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WHITE PAPER

ADAS and AD 101: Understanding the Technology, Driving Factors and Investment Opportunity

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Fascinating World of ADAS and AD

The advanced driver assistance systems (ADAS) and autonomous driving (AD) market is projected to reach $42 billion by 2030, growing at a compound annual growth rate (CAGR) of 11% between 2020 and 2030, according to McKinsey's report Outlook on the Automotive Software and Electronics Market Through 2030. The ADAS and AD market can be divided into three categories: environmental perception, functional integration, and prediction and planning. Environmental perception serves as the foundational technology upon which ADAS and AD are built. Driven by increasing consumer demand, regulatory requirements and industry transformation, ADAS and AD are becoming central to the automotive ownership and manufacturing experience.

Self-driving vehicles can travel from point A to point B without human intervention. The last few decades have witnessed a surge in interest in developing autonomous vehicles to improve road safety, reduce accidents and provide a superior mobility experience to all commuters. Autonomous vehicles come in different shapes, sizes, markets and technological capabilities.

This White Paper aims to provide an overview of the technologies enabling ADAS and AD, the various levels of vehicle automation and the factors influencing the adoption of automated vehicles. For deeper insights, we invite you to explore additional White Papers from LeddarTech:

- Cybersecurity in ADAS: Protecting Connected and Autonomous Vehicles
- A Comprehensive Overview of China NCAP 2024 Regulations
- From Hype to Highway: Today's Opportunities in Automated Driving
- An Explanation of Perception Performance Paradigm in ADAS and AD
- Exploring the Relationships Between ADAS, E/E Architecture and Perception Systems

The Five Levels of Autonomous Vehicles

The Society of Automotive Engineers (SAE) has categorized driving automation into six levels, spanning from Level 0 (*no driving automation*) to Level 5 (*full driving automation*). Each of these levels is explained below:

- **Level 0 (No Automation):** At this level, the vehicle's system provides no control over its dynamics; it remains entirely under the driver's manual control.
- **Level 1 (Driver Assistance):** In this category, specific control functions such as steering or acceleration/deceleration are automated, but not simultaneously. An example is adaptive cruise control (ACC).
- **Level 2 (Partial Automation):** At this stage, the vehicle takes charge of steering and acceleration/ deceleration based on information about the driving environment. Nevertheless, the human driver must remain actively engaged, supervising the system and ready to assume full control when prompted or in response to system limits or failures.
- **Level 3 (Conditional Automation):** The vehicle can execute all aspects of the dynamic driving task within specific conditions, such as highway driving. It will prompt human intervention when these conditions are not met. While the driver must be available to take over, continuous monitoring of the environment is not mandatory.
- **Level 4 (High Automation):** The vehicle can independently achieve all driving tasks within specific conditions, such as geofenced areas or road types. No human driver intervention is expected in these predefined environments, and no continuous driver attention is necessary.
- **Level 5 (Full Automation):** This is the highest level of automation, where the vehicle can perform all driving functions under all conditions. The vehicle is designed to be fully autonomous and operate without the need for a human driver.

Every level represents a significant step in integrating and advancing intricate systems, encompassing sensor fusion, machine learning, sophisticated decision-making algorithms and robust fail-safe mechanisms, pivotal for ensuring the safety and efficiency of autonomous and assisted vehicle operations.

Levels 1 and 2 (L1/L2) are considered advanced driver assistance systems (ADAS), wherein the onboard vehicle technology is intended to augment the driver's capabilities instead of taking over the driving task. L3 is also known as conditional automated driving, while L4/L5 are referred to as highly automated driving systems.

