Concept Project: OpenDRIVE lite with linked CityGML

Project Number	P_YYYY_NO
Project name	Combining reference-line based OpenDRIVE and CityGML for an interoperable, comprehensive road space modelling
Domain	Simulation
Impacted standard(s)	OpenDRIVE CityGML OpenMATERIAL
Project type	Concept
Start date	06.01.2025
End date	31.10.2025
TSC Submission:	04.11.2024
Proposer(s)	*Should this project be approved, and no other volunteers be identified up to the kickoff workshop to take on the role of project leadership, the Proposer(s) take on the Project Lead role by default.*
ASAM Office Responsible (OR)	Yash Shah
Initiating Companies	Deutsches Zentrum für Luft- und Raumfahrt e.V. Hexagon TU München Virtual City Systems Volkswagen AG
ASAM funds	
Backwards Compatibility	n/a

For more information on the ASAM project process and the proposal phase in particular, please refer to the ASAM Project Guide.

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1 Executive Summary

For testing and validation of advanced driver assistant systems and automated driving simulation is used. The complex systems under test do not only need precise and detailed modeling of the road but also a growing amount of information about the environment, too.
Currently, ASAM OpenDRIVE is fulfilling the task for the road description quite well, thus it became de-facto standard in automotive domain. The newest version 1.8 was published in November 2023. Nevertheless, disadvantages and issues arose, including the following:

- Simulation settings and road settings became more and more complex and therefore the handling of the data does not scale.
- More real-world data was introduced. The modeling approach of OpenDRIVE is stretched to its limits.
- The databases were linked with various other databases for sensor simulation.

The standard CityGML issued by the international Geospatial Consortium (OGC) is the most commonly used format for storing, modeling and exchanging semantic 3d environments. Highly accurate geo-referenced, geometric and topological information as well as semantic capabilities are key strengths of CityGML. Different thematic modules are available to cover diverse use cases, including simulations and analyses. The newest version 3.0 of CityGML was published in September 2021 and contains revised and extended concepts for modelling the street space. Compared to OpenDRIVE, CityGML follows a completely different geometric modelling approach based on discrete areas using explicit coordinates. As general exchange standard for 3d city models CityGML does not cover all requirements for a specific application, which results in some drawbacks regarding the automotive domain:

- City management applications often require a fragmented view of the traffic area, which does not match a simulation view.
- Semantic concepts differ with respect to their approach to segmenting the street space into individual objects as well as modeling the road (e.g. linear referencing, parametric geometries).

Simply including OpenDRIVE into CityGML does not solve the OpenDRIVE issues. CityGML contains a built-in mechanism for extending the data model of the standard with concepts not originally within its scope called Application Domain Extensions (ADE). This could help to bridge the gap between the two standards.

The proposal for this concept project is to re-think the road modeling approach incorporating requirements of automotive domain.

- Use CityGML strength to model a semantic 3d environment
- Define a compact standard based on OpenDRIVE 1.x to model road logics
- Define a linkage concept to meet requirements of the whole simulation domain and improve interoperability between GIS and automotive domain
- Re-use the linkage concept to connect to additional relevant road information

The concept project will bring together the expertise of both, automotive and city modeling domain to propose an easy and modular solution that is easy to use and extendable by further relevant stakeholders (e.g. traffic or energy management).

2 Overview / Goals

2.1 Motivation

OpenDRIVE was initially created to describe a road network's logic for synthetic roads. Over time more and more features were added driven by growing use cases and the need for a detailed description of the road space. In addition, semantics and shapes of further features linked to a road network were added, which led to an increase in complexity of the standard. Also, the way OpenDRIVE is designed limits the level of detail of a road space description including its environment to a certain extent. Nevertheless, the design principle allows smooth simulation of the movement of all traffic participants including the system under test.
With new applications like sensor simulations arising, modeling of surface and material information becomes more and more important. Instead of further bloating the existing OpenDRIVE standard, we propose to slim it down to its original purpose and outsource additional needs.
To find a new home for 3d environment definition, OGC's CityGML standard is a promising candidate, which allows a semantically well-defined description. CityGML is used all over the world for 3d city modeling and can easily be converted to visualization formats like glTF. Also, using an accepted format can open new data pools, simplify data generation and handling by improving interoperability.
By defining a standardized linkage concept new challenges requiring a detailed road network description can be addressed by making use of the strength of existing concepts.

