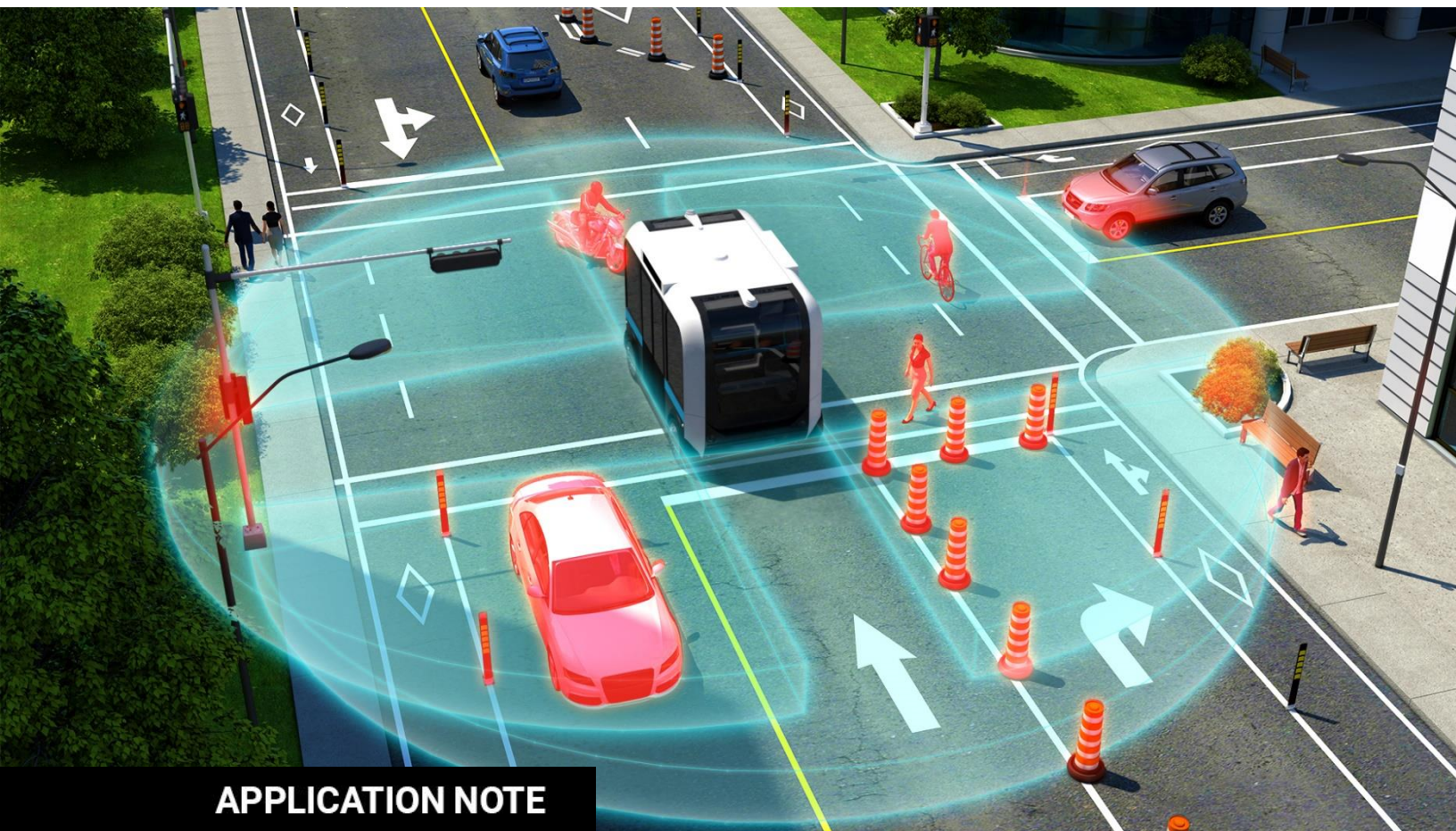


AUTONOMOUS SHUTTLES TURN TO 2D FLASH LIDAR TECHNOLOGY TO ELIMINATE BLIND SPOTS AND ENSURE ULTIMATE SECURITY



APPLICATION NOTE

The gradual shift towards autonomous vehicles is causing a ripple effect throughout the automotive industry as key vehicle manufacturers implement ADAS and autonomous driving capabilities into their vehicles at an accelerated pace. More and more test drives for fully autonomous passenger vehicles are underway. This application note explores the LiDAR technologies behind autonomous shuttles and presents the cost-effective solutions that are used to successfully address critical safety issues.

