Driver Direct-Vision Measurement Protocol

Version I DRAFT

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IIHS

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Contents

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OVERVIEW

This protocol describes the process for measuring driver vision and quantifying blind zones from motor vehicle structures. It is based on the findings of Insurance Institute for Highway Safety research (Mueller et al. 2025).

This measurement protocol applies to passenger and commercial vehicles.

Other supporting documents for the Insurance Institute for Highway Safety's (IIHS's) driver direct-vision measurement process are available from the *Test Protocols and Technical Information* section of the IIHS website.

EQUIPMENT

Dummies

In this protocol, the eye position of the following dummies is measured from the driver seat of the test vehicle:

- Hybrid III 50th percentile male dummy
- Hybrid III 5th percentile female dummy

From this point forward, we refer to these dummies as the

- 50th male and
- 5th female, respectively.

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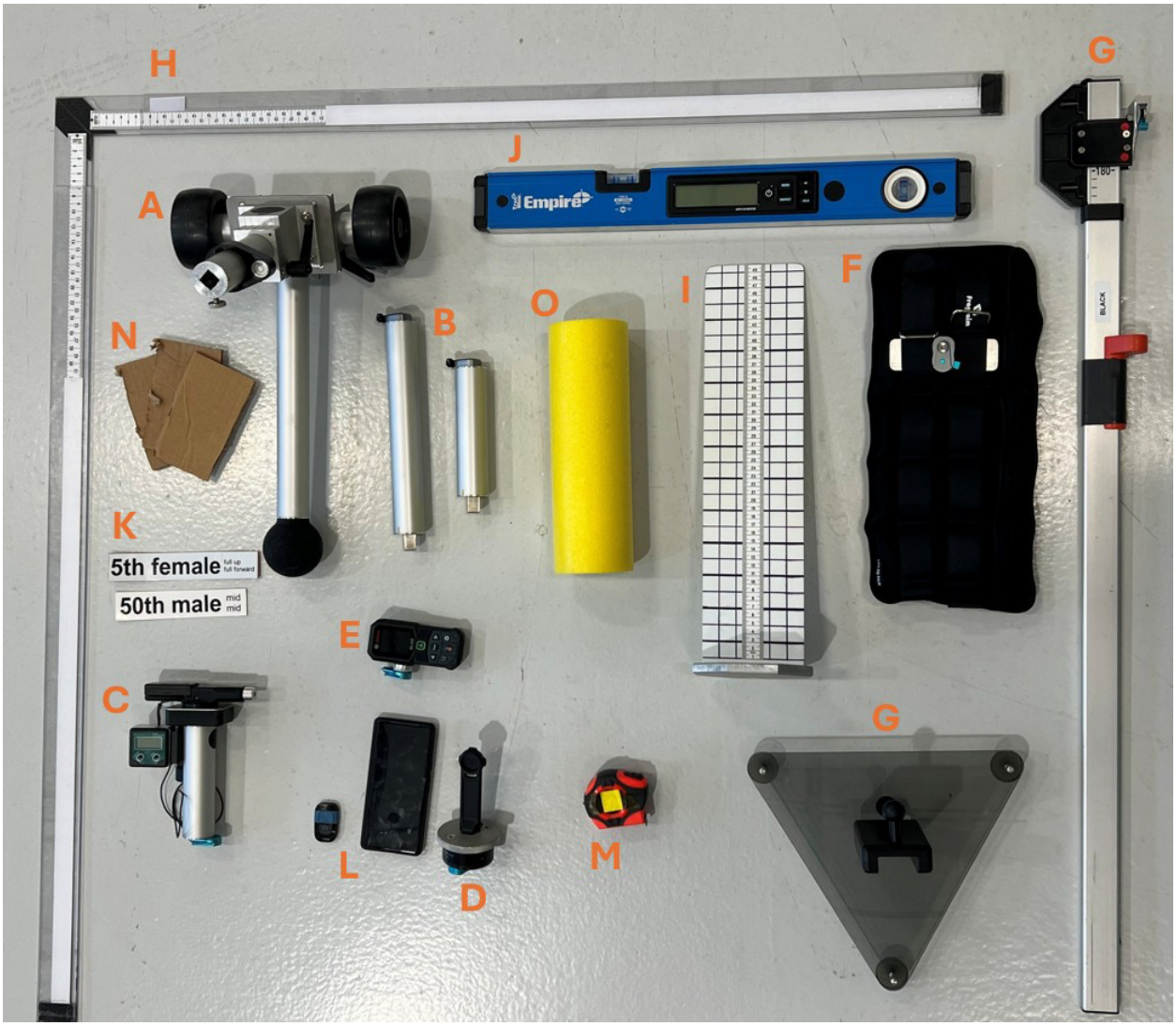
Inventory

Ensure the following items are present (Figure 1).

