| | |
|---|---|
| ASAM | **P2019-06**<br>**Evaluation and Selection of an OpenDRIVE Reference Visualization and Checker Tool** |

| **Project** | | | | |
|---|---|---|---|---|
| Number | P2019-06 | Type | Implementation Project | |
| Standard Name/ Project Name | Evaluation and Selection of an OpenDRIVE Reference Visualization and Checker Tool | | | |
| Current Version | n/a | | Next Version | n/a |
| End Date | 10/2019 | | ASAM Funds | 0 € |

| **Submitter** | | | |
|---|---|---|---|
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| **Change History** | | |
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| Date | Author | Chapter + Description |
| 01.02.2019 | Kaths, J. | Section 1, first version |
| 11.02.2019 | Kaths, J. | Include content comments from Mr. Thomsen |
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# Contents

# Section 1: Project Proposal

## 1 Executive Summary

In order to strengthen the application of the ASAM OpenDRIVE standard, supplementary products shall be provided together with the standard. The goal of this project is to implement and deliver such products. These software tools should support users that are new to the standard as well as existing users of OpenDRIVE. Most relevant among peers are a reference visualization and a checker tool, both of which will help to validate existing OpenDRIVE road network description files with regard to their syntax, semantics and content.

OpenDRIVE is new to ASAM, but has been well-established already. Therefore, a number of tools already exist that address the visualization and checking of OpenDRIVE files. This project will take the first step towards extending the OpenDRIVE standard with supplementary tools by defining requirements for these tools and evaluating existing implementations against these requirements. Subsequently, tools for checking and visualizing OpenDRIVE road network will be selected and a decision will be taken on how to implement these further.

# 2 Motivation

## 2.1 General Description

OpenDRIVE files are based on the XML format and are, therefore, readable by machines and humans. However, road network descriptions easily include more than 10.000 lines for just a few kilometers of road and can be very complex when many junctions and links exist. This makes a manual validation of OpenDRIVE files hardly possible. To facilitate the validation of OpenDRIVE files, a reference visualization should be available that demonstrates how the data from an OpenDRIVE file shall be rendered. Such a reference visualization can be of great help when a specific OpenDRIVE file should be compared to a real-world dataset or the mind-model of a user. Furthermore, a checker tool should be provided that allows to check syntax, and plausibility of an OpenDRIVE file. Such a checker tool – in contrast to a visualization tool – will allow for automatic checking and can detect problems that might be undetectable in the visualization.

The provision of such supplementary tools will make daily work for OpenDRIVE users easier and will ease the adaptation of the standard for new users.

This project focusses on the evaluation of existing checker and visualization tools. In a first step, functional requirements will be defined for these tools. Subsequently, existing tools will be evaluated against these requirements. The possibility to transfer the reviewed tools into ASAM will also be taken into account. Based on this evaluation, one or more tools will be selected for further development and a decision on the modalities of the software development will be made.

## 2.2 Use-Cases

The standard shall cover the following use-cases.

TABLE: USE-CASES

| ID | B001 | Type | Business Use-Case |
|---|---|---|---|
| Title | Validation of existing road network descriptions | | |
| Description | Road network descriptions can be a big asset and in companies where OpenDRIVE is widely used, plenty of files will be available, possibly stemming from different providers. The files should be validated automatically on a regular basis to ensure standard conformity. In case problems occur, visualization of single files can help to further track down problems. | | |
| Actors | • Methods/simulation department of OEMs<br>• Methods/simulation department of suppliers | | |
| Notes | | | |
| Mapping | | | |

TABLE: USE-CASES

| ID | B002 | Type | Business Use-Case |
|---|---|---|---|
| Title | Validation of road network creation toolchain | | |
| Description | Before delivering an OpenDRIVE file to a customer, the standard conformity should be checked along the toolchain. This can be done automatically with the checker tool. For thorough validation, a visual check should be performed on single files as well. | | |
| Actors | • Mapping/surveying service providers<br>• OpenDRIVE editor vendors | | |
| Notes | | | |
| Mapping | | | |

TABLE: USE-CASES

| ID | B003 | Type | Business Use-Case |
|---|---|---|---|
| Title | Comparison to specific implementations | | |
| Description | Multiple tools already exist that support the OpenDRIVE standard and an increasing number can be expected. To ensure standard conformity and avoid ambiguity, own tool implementations can be compared to the supplementary tool results. E.g. files passing the checker tool shall be usable in own implementation and reference visualization should be met. | | |
| Actors | • Tool vendors<br>• OEMs/suppliers with own tools | | |
| Notes | | | |
| Mapping | | | |

