IDX4rail Datenmodell Beta 2

Agenda

- Positionierung → Positioning
- Gleisgeometrie → Track Geometry
- Bahnübergang → Level Crossing
- Gleisbett → Track Bed
- Zustands- und Instandhaltungsdaten → Survey Data

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mFUND Das Startkapital für die Mobilität der Zukunft
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Positioning

Positioning in railways must be unambiguous

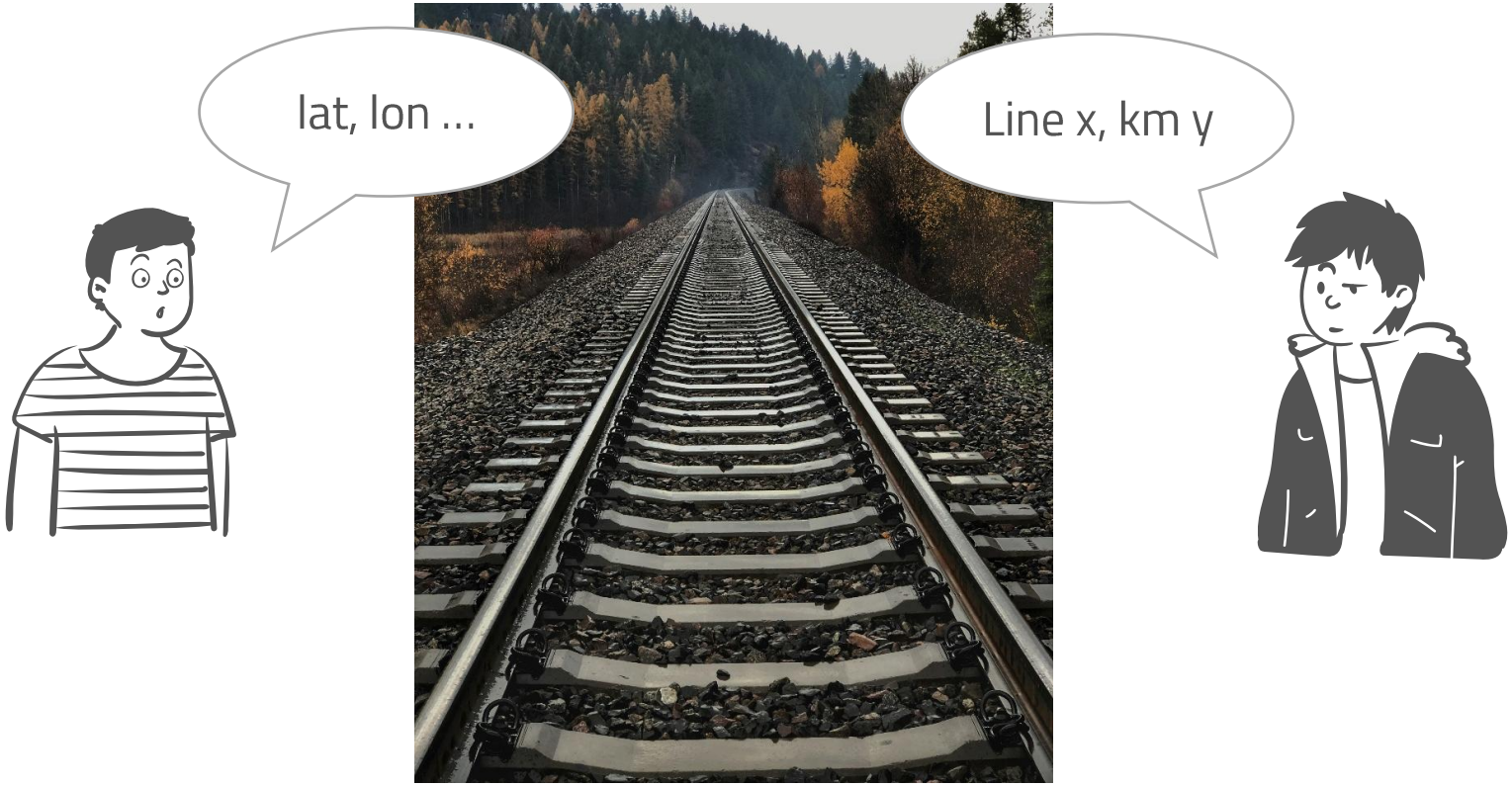

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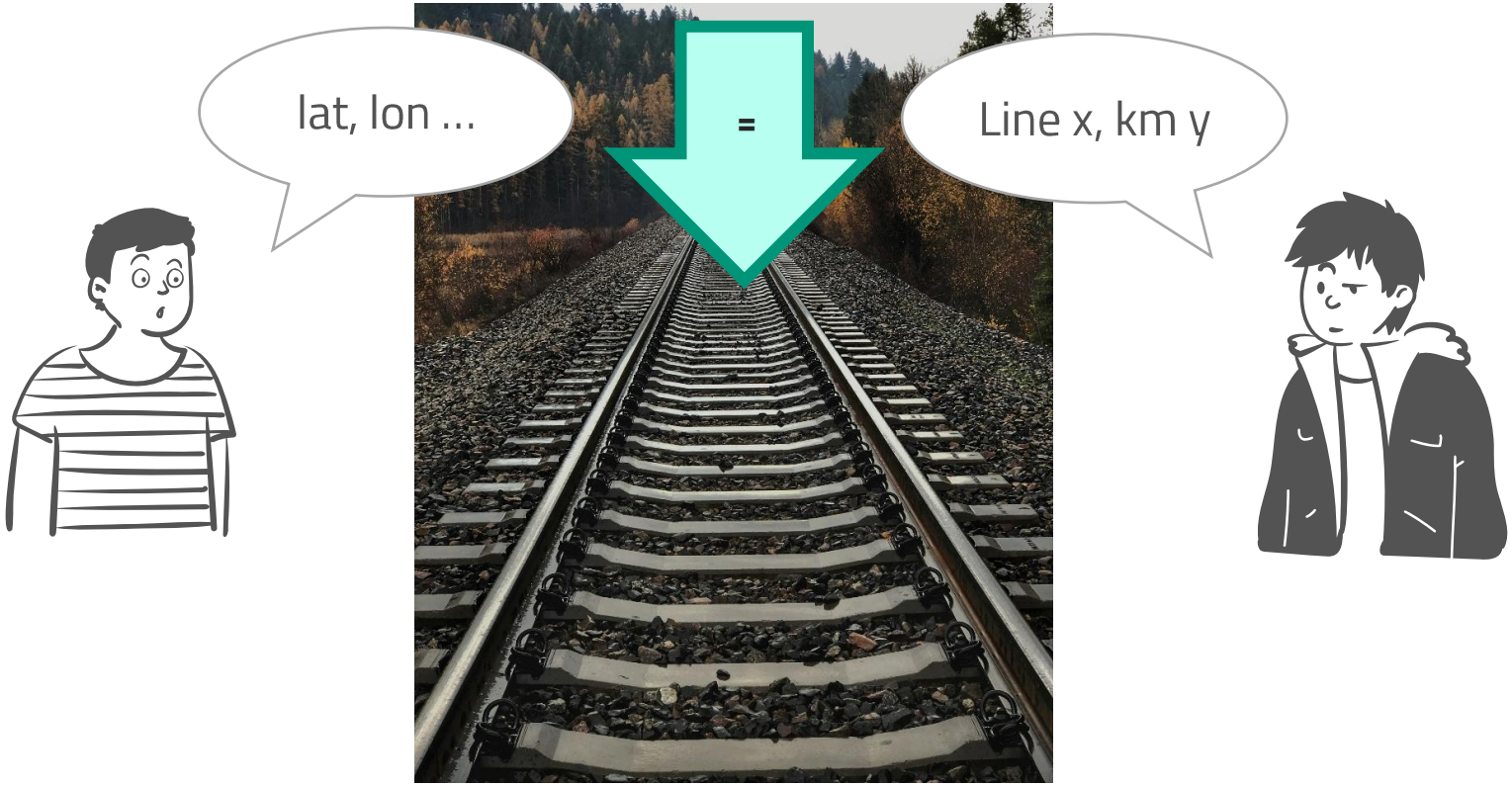
Image Source: Railway track © Kendrew Schexnider (Source; Archive; Unsplash License)

Positioning

Positioning in railways must be unambiguous



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Positioning

How many options exist for modelling the location of … e.g. a signal?

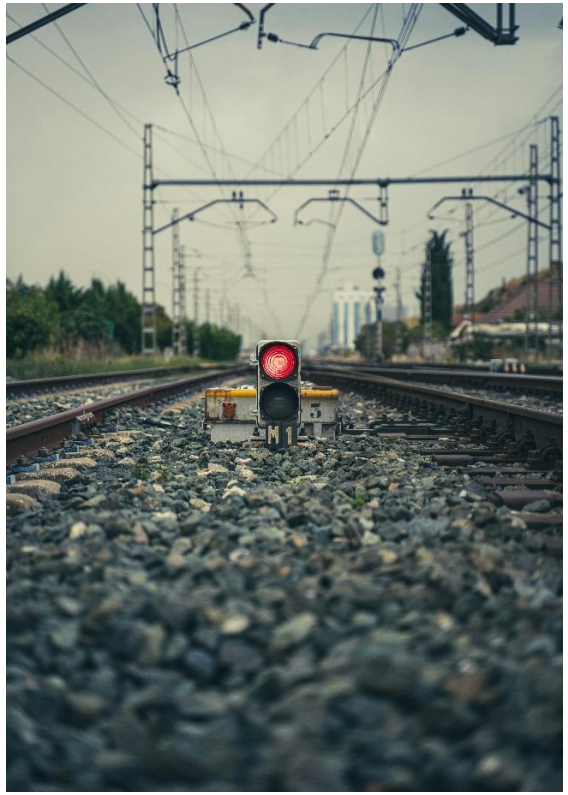

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Image Source: Signal in Pamplona, Spain © DaYsO (Source; Archive; Unsplash License)

Positioning

How many options exist for modelling the location of … e.g. a signal?

- Entity Location
  - Spot Location
  - Linear Location
  - Area Location
- Level of aggregation
  - Micro
  - Meso
  - Macro
- Object coordinate
  - Topologic
  - Geographic
  - Mileage
  - Screen

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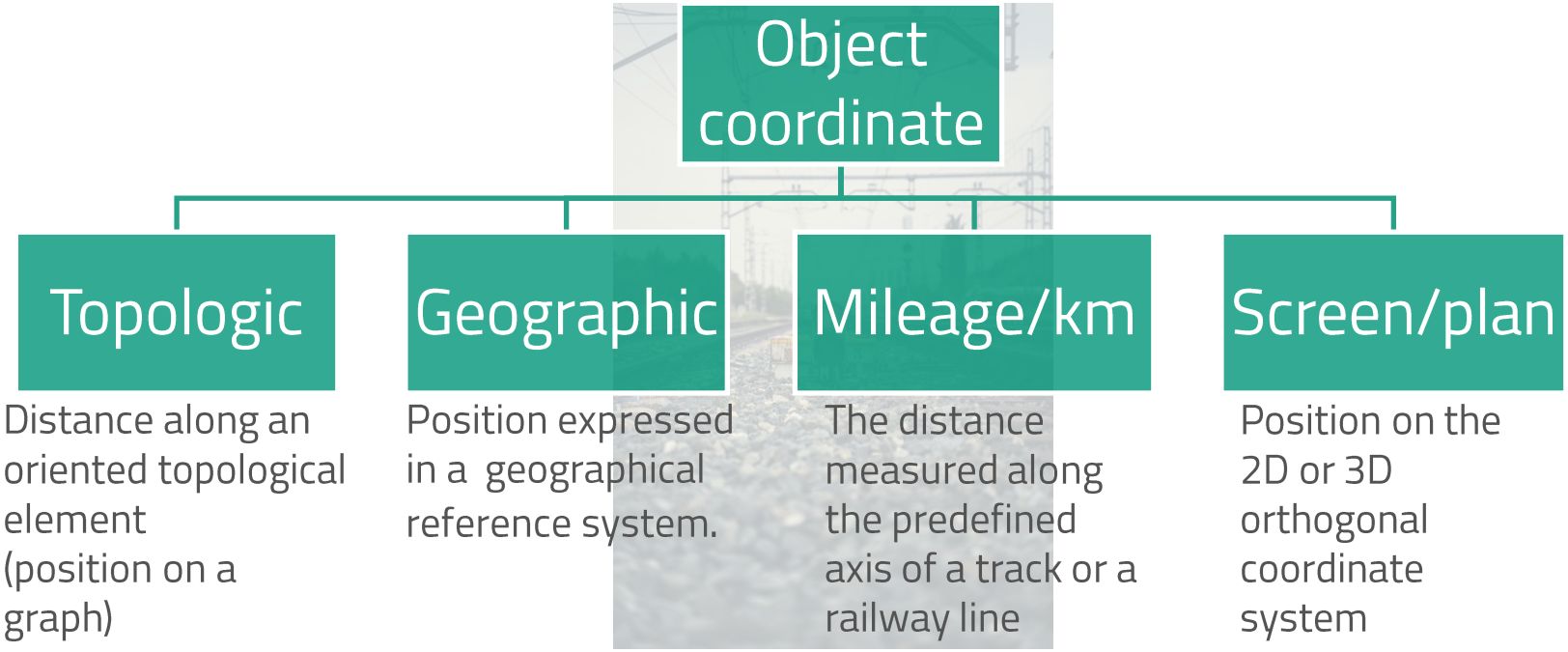

Distance along an oriented topological element (position on a graph)

Position expressed in a geographical reference system.

The distance measured along the predefined axis of a track or a railway line

Position on the 2D or 3D orthogonal coordinate system

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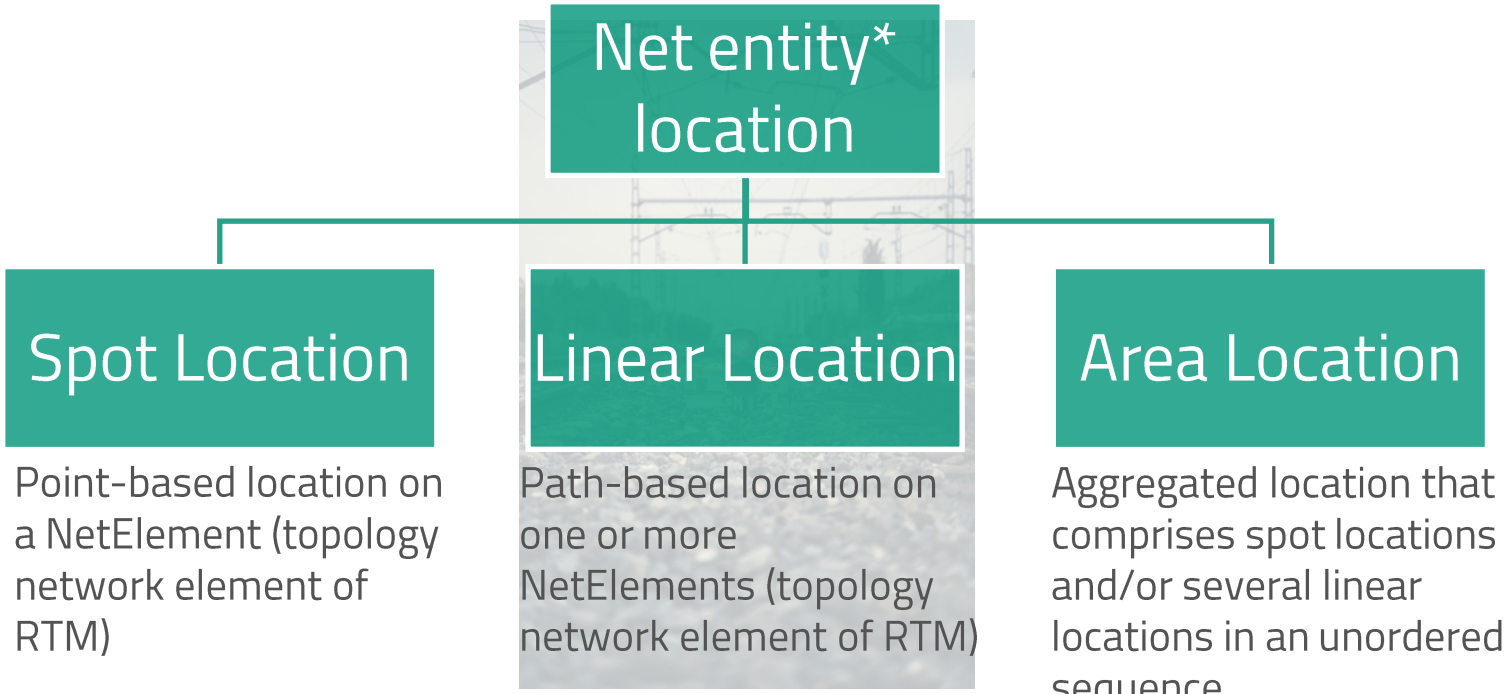

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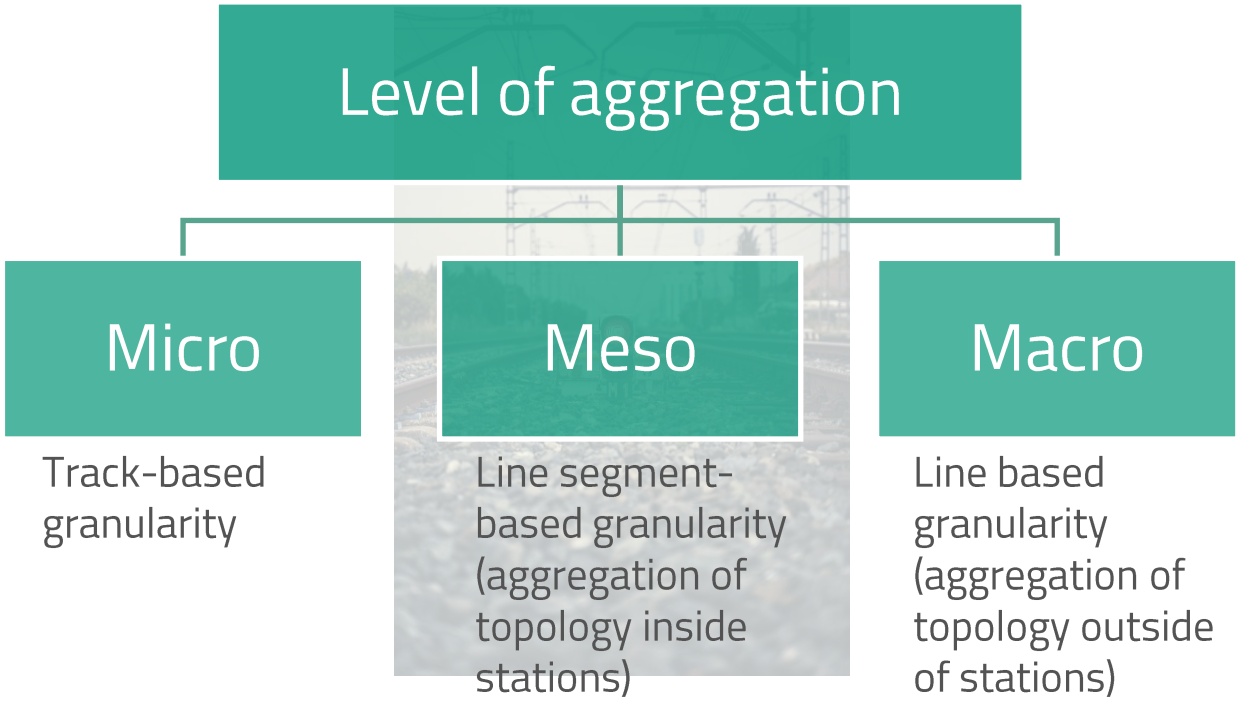

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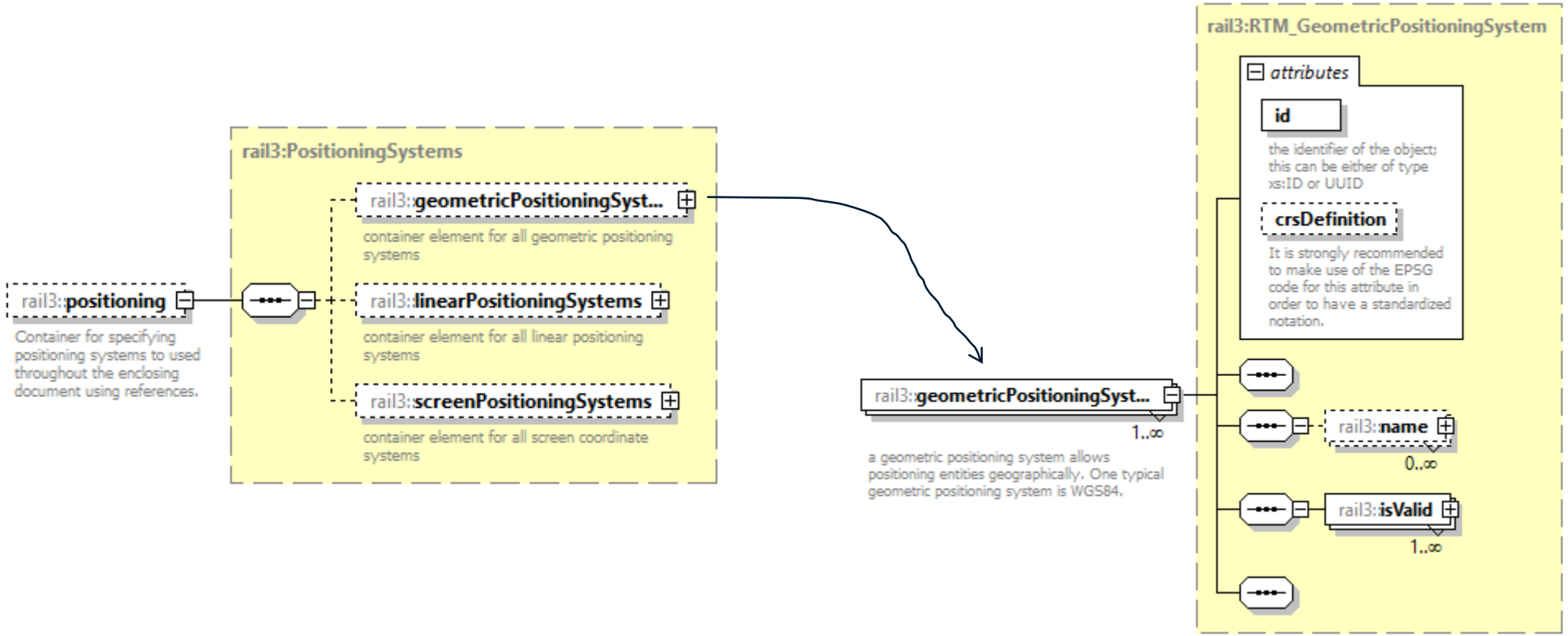
Positioning



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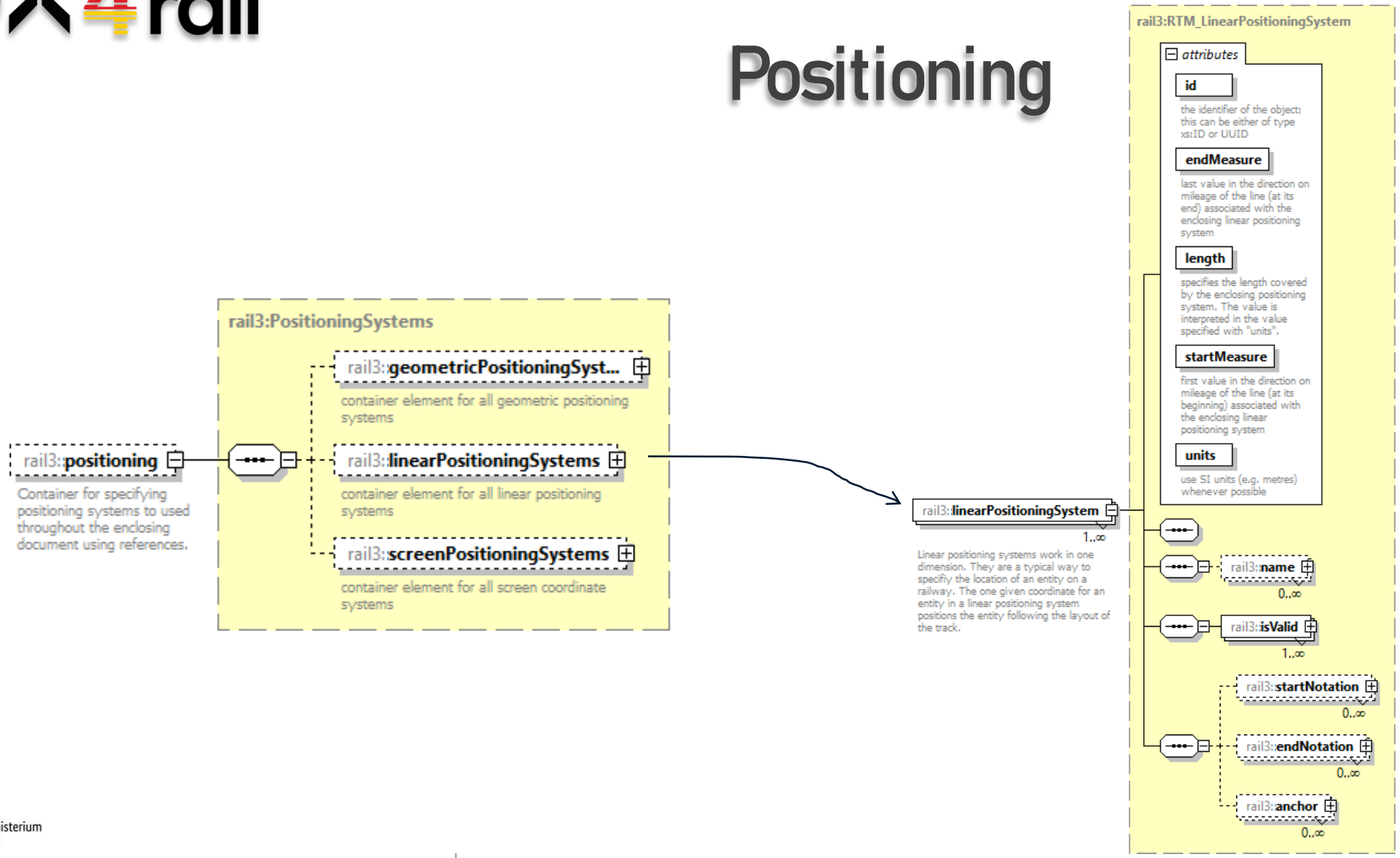

