Conférence Européenne des Directeurs des Routes

Conference of European Directors of Roads

AMSFree

CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME

Exchange and exploitation of data from Asset Management Systems using vendor free format

Deliverable 4.2/4.3

Information Container for Road Maintenance Planning and Bridge Condition Assessment

February 2021

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1 Introduction

In this report, the detailed data models for the exchange of information for the asset management of bridges and roads are presented as examples. As explained in report 3.2, the information is exchanged between different actors based on information containers according to ISO 21597. Individual ontologies are used so that the information containers can be evaluated in a uniform way and supplemented in a country-specific way. Some ontologies already exist (e.g. results of the INTERLINK project). Other ontologies had to be newly created so that all information can be handled in a uniform approach.

Example data exchange for maintenance planning and bridge inspection will be presented. Existing standards and procedures from the individual countries were considered during implementation. For this purpose, corresponding templates were evaluated and converted into data models.

2 Maintenance planning of roads

Maintenance planning is an important part of overall asset management. In addition to Report 3.2, the use case "maintenance planning" for roads with asphalt pavements is explained and implemented.

2.1 Data exchange

The process for maintenance planning is described in the report 4.1 in detail. In the following, a simplified process description is used, which only considers data exchange (see Figure 1).

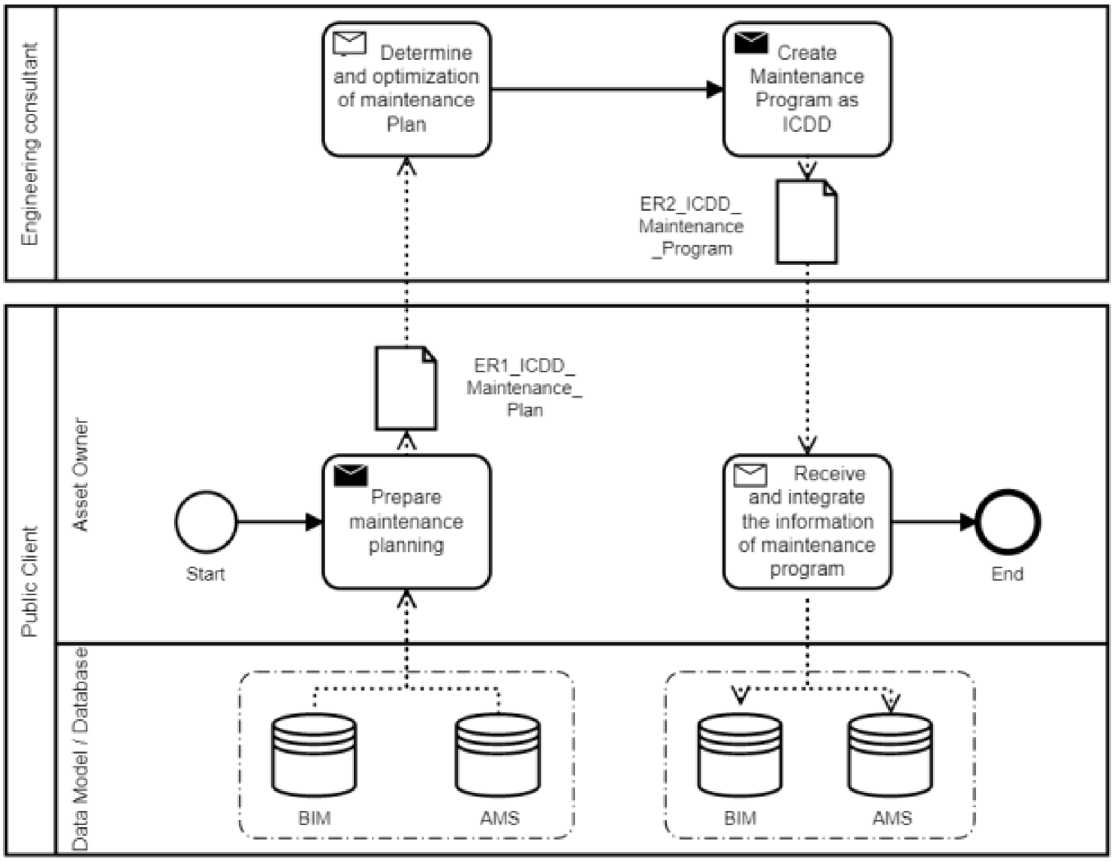


Figure 1: Data exchange for maintenance planning of roads

In general, two information containers are used (see Figure 2). The first container holds the fundamental information needed for maintenance planning. The second container returns the results represented as a maintenance plan.

Process Model			
Name:	PM_MaintenancePlanning		
Identifier:			
Autors:			
Create Date:			
Document Owner:			
Task	**Name**		**Description of Task**
	Prepare Maintenance Planning		Asset Owner requests for the maintenance planning and prepares the ICDD: - extracting parts of the IFC model - dipiction of condition assessment regarding road section - using a template for the maintenance program
	Determine and optimization of maintenance plan		The engineering consultant receive the ICDD for maintenance planning - considering the condition of road section - defining the need of maintenance - optimization of maintenance plan
	Create ICDD Condition Assessment		The engineering consultant stores the result of maintenance program in the ICDD: - in according to the data model "ER1_ICDD_Maintenance_Plan" - linking the different information - checking the results and fulfillment of the information requirements The result of maintenance program are delivered in the form of ICDD
	Receive and integrate the information of maintenance program ICDD Condition Assessment		Asset Manager receive the ICDD, the data will be saved back to the BIM/AMS.
Exchange Requirements	**Name**	**Type**	**Description of Dokumentation**
	ER1_ICDD_Maintenance_Plan	ICDD	Information Container for linked Document delivery with all necessary information for preparing the maintenance program.
	ER2_ICDD_Maitenance_Program	ICDD	Information Container for linked Document deliverey with results of the maintenance program
Object Data	**Name**	**Type**	**Description of Object Data**
	BIM	ifc	An as-built model using IFC
	AMS	-	Asset management system for storing the condition and maintenance results

Figure 2: Description of tasks, requirements and data for maintenance planning of roads

2.2 *Information containers*

The information containers mainly comprise three parts describing the ontology resources, documents and data triples (see Figure 3).

Exchange Requirements Model		
Name:	Road Maintenance Plan	
Identifier:	ER1_ICDD_Maintenance_Plan	
Description:	**Name**	**Type**
Index:		
	Index.rdf	rdf
Ontology Resources:		
	Container.rdf	rdf
	LinkSet.rdf	rdf
	AsphaltCondition.rdf	rdf
	MaintenanceProgram.rdf	rdf
Payload Dcuments:		
	RoadModel.ifc	ifc
	RoadSections.ifc	ifc
	Condition.xml	xml
	MaintenanceProgram.xsd	xsd
Payload triples:		
	RoadSectionCondition.rdf	rdf

Exchange Requirements Model		
Name:	Road Maintenance Program	
Identifier:	ER2_ICDD_Maintenance_Program	
Description:	**Name**	**Type**
Index:		
	Index.rdf	rdf
Ontology Resources:		
	Container.rdf	rdf
	LinkSet.rdf	rdf
	AsphaltCondition.rdf	rdf
	MaintenanceProgram.rdf	rdf
Payload Dcuments:		
	RoadModel.ifc	ifc
	RoadSections.ifc	ifc
	Condition.xml	xml
	MaintenanceProgram.xml	xml
Payload triples:		
	RoadSectionCondition.rdf	rdf
	RoadSectionMaintenance.rdf	rdf

Figure 3: Information containers for maintenance planning of roads

Ontology Resources

Container.rdf and *LinkSet.rdf* are the standard ontologies for defining the documents and the links of the container.

AsphaltCondition.rdf is an ontology to capture the condition of roads comprising asphalt construction. Since the evaluation of the condition of asphalt is carried out according to national standards, the presented ontology includes only common indicators valid for different countries. The properties can be extended country-specifically by an ontology for each asset owner.

MaintenanceProgram.rdf is an ontology to describe the recommend actions related to specific locations. The ontology contains only essential data for the creation of a maintenance program. It is defined in a very general way to be used for maintenance planning in different countries.

Payload Documents

RoadModel.ifc describes the as-built model of the road using IFC format. The model contains all relevant geometric and semantic information required for maintenance planning. Furthermore, planning fundamentals, e.g. road classification, traffic volume, are attached to corresponding model elements as additional properties. The road model will not be modified during maintenance planning. Additional information to be managed later in the asset management system is added to the BIM model as external information or additional properties.

RoadSections.ifc describes the homogenous sections of the road model, which are linked with condition data. The length of each section can be defined individually based on national specifications.

Condition.xml contains the asphalt condition values for each road section. The *AsphaltCondition.rdf* ontology is used to classify each piece of information. The condition values are taken from existing road agency asset management systems and passed in this file.

MaintenanceProgram.xsd defines the data schema for storing a maintenance program. it contains the action of maintenance related of the road sections.

MaintenanceProgram.xml stores the results of the maintenance program. Each maintenance suggestion can apply to one or more road sections.

Payload Triples

RoadSectionCondition.rdf contains the links between the road sections and the condition data using the payload documents *RoadModel.ifc*, *RoadSections.ifc* and *Condition.xml.*

RoadSectionMaintenance.rdf contains the links between the road sections and the defined maintenance using the payload documents *RoadSections.ifc* and *MaintenanceProgram.xml*.

Figure 4 shows a schematic representation of the documents with the links to exchange information about the condition and maintenance plan for roads

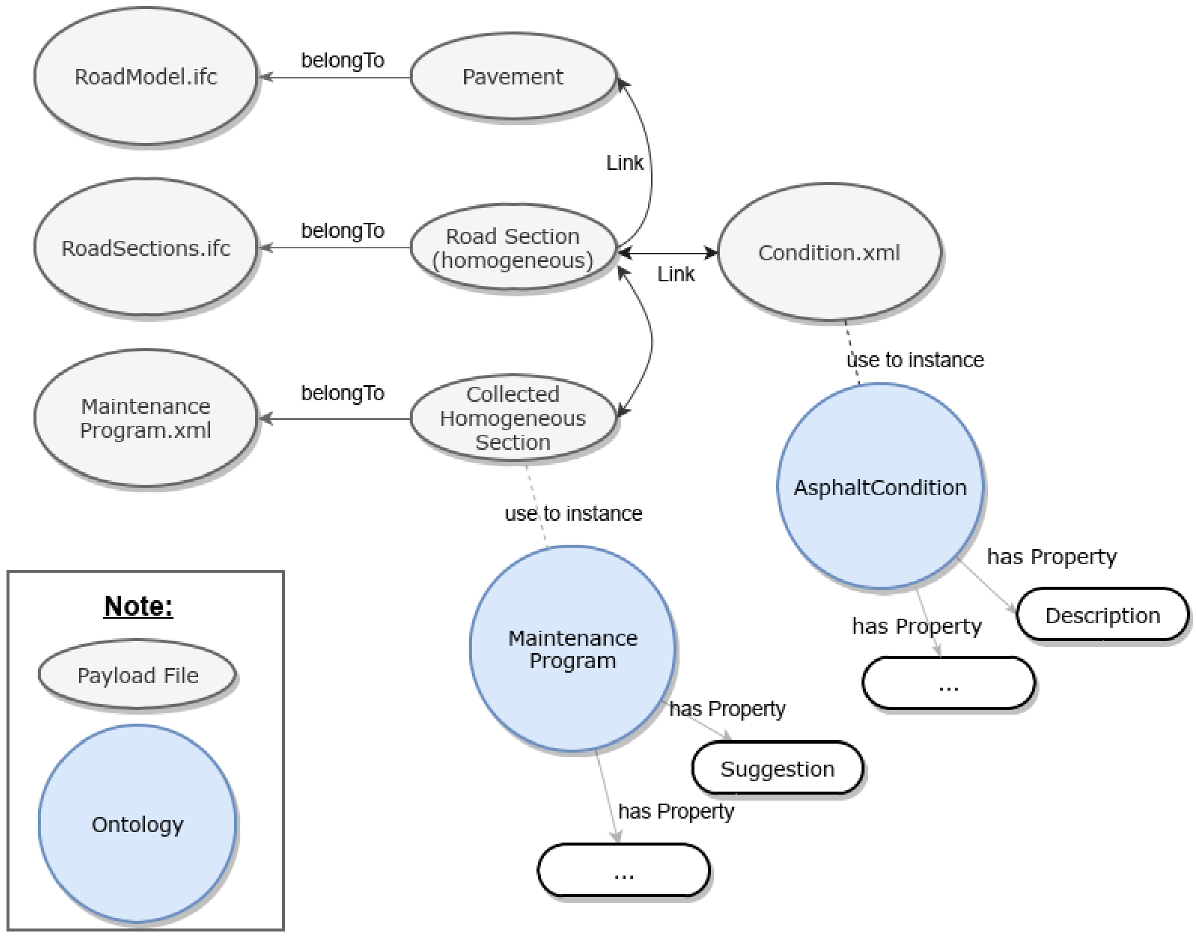


Figure 4: Relations of the information container for the maintenance planning of roads

2.3 *Property sets for asphalt pavements*

The data sets given in Report 4.1 are used to describe the condition of asphalt pavements in detail. The data sets are implemented as extended property sets using the IFC, which are then attached to the corresponding pavement segment and layers of a road model. To ensure that the additional properties can also be queried uniformly, an ontology is defined. This means that the condition information can also be stored in a separate file based on the ontology. The external file with the condition information is then only linked to the model and not directly integrated (cf. Figure 4). Both options can be used to provide the information needed for maintenance planning. The following section shows the extended property sets (ePset) for asphalt performance and asphalt condition rating.