The Challenge

At the core of a typical, fully autonomous shuttle lies two essential central processing units (CPUs) that work in tandem to ensure complete collision avoidance and safety: the main navigation system CPU and the safety CPU.

The main navigation system CPU interfaces with one or a few LiDAR sensors that offer high ranges and high resolutions for localization, mapping and collision avoidance. Many autonomous shuttles today rely on a mechanical-scanning LiDAR sensor that is placed on top of the shuttle, which provides long-range detection and 360 degrees of coverage around the vehicle.

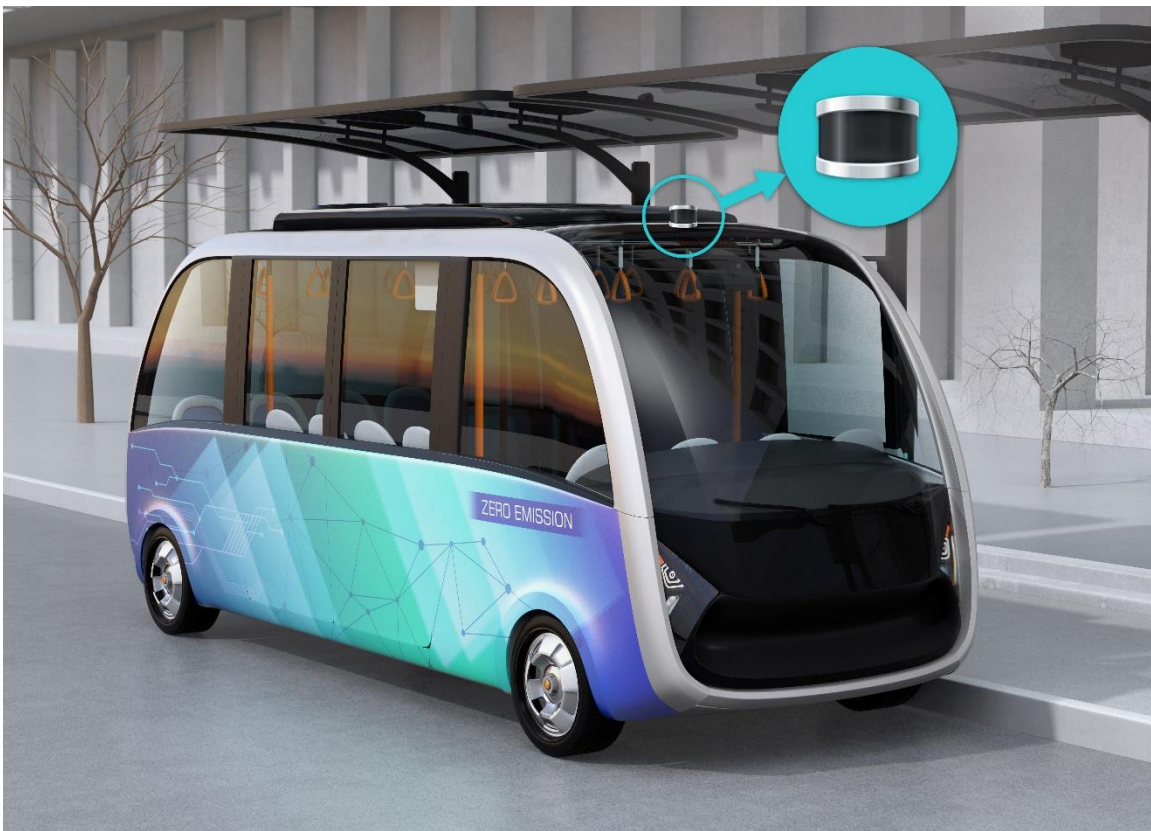


Figure 1. A mechanical scanning LiDAR sensor at the top of the shuttle.