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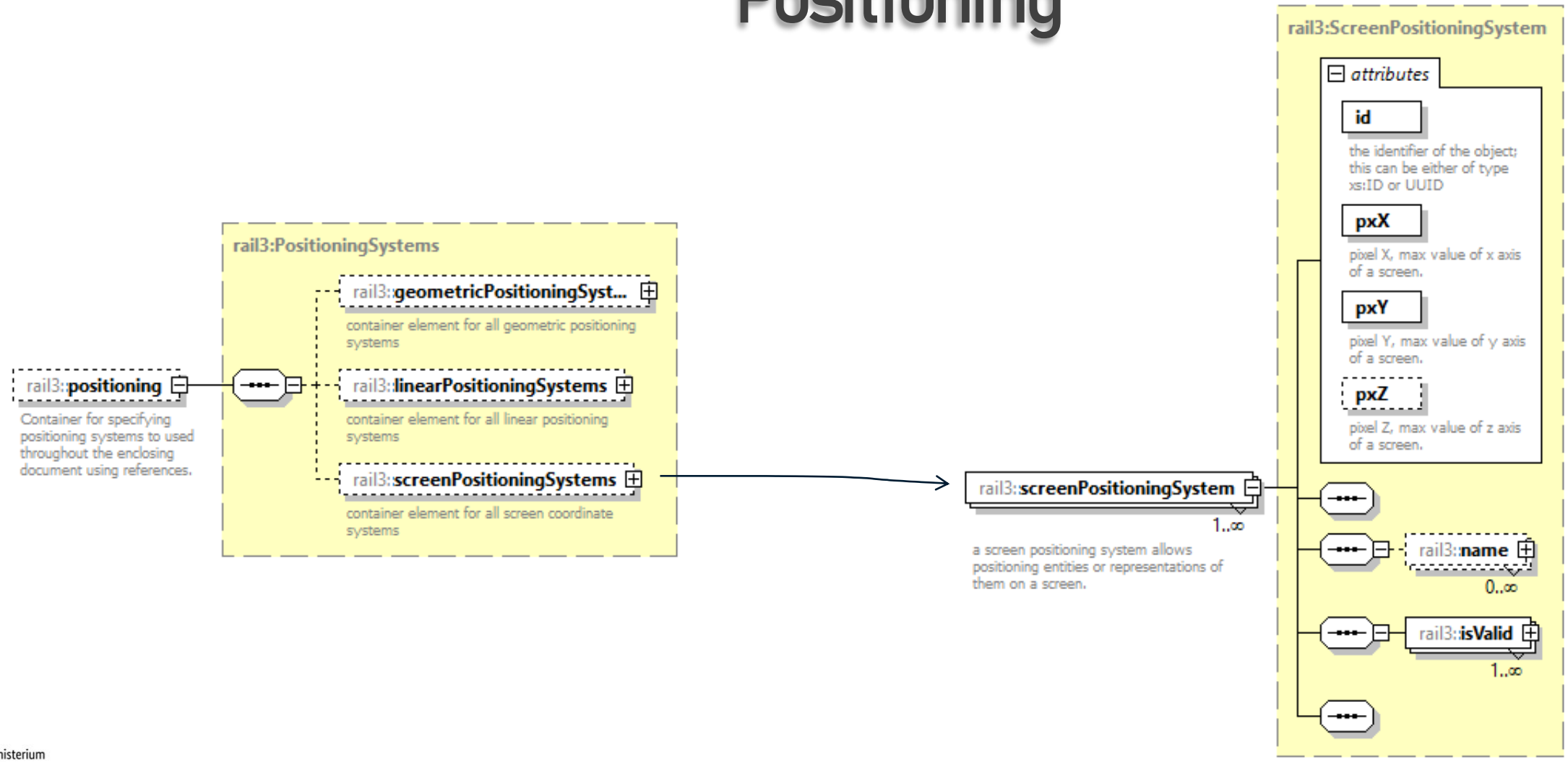
Positioning



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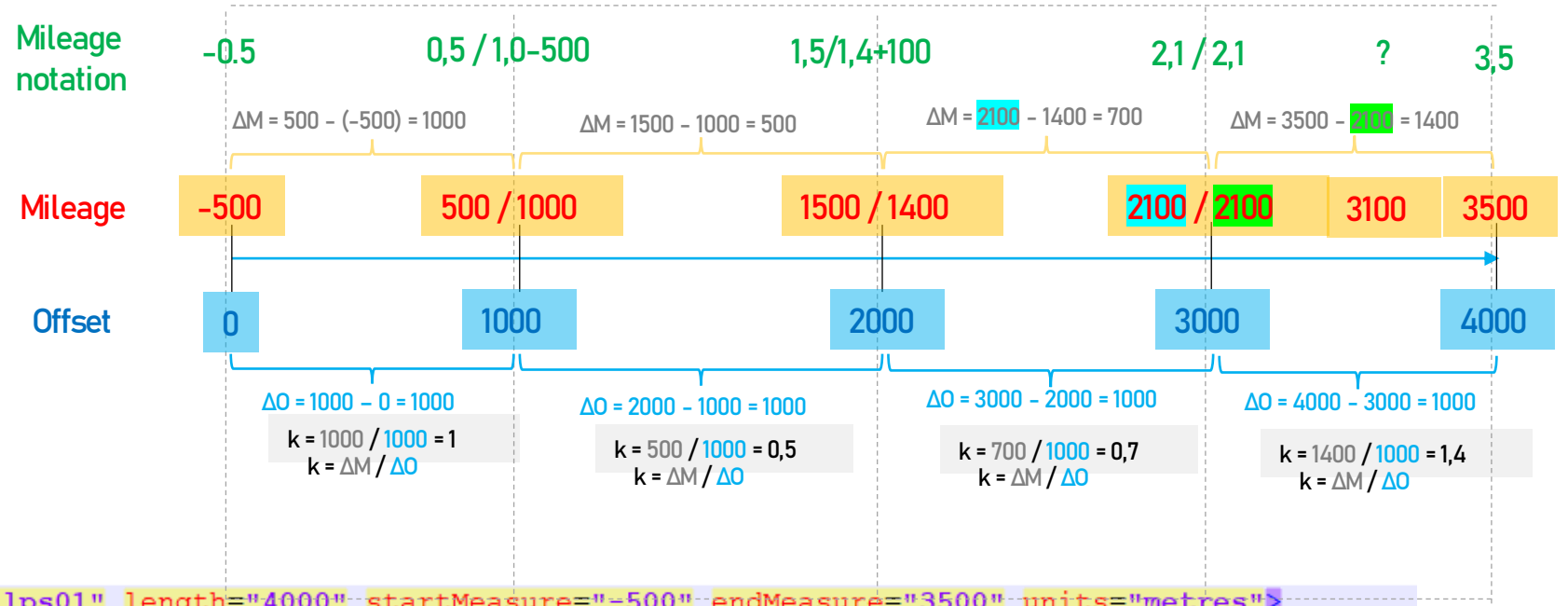
Positioning

- Example for a linear positioning system:




```
<linearPositioningSystem id="lps01" length="4000" startMeasure="-500" endMeasure="3500" units="metres">
  <isValid/>
  <startNotation entry="-0,5" register="RIL885.Km"/>
  <endNotation entry="3,5" register="RIL885.Km"/>
  <anchor id="anchor01" offsetToStart="1000" sequenceNumber="1" incomingMeasure="500" outgoingMeasure="1000">
    <incomingMileageNotation entry="0,5" register="RIL885.Km" />
    <outgoingMileageNotation entry="1,0-500" register="RIL885.Km" />
  </anchor>
  <anchor id="anchor02" offsetToStart="2000" sequenceNumber="2" incomingMeasure="1500" outgoingMeasure="1400">
    <incomingMileageNotation entry="1,5" register="RIL885.Km"/>
    <outgoingMileageNotation entry="1,4+100" register="RIL885.Km"/>
  </anchor>
  <anchor id="anchor03" offsetToStart="3000" sequenceNumber="3" incomingMeasure="2100" outgoingMeasure="2100">
    <incomingMileageNotation entry="2,1" register="RIL885.Km"/>
    <outgoingMileageNotation entry="2,1" register="RIL885.Km"/>
  </anchor>
</linearPositioningSystem>
```

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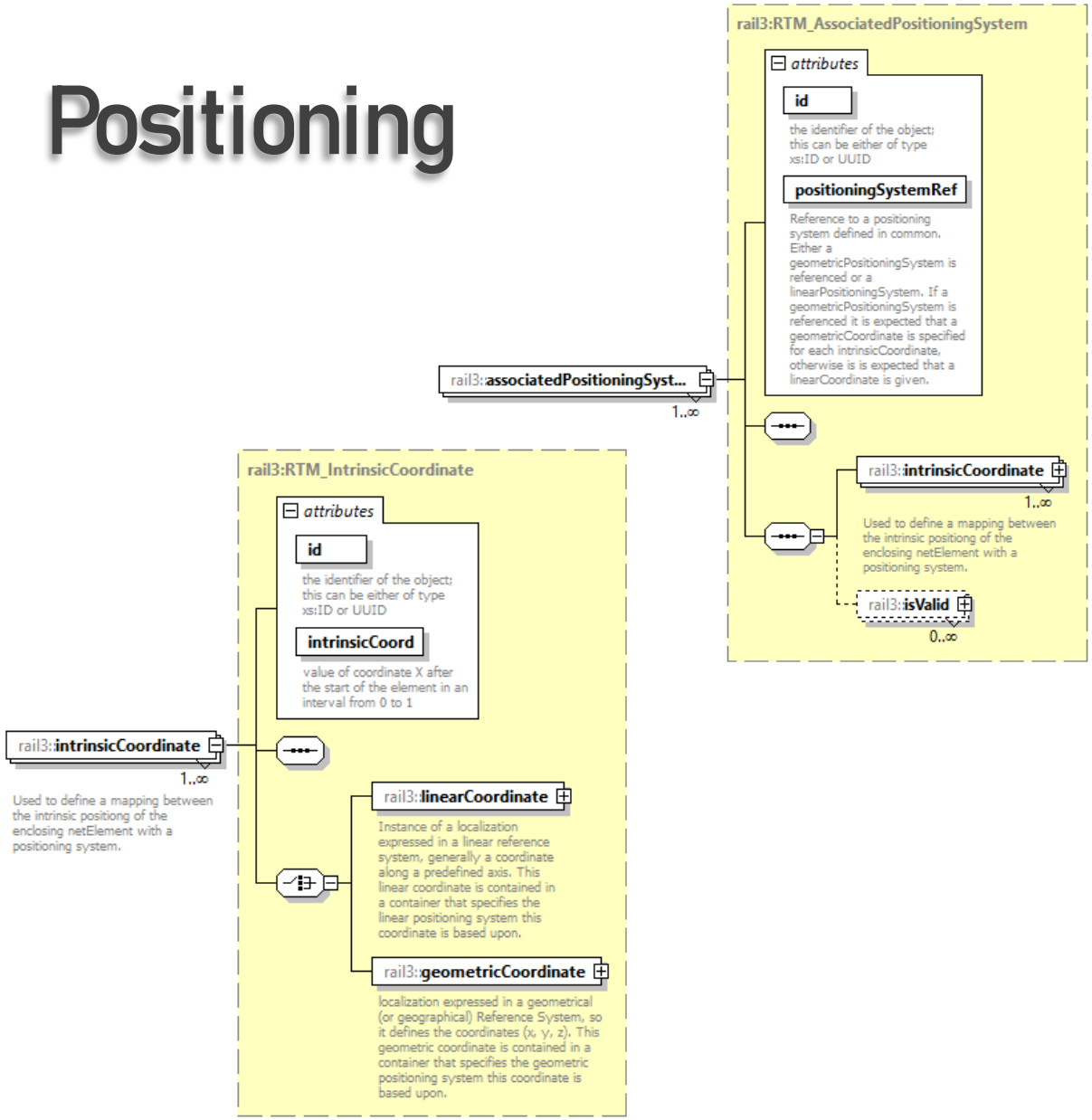
Positioning

- NetElement (Topology)
  - <associatedPositioningSystem> is mandatory (1..n)
    - Reference to positioning system via @positioningSystemRef – mandatory
    - Definition of intrinsic coordinates (at least 1) via <intrinsicCoordinate>
      - @intrinsicCoord is mandatory
      - Choice: child element <linearCoordinate> or <geometricCoordinate> is mandatory



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- NetElement (Topology)
  - <associatedPositioningSystem> is mandatory (1..n)
    - Reference to positioning system via @positioningSystemRef – mandatory
    - Definition of intrinsic coordinates (at least 1) via <intrinsicCoordinate>
      - @intrinsicCoord is mandatory
      - Choice: child element <linearCoordinate> or <geometricCoordinate> is mandatory

```
<netElement id="ne01">
  <associatedPositioningSystem id="aps01" positioningSystemRef="lps01">
    <intrinsicCoordinate id="ic01" intrinsicCoord="0">
      <linearCoordinate offsetToStart="500">
        <mileageNotation entry="0" register="RIL885.Km"/>
      </linearCoordinate>
    </intrinsicCoordinate>
    <intrinsicCoordinate id="ic02" intrinsicCoord="1">
      <linearCoordinate offsetToStart="3700">
        <mileageNotation entry="3,08" register="RIL885.Km"/>
      </linearCoordinate>
    </intrinsicCoordinate>
  </associatedPositioningSystem>
</netElement>
```

Mapping with positioning system

NetElement length is difference of offset values of begin and end

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Positioning

- Location of functional infrastructure elements in the topological network:
  - <spotLocation>
  - <linearLocation>
  - <areaLocation>
- Each located infrastructure element shall have at least one <*Location> element

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Positioning

- Location of functional infrastructure elements in the topological network:
  - <spotLocation>
    - @netElementRef is mandatory
    - @applicationDirection is mandatory
    - <topologicalCoordinate> is mandatory
      - Either: <intrinsicCoordinate> with @intrinsicCoordinate in range {0..1}
      - Or: <linearCoordinate> with reference to a <linearPositioningSystem>, where @offsetToStart equals the distance of this infrastructure element relative to the beginning of the referenced linear positioning system
    - Further <*Coordinate> is optional

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Positioning

- Location of functional infrastructure elements in the topological network:
  - <spotLocation>

```
<levelCrossingIS id="lcr01" activation="infrastructureAutomatic">
   <name name="LX Arnau-CStadt" language="en" />
   <spotLocation id="lcr01_sloc01" netElementRef="ne01" applicationDirection="both">
      <topologicalCoordinate>
         <intrinsicCoordinate intrinsicCoordinate="0.6" />
      </topologicalCoordinate>
   </spotLocation>
   <spotLocation id="lcr01_sloc02" netElementRef="ne01" applicationDirection="both">
      <topologicalCoordinate>
         <linearCoordinate offsetToStart="2500" positioningSystemRef="lps01" />
      </topologicalCoordinate>
   </spotLocation>
   <protection barriers="singleHalfBarrier" lights="none" acoustic="none" />
</levelCrossingIS>
```

Option 1: intrinsic coordinates

Option 2: linear coordinates / offset

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Positioning

- Location of functional infrastructure elements in the topological network:
  - <linearLocation>
    - <associatedNetElement> for each NetElement that is (at least partially) covered
    - <associatedNetElement>@netElementRef is mandatory
    - <associatedNetElement / topologicalCoordinate> is mandatory
      - Either: <intrinsicCoordinateBegin> and <intrinsicCoordinateEnd> with @intrinsicCoordinate in range {0..1}
      - Or: <linearCoordinateBegin> and <linearCoordinateEnd> with reference to a <linearPositioningSystem>, where @offsetToStart equals the distance of this infrastructure element (begin/end) relative to the beginning of the referenced linear positioning system
    - <associatedNetElement / geometricCoordinate*> is optional

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Positioning

- Location of functional infrastructure elements in the topological network:

```
<levelCrossingIS id="lcr01" activation="infrastructureAutomatic">
   <name name="LX Arnau-CStadt" language="en" />
   <linearLocation id="lcr01_lloc01" applicationDirection="both">
      <associatedNetElement netElementRef="ne01">
         <topologicalCoordinate>
            <intrinsicCoordinateBegin intrinsicCoordinate="0.59" />
            <intrinsicCoordinateEnd intrinsicCoordinate="0.61" />
         </topologicalCoordinate>
      </associatedNetElement>
   </linearLocation>
   <linearLocation id="lcr01_lloc02" applicationDirection="both">
      <associatedNetElement netElementRef="ne01">
         <topologicalCoordinate>
            <linearCoordinateBegin offsetToStart="2497" positioningSystemRef="lps01" />
            <linearCoordinateEnd offsetToStart="2503" positioningSystemRef="lps01" />
         </topologicalCoordinate>
      </associatedNetElement>
   </linearLocation>
   <protection barriers="singleHalfBarrier" lights="none" acoustic="none" />
</levelCrossingIS>
```

Option 1: intrinsic coordinate

Option 2: linear coordinate / offset

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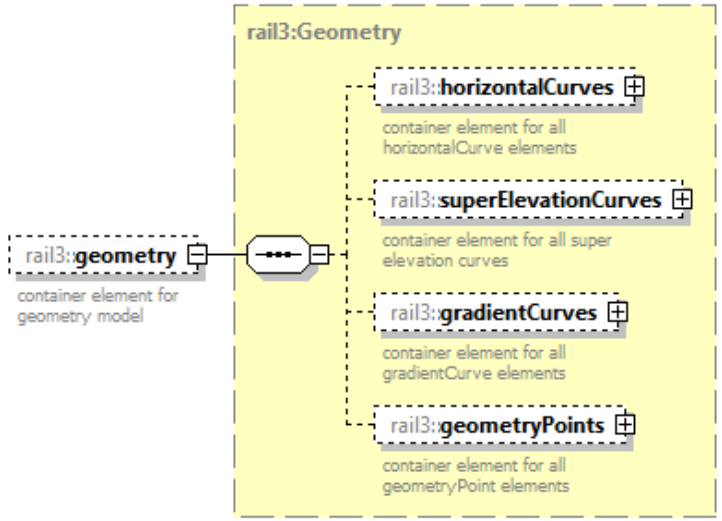
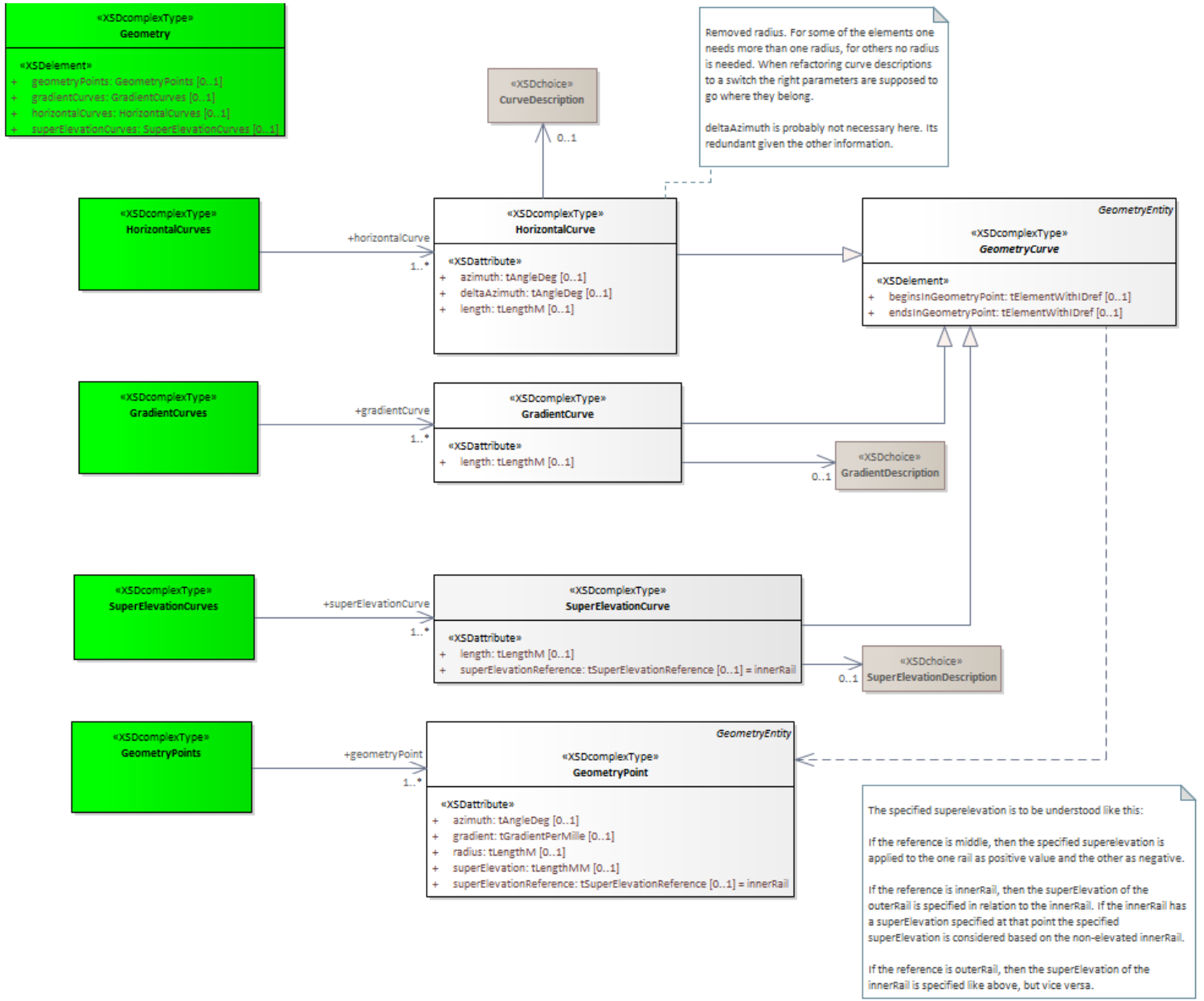
Track Geometry

- Horizontal alignment
- Gradients
- Superelevation





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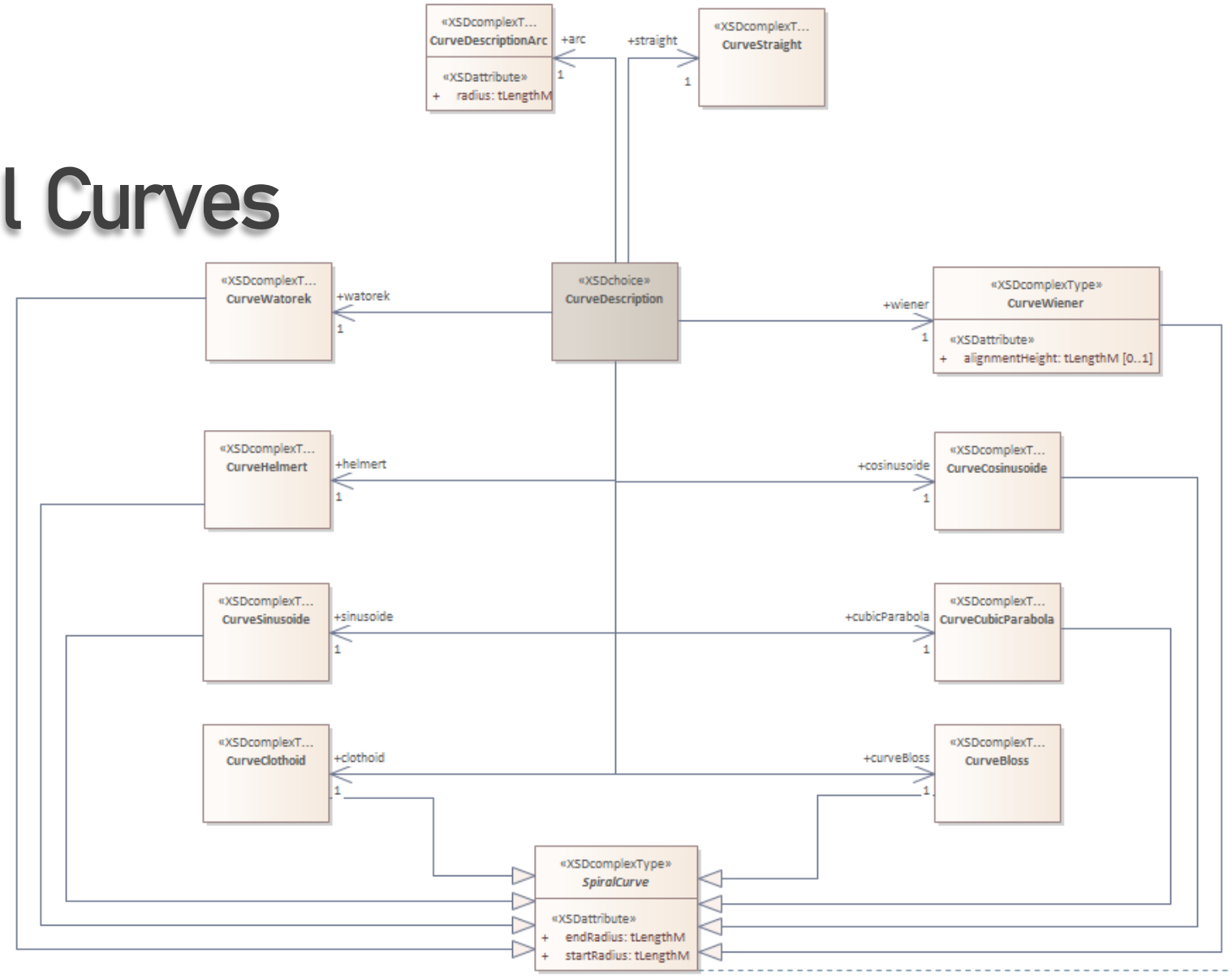
Horizontal Curves



It is debatable if the radius should actually be a curvature. Curvature is defined as 1/radius. The benefit would be that transitional curves between a straight line and an arc could be described more easily and mathematically correct, as the curvature of a straight line is 0 while the radius of a straight line is infinite.
Drawback probably is the possible loss of precision when working with very small floating point numbers.

