Uber Advanced Technologies Group

Public Safety Officials and First Responders' Guide

Interacting with Uber ATG Vehicles Operated by Mission Specialists

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Introduction

This guide describes how to identify Uber Advanced Technologies Group's (Uber ATG's) developmental self-driving vehicles in the event of an emergency situation, and provides guidelines for safe interaction with those vehicles. It is intended for use by trained public safety officials and first responders in ATG operating locations, and assumes appropriate familiarization with safe emergency response procedures.

This version of the guide is scoped to support Uber ATG's self-driving testing with Mission Specialists, i.e., trained safety drivers. ATG will make a subsequent version of this guide available to cover emergency response protocols or interactions with a driverless self-driving vehicle. Currently, Uber ATG is conducting testing with two Mission Specialists in the front seats of the vehicle. Mission Specialists undergo training that prepares them to respond to scenarios such as those involving emergency vehicles, manually-directed traffic, and routine traffic stops. They also undergo incident response training that prepares them to respond following an incident, including engagement with emergency personnel. This guide does not address self-driving vehicles owned and/or developed by third-parties that may be operating on the Uber network in the future, and only covers that data that relates to an incident involving an Uber ATG vehicle.

The information contained in this guide references and complements that found in our Voluntary Safety Self-Assessment and is intended to further the U.S. Department of Transportation's recommendation to engage in robust public education as an essential aspect of the development of self-driving technology. More information on our approach to safe development and testing of developmental self-driving vehicles is available at uber.com/ATG/safety.

01 → Uber ATG Self-Driving Vehicles

Identifying an Uber ATG Self-Driving Vehicle

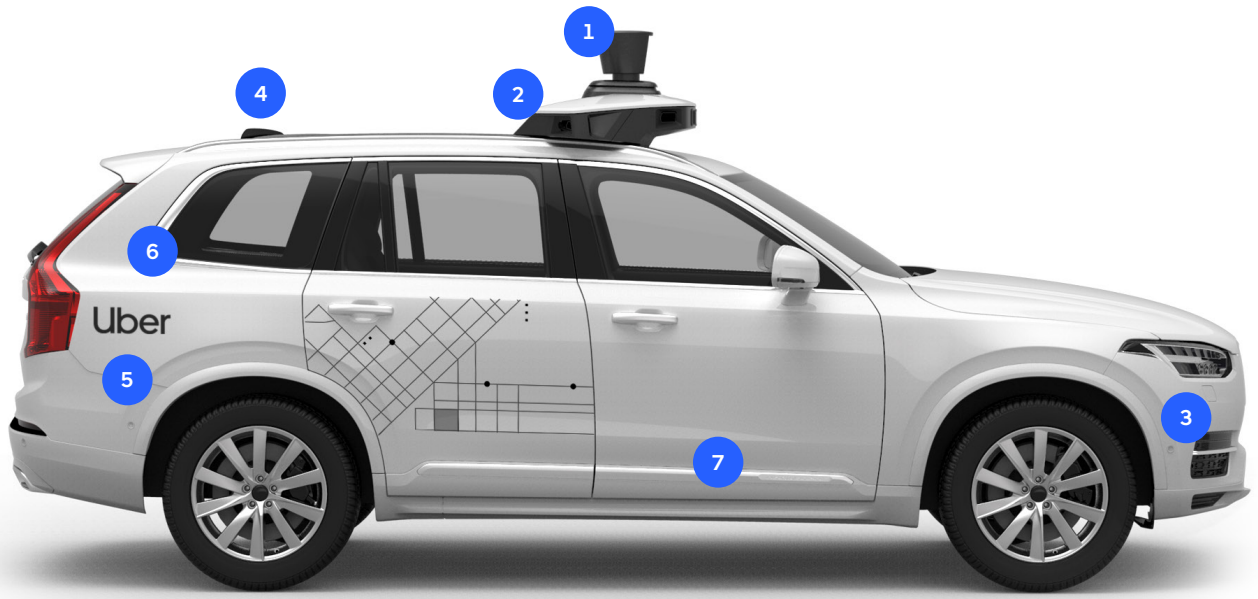
Uber ATG currently operates a small, developmental fleet of self-driving vehicles. The fleet is currently comprised of Uber ATG's Second Generation Volvo vehicles, XC90 T8 Hybrid Electric SUVs, upfitted with sensors and our developmental self-driving technology.

