Selim Solmaz, Jakob Reckenzaun

Infrastructure for the Extension of ODDs – applied in Connected and Automated Driving and Standardization Procedures

This article introduces the iEXODDUS project, which aims to enhance the infrastructure supporting automated vehicles to manage the complexities of their environments. The project is advancing digital technologies and navigation services to improve safety, security, and sustainability in the mobility sector, thus paving the way for more reliable automated transportation. iEXODDUS will assess existing Operational Design Domains (ODDs) to identify limitations and areas for improvement, fostering a comprehensive understanding of ODD challenges and opportunities. This analysis will form the foundation for a framework to assess and categorize ODDs across various automated driving scenarios. A key focus is on enhancing sensor technologies and perception capabilities through advanced data fusion methods, expanding ODDs beyond current limits while considering environmental factors such as weather conditions and road infrastructure.

Transportation has undergone a paradigm shift due to rapid development of multi-level autonomous vehicle technology, promising improvement in both efficiency and safety. However, the operational capability of autonomous vehicles remains constrained by system component limitations such as sensor perception, behaviour prediction, and reliability. These challenges impose significant restrictions on their Operational Design Domains (ODDs). Figure 1 illustrates ODD interruptions for an Automated Lane-Keeping System (ALKS) on a motorway. The first and last mile of any journey, due to ALKS system limitations, still necessitate manual human-lead driving. In theory, the ALKS system assumes operation for the entire time the vehicle is on the motorway. However, in practice, events such as accidents, roadwork zones, or specific infrastructure challenges i.e. tunnels often require the driver to reassume control.

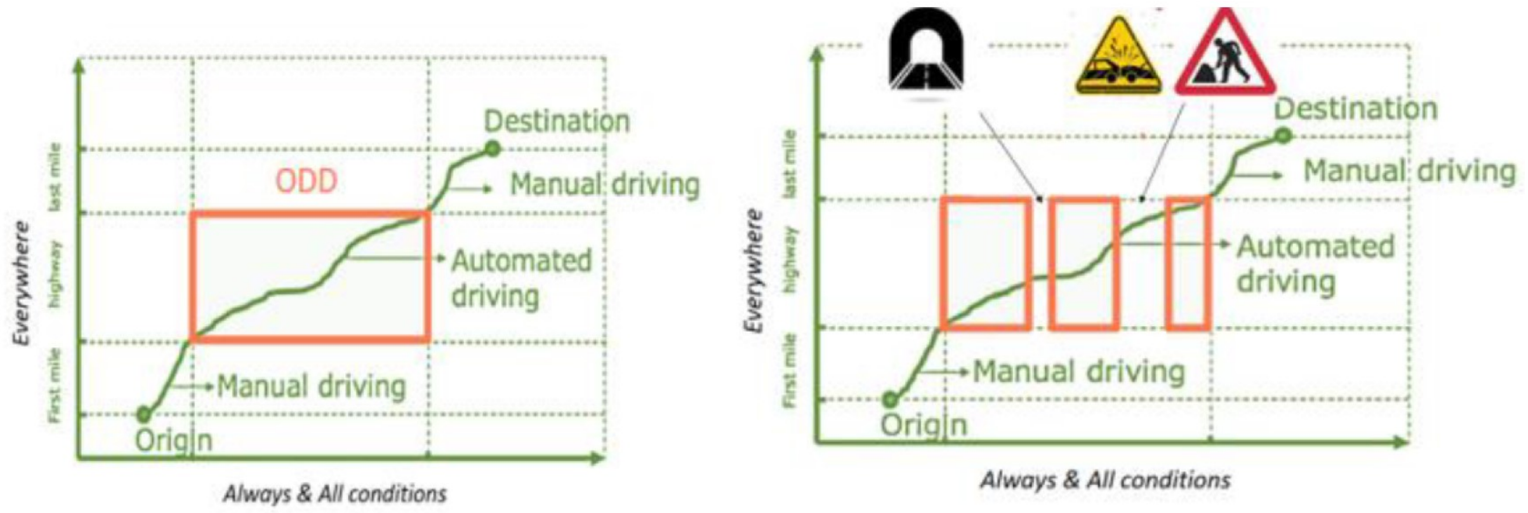


Fig. 1. Highway ODD and ODD interruptions baed on [9].

