## Project: OpenDRIVE®

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<tr>
<th>Date:</th>
<th>2nd January 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author:</td>
<td>Marius Dupuis e.a.</td>
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<td>VIRES Simulationstechnologie GmbH</td>
</tr>
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</tr>
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## Note:

Modifications to the previous release are marked in red color.
OpenDRIVE® Format Specification, Rev. 1.2

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FOR
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5.3.8.7 Access Restriction Types
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5.3.8.1 Road Lane Record
5.3.7.1 Road Lane Section Record
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5.3.6.2 Crossfall Record
5.3.6.1 Road Superelevation Record
5.3.5.1 Junction Record
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1 Preface

1.1 Scope
The OpenDRIVE® format provides a common base to describe track-based road networks. The data stored in an OpenDRIVE® file describes the geometry of roads as well as features along the roads that influence the logics (e.g. lanes, signs, signals).

The format is organized in nodes which can be extended with user-defined data. By this, a high degree of specialization for individual applications is feasible while maintaining the commonality required for the exchange of data between different applications.

1.2 Developers
The initial OpenDRIVE® format was developed by VIRES Simulationstechnologie GmbH, Germany, in close co-operation with Daimler Driving Simulator, Berlin, Germany.

The contents of the file format are reviewed by a core team before publication. For the current members of the core team, please visit the OpenDRIVE® website (see below).

This standard has been created for its users. So, if you feel anything is missing, should be clarified or modified, please don't hesitate to contact us (see below).

1.3 Point of Contact
Further assistance on OpenDRIVE® is provided

via the OpenDRIVE® website

   www.opendrive.org

via email

   opendrive@vires.com

and via the "classic style" of direct contact with human beings:

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   Oberaustrasse 34
   83026 Rosenheim
   Germany
   phone +49.8031.463640
   fax +49.8031.463645

Copyright note according to DIN 34. Use of this data is subject to the OpenDRIVE public license policy.
2 Conventions

2.1 Naming Conventions
In this document, the following conventions apply:
- **data types** are given according to IEEE standard
- **track** signifies the chord line of a road

2.2 Units
All numeric values within this specification are in SI units, e.g.:
- position/distance in [m]
- angles in [rad]
- time in [s]
- speed in [m/s]

2.3 Co-ordinate Systems

2.3.1 Overview
The following figure gives an overview of the co-ordinate systems used in this specification (for details, see the following chapters).
2.3.2 Inertial System

The inertial system is a right-handed co-ordinate system according to ISO 8855 with the axes pointing to the following directions:

\[
\begin{align*}
x & \quad & \text{forward} \\
y & \quad & \text{left} \\
z & \quad & \text{up}
\end{align*}
\]

For geographic reference, the following convention applies:

\[
\begin{align*}
x & \quad & \text{east} \\
y & \quad & \text{north} \\
z & \quad & \text{up}
\end{align*}
\]

Within the inertial system, the following angles are defined:

\[
\begin{align*}
\text{heading} & \quad & \text{around z-axis, } 0.0 = \text{east} \\
\text{pitch} & \quad & \text{around y-axis, } 0.0 = \text{level} \\
\text{roll} & \quad & \text{around x-axis, } 0.0 = \text{level}
\end{align*}
\]

The following image shows the positive axes and positive directions of the corresponding angles.
2.3.3 Track System

The track co-ordinate system applies along the centerline (chord line) of a road. It is also a right-handed co-ordinate system. The following degrees of freedom are defined:

- **s** position along chord line, measured in [m] from the beginning of the track, calculated in the xy-plane (i.e. not taking into account the elevation profile of the track)
- **t** lateral position, positive to the left
- **z** up

heading around z-axis, 0 = forward
pitch around t-axis, 0 = level
roll around s-axis, 0 = level

The following image shows the positive axes and positive directions of the corresponding angles.

2.3.4 Curvature

Positive curvature indicates a left curve
Negative curvature indicates a right curve
3 Road Layout

3.1 General

The following figure depicts the principles of road layout covered by this specification:

All roads consist of a chord line (track) which defines the basic geometry. Along this line, various properties of the road can be defined. These are, e.g. elevation profile, lanes, traffic signs etc. Roads can be linked to each other either directly (when there is only one connection possible between two given roads) or via junctions (when more than one connection is possible from a given road to other roads).

All properties may be parameterized according to the standards laid out in this specification and, optionally, by user-defined data.

The convention applies that properties of the same type defined along a single chord line must be defined in ascending order. This means that the start co-ordinate (parameter s, see above) of a property must either be the same or greater than the start co-ordinate of the preceding property of same type on the same track.

3.2 Chord Line (Track)

The geometry of the chord line is described as a sequence of sections of various types. The available types are:

- straight line (constant zero curvature)
- spiral (linear change of curvature)
- curve (constant non-zero curvature)
- polynom (of 3rd order)

The following figure illustrates this principle.
3.3 Lanes

3.3.1 General

Lanes are identified by numbers which are
- unique (per lane section, see below)
- in sequence (without gaps),
- starting from the chord line (lane no. 0)
- ascending to the left
- descending to the right

The total number of lanes is not limited. The chord line itself is defined as lane zero and must not have a width entry (i.e. the width must always be 0.0).
3.3.2 Lane Sections

The lanes appearing in a given cross-section along the road are defined in so-called lane sections. Multiple lane sections may be defined in ascending order along a chord line. Each lane section is valid until the next lane section is defined. Therefore, in order to be usable, each track must at least be equipped with one lane section starting at \( s = 0.0 \) m.

The following figure depicts the principles of lane sections:

Per lane section, the number of lanes is constant. However, the properties of each lane (e.g. width, road marks, friction etc.) may change.

3.3.3 Lane Properties

Lane properties are defined relative to the start of the corresponding lane section. Offsets start at 0.0 for the beginning of the lane section and increase corresponding to the track co-ordinate \( s \). Lane properties are valid until a new property of the same type is defined or the lane section ends. Lane properties of identical types must be defined in ascending order. Lane properties may be point or range properties. They are valid at a given point only or over a given range, respectively.

If a property is not defined within a given lane section or not covering the entire section, the application may assume default values.
3.4 Superelevation and Crossfall

In most cases, a road cross section will not be parallel to the surrounding terrain. Instead, it will be elevated to one side (e.g. in curves) or to the center (for drainage). Both properties are covered by the OpenDRIVE format with the former being called “superelevation” and the latter “crossfall”. The following figure illustrates both properties:

Superelevation and crossfall can be superimposed in order to provide smooth transitions between e.g. straight sections with crossfall and curves with superelevation.

As can be seen from the above figures, the superelevation is defined per entire road cross section whereas the crossfall is defined per side of the road.

Single lanes can be excluded from the application of the superelevation and crossfall properties. Pedestrian walkways, for example, will always run on level planes (see following figure).
3.5 Road Linkage

3.5.1 Overview

In order to navigate through a road network, the application must know about the linkage between different roads. Two types of linkage are possible:

- standard successor/predecessor linkage
- junctions

Whenever the linkage between two roads is clear, a standard linkage information is sufficient. A junction is required when the successor or predecessor relationship of a road is ambiguous. Here, the application needs to select one of several possibilities.

The following figure and table illustrate the different cases:

```
<table>
<thead>
<tr>
<th>Road</th>
<th>Predecessor</th>
<th>Successor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>ambiguous</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>5</td>
</tr>
</tbody>
</table>
```

Usually, a junction would imply more ambiguous connections than listed in the table above.

In order to facilitate navigation through a road network on a per-lane basis, additional linkage information can be provided on the lane level.
3.5.2 Junctions

The basic principle is very simple:

Junctions link in-coming roads via paths (connecting roads) to out-going roads.

The following figure shows a complex junction scenario:

Connecting Roads are also modeled as roads according to the rules laid out here for all other roads. They consist of tracks with lane sections etc. Usually, in-coming roads also serve as out-going roads, with the actual usage of a road being determined by its lanes.

Junctions consist of a connection matrix which indicates all possibilities to enter a connecting road from a given in-coming road. These connections are listed on a per-lane basis in order to facilitate navigation. Once a connecting road is entered, the following connection to the corresponding out-going road can be retrieved from the general successor/predecessor information that is stored with each road. Within the junctions, priorities of roads relative to each other may be stored but they may also be retrieved by evaluating the signs/signals and geometry.
3.5.3 Neighbors

Roads may not only be linked to predecessors and successors but also to neighbors. This type of link information may be required when only one driving direction is defined per chord line (i.e. only left or only right lanes), or when only a fraction of the total number of lanes is defined per chord line. Each road may have up to two neighbors.