However, due to the position of this mechanical-scanning LiDAR sensor on the shuttle, there is an area around the entire vehicle where objects cannot be detected; this creates a blind spot zone, as illustrated in Figures 2.

The radius of the blind spot zone varies in size depending on several factors, including the vertical field of view (FoV) of the mechanical-scanning LiDAR sensor, where it is placed on the vehicle, and the size and shape of the shuttle. However, it is worth noting that oftentimes, the mechanical-scanning LiDAR sensor is not configured to acquire close range data or positioned in an optimal way to completely cover 360 degrees, which causes additional blind spot zones around the shuttle.

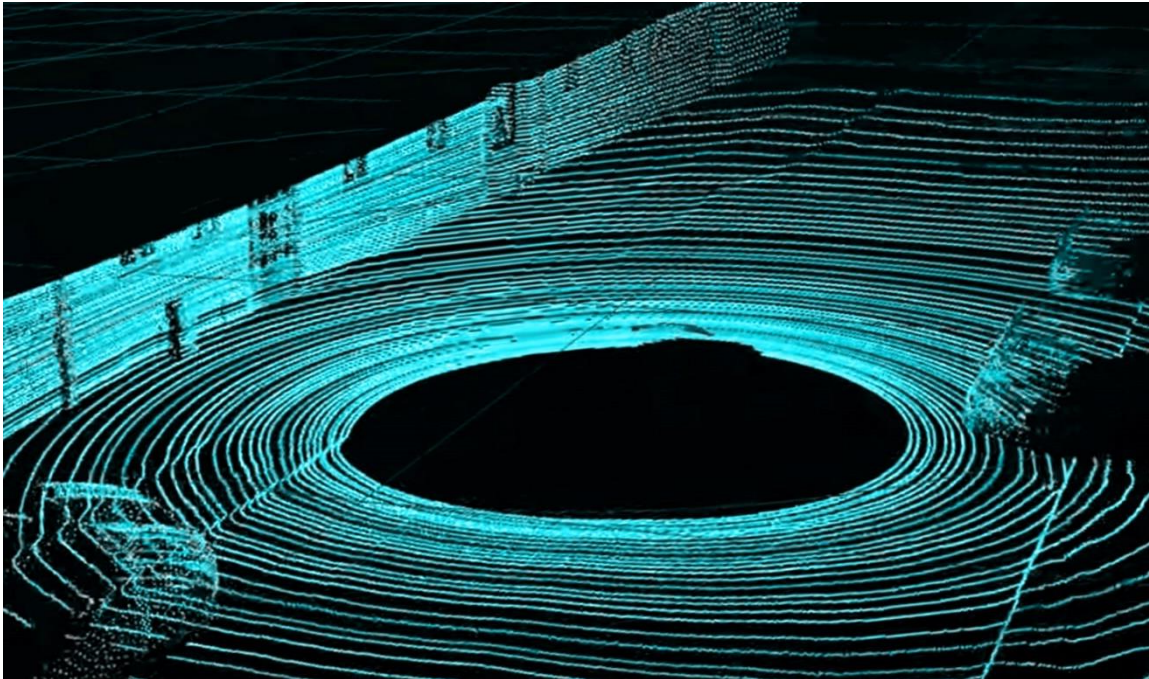


Figure 2. Mechanical-scanning LiDAR creating a blind spot around the vehicle.

Detecting the obstacles within the blind spot zone is critical to ensure safe and successful autonomous driving. When the vehicle is turned on, the shuttle cannot move if it has not detected its surroundings to confirm that there are no obstacles nearby. Furthermore, throughout the shuttle's run, in stop-and-go situations, the system needs to validate whether a person, vehicle or any other object is close before moving forward. For example, when picking up passengers, the system needs to confirm whether a person has successfully boarded the shuttle or if they are still in the blind spot zones. The same detection process is required for other objects located in the shuttle's blind spot zones, such as open car hatches, forklift forks, trailers, etc.