2.3.1 Asphalt performance

The following properties can be used for describing the asphalt performance.

ePSET_Fatique_FourPointFlexuralTest

Name	Property Type	Data Type	Description

e6	P_SINGLEVALUE	IfcReal	strain, corresponding a long-term durability of 106 cycles
A0	P_SINGLEVALUE	IfcReal	parameter A0 of fatigue curve
A1	P_SINGLEVALUE	IfcReal	parameter A1 of fatigue curve

ePSET_Fatique_DynamicIndirectTensileTest

Name	Property Type	Data Type	Description
NMakro	P_SINGLEVALUE	IfcReal	cycles-to-failure
C1	P_SINGLEVALUE	IfcReal	material-specific parameter of fatigue function
C2	P_SINGLEVALUE	IfcReal	material-specific parameter of fatigue function
eel,anf	P_SINGLEVALUE	IfcReal	initial elastic expansion, at 100. load change
|E|100	P_SINGLEVALUE	IfcReal	stiffness modulus after 100 cycles

ePSET_Deformation_WheelTracking

Name	Property Type	Data Type	Description
RDair	P_SINGLEVALUE	IfcReal	rut depth
PRDair	P_SINGLEVALUE	IfcReal	proportional rut depth

ePSET_Deformation_UniaxialCompressiveStrengthTest

Name	Property Type	Data Type	Description
Ɛw*	P_SINGLEVALUE	IfcReal	strain rate at point of inflexion
Ɛw	P_SINGLEVALUE	IfcReal	strain at point of inflexion
n	P_SINGLEVALUE	IfcReal	number of cycles til point of inflexion
n oder Ɛ	P_SINGLEVALUE	IfcReal	stop criterion (n=10.000 or strain = 40‰)

ePSET_Deformation_TriaxialCompressiveStrengthTest

Name	Property Type	Data Type	Description
fc	P_SINGLEVALUE	IfcReal	creep rate
en	P_SINGLEVALUE	IfcReal	total axial deformation
A	P_SINGLEVALUE	IfcReal	regression parameter 1
B	P_SINGLEVALUE	IfcReal	regression parameter 2

ePSET_Deformation_DynamicIndenterTest

Name	Property Type	Data Type	Description
fc,Ende	P_SINGLEVALUE	IfcReal	creep rate
eEnde	P_SINGLEVALUE	IfcReal	plastic compressive strain
epd,w	P_SINGLEVALUE	IfcReal	plastice compressive strain at point of inflection
nw	P_SINGLEVALUE	IfcReal	number of cycles til point of inflexion
fc,w	P_SINGLEVALUE	IfcReal	strain rate at point of inflexion

ePSET_Stiffness_DynamicIndirectTensileTest

Name	Property Type	Data Type	Description
T	P_SINGLEVALUE	IfcReal	test temperature
eel	P_SINGLEVALUE	IfcReal	elastic strain
|E*|	P_SINGLEVALUE	IfcReal	stiffness modulus

ePSET_Stiffness_FourPointFlexuralTest

Name	Property Type	Data Type	Description
e6	P_SINGLEVALUE	IfcReal	strain, corresponding a long-term durability of 106 cycles
A0	P_SINGLEVALUE	IfcReal	parameter A0 of fatique curve
A1	P_SINGLEVALUE	IfcReal	parameter A1 of fatique curve

ePSET_LowTempPerformance_CoolingTest

Name	Property Type	Data Type	Description
Tc	P_SINGLEVALUE	IfcReal	breaking point
σc	P_SINGLEVALUE	IfcReal	breaking stress
σkry (T)	P_SINGLEVALUE	IfcReal	cryogenic tensile stress progress

ePSET_LowTempPerformance_UniaxialTensionTest

Name	Property Type	Data Type	Description
T	P_SINGLEVALUE	IfcReal	test temperature
Ɛbreak	P_SINGLEVALUE	IfcReal	breaking elongation
βt	P_SINGLEVALUE	IfcReal	tensile strength

ePSET_LowTempPerformance_UniaxialDynamicTensileTest

Name	Property Type	Data Type	Description
|E*|100	P_SINGLEVALUE	IfcReal	stiffness modulus

NBr	P_SINGLEVALUE	IfcReal	cycles-to-failure

2.3.2 Asphalt condition assessment

The following properties can be used for describing the condition of an asphalt pavement.

ePSET_LongitudinalEveness

Name	Property Type	Data Type
SpectralDensityOfUneveness_AUN	P_SINGLEVALUE	IfcReal
IndicatorOfLongitudinalEveness_LWI	P_SINGLEVALUE	IfcReal
WeightedLongitudinalProfile_DBL	P_SINGLEVALUE	IfcReal
InternationalRoughnessIndex_IRI	P_SINGLEVALUE	IfcReal
StandardDeviationOfAngleValue_Sw	P_SINGLEVALUE	IfcReal

ePSET_TransverseEveness

Name	Property Type	Data Type
MeanRutDepth_MSPT	P_SINGLEVALUE	IfcReal
RutDepth_SR	P_SINGLEVALUE	IfcReal
TrackDepth_T	P_SINGLEVALUE	IfcReal
TheoreticalWaterDepth_MSPH	P_SINGLEVALUE	IfcReal

ePSET_Roughness

Name	Property Type	Data Type
SidewayForceCoefficient_ µSKM	P_SINGLEVALUE	IfcReal
MeasuringSpeed_v	P_SINGLEVALUE	IfcReal
FrictionCoefficient_ µRS	P_SINGLEVALUE	IfcReal

ePSET_Surface_Cracks

Name	Property Type	Data Type
AffectedArea_RISS	P_SINGLEVALUE	IfcReal
Cracks_RI	P_SINGLEVALUE	IfcReal
AffectedArea_RSFA	P_SINGLEVALUE	IfcReal
JointDamage_ONA	P_SINGLEVALUE	IfcReal
Patches_FLI	P_SINGLEVALUE	IfcReal

Inserted_Patches_EFLI	P_SINGLEVALUE	IfcReal
CoatedPatches_AUFLI	P_SINGLEVALUE	IfcReal
Raveling_AUS	P_SINGLEVALUE	IfcReal
AccumulationBinder_BIN	P_SINGLEVALUE	IfcReal
SurfaceSmoothness_M_OF	P_SINGLEVALUE	IfcLabel
CoatingDamages_M_BS	P_SINGLEVALUE	IfcLabel
CoatingDeformation_M_BV	P_SINGLEVALUE	IfcLabel
StructuralDamages_M_SS	P_SINGLEVALUE	IfcLabel
Patches_M_FLI	P_SINGLEVALUE	IfcLabel
SurfacDamages_OS	P_SINGLEVALUE	IfcReal

ePSET_BearingCapacity

Name	**Property Type**	**Data Type**
BearingCapacity_Benk	P_SINGLEVALUE	IfcReal
BearingCapacity_TSD	P_SINGLEVALUE	IfcReal
BearingCapacity_FWD	P_SINGLEVALUE	IfcReal

ePSET_Texture

Name	**Property Type**	**Data Type**
MeanProfileDepth_MPD	P_SINGLEVALUE	IfcReal

ePSET_Acustic

Name	**Property Type**	**Data Type**
SoundPressureLevel_Lp	P_SINGLEVALUE	IfcReal

ePSET_Refelction

Name	**Property Type**	**Data Type**
luminance_Lv	P_SINGLEVALUE	IfcReal

2.4 Ontologies for maintenance planning of roads

2.4.1 Asphalt condition ontology (ACA)

Condition assessment provides important information for determining maintenance needs. To create information containers for maintenance planning, an ontology for asphalt condition assessment has been defined (see Figure 5). The same properties are used as in the example for using a property set (see Chapter 2.3). The ontology for asphalt condition assessment has the prefix aca. The ontology consists of eight main classes shown in Figure 5. The class *aca:SurfaceProperties* contains further subclasses for details condition of pavement surface.

In addition to the classes, associated DatatypeProperty are also defined as shown in the right side of Figure 5. This whole ontology is presented in Appendix 7.1.

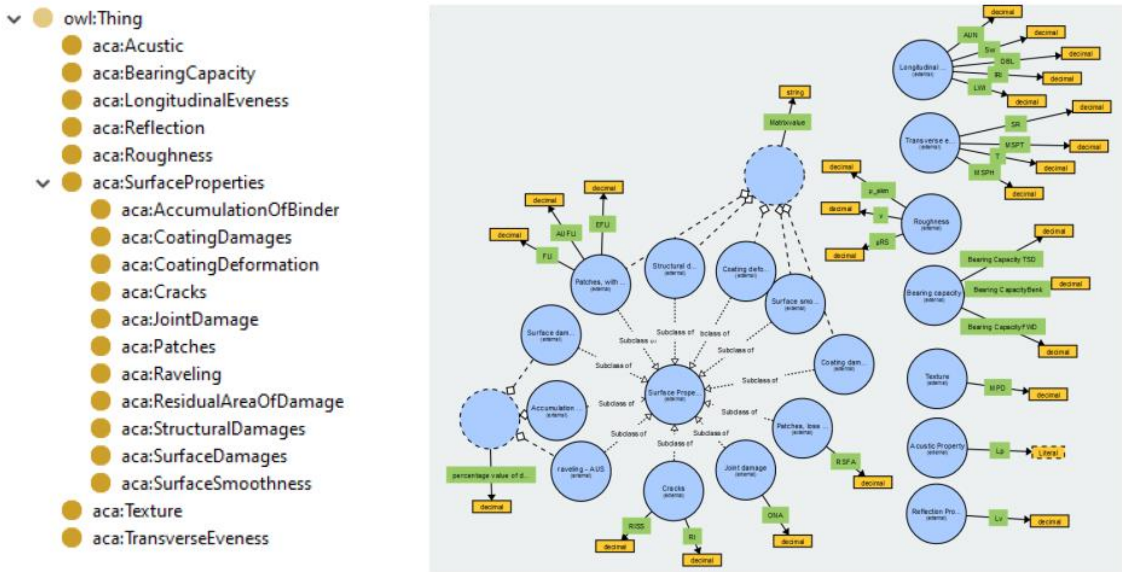


Figure 5: Asphalt condition assessment ontology (ACA)

2.4.2 Maintenance program ontology (MAINTP)

The maintenance location is described using a name or identifier of the road, the start station, the end station, and the lane. For the maintenance action, information about the type of action, a detailed description, the recommended year for performing the action and the estimated costs are stored in the ontology. The maintenance program ontology is created with prefix *maintp*. It contains two classes *maintp:Location* and *maintp:Measure* as shown in Figure 6. Each class include the DataTypeProperty for the basic information as shown in Figure 6 on the right side. This ontology can be extended for individual needs. This whole ontology is presented in Appendix 7.2.

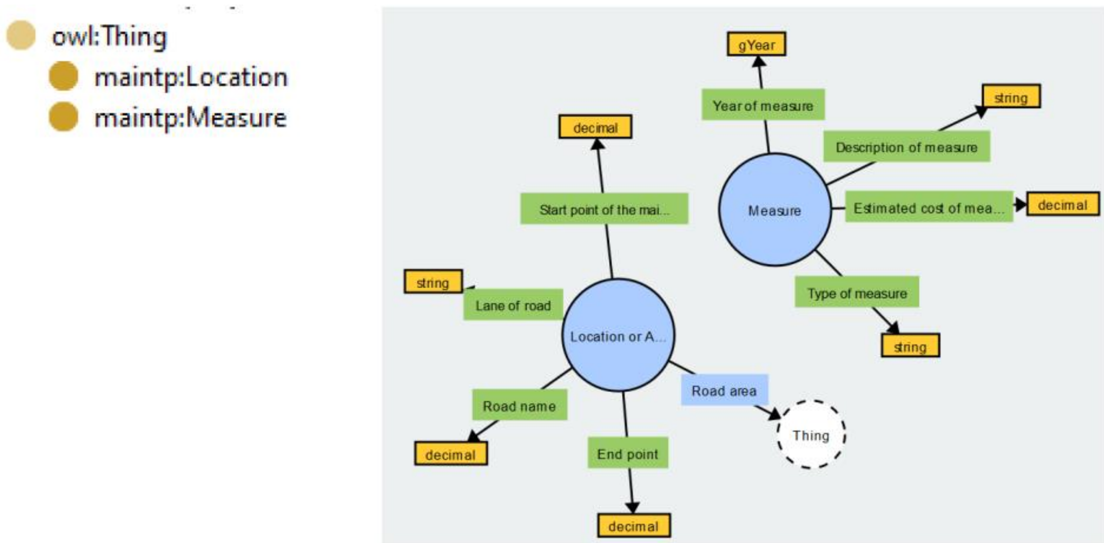


Figure 6: Maintenance program ontology (MAINTP)

2.5 Maintenance program

A maintenance program is delivered as result of the maintenance planning. The essential information can be modelled as instances of the maintenance program ontology, which can be linked with road sections. Currently, no specific report template for the maintenance program has been provided by the road administrations as an example. The developed report template of maintenance program as XML schema contains some meta information about the road, the corresponding engineer consultant and the recommend actions as shown in Figure 7. The XML schema is presented in Appendix 7.3.

Meta information of the road

Meta information of maintenance planning

Maintenance program of road section

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema targetNamespace="http://amsfree.eu/MaintenanceProgram"
    elementFormDefault="qualified"
    xmlns="http://amsfree.eu/MaintenanceProgram"
    xmlns:mstns="http://amsfree.eu/MaintenanceProgram"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
>
  <xs:element name="MaintenanceProgram" type="MaintenanceProgramType"/>
  <xs:complexType name="metadataPavementType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="adminAuthority"/>
      <xs:element type="xs:string" name="roadID"/>
      <xs:element type="xs:string" name="roadName"/>
      <xs:element type="xs:string" name="roadDesign"/>
      <xs:element type="xs:gYear" name="constructionYear"/>
      <xs:element type="xs:string" name="pavementTypeMaterial"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="metaDataMaintenancePlanType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="consultEngineer"/>
      <xs:element type="xs:string" name="consultDate"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="headerType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:short" name="MaintenanceYear"/>
      <xs:element type="metadataPavementType" name="metadataPavement"/>
      <xs:element type="metaDataMaintenancePlanType" name="metaDataMaintenancePlan"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="roadSectionType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="typeMeasure"/>
      <xs:element type="xs:string" name="descriptionMeasure"/>
      <xs:element type="xs:gYear" name="measureYear"/>
      <xs:element type="xs:float" name="measureEstimatedCost"/>
    </xs:sequence>
    <xs:attribute type="xs:float" name="startPoint" use="optional"/>
    <xs:attribute type="xs:float" name="endPoint" use="optional"/>
  </xs:complexType>
  <xs:complexType name="measureType">
    <xs:sequence>
      <xs:element type="roadSectionType" name="roadSection" maxOccurs="unbounded" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="tableType">
    <xs:sequence>
      <xs:element type="measureType" name="measure"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="MaintenanceProgramType">
    <xs:sequence>
      <xs:element type="headerType" name="header"/>
      <xs:element type="tableType" name="table"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

Figure 7: Maintenance program as XML schema

3 Bridge Condition Assessment

3.1 Ontology resources

3.1.1 Bridge classification ontologies

In the context of bridges, ontologies provide unambiguous names of bridge elements and a clear explanation of their meaning. For the information containers, bridge classification ontologies will represent a supplementary information, improving readability of the payload documents, i.e. IFC files. In other words, ontologies will serve as some kind of a key for reading an IFC file. By providing an ontology for bridge element classification, any NRA will be able to relate any part of its inventory with specific IFC elements, or groups of elements.

