LiDAR Technologies and Markets: What's Changing?

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Outline

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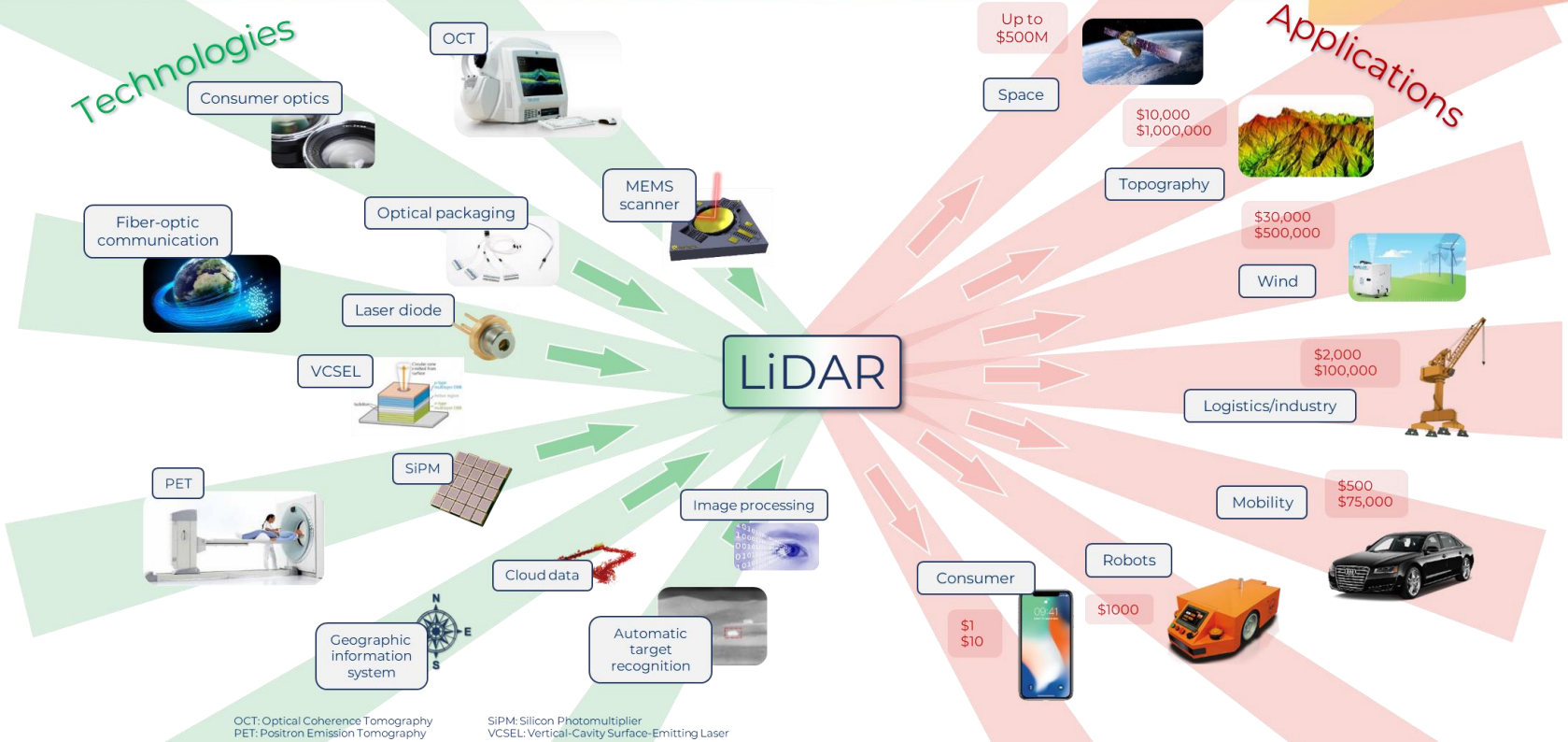
Introduction

From technologies to applications



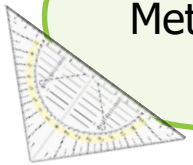
OCT: Optical Coherence Tomography
PET: Positron Emission Tomography

SiPM: Silicon Photomultiplier
VCSEL: Vertical-Cavity Surface-Emitting Laser

The two main LiDAR market groupings

Depth/3D vision for machines

- Wearables
- Smartphones
- Robots (home, industrial, security, military)
- Transportation (cars, planes, spacecraft)
- Security



