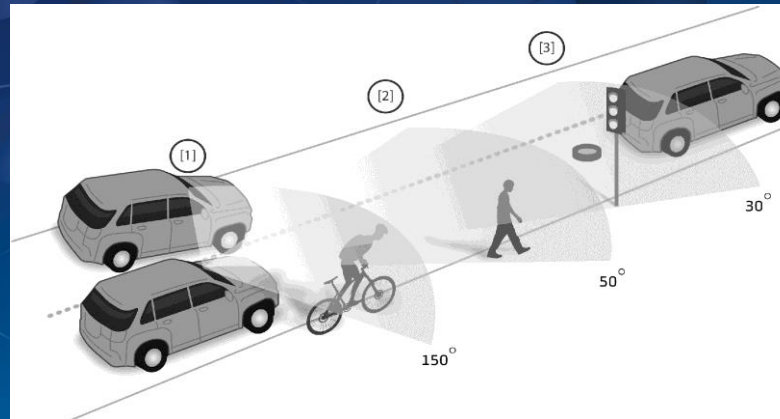


Sensor Alert (TechVision)

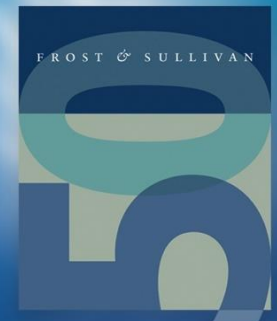


LIDAR Sensors

LIDAR sensors poised to impact the automotive industry

D727-TV

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LIDAR—An Overview

LIDAR (Light Detection and Ranging)

An Overview

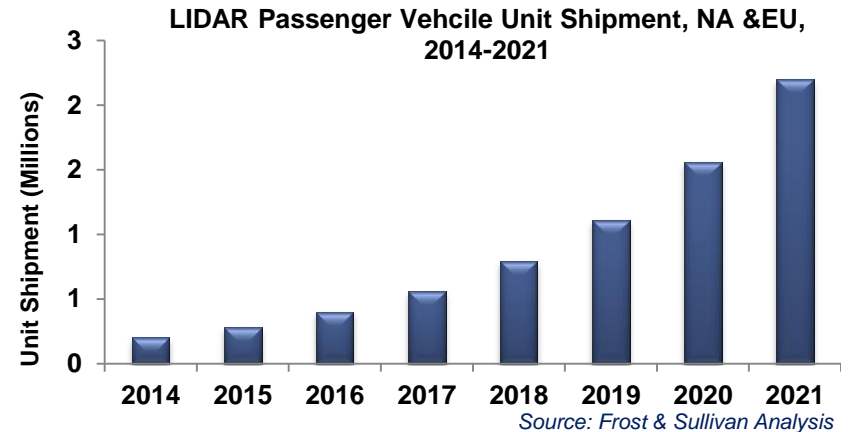
Light detection and ranging (LIDAR) is an optical sensing technology which makes use of pulses from a laser to illuminate the target and precisely measure the distance and other attributes (for example, position) of the target. Numerous laser pulses are typically bounced off a spinning mirror per second to optically scan the laser pulses. The distance is accurately measured by recording the time of flight of reflected pulses using photodetectors. The data received from the scan provides a high-resolution detailed picture of the surroundings.

Key Market Trends

Initial high definition LIDAR with 64 channels for autonomous vehicles did cost around \$70,000 to \$80,000.

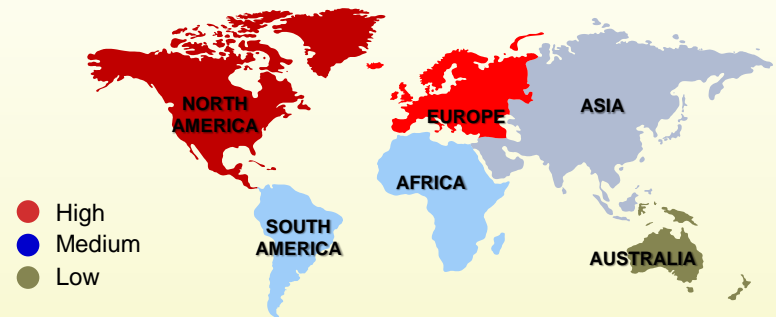
While prices of LIDAR for autonomous vehicles have declined, the high price of the laser emitter has influenced LIDAR cost. It is expected decrease over the next few years.

