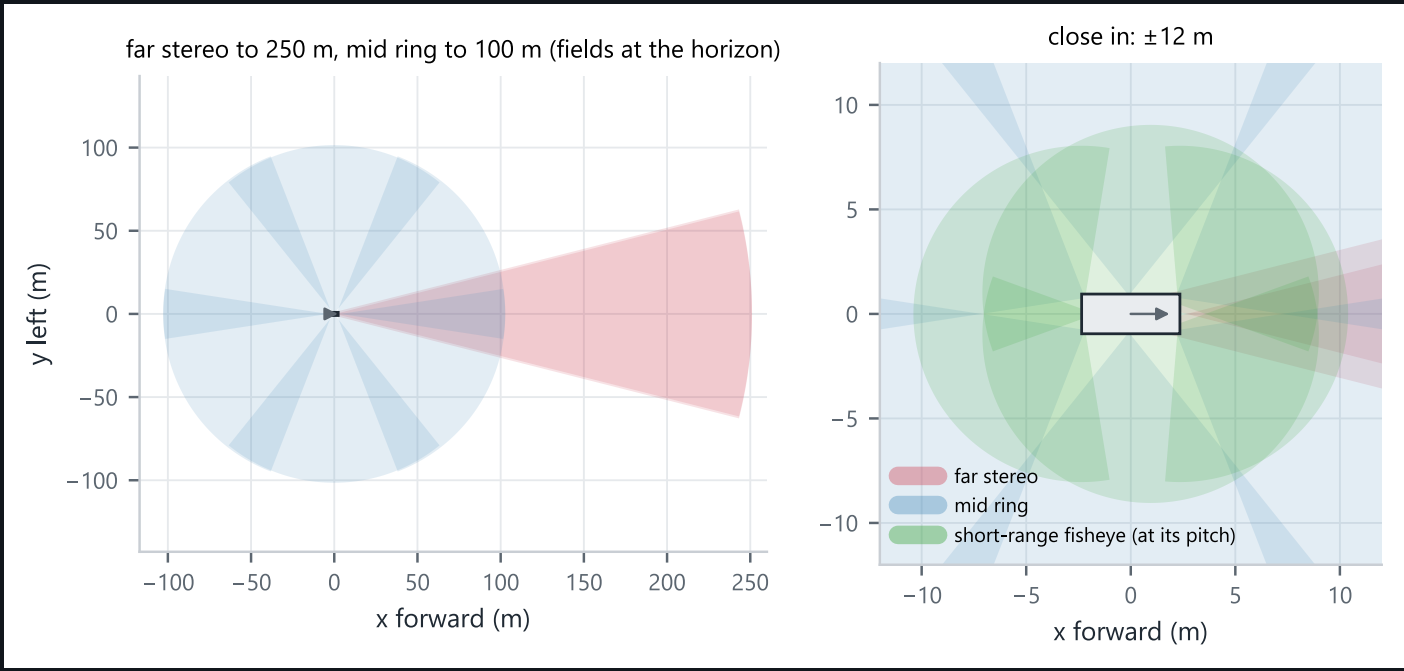
CASE STUDY 2 · VISION-ONLY CAR · 28 OCTOBER 2026

Fifteen cameras, no blind spots that matter

Without lidar or radar, the camera set has to see every direction that can hold a hazard, at the range where the car must react. This study places the fifteen cameras on a generic electric crossover and maps what each one sees with its own lens: the real chief-ray mapping the Paraxial API traced for the CS1 designs, not a nominal field angle. It checks coverage all around the car and on the ground beside it, pixels on a car or a child at range, stereo depth error, the garage ceiling, and the two cabin cameras.



Top view: the far stereo pair to 250 m and the mid ring to 100 m (fields at the horizon), and the short-range fisheyes close in, from each lens's API mapping.

