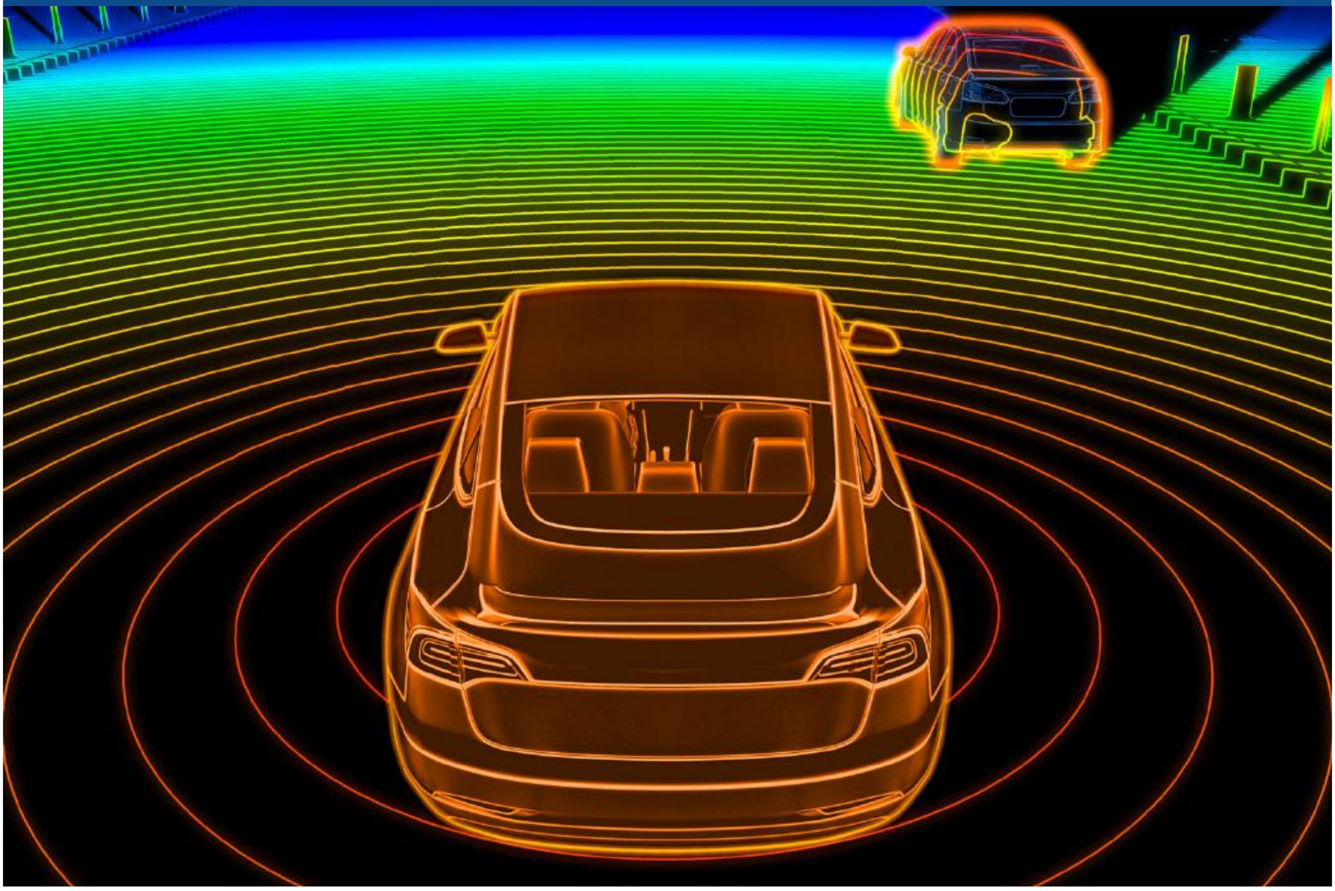
DVN

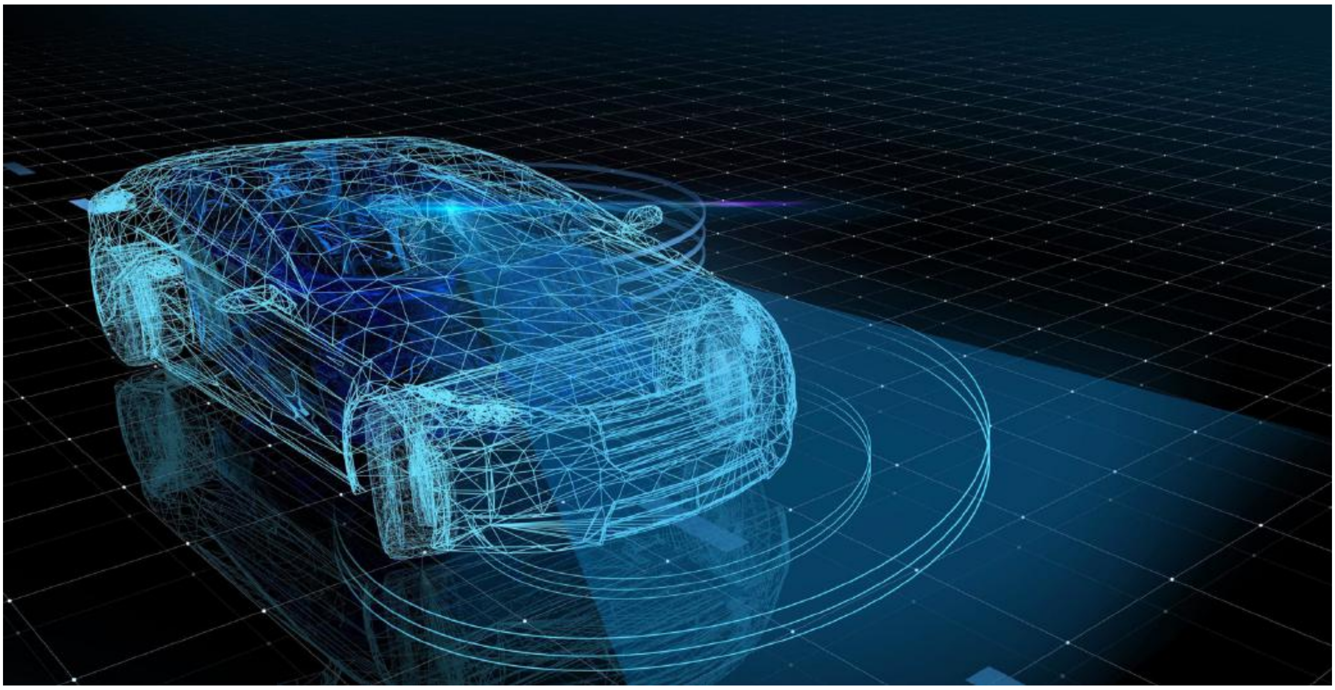
Lidar

Monthly newsletter #4

JULY 6, 2022



Regulatory, Industry Developments Favour Lidar



Editorial ·July 2022

In this month's DVN-Lidar Newsletter you will find a bucket of interesting topics and as usual with comments from our DVN-Lidar team. Here are some highlights:

- The World Forum for Harmonization of Vehicle Regulations—the body which promulgates UN Regulations used by most of the world (except on the North American regulatory island) amended UN Regulation № 157 to raise the speed limit on L^3 automated driving and to allow automated lane changes.
- A coalition of major lidar suppliers has been formed with the target to reduce growing pedestrian fatalities in the US. The coalition is approaching policy makers and governmental institutions to make the case for lidar sensors as a remedy to pedestrian fatalities.
- Stellantis will sell lidar equipped vehicles from 2024. This, the № 4 global automotive group will provide multiple models with L^3 AD capability using the latest Valeo lidar system.

- The next DVN-Lidar event is to be a Workshop in Frankfurt on 12-13 September, with the rubric **A Deep Dive on Four Topics**. You'll find more details at the end of this newsletter—and also keep in mind the fifth DVN-Lidar Conference on 30 November–1 December in Wiesbaden; you'll have received a save-the-date flyer recently.

We're glad to have you in the DVN-Lidar community. Enjoy the July newsletter, and as always, we welcome your questions, comments, and feedback; **drop us a note** any time!

Sincerely yours,

Alain Servel

DVN LIDAR ADVISOR
FORMERLY WITH PSA GROUP

Interview Michael Kiehn, Head Lidar Sensor Development at Ibeo

DVN: Michael, you have worked at Ibeo for 24 years, meaning you have been there from the early stage just after Ibeo was founded in 1998. If you look back to those days and compare with today: what has changed essentially? Which key steps did the company and the lidar technology experience in those 24 years?

Michael Kiehn: 24 years is a long time in which a lot has changed. This extends to technology, the market and competition.

Ibeo Automotive Systems was founded as a subsidiary of Ibeo Holding under the name Ibeo Automobile Sensor in June 1998. At that time, Ibeo was already developing, building, and selling lidar sensors, with applications in various areas in the industry. Then, hardly anyone thought about lidar at vehicles on the road, but nevertheless Ibeo Automobile Sensor set out to bring the existing lidar technology to the car.

To do this, we first took Ibeo's existing mechanical scanning devices and developed object detection and tracking algorithms for them. These lidar sensors were designed for indoor use and only on slow-moving vehicles and they were a far cry from the 3D lidars we know today. Accordingly, the sensors also required work to make them suitable for use in cars. For example, they could only scan in one plane. If the car did pitch movements or load conditions changed it could happen that objects were lost, or the ground was detected as an object.