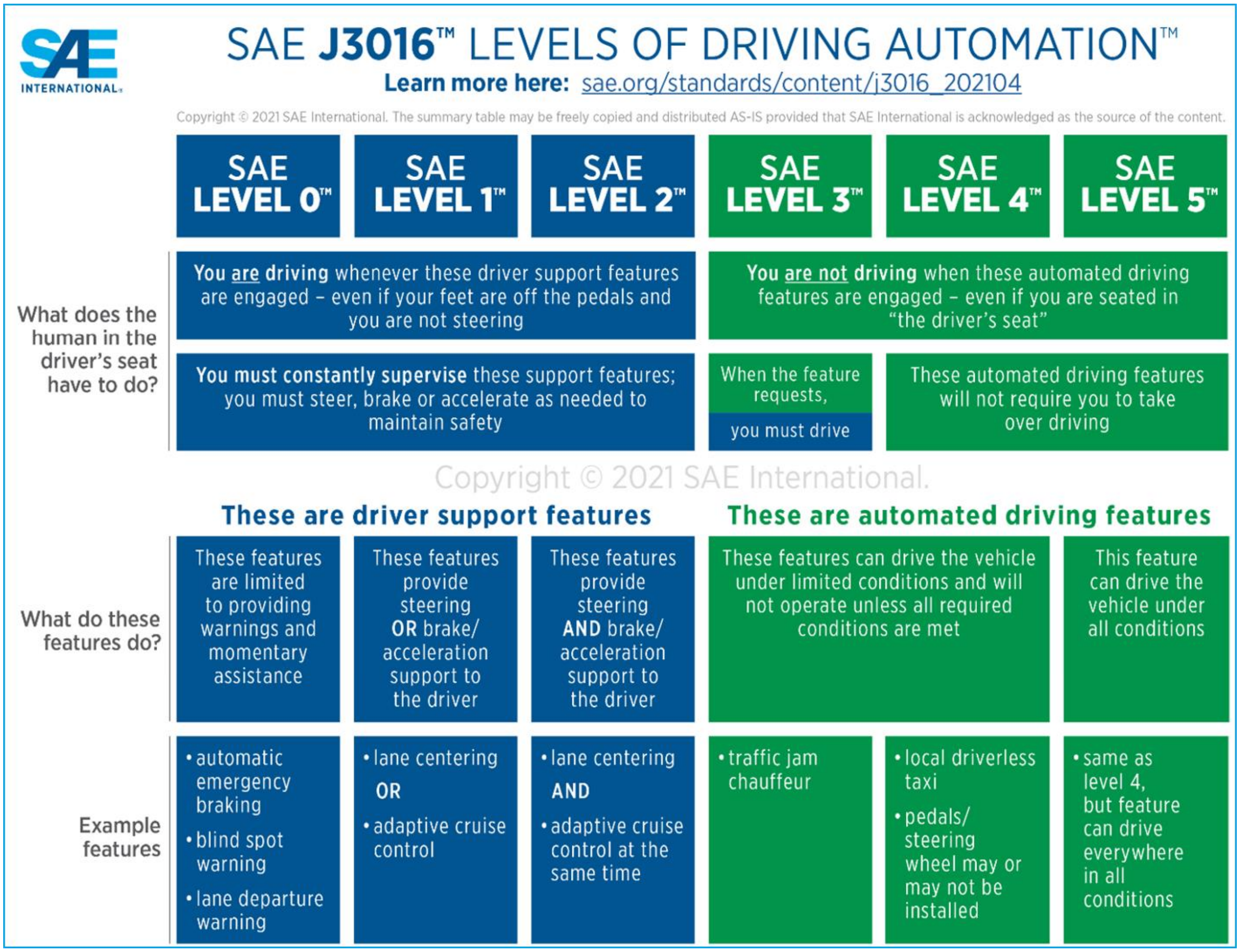


Figure 1 – The different levels of driving automation as defined by SAE International

Almost all new passenger vehicles sold in North America are equipped with L1 capabilities, while most are equipped with L2 capabilities. In Asia and Africa, the fitment rates vary depending on the specific country. Most new vehicles sold in countries like Japan, China and South Korea are equipped with L1/L2 capabilities. In contrast, new vehicles sold in many African countries might only be equipped with L1 capabilities.

Only a handful of on-road passenger vehicles are certified for L3 and commercially available for public purchase. L3 represents the most advanced technology currently available for public purchase. Companies like Waymo, Cruise and Baidu operate vehicles equipped with technology that meets L4 requirements. However, these vehicles are not available for purchase.

L4 vehicles can perform all driving tasks within specific areas and under certain conditions. However, they are limited by technological constraints, which remain a key barrier to the widespread deployment of fully autonomous vehicles. As such, it can be concluded that there are no L5 autonomous vehicles on the road today.

Growing Importance of Scalability

The path to autonomous driving passes through ADAS. The development of autonomous driving systems is a gradual process driven by incremental technical advancements and breakthroughs. Furthermore, the market may not yet be ready for fully autonomous vehicles, as many drivers and consumers remain skeptical about relinquishing control of their vehicles to a machine.

As such, scalability is critical to enabling ADAS and AD. Technology providers that can seamlessly scale their solutions from L2 ADAS to L5 AD are likely to be the preferred partners of car manufacturers. Reduced rework, faster development cycles, rapid feature additions and fixes and shorter time-to-market are significant advantages for car manufacturers as they progress toward offering automated driving features.