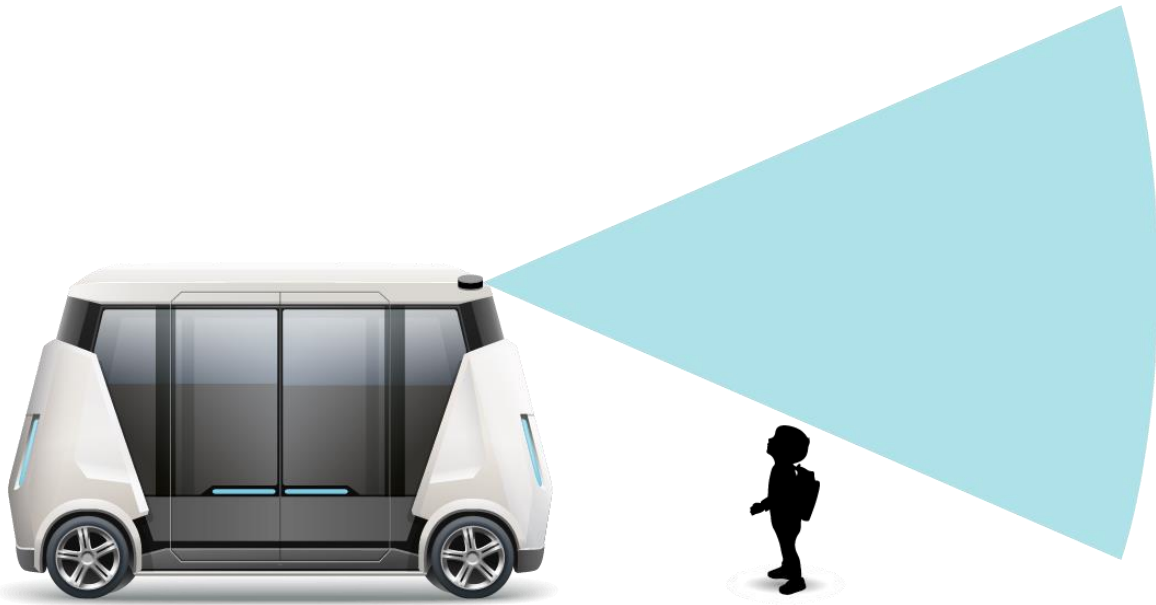


Figure 3. Having a blind spot zone could have disastrous consequences, as illustrated with an undetected child close to the vehicle.

This is where the safety CPU plays a key role in preventing the shuttle from moving or bringing it to a complete stop should a hazardous situation be detected. An integral part of the most recent autonomous shuttle designs, the safety CPU requires short- to mid-range collision-avoidance detection to bring the vehicle to a complete stop when the main navigation system is unable to identify an obstacle or fails.

The safety CPU is a low-power, redundant and cost-effective system that requires low data rates—but must nevertheless ensure complete coverage of its surroundings (360 degrees with full horizontal and vertical surface coverage). This poses a significant challenge as the need itself goes against the basic concepts of scanning in which more coverage by default means more data. For example, scanning LiDAR devices return anywhere from 600,000 to 2.2 million points per second, depending on the resolution and the number of vertical lines (16 to 64) that the selected sensor offers.

Looking for the Right Technology

To cover the blind spot zones that surround the shuttle, different detection technologies have been considered and tested (i.e., sonar, radar and camera solutions), yet each of these technologies presents considerable limitations:

- Sonar: Limited range and low resolution
- Radar: Permeable surface and static object detection issues
- Camera: Lack of range information and important weather degradation

Other solution criteria are equally as important. For one, since the solution will play a fundamental role in the safety CPU, it cannot send too much data to the system to avoid interfacing issues that may occur with data overload. The optimal data input for safety CPUs is estimated to be between 3,000 to 60,000 points per second for 360 degrees of coverage.

The technology must also offer a resolution that is high enough to detect small objects, enable precise trajectories and speeds by the implementation of tracking algorithms, and provide precise object positioning for effective avoidance decision-making.

Another important factor to consider is that the selected solution must have complete coverage of the field of view and offer a very high detection rate on all type of surfaces, which is critical in a security system that will be used to detect objects that may otherwise be missed by a low-resolution sensor.

