Wideye by AGC

Integrating a LiDAR unit behind IR-transparent glass in a B-pillar

A collaborative project between
Sony Depthsensing Solutions and Wideye by AGC.

USE CASE

CONTEXT

As the automotive market relentlessly evolves towards autonomous vehicles, safety is the number one concern for all passengers – hence the sensors installed all around the vehicle to deliver critical perception data. These sensors must be fully protected to ensure they remain effective and operational under all conditions, in all situations and regardless of the obstacles they have to detect – near or far, day or night. When integrating sensors into the vehicle, it is essential to aim for a reliable, high-performance solution that is also aesthetically pleasing.

The market has started adopting the B-pillar (see *Figure 1*) as the preferred location for the camera and radar sensors, but not yet for LiDAR sensors. This is an ideal location for ADAS and telematics functionalities, such as parking space detection, lane detection, facial recognition required for access control and more. For ADAS applications, installing the sensor on the side of the vehicle delivers multiple benefits:

- large FoV (field of view) thanks to its high and central location in the car;
- better protection for the sensor, including excellent scratch resistance;
- cost optimisation by merging ADAS and telematics applications;
- aesthetic design, since the sensors are concealed behind tinted glass and seamlessly embedded in the B-pillar.

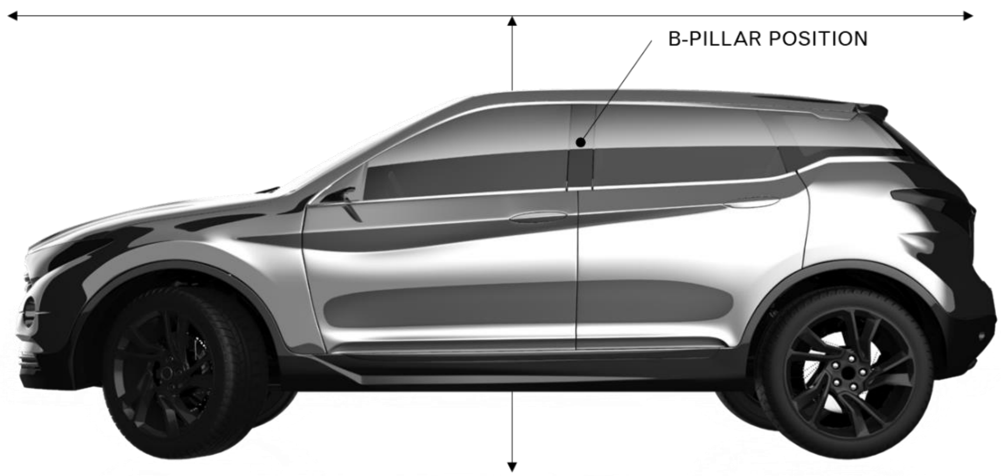


Figure 1 B-pillar location

Wideye and Sony Depthsensing Solutions joined forces on a project to integrate a LiDAR sensor in the B-pillar, ultimately developing a prototype that combines a Sony Depthsensing Solutions' sensor with Wideye glass.

The prototype had to comply with key technical specifications:

- optical performance: high resolution and large FoV;
- automotive quality: reliable in a vehicle environment under all driving conditions;
- form factor: product design suited to the existing B-pillar structure.

With those requirements in mind, Sony Depthsensing Solutions contributed a Time-of-Flight (ToF) camera which is a type of scanner-less LiDAR whose specifications were ideal for this use case, delivering high resolution, a wide FoV and a short detection range.

Wideye provided glass perfectly optimised for the ToF camera. The glass is transparent to infrared signals and can be assembled seamlessly and aesthetically into the B-pillar thanks to its glossy black appearance. One of the major benefits of Wideye glass over plastic solutions and other glass products on the market is its unique combination of excellent optical transmission and performance, robustness and reliability, all of which are necessary for this kind of exterior application.

METHODOLOGY

Wideye and Sony Depthsensing Solutions proceeded with a standard development workflow based on specifications, simulations, testing, design work and prototyping.

1. Performance test

Sony Depthsensing Solutions engineers carried out multiple performance tests in order to determine whether the infrared signals from the ToF camera of Sony Depthsensing Solutions could be correctly transmitted through Wideye glass. Additional in-depth tests were also carried out to determine the best position for the sensor relative to the glass surface.