Example 1 (two roads being each other’s neighbor):

![Example diagram showing two roads linked as neighbors]

Example 2 (three roads):

![Example diagram showing three roads]

Note:
The neighbor entry has been introduced mainly for legacy purposes. For the design of new road networks, it is recommended to define both driving directions of a road along a single chord line and to avoid using the neighbor entry (this recommendation applies outside junctions only; within junctions, single chord lines may be used for each driving direction, however).
3.6 Surface
OpenDRIVE provides two approaches for describing surface properties:

- **Standard description:**
  
  In the standard case, a `<material>` record may be defined per lane of the road, providing parameters for:
  - surface material code
  - roughness
  - friction

- **Extended description (new in OpenDRIVE 1.2):**
  
  A more detailed description of road surface data (e.g. from measurements), which is not limited to the definition of material properties within lane boundaries, may be provided within the newly introduced `<surface>` record. This data may be applied to an entire cross section or parts thereof.

  Due to the potentially very large amount of data that is contained in detailed surface information and due to the fact that publicly available data formats already exist for surface data, OpenDRIVE does not define its own XML implementation of surface descriptions but will provide references to the respective data files instead.

  Formats officially supported as surface import formats to OpenDRIVE are listed below. This list may be extended in future revisions of OpenDRIVE depending on the purposes served by additional formats.

  In order to guarantee the portability of an OpenDRIVE description, this standard recommends using the CRG format as preferred extended road surface description.

  List of supported surface data formats:

<table>
<thead>
<tr>
<th>no.</th>
<th>name</th>
<th>revision</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>curved regular grid (CRG)</td>
<td>April 2007</td>
<td>data format by TÜV Süd in co-operation with DaimlerChrysler AG.</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Further information:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><a href="http://www.opendrive.org/tools/CRG-public-070320.zip">http://www.opendrive.org/tools/CRG-public-070320.zip</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Measurements (incomplete list):</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><a href="http://www.tuev-sued.de/3D-Track">http://www.tuev-sued.de/3D-Track</a></td>
</tr>
</tbody>
</table>

  For the application of this data to the OpenDRIVE road see chapter 5.3.10.
3.7 Alternative Layouts

Depending on the individual application, it might be necessary to describe various possible setups of a road network’s properties, so that the OpenDRIVE file does not only contain one description of these properties but provides access to all pre-defined setups.

For this purpose, the `<set>` record is being introduced (see 5.8). It allows the user to define alternative instances of a property within its level.

The `<set>` record may be used at any level without restrictions, however users should take into account that the portability of an OpenDRIVE road description may suffer with sets being defined at levels where another user might not expect them. In the future, this document shall contain hints where sets have been used successfully in applications, in order to give an indication where sets are encouraged and where they should be avoided.
4 File

4.1 Format
OpenDRIVE® data is stored in an XML file.

4.2 Extension
OpenDRIVE® files have the extension “.xodr”. Compressed OpenDRIVE® files have the extension “.xodrz”.

4.3 Structure
The OpenDRIVE® file structure is laid out according to XML rules and with reference to the respective schema file.

Beads are organized in levels. Beads with a level greater than zero (0) are children of the preceding level. Beads with a level of one (1) are called primary beads.

Each bead can be extended with user-defined data. This data is stored in so-called ancillary beads (see 5.6)

4.4 Notation
All floating point numbers are “double” per default. It is highly recommended to use a 16 digit scientific representation for floating point numbers.

4.5 Schema
The schema file for the OpenDRIVE® format can be retrieved from www.opendrive.org

4.6 Combining Files
Multiple files can be combined by means of an include tag at the appropriate locations. Upon parsing this tag, OpenDRIVE readers shall immediately start reading the file specified as argument to the tag. It is the user’s responsibility to make sure that contents read from an include file are consistent with the context from which the inclusion starts.
### 4.7 Overview of Beads

The following table provides a simplified overview of all beads that may occur within an OpenDRIVE™ file. It also indicates whether beads are optional or may occur multiple times. Children of optional beads must not be present if their respective parent is omitted. The levels of the beads are indicated by indentation and by the appropriate numbers.

<table>
<thead>
<tr>
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<th>level</th>
<th>optional</th>
<th>max. instances per parent</th>
<th>parent</th>
</tr>
</thead>
<tbody>
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<td>0</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>-header</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>OpenDRIVE</td>
</tr>
<tr>
<td>-road</td>
<td>1</td>
<td>-</td>
<td>unlimited</td>
<td>OpenDRIVE</td>
</tr>
<tr>
<td>-link</td>
<td>2</td>
<td>+</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-predecessor</td>
<td>3</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-successor</td>
<td>3</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-neighbor</td>
<td>3</td>
<td>+</td>
<td>2</td>
<td>link</td>
</tr>
<tr>
<td>-type</td>
<td>2</td>
<td>+</td>
<td>unlimited</td>
<td>road</td>
</tr>
<tr>
<td>-planview</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-geometry</td>
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<td>unlimited</td>
<td>planview</td>
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<td>-line</td>
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<td>1</td>
<td>geometry</td>
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<td>geometry</td>
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<td>1</td>
<td>geometry</td>
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<td>+</td>
<td>unlimited</td>
<td>elevationProfile</td>
</tr>
<tr>
<td>-lateralProfile</td>
<td>2</td>
<td>+</td>
<td>1</td>
<td>road</td>
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<tr>
<td>-superelevation</td>
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<td>+</td>
<td>unlimited</td>
<td>lateralProfile</td>
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<tr>
<td>-crossfall</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>lateralProfile</td>
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<tr>
<td>-lanes</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-lane section</td>
<td>3</td>
<td>-</td>
<td>unlimited</td>
<td>lanes</td>
</tr>
<tr>
<td>-left</td>
<td>4</td>
<td>+</td>
<td>1</td>
<td>lane section</td>
</tr>
<tr>
<td>-lane</td>
<td>5</td>
<td>-</td>
<td>unlimited</td>
<td>left</td>
</tr>
<tr>
<td>-link</td>
<td>6</td>
<td>+</td>
<td>1</td>
<td>lane</td>
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</tr>
<tr>
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<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-width</td>
<td>6</td>
<td>-</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-roadMark</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-material</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-visibility</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-speed</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-access</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-height</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-center</td>
<td>4</td>
<td>+</td>
<td>1</td>
<td>lane section</td>
</tr>
<tr>
<td>-lane</td>
<td>5</td>
<td>-</td>
<td>1</td>
<td>center</td>
</tr>
<tr>
<td>-link</td>
<td>6</td>
<td>+</td>
<td>1</td>
<td>lane</td>
</tr>
<tr>
<td>-predecessor</td>
<td>7</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-successor</td>
<td>7</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-roadMark</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-right</td>
<td>4</td>
<td>+</td>
<td>1</td>
<td>lane section</td>
</tr>
<tr>
<td>-lane</td>
<td>5</td>
<td>-</td>
<td>unlimited</td>
<td>right</td>
</tr>
<tr>
<td>-link</td>
<td>6</td>
<td>+</td>
<td>1</td>
<td>lane</td>
</tr>
<tr>
<td>-predecessor</td>
<td>7</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-successor</td>
<td>7</td>
<td>+</td>
<td>1</td>
<td>link</td>
</tr>
<tr>
<td>-width</td>
<td>6</td>
<td>-</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-roadMark</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-material</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-visibility</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-speed</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-access</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-height</td>
<td>6</td>
<td>+</td>
<td>unlimited</td>
<td>lane</td>
</tr>
<tr>
<td>-objects</td>
<td>2</td>
<td>+</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-object</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>objects</td>
</tr>
<tr>
<td>-repeat</td>
<td>4</td>
<td>+</td>
<td>1</td>
<td>object</td>
</tr>
<tr>
<td>bead name</td>
<td>level</td>
<td>optional</td>
<td>max. instances per parent</td>
<td>parent</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
<td>----------</td>
<td>---------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>outline</td>
<td>4</td>
<td>+</td>
<td>1</td>
<td>object</td>
</tr>
<tr>
<td>-cornerInertial</td>
<td>5</td>
<td>+</td>
<td>unlimited</td>
<td>outline</td>
</tr>
<tr>
<td>-cornerRoad</td>
<td>5</td>
<td>+</td>
<td>unlimited</td>
<td>outline</td>
</tr>
<tr>
<td>-cornerRelative</td>
<td>5</td>
<td>+</td>
<td>unlimited</td>
<td>outline</td>
</tr>
<tr>
<td>validity</td>
<td>4</td>
<td>+</td>
<td>number of lanes</td>
<td>object</td>
</tr>
<tr>
<td>-objectReference</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>objects</td>
</tr>
<tr>
<td>validity</td>
<td>4</td>
<td>+</td>
<td>lanes in road</td>
<td>objectReference</td>
</tr>
<tr>
<td>-tunnel</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>objects</td>
</tr>
<tr>
<td>-validity</td>
<td>4</td>
<td>+</td>
<td>number of lanes</td>
<td>tunnel</td>
</tr>
<tr>
<td>-bridge</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>objects</td>
</tr>
<tr>
<td>-validity</td>
<td>4</td>
<td>+</td>
<td>number of lanes</td>
<td>bridge</td>
</tr>
<tr>
<td>-signals</td>
<td>2</td>
<td>+</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-signal</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>signals</td>
</tr>
<tr>
<td>-validity</td>
<td>4</td>
<td>+</td>
<td>lanes in road</td>
<td>signal</td>
</tr>
<tr>
<td>-dependency</td>
<td>4</td>
<td>+</td>
<td>unlimited</td>
<td>signal</td>
</tr>
<tr>
<td>-signalReference</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>signals</td>
</tr>
<tr>
<td>-validity</td>
<td>4</td>
<td>+</td>
<td>lanes in road</td>
<td>signalReference</td>
</tr>
<tr>
<td>-surface</td>
<td>2</td>
<td>+</td>
<td>1</td>
<td>road</td>
</tr>
<tr>
<td>-CRG</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>surface</td>
</tr>
<tr>
<td>-controller</td>
<td>1</td>
<td>+</td>
<td>unlimited</td>
<td>OpenDRIVE</td>
</tr>
<tr>
<td>-control</td>
<td>2</td>
<td>-</td>
<td>number of signals</td>
<td>controller</td>
</tr>
<tr>
<td>-junction</td>
<td>1</td>
<td>+</td>
<td>unlimited</td>
<td>OpenDRIVE</td>
</tr>
<tr>
<td>-connection</td>
<td>2</td>
<td>-</td>
<td>unlimited</td>
<td>junction</td>
</tr>
<tr>
<td>-lane link</td>
<td>3</td>
<td>+</td>
<td>unlimited</td>
<td>connection</td>
</tr>
<tr>
<td>-priority</td>
<td>2</td>
<td>+</td>
<td>unlimited</td>
<td>junction</td>
</tr>
<tr>
<td>-controller</td>
<td>2</td>
<td>+</td>
<td>unlimited</td>
<td>junction</td>
</tr>
</tbody>
</table>

