FUTURE SENSORS FOR AUTONOMOUS DRIVING

Robust Detection of Any Obstacle Under Any Weather and Lighting Conditions

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FORESIGHT

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All figures are approximate.

About Foresight Automotive

- Founded July 2015, 65 employees, majority in R&D
- Technology derived from HLS solutions
- Designs and develops unique sensors for assisted and autonomous driving
- Demo systems already operational
- Extensive R&D efforts in order to complete product development

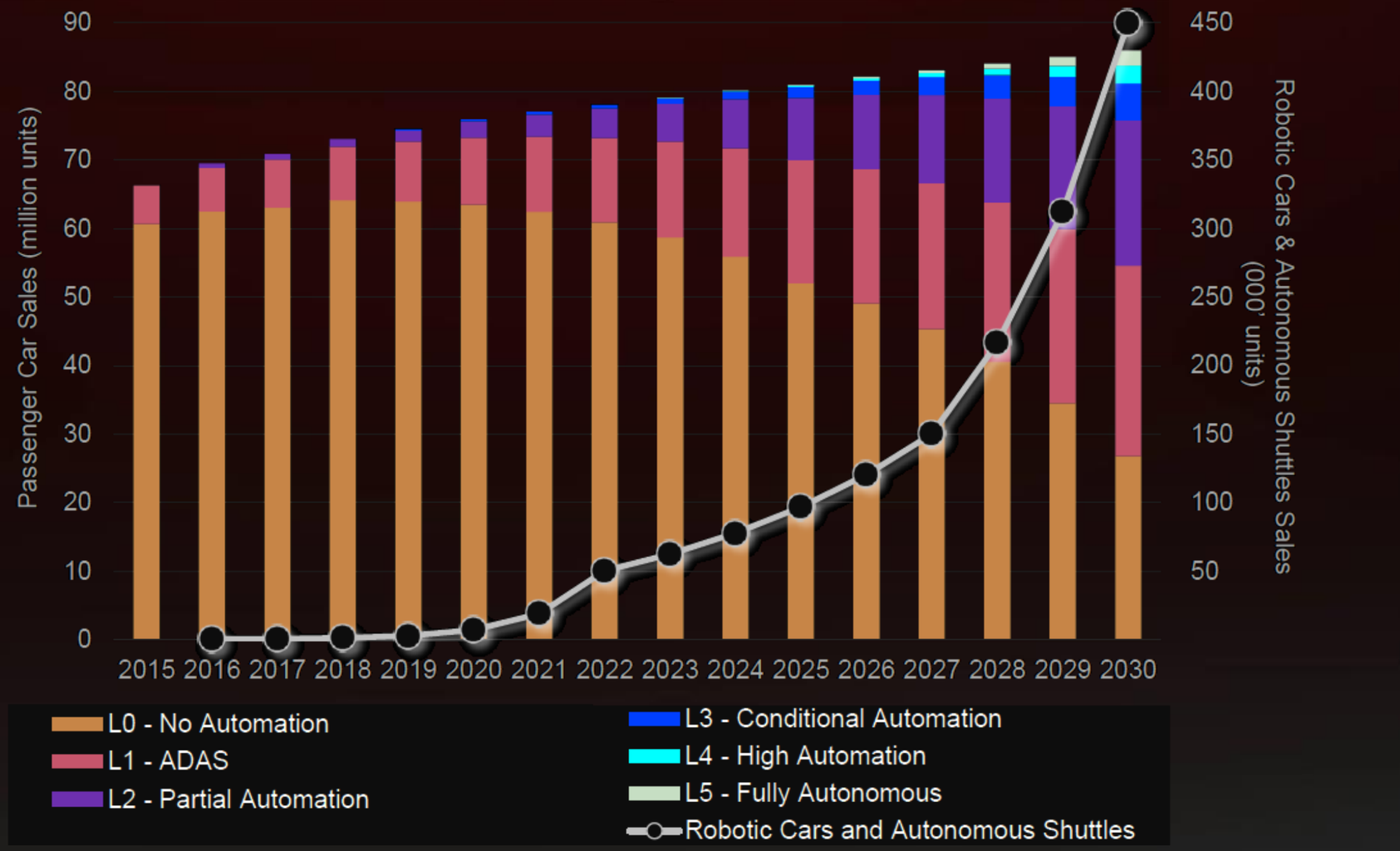
From Human To Autonomous Driving

By 2019: L3 1st deployment

By 2022: L4-5 1st deployment

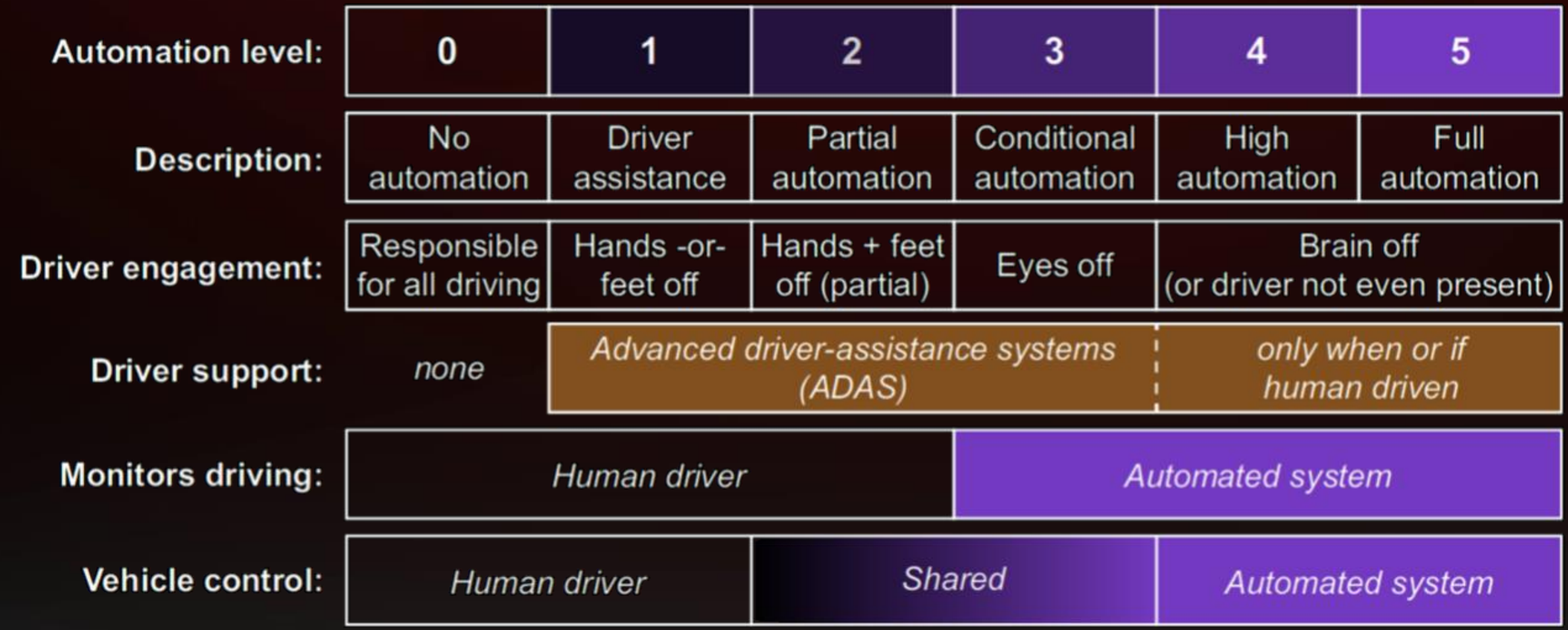
By 2030:

- **49** million vehicles will be equipped with some kind of ADAS and partial automation feature
- **10.2** million vehicles will have autonomous driving capabilities



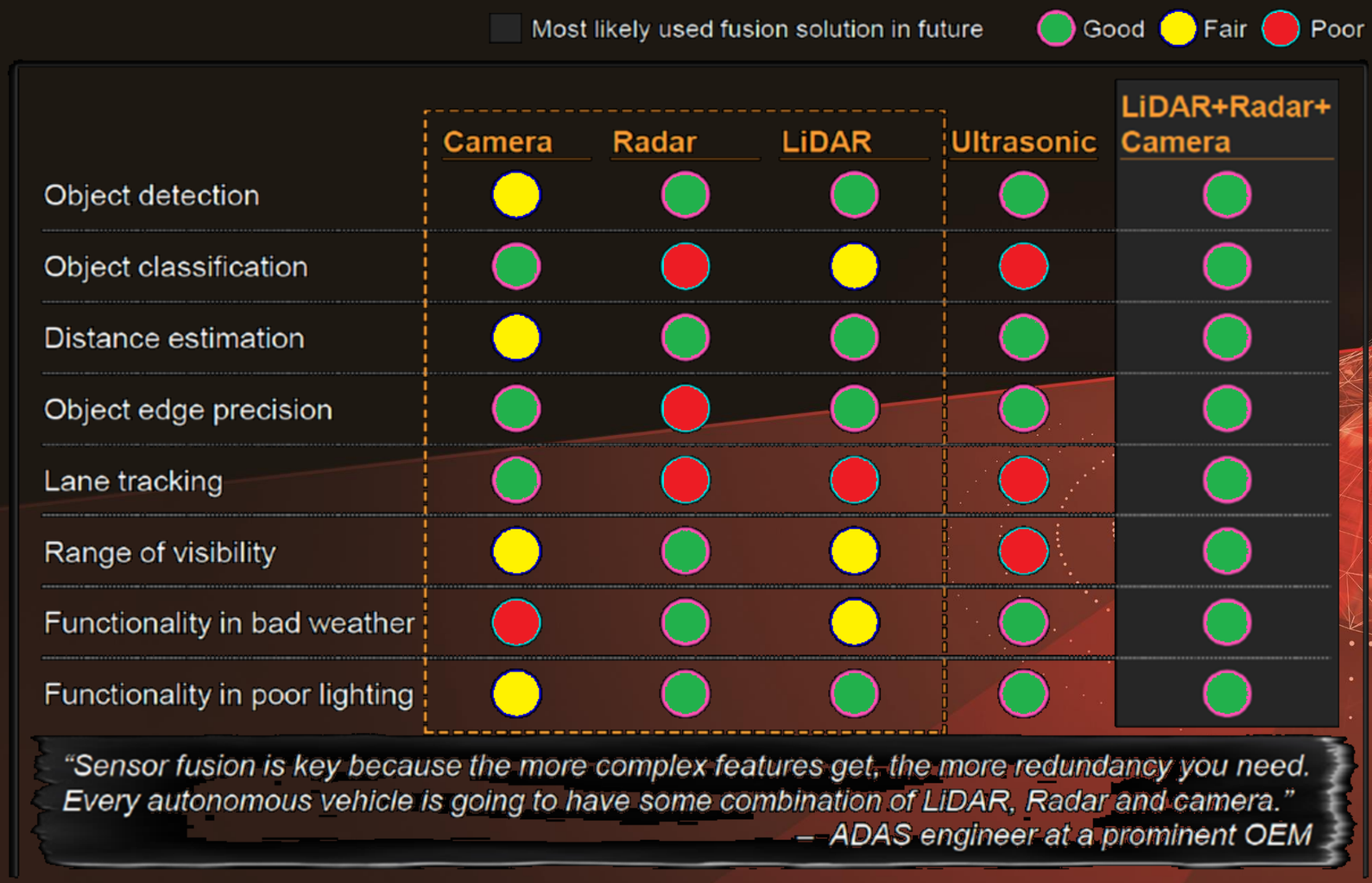
Source: Autonomous Driving LiDAR Market 2018-2030, M14Intelligence, October 2018

