ASAM OpenDRIVE

List of Features and Requirements

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Content

1 Purpose

The purpose of this document is to capture features and requirements for the further development of OpenDRIVE. The input for this document originates from a series of meetings with industry-experts on the subject matter. Their statements from presentations and discussions has been compiled into concise and non-overlapping feature- and requirements descriptions. They are the foundation for further project planning and project proposals at ASAM.

A "feature" in the context of this document is tool functionality, which is perceivable by a user of a standard-compliant tool, with which he can interact, and which is clearly separated from other functions of the tool.

A "requirement" in the context of this document is a description of a necessity that shall be met by the standard or the standard-compliant tool, respectively. Requirements can also be used for describing details of a feature.

The list of features for OpenDRIVE shall be as complete as possible in this document. Features typically describe major parts of a standard. One feature can correspond to one chapter in the later standard document. The specification effort for features is typically very high. This must be known prior to project start, so that the necessary resources for the project can be allocated.

The list of requirements does not have to be complete prior to project start. Requirements typically have a lesser impact on the efforts to create a standard. This document shall only include those requirements, which are deemed as important and require acceptance by the ASAM community prior to project start. All further requirements for standard development can be defined after the project start.

The chapter "Other Topics" includes those expert contributions, which can neither be classified as a feature nor as requirement, or which will certainly not be part of an OpenDRIVE standardization project. Most of the topics would potentially be realized in a software implementation project, which would produce source code or tools that support the application of OpenDRIVE.

2 Features

ID	F001	Priority	Normal
Title	Junction Model		
Description	The junction model shall be revised, offering easier ways to describe complex lane geometries, while avoiding the need to keep redundant parameters consistent. New objects shall help to ease and unify the topology description of junctions. For example, introduce the new object 'Node', which stores information about lane connectivity at the junction's interior and perimeter. Add distinct junction height definition. Add distinction between left-side traffic (Germany, France, USA) and right-side traffic (UK, India, Japan). Add lanes with type "tram", "sidewalk", "median" and "not-drivable area", and consider that they link differently than lanes for cars. Consider easy parameter variation, i.e. local changes shall have no impact on other road sections. Consider easy modeling of standard junction types, such as 'crossing', 'drive-up', 'forking' and 'transition'.		
Rational	The specification effort of complex junctions is currently very high. In the current data model, there is just one way to describe the lanes of a junction. For example, lanes must start and end at the same perpendiculars. As a consequence, complex junctions can only be described by 'tricky' modeling styles, e.g. 'invent' complex geometries, group simple junctions to one complex junction, etc. The concatenation of lanes in a junction regularly yields in overlaps. To avoid overlaps of nearby junctions, they actually must be merged to one junction, which even more increases the complexity of the description. This causes a complicated and unintuitive modeling style with many redundant parameters, which must be kept consistent. A better junction model shall ease the specification efforts and reduce the number of parameters.		

ID	F002	Priority	Normal
Title	Road Geometry Models		
Description	Extend the model to describe roads by further data model elements: • DLM (detailed lane model) • Polylines (as in NDS) • Reference trajectory, aka centerline model • Shape point list • Beziers curve		

Rational	The current OpenDRIVE road geometry model is based on mathematical formulas and is mostly suitable for describing synthetic and manually created road networks, typically originating from road editors. When road descriptions originate from other sources, such as NDS or real-world measurements, then transferring this data to OpenDRIVE is very complicated. Other models shall be added to the standard to support those alternative data sources.

ID	F003	Priority	Normal
Title	Arbitrary Spaces Model		
Description	Provide elements to define arbitrary spaces, such as parking spots or other drivable areas.		
Rational	The OpenDRIVE data model for roads is based upon defining a reference line with parameters for the width of lanes, effectively describing areas along this line. If any other areal object shall be described, which does not just follow a line, then this method is not well suited.		

ID	F004	Priority	Normal
Title	International Signs Model		
Description	The standard shall have a model to describe traffic signs, traffic lights, electronic sign-bridges and painted signs on the road. Provide a picture for each sign. Provide parameters for signs, e.g. the 'Speed Limit' sign shall have a parameter for the actual value of the speed limit. Include traffic signs in all major jurisdictions, e.g. North America, Europe, China and Japan. The jurisdictions shall be stated in the separate country parameter (e.g. 'country=CHN').		
Rational	For simulation and testing of ADAS and AD systems, the rendering of traffic signs is essential. They must be correctly recognized and interpreted by the ego vehicle. The model shall consider international signs, not just the German StVO.		