2.2 Relations to Other Standards, Projects, or Organizations

2.2.1 Standard and Standardization Activities

2.2.1.1 Current OpenDRIVE

Upcoming applications in the automotive domain aim at enabling realistic representations of real-world data on a larger scale. Regarding this, the following issues with the current OpenDRIVE emerge:

- Modeling is based on reference lines with relative lane definitions. These are usually virtual constructs, based on clear rules. However, roads in complex urban scenarios are often not built according to these road construction guidelines.
- Due to the modeling approach, auxiliary constructions are often necessary, which leads to even more complexity, ambiguities or gaps. It is therefore very difficult to update or patch parts of a complex road model.
- The hierarchical XML specification can lead to multiple definitions of the same elements, such as road marks. The strict hierarchy leads to costly and time-consuming update procedures of subordinate elements in one OpenDRIVE file.
- Real-world data cannot be transformed into OpenDRIVE syntax directly. This is due to OpenDRIVE being a virtual construct. This means, its modeling procedures are not common among other domains, such as road operators or public authorities.
- Scalability and data exchange are very limited, due to a large XML structure that does not have abbreviations, such as namespaces. It is therefore necessary to facilitate huge databases of urban or long motorway settings.

2.2.1.2 Current CityGML

CityGML is the most commonly used data model and exchange format for semantic 3d city models [Kolbe et al. 2021]. Version 3.0 of the international OGC standard CityGML was published in 2021 and introduced revised and extended concepts for modelling transportation infrastructure [Kutzner et al. 2020]. This contains geometric, semantic, topological, temporal and visual concepts for virtually representing cities. The modular structure of the standard provides individual concepts for representing buildings, city furniture, vegetation or transportation objects. The transportation module contains standardized concepts for representing road infrastructure. Objects are hierarchically structured and semantically decomposed. Large road networks, for example, are segmented into individual roads, which are further split into sections and intersections, which again can consist of individual traffic areas representing driving lanes, sidewalks, bicycle paths, etc. This information is contained within dedicated function or usage attributes. Further classes for modelling road markings, holes in a road's surface (such as manholes or roadway damage) as well as clearance spaces are available. Each object contains a unique identifier (`gml:id` attribute).

All geometries are generally georeferenced using explicit real-world coordinates. Road objects can be represented using linear (graph-based), areal (surface-based) or volumetric geometries in three levels of granularity, ranging from generalized representations of an entire road down to lane-level representations. Topological concepts for representing predecessor and successor relations (e.g. to represent traffic logic) as well as information on traffic directions are available.

Additionally, further thematic modules provide concepts for representing city furniture objects (e.g. traffic signs or traffic lights), vegetation (e.g. trees), buildings, bridges or tunnels. Thus, CityGML provides consistent and integrated concepts for modeling entire city and street space environment models. CityGML concepts can be extended by introducing generic classes and attributes or by defining a formal extension to the data model with an Application Domain Extension (ADE).

While CityGML is not a visualization format, common visualization formats such as OBJ, 3D Tiles, glTF, COLLADA or KML can be derived from CityGML using existing tools or ETL processes. In this way existing processing chains and tools can be expanded by making use of the standardized CityGML data model without the need for further implementation.

An added value of CityGML is the broad availability of commercial and freely available open datasets [CityGML Open Data examples].

2.2.1.3 Other formats and activities

The project also aims to investigate that the approach aligns well with further standards of ASAM standards. This includes road network and environment descriptions aspects for standards OpenSCENARIO XML and OpenSCENARIO DSL. Furthermore, the OpenMATERIAL project standardizes material properties required for physical sensor simulations.

In addition to formats primarily used during the development phase, there are also lane-level road representations used during the operational phase and should also be considered in this project. This includes the format of the Lanelet2 project and the Open Lane Model from the Navigation Data Standard (NDS). The ISO also develops and provides standards for representing maps, such as the "Geographic Data Files" (ISO 20524-1:2020) and the "Dynamic data and map database specification" (ISO/AWI TS 22726).

