Eliminating the Forward-Facing Radar: Why Two Eyes Are Better Than One

This may sound strange coming from the company that first introduced the forward-facing radar more than 20 years ago, but there is a strong case for OEMs to eliminate it from some vehicles.

Despite all the benefits that front radar has provided as a foundational element for ADAS systems, there are good reasons that it will not be missed when it can be avoided. Taking out the forward-facing radar can obviously save hardware cost and weight – not just the sensor itself, but also the brackets, wiring, power supplies and other overhead associated with the sensor. It simplifies packaging, freeing up the middle of the grille for more flexible styling and simpler thermal management. And it allows OEMs to maintain a more consistent architecture across their models, which reduces software development and integration costs.

Best of all, OEMs can achieve these results without compromising an inch on safety – in fact, they can actually improve safety by using alternative configurations that are much more effective than a single front radar and camera at addressing many of the intersection and turning scenarios included in Euro NCAP 2023 testing.

Two key ADAS technologies are fundamental to making this possible: advanced corner radars and sensor fusion. These software and hardware technologies have developed and matured since Aptiv introduced that first forward-facing radar all those years ago, achieving breakthrough levels of performance with the application of AI and machine learning. The catalyst for these technologies was the demand for Level 2+ hands-free and automated driving, which required systems that could deal with difficult corner cases – cases that a simple forward-facing radar and camera would struggle with or fail to handle altogether on their own.

ADVANCED CORNER RADARS

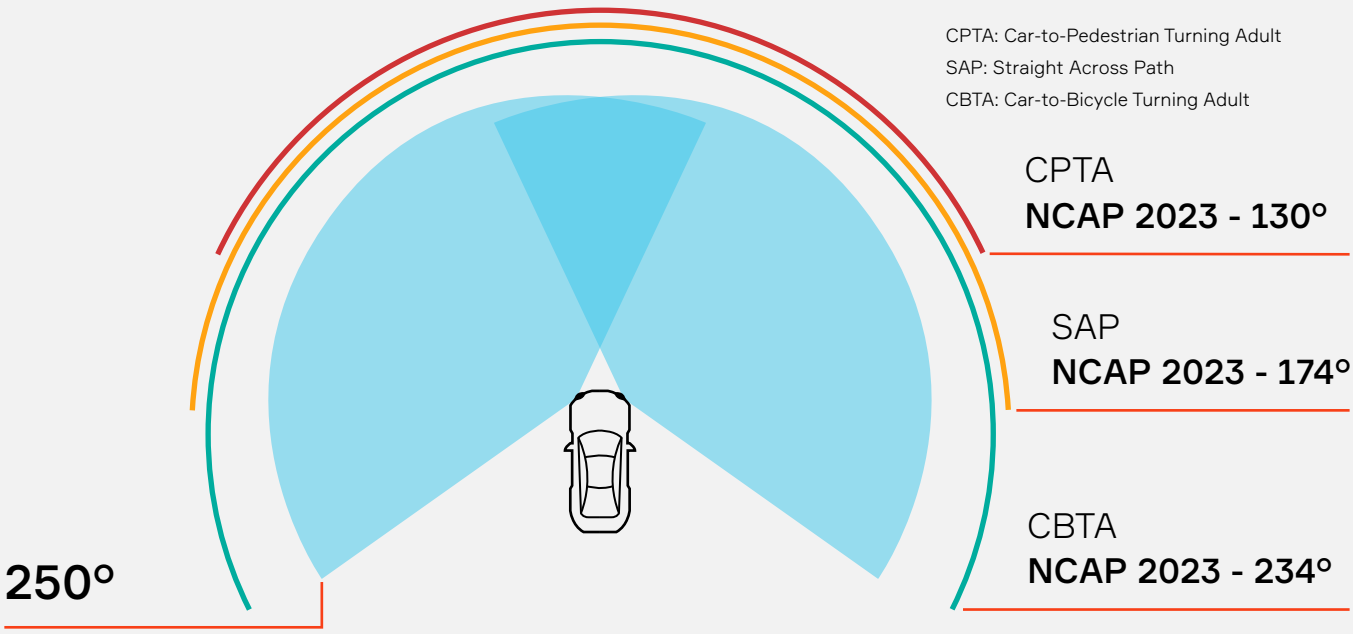
In the past, corner radar – sometimes also called "short range radar" – was primarily installed on the rear of a vehicle for addressing blind spots and lane-change scenarios. However, this is no longer the case.