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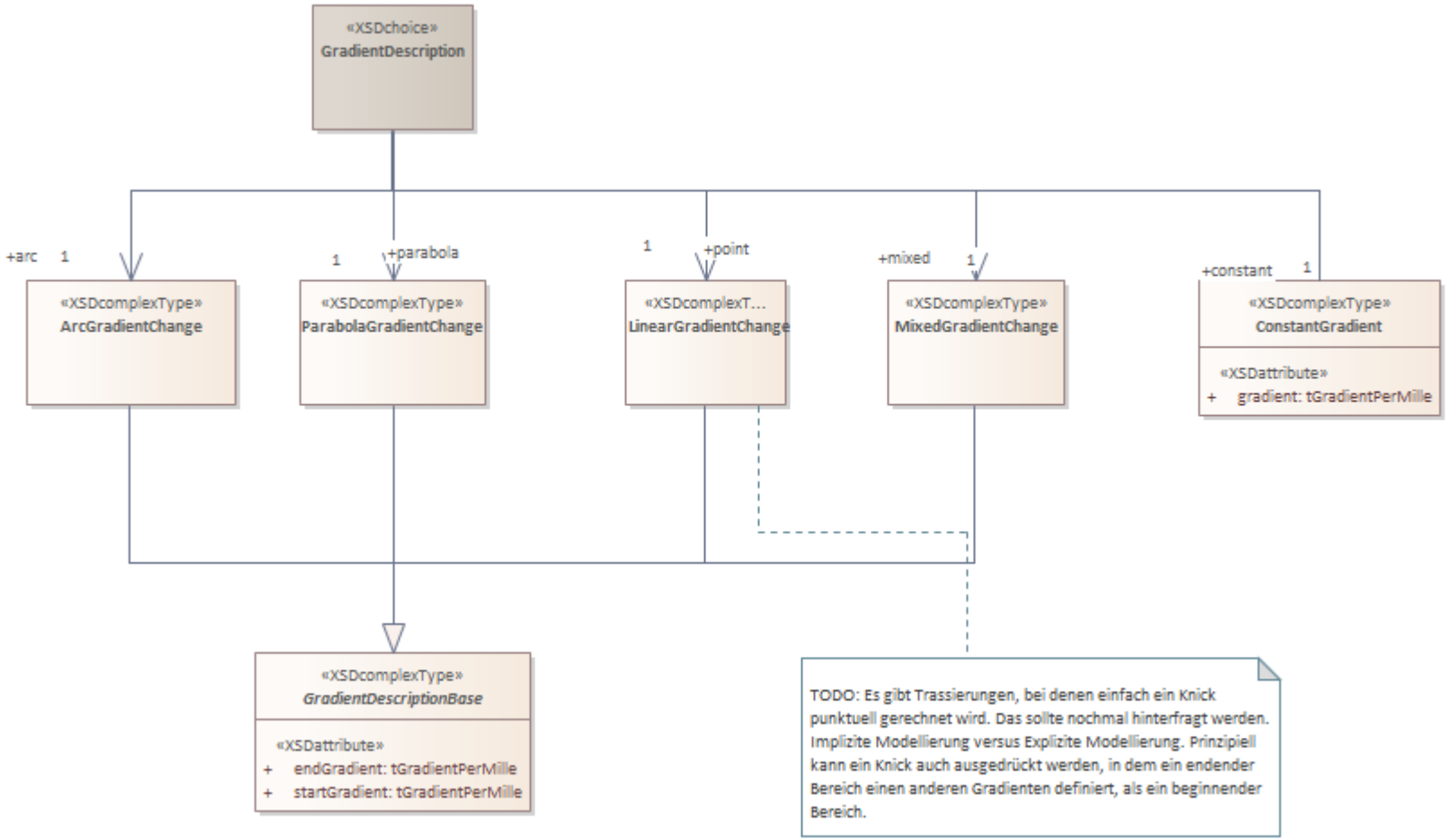
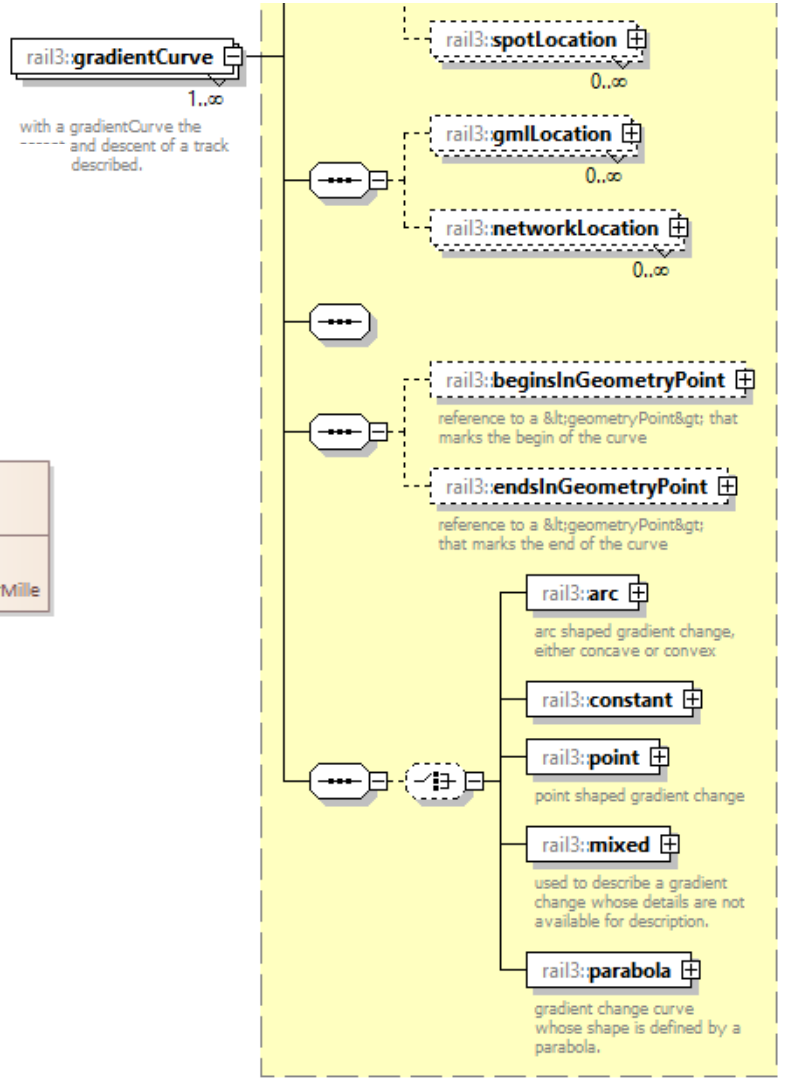
Gradient Curves





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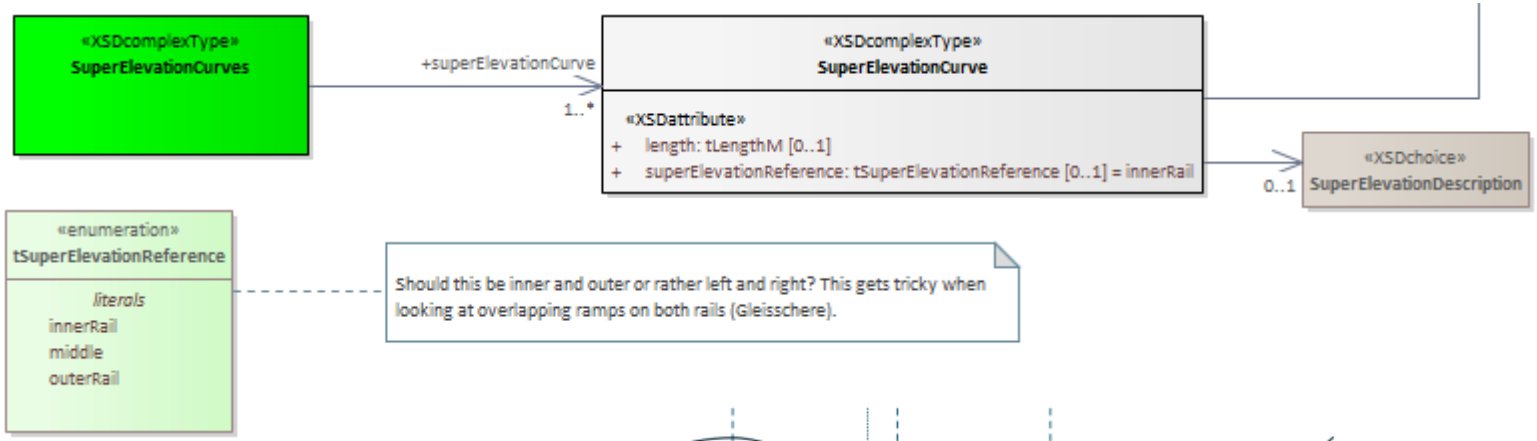
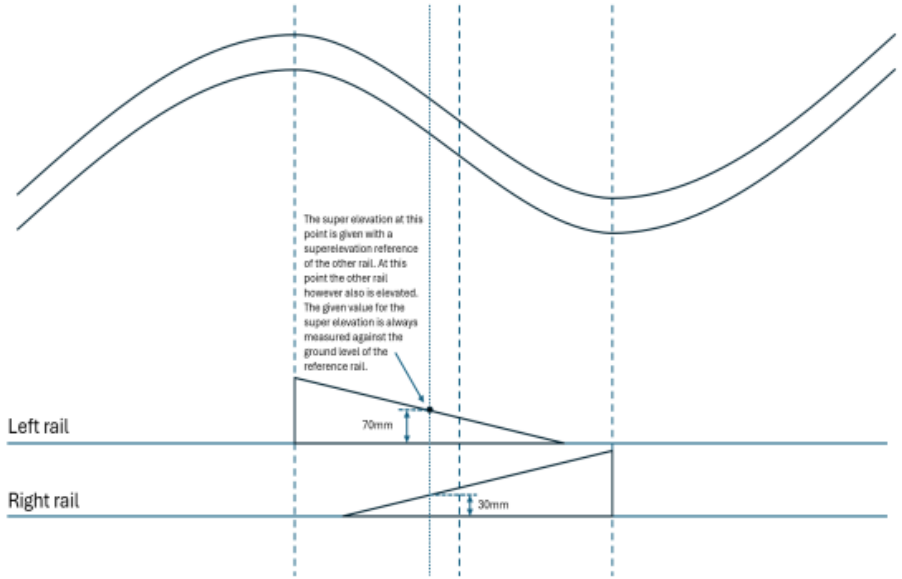
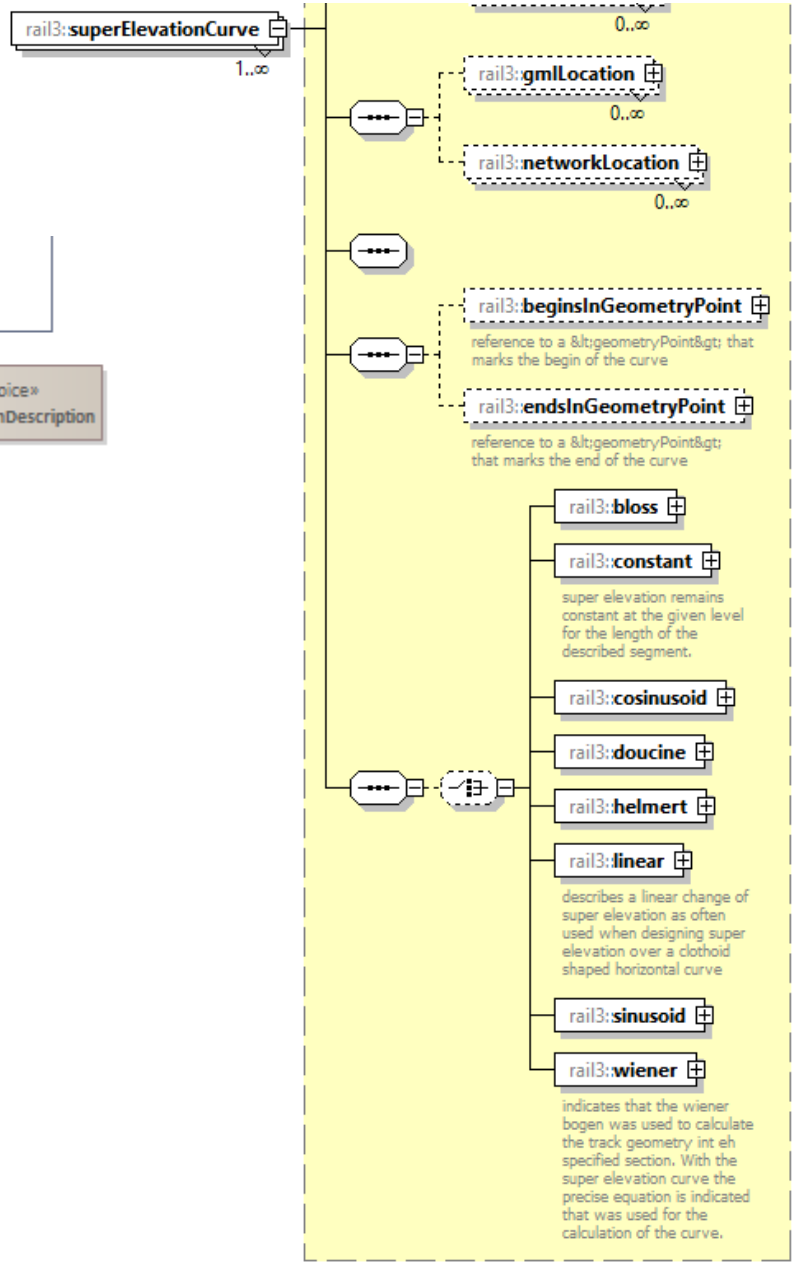
Superelevation Curves







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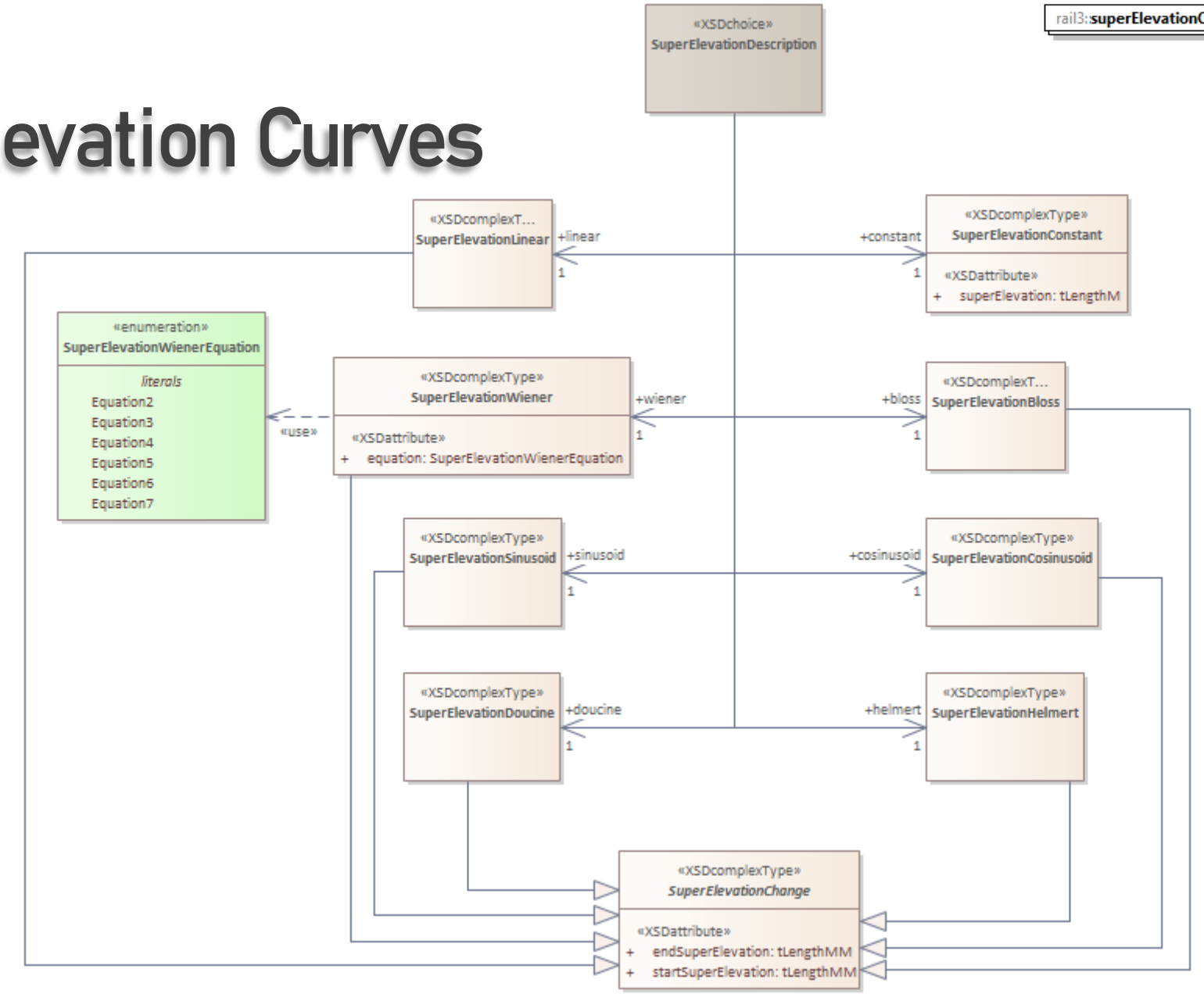
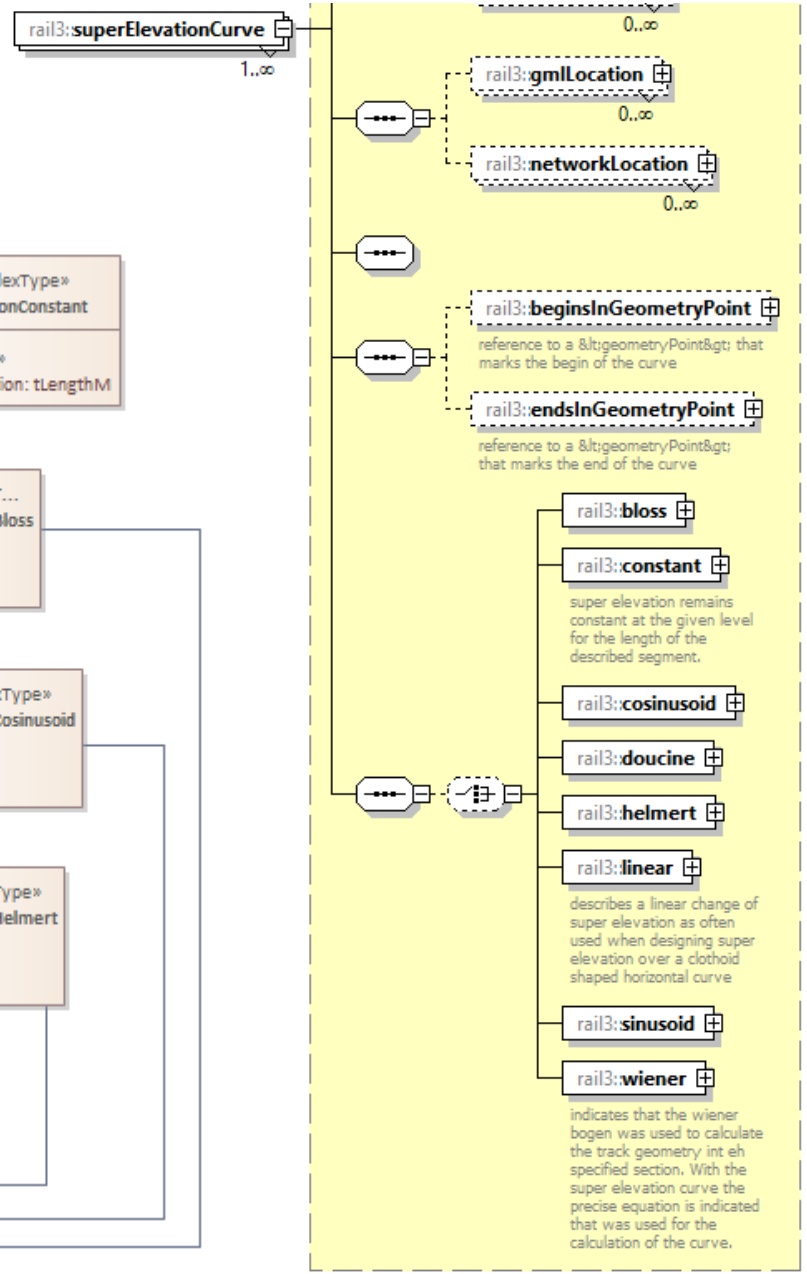
Superelevation Curves





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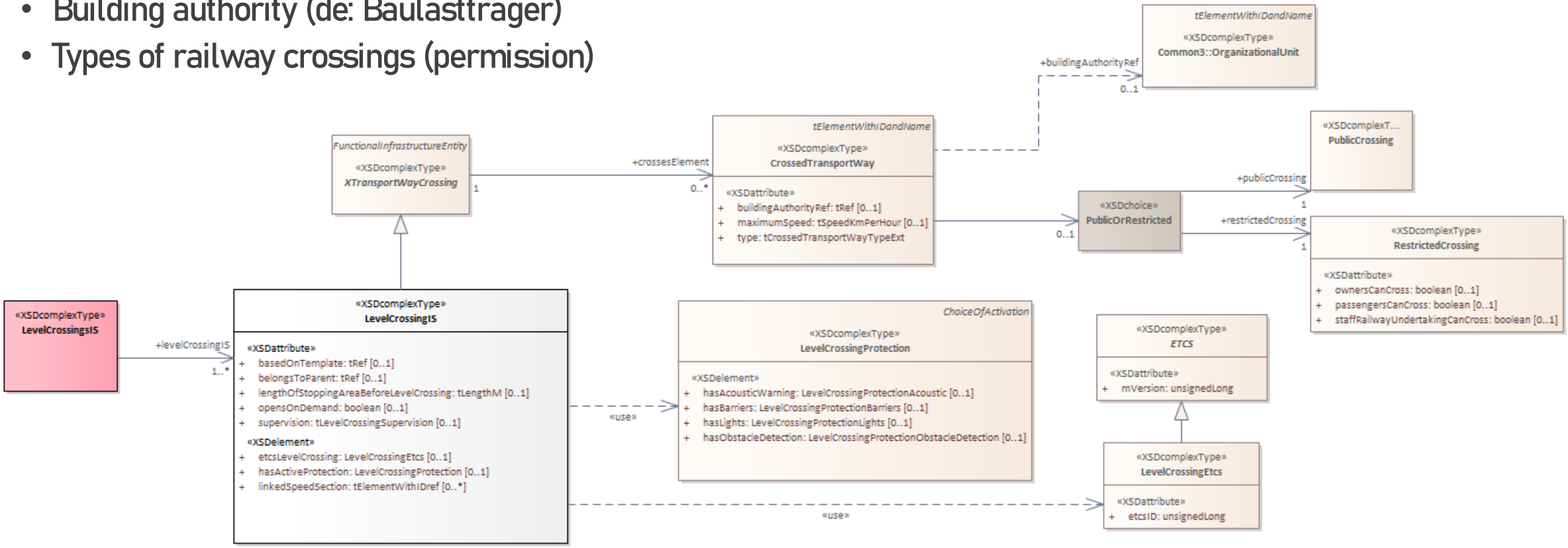
Level Crossing

