NEXT GEN LiDAR

The view that Luminar Technologies sensors give to self-driving cars helps pinpoint obstacles.

LiDAR, from autos to smart city infrastructure applications.

By Robert E. Calem

As self-driving cars continue to advance, makers of one sensor component of those vehicles — LiDAR — are pivoting so they can serve up their technologies sooner, in vehicles that are merely "automated" on the path to autonomy. A light detection and ranging device, LiDAR helps the vehicle see and understand what is going on around it, then react accordingly.

While some older types of LiDAR are on the road, newer forms will arrive in vehicles as soon as 2022. There are myriad competitors and diverging claims in the market with some LiDAR makers looking beyond autos to smart city infrastructure applications.

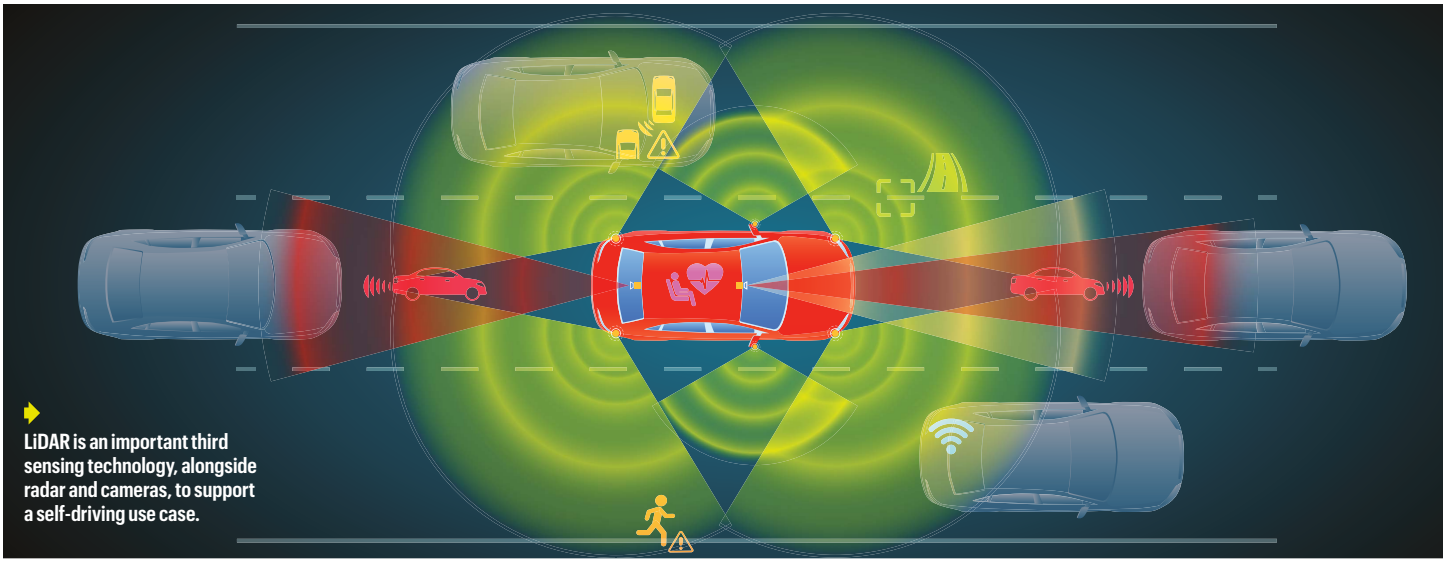
CHANGING PERCEPTIONS

"There's some repositioning happening," says Jeremy Carlson, principal analyst, autonomy, at IHS Markit in Los Angeles. Over the last several years, the marketing of fully self-driving vehicles was pushed out, but many cars come equipped with advanced driver assistance systems (ADAS) and even automated-driving technology, "and that's where we're starting to see new technologies enter the market."

Carlson says, LiDAR is an important third sensing technology, alongside radar and cameras, to support a self-driving use case. Yet even for automated vehicles that sometimes allow independent driving — described by the SAE as Level 3 autonomy — "we're starting to see LiDAR become more common because the liability balance shifts toward the product, and therefore the automaker," he says. There may be only one LiDAR in such vehicles, rather than the multiple units found in self-driving cars, yet for automakers this LiDAR is a means of redundant sensing that provides "more confidence the system is going to do what it's supposed to in situations where the system is active and can help manage or reduce the risk of that liability shift."

