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LIDAR: On the road to autonomous driving

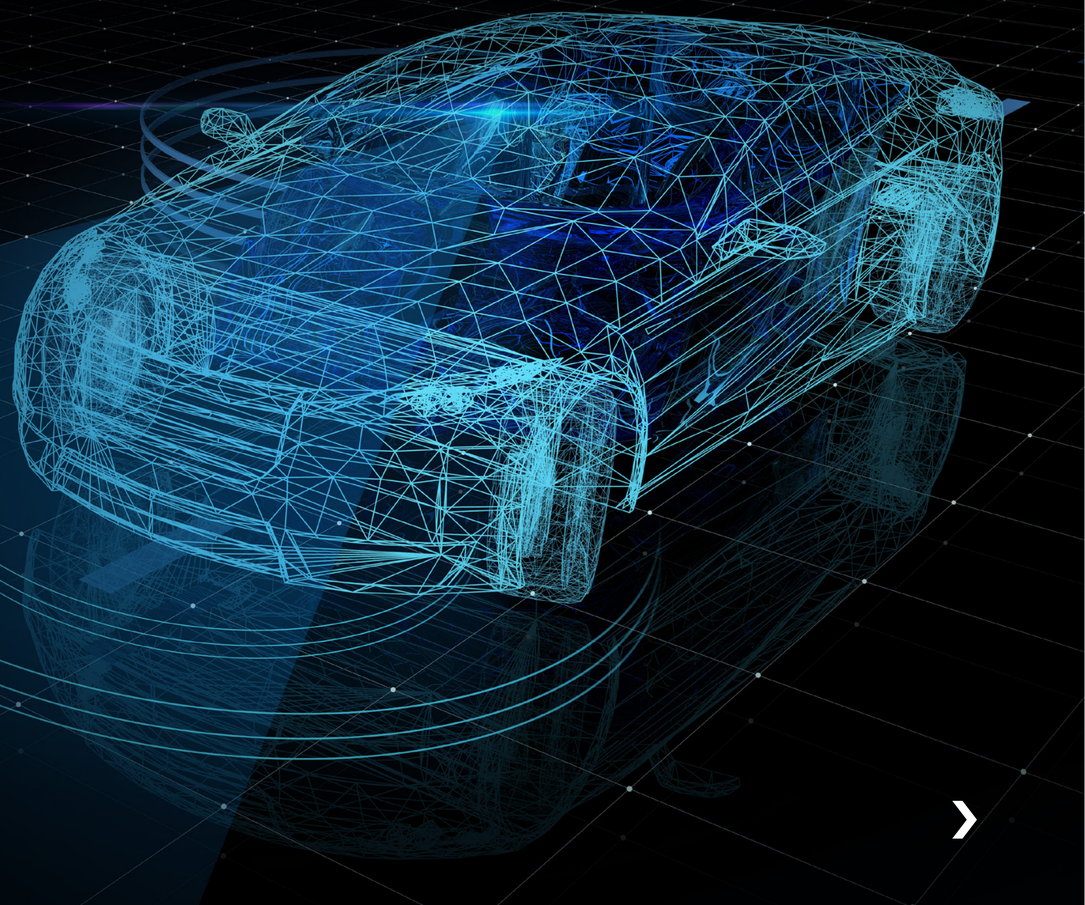
As cars progress in capability from advanced driver assistance systems (ADAS) to autonomous driving, LIDAR is expected to play a major role in the future.

In LIDAR—or Light-Identified Detection and Ranging—a laser light beam is fired around the car to create a high-resolution 3D map of the surrounding environment. Combined with cameras, radar and other sensing software, the laser map enables a car to drive on its own without a human driver.

The key is 3D: LIDAR mapping creates depth perception in three-dimensional space that mimics the scope of the human eye and helps prevent accidents for self-driving cars.

LIDAR is important for cars to achieve more sophisticated autonomous functions

- LIDAR is used today with ADAS sensors for car-safety functions like collision warning and automatic emergency braking. But while ADAS taps only into LIDAR's basic functions, LIDAR will be critical for self-driving cars of the future
- LIDAR will serve as a key redundancy to cameras, radar and ultrasonic sensors by providing a full 360-degree view to monitor a car's environment
- By supporting cameras and radars with object recognition, distance estimation and elimination of false positives, LIDAR can increase OEM confidence to deploy cars with progressively greater levels of autonomy—i.e., L3, L4 and L5 vehicles *



* Levels of vehicle automated driving are designated from L0 to L5: L0 represents no automated functions, while L5 represents fully automated driving.