Uber ATG developmental self-driving vehicles are clearly identifiable by:

1 Uber branding on both sides of the vehicle.

2 The sensor wing attached to the roof.

Technology Overview



1 Light Detection and Ranging (LIDAR)
LIDAR is a remote sensing method that uses light in the form of a pulsed laser to measure distances to actors and objects. Each upfitted XC90 is equipped with one top-mounted LIDAR unit. Uber ATG's self-driving system utilizes a LIDAR unit with a range of over 100 meters (m).

2 Cameras
Each upfitted XC90 is equipped with cameras that provide high resolution, near-, medium-, and long-range imagery. There are cameras mounted in the sensor pod on top of the vehicle and around the vehicle for 360° coverage. The camera hardware and accompanying firmware are custom to the Uber ATG self-driving system. Some of these cameras have a wide field of view and some have a narrow field of view. A system of cameras provides imagery to support near-range sensing of people and objects within 5m from the vehicle, in particular to assist during pick up and drop off, lane changing, and parking.

3 Radar
Each upfitted XC90 is equipped with radars that provide object detection, ranging, and relative velocity of objects. Forward-facing radars are mounted below the headlamps, side-facing radars are mounted in the front and rear corners of the vehicle, and rear-facing radars are mounted near the ends of the bumper beam.

4 Global Positioning System (GPS)
The GPS system provides rough position to support localization, vehicle command, map data collect missions, and satellite measurements.

5 Self-Driving Computer
The self-driving computer is the main system computer running Perception, Prediction, Motion Planning, and other software. The computer hardware and firmware are custom to Uber ATG's self-driving system. The computer is liquid-cooled for high power heat rejection.

6 Telematics
Custom telematics hardware and software provide cellular data communication to support carrier network redundancy, secure mobile data traffic, and authenticated cloud communication.

7 Vehicle Interface Module (VIM)
The VIM is a gateway to allow the self-driving computer to communicate with the various vehicle control systems.

On-Road Operations

Currently, Uber ATG operates developmental self-driving vehicles with two Mission Specialists in the front seat of the vehicle. Both Mission Specialists undergo training on our developmental vehicles, which prepares them to operate the vehicles on our test track and on public roads. Training includes education on the self-driving system and operating skills.

- **The Pilot**, or operator behind the steering wheel, is solely focused on ensuring safe operation of the vehicle.
- **The Co-Pilot**, the second operator in the right front seat, is tasked with monitoring and annotating the behavior of the self-driving system via a laptop.

Each vehicle is equipped with a touchscreen tablet, the Operator Tablet, that communicates important information to our Mission Specialists, including turn-by-turn directions and self-driving system mode. It is located on the center dashboard and follows NHTSA's Human Factors Guidance for Driver-Vehicle Interfaces[1] to minimize distraction connected to installed vehicle components. It does not require input from the Pilot while driving and automatically limits device functionality when traveling over 5 miles per hour.

[1] NHTSA, 2016, 'Human Factors Design Guidance For Driver-Vehicle Interfaces.'

02 → Post-Crash Features of the Vehicle

Post-Crash Behavior

In the event of a collision, the Volvo XC90 base vehicle's post-impact safety features will continue to function as expected and may perform a variety of actions depending on the type and severity of the collision detected, including:

- **Passive Safety Feature Activation**
  Deploys front and side curtain airbags, activates seat belt tensioners, and automatically unlocks doors.
- **Safety Mode Activation**
  Reduces vehicle functionality when any of the vehicle's vital functions may have been damaged in a collision. When activated, a warning may be shown on the dashboard with the message "Safety mode See Owner's manual."[2]
- **Post-Impact Braking**
  Brings the vehicle to a controlled stop after the collision to avoid the vehicle entering the path of other vehicles.
- **Hazard Lights Illumination**
  Warns other approaching drivers of the potential hazard.
- **High-Voltage Battery Disconnection**
  Disconnects the high-voltage battery to minimize risk of electric shock to passengers and first responders. Should the collision result in the automatic disconnection of the high-voltage battery, the self-driving system will also lose power within 30 seconds.
- **Fuel Supply Disconnection**
  Disconnects the fuel supply to the engine.
- **Emergency Services Notification**
  Automatically makes an emergency call to personnel trained to immediately assist. The GPS location of the vehicle is automatically sent so that first responders can be called directly to the scene of the incident.

