



Arbe Recognized for

2021

New Product Innovation

European 4D Imaging Radar
for Autonomous Vehicles Industry

Excellence in Best Practices

Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each award category before determining the final award recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. Arbe excels in many of the criteria in the 4D imaging autonomous vehicle radar market.

AWARD CRITERIA	
<i>New Product Attributes</i>	<i>Customer Impact</i>
Match to Needs	Price/Performance Value
Reliability	Customer Purchase Experience
Quality	Customer Ownership Experience
Positioning	Customer Service Experience
Design	Brand Equity

Filling the Gaps

Headquartered in Tel Aviv-Yafo, Israel, Arbe develops four-dimensional (4D) imaging radar chipsets for advanced driver-assistance systems (ADAS) and Autonomous Driving. Most radar technologies, such as two-dimensional and three-dimensional, and other solutions, such as light detection and ranging (LiDAR), do not offer full functionality. The more expensive LiDAR solutions, for example, fail to provide reliability in various environments, such as snow, dust, rain, and bright sunlight. Meanwhile, current

“Frost & Sullivan’s research finds competing 4D radar vendors struggle to provide the high resolution, long range, and accuracy achieved by Arbe’s technology, as well as the optimized power consumption and number of channels provided.”

- Samantha Fisher, Best Practices Research Analyst

radar technology fails to detect pedestrians stepping into the road or stationary objects. The comprehensive sensing capability is critical for highly accurate perception algorithms. Frost & Sullivan finds vehicles require robust radar technology with a long-range, wide field-of-view (FOV) and high resolution to achieve nominal ADAS and AV performance. Arbe fills this gap with its innovative, first-mover technology geared toward advancing autonomous vehicle technology.

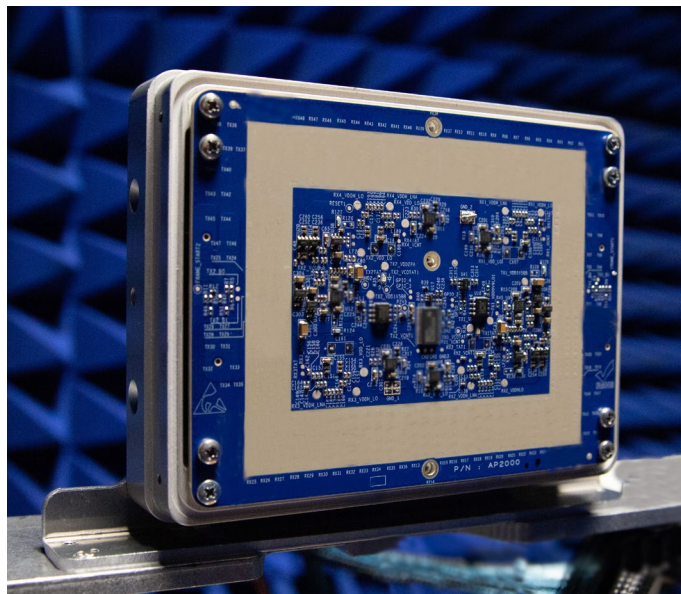
Arbe’s technology solves the most critical challenges of current generation of automotive radars, it enables high resolution in both azimuth and elevation, it eliminates radar false alarms, it removes the doppler ambiguities, and it detects stationery objects. This

enables the 4D Imaging radar to provide a real-time, accurate, and meaningful information about the driving environment required for advanced perception capabilities.

Arbe developed and launched its ultra-high-resolution radar solution on a proprietary chipset based on GLOBALFOUNDRIES' 22FDX® technology. The company's radar offers a resolution of one-degree azimuth and 1.8-degree elevation at distances exceeding 300 meters (m) and at a wide FOV of 100 degrees. As a result, Arbe's three-chip solution offers all-weather, high-reliability performance. Its Everest radar processing unit offers advanced controls supporting up to 48 receiver by 48 transmitter radar RF channels, avoiding mutual interference through patented technology, and its small size is optimal for concealed installation. The radar transmitter, receiver, and processor enable the company's technology to process high-definition (HD) radar pictures of the environment in real-time, at 30 frames per second. As a result, Arbe's 4D ultra-high resolution is 12 times better than competitors' offerings.