100.0 %
of the −5/+20° band around the car
seen by the mid ring at 100 m

55 px
across a car's rear at 250 m
in each far stereo camera

0.28 m
largest blind gap on the ground
next to the body

Paraxial · fea deployment · project “Vision-Only Car Demo”

THE SET 01

Where the cameras go

The car is a generic two-row electric crossover, 4.70 × 1.90 × 1.62 m (research/vehicle.md). Camera positions are decisions inside the cited mounting zones: the far pair at the upper corners of the windshield, 1.2 m apart; the mid ring at the headlamp and tail-lamp surrounds and the B-pillars; fisheyes in the bumpers and mirrors; one up-looking fisheye at the top of the windshield; the occupant camera in the overhead console and the driver monitor on the column.

LENS	CAMERAS	POSITIONS	EFL (MM)	LARGEST TRACED FIELD
Far stereo	2	Far L, Far R	16.11	16.0°
Mid ring	6	Mid front L, Mid front R, Mid side L, Mid side R, Mid rear L, Mid rear R	5.76	38.8°
Short-range fisheye	4	Fisheye front, Fisheye rear, Fisheye left, Fisheye right	2.59	87.5°
Short-range fisheye	1	Up-looking	2.59	87.5°
Cabin occupant	1	Occupant	2.73	75.0°
Driver monitor	1	Driver monitor	5.15	31.0°

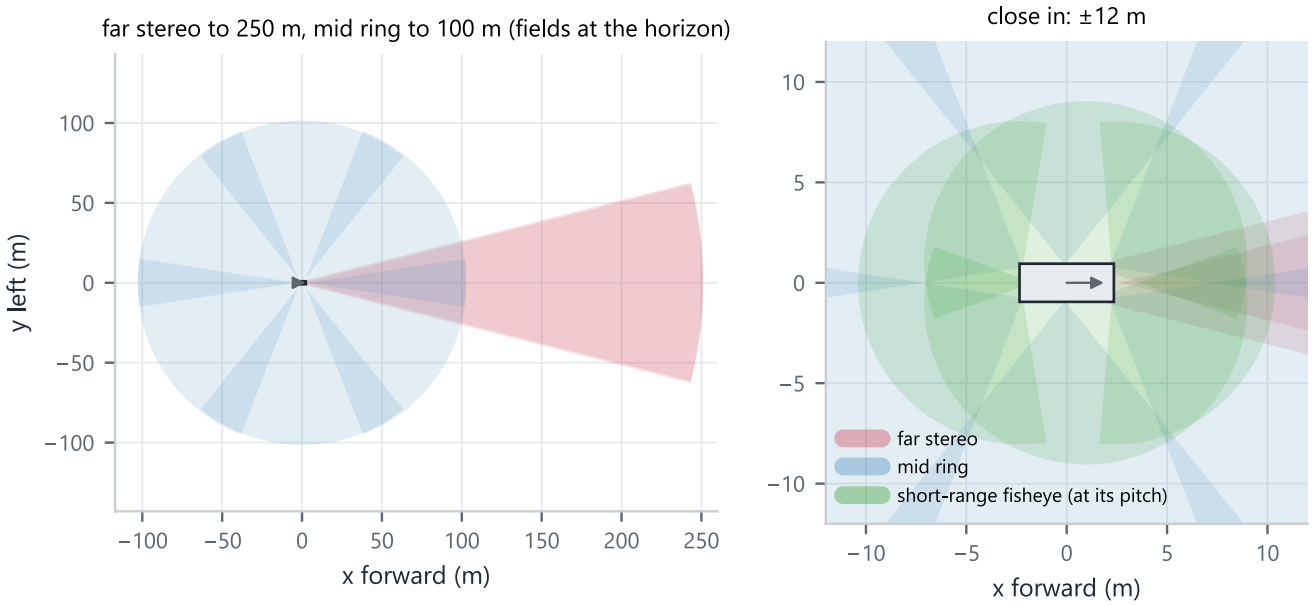


Figure 1. Horizontal fields from each lens's real chief-ray mapping (API distortion data).

RESULTS 02

What the set achieves

The pixel and blind-zone goals are this study's decisions (no public requirement for a vision-only set was found): 20 pixels across a target is a common detector minimum; 0.3 m is a child's foot. The stereo goal assumes the matcher reaches a quarter-pixel disparity precision, which is an assumption, not a measurement.

