

Waymo

Test-Driver Training Program Outline

March 2, 2018

Waymo's Test Driver Training Program is designed to match the level of training to the complexity of testing and operation of our vehicles.¹ Each of the following training modules is conducted by an experienced driver and requires each trainee to pass a post-training evaluation with an instructor before being considered a qualified Test Driver of a Waymo autonomous vehicle.

Test Driver Training Program consists of a combination of in-vehicle training, a defensive driving course, and classroom time all under instruction. During in-vehicle training, two trainees will be paired with an instructor and will be taught on the manual and autonomous operation and limitations of the vehicle. Additionally, trainees will receive third party driver training on a closed course, using non-autonomous vehicles, where they will learn behind-the-wheel defensive driving techniques and experience exercises in recovering from hazardous driving scenarios. If the trainee fails an evaluation, Waymo may provide remedial training. If the trainee cannot pass after such remedial evaluations, he or she will exit the program. Trainees will not be permitted to operate a Waymo autonomous vehicle (outside of instruction) until they have successfully completed the Test Driver training program, including passing the final evaluation. An individual's training progression is subject to extension based on management discretion.

Test drivers will train and operate as solo operators in Waymo autonomous vehicles on public surface streets and highways, as well as closed course, private roads.

All training materials and concepts are subject to change as the autonomous technology or vehicle platforms evolve.

Additional details of the test driver training program are below.

¹ The Waymo *Test-Driver Training Program* is only applicable to Waymo vehicles that require a human operator to engage in the dynamic driving task, as required under our current AVT permit from the CA DMV. Waymo vehicles that may be tested in California subject to the Department of Motor Vehicles' recently released *Driverless Testing and Deployment Regulations* will not allow a human to engage in the dynamic driving task. Any Waymo employees or agents that may be occupants in such vehicles would go through separate training processes, as they would not be considered test drivers.

Basic Test Driver Training (approx. 2-3 weeks):

Week 1: Manual Driving on Public Roads (Non-Autonomous Chrysler Model), Third-Party Driver Training School

- **Manual driving on public roads**
 - In-car training will be with a 2 trainee:1 instructor ratio.
 - Trainee spends 1.5 days (roughly 3.5 hours in-vehicle) under instruction on public surface streets and highways while being evaluated on their manual driving skills. They operate non-autonomous Chrysler Pacifica minivans, the same make and model as Waymo's autonomous vehicles. Drivers are evaluated and coached on their ability to follow best driving practices and local driving laws, including executing full stops at stop signs, following speed limits, proper turn signal usage, spatial awareness using mirrors, safe merging on and off highways, unprotected left turns, and proper parking and reversing techniques.
 - Trainees are then formally evaluated on their driving during an in-field manual driving test. If a trainee does not pass the initial test, they may re-take it after appropriate feedback and at management discretion. If the trainee cannot pass the test after the remedial instruction, he or she will exit the training program.
- **Emergency procedure drills**
 - Trainees spend 30 minutes reviewing post-collision procedures in the event they're involved in a collision.
 - This involves a role-playing exercise with a senior driver, as well as a procedural document review.
 - On a closed course, trainees spend 20 minutes behind the wheel of a specially-built vehicle that can experience vehicle failures on-demand, including loss of power steering, power brakes, and throttle. This prepares test drivers for worst-case vehicle failure scenarios.
- **Third-party defensive driver training course**
 - Third-party defensive drivers training is a 1-day closed-course training program where trainees learn how to maneuver Chrysler Pacificas and 2-door sports cars through various dynamic exercises designed to simulate hazardous driving scenarios. The vehicles used during this training are standard, non-autonomous vehicles. All test drivers must pass this training before becoming eligible to drive autonomous Waymo vehicles in either Manual or Autonomous mode.
 - Two classroom sessions (approx. 2 hours total)
 - Behind-the-wheel instruction and rear-seat observation in various exercises (approx. 5 hours)
 - Review of track rules and safety procedures
 - Safe seating position