In October 2020, the company launched its Radar Development Platform, enabling Tier 1 as well as original equipment manufacturers (OEMs) to enhance their perception algorithms. The platform also helps autonomous vehicles avoid road accidents and makes the imaging radar road-safe. When combined with Arbe's imaging radar solution, the company's platform enables free space mapping, determining the orientation and velocity of other vehicles to know what lies ahead, stationary object detection with no false alarms which eliminates phantom braking, in all environmental conditions, outperforming conventional radar solutions. Arbe also leverages a unique form of frequency-modulated continuous-wave (FMCW) radar to simplify its processes and reach a higher range resolution than its competitors.

Today, most automotive radar operates under FMCW radar; however, Arbe uses its patents and algorithms to process a large amount of data in real-time and generate full HD pictures based only on the radar. Moreover, this unique FMCW approach enables Arbe to avoid Doppler ambiguity, differentiating the company as one of the few types of radar to achieve it.



Arbe's Radar Development Platform

Leveraging an Advanced Silicon Process

Arbe's real-time 4D imaging radar consists of a Phoenix chipset, including radar sensors and artificial intelligence (AI)-based processing. The chipset leverages a 22 nanometer FDX, which reduces the power consumption per channel and increases channel isolation. This process allows for additional virtual channels on the chipset, while reducing the silicon's size and provides higher efficiency and a competitive price point for the system. This always-available, object detection also offers automatic interference avoidance and mitigation against other FMCW radar systems.



Arbe's Radar Processor Chip

Providing the Critical Information Needed for Optimizing Perception

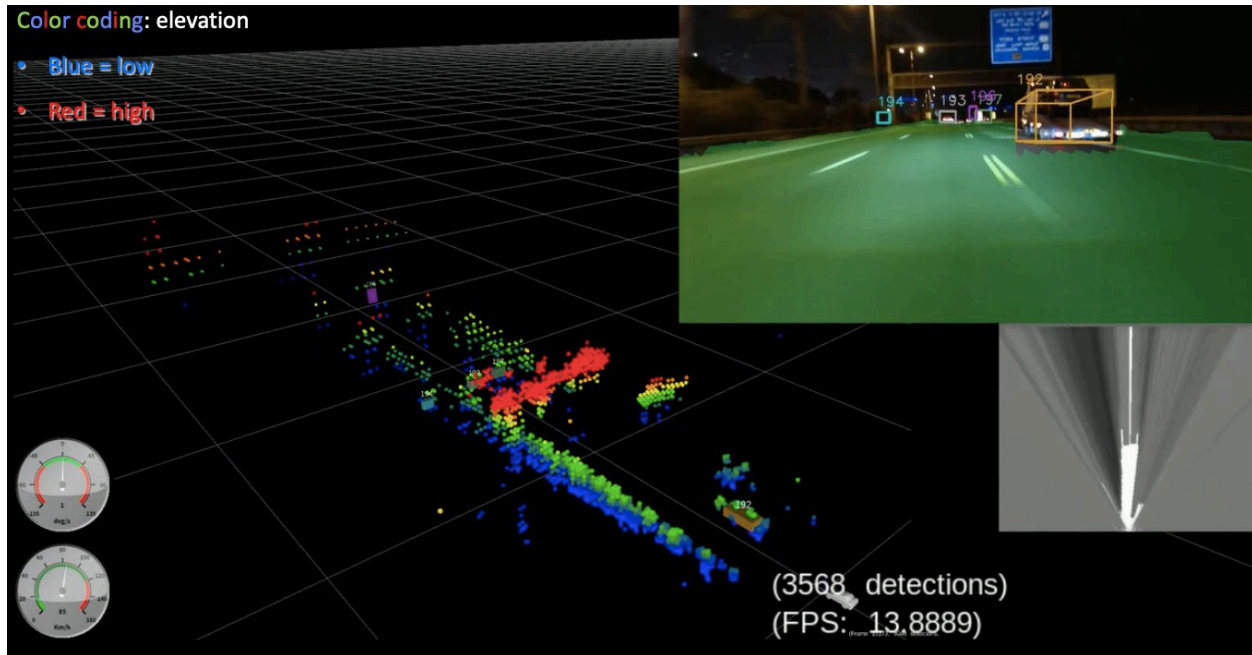
Arbe's radar processing unit supports an ultra-high resolution in azimuth and elevation, low false alarm rates, and high refresh rate. It features integrated AI-based image processing perception algorithms that apply logic to process the information in the following two stages: (1) minimizing information and maintaining power consumption for the chipset, and (2) making huge data volumes coherent, which enables the computer receiving the data analysis to make decisions while driving. The algorithms offer real-time, free space mapping, low-latency dynamic object tracking, classification, and detection of 100s of stationary and moving targets in the vehicle environment.