At any level, there may be the following beads:

<table>
<thead>
<tr>
<th>bead name</th>
<th>level</th>
<th>optional</th>
<th>max. instances per parent</th>
<th>parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>userData</td>
<td>any</td>
<td>+</td>
<td>unlimited</td>
<td>any</td>
</tr>
<tr>
<td>include</td>
<td>any</td>
<td>+</td>
<td>unlimited</td>
<td>any</td>
</tr>
<tr>
<td>set</td>
<td>any</td>
<td>+</td>
<td>unlimited</td>
<td>any</td>
</tr>
<tr>
<td>[-instance</td>
<td>set+1</td>
<td>-</td>
<td>unlimited</td>
<td>set</td>
</tr>
</tbody>
</table>
5 File Entries

5.1 Enclosing Tag
The overall enclosing tag of the file is:

Delimiters: `<OpenDRIVE>...<OpenDRIVE>

Maximum Instances: 1
Optional: no
Arguments: none

5.2 Header
The header record is the very first record within the OpenDRIVE tag.

Delimiters: `<header>...<header>

Parent: `<OpenDRIVE>

Maximum Instances: 1
Optional: no
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>revMajor</td>
<td>ushort</td>
<td>major revision number of OpenDRIVE® format (currently 1)</td>
</tr>
<tr>
<td>revMinor</td>
<td>ushort</td>
<td>minor revision number of OpenDRIVE® format (currently 2)</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>database name</td>
</tr>
<tr>
<td>version</td>
<td>float</td>
<td>version number of this database (format: a.bb)</td>
</tr>
<tr>
<td>date</td>
<td>string</td>
<td>time/date of database creation</td>
</tr>
<tr>
<td>north</td>
<td>double</td>
<td>maximum inertial y value in [m]</td>
</tr>
<tr>
<td>south</td>
<td>double</td>
<td>minimum inertial y value in [m]</td>
</tr>
<tr>
<td>east</td>
<td>double</td>
<td>maximum inertial x value in [m]</td>
</tr>
<tr>
<td>west</td>
<td>double</td>
<td>minimum inertial x value in [m]</td>
</tr>
<tr>
<td>maxRoad</td>
<td>uint</td>
<td>maximum road id</td>
</tr>
<tr>
<td>maxJunc</td>
<td>uint</td>
<td>maximum junction id</td>
</tr>
<tr>
<td>maxProgr</td>
<td>uint</td>
<td>maximum traffic light program id</td>
</tr>
</tbody>
</table>
5.3 Road Records
Rocks are the principal containers of information within a database. For an overview of records which can be stored within a road, see chapter 4.7.

5.3.1 Road Header Record
The road header record defines the basic parameters of an individual road. It is followed immediately by other records defining geometry and logical properties of the road.

Delimiters: 

Parent: <OpenDRIVE>

Maximum Instances: unlimited

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>string</td>
<td>name of the road</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>total length of the chord line in the xy-plane</td>
</tr>
<tr>
<td>ID</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
<tr>
<td>junction</td>
<td>string</td>
<td>ID of the junction to which the road belongs as a path (= -1 for none)</td>
</tr>
</tbody>
</table>

5.3.2 Road Link Record
This record follows the Road Header Record if the road is (as usual) linked to a successor, a predecessor, or a neighbor (see children of the link record). Isolated roads may omit this record.

Delimiters: 

Parent: <road>

Maximum Instances: 1

Optional: yes

Arguments: none
5.3.2.1 Road Predecessor
This record provides detailed information about the predecessor of a road. The predecessor may be of type road or junction.

Delimiters: `<predecessor.../>`
Parent: `<link>`
Maximum Instances: 1
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>elementType</td>
<td>string</td>
<td><code>road</code> or <code>junction</code></td>
</tr>
<tr>
<td>elementId</td>
<td>string</td>
<td>ID of the linked element</td>
</tr>
<tr>
<td>contactPoint</td>
<td>string</td>
<td>contact point of link on the linked element, may be <code>start</code> or <code>end</code></td>
</tr>
</tbody>
</table>

5.3.2.2 Road Successor
This record provides detailed information about the successor of a road. The successor may be of type road or junction.

Delimiters: `<successor.../>`
Parent: `<link>`
Maximum Instances: 1
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>elementType</td>
<td>string</td>
<td><code>road</code> or <code>junction</code></td>
</tr>
<tr>
<td>elementId</td>
<td>string</td>
<td>ID of the linked element</td>
</tr>
<tr>
<td>contactPoint</td>
<td>string</td>
<td>contact point of link on the linked element, may be <code>start</code> or <code>end</code></td>
</tr>
</tbody>
</table>
5.3.2.3 Road Neighbor

This record provides detailed information about the neighbor of a road. The neighbor must be of type road.

**Delimiter:** `<neighbor.../>`

**Parent:** `<link>`

**Maximum Instances:** 2

**Optional:** yes

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>side</td>
<td>string</td>
<td>left or right</td>
</tr>
<tr>
<td>elementId</td>
<td>string</td>
<td>ID of the linked road</td>
</tr>
<tr>
<td>direction</td>
<td>string</td>
<td>same or opposite</td>
</tr>
</tbody>
</table>

**Illustration:**

- Blue: has left neighbor (opposite)
- Green: has left neighbor (opposite), right neighbor (same)
- Yellow: has left neighbor (same)
5.3.3 Road Type Record

The type of a road may change over its entire length. Therefore, a separate record is provided for the definition of the road type with respect to a certain section of the road. A road type entry is valid for the entire cross section of the road. It is also valid until a new road type record is provided or the road ends.

Delimiter: 

Parent: 

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>for supported types, see chapter 6.1</td>
</tr>
</tbody>
</table>
5.3.4 Road Plan View Record
The plan view record contains a series of geometry records which define the layout of the road's chord line in the x/y-plane (plan view).

Delimiters: `<planView>...</planView>`
Parent: `<road>`
Maximum Instances: 1
Optional: no
Arguments: none

5.3.4.1 Road Geometry Header Record
A sequence of road geometry records defines the layout of the road's chord line in the x/y-plane (plan view). The geometry records must occur in ascending order (i.e. increasing s-position). The geometry information is split into a header which is common to all geometric elements and a subsequent bead containing the actual geometric element's data (depending on the type of geometric element).

