

LiDAR - The multi
billion dollars
opportunity for
automotive
suppliers

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THE TWO ROOTS OF LiDAR

Some LiDAR are coming from cameras. Others are coming from distance metrology.

2D

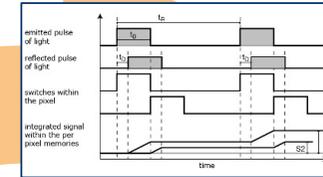
Digital Photography



- Digital photography allows to obtain a digital 2D representation of space.

Gated imaging

- Gated imaging allows to add distance measurement to a 2D image.



3D

ToF Camera

Out of scope

- Range gated imagers.
- Performances are limited to a few meters.

3D

In scope

Flash LiDAR



- Direct ToF.
- Phase-shift.
- Frequency modulation.
- Array of photodetectors

1D

Laser Rangefinder



- A laser rangefinder allows to obtain a distance for one point.

Scanning of laser or system

- Scanning allow to form 3D images from distance measurement.

3D

In scope

LiDAR



- Direct ToF.
- Phase-shift.
- Frequency modulation.
- Scanning LiDAR

ToF: Time of Flight

THE SCALING OF LiDAR

There is a factor one million for several properties of LiDAR from consumer applications to space applications, with industrial and automotive applications in between.

LiDAR have been developed from millimeter size to meter size.

Consumer

The smallest ToF sensor



- Price: \$1
- Range: Up to 2 m
- Laser: VCSEL
- Photodetector: SPAD
- Size: millimeter size
- Weight: < 1g
- Application: Mobile

Automotive



- Price: \$1000
- Range: Up to 150 m
- Laser: NA
- Photodetector: EEL
- Size: 10 centime size
- Weight: NA
- Application: ADAS

Industrial



- Price: \$100 000
- Range: Up to 6 km
- Laser: NA
- Photodetector: NA
- Size: 50 centime size
- Weight: 14 kg
- Application: Topography

Space/Scientific

LITE Mission from NASA



- Price: Around \$400M
- Range: Up to 250 km
- Laser: Flashlamp laser
- Photodetector: NA
- Size: few meters size
- Weight: 4 tons
- Application: Atmosphere study



EEL: Edge-Emitting Laser
 SPAD: Single Photon Avalanche Photodiode

DRIVER FOR AUTOMOTIVE LiDAR



Traditional car makers



ADAS Levels

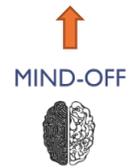


2010~

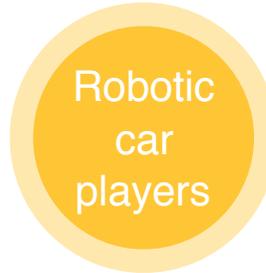
2017~

2025~

2035~



While traditional car makers are integrating autonomous functions in consumer cars little by little, newcomers have challenged this approach by short-cutting technological developments and proposing a new business model: transportation as a service. This move has triggered new investments in LiDAR technologies.



