**Table 20. GM Models with RSRT**

Year	Make	Make	Trim Level
2017, 2018, 2019, 2020	GMC	Acadia	All
2017, 2018, 2019, 2020, 2021	GMC	Canyon	All
2017, 2018	GMC	Sierra (4-door)	All
2017, 2018, 2019, 2020, 2021	GMC	Yukon	All
2017, 2018, 2019, 2020	GMC	Yukon XL	All
2019, 2020	GMC	Sierra 1500	All
2019, 2020	GMC	Sierra 1500 Limited	All
2019, 2020	GMC	Sierra 2500HD	All
2019, 2020	GMC	Sierra 3500HD	All
2019, 2020	GMC	Terrain	All
2017, 2018, 2019	Buick	LaCrosse	All
2018, 2019, 2020	Buick	Enclave	All
2019, 2020	Buick	Encore	All
2019, 2020	Buick	Envision	All
2019	Buick	Regal	All
2019, 2020	Buick	Regal TourX	All
2020	Buick	Encore	All
2020	Buick	Encore GX	All
2020	Buick	Regal Sportback	All
2020	Buick	Regal GS	All
2017	Cadillac	CT6 (2017i)	All
2017, 2018, 2019, 2020, 2021	Cadillac	Escalade	All
2018	Cadillac	ATS (sedan)	All
2018, 2019, 2020	Cadillac	CT6	All
2018, 2019	Cadillac	CTS	All



<b>Year</b>	<b>Make</b>	<b>Make</b>	<b>Trim Level</b>
2018	Cadillac	CTS (V series)	All
2018, 2019, 2020	Cadillac	XT5	All
2019, 2020	Cadillac	XT4	All
2019	Cadillac	XTS	All
2020	Cadillac	CT4	All
2020	Cadillac	CT5	All
2020	Cadillac	CT6-V	All
2020	Cadillac	Escalade ESV	All
2020	Cadillac	XT6	All
2017, 2018, 2019, 2020	Chevrolet	Bolt EV	All
2017, 2018, 2019, 2020, 2021	Chevrolet	Colorado	All
2017, 2018, 2019	Chevrolet	Cruze	All
2017, 2018, 2019, 2020	Chevrolet	Malibu	All
2017, 2018	Chevrolet	Silverado (Crew Cab)	All
2017, 2018, 2019, 2020, 2021	Chevrolet	Suburban	All
2017, 2018, 2019, 2020, 2021	Chevrolet	Tahoe	All
2018, 2019, 2020	Chevrolet	Equinox	All
2018, 2019, 2020	Chevrolet	Traverse	All
2019, 2020	Chevrolet	Blazer	All
2019, 2020	Chevrolet	Silverado 1500	All
2019	Chevrolet	Silverado 1500 LD	All
2019, 2020	Chevrolet	Silverado 2500HD	All
2019, 2020	Chevrolet	Silverado 3500HD	All
2019, 2020	Chevrolet	Spark	All
2019, 2020	Chevrolet	Trax	All
2019, 2020	Chevrolet	Volt	All
2021	Chevrolet	Trailblazer	All



**Figure 14. Photo. 2017 GMC Acadia.**

### ***How System Is Armed***

The RSR comes enabled on GM vehicles but can be disabled manually via the settings menu. GM's RSR is based on a rear door logic window of 10 minutes, meaning that the system will arm if the rear door is opened up to 10 minutes before the engine is turned on or while the engine is already running. The system then remains armed until the car is turned off, regardless of whether the rear door has been opened and closed again since the time of arming. Once the system is armed, an alert is issued as follows after the engine is turned off.

- 1) Level 1:
  - a. A visual alert that displays the message "Rear Seat Reminder Look in Rear Seat" in the middle of the instrument cluster for 10 seconds.
  - b. An auditory alert sounds five quick and short chimes.

The GM RSR system does not have an option to manually disarm the audio alert before it is issued; however, when the visual message appears in the instrument cluster, there is an option to "Dismiss" the alert and clear the message if desired (Figure 15). The RSR alert system is automatically disarmed after the visual and auditory notifications are issued.



**Figure 15. Photo. GM RSR alert.**

***How Alerts Performed Under Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** The GM RSR system alerted the research team at the final destination in 75% of the tested conditions under which a child would be knowingly or unknowingly left unattended in a vehicle (Table 21). The GM RSR system did not alert drivers at the final destination for scenarios in which a driver turns the ignition off and leaves the vehicle before entering again to complete a drive (e.g., getting gas, dropping another child off, etc.). During these scenarios, the alert would go off at that mid-trip stop and not at the final destination since the logic for the system is based on the rear door opening with a new ignition cycle to engage the system.

**Table 21. GM RSR alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓

*Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked*

**Child Gains Access:** The GM RSR system did not issue an alert for any scenario in which a child independently gained access to a vehicle. The GM RSR is not designed for such a scenario, as the ignition must be turned on to fully arm the system.

**Table 22. GM RSR alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL

*Note: “✓” denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked*

***Competing Alerts and Activities***

Even though the GM RSR system is integrated into the vehicle, there were some issues with competing notifications that altered how the RSR technology was delivered and possibly received. If music is playing in the vehicle, the auditory alert takes precedence and the music volume is lowered. However, if the driver is on their phone via Bluetooth, the alert is still issued but does not interrupt or turn the volume down on the call as the system does with music. The open hood alert overrode the RSR alert partially or entirely two out of the four times tested, but did not do so in any consistent manner researchers could determine.

**Table 23. GM RSR alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓*	✓	✓	✓*	✓	✓	✓	✓*

*Note: “✓” denotes that the alert was issued  
\* denotes that while an alert was issued, a possible conflict with system could change normal alert delivery*

***Challenges and Inconsistencies***

During the testing of the GM RSR system a number of inconsistencies were found. For any testing in which the system was placed into accessory mode before exiting the vehicle, the visual alert would briefly appear before being interrupted by the message, “Press brake to start.” The alert was issued inconsistently for times where the vehicle hood was opened before the engine was started, at times issuing both the visual and auditory alert, sometimes only the visual alert, and other times neither alert. Notably, the GM RSR alert does not provide any secondary alerts if the driver leaves the vehicle without checking the rear seat. The system does not provide solutions to drivers for any gained access scenarios.

***Overall System Assessment***

The GM RSR alert system relies on any short opening of a rear door to arm the system. This means that a quick opening and shutting of a rear door (e.g., to put an item in the back of the vehicle) could result in the driver receiving an RSR alert. However, as the manual notes, this is exactly what the system is designed to do, and does so effectively: remind a driver that there may be something in the rear seat when they exit, though the “something” may not necessarily be a child (General Motors, 2018; Appendix E). But this also means that drivers may hear this alert

frequently for all varieties of items left in a rear seat, and possibly begin to ignore alerts, even when a child is actually in the rear seat. At worst, a driver may choose to turn the feature off altogether via the vehicle’s settings if it is deemed an annoyance. The alert chime is also similar to other chimes in the vehicle, which may make it easier for the driver to confuse it with another alert.

In situations where the vehicle was placed into accessory mode upon leaving the vehicle, the RSR alert was issued briefly when the ignition was initially switched off in order to access the accessory mode but was swiftly replaced by another message and hence could easily be missed. The RSR system issues alerts to remind caretakers of a possible child in the rear seat but there are no additional alerts should a caretaker not hear or see these alerts and leave the vehicle. If a caretaker leaves the vehicle without taking action, there are no further alerts to address the situation.

## **Subaru RSR**

### ***System Overview***

The Subaru RSR system uses door logic to determine whether to issue an alert to a driver. The RSR system issues an alert upon turning the ignition off if a rear door has been opened up to 30 minutes before the engine starts, or if a rear side door is opened and closed while the vehicle is running and stationary. In addition, Subaru’s RSR remains armed and issues an alert if the engine is turned off and back on again within 30 minutes of completing a trip that met previous conditions during which all rear side doors remained closed.

Subaru’s RSR system provides a single-level auditory and visual alert, relying on the combined information of the rear door opening and engine status to determine whether issuing an alert is warranted. Users can opt to turn this feature off via the vehicle settings. See Table 15 for a list of Subaru models with RSR door-logic system. The vehicle tested for this study was the 2020 Subaru Ascent (Figure 16).

**Table 24. Subaru models with RSR.**

<b>Year</b>	<b>Model</b>	<b>Make</b>	<b>Trim Level</b>
2020	Subaru	Forester	All
2020	Subaru	Crosstrek	All*
2020	Subaru	Crosstrek Hybrid	All
2020	Subaru	Impreza	All*
2020	Subaru	Ascent	All
* indicates optional feature (not standard)			



**Figure 16. Photo. 2020 Subaru Ascent.**

### ***How System Is Armed***

The RSR comes enabled on the Subaru but can be disabled manually via the Combination Meter Display. Subaru states that the RSR is armed when the ignition is turned “on” within 30 minutes of a rear door being opened and closed or while the ignition is already “on” (Camden, 2019). The system then remains armed until the car is turned off, regardless of whether the rear door has been opened and closed again since the time of arming. Once the system is armed, an alert is issued per the following approach once the engine is turned off.

#### Level 1:

- a. A visual alert that displays the message “Reminder, Look in Rear Seat” in the middle of the instrument cluster for 10 seconds (Figure 17).
- b. An auditory alert of two short chimes.

Unless the RSR feature was disabled in the vehicle’s settings, users do not have an option to manually disarm the audio or visual alert before or at the time it is issued. The system will alert drivers each time the engine is turned off when conditions are met. After the system issues the auditory alert, it is then automatically disarmed until conditions are met again to arm the system and deliver the alert.



**Figure 17. Photo. Subaru RSR Look In Rear Seat message.**

***System Performance Across Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** The Subaru RSR issued alerts at the final destination in all conditions under which a child would knowingly or unknowingly be left in a vehicle. In all mid-trip conditions in which the car was turned off for a brief amount of time (such as getting gas), the alert was issued at the mid-trip stop as well as at the final destination since the system remains active if the engine is turned off and then back on again within 30 minutes of a previous trip in which the system was armed and no rear door was opened.

**Table 25. Subaru RSR alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

*Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked*

**Child Gains Access:** The Subaru RSR system did not issue an alert for any condition in which a child might independently gain access to a vehicle. The Subaru RSR is not designed for such a scenario due to its need to have the ignition turned on in order to fully arm.

**Table 26. Subaru RSR alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL

*Note: “✓” denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked*

**Competing Alerts and Activities**

There were no competing systems or alerts with the Subaru’s RSR visual alert in the instrument cluster. There were also no competing systems or alerts with the RSR’s auditory alert. However, researchers found that loud music could easily drown out the alert, as the system did not mute the music when issuing the auditory alert.

**Table 27. Subaru RSR alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓*	✓	✓*	✓

*Note: “✓” denotes that the alert was issued*  
*\* Denotes that while an alert was issued, a possible conflict with system could change normal alert delivery*

**Challenges and Inconsistencies**

By nature of its design, the RSR alert does not issue any secondary alerts if the driver leaves the vehicle without checking the rear seat, even if they have locked the doors with no intention of going back to check the rear seat. The auditory portion of the alert consists of two chimes that are identical to the chimes used when starting the vehicle, though the starting chimes are repeated six times. This same chime tone could also be used for other alerts not encountered during testing, creating a non-distinctive auditory cue and possibly resulting in drivers becoming desensitized to the alert. The system does not provide solutions to drivers for any gained access scenarios.

**Overall System Assessment**

The Subaru RSR alert system relies on any short opening of a rear door to arm the system. This means that a quick opening and shutting of a rear door (e.g., to put an item in the back of the vehicle, etc.) could result in the driver receiving a RSR alert. This is exactly what the system is designed to do, and does so effectively: remind a driver that there may be something in the rear seat as they exit the vehicle (Subaru Corporation, 2019; See Appendix F). However, this also means that drivers may hear this alert frequently for all varieties of items left in a rear seat and could begin to ignore the chimes even in situations where a child is left in the rear seat. The manual also states that the RSR is armed when rear doors are opened and closed while the engine



is on. However, the system also recognizes rear door opening and closings up to 30 minutes before the engine is turned on.