2.2.1.4 Already proposed innovation for road modeling

In the OpenDRIVE concept project the WP05 Area Concept [OpenDRIVE Concept Document] already addressed these issues. To achieve this, in the Area Concept the way of modeling a road network is changed in order to bridge the gap between current simulation use cases and the upcoming challenges of introducing more real-world settings into the simulation as well as data with a higher level of detail. The key motivations are:

- Model roads as they are, without creating gaps.
- Simplify the modeling of complex urban situations.
- Make the usage of existing real-world data easier by integrating data of public authorities faster.
- Use shared geometries to ensure the integrity of topological data and avoid unintended gaps.
- Do not use artificial modeling constructs or helping constructions, such as reference lines, junction containers or hard-coded lane structures, in order to model real-world data.
- Avoid using relative coordinate referencing at any time that is referencing along imaginary reference lines. Instead, use absolute coordinates wherever possible.
- Simplify the linkage to other databases in order to easily provide supplementary information.
- Store separate content in layers for flexible access and extension. Layers may be arbitrarily user-defined.
- Improve the maintainability of a database by making it easier to update individual parts or elements.
- Avoid large XML files and enable spatial indexes and queries by using geographic information system (GIS) technology to quickly access and process large databases.
- Improve scalability, since the current OpenDRIVE is not scalable at all.

A detailed lineup of differences between the proposed Area Concept and OpenDRIVE 1.x is provided in documentation of the OpenDRIVE concept project work package WP05 description in Section 1.3.1.

The Area Concept facilitates stand-alone polygons for the description of the usable area, for example for transport modes or traffic participant types. All polygons belonging to one traffic mode are grouped into a layer. This results in having different independent layers for different traffic modes, which simplifies the modeling of complex urban scenarios. The elements can be combined in a variety of ways:

- Polygons (areas) within the same layer are linked to each other implicitly using shared geometries, which superimpose topology constraints. These topology constraints ensure data integrity and are easy to handle on a database level. The necessary tool support is already available in the GIS domain and partly standardized.
- Explicit linking of elements within one layer or between layers can be achieved on a flat attribute level. Such an approach offers great flexibility and easy extensibility.
- Additional "logical linking layers", for example using reference lines, lane center lines or movement paths, can be included into the layer tree at any time.

The current OpenDRIVE works well for automated test case generation with a limited scope. The Area Concept focuses on the extensive use of real-world representations, which is very restricted in OpenDRIVE. Here, the formerly proposed Area Concept overlaps in many aspects with the road space model of the current CityGML 3.0 Transportation Model. In both approaches, test case creation of smaller settings is also possible with appropriate tool support. Once the complexity of test cases increases and test cases incorporate more real-world data, such areal modelling approaches will play out their advantages.

This leads to the conclusion to perform the 3d environment modeling in a GIS-like environment, to follow civil engineering as well as to keep the essence of OpenDRIVE for simulation purposes. The linkage between different layers enables the possibility to add more data if available without the need to reflect all these features in one data format. A reduced OpenDRIVE and a utilized CityGML connected via a linkage mechanism sounds promising.

2.2.2 Backward Compatibility to Earlier Releases

No backwards compatibility with OpenDRIVE 1.x is planned, but a migration guide from OpenDRIVE 1.x to the proposed approach is to be developed in a Standardization Project. Moreover, the project intends to investigate the linkage possibilities to OpenSCENARIO XML and DSL.

2.3 Use Cases

The concept proposal shall cover at least the domains of automotive development, test and verification as well as city modeling. These domains are the intrinsic driver of comprehensive environment modeling, but more stakeholders can benefit from an overall digital twin. Also, within the two mayor domains the use cases can vary. Therefore, the following use cases should give an idea of the versatility of the proposed concept but are not limited to the mentioned.