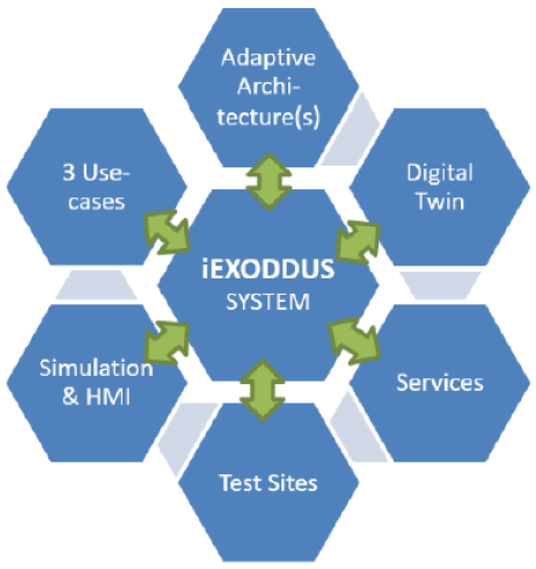


Fig. 4. iEXODDUS System and innovations.

The iEXODDUS project introduces key architectural innovations aimed at extending the ODDs for connected and automated vehicle operations. These innovations, illustrated in Figure 4, focus on creating a robust and scalable system that integrates real-time data, advanced digital twins, and vehicle- to-infrastructure communication. By extending the ODD to cover complex environments such as highway construction sites and incident zones, the project seeks to enhance the safety, efficiency, and functionality of automated driving, ensuring seamless vehicle operation even in challenging conditions.

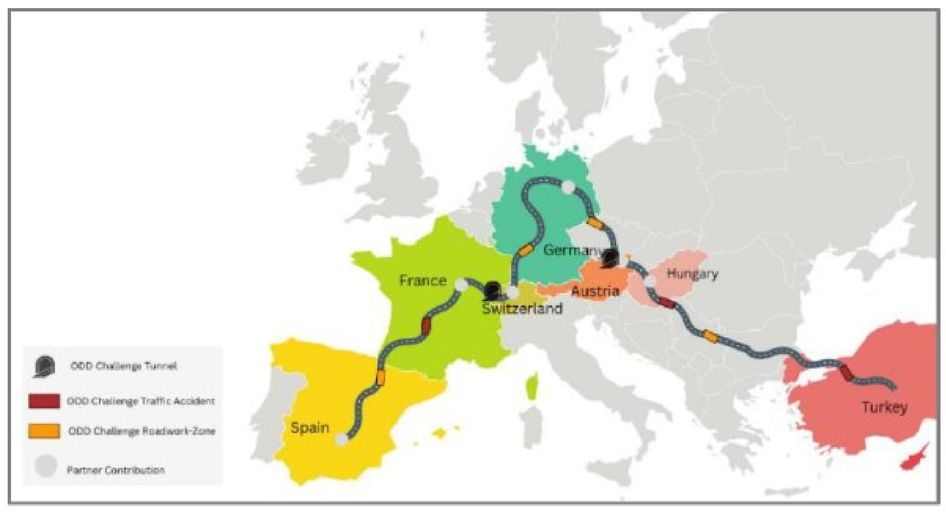
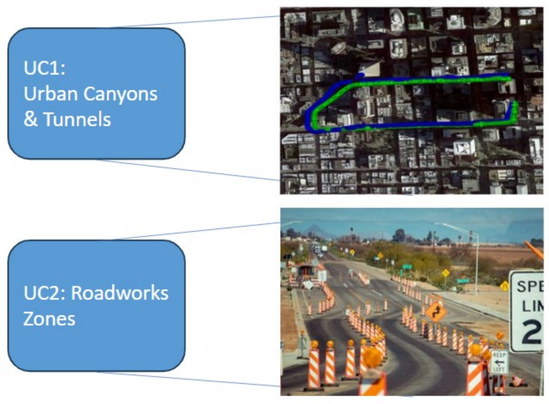


Fig. 2 illustrates the ultimate goal of seamless integration: a trip of an automated vehicle from Turkey to Spain via several European partner countries.