In situations where the vehicle was placed into accessory mode upon leaving the vehicle, the RSR alert was issued when the ignition was first switched off but then stopped once accessory mode was engaged. The RSR system issues alerts to remind caretakers of a possible child in the rear seat but there are no additional alerts should a caretaker not hear or see these alerts and leave the vehicle. If a caretaker leaves the vehicle without taking action, there are no further alerts to help address a situation in which a child remains in the rear seat.

In scenarios in which a driver would turn off the engine, exit the vehicle for a time, and then return to drive the vehicle within 30 minutes (e.g., getting gas, dropping off another child, etc.), the alert would be issued both upon the first and final exit as long as the rear door remained closed. This feature could be beneficial to caregivers with commutes to destinations involving short-duration stops en route.

## **Toyota Rear Seat Reminder**

### ***System Overview***

Toyota's RSR system relies on door logic to determine whether to issue an alert to the driver. This RSR system will issue an alert upon turning the ignition off if a rear door has been opened during a period of up to 10 minutes before the engine was originally started, or while the engine was already running.

Toyota's RSR system provides a single-level auditory and visual alert to the driver if the aforementioned conditions are met, and the alert can be turned off via the vehicle settings. Toyota's RSR is currently only available on 2020 Highlanders, which was the vehicle tested in this study (Figure 18).



**Figure 18. Photo. 2020 Toyota Highlander.**

## *Description of Alerts*

### **How System Is Armed**

The Toyota RSR comes from the OEM enabled but can be disabled manually via the vehicle settings. Toyota's RSR relies on a rear door logic, where the system arms if the rear door is opened for at least 2 seconds during a period of up to 10 minutes before the engine starts, or while the engine is already running. With an armed system, an alert is issued per the following approach upon turning the ignition off.

- 1) Level 1:
  - a. A visual alert that displays the message "Attention: Check Rear Seat" in the middle of the instrument cluster for 6 seconds (Figure 19).
  - b. An auditory alert of a single extended chime.

Once armed, users do not have the option to manually disarm the audio or visual alert before it is issued. The system will alert drivers each time the engine is turned off when conditions are met. After the system issues the auditory alert, it is then automatically disarmed until conditions for arming are again met.



**Figure 19. Photo. Toyota RSR Attention: Check Rear Seat message.**

### *System Performance Across Scenarios*

**Child Knowingly or Unknowingly Left in Vehicle:** The Toyota RSR system alerted the research team at the final destination in 75% of the tested conditions under which a child would knowingly or unknowingly be left unattended in a vehicle. The Toyota RSR system did not alert drivers at the final destination for scenarios in which a driver turned the ignition off and left the vehicle before entering again to complete a drive (e.g., stopping for gas, dropping off another child, etc.). During these scenarios, the alert would go off at that mid-trip stop and not at the final destination.

**Table 28. Toyota RSR alert issued in unknowingly/knownly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** The Toyota RSR system did not issue an alert for any condition in which a child might independently gain access to a vehicle. The Toyota RSR is not designed for such a scenario due to the requirement that the ignition be turned on in order to fully arm the system.

**Table 29. Toyota RSR alert issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: "✓" denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

**Competing Alerts and Activities**

There were no systems or alerts that competed with the Toyota’s RSR visual or audio alert. Music and telephone calls were stopped whenever the alert was issued so the audio alert was never drowned out.

**Table 30. Toyota RSR alert issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Note: "✓" denotes that the alert was issued</i>									

**Challenges and Inconsistencies**

By nature of its design, the RSR alert does not issue any secondary alerts if the driver leaves the vehicle without checking the rear seat, even if the driver has locked the doors and has no intention of going back to check the rear seat. The system does not provide solutions to drivers for any gained access scenarios.

### ***Overall System Assessment***

The Toyota RSR alert system relies on a rear door opening for least 2 seconds in order to arm the system. This means that a quick opening and shutting of a rear door (e.g., to put an item in the back of the vehicle) may not result in the issuance of an RSR alert. This 2-second requirement could reduce alerts for situations in which an item (e.g., bag, jacket, etc.) is simply placed in the back of the car quickly. This approach may help to address the potential of a driver receiving too many reminders for unnecessary items and may consider the system a nuisance and disregard or disable the alerts.

In situations where the vehicle was placed into accessory mode upon leaving the vehicle, the RSR alert was issued briefly when the ignition was initially switched off in order to access the accessory mode. The RSR system issues alerts to remind caretakers of a possible child in the rear seat but there are no additional alerts should a caretaker not hear or see these alerts and leave the vehicle. If a caretaker leaves the vehicle without taking action and a child remains in the rear seat, no further alerts or steps of action occur.

In scenarios in which a driver would turn off the engine, exit the vehicle for a period, and then return to drive (e.g., getting gas, dropping off another child), the alert would only be issued at the initial stop and the system would need to be armed again by opening a rear door, which would trigger the alert at the final destination.

### **Nissan Rear Door Alert**

#### ***System Overview***

The Nissan Rear Door Alert (RDA) system also uses door-logic to determine whether to issue an alert to a driver. The RDA system issues an alert when a rear door has been opened within up to 10 minutes of turning the engine on or while the engine is already on and is then turned off. In addition, if the rear door is not opened after these first alerts are issued, a secondary audio and visual alert is issued once the doors are locked from either inside or outside the vehicle.

Nissan's RDA provides a two-level auditory and visual alert. Information on rear door opening, engine status, and door lock status is combined and used to determine whether an alert is warranted. See Table 23 for a list of Nissan models with the RDA system. For this report, researchers evaluated the RDA system on a 2020 Nissan Rogue (Figure 20).

**Table 31. Nissan models with rear reminder technology.**

<b>Year</b>	<b>Make</b>	<b>Model</b>	<b>Trim Level</b>
2018, 2019, 2020	Nissan	Pathfinder	All
2019, 2020	Nissan	Altima	All
2019, 2020	Nissan	Armada	All
2019, 2020	Nissan	Leaf	All
2019, 2020	Nissan	Maxima	All
2019, 2020	Nissan	Murano	All
2019, 2020	Nissan	Rogue	All
2019, 2020	Nissan	Rogue Sport	All

Year	Make	Model	Trim Level
2019, 2020	Nissan	Titan (4-door)	All
2020	Nissan	Kicks	SV, SR
2020	Nissan	Versa	SV, SR
2020	Nissan	Sentra	All



**Figure 20. Photo. 2020 Nissan Rogue.**

### ***How System Is Armed***

The Nissan RDA does not come enabled; the driver must manually enable the system in the vehicle settings. Once the alert is enabled, drivers may choose to have a visual alert only or the visual alert plus the horn alert. The RDA is armed using rear door logic. The system detects if the rear door is opened up to 10 minutes before the engine is started (using the key or remote start) or opened once the engine is already running. A message appears in the instrument cluster to alert the driver that the RDA is armed once conditions are met (Figure 21). This message reappears once the engine is turned off. If the driver does not disarm the system at this time, an alert is issued per the following approach once the driver's door is opened and closed.

1. Level 1:
  - a. A visual alert that displays the message “Check Rear Seat for All Articles” on the instrument cluster (Figure 22).
2. Level 2 – issued after a level 1 alert if the rear door remains closed and doors are locked using either the interior or external locking mechanisms:
  - a. A series of three quick horn honks that will cycle through twice.



**Figure 21. Photo. Nissan RDA is activated message.**



**Figure 22. Photo. Nissan Check Rear Seat for All Articles message.**

The Nissan RDA system allows for manually disarming or dismissing the alerts at two different stages. The message that appears in the instrument cluster to inform the driver that the RDA is armed gives the option to dismiss the message or disable (disarm) the alert for that trip (Figure 21). If the driver does nothing or chooses “Dismiss message” to clear the message, the alert remains armed. The driver is also given the option of selecting “Disable Alert” in the level 1 alert message in order to prevent the system from issuing the level 2 alert, if enabled. To dismiss the level 2 alert after it has been issued, the rear door must be opened. After the system issues all relevant alerts, it is then automatically disarmed until arming conditions are met again.

### ***System Performance Across Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** The Nissan RDA issued alerts at the final destination in conditions under which a child would be knowingly or unknowingly left in a vehicle only for trips with no mid-trip stops or rear door openings prior to turning the vehicle off (25% of conditions). If there were any mid-trip stops, the RDA would issue an alert at the stop but not at the final destination (e.g., getting gas, quick stop at a convenience store, etc.) For



scenarios where a rear door was opened mid-trip with the engine remaining on (e.g., a rear seat occupant exiting the vehicle without the driver opening their door), the alert was not issued at the end of the trip.

**Table 32. Nissan RDA issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓	✓	✓												
<i>Note: "✓" denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** The Nissan RDA system did not issue an alert for any condition in which a child independently gained access to a vehicle. The Nissan RDA system is not designed for such a scenario, as the engine must be turned on in order to fully arm the system.

**Table 33. Nissan RDA issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
<i>Note: "✓" denotes that the alert was issued. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

### ***Competing Alerts and Activities***

Though the Nissan’s RDA system always delivered either the visual or audio alert with competing alert systems, these were often shortened, overridden, or delayed by other vehicle alerts. When the vehicle is using navigation and stops mid-trip, the instrument cluster continues to display the navigation screen instead of the RDA alert. However, the level 2 alert is issued in this condition if the rear door is not opened. If the trunk is ajar, the visual reminder of an open trunk overrides the RDA alert in the instrument cluster for 30 seconds. The RDA system will not issue a level 2 auditory alert until the trunk is closed.

**Table 34. Nissan RDA issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓* <sup>1</sup>	✓	✓	✓* <sup>1,2</sup>	✓	✓	✓	✓	✓* <sup>1</sup>	✓* <sup>1</sup>
<p><i>Note: “✓” denotes that the alert was issued</i>  <i>* Denotes that while an alert was issued, a possible conflict with system could change normal alert delivery.</i>  <sup>1</sup>Level One Alert  <sup>2</sup>Level 2 Alert</p>									

### ***Challenges and Inconsistencies***

Nissan’s RDA system does not come factory-enabled. This means that the caretaker must be aware that the system is available, know how to enable it, and go through the steps to actually enable the feature through the vehicle settings. During testing of the RDA, researchers noted a few instances in which the alert might not perform as anticipated. The level 1 visual alert is not issued until after the driver’s door opens and shuts, which is presumably when the driver has already exited the vehicle and hence is not looking at the instrument cluster. Overall, the alert was not consistently triggered by the same actions during testing. Sometimes the alert was not issued even though all conditions had been met, and sometimes only the visual alert was issued; the audible horn honk was not issued even though both alert levels were enabled in the vehicle settings. At other times, the display would issue a message that the RDA was armed, but no alert was issued when conditions were met. Researchers could determine no reason for this inconsistency, but the arming of the alert was confirmed via the vehicle message before testing each scenario. Sometimes the vehicle was reset by leaving all doors closed and untouched with the ignition off for at least 10 minutes after opening a rear door. Opening a rear door within 10 minutes of an engine start arms the system according to the Nissan manual (Nissan, 2019; Appendix G). The system does not provide solutions for any gained access scenarios.

### ***Overall System Assessment***

Because Nissan’s RDA system is not enabled as the default on delivery, the onus is on the driver to know that the vehicle is equipped with the system, learn how it works, and then enable it for use. Nissan’s RDA system has a second level alert, which can be beneficial in reminding a caregiver of a child left in the rear seat. The ability to easily dismiss and disarm an alert manually for each trip may also cut down on nuisance alerts, which may lead caregivers to disable the alert system. The absence of alerts during scenarios with mid-trip stops or additional rear door openings, however, is concerning. Though this can be beneficial in cutting down on nuisance alerts if a child has been dropped off mid-trip, it can also lead to a potential number of missed situations where an alert could be warranted. The inconsistency of alerts issued under conditions which met the criteria is also problematic.



## Hyundai/Kia Rear Occupant Alert and Ultrasonic Rear Occupant Alert

### *System Overview*

Hyundai and Kia offer two rear seat reminder systems: a first level Rear Occupant Alert (ROA) door-logic system and a second level Ultrasonic Rear Occupant Alert (UROA) sensor-based system with ceiling-mounted ultrasonic sensors (Figure 23) designed to detect movement in the rear seats. When armed, the first level of the system issues an auditory and visual alert upon turning the ignition off and opening the driver’s door. The UROA system issues a subsequent auditory and visual alert if the ultrasonic sensors detect movement in the rear seats after the doors are locked.