- Extending level crossing model:
  - Building authority (de: Baulastträger)
  - Types of railway crossings (permission)



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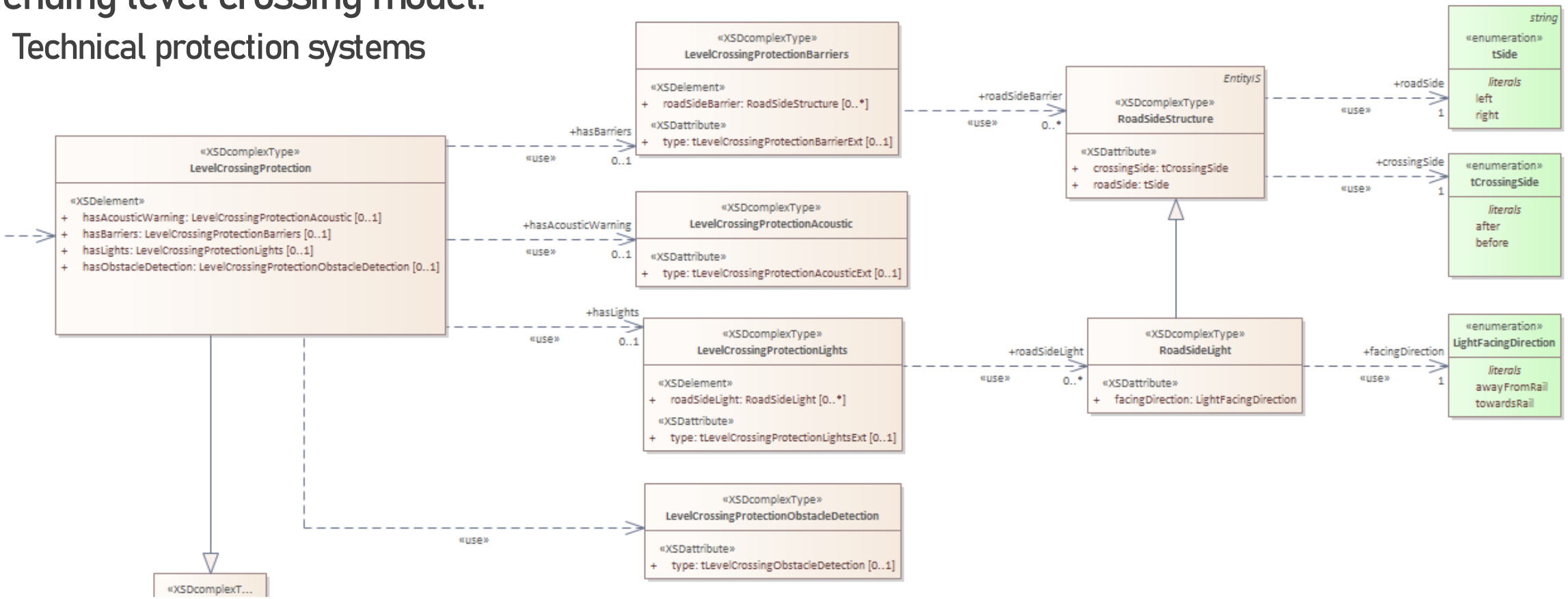
Level Crossing

- Extending level crossing model:
  - Technical protection systems



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Level Crossing

- Extending level crossing model:
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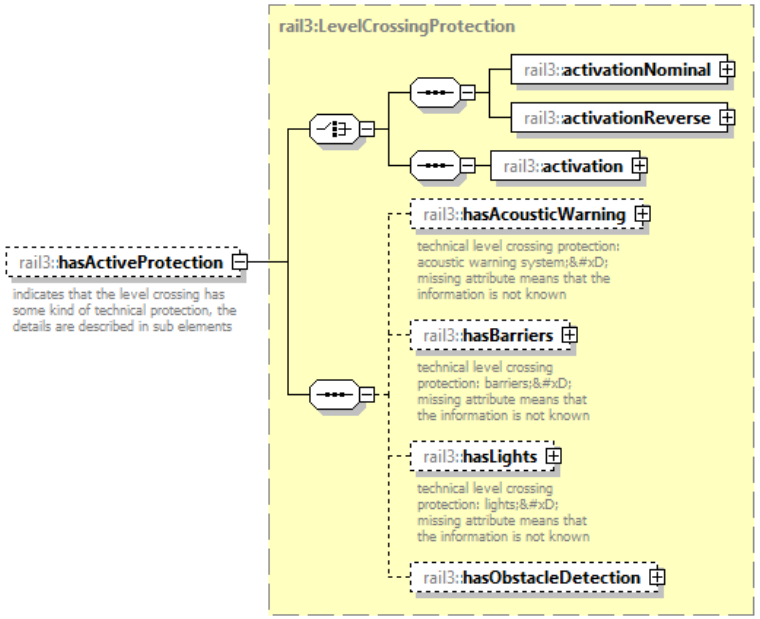

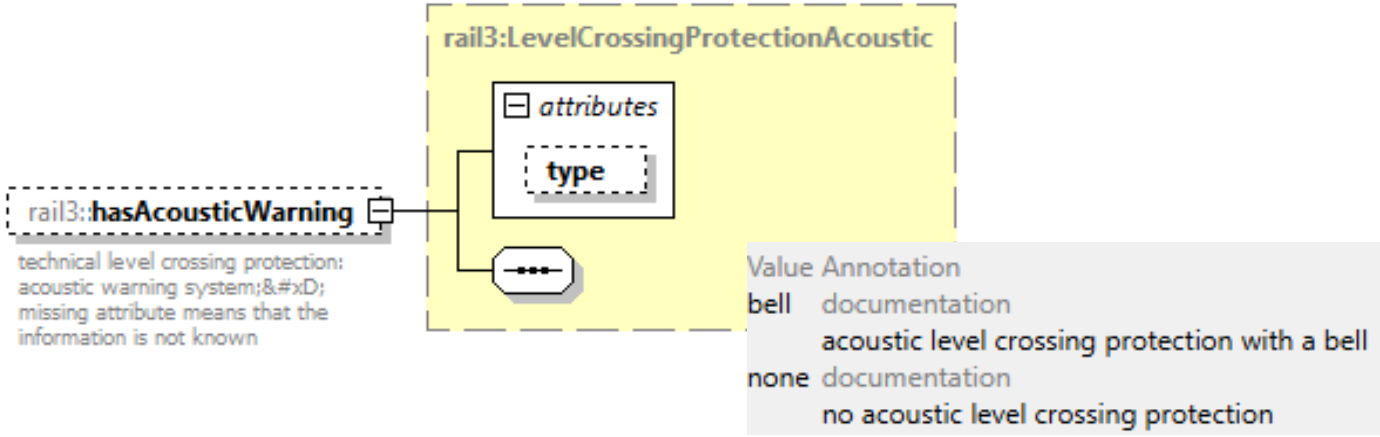

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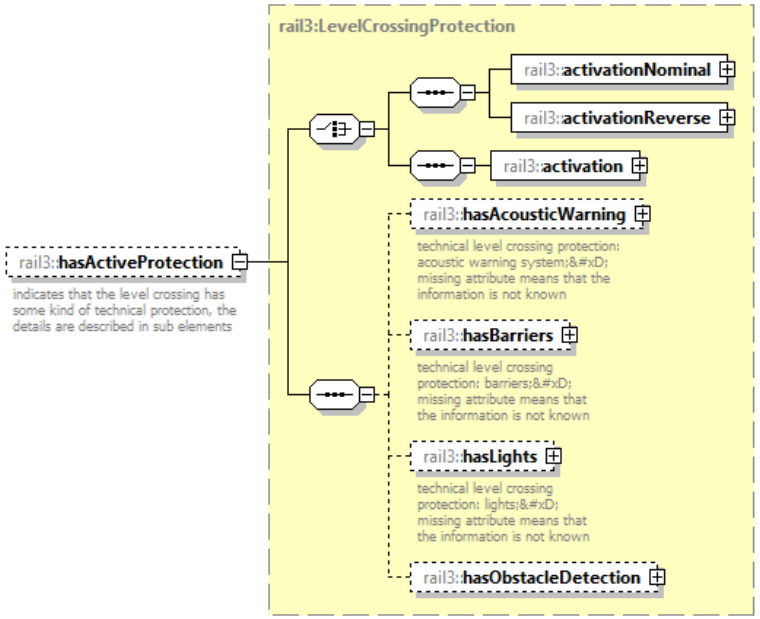
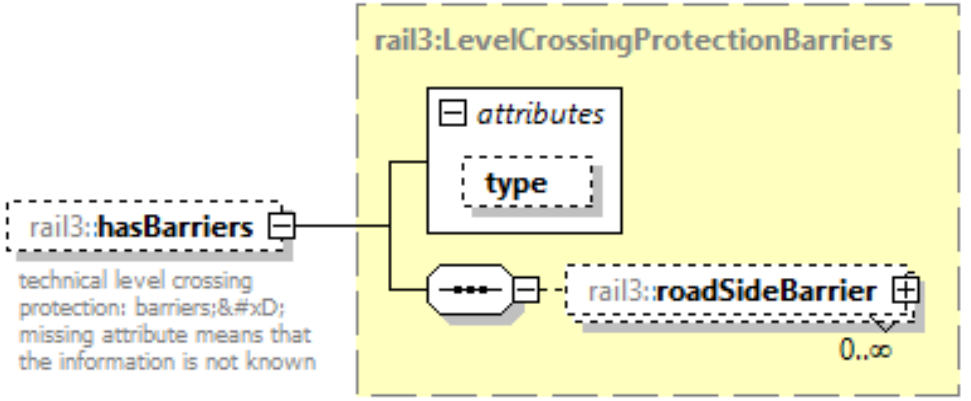
  - Technical protection systems





Value	Annotation
doubleHalfBarrier	documentation
	protection of the level crossing with half barriers on entry and exit side
none	documentation
	no barriers
singleFullBarrier	documentation
	protection of the level crossing with full barriers
singleHalfBarrier	documentation
	protection of the level crossing with half barriers on entry side
turnStile	documentation
	turnstile access system to protect access to the rail. used for protection of footway crossings

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mFUND Das Startkapital für die Mobilität der Zukunft

Project Partners:

railML.org

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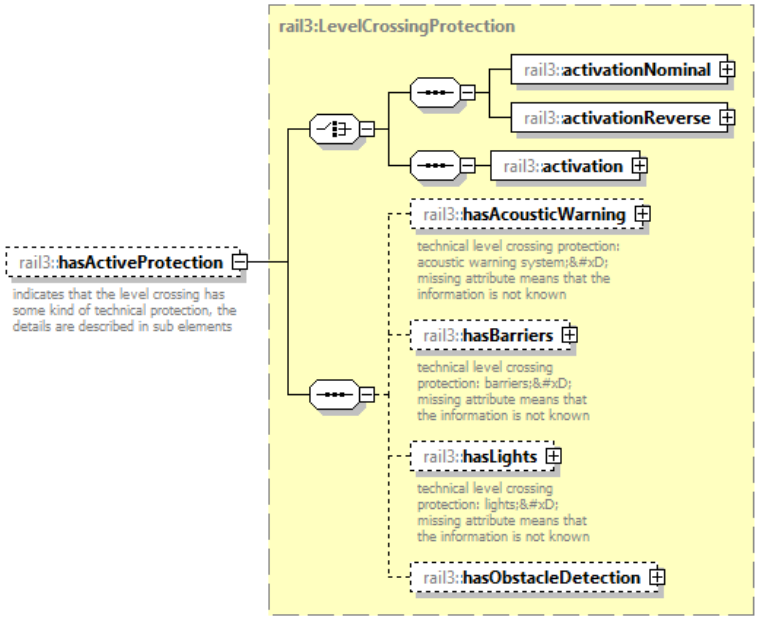
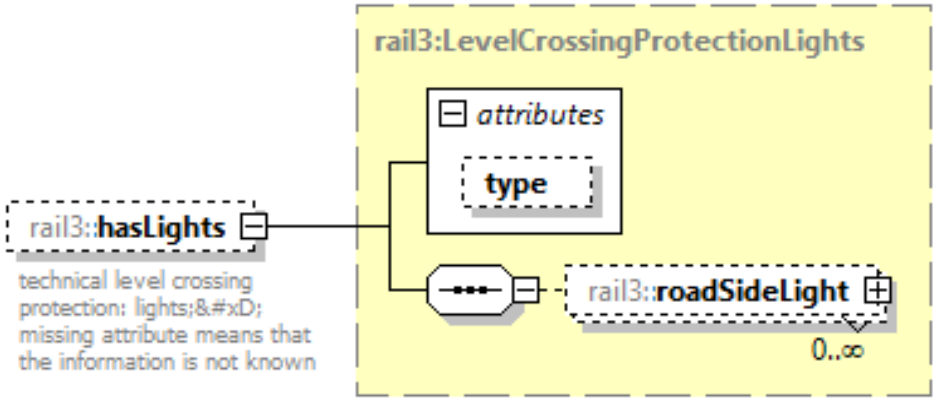
Level Crossing

- Extending level crossing model:
  - Technical protection systems





Value	Annotation
continuous	documentation
	visual level crossing protection with continuous light
flashing	documentation
	visual level crossing protection with flashing light
none	documentation
	no visual level crossing protection with lights
trafficLight	documentation
	Classic traffic light with lamps in green and red (at least)

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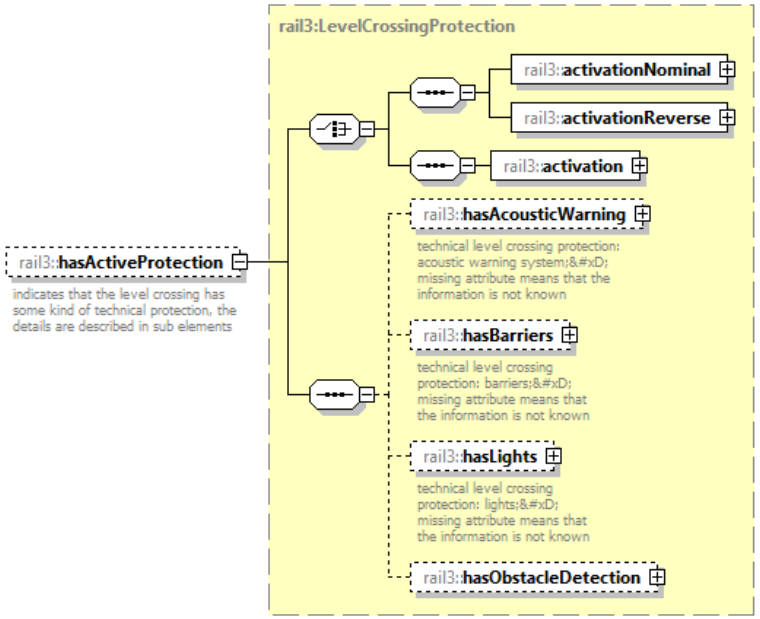

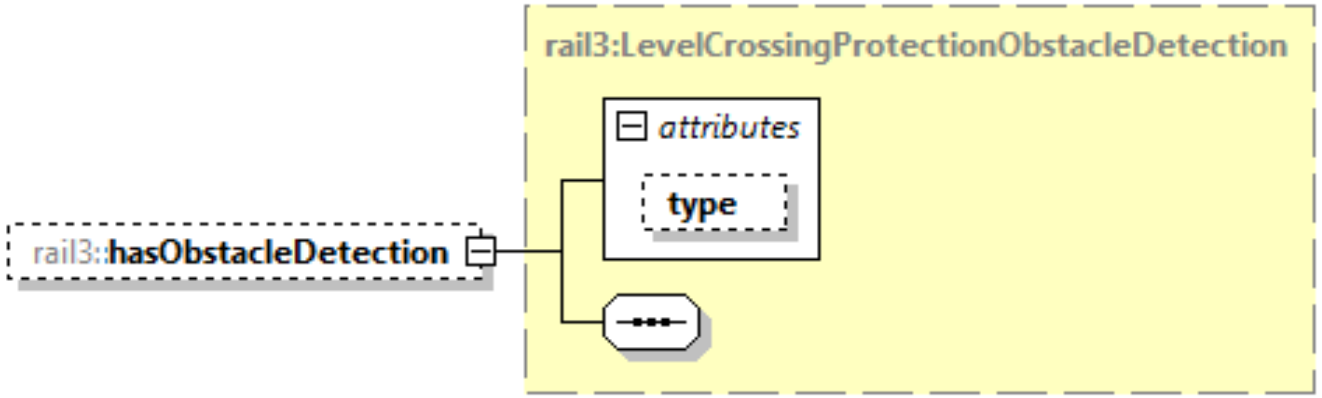

Value	Annotation
automatic	documentation
	obstacle detection in level crossing danger area is done automatically (e.g. via radar)
manual	documentation
	obstacle detection in level crossing danger area is done manually (e.g. via dispatcher looking)
none	documentation
	there is no obstacle detection taking place in the level crossing danger area

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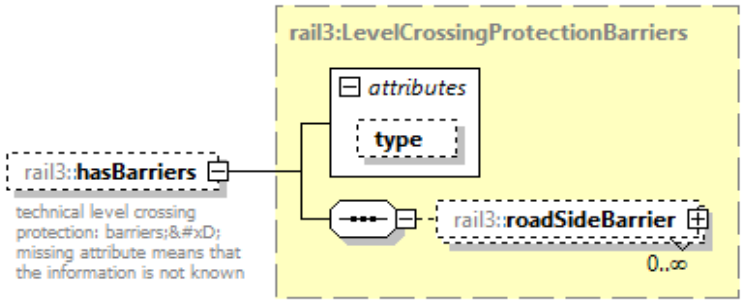

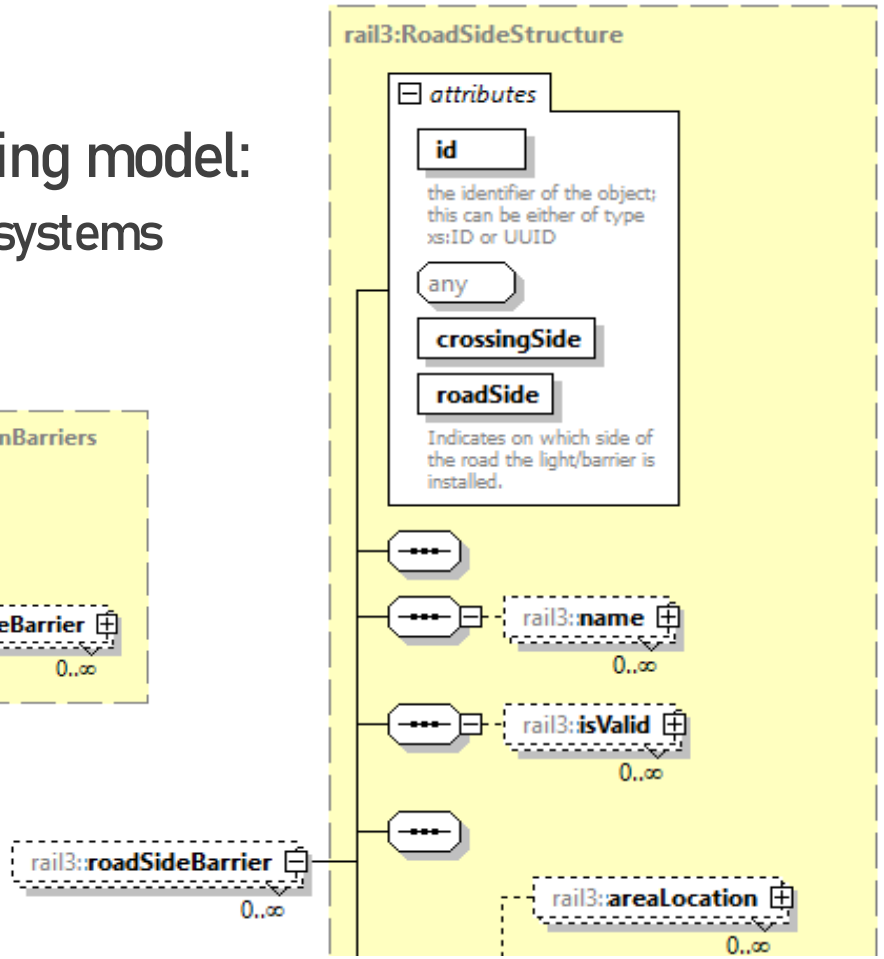

rail3:tCrossingSide

use required

Kind	Value	Annotation
enumeration	after	
enumeration	before	

rail3:tSide

use required

Kind	Value	Annotation
enumeration	left	documentation indicates the left side in orientation of the enclosing element
enumeration	right	documentation indicates the right side in orientation of the enclosing element

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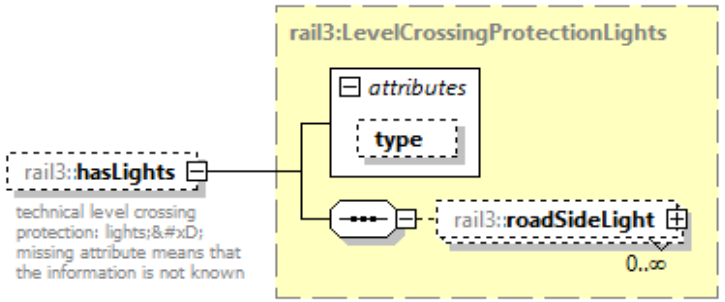
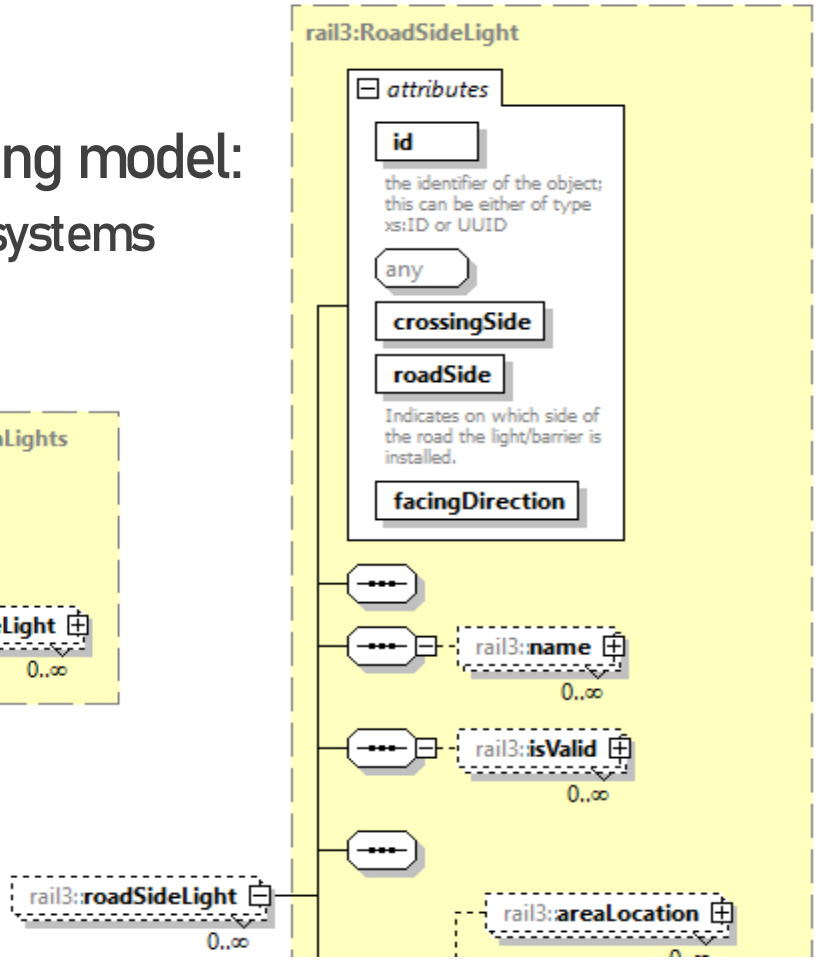
Level Crossing

