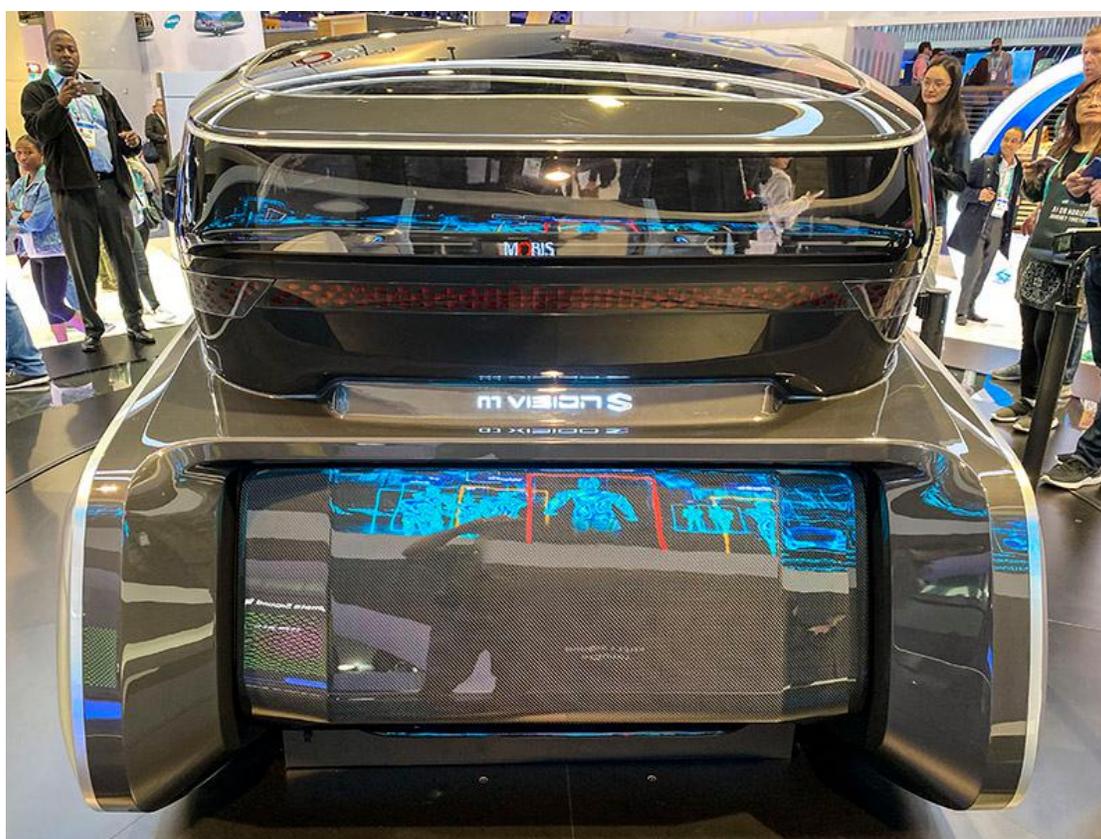
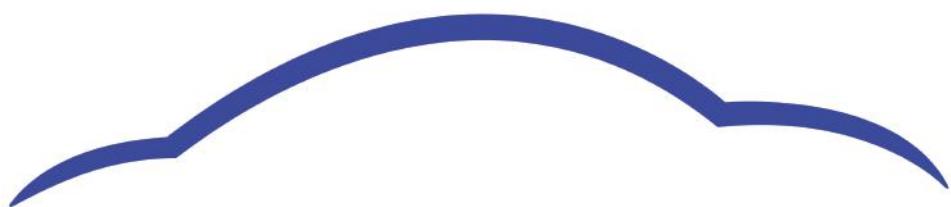


# Consumer Electronics Show 2020

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automotive lighting and driver assistance technologies

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## About the author



**Daniel Stern**, DVN's Chief Editor based in Vancouver, BC, Canada, is considered by DVN President Hector Fratty as one of the five greatest lighting experts in North America. He is an appointed member of the US transportation Research Board Visibility Committee, which steers North America research on matters related to automotive conspicuity, lighting performance and regulation. He is an active member of the SAE Lighting Systems Group, and attends and participates in the world's automotive symposia and technical conferences.

## Executive Summary

CES, the massive Consumer Electronics Show in Las Vegas, increasingly caters for the long-run concepts in the reimagining of mobility. Key takeaways from this year's show:

- There were some concept and prototype cars, maybe a few more than last year, but still not very many of them. Still, we were quite amazed at the progress made by Byton, Rivian, and Fisker out of the work-in-progress realm—this year they showed vehicles looking very nearly ready for production. High-quality prototype cars were shown by the likes of Nissan, Hyundai Mobis, and Mercedes, and dream/concept cars by brands including Chrysler, Fiat, and Sony. There were quite a few car-plausible bucks built for showing how suppliers' technology might be integrated.
- Overall, there was quite a lot of vehicle and driving technology on display. We got the sense that showing these kinds of technology was easier this year: last year, companies had to put a lot of effort into explaining what the various parts of the transport ecosystem might look like and how they might fit and work together. With those lessons having percolated in the public mind over a year's time, providers could more readily show their innovations without having to explain every basic aspect of what they are and how they fit in the world.
- Lidar, lidar, lidar. There was an enormous amount of lidar hardware on display. It's getting smarter, it's getting smaller, and it's migrating toward solid-state (and away from moving parts). There appears to be a broad consensus that lidar will soon be ordinary equipment on most all vehicles, Elon Musk's staunch anti-lidar opinion notwithstanding. There's a great deal of jockeying for position by a lot of companies, and industry analysts increasingly say the current superproliferation of lidar suppliers must boil down before too long.
- Integration and interaction are basic bedrock in the transport revolution. In the way vehicles use infrastructure, in the way humans use vehicles, in the way vehicles use data, and in the way technology is configured and deployed, integration and interaction will be found all up and down the scale.
- Not a whole lot of lighting innovation on display this year, but there was some. SLD Laser, Dr. Shuji Nakamura's company working on laser-based lighting, have made some big strides in the last year. Stanley are aggressively pushing into the UV-C LED space for killing bacteria without endangering human beings. The push to integrate ADAS/AD sensors into car lights continues, as does the pushback from those worried about cost and feasibility of car repairs. Last year's notable lighting innovation powerhouses—AL and Varroc, for example—were dramatically scaled back or not present this year, though interesting new technology was shown by Osram.
- What used to be considered "high resolution" for variable-message/variable-image pixellated display screens on the outside of vehicles, is now considered low resolution. The improvement in just a single year's time is remarkable. The same goes for ADB, and we also noticed the spread of ADB-like technology—that is, the dynamic selective shade-out of light—to other areas of the car.

## Introduction

CES has exhibits of the newest technology applications in every possible context a person might encounter. If you're interested in disruptive internet-enabled smart drone toothbrushes with blockchain, you're sure to learn all about the latest developments in that field at CES—but not in this report, which is a close-up look at new and notable technology for drivers and cars to see and be seen.

Although the "C" in "CES" stands for "Consumer", the show is officially closed to the general public. It's open to (broadly-defined) industry and to the press; consumers are meant to learn of the show's content via the news media. To make the most efficient use of your time as you read this report, we've deliberately excluded high-profile exhibits with heavy coverage in the popular press; the main intent of this report is to show you relevant technology that doesn't make headlines in the mass media. Coverage is alphabetical by exhibitor name.

There were some interesting concept and prototype cars. Companies like Byton, Rivian, and Fisker have worked their way up from the dream-car level; their display models this year looked plausibly almost ready for production. High-quality prototype cars were shown by the likes of Nissan, Hyundai Mobis, and Mercedes, and dream/concept cars by brands including Chrysler, Fiat, and Sony. There were quite a few car-plausible bucks built for showing how suppliers' technology might be realised and integrated.

Suppliers and idea farms have clearly grown more comfortable with showing automotive and mobility technology. It seems a lot of the heavy lifting has been done of educating showgoers about the context in which to imagine the displayed technology, so exhibitors have a clearer, more direct line of enticement without having to stop and explain what the various parts of tomorrow's transport ecosystem might look like and how they might fit and work together. With those lessons having percolated in the public mind over a year's time, providers could more readily show their innovations without having to explain every basic aspect of what they are and how they fit in the world.

There was a huge amount of lidar hardware on display. Smarter lidars, smaller lidars, more varieties of solid-state lidar. The rotating-head variety is still quite present, but the writing is on the wall—just as we saw with the migration away from moving parts in ADB systems. Almost everyone agrees lidar will soon be basic equipment on most all vehicles; Elon Musk disagrees in his usual colourful manner, but even he and his Tesla company may eventually have to admit it. There's a great deal of jockeying for position by a lot of companies, and industry analysts increasingly say the current superproliferation of lidar suppliers must boil down before too long. And the supplier shakeups and musical-chairs games are under way outside the lidar sector, too. We noticed longtime mirror magnates Gentex expanding into driver monitoring and integral camera/display units intended to replace actual silver-on-glass mirrors, for example.