From L3 onward, most of the car's sensing and driving responsibilities gradually shift from humans to the vehicle's autonomous driving system. As a result, car OEMs become more accountable for the safety of passengers inside cars.

Key automated driving applications for LIDAR

Parameter	L2*	L3**	L4**	L5**
Automation level	Partial	Conditional	High	Full
Steering/braking	System	System	System	System
Monitoring of driving environment	Human	System	System	System
Fallback responsibility of driving task	Human	Human	System	System
System capability	Some driving modes	Some driving modes	Some driving modes	All driving modes

*L2 to L5 descriptions are based on the definitions originating from the Society of Automotive Engineers on levels for autonomous driving systems.

**L3, L4 and L5 platforms require increased levels of sensor redundancy.

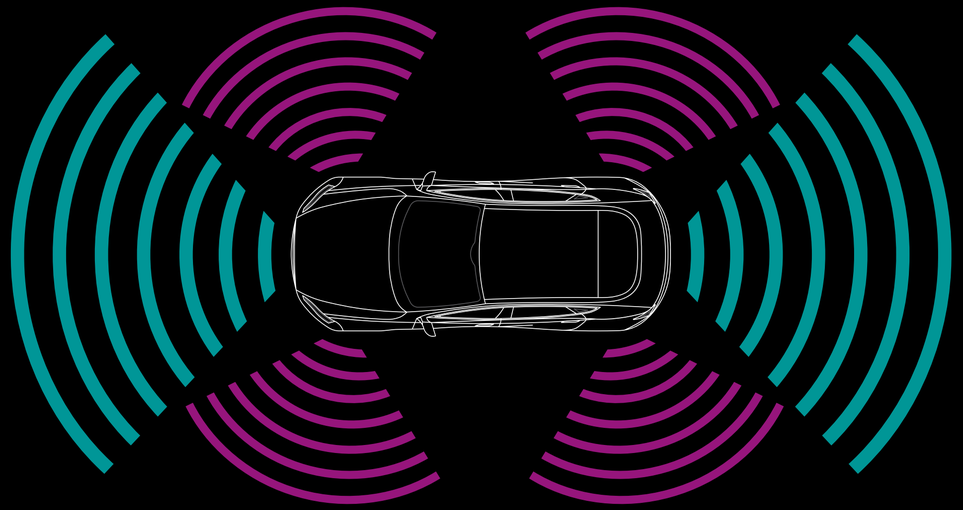
Typical automotive applications for LIDAR

SHORT-RANGE LIDAR

- L2 and L3: LIDAR competes with radar
  - To detect pedestrians and cyclists at corners
- L4 and L5: LIDAR complements radars and cameras
  - Sensing range up to 200m to detect vehicles traveling at high speeds around junctions (e.g., unprotected left turns)

LONG-RANGE LIDAR

- L3, L4 and L5: LIDAR complements radars and cameras
  - Sensing environment up to 250m (e.g., on freeways)
  - Some OEMs are requesting specs up to 400m



Long-range LIDAR (LRL) Short-range LIDAR (SRL)

For autonomous driving, LIDAR should detect objects at long range (250–400m), with low reflectivity (~10%) and be eye-safe (class 1 laser product)

Key LIDAR technologies

Flash
(3 technologies)

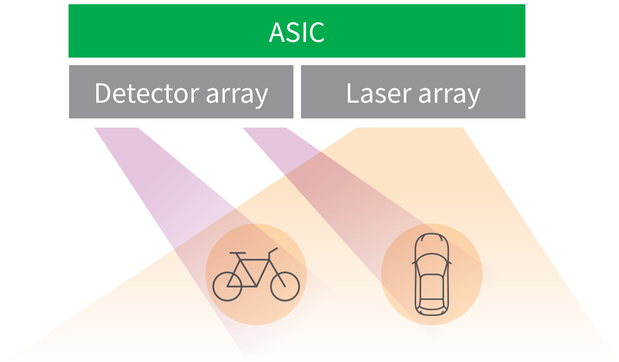
- Laser emitter arrays illuminate entire scene by sending out light pulses
- Photo detectors collect reflected light waves off objects