NOTE : In a low-impact collision, these features may not be automatically triggered. In the case of a low-impact collision, see Section 03: Disengagement, Immobilization, and Powering Down.

[2] Volvo Cars, 2018, 'Safety mode.'

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Disengagement, Immobilization, and Powering Down

03 → Disengagement, Immobilization, and Powering Down

Under many different types of circumstances, Mission Specialists are trained to take manual control of the vehicle, which automatically disengages the self-driving system. While we do not anticipate public safety officials or first responders needing to manually disengage, immobilize, or power down the system, familiarity with these protocols will enable first responders to understand the state of the automation system, should the Mission Specialist be unable to act or respond.

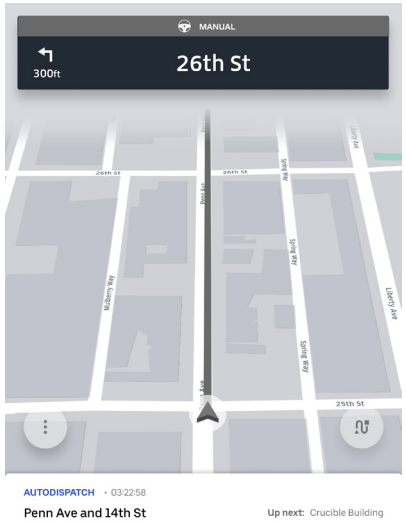
Disengagement

Transitions to and from manual driving help facilitate safe testing and manage a number of types of risk. These transitions are traditionally completed only by Mission Specialists who have received the training necessary to understand how and when to do so safely.

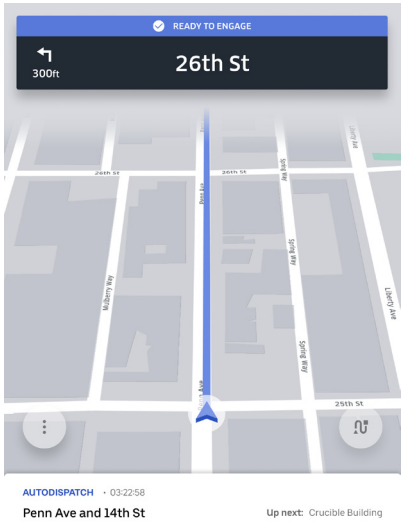
Identifying the System State

In each discrete self-driving system state (manual, ready to engage, self-driving), the current operational mode is displayed to the Mission Specialist on the Operator Tablet using a persistent banner that changes color and text depending on the mode. Turn-by-turn instructions, including route lines, are displayed on the tablet; route lines match the color of the banner.

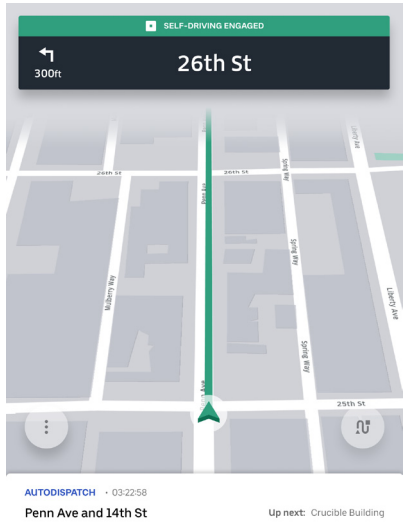
→ Manual



→ Ready To Engage



→ Self-Driving



Disengaging the Self-Driving System

We have designed the self-driving system to have multiple means of shifting from self-driving to manual driving.