REQUIREMENT	TARGET	RESULT	STATUS
Mid ring sees the −5/+20° band at 100 m	100 %	100.0 %	✓ Met
Whole set sees the band at 20 m	100 %	100.0 %	✓ Met
Pixels across a car at 250 m (far)	≥ 20 px	55 px	✓ Met
Pixels across a car at 100 m (mid, forward corner)	≥ 20 px	49 px	✓ Met
Pixels on a standing adult at 100 m (mid, side)	≥ 20 px	49 px	✓ Met
Stereo depth error at 250 m (1σ)	≤ 5 % of range	1.7 m (0.7 %)	✓ Met
Ground blind gap next to the body	≤ 0.3 m	0.28 m	✓ Met
Child-height blind gap next to the body	≤ 0.3 m	1.32 m	✗ Not met
Garage barrier (2.134 m) seen by the up-looking camera	from the bumper	0.25 m ahead	✓ Met
Occupant camera sees the driver	in frame, ≥ 40 px per face	yes, 345 px	✓ Met
Occupant camera sees the front passenger	in frame, ≥ 40 px per face	yes, 345 px	✓ Met
Occupant camera sees the rear left	in frame, ≥ 40 px per face	yes, 140 px	✓ Met
Occupant camera sees the rear centre	in frame, ≥ 40 px per face	yes, 147 px	✓ Met
Occupant camera sees the rear right	in frame, ≥ 40 px per face	yes, 140 px	✓ Met
Driver monitor: pixels across an eye (30 mm)	≥ 10 px	71 px	✓ Met

COVERAGE 03

All around, at 20 to 250 m

Each direction of the band (0.5° steps, from 1.0 m above the car's centre) is checked against every exterior camera: seen if the real chief-ray image of that direction lands on the sensor and the line of sight does not cross the body. At 100 m the mid ring alone sees 100.0 %; two or more cameras see 97.5 % (the 10° seams and the forward overlap). At 250 m only the far pair reaches, and the set as a whole covers 100.0 % of the band (everything the mid ring sees to 100 m counts too, since the cylinder is a direction set).