Finally, data from the safety CPU will then be fed into the navigation CPU for redundancy purposes. Redundant sensors increase system performance levels, detection rates and robustness. What could potentially be missed by one sensor will be captured by another, thereby significantly increasing the system's performance and ensure a safe operation, which is of paramount importance in fully autonomous applications involving multiple passengers.

The Solution with the Right Performance-to-cost Ratio and Safety Levels

Based on these requirements and inherent sensor technology limitations, many shuttle developers turn to solid-state Flash LiDARs to eliminate the blind spots around the shuttle. Flash LiDARs provide highly reliable short-range detection at a much lower cost and mean-time-between-failures (MTBFs) than mechanical scanning LiDARs as well as offer 100% light density and complete coverage of the field of view. Data provided by Flash LiDARs enables object tracking at high measurement rates of up to 100Hz to anticipate possible collision based on velocity, directionality and position—all while eliminating any possible dead zones around the vehicle.

When the main long-range detection system is unable to detect an object because of a failure or a false negative, a LiDAR solution offers the range needed to be a redundant braking and collision avoidance system that respects maximum deceleration rate, especially at the maximum cruising speeds of many typical shuttles.

In addition, if an object is detected in the close proximity of the vehicle, an emergency braking procedure will be activated. Moreover, a certain breaking distance is required in order to keep deceleration at a safe level for shuttle passengers, who oftentimes do not wear safety belts and often stand. For example, considering a 3.5 m/s^2 deceleration rate, a shuttle moving at the speed of 40 km/h would take 23 meters to stop, including a 0.5 second reaction time.

To provide sufficient range, many LiDAR solutions will require more powerful, expensive optics and laser sources. By optimizing signal processing on the software side through patented methods, LeddarTech's flash LiDAR technology is able to deliver the range and performance required at costs that make them highly attractive for commercial deployments in shuttle applications, such as emergency braking and blind zone monitoring.

The End Results

To ensure that all blind spot zones are covered, two main architecture types can be implemented using Leddar sensor modules. However, if shuttle manufacturers require other levels of resolution, range or coverage, options are available to adapt the modules or architecture, depending on the specific application. Therefore, fewer sensors may be needed if some blind spot zones are acceptable by the design team.

1. The first architecture provides short-range safety cocoon that covers all sides of the shuttle and eliminates the blind spot zone. To achieve this, eight Leddar M16-LSR LiDAR modules, which have a 100-degree horizontal field of view and range of 12 m (on low-reflectivity pedestrians), are installed directly into the body of the shuttle at a height of 20 to 75 cm from the ground to detect close objects that are small in height.