An important technical step was to develop lidar sensors that could measure in multiple planes. These were still not 3D lidars as we know them today, called them 2.5D then. The planes were sufficient to compensate for the pitching movements of the vehicle to a certain degree and to recognize ground detections as such. Another disadvantage of the devices was that they could only detect a single reflection by laser shot at that time. When used indoors, this is perfectly adequate. Outside, however, this leads to some problems. For example, raindrops do lead to detections. If a raindrop is detected, the relevant object can no longer be detected. Under certain circumstances, even a slight soiling of the windshield can lead to detections, so that nothing but the windshield can be detected any longer.

Consequentially, another logical step in improving the technology was to develop sensors that could process more than just one echo. These two improvements basically made lidars usable in automobiles in the first place. Large part of these developments took place in projects funded by the European Commission. Products like the Ibeo LUX or Valeo's Scala, which is derived from the LUX, are basically based on this technology we developed that time.

Ibeo had applications for lidar sensors in a wide variety of areas, such as surveying the instrument landing system at airports or the semi-automatic unloading of container ships. Sensors for personnel protection in manufacturing plants or warehouses were also an important area of application. However, there was no market for automotive lidars, at that time.

Ibeo was able to deliver a few sensors as prototypes for development to OEMs' or Tier 1s' research departments and sold them to universities and research institutes. In the late 1990s, early 2000s, we assumed that lidar could be used for Adaptive Cruise Control, which was a new application at that time. Apart from Ibeo, Hella together with Spiess was also working on lidars for this functionality. Their approach, however, was much more reduced than the scanning systems that Ibeo offered. It was based on 12 fixed measuring beams. With that Hella even achieved a nomination with Chrysler. Eventually, however, radar prevailed as the sensor for Adaptive Cruise Control, and lidar became an afterthought.

In 2009, Hella stopped lidar development and Ibeo was the only company left on the market for Automotive lidar. The turning point, however, also falls in this period. The DARPA Grand and Urban Challenges revived interest in automated driving and thus in lidar sensors. Since then, it feels like hardly a week goes by without a new lidar startup being founded.

A milestone for Ibeo was the nomination of Valeo as supplier for the first lidar sensor at Audi. We were able to support Valeo in developing the Scala as a sensor for automated driving. Even though the number of units for this first generation remained manageable, further nominations for Valeo also with the second and third generation show that a breakthrough is achieved here and lidar seems to be finding its place in the automotive market.