**Figure 23. Photo. Hyundai/Kia rear optical sensor.**

The feature can be disabled via the vehicle’s settings. See Table 35 for a list of current and upcoming Hyundai/Kia models with the ROA and/or UROA system. Kia plans to make rear seat reminder systems standard on most of its new vehicles by 2024 according to a 2019 industry commitment (Alliance of Automobile Manufacturers & Association of Global Automakers, 2019; now the Alliance for Automotive Innovation). Genesis brand (a division of Hyundai) has also announced plans for including the UROA system in future vehicles (Smith, 2020). For this report, researchers evaluated the UROA system on the 2020 Hyundai Palisade in order to test the UROA system’s performance considering both second and third-row seating (Figure 24).

**Table 35. Hyundai/Kia/Genesis models with rear seat reminder technology.**

Make	Model Year	Model	Availability	
			ROA Type	Trim
Hyundai	2019	Santa Fe	Door Logic + Ultrasonic	SEL+, Limited, and Ultimate
	2020	Sonata	Door Logic	Standard
		Sonata HEV	Door Logic	Standard
		Santa Fe	Door Logic	Standard
			Door Logic + Ultrasonic	SEL and Limited
Palisade	Door Logic	All		

Make	Model Year	Model	Availability	
			ROA Type	Trim
			Door Logic + Ultrasonic	SEL and Limited
	2021	Elantra	Door Logic	All
		Sonata	Door Logic	All
		Sonata HEV	Door Logic	All
		Santa Fe	Door Logic	All
			Door Logic + Ultrasonic	SEL, Limited, and Calligraphy
		Palisade	Door Logic	Standard / All
	Door Logic + Ultrasonic		SEL, Limited, and Calligraphy	
Genesis	2021	G80	Door Logic + Ultrasonic	Optional on 2.5T; Standard on 3.5T
		GV80	Door Logic + Ultrasonic	Optional on 2.5T; Standard on 3.5T
Kia	2020	Telluride	Door Logic + Ultrasonic	All
	2021	Seltos	Door Logic	All
		Soul	Door Logic	All
		K5	Door Logic	All



**Figure 24. Photo. 2020 Hyundai Palisade.**

### ***How System Is Armed***

Hyundai/Kia’s ROA and UROA systems come enabled on equipped Hyundai/Kia vehicles but can be manually disabled by the driver in the vehicle settings. The ROA system uses rear door logic; however, there is no time window that the rear door must be opened before the engine starts in order to arm the system. If either rear door opens at any point before or while engine is

on and is locked upon shutting the ignition off, the ROA and UROA systems become armed, issuing alerts per the following approach after turning the vehicle off and opening the driver door.

1. Level 1 (ROA)
  - a. A visual alert that displays the message “Check Rear Seats” on the instrument cluster.
  - b. An auditory alert consisting of two short beeps.
2. Level 2 (UROA) is issued following the level 1 alert if the doors are locked and movement is detected in the rear seats.
  - a. An auditory alert of a continuous series of long honks lasting approximately 25 seconds and up to eight cycles.
  - b. Flashing LED lights in front and rear of vehicle.
  - c. A text/email message alert sent to the owner should they opt to receive this alert (requires owner opt-in and paid Blue Link subscription service).

The Hyundai/Kia approach does not allow for manually disarming the ROA once the system is armed, but the system will automatically disarm after the vehicle is locked. However, the system does allow for manually disarming the UROA system. During the ROA on the instrument cluster, the driver is given the option of pressing “OK” on the steering wheel and disabling the UROA until the next ignition on (Figure 25). Choosing “OK” gives the driver feedback stating, “Rear occupant alert disabled until next engine cycle” and will stop the UROA alerts from being issued even if movement is detected. However, if “OK” is not selected, the UROA system remains armed and an alert will be issued if movement is detected in the rear seats. A driver can dismiss the UROA alerts by unlocking the doors. The UROA system will disarm automatically following 24 hours of the engine being turned off regardless of movement detection (Monticello, 2018).



**Figure 25. Photo. Hyundai/Kia ROA check rear seats alert.**

### ***System Performance Across Scenarios***

**Child Knowingly or Unknowingly Left in Vehicle:** The Hyundai/Kia ROA and UROA systems issued alerts (either ROA alerts only or ROA and UROA alerts) in all tested situations where a child could be knowingly or unknowingly left behind unless the vehicle was left in

accessory mode before opening the driver door. When the vehicle was switched to accessory mode, the instrument cluster displayed the message “Vehicle is On, Key not in Vehicle” instead of the ROA alert, reminding the driver to check the rear seats. In addition, if the vehicle was in accessory mode, it could not be locked via the key fob and, while it could be locked internally, the UROA never issued the level 2 alert since the vehicle was considered to be “on.” However, once the vehicle was fully off, the level 1 visual and audio alert was issued. Notably, UROA warnings were not issued unless all doors were locked. In mid-trip scenarios where the engine was turned off but the rear door never opened (i.e., getting gas, quick trip into a store, etc.), the ROA alert went off both at the mid-trip stop and again at the final destination.

**Table 36. Hyundai/Kia ROA and/or UROA system alert issued in unknowingly/knowingly left scenarios at final destination.**

Scenario Condition															
Driving straight to destination				Idle stop mid-drive with rear door opening while vehicle in park				Stopping mid-drive with driver exiting and ignition off				Idle stop mid-drive with driver door and rear door opening while vehicle is in park			
Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode		Ignition Off		Accessory Mode	
L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL	L	UL
✓	✓			✓	✓			✓	✓			✓	✓		
<i>Note: “✓” denotes that the alert was issued at the final destination. L= Vehicle Locked, UL= Vehicle Unlocked</i>															

**Child Gains Access:** The Hyundai/Kia UROA system can detect a child who gains access to a vehicle and becomes locked inside under specific conditions. The vehicle must have been running within the previous 24 hours and have activated the UROA on the last trip for the UROA to be armed. In addition, the doors must be completely closed and locked in order for the UROA to issue an alert. If the doors are not fully closed, the doors will not lock and the UROA system will not issue an alert.

Researchers also tested the UROA alert system in the scenario that a child accessed the vehicle by going through the trunk open door instead of a passenger door and determined that under this circumstance the UROA never issued an alert. This scenario was not originally part of the 32 test scenarios but added during the testing specifically for the UROA system.

**Table 37. Hyundai/Kia UROA issued in gained access scenarios.**

Scenario Simulation Condition							
Doors Initially Locked				Doors Initially Unlocked			
Door Completely Shut		Door Partially Latched Shut		Door Completely Shut		Door Partially Latched Shut	
L	UL	L	UL	L	UL	L	UL
✓				✓			
<i>Note: “✓” denotes that the alert was issued within 5 minutes of final action. L= Vehicle Locked, UL= Vehicle Unlocked</i>							

***Competing Alerts and Activities***

The Hyundai/Kia’s ROA alert had no direct interference with the competing alerts tested. In addition, when the driver door was opened with music playing, the music stopped and the ROA auditory alert was heard with no noise competition. The UROA alert was issued in all but two circumstances: if the vehicle had an open hood or an open trunk.

**Table 38. Hyundai/Kia ROA and/or UROA issued without conflict with other alert systems.**

Possible Conflicting System									
Navigation On	Open Gas Door	Open Hood	Open Trunk	Open Sun-Roof	Phone on Bluetooth	Music On	Windows Open	Navigation and Music On	Navigation and Phone on Bluetooth
✓	✓	✓* <sup>2</sup>	✓* <sup>2</sup>	✓	✓	✓	✓	✓	✓
<i>Note: “✓” denotes that the alert was issued            * denotes that while an alert was issued, a possible conflict with system could change alert delivery.  <sup>2</sup>UROA alert</i>									

***Challenges and Inconsistencies***

The ROA audio and visual alert is reliant on the driver door opening before the alert is issued. This means that the driver is already directing their attention to opening the door when the alert is issued, possibly looking towards the door handle or out of the door instead of at the instrument cluster where the visual alert is displayed. The requirement for the vehicle to be locked after the driver exits in order to arm the UROA system resulted in a number of “child gains access” conditions without an alert being issued. In order for the vehicle to lock, all doors must be closed completely; any only partially latched door disables the vehicle’s ability to lock and arm the UROA. In addition, any scenario in which a caregiver fails to lock the doors eliminates the UROA’s ability to provide an alert.

Though this did not occur in the current study, according to the owner’s manual, if the windows are left open, there is a chance that movement from inside the vehicle due to wind or insects could occur and trigger the system into issuing an alert (Hyundai, 2020).

An additional UROA can be issued as a text message or an email to the owner via Hyundai’s Blue Link telematics. Researchers were not able to test this part of the alert because the owner must create an account on the MyHyundai owner site and register the vehicle before adding Hyundai Blue Link to their account to receive the alerts (Hyundai, 2020). Blue Link is compatible with most but not all Hyundai vehicles and trim levels (for example, the lowest trim 2020 Palisade SE does not have Blue Link capabilities). There is also no information in the owner’s manual describing in detail how this connection to Blue Link can be configured and how it functions (Hyundai, 2020).

***Overall System Assessment***

The UROA can be successful in getting the attention of a driver who may be dismissive of or distracted from the initial alert in the instrument cluster. However, the requirement that the doors

be locked to trigger an alert may lead to a number of missed alert occasions. Not everyone consistently locks their doors when leaving their vehicles. An option for the vehicle to automatically lock when the driver leaves the vehicle might address this loophole. In addition, children are not always able to completely shut/latch a car door, which is required in order to lock the doors and arm the UROA. Some PVH deaths have been attributed to a child gaining access to a car that was not locked, meaning they were trapped not because of a locked door but due to their inability to open the door themselves. This restriction of needing the doors to be locked in order to enable the UROA system and, furthermore, requiring that all doors be completely shut in order to lock the doors, limits the situations in which another individual could be alerted to a child who has gained access to a vehicle.

Researchers tested the UROA from both the second and third row seating. In both cases, the movement had to be more than just breathing or a turning of the head; instead, a larger body movement, such as a raising of the hand, was required to trigger the system. How well the UROA would be able to detect children of different ages (i.e., sleeping newborn vs. alert 2-year old) is unknown but is a consideration for future evaluations. The manual describes the system’s functionality and use (see Appendix H.)

**OTHER OEM TECHNOLOGY WITH POTENTIAL PVH BENEFITS**

This section highlights other available features that are not specifically designed to address PVH but may nonetheless provide some benefit in preventing its occurrence.

**Tesla Dog Mode and Temperature Control-Function**

*System Overview*

The Tesla Dog Mode system uses the climate control to hold a desired temperature in the vehicle while a driver is absent. This system is marketed as intended for use with dogs only. The temperature control-function prevents the interior temperature of the vehicle from exceeding 105 degrees Fahrenheit (Valdes-Dapena, 2016). See Table 39 for a list of Tesla models with Dog Mode. The vehicle investigated for this study was a 2017 Tesla Model X (Figure 26).

**Table 39. Tesla models with Dog Mode.**

Year	Make	Model	Trim
2013	Tesla	S	All
2014	Tesla	S	All
2015	Tesla	S	All
2016	Tesla	S	All
2016	Tesla	X	All
2017	Tesla	S	All
2017	Tesla	X	All
2017	Tesla	3	All
2018	Tesla	S	All
2018	Tesla	X	All
2018	Tesla	3	All

Year	Make	Model	Trim
2019	Tesla	S	All
2019	Tesla	X	All
2019	Tesla	3	All
2020	Tesla	S	All
2020	Tesla	X	All
2020	Tesla	3	All
2020	Tesla	Y	All



**Figure 26. Photo. Tesla Model X.**

The Tesla Dog Mode provides a message for passersby that appears on the infotainment screen stating, “My owner will be back soon. Don’t worry! The A/C [or heater] is on and it’s XX°F” (Figure 27). This system is not designed for, and does not work in alerting drivers to, unattended children left in vehicles. However, it does offer a cooling system for short time frames when owners may temporarily leave their pet unattended in the vehicle. Dog mode will keep the climate control on when the driver leaves the vehicle until the car battery reaches 20%, at which point the climate control will turn off and a push notification goes to the owner’s phone prompting them to return to their vehicle and retrieve their pet. The temperature control function automatically engages if the interior temperature of the vehicle is approaching the 105 degrees Fahrenheit threshold. At 105 degrees Fahrenheit, vents will open and the air conditioner will then engage regardless of whether vehicle being on and will continue to run for up to 12 hours with a sufficient battery charge (Valdes-Dapena, 2016).