In the first test, the engineers observed that due to scattering, more than two thirds of the infrared image was lost (see *Figure 2*). The scene was correctly illuminated but the depth data and 3D point cloud could not be properly computed.

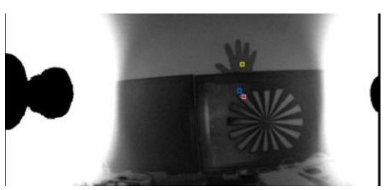
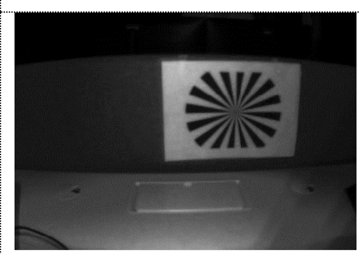
No glass	**Wideye** Clear Glass	**Wideye** Black Glass	**Wideye** Black Glass with Emitter & Receiver separated
			

Figure 2: Results of combining Wideye glass with the ToF sensor of Sony Depthsensing Solutions

After multiple trials, the engineers discovered that the optimal solution was to separate the emitter and receiver in order to prevent the receiver from blinding itself through the direct reflection of transmitted light.

2. Optical simulation

At the same time, Wideye built an optical model of the sensor from Sony Depthsensing Solutions to help engineers adjust and modify the design of the system, analyse the sensor's behaviour and assess the impact on various system parameters:

- Transmission: simulation of glass transmission at LiDAR operating wavelengths in both one-path (forward) and two-path (forward and backward). This transmission data allows to deduce LiDAR performance (e.g. maximum range). This helps the design work of following elements:
    - Glass: material, lamination, coating, installation angle, etc.
    - Integration: LiDAR position and orientation, FoV segmentation, etc.

- Distortion: simulation of both optical quality control methods (such as ISRA and wavefront deviation) and impact on LiDAR performance. This helps to properly define and check optical quality in the feasibility study, prototyping and mass production phases.

- Flare: simulation of flare, either directly from the glass surface or from inside the glass. This helps the engineers to design the ideal brackets, optical coupling/decoupling components and so on.

The optical model was validated by correlating the simulation results with the measurement data (see *Figure 3*).

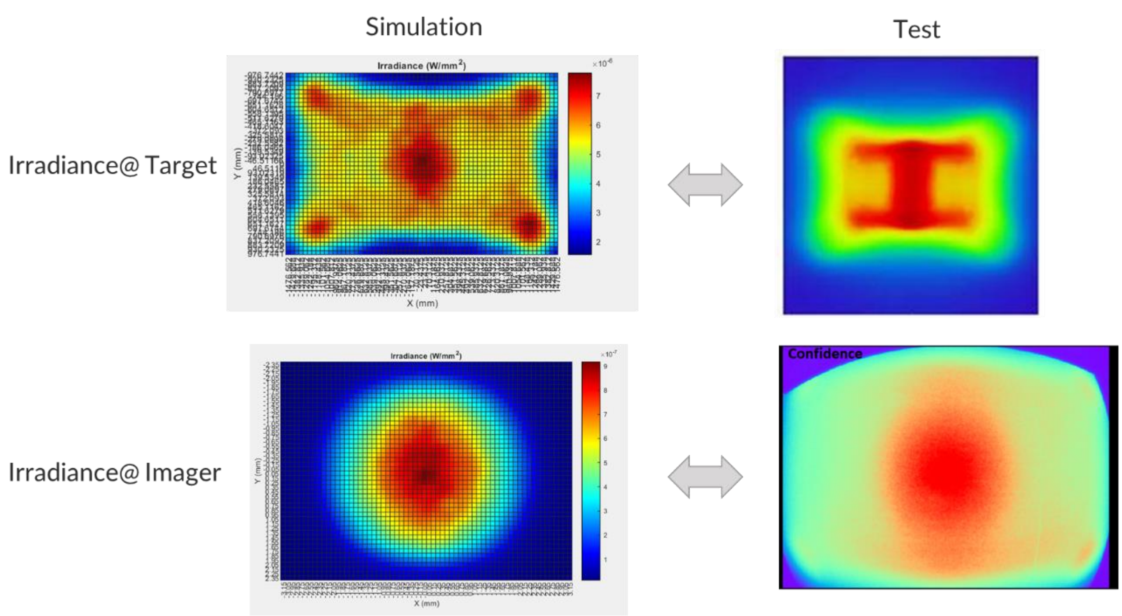


Figure 3: Correlation between simulations and test results

Multiple simulation tests made it possible to ensure that the sensor could deliver optimal performance behind the glass.