LeddarTech's AI-based technology is uniquely positioned to support car manufacturers in this endeavor. Its single LeddarVision™ platform enables the development of vehicles with front-to-surround-view environmental perception capabilities by simply adding sensors and performing recalibration.

Technology Driving ADAS and AD

The underlying technology behind advanced driver assistance systems and autonomous driving systems is fundamentally the same. However, as development progresses from ADAS to AD systems, the complexity, output and requirements of the technology increase significantly. The inability to scale effectively remains a major challenge to the mass deployment of autonomous driving systems.

The technology required to enable ADAS and AD systems can be categorized into four main areas:

1. **Sensing:** Sensors such as cameras, LiDAR, radar and ultrasonic sensors collect real-time data about the vehicle's environment. They provide critical inputs for detecting objects, road conditions and other factors necessary for safe navigation. High-resolution sensors must operate reliably under diverse conditions, including low light, rain and fog to ensure consistent performance.
2. **Perception:** Once the sensors capture data, it is processed through perception algorithms to detect objects, lanes and the surrounding environment. Perception systems leverage artificial intelligence and computer vision to identify and track key elements such as pedestrians, vehicles and road signs. These systems are vital for interpreting the dynamic environment and predicting potential hazards. By utilizing advanced object detection models, perception technologies enable the vehicle to respond effectively to complex scenarios, including crowded intersections and high-speed traffic.
3. **Fusion:** Fusion refers to the process of combining outputs from multiple sensors to create a cohesive understanding of the environment. There are two main approaches to sensor fusion: object-level fusion and low-level (raw data) fusion.

   ✓ **Object-level fusion** involves running perception algorithms separately on each sensor and then combining the outputs.

   ✓ **Low-level fusion,** or raw data fusion, combines the raw data from all sensors before running perception algorithms on the unified dataset.

   Currently, most sensor fusion solutions rely on object-level fusion, where each sensor (e.g., radar, camera, LiDAR) identifies and classifies objects independently, despite its inherent limitations. This approach often results in suboptimal performance because no single sensor can detect all objects reliably under all conditions. Moreover, when sensor data is not fused effectively, the system may receive conflicting inputs from sensors, leading to uncertainty in determining the appropriate next action.

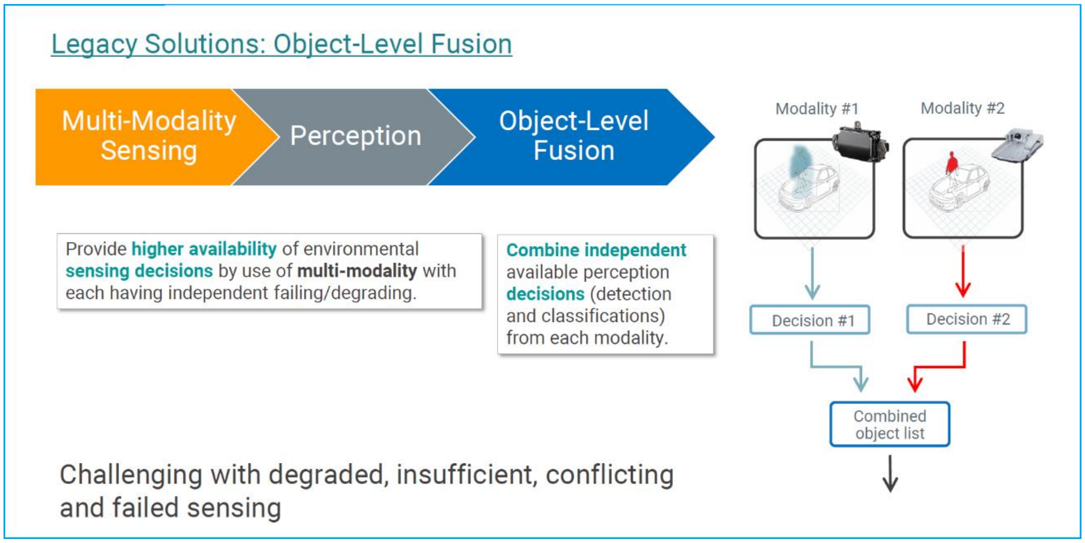


Figure 2 – Illustration of the object-level fusion process

Low-level fusion offers several advantages over object-level fusion. It provides inherent system redundancy, as it is not reliant on any single sensor. Additionally, the weaknesses of one sensor, such as limited LiDAR range, can be offset by the strengths of another, such as radar. Low-level fusion also enables scalability, allowing the same system to be adapted for both ADAS and AD applications. This significantly reduces research and development efforts, accelerates time-to-market and minimizes rework.

