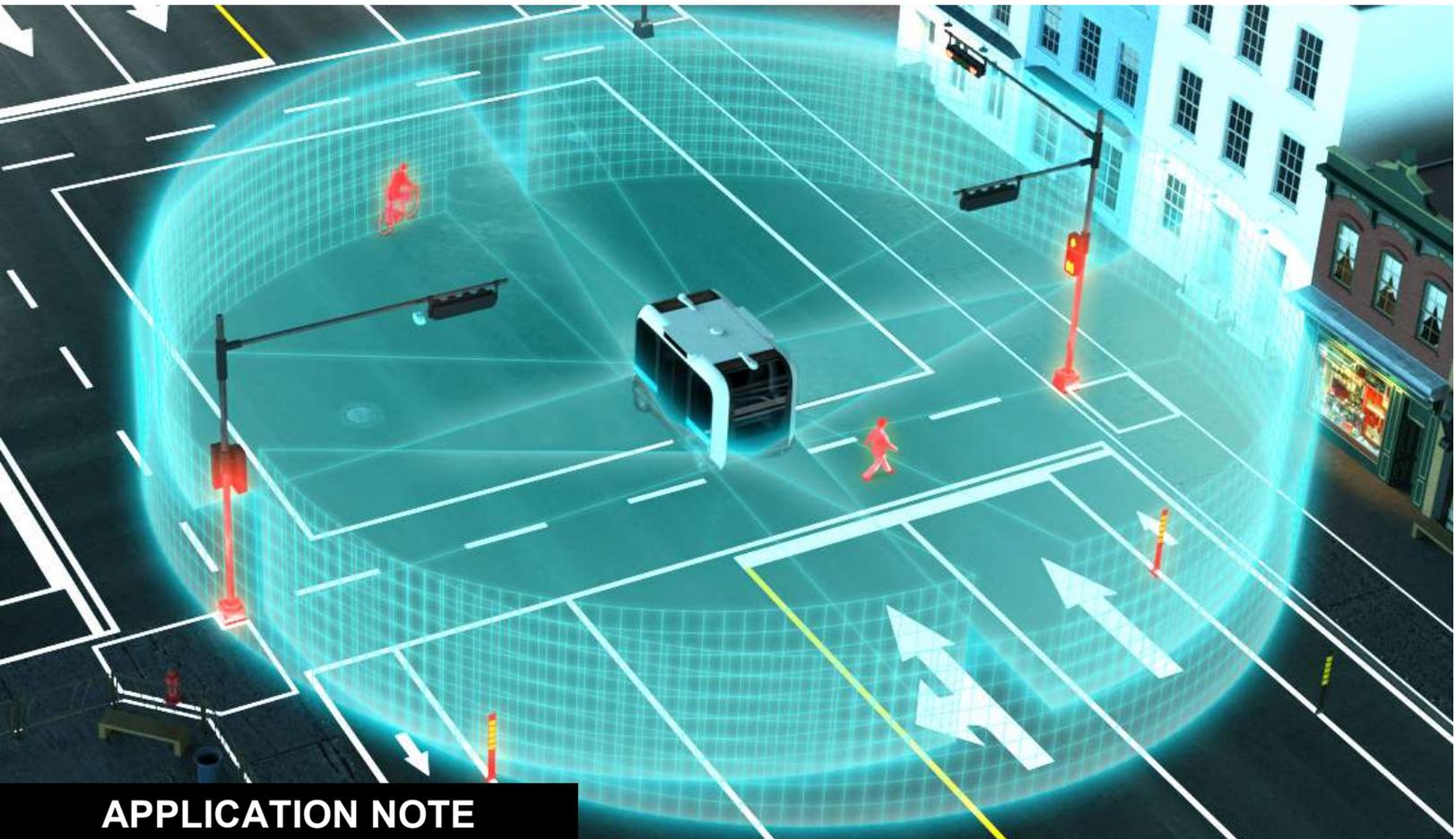


HOW 3D LIDAR DEPLOYMENT IN ADAS APPLICATIONS ENHANCES VULNERABLE ROAD USER DETECTION



APPLICATION NOTE

ABSTRACT

The technological progress made in passenger cars, buses, shuttles, trucks, and robotaxis is a result of the incremental deployment of Advanced Driver-assistance System (ADAS) and Autonomous Driving (AD) applications. LiDAR technology is a critical component deployed in a variety of automotive and mobility applications worldwide. Since its original inception over ten years ago, LiDAR has been in a constant state of evolution: Research and development into the technology have allowed us to achieve better performance, lower costs, and improved form-factors.