IHS Markit considers cars with ADAS to fall within SAE Levels 0 and 1, while Level 2 and Level 3 cars are automated-driving vehicles, and Level 4 and Level 5 cars are fully self-driving. The distinctions are defined by the amount of supervision needed by a human. There's also a consensus in the auto industry around a Level 2+ designation for automated vehicles which are not quite to Level 3 capabilities.

Courtesy Luminar Technologies



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Carlson says for automated Level 2 and Level 2+ vehicles, LiDAR can provide "a scalable platform, to expand upon going forward" allowing a vehicle to jump to the next level by adding functions via over-the-air software and firmware updates on top of hardware. "It's more coincidental that LiDAR sensors would be used for some basic ADAS features, like automated emergency braking," he says, "but if you've got it in your car, why not use it for all functions where it might be applicable?"

However, the IHS Markit forecast for Level 3 and higher systems is conservative. Automakers will be "deliberate in how they deploy those," Carlson predicts. "It won't be available on every vehicle within 12 or even 36 months." But three to five years out more of the automotive industry's business model will shift to fleet-based services in conjunction with Level 4 self-driving vehicles, resulting in "targeted geographical deployment of LiDAR technology in greater numbers per vehicle," Carlson says.

"LiDAR has faced a chicken-and-egg problem," in which automakers haven't adopted the technology because it cost too much, but it costs so much because it hasn't been widely adopted, says Michael Filatov, vice president in equity research at Berenberg Capital Markets in New York. "Brilliant people have been working on this for decades, and we have yet to get to the point of peak adoption or accelerated adoption."

After the automaker's basic need for performance, Filatov adds, what matters most is cost, scale and reliability "and that is more challenging than just performance to see high volume adoption."

Some automakers have built LiDAR into cars, Filatov notes. The 2018 Audi A8 was the first LiDAR-equipped production car, which integrated a Valeo LiDAR; the 2021 Honda Legend, a Level 3 self-driving car available in Japan, contains five LiDARs supplied by Valeo; and the Mercedes-Benz S-Class, integrates two Valeo LiDARs. Other examples are the upcoming all-electric 2022 Mercedes-Benz EQS sedan, and the 2022 Hyundai Genesis G90, that automaker's first Level 3 self-driving car, debuting next year. Both the EQS and the G90 likely will have Valeo LiDARs.

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"Valeo is the incumbent in supplying LiDAR to series production customers," Filatov says. "They won years ago because they were the only one with automotive-grade at the time with a higher performance, reliable enough product to go into consumer vehicles."

However, its LiDARs are being challenged by Innoviz Technologies and Luminar Technologies Inc., in areas like operating range of up to 200 meters and resolution. Filatov says, "That's the baseline for a Level 3 system that is going to work at highway speed. In multiple weather conditions if it's raining or snowing you need at least 200 meters of range" to operate safely, ensuring that a vehicle has sufficient time to stop.

New contenders will be installed in vehicles in 2022: Innoviz in BMW's iX and Luminar in the next-generation XC90 SUV. Their InnovizOne and Luminar Iris LiDARs respectively are capable of 200 meters range and meet the needs for Level 3 conditional autonomy at 70 miles per hour.

Still, Filatov is skeptical they'll be used to their maximum advantage. Instead, he expects BMW and Volvo to launch with Level 2+ systems that can be upgraded to Level 3 capability.

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FALLING PRICES, NEW USE CASES

Filatov declares Innoviz and Luminar are "the best examples of higher-performance LiDARs" competing for automakers' contracts, and they also exemplify different approaches to the technology. Others include startup Opsys, and Velodyne, a LiDAR supplier that is active in self-driving research and development vehicles.

Innoviz and Valeo engineered around traditional diode lasers in the 905 nanometer (nm) wavelength (of light), which by its nature must be power-limited to avoid damaging the eyesight of anyone around it. This, in turn, limits the LiDARs range. By contrast, Luminar uses a 1550nm wavelength fiber laser that offers better range and eye safety at higher power but is far more expensive to produce — at least $200 per unit in large volumes and upwards of $1,000 per unit in small volumes, versus as low as $5 to $100 for a 905nm laser, says Filatov.

Despite the power limitation, Filatov claims Innoviz has devised a better receiver technology that maximizes the amount of returning light and associated data collected from the given power output — measured as signal-to-noise ratio — to accomplish a range of 220 meters at 10% reflectivity, while keeping down the price to automakers. It's a winning formula, Filatov says.