**Figure 27. Photo. Tesla Dog Mode message display screen.**

### ***How System Is Armed***

This feature is not automatically armed and must be turned on each time a driver wants to use it. To use this feature, the vehicle must be on and the driver must press the AC temperature control button on the center console infotainment system. A box appears on the screen providing the option to have the climate control turn off, remain on, or be in Dog Mode under the “Keep Climate On” settings when the driver leaves the vehicle. Drivers can then choose the desired temperature and activate the feature. The Dog Mode feature turns off once the driver unlocks the vehicle.

### ***Challenges and Inconsistencies***

This system is not intended for humans and must be manually armed every time it is used. The battery also must be at a sufficient level for the system to remain active.

### ***Overall System Assessment***

Though this function is only designed for pets, the ability to keep a car cool could be useful to help combat PVH. If a feature like Dog Mode could be constantly enabled and only activated when motion is sensed in a vehicle with the ignition off, it may help mitigate PVH-critical situations until an intervention can take place.

## **Honda CabinWatch**

### ***System Overview***

The Honda CabinWatch is a rear seat monitor that shows a view of the rear cabin in the vehicle’s touch screen display. See Table 40 for a list of Honda models with CabinWatch. For this report, researchers evaluated the Honda CabinWatch system on a 2020 Honda Odyssey (Figure 28).



**Table 40. Honda Models with RSR technology.**

Make	Model Year	Model	Availability	
			Type	Trim
Honda	2019	Odyssey	CabinWatch	Touring and Elite
	2020		CabinWatch	Touring and Elite
	2021		Door Logic	Standard
			Door Logic + CabinWatch	Touring and Elite



**Figure 28. Photo. Honda Odyssey.**

Honda CabinWatch uses a camera accompanied by two infrared cameras mounted in the headliner to provide a live feed of rear passengers in the second and third rows to the center display (Figure 29). The system is activated by selecting CabinWatch in the center display. This feature can be selected while the vehicle is in motion and can also be used at night. This feature will also capture children in a rear-facing car seat and allows the caregiver to use the display to scan and zoom in on specific areas of the vehicle.



**Figure 29. Photo. Honda CabinWatch™.**

Honda plans to incorporate an RSR with an integrated camera for 2021 Odysseys (Honda Auto News, 2020). The RSR will come standard with a visual and audio alert in the driver display. In the Touring and Elite models, Honda plans to utilize the CabinWatch feature to assist the RSR with a live view of the rear seats in the infotainment display.

### ***How System Is Armed***

This feature is always available but must be selected each time a driver wants to use it. To use this feature, the vehicle must be on and the driver must navigate to the center display to find and press the CabinWatch button.

### ***Challenges and Inconsistencies***

This system is not intended to remind caregivers that a child remains in the vehicle. Even if the system is left on, there is no audio alert to remind the driver of a child's presence in cases where the child is sleeping or quiet. The RSR alert coming to Honda models in 2021 relies on door logic and does not account for children gaining access to vehicles and becoming trapped. Furthermore, the addition of the CabinWatch feature will only be available for Touring and Elite trim models, which cost more than other, more basic, trim models.

### ***Overall System Assessment***

Even though this function is currently only designed to allow parents to monitor the back seat during commutes, Honda saw the potential for making it more personal by providing a live view of the rear seat. Being able to physically see a child in the back whether the car seat is rearward facing or not could remind a caregiver that a child is in the vehicle.

## **TECHNOLOGY SCORING**

Scores for all ROA technology are presented in Table 41. All technologies were scored according to a schema developed by researchers to compare performance across available ROA systems. Researchers calculated six scores for each technology based on how well the targeted PVH death scenarios were addressed, system ease of use, ability to gain attention, lack of conflicts with other vehicle systems and alerts, and alignment to the pending HOT CARS Act H.R.3593 and S.1601. See Table 41 for a description and explanation of all scores.

**Table 41. Description of scoring system for RSRTs.**

Score Number	Score Name and Possible Value Range	Importance of Score	Factors Considered for Score	Factor Value*
1	Ability to address PVH death scenarios (0–10)	Out of the total number of scenarios tested, this score reveals how many PVH scenarios are addressed by each examined implementation.	The percentage of PVH deaths due to these circumstances is based on data stating that 73.2% of PVH deaths are due to the child being forgotten or knowingly left by a caregiver and 25.2% are due to a child having gained access to a vehicle on their own without caregiver knowledge.† This leaves 1.5% of PVH deaths of unknown cause. For the purpose of scoring, the 1.5% was weight-distributed across the two primary circumstances: 73.3% + (73.3 × .015) = 74.4% and 25.2 % + (25.2 × .015) = 25.6%.	= (# of successfully issued alerts for un/knowingly left scenarios/16) × .744 × 10 + (# of successfully issued alerts for child gained access scenarios/8) × .256 × 10
2	Ease of Use (0–4)	Technology must be intuitive and easy to use in order for it to be properly utilized.	Automatically enabled/no driver buy-in	No = 0 Yes = 1
			Once enabled, activates under normal behavior	No = 0 Yes = 1
			Arms consistently on first try	No = 0 Yes = 1
			Issues alert consistently	No = 0 Yes = 1
3	Ability to gain attention of caregiver/bystander/emergency contact/emergency services	Issued alerts should get users' attention so they cannot be easily ignored or cause users to become habituated to them. The volume level of the alert is important to ensure it can grab attention	Visual alert (either interior or exterior of vehicle) is clear and easy to see (font, color, unobstructed)	No = 0 Yes = 1
			Audio alert in level 1 is distinct for the situation (not used for other alerts)	No = 0 Yes = 1

Score Number	Score Name and Possible Value Range	Importance of Score	Factors Considered for Score	Factor Value*
	(0-9)	according to the importance of the situation. Volume level was rated subjectively compared to volume level of talking. In addition, a system should issue alerts until action has been taken.	Volume level of the audio alert (level 1 or level 2)	No Audio = 0 As Loud as Talking = 1 Louder than Talking = 2
			Presence of alert should driver potentially leave a child unattended in a vehicle	No = 0 Yes = 1
			Presence of an auditory alert perceptible to bystanders	No = 0 Yes = 1
			Presence of a visual alert perceptible to bystanders	No = 0 Yes = 1
			Alert issued for direct contact with driver/caretaker by way of a push notification through an application on a mobile phone. Alert should require a response, be a direct phone call, etc.	No = 0 Yes = 1
			Alert attempt for direct contact with another emergency contact or emergency personnel such as 911 should caretaker not take appropriate action?	No = 0 Yes = 1
4	Lack of conflicts with other vehicle systems and alerts (0-10)	Technology alerts should be clearly issued even if other vehicle alerts must be issued as well or other vehicle systems, such as navigation, music, or phone, are in use.	RSR alert issued with navigation system in use	No = 0 Yes = 1
			RSR alert issued with gas door open	No = 0 Yes = 1
			RSR alert issued with hood open	No = 0 Yes = 1
			RSR alert issued with trunk open	No = 0 Yes = 1
			RSR alert issued with sunroof open	No = 0 Yes = 1
			RSR alert issued with phone in use over Bluetooth	No = 0 Yes = 1

Score Number	Score Name and Possible Value Range	Importance of Score	Factors Considered for Score	Factor Value*
			RSR alert issued with music playing using Bluetooth	No = 0 Yes = 1
			RSR alert issued with windows down	No = 0 Yes = 1
			RSR alert issued with navigation system in use and phone over Bluetooth	No = 0 Yes = 1
			RSR alert issued with navigation system in use with music playing using Bluetooth	No = 0 Yes = 1
<p>* All scenarios with various conditions of accessory mode on or off or doors locked or left unlocked are weighted equally, which may not accurately reflect actual percentage of caregivers who engage in these behaviors.</p> <p>† Noheatstroke.org</p>				

Table 42 describes the features the HOT CARS Acts (H.R.3593 and S.1601) would require from technologies. Both Acts require that the system be activated when the engine is turned off. We interpreted this requirement to mean that the system should activate upon physically turning off the engine versus only being active when the engine is off.

**Table 42. Alignment to pending HOT CARS Acts.**

Score Name and Possible Value Range	Importance of Score	Factors Considered for Score	Factor Value
Alignment to the pending HOT CARS Act H.R.3593 (0–7)	Should the HOT CARS Act H.R.3593 be passed, this score indicates how well the RSR technology fulfills the proposed requirements.	Has a distinct auditory alert to notify individuals inside the vehicle of the presence of an occupant (could be via mobile phone).	No = 0 Yes = 1
		Has a distinct visual alert to notify individuals inside the vehicle of the presence of an occupant (could be via mobile phone).	No = 0 Yes = 1

Score Name and Possible Value Range	Importance of Score	Factors Considered for Score	Factor Value
		Has an interior haptic warning (vibrations) to notify individuals inside the vehicle of an occupant still in vehicle (could be via mobile phone).	No = 0 Yes = 1
		Has a distinct auditory alert to notify individuals outside the vehicle of an occupant still in vehicle (could be via mobile phone).	No = 0 Yes = 1
		Has a distinct visual alert to notify individuals outside the vehicle of an occupant still in vehicle (could be via mobile phone).	No = 0 Yes = 1
		Is activated when the vehicle engine is turned off.	No = 0 Yes = 1
		Detect the presence (or indication of presence; i.e., movement) of any occupant unable to independently exit the vehicle and detect the presence of a child who has entered an unoccupied vehicle independently.	No = 0 Yes = 1
Aligning to the pending HOT CARS Act S.1601 (0-3)	Should the HOT CARS Act S.1601 be passed, this score indicates how well the RSR technology fulfills the proposed requirements.	Has a distinct auditory alert to notify operator inside or outside the car to check rear designated seating positions (could be via mobile phone).	No = 0 Yes = 1
		Has a distinct visual alert to notify operator inside or outside the car to check rear designated seating positions (could be via mobile phone).	No = 0 Yes = 1
		Is activated when the vehicle engine is turned off.	No = 0 Yes = 1

Table 43 through Table 47 give the individual scoring for each feature in each scoring system for each technology.

**Table 43. Technology scores for ease of use.**

<b>Feature</b>	<b>Sense A Life Score</b>	<b>Elepho eClip III Score</b>	<b>ChildMinder SoftClip Score</b>	<b>Sensor Safe Score</b>	<b>Ride N Remind Score</b>	<b>GM RSR Score</b>	<b>Subaru RSR Score</b>	<b>Toyota RSR Score</b>	<b>Nissan RDA Score</b>	<b>Hyundai/Kia UROA Score</b>
Initially enabled	0	0	0	0	0	1	1	1	0	1
Is enabled under normal behavior for putting a child in a car seat without further input from driver	1	0	0	1	1	1	1	1	1	1
Enables consistently on first try	0	1	1	1	1	1	1	1	1	1
Arms consistently	0	1	1	1	1	1	1	1	0	1
<b>TOTAL</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>

**Table 44. Technology scores for ability to gain attention of caregiver/bystander/emergency contact/emergency services.**

<b>Feature</b>	<b>Sense A Life Score</b>	<b>Elepho eClip III Score</b>	<b>ChildMinder SoftClip Score</b>	<b>Sensor Safe Score</b>	<b>Ride N Remind Score</b>	<b>GM RSR Score</b>	<b>Subaru RSR Score</b>	<b>Toyota RSR Score</b>	<b>Nissan RDA Score</b>	<b>Hyundai/Kia UROA Score</b>
Visual alert (either interior or exterior of vehicle)	0	1	0	1	0	1	1	1	1	1
Audio alert in level 1 is distinct for the situation	1	1	1	1	1	1	0	1	0	1