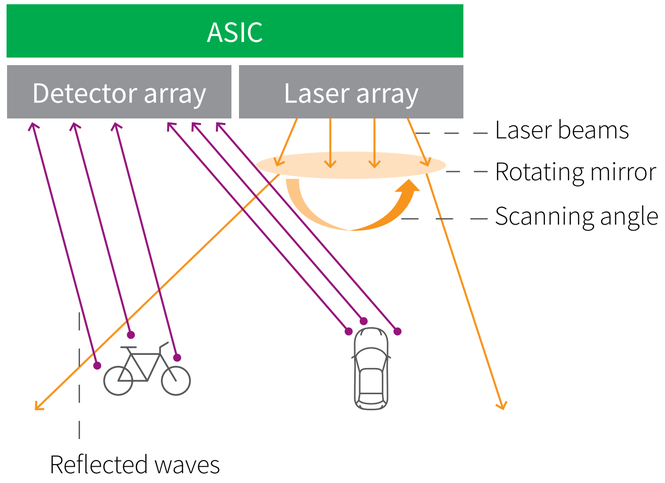
Solid-state scanning
(4 technologies)

- Laser beams are thrown onto 1D or 2D MEMS mirror. MEMS mirror sends beams onto road to project the scene
- APDs (avalanche photodiodes) are then used to reconstruct image from cloud-points created by the beams

Other solid-state
(Up tp 3 technologies)

- Information on this technology is closely held at present and remains proprietary





Key technologies enabling next-generation automotive LIDAR

Most new LIDAR suppliers now differentiate at the semiconductor level. But it is unclear what combination of LIDAR next-generation technology—emitter, detector or beam steering—will lead the field 10 years from now.

Emitter

(4 technology types)

Key to achieving long range for low-reflectivity targets and to maintain eye-safe class 1

Detector

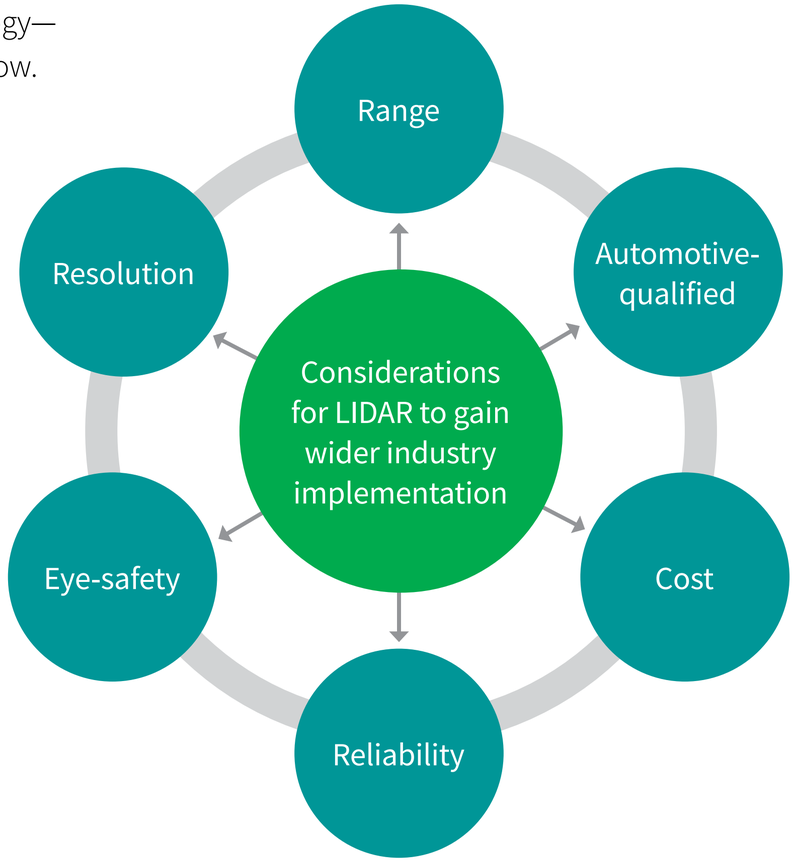
(5 technology types)