- Extending level crossing model:
  - Technical protection systems





rail3:tCrossingSide

use required

Kind	Value	Annotation
enumeration	after	
enumeration	before	

rail3:tSide

use required

Kind	Value	Annotation
enumeration	left	documentation indicates the left side in orientation of the enclosing element
enumeration	right	documentation indicates the right side in orientation of the enclosing element

rail3:LightFacingDirection

use required

Kind	Value	Annotation
enumeration	awayFromRail	
enumeration	towardsRail	

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Level Crossing

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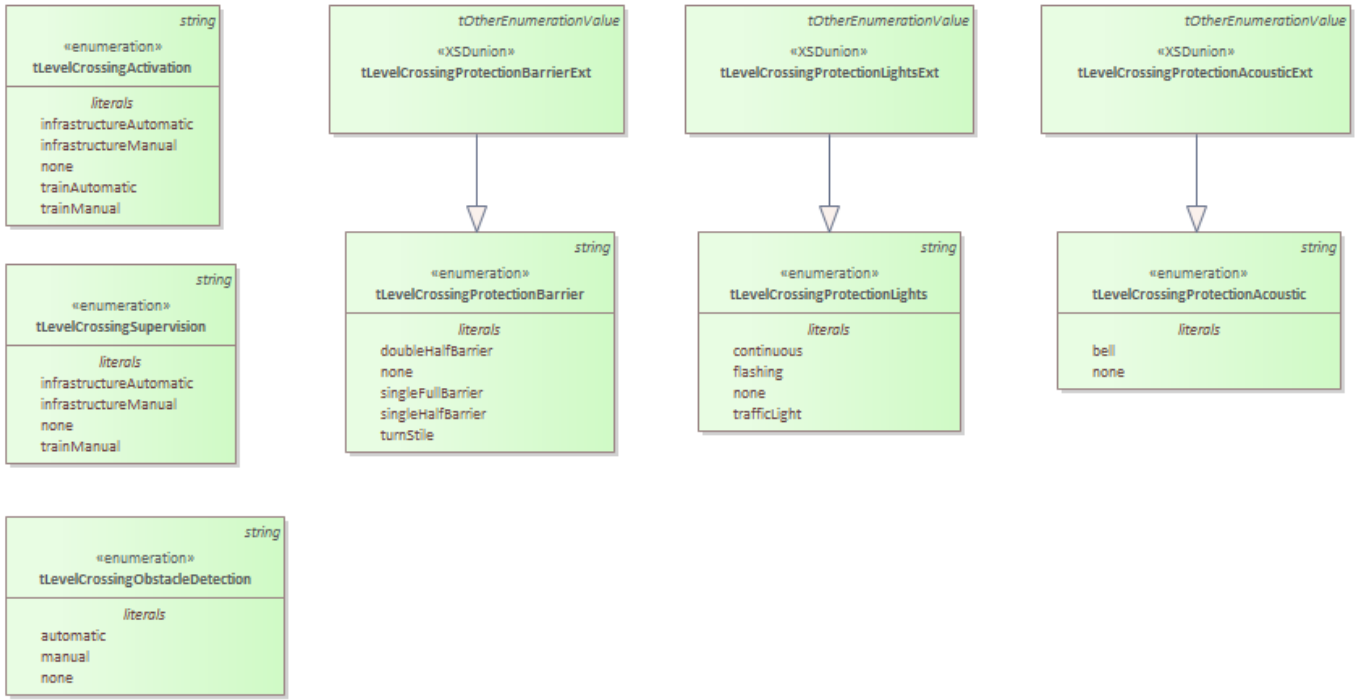

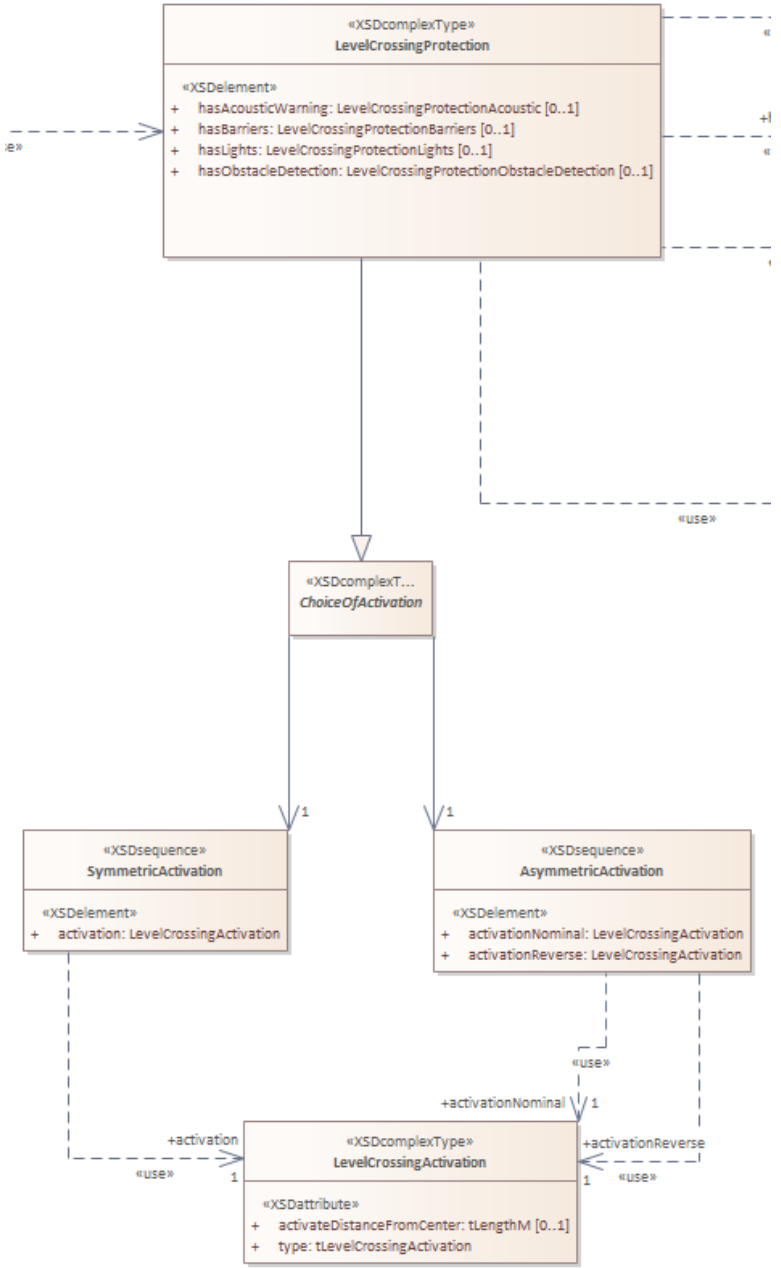

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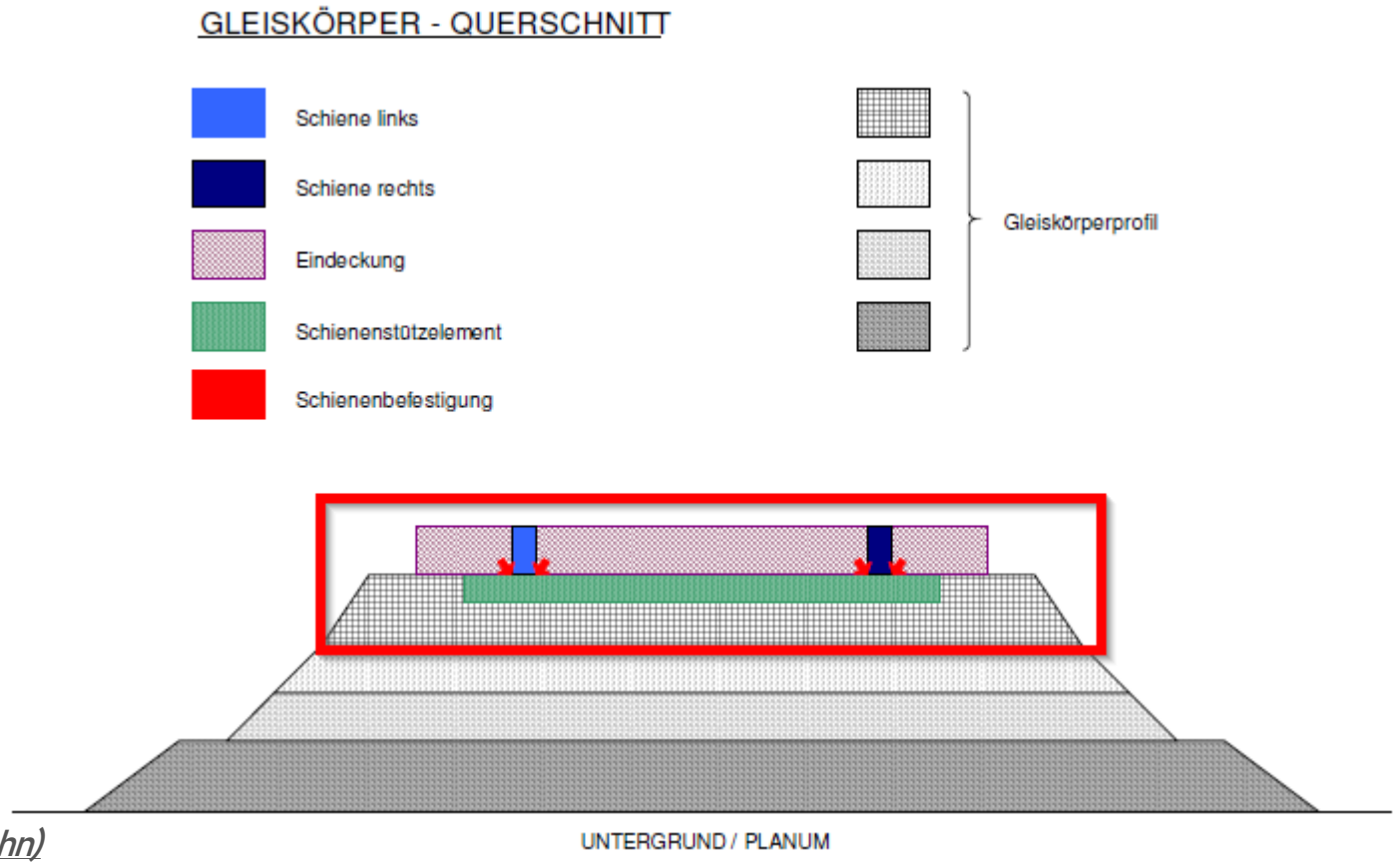
Track Bed

- Track bed model
  (de: Gleiskörper-Oberbau)



Source: https://de.wikipedia.org/wiki/Oberbau_(Eisenbahn)

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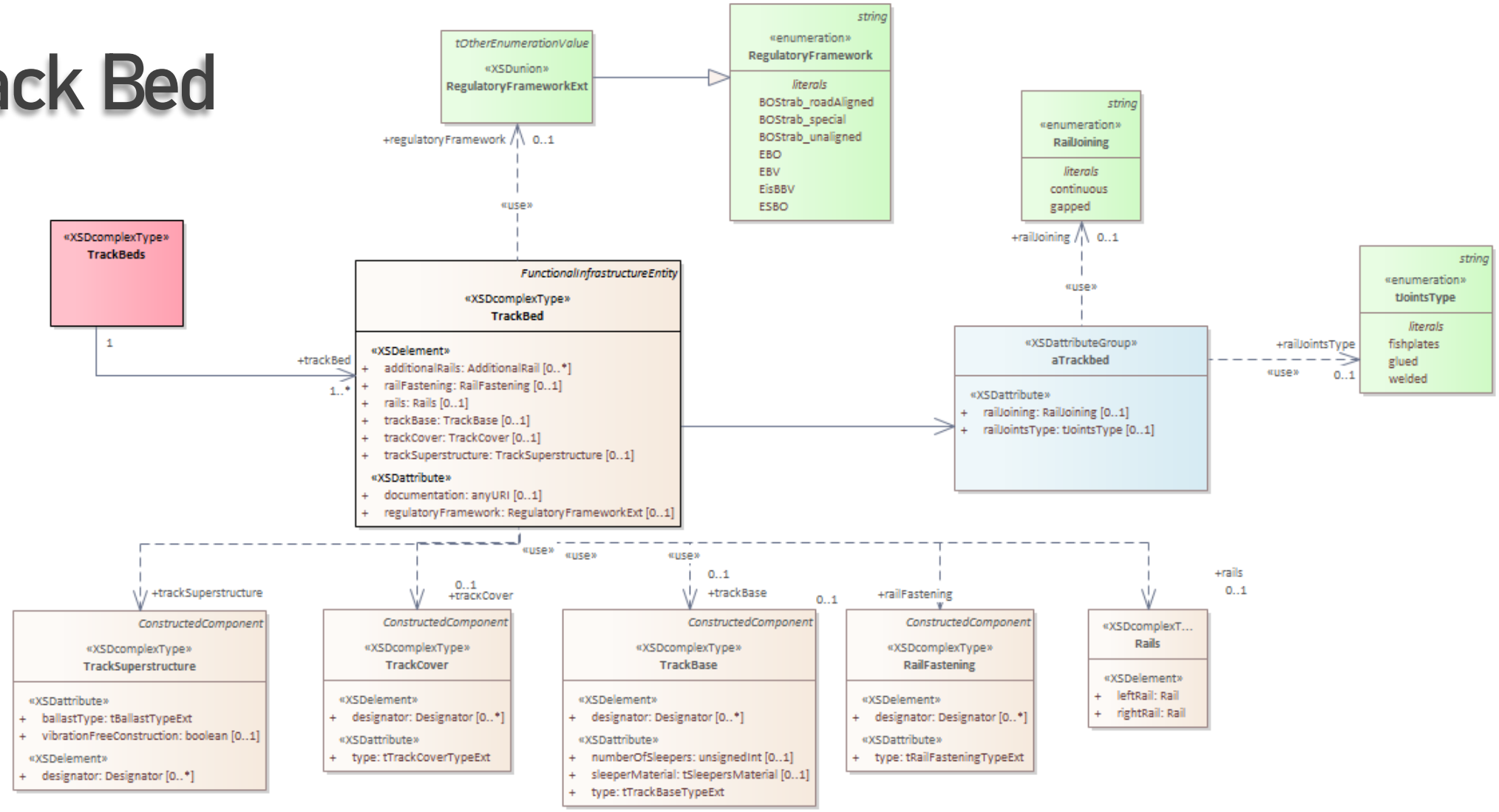
Track Bed



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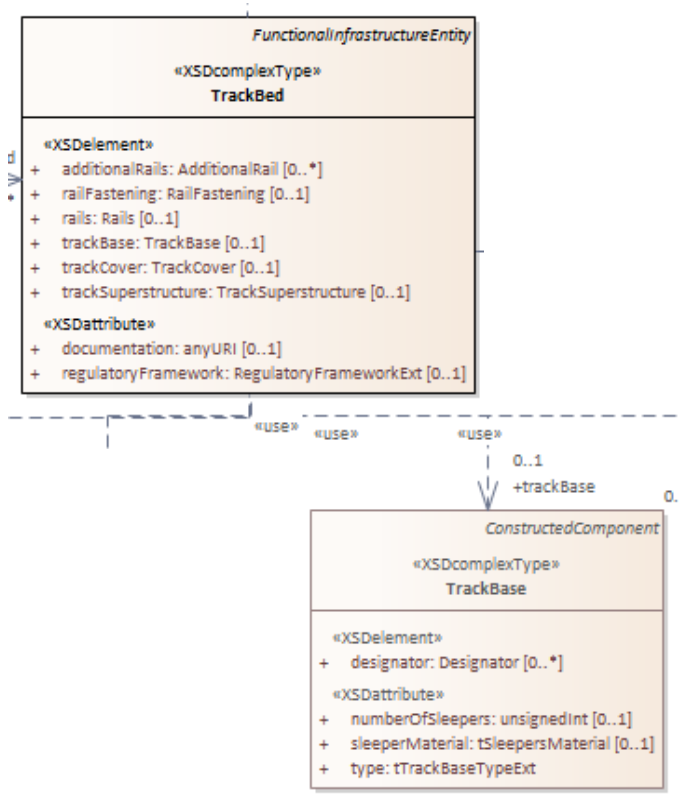
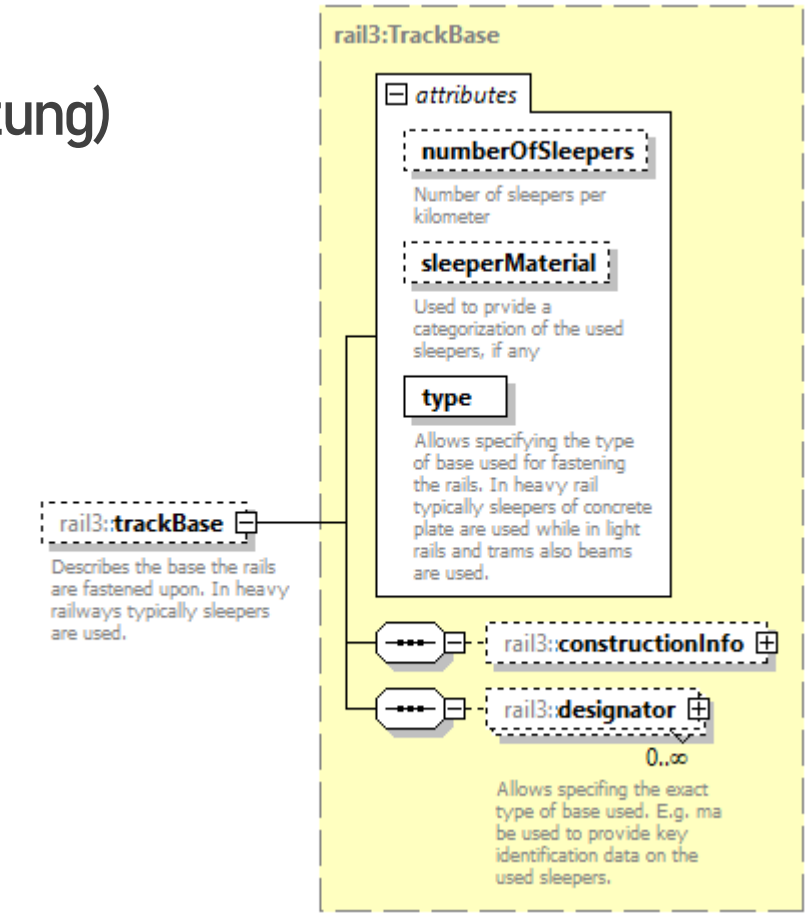
Track Bed

- Track base (de: Schienenunterstützung)





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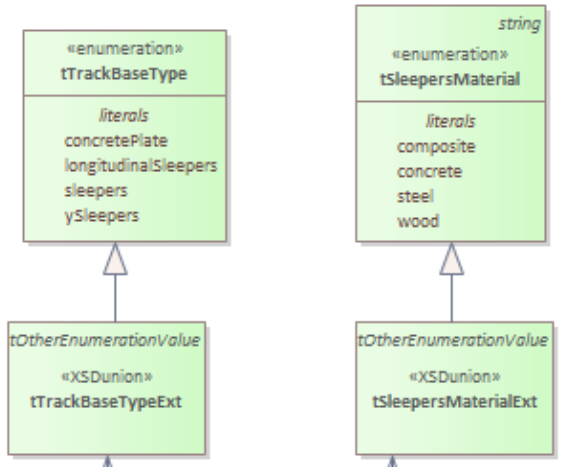
Track Bed

- Track base (de: Schienenunterstützung)



composite	documentation	
		the sleepers are made from a composite material.
concrete	documentation	
		the sleepers are made from concrete
steel	documentation	
		The sleepers are made from steel
wood	documentation	
		The sleepers are made from wood

concretePlate	documentation	
		The rails are attached to a concrete plate. This is typically the case for high speed railways.
longitudinalSleepers	documentation	
		The rails are attached to beams that are placed along the direction of the rail. This is a type of construction that is often used in light rails and trams.
sleepers	documentation	
		The rails are attached to sleepers that are placed crosswise (perpendicular) to the rails
ySleepers		

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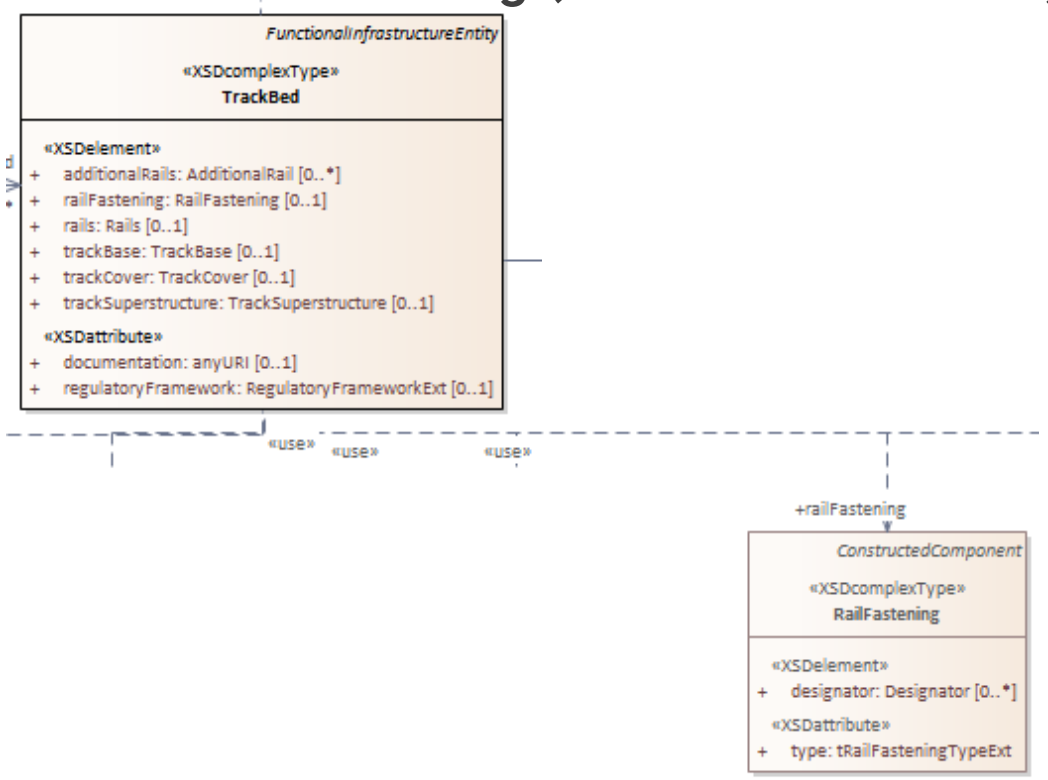
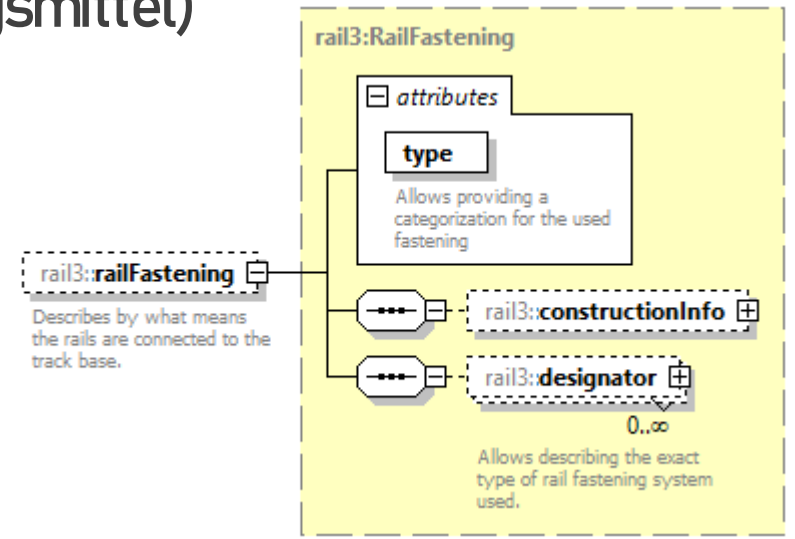
Track Bed

- Rail fastening (de: Schienenbefestigungsmittel)





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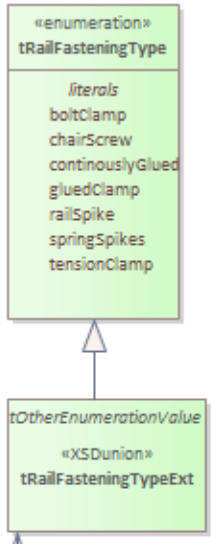
Track Bed