Currently, three types of geometric elements are supported:
- straight lines
- spirals
- arcs

Delimiters: `<geometry>...</geometry>`
Parent: `<planView>`
Maximum Instances: unlimited
Optional: no
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
<tr>
<td>x</td>
<td>double</td>
<td>start position (x inertial)</td>
</tr>
<tr>
<td>y</td>
<td>double</td>
<td>start position (y inertial)</td>
</tr>
<tr>
<td>hdg</td>
<td>double</td>
<td>start orientation (inertial heading)</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of the element's chord line</td>
</tr>
</tbody>
</table>

This record is followed immediately by a record with more information about the actual geometry element.
5.3.4.1.1 Geometry, Line Record
This record describes a straight line as part of the road’s chord line.

Delimiters: <line.../>

Parent: <geometry>

Maximum Instances: 1

Optional: no

Arguments: none

5.3.4.1.2 Geometry, Spiral Record
This record describes a spiral as part of the road’s chord line. For this type of spiral, the curvature change between start and end of the element is linear.

Delimiters: <spiral.../>

Parent: <geometry>

Maximum Instances: 1

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>curvStart</td>
<td>double</td>
<td>curvature at the start of the element</td>
</tr>
<tr>
<td>curvEnd</td>
<td>double</td>
<td>curvature at the end of the element</td>
</tr>
</tbody>
</table>

5.3.4.1.3 Geometry, Arc Record
This record describes an arc as part of the road’s chord line.

Delimiters: <arc.../>

Parent: <geometry>

Maximum Instances: 1

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>curvature</td>
<td>double</td>
<td>constant curvature throughout the element</td>
</tr>
</tbody>
</table>
5.3.4.1.4 Geometry, Cubic Polynom Record

This record describes a cubic polynom as part of the road’s chord line. The polynom is described in the local u/v coordinate system of the starting point (with u pointing in the local s direction and v pointing in the local t direction). Each local coordinate is calculated by:

\[ v_{local} = a + b \cdot du + c \cdot du^2 + d \cdot du^3 \]

The conversion of u/v coordinates into x/y coordinates can be performed easily by simple geometric transformations (i.e. one translation and one rotation) relative to the starting point.

Delimiters: `<poly3.../>`

Parent: `<geometry>`

Maximum Instances: 1

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>double</td>
<td>parameter A</td>
</tr>
<tr>
<td>b</td>
<td>double</td>
<td>parameter B</td>
</tr>
<tr>
<td>c</td>
<td>double</td>
<td>parameter C</td>
</tr>
<tr>
<td>d</td>
<td>double</td>
<td>parameter D</td>
</tr>
</tbody>
</table>

Illustration:
5.3.5 Road Elevation Profile Record

The elevation profile record contains a series of elevation records which define the characteristics of the road's elevation along the chord line.

**Delimiters:** `<elevationProfile>...</elevationProfile>`

**Parent:** `<road>`

**Maximum Instances:** 1

**Optional:** yes

**Arguments:** none

5.3.5.1 Road Elevation Record

The elevation record defines an elevation entry at a given chord line position. Entries must be defined in increasing order along the chord line. The parameters of an entry are valid until the next entry starts or the road's chord line ends. Per default, the elevation of a road is zero.

The elevation is stored in a polynomial function of third order. It looks like:

\[ \text{elev} = a + b \cdot ds + c \cdot ds^2 + d \cdot ds^3 \]

\[ \text{with} \]

\[ \text{elev} \] being the elevation (inertial z) at a given position
\[ a, b, c, d \] being the coefficients and
\[ ds \] being the distance along the chord line between the start of the entry and the actual position.

Therefore, \( ds \) starts at zero for each entry. The absolute position of an elevation value is calculated by

\[ s = s_{\text{start}} + ds \]

\[ \text{with} \]

\[ s \] being the absolute position (track co-ordinate system)
\[ s_{\text{start}} \] being the start position of the entry in the track co-ordinate system
\[ ds \] being the delta between the start position and the requested position
5.3.6 Road Lateral Profile Record

The lateral profile record contains a series of superelevation and crossfall records which define the characteristics of the road surface's banking along the chord line.

Delimiters: <lateralProfile>...</lateralProfile>
Parent: <road>
Maximum Instances: 1
Optional: yes
Arguments: none
5.3.6.1 Road Superelevation Record

The superelevation of the road is defined as the road section’s roll angle around the s-axis (superelevation is positive for road surfaces “falling” to the right side, i.e. the following figure shows a negative superelevation).

Each superelevation record defines an entry at a given chord line position. Entries must be defined in increasing order along the chord line. The parameters of an entry are valid until the next entry starts or the road’s chord line ends. Per default, the superelevation of a road is zero.

The superelevation is stored in a polynomial function of third order. It looks like:

\[ s_{Elev} = a + b \times ds + c \times ds^2 + d \times ds^3 \]

with

- \( s_{Elev} \) being the superelevation at a given position, default: \( s_{Elev} = 0 \)
- \( a, b, c, d \) being the coefficients and
- \( ds \) being the distance along the chord line between the start of the entry and the actual position.

Therefore, \( ds \) starts at zero for each entry. The absolute position of a superelevation value is calculated by

\[ s = s_{start} + ds \]

with

- \( s \) being the absolute position (track coordinate system)
- \( s_{start} \) being the start position of the entry in the track coordinate system
- \( ds \) being the delta between the start position and the requested position

Delimiters: 

\[ \langle \text{superelevation...} \rangle \]

Parent: 

\[ \langle \text{lateralProfile} \rangle \]

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
<tr>
<td>a</td>
<td>double</td>
<td>parameter A (superelevation in [rad])</td>
</tr>
<tr>
<td>b</td>
<td>double</td>
<td>parameter B</td>
</tr>
<tr>
<td>c</td>
<td>double</td>
<td>parameter C</td>
</tr>
<tr>
<td>d</td>
<td>double</td>
<td>parameter D</td>
</tr>
</tbody>
</table>
5.3.6.2 Crossfall Record

The crossfall of the road is defined as the road surface’s angle relative to the t-axis. Positive crossfall results in a road surface “falling” from the chord line to the outer boundary.

The crossfall can be defined per side of the road. It will be applied to each lane of the respective side which is not being explicitly excluded from its application.

The crossfall is stored in a polynomial function of third order. It looks like:

\[ crfall = a + b \cdot ds + c \cdot ds^2 + d \cdot ds^3 \]

with

- \( crfall \) being the crossfall at a given position, default: \( crfall = 0 \)
- \( a, b, c, d \) being the coefficients and
- \( ds \) being the distance along the chord line between the start of the entry and the actual position.

Therefore, \( ds \) starts at zero for each entry. The absolute position of a crossfall value is calculated by

\[ s = s_{\text{start}} + ds \]

with

- \( s \) being the absolute position (track co-ordinate system)
- \( s_{\text{start}} \) being the start position of the entry in the track co-ordinate system
- \( ds \) being the delta between the start position and the requested position

Delimiters:  
\(<\text{crossfall}.../>\>

Parent:  
\(<\text{lateralProfile}>\>

Maximum Instances:  
unlimited

Optional:  
yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>side</td>
<td>string</td>
<td>applicable side of the road (left / right / both)</td>
</tr>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
<tr>
<td>a</td>
<td>double</td>
<td>parameter A (crossfall in [rad])</td>
</tr>
<tr>
<td>b</td>
<td>double</td>
<td>parameter B</td>
</tr>
<tr>
<td>c</td>
<td>double</td>
<td>parameter C</td>
</tr>
<tr>
<td>d</td>
<td>double</td>
<td>parameter D</td>
</tr>
</tbody>
</table>
5.3.7 Road Lanes Record

The lanes record contains a series of lane section records which define the characteristics of the road cross sections with respect to the lanes along the chord line.

Delimiters: <lanes>...</lanes>

Parent: <road>

Maximum Instances: 1

Optional: no

Arguments: none

5.3.7.1 Road Lane Section Record

The lane section record defines the characteristics of a road cross-section. It specifies the numbers and types of lanes and further features of the lanes. At least one record must be defined in order to use a road. A lane section record is valid until a new lane section record is defined. If multiple lane section records are defined, they must be listed in ascending order.

The actual lanes and their properties are children of the lane section record and the lane records, respectively.

Delimiters: <laneSection>...</laneSection>

Parent: <lanes>

Maximum Instances: unlimited

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
</tbody>
</table>

For the naming convention of lanes, see chapter 3.2.
5.3.7.1.1 Left / Center / Right Records

For easier navigation through a road description, the lanes under a lane section are grouped into left, center and right lanes. At least one entry (left, center or right) must be present.

