

FROST & SULLIVAN



2022 NEW PRODUCT INNOVATION

*GLOBAL
AUTOMOTIVE LIDAR INDUSTRY*

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. Baraja excels in many of the criteria in the automotive light detection and ranging (LiDAR) space.

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

Positioning and Design

Autonomous driving is revolutionizing the automotive industry. Self-driving cars, trucks, taxis, and buses serve as use cases demonstrating how technology advancements impact and transform the entire mobility structure. Various sensors are used in vehicles to achieve autonomous driving, with LiDAR sensors expected in almost all future vehicles offering autonomous driving with Level 2 capabilities and above. The automotive LiDAR industry is highly competitive. The primary goal of original equipment manufacturers is to use highly reliable LiDAR sensors and move away from mechanical to solid-state LiDAR sensors. Solid-state LiDAR sensors hold an upper hand over their mechanical counterparts because they have no moving parts in the system. The more moving parts a sensor has, the larger and bulkier it is with decreased reliability and robustness. Australia-based Baraja enters this market with its Spectrum-Scan™ solid-state fast axis scanning (FAS) mechanism that utilizes no moving parts in the fast scanning axis.

With expertise in optical engineering, Federico Collarte and Cibby Pulikkaseril founded Baraja in 2015 and designed the groundbreaking Spectrum-Scan™ sensor. Unlike legacy LiDAR sensors, Spectrum-Scan™ LiDAR is an advanced random modulated continuous wave (RMCW) sensor, in which a pseudorandom binary sequence modulates the light wave. It ranges distance by analyzing the reflected beam and comparing it with the original beam targeted at the object. Using refractive prism-like optics to steer the beam instead of mechanical means is one of the key breakthroughs that helped Baraja eliminate moving parts and accomplish a true solid-state LiDAR sensor.

Capitalizing on the RMCW technology distinguishes Baraja from the competition. The RMCW technology results in fewer distortions of the return signal than the conventional time-of-flight method of ranging distances. The Spectrum-Scan™ design uses laser beams operating at 1,550 nanometers, unlike competing LiDAR sensors that use 9xx nanometer laser beams. This feature enables Baraja's LiDAR sensor to perform at a higher power output safe for the human eyes. Each point sent out by the device is of a different wavelength ranging between 1530 and 1570 nanometers. This wavelength difference significantly reduces interference, distortion, and noise from other sources as the receptor picks the correct wavelength. In addition, Spectrum-Scan™ technology coupled with RMCW guarantee the highest immunity to interference. The receiver unit captures only the reflected light that was transmitted by the specific unit rejecting all other potentially interfering signals.

Frost & Sullivan applauds Baraja for its next-generation solid-state LiDAR sensor that is among the latest technologies in autonomous driving.

Brand Equity

Baraja started with investments from friends and family in 2015. Since then, the company has grown multifold, generating about \$70 million in funding from seed and series funding rounds. Baraja now has more than 150 employees scattered worldwide and more than 70 filed patents in the automotive space.

"Frost & Sullivan believes Baraja has pioneered an innovative solid-state LiDAR that paves the way for future advancements."

*– Thirumalai Narasimhan,
Senior Research Analyst*

It has 20 prospective customers, of which five have entered into strategic partnerships and signed memorandums of understanding with the company. Among the five is automotive technology provider Veoneer, which chose Baraja as its partner for autonomous vehicle sensors after performing extensive research on 70 LiDAR developers. In addition to automotive use cases, Baraja's sensors have been

deployed in Australian mines since 2018. For example, Hitachi Construction Machinery has been using Spectrum-Scan™ for over three years to optimize production efficiency and safety in its heavy mining equipment.

Reliability and Performance Value

Baraja's Spectrum-Scan™ LiDAR features per-point Doppler capabilities in the hardware, a standout feature in automotive LiDAR sensors. The reliability of the Spectrum-Scan™ is enhanced because it uses prism-like optics for the fast axis scanning eliminating mechanical parts prone to failure. When coupled with a 1,550 nanometer operating wavelength, the sensor's range is also substantially increased. Since Spectrum-Scan™ operates on multiple wavelengths, the resolution in both sensor axes is vastly improved. Baraja Spectrum-Scan™ sensors can provide 2000 lines of discrete vertical resolution, or 'channels'. This means that there are more points on more objects in a larger field-of-view at long-range. Additionally, Baraja Spectrum-Scan™ technology enables the distribution of points wherever needed. The theoretical resolution value could be limited in the real world, but Spectrum-Scan™ already offers improved reliability, range, and resolution over competing LiDAR sensors.

Match to Needs

Sensors are subject to shock loads from autonomous driving because of the road conditions. Sensors in mining industries are subject to harsher light, temperature, and environmental conditions than the automotive space. Baraja's Spectrum-Scan™ can cater to both industries because it uses a coaxial system and robust passive optics to tackle challenging environments. Baraja adopts a coaxial LiDAR system that uses the same set of optics for both transmitted and received beams to ensure proper alignment over long distances. The system is also modular with its use of non-power-consuming passive optics. The system's computing engine can be connected to multiple sensors to merge and provide a single point cloud system. Baraja has designed Spectrum-Scan™ LiDAR to be more durable to shock loads and demanding conditions, demonstrated by multiple years of real-world testing and operation in some of the harshest mining environments

Innovative use of RMCW technology for ranging, a refractive prism for beam steering, and a high-powered laser safe for the human eyes enable Baraja's Spectrum-Scan™ to achieve improved reliability, range, resolution, durability, and point cloud data over competing solutions in the LiDAR market. Frost & Sullivan is impressed with how Baraja meets industry needs with its revolutionary and robust LiDAR technology.

Conclusion

Baraja's Spectrum-Scan™ is among the latest advancements in autonomous driving technology. By using different wavelengths and refractive optics such as a prism, Baraja has achieved a pure solid-state fast axis scanning LiDAR with a high-resolution beam steering solution. The RMCW technology for ranging and the novel beam steering method ensure the sensor's high reliability, range, resolution, and lifespan. The Spectrum-Scan™ LiDAR can endure shock loads from autonomous driving and the challenging conditions of mining industries. Frost & Sullivan believes Baraja has pioneered an innovative solid-state LiDAR that paves the way for future advancements.

With its strong overall performance, Baraja earns Frost & Sullivan's 2022 Global New Product Innovation Award in the automotive LiDAR industry.

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

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The Growth Pipeline Engine™

Frost & Sullivan’s proprietary model to systematically create ongoing growth opportunities and strategies for our clients is fuelled by the Innovation Generator™.

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Key Impacts:

- **Growth Pipeline:** Continuous Flow of Growth Opportunities
- **Growth Strategies:** Proven Best Practices
- **Innovation Culture:** Optimized Customer Experience
- **ROI & Margin:** Implementation Excellence
- **Transformational Growth:** Industry Leadership



The Innovation Generator™

Our 6 analytical perspectives are crucial in capturing the broadest range of innovative growth opportunities, most of which occur at the points of these perspectives.

Analytical Perspectives:

- **Mega Trend (MT)**
- **Business Model (BM)**
- **Technology (TE)**
- **Industries (IN)**
- **Customer (CU)**
- **Geographies (GE)**