Fully autonomous vehicles in 2017



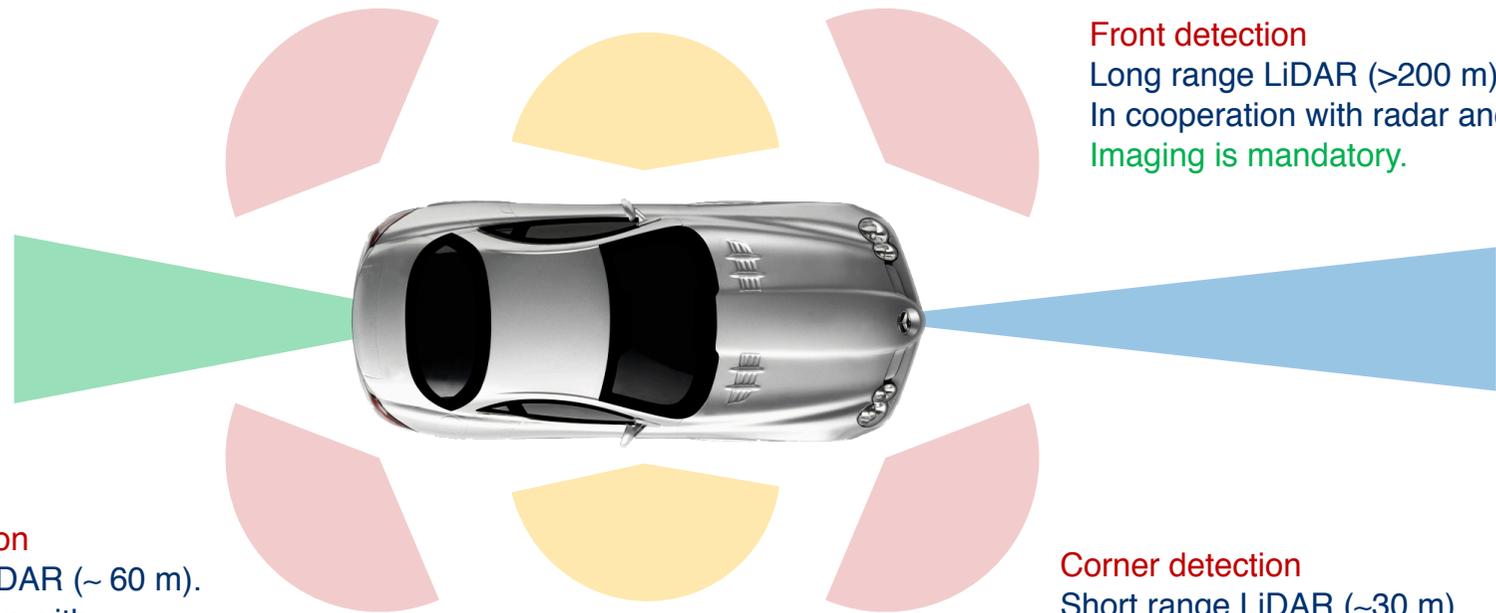
TESLA

AUTOMOTIVE LiDAR BY FUNCTIONS



Who will take care of LiDAR design at the vehicle level?

Different LiDAR technologies may be used for different functions in autonomous cars.



Front detection
Long range LiDAR (>200 m).
In cooperation with radar and cameras.
Imaging is mandatory.

Back detection
Mid range LiDAR (~ 60 m).
In cooperation with cameras.
Cooperation or competition from long range radar.
Imaging is better.

Side detection
Short range LiDAR (~10 m).
Cooperation or competition from short range radar and ultrasonic sensors.
Imaging is less important.

Corner detection
Short range LiDAR (~30 m).
Cooperation or competition from short range radar and ultrasonic sensors.
Imaging is mandatory.

POSSIBLE LIDAR INTEGRATION IN CARS



Integration requirements

- Aesthetic
- Cleaning
- Heat management
- Optics

Behind the windshield

- Easy cleaning
- Possible obstruction of driver view

In the grille

- Good position for front LiDAR
- Heat from the engine
- Difficulty of cleaning

Integration challenges

IR Transparent Materials
Image deformation must be taken care of.

Ceramic Packaging
Can be key for heat management



LiDAR integration in cars will ease adoption and industrialization.

