VDA German Association of the Automotive Industry

Position

LEO-PNT

Automotive industry expectations for LEO-PNT system being established by the European Space Agency and the European Commission

Executive Summary

Germany's automotive sector, representing one of Europe's most advanced and export-driven industries, considers precise and resilient Position, Navigation and Timing (PNT) as critical infrastructure for maintaining global competitiveness. LEO-PNT presents an opportunity for Europe to secure technological sovereignty.

The European automotive industry is entering a new phase of transformation towards highly automated and autonomous driving. These systems depend critically on precise, reliable and resilient Positioning, Navigation and Timing (PNT) data. While Global Navigation Satellite Systems (GNSS) and augmentation services provide an essential foundation, their limitations in availability, integrity, and resilience – especially in urban and obstructed environments – as well as the lack of a service warranty, restrict their suitability for safety-critical automotive applications.

Low Earth Orbit Positioning, Navigation, and Timing (LEO-PNT), as proposed under ESA's FutureNAV initiative, offers significant potential to complement and enhance existing GNSS. Expected benefits include improved availability, faster convergence, enhanced accuracy and greater resilience against interference. However, from the perspective of the automotive sector, these advantages still need to be demonstrated in real-world conditions. ESA and its industrial partners must validate the claimed performance improvements through transparent, user-centered testing and service definition. The system's planned operation within the L-band is particularly welcome, as it promises backward compatibility with existing GNSS hardware, simplified integration, and reduced total lifecycle cost for vehicle manufacturers and suppliers.

To enable large-scale adoption, LEO-PNT must meet stringent automotive requirements regarding continuity, integrity, and safety-of-life (SoL) assurance. At the same time, the total lifecycle cost – including integration, operation and correction services – must remain competitive with existing GNSS-based solutions.

The German automotive industry calls on ESA to ensure that the Celeste constellation is developed in close coordination with user industries, under a transparent roadmap that guarantees interoperability, economic viability and regulatory readiness before service rollout.

Content

1 Motivation and PNT Challenges

The automotive sector is rapidly advancing toward higher levels of driving automation, with Level 3 and Level 4 systems expected to represent a significant share of new vehicles by 2035 [12],[13]. This evolution depends fundamentally on robust and trustworthy PNT information [2],[3]. While GNSS forms the global backbone for absolute positioning, it faces well-known constraints. In dense urban canyons, tunnels, or under intentional interference such as jamming and spoofing, GNSS signals can be degraded or unavailable [4],[5]. Existing augmentation techniques, like Precise Point Positioning (PPP), Real-Time Kinematic (RTK), and PPP-RTK, enhance performance but still fail to guarantee the levels of availability and reliability required for safety-critical automated driving [3],[6],[7].

As the European Space Agency (ESA) and its partners explore LEO-PNT (Low Earth Orbit Positioning Navigation and Timing) through the FutureNAV program, the automotive industry recognizes its potential as a complementary PNT layer. Nevertheless, the sector emphasizes that ESA must empirically validate LEO-PNT's promised advantages, such as reduced latency, higher accuracy and improved resilience. Only verified, operationally proven performance can justify integrating LEO-PNT into the automotive navigation ecosystem.

For the automotive industry, reliable PNT information underpins not only driving automation but also logistics, production, and vehicle connectivity. Insufficient GNSS performance can lead to operational disruptions in fleet management, over-the-air updates, and connected safety services.

The recent geopolitical tensions have already led to a growing interference with GNSS services in politically sensitive regions. Jamming and spoofing are becoming increasingly frequent near conflict zones, particularly in Eastern Europe and certain parts of Asia. This growing vulnerability directly affects the reliability of standalone GNSS, making resilience a key concern for critical applications. Furthermore, the possibility of losing access to foreign-operated constellations, such as GPS, GLONASS or BeiDou, cannot be dismissed in the context of escalating global tensions. [13],[14] Hence, enhancing PNT resilience is directly linked to maintaining the international competitiveness of European automotive manufacturers.

2 Automotive Requirements for Future PNT Solutions

Automotive PNT systems must support diverse operational design domains, from urban to rural and highway environments. Key performance areas include the frequency, continuity, availability, accuracy, integrity, resilience and Safety-of-Life assurance, while specific values depend on vehicle automation level and application.
In addition, cost remains a decisive factor. The total cost of ownership, including receiver integration, correction subscriptions and operation, must remain comparable to or below that of existing GNSS and augmentation systems.

From a European automotive perspective, the evolution toward LEO-PNT must follow the principle of compatibility before innovation. The new service layer shall transmit within the L-band to ensure coexistence with current GNSS receivers and antennas. This design choice minimizes additional hardware costs and allows software-defined receivers already deployed in production vehicles to benefit from firmware upgrades rather than hardware replacement. Such compatibility represents a non-negotiable design criterion from an automotive viewpoint. LEO-PNT is an additional layer that enhances robustness, integrity, and availability. In the vehicle, the resulting position solution will continue to be fused with other sensor modalities—such as radar, lidar, camera-based perception, and emerging 5G/6G positioning signals—to create a resilient and redundant navigation framework suitable for safety-critical automotive applications.