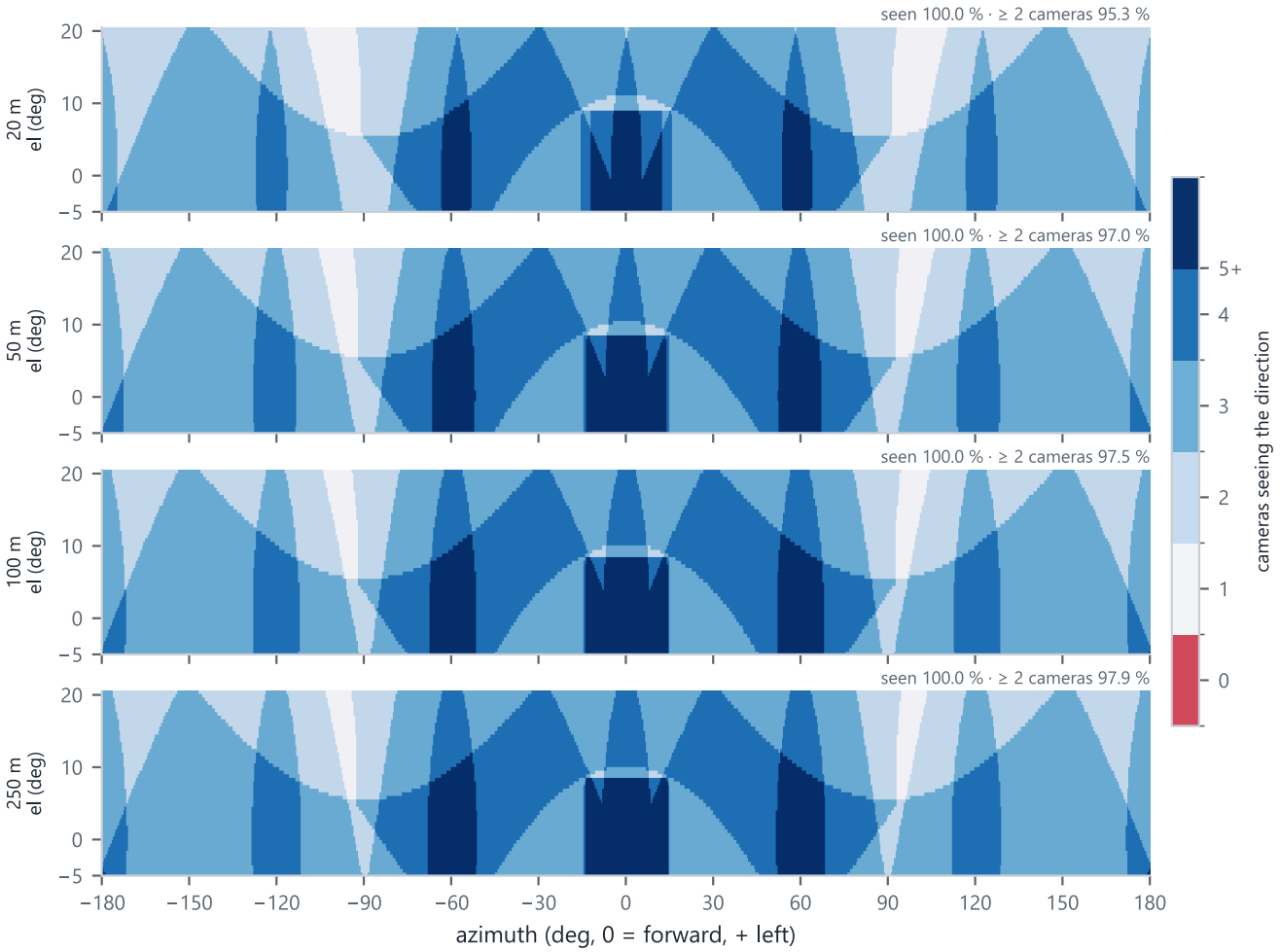


Figure 2. Cameras seeing each direction of the −5/+20° band at four ranges. Red: unseen.

CLOSE IN 04

The ground and a child next to the car

On the ground (z = 0) the largest gap between the body and the first seen point is 0.28 m; 0.3 m above the ground (a curb, a toy) it is 0.20 m; at a child's head height (1.15 m) 1.32 m. The body is two boxes (a decision, not the CAD), which occludes slightly more than a rounded body.

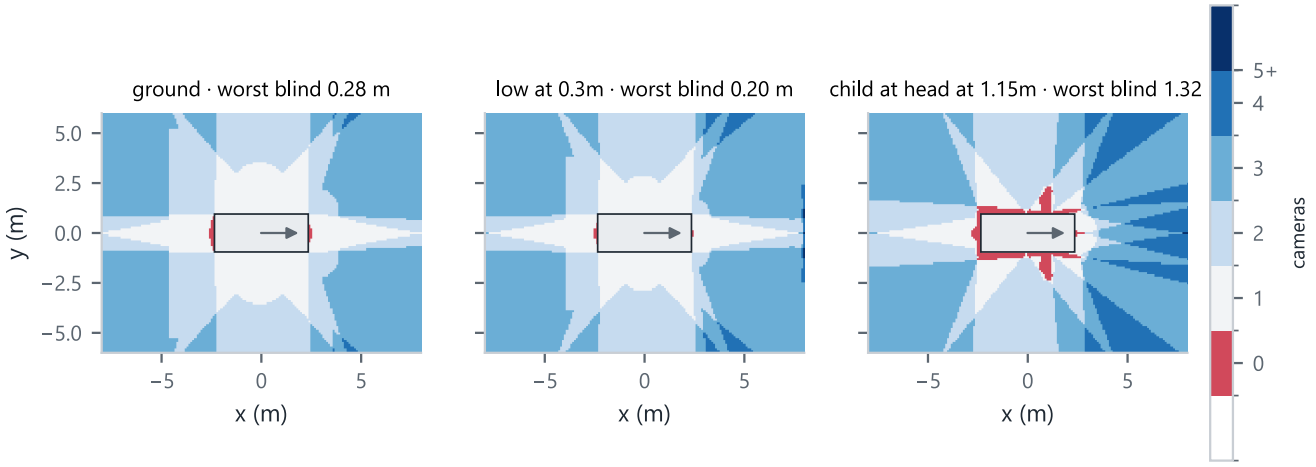


Figure 3. Number of cameras seeing each point within ±8 m at three heights; the car is the grey rectangle.