Using ontologies to classify bridge elements, two existing gaps for linking different IAMS with BIM models are addressed. The first one is caused by the different bridge decomposition (i.e. element hierarchy) used in various NRAs, whereas the second one is caused by different classification of structural elements between NRAs. Figure 8 illustrates a typical bridge decomposition difference between NRAs. For clarity, only the bridge structure is considered. Red arrows represent a hierarchical approach, whereas blue arrows represent direct decomposition. The bridge is firstly decomposed in two general element groups (red arrows): superstructure and substructure. Afterwards, each group is decomposed into separate elements. The blue arrows, on the other hand, show an approach where the bridge is directly decomposed into separate elements. In practice, this means that the “red”, approach enables an information to refer to the entire substructure or superstructure, as well as to separate elements. The “blue” approach, however, limits this information referencing only to separate elements.

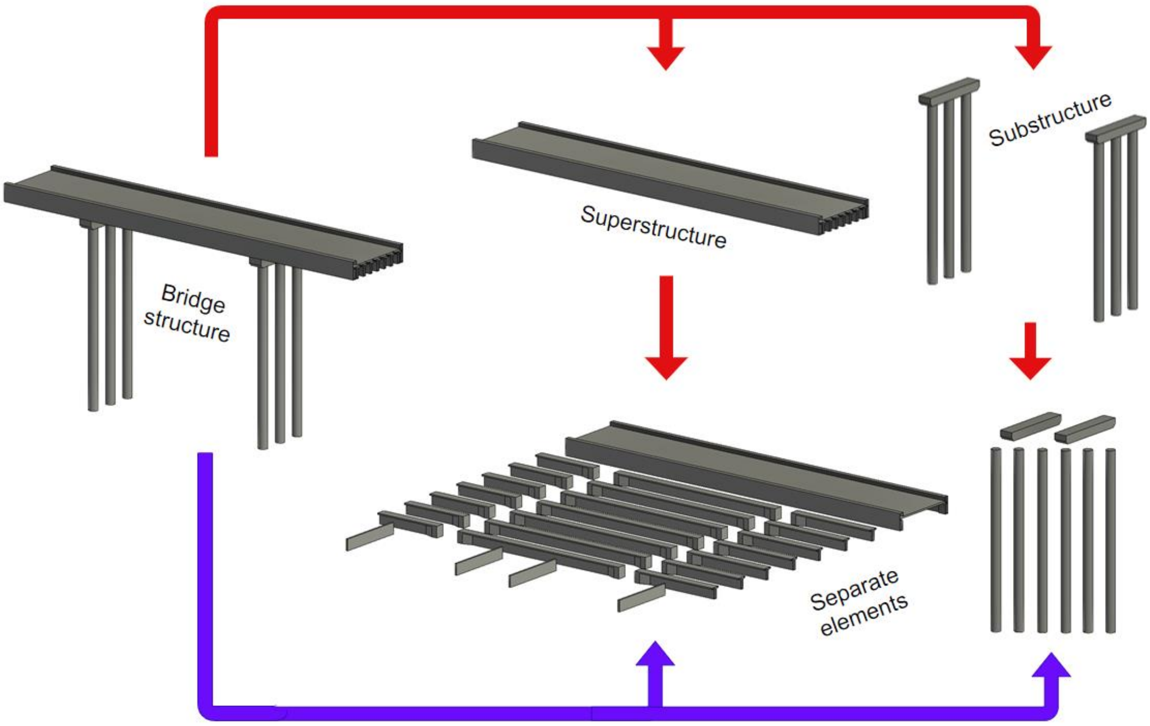


Figure 8: Different approaches of bridge structure decomposition used in different NRAs

The classification difference is mainly related with language differences but is also a result of differently established bridge management practices between countries. The lack of definitions of bridge-specific concepts in the official schema releases of the IFC data format, and limited export capabilities of the commercial BIM software are perhaps the most important implementation issues. By relating the IFC model with the element classification ontology, each bridge element will be associated with the corresponding label from the ontology. This means that element semantics will be independent of the IFC entity representing it. This means that every bridge element could be modelled as IfcBuildingElementProxy (IFC 4.0.2.1) or IfcBuiltElement (IFC 4.3), but it would be assigned to element type according to the provided element classification ontology before introducing to the IAMS. Therefore, the proposed approach fully complies with both the official IFC 4.0.2.1 scheme (BuildingSMART International, 2020), as well as with any upcoming release.

3.1.1.1 Germany

The German federal highway research institute (Bundesanstalt für Straßenwesen - BASt) defines all terms relevant for the description of infrastructure assets in a hierarchically structured catalog called “Anweisung Straßeninformationsbank für Ingenieurbauten, Teil-system Bauwerksdaten (ASB-ING)”. According to ASB-ING (Bundesanstalt für Straßenwesen (BASt), 2013), a civil engineering structure can consist of the components such as superstructure, substructure, structure, prestressing, foundations, ground and rock anchors, bridge cables and ropes, bearings, roadway transitions, sealings, coverings, caps, protective devices, and others. For each of the listed components, the ASB-ING defines its subcomponents.

Within the scope of the research project INTERLINK, an ASB-ING ontology for classification of structural assets is automatically generated. It includes 9500 object types (O’Keeffe, Weise, van Lanen, Hoel, & Stolk, 2018). Figure 9 shows classification ontology snippets illustrating bridge superstructure classes, and their subclasses.

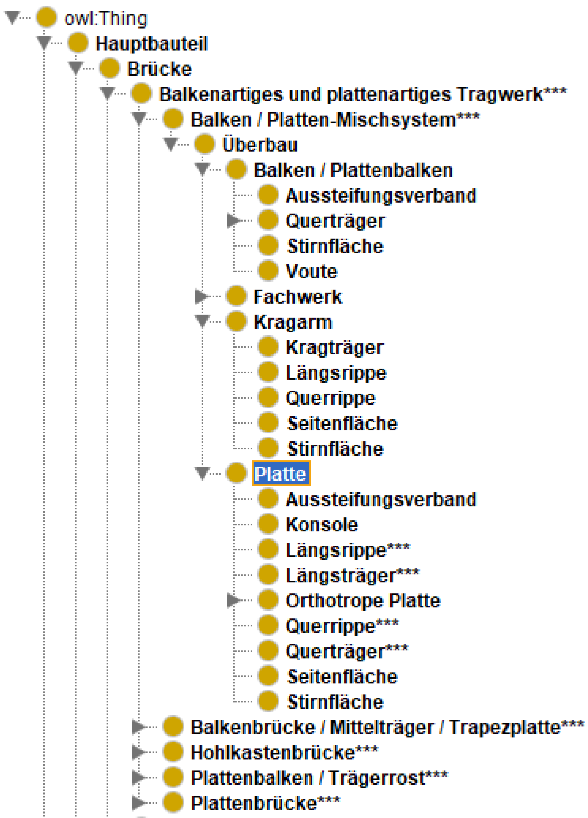


Figure 9: ASB-ING Classification ontology. Class hierarchy snippet showing bridge (beam/slab mixed system) superstructure (Brücke:Balken/Platten-Mischsystem:Überbau) classes.

3.1.1.2 Denmark

The Danish NRA, Vejdirektoratet, provides neither a formal bridge element classification ontology, nor an informal catalogue of concepts describing infrastructure assets. However, Vejdirektoratet uses a consistent element naming convention in the bridge inspection instructions as well as in the provided inspection reports and element hierarchy example (Vejdirektoratet, 2020). Based on these documents, an element classification ontology is generated. The most detailed list of mandatory inspected elements is provided in the Element Hierarchy Example (Vejdirektoratet, 2020), which refers to the New Little Belt Bridge, a 1700 meter long suspension bridge, made of steel and reinforced concrete. Considering the fact that the test case bridge, which will be described in detail in the section 3.2.1, is a 12 meter span reinforced concrete bridge, the provided element hierarchy is reduced to the point where only elements comprising a simple reinforced concrete bridge remain. Figure 10 shows the resulting ontology as a collapsed graph. Expanded class hierarchy is shown in Figure 11. Currently, only the labels and the inheritance concept have been implemented in the resulting ontology.

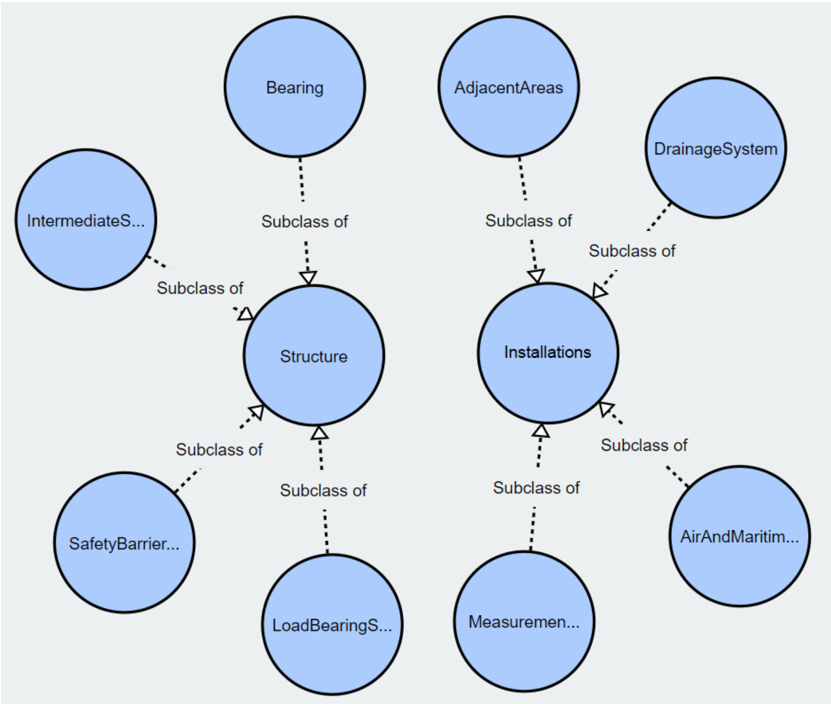


Figure 10: Main classes of the Danish bridge classification ontology

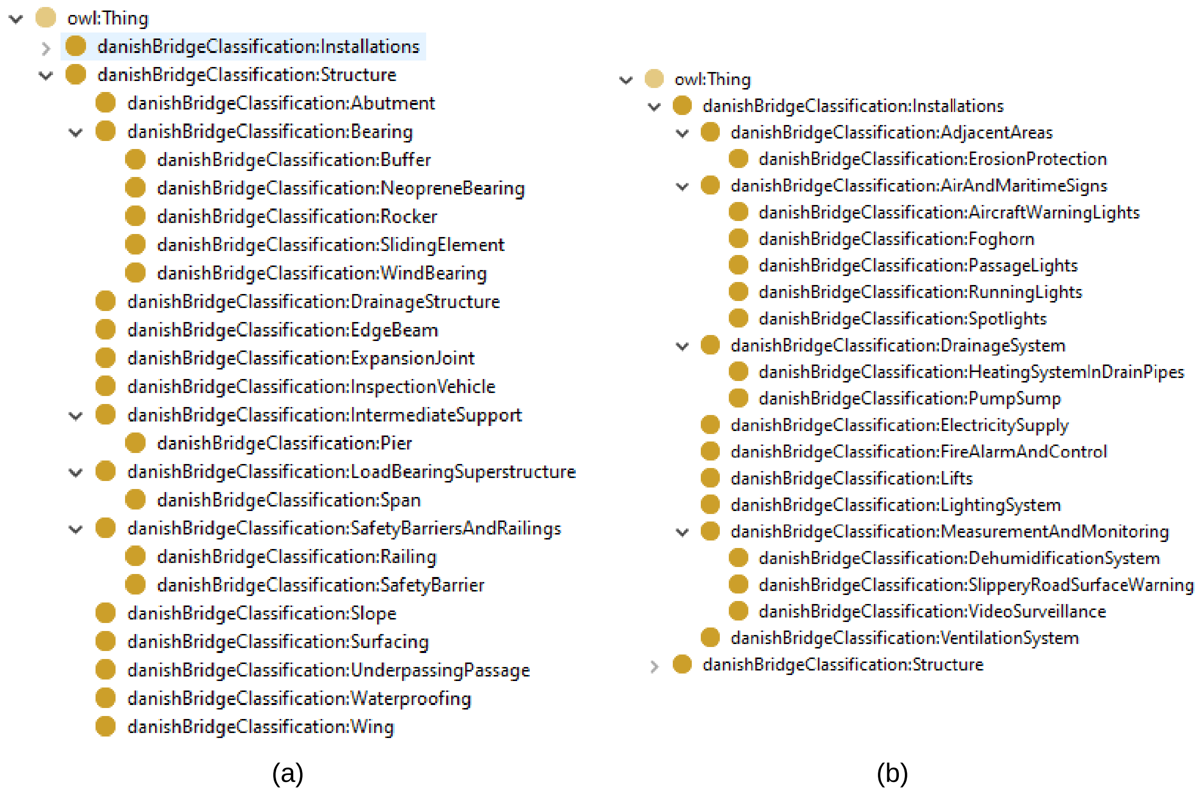


Figure 11: Class hierarchy of the Danish bridge classification ontology:
(a) – structural elements, (b) – installations

3.1.1.3 Netherlands

Originally intended for condition monitoring, the Dutch standard NEN2767 (Royal Netherlands Standardization Institute, 2019), along with its underlying standard for decomposition of infrastructure assets, NEN2767-4 (Royal Netherlands Standardization Institute, 2010), provides detailed guidelines for decomposition of infrastructure assets of all kinds. Besides the hierarchical decomposition standard, Netherlands has a general ontology for the built environment, named CB-NL. A part of this ontology is shown in Figure 12.

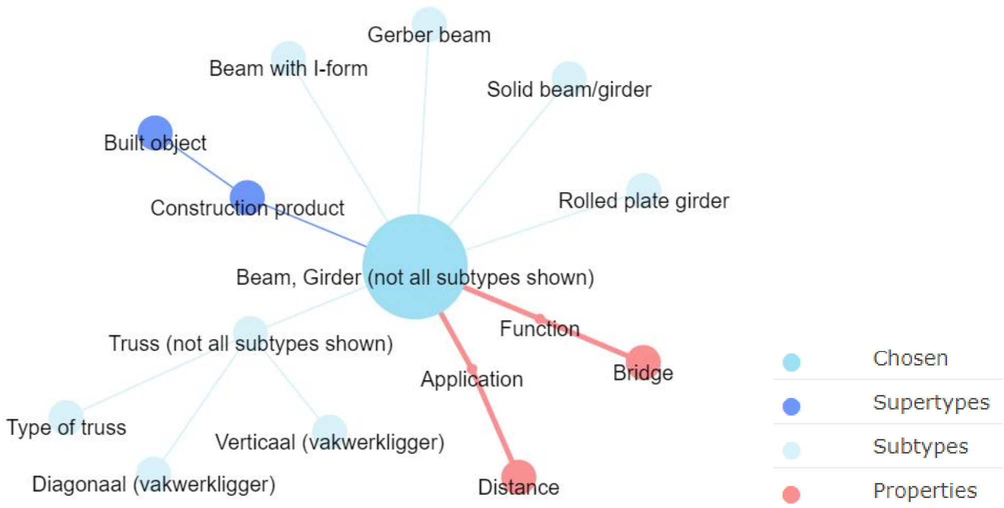


Figure 12: Bridge girder represented by the CB-NL ontology

3.1.2 Damage and condition ontologies

For the classification and description of bridge damage, a damage ontology should be used. When analysing the information needs for describing bridge damages in Germany, Denmark and the Netherlands, the existing ontology "Damage Topology Ontology" presented in Hamdan et al 2019 provides a good basis. According to the relevant national standards and guidelines, this ontology has been extended to include additional classes and properties. These extensions are explained in the following sections.

