TERADAR

Advanced Autonomy

Teradar Vision enables Scalability and Commercialization of Level 4 and 5 Autonomy

Executive Summary

Autonomous trucks and passenger vehicles need to operate safely and reliably in all operational design domains (ODDs), in all weather, on highways and on urban roads. This means that their environmental perception system, using the best available sensing technologies, must enable them to handle every scenario better than a human driver can, including "edge cases" and adverse conditions. Commonly used sensors such as cameras, radar and lidar offer their unique strengths, but face significant limitations in providing high resolution in harsh conditions like fog, heavy rain or bright sunlight glare. As a consequence, business models relying on autonomous vehicles (AV) to be available at all times and in all conditions, can not be rolled out at scale.

Teradar Vision, built on terahertz imaging technology, changes everything. It overcomes the limitations of current sensing technologies and delivers long-range, high-resolution sensing in all weather, powered by a rugged, solid-state architecture that can seamlessly integrate into any vehicle sensor system.

This white paper outlines the critical importance of advanced sensing capabilities for the successful deployment of AVs at scale. Teradar Vision, with its high resolution and ability to deliver precise and reliable object data in all weather conditions, will speed up the widespread adoption of AVs and become a key part of their future sensor systems.

Challenges of L4/L5 Environmental Perception

For SAE L4 and L5 vehicles, perception must be superhuman. Autonomous vehicles must “see” every detail at all ranges up to 300+ meters, resolve critical corner cases with sub-degree precision and safely detect and classify pedestrians, vehicles and other road users even in fog, rain, snow, direct sun, glare, and dust. Technical challenges include:

- **Edge Cases**: Autonomous vehicles need to handle novel, unexpected "edge cases" and even situations not encountered during training. Autonomous vehicles need to learn and make correct inferences from data in real-time, effectively understanding the underlying meaning of its surroundings.
- **Sensor Limitations and Data Fusion**: Achieving comprehensive and reliable environmental awareness requires the robust fusion of data from multiple sensor types. Sensors must complement each other to overcome technical limitations.
- **Adverse Weather Conditions**: Camera and lidar technology degrade in weather conditions with low visibility. Radar technology is robust against weather but does not deliver on high resolution requirements and object separability.

Terahertz Vision Fundamentals

Terahertz waves (roughly 0.1–10 THz, or 3 mm–30 µm wavelength) are situated between radiowaves and infrared light, occupying a “Goldilocks” band that inherits the best of both worlds: the weather robustness of radar and the high resolution of cameras and lidar. Based on the physical properties of the wavelength, terahertz imaging delivers high-resolution, long-range imaging that’s robust against heavy weather.

Key Physical Advantages:

- **Unprecedented resolution**: up to 0.1 degree native angular resolution with best in class object separation, supporting accurate object detection and scene understanding for all corner cases.
- **High Density Point Cloud**: optional high density point cloud in region of interest (ROI), e.g. 30 x 10 degrees, for superior detection of small objects.
- **Long-range performance**: Precise ranging from close range to 300 m with +/- 1.5 cm range resolution.
- **Field of View without Compromise**: Field of view of 120 x 30 degrees with the option to extend vertically by digital beam steering.
- **All-weather penetration**: The Terahertz wavelength passes through airborne water droplets, fog, rain, dust, and snow, delivering reliable detections when lidar and cameras degrade in adverse weather.

Design Simplicity and Robustness

Teradar Vision comes with a highly modular all-solid-state sensing architecture. Build on proprietary transmit (TX), receive (RX) and core processing chips, the Modular Terahertz Engine (MTE) is packaged as customizable modules that can be configured to the needs and use cases of the AVs.

Design Simplicity and Solid-State for Automotive Robustness

- TX, RX and core processing chips are produced on high volume silicon process
- Antennas are integrated in chip design avoiding the need for waveguides
- No moving parts, MEMs or mechanical scanners
- Automotive-grade components built for Automotive Qualification

Simplified Integration and Low Power Consumption

- Sensor packaging and integration is in line with current automotive radar practice
- Low-voltage, low-current operation accepts standard power supplies and network interfaces.
- Standard vehicle interface supports streaming of point cloud data into conventional ADAS/AV compute architectures

Integration of Teradar Vision in Next-Gen Sensor Architecture

Based on the modular architecture Teradar Vision can be used as long-range high resolution sensor (LRT) and/or as high resolution short range sensor (SRT). Integrated in a next generation sensor architecture LRT and SRT will improve the sensing performance of AVs and will help to provide redundancy in case of failure or degradation of other sensor modalities.

- **Replacing Lidar:** Implementing Teradar Vision as a replacement for long range and short range lidar will reduce system costs while dramatically improving system robustness in challenging weather conditions. As an additional benefit terahertz imaging technology does not compromise vehicle design and does not require cleaning.
- **Replacing Radar & Lidar:** Teradar Vision outperforms imaging radar in resolution while keeping the advantages of weather robustness. As a result, Teradar Vision can improve the sensing performance in the system and it can be used as primary sensor in challenging conditions, e.g. when cameras degrade in fog or rain.
- **Safety by Redundancy:** Sensor systems in AVs have to plan for redundancy to guarantee system safety in case of sensor failure or degradation. Terahertz imaging is a new sensing category which is defined by the physical properties of terahertz waves. It increases options on how to design redundancy for Next-Gen Sensor Architectures.

Roadmap and Availability

Teradar Vision is currently under test by major OEMs and Tier-1s in the United States and Europe in pre-production vehicles for L4/L5. Teradar's production roadmap supports:

- Prototype availability in US and Europe in 2026.
- Global availability for high-volume programs in 2028.

Conclusion

Teradar Vision, utilizing terahertz imaging technology, is here to disrupt the sensing architecture for autonomous vehicles. It surpasses current sensing limitations by providing long-range, high-resolution perception in any weather, based on solid-state sensing architecture, designed for automotive quality and robustness. By dramatically increasing safety, utilization and reliability, Teradar Vision is key to the acceptance, scalability and commercialization of autonomous vehicles.