Smart corner by Magneti Marelli



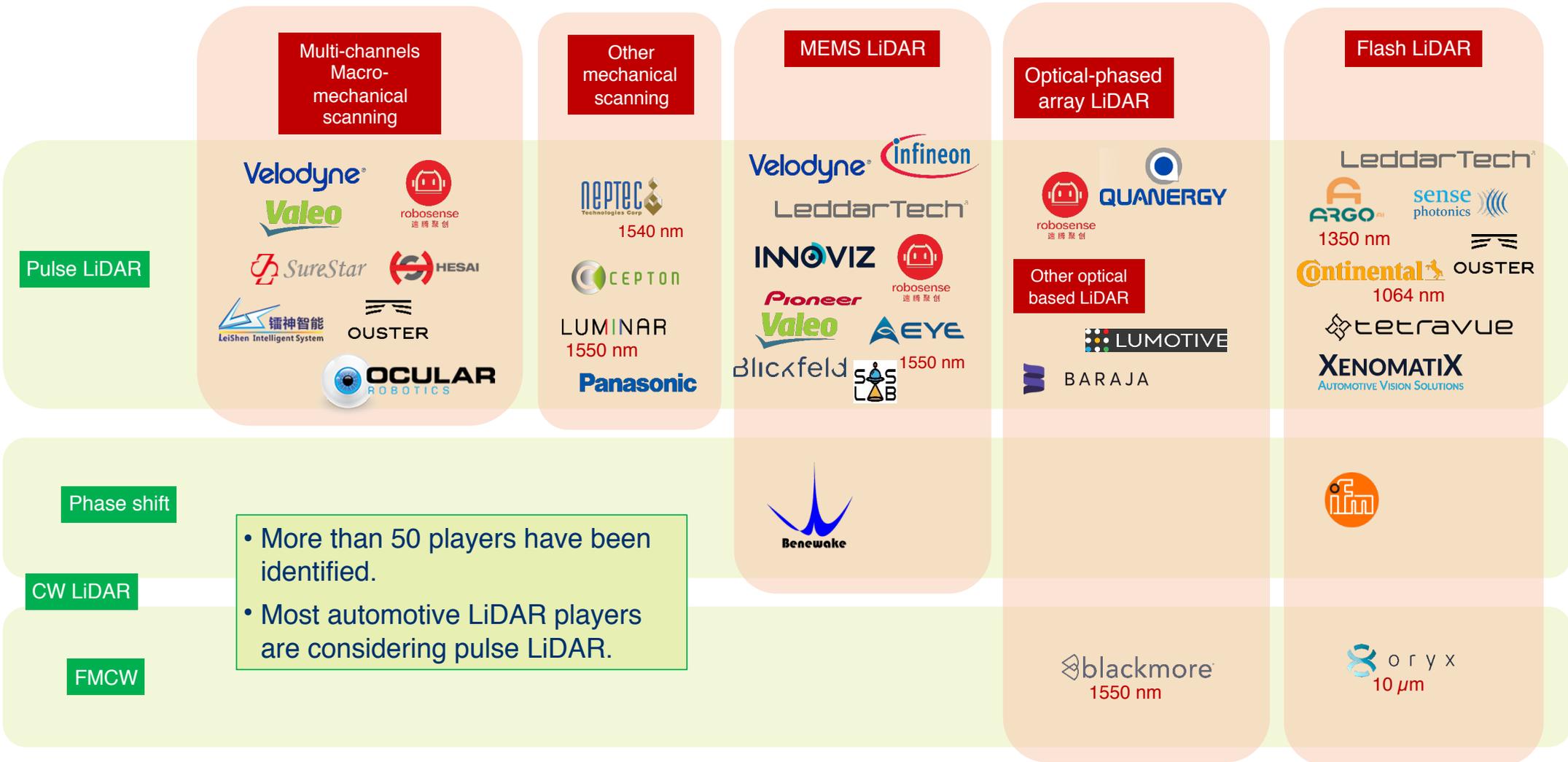
In headlights

- Easy integration
- Good for corner (short-range) LiDAR
- Photonic pollution
- Heat management

In bumper

- Easy integration
- Low position ⇒ More dirt
- Absence of bumper?
- Difficulty of cleaning

AUTOMOTIVE LiDAR PLAYERS



- More than 50 players have been identified.
- Most automotive LiDAR players are considering pulse LiDAR.