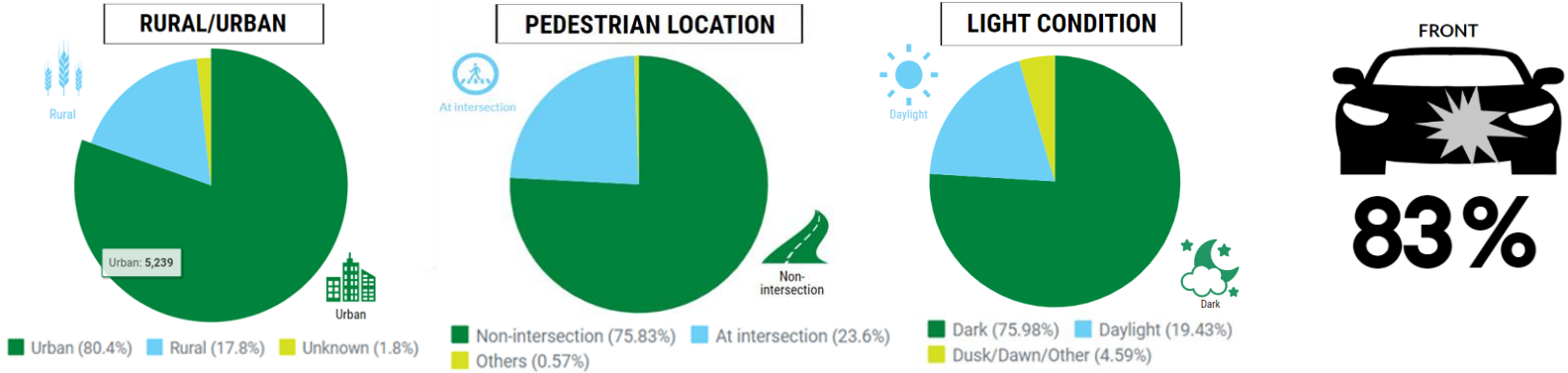
Metrology

- Atmosphere
- Space
- Topography
- Wind
- Underwater

Application and market trends

After "Dieselgate," an "ADASgate"?

US Pedestrian fatalities overview, 2020



Source: NSC Injury facts - *Pedestrians and Car Crashes - Injury Facts (nsc.org)*

OEMs are developing safety features according to regulations and to get 5-star ratings.

Since 2019, agencies are showing that AEB performance (based on camera and radar) is not good enough.

Better performance can be obtained with more severe tests from rating agencies and with the use of more sensors and/or better data processing.

EURO NCAP FOR SAFER CARS

AAA

IIHS Insurance Institute for Highway Safety

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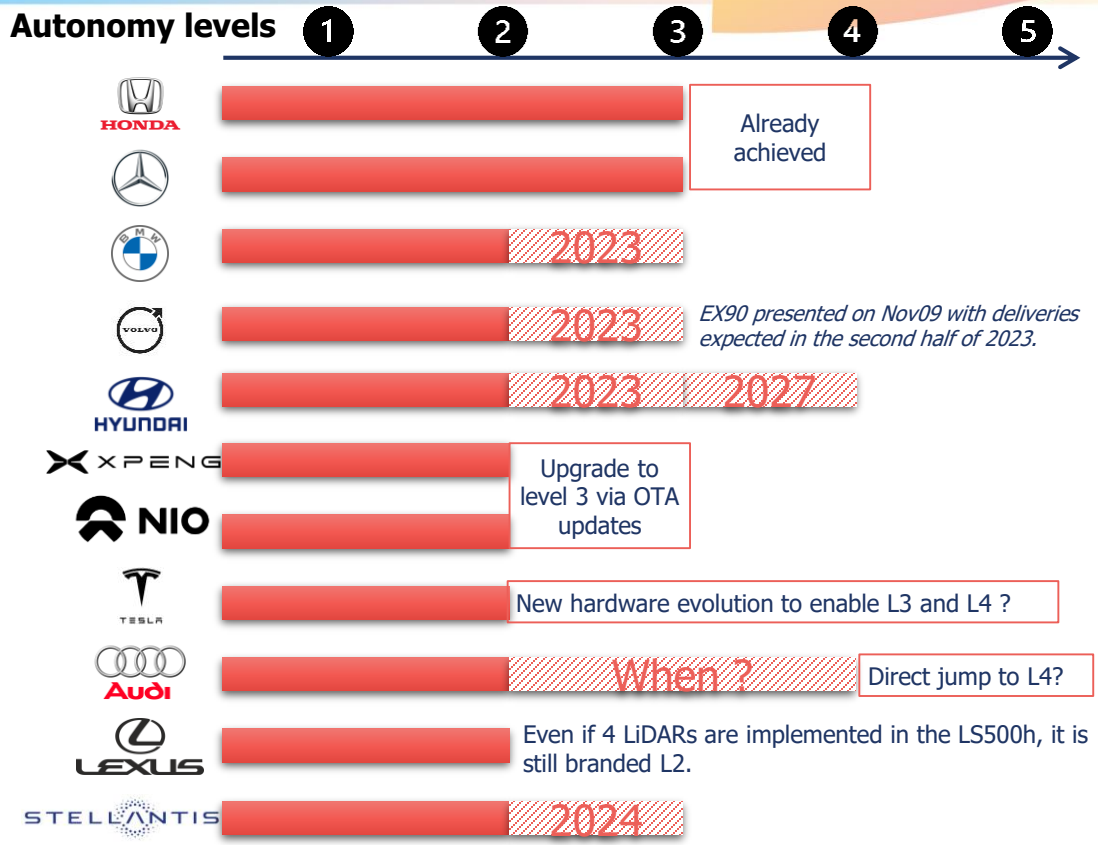
OEM limited achievements on automated driving

