講演番号	181

Standards for testing and homologation of autonomous driving vehicles with digital twins

Yoshiaki Shoi[1)]

1) ASAM Japan G.K.
1-2-20 Kaigan, Minato, Tokyo, 105-0022, Japan (E-mail: yoshiaki.shoi@asam.net)

KEY WORDS: **Software and its underlying technologies, HILS, SILS, Digital Twin, Standardization**[E3]

Abstract

As autonomous driving (AD) systems grow in complexity, traditional physical testing is no longer sufficient for comprehensive safety verification. To address this, international bodies such as UNECE WP29 and ISO have established guidelines and process standards that incorporate digital twin methodologies. This paper provides an overview of ASAM OpenX, a suite of implementation-level standards developed by ASAM to enable the seamless exchange of data and components within digital twin-based environments for testing and homologation.

The Role of Digital Twin in Standardization

Digital twins allow for high-fidelity simulations of driving environments, enabling the testing of AD systems under diverse and rare scenarios that are difficult to reproduce in the real world. UNECE WP29 recommends a multi-pillar approach to safety verification, utilizing simulation alongside track and real-world testing. Within this framework, ISO (specifically ISO 34501 through 34505) defines the terminology and high-level frameworks for scenario-based safety evaluation. ASAM OpenX serves as the practical implementation layer for these international frameworks, ensuring that different simulation tools and models can interoperate effectively.

Key ASAM OpenX Standards

Fig.1 shows the relationship between digital twin elements and each ASAM OpenX standard. The ASAM OpenX portfolio consists of several specialized standards that define various interfaces in the digital twin environment:

ASAM OpenDRIVE & OpenCRG: ASAM OpenDRIVE standardizes the description of road networks, including lanes and traffic signs, while ASAM OpenCRG focuses on high-resolution road surface characteristics.

ASAM OpenSCENARIO: This standard defines the dynamic behavior of agents within the simulation, supporting both specific XML-based scripts and abstract, large-scale verification via Domain Specific Language (DSL).

ASAM OSI (Open Simulation Interface): ASAM OSI provides a standardized interface between various models —such as world model, sensor model, and AD processing model— allowing components from different suppliers to be integrated into a digital twin-based verification environment.

ASAM OpenLABEL: This standard is designed to facilitate data reuse and management by tagging measurement data obtained during driving verification with annotation descriptions.

ASAM OpenMATERIAL 3D: It defines the physical and visual properties of objects (assets) in the simulation, ensuring that sensors like LiDAR and radar perceive them accurately across different platforms.

ASAM OpenODD: This standard was initially developed to describe the Operational Design Domain (ODD) in digital twin environments, incorporating ISO 34503. Its capabilities have since been expanded to include the Target Operational Domain (TOD) and Testbed OD, thereby facilitating the mapping of regulatory requirements to specific test environments.

Future Outlook and Standardization Process

ASAM continues to evolve its standards through a member-led process based on use cases and requirements. Upcoming initiatives include **ASAM QSQ**, which aims to quantify simulation quality by 2027, and an expansion of **ASAM OSI** for high-fidelity sensor simulation. The latter will introduce interfaces for "Status Notation" and "Change Orders" to support more complex interactions between sensor models and the virtual world.

Conclusion

By providing a unified set of implementation standards, ASAM OpenX addresses the critical need for interoperability in AD verification. This ecosystem not only supports current requirements but also provides a scalable foundation for future challenges in autonomous vehicle safety.

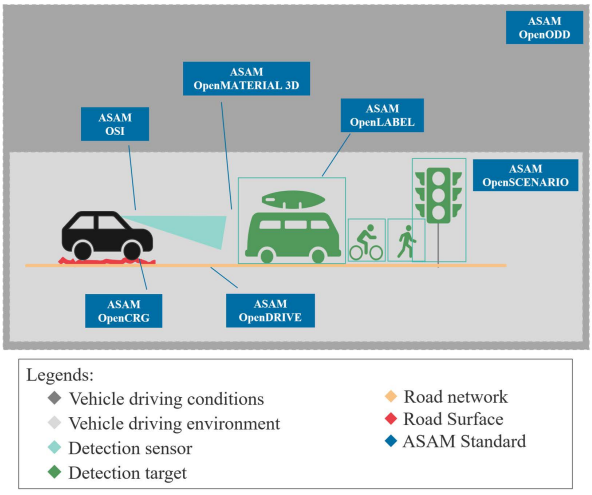

Fig.1 Digital Twin Elements and ASAM OpenX standards