Integration and interaction were on display as basic bedrock in the transport revolution. In the way vehicles use infrastructure, in the way humans use vehicles, in the way vehicles use data, and in the way technology is configured and deployed, integration and interaction are found all up and down the scale. It's no longer such a radical new idea that people and transport systems will interact in ways resembling person-to-person social interaction.

There wasn't a great deal of lighting innovation on display this year, but "not much" doesn't mean "none". SLD Laser, Dr. Shuji Nakamura's company working on laser-based lighting, have made some big strides in the last year. Stanley are aggressively pushing into the UV-C LED space for killing bacteria without endangering human beings—a key element for public acceptance of shared cars. The push to integrate ADAS/AD sensors into car lights continues, as does the pushback from those worried about cost and feasibility of car repairs. We were dismayed that some of last year's notable lighting innovation powerhouses—AL and Varroc, for example—were dramatically scaled back or not present this year.

What used to be considered "high resolution" is now considered low resolution for variable-message/variable-image pixellated display screens on the outside of vehicles, The advances in just a single year's time is remarkable. The same goes for ADB, and we also noticed the spread of ADB-like technology—that is, the dynamic selective shade-out of light—to other areas of the car. The long-humble sunvisor, for example, stands to be radically upgraded by a very ADB-like concept put forth by Bosch.

You'll find more detail on all of this in the pages you're about to view.

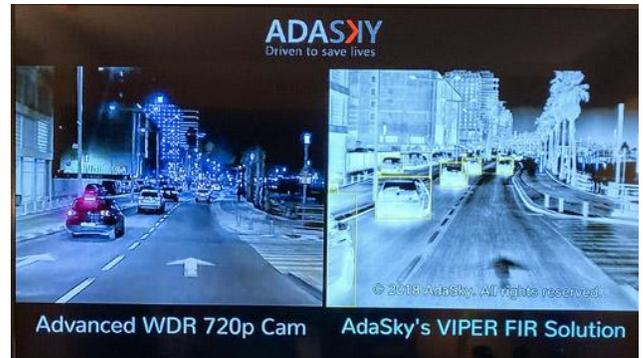
## Adasky



Israeli supplier Adasky showed off their Viper Thermal Camera, a comprehensive sensing technology for high-level automated driving. It's a far infrared thermal camera with advanced machine vision algorithms that lets autonomous vehicles as well as smart infrastructure see and understand the road in any lighting or weather condition—including heavy rain, direct sunlight, and dense fog that can dazzle or effectively blind other kinds of sensors.

The Viper passively collects the heat (infrared) signature from objects in the field of view, converts the heat images to VGA video, then applies Adasky's deep-learning algorithms to provide accurate object detection, classification and scene analysis. The computer-vision capabilities include multi-class object detection and classification, which enables a vehicle to simultaneously detect and classify pedestrians, vehicles, trucks, bicycles and

motorcycles. Detected objects are rigorously kept track of individually; there is robust anti-cluster/anti-clumping technology so *each* pedestrian, bicyclist, or animal in a group, for example, is tracked individually.

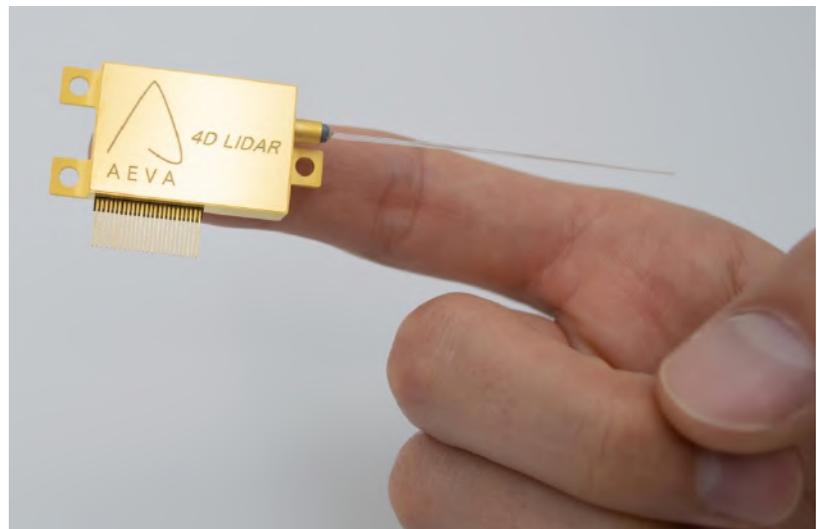


The Viper system was honoured this year with CES Innovation Award.

## Aeva

California-based Aeva got started in 2017 by engineers from Apple and Nikon. This year, they showed a frequency-modulated continuous-wave lidar system called the Aeries, integrating all the key elements of a lidar sensor into a miniature photonics chip.

This "4D lidar on a chip" features a 120-degree field of view, and is radically smaller than other lidar solutions with similar capabilities: over 300 metres' seeing distance for low reflective objects, and it can measure instant velocity for every point—Aeva call that a first for the autonomous vehicle industry. They're predicting a cost of under USD \$500 at scale, which is another radical miniaturisation.



The Aeries isn't affected by other sensors or sunlight, and it operates at only a fraction of the optical power typically required to achieve such long range performance (yet another radical miniaturisation). Aeva say it provides ultra-high-fidelity data by dint of over two million points per second for each beam. The Aeries breaks the dependency between maximum range and points density, which has been a barrier for time-of-flight and FMCW lidars. Aeva say it meets production requirements for autonomous robo-taxis and large volume ADAS customers, and will be available for use in development vehicles in the first half of this year.

Porsche recently poured a lot of money into Aeva, who regard the investment as a VW Group endorsement of Aeva's approach. Alex Hitzinger, Senior VP of Autonomous Driving at VW Group and CEO of VW Autonomy, says "We have scanned the market closely and believe Aeva's 4D LiDAR on a chip technology is the best lidar solution on the market, solving a fundamental bottleneck for perception in taking autonomous driving to mass scale. Together we are looking into using Aeva's 4D LiDAR for our VW ID Buzz AV, which is scheduled to launch in 2022–23".

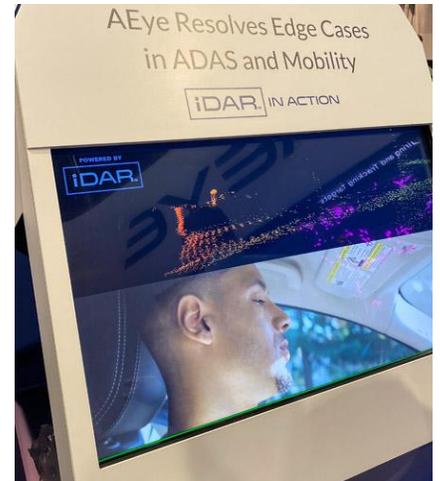
## Aeye



In the engineering world, a "corner case" is a situation wherein multiple variables or conditions are simultaneously at extreme levels, even though each is within its own normal range. This is in contrast with an edge case, which occurs when only a single variable or condition is at an extreme level. AEye put together a booth demonstrating how their AI-driven iDAR™ technology addresses what they call the toughest corner cases that must be solved to bring safe, reliable autonomous driving to the world's roads.

The booth featured a basketball hoop and half-court. Attendees grabbed

the ball and aimed for the basket, and iDAR's real-time motion forecasting predicted in real time the ball's path and whether it would



hit the backboard, the rim, or swish right through the net. The analogy to the traffic space is clever: given a roadway, a car, and pedestrians, there's only a limited number of things that could happen, but it's crucial to be able to predict which of them will actually occur. The Aeye booth also featured interactive displays showing how partners are integrating and extending iDAR's capabilities to enable systems to predict behaviour.

## Audi



checkerboard theme to its front and rear lights alike. The lights are capable of glitzy dancing-light displays; photos here show the white daytime running light and (sequential) amber turn signal functions up front and the red tail/stop lights.



holding an eye-catching, highly dynamic, multi-layer/multi-level digital OLED assembly with highly variable display capabilities. It's shown here displaying checkerboards on the horizontal surfaces and exclamation points on the vertical surfaces, showing off the high gradient, low bleed, and homogeneous illumination achievable with OLEDs.