- Audi was the first to implement LiDAR to target level 3 applications in 2018, but stepped back a few times due to a lack of regulation and the fear of liability in case of accidents.
- New EV OEMs like Xpeng and Nio are embedding the necessary hardware to enable level 3 applications, but it is not yet activated. This will be activated using OTA updates.
- Big players like VW or Toyota are still not delivering cars with L3 features.
- Stellantis has recently partnered with Valeo to develop L3 functionality.



LiDAR industrial applications

Topography

Construction of buildings and infrastructure.


Energy

Construction and monitoring of wind turbines.

Manufacturing

The action of making goods. Farming and food processing are included here.


Logistics

The flow and storage of goods. Mining is included here.

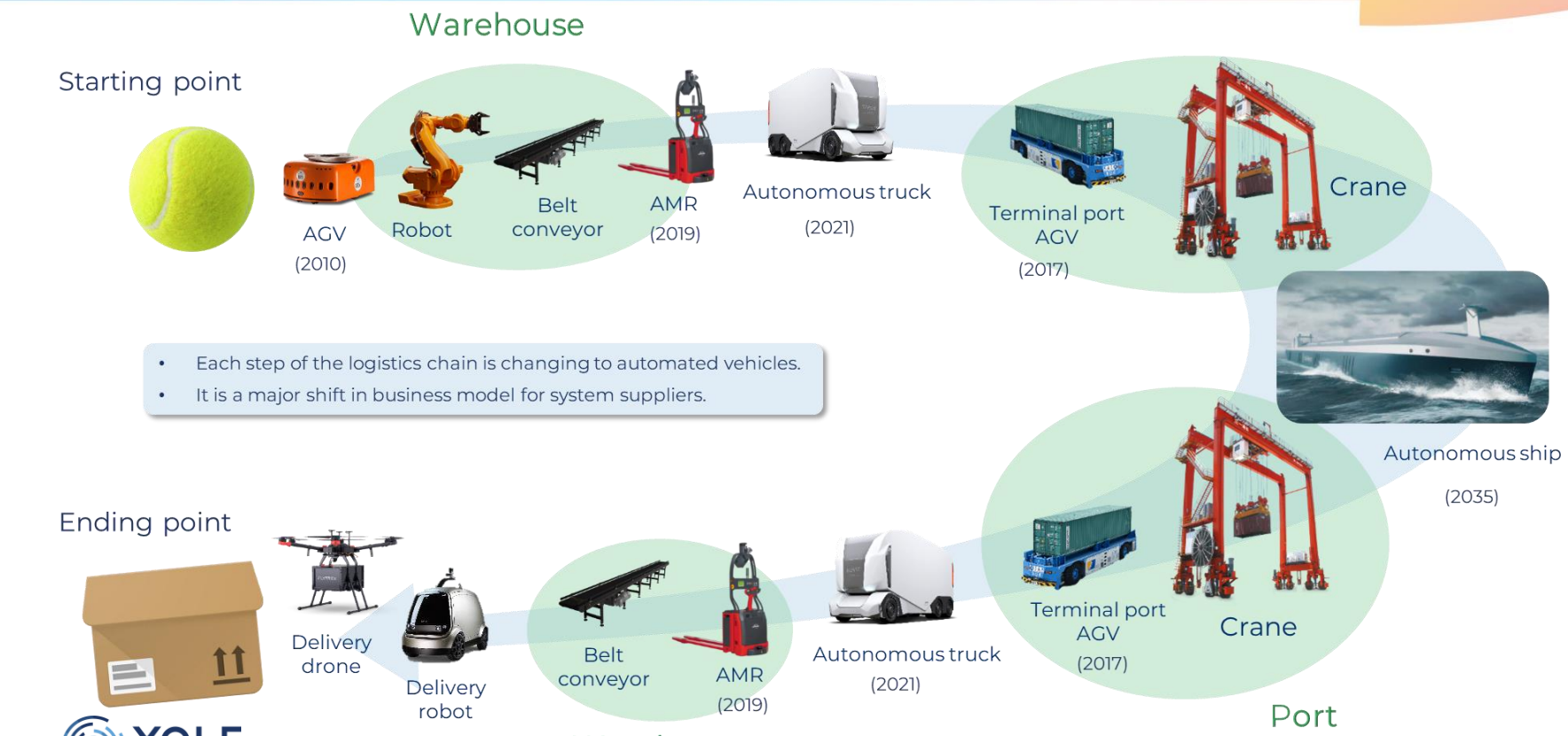

Smart infrastructure

Smart cities and buildings with sensors and data management. Security and retail are included here.


Entertainment

Including movies, music videos, games.


Logistics is moving towards full automation



- Each step of the logistics chain is changing to automated vehicles.
- It is a major shift in business model for system suppliers.

Smart infrastructure applications

Traffic management
Optimize traffic flow with increased intelligence, efficiency, and safety.

Crowd monitoring
Analyze crowd activity to improve the experience for shoppers and tourists.

Vehicle classification
Profile fast-moving objects and classify vehicle types at highway speeds.

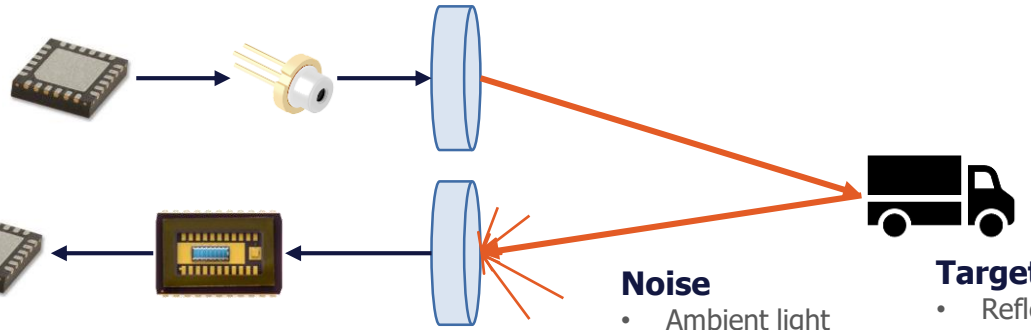
Platform monitoring
Monitor boarding status and platform safety to keep transit systems up and running.

Occupancy tracking
Track the occupancy of buildings and streets based on real-time 3D data.

Public safety
Protect people and property with full-coverage anonymized surveillance.

Technology trends

Overview of components and key parameters