The move toward fully autonomous vehicles will drive opportunities for LIDAR with high detection range capabilities.



Competitive Landscape

- Commercially viable LIDAR from Tier 1 automotive suppliers is expected to be in the market in higher volumes by 2020.
- Tier 2 participants are typically not well equipped to address the automated driving needs with their LIDAR system.
- Tier 1 and 2 participants are expected to raise the standard of their LIDAR systems.
- Tier 1 suppliers include Continental AG, Hella AG, Delphi, (working with Quanergy Systems) Robert Bosch, and Valeo. Tier 2 suppliers include Ibeo and Velodyne.



Innovations in LIDAR

Low-Cost Solid State 8-Beam LIDAR

Quanergy Systems Inc., USA—3D LIDAR for 3D mapping in vehicles

Unmet Needs

- Several vehicle manufacturers (and Google) have already demonstrated automated vehicle prototypes using LIDAR. LIDAR has opportunities for active safety and automated driving due to its three-dimensional (3D) mapping and object detection capabilities.
- At present, LIDAR systems available in the market are not cost effective. When the driver is taken out of the loop, the vehicle needs to be more agile, availing near-human perception of the road with high accuracy and 3D imaging.

Innovation Attributes

LIDAR will be used for high-to-fully automated driving. It will face competition for integration in level 5 fully automated vehicles and will likely be used with other ADAS (advanced driver assistance system) sensors.



Capabilities of their 8-beam LIDAR include 360 degree horizontal field of view with a vertical field of view that is more than 3 degrees or less than 17 degrees.



Lightweight, that is, 1Kg, range up to 300 meters with 30Hz of scanning frequency and 0.1 degrees of angular resolution.



Quanergy is working with Delphi on a solid-state LIDAR that uses an optical phased array as a transmitter. The LIDAR sensor is expected to cost \$250 or less in volume.

Analyst Perspective

The cost of the LIDAR sensor and system needs to be reduced for use in production automated vehicles. This technology can provide enhanced location and mapping, but additional channels may be helpful for fully autonomous vehicles.

Technology Profile



Who

Quanergy is a solid state 3D LIDAR startup backed by venture capital funding (\$30 million). Delphi has a stake in Quanergy.

Where

Quanergy is a US-based company with offices in Europe, China, Japan, the Middle East, and North Africa.



What

- ✓ Quanergy has developed an 8-beam LIDAR called Mark 8 Laser scanner.
- ✓ The company has filed 8 patent applications for 8-beam LIDAR using the time of flight principle.
- ✓ The Mark-8 LIDAR is capable of sensor fusion and is packaging friendly.
- ✓ Quanergy has started testing its second generation of LIDAR sensors.

Partnership

- ✓ Mercedes Benz
- ✓ Hyundai
- ✓ Renault-Nissan
- ✓ Sensata Technologies

Potential Applications

- Passenger vehicles
- Commercial/corporate and municipal fleets
- Unmanned aerial vehicles (UAVs), unmanned ground vehicle (UGVs)
- Robotics
- Automation

Commercialization Strategy

In 2014, Quanergy and Mercedes-Benz R&D (North America) entered into a strategic partnership to develop automated vehicles using Quanergy's LIDAR.

High-Speed LIDAR Emitters

TriLumina, USA—Ultra fast infrared emitters for LIDAR systems



All major automakers across the world feel the need to create some sort of an automated vehicle in order to be aligned with the goals of global regulatory bodies on reducing road fatalities. Traditionally, automakers have employed radar, ultrasonic, and vision-based sensors to assess the driving environment and traffic to help the driver make better informed driving decisions.