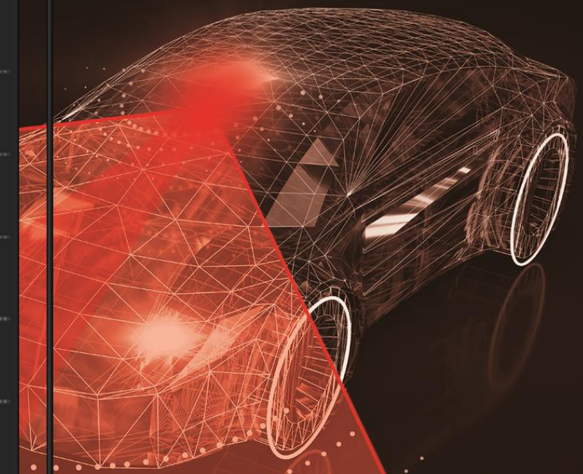
From Human To Autonomous Driving



Source: SAE International, 2016-2018

Sensors for Automated and Autonomous Vehicles



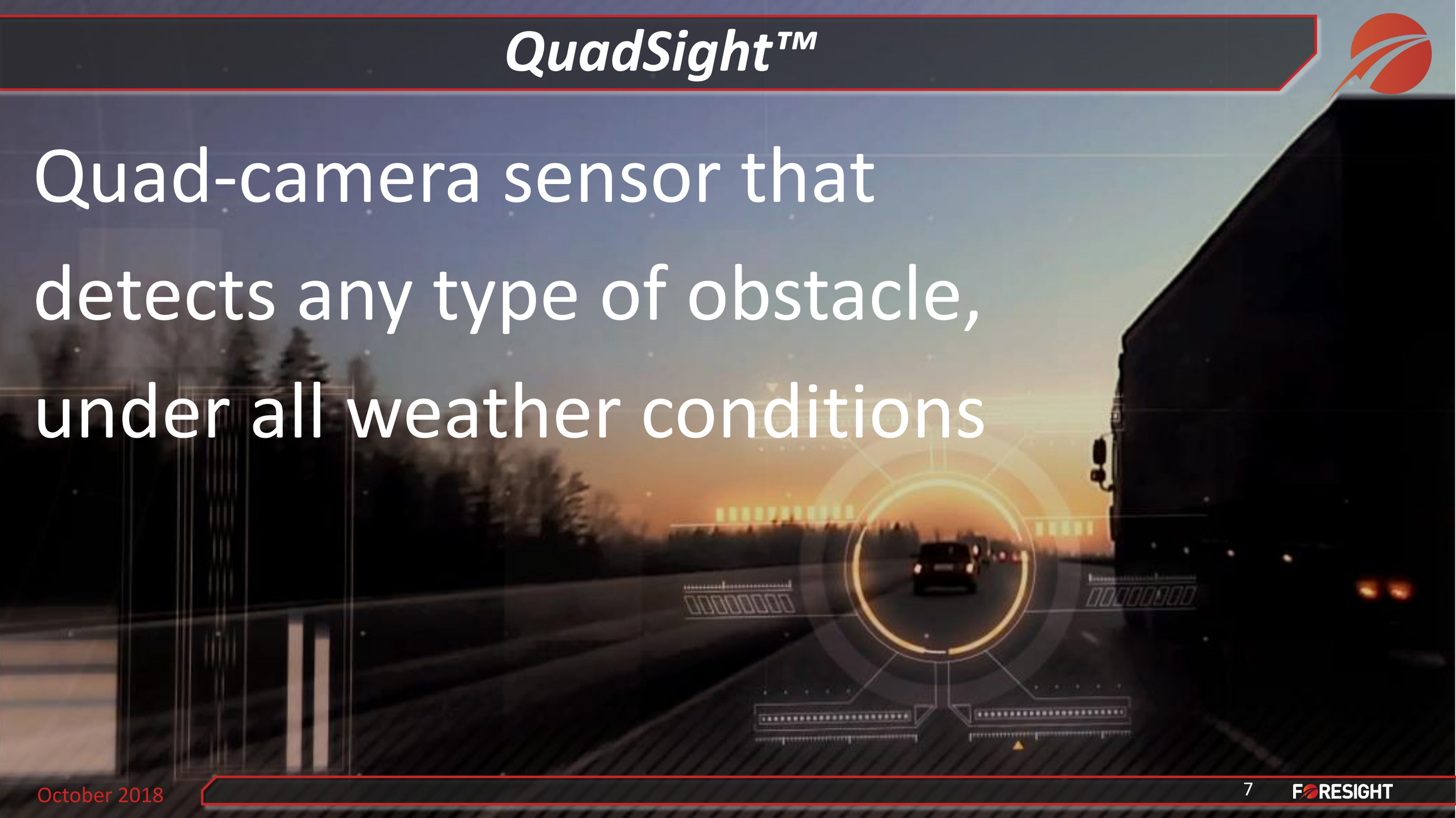


Source:
Woodside Capital Partners, 2016