The main task of a visual bridge inspection is to evaluate the condition of the structure. The determination of a condition rating, the identification of the safety risk, the development of proposals for further inspections or possible maintenance can be the result of a bridge inspection. The requirement for condition assessment depends on the national guideline for damage classification. By analysing the national standards and guidelines, the requirements for condition assessment have been identified. The existing ontology from the INTERLINK project was also investigated. In the following section, the existing ontologies from the INTERLINK project are briefly presented. A state estimation ontology is then developed. All newly created ontologies can be found in the appendix.

3.1.2.1 Germany

In Germany, the national standard DIN 1076 and the guideline for the maintenance of engineering structures "RI-ERH-ING" are used for the condition assessment of bridges. For a visual inspection of a reinforced concrete bridge, the damage description and condition assessment can be recorded using the existing ontology "Concrete Damage Ontology" [Hamdan et al, 2019] and "asb-ing-condition" developed within the INTERLINK project.

Concrete Damage Ontology (CDO and CDOEX)

The Concrete Damage Ontology with prefix cdo is a subclass of the Damage Topology Ontology (DOT). The most common defects of concrete and reinforcement are provided as classes of this ontology. These include the classes cdo:ChemicalDamage for damage caused by chemical aggression, cdo:Crack for cracks in concrete, and cdo:Spalling for spalling in concrete. For further analysis and assessment of the damages, an extension is needed. The extended ontology is defined with the prefix codex as a subclass of DOT. To describe other types of damages, subclasses are created for more detailed classification, for example due to exposed reinforcement (class cdoex:ExposedReinforcement) or insufficient concrete compaction (class cdoex:InsuficientConcreteCompaction). For the most commonly detected damages such as cracks and spalling in concrete, the degree of damage can be captured using the DatatypeProperties cdo:crackWidth and cdo:spallingArea. The ontology is shown in Figure 13. The damage ontology cdo with the extended ontology codex provides thus a possibility to describe the most common damages of a reinforced concrete bridge. This generic ontology can also be used to describe damages in Denmark and the Netherlands.

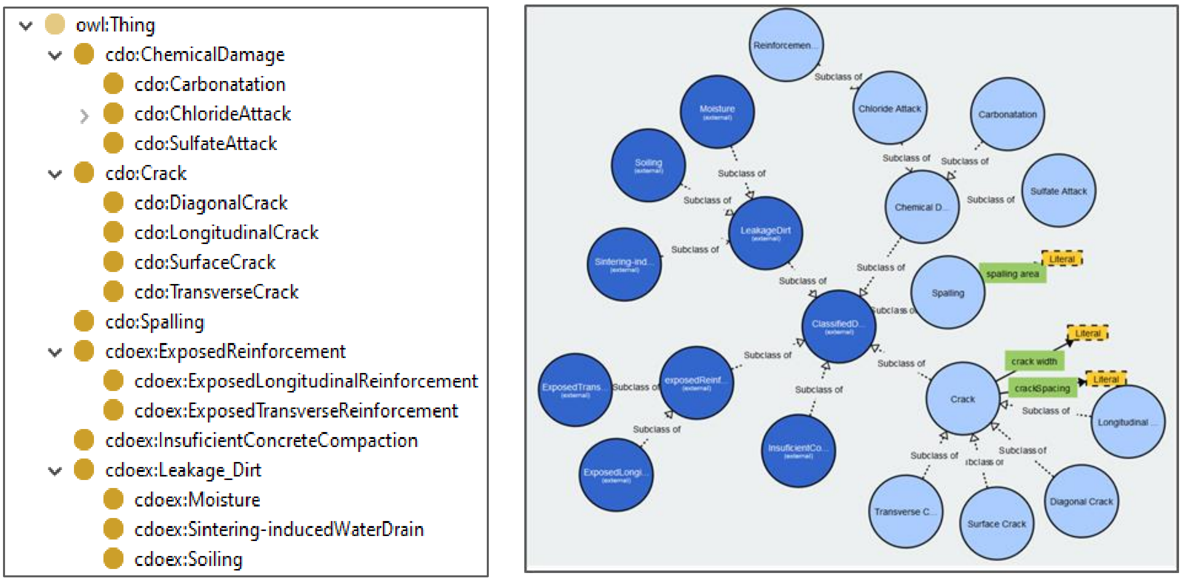


Figure 13: Concrete damage ontology (cdo)

Condition assessment ontology according to ASB-Ing

The condition assessment ontology for the German infrastructure has already been developed by the INTERLINK project. It is based on the guideline "RI-ERH-ING". This ontology with URI http://asbing.de/condition/def/ has no defined prefix. For better understanding, "condition:" is used as prefix in the following description. All classes in this ontology are defined as subclasses of eurol:Condition. As required by the guideline, condition assessment is divided into three classes: condition:Durability, condition:Safety, and condition:Stability. Each class contains five subclasses that perform condition assessment from category 0 for "no impact" to category 4 for "highest impact". The ontology is shown in Figure 14. This condition rating ontology cannot be used for Denmark and the Netherlands.

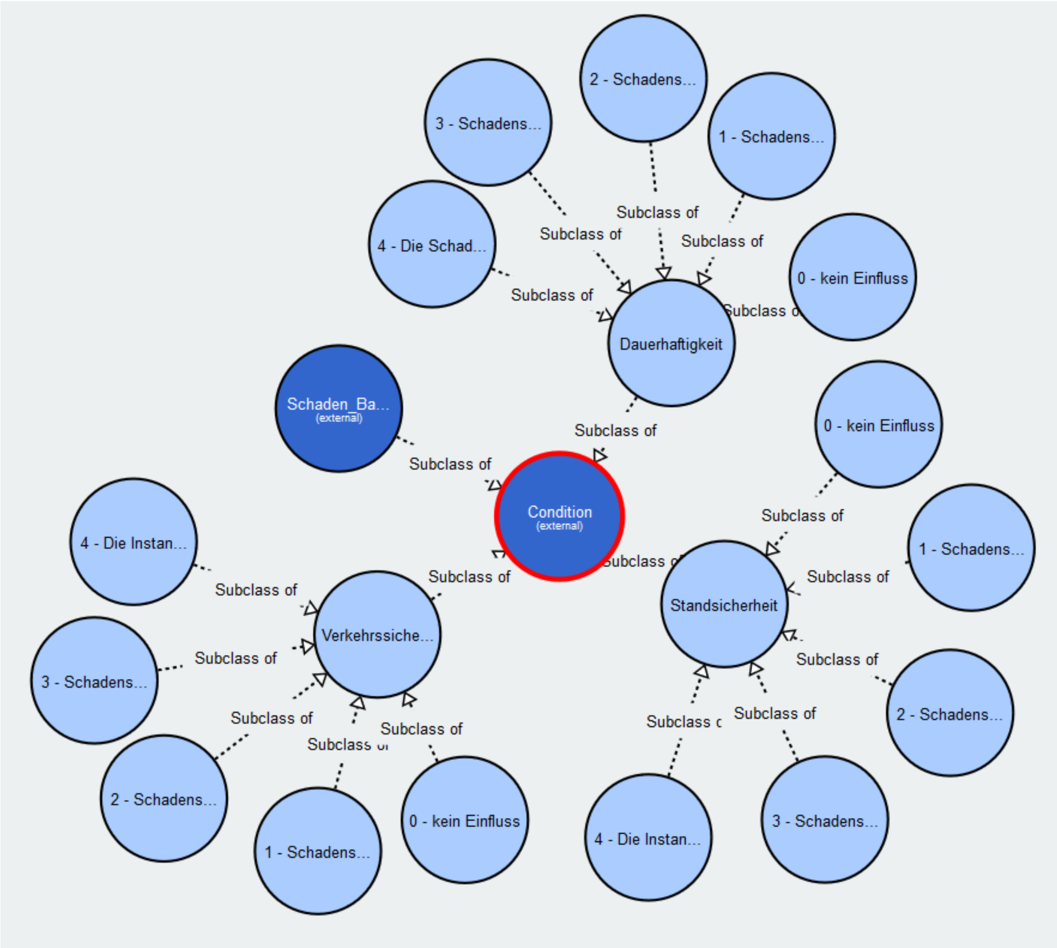


Figure 14: Condition assessment ontology according to ASB-Ing

3.1.2.2 Denmark

Concrete Damage Ontology (CDO and CDOEX)

The analysis of the documents provided by the Danish asset owner did not indicate any specific classification of damages. Therefore, the damage ontology cdo and codex can also be used for bridge inspection in Denmark.

Condition Assessment Ontology (COAS)

For the assessment of the condition of bridge structures, a condition assessment ontology is developed for Denmark with the prefix coas. The ontology is based on the delivered bridge inspection documents from the Danish Road Authority. The main four aspects of the condition assessment are defined as classes in the ontology (see Table 1).

Table 1: Classes of the Condition Assessment Ontology (coas) for Denmark

Aspect of Danish bridge inspection	**Class of *coas***
Condition grade (indicated with form -, 1 to 5)	*coas:GradeOfCondition*
Need of special inspection (indicated with ‘A’ and ‘B’)	*coas:SpecialInspection*
Safety matters (indicated with ‘S’)	*coas:SafetyRisk*
Need of periodic maintenance (indicated with ‘-’ and ‘+’	*coas:PeriodicMaintenance*

Special properties have been defined for capturing the individual values of the condition grade. For example, a Danish indicator coas:ConditionGradeDK is defined to describe the grade of condition. The representation of the ontology can be seen in Figure 15.

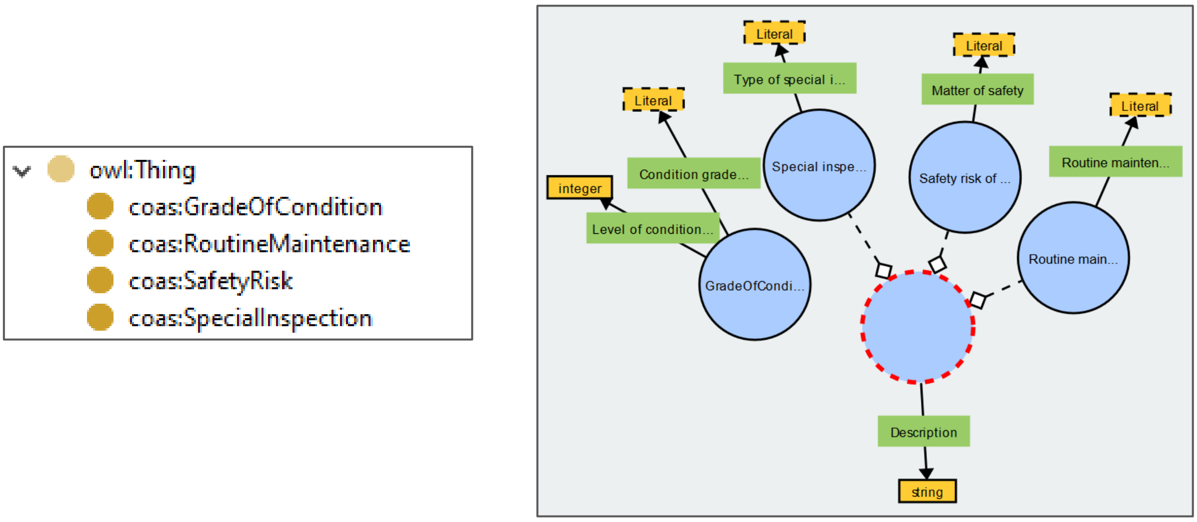


Figure 15: Graphic representation of Condition assessment ontology (*coas*).

3.1.2.3 Netherlands

Concrete Damage Ontology (CDO and CDOEX)

As mentioned in Section 3.1.2.1, the damage ontology can also be used for bridge inspection in the Netherlands.

Condition Assessment Ontology (COAS)

The development of a condition assessment ontology for bridges in the Netherlands could not yet be completed due to late delivery of documents.

3.2 Payload documents

3.2.1 Bridge model

The proposed approach for establishing relations between elements of infrastructure asset from various IAMSs and corresponding BIM elements requires a reasonably fine-grained fragmented BIM. The fragmentation density needs to comply to the depth of the deepest and most detailed element classification hierarchy (as explained in Section 3.1.1, these hierarchies, if exist, are converted into ontologies for further use). Out of three exemplary NRAs, German BASt has the deepest classification ontology, ASB-ING. Thus, the targeted BIM fragmentation density of the test case model complies with the depth of ASB-ING. Figure 16 shows the abutment decomposition according to (Haveresch & Maurer, 2010).