Lidar can provide more detailed, 360-degree information compared to ultrasonic, and vision-based sensors, but LIDAR with 8 to 64 channels is not geared to provide depth resolution.

Innovation Attributes

Developed smart illumination product for both automotive and consumer electronic devices. Small form factor and consists of over 400 lasers on a chip.

Enables high-resolution LIDAR with 3D sensing, and multi array configuration option is available. IR VCSEL array emitters enable depth sensing.

- High depth resolution with a pulse width of approximately 50 ps
- Peak pulsed power of 10 to 1000s of watts

Funding \$ Amount

TriLumina has raised \$8.5 million funding from the first round of investment. In addition, Caterpillar has invested in TriLumina Corp.

Future Plans

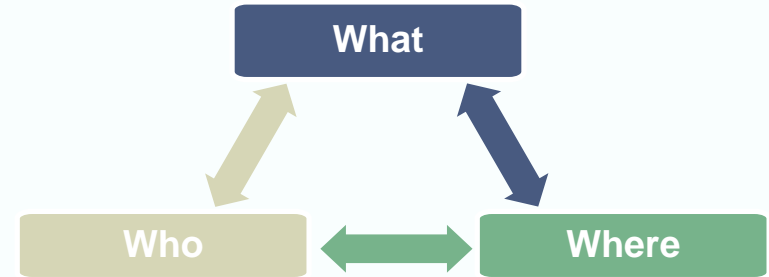
TriLumina's solutions will help LIDAR in automotive to achieve high levels of performance. The company is planning to accelerate the automotive market by moving into autonomous operations.

Analyst Perspective

TriLumina will be well-positioned in enhanced gesture control systems. The company and eyesight Mobile Technologies (Israel) have received funding to develop a smart illumination gesture control system for consumer electronics.

Technology Profile

TriLumina is a family of ultra fast scalable high-speed LIDAR emitters for ADAS and natural user interfaces. TriLumina's light engine drives IR emitters at high speed to produce pulse widths in sub nanoseconds. Microlenses are integrated into the LIDAR emitters to compress the optical path and eliminate external optics.



TriLumina develops light engine LIDAR and infrared emitters. The company's solutions help to provide LIDAR with high depth resolution.

TriLumina is a US-based startup in automotive electronics.

Potential Applications

- Automotive safety systems
- Driver monitoring
- Smart selective field of view (FOV) illumination
- Mobile device 3D sensing
- Solid-state scanning of FOV

Commercialization Strategy

TriLumina is expected to license its laser scanning technology to Tier 1 and automotive OEMs (original equipment manufacturers).

4-and 8-Beam LIDAR System

IBEO Automotive Systems, Germany—Low cost, lightweight LIDAR

Technology Profile

Where

IBEO Automotive is a German company. The company has established world wide network of distributors

Who

IBEO Automotive Systems is focused on the development of cost-competitive automotive-grade laser scanners. IBEO's new wide angle laser scanning sensor, the result of a collaboration with Valeo, is expected to be mass-produced by Valeo in 2016.

What

Object tracking and classification algorithms are embedded in the digital signal processing of the sensor and offered as a standard feature. IBEO also offers off-the shelf scalable sensor-fusion systems for the synchronization of multiple sensors.

Potential Applications

Adaptive cruise control, lane departure warning systems, blind spot monitors, pedestrian detection, collision mitigation brake systems



Collaboration

Works with Valeo (Tier-I supplier) where IBEO Automotive is responsible for research and development (R&D) and Valeo is responsible for mass production and OEM sales.

Innovation Attributes

145 degrees horizontal field of view with ± 3.2 degrees vertical field of view.

Double 6.4 degree vertical field of view managed in two pairs of 4 layers. Multiple echo detection for noise cancellation and excellent performance.

150 meters of range and weight of 0.5 kg

Commercialization Strategy

The company employs the collaboration model to bring its products to the market.

Analyst Perspective

IBEO's products allow the synchronization of multiple sensors.

