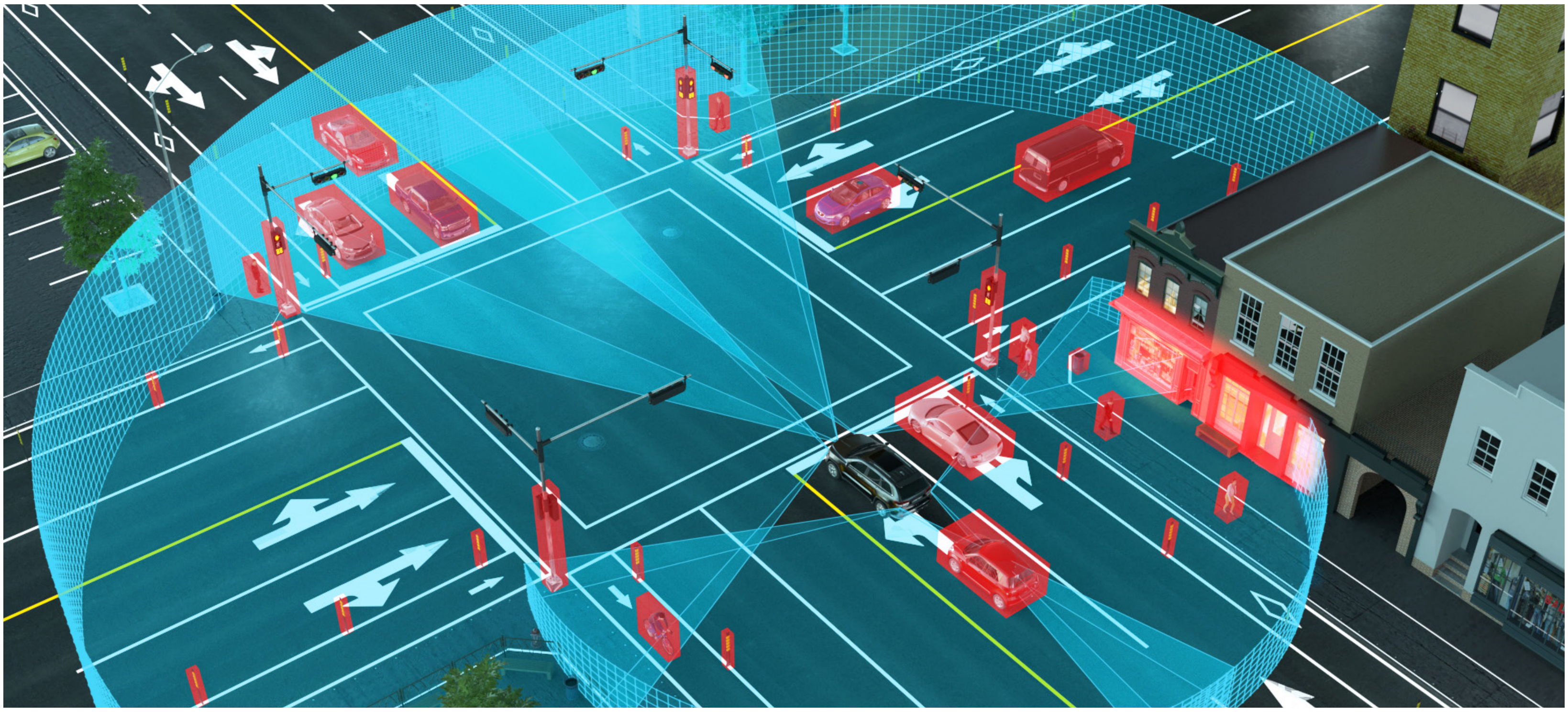
SOLID-STATE LiDARS: ENABLING THE AUTOMOTIVE INDUSTRY TOWARDS AUTONOMOUS DRIVING



Autonomous vehicle technologies are evolving at an accelerated pace in the automotive industry, as the race to bring to consumers a driverless vehicle that requires no human intervention or oversight—while ensuring maximum safety—is gaining momentum, profoundly disrupting the core of the automotive industry as we know it. The lines between automotive OEMs, high-tech companies and transportation service providers are becoming increasingly blurred as a variety of advanced applications and new services (such as active safety features, robotaxis, and mobility-as-a-service, to name a few) are expected to transform entire mobility sectors.

With this transformation comes substantial investments in time, money, and research and development. Between 2015 and 2025, it is estimated that US$ 130 billion will be invested in R&D for autonomous-driving (AD) technologies, representing the largest segment in automotive R&D and surpassing electrification (at US$ 115 billion) and remote connectivity (at US$ 100 billion)[1].

1–source: Wall street research and Frost and Sullivan

GLOBAL AUTOMOTIVE OEMS ARE ACTIVELY PURSUING AUTONOMOUS DRIVING

The Big Three automakers in the United States, as well as technology heavyweight players, such as Waymo, Apple and Uber, have been actively pursing autonomous driving since its onset, making North America a fertile ground for the R&D activities of autonomous vehicles. The region has fostered favourable conditions for automotive technology start-ups and has seen its fair share of venture capital invested in growing LiDAR companies.