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3. System design

The performance test and optical simulation results were the main inputs used to refine the system's specifications and the mechanical design guidelines. *Figure 4* summarises the various design constraints that were taken into consideration:

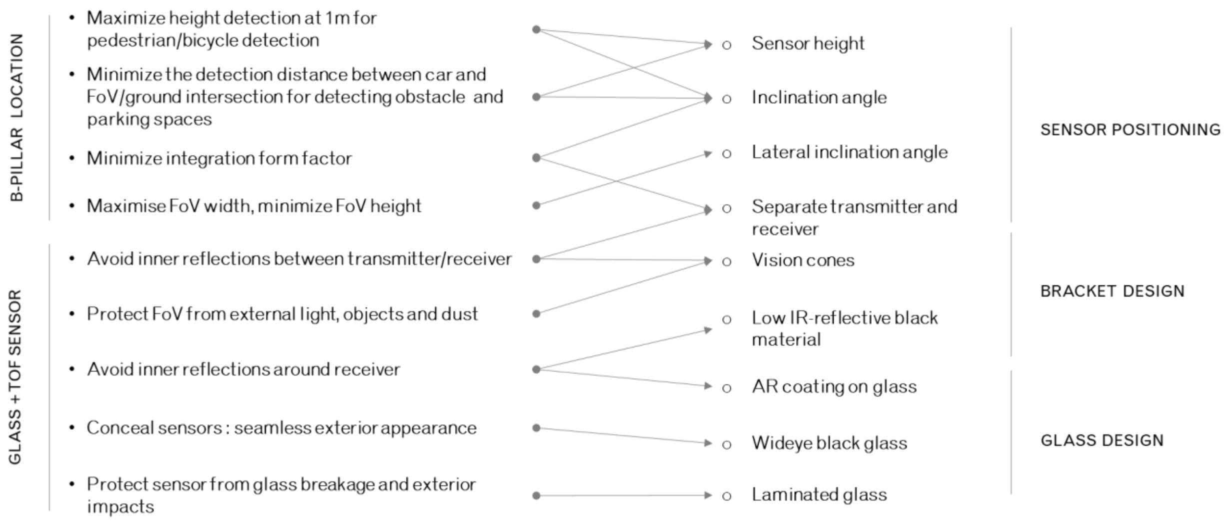


Figure 4: System design challenges

The simulations and mock-ups showed that performance would be improved by separating the receiver and emitter in order to lessen direct reflections between the lasers and the sensor. Since it was necessary to physically separate the emitter and receiver shutters, a minimum distance had to be maintained between those two optical components (see *Figure 5*). Unbundling the system in this way delivered another benefit: it helped to minimise the sensor form factor so that it could comply with the B-pillar package size constraints.

Positioning the sensor – and therefore the emitter with respect to the receiver's location – in the vehicle was governed by two key factors: (FoV) and size constraints. Since the minimum distance between the emitter and the receiver had a direct impact on the sensor FoV, a compromise had to be found between:

- a narrower FoV, resulting from a shorter distance between emitter and receiver, enables a smaller overall package;
- a wider FoV, resulting from a longer distance between emitter and receiver, means a larger overall package, but enables better lateral perception of the car's immediate surroundings.

Our solution favours the latter option, i.e. a wider FoV and despite a larger package, to obtain an optimized performance of the sensor.

Figure 5: Separation of emitter and receiver (minimum distance)

The engineers also considered another design constraint: a standard human standing one metre from the B-pillar had to be fully captured, with the B-pillar at standard height. Accordingly, this meant refining the position and orientation of the sensor with respect to the emitter as well as its absolute position, factoring in vertical and horizontal FoV and the minimum detection distance (see *Figure 6*).