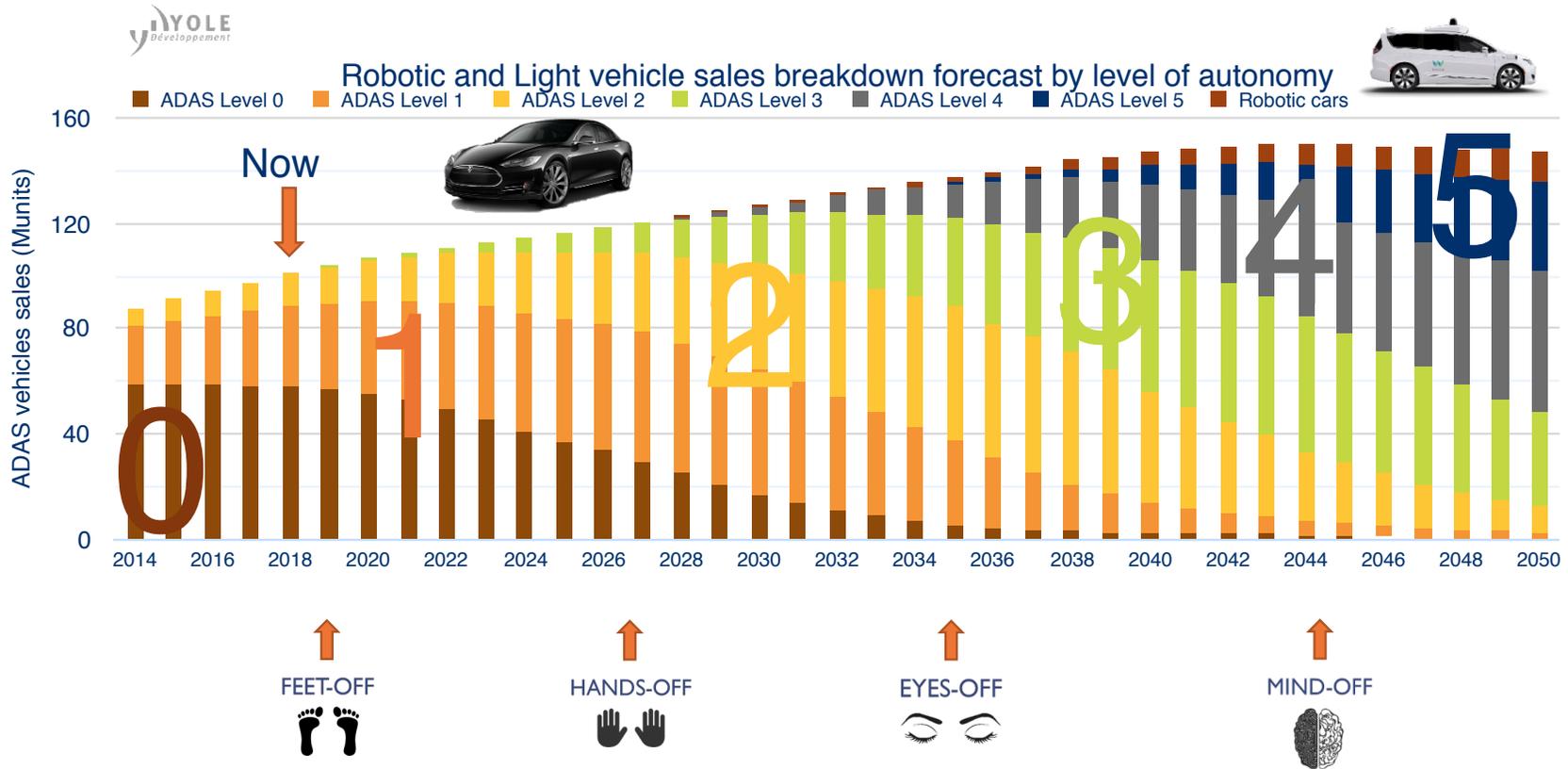
Except when noted, wavelength is between 830 nm and 940 nm.