- Rail fastening (de: Schienenbefestigungsmittel)



boltClamp	documentation a bolt is used to fix the rail to the base
chairScrew	documentation A chair screw (also known as coach screw [16]) is a large (~6 in or 152 mm length, slightly under 1 in or 25 mm diameter) metal screw used to fasten a rail. (DE: Schienenschraube)
continouslyGlued	documentation The track is continously glued to the base. This is a type of fastening often used in light rail or tramways.
gluedClamp	documentation used in light rail and tramways
railSpike	documentation A rail spike (also known as a cut spike or crampon) is a large nail with an offset head that is used to secure rails (DE:Schienennagel)
springSpikes	documentation Spring spikes or elastic rail spikes are used with flat-bottomed rail, baseplates and wooden sleepers. The spring spike holds the rail down and prevents tipping and also secures the baseplate to the sleeper. (DE: Doppelspannnagel)
tensionClamp	documentation The foot of the rail is fastened to the track base using a tension clamp that is bolted to the base. (DE: Oberbau W/Oberbau KS)

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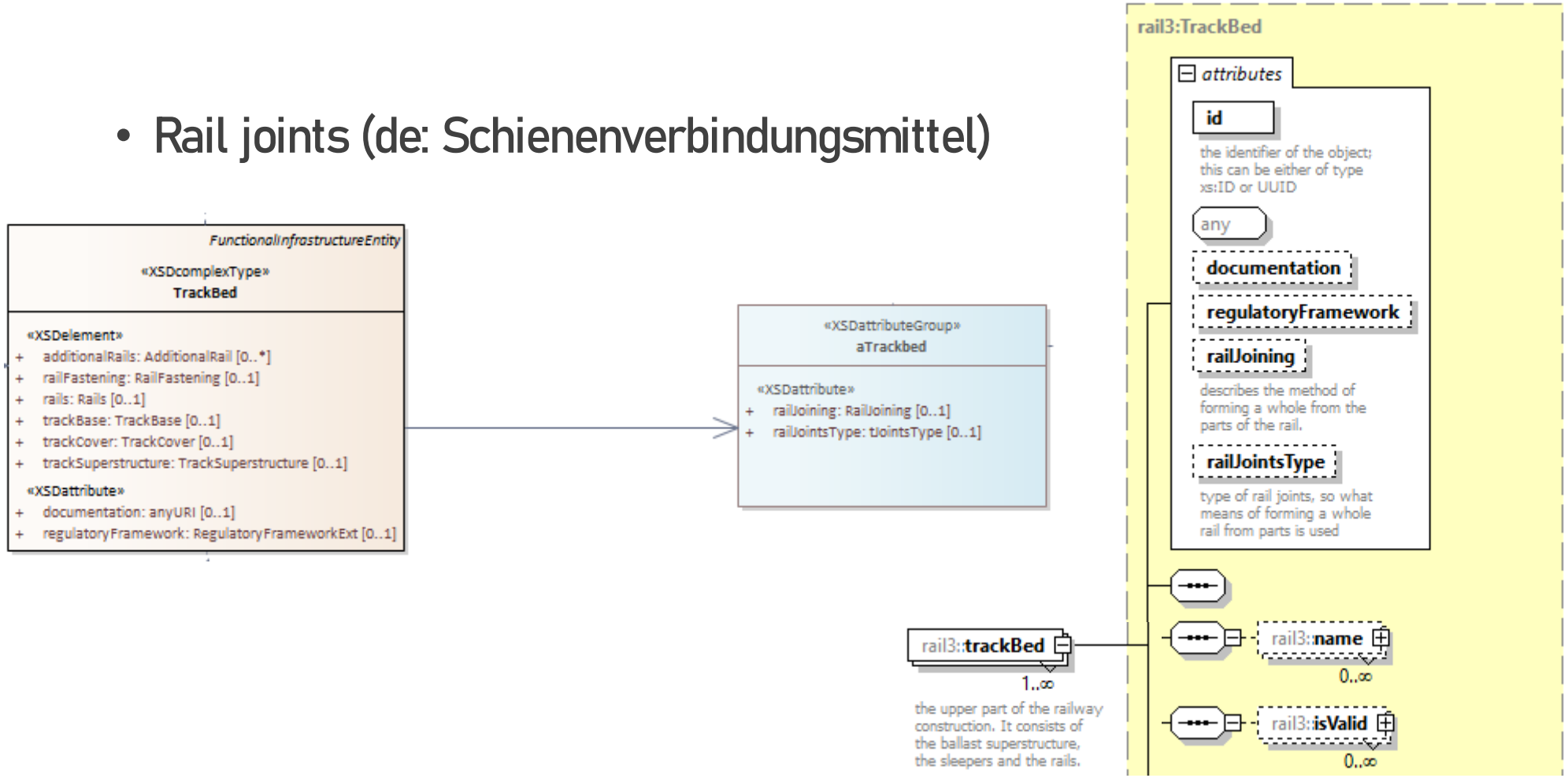
Track Bed

- Rail joints (de: Schienenverbindungsmittel)



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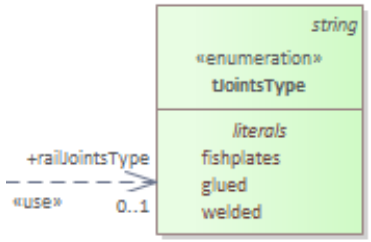
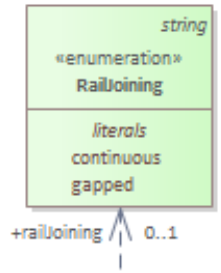
Track Bed

- Rail joints (de: Schienenverbindungsmittel)



fishplates	documentation
	a metal connecting plate used to bolt the ends of two rails
glued	documentation
	Indicates that the individual rails are glued together. All the gaps are filled with epoxy resin, increases the strength
welded	documentation
	Indicates that the individual rails are welded together



continuous	documentation
	continuous welded rail (CWR), sometimes referred to as ribbon rails or seamless rails. In this form of track, the rails are welded together by utilising flash butt welding to form one continuous rail that may be several kilometres long. Because there are few joints, this form of track is very strong, gives a smooth ride, and needs less maintenance; trains can travel on it at higher speeds and with less friction
gapped	documentation
	track is made using lengths of rail, bolted together using perforated steel plates known as fishplates. Small gaps which function as expansion joints are deliberately left between the rail ends to allow for expansion of the rails in hot weather. Because of these small gaps, when trains pass over jointed tracks they make a "clickety-clack" sound.

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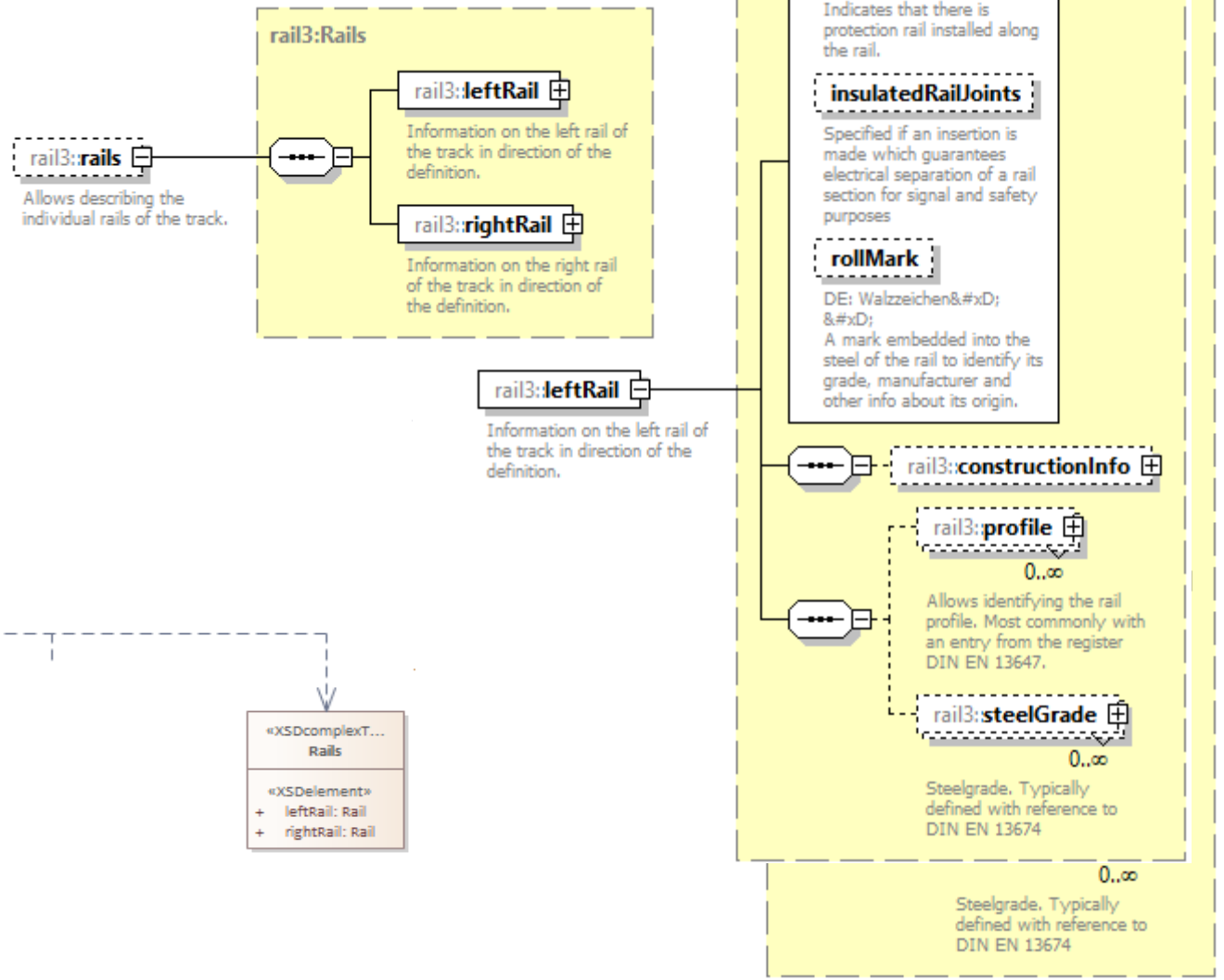
Track Bed

- Rails (de: Schienen)



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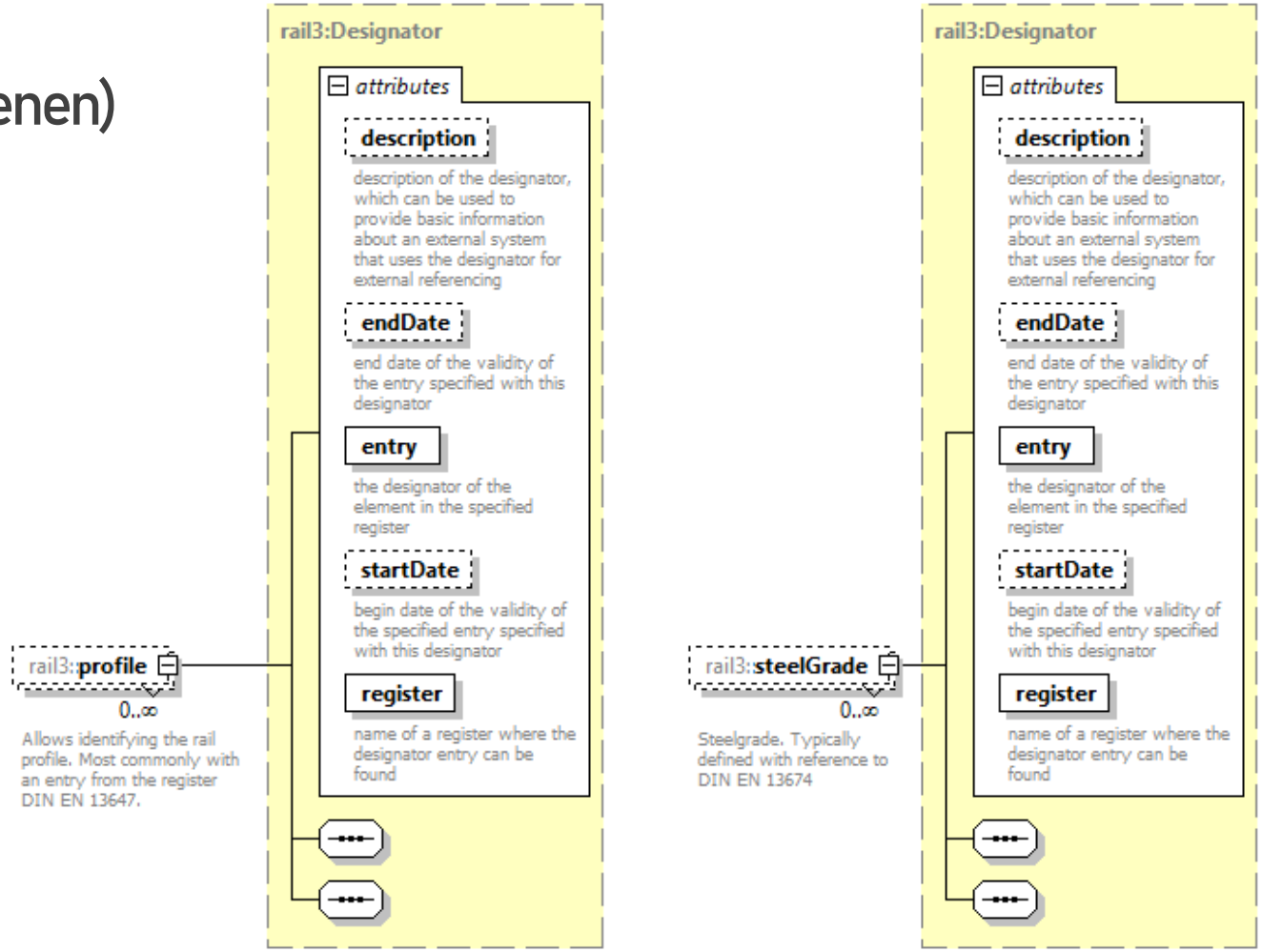

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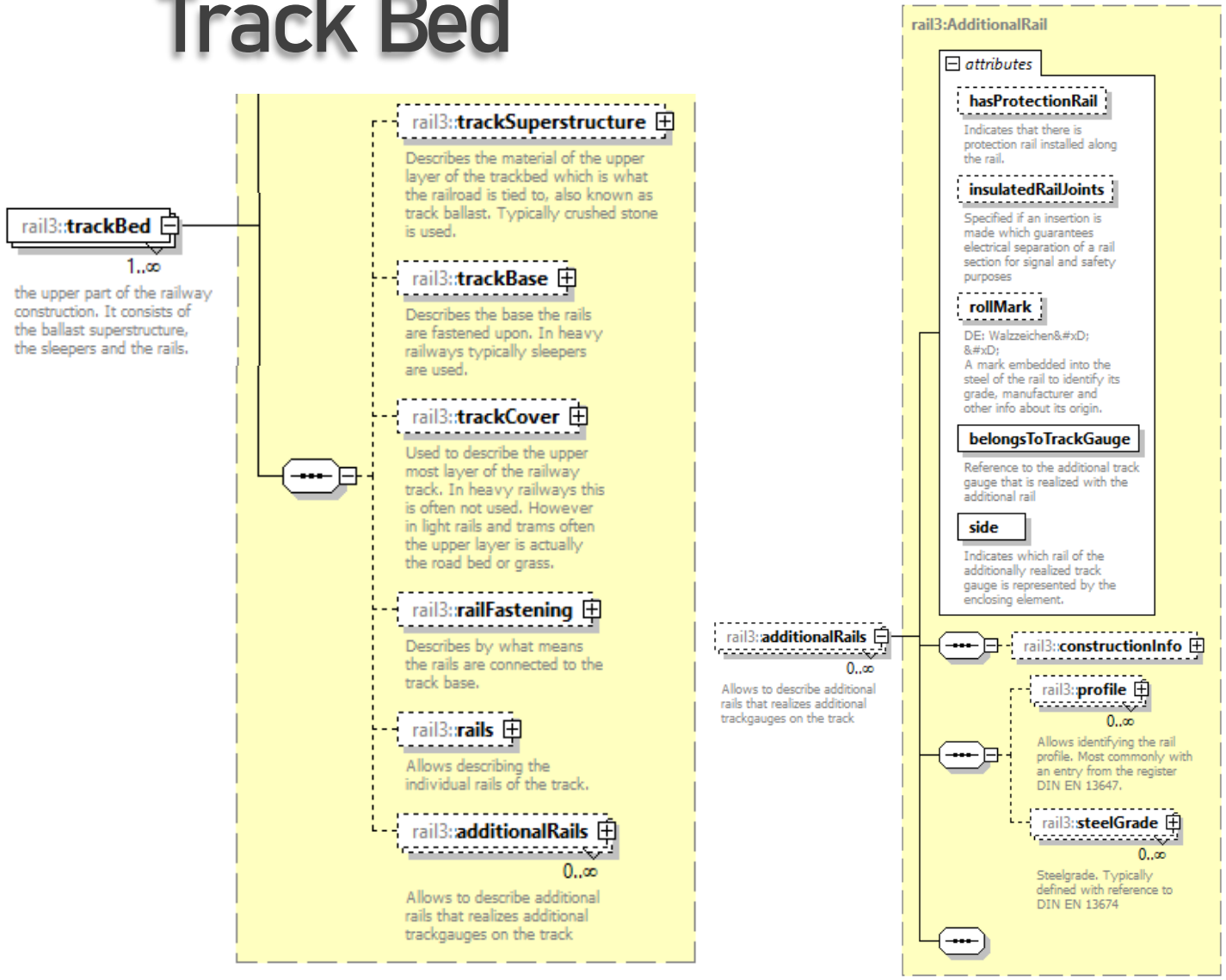
Track Bed

- Rails (de: Schienen)



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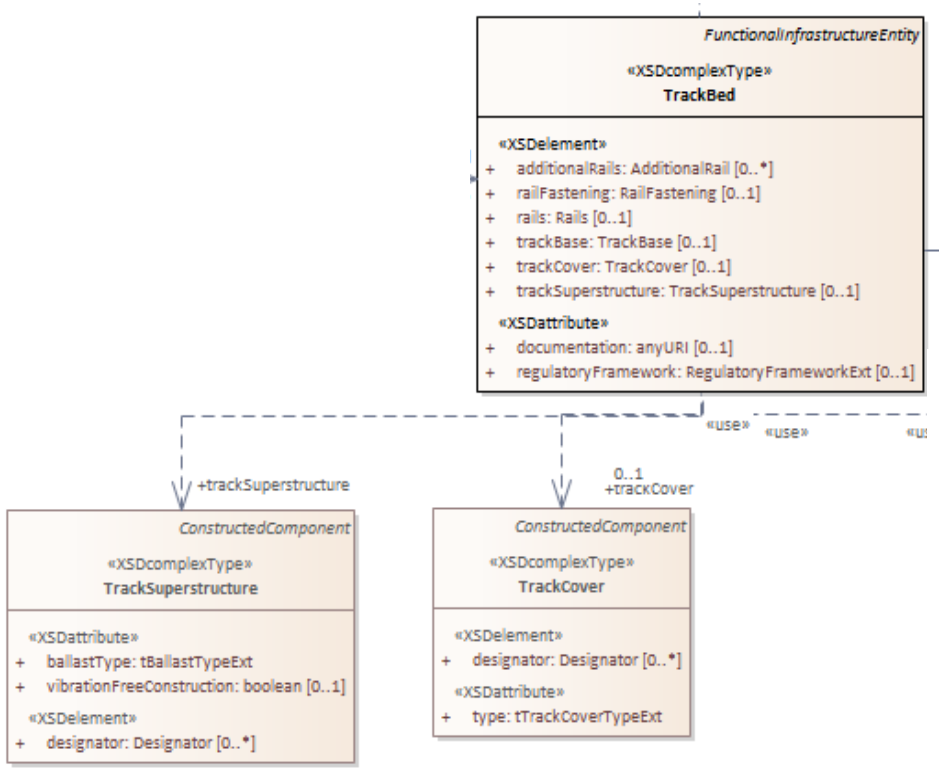
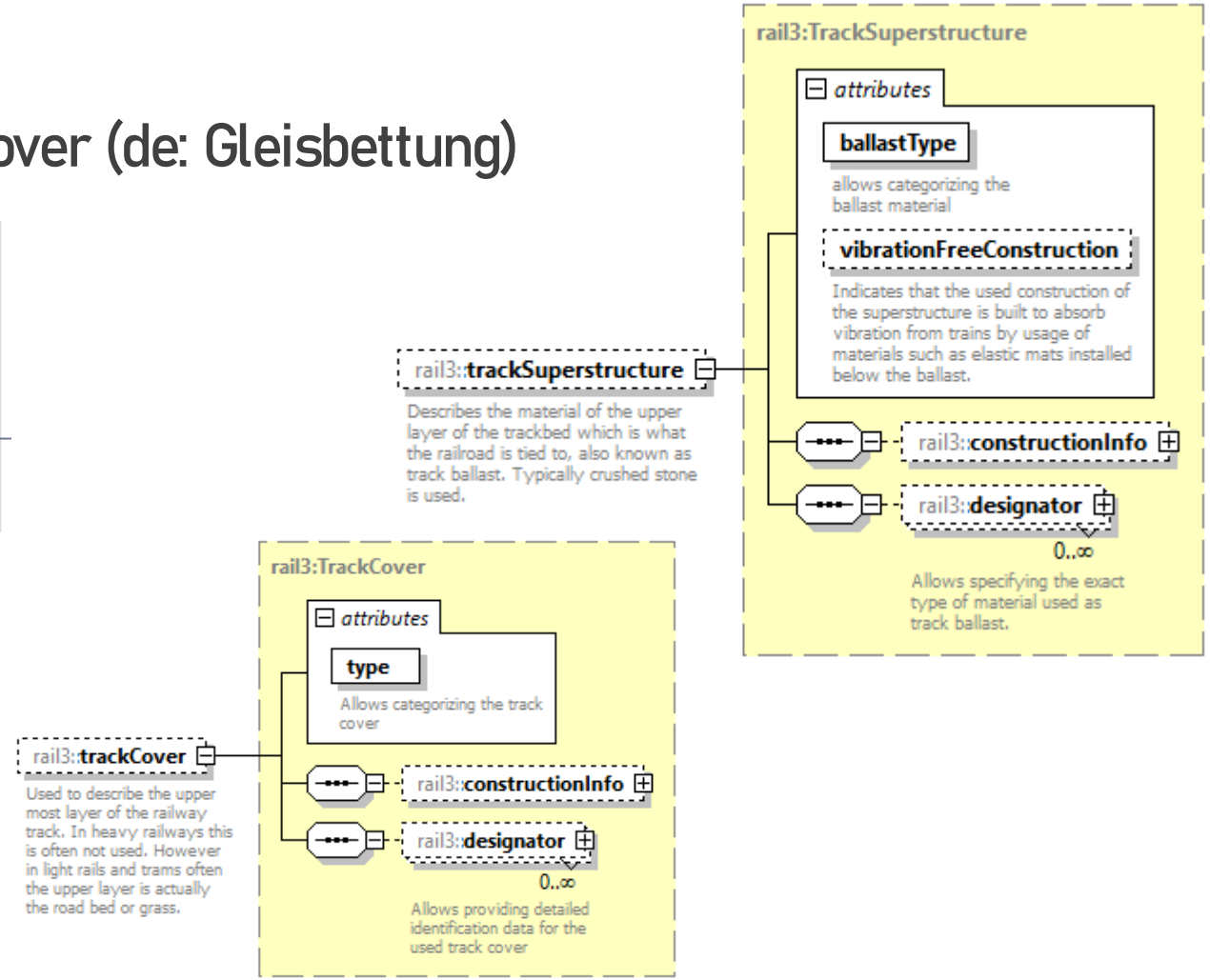
Track Bed

- Track ballast & track cover (de: Gleisbettung)





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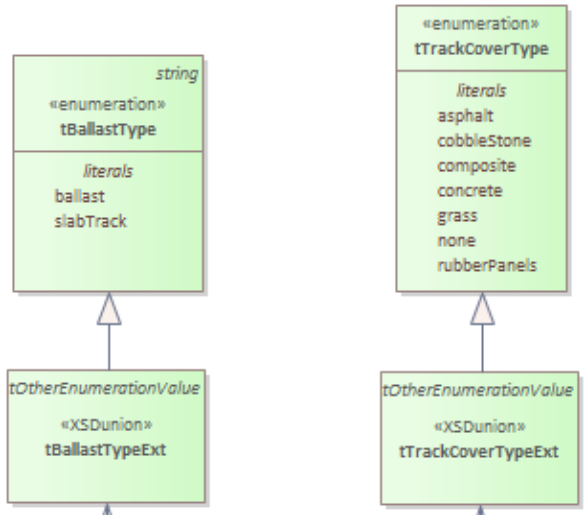
- Track ballast & track cover (de: Gleisbettung)



asphalt
cobbleStone
composite documentation
The track bed is made of a composite material.
concrete documentation
The track bed is made of concrete. This is often the case at level crossings.
grass documentation
The track cover is made of grass (DE: Grüngleise)
none documentation
No track cover is in use
rubberPanels documentation
The track cover is made from hard rubber panels.

ballast documentation
"Track ballast is the material which forms the trackbed upon which railroad ties (UK: sleepers) are laid. It is packed between, below, and around the ties. It is used to bear the compression load of the railroad ties, rails, and rolling stock; to facilitate drainage; and keep down vegetation that can compromise the integrity of the combined track structure. Ballast also physically holds the track in place as the trains roll over it. Not all types of railway tracks use ballast. [Wikipedia]"
slabTrack documentation
A ballastless track or slab track is a type of railway track infrastructure in which the traditional elastic combination of sleepers and ballast is replaced by a rigid construction of concrete or asphalt [Wikipedia].