The integration of AI is crucial for optimizing perception algorithms and decision-making because the technology analyzes the changing environment (with no global positioning system [GPS]) and distinguishes stationary and dynamic objects around the vehicle. The AI-based SLAM algorithms are used by the third chip that performs several tasks during post-processing: self-localization, dynamic object tracking, and free space mapping.

- **Self-localization:** Applying logic to the information helps realize what the object is instead of processing frame-by-frame. Because the vehicle moves along with the objects around it, processing the environmental information helps locate the vehicle with respect to its

surroundings. This approach enables the vehicle to switch lanes and work in tunnels with no GPS due to a lack of connectivity.

- **Free Space Mapping:** This feature helps indicate where the vehicle can go (i.e., the free space in the environment with no obstacles). It is the basis for navigation, path planning, and obstacle avoidance.
- **Object tracking:** a coherent understanding of the dynamics of all environmental objects — whether a vulnerable road user, speeding car, or bicycle— which improves path planning and hazard avoidance, and optimizes the perception algorithm



Free Space Mapping By Arbe's 4D Imaging Radar Solution

Frost & Sullivan's research finds competing 4D radar vendors struggle to provide the high resolution, long-range, and accuracy achieved by Arbe's technology, as well as the optimized power consumption and a number of channels provided.

High-quality Results

As a relatively niche market, the 4D radar market continues to attract new startups with solutions that aim to streamline and simplify the journey to fully autonomous vehicles. Arbe sets itself apart in multiple ways, particularly ultra-high-resolution radar based on millimeter-wave radio, providing the company with a significant advantage. This technology penetrates weather-related issues, including snow, fog, rain, and dust, which differentiates it from competing solutions, such as LiDAR, which continues to struggle with these same weather conditions. Arbe's imaging radar also positions the company as a first-mover, as its radar is the only technology that offers full long-range functionality at night. The company's post-processing enhances perception algorithms and simplifies sensor fusion through a 4D point cloud output over Ethernet, without high power requirements.

Arbe developed its radar to integrate anywhere in the vehicle, such as the grill or the headlights, depending on the automotive company, and within the ADAS and autonomous sensor suite. Frost & Sullivan's research indicates Arbe ensures its radar technology's scalability by adding more channels to the Everest processing chip to enable higher resolution, longer range, quicker notifications, and better detection of the environment than competing technologies. More importantly, Arbe maintains a key

"Frost & Sullivan finds Arbe delivers substantiated value for the price as its 4D radar technology outperforms LiDAR and traditional radar in areas such as weather and night driving. More importantly, 4D radar technology holds the potential to replace LiDAR in Level 3 autonomous vehicles, bringing down the overall costs significantly."

- Samantha Fisher, Best Practices Research Analyst

focus on quality and possesses several certifications with various organizations, including the International Standards Organization (26262, Automotive Safety Integrity Level-B), the Federal Communication Commission, European Telecommunications Standards Institute, and Telecom Engineering Center-Japan.

Valuable Design and Performance

While radar as a sensor has existed in vehicles for the last 15 years, these legacy sensors offer poor resolution and stationary object detection. Arbe purpose-designed its 4D radar to separate, track, and identify objects in ultra-high resolution in depth, width, height, and speed

via its proprietary chipset with a significantly high channel count and the first dedicated automotive radar processor on a chip. As a result of its innovation and constant updates to its technology, Arbe offers the market's first 4D radar to provide keen object detection and high resolution. The company's radar detects over 450 objects (stationary or moving) in various weather and lighting conditions, which results in improved safety for pedestrians, cyclists, drivers, and others. It also offers near-zero false alarms and false-negative rates for low radar cross-section targets such as vulnerable road users. Moreover, Arbe's technology offers key specifications that deliver optimal results, such as frequency ranges from 76 to 81 gigahertz (GHz) and bandwidth up to 2 GHz, with range resolution from 9.5 centimeters (cm) at 26 m and 60 cm at 300 m. The azimuth for resolution is 1 degree, elevation at 1.8 degrees, and Doppler at 0.1 m per second. Detection offers up to 300 m range, with -50 to +50 degree azimuth FOV and -15 to +15 degree elevation FOV, and -70 to +140 m per second Doppler.