Table 1 Generation of High-Definition Road Networks

ID	
Description	Traffic simulation, vehicle dynamics simulation, sensor simulation as well as virtual development, test and validation require synthetic as well as geo-referenced, high-definition maps of road networks. Such kinds of maps are either created based on scenario definitions or by map data provider (e.g., surveying companies) or derived from aerial images and requested by public authorities, car manufacturers, simulation tool vendors, urban planners etc. The road networks should be interchangeable among stakeholders.
Actors	• Surveying companies and map makers • Public authorities • Vehicle manufacturers and their suppliers • Simulation tool vendors • Urban planners

Table 2 Traffic Simulation

ID	
Description	Macroscopic and microscopic simulation of traffic on road networks. Traffic simulation may incorporate large numbers of various traffic participants, e.g. pedestrians, cyclists, road and rail vehicles etc. Traffic simulation is used to simulate surrounding traffic of a system under test, traffic volume in specific areas, accident probabilities, traffic management strategies, impacts of changes in the road network etc. Traffic simulation requires a logical description of corresponding road networks for varying kinds of traffic participants.
Actors	• Public authorities • Mobility (as a service) operators • Road operators • Vehicle manufacturers and their suppliers • Simulation tool vendors • Urban planners

Table 3 Sensor Simulation

ID	
Description	Simulation of sensors as a device, module or subsystem of a vehicle or infrastructure is indispensable for the selection of individual sensors as wells as for the compilation of sensor sets and the development of sensors and sensor-based functionalities in the automotive and traffic management context. Sensor simulation provides the foundation for development and test of driving assistance functions, for automated and autonomous driving functions as well as for intelligent traffic management. The environment and its physical appearance have a strong influence on sensor's behavior.
Actors	• Vehicle manufacturers and their suppliers • Simulation tool vendors • Road operators • Urban planners

Table 4 Virtual Development, Test and Validation

ID	
Description	Development, testing, validation and verification of automated and autonomous driving functions are increasingly carried out virtually. Also, a function's final approval will be based heavily on virtual testing and verification. The reproduction of countless, realistic journeys over millions of kilometers requires complex road networks and an extensive number of scenarios as input files. Major requirements on corresponding file formats are standardization and exchangeability.
Actors	• Vehicle manufacturers and their suppliers • Simulation tool vendors • Public Authorities • Testing organizations

Table 5 City Planning

ID	
Description	The overall planning of urban areas has to include various aspects such as change of mobility, livability (regarding supply and emission reduction), ecological as well as economic impact, solar potential calculation, heat distribution, air and emission flow simulation, citizen needs, etc. A lot of these aspects are influencing each other. Therefore, a detailed modeling of the environment with supply infrastructure – including traffic networks – is crucial, especially if different simulation tools are used. Using the same data source ensures that everybody is simulating on the same basis.
Actors	• Simulation tool vendors • Public Authorities

Table 6 City Management and Operation

ID	
Description	The management of urban areas covers not only the road operation but also energy management, green-space management, etc. Road operations should manage their infrastructure assets in a way that, e.g., traffic simulation can use this knowledge to calculate impacts of changed traffic flows, such as for temporary construction sides. For that, a detailed modeling of the road and roadside infrastructure as well as environment is necessary.
Actors	• Simulation tool vendors • Public Authorities • Mobility (as a Service) operators • Road operators

3 Technical Content

The project aims to establish a data model that provides a comprehensive, standardized, and easily understandable description of drivable area street space. This involves clearly separating logic and visualization. OpenDRIVE's role is reduced to defining the minimal viable drivable area, while other essential information for visualization or other applications is outsourced and linked in a standardized manner.

3.1 Description of Road Space Using OpenDRIVE and CityGML

The modelling of road space is segmented into different components, leveraging established concepts and formats to enhance acceptance and leverage different modelling approaches and domains.

3.1.1 Components Modelled in OpenDRIVE

OpenDRIVE was initially designed to depict road network logics. The reference line-based model is well established and shall be maintained. The future proposed OpenDRIVE should include:

- Course of the road
- Road lane definitions
- Lane linkages
- Temporary lane definitions (e.g., for construction sites)

All other details such as road markings or object shapes are excluded from OpenDRIVE to maintain a streamlined base definition.