Laser driver
- Rise & fall time
- Frequency
- Pulse width
- Output power

Laser
- Wavelength
- Power
- Beam quality
- Eye safety

Possible lasers:
EEL
VCSEL
Fiber laser
LEDs also possible

Read-out
- Amplification gain
- Threshold
- TDC

Sensor
- PDE
- Recovery time
- Gain
- Exposure time

Possible sensors:
APD / SPAD / SiPM

Optics
- Angle of view
- Lens diameter
- Band-pass filter
- ND filter

Noise
- Ambient light condition

Target
- Reflectivity
- Distance

Technology roadmap 1/2

2017 2018 2019 2020 2021 2022 2023 2024 2025

Mechanical LiDAR

credits: Valeo Scala Gen 1

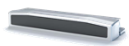
credits: Valeo Scala® Gen2

Valeo Scala® Gen3 (illustration only)

The second generation was released in 2022 in the Mercedes S-Class and EQS.

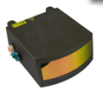
The third generation, using a similar architecture, should be released in 2024.

Mechanical LiDARs at 1,550nm using fiber laser are entering the market in low volume, due to their high price compared to 905nm LiDARs.



credits: Luminar

MEMS LiDAR



credits: Robosense

In 2021, the first MEMS LiDAR from Robosense was implemented by Lucid.

Flash LiDAR

credits: Continental

In 2021, the first flash LiDAR from Continental was implemented by Lexus and Toyota.

Similarities:

- NIR light source
- Pulse time-of-flight
- Silicon-based sensor

- Most popular ranging method, as it is the easiest.
- Lower cost of components.

Technology roadmap 2/2

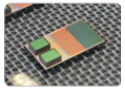
2025 ? 2030

FMCW LiDAR

credit: Insight LiDAR

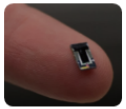
New LiDAR start-ups are developing sensors using FMCW ranging method. Mobileye is working on such technology using silicon photonics platform. Such products are not expected before 2025.

credit: Analog Photonics



credit: SILC Technologies

credit: Voyant Photonics



OPA LiDARs

Similarities:

Suitable for 1550nm

Coherent detection.