When Arbe designed its technology, the assumption was that front-facing high-resolution radar would carry a roughly \$100 price tag. Currently, the company offers its solution with two configurations: \$150 for high-end robot taxis and \$100 in mass production for modern applications. Arbe continues to engage with leading Tier 1s in the market that supply radars to car companies based on the Arbe chipset; these Tier 1s currently quote this figure to car manufacturers. Frost & Sullivan finds Arbe delivers substantiated value for the price as its 4D radar technology outperforms LiDAR and traditional radar in areas such as weather and night driving. More importantly, 4D radar technology holds the potential to replace LiDAR in Level 3 autonomous vehicles, bringing down the overall costs significantly. Arbe ups the ante further by designing its technology to integrate with camera, LiDAR and other complementing solutions, opening up broader markets in Level 4 and Level 5 autonomous vehicles, well-positioning Arbe for the future.

Steady and Strategic Growth

Arbe continues to make critical strides toward the future that ensure growth and strengthens its brand equity. In May 2021, the company announced its imaging radar availability on the open NVIDIA DRIVE platform. This strategy aims to accelerate autonomous vehicle development. By allowing leading OEMs and Tier 1 suppliers access to the 4D imaging radar data on NVIDIA's platform, Arbe serves as the basis for advanced safety applications, sensor fusion, and perception algorithm development. Hundreds of companies develop on NVIDIA DRIVE (e.g., suppliers, robotaxis, sensor and mapping companies). Arbe's availability on the platform provides the company additional visibility to a wide audience, encouraging future growth. In April 2021 AutoX announced that it selected Arbe's 4D Imaging Radar Platform for Level 4 Autonomous Vehicles. AutoX Will Integrate 400,000 Arbe-Based Ultra-High Resolution Radar Systems into L4 Vehicles to Achieve Greater Safety and Performance. As of 2021, the company boasts significant traction with leading OEMs and Tier 1 partners, including Valeo, HIRAIN, Weifu, and Qamcom. Of the ten leading radar Tier 1s in the market, Arbe reports 50% selected its technology, and 25% are in advanced evaluations. The company plans to start full production in 2022, and it already has contacts with many customers. In the second half of 2022, Arbe plans for robotaxis and delivery robots outfitted with radar-based on its technology to appear in the market. It also aims for production in regular cars in fiscal year 2024 to surpass \$300 million in revenue by 2025. Since it is already in mass production and continues to gather interest, Arbe is confident in these numbers.

Conclusion

Despite the continued push for autonomous vehicles, the existing solutions, such as light detection and ranging sensors, struggle to perform in various environments, such as snow and direct sunlight, and current four-dimensional (4D) radars lack the technology necessary for moving and stationary object detection on the road. Founded in 2015, Israel-headquartered Arbe fills these gaps through its innovative proprietary 4D radar technology available for ADAS, Level 2+ and fully autonomous vehicles. The company's three-chip solution delivers keen metrics designed to overcome challenges provided by multiple environmental factors while simultaneously delivering industry-leading object recognition with high resolution. Arbe builds on preceding technologies by leveraging a unique form of frequency-modulated continuous-wave radar, as well as integrated artificial intelligence-based perception enhancing algorithms. Most importantly, the company continues to move forward by partnering with key original equipment manufacturers to increase availability and visibility.

For its unique and differentiated technology, proven results, ongoing innovation, and strong overall performance, Arbe is recognized with Frost & Sullivan's 2021 European New Product Innovation Award in the 4D imaging autonomous vehicle radar market.

What You Need to Know about the New Product Innovation Recognition

Frost & Sullivan's New Product Innovation Award recognizes the company that offers a new product or solution that uniquely addresses key customer challenges.

Best Practices Award Analysis

For the New Product Innovation Award, Frost & Sullivan analysts independently evaluated the criteria listed below.

New Product Attributes

Match to Needs: Customer needs directly influence and inspire product design and positioning

Reliability: Product consistently meets or exceeds customer performance expectations

Quality: Product offers best-in-class quality with a full complement of features and functionality

Positioning: Product serves a unique, unmet need that competitors cannot easily replicate

Design: Product features an innovative design that enhances both visual appeal and ease of use

Customer Impact

Price/Performance Value: Products or services provide the best value for the price compared to similar market offerings

Customer Purchase Experience: Quality of the purchase experience assures customers that they are buying the optimal solution for addressing their unique needs and constraints

Customer Ownership Experience: Customers proudly own the company's product or service and have a positive experience throughout the life of the product or service

Customer Service Experience: Customer service is accessible, fast, stress-free, and high quality

Brand Equity: Customers perceive the brand positively and exhibit high brand loyalty