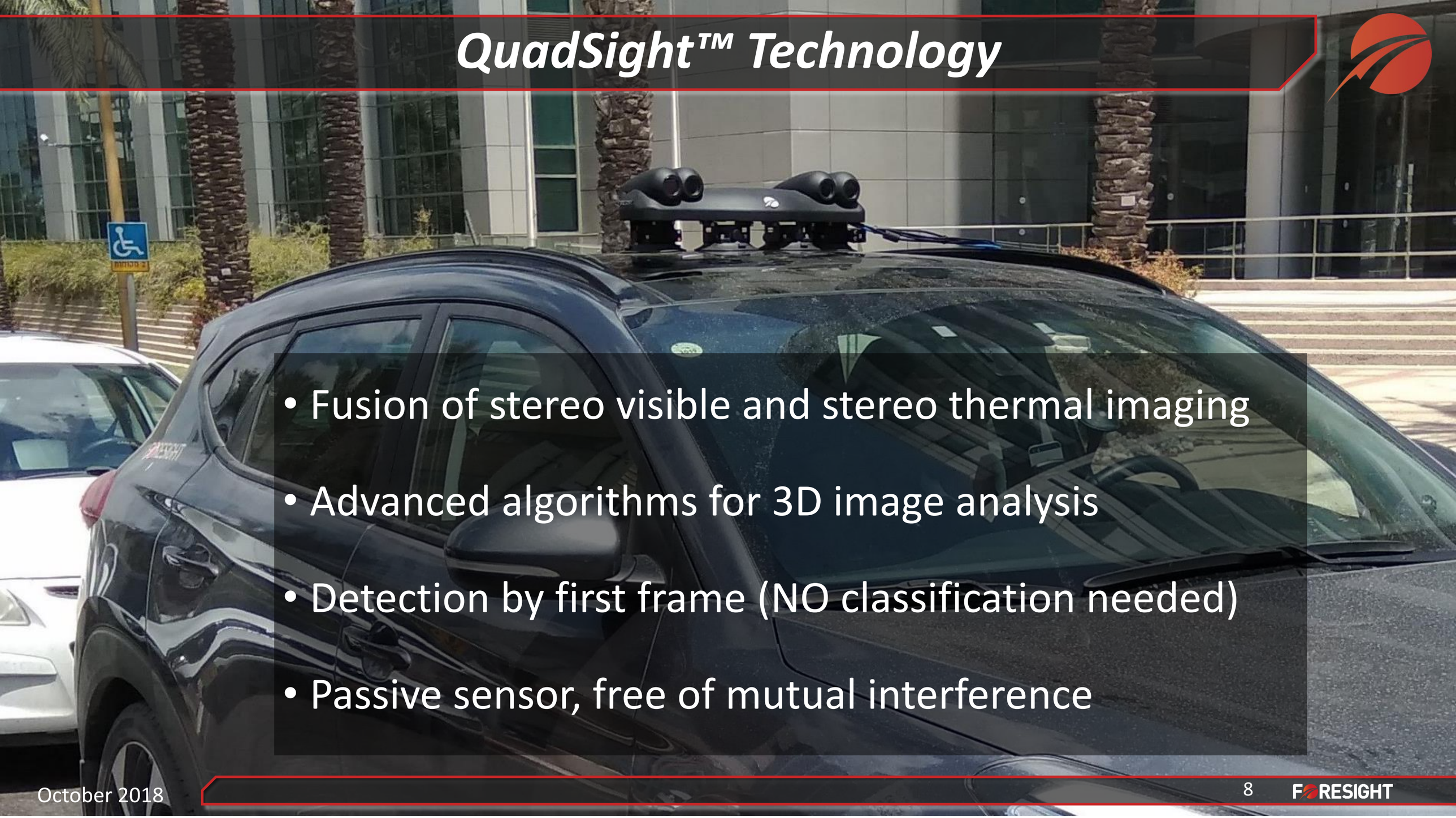
Automated (L3) and autonomous (L4-5) driving requires the use of multiple redundant sensors

QuadSight™

Quad-camera sensor that detects any type of obstacle, under all weather conditions