Figure 1
Equipment inventory



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The following table identifies the equipment in Figure 1.

Letter	Name
A	Measurement rig base
B	Two neck extensions for the measurement rig base: one for the 50th male dummy and one for the 5th female dummy
C	Laser-angle measurement tool
D	Camera mount
E	Digital measurement tool
F	Sandbag
G	Measurement pole with base
H	Foldable measurement square (clear, made of plastic)
I	Floor target grid and base
J	Large digital level
K	Placards
L	Camera and remote control
M	Tape measure
N	Shims
O	Foam roller

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Rig assembly

Assemble the measurement rig (Figure 2). First, attach the 50th-male neck extension to the rig base. Align the black marks and tighten the set screw (Figure 3).

Do not assume the set screw is tight enough that you can hold the device by the neck extension. Always have at least one hand holding the device below the set screw on the base.

Figure 2
Direct-vision rig base with 50th male and 5th female neck extensions

Figure 3
Align marks on neck extension and base and tighten set screw

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VEHICLE SETUP

1. General vehicle setup

1.1 Place the vehicle on a reasonably flat and level ground surface, with space in front of the vehicle that creates a clear contrast from the ground and the hood line of the vehicle.

1.2 Check the vehicle for any items blocking the view from the windows, and remove all that you find. For example, check for items on the dashboard, hood, and rearview mirror; and check for child safety seats in the second row.

1.3 If the vehicle comes with an adjustable suspension, adjust it to normal driving mode. Make a note if this feature is present (e.g., "adjustable suspension, set to normal mode").

1.4 Record the vehicle's model year, make, model information, and vehicle identification number (VIN).

1.5 Take a photo of the VIN, the front of the vehicle, and the back of the vehicle (for reference).

1.6 Roll down the front-row windows.

1.7 Check that the vehicle wheels are straight and the steering wheel is upright.

2. Steering wheel setup

2.1 Set the steering column to the fully stowed position (toward the dashboard).

2.2 Adjust the steering column to mid-tilt (midway through the column's tilting range).

2.3 Measure and record the minimum and maximum tilt angles of the steering column, using the large digital level (Figure 4):

2.3.1 Place the level across the steering wheel.

2.3.2 Hold the level in place.

2.2.3 Adjust the steering column to the maximum tilt angle, then record this value.

2.3.4 Adjust the steering column to the minimum tilt angle, then record this value.

2.4 Calculate the mid-tilt angle.

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Figure 4
Large level to adjust the steering column's tilt angle

3. Vehicle side-mirror measurements

Measure the tallest and widest parts of a side mirror on the test vehicle with a tape measure. Include the mirror's housing in both measurements.

3.1 Slide a tape measure along the height a side mirror at its widest point, as shown in Figure 5 (left side); record the value.

3.2 Slide a tape measure along the width of the same side mirror at its widest point (Figure 5, right side); record the value.

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Figure 5
Measure the height and width of side mirror

SEAT POSITIONING

1. Driver seat positioning

1.1 50th-male seat position: mid-track and mid-height

The first set of driver direct-vision measurements are taken from the 50th-male eye position, with the seat positioned at mid-track and mid-height.

The following steps must be done to ensure consistent positioning of the seat. After completing the setup of the 50th male dummy in the driver seat, skip to the *Right front-passenger seat* section to continue the measurement process.

1.1.1 Adjust the driver seat to its lowest vertical height.

1.1.2 If the vehicle is equipped with adjustable lumbar support, ensure the feature is off or retracted.

1.1.3 Install the floor target on the driver-side floorboard.

1.1.4 Place the digital-measurement tool on the driver seat, then align the tool with the floor target. Ensure the laser is forward and projecting onto the floor target (Figure 6).

The lateral location on the seat is arbitrary; ensure it aligns with the floorboard target, as each vehicle may accommodate the floor target differently.