Vehicle manufacturers today require such technologies to be readily available, scalable and designed according to their specifications. The recent availability of LiDAR as a viable, usable technology that can be deployed according to these requirements makes it an ideal solution to fulfill the immediate needs of ADAS/AD applications.

LiDAR technology offers many advantages for ADAS and AD as a complement to other sensing technologies. Firstly, LiDARs do not have any performance degradations during the night or in lower visibility conditions. Additionally, LiDAR is the sensing technology that provides the most distance accuracy to position objects. These overall benefits are ideal for automotive applications, where vehicle speeds rise to elevated levels. Furthermore, LiDARs offer the same sensitivity performance across both high-speed and low-speed targets, making it adaptable across changing environments such as highway roads and urban centers.

This application note will dive into one of the most important use cases in ADAS; Vulnerable Road User (VRU) Detection. Collisions between VRUs and vehicles are the type of accidents causing 50% of the road traffic fatalities in the world every year¹. Driver-assistance systems are already used in the automotive market, but their requirements are evolving. This evolution is resulting in the definition of standards and regulations with deeper concerns towards safety. These new standards will be studied in accordance with the main challenging use cases to define the performances of sensors required to comply with those standards and regulations. Finally, the application note will address the benefits of a comprehensive solid-state 3D flash LiDAR solution to address this evolution in safety requirements for ADAS and VRU detection.

STANDARDS AND REGULATION ANALYSIS

EURO NCAP AEB VRU DETECTION FOR PASSENGER CARS

The European New Car Assessment Program (*Euro NCAP*) is an organization managing a car safety program for new automotive design. This organization does not manage or establish regulation in any way, but it advises the public on the safety of newly released vehicles, based on established criteria and scenarios. The five-star system created by the program helps consumers easily compare vehicles, based on a series of tests. The tests protocols are based on real-life scenarios of challenging and risky situations, tested in a simplified way. The better a vehicle model performs in a test, the more stars it gets for this specific attribute. The star rankings from Euro NCAP have a lot of credibility in the automotive market and can influence customers in their purchasing choices².

There are many organizations similar to Euro NCAP that have oversight in other regions of the world, such as Japan, Australia, United States, China, and more. Additionally, there are other independent non-profit organizations actively working on road safety protocols, such as the Insurance Institute for Highway Safety (*IIHS*), based in the United States. Finally, federal organizations

such as the National Highway Traffic Safety Administration (*NHTSA*) in the United States help draft the necessary legislation to address this issue. In this application note, the Euro NCAP protocols, known for its strict success criteria and its extensive documentation, will be used as a reference.

The Euro NCAP defines a specific test protocol for the detection of VRUs, associated with a vehicle function called Automated Emergency Braking (AEB). This function is available in vehicles for many years now, but the success criteria from Euro NCAP is in constant evolution. The analysis made in this application note is based on the newest version of the AEB VRUs detection test protocol v.3.0.1 that will be coming into effect in January 2020³.

Different scenarios are described for collision avoidance between a vehicle and a pedestrian or cyclist in specific situations. To evaluate the minimum viable performance of a LiDAR sensor required to complete all the scenarios, only the ones presenting the worst-cases were analyzed in detail:

1. A cyclist crossing the road at 20 km/h (CBFA);
2. A running pedestrian crossing the road 8 km/h (CPFA-50);
3. Vehicle turning at an intersection while the pedestrian is crossing the road (CPTA).

The first two scenarios present the worst-case in terms of the range of detection required, with a maximum speed of the vehicle at 60 km/h and the target speeds stated above. The Euro NCAP scenarios do not indicate the range of detection needed to pass the test, but with the speeds of each actor and the calculation of the stopping distance of the vehicle, the minimum range required can be estimated.

$$\text{Stopping distance} = R.\text{time} \cdot V.\text{speed} + \frac{(V.\text{Speed})^2}{2 \cdot \text{Dec}}$$

→ V.speed = Vehicle speed in m/s = 60 km/h → 16.7 m/s

Example of average parameters (might vary by vehicle model and AEB system):

→ R.time = Reaction time of AEB system in s = 0.5 second⁴

→ Dec = Deceleration in m/s² = 7 m/s²⁵

From there, it was calculated for scenario 1 and 2 in Figure 1 that the range of detection required on the cyclist and the pedestrian is 33 meters and 28 meters, respectively. The value depends on the position of the target from the side of the road.