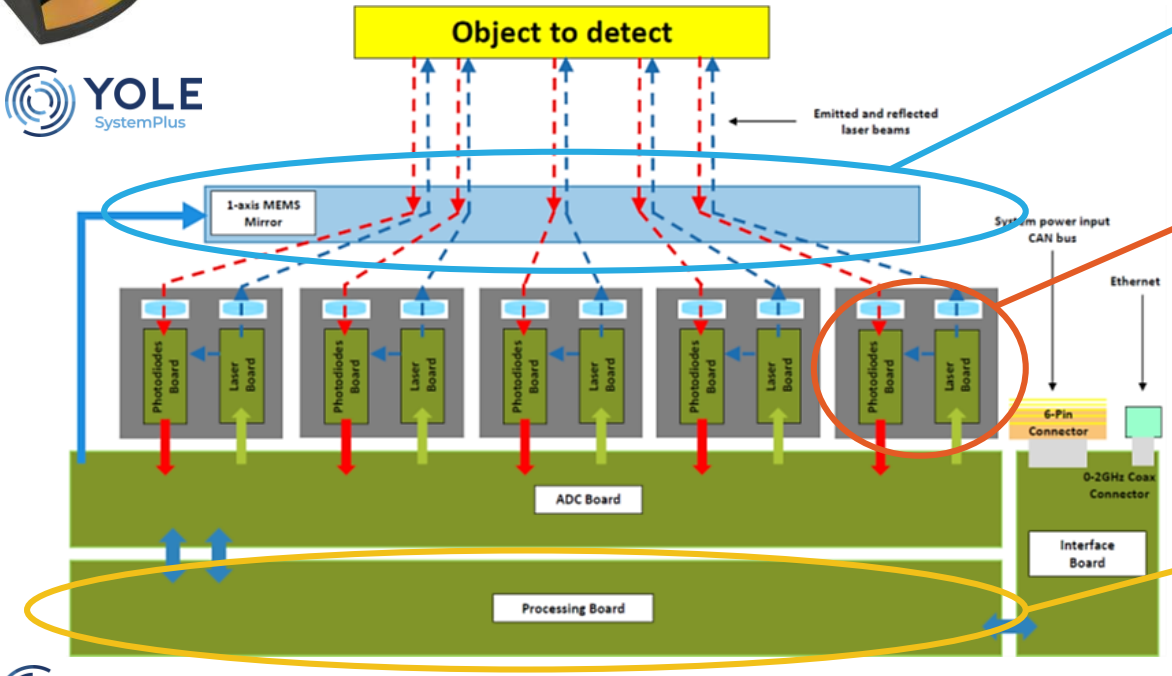
Radial velocity measurement.

Alternative to mechanical or MEMS scanning.

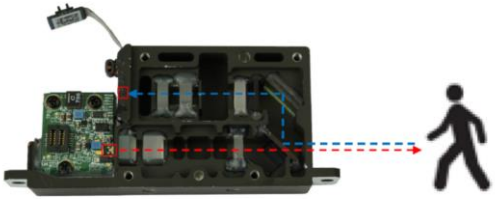
Still not ready for industrial applications.

Teardown of RoboSense's RS-LIDAR-M1

The first MEMS-based LiDAR in a car, including SiPM (Silicon Photomultiplier) as receivers, instead of APD (Avalanche Photodiode).