In Europe, OEMs and Tier-1 manufacturers have established significant AD technology development programs, supported by regulations that will improve active safety features making them more appropriate in preventing collisions between vehicles and vulnerable road users (VRUs), including pedestrians and cyclists.

Asia's automotive and technology players are also getting on board with AD initiatives. In Japan, where the upcoming Olympic games are seen as a world stage for showcasing the latest technologies, a particular focus has been put on automated mobility and autonomous shuttles, which should be deployed for the big event. In China, the context has become particularly favourable to the deployment of autonomous-driving applications. The economic, social and environmental benefits of efficient mobility are well recognized by the authorities—with regulations that encourage the development of eco-friendly and automated transportation solutions. Driven by initiatives such as Baidu's Apollo platform and a dynamic venture-capital investment market supporting new automotive technologies, the pace of innovation in this country is rapidly accelerating.

FIG.1 **A Global Phenomenon: Autonomous Driving Spurs LiDAR Demand**

Source: Wall Street research.

LiDAR, AT THE HEART OF THE AUTONOMOUS-DRIVING SENSOR SUITE

Industry experts agree that to enable autonomous driving, LiDARs will be required in the sensor suite. OEMs who are developing autonomous driving systems a comprehensive sensor suite for AD which should integrate anywhere between one to nine LiDAR sensors, along with cameras and radars.

No standards currently exist that define the required or the 'ideal' sensor combination for autonomous vehicles. However, it is expected that with time, such standards as well as new regulations, could dictate the exact number and type of sensors required to implement with each level of autonomy.

AS AUTOMATION INCREASES, SO TOO WILL THE USE OF LiDAR

The mass-market deployment of fully autonomous vehicles is a long-term goal for which the time frame will be determined by various factors, such as technological development, legislation, public acceptance, and readiness of infrastructure. However, most industry leaders agree that Level 4 and Level 5 autonomous vehicles will require LiDAR technology integration.

For the next decade, passenger cars within the Level 2+ and Level 3 automation categories will most likely represent the biggest opportunity for automotive LiDARs, as rapid advancements in active safety and advanced driver assistance systems (ADAS) will enable a number of new semi-autonomous driving capabilities to hit the market in the coming years. With these advances, consumers are likely to begin seeing several production vehicles that have LiDARs integrated into their sensor suite.

TABLE 1 **LiDAR Adoption per Level of Autonomy**

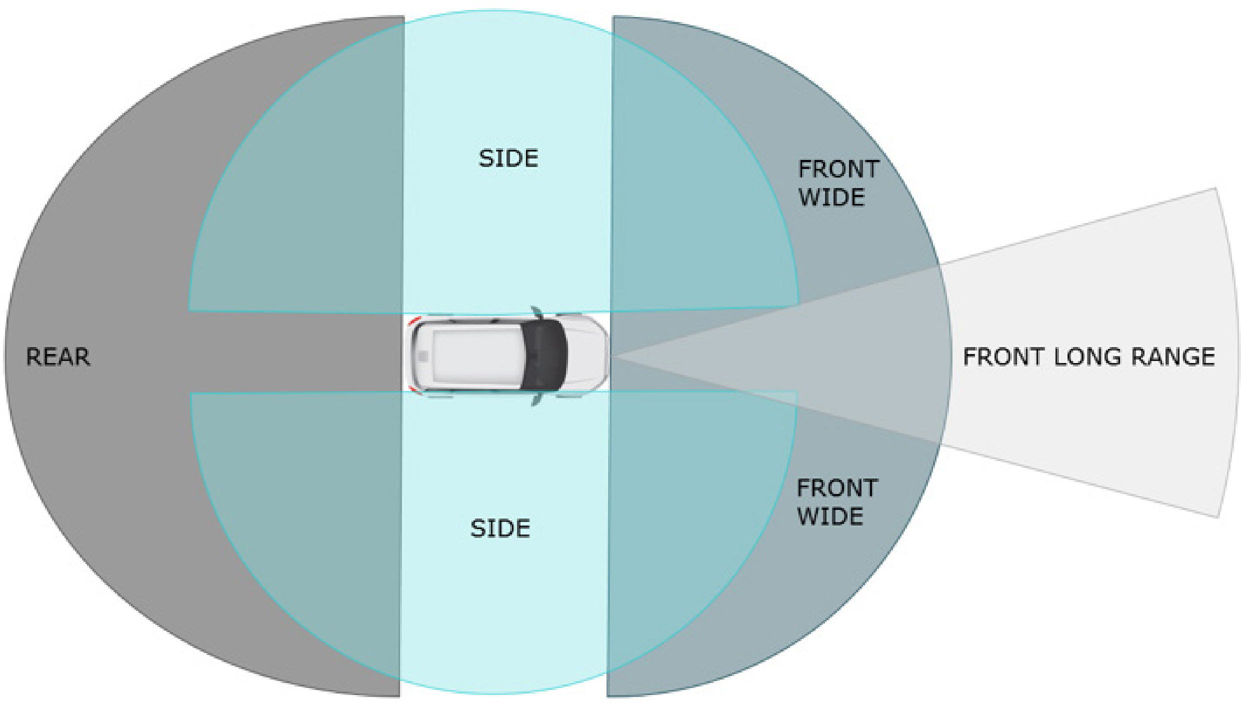
LEVEL OF AUTONOMY	EXAMPLE OF APPLICATIONS	LiDAR ADOPTION
Level 1	Automatic Emergency Braking (AEB) Adaptive Cruise Control (ACC) Lane Keep Assist (LKA)	Little to no LiDARs
Level 2	Parking Assist (PA) Traffic Jam Assist (TJA)	Some will use LiDARs
Level 3	Highway Pilot	Most will use LiDARs
Level 4	Automated Urban Mobility	LiDAR is Necessary
Level 5	Full Automation	LiDAR is Necessary