DVN: For the outside automotive world, a key cornerstone was the design of Scala 1 together with Valeo based on Ibeo technology, which was launched in 2018. Can you give us a rough summary, which hurdles Ibeo had to overcome and how much time it took to bring this product to market maturity?

MK: The biggest hurdle was making the sensor mass producible. This had a significant influence on the design of the device. The LUX was designed to produce 1000 units per year. Now, however, it had to be manufactured more than 300,000 times per year. No one had done that before, so in addition to the design, a fundamental development of the manufacturing processes and tools was necessary. It was fascinating to see how the quality of the sensors continuously improved.

DVN: Currently, you are presenting your second product generation called ibeoNEXT, a full solid-state design. What are the key specifications and engineering elements differentiating ibeoNEXT from Scala 1?

MK: The biggest difference in the specification is that the first-generation Scala could capture a few tens of thousands of points per second, while the ibeoNEXT is capable of capturing a few hundred thousand points per second. This is reflected in the fact that with the ibeoNEXT a true 3D point cloud can be generated, and significantly more details can be captured. In addition to distance and angle information the IbeoNEXT sensor provides intensity information on the measurement points as well. So, it is in fact a 4D sensor

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DVN: Some more detailed technical questions. As far as we know you have made the decision for 885 nm emitter wavelength. Why not use 905 nm or even 1550 nm?

MK: There is a general debate in the business whether Near Infrared (NIR, ~900nm) or Short Wave Infrared (SWIR, ~ 1550nm) is the best choice. There are some advantages of SWIR like the much higher eye safety limits that would allow for larger range of the lidar. But it is our estimation that the available technology is not yet competitive with respect to maturity and cost. Therefore, we have decided for NIR.

In NIR, the most commonly used wavelength is 905 nm. When using silicon as material for the detectors –which is favourable because of cost- then one must accept that the sensitivity drops with longer wavelengths. When we started the development of the ibeoNEXT, the SPAD detectors we planned to use were not optimized for larger wavelengths. So, the choice was to stay with wavelengths as short as possible. This 'as possible' is actually limited by the ability of humans to see light. It is assumed that humans can see light up to ~700nm. This is true when it is about clearly seeing something. When it comes to just seeing something deep red, then there are people that can see much longer wavelengths. Therefore, we concluded that 885nm was the shortest possible wavelength to be used.

DVN: The power consumption of lidar systems is estimated to be 7-10 Watts per lidar sensor. This is comparable to the consumption of a simple LED headlight. Will power consumption become a key criterion for application of lidar sensors?

MK: I won't say it is actually a key criterion. But thinking about electric vehicles, each consumer on board is an issue with respect to battery lifetime. This is basically true for any kind of equipment. On the other hand, there is the requirement to have a very small package size for lidar sensors. This is to enable better integration into the vehicle. But this also means that the power dissipation needs to be transported out of the package and the smaller the package the higher the temperature will rise inside. So, power consumption is at least a critical parameter for the design.

DVN: ibeoNEXT will provide 4D data, the fourth dimension being luminance of an object. What is the added functionality this feature will generate compared to 3D data only?

MK: This feature also turns the lidar into a camera. Today, the resolution of lidar sensors is low compared to cameras, but it is still amazing to see the degree of detail which can already be detected in the intensity images of these lidar sensors. What we can do with this now is to support object classification. When resolution of the lidar sensor increases in future generations this feature might be used also as kind of an infrared camera e.g. as a redundant path for reading traffic signs. In fact, this would be kind of an active camera, coming with the advantage that it is largely independent of the ambient light.

DVN: ibeoNEXT is a modular concept which can be adapted to different FoVs and ranges by changing the optics. What is your estimation about the number of near range/mid-range/long range lidar sensors needed by the end of this decade on a premium vehicle?

MK: Of course, this depends on the requirements of the specific application and usually the system architecture of the vehicle is up to the OEM. Today, we have a front-looking system consisting of three to four ibeoNEXT sensors. Two of them for the mid-range and one to two for the long-range. In the future, this will have to work with two sensors, one for long range with a limited field of view and one for mid-range with large field of view.

Furthermore, I think we will have one short-range sensor on each side of the vehicle to monitor the entire side of the vehicle. To the rear, I think the vehicle will get by with a single mid-range sensor. For a lane change function, we could think about a single long-range lidar in the rear as well. However, in my view, that makes little sense. Unlike the long-range sensor in the front, which is essentially intended to monitor its own lane, the aim in at the rear is to monitor also the adjacent lanes. With a single long-range sensor in the middle of the vehicle, however, it has to be considered that the adjacent lanes can be obscured by vehicles driving behind the ego vehicle.

If the high resolution of the long-range lidar is required for the lane change, e.g. to be able to determine on which of these lanes a vehicle is approaching from behind when there are several adjacent lanes, then two long-range sensors one at each corner of the vehicle must be used. A lidar sensor system could thus consist of five to seven lidar sensors towards the end of this decade.

DVN: It was announced in 2021 that ZF will produce the ibeoNEXT sensor in their factory located in Brest, France. When will/has been production start? Will it be for the global market or Europe only?

MK: Our current plan is to start series production during the first quarter of 2023. Initially, we will serve the global market from Brest. However, it is planned that at least the final assembly of the sensors can also take place at other manufacturing sites. This will be of particular importance for Asian customers.

DVN: What will come after ibeoNEXT? In an earlier communication with one of your colleagues, we got the answer ibeoNEXT NEXT. Maybe you can give us some more information about future plans?

MK: I think my colleague has found a good answer. But let's take a look at what will make up the next generation of the ibeoNEXT. We will certainly continue or further develop the solid-state concept started with the ibeoNEXT. This means that the next generation will also be completely without moving parts. We see this as a clear advantage for the robustness of the product but also an advantage for its manufacturability.