TABLE: USE-CASES

| ID | E001 | Type | End-User Use-Case |
|---|---|---|---|
| Title | Validation of a modified road network file | | |
| Description | A simulation engineer receives an OpenDRIVE file from the simulation department and modifies it for a specific use-case. To ensure validity of the file, the engineer checks it with a checker tool. | | |
| Actors | • Simulation engineer | | |
| Notes | | | |
| Mapping | B001 | | |

TABLE: USE-CASES

| ID | E002 | Type | End-User Use-Case |
|---|---|---|---|

| | |
|---|---|
| Title | Validation of a received road network file |
| Description | A simulation engineer receives an OpenDRIVE file from a mapping vendor and needs to check the formal standard conformity and a correct visualization before entering the file into the companies' database. |
| Actors | • Simulation engineer |
| Notes | Can be extended to automatically check and validate databases. |
| Mapping | B001 |

TABLE: USE-CASES

| | | | |
|---|---|---|---|
| ID | E003 | Type | End-User Use-Case |
| Title | Validation of a road network file created from measurements | | |
| Description | A surveying engineer prepares a set of measurements in order to create an OpenDRIVE file for a customer. Before delivering this file, standard conformity is checked formally with the checker tool and visually with the reference visualization. | | |
| Actors | • Surveying engineer | | |
| Notes | | | |
| Mapping | B002 | | |

TABLE: USE-CASES

| | | | |
|---|---|---|---|
| ID | E004 | Type | End-User Use-Case |
| Title | Validation of a road network file created with an editor | | |
| Description | A software engineer developing an OpenDRIVE editor will have to ensure that OpenDRIVE files are exported in a way that they are standard-conform and lead to expected visualization results. | | |
| Actors | • Software engineer | | |
| Notes | | | |
| Mapping | B002 | | |

TABLE: USE-CASES

| | | | |
|---|---|---|---|
| ID | E005 | Type | End-User Use-Case |
| Title | Comparing new feature implementation to reference | | |
| Description | When a new feature is released within the OpenDRIVE standard, existing tools that support OpenDRIVE will likely have to be updated. The tool developer compares the own tool with the reference given by the checker and/or visualization. | | |
| Actors | • Software engineer | | |
| Notes | | | |

| | |
|---|---|
| Mapping | B003 |

TABLE: USE-CASES

| | | | |
|---|---|---|---|
| ID | E006 | Type | End-User Use-Case |
| Title | Getting started with OpenDRIVE | | |
| Description | A tool-provider that uses a different road description will be curious to see what elements and in what detail they are supported by OpenDRIVE. A reference visualization in conjunction with example files can help to lower the threshold. | | |
| Actors | • Software engineer | | |
| Notes | | | |
| Mapping | B003 | | |

## 2.3 **Features**

The standard shall include the following new or revised features.

TABLE: FEATURES

| Feature | Type |
|---|---|
| Selected checker tool for validation of OpenDRIVE files regarding syntax and plausibility. | New |
| Selected reference visualization tool for rendering of OpenDRIVE files. | New |

# 3 Technical Content

OpenDRIVE files are descriptions of road networks in XML (Extensible Markup Language) format with the file ending XODR. The description includes the geometrical and logical road layout and the static surroundings of the road such as signs, poles, etc. The OpenDRIVE standard includes an XML Schema Definition (XSD) that prescribes the definition of XML instances. Road marks for example can have different characteristics e.g. solid lines or broken lines referred to as types here. For this example the XSD schema prescribes the following restrictions:

```
<xsd:simpleType name="roadmarkType">
    <xsd:restriction base="xsd:string">
        <xsd:enumeration value="none"/>
        <xsd:enumeration value="solid"/>
        <xsd:enumeration value="broken"/>
        <xsd:enumeration value="solid solid"/>
        <xsd:enumeration value="solid broken"/>
        <xsd:enumeration value="broken solid"/>
        <xsd:enumeration value="broken broken"/>
        <xsd:enumeration value="botts dots"/>
        <xsd:enumeration value="grass"/>
        <xsd:enumeration value="curb"/>
    </xsd:restriction>
</xsd:simpleType>
```

A specific XML instance of a road network description can then include a correctly defined road marking type:

```
<roadMark sOffset="0.0000" type="broken"
weight="standard" color="standard" width="0.15"
material="standard">
```

An incorrect definition could look as follows:

```
<roadMark sOffset="0.0000" type="dashed"
weight="standard" color="standard" width="0.15"
material="standard">
```

This example is an example for syntactical checking which can easily be performed as described in 3.2. The OpenDRIVE standard, however does not only provide syntactical, but also logical rules. A simple example is that IDs for elements of the same type have to be unique. For lane elements, these IDs additionally have to be:

- in sequence (i.e. without gaps),
- starting from 0 on the reference line
- ascending to the left (positive t-direction)
- descending to the right (negative t-direction).