Still, he says, "there is room for several players, including Luminar and other LiDAR makers focused on both long- and short-range applications, to carve out a sizable piece of the expanding automotive LiDAR pie."

Omer Keilaf -Innoviz

Low cost is the holy grail for automotive LiDAR, says Omer Keilaf, co-founder and CEO of Innoviz in Rosh Ha'Ayin, Israel. Keilaf confirms, Innoviz engineered a LiDAR composed of four 905nm lasers positioned at different angles behind several mirrors that oscillate together and capture returning light. In combination with computer vision software developed by Innoviz to interpret the incoming reflections, Keilaf says, the system provides an expanded field of view (FoV) and a sharp image of the vehicle's surroundings. Founded in 2016, the company has formed partnerships with four "tier-one" automotive suppliers — Aptiv, Harman Automotive, HiRain Technologies and Magna International. Its first product, the InnovizOne will be manufactured by Magna in Holly, MI.

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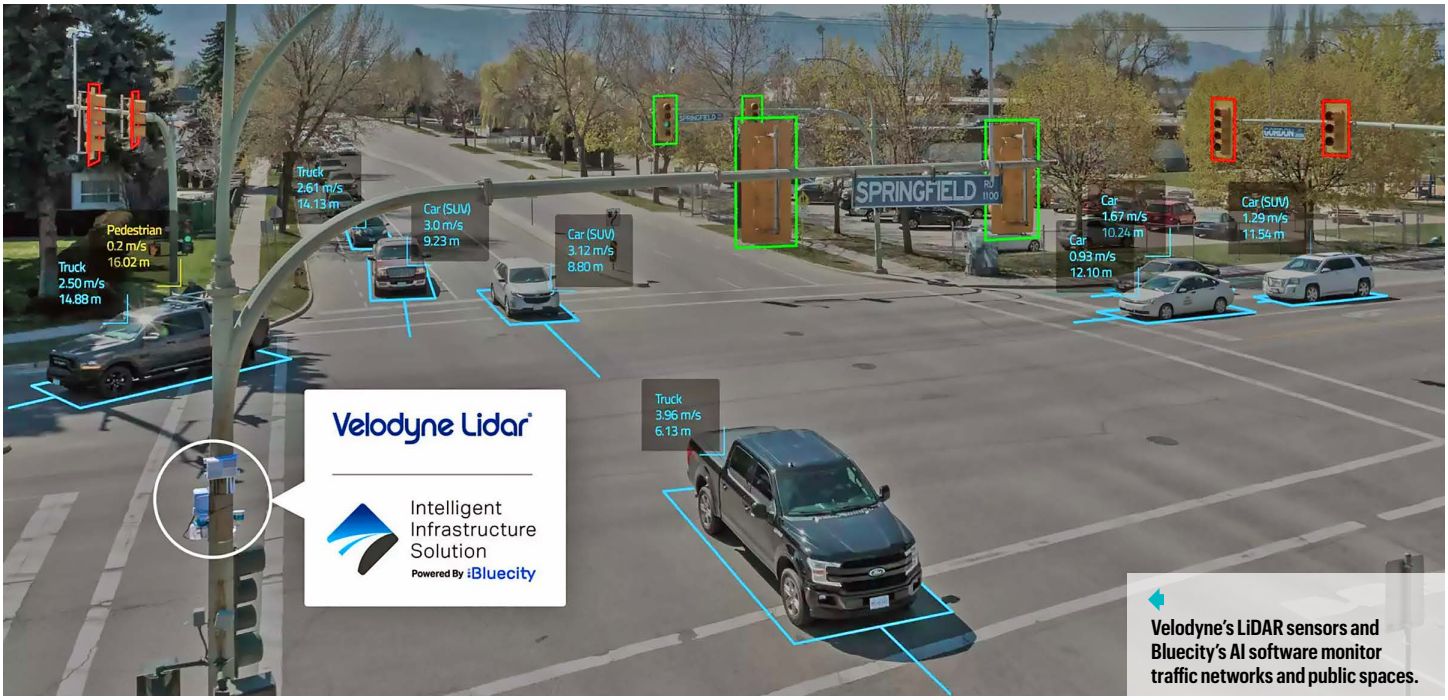
The InnovizOne will be built into cars in mid-2022, Keilaf says. A second-generation LiDAR named InnovizTwo is also in the works. It provides 30 times the performance of the InnovizOne — four times the resolution, twice the frame rate, twice the range and almost double the FoV — with bigger mirrors and greater sensitivity due to higher signal-to-noise ratio. InnovizTwo is 70% less expensive than InnovizOne, Keilaf says. The first InnovizTwo engineering samples will be available end of year, and automotive-grade units will be ready for high-volume production for 2024 vehicles, he says. InnovizOne also is expected to be built into a public transit system self-driving "people mover" by the end of next year.