MEMS mirror



Optical module with both emitter and receiver

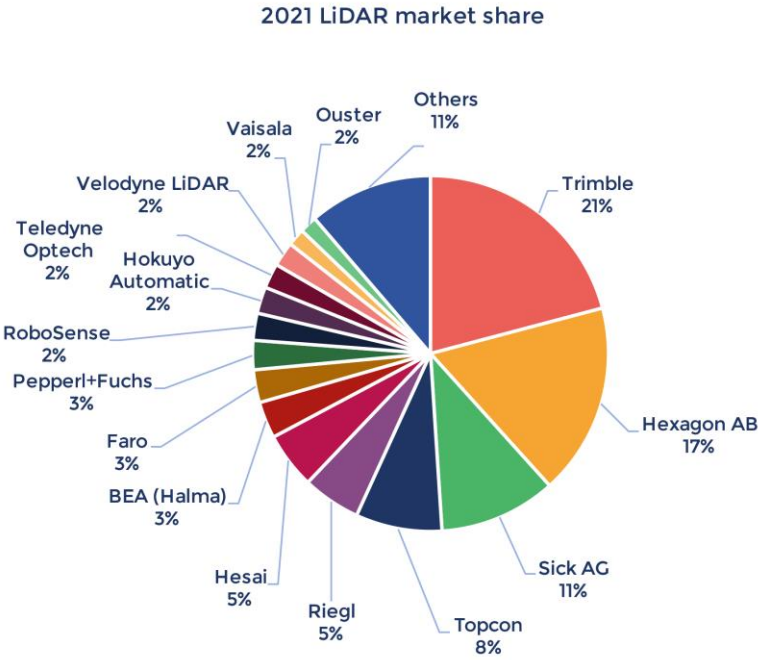
Xilinx XA Zynq UltraScale+

Industry and market shares

LiDAR market share, by revenue

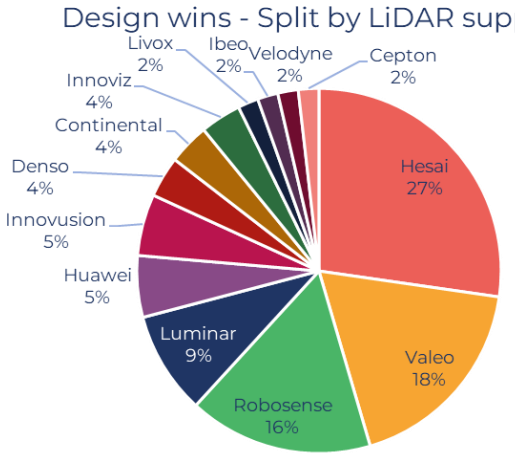
- The main players for LiDAR are those in the traditional topography and manufacturing segments.
- Newcomers in the top 15 include RoboSense, Hesai, Velodyne, and Ouster. Real-time 3D LiDAR is starting to generate more and more revenue with a total of $215M, which is more than 10% of the total.
- In 2021, automotive was not a significant market and even the leader, Valeo, had lower revenue than the 15th ranked LiDAR manufacturer.

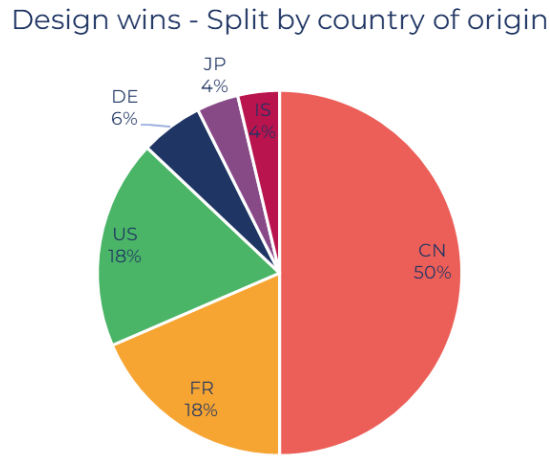
Total market: $2,152M



Automotive LiDAR known design wins (2018-2022)

- Chinese LiDAR suppliers represent 50% of the design wins, closely linked to the release of electric vehicles from new Chinese OEMs.
- Hesai and Robosense have completely changed the landscape, ranked in 1st and 3rd position, respectively.





Total of 55 design-wins (2018-2022)

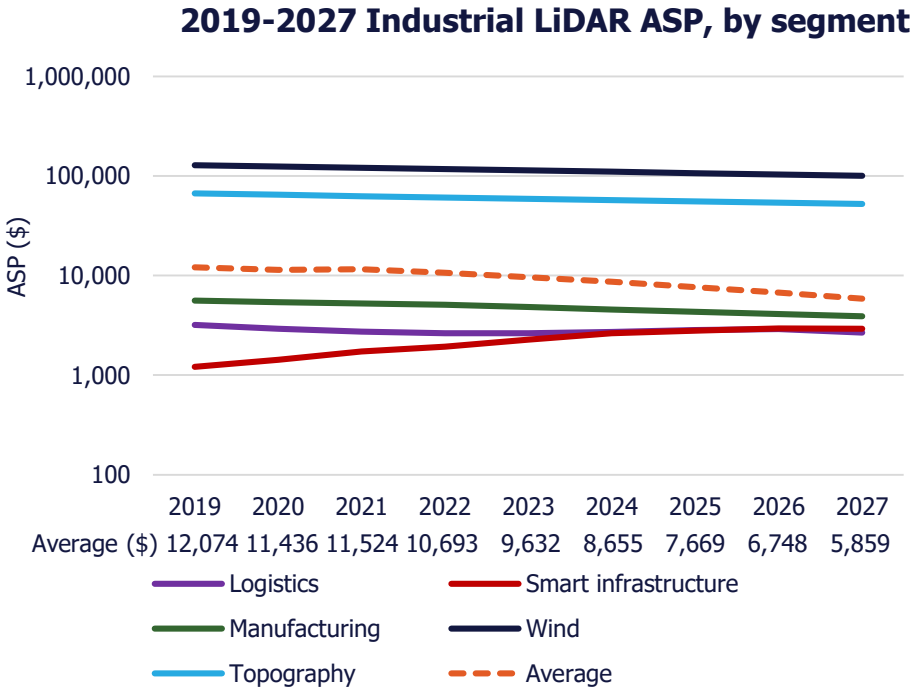
- The US activity is led by Luminar with partnerships with Volvo, Polestar or SAIC, and Innovusion.
- Europe is represented by Valeo, Continental, and Ibeo (24% of design wins), and Middle-east is represented by Innoviz.