DVN regularly reports on the steady stream of magic light innovations from Audi, and so far, show by show, they have yet to disappoint. Leaving aside the very impressive and well publicised AI:Me self-driving demonstrator car that whizzed around the roof of the Aria Hotel near the show grounds, there was a great deal of lighting and vision technology at the expansive Audi booth. The e-tron was on display, showing



Audi also made a point of showing their progress on OLEDs, with a glass-case display



## Audi, cont'd



And two of Audi's lighting magicians were on hand to talk about their latest wizardry. Stephan Berlitz and Wolfgang Huhn gave a presentation, "Digital Light for Digital Cars", in which they discussed the functions and roles of advanced lighting systems in today's cars and in the reconceived transport systems of tomorrow. One of the many interesting slides from the presentation



showed a much higher take rate than anticipated for the optional OLED taillights on the A8. Another interesting tidbit from the Audi booth: NHTSA lighting rulemakers, scheduled to stop by for a quick chat, wound up talking with Berlitz and Huhn for well over an hour. Could it mean a ray of hope about the apparently stalled efforts toward realistic (or any) rules for ADB in the USA? Only time will tell...!

## Baraja

Australia-based lidar supplier Baraja showed off their newest work, the Spectrum-Scan lidar designed for extreme immunity from interference. It's not such an issue now, but looms as a problem when lidar-equipped cars proliferate. Baraja say their randomly-modulated, continuous-wave approach, based around 1550 nm emitters, offers inherent protection.

Interference occurs when a lidar picks up a source of light other than the reflection of its own emitters, from a different laser or environmental source like bright sunlight, creating errors and uncertainty that manifest as vehicle blind spots. If it grows bad enough, today's autonomous-drive systems give up and relinquish control to the human driver.

Baraja's "SpectrumScan" gets around this problem by rapidly switching the laser's wavelength and transmitting it through a prism to diffract each wavelength onto a slightly different path. That way, when the light returns to the sensor, it is only processed if the wavelength, angle, timing, and encoding match on all signals—thus excluding any light the system itself didn't put out.

Baraja say their system is sensitive enough to detect objects with 10% reflectivity at 200 metres' distance.

## Becom

Becom might not be on the short list of names instantly recognised by those in the lighting and vision world, but their work is all around us.



They're an important tier-1 supplier to BMW, among others; for example, they build LED front lamp assemblies for BMW motorcycles as shown here. They also supply 3D TOF (time-of-flight) cameras, as well as solutions for gesture control, head tracking, and body tracking—all important technologies for inside self-driving cars.



## Bertrandt

Bertrandt were a first-time exhibitor at CES this year, and they used the occasion to unveil their HARRI innovation platform. HARRI offers new solutions for the automotive sector.



As an innovation platform for solutions relating to all aspects of automated, connected, and

electric driving, HARRI's integrated solutions include four lidar sensors, 16 ultrasonic sensors, and 12 cameras that enable HARRI to drive

independently. The HARRI use case on display at CES was a park-and-charge valet service that goes from manual to autonomous when assigned a targeted location. In addition to addressing the automotive sector, Hacker sees possible solutions for municipal infrastructure, logistics companies, passenger transport and more. The car buck featured the turquoise lighting rapidly becoming associated with self-driving vehicles, as well as large front and rear exterior display screens for vehicle-to-world communication.



The HARRI innovation platform presents a user experience integrating psychological and technical approaches, presenting an intuitive HMI and demonstrating functionality such as a solid backend structure, fast recognition and processing of collected data, and V2X communication.

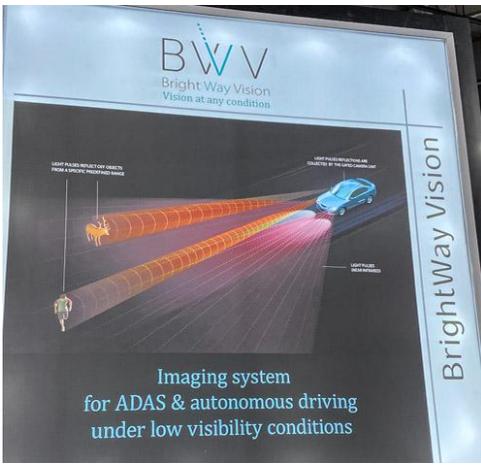
## Bosch



Bosch's big news in the driver-vision sphere: a giant, radical update to the low-tech sunvisor, which hasn't changed much since its inception: swing it down to block the sun, which it does, but it also blocks out large parts of the driver's visual field. They can't see traffic lights, and seeing distance is seriously curtailed on hilly, winding roads. Bosch's new Virtual Visor aims to fix that. It's a transparent LCD panel with integral camera, designed and positioned like a regular visor, but it shades only the sunlight from the driver's eyes.

The Virtual Visor uses a transparent LCD panel, a driver-monitoring camera, and facial detection to track the driver's eyes and block the sun accordingly. It's conceptually similar to ADB: the bright light is dynamically shadowed out from the driver's line of sight; everything else remains clear. Artificial intelligence determines specific features on the driver's face, such as the eyes, nose and mouth, and identifies where shadows from the sun are cast on the face. Transparent hexagonal pixels on the screen allow for digital movement of the shaded areas of the visor to adjust to where the driver's eyes go.

## BrightWay Vision



BrightWay Vision are a(nother!) Israeli tech company specialising in machine-vision systems to enable human drivers and self-driving cars to see better than they ordinarily can in difficult conditions. Their innovative slice-view gated technology readily sees through fog and rain to deliver clear, sharp, highly-detailed, easily-recoloured augmented vision for drivers, and the hardware is readily integrated into compact vehicle lights. The system synchronises the gated camera and the illuminator pulses, generating a clear image. The captured images, in turn, allow the generation of range maps. This TOF (time of flight) imaging technology consists of a gated CMOS image sensor with tightly controlled opening and closing times of the sensor's pixelated gate array.

## Byton

We were pleasantly surprised to see the enormous progress Byton have made toward road-readiness for their M-Byte car. Last year's prototype had lights that were further along than pure mockups, but couldn't really be called production-plausible. This year, the lighting system looks almost legal. The white car shows last year's front lighting concept, with blue crisscross lines and super-slim ice cube headlight placeholders.



thoroughly believable projector headlamp, while the ice cubes have given way to an equally plausible trio of daytime running light emitters, and the blue swoosh line at the bottom, too, has gone white. No sign of side marker light or retro-reflector, but there appears to be space for it.

Last year's rear lighting, on the white car shown here, wasn't too far-fetched, though it was difficult to imagine the lit area being adequate.



Down below, tucked into the rear fascia, is a small additional lighting unit that appears to contain a reversing lamp, a side marker light, and a retro-reflector:

While some of this year's developments (such as SLD Laser's prototypes shown later in this report) are getting close to making this kind of slim ice cube into a feasible headlamp design, that was not the case last year and it's still somewhat far off. So this year's lighting package, shown here on the dark silver car, retains some of the crisscross-line decoration—now in white, not blue—and with a



This year's rear lighting setup looks more realistic, with the lower line enlarged and thickened to increase the lit area. The crisscross styling is still prominent—perhaps even more so than in the earlier design:



## Cerence



The Cerence e.Go Mover is an autonomous electric bus bristling with all kinds of new-mobility technology.

Show attendees could take a simulated ride from an airport to a mobility hub, interacting with the vehicle's technology, including multi-language automatic speech recognition and natural language understanding so passengers and people outside the vehicle can converse with the bus in their native language; text-to-speech and natural language output so the bus can talk or text back to humans with smooth, realistic speech—including speaking style changes based on content and circumstances (important alerts can be communicated with an urgent tone of voice, and delays can be announced in an apologetic tone, for example). Meanwhile, speech signal enhancement removes noise from microphone inputs and creates distinct speaking zones so speech from only one speaker is picked up—important for the shared vehicle environment and for interaction with the bus from the outside.

Perhaps of greater direct relevance to the vision industry, transparent screen technology from glassmaker Saint-Gobain Sekurit enables projection of information both inside and outside the vehicle. Applications include a concierge or rider assistant avatar positioned behind what used to be called the driver's seat, overview information about the trip displayed throughout the vehicle, opportunities for personal interaction (advertising...?) positioned near each seat, and external projection to show those outside the vehicle information like its route. Passengers' view is not compromised, as they can see right through the projected images.

(Shown here is the Hella LED lighting and a lidar unit on the front of the e.Go Mover)

## Chrysler

Chrysler displayed a dream car called the Airflow Vision. It's an electric, highly-connected crossoverlike car full of screens. The name is pulled from the Airflow car Chrysler sold between 1934 and 1937, which was so radically aerodynamic and technically advanced that it was not a commercial success. So it's a bit of a daring choice of name, but perhaps Chrysler are banking on today's public being less averse to radical departures from the norms. The car doesn't look production-plausible, but it does bear trim, nicely-designed LED lighting mockups.