More complex examples for rule descriptions can easily be found when evaluating the linkage of road segments which is described by link or junction elements. Such logical rules are not defined in the XSD schema and their checking is more complex.

## 3.1 Importing, Parsing, Querying

To work with an OpenDRIVE file, the XML file typically has to be imported and parsed first in order to be able to make queries. E.g. receive tire contact points or – as in the example above – the current road mark at a given lane on a road segment. These functionalities serve as a basis for dynamic simulations, but are also necessary for checking an OpenDRIVE file as described in the following paragraph. An existing, commercially available example for such a tool is the OpenDRIVE Manager by Vires. Its working principle is illustrated below.

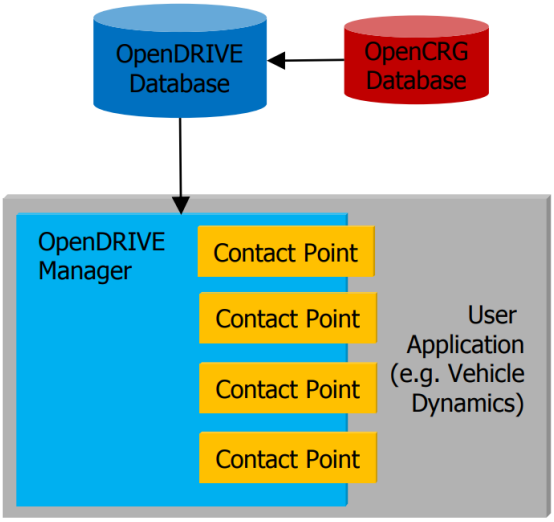


**Figure 1: Working principle of the Vires OpenDRIVE Manager**

## 3.2 Syntax and Plausibility Checker Tool

Since the standard includes an XSD schema, the syntactical and structural checking of OpenDRIVE files is straight-forward, because compliance of an XML file to the XSD schema can be checked easily. Several tools that are not domain-specific are available for this purpose.

Besides this syntactical check, a content validation should be performed by the checker tool. This validation should include checks for plausibility, consistency, logical coherence, realism, completeness and unambiguity of the data in the OpenDRIVE file. Examples for logical rules described in the OpenDRIVE are given in the beginning of this chapter. These logical rules are much more challenging than the syntactical check and can hardly be performed in an exhaustive way across all user-domains. Therefore, an integration for a language to specify checker-rules was proposed in order to allow users to add their own (domain-specific) rules to the ruleset. A set of rules could, for example, ensure that all routes within the road network that are valid in reality can also be performed along the road segments and junctions in an OpenDRIVE network. Audi and Siemens mentioned that internally available tools exist for this purpose.

## 3.3 Reference Visualization

A reference visualization should demonstrate how the data from OpenDRIVE files shall be rendered according to the standard definitions. This should include all objects defined by the standard including road geometry, traffic signs and signals, road marks etc. For this task, the information from the OpenDRIVE file has to be analyzed and interpreted in order to place textures and objects from a catalog into the scene. The figure below shows an

image of an OpenDRIVE file rendered by TESIS DYNAanimation. Again, broken road marks from the example above are included here. A number of other tools exist for visualizing OpenDRIVE roads in 2D or 3D.

**Figure 2: OpenDRIVE file provided by 3DMapping Solutions rendered in TESIS DYNAanimation**

## 3.4 Review of Existing Tools and Usage Conditions

To achieve a fast release of supplementary tools and to avoid double implementation, it has been stated in the ASAM workshops that a re-implementation of existing tools should be avoided. Since the OpenDRIVE standard is already well-established, a number of tools already exist that fully or partially fulfill the requirements of the proposed implementations. However, these tools might be (part of) a commercial product and/or need to be adapted to fulfill the stated requirements. Therefore, the valid requirement of freely available tools with open sources is potentially conflicting with the requirement to avoid double implementation and deliver tools fast.