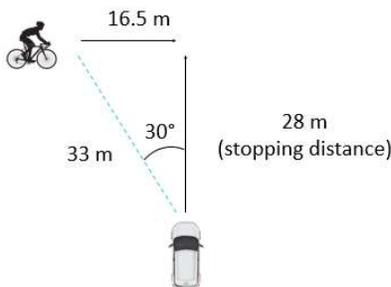


Figure 1. Range of detection and (FoV) required by a cyclist, based on the values from Euro NCAP in scenario CBFA, 3 seconds before the collision.

For scenario 3, the minimum horizontal Field of View (FoV) was calculated based on the position of the vehicle on the road and the type of intersection considered. The

result showed that a field of view of at least 80° is required to complete this scenario, as represented in Figure 2 successfully.

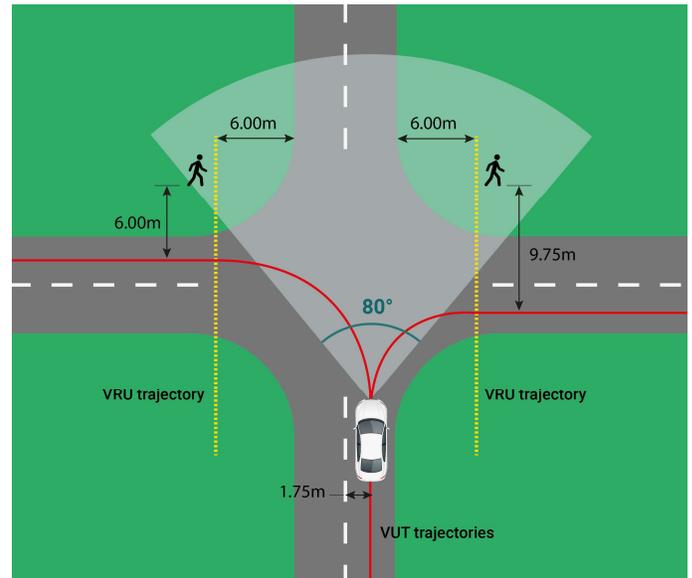


Figure 2. CPTA scenario reproduction of a vehicle turning at an intersection while a pedestrian crosses the street.

Even if the scenarios from Euro NCAP require quite narrow to medium horizontal FoV, real-life scenarios can be much more challenging. For example, a car stopped at an intersection with a bicycle crossing the intersection would demand a FoV wider than 160°, as illustrated in Figure 3. Euro NCAP does not cover all the use cases that may require wider FoV, such as the one illustrated below, where a FoV of at least 160° is needed. These types of use cases also need to be taken into consideration for safety purposes when developing ADAS features.

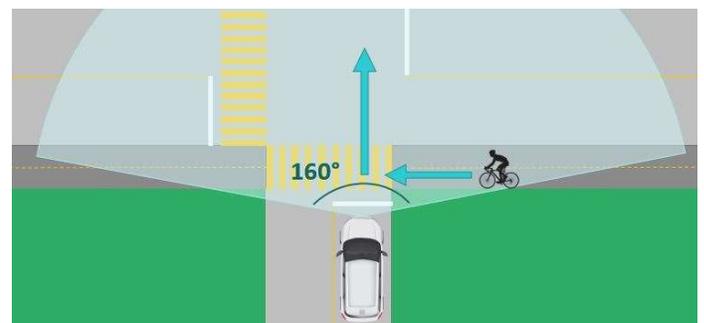


Figure 3. A Bicycle is crossing an intersection while a vehicle is stopped, requiring at least 160° FoV for detection.

UNECE REGULATION FOR COMMERCIAL VEHICLES

The United Nations (UN) is a worldwide organization, comprised of 5 regional commissions, subdivided into many working groups for different purposes. One of its regional commissions, the Economic Commission for Europe (ECE) has been acting on cross-border harmonization and technical regulation since the agreement was signed in 1958⁶. The agreement now contains more than 150 regulations on wheeled vehicles, from which the European Union (EU) and many other countries must all apply harmoniously, for a total of 51 countries⁷.

