ASAM	**P2019-05** **OpenCRG Transfer and Further Development Project**

Project				
Number	P2019-05	Type	New Standard Development	
Standard Name/ Project Name	OpenCRG Transfer and Further Development Project			
Current Version	from 29.06.2017 (non-ASAM)		Next Version	tbd
End Date	31-07-2020		ASAM Funds	€24.500

Submitter			
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Change History		
Date	Author	Chapter + Description
05.03.2019	Sebastian Tuttas	Draft
06.03.2019	Sebastian Tuttas	First Revision based on ASAM office feedback
07.03.2019	Sebastian Tuttas	Second Revision based on discussion with ASAM office
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Contents

Section 1: Project Proposal

1 Executive Summary

This project is intended to establish an ASAM standard based on the open file format OpenCRG. This proposal combines the intentions of a transfer proposal as well as a proposal for further development.

The purpose of the Transfer Project part is the transfer of the existing OpenCRG format description to ASAM standards.

The purpose of the Further Development Project part is to address the features that shall be included in future OpenCRG releases. The features and requirements discussed in 2.3 Requirements and in 3 Technical Content were extracted from the presentations and discussions that arose during both the Kickoff workshop and the proposal workshop held by ASAM in Höhenkirchen on October 10 and on January 16, 2019, respectively. The requirements and features shall be included in the standard as well as in the source code which is delivered with OpenCRG.

2 Motivation

2.1 General Description

OpenCRG comprises open file formats and open source tools for the detailed description, creation and evaluation of road surfaces. As basic functionality OpenCRG describes the geometry of the road surface based on a reference line and a height grid (which can also be used for other scalar data). It is intended for vehicle dynamics, tire, vibration and driving simulations (see 2.2 Use-Cases). For these purposes the OpenCRG project provides the following features: ASCII and binary file formats with clear-text headers, an open source C-API for data handling and evaluation and open source MATLAB® API for data manipulation and generation and a library of sample data. [2]

OpenCRG is to be understood as a complementary standard to OpenDRIVE. While OpenDRIVE files are describing road networks with respect to all data belonging to the road environment, OpenCRG describes the road surface in detail. OpenDRIVE allows the referencing to OpenCRG files. [1], [2]

OpenCRG shall be transferred to an ASAM standard, whereby new features shall be added (see Chapter 2.3) and existing issues shall be solved (see Chapter 2.4).

2.2 Use-Cases

The standard shall cover the following use-cases.

TABLE: USE-CASES

ID	01	Type	Business Use-Case
Title	Generation of high-quality surface models		
Description	These surface models are created artificially or are ordered from surveying companies to describe real roads, by car manufacturers, simulation tool vendors, urban planners etc. The de-facto standard for surface models in simulation environments is OpenCRG.		
Actors	• Surveying Companies • Vehicle manufacturers and their suppliers • Simulation tool vendors • Road Construction Industry		
Notes			
Mapping			

TABLE: USE-CASES

ID	02	Type	Choose an item.
Title	Driving and Vehicle Dynamics Simulation		

Description	For performing driving or vehicle dynamics simulations the road geometry the vehicle drives on is an essential input parameter. OpenCRG provides a standardizes way to provide the road surface for the simulation tools, so that simulations can be performed. OpenCRG can be and is used in several commercial simulation tools and manufacturer own simulation tools.
Actors	• Vehicle manufacturers and their suppliers • Simulation tool vendors
Notes	
Mapping	

Features

The standard shall include the following new or revised features.

TABLE: FEATURES

Feature	Type
Creation of the ASAM OpenCRG standard document by transferring the existing user manual to a document which fulfills the definitions of the ASAM Style.	Change
Georefencing	New
Multiple Data Layers	New
Special Areas	New

2.3 Requirements

The standard shall meet the following requirements.