16, 32 and 64 Beam LIDAR

Velodyne LiDAR Inc., USA–LIDAR with 360 degree horizontal scanning capabilities

Problem Statement

?

The 64-channel architecture-based sensors that offer high-definition data processing have cost around \$70,000 or so for automated vehicle applications. The industry seeks solutions that would provide accurate localization and mapping on par with the 64-channel architecture sensors and yet be more affordable.

Meanwhile, on the other end of the spectrum, there are sensors based on 3, 4 or 8-channel architecture, which use fewer data collection points and thus offer little reliability and accuracy.

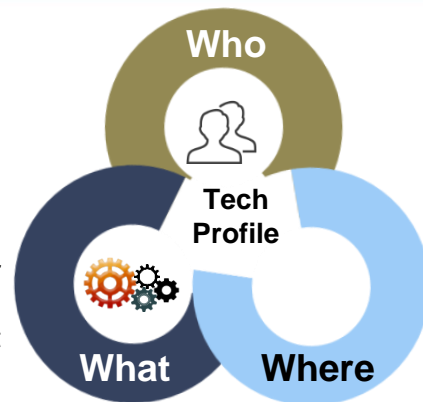
Innovation Attributes

VLP-16 LIDAR is a 16 channel LIDAR, which has a range of up to 100 meters, capturing close to 300,000 data points every second. It offers a 360 degree horizontal field of view and upto 30 degrees vertical field of view with ± 15 degrees data capture in both directions. Later versions are expected to have a more sensitive mode of operation that allows for a range of 150 to 200 meters. The Puck can be installed in a car's side-view mirror.

VLP-16 is designed in such a way that the rotating parts are enclosed in the casing, thereby allowing for a better fit in several configurations within the vehicle, which makes the solution ideal for OEMs' needs.

Velodyne LiDAR has developed three types of LIDAR–16, 32, and 64 beam–all with 360-degree horizontal scanning capabilities.

Velodyne's 16-channel VLP-16 tracks a number of key data points and is on par with the 64-channel system. It was developed to cater to mass-market consumers, boasting essential features such as real-time, 360 degrees, 3D distance, and calibrated reflectivity measurements.



Velodyne LiDAR is a Silicon Valley, US-based company. The company has resellers across the world.

Market Potential

Velodyne LiDAR has strong growth potential in the future with sales expected to cross several thousands of units when autonomous vehicles become a norm in the industry.

Products

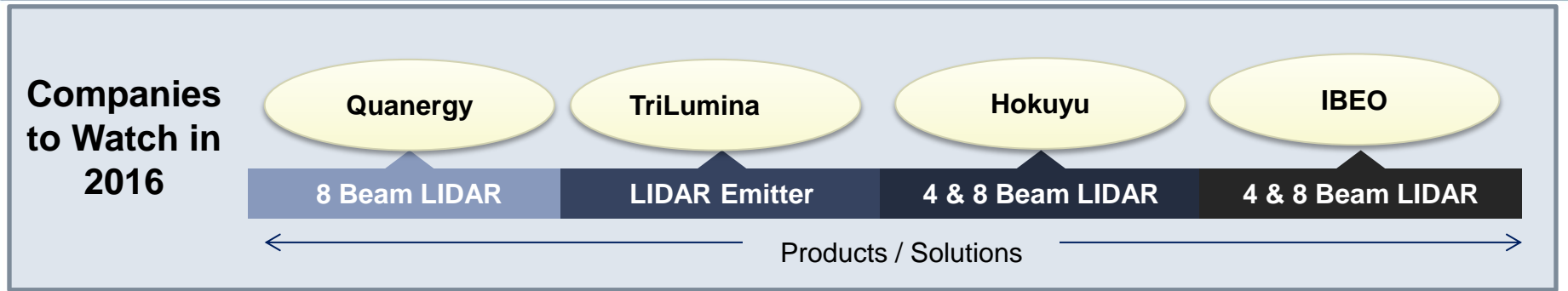
Velodyne has three types of LIDAR in its product line with prices ranging from \$8000 to \$75000.