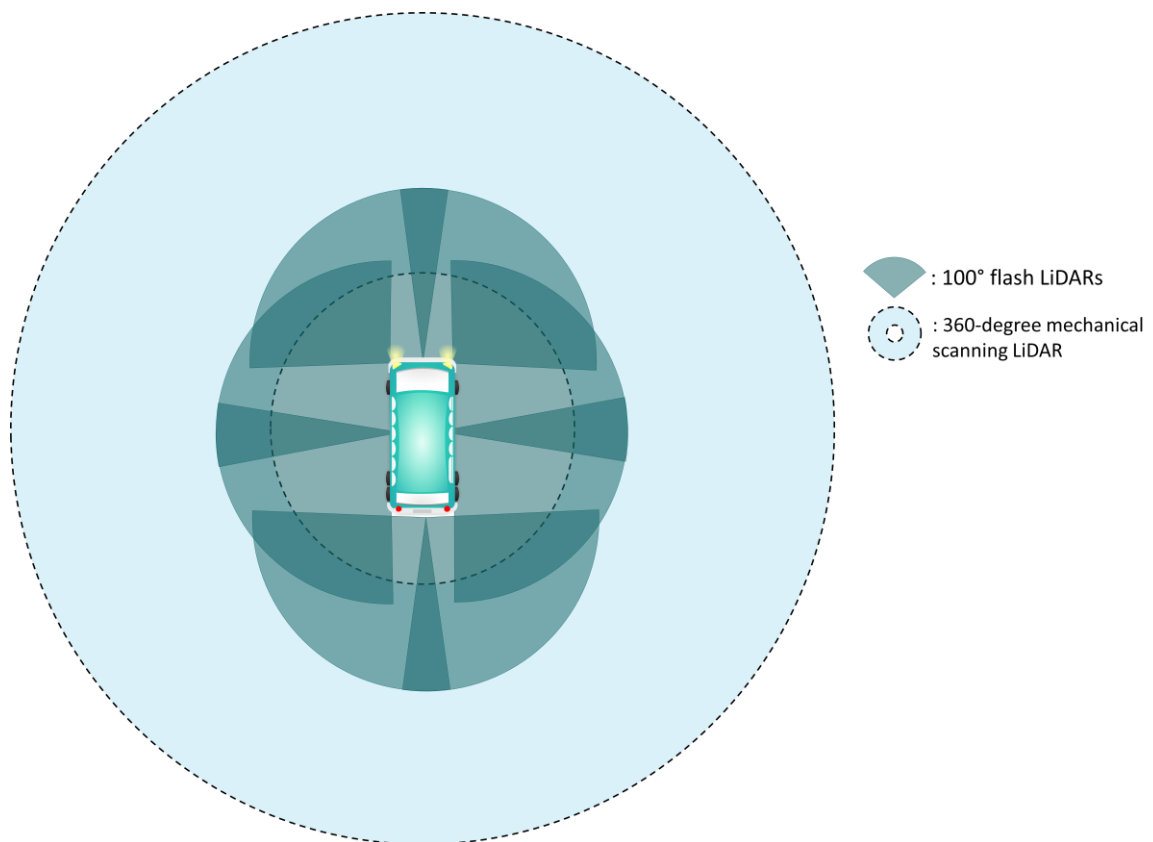


Figure 4. View of the short-range safety cocoon that the first sensor architecture offers.

2. The second architecture type uses short-range coverage on the sides and in the back of the shuttle with extended range in the front for a redundant collision avoidance system. To achieve this, five M16-LSR LiDAR modules with 100-degree FOV are placed on the sides and the back of the shuttle, while two LiDAR sensors that provide higher range and higher resolution, the M16-LSR LiDAR modules with 48-degree FOV and 30 m range on pedestrians, are placed in the front.