## Covestro



Covestro specialise in polycarbonates and other advanced polymer materials, and they had a fine presence at CES this year. In their automotive booth they displayed an array of see-and-be-seen concepts and prototypes including high-resolution, high-durability, full-colour display screens to take the place no longer needed by a radiator grille.

There were multiple headlamp prototypes on display, each packed with a great deal of new technology.

From the usual outside view, one could see new features—provisions for vehicle-to-world communication, AD marker lights, and so on—alongside conventional lighting functions. Things got really interesting, though, with a closer look at how these lights are constructed.

Covestro have been hard at work perfecting new materials, including thermally-conductive polymers, and the multifunction lights on display showed not only a great many features packed in, but also a remarkable reduction in component count and overall mass and volume. Conductive-plastic heat sinks figure in, as well as refined manufacturing techniques. Here's a multifunction light unit made with new Covestro technology by Myotek.



Another multifunction light unit, which Covestro described as "polycarbonate-centric", was designed to show off Covestro's range of materials and their capabilities. Claimed advantages include seamless sensor integration, a multi-shot moulding process to reduce component count and assembly steps, an integral nonmetallic heat sink, and trim integration of seeing and communication light functions.



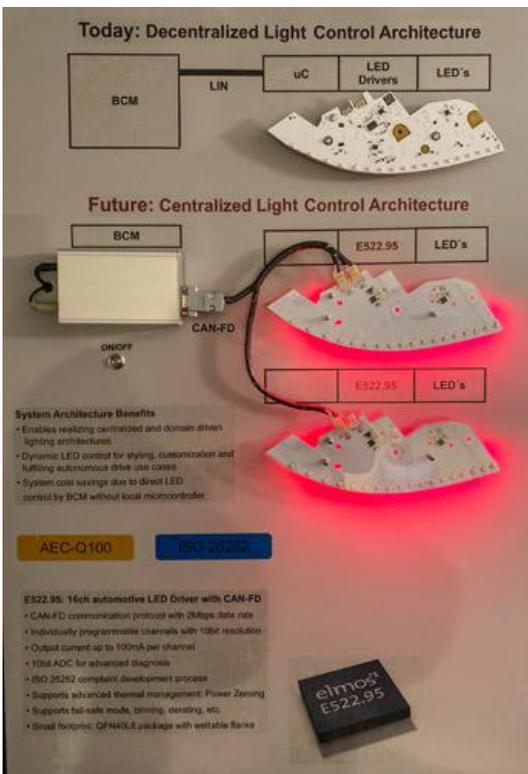
## Cub



Most of the technology at CES is aimed at OEMs, but there was some aftermarket presence, as well. Cub are an outfit offering retrofit driver assistant systems, mainly for trucks and larger vehicles. They showed tail lights with inbuilt radar for blind spot warning, lane change alert, and rear cross traffic alert systems. They also showed a universal add-on blind spot monitor system for commercial vehicles.



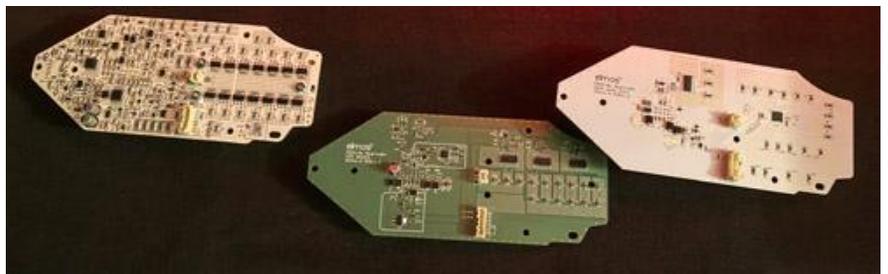
## Elmos



Germany-based Elmos develop, make, and market semiconductors and sensors for the automotive industry. This year they showed impressive developments in simplifying car lights by eliminating lighting control units. Elmos' new E522.95 LED control IC, developed in accord with the ISO 26262 Functional Safety development process, offers a full suite of integral diagnostic features to ensure consistent, dependable operation of LED drivers and achievement of ASIL-B ratings at the system level. The 16-channel E522.95 has a maximum output current of 100 mA per channel and has sophisticated power management to ensure constant light intensity from the LEDs even under difficult thermal conditions.

The demonstrators in Elmos' booth showed high-level functionality with smooth, wide-range intensity ramping (e.g., for sequential turn signals). Perhaps even more impressive is the dramatic reduction in component count made possible by Elmos' new architecture. The photo here shows three circuit boards for a particular multifunction rear lamp. The difference in parts count is

quite stark between the conventional present design (left) and the Elmos 2nd-generation design (right). And the capabilities of the Elmos architecture is such that improvements of this nature can be made as a drop-in running change without need of extensive re-engineering.



## Fiat



Fiat's Centoventi ("A hundred and twenty", signifying Fiat's age in years) is a battery-electric vehicle prototype whose main fame claim is extreme customisability. Interior configuration, battery capacity, and numerous other aspects of the car can be customised to suit whatever needs might present. There are exterior screens at front and rear for vehicle-to-world

communication.

The lighting package is closer to production-plausible than to dream-car placeholder. Thick, homogeneously-lit C-shaped tail lights flank the rear screen, while the front lights are small oval projectors ringed in white.



## Fisker



Fisker came roaring back this year with a near-production-ready version of their Ocean crossover. How nearly ready? Nearly enough that details of the planned buy/own/subscribe models were available and signups were being taken. It's got some interesting and unconventional features, like turn signal repeaters in the D-pillars, of all places. The rest of the lighting system rings some alarm bells, given how almost-final Fisker were claiming the show car to be: where are they planning to put the side marker retroreflectors, for example? And where are the required 50 square centimetres of brake and rear turn signal light lit area? Nevertheless, the rest of the lighting system is attractive. The headlamps have two (very) miniature oblong emitters separated by two vertical pillars. There are two curvilinear white arrays

presumably providing the daytime running and front position light functions: one underlining the headlamp and continuing inboard from there, the other down below in the fascia.

Fisker claim a battery range of up to 480 km, and have put together a novel app-based leasing program. They're taking reservations (\$250/ea) through their website and a dedicated app, though reportedly the first year's worth of production is already completely sold out.



## Flir



FLIR make thermal cameras for ADAS and AVs—notably automatic emergency braking. The company say their cameras can dependably classify objects in the dark and through obscurants including smoke, sun glare, and most fog, during the day or after dark. The FLIR commercial test vehicle featuring multiple automotive developer kit (ADK) thermal cameras was on display, demonstrating FLIR thermal camera integration with radar, lidar, and visible cameras already taken for granted on AVs. Another FLIR thermal camera was deployed as an attractant: attendees were invited to step in front of the camera and create a "thermie", a thermal-camera image of themselves. The author's thermal image shown here demonstrates the IR-absorbing properties of his eyeglasses and beard.

## Ford



Ford's Mustang Mach-E electric crossover pulled eager crowds of gawkers over the course of the show. It's designed and intended to compete against the Tesla Model Y (and, newly, the Fisker Ocean). Much has been written in the popular press about this electric Ford,



so we focused on its lighting system: up front, there's an iteration of the mini-oblong LED headlamps that find favour with Ford's stylists, if not with IIHS' headlight evaluators. The overall design of the front lamp is right in line with established modern trends. The rear lights show the iconic Mustang triple-vertical-bar styling theme, this time with colourless lenses rather than red.



As in years past, Ford also made a strong showing of their collaborative work with partners toward tomorrow's connected, autonomous, electrified, and shared automotive mobility. Here's a Ford Transit Connect van done up in Agility Robotics livery and extensively outfitted with AD technology, including what might still be a spinner-type lidar head on the roof.

## Gentex



Gentex have long been strong in the mirror space; now they're branching out in recognition that the silver-on-glass era might be showing signs of coming to an end. So they're branching out into driver monitoring and integral camera/display units for application in place of traditional mirrors. Concepts on display included display-mirrors optimised for rideshare cars, for 360-degree video capture, and for other use cases. The Gentex driver-monitoring system is smart enough to discern when the driver

has eyes on versus off the road; the green bar in the upper-left corner of the photo here indicates that the system perceives the driver to be paying appropriate attention to the driving task. The eye-tracking function works even despite eyeglasses.



## Hamamatsu



Hamamatsu supply pulsed laser diodes for lidar, and a variety of high-sensitivity photosensors applicable for short-, mid-, and long-range detection by ADAS and autonomous vehicles. The photosensor range includes Si PIN photodiodes, Si APD, InGaAs APD, MPPCs (SiPMs), and distance image sensors.