3.1.2 Components Modelled in CityGML

CityGML provides a detailed, three-dimensional representation of the urban environment, offering semantic and geometric data for:

- General terrain
- Road cross-sections (including lane elevations)
- Real-world objects (e.g., vegetation, street furniture, buildings) with material data
- Road layouts not covered by lane definitions (e.g., central islands, restricted areas)
- Road markings
- Traffic signs and signals

Compared to current possibilities of OpenDRIVE, this enables the modelling of an aerial, non-redundant 3d street space. CityGML's current capabilities can be validated to collect missing features and initiate further extensions. Two requirements towards CityGML representation, that can already be stated are:

- Extend modeling of entities with material description (such as OpenMATERIAL) for sensor simulation
- Enable access to entities for animation and state control

3.2 Standardizing Linkage

Additional information beyond the road network's logic will not be directly defined in OpenDRIVE but rather linked externally. Therefore, a well-defined linking mechanism must be established.

3.2.1 Linkage Between OpenDRIVE and CityGML

Standardizing the integration between OpenDRIVE and CityGML ensures seamless interoperability. Key considerations include:

- Defining a concept to reference features: Establishing a robust referencing system for accurate data representation across formats.
- Bi-directional or one-directional interface: Determining the interface directionality to optimize data flow between CityGML and OpenDRIVE.
- Utilizing CityGML Global Identifiers: Leveraging CityGML's existing global identifier system to establish references in OpenDRIVE for efficient data integration.
- Linking via identifier in OpenDRIVE: Incorporating CityGML global identifiers into OpenDRIVE to establish direct references, ensuring alignment between logical road network representations and spatial features.

Several questions remain regarding the interface specifics:

- Content of OpenDRIVE (ODR): Defining the exact scope of OpenDRIVE content, influencing interface design.
- Objects requiring direct reference: Identifying critical objects necessitating explicit references between OpenDRIVE and CityGML.
- Implicitly linked objects: Determining objects that can be linked implicitly based on attributes and spatial relationships, streamlining the referencing system.

3.2.2 Linkage Between OpenDRIVE and Auxiliary Data Layers

In addition to CityGML, OpenDRIVE interfaces with auxiliary data layers, including road regulation data, fleet drive paths, and environmental impacts on road usage. Standardizing these linkages through an API facilitates comprehensive data integration.

3.3 Summary of key features

Key features of the planned standardized components are:

- A slim OpenDRIVE: Focuses solely on road network logics for enhanced efficiency.
- Non-redundant 3D Street Space Model in CityGML: Provides accurate urban environment representations.
- Improved interoperability: Facilitates adoption across domains like simulation and urban planning.

The proposed changes aim to enhance the current standard by:

- Simplifying street space modeling: Introducing new approaches to make the process more intuitive and versatile.

- Outsourcing of non-essential concepts: Streamlining OpenDRIVE by removing elements it was not originally intended to handle.
- Bridging the gap between research and real-world data: Ensuring the standard can accommodate high-level research data as well as practical, end-user applications.
- Enhanced interoperability and extendibility: Creating defined interfaces to avoid misuse of non-standard data tags.

3.4 Methods of Standardization

The standardization process begins with a proposal for a specification, which includes:

- Top-level requirements: Establishing the essential criteria for developing the standard.
- Data model: Defining the structure and relationships between different data components.

For better understanding and practical testing of proposed concepts some example datasets may be created.

3.5 Assumptions

The standardization effort is based on several assumptions:

- CityGML's comprehensive Modelling: CityGML can effectively represent environments at various levels of detail.
- Extension mechanism: CityGML’s extension mechanism is robust and well-established.
- Impact of reduced scope in OpenDRIVE: Simplifying OpenDRIVE will lead to breaking changes but result in a more precise and lightweight road space description.

4 Deliverables

Provide a list of deliverables, which are handed over to ASAM at the end of the project. Deliverables must be material items, e.g., documents, code, or executables. They are delivered in an electronic format, e.g., as files.

Please note that the sources for generating or compiling the deliverables, including tool-related files that are needed for the generation or compilation process, must be delivered to ASAM, too. Those sources and files need not to be listed in this chapter.

At the end of the project, the project group will hand over the following deliverables to ASAM:

Table 1 Deliverables

Item No.	Description
1	Proposal for OpenDRIVE 2.0 (lite) standard for road logic definition including linkage concept with CityGML
2	Impact analysis regarding opportunities and implications for stakeholders to migrate from OpenDRIVE 1.x to OpenDRIVE 2.0 (lite) with CityGML environment representation
3	Example dataset including linked OpenDRIVE 2.0 (lite) and CityGML

4.1 Review Process

The process for deliverable review documented in the project guide is applicable to all projects (see here).