For example, consumers of OpenDRIVE files such as Audi and Siemens have stated they could potentially provide existing solutions for a checker tool. However, these tools require the commercially available OpenDRIVE Manager from Vires. This tool itself is the current reference for parsing and querying OpenDRIVE files and Vires prospected a usage within the ASAM standardization. However, an opening of sources does not seem feasible in this case. The same holds true for the commercially available tool DYNAanimation by TESIS that has been prospected as a basis for the reference visualization tool.

Besides a review of the functionality of existing solutions, this project should also evaluate the existing solutions regarding the possibility of usage within the ASAM standardization. Therefore, it has to be clarified:

- if sources of tools have to be openly available
- how development to meet requirements specified by ASAM members can be funded

- how pricing of tools for ASAM members and others could be.

## 3.5 Tool selection for reference visualization and checking

Building on the findings from review of existing tools and their usage conditions as well as a collection of required features, tools for visualization and checking can be selected. It is unlikely to find one tool that will meet all requirements and therefore, the project group will have to consider the degree of requirements fulfillment and the efforts that it would cost for to transfer the tool to ASAM. Furthermore, the efforts for development of the tools to meet current and potentially future requirements has to be estimated. At the end of this process, the group shall come to a decision, which tool (or tools) to select for OpenDRIVE reference visualization and file checking.

## 3.6 Concept for further tool development

A concept has to be developed on the modalities of further tool development. This will strongly depend on the current owner of the selected tool and the extent to which the source code is currently open. Furthermore, the willingness and capacity for development among ASAM members has to be taken into account. The concept may be based on one of the following propositions:

- Tool development by a paid contractor. Only the tool will be distributed to ASAM members. The sources will not be published.
- Collaborative tool development by project group members. Only the tool will be distributed to ASAM members. The sources will not be published and are only available to the project group members.
- Open-Source tool development by all ASAM members. Sources are openly available to all ASAM members (e.g. via GitHub) and are voluntarily and spontaneously further developed. ASAM may provide an executable, or alternatively members have to compile the executable themselves.

# 4 Quality Assurance

The following quality assurance measures shall be carried out by the project:

TABLE: QA-MEASURES

| Check | QA-Measure | Responsible |
|---|---|---|
| ☐ | Peer reviews | Choose an item. |
| ☐ | Editorial review | Choose an item. |
| ☐ | Public review | Choose an item. |
| ☐ | Reference implementation | Choose an item. |
| ☐ | Implementation project | Choose an item. |
| ☐ | Validator project | Choose an item. |
| ☐ | <other QA measure> | Choose an item. |

# 5 Deliverables

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

TABLE: DELIVERABLES

| Item No. | Description |
|---|---|
| 1 | Requirements and use-cases for checker tool and reference visualization |
| 2 | Review of existing tools with regard to their fulfillment of requirements from Item 1 and with regard to the possible usage conditions under ASAM |
| 3 | Recommendation of tool(s) to transfer to ASAM and concept for further implementation of checker tool and reference visualization |
| 4 | Project proposal for follow-up project to (further) implement tool(s) for checking and reference visualization and/or transferring them to ASAM |

# 6 Project Plan

## 6.1 Resources

Member companies contribute resource for the project as per the following table.

For standard development projects only: After the project end, the project group members are available to serve as Standard Expert Group members after the standard release. Those efforts are not included in the following table.

TABLE: RESOURCES - WORK AND FUNDS

| Company (Name, Location) | Committed Work (Man-days) | Committed Funds (Euros) | Project member's name, phone, email |
|---|---|---|---|
| TESIS GmbH, Munich, Germany | 15 | | • Dr. Jakob Kaths<br>• +49 89 74 7377-63<br>• jakob.kaths@tesis.de |
| | | | • |
| | | | • |
| Total: | | | |

The following intellectual property will be transferred from member companies to ASAM:

TABLE: RESOURCES - INTELLECTUAL PROPERTY

| Company (Name, Location) | Intellectual Property Description | Value (Euros) |
|---|---|---|
| | | |
| | | |
| | Total: | |

## 6.2 Work Efforts

The project consist of the following work packages:

