Using 3D Flash LiDAR for Collision Avoidance Applications in Commercial and Industrial Vehicles

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The recent trend of deploying advanced driver-assistance systems (ADAS) in vehicles is not only affecting the passenger car industry, but also commercial and industrial vehicles as well. However, these types of vehicles are used in applications that are different from passenger cars, are often deployed in different environments and come with their own unique sets of requirements. This application note aims to provide some specific insights on the subject through the use case of Blind Spot Information System for the detection of bicycles.

Market overview

Commercial vehicles

Large vehicles driven on public roads (i.e. buses, tractor-trailers, dump trucks, etc.) can significantly benefit from new advanced driver-assistance systems (ADAS) and active safety features that support drivers 24/7, making the roads safer for all. Such systems require highly efficient, versatile sensor technology that can cover all key areas around the vehicle. They must provide enough range, a large field-of-view, and a reliable detection of vehicles, pedestrians, and obstacles in any environmental conditions. These vehicles have significant blind spots, amplified by their height and size. They are also at significant risk of forward collisions, as a loaded truck takes 20-40 percent farther than cars to stop—and even longer in wet conditions. Reduced overhead clearance also increases the occurrence of collisions with structures and overpasses.

Furthermore, emerging automated driving solutions such as automated delivery vehicles and truck platooning are considered as a way of increasing efficiency and reducing the cost of transporting and delivering goods over short and long distances. These specific applications also benefit from ADAS and other active safety features.

Industrial vehicles

Operators of industrial vehicles and heavy machinery (such as haul trucks, loaders, bulldozers, etc.) must accomplish complex tasks in challenging environments. They are facing the constant challenge of keeping track of all activities and obstacles around the vehicles, in addition to dealing with significant blind spots. Multiple sources of distraction may temporarily affect the attention of even the most experienced driver. Despite existing safety measures, accidents involving heavy machinery remain a serious issue in many industrial sectors, such as construction, road works, mining, quarries, freight, and warehousing.

Proximity detection alerts and collision avoidance systems, which generate warning signals and can stop the vehicle's movement, are part of the ongoing efforts to improve industrial vehicle safety and automation. Tag-based systems (such as RFID) that are installed on vehicles and worn by workers in controlled environments may help indicate the presence within a certain area around the vehicle or warn of incoming traffic. On-board cameras are also used to provide up to 360-degree vision to operators and to cover blind spots. Such solutions alone do not cover all risk scenarios, as non-tagged objects, people, and vehicles may not be detected, and cameras also have their limitations. Moreover, since the operator's attention cannot be constantly shifting between the task at hand and multiple screens, additional safety issues arise.

Market requirement example: UNECE Regulation for Commercial Vehicles - Blind Spot Information System for the Detection of Bicycles

The United Nations Economic Commission for Europe's (UNECE) main purpose is to promote greater economic integration and cooperation through its 56 member states in Europe, North America and Asia. One of its activities is to set out norms, standards and conventions.

In recent years, UNECE has been focusing on the safety of, not only the vehicle occupant, but also on Vulnerable Road Users (VRUs). Driver-assistance systems have been part of a new regulation to reduce the number of accidents between large vehicles that are turning and 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 2024[1]. 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 tonnes[2].

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 1.4s. 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 required to detect a cyclist and to warn the driver within an adequate margin of time to take corrective action. The worst-case scenarios that are the most demanding in terms of the range are as follow, in Figure 1 and Figure 2:

Figure 1 - Example scenario: Vehicle at 20 km/h with bicycle at 10 km/h in front of the vehicle

[1] "177th session", *Unece.org*, 2019. [Online]. Available: https://www.unece.org/fileadmin/DAM/trans/doc/2019/wp29/ECE-TRANS-WP.29-1145e.pdf. [Accessed: 17- Jun- 2019].

[2] "Definition of vehicle categories", *Vehicle-certification-agency.gov.uk*, 2019. [Online]. Available: https://www.vehicle-certification-agency.gov.uk/vehicletype/definition-of-vehicle-categories.asp. [Accessed: 17- Jun- 2019]

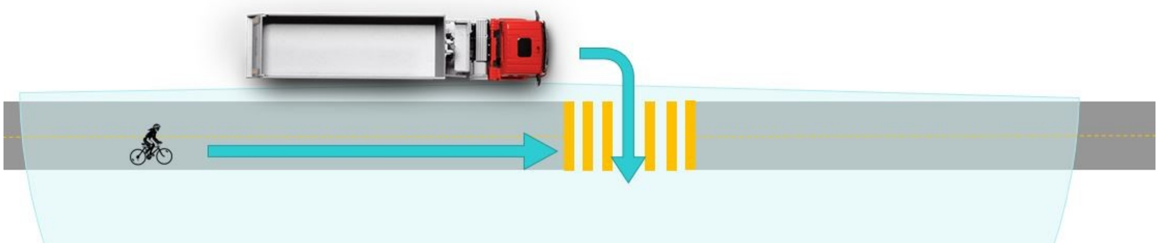
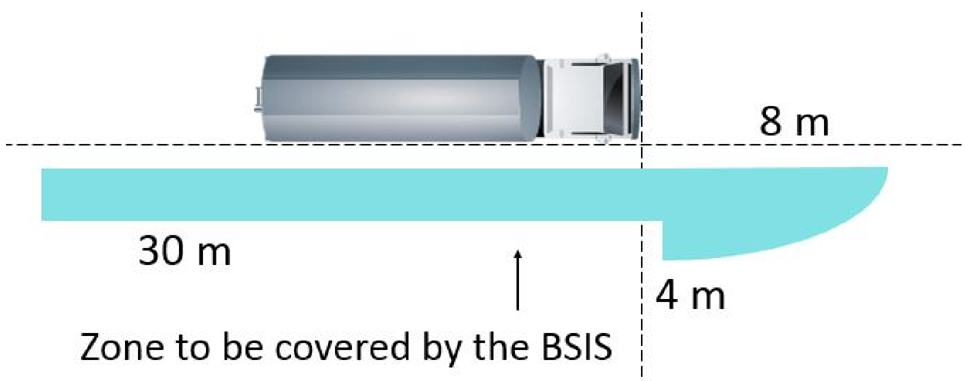