Any of the following actions will independently disengage the self-driving system:

1 Press the accelerator pedal.

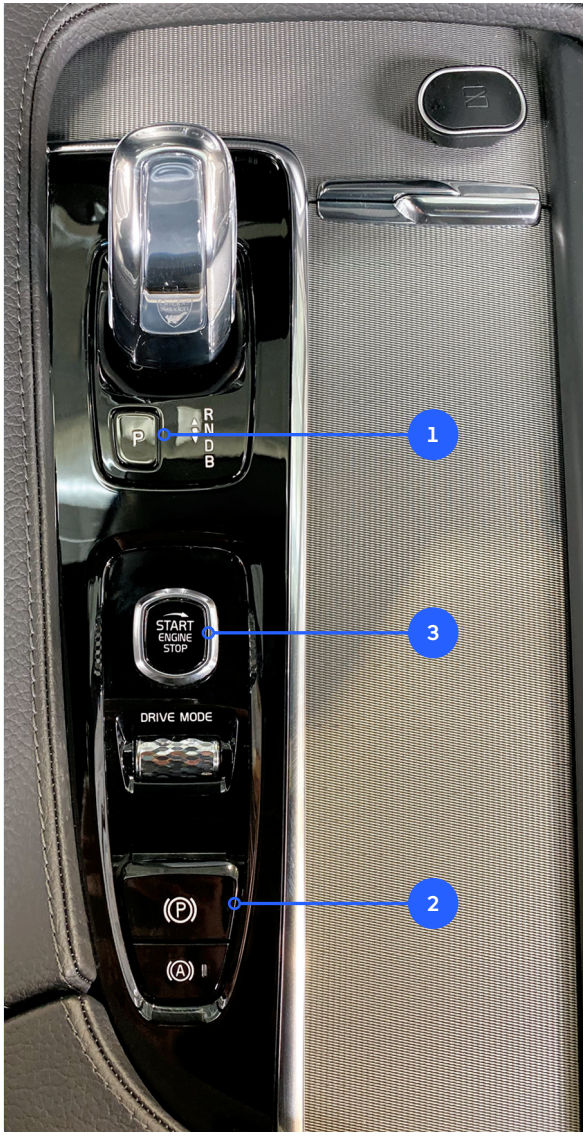
2 Press the brake pedal.

3 Rotate the steering wheel.

4 Press and hold both steering wheel paddles.

While not intended as primary disengagement methods, a Pilot disconnecting their seatbelt or opening their door will also disengage the self-driving system.

03 → Disengagement, Immobilization, and Powering Down



Immobilization / Locking the Wheels

The Park Switch and Electronic Parking Brake provide two methods for locking the vehicle wheels, in order to prevent rollaway. In the event that these controls are not automatically applied, both can be activated manually by controls located on the center console. Once activated, these controls will continue to keep the wheels locked even in the event that electrical power is lost.

1 Park
Push the P button to place the vehicle in Park.

2 Electronic Parking Brake
Pull the rocker switch (P) upwards and hold for 3 seconds to apply.

Powering Down / Stopping the Engine

In the event of a collision, to power down the developmental self-driving vehicle follow the same protocol as powering down a standard Volvo XC90 by using the Start/Stop knob. The Start/Stop knob is located on the center console. This method will prevent any further vehicle propulsion.

3 Start / Stop Engine
Twist the knob clockwise and hold for 3 seconds to power off the vehicle.

Uber ATG developmental self-driving vehicles contain an additional low voltage 12-volt battery used to power the self-driving sensors and computer. This battery is located in the trunk area and secured below a tamper-proof load-bearing floor. The 12-volt battery will power off automatically with the loss of high-voltage power; systems powered downstream of the battery will power off within 30 seconds. Actuation of the vehicle controls will be disabled immediately once the ignition is off.