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Check that the digital measurement tool is stable and will not shift as the seat is moved. These numbers are relative (arbitrary) but help us determine the seat range. If you remove any part of this assembly before the final positioning, you must start the process of finding the mid-track and mid-height positions over again.

Figure 6
Digital measurement tool and floor target setup

1.1.5 Move the driver seat to its forwardmost longitudinal position and record the distance. If the digital-measurement tool cannot measure because it is too close, readjust the digital measurement tool rearward on the seat and restart the measurement process.

1.1.6 Move the driver seat to its rearwardmost longitudinal position and record the distance.

1.1.7 Compute the mid-track distance.

1.1.8 Position the seat at mid-track.

1.1.9 From the mid-track position, use the vertical seat adjustment to go from the lowest to highest seat height and record the values. If the seat begins to move forward as it moves up, allow it to do so—do not readjust the seat rearward.

1.1.10 Calculate the mid-height position, and adjust the seat down to that height.

1.1.11 Place the large level across the driver seat back along its centerline (Figure 7). Feel for a structural bar near the top and bottom of the seat back to use as reference points. Adjust the seat back angle to 67° $\pm$ 1°.

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1.1.12 Go to the *Seat positioning* section > *2. Right front-passenger seat position*.

Figure 7
Large level for adjusting the driver seat back

1.2 5th-female seat position: full forward and full up

1.2.1 Remove the 50th-male neck extension from the rig base.

1.2.2 Attach the 5th-female neck extension to the rig base. Do not remove the whole rig from the seat.

1.2.3 Adjust the driver seat to the full-forward position.

1.2.4 Adjust the driver seat height to the full-up position. Some seats move forward and upward in a way that is not a realistic seating position.

1.2.5 Determine if any point along the seat has a clearance of less than 10.5 cm between the dashboard and the front of the seat pan, using the 10.5-cm foam roller.

If the foam roller is pinched between the seat and dashboard (you can hold the roller in place), move the seat rearward (do not adjust the height) until the clearance between the seat and the dashboard is at least 10.5-cm along all parts of the seat.

The foam roller should slide freely through the gap between the seat and the dashboard.

Be sure to keep the foam roller low near the steering column so you are not adjusting the seat to accommodate the space between the steering column and seat, but are adjusting the seat to accommodate the space between the dashboard and seat, as shown in Figure 8.

1.2.6 Go to the section *Direct-vision rig installation*.

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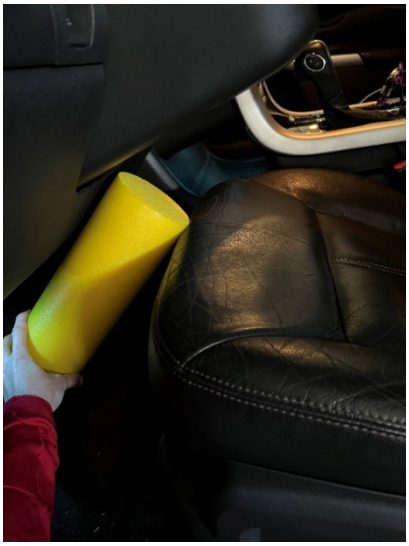
Figure 8
Foam roller check for the 5th-female's seating position (full forward and full up)



2. Right front-passenger seat position

2.1 Adjust the right front-passenger seat to its lowest vertical height.

2.2 Adjust the right front-passenger seat to match the mid-track longitudinal position of the driver seat, by lining it up with the driver seat while at mid-track. Use a reference point on both seats to assist with this process.

For the 5th-female driver, leave the passenger seat in the mid-track position; do not adjust the passenger seat to match the 5th-female seating position at full forward).

2.3 Place the large level across the vehicle seat back along the centerline.

2.4 Feel for a structural bar near the top and bottom of the seat back to use as reference points. Adjust the seat back angle until it is 67° $\pm$ 1°.

2.5 Set the right front-passenger head restraint to its lowest vertical height and its neutral or rearmost longitudinal position.

3. Second- and third-row seat positions

3.1 Check the second-row seats for a seat back adjustment lever or controls. If the seat back can be adjusted, move it to the first locking position (its most upright position).

3.2 Set the head restraints in the second-row seats to the lowest vertical locking position, or stow the second-row seats, if possible to do so in the vehicle.