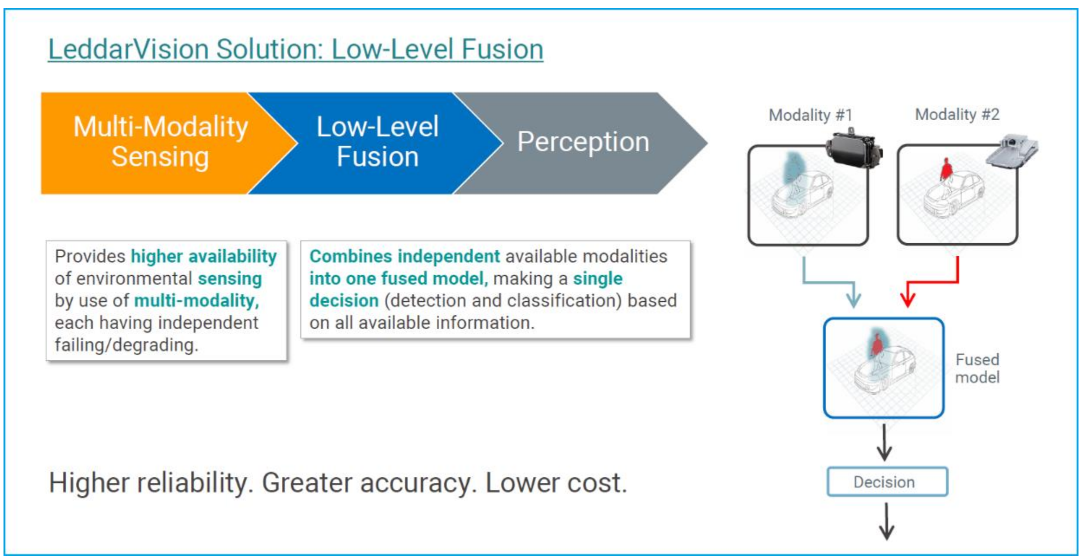


Figure 3 – Illustration of the low-level fusion process

4. **Localization:** Localization determines the vehicle's precise position in its environment, a critical aspect of autonomous navigation. Combining GPS, high-definition maps and inertial measurement units (IMUs), localization systems provide sub-centimeter accuracy. These systems must also function in GPS-denied environments, such as tunnels or urban canyons, ensuring consistent and reliable navigation under all conditions.

5. **Path Planning:** Path planning refers to developing an autonomous driving route from point A to point B. As the road environment is dynamic, the path-planning algorithm must be adaptable and robust to handle changes while also considering legal and ethical implications of decision making.
6. **Control:** Control systems translate the decisions made by the vehicle's artificial intelligence (AI) into physical actions such as steering, acceleration and braking. These systems rely on drive-by-wire technology and advanced actuators to execute high-precision, responsive commands. Control systems are equipped with fail-safe mechanisms and redundancy to ensure reliability, which is vital for maintaining safety in critical situations.

The role of perception systems is pivotal for ADAS and AD developers, who aim to enhance system reliability and performance. When assessing the performance of perception systems, automotive original equipment manufacturers (OEMs) and Tier 1 providers must consider factors such as false alarms, object separation capability at large distances, occluded object detection ability, perception range for a given sensor set and performance in adverse conditions. Sensor fusion and perception systems that excel in all these areas enable automotive OEMs and Tier 1s to develop ADAS and AD systems that improve the mobility experience, operate reliably and achieve a 5-star performance in safety tests. LeddarTech's proprietary AI-based low-level sensor fusion and perception technology, available on an embedded processor, is at the forefront of facilitating the widespread adoption of ADAS and AD systems.