TABLE: REQUIREMENTS DESCRIPTIONS

ID	Title/Description
R001	Harmonize the refence line definition with OpenDRIVE • Description: Adaption of the openCRG axis representation to allow integration in openDRIVE without inconsistencies in axis length. • Rationale: OpenCRG and OpenDrive follow different road axis (reference line) representations. Especially for axes with high curvatures and with larger grid size (i.e. axis increment) this leads to inconsistencies in the axis length and consequently to errors in the resulting heights for a query on a certain axis position. This is especially relevant, when the mode “attached” is

	used where the reference line of the CRG data is replaced with the OpenDRIVE road's reference line.
R002	Allow wide roads with high curvature • Description: Allow wide roads with high curvature. Minimum requirement would be to allow the center of the maximum reference line curvature to be in the NaN area, for example by checking with local CRG width during the curvature check. • Rationale: Curvature check for a CRG is performed based on the maximum width of the CRG. It is checked if the center of maximum reference line curvature is inside road limits. That means for example that you cannot combine a wide road part followed by a narrow part with high curvature, even when the curvature constraints within the narrow part are not violated.
R003	Show reference line on maps from multiple map-providers • Description: The current MATLAP API allows the reference line to be shown on Google-Maps. The API shall be extended to plot the reference line on other free mapping services, such as OpenStreetmap, and commercial services such as Bing, Apple or Here. • Rationale: The license terms & conditions of Google-Maps have changed. This function is not freely available any longer. An API-key is re-quired to use this function.

3 Technical Content

3.1 Transfer of the existing document to the ASAM Style

The new specification shall be aligned with the ASAM standard template.

This incorporates the transfer of the OpenCRG version 1.1.2 specification to the ASAM standards template, including adjustments of document styles. This implies the extraction of the normative parts of the user manual [3] and the creation of the ASAM OpenCRG standard from them.

Additionally, the following mandatory chapters must be added:

- Relation to other standards
- Terms and definitions
- Symbols and abbreviated terms
- Bibliography
- Appendix with at least figure and table directories.

It is recommended to add the following introductory chapters:

- Description of areas of application
- Use-Case definitions
- List of limitations and open issues

3.2 Clarification of Open Issues

OpenCRG is in practical use since many years. The project shall give users the opportunity to resolve open issues with the existing specification and file format. Users may bring up errors, unclear definitions of syntax and semantics, ambiguities or specification gaps. The project group will then develop a solution to be implemented in the standard.

3.3 Features

3.3.1 Georeferencing

- Description: The data model of OpenCRG shall be extended with georeferencing parameters for coordinates in order to transform internal coordinates (u,v) to geographic coordinates. This implies the usage of UTM coordinates. Other projections are optional and part of discussion. The chosen georeferencing shall be independently usable with other standards.
- Rationale: The current data model of OpenCRG has an internal coordinate system (u,v). This CRG-internal coordinate system does not easily work with other standards that use geocoordinates such as longitude and latitude. Parameters for precisely transforming the internal coordinates to a public geocoordinate system shall be added to the data model. This would make OpenCRG usable with other standards for road network description.

3.3.2 Multiple Data Layers

- Description: OpenCRG shall support multiple datasets per reference line, i.e. z(u,v) effectively results in a vector. The elements of the vector include values of different physical properties of the surface, e.g. elevation, friction (μ), luminance/gray values (L_v).
- Rationale: OpenCRG currently supports just one dataset per reference line, i.e. z(u,v) returns a scalar. The scalar typically represents the sur-face elevation. Other physical properties such as friction (for vehicle dynamics simulation) and gray values (for testing optical sen-sors) are needed for specific simulation use-cases.

3.3.3 Special Areas (optional)

- Description: Allow holes in CRG grid by filling it with NaN or special key-values for indicating non-drivable areas in the CRG data.
- Rationale: CRG does not allow holes, i.e. parts with missing heights within the grid data. Allowing this may be useful for skipping parts which are not passable like traffic islands. This is especially useful when combining openCRG with openDRIVE where these objects are explicitly modelled and have thus no road surface.