<b>Feature</b>	<b>Sense A Life Score</b>	<b>Elepho eClip III Score</b>	<b>ChildMinder SoftClip Score</b>	<b>Sensor Safe Score</b>	<b>Ride N Remind Score</b>	<b>GM RSR Score</b>	<b>Subaru RSR Score</b>	<b>Toyota RSR Score</b>	<b>Nissan RDA Score</b>	<b>Hyundai/Kia UROA Score</b>
Volume level of the audio alert (level 1 or level 2)	2	2	1	2	2	1	1	1	2	2
Presence of alerts should driver walk away with child still potentially in vehicle	0	1	1	1	1	0	0	0	1	1
Presence of an auditory alert perceptible to bystanders	0	0	0	0	1	0	0	0	1	1
Presence of a visual alert for bystanders	0	0	0	0	0	0	0	0	0	1
An alert issued for direct contact with driver/caretaker via mobile phone	0	1	0	1	0	0	0	0	0	1
An alert attempt for direct contact with another emergency contact or emergency personnel via mobile phone	0	0	0	1	0	0	0	0	0	1
<b>TOTAL</b>	<b>3</b>	<b>6</b>	<b>3</b>	<b>7</b>	<b>5</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>5</b>	<b>9</b>



**Table 45. Technology scores for lack of conflicts with other vehicle systems and alert.**

<b>Feature</b>	<b>Sense A Life Score</b>	<b>Elepho eClip III Score</b>	<b>ChildMinder SoftClip Score</b>	<b>Sensor Safe Score</b>	<b>Ride N Remind Score</b>	<b>GM RSR Score</b>	<b>Subaru RSR Score</b>	<b>Toyota RSR Score</b>	<b>Nissan RDA Score</b>	<b>Hyundai/Kia UROA Score</b>
RSR alert issued with navigation system in use	1	1	1	1	1	1	1	1	0	1
									1*	
RSR alert issued with gas door open	1	1	1	1	1	1	1	1	1	1
RSR alert issued with hood open	1	1	1	1	1	0	1	1	1	1
										0*
RSR alert issued with trunk open	1	1	1	1	1	1	1	1	0	1
										0*
RSR alert issued with sunroof open	1	1	1	1	1	1	1	1	1	1
RSR alert issued with phone in use over Bluetooth	1	1	1	1	1	0	1	1	1	1
RSR alert issued with music playing using Bluetooth	1	1	1	1	1	1	0	1	1	1
RSR alert issued with windows down	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	0	1	0	1

Feature	Sense A Life Score	Elepho eClip III Score	ChildMinder SoftClip Score	Sensor Safe Score	Ride N Remind Score	GM RSR Score	Subaru RSR Score	Toyota RSR Score	Nissan RDA Score	Hyundai/Kia UROA Score
RSR alert issued with navigation system in use and phone over Bluetooth									1*	
RSR alert issued with navigation system in use with music playing using Bluetooth	1	1	1	1	1	0	1	1	0	1
									1*	
<b>TOTAL</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>7</b>	<b>8</b>	<b>10</b>	<b>6</b>	<b>10</b>
									<b>9*</b>	
<i>*Denotes that this score is specific to the level 2 alert system</i>										

**Table 46. Technology scores for aligning with the HOT CARS Act H.R.3593**

Feature	Sense A Life Score*	Elepho eClip III Score*	ChildMinder SoftClip Score*	Sensor Safe Score*	Ride N Remind Score*	GM RSR Score	Subaru RSR Score	Toyota RSR Score	Nissan RDA Score	Hyundai/Kia UROA Score
Has a distinct auditory alert to notify individuals inside the vehicle of an occupant's presence.	1	0	0	1	1	1	0	1	0	1
Has a distinct visual alert to notify individuals inside the vehicle of an occupant's presence.	0	0	0	0	0	1	1	1	1	1

<b>Feature</b>	<b>Sense A Life Score*</b>	<b>Elepho eClip III Score*</b>	<b>ChildMinder SoftClip Score*</b>	<b>Sensor Safe Score*</b>	<b>Ride N Remind Score*</b>	<b>GM RSR Score</b>	<b>Subaru RSR Score</b>	<b>Toyota RSR Score</b>	<b>Nissan RDA Score</b>	<b>Hyundai/Kia UROA Score</b>
Has an interior haptic warning (vibrations) to notify individuals inside of the vehicle of an occupant's presence.	0	0	0	0 <sup>+</sup>	0	0	0	0	0	0
Has a distinct auditory alert to notify individuals outside the vehicle of an occupant's presence.	0	1	1	1	1	0	0	0	1	1
Has a distinct visual alert to notify individuals outside the vehicle of an occupant's presence.	0	1	0	1	0	0	0	0	0	1
Is activated when the vehicle engine is turned off.	0	0	0	1	1	1	1	1	0	0
Detect the presence (or indication of presence; i.e., movement) of any occupant unable to independently exit the vehicle as well as detect the presence of a child who has entered an unoccupied vehicle independently.	0	0	0	0	0	0	0	0	0	1
<b>TOTAL</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>4</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>5</b>
* The pending HOT CARS Act, as currently written, would only be applicable for new vehicle models. These systems are aftermarket systems and not included in the bill. However, they are included here for evaluation based on their potential safety benefits.										

Feature	Sense A Life Score*	Elepho eClip III Score*	ChildMinder SoftClip Score*	Sensor Safe Score*	Ride N Remind Score*	GM RSR Score	Subaru RSR Score	Toyota RSR Score	Nissan RDA Score	Hyundai/Kia UROA Score
<p>+ This system has ability to send a vibration alert to a user's cell phone, which could be located inside or outside of the vehicle. Researchers considered normal operation of a user leaving with their cell phone and receiving this alert and therefore decided that this alert would be issued outside the vehicle.</p>										

**Table 47. Technology scores for adherence to the HOT CARS Act S.1601.**

Feature	Sense A Life Score*	Elepho eClip III Score*	ChildMinder SoftClip Score*	Sensor Safe Score*	Ride N Remind Score*	GM RSR Score	Subaru RSR Score	Toyota RSR Score	Nissan RDA Score	Hyundai/ Kia UROA Score
Has a distinct auditory alert to operator to check rear designated seating positions.	1	1	1	1	1	1	0	1	1	1
Has a distinct visual alert to notify operator to check rear designated seating positions.	0	1	0	1	0	1	1	1	1	1
Is activated when the vehicle engine is turned off.	0	0	0	1	1	1	1	1	0	0
<b>TOTAL</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>
<p>* The pending HOT CARS Act, as currently written, would only be applicable for new vehicle models. These systems are aftermarket systems and not included in the bill. However, they are included here for evaluation based on their potential safety benefits.</p>										

Table 48 compares the scoring of all tested RSRTs across categories and gives one overall score for each. The top three technologies all had high scores in their ability to address PVH death scenarios and their ability to get the attention of a caregiver, bystander, emergency contact, or emergency services should a child be in potential danger. Hyundai/Kia’s UROA system was the only OEM technology with an optional alert to contact a caregiver or third party in PVH-critical situations, whereas two aftermarket technologies (Sensor Safe 2.0 and Elepho E-clip) also used a connection to the caregiver’s mobile phone to attempt secondary contact if a child is in a potential PVH scenario. Arguably, these two areas—alerting a caregiver and alerting a third party if the caregiver does not respond—are critical system components in preventing PVH deaths. It is important to note that many of these systems were not specifically designed to address all of the scenarios investigated in this evaluation but instead focused on the unintentional leaving of a child. Due to our scoring system, which considered all three main scenarios, some systems received poor scores even though they remained highly effective for the scenarios for which they were designed.

**Table 48. RSR technology scores.**

<b>Technology</b>	<b>Score 1 (0–10)</b>	<b>Score 2 (0–4)</b>	<b>Score 3 (0–9)</b>	<b>Score 4 (0–10)</b>	<b>Overall Score</b>
Hyundai/Kia ROA and UROA	6.22	4	9	10	29.22
				8 <sup>†</sup>	27.22
Sensor Safe 2.0	7.44	3	7	10	27.44
Elepho E-Clip	7.44	2	6	10	25.44
Ride N Remind System	5.58	3	5	10	23.58
Toyota RSR	5.58	4	3	10	22.58
ChildMinder Soft Clip	7.44	2	3	10	22.44
Sense-A-Life	7.44	1	3	10	21.44
Subaru RSR	7.44	4	2	8	21.44
GM RSR	5.58	4	3	7	19.58
Nissan’s RDA	1.86	2	5	9*	17.86
				6	14.86
Score 1: How well the technology addresses PVH death scenarios Score 2: Ease of use Score 3: Ability to gain attention of caregiver/bystander/emergency contact/emergency services Score 4: Lack of possible conflicts with other vehicle systems and alerts <sup>†</sup> UROA alerts * Level 2 alerts					

Table 49 compares the number of available features that may be required if the HOT CARS Acts were enacted across the tested technologies.

**Table 49. Alignment with the pending HOT CARS Acts.**

<b>Technology</b>	<b>HOT CARS Act H.R. 3593 (0–7)</b>	<b>HOT CARS Act S. 1601 (0–3)</b>
Hyundai/Kia UROA	5	2
Sensor Safe 2.0	4	3
GM RSR	3	3
Toyota RSR	3	3
Ride N Remind System	3	2
Elepho E-Clip	2	2
Subaru RSR	2	2
Nissan’s Rear Door Alert RDA	2	2
Sense-A-Life	1	1
ChildMinder Soft Clip	1	1

## CHAPTER 4. DISCUSSION

One main goal of the current project was to develop an assessment procedure for PVH preventative technologies for three main types of PVH scenarios: (1) child knowingly left in vehicle, (2) child unknowingly left in vehicle, and (3) child gains access to an unattended vehicle. This current research is the first step in creating testing procedures for current and future technologies and it is the authors' intent to improve these procedures for future evaluations. This effort examined available aftermarket and OEM RSRTs across these developed assessment procedures.

RSRTs have the capacity to prevent PVH incidents involving children and other vulnerable populations (i.e., pets, the elderly, and mentally and physically disabled individuals). However, the currently available options are not capable of issuing alerts in all the developed scenarios within the three PVH scenario types. Though all technologies tested were able to alert caregivers of a possible occupant in the rear seat under straightforward conditions (e.g., a direct drive to a destination with no stops), any deviation from this, such as mid-trip stops, additional door openings, the engine turning off and back on again, or vehicles placed in accessory mode, opened up possibilities where systems might fail to issue an alert. None of the systems evaluated herein were based on actual detection of an occupant, but rather on triggers or sensors indicating that there might be an occupant in the rear seat. Examples include a rear door opening and closing, weight on a sensor pad, a fastened harness clip, or detected movement in the rear seating area. Rear doors can open and close for other reasons beyond passenger entry/exit, weights on a sensor can shift, children can unbuckle harness clips, and very small or sleeping children may not move to a degree that is detectable by a monitoring system. These are the primary reason that systems issued alerts when unnecessary and failed to issue alerts when necessary.

Those who have lost a child to PVH almost certainly never anticipated such a traumatic event or may not even have been aware of the danger to children left unattended in vehicles. In the conclusion of NHTSA's 2015 study evaluating PVH preventative technology, the authors suggested that this technology would be more beneficial if it came pre-installed in vehicles than if its use depended on consumers deciding that the alert system would be beneficial to them. Currently, a voluntary agreement among the Alliance for Automotive Innovation and 21 vehicle manufacturers states that all their new vehicles will have a version of an RSR technology by model year 2025, providing an audio and visual alert to a driver once the engine is turned off and there is the possibility of an occupant remaining in a rear seat (Alliance of Automobile Manufacturers, Inc. & Association of Global Automakers, Inc., 2019). While this voluntary agreement is a good first step to combating PVH, the evaluation outlined in this report demonstrates that continued research is needed to fully address all real-world situations that result in child PVH fatalities. Notably, this agreement covers a large number of manufacturers, but not all. The HOT CARS Acts presented to the House of Representatives attempts to create a federal mandate to ensure that all new vehicles meet a minimum level of PVH preventative technology requirements. However, it is still crucial for aftermarket companies to continue to improve their available technology, as even once all new cars have RSR technology, many older vehicles will still be in use. Currently, the average age of cars and light trucks in the United States is 11.9 years old (HIS Markit, 2020). Aftermarket systems available to retrofit these older vehicle models will help ensure that no child is left unprotected.