Key to achieving long-range and resolution

Beam steering

(12 technology types)

Helps achieve required field of view, resolution and miniaturization of LIDAR modules



LIDAR OEMs & suppliers: the business today

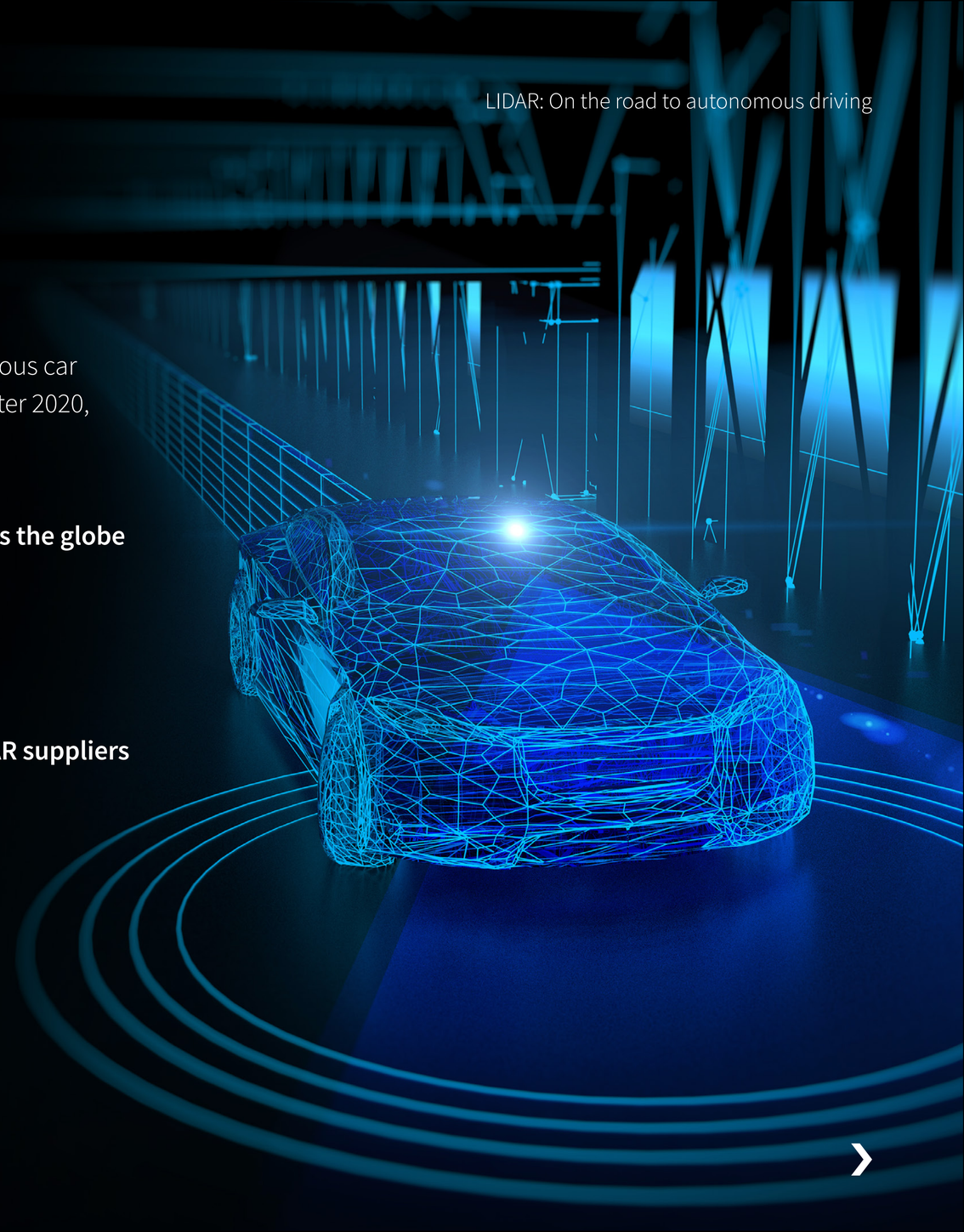
OEMs are currently technology agnostic but aim to roll out autonomous car platforms by 2020. The LIDAR market will be increasingly crowded after 2020, when more than 10 suppliers enter the fray with different solutions.