CW: Continuous Wave
FMCW: Frequency Modulated Continuous Wave

MARKET PENETRATION OF ADAS VEHICLES



The introduction of ADAS level 3 and above will take some time.



By 2045, more than 70% of all vehicles sold will integrate autonomous capabilities.

ROBOTIC VEHICLE MARKET TREND



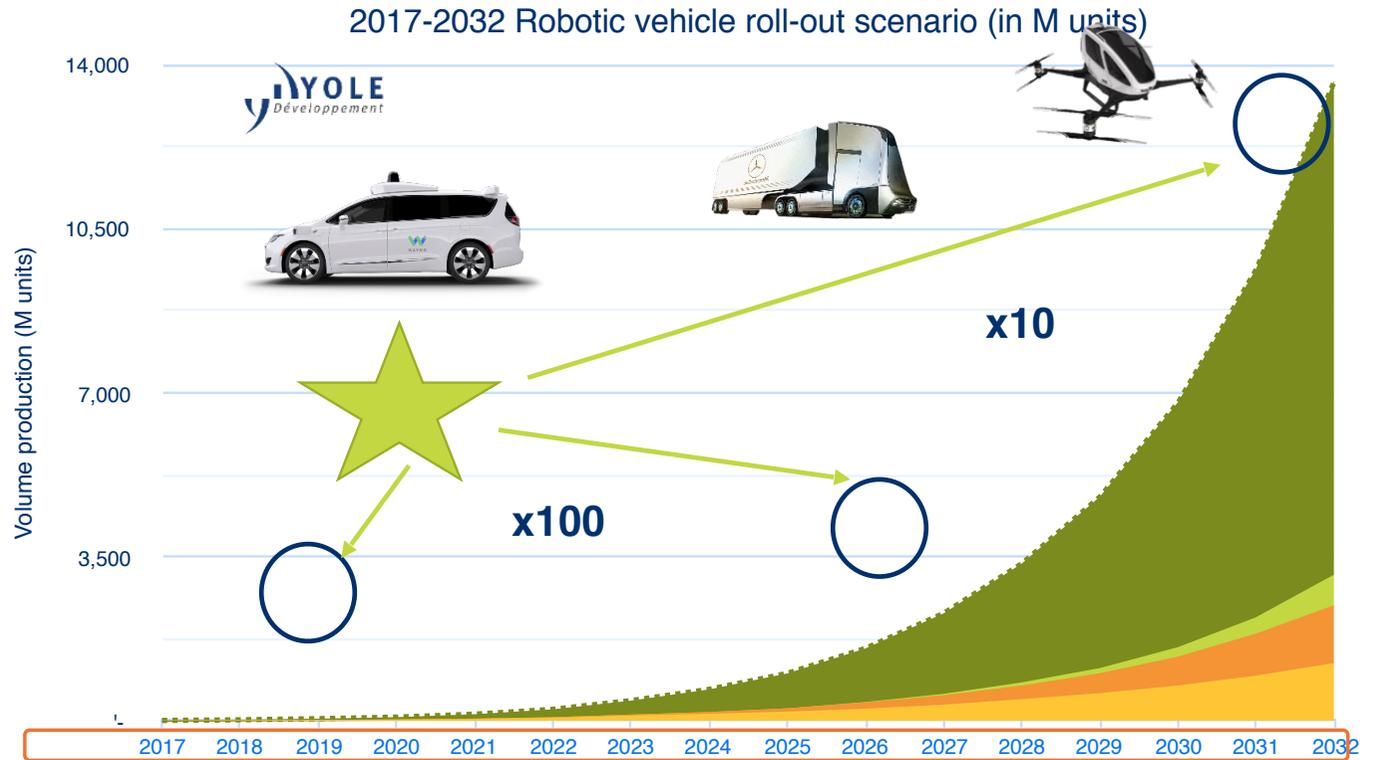
In 2032 we expect 5M robotic vehicles on the road.

Cumulated production of robotic vehicles could reach 10M units by 2032.