LiDAR market forecasts

LiDAR average selling price (ASP) forecast

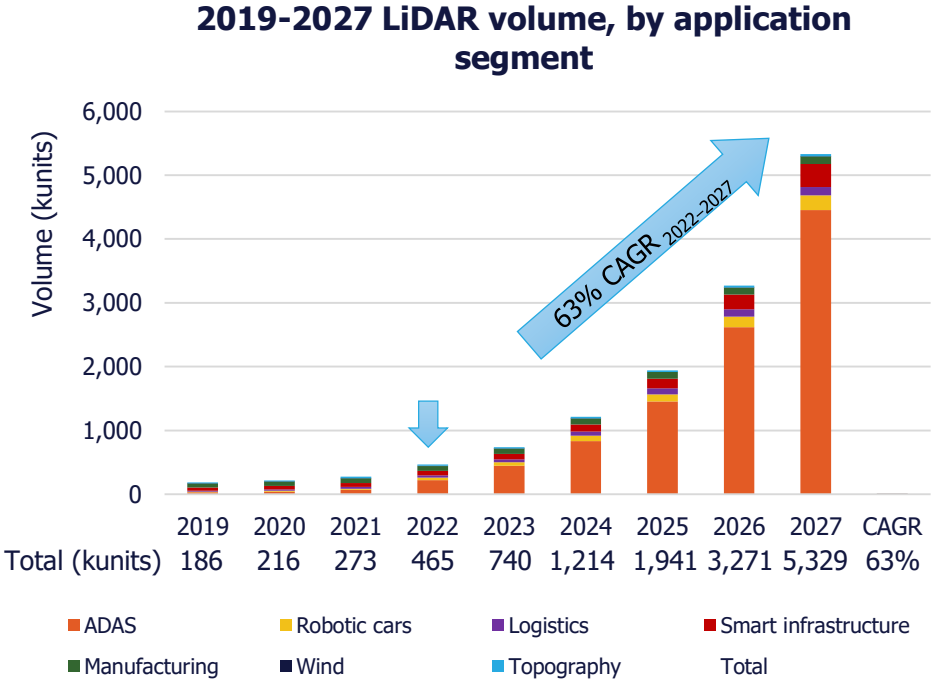
- The average selling price (ASP) of LiDAR for industrial applications is expected to decrease significantly in the coming five years. The decrease is mainly due to the introduction of cheaper technologies and increased competition, beyond typical price erosion.

- For automotive, typical ADAS LiDAR ASP is around $300 for short range and $600 for long range, and in the $1,000-10,000 range for robotic cars.