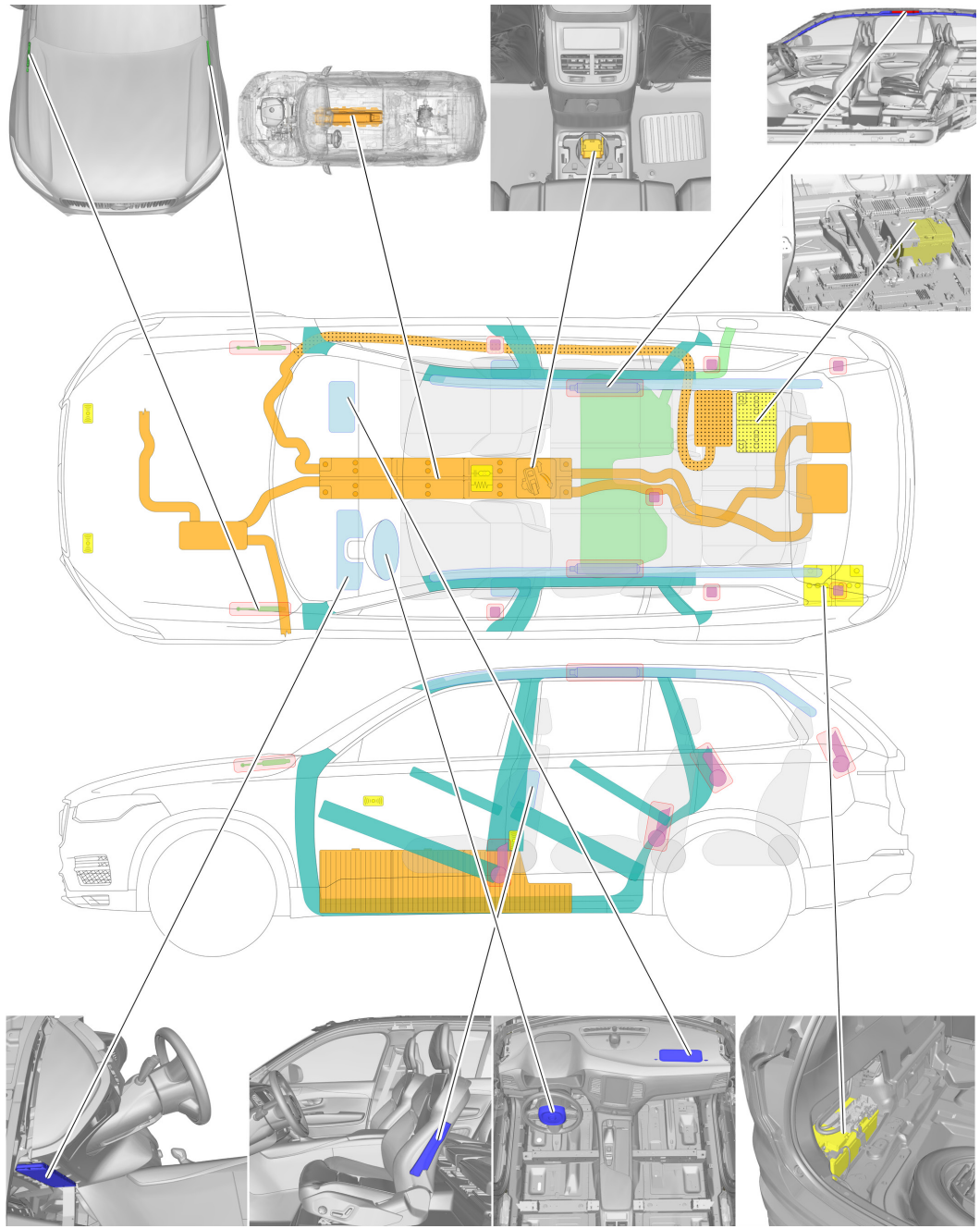
04 → Vehicle Extrication

Vehicle Extrication

The following diagram details information about and location of the different types of stored energy, e.g., pyrotechnical, fuel, and electric voltage, found in the Uber ATG developmental self-driving vehicle. These locations should be taken into consideration during rescue activities, including extrication, to avoid accidental activation or ignition of systems. It is important to note that, in addition to the Volvo XC90 base vehicle high-voltage system, Uber ATG adds an additional high-voltage line along the passenger side of the vehicle, and it is connected to the base vehicle high-voltage system. In the event the high-voltage system is disconnected, this line will be disconnected as well. The Volvo base vehicle 12-volt battery and high-voltage system isolation process remain unchanged from the base vehicle.