QuadSight™ Technology

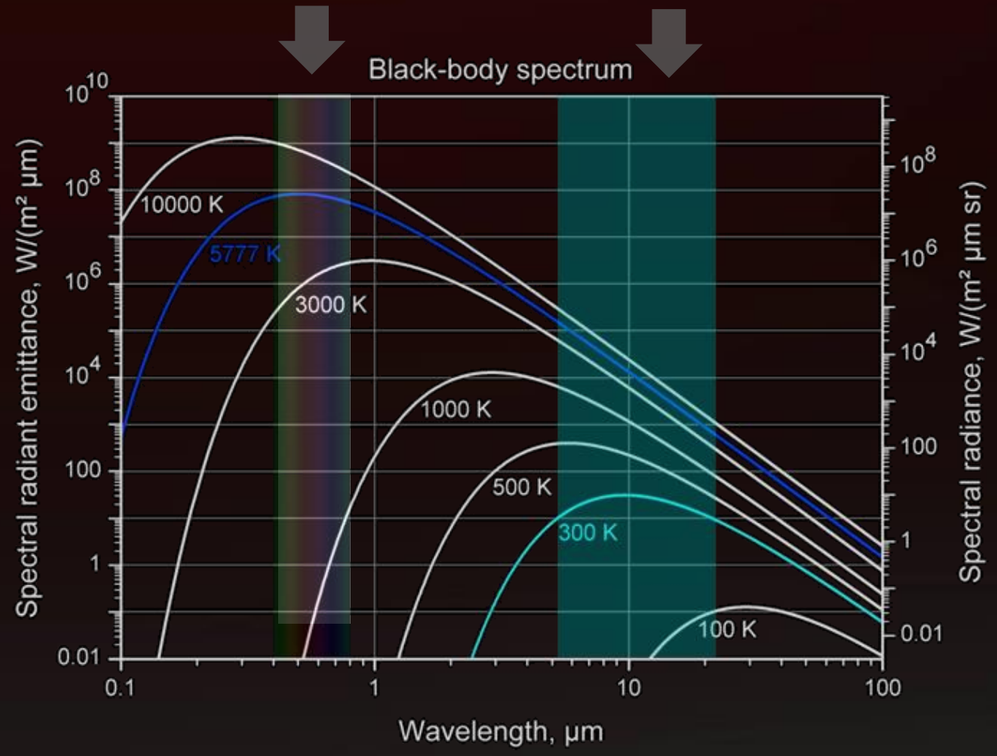


- Fusion of stereo visible and stereo thermal imaging
- Advanced algorithms for 3D image analysis
- Detection by first frame (NO classification needed)
- Passive sensor, free of mutual interference

Why Thermal?

- A visible light camera system is working with the **same or less** information than the human eye

  Thermal adds the parameter of heat
- Captures a very unique representation of the world
- Independent of scene illumination
- Unaffected by severe conditions:
  - Fog
  - Heavy Rain
  - Snow
  - Darkness
  - Directly viewing the sun
  - Reflected glare



Visible and thermal sensing together offer dense point cloud information for all weather and lighting conditions

Why Thermal?

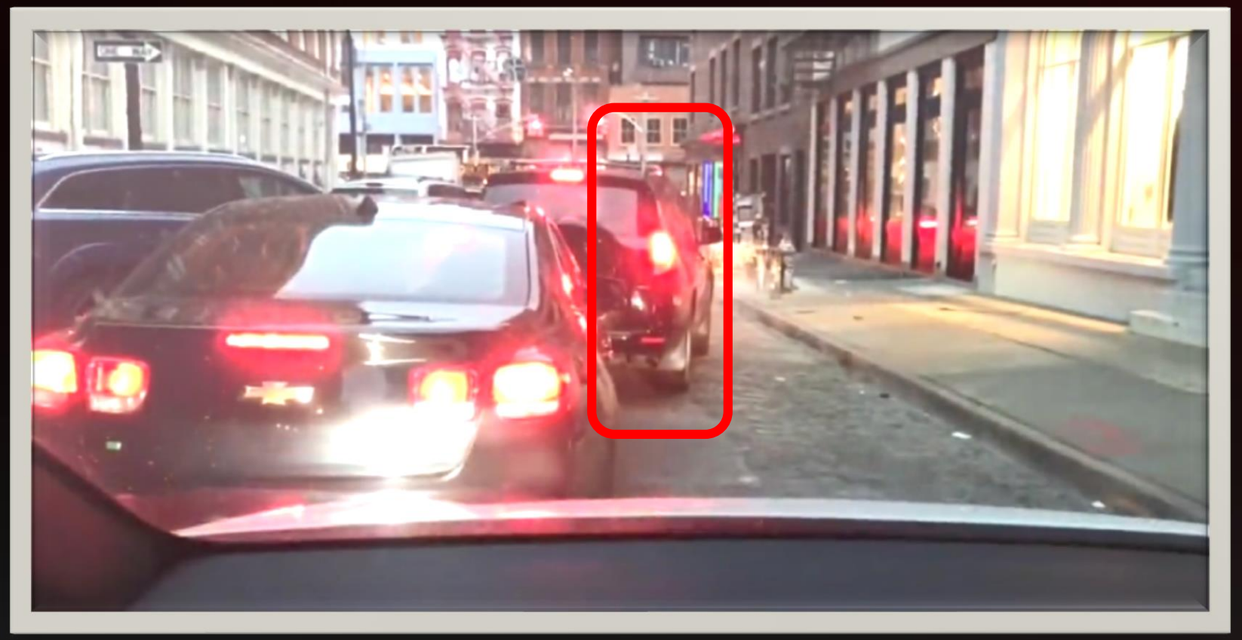
Tracks=1 Scan=2831 Wr=5000000 Re=5001721 F.time = 09:05:30