Various business models now exist to serve multiple OEMs across the globe

- LIDAR supplied with raw data (point-clouds) as output
- LIDAR supplied with object detection and other applications

Multiple entry points into the supply chain are available for LIDAR suppliers

- Current: Most suppliers do business with Tier-2 companies
- Goal: Attract the bigger and more established Tier 1-companies



Strategic LIDAR partnerships along the supply chain

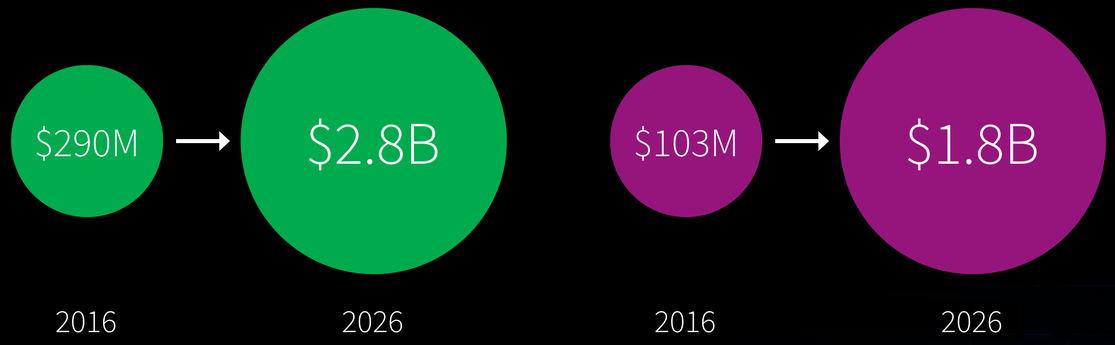
LIDAR technology is driven mostly by non-automotive optical companies and many start-ups. But as a new business model, partnerships are also starting to form among established automotive Tier-1s and LIDAR suppliers.

- **Autoliv** acquiring LIDAR expertise from **Fotonic i Norden AB**
- **Autoliv** LIDAR modules to use **Velodyne** software
- **Magneti Marelli** acquisition of stakes in Leddartech
- **Delphi** and **Magna** funding and offering **Innoviz Technologies** LIDAR to OEM customers
- **Magna** partnering with **Innoviz Technologies** for MEMS-scanning LIDAR
- **Osram** acquiring 25% stake in **Leddartech**
- **Trilumina** and **Analog Devices** joining forces for solid-state LIDAR chip solutions

And many more...

LIDAR prospects: solid and robust

Revenues for automotive LIDAR are projected to rise dramatically between 2016 and 2026.



Where to from here?

Today's commercialized LIDAR technologies do not yet meet the performance requirements of autonomous driving. The good news: car OEMs need LIDAR for autonomous driving, and LIDAR prospects will only improve moving forward.

CHALLENGES

- Mechanical scanning LIDAR is vulnerable to shocks, vibration and degradation
- Large form factor and high cost are currently barriers to volume production
- Production of high-resolution solid-state LIDAR with stringent automotive requirements—the next step forward in autonomous driving—continues to be demanding due to high cost of system development efforts, including new semiconductor design and manufacturing process

OPPORTUNITIES

- OEMs are starting to adopt LIDAR on L3 and L4 platforms during vehicle production
- A shake-out in the next 10-15 years—leaving just three LIDAR technologies out of 12 today—will present the greatest opportunities to those suppliers aligned with the remaining winning technologies

IHS Markit has detailed analysis of the LIDAR market, including:

- LIDAR suppliers by technology segment
- Pros and cons of LIDAR technologies, and likely winners by 2020 to 2025 time frame
- Supply chain and cost breakdown of different LIDAR technologies
- LIDAR forecast (system and semiconductor) by range, technology, volume and revenue

Find out more

The global automotive industry is surging, along with the demand for—and the complexity of—in-vehicle infotainment systems, connectivity and ADAS. IHS Markit provides detailed insights and analysis on everything from automotive semiconductors to ground-breaking vehicle technologies. For more information on automotive technology trends or on IHS Markit research relevant to this topic, please visit: https://technology.ihs.com/Research-by-Market/450422/automotive-technology

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