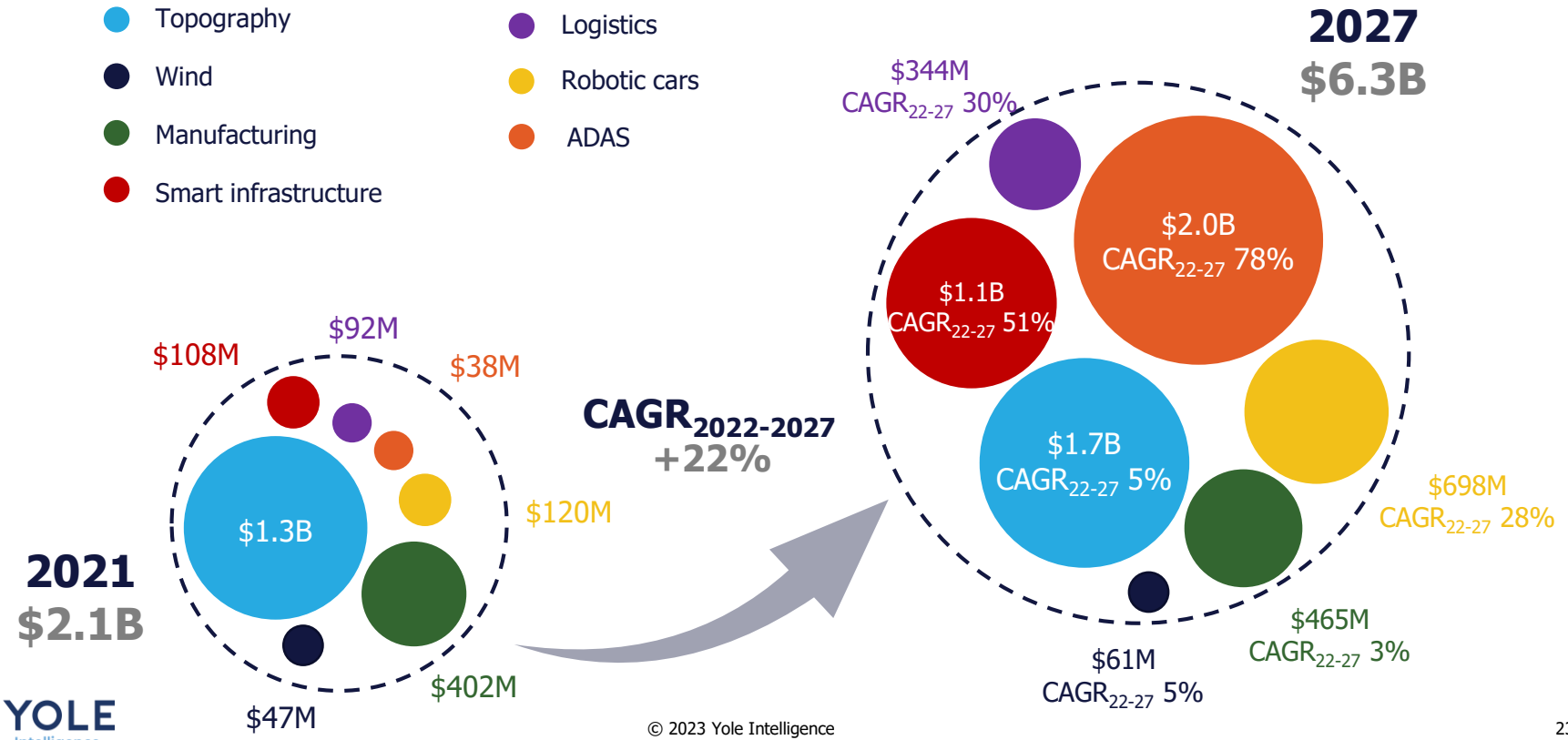


Automotive and industrial markets forecast

- In 2027, we expect almost 5.3 million LiDARs to be shipped, with an impressive 63% CAGR over the 2022–2027 period. Most of them (4.5 million) will serve the automotive market, whose volume should remain under the one-million-unit mark until 2024.
- LiDAR shipments for industrial applications are expected to grow with a 27% CAGR in the next five years, supported by traditional applications such as wind and topography monitoring, but also robotics and increased automation trends for manufacturing and logistics, and smart infrastructure applications including smart cities projects.



2021-2027 LiDAR forecast, by application



LiDAR industry outlook

- The LiDAR industry for automotive and industrial applications has been growing for many years.
  - In the automotive industry, there have been 55 design wins for 13 LiDAR suppliers (ADAS), with 32 OEMs implementing LiDAR.
    - 27% of them are for Hesai, a new entrant, pushed by partnerships with Chinese OEMs.
- In the industrial market, LiDAR is finding applications in almost every aspect of logistics, and expanding very fast in smart infrastructure, with applications in crowd monitoring in airports, autonomous checkouts, and traffic monitoring on highways and at intersections.
- In 2021, investments in LiDAR companies remained very high and even higher compared to 2020: a total of $2,644M was invested in 2021. But this high investment period seems to be coming to an end.
- These new LiDAR applications and investments are expected to drive the LiDAR market to $6.3B in 2027, from $2.1B in 2021.
  - The fastest growth is expected to be in the ADAS market, with a CAGR of 78% between 2022 and 2027.

Resources

Yole Group resources

LiDAR 2022 – Focus on Automotive and Industrial
https://www.yolegroup.com/product/report/lidar---market--technology-trends-2022/

Computing and AI Technologies for Automotive 2022
https://www.yolegroup.com/product/report/computing-and-ai-for-automotive-2022/

Yole Group other related products
https://www.yolegroup.com/products

2023 Embedded Vision Summit

"3D Sensing: Market and Industry Update" (Talk)
Business Insights, Tuesday, 2:40 pm