- **Delimiters:** `<left>...</left>`
  `<center>...</center>`
  `<right>...</right>`

- **Parent:** `<laneSection>`

- **Maximum Instances:** 1

- **Optional:** no

- **Arguments:** none

5.3.7.1.1.1 Lane Record

Lane records are found within the left/center/right records. They define the IDs of the actual lanes (and, therefore, their position on the road, see conventions in 3). In order to prevent confusion, lane records should represent the lanes from left to right (i.e. with descending ID). All properties of the lanes are defined as children of the lane records.

- **Delimiters:** `<lane>...</lane>`

- **Parent:** `<left> / <center> / <right>`

- **Maximum Instances:** unlimited

- **Optional:** no

- **Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>int</td>
<td>id of the lane (according to convention)</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the lane, see chapter 6.5</td>
</tr>
<tr>
<td>level</td>
<td>string</td>
<td>&quot;true&quot; = keep lane on level, i.e. do not apply superelevation or crossfall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;false&quot; = apply superelevation and crossfall to this lane (default, also used if argument level is missing)</td>
</tr>
</tbody>
</table>

  Lanes are also kept on level if the argument level is present but no superelevation or crossfall have been defined.
5.3.7.1.1.1.1 Lane Link Record

In order to facilitate navigation through a road network on a per-lane basis, lanes should be provided with predecessor/successor information. Only when lanes end at a junction or have no physical link, this record should be omitted.

For links between lanes on the same physical road (i.e. identical chord line), the lane predecessor/successor information provides the ids of lanes on the preceding or following lane section. For links between lanes on different roads, i.e. roads directly connecting to each other without a junction, the complete link information must be composed from the corresponding road link record and the lane link record.

Delimiters: <link>...</link>

Parent: <lane>

Maximum Instances: 1

Optional: yes

Arguments: none

5.3.7.1.1.1.1.1 Lane Predecessor

This record provides detailed information about the predecessor of a lane.

Delimiters: <predecessor.../>

Parent: <link>

Maximum Instances: 1

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>int</td>
<td>ID of the linked lane</td>
</tr>
</tbody>
</table>
5.3.7.1.1.1.1.2 Lane Successor
This record provides detailed information about the successor of a lane.

Delimiters: <successor.../>
Parent: <link>
Maximum Instances: 1
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>int</td>
<td>ID of the linked lane</td>
</tr>
</tbody>
</table>

5.3.7.1.1.1.2 Lane Width Record
Each lane within a road cross section can be provided with several width entries. At least one entry must be defined for each lane, except for the center lane which is, per convention, of zero width (see 3.2). Each entry is valid until a new entry is defined. If multiple entries are defined for a lane, they must be listed in ascending order.

The actual width at a given point is computed with a polynomial function of third order. It looks like:

\[
width = a + b*ds + c*ds^2 + d*ds^3
\]

with
- \(width\) being the width at a given position
- \(a, b, c, d\) being the coefficients and
- \(ds\) being the distance along the chord line between the start of the entry and the actual position.

Therefore, \(ds\) starts at zero for each entry. The absolute position of a width value is calculated by

\[
s = s_{section} + offset_{start} + ds
\]

with
- \(s\) being the absolute position (track co-ordinate system)
- \(s_{section}\) being the start position of the preceding lane section record (see 5.3.7) in the track co-ordinate system
- \(offset_{start}\) being the offset of the entry relative to the preceding lane section record
- \(ds\) being the delta between the offset (\(s_{start}\)) and the requested position

The following figure illustrates this convention for a lane with varying width over a given range:
A new width entry is required each time the polynomial function changes.

Delimiters: \[<width.../>\]

Parent: \[<lane>\]

Maximum Instances: unlimited

Optional: no

Restrictions: not allowed for center lane (laneId=0)

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding</td>
</tr>
<tr>
<td>a</td>
<td>double</td>
<td>parameter A (width in [m])</td>
</tr>
<tr>
<td>b</td>
<td>double</td>
<td>parameter B</td>
</tr>
<tr>
<td>c</td>
<td>double</td>
<td>parameter C</td>
</tr>
<tr>
<td>d</td>
<td>double</td>
<td>parameter D</td>
</tr>
</tbody>
</table>
5.3.7.1.1.3 Road Mark Record

Each lane within a road cross section can be provided with several road mark entries. The road mark information defines the style of the line at the lane’s outer border. For left lanes, this is the left border, for right lanes the right one. The style of the line separating left and right lanes is determined by the road mark entry for lane zero (i.e. the center lane)

**Delimiter:** `<roadMark>...</roadMark>`

**Parent:** `<lane>`

**Maximum Instances:** unlimited

**Optional:** yes

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the road mark, see chapter 6.2</td>
</tr>
<tr>
<td>weight</td>
<td>string</td>
<td>weight of the road mark, see chapter 6.3</td>
</tr>
<tr>
<td>color</td>
<td>string</td>
<td>color of the road mark, see chapter 6.4</td>
</tr>
<tr>
<td>width</td>
<td>double</td>
<td>width of the road mark in [m] – optional</td>
</tr>
<tr>
<td>laneChange</td>
<td>string</td>
<td>[increase</td>
</tr>
</tbody>
</table>

The parameter `weight` may be used for a categorized definition of the width of a road mark (e.g. “standard” and “bold” according to the corresponding country’s design rules) whereas the optional parameter `width` may be used for an exact definition of an individual road mark’s width. This may be required e.g. in cases which deviate from a common design rule.

For an exact evaluation or a road mark’s borders including the width of the mark, the convention shall apply that a road mark’s centerline is always positioned on the respective lane’s outer border line (so that the outer half of the road mark is physically placed on the next lane).

**Illustration:**

![Illustration of road marks](image)
5.3.7.1.1.3.1 Road Mark Type

Road Marks may be further described depending on their type. Instead of providing additional parameters to the roadMark tag, certain types shall be defined as children to the roadMark tag. For the current definition of OpenDRIVE, only the possibility shall be foreseen to add these tags. The actual tags will be defined in upcoming versions of OpenDRIVE according to incoming user requirements or specifications.

5.3.7.1.1.4 Lane Material Record

Each lane within a road cross section may be provided with several entries defining its material. Each entry is valid until a new entry is defined. If multiple entries are defined, they must be listed in increasing order.

Delimiters: <material.../>

Parent: <lane>

Maximum Instances: unlimited

Optional: yes

Restrictions: not allowed for center lane (laneId=0)

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>surface</td>
<td>string</td>
<td>surface material code [-], depending on application</td>
</tr>
<tr>
<td>friction</td>
<td>double</td>
<td>friction value [-]</td>
</tr>
<tr>
<td>roughness</td>
<td>double</td>
<td>roughness [-] (for sound and motion systems)</td>
</tr>
</tbody>
</table>

5.3.7.1.1.5 Lane Visibility Record

Each lane within a road cross section may be provided with several entries defining the visibility in four directions relative to the lane’s direction. Each entry is valid until a new entry is defined. If multiple entries are defined, they must be listed in increasing order.

For left lanes (positive ID), the forward direction is oriented opposite to the track’s direction, for right lanes, the forward direction and the track’s direction are identical.

Delimiters: <visibility.../>

Parent: <lane>

Maximum Instances: unlimited

Optional: yes

Restrictions: not allowed for center lane (laneId=0)
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>forward</td>
<td>double</td>
<td>visibility in forward direction [m]</td>
</tr>
<tr>
<td>back</td>
<td>double</td>
<td>visibility in reverse direction [m]</td>
</tr>
<tr>
<td>left</td>
<td>double</td>
<td>visibility to the left [m]</td>
</tr>
<tr>
<td>right</td>
<td>double</td>
<td>visibility to the right [m]</td>
</tr>
</tbody>
</table>

5.3.7.1.1.1.6 Lane Speed Record
This record defines the maximum allowed speed on a given lane. Each entry is valid in direction of the increasing s co-ordinate until a new entry is defined. If multiple entries are defined, they must be listed in increasing order.

Delimiters: `<speed.../>`
Parent: `<lane>`
Maximum Instances: unlimited
Optional: yes
Restrictions: not allowed for center lane (laneId=0)

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>max</td>
<td>double</td>
<td>maximum allowed speed in [m/s]</td>
</tr>
</tbody>
</table>

5.3.7.1.1.1.7 Lane Access Record
This record defines access restrictions for certain types of road users. The record can be used to complement restrictions resulting from signs or signals in order to control the traffic flow in a scenario. Each entry is valid in direction of the increasing s co-ordinate until a new entry is defined. If multiple entries are defined, they must be listed in increasing order.

Delimiters: `<access.../>`
Parent: `<lane>`
Maximum Instances: unlimited
Optional: yes
Restrictions: not allowed for center lane (laneId=0)
5.3.7.1.1.1.8 Lane Height Record

The surface of a lane may be offset from the plane defined by the chord line and the corresponding elevation and crossfall entries (e.g. pedestrian walkways are typically a few centimeters above road level). The height record provides a simplified method to describe this offset by setting an inner and outer offset from road level at discrete positions along the lane profile.