## Hesai

Shanghai-based Hesai make lidar sensors. Reflecting pride in their Chinese nationality, their product names incorporate "panda". In addition to their flagship product, Pandar64, whose strengths lie in long-range performance, their exhibits at CES included PandarQT, a 64-channel short-range lidar intended to address difficulties in AV lidar applications by dint of its  $104.2^\circ \times 360^\circ$  ultrawide field of view, which Hesai say is ideal for vehicle blind spot coverage. It incorporates technology to prevent interference from nearby working lidars, thus reducing the false-detection rate. And it supports PTP (Precision Time Protocol) time synchronisation to greatly simplify cabling.



## Honda



Honda's Augmented Driving Concept presented a seamless transition from autonomous to semi-autonomous driving operation. The autonomous driving system is constantly on standby, ready to intervene and control the vehicle when needed. The driving system changes between automatic and manual mode with a switch, and features more than eight modes between fully autonomous and semi-autonomous operation.

Various sensors in the vehicle continuously read the user's intention to smoothly shift between these modes, creating an instinctive driving experience.

The reconceived steering wheel offers new types of driving experiences. It can be passed back and forth from left-front to right-front passenger, and it also serves as a unitised control: Pat the steering wheel twice to start the car. Pull the steering wheel back and the vehicle will slow down; push the wheel forward and the vehicle will accelerate. Attendees could sit in the car and experience a simulated demonstration. The car itself has the shape of an old-time race car.



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Honda also showed the latest iteration of their Safe Swarm system, first shown at CES 2017. The idea is to improve traffic flow by taking information from vehicles ahead to head off traffic jams, take early braking action to help avoid a wave of emergency braking, or change lanes if needed. It does this through an on-board system with V2X communication, as well as the existing sensors on the vehicle and sensors in surrounding infrastructure.

## IAV



IAV showed off their Smart Guide augmented-reality navigation system. As with conventional nav systems, the driver enters a destination and Smart Guide calculates the fastest route including the time it will take. At the same time, it also calculates alternative routes in real time that can get to the destination within that time window. The software keeps real-time track of all calculated routes in relation to the vehicle's current position and the traffic situation, so rerouting is seamless.

The route appears on the windshield: for the driver, it's a green path that appears to be directly on the road ahead—that's the augmented reality aspect. IAV say the

system's real advantages come into play when the driver has to make a detour around unforeseen hindrances. In this case, the driver knows immediately, for example, that the road on the left will lead to the destination within the calculated time window, but not the road on the right.

The Smart Guide also makes it very easy to cope with particularly complex junctions, traffic roundabouts, and unfamiliar multi-lane roads. The driver just has to follow the markings on the windshield to get to the destination safely and on time. This reduces stress and avoids abrupt lane changes, so helps to reduce the risk of an accident.



## Ibeo



Ibeo showed their new 4D lidar system, called IbeoNEXT. It's a solid-state lidar sensor—no moving parts. Its compact design and light weight suit it for easy integration into vehicles (perhaps also into headlamps and rear lamps?). The sensor generates a 3D point cloud and an intensity image similar to the photo taken by a black-and-white camera—this is considered the fourth dimension. The system's seeing distance is  $\geq 300$  metres and it offers high spatial resolution of  $0.05^\circ$ .

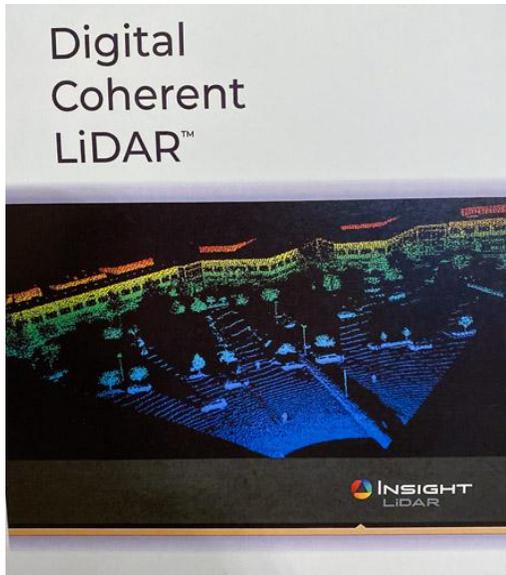
## ICVS



ICVS exhibited their sensor-cleaning technology and their electronic mirror-replacement displays, which offer the ability to automatically zoom in and out to tailor the field of view to whatever task is at hand—different for cruising at speed on the highway versus reversing into a difficult parking spot, for example.



## Insight Lidar



Insight say their Digital Coherent Lidar excels in range, resolution, reliability, safety and affordability. It's an FMCW system; Insight say their akinetic swept-laser source allows it to deliver resolution of 0.025° with a range of more than 200 metres, and say their "all-chip" approach is sensitive enough to pick up low-reflectivity objects at long distances—a feat that's long been difficult for lidars, especially on fast-moving vehicles in dynamic traffic. They also say their technology allows for a dramatic increase in pixel count together with direct velocity information, which addresses difficult edge cases in road-vehicle machine vision.

It's said to give a direct Doppler velocity reading with every pixel, accelerating object recognition and classification. Objects can be identified and classified up to 5× faster using this data method, because no frame-to-frame analysis or calculations are required. Direct doppler velocity data, enabling very rapid object

identification and classification.

## Koito

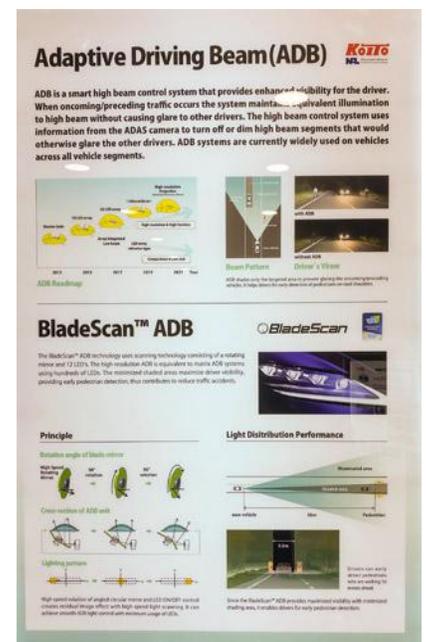


Koito's booth this year was centred round a shared autonomous vehicle concept prototype bristling with Koito vision technology. The amber and white dashed light lines projected on the ground behind the car (photo, left) are new Koito technology for improving the visibility of turning and reversing cars. We also see the turquoise light characteristic of new front lights for self-driving cars, though here it's displayed on the side of the car, and it's surrounding an information display.

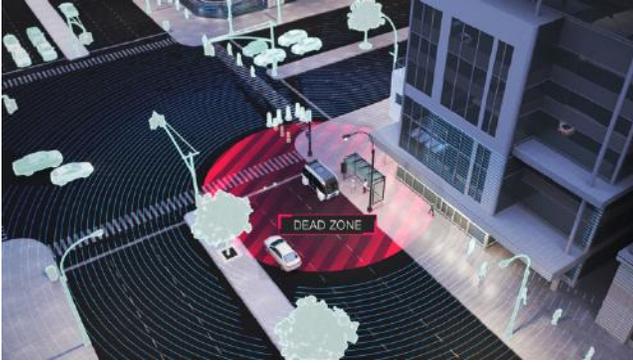
The prototype car had Koito's modularised Smart Sensor, which is an integral camera + lidar unit. It had sensors built into front and rear lights. It had new exterior lights to replace driver eye contact and gestures for communication

with pedestrians and the world at large.

Another Koito technology proudly promoted at the booth: their BladeScan high-resolution ADB, with sharply-defined, tightly-sized shadow zones to maximise visibility by minimising dead zones on either side of the de-glared car ahead. It also optimises the illumination cast on retro-reflective road signs to avoid backdazzle from excessively bright reflections.



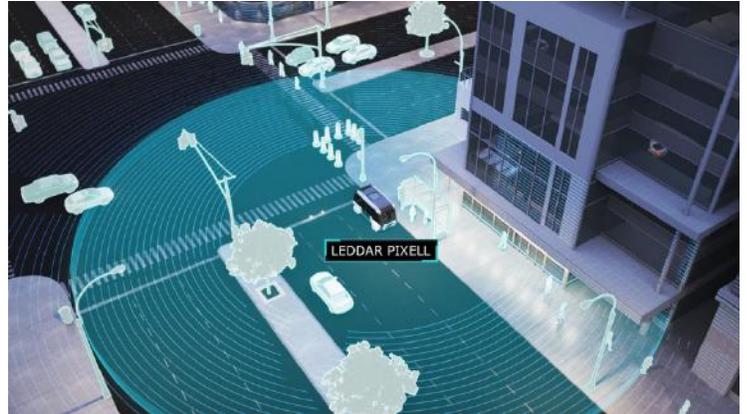
## LeddarTech



LeddarTech scooped up a CES 2020 Innovation Award in the Vehicle Intelligence & Transportation category for their Pixell cocoon lidar system for autonomous vehicles.