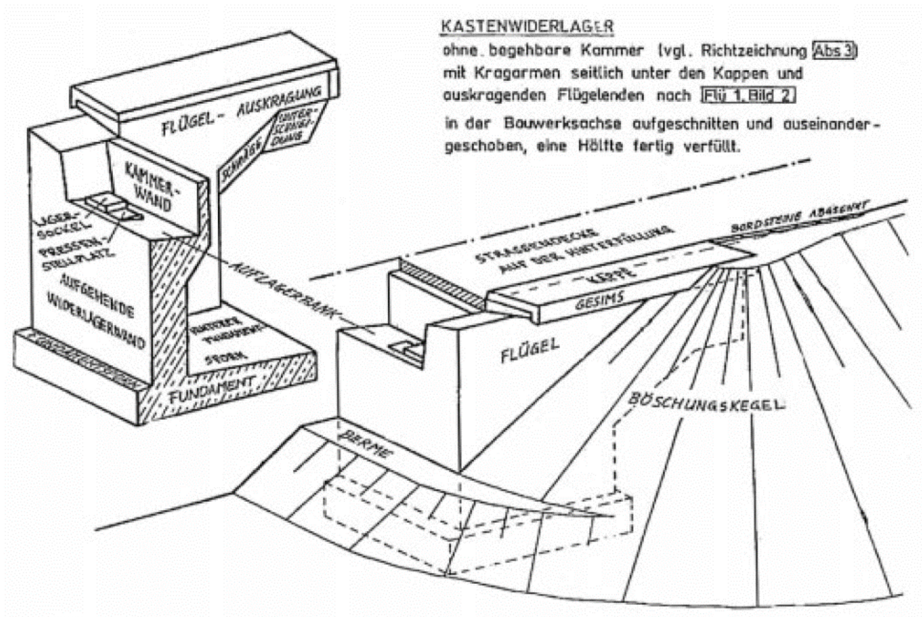
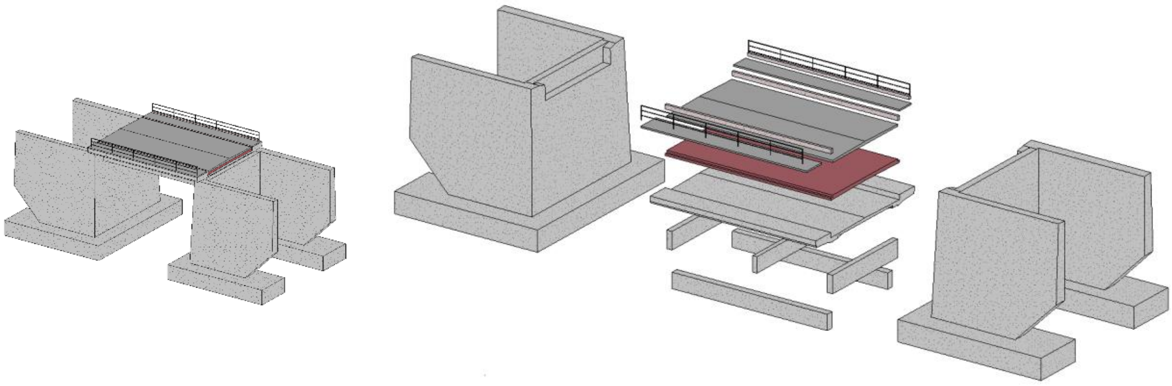


Figure 16: Abutment decomposition. Retrieved from (Haveresch & Maurer, 2010)

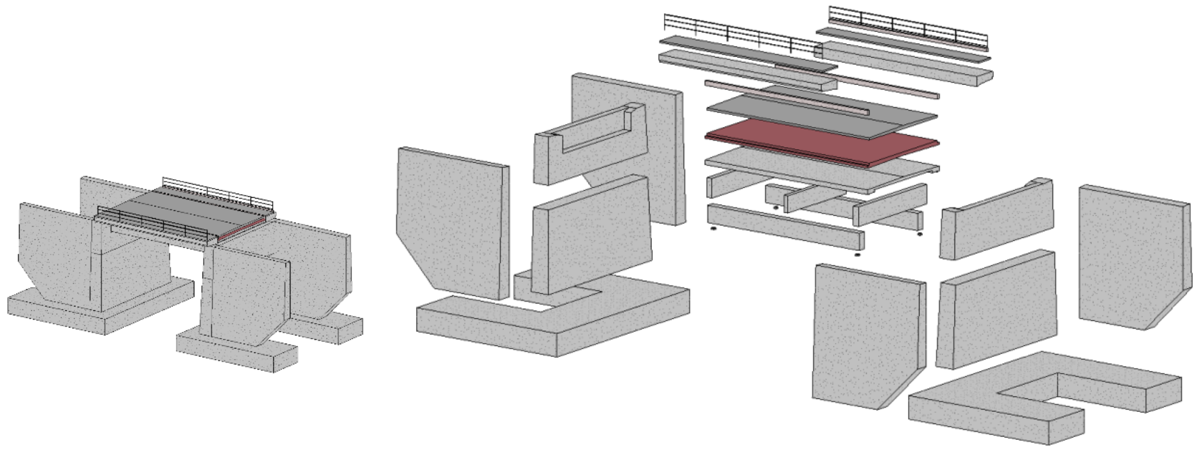
The exemplary BrIM is generated as a part of the doctoral dissertation research (Isailović, Digital representation of as-damaged reinforced concrete bridges, PhD thesis, 2020). It is a model of a 12.5 meter spanned simply supported double girder bridge made of reinforced concrete. Figure 17 shows the original model comprising 16 elements (i.e. instances of *IfcBuildingElement* subclasses).



(a) (b)

Figure 17: Original exemplary BrIM: (a) collapsed, and (b) exploded view

The original BrIM could not represent all the elements listed in the ASB-ING hierarchy. More precisely, abutments were modelled as monolithic elements, thus preventing one to address all the abutment sub elements shown in Figure 16. The deck was also represented by a monolithic element. Therefore, the bridge was remodelled by dividing the abutment into five independent elements (support bench, front wall, two wing walls, and foundation), whereas the deck was divided into three elements (one deck with two deck consoles). Finally, four bearings are modelled as simple rectangular prisms. The resulting BrIM (Figure 18) comprises 30 elements (i.e. instances of IfcBuildingElement subclasses).



(a) (b)

Figure 18: Remodelled exemplary BrIM: (a) collapsed, and (b) exploded view

As a part of preparatory work for the prototypical software implementation, each relevant concept from all three national ontologies is related to corresponding BrIM element. All the elements and addressed concepts are provided in the Appendix 7.4.

3.2.2 Data schema for bridge inspection reports

Today, the result of a bridge inspection is presented in a report. The report contains the documented damage and includes an overall assessment. The form and content of such reports are country-specific. Each country has its own templates. Examples from Germany and Denmark are presented below. In order for such reports to be digitally evaluated and linked to individual bridge elements, a data schema must be defined. For this purpose, XML schemas have been developed for the individual countries. The following section explains the content as well as the implementation of a report using XML for Germany and Denmark. So far, no report has been submitted for the Netherlands to develop an associated data schema. The XML schemas are listed in detail in the appendix.

3.2.2.1 Inspection report for Germany

For Germany, the structure and content of a bridge inspection report is defined in the guideline "RI-EBW-PRÜF". The report mainly consists of four components: Meta information, damage description, evaluation of the individual structure elements and the overall structure, and a maintenance suggestion.

Figure 19 shows the title page of a visual inspection of a bridge. It contains the important information of the structure and the inspection, e.g. structure name, location, responsible road authority, responsible person, inspection date and the condition grade. Based on this, a corresponding XML schema was defined.

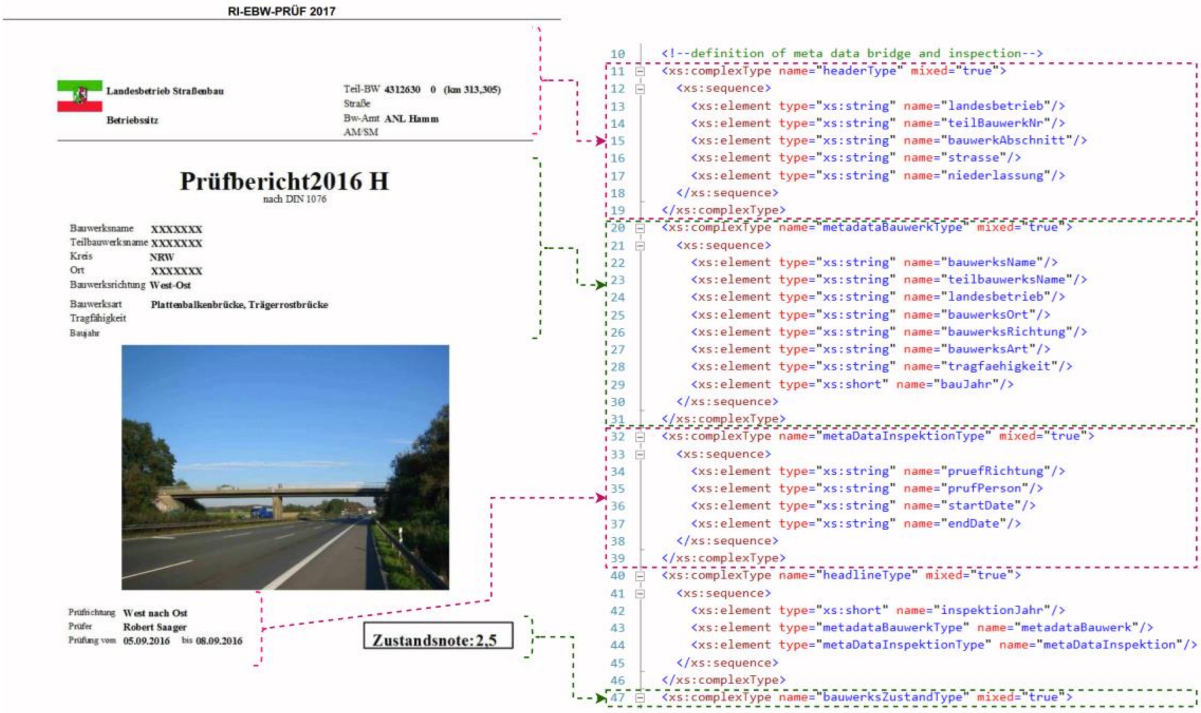


Figure 19: Report and XML schema for Germany

The damage description represents the result of the inspection. The following information on damage to a bridge element is recorded in the report (see Figure 20):

- Damage Description
- Damage assessment
- Images of the damage

This information was also converted into an XML schema.

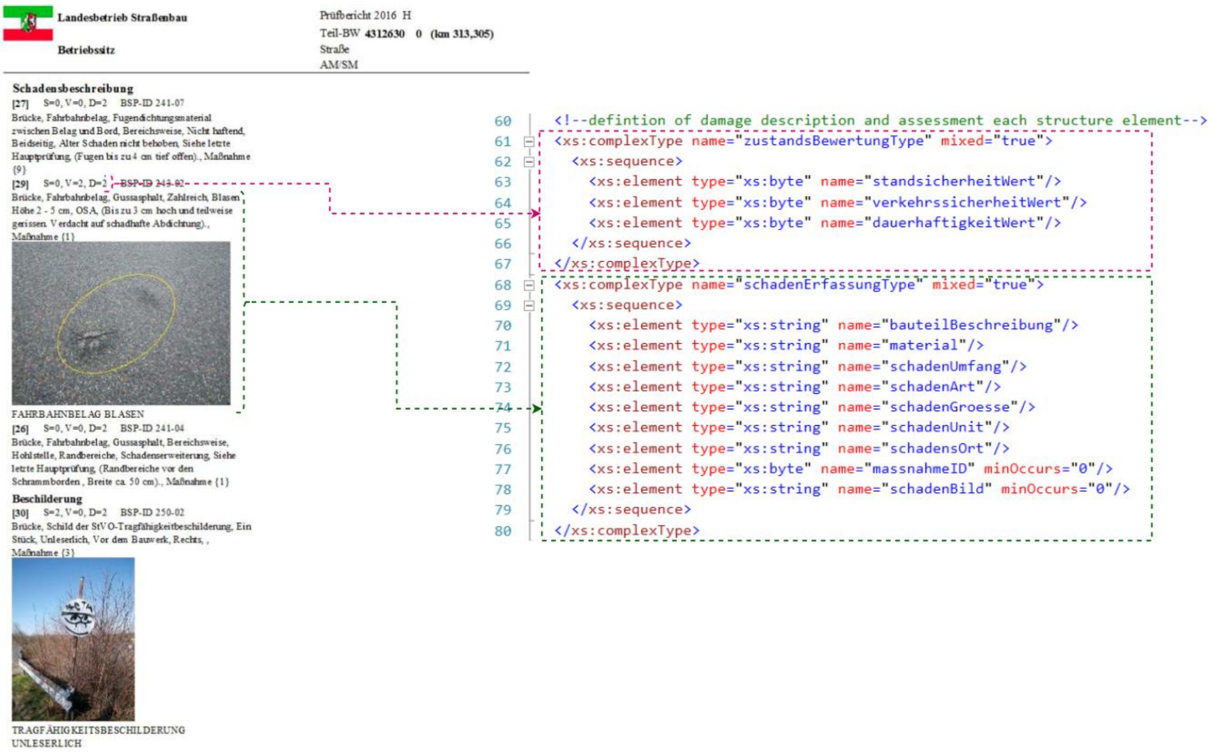


Figure 20: Damage description in the form of a report for Germany

The inspector's condition assessment of the entire structure is then documented (see Figure 21). In addition, the repair recommendation as well as the estimated costs can be indicated.

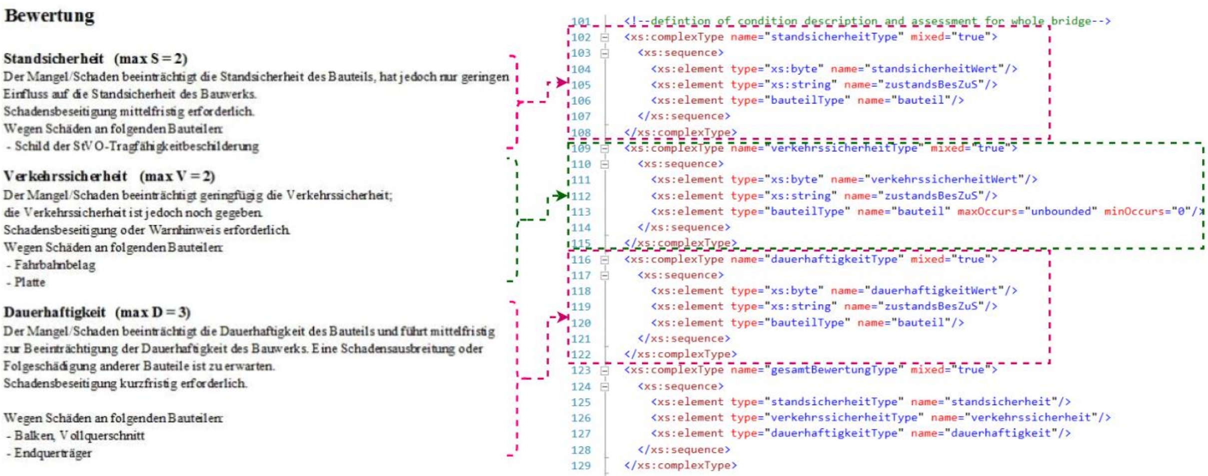


Figure 21: Condition assessment in the form of a report for Germany

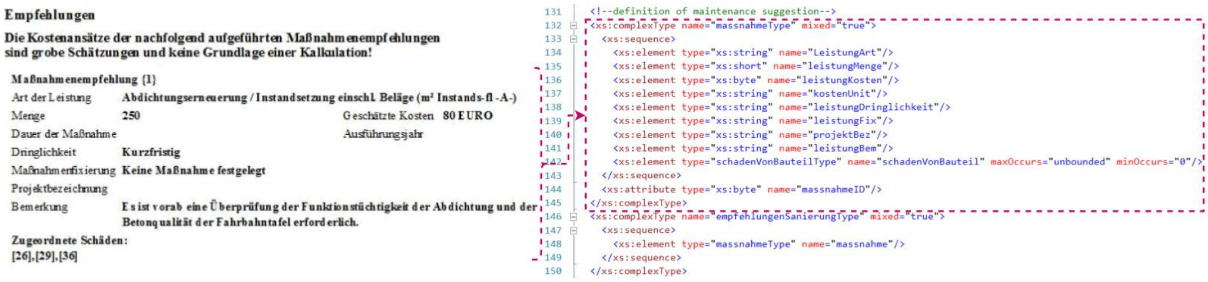


Figure 22: Maintenance Suggestion of report in Germany.