RESOLUTION 05

Pixels on target and stereo depth

Pixels across a target come from the lens's pixel density at that field angle (the smaller of the radial and tangential densities of the API mapping) times the target's angular size. A car's rear is 55 pixels wide at 250 m in each far camera and 49 pixels at 100 m in a forward mid camera.

With f = 7672 px (API EFL over the 2.1 µm pixel) and a 1.2 m baseline, the 1σ depth error at 250 m is 1.7 m for σd = 0.25 px; the disparity there is 36.8 px. The two far fields overlap from 2.3 m. The commonly quoted 12 cm automotive stereo baseline would give 17 m at 250 m.

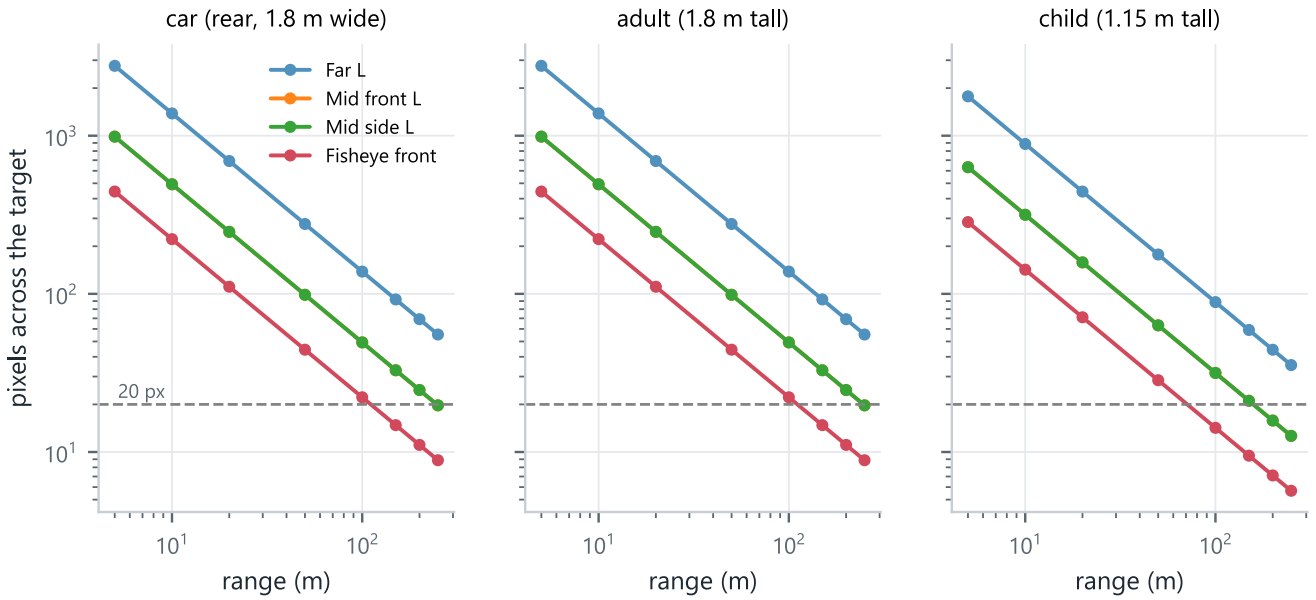


Figure 4. Pixels across a car, an adult and a child against range.