Figure 2 - Example scenario: Vehicle at 10 km/h with bicycle at 20 km/h coming from behind the vehicle

Considering these scenarios, Figure 3 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 of the bicycle is deduced from parameters given by the UNECE protocol, in the worst-case 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 3 - Coverage required to pass the test protocol from 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.

Leveraging the latest advancements in 3D Flash LiDARs

Commercial and industrial vehicles of all types can greatly benefit from active safety features. Integrating advanced solid-state LiDAR sensors into vehicles improves spatial awareness and obstacle detection up to 360° around the vehicle. An active sensing solution based on 3D flash LiDARs contributes to the efficient detection and location of vehicles, objects, structures or people when drivers, operators or other detection systems fall short.

Implementing 3D Flash LiDAR sensing capabilities on large vehicles assists drivers with enhanced situational awareness and enables active safety features, such as:

- Collision avoidance/warning
- Blind-spot monitoring/Lane change assistance
- Overhead clearance alert
- Cross-traffic alert
- Perimeter monitoring
- Navigation in tight quarters and low visibility conditions
- Underground mining operations
- Vehicle automation and guidance

The result of years of focused R&D, Leddar is an innovative, cost-effective Lidar technology which can contribute to the significant reduction of the occurrence of incidents involving large commercial or industrial vehicles. By digitizing full signal waveforms and processing them through advanced proprietary algorithms, Leddar technology provides higher sensitivity and increased detection range, delivering an unbeatable cost-performance ratio for commercial and industrial vehicle applications.

Among the unique benefits of 3D flash LiDARs based on Leddar are robust detection in adverse environmental conditions, immunity to ambient light for reliable day and night performance, rapid acquisition rate, and large illumination area. They also provide redundant sensing functions when deployed as part of a sensor fusion system.

Unlike scanning laser technologies, a 3D flash LiDAR sensor can fully illuminate a wide field of view (FOV) at once without any moving parts. This simple, robust design translates into long-term reliability and high MTBF (mean time between failure). Leddar optical sensing also provides more effective detection capabilities than radio wave technologies (radar) for still objects, pedestrians, structures and surfaces as well as a wide range of materials.

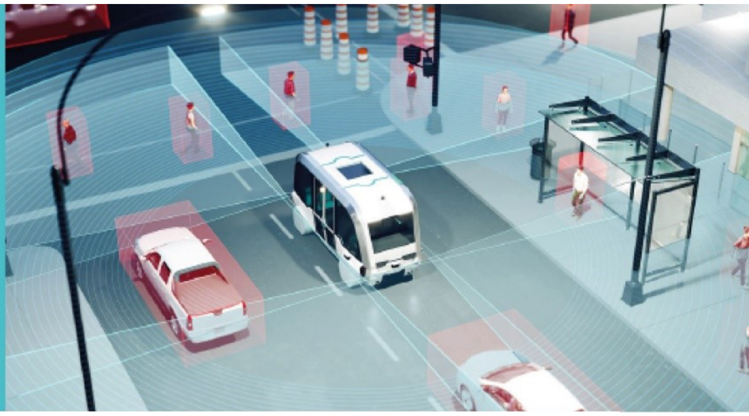
Product Focus: Leddar Pixell

LeddarTech developed the Leddar™ Pixell "cocoon LiDAR" specifically to meet the requirements for vulnerable road user detection in a vehicle's surroundings. This road-ready solid-state 3D flash LiDAR sensor has a wide field of view coverage of 180° x 16° that provides highly reliable detection of pedestrians, cyclists and other obstacles in the vehicle's vicinity and is optimized for use in perception platforms that are meant to improve the safety and protection of vulnerable road users.

Key features include:

- 96 horizontal and 8 vertical segments providing 768 independent surfaces with simultaneous acquisitions
- 3D flash illumination technology providing 100% scene coverage
- Pedestrian detection range of up to 32 meters
- 100% solid-state, vibration and shock-resistant
- IP67 enclosure with impact-resistant windows and automotive-grade connectors
- Wide operating temperature range (-30°C to +65°C)
- Compliant to IEC 600068-2-6 (vibration resistance) and IEC 60068-2-27:2008-02 (shock resistance).

The Pixell has been designed using the state-of-the-art LCA2 LeddarEngine, the powerful LiDAR core for automotive and mobility applications leveraging LeddarTech's patented signal acquisition and processing and highly integrated LiDAR SoC.



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