It's a 3D flash lidar with a 180° field of view, specifically designed for ADAS and autonomous driving applications. Leddar say the Pixell provides highly reliable detection of pedestrians, cyclists and other obstacles in the vehicle's vicinity and is ideal for use in perception platforms that are meant to ensure the safety and protection of vulnerable road users.

The robust, solid-state Pixell compensates for the limitations of mechanical scanning lidars used for geopositioning, which generate "dead zones", blind areas that can extend out up to several metres away from the equipped vehicle—shown in red in the picture above. The Pixell enables a comprehensive detection "cocoon", shown here in blue, that surrounds the vehicle to provide complete blind spot coverage without dead zone in the illuminated field of view.



## Magna



Magna have been hard at work on advanced LED technology, and it certainly showed in their display booth. They had a prototype taillamp and a grille-replacement display, both with their new FlecsForm technology offering high resolution, homogeneous illumination, new lightstyling prospects, and an attractive piano-black appearance when unlit.



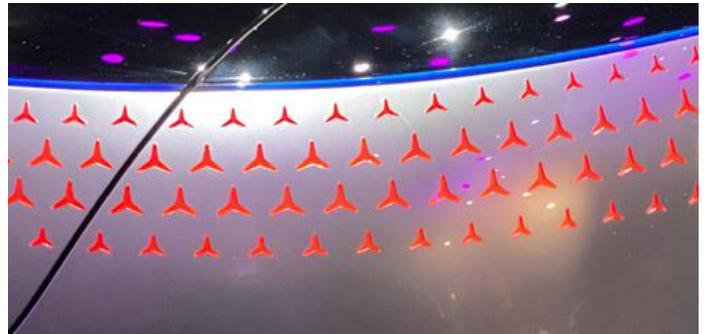
## Mercedes-Benz



As well publicised in mass media, Mercedes had a grand booth showing a concept electric vehicle, called the Concept AVTR, described as "envisioning a completely new form of interaction between humans, technology and nature". There was a 90-minute wait in queue to see it. Mercedes say they intend to introduce 10 EV models by 2022, starting with the EQC electric compact crossover set to become available from next year.

The Vision EQS prototype had intriguing lights. The rear lights comprise a veritable swarm of little red-lit Mercedes three-pointed stars.

Up front, there are depth-effect multifunctional headlamps with extensive animated-light capabilities, flanking a giant grille-replacement shown here as an effervescent blue sea with a white-lit Mercedes logo island in the middle.



## Mobileye

Intel Senior Vice President and Mobileye CEO Professor Amnon Shashua, in his annual CES address, shared the company's latest ADAS innovations, technology-neutral formal model for automated vehicle safety assurance and global MaaS industry collaborations. He called for more transparency in technology to enable the future of autonomous driving. Shashua presented Mobileye's latest technology advances including "vidar", Mobileye's concept for achieving outputs akin to lidar using only camera sensors (could this idea vindicate Elon Musk's hatred for lidar?). He detailed how Mobileye achieves pixel-level scene segmentation to detect tiny fragments of road users such as wheelchairs and open vehicle doors, as well as the ways Mobileye technology turns two-dimensional sensor data into 3D understanding.

Mobileye are developing two redundant sensing systems: one with surround-view cameras alone, and the other with radars and lidars. In an [unedited video](#) demonstrating the camera-only technology in Jerusalem, you can see the Mobileye car successfully navigate a complex driving environment replete with pedestrians, unguarded junctions, delivery vehicles, and suchlike.

Using crowdsourced Road Experience Management technology, Mobileye created a demonstration high-definition map of more than 400 km of Las Vegas roads from over 16,000 drives—and it took less than 24 hours to produce a map providing centimetre-level accuracy for thousands of on-road and near-road objects including 60,000 signs, 20,000 poles, and more than 1,500 km of lane centrelines. The near-real-time capability of REM coupled with low-bandwidth data upload (about 10 kilobits/km) from millions of Mobileye-equipped cars makes this technology highly scalable and practical for both advanced ADAS (L2+) solutions and full AVs including driverless MaaS fleets.

The REM mapping technology has also given rise to a spinoff data business: onboard cameras can be used to capture data about what they see, from roadside infrastructure assets to numbers of pedestrians at bus stops. This data generates what Mobileye call "actionable insights" to enable evidence-based urban planning improvements far beyond the automotive sphere.

## Mobis

The Hyundai Mobis M.Vision S starred as a fully autonomous concept car built expressly for shareable mobility. Mobis say reliability and comfort, long keys to a vehicle's success, are now just about universal: most cars available today are reliable and comfortable, so to be competitive today's cars need to do more. Mobis think that means the car should be able to understand and empathise with its users.

The M.Vision S uses communication technology to send messages to other drivers and pedestrians. Blue light means the car is in self-driving mode, while yellow indicates a



human is driving. Front and rear light displays can put up messages to other drivers or to pedestrians, like "Be careful", "Go ahead", et cetera—no word on just how customisable these messages might be; given the full range of hand gestures today's drivers use to convey their feelings, we wonder whether the road rage of tomorrow might be triggered by a mealymouthed message sent with lit letters rather than, for example, a raised finger.

In any event, the car has eye-catching styling and is peppered with all kinds of sensors and vision technology, such as the Integrated Sensor System shown here: radar, lidar, and visible-light camera in one unitised housing.



## Nissan



The star of Nissan's booth was their new Ariya electric crossover concept, which could morph into an actual, real production vehicle by next year. Nissan have told dealers it will have a 480-km battery range and go from 0 to 100 km/h in 5 seconds or less. It has Nissan's ProPILOT 2.0 advanced driver assistance system and twin-motor all-wheel-control, is

built with what's described as acoustic meta-materials, and offers a "smart route planner".



Its lighting system looked very plausible, and we were intrigued to note the DRLs are bigger and more prominent than the miniature headlamps, which for their part comprise four very small rectangular optics. The rear lights have a bent-line shape to them, in line with current trends (viz Toyota RAV4, VW Atlas and Tiguan, for example).

## Osram



Osram had a sizeable booth, but there was quite a bit less lighting technology visible—at first. We were ushered into an invitation-only interior suite where the good stuff was hidden away: new generations of Eviyos microLED headlamp light engines, for example, with all the benefits everyone wants: more light, higher resolution, smaller size, lower mass. They're not ready yet, and photos weren't allowed, but they're under very active development and it's only a matter of time—probably not very much of it—before Osram make a public announcement.

Back outside again, we saw expanded range and application of Osram's XLS eXchangeable Light Sources—the "LED bulbs" targeted at tier-1s and OEMs as the heart of a very affordable and therefore highly cost-effective LED signal lighting system. These can be seen in traffic on cars like the Toyota Corolla Sport and Mazda 3.

## Ouster



California-based Ouster showed what they call an entirely new category of lidar, designed to provide an ultra-wide field of view. Their new 128-channel "OS0" product offers a 95° vertical field with a 50-metre range, while their "OS2" system, also new, combines a range of more than 240 metres at 80% reflectivity and features a vertical angular resolution of 0.18° uniformly across a 22.5° vertical field.



Ouster partnered with Flex-N-Gate to equip a Ford F-Series pickup truck front end with Ouster technology integrated into the headlamp housings. The truck front also featured special low-mass LED fog lamps by Myotek.

## Quanergy



Quanergy showed off their S3 solid-state lidar with a red Mercedes visibly bristling with Quanergy hardware. Quanergy also leveraged the show as a platform to announce they've been chosen as a lidar partner for Geely Automotive Group. The two companies will collaborate on the development and broad deployment of smart city and autonomous vehicle systems in ongoing trials in China.

## Rivian



As with Fisker, we were impressed with Rivian's progress toward realistic production-readiness with their electric pickup truck and SUV. We still have some puzzlement over exactly how the front lighting system will work, but it's shaping up nicely. Up front there's a vertical stack of four very small round projector eyes within a tunnel-effect



white-lit vertical oblong shape. Down below is a horizontal array of three oblong projector lenses flanked by sensor bubbles inboard and below. Rear lighting consists of a full-width red bar. Down in the bumper fascia are slimline retroreflectors, in which are slotted tiny, slitlike reversing lamps to remind us that the

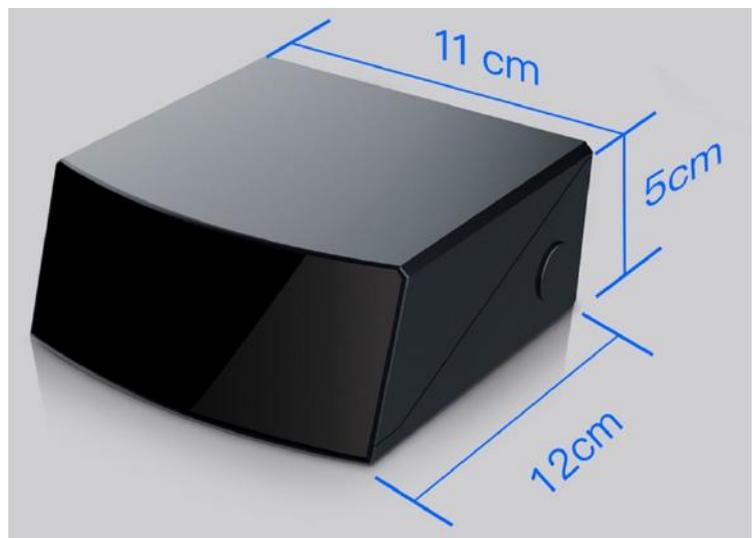
regulations don't require reversing lamps to help the driver see—only to warn others the vehicle is backing.