ID	F005	Priority	Normal
Title	Environment Representation		
Description	The standard shall include ways to specify the environment of the road network. This includes the description of areas between the lanes and outside the lanes of the road network. Different approaches have been proposed: • Provide reference to an external 3D environment model		

	• Provide a data model for the specification of a simple environment in the immediate vicinity of roads In case of the first choice (reference to external 3D environment model), OpenSCENARIO shall include some meta information about the objects, such as type, location, orientation, reference road and scale, and the reference to the third party 3D model library. This shall include the specification of a horizon (end-of-terrain), e.g. city, mountains, forest, wall, fence, etc. The chosen approach shall allow to add the following objects to the environment: • Bridge • Tunnel • Noise barrier • Bus stop • Rails and streetcars • Guide post • Guard rail • Street light • Curbstone • Roadside vegetation (bush, tree) • Pedestrian • Animal The objects shall be scalable. Add hints for positioning. Animation shall be supported for some objects, e.g. walking pedestrians, switch on & off of street lights, etc. Supported 3D environment standards shall be: • OpenFlight (.flt) • Wavefront (.obj) • Collada (.dae) • CityGML (.xml/GML3)
Rational	The goal of this feature is to have the specification of a complete static scenario within OpenDRIVE. The current standard does not provide any means to specify the environment of the road network. This sometimes leads to odd renderings, e.g. roads with heightened elevations hovering in midair. Some simple parameters to create a default-environment shall avoid this. A library of 3D objects or link to an external 3D-environment model shall allow fully-featured environment renderings.

ID	F006	Priority	Normal
Title	Roundabouts		
Description	Add an easy way to describe roundabouts. Consider distinction between left-side traffic (Germany, France, USA) and right-side traffic (UK, India, Japan).		
Rational	In the current data model, roundabouts have to be assembled by using multiple junctions and curved lanes. This makes the modeling of roundabouts complex. However, roundabouts are a standard road feature in many countries. A special element that eases the specification of roundabouts shall be added to OpenDRIVE.		

ID	F007	Priority	Normal
Title	Parametrization & Variation		
Description	It shall be possible to generate variations of road descriptions from an OpenDRIVE file for the purpose of testing. This is primarily done by changing parameters of the descriptions, e.g. the width, length or curvature of roads. Two approaches have been suggested: • Create a DSL (domain specific language), which models the variants. A generator then generates from the DSL-file multiple XODR-files. • Parameter variants become part of the OpenDRIVE data model. Variants are directly derived from the XODR-file. In case of parameter variants become part of the OpenDRIVE data model: Parameters shall optionally have an URI. Parameters shall have a defined name space. Besides standardized parameters, it shall be possible to have user-defined parameters.		
Rational	OpenDRIVE files are used in test-cases. For efficiency-purposes, multiple test-cases shall be automatically derived from one road description. The URI attribute of a parameter shall allow to share parameters. The name space allows to distinguish between standardized parameters and user-defined parameters. The name space also allows to define country-variants of parameters.		

ID	F008	Priority	Normal
Title	Georeferencing		
Description	The data model of OpenDRIVE shall be extended with geographic coordinates for road descriptions. The chosen georeferencing shall be independently usable with other standards.		

Rational	The current data model of OpenDRIVE describes roads based on a reference line. This method is well suited for editing tools, where artificial road networks are manually created by humans. When data from real-world measurements (camera and LIDAR) shall be transferred to the OpenDRIVE format, then this description method is not well suited. An alternative way of road description shall be provided using geographic coordinates, e.g. longitude and latitude. Elevation shall also be included. This data is typically directly available in the measurement dataset.

ID	F009	Priority	Normal
Title	Crosswalk		
Description	Roads and junctions shall optionally have crosswalks as lanes where pedestrians can cross the road.		
Rational	Crosswalks shall not just be a road marking. It shall be a lane for pedestrians, which allows to simulate pedestrians crossing the road.		

3 Requirements

ID	R001	Priority	Normal
Title	Add More Model Parameters		
Description	Specific elements of the data model shall receive more parameters to describe needed details for simulation. For example, lanes shall receive the following parameters: • drivable (yes, no) • driving direction (left, right) • overtaking allowed (yes, no) • turn (left, straight, right) • special purpose lanes (pedestrian, bicycle, bus, shoulder, passing) • drive restrictions (time, vehicle height) The need for additional parameters, particularly in an international context, shall be reviewed for all data model elements. Allow lanes to change their width. Add parameters that describe the quality of road definitions.		
Rational	Additional parameters are needed for correct traffic simulation, and for testing and evaluating the results for ADAS and AD functions. For example, it is necessary to know the driving direction of a lane to judge, if an AD-car has chosen to drive on a lane with the correct driving direction. If road descriptions originate from scanned real-world roads, then quality data shall provide information about the accuracy of the description.		