The ASAM OR will provide further details on quality criteria and tools used prior to the initiation of a review in a project.

Table 2 Selection of Review Type

Please indicate whether the project is aiming to perform an ASAM member review or a full public review. This is not required for maintenance projects.	Public Review

5 Project Plan

5.1 Work Packages

The project consists of the following work packages:

Table 11 Work Packages

No.	Work package	
1	**Title**	**Project coordination / CCB**
	Description	Effort for coordination
2	**Title**	**Education: Kickoff + Get up to speed with ODR & CityGML**
	Description	This session aims to align all participants with the fundamental concepts and scope of the ODR (OpenDRIVE) and CityGML standards. Through a series of introductory presentations and discussions, the goal is to ensure that everyone has a solid understanding of both standards, their relevance to the project, and how they may interact.
	Aim	• Get everyone aligned with the scope of the project • Familiarize with the concepts of both standards
	Contribution	• Understand and evaluate existing concepts • Align with other standards and running projects

3	**Title**	**Scope**
	Description	This work package is dedicated to the harmonization and integration of ODR (OpenDRIVE) and CityGML data standards, with the goal of establishing clear guidelines on how and where data should be allocated between these two standards within the context of road networks and (urban) environments. The project aims to ensure that the integration supports existing and emerging technological solutions while maintaining high standards of data consistency, performance, and version control. The goal is to support both synthetic as well as real-world data.
	Aim	• Clarify content distribution between ODR and CityGML • Define minimal required scope for ODR • Define content represented by CityGML • Collect use cases with corresponding data requirements
	Contribution	• **Tool Providers:** Evaluate requirements and challenges for existing tools for ODR and CityGML integration • **Data Providers:** Ensure best practices for data allocation, consistency, and version control. • **OEM (V&V):** Validate and verify data integration against industry standards. • **Sensor Manufacturers:** Evaluate requirements for integration of sensor data • **Public Authorities:** Align framework with public requirements and use cases. • **Research Institutions:** Explore innovative data integration approaches and address challenges in continuity and version control.

4	**Title**	**Linkage**
	Description	This work package focuses on creating a robust linkage framework between CityGML and ODR (OpenDRIVE). The objective is to develop methods for linking CityGML to ODR and vice versa. Additionally auxiliary data layers may be incorporated. The framework should improve interoperability to facilitate connecting common external data sources such as OSM (OpenStreetMap), HERE, and NDS (Navigation Data Standard). Additionally, the work package will involve creating sample datasets that demonstrate effective linkage and integration. Alignment with OpenMATERIAL will also be explored to enhance the interoperability and utility of the data.
	Aim	• Develop methods for bidirectional linkage between CityGML and ODR data. • To incorporate auxiliary data layers • To create sample datasets that illustrate successful data linkage. • Improve interoperability and facilitate external data incorporation
	Contribution	• **Tool Providers:** Evaluate framework requirements for tools linking CityGML and ODR • **Data Providers:** Provide input on how to collect and manage data on different layers effectively • **OEM (V&V):** Validate sample data with linkage to ensure accuracy and practical application. • **Sensor Manufacturers:** Contribute data and expertise to support the integration of sensor data within the linkage framework. • **Public Authorities:** Ensure that linkage methods comply with public requirements. • **Research Institutions:** Investigate innovative techniques for data linkage and integration and contribute to the development of sample datasets.

5	**Title**	**Proof of Concept**
	Description	The goal is to evaluate the practical application of a slim ODR linked with CityGML in driving simulation environments. Focus is on representing surfaces and transportation areas according to the CityGML standard, while describing the road logics in ODR. Key tasks include creating sample data (scope will be defined in the work package), developing methods to efficiently determine if an object is on the current trajectory, and defining requirements for an implementation of a proof of concept.
	Aim	• Provide ODR and CityGML sample data focusing on surfaces and transportation areas. • Evaluate practical application of the proposed concept. • Develop methods for efficiently determining object placement relative to the current trajectory. • Define scope of implementation.
	Contribution	• **Tool Providers:** Provide expertise on challenges to develop adapted simulation tools, focusing on trajectory analysis. • **Data Providers:** Supply requirements for ODR and CityGML data, particularly for surfaces and transportation areas. • **OEM (V&V):** Validate the ODR and CityGML data within driving simulations to ensure accuracy and realism. • **Sensor Manufacturers:** Provide requirements and insights on integrating sensor data into the CityGML framework. • **Public Authorities:** Ensure that the CityGML implementation complies with relevant standards and supports public infrastructure planning. • **Research Institutions:** Contribute to the development and testing of methods for object trajectory analysis and support the creation of sample datasets.