Aptiv's latest generation of corner radar is the SRR6+, which maintains the 150-degree field of view of the previous-generation corner radar, but benefits from far better discrimination and a much longer range as a result of the application of AI and machine learning. In fact, the SRR6+ can detect objects that are more than 200 meters away and at an elevation of ±15 degrees.

With common positioning at the front two corners (see diagram), this wide field of view allows the vehicle to perceive objects not only to the sides, but also in front of the vehicle and even behind it. This provides far greater situational awareness than a forward-facing radar on objects that are just to the side or slightly offset from the vehicle. For example, if a car in an adjacent lane starts to perform a "close cut-in," (pulling quickly into the vehicle's lane just in front of it), forward-facing sensors alone may not detect the car until it has moved significantly into the lane, causing the vehicle to brake suddenly and creating a perception with the driver that the vehicle missed the cut-in or was late to react.

An Expanded Field of View

Two advanced corner radars can provide 250 degrees of coverage, providing significant overlap directly in front of the vehicle and exceeding several anticipated safety tests from the European New Car Assessment Program (Euro NCAP).



Taken together, the two front corner radars provide 250 degrees of perception with all of radar's strengths. Radar provides strong distance and speed detection through a wide range of environmental conditions – including harsh weather, poor lighting and heavy dust and dirt – while also allowing OEMs to package the sensors behind fascia and in tight spaces.

This radar-centric approach positions OEMs for the future, as well. As they add sensors, radar's lower computing requirements – an order of magnitude less than camera-based systems – will keep down costs, power consumption and heat generation, avoiding the need for liquid cooling. As individuals and governments increasingly raise privacy concerns with camera-based systems, those issues do not apply to radar. And as OEMs continue to include rear corner radars in their vehicles, the combination with two front corner radars provides 360-degree perception with overlap. In short, a radar-centric approach results in a perception system that is more robust, cost efficient and flexible than alternative solutions.

Sensor fusion

Still, translating those sensor inputs into a comprehensive view of the environment around the vehicle is no easy task. Adding to the challenge is that sensor performance at the periphery of its field of view is rarely as good as it is at "boresight" – the axis extending straight out from the face of the radar antenna.

Sensor fusion addresses this, enabling software to use inputs from multiple sensors to stitch together a single model of the environment around the vehicle. In a vehicle with radars at the front two corners, the wide field of view on those radars begin to overlap in an area 1.4 meters (4.6 feet) directly in front of the vehicle. The system can use sensor fusion to reconcile the returns from both radars for that overlapping area, resulting in a high degree of confidence about the objects there. Because each radar has a 150-degree field of view, this overlapping area is substantial. By contrast, the maximum field of view available from today's cameras is 120 degrees, and further increases are limited by the associated megapixel and processing requirements to achieve a high enough resolution.

Here again, AI and machine learning are fundamental to achieving the necessary performance. AI/ML-enhanced algorithms allow the vehicle to make the most of those radar returns and quickly and accurately identify the objects in that wide, long-range field of view. Even with returns that might appear faint, properly trained fusion algorithms can pull out meaningful data and establish the location, velocity and size of objects in the distance.

As a result, AI/ML-enhanced sensor fusion makes it possible to create a next-generation "tracker" capable of using two corner radar for forward-facing compliance features. In addition to tracking objects throughout the combined fields of view, the tracker can ensure that any objects that travel within the modest blind spot just in front of the bumper are accounted for, by fusing together inputs from the forward-facing camera as well as ultrasonic sensors. Developers can also train the tracker to account for any objects that move into that space, and treat them as if they are still there.

This combination of two advanced corner radars and sensor fusion makes sense across a wide range of vehicles, as it can cost-effectively support algorithms for basic active safety and some lower-level vehicle automation by reducing dependency on vision and eliminating the need for a forward-facing radar. It also means that investments in feature development, integration and testing can apply to a large portion of a given platform mix, and the system provides a foundation for future requirements, where higher-speed corner cases – and therefore longer distances – are likely to present further challenges to attaining 360-degree perception around the vehicle.