Future Plans

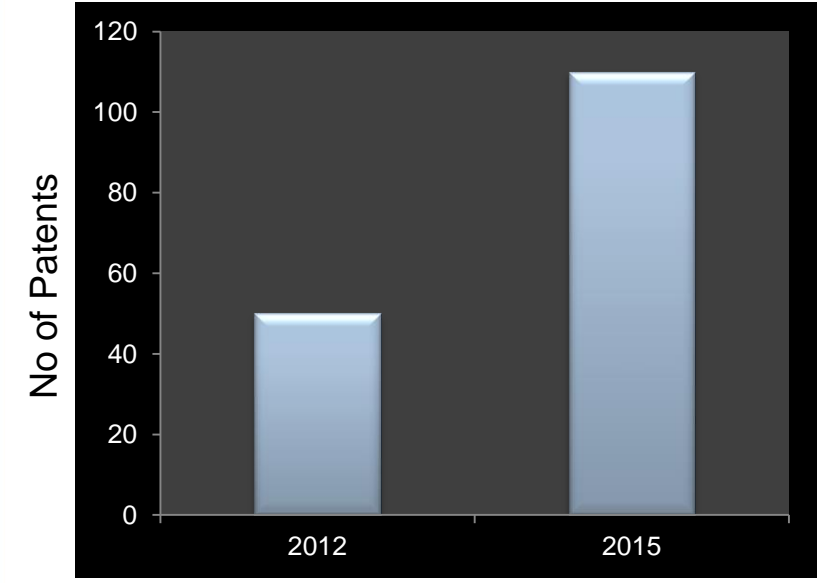
To bridge the gap in enabling level-5 fully autonomous vehicles with its HDL-64E LIDAR.

Strategic Insights

Strategic Insights



Intellectual Property (IP)



Source: WIPO/Frost & Sullivan

- Original equipment manufacturers are using expensive sensor suites with best-in-class LIDAR sensors that can cost up to six figures, or four-figures (in US dollars) at best. This cost factor makes it impractical for LIDAR sensors to be part of a sensor suite for series production.
- R&D activities are increasing, with the aim to reduce the cost and improve the imaging, mapping, and localization efficiency.
- The United States has filed the highest number of patents for sensing in the automotive arena followed by China and Europe.

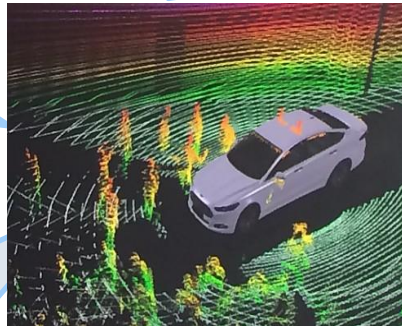
Strategic Insights

Key R&D Focus Areas: Multi target capability, multi layer technology, scan frequency and angle resolution

- 3D mapping
- ADAS
- Autonomous vehicles
- Programmable logic devices
- Sensor fusion
- V2V Communications
- Packaging
- System integration

Growth Factors:

- Design flexibility
- New product development
- Strong R&D efforts
- Technology advancements
- Greater demand for enhanced user experience
- Advanced sensor platforms, sensor fusion software, and algorithms



Adoption Barriers

- Cost of the sensors
- System reliability issues
- Challenges in precisely mapping the surroundings; Limited range
- Potential environmental scanning limitations under certain weather conditions such as rain, fog, or snow

Government Initiative:

Governments consistently look at new regulations to reduce accidents and increase safety while driving and aiding companies to devise a solution that effectively addresses the issue. The automotive industry is also working toward developing cost-effective and reliable sensor-based systems to enhance vehicle safety and performance.

The 2020 Scenario

With the advent of technologically improved LIDAR, more features pertaining to automated driving and active safety can be incorporated into future vehicles. Although LIDAR has the potential to replace other ADAS sensors (for example, radar), at least during the near future, LIDAR will work in tandem with other sensors to produce best-in-class sensor fusion.