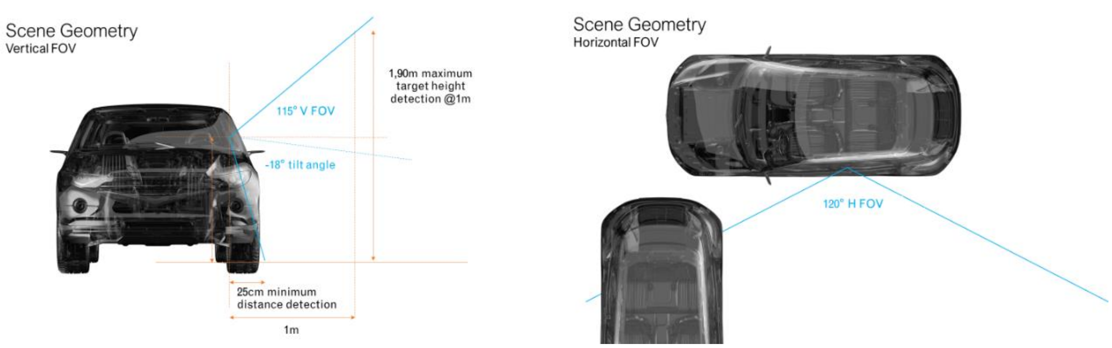


Figure 6: Sensor position and orientation constraints

Once the positions of the emitter and receiver had been decided, the engineers then tackled thermal management to ensure the system would operate correctly. They opted for natural convection, enhanced with active cooling using small standard fans.

OUTCOME

An initial functional prototype was produced. The CAD visualisation is shown in *Figure 7* and the obstacle detection output can be seen in *Figure 8. In Figure 8*, the different colours, ranging from white to red, correspond to different distances.

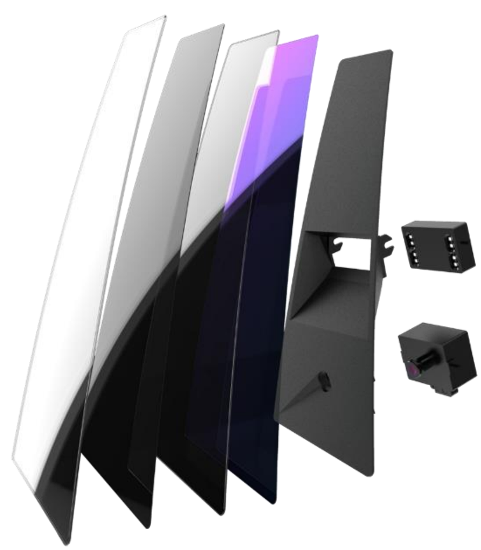
Assembly view	Exploded view
	

Figure 7: CAD prototype

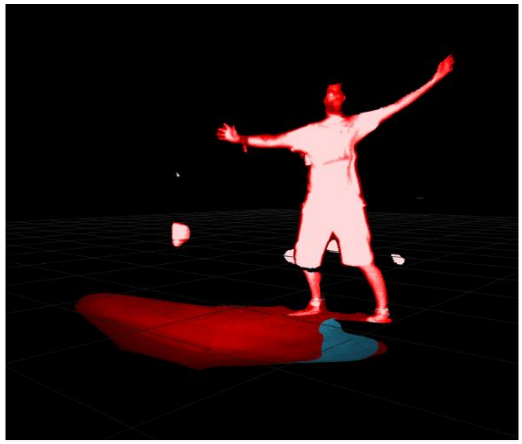


Figure 8: Detection output

The prototype met the requirements for object detection and mechanical integration. The next step was to have the concept validated by the market. To this end, the prototype (*Figure 9*) was shown to the public for the first time at CES 2022, where visitors praised its design and performance.

Figure 9: B-pillar module prototype at CES 2022

CONCLUSION

Wideye and Sony Depthsensing Solutions have achieved a major success, jointly developing a B-pillar module that seamlessly incorporates scanner-less LiDAR (ToF camera) behind an aesthetically pleasing glass cover.

Both parties' contributions were needed to make this project succeed: Sony Depthsensing Solutions' expertise in optical sensors and ADAS/AD applications, and Wideye's optimized glass solutions.

The next goal will be to upgrade the current design and offer it to the automotive industry.

Working together, the two companies not only showed the market a new sensor integration concept, but also its potential value in for ADAS/AD applications. The next step for Sony Depthsensing Solutions and Wideye would be to offer carmakers this embedded solution for real-life deployment.