In this time frame, production will climb 3 orders of magnitude

8ku	in 2018	3 years
44ku	in 2021	5 years
400ku	in 2026	7 years
3.1Mu	in 2032	

Life cycle of each vehicle will be relatively short, in the order of 5 years.



AUTOMOTIVE LiDAR SHIPMENT FORECAST



ADAS vehicles will be responsible for massive LiDAR shipments in the next five years.

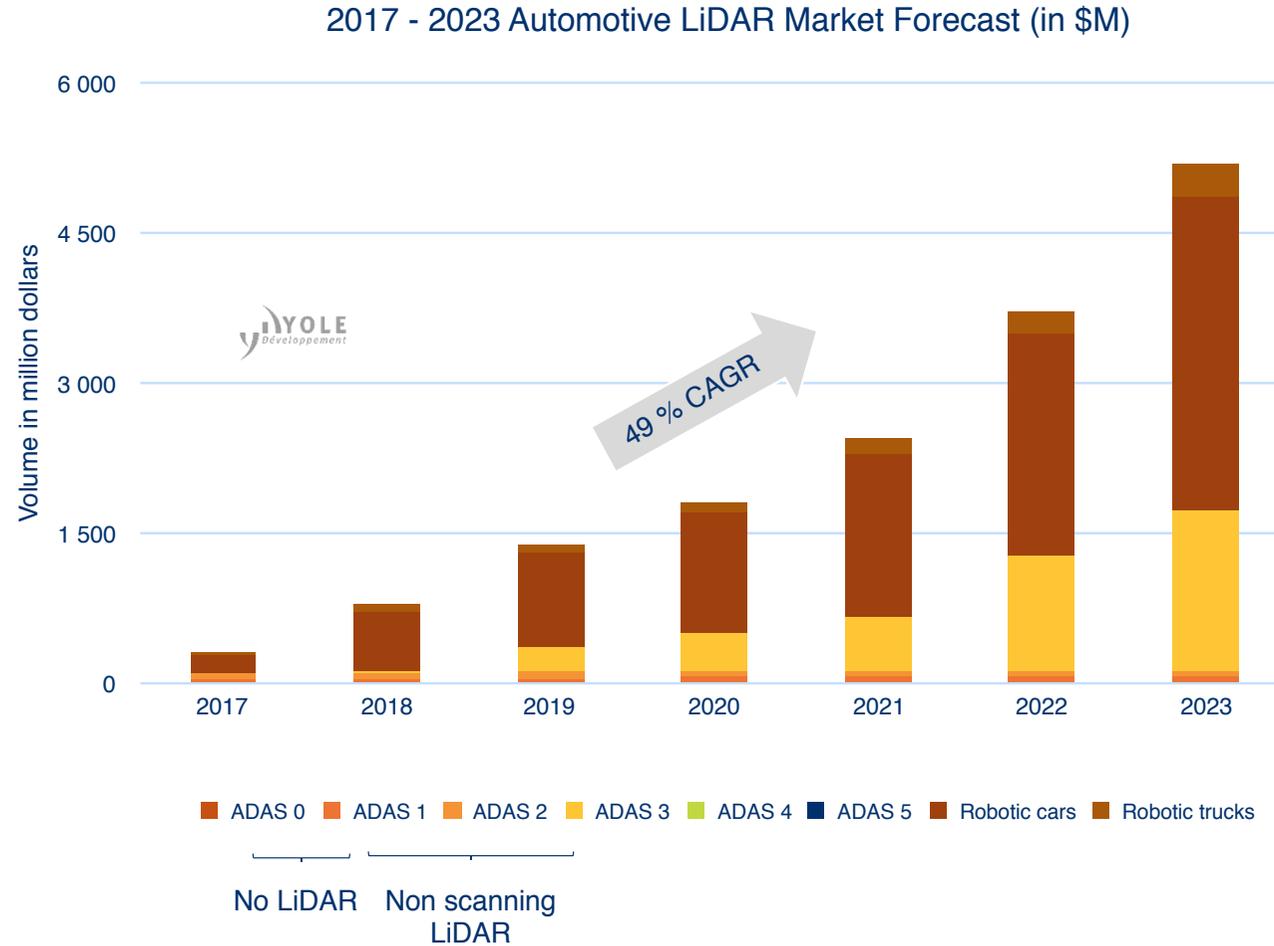
2017 - 2023 Automotive LiDAR Shipment Forecast (in million unit)