3.2.2.2 Denmark

The structure and content of the Danish report for bridge inspection was taken from a provided example. It has a clear structure with three main parts: Information about the bridge, a table with the damage description and the corresponding images of the damages.

Meta data

As shown in

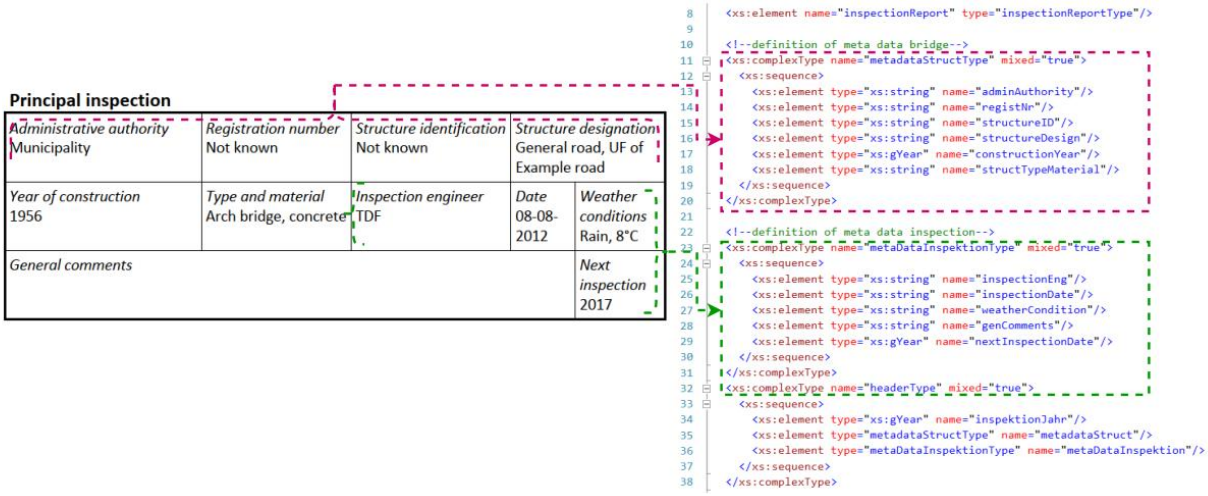


Figure 23, the information about the bridge is modelled for the report as meta data. The XML schema for the meta data is created based on the report example.

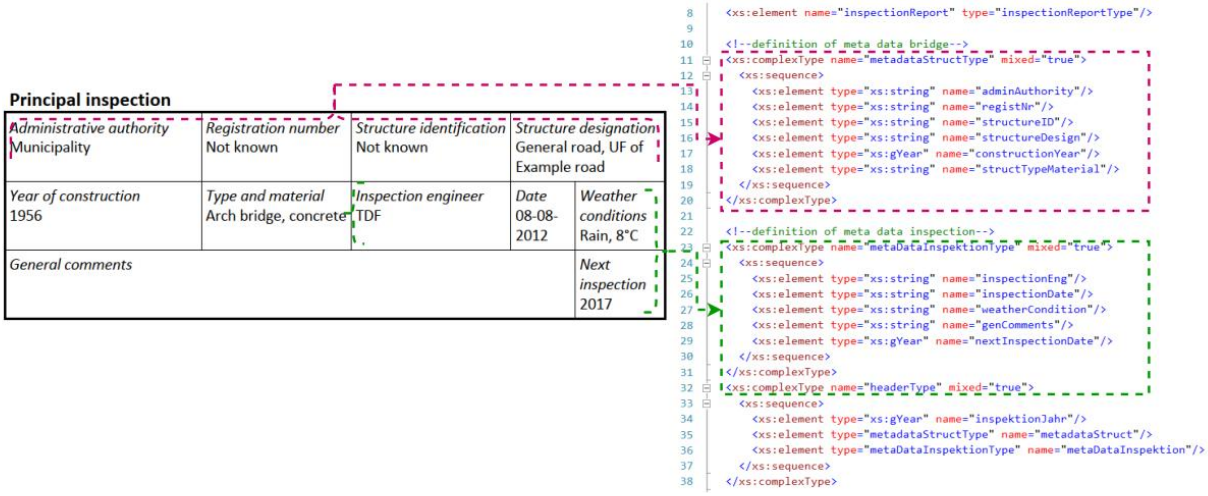


Figure 23: Metadata of an inspection report for Denmark

The result of an inspection is documented as follows:

- Description of the damage, causes and locations
- Classification of damage with detailed information, such as photos, condition notes, special inspections
- Proposal for maintenance actions with recommended year and approximate cost.

All information is stored in the form of a table, (see Figure 24). Again, a corresponding XML schema was developed. The images are attached as separate files (see Figure 25).

Description of damage, cause and location	Photo no.	Condition grade	Special inspection	Safety	Routine maintenance	Repair works	Year	Price (DKK '000)
1. *The entire structure* The bridge is generally in a good condition. However, leaking waterproofing locally.	1 2	3			+			
2. *Wing walls* Local fine, fine-meshed map cracks in the south-eastern wing wall and throughout the previously repaired area in the south-western wing wall. Cause: Creep.	3	0			+			
3. *Slopes* Subsidence in the entire western slope under the bridge and locally in the eastern slope where SF-blocks have been pushed 4-5 cm out and some are broken. Cause: Most likely insufficiently compacted gravel fill. The subsidence is most significant on the western slope. The development of the subsidence should be assessed in future principal inspections. Dense vegetation on paving blocks on slopes next to the bridge (worst on the southern side).	4 5	2			-			

```
<!--definition of condition description and assessment-->
<xs:complexType name="pictureType">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute type="xs:string" name="picID" use="optional"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="structElementType">
  <xs:sequence>
    <xs:element type="xs:string" name="structDescription"/>
    <xs:element type="pictureType" name="picture" maxOccurs="unbounded" minOccurs="0"/>
    <xs:element name="conditionGrad">
      <xs:simpleType>...</xs:simpleType>
    </xs:element>
    <xs:element name="specialInspection" minOccurs="0" maxOccurs="1">
      <xs:simpleType>...</xs:simpleType>
    </xs:element>
    <xs:element type="xs:string" name="safety" minOccurs="0" maxOccurs="1" fixed ="S"/>
    <xs:element name="routineMaintenance" minOccurs="0" maxOccurs="1">
      <xs:simpleType>...</xs:simpleType>
    </xs:element>
    <xs:element type="xs:string" name="recommendRepairWorks"/>
    <xs:element type="xs:gYear" name="recommendYear"/>
    <xs:element type="xs:decimal" name="recommendPrice"/>
    <xs:element type="xs:string" name="recommendPriceUnit"/>
  </xs:sequence>
  <xs:attribute type="xs:byte" name="structElementID" use="optional"/>
  <xs:attribute type="xs:string" name="structElementName" use="optional"/>
</xs:complexType>
<xs:complexType name="damageType">
  <xs:sequence>
    <xs:element type="structElementType" name="structElement" maxOccurs="unbounded" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="tableType">
  <xs:sequence>
    <xs:element type="damageType" name="damage"/>
  </xs:sequence>
</xs:complexType>
```

Figure 24. Damage description of an inspection report for Denmark.

```
<!--definition of damage images-->
<xs:complexType name="pictureCollectionType">
  <xs:sequence>
    <xs:element type="pictureType" name="picture" maxOccurs="unbounded" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
```

Figure 25: XML schema for describing damage images for Denmark

3.2.2.3 Netherlands

An example for the Netherlands could not be modelled because an example inspection report was not available timely.

3.3 Inspection finding

Once the damage is identified and classified, in order to be completely described, its location needs to be represented in an unambiguous way. Whereas assigning a damage to the specific element provides an information on the rough location of the damage, the precise damage location still misses. To fill this information gap, the report D3.2, named "Information Delivery Manual (IDM) for condition assessment", proposes defining areas for locating information for condition assessment, in a form of the extension of the BIM model of the assessed asset (i.e. *LocalPlacement.ifc*. As a preparatory task for defining these areas, a real inspection report is discretized by extracting the key phrases and measures describing the damage locations.

Some changes of the original location descriptions, written in the report, has been made, so that they can fully correspond to the exemplary bridge model. The complete list of discretized descriptions of damage areas is provided in the Appendix 7.9 (damage area in the appendix table). In addition to the discretized damage location, this appendix provides the exact damage classification for each inspection finding entry, based on ASB-ING.

4 Reference architecture for BIM-based asset management

For asset management of bridges and roads, different data sources have to be merged and evaluated as a whole. Different approaches and legacy systems have been developed in different countries over the last decades. In many cases, individual databases and interfaces have been developed for specific applications. Geographical information systems (GIS) have essentially been used for the geographical location and description of surfaces (e.g. for road management). With the introduction of BIM, three-dimensional information is now available since a few years. BIM models provide new possibilities for the planning, construction and operation of bridges and roads.

The AMSfree project follows the approach that existing legacy systems are used for BIM-based asset management with the help of Linked Data concepts. In contrast, a central database in the sense of a data warehouse could also be developed, which stores only the necessary information from the legacy systems. Thereby, a data warehouse is a topic-oriented, integrated, chronologized and persistent collection of data to support management in its decision-making processes. However, a major challenge of a data warehouse approach is that the information from the individual connected databases must be transferred to the central database at regular intervals.

The main difference of the Linked Data approach is therefore that no data is copied and instead used directly from the individual data sources for the asset management processes via standardized queries. A similar approach is used in ISO 21597 for the exchange of data by using information containers. The proposed reference architecture for BIM-based asset management therefore consists of a total of five layers (cf. Figure 26):

Data layer: The data layer comprises the existing legacy systems for asset management. Here, it is important that only one source is responsible for managing a particular data set. For example, information about the condition assessment should only be stored in one system. However, if information needs to be stored in two databases, the system responsible for management must be clearly identifiable.

Access layer: It must be possible for each legacy system to access the data it contains. Different access options usually exist for the different systems. A user login is usually required for access. For this purpose, a system should also have the option of integrating a single sign-on concept. With the single sign-on concept, a user can access all services for which he is authorized from the same workstation after a one-time authentication, without having to log on to the individual services each time. In case this has not yet been realized, the corresponding system must be extended.

Ontology layer: Uniform access to data is provided using the Resource Description Framework (RDF). For this purpose, the data models of the legacy systems must be modelled using RDF. In general, RDF provides standardizations for the vocabulary used to characterize ontologies. To prevent the ontologies and RDF description from becoming too complex, only information from the underlying systems that is relevant should be modelled. If all systems are mapped in this way, standardized query languages (e.g., SPARQL) can be used to access the data. SPARQL is an RDF query language to retrieve and manipulate data stored in RDF format. The ontology layer must be implemented and made available for each data source or system.

Linking layer: A linking layer can be built to link the different data sources using the RDF approach. The link layer is also implemented using RDF. Similar concepts are also provided in ISO 21597. In addition, higher-level ontologies can also be defined. This allows terms to be merged even though they have different names or identifiers in the individual systems. Through the linkage and the additional ontologies, uniform queries can be realized across all data sources. This approach is also the basis of the Semantic Web and has already been successfully implemented for other applications. In addition to SPARQL, GeoSPARQL can also be used to enable geographic queries. GeoSPARQL is a standard for representation and querying of geospatial linked data for the Semantic Web from the Open Geospatial Consortium (OGC). The definition of a small ontology based on well-understood OGC standards is intended to provide a standardized exchange basis for geospatial RDF data which can support both qualitative and quantitative spatial reasoning and querying with the SPARQL database query language. The link layer should be operated centrally by the respective national authorities. In principle, the individual link layers of the countries can also be merged.

Application layer: The application layer is only considered in a simplified form in the following. The application layer is used for the higher-level use of the data. Services for importing and exporting data as well as options for analysing and visualizing data are implemented. For this purpose, individual queries or update commands are implemented on the basis of SPARQL. In addition to updating, the standardized visualization of geometric data in particular is a major challenge. For geometric querying, various concepts have already been developed in recent years for both the IFC data format and other GIS-based data formats. In the context of the AMSfree project, only a rudimentary examination can be made with regard to geometric queries. The focus in the following reports will be on importing, exporting, and retrieving selected information for bridge and road asset management.

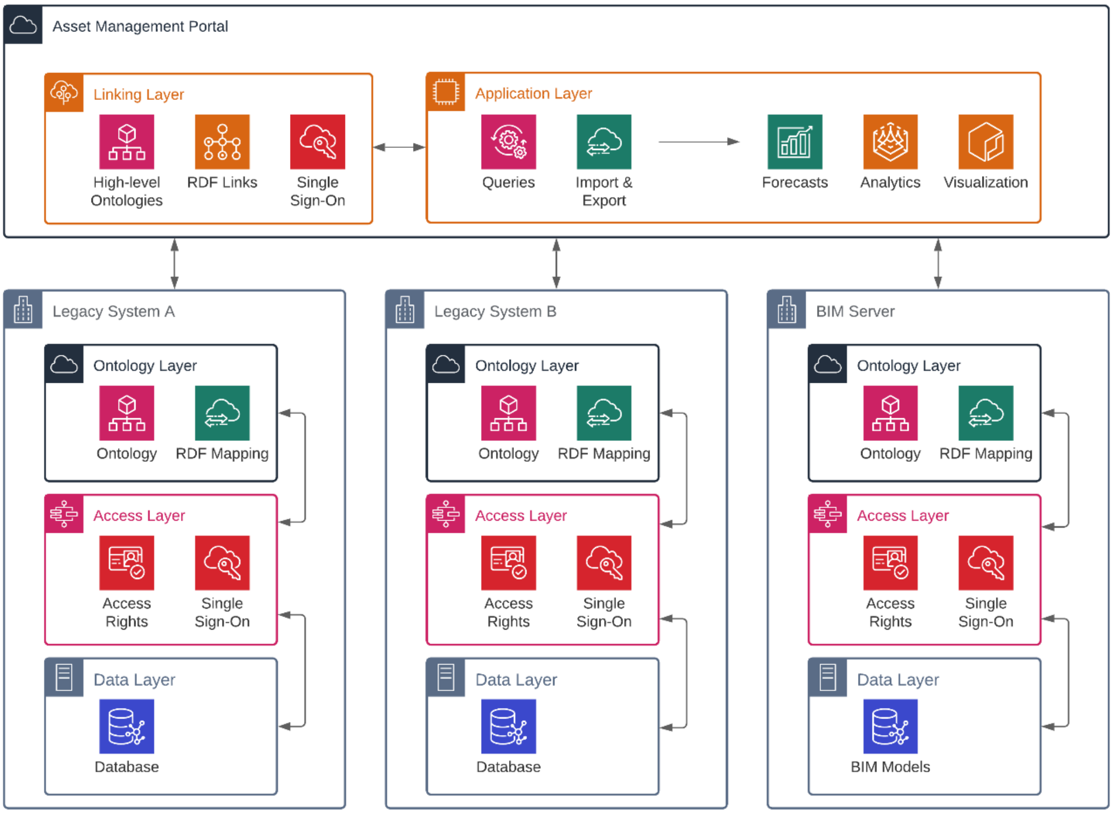


Figure 26: Reference architecture for BIM-based asset management

5 Conclusion

In the report, it could be demonstrated that information containers based on ISO 21597 can be used for consistent and detailed information exchange for asset management. Ontologies are used so that the information can be queried in a uniform manner. On the one hand, the ontologies enable the description of uniform information and, on the other hand, the flexible tailoring with respect to national guidelines. For selected examples precise ontologies and data formats were developed. This means that asset management processes can be digitally supported in a better way. In the next step, the different information containers will be integrated into a holistic data management concept. For this purpose, a reference architecture was presented, which will be implemented as a prototype in the next step.