In recent years, UNECE has been focusing on the safety of the vehicle occupant, but also on VRUs. One of the main areas of concerns is the collision between trucks turning right and cyclists continuing in their lane, which results in accidents with serious consequences. Over the years, many regulations have been drawn up to try and reduce the numbers of accidents. For example, wider mirrors and underrun protection have been implemented in commercial vehicles. However, these methods fall short of eliminating or significantly reducing the problem.

Driver-assistance systems have been part of a new regulation to reduce the numbers of accidents between large vehicles that are turning and the cyclists in their vicinity. The main objective is to standardize on a sensing system that can warn the driver before a collision; early enough to leave the driver with enough time to adjust its maneuvering. This new regulation, referred to as the Blind Spot Information System (*BSIS*) for the Detection of Bicycles, was approved and adopted in March 2019 and will be implemented on the new model cycle of vehicles (i.e., redesigned) by May 2022, and on all new vehicles by May 2024⁸. The vehicles targeted by this regulation are class N2 and N3, which represent motor vehicles with at least four wheels designed and constructed for the carriage of goods, with a weight of more than 3.5 tonnes⁹.

Because it is a warning system, the sensor needs to be able to detect a potential collision much earlier than a driver would, since the driver's reaction time is based on their understanding of the whereabouts of the danger and the time required to adjust maneuvering to avoid a potential collision.

The documentation regarding the regulation clearly explains the critical scenarios, with the context and the parameters, to be able to reproduce the scenarios and satisfy certain success criteria. The maximum speed of the vehicle considered for this regulation is 30 km/h, with a deceleration capability of 5 m/s² and the driver's reaction time to be 1.4 seconds. There are two types of scenarios measured: dynamic and static.

These values, paired with the parameters from the dynamic and static scenarios, can be analyzed to deduce the range of detection required on the cyclist to warn the driver safely within an adequate margin of time. The worst-case scenarios that are the most demanding in terms of the range are as follow, in Figure 4 and Figure 5:

1. Vehicle at high-speed (20 km/h) with bicycle at low-speed (10 km/h) in front of the vehicle.

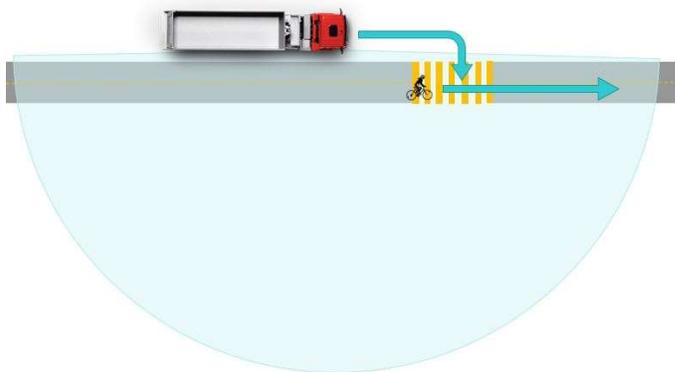


Figure 4. Example of the dynamic critical scenario considered in the BSIS regulation for detection of bicycles.

- Vehicle at low-speed (10 km/h) with bicycle at high-speed (20 km/h) coming from behind the vehicle.

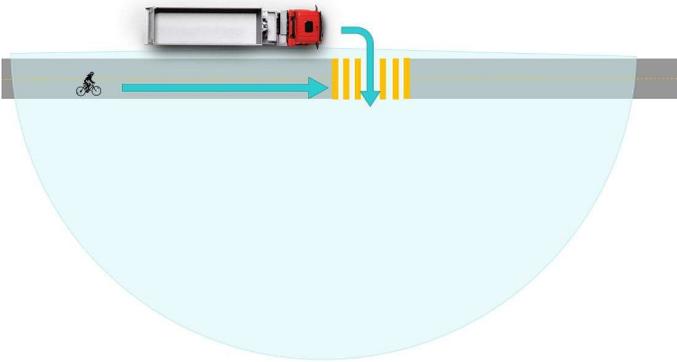


Figure 5. Example of the dynamic critical scenario considered in the BSIS regulation for detection of bicycles.