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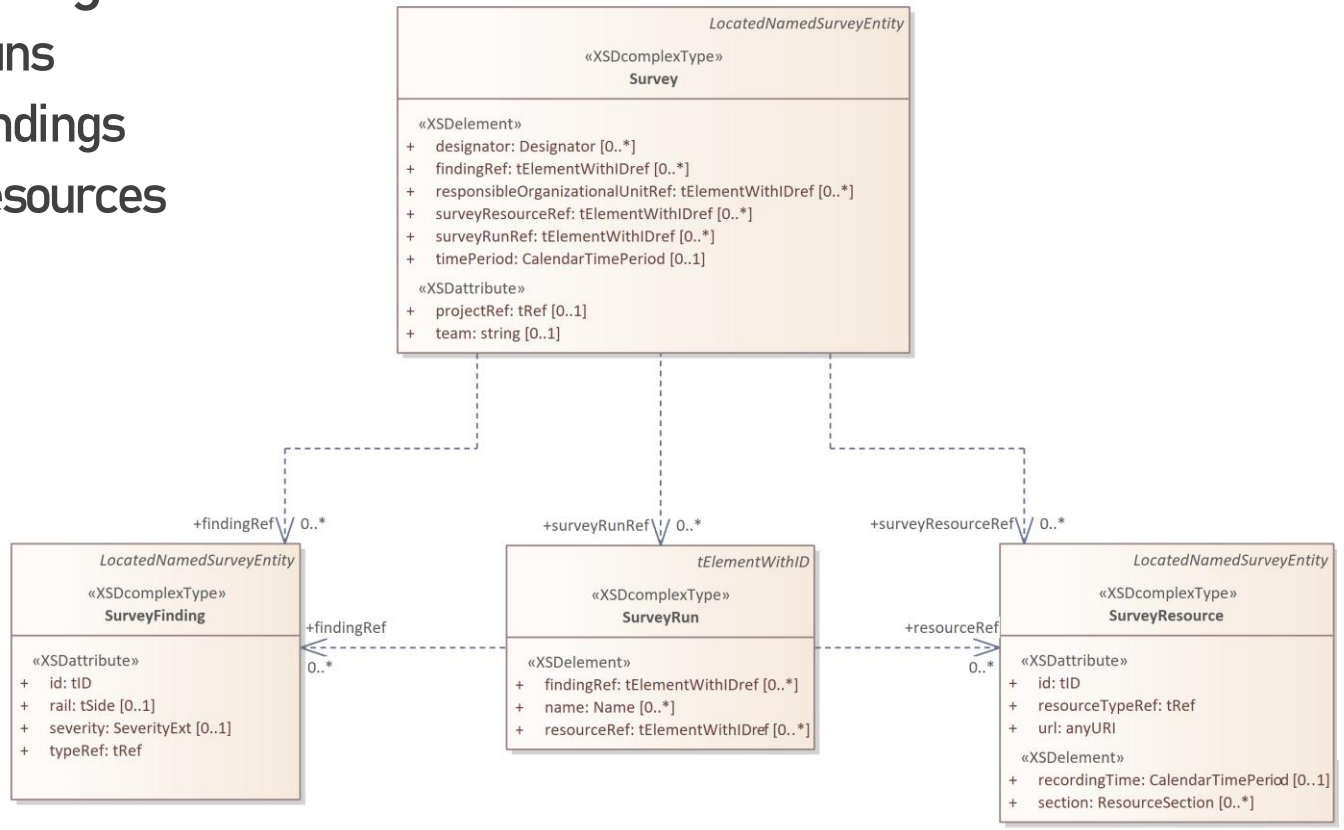
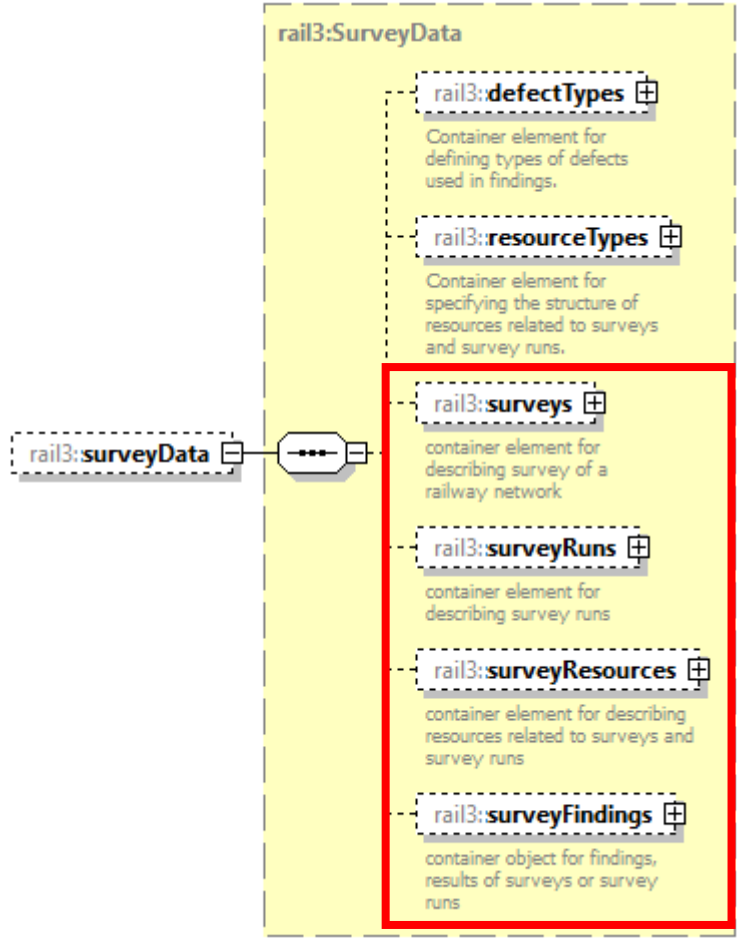
Survey Data

- Surveys are organized into
  - Survey runs
  - Survey findings
  - Survey resources





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Survey Data

- **Survey** collects header data
  - Designators
  - Responsible organizational units
  - Timeframe of the survey
  - Project the survey belongs to
  - Information on the involved team

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  </surveys>
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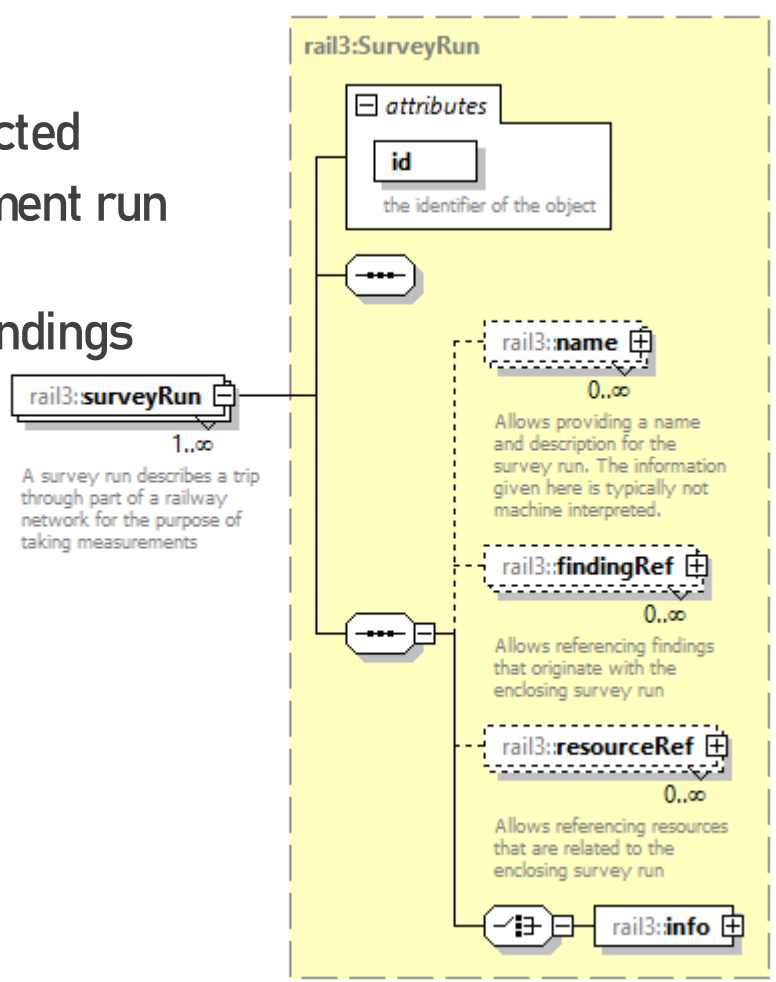
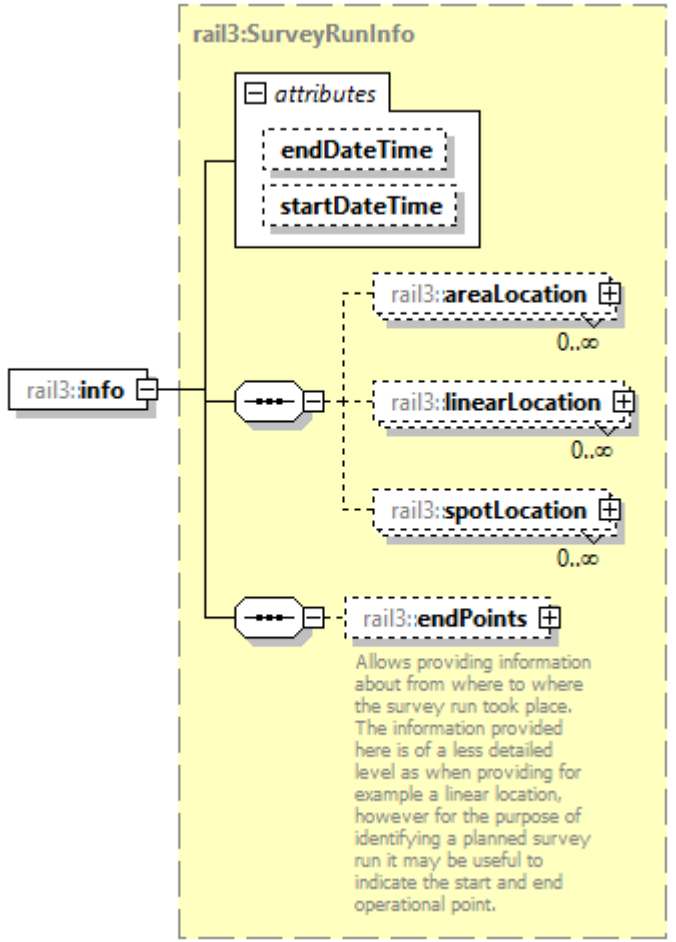
Survey Data

- **Survey Run**
  - Describes how the data was collected
  - From where to where a measurement run was conducted
  - Allows assigning resources and findings





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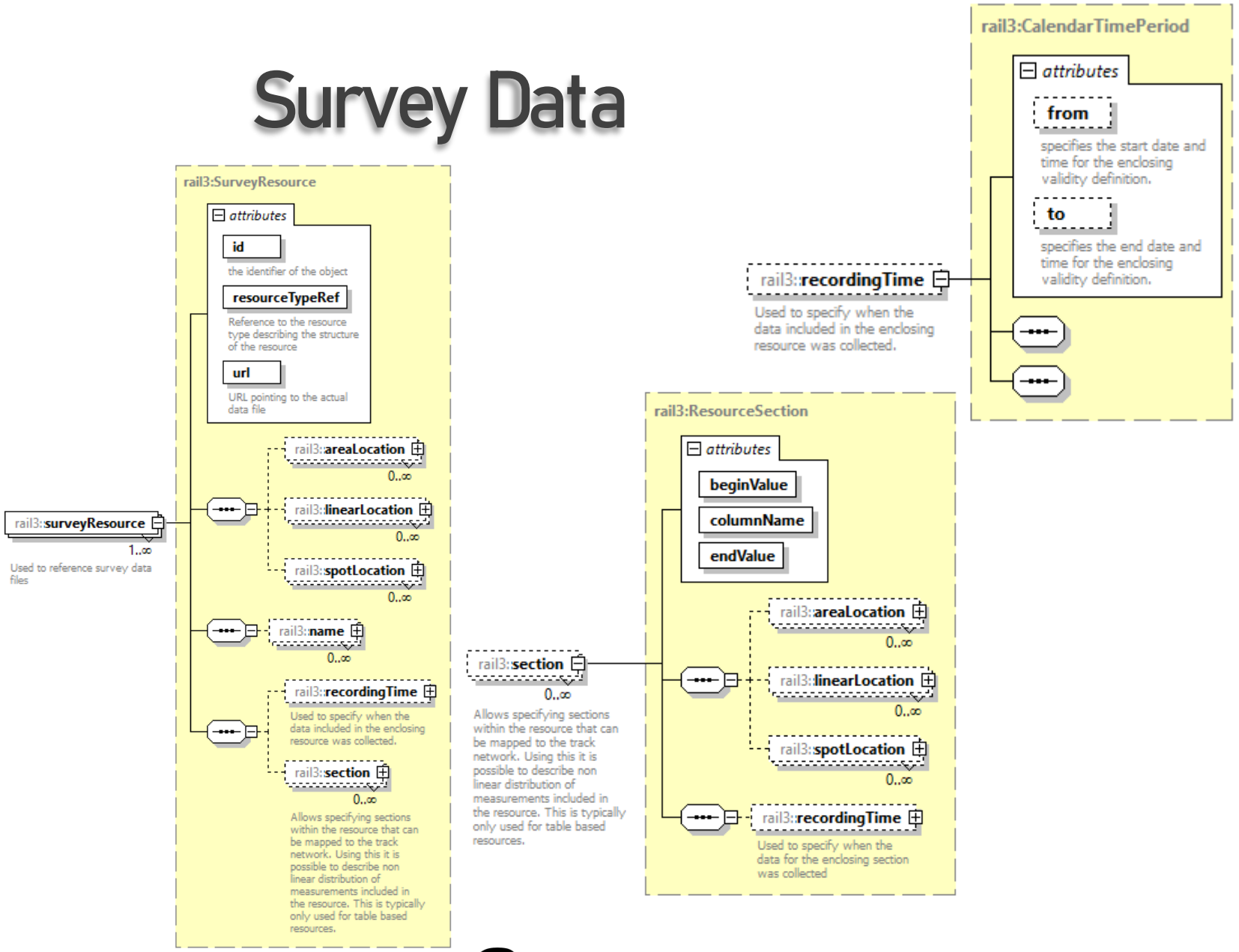
Survey Data

- **Survey Resources**
  - Descibe area and recording time of data
  - Area may be split into several sections (helps with segmentation of tablebased data)



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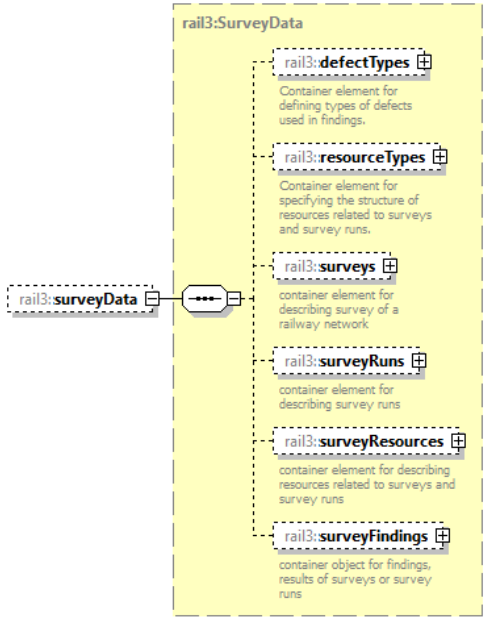
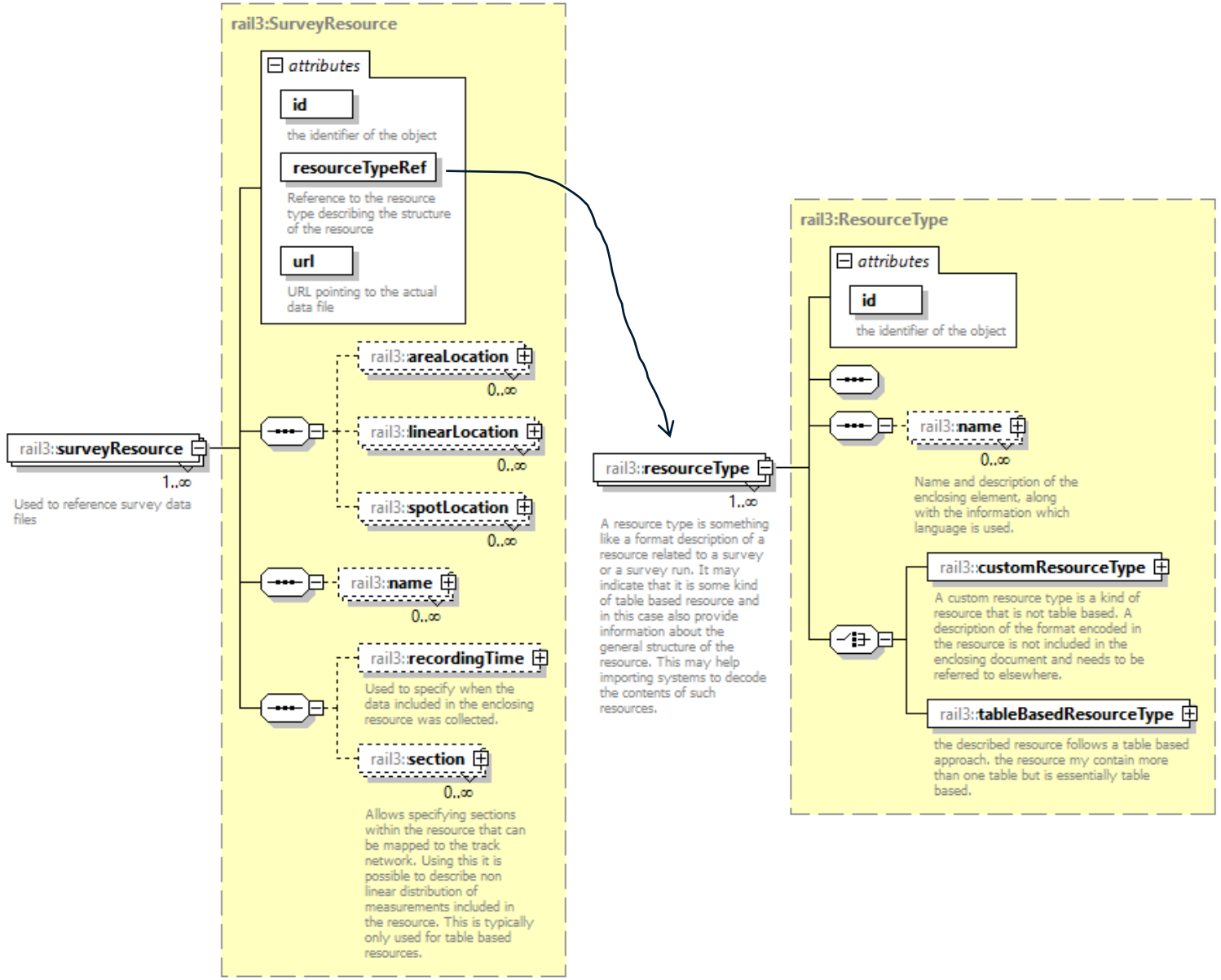
Survey Data

- **Survey Resources**
  - Allow referencing external files (resources) via @resourceTypeRef





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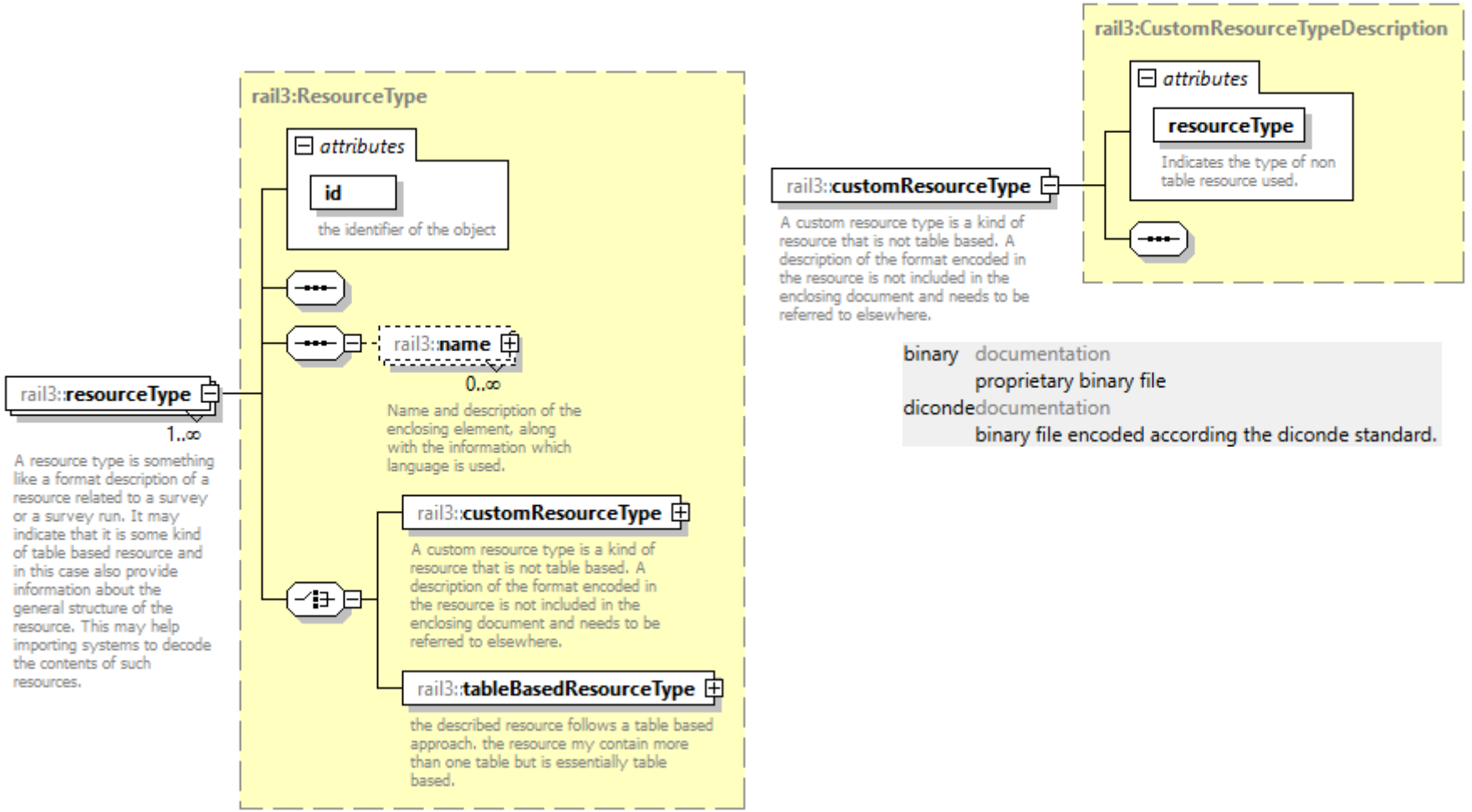
Survey Data

- **Survey Resources**
  - Support for
    - Binary
      - DICONDE
      - proprietary