3.4 Source Code

OpenCRG is delivered with source code. The source code can be integrated in self-written tools or executed in the MATLAB environment. This project has the goal to update and further develop the source code so that it matches the content of the standard and is usable with current compilers and interpreters. In detail, the following work is proposed to be undertaken:

- Migrate the C source code to comply with the current language definition ISO/IEC 9899:2018.
- Migrate the MATLAB source code to comply with the current MATLAB release 2019a.
- Optionally, test the MATLAB source code with the current version of Octave 5.1 and potentially modify the code so that it correctly runs with both interpreters.
- Implement new features in MATLAB and, if necessary, in C source code, as described in chapter 3.3. New features shall be implemented in a way that the source code is backwards compatible to prior MATLAB releases?
- To meet the requirements, at least for R002 and R003, source code adaptions are necessary.

The source code development is primarily carried out by a service provider. The project group members primarily express requirements for the development of the source code and check/review the work results of the service provider.

For the review of the new features, appropriate test data is created, which must be successfully read, evaluated and written. For the feature georeferencing this includes data from different parts of the world and, if necessary, for different projection types. For multiple data layers at least on data set for each layer (alone and in combination with the others) is created.

4 Quality Assurance

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

TABLE: QA-MEASURES

Check	QA-Measure	Responsible
☒	Peer reviews	Project Team
☒	Editorial review	Service Provider
☐	Public review	Choose an item.
☐	Reference implementation	Choose an item.
☐	Implementation project	Choose an item.
☐	Validator project	Choose an item.
☒	Proof of concept implementation (when needed, for concept features and requirements only).	Project Team
☒	Creation of appropriate test data for source code validation	Project Team

5 Deliverables

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

TABLE: DELIVERABLES

Item No.	Description
01	OpenCRG specification document
02	OpenCRG User Manual
03	Version 1.0 Source Code M + C

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
3D Mapping Solutions GmbH	20		• Sebastian Tuttas, +49 8024 46041-20, Sebastian.tuttas@3d-mapping.de
			•
			•
			•
			•
Total:	20		

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 consists of the following work packages:

TABLE: WORK PACKAGES

WP-No.	Title / Description • Deliverable	Effort (Man-days)
1	Specification creation	
	• OpenCRG document as ASAM standard • OpenCRG User Manual	25 10
2	Concepts for feature implementation	
	• Concepts for standard implementation	30
3	Standard implementation review	
	• Review of the standard	15
4	Feature implementation review	
	• Test data • Beta Test of Source Code	10 15
	Total Effort of Work Group:	105

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

TABLE: SERVICE PROVIDER TASKS

Task No.	Title / Description • Deliverable	Effort (Man-days)
1	Standard implementation	
	• Standard	4
2	Implementation of new features	
	• Source Code (M+C) • Standard with new features	14 3
3	Source Code Tests (Test implementation and test execution)	
	• Tests and Test Environment	10
4	Editorial Proof Reading (Language Check)	
	• OpenCRG document as ASAM standard	4
	Total Effort of Service Providers:	35

The total work effort for the project is:

TABLE: TOTAL WORK EFFORT

	Formula	Amount (Man-days)
Total Effort of Work Group		105
Total Effort of Service Providers	+	35
Total Work Effort		140

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	Specification creation	☐	☐	☐	☐	☐	☒	☒	☐	☒	☐	☐	☐
2	Concepts for feature implementation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐
3	Standard implementation review	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	Feature implementation review	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

TABLE: TIME SCHEDULE

WP-No.	Title / Description	2020											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Specification creation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	Concepts for feature implementation	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	Standard implementation review	☐	☒	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐

4	Feature implementation review	☐	☐	☐	☐	☒	☒	☒	☐	☐	☐	☐	☐

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	35	× €700 =	24 500
Total Committed Funds		-	0
ASAM Funds			24 500

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	140	× €700 =	98 000
Total Committed Funds		+	0

Total Transferred IP	+	0
Subtotal		98 000
Upper Limit for ASAM Funds	× Factor =	24 500
	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

OpenCRG is related to the OpenDRIVE standard.

8 References

[1] OpenDRIVE Concept Project Proposal, Joan Roca

[2] http://www.opencrg.org/, VIRES Simulationstechnologie GmbH

[3] OpenCRG User Manual, VI2009.55 from June 26, 2017, https://www.vires.com/open-crg/docs/OpenCRGUserManual.pdf