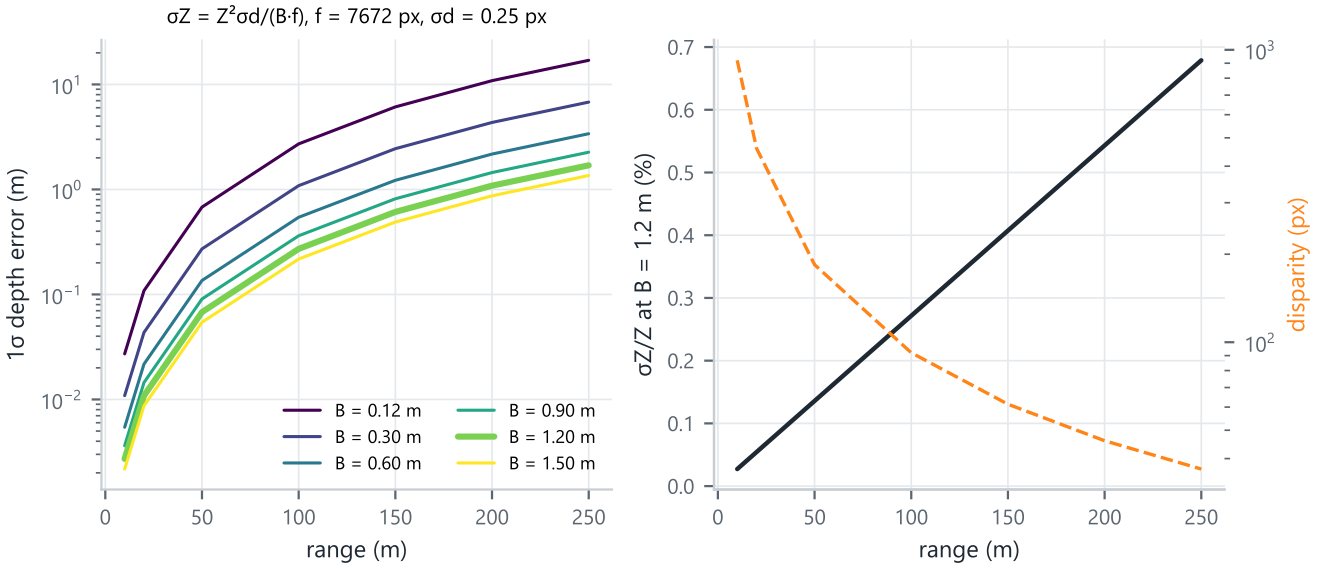


Figure 5. Stereo depth error against range for six baselines, and the relative error and disparity at 1.2 m.

GARAGE 06

The up-looking camera and a height barrier

A height-limit bar at 2.134 m (the common 7 ft garage clearance, research/vehicle.md) is checked at each distance ahead of the bumper. The far cameras lose it as it comes close, above their field; the up-looking fisheye, pitched 60° up behind the top of the windshield, keeps it to 0.25 m ahead of the bumper.