TABLE: WORK PACKAGES

| WP-No. | Title / Description | |
|---|---|---|
| | • Deliverable | Effort (Man-days) |
| 01 | Definition of Use-Cases and Requirements to set the Scope<br>- Review use-cases from this proposal and enhance/consolidate them | |

| | | |
|---|---|---|
| | - Define further requirements<br>- Define possible further technical feature requests (e.g. supported platforms)<br>- Prioritize requirements<br>- ~1 meeting, 2 days | |
| | • Requirements and use-cases for checker tool and reference visualization | 10 |
| 02 | Candidate Tool Evaluation<br>- Call for tool presentation by legal owners of existing tools<br>- Review / beta-test tools against specifications from WP 1<br>- Identify usage conditions under ASAM<br>- Identify possible blockers<br>- ~3 meeting, 2 days each | |
| | • Review of existing tools with regard to their fulfillment of requirements from Item 1 and with regard to the possible usage conditions under ASAM | 60 |
| 03 | Recommendation for Tool Development<br>- Result documentation and drawing conclusions from WP 1<br>- e.g. strenght/weaknesses matrix<br>- Define process for (further) development<br>- ~2 meeting, 2 days each | |
| | • Recommendation of tool(s) to transfer to ASAM and concept for further implementation of checker tool and reference visualization | 30 |
| 04 | Project Proposal for Follow-up Project | |
| | • Project proposal for follow-up project to (further) implement tool(s) for checking and reference visualization and/or transferring them to ASAM | 2 |
| | Total Effort of Work Group: | 102 |

Projects may use optional service providers, which have the following tasks:

TABLE: SERVICE PROVIDER TASKS

| Task No. | Title / Description | |
|---|---|---|
| | • Deliverable | Effort (Man-days) |
| | | |
| | • | |
| | | |
| | • | |
| | Total Effort of Service Providers: | |

The total work effort for the project is:

TABLE: TOTAL WORK EFFORT

| | Formula | Amount (Euros) |
|---|---|---|
| Total Effort of Work Group | | 102 |
| Total Effort of Service Providers | + | 0 |
| Total Work Effort | | 102 |

## 6.3 Time Schedule

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

TABLE: TIME SCHEDULE

| WP-No. | Title / Description | 2019 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | Definition of Use-Cases and Requirements to set the Scope | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | Candidate Tool Evaluation | ☐ | ☐ | ☐ | ☐ | ☒ | ☒ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | Recommendation for Tool Development | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| 4 | Project Proposal for Follow-up Project | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |

## 6.4 Budget

The service budget to pay the service providers and the share of funds provided by ASAM are:

TABLE: SERVICE BUDGET

| | Total Effort of Service Providers (Man-days) | Formula | Amount (Euros) |
|---|---|---|---|
| Service Budget | | × €700 = | |

| | | |
|---|---|---|
| Total Committed Funds | - | |
| ASAM Funds | | |

A budget for video conferencing can be requested, if the project group members originate from locations that would require long-distance (i.e. intercontinental) business trips to regularly participate at project meetings and if means for carrying out video conferencing are not available through the members themselves:

TABLE: VIDEO CONFERENCING BUDGET

| | Number of Meetings (Days) | | Cost per Meetings (Euros) | | Amount (Euros) |
|---|---|---|---|---|---|
| Video Conferencing Budget | | × | | = | |

## 6.5 **Resource Checks**

Funds provided by ASAM are subject to spending limits. The next table allows the requester to check, whether the ASAM Funds, as calculated in the preceding chapter, are within these limits. Please note that projects of type "Implementation Project" have no given spending limits, so the below check does not apply for this project type.

TABLE: ASAM FUNDS LIMIT CHECK

| | Effort (Man-Days) | Formula | Amount (Euros) |
|---|---|---|---|
| Total Work Effort | | × €700 = | |
| Total Committed Funds | | + | |
| Total Transferred IP | | + | |
| Subtotal | | | |
| Upper Limit for ASAM Funds | | × Factor = | |

| Project Type | Factor |
|---|---|
| New, major, minor or revision standard development project | 0.25 |
| Study project | 0.25 |
| Concept project | 0.75 |

| | | |
|---|---|---|
| Check | ASAM Funds ≤ Upper Limit for ASAM Funds | ☐ |

The total work effort required from the project group members shall be equal or less than the total committed work from member companies:

TABLE: WORK RESSOURCES CHECK

| | Formula | Amount (Man-days) |
|---|---|---|
| Total Effort of Work Group | | |
| Total Committed Work | | |
| Check | Total Effort of Group ≤ Total Committed Work | ☐ |

# 7 Relations to Other Standards, Projects or Organizations

This project is strongly related to the OpenDRIVE Transfer Project and the OpenDRIVE Concept Project. More loosely, it is also related to the corresponding OpenSCENARIO projects.