Factors Influencing ADAS and AD Development

Autonomous vehicles were expected to become widely available by now, but this has not yet materialized. Advanced driver assistance systems are rapidly growing in importance, while autonomous driving systems are becoming a longer-term goal. ADAS is both a key requirement and a safety prerequisite. There are many factors influencing the development and wider adoption of ADAS and AD functions, some of which are explained below:

1. **Legal Factors:** As safety enhancers, ADAS applications are a legal requirement in certain regions. Europe's General Safety Regulations (GSR) mandate that new vehicles be equipped with ADAS safety features such as automatic emergency braking (car-to-car, car-to-pedestrian and car-to-motorcycle scenarios), emergency lane keeping and blind spot information systems. Similarly, the USA's National Highway Traffic Safety Administration (NHTSA) and China's New Car Assessment Program (C-NCAP) extensively test ADAS applications on new vehicles, providing a safety rating based on the results.
2. **Political Factors:** The regulations governing the development, deployment and testing of AD technologies are shaped by political decisions. Different approaches across States and nations highlight this variation. For instance, China and Korea have been leaders in Asia, encouraging AD testing by granting licenses and establishing special zones with infrastructure tailored for real-world testing. In Europe, policies such as the General Data Protection Regulation (GDPR) impact how AD systems handle data, while strict emissions targets drive the integration of electric and autonomous technologies. Additionally, national governments provide incentives for AD testing and infrastructure upgrades. In North America, individual States have adopted varying approaches, with Georgia, California and Arizona being frontrunners in AD adoption. Nevada has also issued licenses for AD deployment and consumer-paid rides.
3. **Consumer Trends:** Consumers are increasingly inclined to purchase vehicles with advanced ADAS features. This is evident in McKinsey's Hands-Off: Consumer Perceptions of Advanced Driver Assistance Systems report, which states: "For future purchases, we see a stronger consumer pull for increasing degrees of driving assistance and technology-enabled autonomy in their next cars, especially as more people seek electrified mobility options. Only 5 percent of electric vehicle (EV) buyers say they do not want any ADAS features in their cars; in the premium segments, that figure falls to less than 1 percent of consumers".

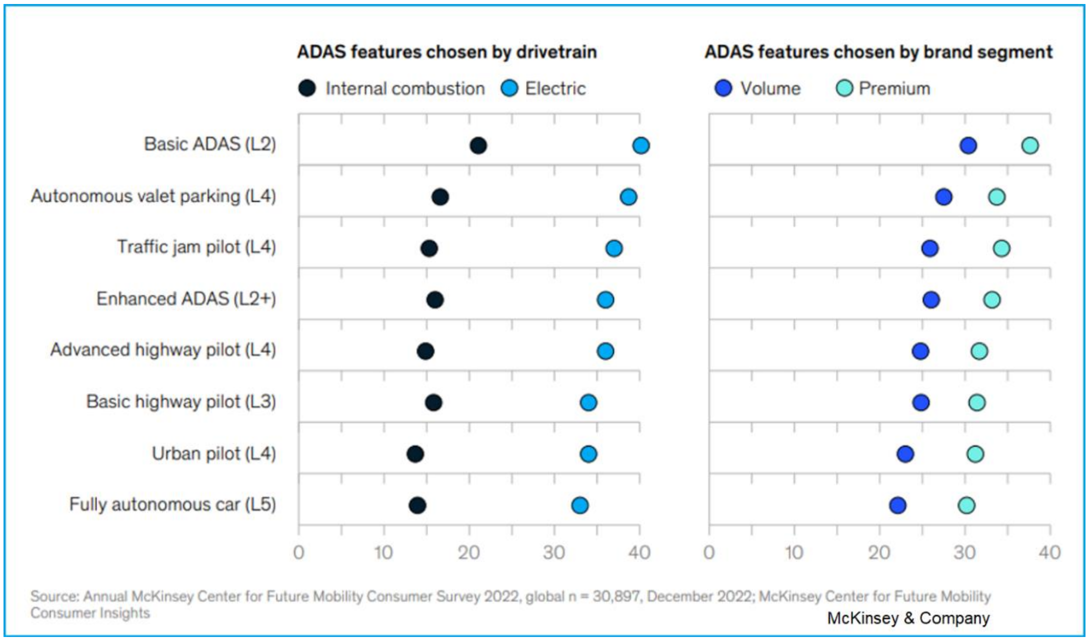


Figure 4 – ADAS features that consumers would consider purchasing, % of respondents (source: McKinsey's Report on Consumer Perceptions of ADAS)

4. **Economic Trends:** Faced with aggressive Chinese OEMs expanding their reach into European and North American markets, a slowdown in EV sales, new environmental targets by cities, provinces and federal governments and fewer new vehicles sold, OEM executives are under unprecedented pressure to revive their companies and forge a path to success. Many OEMs have spent billions of dollars over many years developing autonomous vehicles. With AD still far off, OEMs are pivoting to offer their customers advanced ADAS features that allow them to generate revenue immediately.