What will change is the performance of the sensor. The aim is to cover a larger field of view with a single module and at the same time achieve long ranges with high angular resolution. In order to offer customers a good solution for level 3 - 5 applications, we expect to increase the number of pixels from today's ibeoNEXT by up to a hundred times. In terms of range, the upcoming generation will surpass the ibeoNEXT by a factor of 1.5 to 2.

DVN: If you look to the global lidar sensor landscape, significant investments and venture capital is flowing into companies and start-ups in US and China. What will be the strategy of European companies to keep their position?

As I mentioned above, hardly a week goes by without a new start-up popping up somewhere in the world announcing the next great leap forward in lidar technology. These ideas generally sound very interesting, but they lack concrete proof of their transferability into the real world and in particular into automotive application and mass manufacturing. Therefore, I believe a viable strategy for European players in the lidar field is to drive proof of the functionality and robustness of our lidar technologies, through defining common standards for testing and rating lidar sensors with respect to their performance but also beyond performance with respect to robustness durability and their readiness for the intended application. Furthermore, it is paramount to have the critical production infrastructure in place with which you're able to ramp up production volume. Ibeo is currently taking the necessary steps to finalize our production line at ZF Autocruise in Brest, France, which will be a huge milestone on our way to the start of series production in Q1 2023.

Additionally, I believe that networking opportunities such as the DVN Think Tank are important tools to exchange ideas with other players in the industry, gain insights into new approaches and technological advances presented by research professionals, and thus strengthen the market position of all participants.

DVN : Michael, we thank you very much for this deep diving interview and we are looking forward to meeting you at one of our upcoming DVN lidar events again!!

UN R157 Amended to Expand L3 Usage

UN Regulation № 157 has been amended to extend L^3 automated driving in certain traffic environments at speeds up to 130 km/h; the previous limit was 60. The amendment also allows for automated lanekeeping systems (ALKS), and will enter into force next January.

The amendment, developed by the Working Party on Automated/Autonomous and Connected Vehicles (GRVA), builds on the experience in various countries following the adoption in June 2020 of the UN Regulation on Automated Lane Keeping Systems (ALKS), the first binding international regulation on L^3 vehicle automation. These developments were guided by UNECE's framework on automated/autonomous vehicles, which places safety at the core of the UN's leading regulatory work in this strategic area for the future of mobility. These L^3 systems can be activated only under certain conditions, on certain controlled-access roads: ones where pedestrians and cyclists are prohibited, and which are equipped with a physical separation that divides the traffic moving in opposite directions. Drivers can override the system, and can be requested by the system to resume control of the vehicle at any moment.

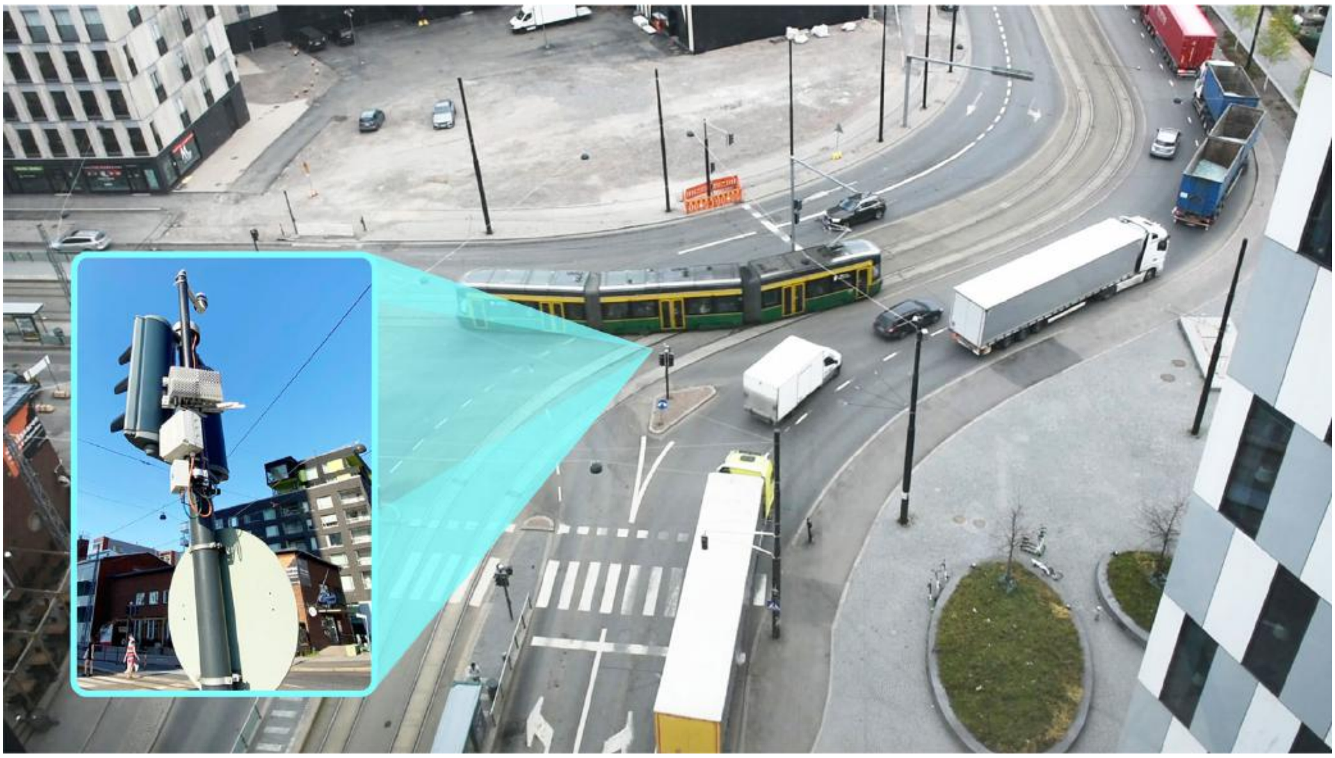
The regulation sets forth clear performance-based requirements: technical requirements, test protocols on test tracks and in real-world conditions; stringent cybersecurity and software update requirements. It also describes the applicable type-approval and conformity-of-production auditing provisions.