3.3 If the second row seats have a seat track and you can adjust the seats forward or backward, then move the second-row seats to the rearmost seat-track position.

3.4 Stow the third row of seats, if applicable.

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DIRECT-VISION RIG INSTALLATION

1. Install the measurement rig on the driver seat.

2. Check that the rig is squarely positioned against the seat back and centered in the seat (Figure 9, left side).

3. Place the sandbag on the base of the rig to secure it in place (Figure 9, right side).

Figure 9
Adjust rig in driver seat and secure it

4. Recline the seat back. It is acceptable if the rig wheels no longer touch the seat back after the driver seat is reclined.

5. Place the digital-measurement tool on the top of the rig in the longitudinal direction, pointed toward the steering wheel.

6. Adjust the neck of the rig until the measurement is within ± 0.5° of being level.

7. Place the digital-measurement tool on the top of the rig in the lateral direction, pointed toward the side windows.

8. Adjust the neck of the rig until the measurement is within ± 0.5° of a level perpendicular to the vehicle's longitudinal centerline.

   If you cannot achieve this because the seat is uneven due to wear, you can place a shim under one of the rig wheels to achieve this level position. Suitable shims include one or two scraps of cardboard or a few cards from a deck of playing cards (Figure 10).

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Figure 10
Example cardboard shim for leveling side-to-side

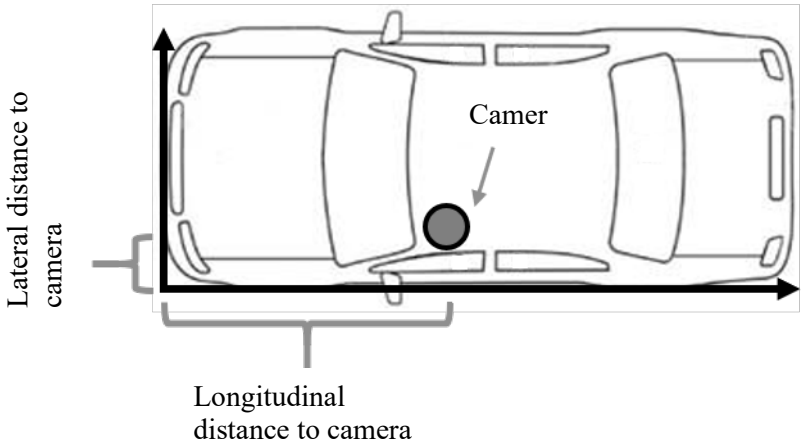
9. Install the camera on top of the rig.

DATA COLLECTION

1. Measurements of the direct-vision rig relative to the vehicle

Obtain the distances from the left front corner of the vehicle at ground level to the camera position, including the lateral distance, longitudinal distance, and height (Figure 11).

Figure 11
Coordinate system from foldable square



1.1 Position the clear, plastic foldable measurement square by aligning it along the length of the vehicle with the front tire.

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1.2 Position the measurement pole in its base at the front center of the vehicle, and align the other leg of the square to this as the forwardmost point (Figure 12).

Figure 12
Coordinate system from foldable square: positioning the measurement pole

1.3 Slide the measurement pole along the front of the square, and adjust the height of the laser until it hits the target next to the camera lens (Figure 13). Record the longitudinal distance from the digital-measurement tool.