Considering these scenarios, Figure 6 below illustrates the inclusive coverage of the BSIS, where the warning must be given to the driver before - or while entering - the blue zone. The detection range on the bicycle is deduced from parameters given by the UNECE protocol, in the worst-cases scenarios. The maximum range required is for the rear detection, with 30 meters of range, while front detection is required up to 8 meters. The UNECE regulation for BSIS requires that the driver-assistance system only monitor one side of the truck – the right side in countries where vehicles drive on the right side of the road, and the left side where vehicles drive on the left. The side of the truck that needs to be monitored requires a full 180° coverage, as the scenarios that the driver-assistance system needs to comply with are designed for cyclists positioned in the rear, the side, and the front of the truck.

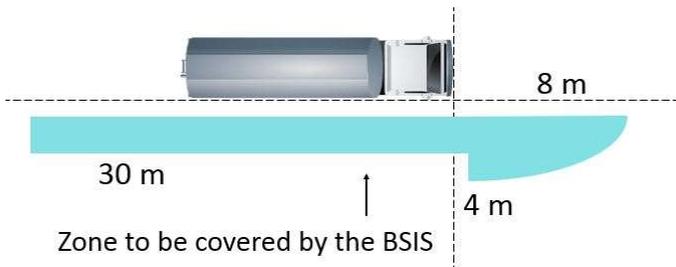


Figure 6. Coverage required to pass the test protocol form UNECE

This regulation from UNECE currently only targets a warning system. However, this warning might transform into an active system as we look ahead and anticipate the progress made in the needs of the market and its associated regulation. This change would necessitate more safety and redundancy within the system, with a very limited amount of false positive or false negative determinations to be tolerated.

LIDAR FULFILLS A CRITICAL NEED IN VRU DETECTION

The actual and future technological requirements for ADAS/AD applications to address critical driver and VRU safety needs have resulted in the proliferation of new alternatives. LiDAR technology offers many advantages as a complement to other sensing technologies. Overall, they do not have any performance degradations during the night or in lower visibility conditions. Additionally, LiDAR is the sensing technology that provides the most distance accuracy to position objects. Given these benefits, LiDAR most likely represents the most compelling sensing solution to address safety concerns.

LEDDARTECH'S 3D FLASH LIDAR SOLUTION ADVANTAGES FOR VRU DETECTION

LeddarTech® is an established LiDAR supplier that drives the automotive and mobility market forward with a comprehensive solid-state 3D flash LiDAR solution to address the evolution in safety requirements.

Its new 3D LiDAR sensor has a wide field of view coverage of 180°x16°. This wide FoV answers the needs of applications requiring wide coverage such as AEB, cross-traffic detection, blind spot detection, parking assist, and 360° cocoon detection at close range (with the use of at least two sensors).

This LiDAR sensor's sturdy design provides a high *MTBF* (mean time between failure), a result of its complete solid-state design with no moving parts, unlike mechanical scanning LiDARs. Housed in an IP67 enclosure with impact-resistant windows and auto-grade connectors, the sensor is road-ready and is qualified for operations in a wide range of temperature.

Using flash LiDAR technology, the sensor delivers full-surface illumination for complete coverage of the scene with no blind spots and zero dead zones, even for objects near the sensor.

Its range of detection of a pedestrian and a bicycle is beyond 30 meters and 50 meters, respectively. This detection capability complies with even the worst cases previously covered in this paper.

3D flash LiDARs offer many advantages compared to 2D LiDARs. This third dimension brings critical, incremental information to the shape of an object: The vertical illumination of the scene aids in the determination of the height of detected objects in the environment, while also supporting object classification.

The resolution, range, and field of view of LeddarTech's new 3D flash LiDAR solution makes it an ideal fit to comply with the Euro NCAP AEB VRU detection criteria, and the BSIS for Detection of Bicycles regulation from the UNECE.

Compatibility with these important industry standards and regulations is what is driving LeddarTech's 3D LiDAR solution forward for ADAS and AD deployments in passenger cars, shuttles, buses, trucks, and robotaxis.

For more information about LeddarTech's 3D LiDAR solutions for automotive and mobility applications, visit [LeddarTech.com](https://www.ledartech.com) or contact a [LeddarTech Representative](#).

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¹ World Health Organization (2015a). Road traffic injuries. Media Centre: fact sheet no. 358. <https://www.who.int/en/news-room/fact-sheets/detail/road-traffic-injuries>

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