DIFFERENT APPLICATIONS CALL FOR DIFFERENT LiDARS

The type and the number of LiDARs deployed in vehicles will be application-dependent and will vary depending on specific OEMs. Along with higher automation levels (Level 4 and Level 5) comes the need for more sophisticated solid-state LiDARs that offer higher ranges and better resolution.

The specifications of LiDARs will also vary according to their position on the vehicle: front LiDARs for highway applications will require the longest range and resolution as well as a narrower field of view (FOV), while side, corner or rear LiDARs may require less range or resolution, but wider FOV.

FIG.2 **360° LiDAR Cocoon Using Various LiDAR Configurations**



GETTING THE RIGHT PERFORMANCE-TO-COST RATIO

One of the key elements that contributes to the expected mass deployments of solid-state LiDARs (SSLs) in the automotive industry is the price. In comparison to more mature and cost-optimized sensing solutions like radar and camera technologies, LiDAR currently represents the highest cost component of the AD sensor suite. As the demand for solid-state LiDAR continues to grow, it is expected that the price of LiDAR will reduce at the same pace. At the moment, the industry is targeting a cost per LiDAR within the $300 to $500 (US) range for the first commercial implementations, with the objective of generating further cost reduction with product maturity and economy of scale over time.

The cost of LiDARs is greatly affected by its required components. LiDARs are built using a combination of various electronic and optical components that include emitter and receiver optics, receiver (i.e., photodetector), emitter (i.e., light source), beam steering device (optional), as well as other electronics such as signal acquisition and time of flight processing components. Table 2 presents an overview of the cost structure for a solid-state scanning LiDAR.

TABLE 2 Typical Cost Structure (For a Solid-State Scanning LiDAR Architecture)

	MECHANICS	ELECTRONICS	OPTICS AND OPTO-ELECTRONICS
% of total LiDAR cost	3 to 5 %	35 to 60 %	40 to 60 %

Cost-Reduction Challenges

Reducing costs can be a challenge for many LiDAR manufacturers since the choice of technology and components used have a direct impact on performance. Furthermore, increasing the performance of a specific LiDAR design generally comes with a higher price tag. Therefore, to achieve an optimal performance-to-cost ratio, compromise is often inevitable. The table below presents the various elements that impact the resolution and the range of a sensor:

TABLE 3 Impact of Various Design Elements on LiDAR Performance

ELEMENTS THAT IMPACT LiDAR'S RESOLUTION	ELEMENTS THAT IMPACT LiDAR'S RANGE
Number of detectors Flash vs. scanning Field of view Processor Number of ADCs Number of detectors	Laser wavelength Laser power APD vs. PIN detector Field of view Processor Resolution of ADCs

The challenge for AD system integrators when selecting a LiDAR solution for mass market deployments in production vehicles is to carefully determine the specific requirements of the application for which it was intended, in order to meet the expected performance levels at the lowest possible cost.

Solving the Performance-to-Cost Ratio Conundrum

Many avenues are available to LiDAR manufacturers to keep costs under control and deliver the optimal performance-to-cost ratio.

Using solid-state designs has been recognized as the best avenue for delivering automotive LiDAR solutions. Their simpler build with no moving mechanical parts makes them intrinsically more cost-efficient to produce and facilitate high-volume manufacturing ramp-up. What's more, electing to design LiDARs based on readily available and more affordable components (e.g., using 905nm lasers instead of the significantly more expensive 1550nm lasers) will go a long way in ensuring that the finished product can be industrialized in a timely fashion and produced in high volumes, while meeting key specifications at the lowest possible cost.

From a software perspective, much can be done to optimize the LiDAR performance. More sensitivity and range can be achieved with a specific LiDAR design by developing highly efficient digital signal-processing algorithms, enabling leading LiDAR providers to reduce overall solution cost.

LOOKING AHEAD

Automakers are eagerly awaiting the upcoming solid-state LiDAR (SSL) solutions that will provide them with optimal cost-performance ratio, while enabling high levels of automation in production vehicles. Mechanical LiDAR scanners, which have proven popular in R&D, prototyping and early AD system development, simply will not fit the bill due to cost, reliability, and mechanical integration limitations. SSLs are on the verge of hitting the market and they will open the door to mass LiDAR integration into production vehicles within the next couple of years, enabling increased levels of automation and safety on our roads.

Learn More About Automotive LiDARs:
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