Putting it in action

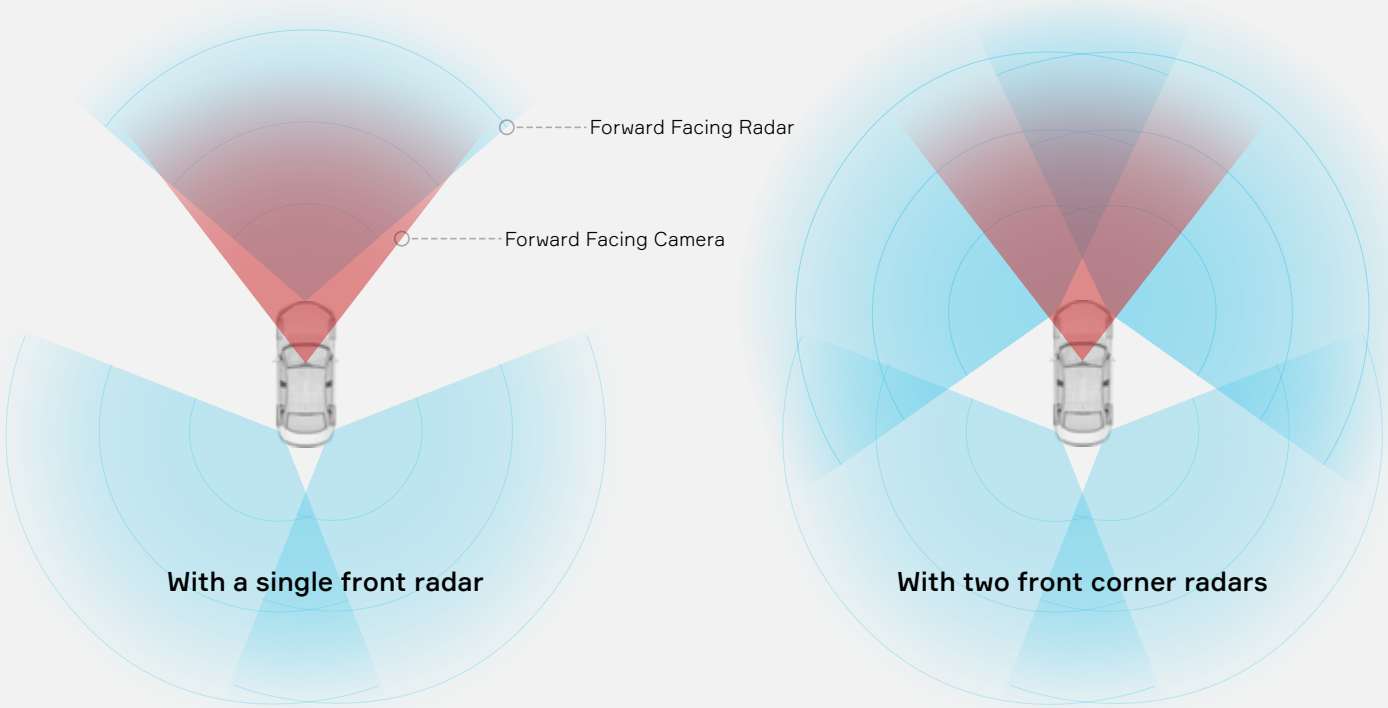
Eliminating the forward-facing radar is not just a theoretical exercise. Aptiv has tested the system and collected data over thousands of kilometers in challenging real-world situations, including nighttime, rain and snow, stop-and-go traffic, and tunnels and bridges. We have tested it across central Europe, in the United States, and are beginning tests in the Asia Pacific region.

This testing has generated data that shows the system will support adaptive cruise control at 180-210 kph (110-130 mph) – a range that depends on the comfort and braking parameters defined by the OEM – and will exceed the performance requirements for a 5-star rating from Euro NCAP.

In short, using dual corner radars with sensor fusion and machine learning represents a compelling opportunity for OEMs looking for a cost-efficient and more elegant solution to use across their various models. While the forward-facing radar was a pioneer in active safety, it is not always necessary in today's software-defined vehicles.

Just Around the Corner

Adding advanced front corner radars allows OEMs to eliminate the forward-facing radar while improving performance. They can then apply this configuration to multiple vehicle variants to simplify packaging, integration and testing.



ABOUT THE AUTHOR

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Lawrence Humm has been a part of the Aptiv team developing advanced driver-assistance systems for more than 25 years. While his focus has been on advanced engineering for most of that time, Lawrence and his team have nevertheless always stayed closely connected to the production activities involved in "making technology work" in real-world situations. Lawrence also worked directly on OEM production programs as European regional product chief for several years in Wuppertal, Germany, and has applied this experience to advance engineering in his current role in Gothenburg, Sweden. Previous to Aptiv, Lawrence worked in the aerospace industry after receiving a degree in electrical engineering from the California Institute of Technology.

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