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>restriction</td>
<td>string</td>
<td>identifier of the participant to which the restriction applies, see also 6.9</td>
</tr>
</tbody>
</table>

**Delimiter:**

```
<height.../>
```

**Parent:**

`<lane>`

**Maximum Instances:**

unlimited

**Optional:**

yes

**Restrictions:**

not allowed for center lane (laneId=0)

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding laneSection record</td>
</tr>
<tr>
<td>inner</td>
<td>double</td>
<td>inner offset from road level in [m]</td>
</tr>
<tr>
<td>outer</td>
<td>double</td>
<td>outer offset from road level in [m]</td>
</tr>
</tbody>
</table>

**Illustration:**

![Diagram of lane height record](image)
5.3.8 Road Objects Record

The objects record is the container for all objects along a road.

**Delimiters:**  
<objects>...</objects>

**Parent:**  
<road>

**Maximum Instances:** 1

**Optional:** yes

**Arguments:** none

5.3.8.1 Object Record

The object record has been introduced for application-dependent elements. It is very flexible due to several parameters that can be used to provide the application with additional information. The most frequently used types of objects may become part of the OpenDRIVE® specification in future releases.

**Delimiters:**  
<object>...</object>

**Parent:**  
<objects>

**Maximum Instances:** unlimited

**Optional:** no

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>string</td>
<td>type of the object</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>name of the object</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
<tr>
<td>s</td>
<td>double</td>
<td>track position [m] (s-position)</td>
</tr>
<tr>
<td>t</td>
<td>double</td>
<td>track position [m] (t-position)</td>
</tr>
<tr>
<td>zOffset</td>
<td>double</td>
<td>z offset from track level [m]</td>
</tr>
<tr>
<td>validLength</td>
<td>double</td>
<td>extent of object’s validity along s-axis in [m] (0.0 for point object)</td>
</tr>
<tr>
<td>orientation</td>
<td>string</td>
<td>&quot;+&quot; = valid in positive track direction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;-&quot; = valid in negative track direction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;none&quot; = valid in both directions</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of the object [m] (inertial dx)</td>
</tr>
<tr>
<td>width</td>
<td>double</td>
<td>width of the object [m] (inertial dy)</td>
</tr>
<tr>
<td>radius</td>
<td>double</td>
<td>radius of the object [m]; alternatively to width and length</td>
</tr>
<tr>
<td>height</td>
<td>double</td>
<td>height of the object [m] (inertial dz)</td>
</tr>
<tr>
<td>hdg</td>
<td>double</td>
<td>inertial heading angle of the object [rad]</td>
</tr>
<tr>
<td>pitch</td>
<td>double</td>
<td>inertial pitch angle of the object [rad]</td>
</tr>
<tr>
<td>roll</td>
<td>double</td>
<td>inertial roll angle of the object [rad]</td>
</tr>
</tbody>
</table>
Illustration for circular (or cylindric) objects:

5.3.8.1.1 Object Repeat Record
In order to avoid multiple definitions for multiple instances of the same object, repeat parameters may be defined for the original object.

Delimiters: \(<\text{repeat}.../>\)
Parent: \(<\text{object}>\)
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate) [m], overrides the corresponding argument in the original (&lt;\text{object}&gt;) record</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of the repeat area [m]</td>
</tr>
<tr>
<td>distance</td>
<td>double</td>
<td>distance between two instances of the object [m]</td>
</tr>
</tbody>
</table>
5.3.8.1.2 Object Outline Record

The default parameters of the object record allow for objects with rectangular and circular footprint to be placed within the database. However, users may need to describe linear features as well as polygonal areas of non-rectangular shape along roads. For this purpose, the outline record may be used. It defines a sequence of corners including height information on the object's extent either in inertial co-ordinates or relative to the road's chord line (mixed definitions may also be used). For areas, the points should – preferably – be listed in CCW order.

The outline record must be followed by at least one corner record.

Delimiters: 

<outline>...</outline>

Parent: 

<object>

Maximum Instances: 1

Optional: yes

Arguments: none
5.3.8.1.2.1 CornerInertial
Defines a corner point on the object’s outline in inertial co-ordinates.

Delimiters:     <cornerInertial.../>
Parent:          <outline>
Maximum Instances: unlimited
Optional:        yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>double</td>
<td>inertial x co-ordinate of the corner</td>
</tr>
<tr>
<td>y</td>
<td>double</td>
<td>inertial y co-ordinate of the corner</td>
</tr>
<tr>
<td>z</td>
<td>double</td>
<td>inertial z co-ordinate of the corner</td>
</tr>
<tr>
<td>height</td>
<td>double</td>
<td>height of the object at this corner in [m]</td>
</tr>
</tbody>
</table>

Illustration:
5.3.8.1.2.2  CornerRoad
Defines a corner point on the object’s outline in road co-ordinates..

Delimiters:  <cornerRoad.../>

Parent:  <outline>

Maximum Instances:  unlimited

Optional:  yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>s co-ordinate of the corner</td>
</tr>
<tr>
<td>t</td>
<td>double</td>
<td>t co-ordinate of the corner</td>
</tr>
<tr>
<td>dz</td>
<td>double</td>
<td>delta z of the corner relative to road's cord line</td>
</tr>
<tr>
<td>height</td>
<td>double</td>
<td>height of the object at this corner in [m]</td>
</tr>
</tbody>
</table>

Illustration:
5.3.8.1.2.3 CornerRelative
Defines a corner point on the object’s outline relative to the pivot point (local u/v co-ordinates). The pivot point and the orientation of the object are given by the s/t/heading arguments of the <object> entry.

Delimiters: <cornerRelative.../>

Parent: <outline>

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>double</td>
<td>local u co-ordinate of the corner</td>
</tr>
<tr>
<td>v</td>
<td>double</td>
<td>local v co-ordinate of the corner</td>
</tr>
<tr>
<td>z</td>
<td>double</td>
<td>local z co-ordinate of the corner</td>
</tr>
<tr>
<td>height</td>
<td>double</td>
<td>height of the object at this corner in [m]</td>
</tr>
</tbody>
</table>

Illustration:
5.3.8.1.3 Lane Validity Record
Per default, objects are valid for all lanes pointing into the object's direction. This default validity may be replaced with explicit validity information for an object. The validity record is an optional child record of the object record. Multiple validity records may be defined per object.

Delimiters: <validity.../>
Parent: <object>
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fromLane</td>
<td>int</td>
<td>minimum ID of the lanes for which the object is valid</td>
</tr>
<tr>
<td>toLane</td>
<td>int</td>
<td>maximum ID of the lanes for which the object is valid</td>
</tr>
</tbody>
</table>

NOTE: For single-lane-validity of the object, provide identical values for fromLane and toLane.

5.3.8.2 Object Reference Record
Since the same object may be referred to from several roads, a corresponding record is being provided. This requires, however, that objects which are to be referred to be provided with a unique ID. The object reference record consists of a main record and an optional lane validity record.

Delimiters: <objectReference.../>
Parent: <objects>
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>track position [m] (s-position)</td>
</tr>
<tr>
<td>t</td>
<td>double</td>
<td>track position [m] (t-position)</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID of the referred object within the database</td>
</tr>
<tr>
<td>zOffset</td>
<td>double</td>
<td>z offset from track level [m]</td>
</tr>
<tr>
<td>validLength</td>
<td>double</td>
<td>extent of object's validity along s-axis in [m] (0.0 for point object)</td>
</tr>
</tbody>
</table>
| orientation | string| "+" = valid in positive track direction  
"-" = valid in negative track direction
"none" = valid in both directions |

5.3.8.2.1 Lane Validity Record
see 5.3.8.1.3
5.3.8.3 Tunnel Record
The tunnel record is – like an object record – applied to the entire cross section of the road within the given range unless a lane validity record with further restrictions is provided as child record.

Delimiters: <tunnel.../>
Parent: <objects>
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s$</td>
<td>double</td>
<td>track position ($s$ co-ordinate)</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of the tunnel in [m] ($s$ direction)</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>name of the tunnel</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the tunnel, see also 6.7</td>
</tr>
<tr>
<td>lighting</td>
<td>double</td>
<td>degree of artificial tunnel lighting [0.0..1.0]</td>
</tr>
<tr>
<td>daylight</td>
<td>double</td>
<td>degree of daylight intruding the tunnel [0.0..1.0]</td>
</tr>
</tbody>
</table>

Illustration:

5.3.8.3.1 Lane Validity Record
see 5.3.8.1.3.

Delimiters: <validity.../>
Parent: <tunnel>
5.3.8.4 Bridge Record

The bridge record is – like an object record – applied to the entire cross section of the road within the given range unless a lane validity record with further restrictions is provided as child record.