- Proper mirror positions
- Proper seating placement
- Proper hand placement
- Proper leg placement
- Walk-through of training exercises and scenarios to be completed
- Exercises (approx. 45 mins per exercise)
 - Slalom
 - Drivers/trainees experience load-balancing, threshold braking, corrective inputs in steering, braking, and throttle
 - Tight course maneuvering (forward/reverse)
 - This exercise challenges drivers/trainees to understand the dimensions of the vehicle and the use of side-view mirrors while they try to maneuver through a tight course both in forward and reverse
 - Evasive lane-change
 - Drivers/trainees practice vehicle load balancing while they enter a Y-shaped course designed to test reflexes and vehicle control; occurs between 35-60 mph
 - Oversteer/Understeer
 - Helps drivers/trainees understand the behaviors of understeer/oversteer on a vehicle and how to safely control the vehicle
 - Emergency braking
 - Drivers/trainees get comfortable accelerating to 40-50 mph and engaging ABS to understand how it feels and understand why it's important that the wheels continue to move (rather than lock) to avoid losing steering control
 - Evaluation - Instructors check-off on the following:
 - Was the driver/trainee able to understand and complete the exercises?
 - Was the driver/trainee able to effectively communicate with the instructor?
 - Proficiency in vehicle control
 - Did the driver/trainee hit any cones?
 - Did the driver/trainee need to add extra input to steering, braking, or acceleration to recover the vehicle?
- **Closed-course autonomous vehicle fault injections**
 - Instructors intentionally cause an autonomous Chrysler Pacifica vehicle to exhibit extremely poor behavior while on a closed-course for approximately 1.5 hours

per trainee. Fault injections are randomized and include: harsh braking, dynamic lateral movement (swerves), aggressive acceleration, and simulated software and hardware errors, etc. Instructors are constantly injecting faults in order to prepare test drivers for worst case scenarios.

- **Classroom Sessions**
 - During three classroom sessions (approx. 30 mins each), instructors cover topics such as the importance of manual driving, Waymo operating policies, driving guidelines and best practices, interacting with the public, and emergency procedures.
 - Each classroom session is followed by an assessment the next day to judge each trainee's retention and mastery of the relevant information.
- **Manual Driving Evaluation**
 - During the evaluation, the trainee is graded on their ability to smoothly and safely operate the vehicle on public roads. In a 1:1 trainee to instructor environment, the trainee must show proper driving position, mirror placement, spatial awareness, ability to follow local driving laws, parking and reverse skills, and show overall good judgement and driving instinct.

Week 2: Test Driver Instruction and Evaluation on Public Roads (Single-Driver Vehicle Operation; Autonomous Chrysler Model)

- **Autonomous driving on public roads**
 - Drivers must complete a minimum of 4 days (approx. 2 hours of in-vehicle driving per day) of autonomous test driving on public surface streets and highways under the evaluation of an instructor.
 - In-car training will be with a 2 trainees:1 instructor ratio.
 - Four classroom sessions (approx. 1.5 hours each) cover topics such as the operational basics and limitations of the autonomous system, vehicle setup, leaving engineering feedback, and troubleshooting.
 - Each classroom session is followed by an assessment the next day to evaluate each trainee's retention of the relevant information.
 - Trainees must satisfactorily complete a written best practices exam.
- **Autonomous Driving and Vehicle Checklist Evaluations**
 - Trainees are eligible to take the Autonomous Field Test and Vehicle Checklist Test at the end of the week, pending completion of all requirements listed above. Both tests are taken with a 1:1 trainee to instructor ratio:
 - During the Vehicle Checklist Test, the trainee must display the skills necessary to efficiently and safely turn on the autonomous vehicle, setup its software, and ensure its roadworthiness.

- Trainees taking the Autonomous Field Test must display their system knowledge while maintaining safe and efficient operation of the vehicle on public roads and highways. They are graded on their technical knowledge of the self-driving system, Waymo company policies, operational best practices, ability to leave engineering feedback, and system disengagement logic and threshold.
- Test drivers must pass both tests in order to complete basic training.
- If a trainee does not pass either test initially, they may re-attempt it during Week 3.

Week 3: Continued Test Driver Instruction and Evaluation on Public Roads (Single-Driver Vehicle Operation; Autonomous Chrysler Model) (Optional)

- If a trainee does not pass either the initial Autonomous Field Test or the Vehicle Checklist Test during Week 2, they may undergo additional days of instruction followed by a maximum of two remedial tests.
 - If the trainee cannot pass after the remedial instruction, he or she will exit the training program.

Ongoing Training and Notable Training Tools/Methods

The following exercises and methods are intended to help our test drivers maintain the highest standard of safety on the road throughout their employment. This continuous training program also helps our test drivers stay up to date on changes to Waymo's autonomous driving system.

- Operator feedback during training
 - Instructors leave feedback on Test Driver trainees after each training session to share progress of trainees. This helps instructors focus and improve on a trainee's strengths and weaknesses from session to session.
- Team scenario review
 - Reviewing "play-back" videos of difficult driving scenarios teams have experienced in the field gives test drivers the advantage of analyzing difficult situations without having to experience them first-hand. This exercise helps flag difficult areas and teach test drivers how to react should they encounter these same situations.
- Instructor check-ins
 - Every quarter, program managers perform random ride-along check-ins on test drivers to ensure they are operating safely and correctly.
- Software release notes

- Test drivers receive regular updates from senior test drivers, instructors, program managers, and/or engineers on continually updated changes to the autonomous technology and expected vehicle behaviors.