Key Patents

Key Patents

No.	Patent No.	Publication Date	Title	Assignee
1	US20160047901	18.02.2016	ROBUST LIDAR SENSOR FOR BROAD WEATHER, SHOCK AND VIBRATION CONDITIONS	QUANERGY SYSTEMS, INC.
	<p>An apparatus and method are used for real-time wide-field-of-view ranging with a time-of-flight lidar sensor having one or a plurality of laser emitters and one or a plurality of photodetectors. When a plurality of laser emitters are used, they are preferably copackaged or are in the form of an integrated multi-emitter chip or emitting multi-chip module in a single package, and when a plurality of photoreceivers are used, they are preferably copackaged or are in the form of an integrated multi-photoreceiver chip or photoreceiving multi-chip module in a single package. Furthermore, the apparatus comprises any combination of (a) no moving external parts in contact with the environment, (b) wireless energy and data transfer between the static and the moving parts of the lidar, and (c) protective body, sealant and/or damage-resistant tamper-resistant theft-resistant cage.</p>			
2	US20160041452	11.02.2016	OPTICAL DEVICE, LIDAR DEVICE AND IMAGING DEVICE	MITSUBISHI ELECTRIC CORPORATION
	<p>An optical device includes: a casing having a waterproof structure; a light transmission part provided in the casing; an air blow port for blowing air onto the light transmission part; a flow path for causing the air to flow to the air blow port, the flow path being provided to maintain the waterproof structure of the casing; an air intake port through which the air flows into the flow path; a blower part generating the flow of the air from the air intake port to the air blow port; and an observation unit accommodated in the casing to receive light from the outside via the light transmission part.</p>			

Key Patents (continued)

No.	Patent No.	Publication Date	Title	Assignee
3	US20160026184	28.01.2016	CURB DETECTION USING LIDAR WITH SPARSE MEASUREMENTS	GM GLOBAL TECHNOLOGY OPERATIONS LLC
	<p>A method of detecting curb-like barriers along a route of travel using a lidar sensing system. Sparse measurement per each ray tracing is captured from a sensor using the lidar sensing system. Each ray tracing is analyzed separately by a processor. Curb candidates are identified for each respective beam. Curb candidates are combined to generate multiple curb representative hypotheses. A weighting factor is applied to each curb hypothesis. Curb hypothesis that represents the curb is selected. The curb detection is applied to an autonomous guidance system related to guiding a vehicle along the route of travel.</p>			
4	US20160018523	21.01.2016	Lidar Measurement Device for Vehicular Traffic Surveillance and Method for Use of Same	Applied Concepts, Inc.
	<p>A Lidar measurement device for vehicular traffic surveillance and method for use of same are disclosed. In one embodiment, video circuitry acquires video of a field of view having a target therein. A steerable laser progressively transmits laser range-finding signals to the field of view in a horizontal and vertical step-wise manner and receives reflected laser range-finding signals from the target. A processing circuit portion determines target data of the target based upon range and time measurements associated with the reflected laser range-finding signals. The processing circuit then integrates the target data into the video such that the video may displayed with an image of the target and speed measurement associated therewith.</p>			

Key Patents (continued)

No.	Patent No.	Publication Date	Title	Assignee
5	WO/2015/189025	17.12.2015	VEHICLE LIDAR SYSTEM	ROBERT BOSCH GMBH
	The invention relates to a vehicle lidar system (101) comprising: • a pulsed laser (103) for emitting laser pulses, • at least one displaceably mounted mirror (105) for deflecting the laser pulses towards objects to be detected (109), • a receiver (111) for detecting the laser pulses reflected by the objects, wherein • the receiver comprises a CMOS-compatible image sensor (113) for detecting the reflected laser pulses and capturing an image of a region that can be illuminated by the deflected laser pulses. The invention also relates to a use of the vehicle lidar system.			

Industry Contacts

Industry Contacts

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