## RoboSense

For the second year in a row, RoboSense have received a CES Innovation Award. This year it's for what they're calling the first MEMS-based smart lidar sensor, the RS-LiDAR-M1.

RoboSense say the compact RS-LiDAR-M1 provides high-resolution 3D point cloud data faster than traditional lidar, and puts out structured semantic-level comprehensive environment information in real-time, including RoboSense's own high-precision positioning, free space detection, dynamic object tracking, and obstacle detection, identification, and classification for autonomous vehicle decisionmaking. The final series-production version will include features like automatic calibration, window fog detection, sleep mode, and automatic wake-up to further improve autonomous driving feasibility and safety.

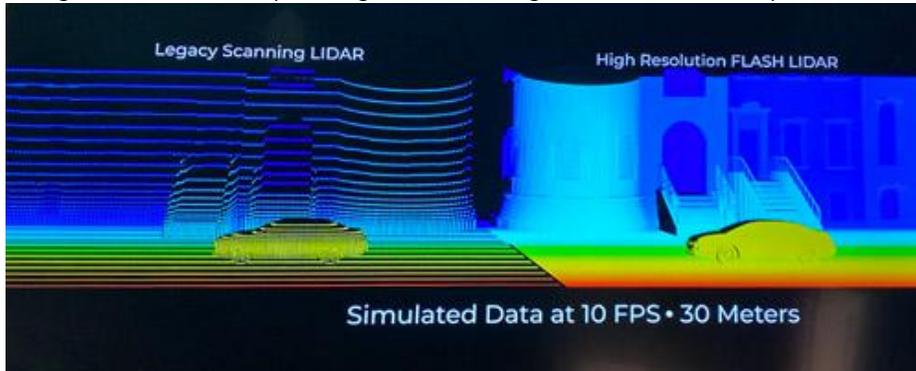


## Sense Photonics

Sense Photonics, who specialise in flash lidar technology for self-driving cars, showed their first modular flash lidar unit for ADAS and AV applications. It's called the Osprey, it looks a lot like a camera, and it's said to provide an unusually detailed data cloud.



The "flash" refers to a lidar system that looks at the entire field of view all at once, leading to camera-like images. The Osprey 30 has a 30° vertical field with 15-metre range for 10%-reflective objects (25 metres for 50% reflectance); the Osprey 75 has a 75° vertical field with 10-metre range at 10% reflectivity (15 metres for 50% reflectance), and both have an 80° horizontal field. The view fields are unusually dense, enabling high-resolution object detection from the street curb to the horizon. It is designed as an easily-integrated modular package, combining an automotive-qualified near-field sensor with Sense Illuminator, a proprietary distributed VCSEL laser array comprising thousands of individual laser elements.



The emphasis on near-field sensors addresses a major concern within the autonomous automobile space: how to eliminate a car's blind spots from top to bottom.

## SightBuddy

SightBuddy showed an interesting technology that reacts to a (human) driver's head movements to provide relevant views for lane changing and other manoeuvres. The idea is to reduce the need for glances over the shoulder and other large motions that take the driver's eyes off the road ahead. Their system is designed for add-on integration into reverse-camera video display systems.



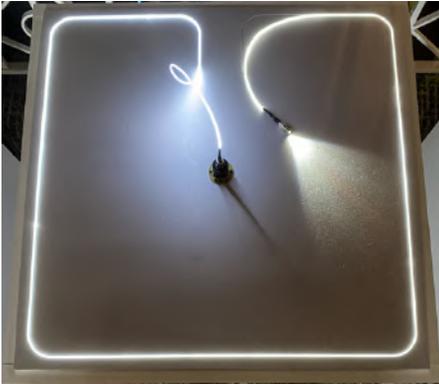
## SLD Laser



SLD Laser work magic with laser diode light sources. No surprise there; they're a spinoff from Dr. Shuji Nakamura's Sora who work magic with white LEDs. This year, SLD Laser repeated last year's nighttime ride-and-drive demonstration adventure at an off-road vehicle trail about half an hour's drive outside of Las Vegas. At the trail facility were big and small trucks equipped with off-road lights built by Baja Designs with SLD laser diode light sources. Attendees could get in the trucks, driven by experienced off-road race drivers, to see firsthand the performance of the lights. They're tight spots, in accord with one of the main strengths of the tiny, high-luminance laser diode light source. The photo here is a view

from the front seat of the equipped truck, showing the spots shining on a hillside about 2.4 km away. We were curious as to the peak intensity, but the Baja Designs employee driving the truck repeatedly stated that intensity applies only to high and low beam headlamps and all other vehicle lights, especially off-road lights, are always only ever measured in lumens.

Also on scene were drones equipped with SLD technology, demonstrating ultra high intensity search light functionality, as well as handheld laser torches (flashlights).



SLD also had a well-outfitted exhibition suite showing their latest work in laser-lit light guides; laser-lit high/low beam headlamps with



ADB capability, laser-lit projectors (built, for example, into the underside of a side-view mirror) giving super-sharp, high-contrast images, and

high-performance laser-lit LiFi with blistering speeds of over 20 gigabytes per second at application-realistic distances of a few metres between transceivers.



## Stanley



Photography was not allowed inside Stanley's exhibition suite, but there was plenty to see, including a demonstration of the superior resolution and control of light from their microLED technology versus competing technology for use in light engines (as, for example, in advanced headlighting systems).

There was considerable space devoted to deep-UV (UV-C) LED lighting, and it was timely; Stanley are right in the middle of having acquired U.S.-based HexaTech, who develop, make, and sell aluminum nitride semiconductor substrates. Those are a key component for UV-C LEDs. With a dominant wavelength of 265 nm—deadly to bacteria, but harmless to humans—such LEDs are being developed with an eye toward replacing bulky, power-hungry fluorescent and HID sterilisation-lighting technology. HexaTech's technology has achieved defect-free, large-diameter growth of the aluminum nitride crystals that are used for the substrates of these LEDs.

The Minamata Convention on Mercury that took effect in 2017 prohibits the manufacture and import-export of products containing mercury starting this year. Mercury lamps for sterilisation are temporarily exempt as there is no practical alternative light source—but Stanley have already achieved a UV-C LED output power of 50 mW, and see the HexaTech acquisition as a key stepping stone toward their goal of 200 mW soon, which would position Stanley well to commercialise UV-C LEDs.

Stanley are hoping to launch new products into the sterilisation market as quickly as possible and to reach sales exceeding ¥50bn in the sector by 2025. At CES last week, they showed application concepts for continuous cleaning of water, refrigerator contents, automobile interior air, food production areas, and more. Too, Stanley expect that aluminum nitride substrates will be used for communication and power transistors in the future, leading to further growth in demand for the HexaTech technology.

## Toyota



Toyota showed a couple of eye-catching concept cars. One was an example of the autonomous shuttle pods Toyota will provide for the Tokyo Olympics later this year. It will be interesting to keep tabs on how well they work and how they're publicly perceived and received.

The other interesting Toyota on display was the LQ, a concept vehicle that Toyota say leverages advanced technology to build an emotional bond between the car and the driver. It's an updated iteration of the Toyota Concept-i car shown at CES 2017, and it is (naturally) equipped automated driving capabilities. It also has what Toyota call Yui, a powerful artificial intelligence-powered interactive agent designed to learn from the driver and deliver a personalised mobility experience. We

noted the very expressive front-light "eyes", which can change expression and colour.



The LQ's rear lights, like those of the Mercedes show car, evince a swarm effect:



## TriEye

Israeli startup TriEye, whose SWIR (short-wave infrared) sensing technology enables machine vision in adverse weather and night-time conditions, cadged not just one but two CES innovation awards this year—one in the embedded technologies category; the other in the vehicle intelligence and transport category.

TriEye CMOS-based SWIR camera cameras are widely deployed in the defence and aerospace industries, but the technology has heretofore been too costly for the automotive field. Now the company's ongoing nanophotonics research has enabled production of an affordable SWIR sensor at commercial scale—which in turn enables a mass-produced compact HD SWIR camera at a much lower cost than before.