The LeddarTech Opportunity

LeddarTech is a leader in environmental perception technology, driven by its innovative LeddarVision software –an AI-based platform that delivers high accuracy, cost efficiency and scalability to automotive OEMs and Tier 1s. These often face challenges with high system costs, integration complexity, long development timelines and ensuring scalability across vehicle platforms. LeddarTech's AI-driven LeddarVision software addresses these issues by delivering high performance with fewer sensors and lower computing power, ultimately reducing overall costs.

With real-world demonstrations and overwhelmingly positive industry feedback, LeddarTech is uniquely positioned to enable OEMs and Tier 1s to develop and deploy advanced ADAS and AD features. The LeddarVision solution is further validated by the close partnerships that LeddarTech has with two industry giants, Texas Instruments and Arm. LeddarTech's collaboration with Texas Instruments integrates LeddarVision with TI's TDA4 processors, creating a pre-validated ADAS/AD solution that reduces complexity, cost and time-to-market for OEMs and Tier 1s. This partnership is further supported by an advanced royalty payment of nearly US$10 million from TI, signaling strong market confidence in LeddarVision.

Similarly, LeddarTech and Arm have been collaborating to enhance the efficiency of LeddarVision. By optimizing critical, performance-defining algorithms within the ADAS perception and fusion stack for Arm CPUs, Arm and LeddarTech have successfully minimized computational bottlenecks and enhanced overall system efficiency using the Arm Cortex-A720AE CPU. Take a closer look at this groundbreaking collaboration: this Case Study provides a detailed account of the two organizations' journey as they push the boundaries of innovation and pioneer the future of automotive safety.

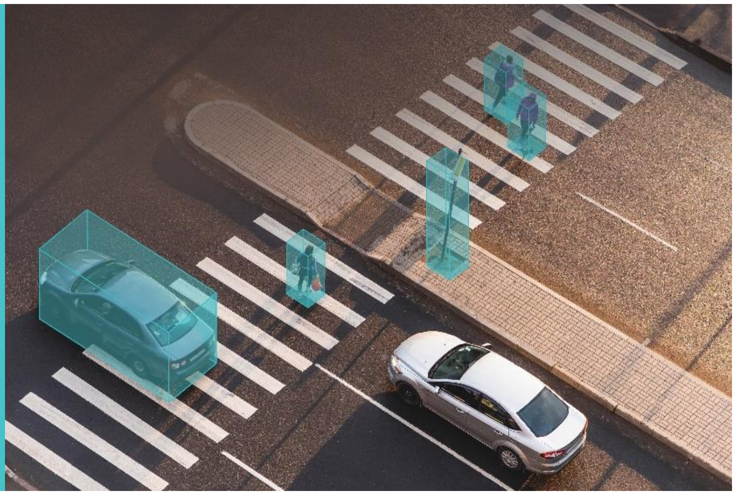
This White Paper does not constitute a reference design. The recommendations contained herein are provided "as is" and do not constitute a guarantee of completeness or correctness.

About LeddarTech

A global software company founded in 2007 and headquartered in Quebec City with additional R&D centers in Montreal and Tel Aviv, Israel, LeddarTech develops and provides comprehensive AI-based low-level sensor fusion and perception software solutions that enable the deployment of ADAS, autonomous driving (AD) and parking applications. LeddarTech's automotive-grade software applies advanced AI and computer vision algorithms to generate accurate 3D models of the environment to achieve better decision making and safer navigation. This high-performance, scalable, cost-effective technology is available to OEMs and Tier 1-2 suppliers to efficiently implement automotive and off-road vehicle ADAS solutions.

LeddarTech is responsible for several remote-sensing innovations, with over 170 patent applications (87 granted) that enhance ADAS, AD and parking capabilities. Better awareness around the vehicle is critical in making global mobility safer, more efficient, sustainable and affordable: this is what drives LeddarTech to seek to become the most widely adopted sensor fusion and perception software solution.

For more information: sales@leddartech.com



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CANADA – USA – AUSTRIA – FRANCE – GERMANY – ITALY – ISRAEL – HONG KONG – CHINA

Head Office
4535, boulevard Wilfrid-Hamel, Suite 240
Québec (Québec) G1P 2J7, Canada
leddartech.com

Phone: + 1-418-653-9000
Toll-free: 1-855-865-9900