Velodyne's LiDAR sensors and Bluecity's AI software monitor traffic networks and public spaces.

Courtesy Velodyne

Opsys has innovated a 900nm-window semiconductor-based scanning LiDAR with no moving parts, harnessing parallel-processing of the collected data at a rate of 1,000 frames per second. Eitan Gertel, executive chairman of the board of directors at the Holon, Israel-based company says, "We way oversample every point before we report it, and then by signal processing can define which point is real and which point is an erroneous reading, significantly raising the probability of detection." By this process, "we improve our signal-to-noise ratio. That basically is as effective as raising the optical power," and results in a 200-meter range at half the power allowed under regulations.

Its first prototype will be installed in a test car in November 2020. Early next year it expects to release automotive-grade, pre-production quality samples. Large-volume fully automotive-qualified deliveries for automakers to launch Opsys LiDARs in production cars will begin in mid-2023, Gertel says. The Opsys LiDAR is cost-effective because it combines a CMOS (complementary metal-oxide-semiconductor) processor and a SPAD (single photon avalanche detector) receiver on a single chip, plus a fully addressable VCSEL (vertical cavity surface emitting laser) array on a separate chip. Thus, an entire car can be outfitted with the Opsys LiDAR tech for 360-degree coverage at a cost of $1,000 in large-scale production, Gertel says.

"The price of LiDAR is coming down by orders of magnitude," says Jon Barad, vice president of business development at Velodyne in San Jose, CA. "It is a very different market, one that's moved from the R&D stage into the deployment stage, which is a result of the maturity of the entire ecosystem. Other sensors and software as well, are enabling us to move the industry forward. In the next few years you will see production vehicles with LiDAR," he projects.

Jon Barad -Velodyne

Radar, camera and LiDAR are complementary to each other, but LiDAR is especially effective at detecting pedestrians at night, when most fatalities occur. Velodyne has developed a pedestrian automatic emergency braking (PAEB) system based on LiDAR. "That's one example of where LiDAR can play a significant role in improving safety in ADAS applications," Barad says.

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> –Jon Barad

SMART CITY INFRASTRUCTURE

In June, Velodyne introduced its next-generation Velabit sensor, a tiny cube that integrates a micro-LiDAR array on a chip, offers a 100-meter range, and has a 70-degree vertical by 90-degree horizontal FoV, ready for production late next year. The company says it's ideal for blind-spot monitoring, cross-traffic detection, PAEB and other ADAS or self-driving car implementations, as well as robotics and smart city infrastructure.

In May, Velodyne introduced its Intelligent Infrastructure Solution (IIS) which combines LiDAR sensors installed on traffic poles with artificial intelligence (AI) software to create real-time 3D maps of roads and intersections to detect vehicles, cyclists and pedestrians, and analyze and predict their movements. One LiDAR can cover an entire intersection, where multiple cameras or radars would be necessary for the same span. A test of the IIS is ongoing at multiple intersections in New Brunswick, NJ, in a collaboration between the New Jersey Department of Transportation and the Rutgers University Center for Advanced Infrastructure and Transportation (CAIT).

The Intelligent Infrastructure Solution combines Velodyne's award-winning LiDAR sensors and powerful AI software to monitor traffic networks and public spaces.

Innoviz is also looking at smart city applications. In May, the company partnered with Sensagrate, a computer vision software company whose SensaVision suite uses AI to enable real-time traffic, pedestrian and cyclist detection and predictive analytics. It will include the InnovizOne among its components. In June, Innoviz added a similar partnership with Cron AI, creating an analogous system named senseEdge.

Filatov concludes, "There are too many approaches [to LiDAR technology] to have standardization and therefore commoditization, but longer term that's certainly a possibility. There are certain Tier 1 suppliers that have grown their radar sales in the last five years from one million to six million" because of the utilization of multiple radars in most cars today. "It's possible we get there with LiDAR." ■

Courtesy Velodyne