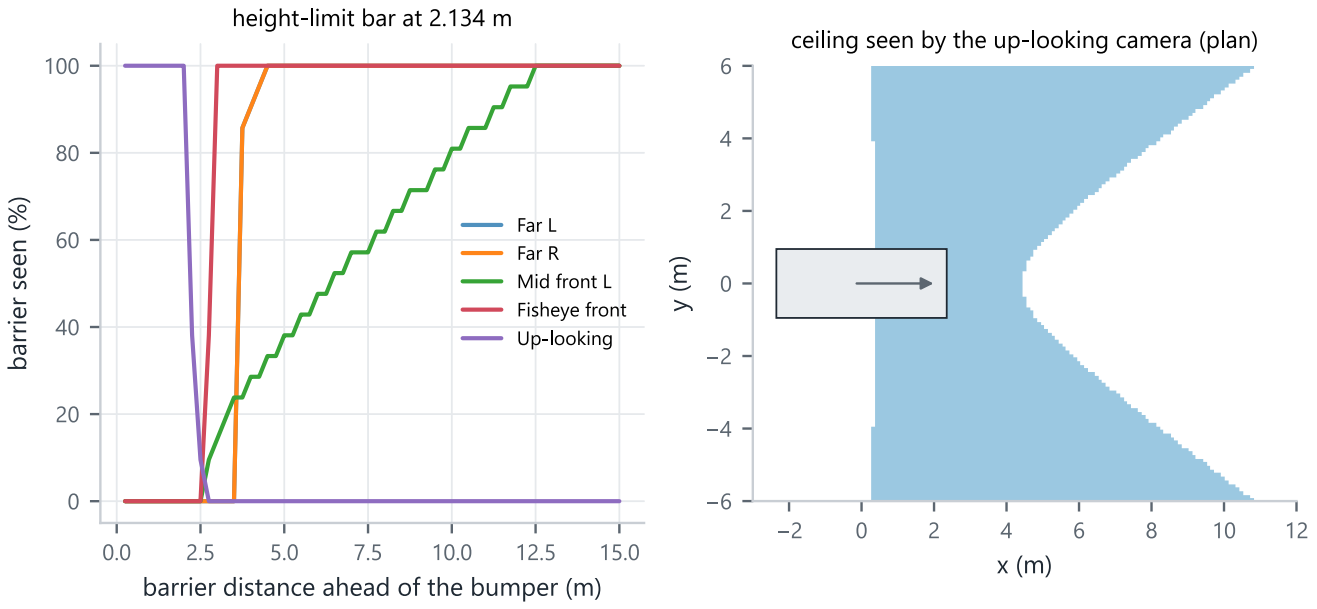


Figure 6. Fraction of the bar seen against distance, and the part of the ceiling plane the up-looking camera sees.

CABIN 07

Occupants and the driver

The occupant camera (f·θ, 120° across) sits in the overhead console facing rearward and down; the driver monitor sits on the steering column. Eye points are decisions for a five-seat two-row car. Pixels per face use a 0.15 m face width.

Tint. The side and rear glass and the glass roof carry switchable tint; the windshield does not (kick-off decision, and the forward cameras look through it). The occupant camera's exposure reading of the cabin and the driver monitor's glare detection drive the tint: dark when the sun loads the cabin or when the car is parked and charging with the screen in use, clear when driving at night. This is control logic over camera statistics, not optics, and is described, not modelled.

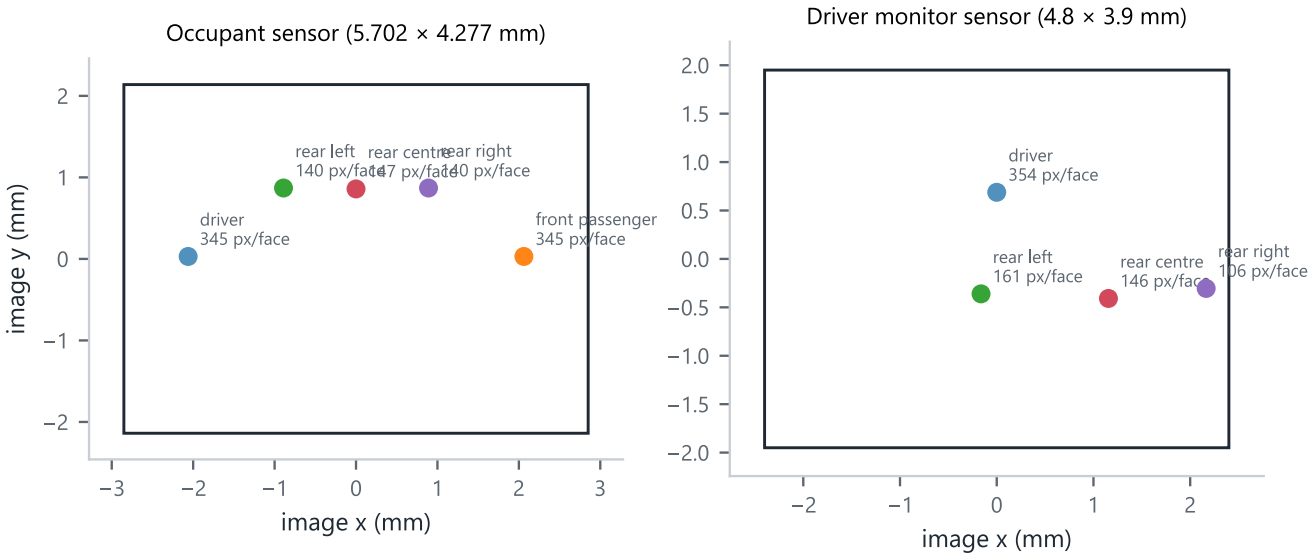


Figure 7. Where each seat's eye point lands on the two cabin sensors.

METHOD 08

How the numbers were made

Each camera's field is its CS1 lens's real chief-ray mapping from the Paraxial API; everything in this study is geometry on those mappings and the car layout. The full report adds the method detail.