AUTOMOTIVE LiDAR MARKET FORECAST



Robotic vehicles will account for a large part of the LiDAR market.

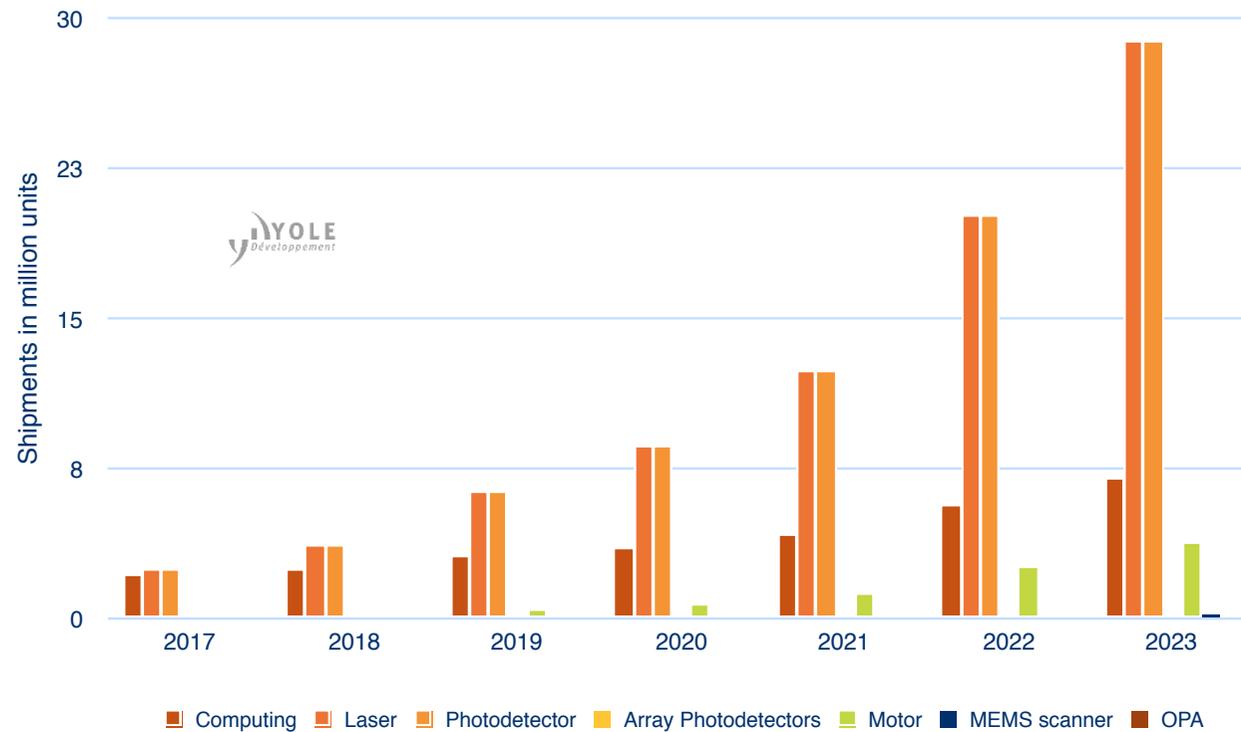


COMPONENT DEMAND FOR AUTOMOTIVE LiDAR



Can the supply chain achieve a 10 fold increase production in 7 years?

2017 - 2023 Automotive LiDAR Technology Split Forecast (in million units)



From Technologies to Markets

Thank you.