Figure 13
Longitudinal and height measurements

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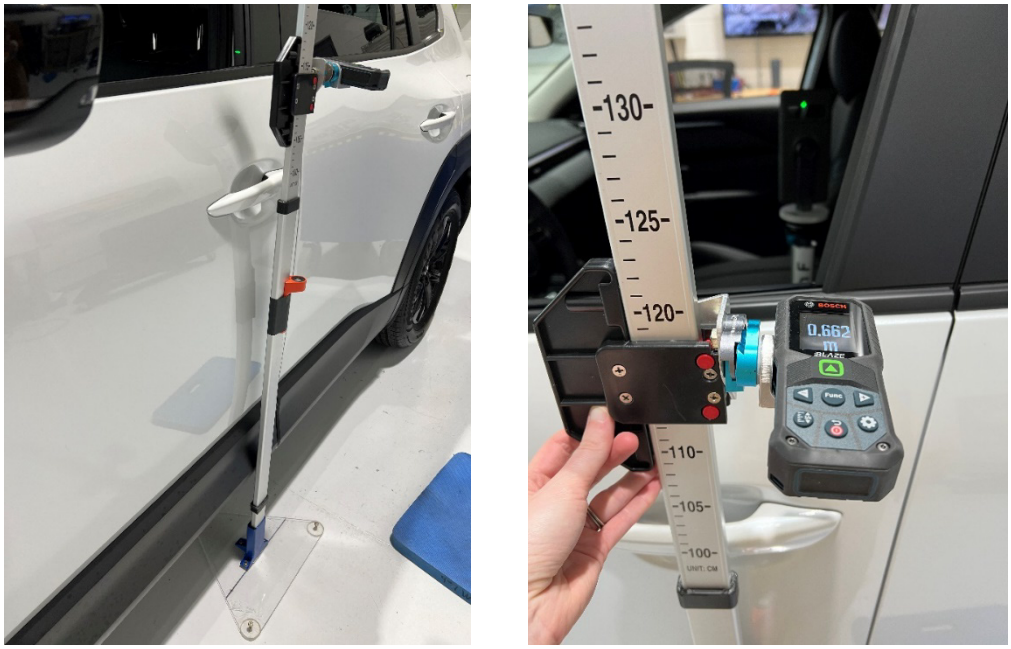
1.4 Move the measurement pole to the side of the vehicle, so it aligns with the camera and touches the side of the vehicle.

1.5 Extend the measurement pole, so the vertical measurement from the ground can be made when the digital-measurement tool is aligned with the camera height (Figure 14).

Record the height of the camera relative to the ground.

1.6 Record the measurements of the distance from the side of the vehicle to the camera from the digital-measurement tool.

Figure 14
Lateral and height measurements



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2. Camera-based measurement collection

2.1 Place the placard for the dummy being measured in the scene of the first photo, facing forward). Ensure the placard will not block the hood line or the dashboard line during measuring. The best placement is probably the dashboard behind the steering wheel (Figure 15). The placard is not needed in other views, only in one view for post-processing.

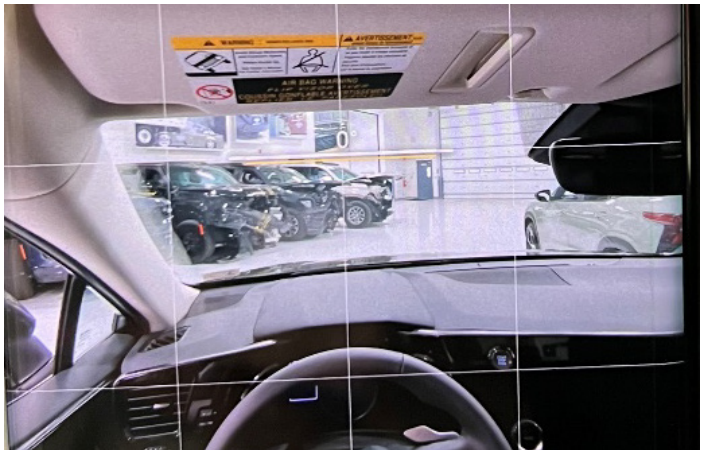
Figure 15
Location of placard in first photo frame

2.2 Turn on the camera.

2.3 Do another check that the camera is mounted in a level position, by checking that the camera level is showing 0° ± 1° on the screen (Figure 16). Do this with the camera facing forward by 0° and facing the passenger side by 90°.

2.4 If the camera is not showing 0° ± 1° degree, you may make adjustments to the rig to level the camera, as in placing cardboard pieces under the legs of the rig or pushing on the rig slightly to achieve a level position.

Figure 16
Camera level



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2.5 Use the remote control to take photos without entering the vehicle.

2.6 Take the first photo at the 0° position, facing forward (Figure 17).

Figure 17
Turntable

2.7 Rotate in a clockwise direction, take photos from every 15° rotation to complete all 360° views of vehicle. Be sure to close any vehicle doors that appear open in the photo.