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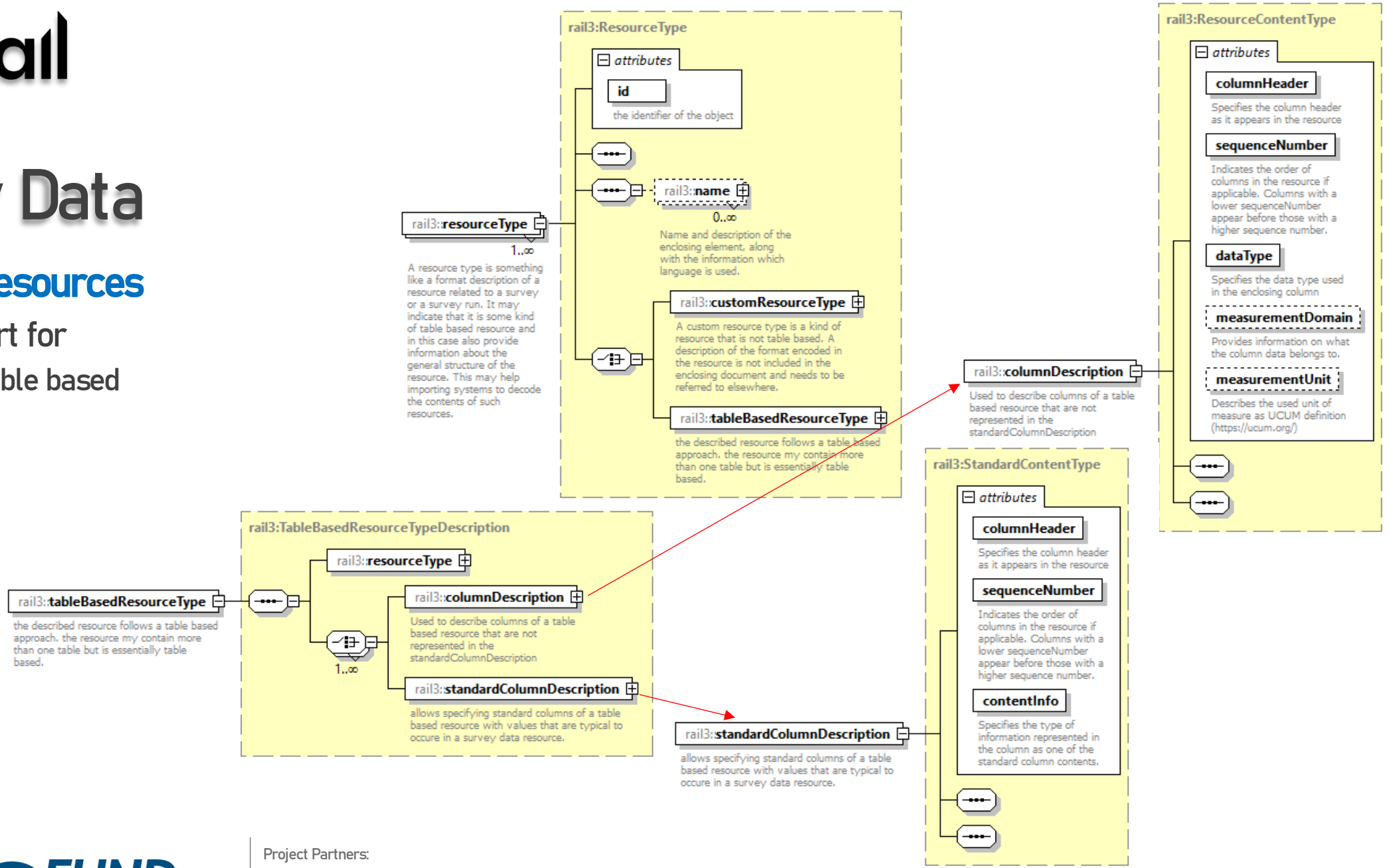
IDX4rail

Survey Data

- **Survey Resources**
  - Support for
    - Table based



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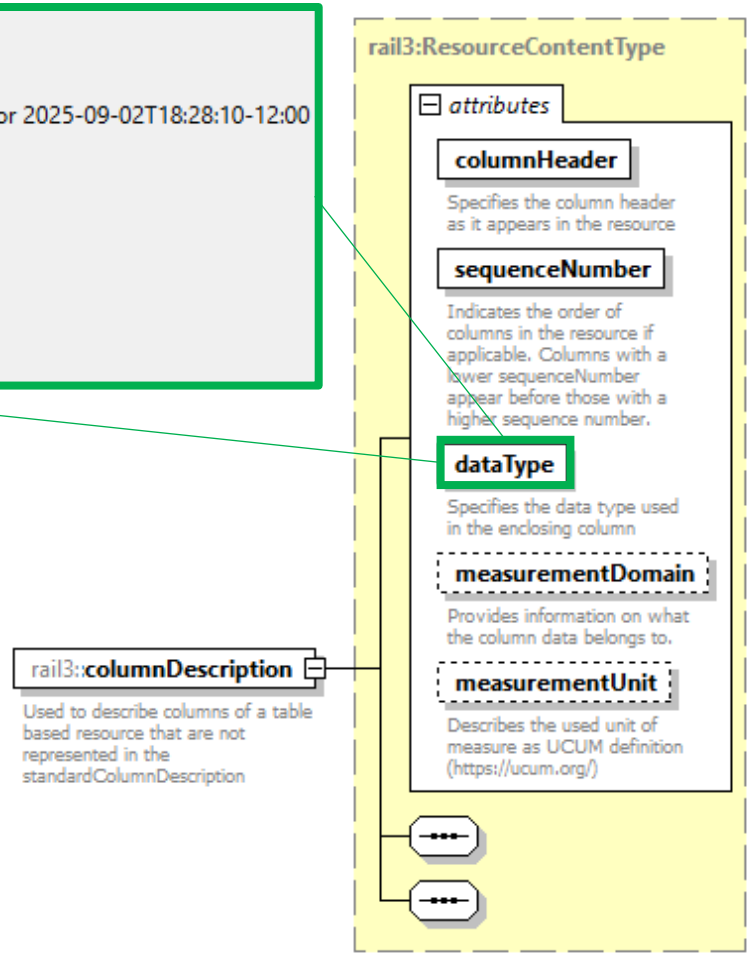
Survey Data

- **Survey Resources**
  - Support for
    - Table based

boolean	documentation	
		Values are limited to "true" and "false"
dateTime	documentation	
		A datetime value encoded according to ISO 8601, e.g. 2025-09-03T06:28:10Z or 2025-09-02T18:28:10-12:00
duration	documentation	
		a time encoded as xs:duration, e.g. PT3M2S
floatingpoint	documentation	
		A floating point number with a decimal point expressed as dot
integer	documentation	
		an integer value with no separators, e.g. 1000000
string	documentation	
		a string value



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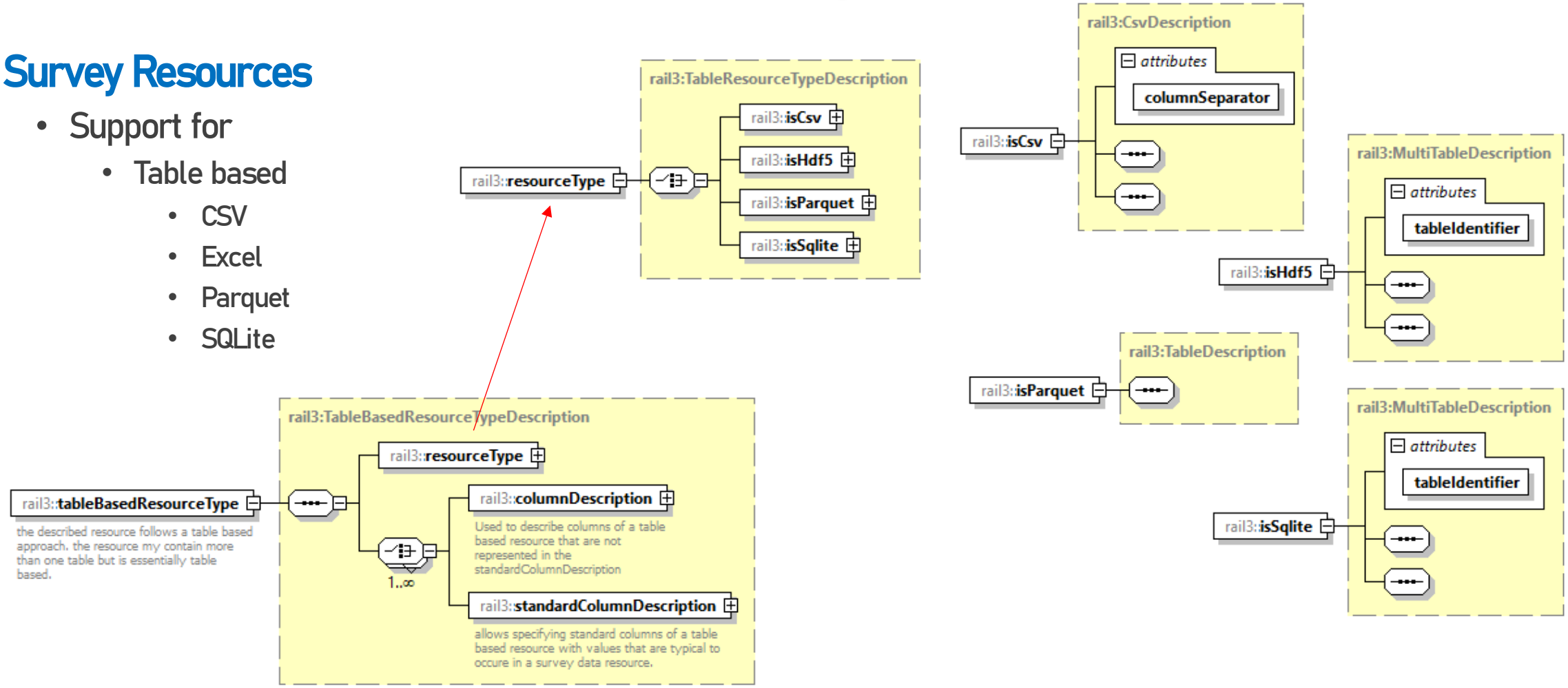
Survey Data

- **Survey Resources**
  - Support for
    - Table based
      - CSV
      - Excel
      - Parquet
      - SQLite



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Survey Data

- **Survey Resources**
  - Support for
    - Table based
      - CSV
      - Excel
      - Parquet
      - SQLite
    - Structure of table-based resource types can be described
      - Columns can be either defined by data type (string, integer, duration, …)
      - Or as predefined content
        - CurrentSpeed in Kmph
        - OffsetDistanceToStart
        - GPS lon, lat
        - …

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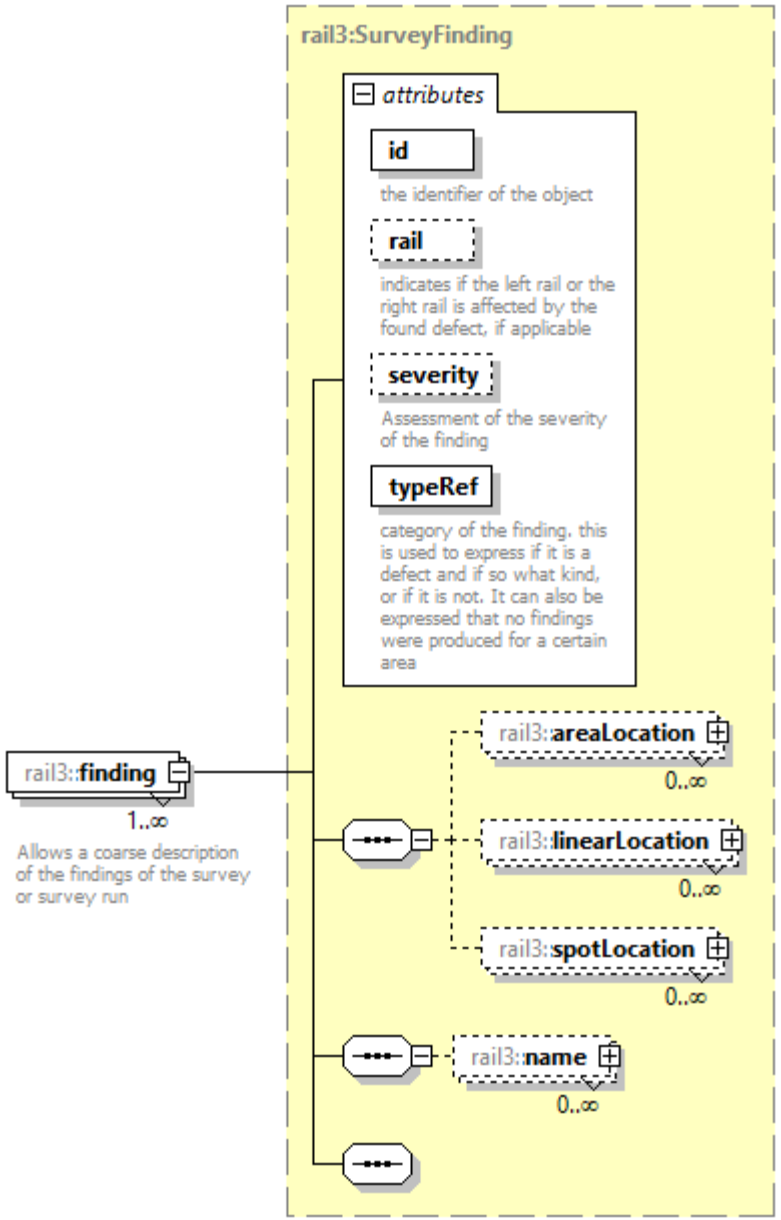
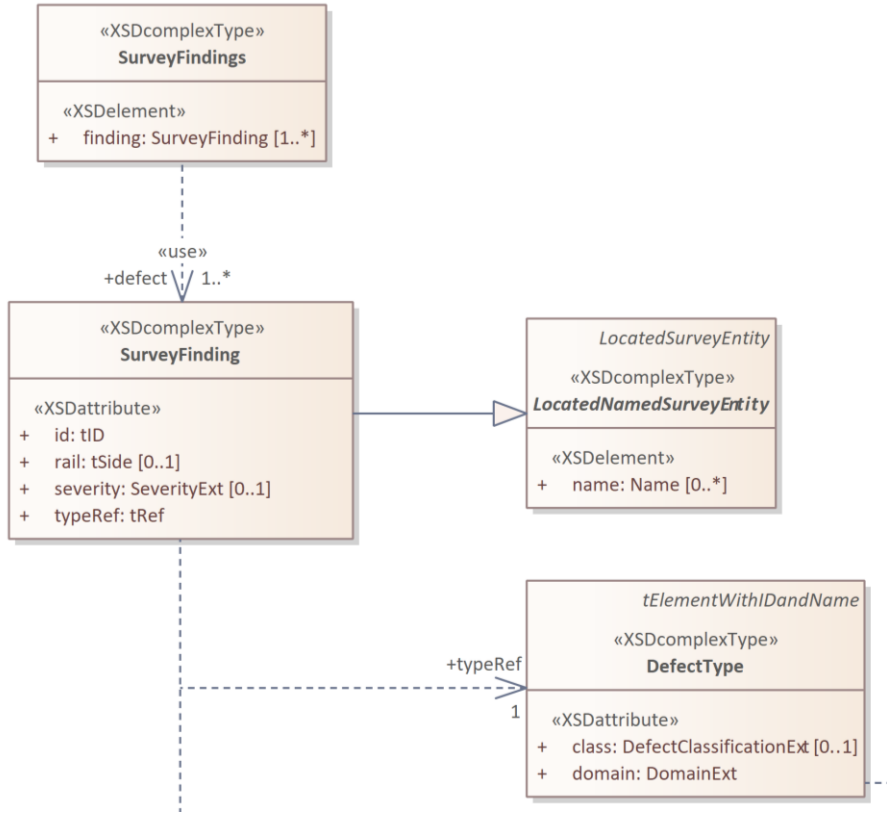
Survey Data

- **Findings**
  - Allow summarizing the results of a survey run
  - Location of finding is specified
  - Model is open for custom types
  - Standard includes general classification
  - Severity can be specified





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Survey Data

- **Findings**
  - Allow summarizing the results of a survey run
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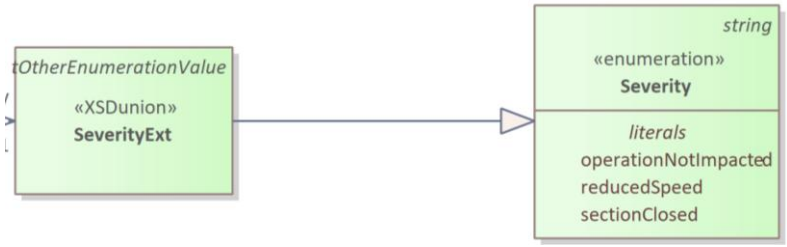

operationNotImpacted	documentation
	Normal operation on the rail can be continued
reducedSpeed	documentation
	Operation over the rail is still possible but with reduced speed.
sectionClosed	documentation
	Section needs to be closed du to the finding

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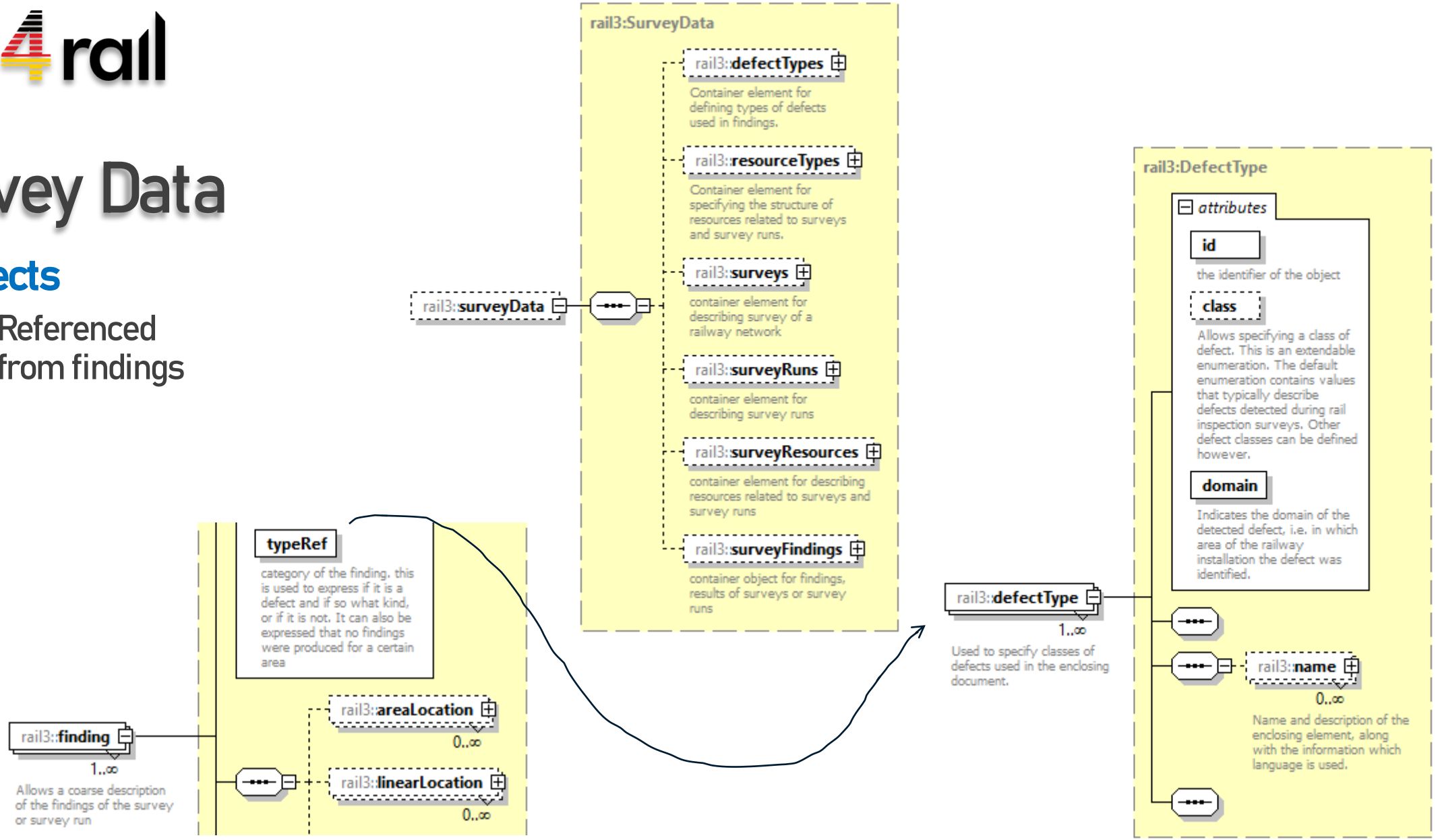
Survey Data

- **Defects**
  - Referenced from findings



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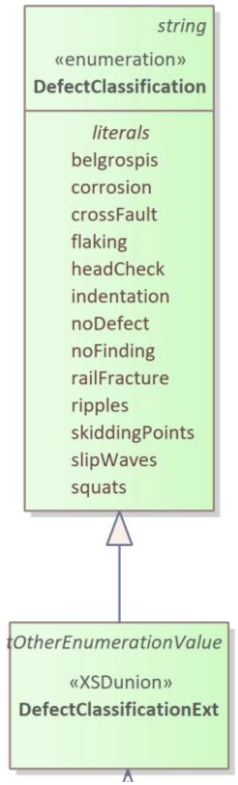
Survey Data

- **Defects**
  - Referenced from findings



belgrospis	documentation Belgrospis are periodic crack nests at the edge of the road
corrosion	documentation Corrosion of the rail
crossFault	documentation Cross faults are cracks that run perpendicular to the direction of travel
flaking	documentation material breakouts on the running edge of the rail in the longitudinal direction of the rail. Not to be confused with HeadCheck. The continuous, typical crack band of the HeadCheck rail defect is not present.
headCheck	documentation Head checks are fine surface cracks that occur at a distance of 2-7 mm, which occur at a 45° angle to the direction of travel
indentation	documentation Indentations are caused by the rolling over of foreign bodies.
noDefect	documentation No defect was detected
noFinding	documentation No finding available. This value indicates that no measurement was taken, possibly due to equipment failure.
railFracture	documentation Rail fracture refers to the complete failure of the rail so that the track can no longer be used.
ripples	documentation Ripples are quasi-periodic uneven running surfaces in straight tracks and track curves of larger radii with wavelengths of around 2 to 10 cm and depths of 0.01 to 0.4 mm.
skiddingPoints	documentation Skidding points occur when drive wheel sets start to skid during start-up. The resulting heat converts the pearlite in the steel into martensite.
slipWaves	documentation Slip waves or short waves are periodic surface irregularities with lengths of 5 to 30 cm and a depth of 0.1-1 mm.
squats	documentation Squats are depressions on the rail head that are initially visible as small, black dots, but then enlarge and form a semi-circular or V-shaped crack, with the opening of the mould pointing towards the running edge.

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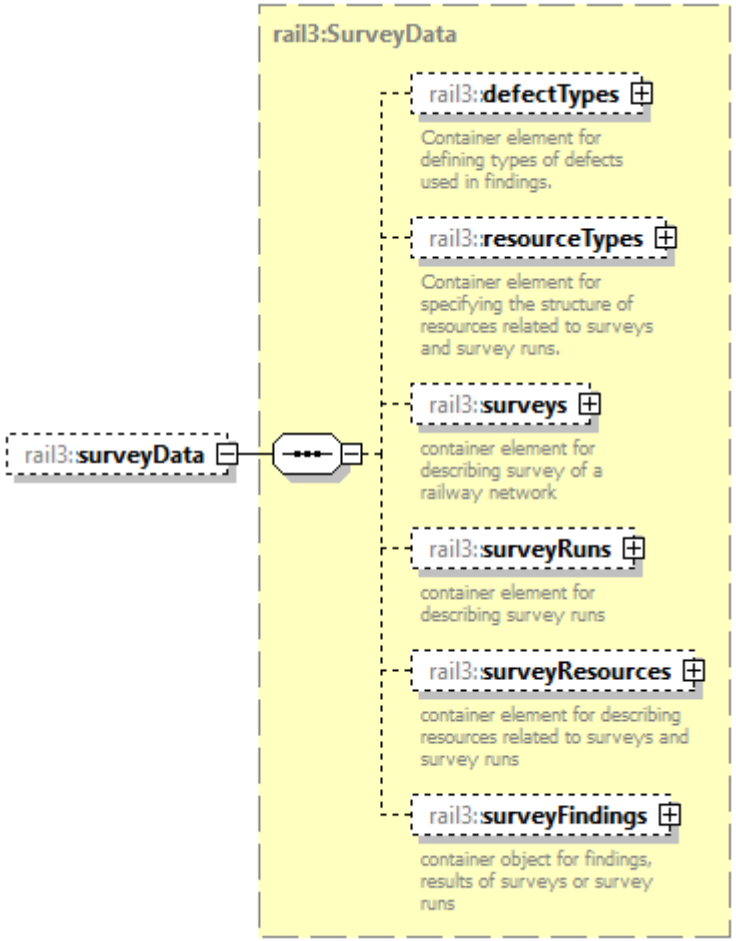
Survey Data

- Summary for Survey Data:
  - Focus of modelling was on extendibility
  - Between fixing things in the standard and keeping it open
  - Solution allows importing software to understand basic structure
  - Data is kept out of the standard – too many different aspects
  - Data is kept in external resources – too much data for any markup language



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Vielen Dank für Ihre Aufmerksamkeit!

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Impressum

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Autor:	Christian Rahmig (DLR), Milan Hoffmann (railML.org e.V.)
Institut:	Verkehrssystemtechnik (TS)
Bildquellen:	divers, siehe jeweilige Folie

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