Most countries accept or require vehicles and components designed and build in accord with the UN Regulations, but the United States exists in a regulatory exile of its own making.

DVN comment

This evolution of UN regulation is a real booster for lidar technologies deployments. Most automakers consider lidar crucial for L3 AD systems' embedded sensing architectures. The AD speed limit increase requires greater reliability and precision from the system and makes lidar even more necessary.

Helsinki Traffic Watched by Velodyne Lidar; AI, V2x



Helsinki, Finland now has Velodyne Lidars to collect traffic data and participate toward road safety improvements. The installations demonstrate the essential contribution of lidar in the counting and classification of multimodal traffic, as well as in the detection and prediction of collisions between vehicles and VRUs and other traffic participants.

The project, called IIS (Intelligent Infrastructure Solution), combines Velodyne lidar sensors; artificial intelligence software from Bluecity, and V2x communications from Commsigna to monitor the flow of traffic—vehicles, pedestrians, and cyclists—at three junctions in Helsinki's Jätkäsaari district.
These intersections are equipped with V2x roadside units to send C-ITS vehicles (Cooperative Intelligent Transport Systems) warning messages before possible collisions with pedestrians or cyclists.

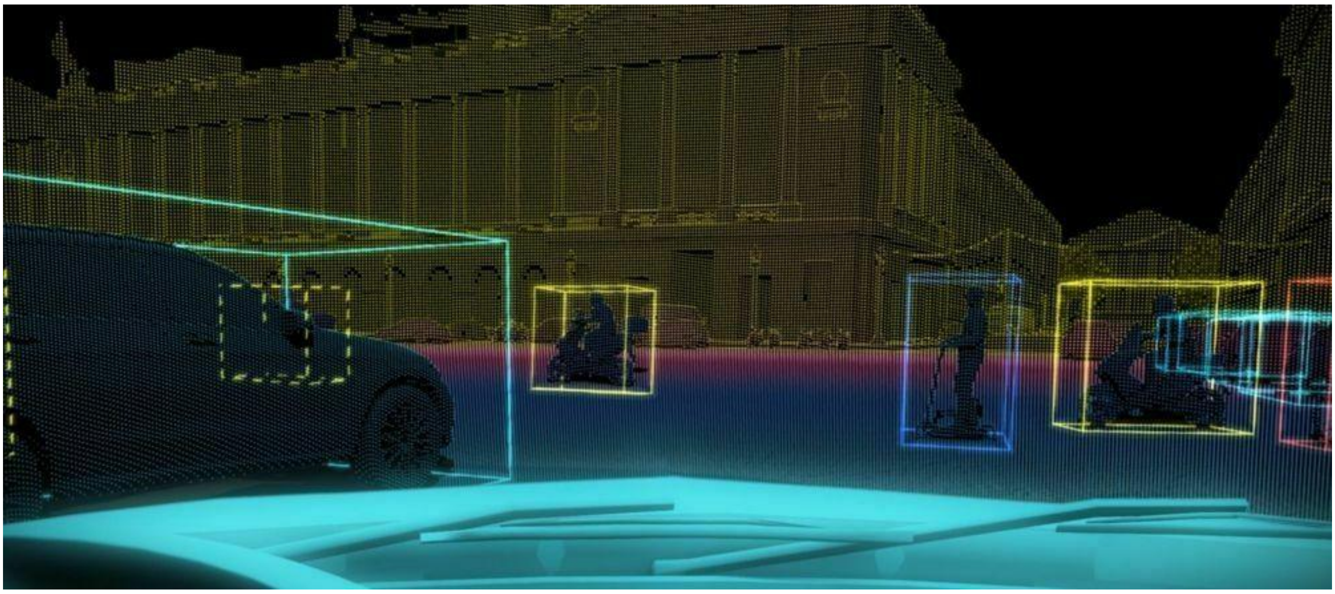
The system is demonstrating its efficacy in traffic measurements and in collision predictions, especially when red-light violations occur. The accurate object detection and classification offered by Velodyne lidars, and the consequent good prediction of vehicles and pedestrian trajectories, will allow dependable cooperation between IIS data and traffic signal controllers.

The full IIS solution stack is deployed on three continents—North American installations are in Texas; Florida; Nevada; California; New Jersey; Missouri, and Canada. In urban applications where cameras can be used to detect pedestrians, the advantage of Velodyne's lidar sensors is to accurately predict pedestrian trajectories while keeping the pedestrians' identities safely anonymous—at any ambient light level.

DVN comment

The integration of lidars in infrastructural perception systems, and more globally in C-ITS ecosystems, is another manner to enrich AD and ADAS embedded systems. In AD vehicles, cooperative sensing systems could efficiently complete the perception offered by lidars, radars, and cameras. In urban situations, the perception's horizon is often limited by masking effects (vehicles, buildings, urban furniture), so AD trajectories could be more accurately predicted with cooperative sensing.

Stellantis All In on Valeo Lidar



Valeo's third-generation lidar will equip multiple vehicle models across Stellantis' brand portfolio, starting in 2024. The Valeo Scala 3 lidar will enable these vehicles to be certified for L^3 automation.

Valeo have already sold more than 170,000 Scala units in the world; earlier Scala lidar sensors have seen wide adoption, for example the Scala 2 sensors in the Mercedes S-Class. Almost every automaker in the world agrees Lidar sensors are a crucial key component for safe and effective L3 automated driving; notoriously cocksure Tesla CEO Elon Musk has scorned lidar as a "fool's errand", even as numerous regulatory agencies increasingly object to Tesla vehicles' alarming autonomous misbehaviour.