It's called the Raven, and TriEye say it will make ADAS more effective and AVs safer and more reliable by providing affordable high-resolution SWIR image data for dependable visualisation at night, in bad weather, and in other low-visibility situations.

The new camera is built round the company's new Raven CMOS image sensor, and puts out data formatted for seamless integration with existing ADAS and AV architecture and compatibility with existing computer vision algorithms. It has a 17° × 12° or 46° × 34° field of view, resolution of 1280 × 960 pixels, 30 fps frame rate, and measures just 3 × 3 × 2.5 cm (excluding lens).

## Valeo



French-based global automotive tier-1 powerhouse Valeo had an enormous amount of technology on display this year. One particularly fascinating item: a motorised wheeled porter made by French startup TwinswHeel with technology by Valeo. There were two of them, actually, of different sizes and capacities; they can transport loads of 60 and 130 kg, respectively, at a speed of 7 km/h—just right to assist a person, whom they dutifully follow at a distance of 5 cm to 3 m. They're meant to operate in closed locations—factories, maintenance centres, warehouses, shopping centres, airports, train stations and suchlike—or outdoors, to help with logistical and delivery tasks. The smaller droid has cameras, ultrasonic sensors, and an electronic control system from Valeo. The larger droid has those plus Valeo's Scala automotive-grade lidar, and it is powered by a 48V electric motor also from Valeo.

Valeo also unveiled their eDeliver4U autonomous electric delivery droid developed in partnership with a leading Chinese e-commerce platform. It's powered by a 48V electric propulsion system and can find its way around all by itself thanks to its Valeo perception systems. At 2.8 m long, 1.2 m wide and 1.7 m tall, the droid can deliver up to 17 meals per trip, autonomously negotiating dense and complex urban environments at about 12 km/h without generating any polluting emissions. With a range of around 100 km, this prototype gives us a glimpse of what home delivery could look like in the near future, especially in the increasing number of zero-emissions zones that are being created around the world

Cleaner mobility means lots of batteries, and batteries are temperature-sensitive. Valeo showed new applications of their thermal-management expertise, to keep propulsion batteries cool.

Valeo also showed their work in artificial-intelligence applications, including Move Predict.ai, which is designed to anticipate the intentions of roadside pedestrians. More broadly, it can perform a detailed analysis of the scene surrounding the vehicle, the behaviour of road users, and their level of attention or distraction—factoring in whether or not they are using a mobile phone, for instance. It uses this information to predict their intentions, such as crossing the road, and associated trajectories. And it can then instantly alert the driver of potential risky behavior by a road user, or activate the vehicle's emergency braking system if necessary.

## Velodyne



Velodyne Lidar showed off their new, remarkably compact Velabit, just 6.1 × 6.1 × 3.5 cm small. It offers a 60° × 10° field, works at distances up to 100 metres, and its laser is not hazardous to eyesight. It's also remarkably inexpensive at just \$100 per sensor.

Velodyne also presented their proposed Five Diamonds rating system to clarify and standardise terminology for ADAS features.

The system aims to encourage transparency

in the marketplace and promote the maximum positive effect of ADAS technologies. Velodyne are working with automotive safety organizations, in collaboration with SAE International, to foster an industry dialogue to refine and advance the system with the goal of improving driver and pedestrian safety.

Other Velodyne technology on display: Alpha Prime, a new sensor using Velodyne's patented surround view technology for outstanding performance in perception, field of view, and range for autonomous markets including transport and trucking; Velarray, a small, embeddable, powerful sensor to allow automakers to create superior ADAS and address edge-cases including curvy roads, potholes, junctions, on/off ramps, residential areas, and roadways with unclear lane markings; and VelaDome especially designed for high-resolution close-range sensing with a 180° × 180° field and the ability to detect objects as close as 0.1 m.

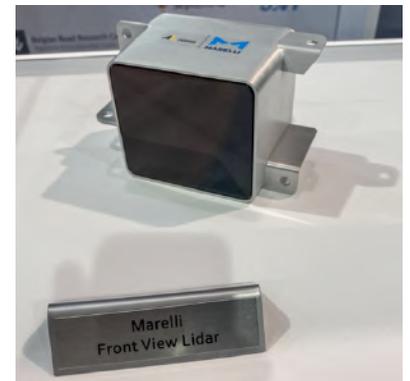


## Xenomatix



Xenomatix's show space reflected their newly-announced coöperation agreement with Marelli. Hardware from both companies was on display, including Marelli front-view lidar, long- and short-range XenoLidar units, and the incredibly compact X-module in its series-production form.

Xenomatix will provide Marelli's Automotive Lighting division with "true solid state lidar" modules for ADAS and AD applications. AL and Xenomatix will combine competencies and technologies to offer modular lidar system solutions to meet future global automotive needs, also leveraging the artificial intelligence perception technology springing from Smart Me Up, the French startup acquired by Marelli in 2018.



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### **27 Car Makers**

Audi, Germany  
Bentley, UK  
BMW, Germany  
Changan Design Center, Italy  
FCA, USA  
Daimler, Germany  
Ford, Germany  
GM, USA  
Great Wall, China  
Harley-Davidson, USA  
Honda, Japan, USA  
Hyundai, Korea, Europe  
Jaguar-Land Rover, UK  
Mahindra Mahindra, India  
Nio, China  
Nissan, Japan, Europe, USA  
Opel, Germany  
Porsche, Germany  
PSA, France  
Renault, France  
SAIC TC UK  
Shanghai-Volkswagen, China  
Seat, Spain  
Skoda, Czechia  
Toyota, Japan, Europe, USA  
Volkswagen, Germany  
Volvo Cars, Sweden

### **19 Univ., labs, Consultants**

FEP, Franhauser, Germany  
Darmstadt university, Germany  
DEKRA laboratory, Nederland  
Fudan university, China  
GranStudio, Italy  
Hannover Leibniz Univ.(HOT), Germ.  
Institut d'Optique Graduate School, Fr.  
Karlsruhe Lighting Institute, Germany  
LAB, France  
Light Sight Safety, Belgium  
Nuremberg university, Germany  
Pacific Insight, USA  
Parma university, Italy  
Rensselaer university, USA  
UMTRI, USA  
University of California, Santa Barbara  
YoungNam University, South Korea  
Mr Shunxing Wang, China  
John Peek- Soraa

### **38 Set Makers**

AL, Germany, USA  
Auer Lighting, Germany  
Denso, Japan  
Elba, Romania  
Farba, Turkey  
FIEM Industries, India  
Flex'N'gate, USA  
Grote, USA  
Harbin Good Time, China  
Hella, Germany  
Hyundai IHL, Korea  
Ichikoh, Japan  
J.W. Speaker, USA  
Koito, Japan, Europe  
Lear, USA, Europe  
Lite-On, Taiwan  
Lumax, India  
Magna, USA, Austria  
Microlight Auto Parts, Taiwan  
Mobis, Korea  
NAL, USA  
Neolite ZKW, India  
Nordic Lights, Finland  
Odelo, Germany  
Olsa, Italy  
Plastic Omnium, France  
Peterson, USA  
Shanghai Koito, China  
SL Corporation, Korea  
Stanley, Japan  
Truck-Lite, USA  
Valeo, France, Spain, China  
Varroc, Germany  
Wipac, UK  
Xingyu, China  
ZF-TRW  
ZKW, Austria  
Zodiac, France

### **51 Lighting Suppliers**

A2Mac1, France  
AML Systems, France  
Anrui Opto, China  
Astron-Fiamm, France  
Auer-lighting, Germany  
Bicomoptics, China  
Bühler Alzenau, Germany  
Covestro, US, China, Europe  
DBM Reflex, Canada  
Delvis, Germany  
Docter Optics, Germany  
Elmos, Germany  
Enmech-Mektec, Germany  
Everlight Electronic, Taiwan, Germany  
GXC Coatings, Germany  
Hitachi, Japan  
Holophane, France  
IAV, Germany, USA  
Infineon, Germany  
Innotec Group, USA  
Instrument Systems, Germany  
Jenoptik, Germany  
Keboda, China  
LG Innotek, South Korea  
LG Electronics, South Korea  
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Lumileds, Nederlands  
Merck, Germany  
Mentor Graphics, Europe, USA  
Myotek Industries, USA  
Nalux, Japan  
Nichia, Japan  
NXP, UK  
ON Semiconductor, Europe, Asia, USA  
Optis, France  
Optoflux, Germany  
Osram, Germany  
Oxyphen, Switzerland  
Panasonic, Japan  
Proper Group, USA  
Sabic, USA  
Samsung LED, Germany  
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