Delimiters: `<bridge.../>`

Parent: `<objects>`

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>track position (s co-ordinate)</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of the bridge in [m] (s direction)</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>name of the bridge</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the bridge, see also 6.8</td>
</tr>
</tbody>
</table>

Illustration:

5.3.8.4.1 Lane Validity Record

see 5.3.8.1.3.

Delimiters: `<validity.../>`

Parent: `<bridge>`
5.3.9 Road Signals Record
The signals record is the container for all signals along a road.

Delimiters: <signals>...</signals>

Parent: <road>

Maximum Instances: 1

Optional: yes

Arguments: none

5.3.9.1 Signal Record
The signal record is used to provide information about signs and signals along a road. Signals are signs that can change their state dynamically (e.g. traffic lights). The signal record consists of a main record and an optional lane validity record.

Delimiters: <signal.../>

Parent: <signals>

Maximum Instances: unlimited

Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>track position [m] (s-position)</td>
</tr>
<tr>
<td>t</td>
<td>double</td>
<td>track position [m] (t-position)</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID of the signal within the database</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>name of the signal (e.g. bead name in graphics)</td>
</tr>
<tr>
<td>dynamic</td>
<td>string</td>
<td>yes or no</td>
</tr>
</tbody>
</table>
| orientation | string | “+” = valid in positive track direction  
            |                                                  | “-” = valid in negative track direction
            |                                                  | “none” = valid in both directions                |
| zOffset | double   | z offset from track level [m]                   |
| country | string   | country code of the signal, see also 6.10       |
| type    | int      | type number according to country code or -1, see 6.11 |
| subtype | int      | subtype number according to country code or -1  |
| value   | double   | value of the signal (e.g. speed for speed restricting signals, weight for weight limiting signals etc.) |
5.3.9.1.1 Lane Validity Record
Per default, signals are valid for all lanes pointing into the signal’s direction. This default validity may be replaced with explicit validity information for a signal. The validity record is an optional child record of the signal record. Multiple validity records may be defined per signal.

Delimiters:    <validity.../>
Parent:       <signal>
Maximum Instances: unlimited
Optional:      yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fromLane</td>
<td>int</td>
<td>minimum ID of the lanes for which the object is valid</td>
</tr>
<tr>
<td>toLane</td>
<td>int</td>
<td>maximum ID of the lanes for which the object is valid</td>
</tr>
</tbody>
</table>

NOTE: For single-lane-validity of the signal, provide identical values for fromLane and toLane.

5.3.9.1.2 Signal Dependency Record
The signal dependency record provides signals with a means to control other signals. Signs can e.g. restrict other signs for various types of vehicles, warning lights can be turned on when a traffic light goes red etc. The signal dependency record is an optional child record of the signal record. A signal may have multiple dependency records.

Delimiters:    <dependency.../>
Parent:       <signal>
Maximum Instances: unlimited
Optional:      yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>ID of the controlled signal</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the dependency, depending on the application</td>
</tr>
</tbody>
</table>
5.3.9.2 Signal Reference Record

Depending on the way roads (especially in junctions) are laid out for different applications, it may be necessary to refer to the same (i.e. the identical) sign from multiple roads. In order to prevent inconsistencies by multiply defining an entire signal entry, the user only needs to define the complete signal entry once and can refer to this complete record by means of the signal reference record.

This requires, however, that signals which are to be referred to be provided with a unique ID. The signal reference record consists of a main record and an optional lane validity record.

Delimiters: <signalReference.../>

Parent: <signals>

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>track position [m] (s-position)</td>
</tr>
<tr>
<td>t</td>
<td>double</td>
<td>track position [m] (t-position)</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID of the referenced signal within the database</td>
</tr>
</tbody>
</table>

5.3.9.2.1 Lane Validity Record

see 5.3.9.1.1.
5.3.10 Surface

The surface record is the container for all surface descriptions which shall be applied along a road.

Delimiters: <surface>...</surface>

Parent: <road>

Maximum Instances: 1

Optional: yes

Arguments: none

5.3.10.1 Curved Regular Grid Record

The interface to a Curved Regular Grid (CRG) surface description file is defined as arguments to the <CRG> tag and as an include operation between the opening and closing <CRG> tags.

Delimiters: <CRG>...</CRG>

Parent: <surface>

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>string</td>
<td>name of the file containing the CRG data</td>
</tr>
<tr>
<td>sStart</td>
<td>double</td>
<td>start of the application of CRG data [m] (s-position)</td>
</tr>
<tr>
<td>sEnd</td>
<td>double</td>
<td>end of the application of CRG [m] (s-position)</td>
</tr>
<tr>
<td>orientation</td>
<td>string</td>
<td>same or opposite</td>
</tr>
<tr>
<td>mode</td>
<td>string</td>
<td>application mode, attached or genuine</td>
</tr>
<tr>
<td>sOffset</td>
<td>double</td>
<td>s-offset between CRG center line and chord line of the road (optional, default = 0.0) [m]</td>
</tr>
<tr>
<td>tOffset</td>
<td>double</td>
<td>t-offset between CRG center line and chord line of the road (optional, default = 0.0) [m]</td>
</tr>
<tr>
<td>zOffset</td>
<td>double</td>
<td>z offset between CRG center line and chord line of the road (optional, default = 0.0) [m]</td>
</tr>
<tr>
<td>zScale</td>
<td>double</td>
<td>z scale factor for the surface description (optional, default = 1.0) [-]</td>
</tr>
<tr>
<td>hOffset</td>
<td>double</td>
<td>heading offset between CRG center line and chord line of the road (required for mode genuine only, optional, default = 0.0) [rad]</td>
</tr>
</tbody>
</table>
As the name indicates, CRG data is organized in a regular grid which is laid out along a reference line (comparable to an OpenDRIVE road’s chord line). At each grid position, it contains the absolute elevation measured along a real road and some additional data which allows for the computation of the delta elevation relative to the reference line.

The key to combining OpenDRIVE and CRG data is to define a correlation between the two chord lines and a rule for using the elevation data of both descriptions.

CRG data may be offset from the OpenDRIVE road’s chord line (see tOffset) and it may be oriented in the same or opposite direction as the layout direction of the road (see orientation).

The CRG data may be applied to a given OpenDRIVE road in two modes:

**Mode attached:**

The reference line of the CRG data set is replaced with the OpenDRIVE road’s chord line, taking into account the tOffset and the sOffset parameters.

The CRG local elevation values (calculated by evaluating the CRG grid and applying zOffset and zScale) will be added to the surface elevation data of the OpenDRIVE road (as derived from the combination of elevation, super-elevation and crossfall).

With this mode, the surface information relative to the original CRG data’s reference line is transferred from an arbitrary CRG road to an OpenDRIVE road without having to make sure that the overall geometries of the road match. The original position, heading, curvature, elevation and superelevation of the CRG road are disregarded. The CRG grid is evaluated along the OpenDRIVE chord line instead of the CRG reference line.
**Mode genuine:**

The start point of the CRG data set’s reference line is positioned relative to the point on the OpenDRIVE road’s chord line at the position defined by $s_{\text{Start}}$, $s_{\text{Offset}}$ and $t_{\text{Offset}}$.

By providing offset values for the longitudinal ($s_{\text{Offset}}$) and lateral ($t_{\text{Offset}}$) displacement, the heading ($h_{\text{Offset}}$) and the elevation ($z_{\text{Offset}}$), the correlation between the two description’s reference lines is clear.

In genuine mode, the CRG data will completely replace the OpenDRIVE elevation data, i.e. the absolute elevation of a given point of the road surface is directly computed from the CRG data (think of it as combining CRG and OpenDRIVE data with the OpenDRIVE elevation, super-elevation and crossfall all being zero).

When using this method, it must of course be made sure that the geometry of the CRG data matches - within certain tolerance - the geometry of the underlying OpenDRIVE road.

Since CRG data may only cover parts of a road’s surface, it must be made sure that outside the valid CRG area, the elevation information derived from OpenDRIVE data can still be used.

**Example:**

```xml
<surface>
  <CRG file="fancyData.crg" sStart="0.0" sEnd="100.0"
       orientation="same" mode="relative"
       tOffset="0.0">
  </CRG>
</surface>
```
5.4 Controller Record
A controller provides consistent states for a group of signals. This may be a set of signals within a junction or a set of dynamic speed restrictions on a motorway. The entire record consists of a header followed by a number of dependency records.