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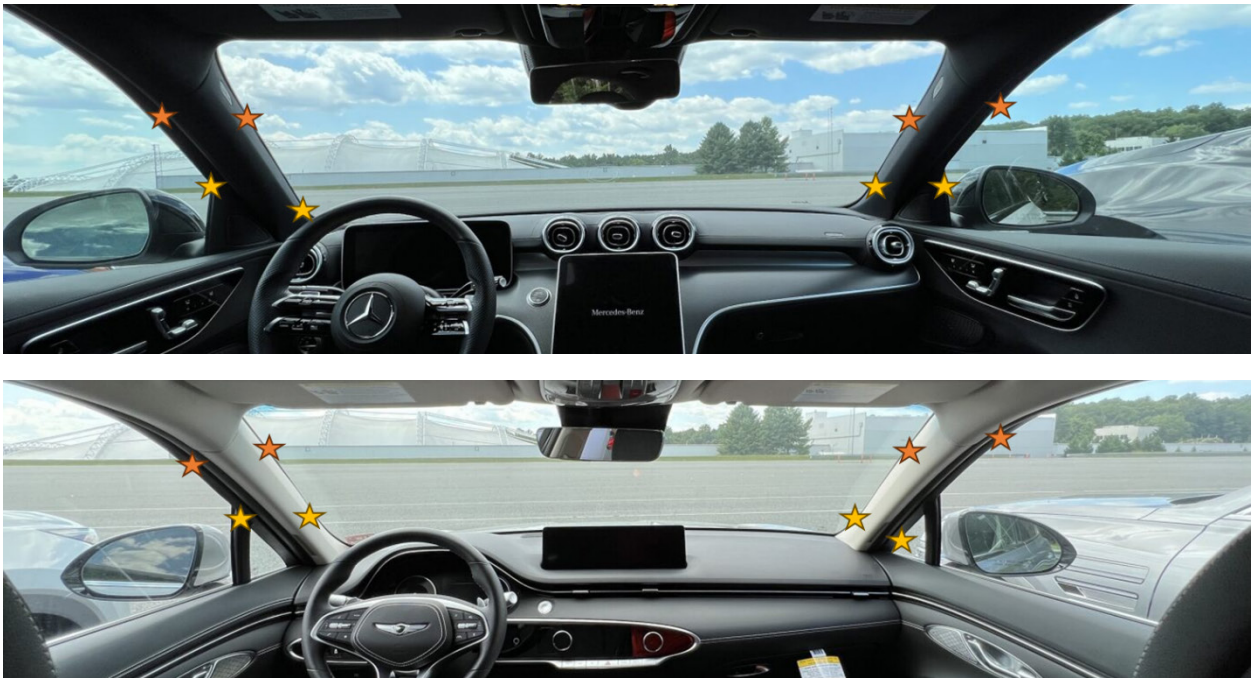
3. Laser-based measurement collection

Angles of the A-pillar are measured using a laser-based angle measurement tool. Figure 18 shows examples of typical points to record for the 50th-male (orange stars) and the 5th-female (yellow stars).

Sometimes, A-pillars connect with structures of the door, so doors should be closed and structures adjacent to the A-pillars should be measured as part of the combined A-pillar complex, as shown in Figure 18.

Figure 18
Example locations of A-pillar measurements



Note. Orange stars = measurement points to record for the 50th-male. Yellow stars = measurement points to record for the 5th female.

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3.1 Place the laser-angle measurement tool on the neck of the rig, with the laser facing forward and pointed at the front windshield (Figure 19). Ensure that the laser-angle tool is secure on the rig.

Figure 19
Laser angle tool attached to the rig

3.2 Close the driver door, as some parts of the A-pillar complex may be attached to the doorframe. You may sit in the rear seat to take measurements.

3.3 Zero the laser-angle tool while snapping its mounting pin into 0°.

3.4 Release the mounting pin and rotate the angle tool freely. Press the button to activate the laser.

3.5 Record these four measurements of the A-pillar complex: driver leftmost angle, driver rightmost angle, passenger leftmost angle, and passenger rightmost angle.

3.6 After you collect the camera-based and laser-based measurements for the 50th -male seat position, go to the *Seat positioning* section > *1.2 5th-female seat position: full forward and full up*.

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REFERENCE

Mueller, B., Bragg, H., & Bird, T. (2025). *Developing a camera-based perspective transformation method for quantifying driver direct visibility for passenger vehicles* (SAE Technical Paper No. 2025-01-8667). SAE International. https://doi.org/10.4271/2025-01-8667

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