3 Expectations for ESA's LEO-PNT (Celeste)

LEO-PNT offers promising characteristics that could mitigate many of GNSS's limitations. With lower orbital altitudes and faster satellite motion, LEO constellations can provide improved geometry, higher signal power, and shorter convergence times. For automotive applications, these features translate into potential improvements in accuracy, signal robustness, and availability in obstructed environments. Furthermore, the combination of LEO-PNT with existing GNSS layers could form a resilient multi-layer PNT architecture. [1],[3],[4],[8],[9],[11],[10],[15]

However, the automotive sector emphasizes that these advantages remain theoretical until validated. ESA and its industrial partners must ensure:

- Transparent testing of prototype satellites and demonstrators under realistic automotive conditions.
- Publicly available service definition documents (SDDs) including integrity guarantees and SoL concepts.
- Long-term economic viability and cost predictability of LEO-PNT services, avoiding over-dependence on proprietary correction models.
- Compatibility with automotive-grade hardware, ensuring compact, low-cost receivers that can be integrated into volume-market vehicles.

For Germany, early pilot projects and field tests are encouraged, ideally conducted in established digital testbeds such as the A9 Digital Motorway Testbed, Testbed Lower Saxony, A93 Rosenheim-Kufstein in the frame of the ESA SoLPOINT project, and urban proving grounds e.g. in Munich, Ingolstadt, Wolfsburg/Brunswik, Stuttgart or other. These environments provide realistic conditions for validating LEO-PNT performance in automated driving scenarios, including high-speed lanes, urban canyons, and V2X-enabled intersections.
ESA should be informed of these activities and outcomes to allow for their systematic consideration and potential integration at program level within the LEO-PNT initiative.

4 Industry Demands and Roadmap for ESA & the European Commission

From the automotive industry's standpoint, a structured roadmap is essential to align ESA's LEO-PNT activities with end-user expectations. The VDA recommends the following steps:

1. Phase 1 – Demonstration and Validation (2025–2027): ESA should conduct transparent, application-oriented validation campaigns using LEO-PNT demonstration satellites. Performance metrics, including availability, integrity and latency, should be systematically measured and published for independent review to demonstrate the expected benefits for safety-critical applications. In parallel, and in line with positions expressed by the VDA, it is important that the European Commission (EC)— in particular DG DEFIS and DG MOVE — is made aware that the automotive sector requires a dedicated, clearly specified PNT service within the LEO-PNT program.

2. Phase 2 – Standardization and Integration (2027–2030): Collaborate with the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), European Telecommunications Standards Institute (ETSI), and the International Organization for Standardization (ISO) to develop common standards for LEO-PNT interoperability, integrity monitoring and Safety-of.Life certification.
3. Phase 3 – Market Readiness (2030–2035): Establish open service interfaces and certification frameworks to enable integration into production vehicles. Automotive suppliers and OEMs must be part of this process from the start.

Throughout all phases, ESA and EC should maintain close dialogue with the automotive sector through structured working groups and transparent governance. The timeline of the phases mentioned above is also crucial for the European car industry. We would ask EC and ESA to focus on the timely deployment of a dedicated PNT service for automotive applications and to avoid combining Safety-of-Life PNT and Public Regulated Service, as a second use case for LEO-PNT, on the same satellite, as this would negatively impact program schedule and cost.
To facilitate the phases outlined above, the validation and demonstration of Celeste should be completed by 2028, with the launch of the final in-orbit satellite constellation beginning in 2028 and concluding by 2032.

To strengthen cooperation, the German automotive industry proposes establishing an ESA–VDA alignment on PNT integration, at best with EC participation. This body should coordinate technical validation, spectrum policy, and standardization across all LEO-PNT (Celeste) phases. Additionally, Germany could serve as an early operational region for pre-commercial testing, especially in the phase 2, allowing the automotive sector to evaluate system maturity before mass deployment. Public-private co-funding mechanisms like those used in previous GNSS test campaigns could accelerate implementation.

5 Conclusion and Call to Action

The German automotive industry welcomes ESA's LEO-PNT (Celeste) initiative as a potential cornerstone for Europe's next-generation PNT ecosystem. However, adoption in the automotive domain requires services that are verified, certifiable, and economically sustainable. LEO-PNT must demonstrate its value not only in terms of precision and resilience, but also in terms of interoperability and affordability. The European Commission (EC) and European Space Agency (ESA) are urged to prioritize user-driven validation, cross-sector collaboration, and transparency in all development stages. From an operational safety perspective, Celeste should therefore include a dedicated framework for Safety-of-Life service evolution, ensuring that integrity, continuity, and availability can be monitored and validated end-to-end across all segments — space, ground, and automotive user.

The automotive industry stands ready to contribute expertise, testing capacity, and application knowledge to help shape Celeste into a truly resilient, multi-layer PNT system that serves Europe's mobility transformation.
Only through such a partnership can Europe ensure strategic autonomy in satellite navigation, enable safe automated driving and maintain technological leadership in the global mobility sector. In this context, establishing a robust collaboration between ESA and the automotive industry is essential to ensure that Celeste delivers both technological excellence and economic efficiency. LEO-PNT's adoption will only succeed if it remains affordable, compatible and verifiable in daily automotive operations.

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The German Association of the Automotive Industry (VDA) consolidates around 620 manufacturers and suppliers under one roof. The members develop and produce cars and trucks, software, trailers, superstructures, buses, parts and accessories as well as new mobility offers.

We represent the interests of the automotive industry and stand for modern, future-oriented multimodal mobility on the way to climate neutrality. The VDA represents the interests of its members in politics, the media, and social groups.

We work for electric mobility, climate-neutral drives, the implementation of climate targets, securing raw materials, digitization and networking as well as German engineering. We are committed to a competitive business and innovation location. Our industry ensures prosperity in Germany: More than 740,000 people are directly employed in the German automotive industry.

The VDA is the organizer of the largest international mobility platform IAA MOBILITY and of IAA TRANSPORTATION, the world's most important platform for the future of the commercial vehicle industry.

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