1. **Airbags**
2. **Danger zone**
3. **Seat belt pretensioner**
4. **Reinforcements**
5. **Fuel**
6. **Battery**
7. **High voltage**
8. **Additional Uber ATG battery**
9. **Additional Uber ATG high voltage**

NOTE: This diagram was modified from its original source to include the additional high-voltage line and 12-volt battery in the Uber ATG developmental vehicle. With added awareness of the additions, all base vehicle emergency response information remains applicable to the Uber ATG developmental self-driving vehicle and can be found in the Volvo XC90 Safety Instructions for Rescue Work.



Descriptions and Locations of Stored Energy in Uber ATG's Second Generation Volvo Developmental Vehicles, Modified from Original Source: Volvo Cars

05→ Post-Incident Response and Data Accessibility

Mission Specialist Response

In the event of a collision involving an Uber ATG developmental self-driving vehicle, Mission Specialists will contact the Uber ATG Operations team and perform the necessary Uber ATG emergency response procedures, which may, depending on local requirements and the facts surrounding a particular incident, include notifying local public safety officials and/or deploying an Uber ATG Operations supervisor to the scene.

Where it is safe to do so, the Mission Specialists remain with the vehicle post-crash to provide reasonable assistance to involved parties, including law enforcement and first responders. Data from the vehicle will not be immediately available on the scene.

In accordance with Uber ATG's incident response training, Mission Specialists and supervisors are required to collect:

- Officer's name
- Agency name
- Badge number
- Phone number
- Police report/citation number
- Information about the incident
- Photos of the vehicle

Safe Vehicle Relocation and Towing

As part of the Mission Specialists' functions, they are trained to move the vehicle to a safe location after an incident, provided it is safe and possible to do so. If it is not possible to move the vehicle, they will follow the appropriate emergency response procedures.

Mission Specialists are trained to avoid turning on the engine after an incident to preserve the data on the vehicle. If a public safety or first responder finds it necessary to turn on the vehicle for any reason, the vehicle should NOT be turned on for an extended period of time. Turning on the developmental vehicle for an extended period of time prior to offloading the data risks data loss or corruption to data captured before or during the incident.

Uber ATG contracts vehicle towing services in each of its operating locations that will respond once contacted, in the event the Uber ATG vehicle cannot be manually operated. The Uber ATG Operations team will provide the contact information for the towing company. Our contracted towing companies are experienced with relocating our vehicles and are trained on the best methods to interact with our vehicles without damaging the base vehicle, self-driving sensors, or self-driving computer.

Post-Incident Data Requests

Our developmental vehicles capture significant quantities of environmental and system data, most of which is useful only when processed through proprietary systems. All of this data must be manually offloaded before being accessed and is therefore not available at the scene of an incident.

Uber maintains an online portal to streamline and simplify requests for data from our self-driving vehicles that might provide necessary information for a law enforcement investigation. To submit a request to the Uber Law Enforcement Response Team (LERT), law enforcement personnel should create an account and submit the request through the LERT Portal at **lert.uber.com**.

The LERT Portal is a central place for law enforcement to communicate securely with our Law Enforcement Operations team on both routine and exigent matters. We have a dedicated team monitoring the portal 24/7, and it is the best way to receive timely, up-to-date responses. The portal can be used to request data preservation, submit legal process for obtaining data, get status updates on responses to legal process, and ask questions.

All other inquiries can be directed to: **info-atg@uber.com**.

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Contact Information

Law Enforcement Response Team
lert.uber.com

General Information
info-atg@uber.com

Additional Resources

Uber ATG Safety Resources
uber.com/ATG/safety

National Fire Protection Association
Alternative Fuel Vehicles Safety Training
Safety Information for Electric Vehicle Fires

National Highway Traffic Safety Administration
Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped With High-Voltage Batteries

Volvo Cars
Volvo XC90 Safety Instructions for Rescue Work