6	**Title**	**Implementation**
	Description	This work package focuses on implementing the proof of concept (PoC) developed in previous work package, potentially using an existing simulation tool. The goal is to bring the PoC to life, demonstrating its practical viability and effectiveness within a simulated environment. The implementation may be carried out by a project member or a service provider, depending on resource and expertise availability. This stage will validate the integration, performance, and usability of the PoC within the chosen simulation platform.
	Aim	• To implement the PoC (within an existing simulation tool), ensuring it functions as intended. • To validate the integration and performance of the PoC in a simulated environment. • To assess the practical application of the PoC by project members or service providers.
	Contribution	• **Tool Providers:** Assist in integrating the PoC into the simulation tool and ensuring it runs effectively. • **Data Providers:** Provide any additional data required to support the implementation and testing of the PoC. • **OEM (V&V):** Validate the implemented PoC to ensure it meets project requirements and industry standards. • **Sensor Manufacturers:** Support the integration of sensor data into the PoC to enhance simulation accuracy. • **Public Authorities:** Monitor the implementation to ensure compliance with potential applications in public infrastructure. • **Research Institutions:** Provide insights and feedback on the implementation process and help refine the PoC based on testing outcomes.

7	**Title**	**Documentation**
	Description	This work package focuses on summarizing all the findings and outcomes of the project in a comprehensive concept paper. The documentation will capture the key insights, methodologies including an impact analysis, and results from each work package, providing a clear and structured overview of the project's achievements. The concept paper will serve as a foundation for proposing a future implementation project, outlining recommendations and best practices based on the work conducted.
	Aim	• To compile and summarize the project’s findings into a detailed concept paper including impact analysis. • To propose a well-defined concept for future implementation projects based on the current project's results.
	Contribution	• **Tool Providers:** Contribute insights and documentation on tool development and integration processes. • **Data Providers:** Provide detailed information on data management, linkage, and usage within the project. • **OEM (V&V):** Offer validation results and recommendations for future applications. • **Sensor Manufacturers:** Share expertise on integrating sensor data into the project and its implications. • **Public Authorities:** Ensure the concept aligns with regulatory requirements and public policy. • **Research Institutions:** Contribute to the documentation of innovative approaches and methodologies.
8	**Title**	**Review**
	Description	This work package reviews all created documents (and data) for final release. It will check that the scope is covered and explained properly to use it for a following standardization project. A native speaker review may be done.
	Aim	• Proof-read the deliverables with scope on understandability and completeness. • Incorporate relevant review feedback.
	Contribution	• Check comprehensibility for relevant stakeholders • Check completeness for foreseen adoption

5.2 Time Schedule

The work packages shall be carried out as per the following time schedule:

Table 12 Time Schedule

		2025											
WP No.	**Work Package Name**	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEC
1	Project Coordination												
2	Education												
3	Scope												
4	Linkage												
5	PoC												
6	Implementation												
7	Documentation												
8	Review												

6 References

See guidance on References in the ASAM Editorial Guide

[1] Kolbe, T.H., Kutzner, T., Smyth, C.S., Nagel, C., Roensdorf, C., Heazel, C.: OGC City Geography Markup Language (CityGML) Part 1: Conceptual Model Standard. Open Geospatial Consortium (2021) https://docs.ogc.org/is/20-010/20-010.html

[2] Kutzner, T., Chaturvedi, K., Kolbe, T.H. CityGML 3.0: New Functions Open Up New Applications. PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science, 19, (2020) http://dx.doi.org/10.1007/s41064-020-00095-z

[3] CityGML Open Data examples: https://github.com/OloOcki/awesome-citygml

[4] OpenDRIVE Concept Document