Though all of the RSRTs evaluated in this study were able to address some PVH scenarios and also had a number of the suggested features, no system—aftermarket or OEM—was able to detect a child at risk for PVH in all scenarios. All of the aftermarket technologies excelled where many of the OEM RSRTs had shortcomings, mainly in their ability to issue an alert even if a vehicle was in accessory mode or if there were mid-trip stops, door openings, or engine cut-offs. However, there are inherent advantages for these preventative technologies to be directly integrated into the vehicle (OEM PVH), such as potentially being able to keep the temperature inside a vehicle cool. Supporting system activation in multiple ways, instead of relying solely on door logic/sequencing, could also increase the chances of alerting a caretaker to a PVH scenario. Based on findings outlined herein, it is important to develop an alert with certain features in order to prevent PVH deaths while also minimizing nuisance alerts and preventing failure to issue alerts based on vehicle settings (e.g., in accessory mode or left unlocked). The following suggestions are provided based on the feature aspects that stood out as highly beneficial during testing or that were found lacking but could prove useful to other systems under development.

Suggestions for rear seat occupancy detection alert systems:

- Be enabled upon delivery to the customer (OEM systems)
- Provide feedback to user regarding system activation and arming
- Optional customization (name, picture for designated occupant)
- Activated under normal behavior for having an occupant in the rear seat
- If door logic is used, set a minimum amount of time a rear door needs to remain open (indicating a passenger needing assistance getting in the vehicle vs. putting an item in the back) to minimize nuisance alerts
- Low battery life warning (if aftermarket)
- Detection capabilities for gained access scenarios always armed regardless of door lock status
- Distinctive audio alert completely different from any other alerts (not merely differing by number of times issued, etc.)
- Actual occupant detection via methods such as movement, weight, or other means for issuing alerts
- Integrated with the vehicle and given priority over other vehicle alerts
- Ability to dismiss or disable alert system at various points
- Visual alerts displayed immediately in instrument cluster when engine is turned off or in the direction of the driver door window when a driver door is opened since that is likely the direction a caregiver will be looking upon exiting the vehicle
- Alert issued when vehicle is in accessory mode
- Have a window of time or distance that a caregiver can be outside a vehicle without issuing an alert
- Passive features activated if occupant is detected (i.e., temperature control)
- Levels of alerts to contact caregiver directly by phone, followed by bystanders, emergency contacts, and/or emergency personnel

There have been significant developments in RSRTs in just the last 5 years, but significant room for improvement remains. With the potential passage of the HOT CARS Act, the automobile industry needs to be ready with technologies that will sufficiently address the various scenarios



in which PVH deaths and injuries occur. In addition, there will be a continued need for aftermarket technologies to adequately address the gap for older vehicles that are not equipped with OEM RSRTs. This current research serves as a guide for the future development and testing of these systems.



## APPENDIX A. H.R. 3539



I

116TH CONGRESS  
1ST SESSION

# H. R. 3593

To require the Secretary of Transportation to issue a rule requiring all new passenger motor vehicles to be equipped with a child safety alert system, and for other purposes.

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### IN THE HOUSE OF REPRESENTATIVES

JUNE 28, 2019

Mr. RYAN (for himself, Ms. SCHAKOWSKY, and Mr. KING of New York) introduced the following bill; which was referred to the Committee on Energy and Commerce, and in addition to the Committee on Transportation and Infrastructure, for a period to be subsequently determined by the Speaker, in each case for consideration of such provisions as fall within the jurisdiction of the committee concerned

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## A BILL

To require the Secretary of Transportation to issue a rule requiring all new passenger motor vehicles to be equipped with a child safety alert system, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*

3 **SECTION 1. SHORT TITLE.**

4 This Act may be cited as the “Hot Cars Act of  
5 2019”.

6 **SEC. 2. FINDINGS AND PURPOSE.**

7 (a) FINDINGS.—Congress finds the following:

1 (1) Children and domestic animals left unat-  
2 tended in vehicles, or independently accessing unoc-  
3 cupied vehicles on their own, are a significant public  
4 health and safety problem.

5 (2) Thirty-eight children on average are killed  
6 by hyperthermia each year as a result of being left  
7 unattended in a vehicle or as a result of gaining ac-  
8 cess independently into an unoccupied vehicle.

9 (3) In 2018, at least 52 children were killed by  
10 hyperthermia as a result of being left unattended in  
11 a vehicle or as a result of gaining access independ-  
12 ently into an unoccupied vehicle.

13 (4) Between 1990 and 2018, at least 889 chil-  
14 dren have been killed by hyperthermia as a result of  
15 being left unattended in a vehicle or as a result of  
16 gaining access independently into an unoccupied ve-  
17 hicle. Of those deaths, where the circumstances were  
18 known, 27 percent were the result of the child ac-  
19 cessing the vehicle independently.

20 (5) Fourteen percent of parents reported leav-  
21 ing a child 6 or younger in a parked, locked car  
22 alone. According to a 2014 Public Opinion Strate-  
23 gies survey, fourteen percent of parents reported  
24 leaving a child six or younger in a parked, locked car  
25 alone. The survey finds that, according to United

1 States Census data, that's nearly 2,000,000 United  
 2 States parents transporting more than 3,300,000  
 3 United States children.

4 (6) In 2018, at least 57 domestic animals were  
 5 killed as a result of being left unattended in a vehi-  
 6 cle.

7 (7) Technology currently exists to detect the  
 8 presence of a child in the rear seat of a vehicle.

9 (b) PURPOSE.—The purpose of this Act is to reduce  
 10 the deaths and injuries that result from occupants being  
 11 left in unattended vehicles as well as instances in which  
 12 children independently access an unoccupied vehicle.

13 **SEC. 3. OCCUPANT SAFETY.**

14 (a) AMENDMENT.—

15 (1) IN GENERAL.—Chapter 323 of title 49,  
 16 United States Code, is amended by adding after sec-  
 17 tion 32304A the following new section:

18 **“§ 32304B. Occupant safety**

19 “(a) DEFINITIONS.—In this section:

20 “(1) PASSENGER MOTOR VEHICLE.—The term  
 21 ‘passenger motor vehicle’ has the meaning given that  
 22 term in section 32101.

23 “(2) REAR DESIGNATED SEATING POSITION.—  
 24 The term ‘rear designated seating position’ means

1 all designated seating positions that are rearward of  
2 the front seat.

3 “(3) SECRETARY.—The term ‘Secretary’ means  
4 the Secretary of Transportation.

5 “(b) RULEMAKING.—Not later than 2 years after the  
6 date of the enactment of the Hot Cars Act of 2019, the  
7 Secretary shall issue a final rule requiring all new pas-  
8 senger motor vehicles with a gross vehicle weight of  
9 10,000 pounds or less to be equipped with a system to  
10 detect the presence of an occupant in a rear designated  
11 seating position after the vehicle engine or motor is deacti-  
12 vated and engage a warning. In developing the rule re-  
13 quired under this subsection, the Secretary shall consider  
14 requiring systems that also detect the presence of any oc-  
15 cupant unable to independently exit the vehicle as well as  
16 detect the presence of a child who has entered an unoccu-  
17 pied vehicle independently.

18 “(c) MEANS.—The alert required under subsection  
19 (b)—

20 “(1) shall include a distinct auditory and visual  
21 alert to notify individuals inside and outside of the  
22 vehicle of the presence of an occupant, which shall  
23 be combined with an interior haptic warning; and

1           “(2) shall be activated when the vehicle motor  
2           is deactivated by the operator and the presence of an  
3           occupant is detected.

4           “(d) PHASE-IN.—The rule issued pursuant to sub-  
5           section (b) shall require full compliance with the rule not  
6           later than 2 years after the date on which the final rule  
7           is issued.”.

8           (2) CLERICAL AMENDMENT.—The analysis for  
9           Chapter 323 of title 49, United States Code, is  
10          amended by striking the item relating to section  
11          32304A and inserting the following:

“32304A. Consumer tire information and standards.  
“32304B. Occupant safety.”.

12          (b) AWARENESS OF OCCUPANTS IN MOTOR VEHI-  
13          CLES.—Section 402 of title 23, United States Code, is  
14          amended by inserting after subsection (k) the following:

15          “(l) UNATTENDED PASSENGERS.—

16                 “(1) IN GENERAL.—Each State shall use a por-  
17                 tion of the amount it receives under this section to  
18                 carry out a program to educate the public on the  
19                 risks of leaving an occupant in a vehicle.

20                 “(2) PROGRAM PLACEMENT.—A State does not  
21                 need to carry out the program described in para-  
22                 graph (1) through the State transportation or high-  
23                 way safety office.”.

24          (c) STUDY AND REPORT.—

1 (1) INDEPENDENT STUDY.—

2 (A) AGREEMENT.—

3 (i) IN GENERAL.—The Secretary of  
4 Transportation shall enter into an agree-  
5 ment or a contract with an independent  
6 third party that does not have any finan-  
7 cial or contractual ties with passenger  
8 motor vehicle manufacturers or technology  
9 companies producing occupant reminder  
10 warning systems or child restraint systems  
11 to perform the services under this para-  
12 graph.

13 (ii) TIMING.—The Secretary shall  
14 enter into the agreement or contract de-  
15 scribed in clause (i) not later than the date  
16 that the Secretary determines is the latest  
17 date by which completion of the services  
18 under this paragraph will allow the Sec-  
19 retary enough time to prepare and submit  
20 the study required under paragraph (2) in  
21 accordance with such paragraph.

22 (B) INDEPENDENT STUDY.—

23 (i) IN GENERAL.—Under an agree-  
24 ment between the Secretary and an inde-  
25 pendent third party under this paragraph,



1 the independent third party shall carry out  
2 a study on retrofitting existing passenger  
3 motor vehicles with technology to address  
4 the problem of occupants left unattended  
5 in motor vehicles.

6 (ii) ELEMENTS.—In carrying out the  
7 study required under clause (i), the inde-  
8 pendent third party shall—

9 (I) survey and evaluate a variety  
10 of methods used by current and  
11 emerging aftermarket technology or  
12 products to solve the problem of occu-  
13 pants being left unattended in the ve-  
14 hicle or occupants gaining access to  
15 the vehicle independently;

16 (II) make recommendations for  
17 manufacturers of such technology or  
18 products to undergo a functional safe-  
19 ty performance to ensure that the  
20 products perform as designed by the  
21 manufacturer under a variety of real  
22 world conditions; and

23 (III) provide recommendations  
24 for consumers on how to select such

1                   technology or products in order to ret-  
2                   rofit existing vehicles.

3           (2) REPORT.—During the 180-day period be-  
4           ginning on the date on which the Secretary of  
5           Transportation issues the final rule required under  
6           section 32304B(b) of title 49, United States Code,  
7           as added by subsection (a)(1), the Secretary shall  
8           submit the results of the study carried out under  
9           paragraph (1) to the Committee on Commerce,  
10          Science, and Transportation of the Senate and the  
11          Committee on Energy and Commerce of the House  
12          of Representatives.

○

**APPENDIX B. S. 1601**

II

**Calendar No. 404**

116TH CONGRESS  
2D SESSION

**S. 1601**

**[Report No. 116-204]**

To direct the Secretary of Transportation to issue a rule requiring all new passenger motor vehicles to be equipped with a child safety alert system, and for other purposes.

---

IN THE SENATE OF THE UNITED STATES

MAY 22, 2019

Mr. WICKER (for himself, Mr. BLUMENTHAL, Ms. CANTWELL, Mr. SCHUMER, Ms. MCSALLY, Mr. MARKEY, Mrs. FEINSTEIN, Ms. SMITH, Mrs. GILLIBRAND, Mr. BROWN, and Ms. WARREN) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

JANUARY 13, 2020

Reported by Mr. WICKER, without amendment

---

**A BILL**

To direct the Secretary of Transportation to issue a rule requiring all new passenger motor vehicles to be equipped with a child safety alert system, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*

1 **SECTION 1. SHORT TITLE.**

2 This Act may be cited as the “Helping Overcome  
3 Trauma for Children Alone in Rear Seats Act of 2019”  
4 or the “HOT CARS Act of 2019”.

5 **SEC. 2. CHILD SAFETY.**

6 (a) AMENDMENT.—

7 (1) IN GENERAL.—Chapter 323 of title 49,  
8 United States Code, is amended by adding after sec-  
9 tion 32304A the following:

10 **“§ 32304B. Child safety**

11 “(a) DEFINITIONS.—In this section:

12 “(1) PASSENGER MOTOR VEHICLE.—The term  
13 ‘passenger motor vehicle’ has the meaning given that  
14 term in section 32101.

15 “(2) REAR DESIGNATED SEATING POSITION.—  
16 The term ‘rear designated seating position’ means  
17 designated seating positions that are rearward of the  
18 front seat.