Valeo's gen-3 Scala lidar can detect all types of objects, even those with very low reflectivity—even when an they are far ahead. It can identify small objects at more than 150 metres, such as flaps of tires lost by trucks on the road. These small obstacles are frequent but generally late to be detected by radars or cameras. This sensor synthesises a 3D image of the vehicle's surroundings based on the point cloud detected ahead in a field of view of about 150° H × 25° V. This frontal point cloud can be used also to map the ground topology and to detect road markings. Through these data collection capabilities, this lidar will enable new services to be offered to Stellantis' customers.

Valeo's lidar also features embedded high-performance software based on artificial intelligence algorithms, which enables it to define the vehicle's trajectory, anticipating obstacle-free zones on the road ahead. Like other types of lidars it can self-diagnose, and self-activates its cleaning system when its field of vision is obstructed.

DVN comment

In the European market—and to some extent in the U.S.—Valeo have built a leading position for lidar sensors as the first choice for a number of carmakers. This choice is not only driven by their sensors' technology and performance but also by Valeo's expertise. Their early industrial investment combined with adjacent market feedback now starts to pay dividends.

Hongqi Pick Robosense as Lidar Partner

Robosense have formed a partnership with FAW's Hongqi. Autonomous driving solutions on the Hongqi Auto FEEA 3.0 platform will use multiple Robosense second-generation solid-state lidar sensors to create superior intelligent driving perception solution on several new Hongqi models to be produced from 2023. The new Robosense lidars use a highly-integrated 2D MEMS chip scanning architecture with a streamlined structure for stable, dependable product performance.

The FEEA3.0 platform is Hongqi's new autonomous vehicle electronic and electrical architecture to underpin vehicle safety; reliability, and scalability, and can provide strong platform support for vehicle development.

Through the association with Hongqi Auto, Robosense intend to boost the production and commercialization of intelligent vehicles worldwide. They plan to further deepen cooperation with Hongqi in the mass production of automotive grade lidar. Robosense will support Hongqi in accelerating their large-scale production and marketing of intelligent vehicles.

Robosense are a tier-1 supplier for more than 40 vehicle models.

DVN comment

The success of Robosense's RS-lidar-M1 among Chinese automakers demonstrates that MEMS-based lidar is a sufficiently mature technology to be integrated in ADAS and L3 AD systems. We forecast that in a couple of years, Chinese lidar suppliers will make inroads on the US and European markets, independent of their specific technology.

Hesai Lead Car Lidar Working Group

Research readiness work for the ISO/PWI 13228 Test Method for Automotive Lidar has got under way. Hesai's Mr. Xin Zhao represents China and acts as group leader in the ISO Working Group ISO/TC22/SC32/AHG1. Valeo are the deputy leaders of the group, which also includes Bosch; Denso; Nissan; Renault; Sony, and ZF. They will work on the new ISO standard.

The objectives and contents of this ISO/PWI 13228 standard intend to define:

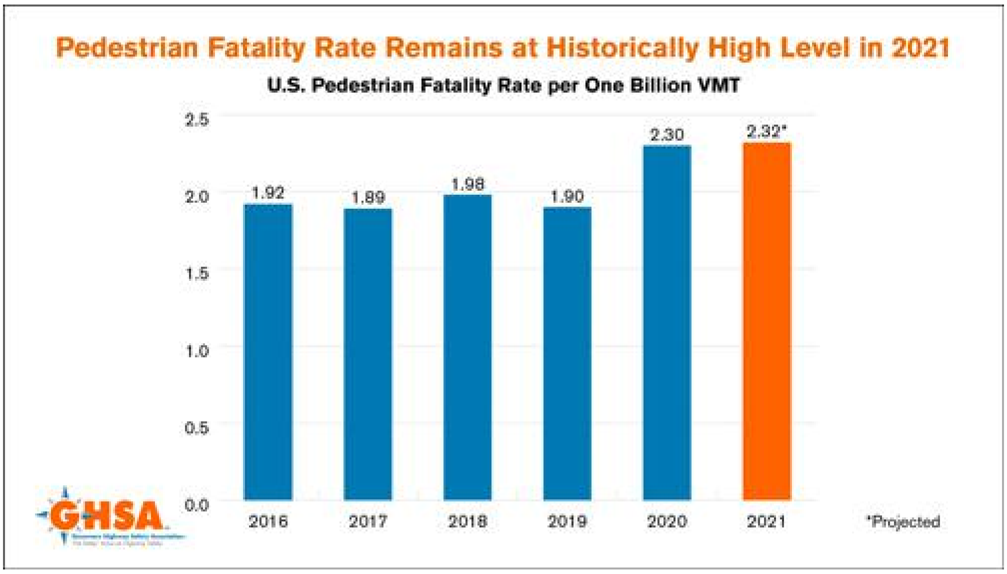
- Unified automotive lidar performance test methods, that can enable at term healthy competition in the global automotive lidar market;
- Solutions to reduce the risk of failure of the perception system when the autonomous vehicles are on the road;
- Guides for governmental organisations to conduct more standardized management of the automotive lidar market to ensure that certified products will meet international minimum standards, and
- A basic consensus on the definition of terms and technical specifications for the automotive lidar

DVN comment

According to a CICC research report, the global market scale of OE automotive lidar is expected to reach more than C¥100bn by 2025. As many series-production vehicles equipped with lidar are set to launch within the next five years, it is important to define—now—international standards for automotive lidar. Technology-neutral, performance-based standards will give common, guidelines for basic functional specifications and testing methods.