Delimiters: <controller.../>
Parent: <OpenDRIVE>
Maximum Instances: unlimited
Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
<tr>
<td>name</td>
<td>string</td>
<td>name of the controller</td>
</tr>
</tbody>
</table>

5.4.1 Control Entry Record
The control entry record provides information about a single signal controlled by the corresponding controller. This record is a child record of the controller record.

Delimiters: <control.../>
Parent: <controller>
Maximum Instances: unlimited
Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>signalId</td>
<td>string</td>
<td>ID of the controlled signal</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of control</td>
</tr>
</tbody>
</table>
5.5 Junction Record

When a road can be linked to more than one successor (or predecessor, depending on the orientation), a junction record is required. It contains the information about all possible connections between roads meeting at a physical junction.

For junctions, two types of roads must be distinguished:

- standard roads
- paths

**Standard roads** are in-coming and out-going roads of the junction. Usually, they don’t require any special treatment except for the fact that they end or begin at a junction.

**Paths** are roads within a junction. For each connection leading from one standard road to another, a path is defined. Paths may link only single lanes or a set of lanes at once. Paths must only contain lanes of one side (left or right). However, within the database, paths having only left lanes and paths having only right lanes may both be contained. The geometric and logic description of paths complies with the rules defined for standard roads (i.e. they contain lanes, elevation entries etc.).

Due to the fact that paths cannot have lanes of both directions, junctions only provide information linking incoming roads to paths. This is the only ambiguous part of a connection. The link between a path and the corresponding outgoing road is clear from the ROAD LINK record of the path (see 5.3.2).

The junction record is split into a header record and a series of link records.

**Delimiters:** 
<junction>...</junction>

**Parent:** 
<OpenDRIVE>

**Maximum Instances:** unlimited

**Optional:** yes

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>string</td>
<td>name of the junction</td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within database</td>
</tr>
</tbody>
</table>
5.5.1 Connection Record

The connection record provides information about a single connection within a junction. It is a child of the junction header record.

Delimiters: `<connection>...</connection>`
Parent: `<junction>`
Maximum Instances: unlimited
Optional: no
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within the junction</td>
</tr>
<tr>
<td>incomingRoad</td>
<td>string</td>
<td>ID of the incoming road</td>
</tr>
<tr>
<td>connectingRoad</td>
<td>string</td>
<td>ID of the connecting path</td>
</tr>
<tr>
<td>contactPoint</td>
<td>string</td>
<td>contact point on the connecting road, may be start or end</td>
</tr>
</tbody>
</table>

5.5.1.1 Junction Lane Link Record

The junction lane link record provides information about the lanes which are linked between incoming road and connecting road. This record may be omitted if all incoming lanes are linked to lanes with identical IDs on the connecting road. However, it is strongly recommended to provide this record.

Delimiters: `<laneLink.../>`
Parent: `<connection>`
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>from</td>
<td>int</td>
<td>ID of the incoming lane</td>
</tr>
<tr>
<td>to</td>
<td>int</td>
<td>ID of the connecting lane</td>
</tr>
</tbody>
</table>
5.5.2 Junction Priority Record

The junction priority record provides information about the priority of a connecting road over another connecting road. It is only required if priorities cannot be derived from signs or signals in a junction or on tracks leading to a junction.

Delimiters: `<priority.../>`

Parent: `<junction>`

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>string</td>
<td>ID of the prioritized connecting road</td>
</tr>
<tr>
<td>low</td>
<td>string</td>
<td>ID of the connecting road with lower priority</td>
</tr>
</tbody>
</table>

5.5.3 Junction Controller Record

Junction controller records list the controllers which are used for the management of a junction.

Delimiters: `<controller.../>`

Parent: `<junction>`

Maximum Instances: unlimited

Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>ID of the controller</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of control for this junction</td>
</tr>
</tbody>
</table>
5.6 Ancillary Data
Ancillary data for a bead may be defined by generating an entry that directly follows the corresponding bead. It is designed to contain user-defined data that is required for specific applications or is not yet covered by the OpenDRIVE® standard.

Delimiters: `<userData.../>
Parent: any
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>string</td>
<td>code for the user data (application specific)</td>
</tr>
<tr>
<td>value</td>
<td>string</td>
<td>user data as string (e.g. hexdump)</td>
</tr>
</tbody>
</table>

5.7 Include Tag
The inclusion of another file can be triggered with an include tag at any location.

Delimiters: `<include.../>
Maximum Instances: any
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>string</td>
<td>location of the file which is to be included</td>
</tr>
</tbody>
</table>
5.8 Alternative Layouts (Sets)
Sets indicate that more than one setup of the properties enclosed by the set’s opening and closing tags are available and that the application may choose one of these setups (the activation of none or more than one setup at a given time is not supported). Sets may be used e.g. for different road mark setups, different signaling etc.

Delimiters: <set>...</set>
Parent: any
Maximum Instances: any
Optional: yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within the database</td>
</tr>
</tbody>
</table>

5.8.1 Layout Instance
Each set may contain one or more alternative setups of the enclosed property. In order to identify a specific setup, it must be enclosed with instance tags.

Delimiters: <instance>...</instance>
Parent: <set>
Maximum Instances: any
Optional: no

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>string</td>
<td>unique ID within the database</td>
</tr>
</tbody>
</table>

Example:

```xml
<road ...>
  <set id="roadWorks">
    <instance id="regular">
      <lanes>
      
      </lanes>
    </instance>
    <instance id="construction">
      <lanes>
      
      </lanes>
    </instance>
  </set>
</road>
```
6 Constants

6.1 Road Type Information
The known keywords for the road type information are:

- unknown
- rural
- motorway
- town
- lowSpeed
- pedestrian

NOTE: In Germany, lowSpeed is equivalent to a 30km/h zone

6.2 Road Mark Type Information
The known keywords for the road mark type information are:

- none
- solid
- broken
- solid solid (for double solid line)
- solid broken (from inside to outside, exception: center lane - from left to right)
- broken solid (from inside to outside, exception: center lane - from left to right)

6.3 Road Mark Weight Information
The known keywords for the road mark weight information are:

- standard
- bold

6.4 Road Mark Color Information
The known keywords for the road mark color information are:

- standard
- yellow
6.5 Lane Type Information
The known keywords for the lane type information are:

- none
- driving
- stop
- shoulder
- biking
- sidewalk
- border
- restricted
- parking
- mwyEntry
- mwyExit
- special1
- special2
- special3

6.6 Object Types
The known keywords for the object type information are:

- obstacle
- wind

6.7 Tunnel Types
The known keywords for the tunnel type information are:

- standard
- underpass (i.e. sides are open for daylight)

6.8 Bridge Types
The known keywords for the bridge type information are:

- concrete
- steel
- brick

6.9 Access Restriction Types
The known keywords for the restriction information are:

- simulator
- autonomous traffic
- pedestrian
6.10 Signal Country Codes

The known keywords for the signal country codes are:

- OpenDRIVE
- France
- Germany
- USA

6.11 Signal Types

For the country codes “Germany” and “OpenDRIVE”, the following signal types shall be defined in addition to the numbers given by the corresponding rule books:

- traffic light 1,000,001
- pedestrian traffic light 1,000,002

Others may be added in future version of this specification.
7 Change Log

Version 1.2A vs. Version 1.1D
- modified / extended:
  - material record ("surface" argument)
  - object record is defined as range, not as single-line definition
  - unique IDs of most elements are allowed to be strings instead of unsigned integers
  - using string parameters for type definitions
  - neighbor entry provides left and right neighbors
  - roadMark entry extended with laneChange information

- introduced:
  - road surface description
  - CRG data
  - roadMark sub-types
  - repeat entry for objects
  - object reference record
  - property sets

Version 1.1D vs. Version 1.1C
- corrected:
  - chapter 2.3.2, description of inertial co-ordinate system
  - minor bugfixes

Version 1.1 vs. Version 1.0
- introduced:
  - chapter 3.4 explaining superelevation and crossfall
  - lateralProfile (replacing crossfallProfile)
  - superelevation record (replacing old "crossfall" record)
  - crossfall record per side of the road
  - definition of object corners relative to a given pivot point
  - signal references
  - include tag

- extended:
  - country code for signal type and subtype IDs
  - lane record (application of crossfall may be restricted)
  - illustration of co-ordinate systems in chapter 2

Version 1.0 vs. Version 0.7
- introduced:
  - geometry primitive poly3
  - lane speed information
  - lane access restrictions
  - lane height information
  - object radius (alternatively to width and length)
  - object outline information
  - tunnel record
  - bridge record

- extended:
  - road mark entry may be provided with exact width information
• corrected:
  ○ some type information of the existing records was incorrect