19 “(3) SECRETARY.—The term ‘Secretary’ means  
20 the Secretary of Transportation.

21 “(b) RULEMAKING.—Not later than 2 years after the  
22 date of the enactment of the HOT CARS Act of 2019,  
23 the Secretary shall issue a final rule requiring all new pas-  
24 senger motor vehicles weighing less than 10,000 pounds  
25 gross vehicle weight to be equipped with a system to alert  
26 the operator to check rear designated seating positions

1 after the vehicle engine or motor is deactivated by the op-  
 2 erator.

3 “(c) MEANS.—The alert required under subsection  
 4 (b)—

5 “(1) shall include a distinct auditory and visual  
 6 alert, which may be combined with a haptic alert;  
 7 and

8 “(2) shall be activated when the vehicle motor  
 9 is deactivated by the operator.

10 “(d) PHASE-IN.—The rule issued pursuant to sub-  
 11 section (b) shall require full compliance with the rule be-  
 12 ginning on September 1st of the first calendar year that  
 13 begins 2 years after the date on which the final rule is  
 14 issued.”.

15 (2) CLERICAL AMENDMENT.—The analysis for  
 16 chapter 323 of title 49, United States Code, is  
 17 amended by striking the item relating to section  
 18 32304A and inserting the following:

“32304A. Consumer tire information and standards.  
 “32304B. Child safety.”.

19 (b) AWARENESS OF CHILDREN IN MOTOR VEHI-  
 20 CLES.—Section 402 of title 23, United States Code, is  
 21 amended by inserting after subsection (k) the following:

22 “(l) UNATTENDED PASSENGERS.—

23 “(1) IN GENERAL.—Each State shall use a por-  
 24 tion of the amounts it receives under this section to

1 carry out a program to educate the public on the  
 2 risks of leaving a child or unattended passenger in  
 3 a vehicle after the vehicle motor is deactivated by  
 4 the operator.

5 “(2) PROGRAM PLACEMENT.—A State does not  
 6 need to carry out the program described in para-  
 7 graph (1) through the State transportation or high-  
 8 way safety office.”.

9 (c) STUDY AND REPORT.—

10 (1) INDEPENDENT STUDY.—

11 (A) AGREEMENT.—

12 (i) IN GENERAL.—The Secretary of  
 13 Transportation shall enter into an agree-  
 14 ment or a contract with an independent  
 15 third-party that does not have any finan-  
 16 cial or contractual ties with passenger  
 17 motor vehicle manufacturers or technology  
 18 companies producing child reminder alert  
 19 systems to perform the services under this  
 20 paragraph.

21 (ii) TIMING.—The Secretary shall  
 22 enter into the agreement or contract de-  
 23 scribed in clause (i) not later than the date  
 24 that the Secretary determines is the latest  
 25 date by which completion of the services

1 under this paragraph will allow the Sec-  
 2 retary enough time to prepare and submit  
 3 the study required under paragraph (2) in  
 4 accordance with such paragraph.

5 (B) INDEPENDENT STUDY.—

6 (i) IN GENERAL.—Under an agree-  
 7 ment between the Secretary and an inde-  
 8 pendent third-party under this paragraph,  
 9 the independent third-party shall carry out  
 10 a study on retrofitting existing passenger  
 11 motor vehicles with technology to address  
 12 the problem of children left in rear des-  
 13 ignated seating positions of motor vehicles  
 14 after the motor vehicles have been deacti-  
 15 vated by the operator of the vehicle.

16 (ii) ELEMENTS.—In carrying out the  
 17 study required under clause (i), the inde-  
 18 pendent third-party shall—

19 (I) survey and evaluate a variety  
 20 of methods used by current and  
 21 emerging aftermarket technology or  
 22 products to solve the problem of chil-  
 23 dren being left in a rear designated  
 24 seating position after the vehicle  
 25 motor is deactivated by the operator;

1           (II) make recommendations for  
2           manufacturers of such technology or  
3           products to undergo a functional safe-  
4           ty performance to ensure that the  
5           products perform as designed by the  
6           manufacturer under a variety of real  
7           world conditions; and

8           (III) provide recommendations  
9           for consumers on how to select such  
10          technology or products in order to ret-  
11          rofit existing vehicles.

12          (2) REPORT.—During the 180-day period be-  
13          ginning on the date on which the Secretary of  
14          Transportation issues the final rule required under  
15          section 32304B(b) of title 49, United States Code,  
16          as added by subsection (a)(1), the Secretary shall  
17          submit the results of the study carried out under  
18          paragraph (1) to the Committee on Commerce,  
19          Science, and Transportation of the Senate and the  
20          Committee on Energy and Commerce of the House  
21          of Representatives.



**APPENDIX C. PHONE SCRIPT TO CONTACT DEALERSHIPS FOR VEHICLE LOAN**

Once you find the dealership with the vehicle equipped with the appropriate RSRT feature use the script below:

**Introductory Statement:**

*Hello. My name is \_\_\_\_\_ and I'm with the Virginia Tech Transportation Institute, in Blacksburg, VA. Thank you for taking our call. We are currently searching for vehicles with rear seat reminder technology. The purpose of this research is to learn more about how this technology helps remind consumers to retrieve items, pets, and children from their vehicle ultimately decreasing heat strokes from happening to children and pets in vehicles. Your dealership has several vehicles on the lot with this type of technology more specifically the (Input Name of Vehicle).*

*Participation in this study involves the research team testing the vehicle in several scenarios at the VTTI campus for half a day. Testing the rear seat reminder technology consists of opening and closing vehicle doors, starting and stopping the engine and driving small distances. Our research team will not install any instrumentation to the vehicle.*

*The data collected will be used to further the research team's knowledge of the RSRT in the (Input Name of Vehicle). The dealerships name can be added to the report as an acknowledgement.*

*Any questions?*

IF the dealer decides to participate process to schedule a time to retrieve the vehicle

Dealership	POC	Phone #	Date & Time Pick Up	Date & Time Return



## APPENDIX D. SAMPLE ARTICLES USED FOR SCENARIO DEVELOPMENT

Kavanaugh, S. (2019, January 30). *A hot car, a dead child: Oregon mom's lawyer explains how it happened*. The Oregonian/OregonLive.  
[https://www.oregonlive.com/pacific-northwest-news/2018/06/a\\_hot\\_car\\_a\\_dead\\_child\\_oregon.html](https://www.oregonlive.com/pacific-northwest-news/2018/06/a_hot_car_a_dead_child_oregon.html)

She awoke last Thursday morning to find her husband fast asleep on the couch. His night shift as an emergency room tech at Mercy Medical Center in Roseburg had ended only hours before.

So Nicole Engler, a pediatric nurse, decided to let him sleep. She would handle his usual day care duties for their daughter, Remington, before heading off to work.

She bundled up their 21-month-old daughter, the adored child she'd spent 15 years trying to conceive. She placed her carefully into the car. She left the house. Her mind drifted to her day ahead, and soon she was on her route to work.

Hours later, the 38-year-old mother left the office and returned to her car. There she found her daughter, known to her family as Remy, unconscious and blue. The mother's shrieks could be heard across the parking lot, witnesses said.

The detailed account, told by Engler's lawyer Thursday, comes a week after that day ended with daughter dead and mother behind bars, begging guards to let her commit suicide.

Attorney David Terry is now calling on Douglas County prosecutors to drop second-degree manslaughter charges filed against Engler.

District Attorney Richard Wesenberg would not comment on the case Thursday, but in a statement said his office was considering all available evidence.

The Douglas County Medical Examiner's office on Thursday ruled Remington Engler's death an accident.

The case garnered international headlines, similar to the roughly 40 incidents in the U.S. each year in which children die from heat-related injuries after being left in vehicles, according to Kids and Cars a national advocacy group.

And, as in those incidents, while some express sympathy, a public outcry demands the parent be thrown in prison.

Terry said his client suffered from a tragic lapse of awareness, one that experts say is common in a number of such cases.

"This is not about a heartless mother who does the unthinkable," the lawyer said.

The night before, mother and daughter, alone in their Gordon Avenue home, ate breakfast for dinner — scrambled eggs — and watched the movie "Ratatouille," Terry said.

Engler followed the normal routine the next morning when she woke up. She got Remy out of bed and clothed her. She gave her daughter a bottle, which she always had while Dad drove her to day care.

But when she saw her husband fast asleep on the couch, she decided to drop Remy off instead.

The two left in the family's Honda CRV. Soon, Engler was on Northeast Diamond Lake Boulevard, following the 4-mile route she took to work each day.

She thought about her duties and work commitments that morning. An 8:15 a.m. appointment with a child. The meeting with parents where she'd deliver them bad news.

Engler never stopped at Cobb Street Children's Learning Center. Lost in thought, she pulled into the parking lot at Evergreen Family Medicine just before 8 a.m.

That afternoon, Engler got back into her car and drove to a Dutch Bros. Coffee stand she visited daily. She excitedly told the servers about the upcoming fishing trip in Mexico her family booked.

She gushed about Remy to the Dutch Bros employees. She returned to work.

About 4:30 p.m., Engler left her office. She arrived at her car. And screamed.

The little girl was unconscious in her car seat. Her skin was blue.

Engler grabbed her daughter. She ran.

At one point, the mother tripped and fell in the parking lot.

Medical staff at Evergreen tried to revive the little girl. They were unsuccessful.

Remy was rushed to Mercy Medical Center, the same place where her father had finished work less than 12 hours before. Engler was arrested and taken to the Douglas County jail.

Terry, Engler's lawyer, said he received a call about the incident from a legal colleague that evening, and he hurried to the hospital.

Terry found Peter Engler in a room, hunched over the bedclothes that swaddled his deceased daughter, sobbing uncontrollably.

"It was one of the saddest moments of my 40-year career," Terry said.

Terry said he then left the hospital and drove to the jail. Engler was pulling out her hair in clumps and pleading to take her own life when he arrived.

After she was able to calm down, Roseburg police drove her to see her daughter, Terry said. Police had kept her in handcuffs until Terry raised a fuss at the hospital's entrance, he said.

Engler and the lawyer were led into the examining room. "And I sat with her while she held the light of her life," Terry said.

The mother was arraigned Friday on second-degree manslaughter charges and released from jail on a \$50,000 bond.

Today, six days later, she and her husband held a private memorial for their daughter.

Covil, W. (2018, August 14). *Mom explains how she forgot infant son in hot car.* WTVR. <https://wtvr.com/2018/08/13/blondia-curry-emporia/>

EMPORIA, Va. -- The mother of the six-month-old boy who died after he was left in a car for hours Friday said she forgot her baby was in the car after childcare plans fell through. Police in Emporia are still investigating Friday's incident.

Blondia Curry, 30, said she was taking her children to stay with various family members Friday before work when she got a call that led to tragedy.

"My youngest daughter's father calls and he said his mother wasn't going to be able to watch [one of her daughters]. That's what I believe threw me off," the mother of four said.

Curry said she arranged for one relative to watch her three oldest children.

After she dropped them off, she said she drove to her job at Domino's Pizza on Market Drive in Emporia -- forgetting to drop off her baby at another relative's home.

"My friend called me on the way to work and asked me about my oldest daughter, checking on her, and I just forgot all about dropping the baby off," Curry admitted.

Police believe baby Dameer was left in his mother's car about five hours, between 4 p.m. and 9 p.m. Friday.

Curry discovered the child in distress when she went outside during a work break.

Witnesses and later police and EMS attempted to revive the child, but it was too late.

Dameer was pronounced dead at the hospital.

"I've been stressed out with my 10-year-old daughter [who was recently diagnosed with diabetes]. I could have lost her. Just been a lot on me," Curry said.

Police said Curry was cooperating with their investigation and they were currently awaiting autopsy result from the Medical Examiner's Office.

"I do everything for my kids, I work hard for them," Curry, who worked this summer at both Domino's Pizza and Greensville High School said. "That's how much I love my kids. They didn't ask to be here, you know? I did anything I could for my kids."