ID	R002	Priority	Normal
Title	Remove or Reduce Redundant Information		
Description	Remove or reduce the number of parametric redundancy in modelling road networks. Define meaningful default values. Create a central data dictionary for the user to define default values.		
Rational	For example, in the current version of OpenDRIVE, junctions are assembled by multiple lanes. The parameters for the start- and end-points of lanes occur in multiple elements of the junction definition and have to be kept consistent. Road geometries require absolute x/y coordinates which have to be kept consistent with the previous geometry shape and length. Without keeping them consistent, the lanes would show overlaps, gaps or kinks. This causes		

	high specification and error-resolution efforts. The model shall apply smart modeling methods that avoids parameter redundancies as much as possible.

ID	R003	Priority	Normal
Title	Harmonize OpenDRIVE with Other Standards		
Description	OpenDRIVE shall be harmonized and usable with other standards: • NDS • OpenCRG, OpenSCENARIO, OSI • cityGML • glTF		
Rational	Data in the OpenDRIVE format may be converted in other formats, such as NDS. This shall be possible without loss of information or reduction of accuracy. Furthermore, OpenDRIVE shall be able to reference to data in other standardized formats, and vice versa. This is required for seamless tool-chain interoperability.		

ID	R004	Priority	Normal
Title	Remove or Reduce Different Ways to Model		
Description	Review the current data model under the aspect of modelling alternatives. Remove alternatives, which are deemed not necessary.		
Rational	The standard offers different ways how to model the same item, such as a multi-lane road or complex junctions. Tool vendors do not always support each alternative, which consequently leads to tool-chain integration problems and interoperability issues. End-users of the standard (e.g. road model creators) may be confused about what is the best way for modelling the same road, and may create different styles of modelling within the same project. The standard shall not provide alternatives, when there is no good reason for it. If there is a good reason for alternative ways to model, then this shall be explained with examples in the "Best Practice Guide".		

4 Other Topics

4.1 Reference Visualization and Checker Tool

The tool has the primary goal to ensure that XODR-files can be exchanged between tools from different vendors and are interpreted in the same way. To meet this goal, the tool shall provide the following functions:

- Schema validation: checking the standard compliance of syntax and structure of the XODR-file.
- Content validation: checking the plausibility, consistency, logical coherence, realism, completeness and unambiguity of the data in the XODR-file.
- Dynamic validation: run simulation, observe behavior and constantly check the behavior against specific rules.
- Reference visualization: showing how the data from XODR-files shall be rendered.
- Statistics: providing statistical data about what kind of data, features and attributes are contained in the XODR-file.

Tool-interoperability is primarily checked by schema and content validation. The schema is automatically generated from the data model specification of the standard (e.g. from the UML model).

Rules for content checking have to be specified by an expert group. The checker shall have a basic rule-set, which is meaningful for all OEMs. The content checker shall also be extensible with OEM-specific rules that can be added to the basic rule-set. The checker-report shall distinguish between basic and OEM-specific issues. Reported issues shall be traceable to the corresponding code-section in the XODR-file.

The reference visualization gives tool implementers a guideline, how the standard authors envision the rendering of road descriptions. The reference visualization does only cover the correct rendering of the data, as intended by the standard. Optionally, reported issues from content validation are flagged in the reference visualization. For end-users, the reference visualization is a quick and inexpensive way to visually check, if their road definitions have any obvious errors, e.g. overlaps, kinks, discontinuities, etc. Those are hard to find in XML-code, but are very obvious in rendered images. Other aspects of visualization, such as a visually appealing and information-enriched rendering, are not considered. This is the responsibility of implementers and the added-value of commercial tools.

Dynamic validation requires the implementation of a checker tool, which comes close to a simulator, i.e. which includes the simulation of maneuvers from an ego car and traffic simulation. The purpose of this type of validation is to figure out the suitability of road definitions for specific maneuvers.

The tool might include linked data from OpenCRG- and OpenSCENARIO-files.

Profiles may be specified for different checking and visualization use-cases.

The tool shall be executable on client PCs and servers. This requires the tool to run under Microsoft Windows and Linux. OEMs shall be able to implemented their checks in a known programming language.

4.2 Reference Examples

XODR examples shall be provided with the standard. The examples shall serve as a reference for the implementation and validation of tools with the following purposes:

- show XML code-patterns as an example to better understand the XODR file format,
- provide test-cases for tools to validate data import and correct processing & rendering of the data.

When using the reference examples with the aforementioned "Reference Visualization and Checker Tool", users receive a golden-master visualization about what output is expected from the examples. Furthermore, the reference examples shall be processed by the checker without any issues (errors, warnings), hence giving examples of well structured and logically consistent XODR files.

4.3 Best Practices Guide

OpenDRIVE offers alternative ways how to model the same item, e.g. roads or junctions. A document shall describe with the help of examples, what are good methods and styles for describing an item. It shall help to choose the easier from all available description methods, and help to choose those that are most likely supported by the majority of tools.

The "Best Practice Guide", aka "Authoring Guidelines", "Style Guide" or "Modeling Guidelines", is not normative and shall be distributed together with the standard.