Number	Dist(m)	SizeX(cm)	SizeY(cm)
45	985	79	138
46	985	79	158
47	985	59	158
48	985	59	158
49	985	59	158
50	985	59	158
51	985	59	158

Why Stereo?

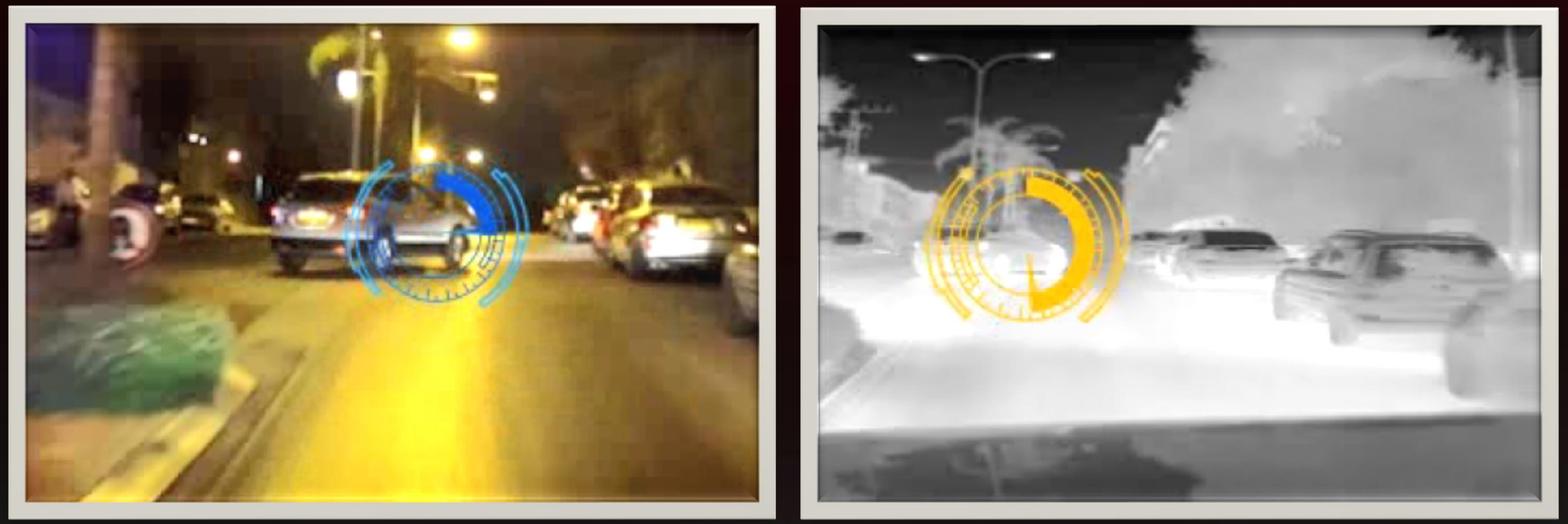
Typical camera ADAS

Deep Learning → Classification → Detection → Alert



Why Stereo?

- All the capabilities of a monocular vision solution
- Provides depth information like LiDAR and Radar systems
- Observes the displacement between two images and calculates accurate 3D scene