Stanley, J. (n.d.). *Sydney Stanley*. KidsandCars.org.  
[https://www.kidsandcars.org/child\\_story/sydney-stanley/](https://www.kidsandcars.org/child_story/sydney-stanley/)

Sunday August 22, 2010 became the worst day of our lives. We experienced the greatest nightmare that a parent has. Our precious earth angel went to be a heavenly angel. That day started out as a regular Sunday. We had our usual battles. Find your shoes, comb your hair, tuck in your shirts, yes, you have to wear something nice... After church service we were gathering our three children to head home. Sydney, our 6 year old daughter, had not finished her craft in Sunday School. She asked if she could bring it home to complete. Of course, I said yes. Once home we had lunch and went about our day. Sydney asked if she could go next door and play with her best friend. This was a very common occurrence. Either her friend was at our house or Sydney was at their house. Sydney's friend's mother and I had an understanding that we would "share" responsibilities watching the girls and neither would take advantage of the situation.

Logan, our oldest who was 12 at the time, went to run errands with me. After we left the first store, I called home. I asked Mike to have Mason, our middle child who was 10 at the time, go next door and tell Sydney to come home. I felt it was "our turn." Mike called back, "Sydney is not next door." I gave him a list of approved homes that she was allowed to play and asked him to call those friends.

You see, we lived in a neighborhood like the ones we grew up in. Kids rode bikes... you could stand on your front porch and yell for the kids to come home for dinner because they played the sport of the season outside.... girls loved to write on the sidewalk with chalk... And you never knew how many kids would end up coming home for dinner. It was a great neighborhood!!!!

Mike called back again and said she was not at any of those homes. I asked him to get in the car and ride around the neighborhood to look for her. Logan and I were at Wal-mart by this time. I left Wal-mart and headed home. As Mike was getting into the car, he found her in a fetal position in the back passenger floor board.

We were about half way home and I received a call from an unrecognized number and could not understand a word that came from the other end. I called the number back. I identified myself and asked if someone needed me. It was the cell phone of a family friend and they said, "yes, Mason called." Mason got on the phone and I could only make out a hand full of his hysterically said words, "we found Sydney and she is very blue." I told him to call 911. He said they already had and they were on the way.

When I arrived, a sheriff's car and an ambulance were in front of our house.

As I ran inside, our neighbor from across the street stopped and said, “you need to know that she is very, very blue.” I continued my race into our home. I found Mike sitting on the stairs. Then I turned the corner and saw the police and paramedics working on her. Mike was hold his knees and saying “it’s too late.. it’s just too late.” I screamed at the paramedics, “please don’t stop, PLEASE don’t stop.”

After what seemed to be forever in some way but seconds in others, the lead EMT told us they were taking her to the hospital. We told them we were right behind them. The head EMT came back into the house before we could leave and said she was so very sorry but they had done all they could do.

We asked to see her before they left. We sat in the ambulance and Mike and I each held a hand of Sydney’s and one of each others.

It was a time that I cannot describe. Such, such sorrow!!!! I had always heard the term, “died of a broken heart,” but I thought it was just a saying. I now know that is it an actual physical pain and I left like dying.

After a time period, I told Mike that we had two other children that needed us now more than ever and we needed to get out of the ambulance and take care of them.

We will never know the reason this happened. But as a mother knows her child, I feel I know what happened. When we returned home from church, I gathered all of the items from Mike’s car and took them into the house. When her friend was not home to play, Sydney stopped at the car on the way into our home to get her unfinished Sunday School craft. Sydney wanted to finish her craft. Who would ever have imagined that Sydney would take the craft to heaven herself.





## Rear Seats

### Rear Seat Reminder

#### Look in Rear Seat Reminder Feature

This message displays under certain conditions indicating there may be an item or passenger in the rear seat. Check before exiting the vehicle.

This feature will activate when a second row door is opened while the vehicle is on or up to 10 minutes before the vehicle is turned on, including if the vehicle was started remotely. There will be an alert when the vehicle is turned off. The alert does not directly detect objects in the rear seat; instead, under certain conditions, it detects when a rear door is opened and closed, indicating that there may be something in the rear seat.

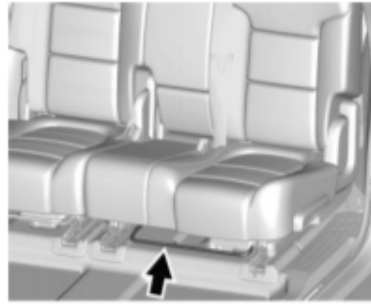
The feature is active only once each time the vehicle is turned on and off, and will require reactivation by opening and closing the second row doors. There may be an alert even when there is nothing in the rear

seat; for example, if a child entered the vehicle through the rear door and left the vehicle without the vehicle being shut off.

The feature can be turned on or off through *Vehicle Personalization* ⇨ 157.

### Rear Seat Adjustment

The second row seats slide forward for more room.



To adjust the seat position:

1. Remove objects on the floor in front of or on the second row seat, or in the seat tracks on the floor.

2. Lift the lever below the seat cushion and slide the seat forward or backward.
3. Push and pull on the seatback to ensure the seat is locked in place.

### Entering and Exiting the Third Row

#### Warning

Using the third row seating position while the second row is folded, or folded and tumbled, could cause injury in a sudden stop or crash. Be sure to return the seat to the passenger seating position. Push and pull on the seat to make sure it is locked into place.

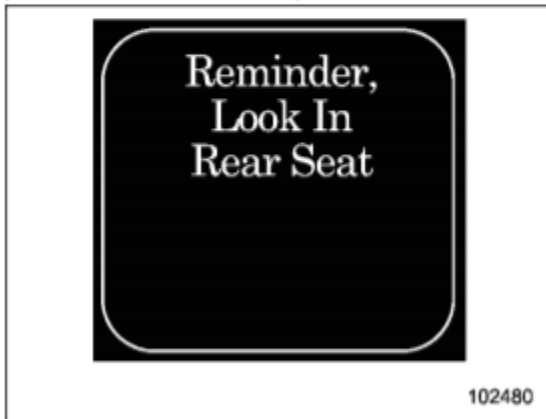


## 1-6. Rear Seat Reminder

This function prompts the driver to confirm the presence of passengers and cargo in the rear. It alerts the driver by warning messages on the display and beeps.

This function will be activated when the rear doors are opened and closed while the ignition switch is in the ON position.

It alerts the driver by warning messages on the display and beeps when the key position is in the OFF position.



### NOTE

- This function does not directly detect passengers and cargo in the rear seat.
- This function detects the opening and closing of the rear doors. In this

situation, there is the possibility that the following phenomenon may occur.

- It may alert the driver even if there are no passengers or cargo in the rear seat.
- It may not alert the driver even if there are passengers and cargo in the rear seat.
- This function can be turned ON/OFF using the meter customizing function. Refer to “Function settings and adjustments on the combination meter display” P26.
- The ON/OFF setting will not be changed even if the ignition switch is turned to the OFF position.
- The ON/OFF setting will be returned to the default setting if the battery is removed.



■ **Conditions affecting the operation of the smart key system or wireless remote control**

→P.132

■ **If the smart key system or the wireless remote control does not operate properly**

Use the mechanical key to lock and unlock the doors. (→P.481)

Replace the key battery with a new one if it is depleted. (→P.428)

■ **If the battery is discharged**

The doors cannot be locked and unlocked using the smart key system or wireless remote control. Lock or unlock the doors using the mechanical key. (→P.481)

■ **Rear seat reminder function**

In order to remind you not to forget luggage, etc. in the rear seat, when the engine switch is turned off after any of the following conditions are met, a buzzer will sound and a message will be displayed on the multi-information display for approximately 6 seconds.

- The engine is started within 10 minutes after opening and closing a rear door.
- A rear door has been opened and closed after the engine was started.


However, if a rear door is opened and then closed within approximately 2 seconds, the rear seat reminder function may not operate.

The rear seat reminder function determines that luggage, etc. has been placed in a rear seat based on opening and closing of a rear door. Therefore, depending on the situation, the rear seat reminder function may not operate and you may still forget luggage, etc. in the rear seat, or it may operate unnecessarily.

The rear seat reminder function can be enabled/disabled. (→P.515)

■ **Customization**

Some functions can be customized. (→P.515)

 **WARNING**

■ **To prevent an accident**

Observe the following precautions while driving the vehicle. Failure to do so may result in a door opening and an occupant falling out, resulting in death or serious injury.

- Ensure that all doors are properly closed and locked.
- Do not pull the inside handle of the doors while driving.

Be especially careful for the front doors, as the doors may be opened even if the inside lock buttons are in locked position.

- Set the rear door child-protector locks when children are seated in the rear seats.

■ **When opening or closing a door**

Check the surroundings of the vehicle such as whether the vehicle is on an incline, whether there is enough space for a door to open and whether a strong wind is blowing. When opening or closing the door, hold the door handle tightly to prepare for any unpredictable movement.

3  
Before driving



# Nissan Owner's Manual

## REAR DOOR ALERT

The Rear Door Alert system functions under certain conditions to indicate there may be an object or passenger in the rear seat(s). Check the seat(s) before exiting the vehicle.

The Rear Door Alert system is initially disabled. The driver can enable the system using the vehicle information display. For additional information, refer to "Vehicle information display warnings and indicators" in this section.

When the system is enabled:

- The system is activated when a rear door is opened and closed within 10 minutes of the vehicle being driven. When the vehicle is started and the system is activated, a visual message appears in the vehicle information display. For additional information, refer to "Rear Door Alert is activated" in this section.
- If a rear door is opened and closed but the vehicle is not driven within approximately 10 minutes, the system will not be activated. A rear door must be opened and closed and the car driven within 10 minutes for the system to activate.

When the Rear Door Alert system is activated:

- When the driver puts the vehicle in the P (Park) position, a notification message appears in the vehicle information display with the options to "Dismiss Message" or "Disable Alert" if desired.
  - Select "Disable Alert" to temporarily disable for that stop.
  - No selection or "Dismiss Message" will keep the alert enabled for that stop.
- If the alert is enabled when a driver exits the vehicle, a message will appear in the vehicle information display that states "Check Rear Seat for All Articles."
  - If "Horn & Alert" setting is selected:
    - An audible horn sound will occur after a short time unless a rear door is opened and closed within a short time to deactivate the alert.
    - If the doors are locked before the alert is deactivated by opening a rear door, the horn will sound.
    - If the liftgate is opened before a rear door is opened, the horn will be delayed until after the liftgate is closed.

### NOTE:

**If "Alert Only" setting is selected, the message alert will still be shown in the vehicle information display but the horn will not sound.**

### WARNING

- **If the driver selects "Disable Alert", no audible alert will be provided regardless of rear door open/close status.**
- **There may be times when there is an object or passenger in the rear seat(s) but the audible alert does not sound. For example, this may occur if rear seat passengers enter or exit the vehicle during a trip.**
- **The system does not directly detect objects or passengers in the rear seat(s). Instead, it can detect when a rear door is opened and closed, indicating that there may be something in the rear seat(s).**





- The Safe Exit Assist (SEA) system will not operate if there is a malfunction with the Blind-Spot Collision Warning (BCW) system as follows:

- When the BCW warning message appears

When the BCW sensor or the sensor surrounding is polluted or covered

- When the BCW does not warn or warns wrongly

For more details, refer to cautions and limitations in "Blind-Spot Collision Warning (BCW)" in chapter 5.

**⚠ WARNING**

- The system does not detect every obstacle approaching the vehicle exit.
- The driver and passenger are responsible for any obstacles while exiting the vehicle.  
Always check the surrounding before you exit the vehicle.

**Rear Occupant Alert (ROA) System (if equipped)**

The Rear Occupant Alert (ROA) system is provided to help prevent exiting the vehicle with the rear passenger left in the vehicle.

- 1st alert

- When you open the front door after opening and closing the rear door and turning off the engine, the "Check rear seats" warning message appears on the cluster.

- You can activate or deactivate the Rear Occupant Alert (ROA) system from the User Settings mode in the cluster LCD display. The option can be found under the following menu:

User Settings → Convenience → Rear Occupant Alert

- 2nd alert (if equipped)

- After the 1st alert the 2nd alert operates when any movement is detected in the vehicle after the driver's door is closed and all the doors are locked. The horn will activate for about 25 seconds. If the system continues to detect a movement the alert operates up to 8 times.

- Unlock the door with the remote key or smart key to stop the alert.

- The system detects movement in the vehicle for 24 hours after the door is locked.

- The 2nd alert is activated only after the prior activation of the 1st alert.



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