A. Use Case-1 (UC1): Navigate through **urban canyons and tunnels** for CCAM Actors: Work zones present a significant challenge for autonomous vehicles, particularly in terms of perception and decision-making. Current sensor capabilities are insufficient for accurately detecting and interpreting work zone setups in advance.

B. Use Case-2 (UC2): Navigate through **road works zones** for CCAM Actors: Current Level-3 autonomous vehicles require a driver handover when passing through tunnel sections, as GNSS-based localization becomes non-functional. To address this limitation, there is a pressing need for ODD extensions that enable automated driving in GNSS-denied environments.

C. Use Case-3 (UC3): Navigate through **incident zones** for CCAM Actors: Navigate Through Incident Zones for CCAM Actors" use case aims to enhance the ability of automated vehicles to safely and efficiently respond to unpredictable situations such as accidents and road closures. By leveraging V2I, V2V communication, and real-time updates to HD maps, CCAM vehicles will navigate incident zones with minimal driver intervention, improving safety and reducing traffic disruptions.

Within this paper, the novel European project iEXODDUS is presented. Currently available driving functions are challenged and the bounderies for existing Highway-ODDs are going to be extended through improved technologies (improved perception, enhanced and robust localisation, robustness against adverse weather) and infrastructure support measures like data provided by infrastructure services. The overall expected technical impact of iEXODDUS is depicted on Figure 5. By realising the three proposed technical use-cases a continuity of the ODD shall be achieved, Europe's path towards a more digital economy is supported and safety for a mixed traffic system is increased.

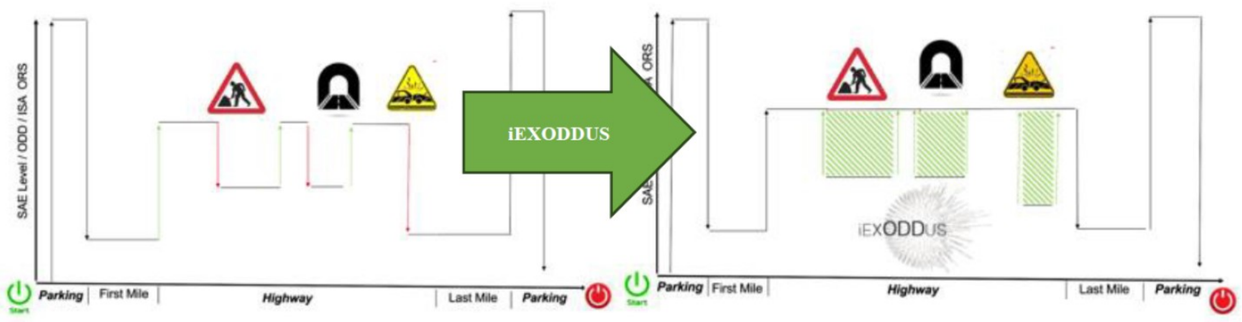


Fig. 5. ODD extension concept by iEXODDUS

Virtual Vehicle Research GmbH has received funding within COMET Competence Centers for Excellent Technologies from BMK, BMAW, the Province of Styria and the Styrian Business Promotion Agency (SFG).
The Austrian Research Promotion Agency (FFG) has been authorised for the programme management.

Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility,
Federal Ministry Republic of Austria Labour and Economy
FFG Promoting Innovation.
Das Land Steiermark Wirtschaft, Tourismus, Wissenschaft und Forschung
SFG