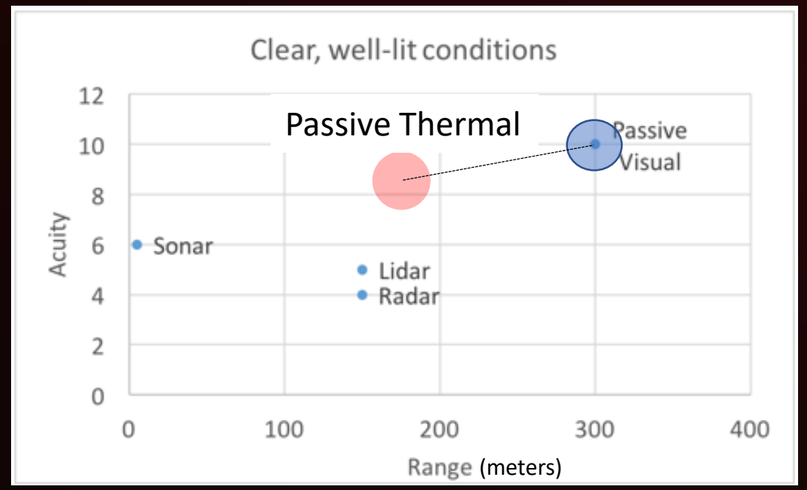


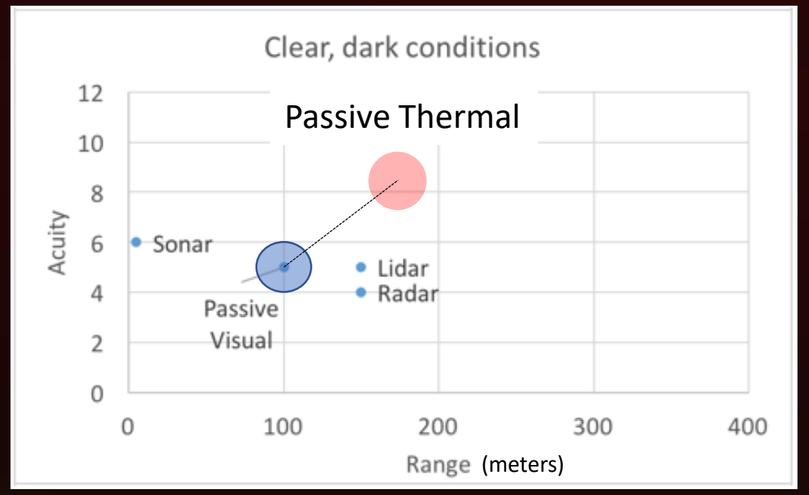
Vehicle merging on the left

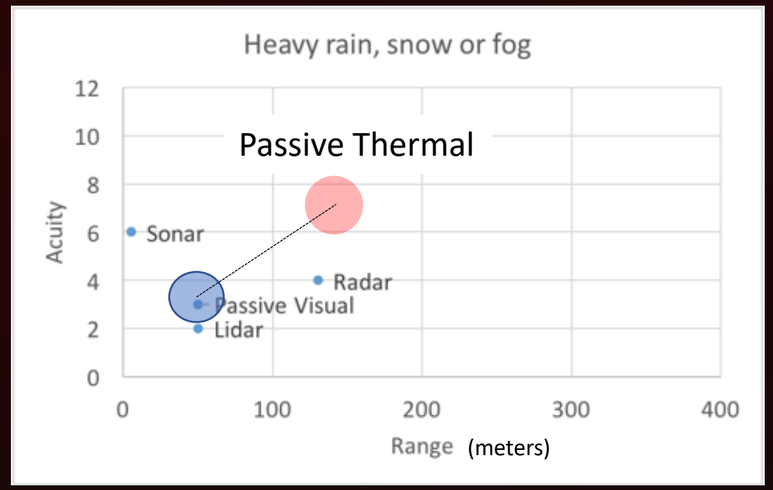
The merging vehicle was detected ahead of time **before** it merged completely into the lane