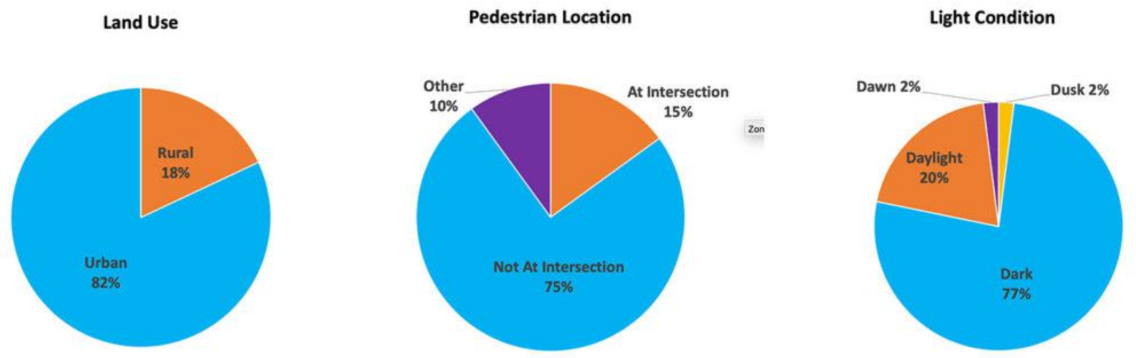
Lidar Coalition to Fight U.S. Pedestrian Deaths

It's increasingly dangerous to be a pedestrian in the states; pedestrian fatality rates, after plateauing some time ago, have in recent years been rising.



U.S. pedestrian fatality rates (Governors' Highway Safety Association)

The statistics for 2020 and 2021 mark a historical peak compared to the last decade. In 2011, 4,457 people were struck and killed by U.S. drivers. By 2020, that number had increased 46 per cent to 6,515 deaths, which accounted for 17 per cent of all traffic fatalities that year. The most recent data from the GHSA estimates that more than 3,400 pedestrians were killed in just the first half of 2021.



Pedestrian death circumstances (NHTSA)

Most pedestrian deaths occur in urban areas, and not at intersections—and about 80 per cent of them happen after dark. This is a an ongoing impetus for the lighting and lidar industries to improve their functions and products. Velodyne; Innoviz; AEye; Cepton; Continental; Ouster, and Quanergy Systems have formed the Lidar Coalition. Velodyne CEO Ted Tewksbury and Innoviz CEO Omer Keilaf say the coalition will work to enhance the capabilities of crash-avoidance technology and infrastructure solutions through the inclusion of lidar, and advocate for policies to help reverse the rising trend in pedestrian deaths.

With efforts such as NHTSA's proposed updates to the New Car Assessment Program, and automatic emergency braking, it is critical that all policies reflect the capabilities and limitations of sensors incorporated into vehicle safety technologies. According to Keilaf and Tewksbury, sensor redundancy optimised to perform in all lighting and weather conditions is critical to making roads safer for pedestrians. By working together, they say, the lidar industry can contribute to the development of new rules and policies—and the application of lidar can be leveraged to help reverse the troubling increase in pedestrian fatalities.

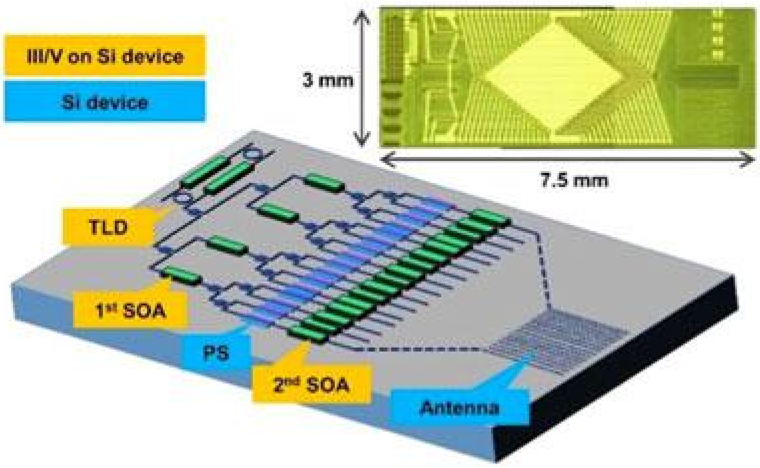
DVN comment

Since most of the pedestrian fatalities happen in urban areas with lower driving speed and shorter visibility distances, emphasis is warranted on the development of short- and midrange lidars with a broad field of view. A key feature of such systems will be the reliable characterization of objects in the scenery, even under crowded traffic conditions. This coalition reflects the need for cooperation in the lidar ecosystem to efficiently bring the full benefits for society.

Samsung's Single-Chip OPA Lidar Prototype

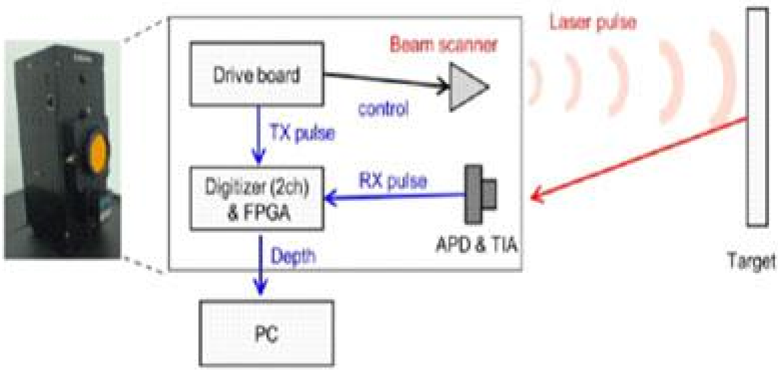
Researchers from Samsung's Advanced Sensor Laboratory have presented a prototype of a real-time imaging lidar using OPA (optical phased array) technology. The key element of the system is based on the prototype development of a single-chip solid-state beam scanner. The beam scanner is integrated with a fully functional 32-channel optical phased array; 36 optical amplifiers, and a tunable laser at central wavelength ~1310 nm, all on a 7.5 × 3 mm^2 single chip fabricated with III-V on silicon processes.

All the optical components, such as wavelength-tunable laser (TLD), splitters, optical amplifiers, phase shifters, and grating antenna, were integrated on the chip.



The laser beam generated at the TLD is divided into 32 channels through cascaded beam splitters, and the phase shifter at each channel adjusts the 32 optical phases. The optical powers attenuated in the circuit are amplified through the 36 SOAs—four in the 1st stage and 32 in the 2nd stage—and finally the focused optical beam is emitted from the grating-based antenna array. The OPA is calibrated with self-evolving genetic algorithm to enable beam forming and steering in two dimensions.