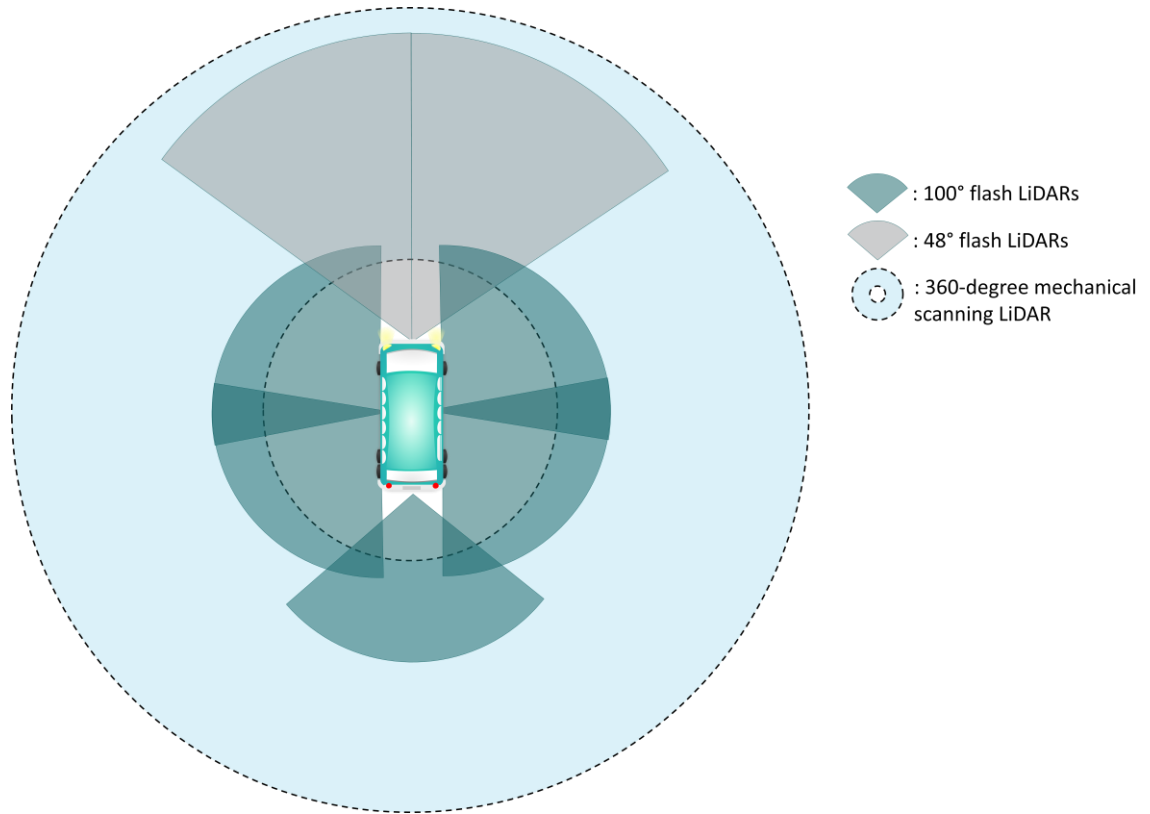


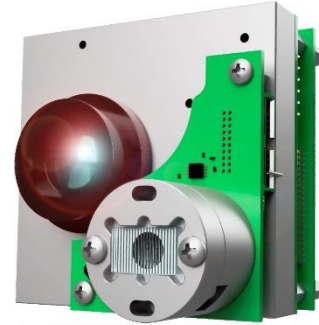
Figure 5. View of the short-range cocoon that the second sensor architecture offers, with a longer range at the front.

Enabling a Shuttle Safety Cocoon with LeddarTech Solid-state LiDAR Technology

Here is an overview of 2D Flash LiDAR solutions offered by LeddarTech and used by autonomous shuttle developers for safety cocoon and emergency breaking applications.

Leddar M16-LED and M16-LSR Modules

Leddar M16 modules are available in two main configuration types that based on illumination methods: the classic LED family and the new laser family. Both M16 families are perfectly suited to outdoor operation: they feature solid-state designs with no motorized mechanisms, wide operating temperature ranges, all-weather performance and immunity to lighting variations.



The M16-LED is the proven Leddar workhorse that clients have come to value for its versatility and reliability. This module's infrared LED light source provides wide-beam illumination at ranges up to 100 m and is offered in six different field-of-view configurations. M16-LSR uses a laser source to achieve even longer ranges and to provide narrower and better-defined vertical FOV—all in a smaller form factor than the M16-LED.

Key features and benefits include:

- Great angular resolution that enables tracking capabilities using 16 independent segments with simultaneous acquisition
- Various beam options for optimized fields of view (FOVs)
- Multitarget and lateral discrimination capabilities
- Up to 165 m detection range (541 ft.) FOV- and target-dependent (for the M16-LSR on a retro-reflective target)
- Rapid data acquisition time (up to 100 Hz)
- Blends in any vehicle configuration, thanks to various beam options

Refer to full specification sheet on www.leddartech.com

What Lies Ahead

Flash LiDAR technology is evolving at a rapid-fire pace. Newer, more powerful solutions are expected to become available, thanks to the intensive development of new LiDAR architectures and ongoing improvement in signal processing, which are driven by the requirements of mass market, high-volume applications. Inevitably, flash LiDAR technology will become even more cost-effective and offer performance levels that will be the driving force in completely replacing mechanical scanners in the coming years—as anticipated by experts in the automotive industry. Therefore, Flash LiDAR solutions, which are already leveraged by autonomous shuttles as part of the complete sensor suite, should play an even more central role as the next generations become widely available.

For more information on how upcoming 3D Solid-State Flash LiDARs, which are based on patented Leddar technology and available soon with superior range and resolution, will address advanced autonomous shuttle detection needs, please [contact a LeddarTech representative today](#).