Autonomous vehicles are required to operate in challenging conditions

Performance Under Different Conditions



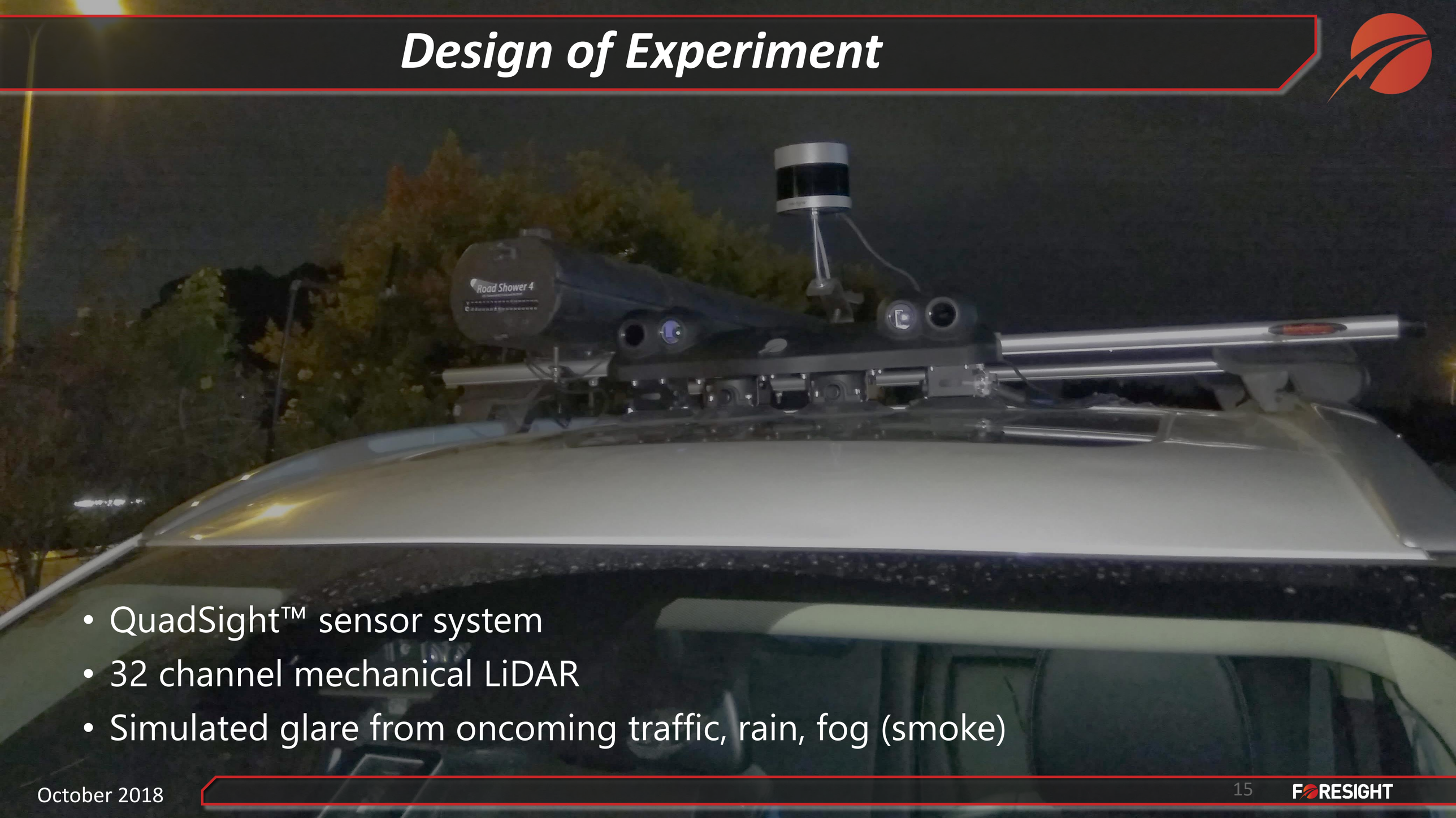




Source: Tesla & Google Disagree About LIDAR — Which Is Right?, Jul 2016

- "Acuity" is an image quality based on a combination of resolution, contrast detection, and color detection
- Passive visual has the longest range and best acuity in good conditions
- It degrades rapidly in terms of the quality of information it can provide under adverse conditions
- LiDAR provides excellent 3D image but degrades under fog, snow, or heavy rain

Design of Experiment



- QuadSight™ sensor system
- 32 channel mechanical LiDAR
- Simulated glare from oncoming traffic, rain, fog (smoke)

Blinding by Front Vehicle and Rain

Daylight camera | Thermal camera | LiDAR

- Daylight camera totally blinded by headlight beams of the oncoming vehicle and by rain
- No effect of glare on LiDAR
- Rain drops are “seen” by LiDAR and require filtering by algorithm
- Thermal camera completely unaffected neither by glare nor by rain drops

Blinding by Front Vehicle and Fog / Smoke

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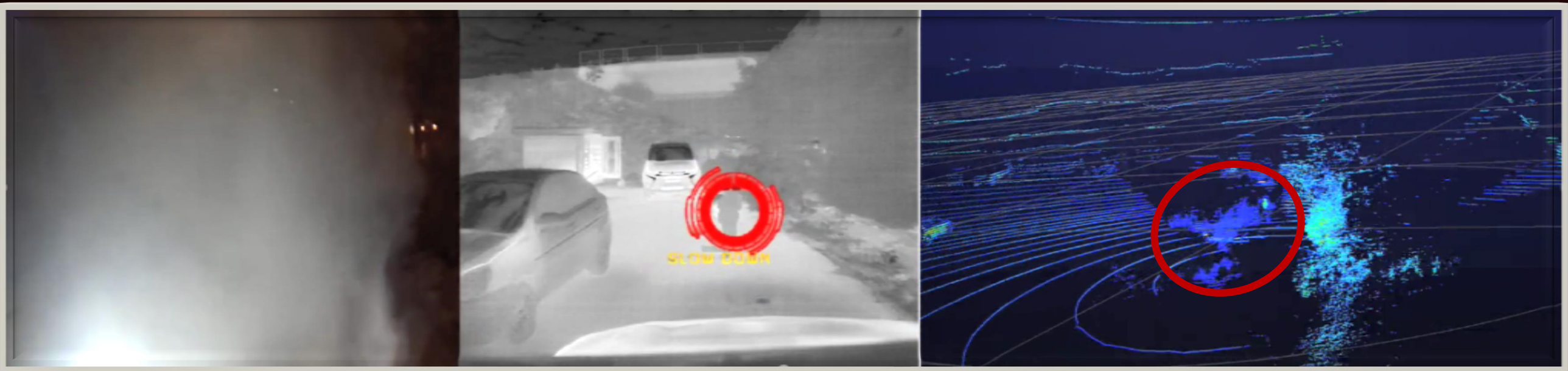
Daylight camera | Thermal camera | LiDAR



- Daylight camera totally blinded by “fog” / smoke
- No effect of glare on LiDAR
- LiDAR cannot see through “fog” / smoke
- Thermal camera completely unaffected

Fusion of Daylight and Thermal Sensors – Not Just Night Vision

Daylight camera

Thermal camera

Fusion of daylight and thermal

Source: Fusion of Thermal and Visible Cameras for the Application of Pedestrian Detection, Dec. 2016

The combination of LWIR and visible images produces the best detector in the daytime (about 5% less average miss rate) compared to just visible or just LWIR features

QuadSight™ - Reflected and Emitted Information

	Mono visible camera	Long Wave IR mono camera	LiDAR	QuadSight™
Reflected light	✓ Mono	✗	✓	✓✓ Stereo
Emitted waves (heat)	✗	✓ Mono	✗	✓✓ Stereo
Information	Deep Learning required Range	Deep Learning required Range	3D point cloud All objects detected	3D point cloud (reflected & emitted) All objects detected

Thank you