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Vejdirektoratet. (25. February 2020). Appendix 2.l Structures - Principal Inspection Report. Copenhagen, Denmark.

7 Appendix

7.1 Asphalt condition assessment ontology (ACA)

```
# baseURI: http://amsfree.eu/ontology/unnamed

@prefix aca: <http://amsfree.eu/ontology/AsphaltConditionAssessment#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

aca:AccumulationOfBinder
  rdf:type owl:Class ;
  rdfs:label "Accumulation of binder - BIN" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Acustic
  rdf:type owl:Class ;
  rdfs:label "Acustic Property" ;
  rdfs:subClassOf owl:Thing ;
.
aca:BearingCapacity
  rdf:type owl:Class ;
  rdfs:label "Bearing capacity" ;
  rdfs:subClassOf owl:Thing ;
.
aca:CoatingDamages
  rdf:type owl:Class ;
  rdfs:label "Coating damages M_BS" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:CoatingDeformation
  rdf:type owl:Class ;
  rdfs:label "Coating deformation M_BV" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Cracks
  rdf:type owl:Class ;
  rdfs:comment "Alligator cracking, accumulation of cracks and individual cracks" ;
  rdfs:label "Cracks" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:JointDamage
  rdf:type owl:Class ;
  rdfs:label "Joint damage" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:LongitudinalEveness
  rdf:type owl:Class ;
  rdfs:label "Longitudinal eveness" ;
  rdfs:subClassOf owl:Thing ;
.
aca:Patches
  rdf:type owl:Class ;
  rdfs:comment "The indicator of M_FLI is matrix value of mainly group FLI" ;
  rdfs:label "Patches, with several indicators" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Raveling
  rdf:type owl:Class ;
```

```
  rdfs:label "raveling - AUS" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Reflection
  rdf:type owl:Class ;
  rdfs:label "Reflection Property" ;
  rdfs:subClassOf owl:Thing ;
.
aca:ResidualAreaOfDamage
  rdf:type owl:Class ;
  rdfs:label "Patches, loss of material, accumulation of binder" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Roughness
  rdf:type owl:Class ;
  rdfs:label "Roughness" ;
  rdfs:subClassOf owl:Thing ;
.
aca:StructuralDamages
  rdf:type owl:Class ;
  rdfs:label "Structural damages M_SS" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:SurfaceDamages
  rdf:type owl:Class ;
  rdfs:comment "Surface damages - percentage value of damaged area" ;
  rdfs:label "Surface damages" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:SurfaceProperties
  rdf:type owl:Class ;
  rdfs:label "Surface Properties" ;
  rdfs:subClassOf owl:Thing ;
.
aca:SurfaceSmoothness
  rdf:type owl:Class ;
  rdfs:label "Surface smoothness M_OF" ;
  rdfs:subClassOf aca:SurfaceProperties ;
.
aca:Texture
  rdf:type owl:Class ;
  rdfs:label "Texture" ;
  rdfs:subClassOf owl:Thing ;
.
aca:TransverseEveness
  rdf:type owl:Class ;
  rdfs:label "Transverse eveness" ;
  rdfs:subClassOf owl:Thing ;
.
aca:affectedAreaCracks
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Affected Area of Cracks - percentage value of damaged area in procent"
;
  rdfs:domain aca:Cracks ;
  rdfs:label "RISS" ;
  rdfs:range xsd:decimal ;
.
aca:bearingCapacityBenk
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "deflection measurement by Benkelman beam in mm/100" ;
  rdfs:domain aca:BearingCapacity ;
  rdfs:label "Bearing Capacity Benk" ;
  rdfs:range xsd:decimal ;
.
aca:bearingCapacityFWD
```

```
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Deflectometer" ;
  rdfs:domain aca:BearingCapacity ;
  rdfs:label "Bearing Capacity FWD" ;
  rdfs:range xsd:decimal ;
.
aca:bearingCapacityTSD
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "deflection measurement by Traffic-Speed-Deflectometer" ;
  rdfs:domain aca:BearingCapacity ;
  rdfs:label "Bearing Capacity TSD" ;
  rdfs:range xsd:decimal ;
.
aca:coatedPatches
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "coated patches area in percentage value" ;
  rdfs:domain aca:Patches ;
  rdfs:label "AUFLI" ;
  rdfs:range xsd:decimal ;
.
aca:damagedAreaCracks
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Damaged Area of Cracks - percentage value of damaged area in procent" ;
  rdfs:domain aca:Cracks ;
  rdfs:label "RI" ;
  rdfs:range xsd:decimal ;
.
aca:densityOfHeightOfUneveness
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Spectral density of height of uneveness, measure of uneveness, in cm3"
;
  rdfs:domain aca:LongitudinalEveness ;
  rdfs:label "AUN" ;
  rdfs:range xsd:decimal ;
.
aca:frictionCoefficient
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Friction coefficient km/h" ;
  rdfs:domain aca:Roughness ;
  rdfs:label "ÂµRS" ;
  rdfs:range xsd:decimal ;
.
aca:indicatorLongitudinalEveness
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Indicator of longitudinal eveness" ;
  rdfs:domain aca:LongitudinalEveness ;
  rdfs:label "LWI" ;
  rdfs:range xsd:decimal ;
.
aca:insertedPatches
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Inserted patches area in percentage value" ;
  rdfs:domain aca:Patches ;
  rdfs:label "EFLI" ;
  rdfs:range xsd:decimal ;
.
aca:internationalRoughnessIndex
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "International roughness index with international measure for
longitudinal eveness in m/km" ;
  rdfs:domain aca:LongitudinalEveness ;
  rdfs:label "IRI" ;
  rdfs:range xsd:decimal ;
.
aca:lengthJointDamage
```

```
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Length of ioint damage in m " ;
  rdfs:domain aca:JointDamage ;
  rdfs:label "ONA" ;
  rdfs:range xsd:decimal ;
.
aca:luminance
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "luminance in cd m-2" ;
  rdfs:domain aca:Reflection ;
  rdfs:label "Lv" ;
  rdfs:range xsd:decimal ;
.
aca:matrixValue
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "This indicator can be used for several condition " ;
  rdfs:domain aca:CoatingDamages ;
  rdfs:domain aca:CoatingDeformation ;
  rdfs:domain aca:Patches ;
  rdfs:domain aca:StructuralDamages ;
  rdfs:domain aca:SurfaceSmoothness ;
  rdfs:label "Matrixvalue" ;
  rdfs:range xsd:string ;
.
aca:meanProfilDepth
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Mean profile depth - parameter for description of makrotexture in mm" ;
  rdfs:domain aca:Texture ;
  rdfs:label "MPD" ;
  rdfs:range xsd:decimal ;
.
aca:meanRutDepth
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Mean rut depth - maximum of average values of right and left rut depth
in mm" ;
  rdfs:domain aca:TransverseEveness ;
  rdfs:label "MSPT" ;
  rdfs:range xsd:decimal ;
.
aca:measuringSpeed
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Measuring speed km/h" ;
  rdfs:domain aca:Roughness ;
  rdfs:label "v" ;
  rdfs:range xsd:decimal ;
.
aca:patchesArea
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Patches area in percentage value" ;
  rdfs:domain aca:Patches ;
  rdfs:label "FLI" ;
  rdfs:range xsd:decimal ;
.
aca:percentageValue
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "This indicator can be used for several condition " ;
  rdfs:domain aca:AccumulationOfBinder ;
  rdfs:domain aca:Raveling ;
  rdfs:domain aca:SurfaceDamages ;
  rdfs:label "percentage value of damaged area" ;
  rdfs:range xsd:decimal ;
.
aca:residualArea
  rdf:type owl:DatatypeProperty ;
```

```
  rdfs:comment "Affected Area of patches, loss of material, accumulation of binder, affected area - percentage value of damaged area in procent" ;
  rdfs:domain aca:ResidualAreaOfDamage ;
  rdfs:label "RSFA" ;
  rdfs:range xsd:decimal ;
.
aca:rutDepth
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Rut depth - ruts, max. rut-depth below 2-m-bar  in mm" ;
  rdfs:domain aca:TransverseEveness ;
  rdfs:label "SR" ;
  rdfs:range xsd:decimal ;
.
aca:sidewayForceCoefficient
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Sideway-force coefficient  - friction coefficient (Sideway-force Coefficient Routine Investigation Machine)" ;
  rdfs:domain aca:Roughness ;
  rdfs:label "Âµ_skm" ;
  rdfs:range xsd:decimal ;
.
aca:soundPressureLevel
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Sound pressure level in dB(A)" ;
  rdfs:domain aca:Acustic ;
  rdfs:label "Lp" ;
.
aca:standardDeviationOfAngleValue
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Standard deviation of angle value in promille" ;
  rdfs:domain aca:LongitudinalEveness ;
  rdfs:label "Sw" ;
  rdfs:range xsd:decimal ;
.
aca:theoreticalWaterDepth
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Theoretical water depth - maximum of average values of right and left theoretical water depth  in mm" ;
  rdfs:domain aca:TransverseEveness ;
  rdfs:label "MSPH" ;
  rdfs:range xsd:decimal ;
.
aca:trackDepth
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Track depth - measure of transverse eveness  in mm" ;
  rdfs:domain aca:TransverseEveness ;
  rdfs:label "T" ;
  rdfs:range xsd:decimal ;
.
aca:weightedLongitudinalProfile
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Weighted longitudinal profile. Modified longitudinal profile by filtering and weightin in mm" ;
  rdfs:domain aca:LongitudinalEveness ;
  rdfs:label "DBL" ;
  rdfs:range xsd:decimal ;
.
<http://amsfree.eu/ontology/unnamed>
  rdf:type owl:Ontology ;
  owl:versionInfo "Created with TopBraid Composer" ;
.
```

7.2 Maintenance program ontology (MAINTP)

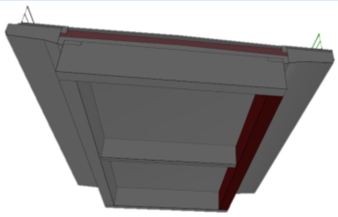
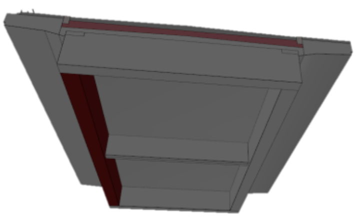
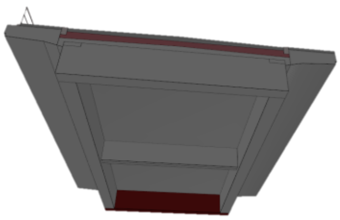
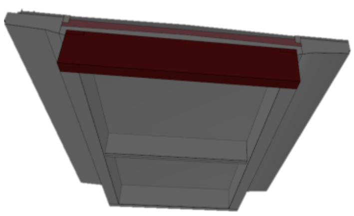
```
# baseURI: http://amsfree.eu/ontology/maintenanceProgram
# prefix: maintp

@prefix maintp: <http://amsfree.eu/ontology/maintenanceProgram#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

<http://amsfree.eu/ontology/maintenanceProgram>
  rdf:type owl:Ontology ;
  owl:versionInfo "Created with TopBraid Composer" ;
.
maintp:Location
  rdf:type owl:Class ;
  rdfs:label "Location or Area of measure" ;
  rdfs:subClassOf owl:Thing ;
.
maintp:Measure
  rdf:type owl:Class ;
  rdfs:subClassOf owl:Thing ;
.
maintp:area
  rdf:type owl:ObjectProperty ;
  rdfs:comment "Road area for the maintenance measure" ;
  rdfs:domain maintp:Location ;
  rdfs:label "Road area" ;
.
maintp:costOfMeasure
  rdf:type owl:DatatypeProperty ;
  rdfs:domain maintp:Measure ;
  rdfs:label "Estimated cost of measure" ;
  rdfs:range xsd:decimal ;
.
maintp:descriptionOfMeasure
  rdf:type owl:DatatypeProperty ;
  rdfs:domain maintp:Measure ;
  rdfs:label "Description of measure" ;
  rdfs:range xsd:string ;
.
maintp:endPoint
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "End point of road section for the maintenance measure" ;
  rdfs:domain maintp:Location ;
  rdfs:label "End point" ;
  rdfs:range xsd:decimal ;
.
maintp:laneOfRoad
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Lane of the road for the maintenance measure" ;
  rdfs:domain maintp:Location ;
  rdfs:label "Lane of road" ;
  rdfs:range xsd:string ;
.
maintp:roadName
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Name of the road for the maintenance measure" ;
  rdfs:domain maintp:Location ;
  rdfs:label "Road name" ;
  rdfs:range xsd:string ;
.
maintp:startPoint
```