Distance measurement is performed by measuring ToF (time of flight) of the emitted laser pulses. The prototype system as used by the team is schematically shown here.

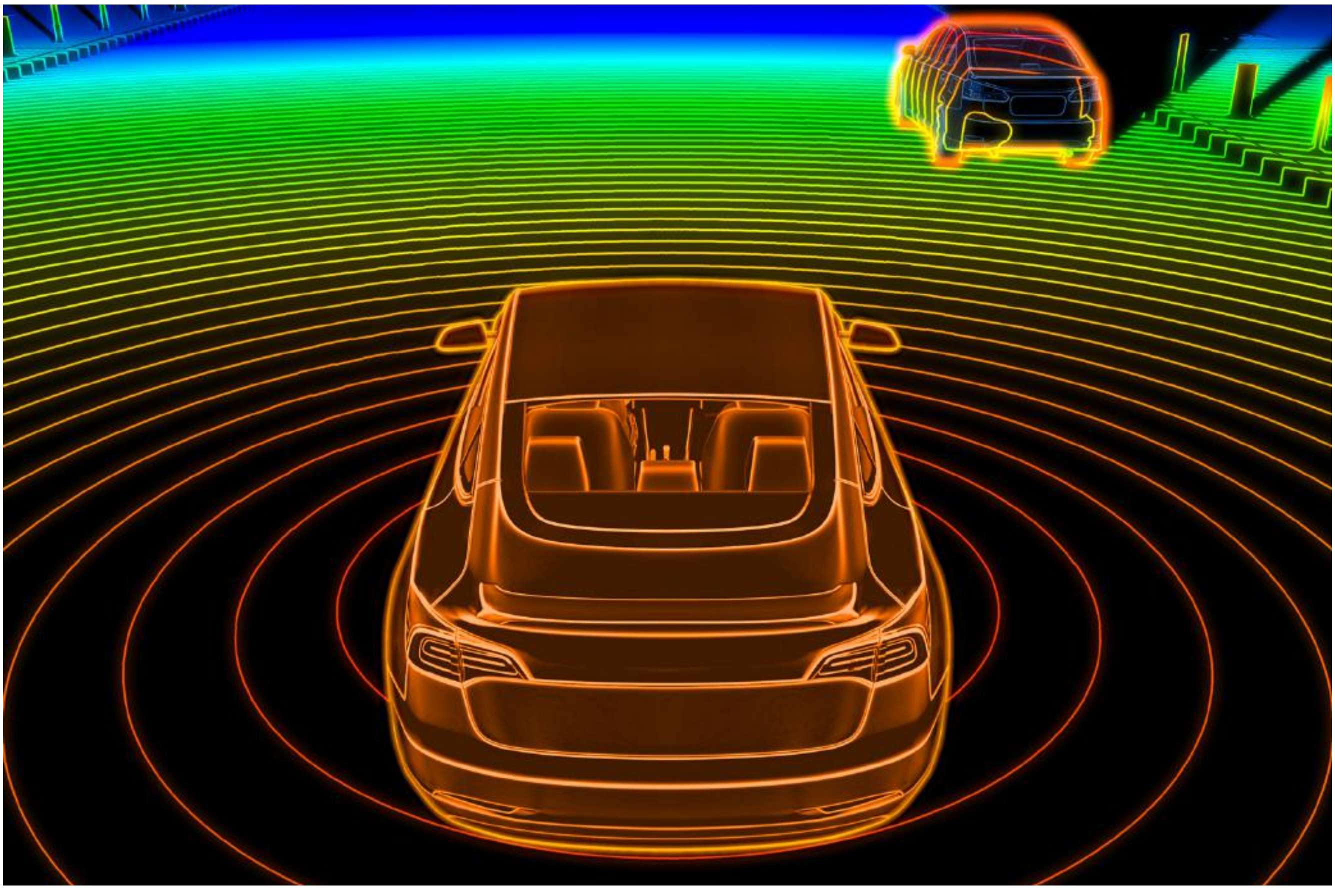


According to the research team, a lidar module using this OPA solution can generate point cloud images with 120 × 20-degree resolution and 20-frame-per-second image acquisition. Currently the achievable range is about 20 metres, and improvements are on the roadmap.

DVN comment

This work presents a chip-scale OPA lidar scanner without any moving parts, and includes the laser light sources on a chip of less than 25 mm2. If realised in mass production, this technology can be an enabler for compact, affordable lidar sensors. With some increase in the detection range, application for short/mid-range lidar sensors will become feasible.

Upcoming DVN-L Events



DVN Lidar Workshop, 12-13 September 2022.

The DVN team are proud to organise our first lidar Workshop, with presentations on four salient topics by lidar community members. This workshop, organised and moderated by DVN's Alain Servel; Hector Fratty; Leo Metzemaekers, and Ralf Schäfer, will be exclusively for our lidar community members and potential new members.

First DVN Lidar Workshop: a deep dive on four topics

The event will be at the Dorint Hotel Frankfurt-Sulzbach, and will be a hybrid event in deference to the pandemic. Of course we encourage live participation as much as possible, and those who are unable to travel can join in online.

Here's the provisional docket:

Monday 12 September

18:30	Welcome of live participants
19:00	Cocktail
20:00	Dinner

Tuesday 13 September

8:30	Opening and introduction of participants
9:00	P. Zegelaaar, Ford:"The role of lidar sensors in the (partially) automated driving stack"
10:00	Coffee Break
10:30	Four breakout groups, each discussing two questions
11:30	Reporting of breakout groups and discussion
12:15	Lunch
13:30	C. Hofmann, AMS Osram: "Emitters"
14:00	J. Ruskowski, Fraunhofer IMS: "Detectors"
14:30	Four breakout groups, each discussing two questions
15:30	Coffee break
16:00	Reporting of breakout groups and discussion
16:30	Wrap-up discussion : what did we learn together?
17:00	Closing remarks