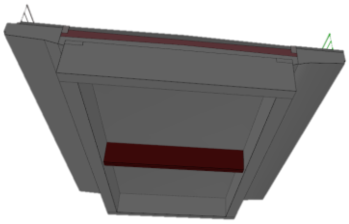
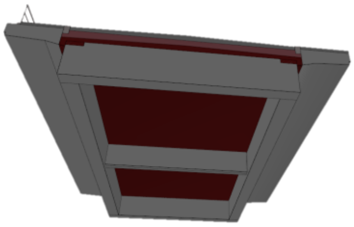
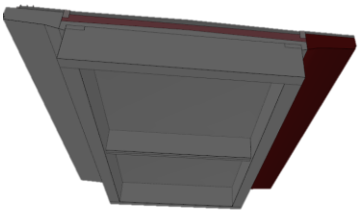
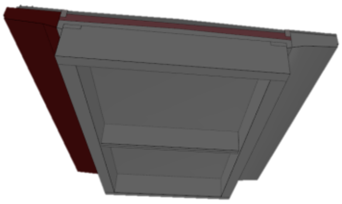
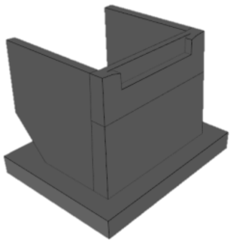
```
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Start point of road section for the maintenance measure" ;
  rdfs:domain maintp:Location ;
  rdfs:label "Start point of the maintenance measure" ;
  rdfs:range xsd:decimal ;
.
maintp:typeOfMeasure
  rdf:type owl:DatatypeProperty ;
  rdfs:domain maintp:Measure ;
  rdfs:label "Type of measure" ;
  rdfs:range xsd:string ;
.
maintp:yearOfMeasure
  rdf:type owl:DatatypeProperty ;
  rdfs:domain maintp:Measure ;
  rdfs:label "Year of measure" ;
  rdfs:range xsd:gYear ;
.
```

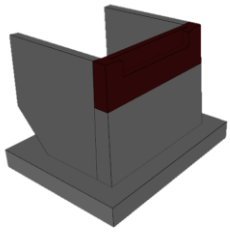
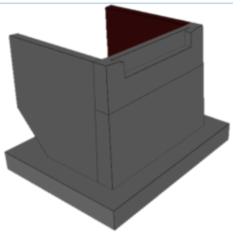
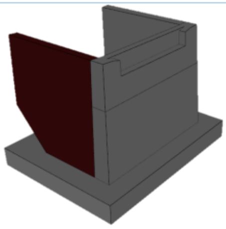
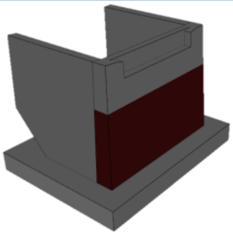
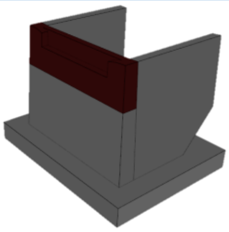
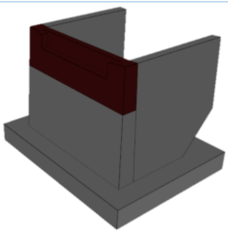
7.3 Report template for a maintenance program

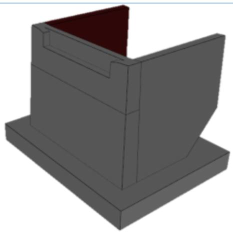
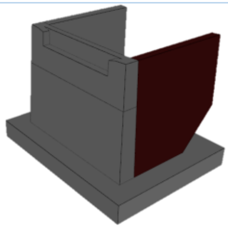
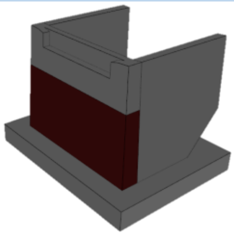
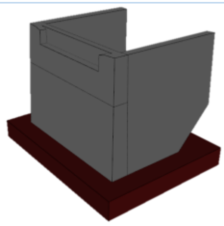
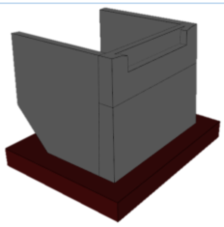
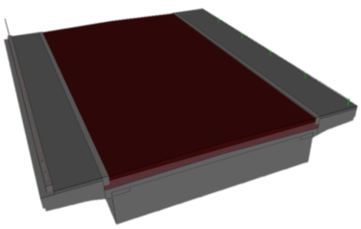
```xml
<?xml version="1.0" encoding="utf-8"?>
<xs:schema targetNamespace="http://amsfree.eu/MaintenanceProgram"
    elementFormDefault="qualified"
    xmlns="http://amsfree.eu/MaintenanceProgram"
    xmlns:mstns="http://amsfree.eu/MaintenanceProgram"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
>
  <xs:element name="MaintenanceProgram" type="MaintenanceProgramType"/>
  <xs:complexType name="metadataPavementType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="adminAuthority"/>
      <xs:element type="xs:string" name="roadID"/>
      <xs:element type="xs:string" name="roadName"/>
      <xs:element type="xs:string" name="roadDesign"/>
      <xs:element type="xs:gYear" name="constructionYear"/>
      <xs:element type="xs:string" name="pavementTypeMaterial"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="metaDataMaintenancePlanType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="consultEngineer"/>
      <xs:element type="xs:string" name="consultDate"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="headerType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:short" name="MaintenanceYear"/>
      <xs:element type="metadataPavementType" name="metadataPavement"/>
      <xs:element type="metaDataMaintenancePlanType" name="metaDataMaintenancePlan"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="roadSectionType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="typeMeasure"/>
      <xs:element type="xs:string" name="descriptionMeasure"/>
      <xs:element type="xs:gYear" name="measureYear"/>
      <xs:element type="xs:float" name="measureEstimatedCost"/>
    </xs:sequence>
    <xs:attribute type="xs:float" name="startPoint" use="optional"/>
    <xs:attribute type="xs:float" name="endPoint" use="optional"/>
  </xs:complexType>
  <xs:complexType name="measureType">
    <xs:sequence>
      <xs:element type="roadSectionType" name="roadSection" maxOccurs="unbounded" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="tableType">
    <xs:sequence>
      <xs:element type="measureType" name="measure"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="MaintenanceProgramType">
    <xs:sequence>
      <xs:element type="headerType" name="header"/>
      <xs:element type="tableType" name="table"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

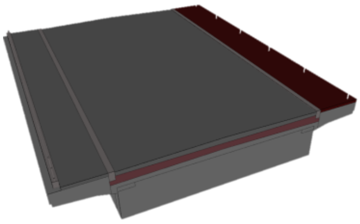
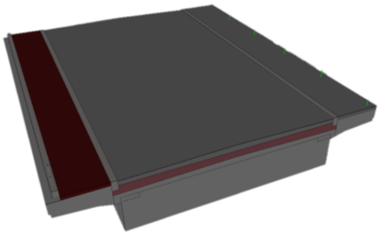
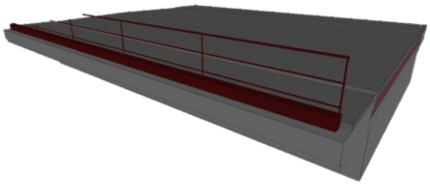
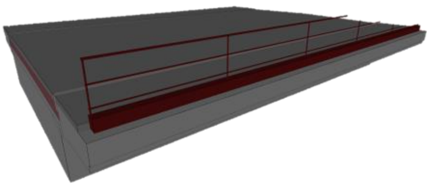
7.4 Bridge Element classification using different ontologies

	Element	IFC instance	ASB-ING	CB-NL	DANBRO
Superstructure	Super-structure	 IfcElementAssembly (#804, #730, #926, #857, #1066, #2772, #650, #2846)	http://server.bim-q.de/258#Uberbau_130011151000000	None	http://amsfree.eu/danishBridgeClassification#LoadBearingSuperstructure
	Main girder (North)	 IfcBeam #804	http://server.bim-q.de/258#Balken_Plattenbalken_130011151200000	http://ont.cbnl.org/cb/def/CB03426	None
	Main girder (South)	 IfcBeam #730	http://server.bim-q.de/258#Balken_Plattenbalken_130011151200000	http://ont.cbnl.org/cb/def/CB03427	None
	Cross girder (West)	 IfcBeam #926	http://server.bim-q.de/258#Endquertrager_130011151241000	http://ont.cbnl.org/cb/def/CB03571	None
	Cross girder (East)	 IfcBeam #857	http://server.bim-q.de/258#Endquertrager_130011151241000	http://ont.cbnl.org/cb/def/CB03572	None

	Cross girder (Middle)	 IfcBeam #1066	http://server.bim-q.de/258#Quertrager_130011151240000	http://ont.cbnl.org/cb/def/CB03573	None
	Deck	 IfcSlab #2772	http://server.bim-q.de/258#Platte_130011151100000	http://ont.cbnl.org/cb/def/CB01662	None
	Deck console (North)	 IfcBeam #650	http://server.bim-q.de/258#Kragarm_1300111514000000	http://ont.cbnl.org/cb/def/CB01756	None
	Deck console (South)	 IfcBeam #2846	http://server.bim-q.de/258#Kragarm_1300111514000000	http://ont.cbnl.org/cb/def/CB01757	None
Substructure	Sub-structure	 IfcElementAssembly (#2128, #1178, #1441, #1942, #2441, #1552, #1815, #2255)	http://server.bim-q.de/258#Unterbau_1300119000000	None	None
Substructure	Abutment (West)	 IfcElementAssembly (#2128, #1178, #1441, #1942)	http://server.bim-q.de/258#Widerlager_130011910000000	http://ont.cbnl.org/cb/def/CB01011	http://amsfree.eu/danishBridgeClassification#Abutment

	Support bench (West)	 IfcWall #2128	http://server.bim-q.de/258#Auflagerbank_130011913000000	None	None
	Wing (North-West)	 IfcWall #1178	http://server.bim-q.de/258#Flugel_130011914000000	None	http://amsfree.eu/danishBridgeClassification#Wing
	Wing (South-West)	 IfcWall #1441	http://server.bim-q.de/258#Flugel_130011914000000	None	http://amsfree.eu/danishBridgeClassification#Wing
	Front wall (West)	 IfcWall #1942	http://server.bim-q.de/258#Wand_130011911000000	None	None
	Abutment (East)	 IfcElementAssembly (#2441, #1552, #1815, #2255)	http://server.bim-q.de/258#Widerlager_130011910000000	http://ont.cbnl.org/cb/def/CB01011	http://amsfree.eu/danishBridgeClassification#Abutment
	Support bench (East)	 IfcWall #2441	http://server.bim-q.de/258#Auflagerbank_130011913000000	None	None

	Wing (North-East)	 IfcWall #1552	http://server.bim-q.de/258#Flugel_130011914000000	None	http://amsfree.eu/danishBridgeClassification#Wing
	Wing (South-East)	 IfcWall #1815	http://server.bim-q.de/258#Flugel_130011914000000	None	http://amsfree.eu/danishBridgeClassification#Wing
	Front wall (East)	 IfcWall #2255	http://server.bim-q.de/258#Wand_130011911000000	None	None
Foundation	Abutment foot (East)	 IfcWall #1332	http://server.bim-q.de/258#Sohlplatte_130021212100000	http://ont.cbnl.org/cb/def/CB03577	None
	Abutment foot (West)	 IfcWall #1704	http://server.bim-q.de/258#Sohlplatte_130021212100000	http://ont.cbnl.org/cb/def/CB03577	None
Coverings	Pavement (Driveway)	 IfcSlab #571	http://server.bim-q.de/258#Fahrbahn_130022510000000	http://ont.cbnl.org/cb/def/CB02125	http://amsfree.eu/danishBridgeClassification#Surfacing

	Pavement (North sidewalk)	 IfcSlab #381	http://server.bim-q.de/258#Fahrbahn_130022510000000	http://ont.cbnl.org/cb/def/CB02126	http://amsfree.eu/danishBridgeClassification#Surfacing
	Pavement (South sidewalk)	 IfcSlab #503	http://server.bim-q.de/258#Fahrbahn_130022510000000	http://ont.cbnl.org/cb/def/CB02127	http://amsfree.eu/danishBridgeClassification#Surfacing
Protective devices	Railing (North)	 IfcRailing #3108	http://server.bim-q.de/258#Gelander_130022121000000	http://ont.cbnl.org/cb/def/CB02948	http://amsfree.eu/danishBridgeClassification#Railing
	Railing (South)	 IfcRailing #3004	http://server.bim-q.de/258#Gelander_130022121000000	http://ont.cbnl.org/cb/def/CB02949	http://amsfree.eu/danishBridgeClassification#Railing

7.5 The extended ontology (CODEX) defined as subclass of DOT

```
# baseURI: https://w3id.org/damagemodels/cdo#
# prefix: cdo

@prefix cdo: <https://w3id.org/damagemodels/cdo#> .
@prefix cdoex: <http://amsfree.eu/damagemodelsextension/cdoex#> .
@prefix dce: <http://purl.org/dc/elements/1.1/> .
@prefix dco: <https://w3id.org/dco#> .
@prefix dcterms: <http://purl.org/dc/terms> .
@prefix dot: <https://w3id.org/dot#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix vann: <http://purl.org/vocab/vann/> .
@prefix voaf: <http://purl.org/vocommons/voaf#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

cdoex:ExposedLongitudinalReinforcement
  rdf:type owl:Class ;
  rdfs:label "ExposedLongitudinalReinforcement" ;
  rdfs:subClassOf cdoex:ExposedReinforcement ;
.
cdoex:ExposedReinforcement
  rdf:type owl:Class ;
  rdfs:label "exposedReinforcement" ;
  rdfs:subClassOf dot:ClassifiedDamage ;
.
cdoex:ExposedTransverseReinforcement
  rdf:type owl:Class ;
  rdfs:label "ExposedTransverseReinforcement" ;
  rdfs:subClassOf cdoex:ExposedReinforcement ;
.
cdoex:InsuficientConcreteCompaction
  rdf:type owl:Class ;
  rdfs:label "InsuficientConcreteCompaction" ;
  rdfs:subClassOf dot:ClassifiedDamage ;
.
cdoex:Leakage_Dirt
  rdf:type owl:Class ;
  rdfs:label "LeakageDirt" ;
  rdfs:subClassOf dot:ClassifiedDamage ;
.
cdoex:Moisture
  rdf:type owl:Class ;
  rdfs:label "Moisture" ;
  rdfs:subClassOf cdoex:Leakage_Dirt ;
.
cdoex:Sintering-inducedWaterDrain
  rdf:type owl:Class ;
  rdfs:label "Sintering-inducedWaterDrain" ;
  rdfs:subClassOf cdoex:Leakage_Dirt ;
.
cdoex:Soiling
  rdf:type owl:Class ;
  rdfs:label "Soiling" ;
  rdfs:subClassOf cdoex:Leakage_Dirt ;
.
```

7.6 Condition assessment ontology (COAS)

```
# baseURI: http://amsfree.eu/ontology/conditionassessment
# prefix: coas

@prefix coas: <http://amsfree.eu/ontology/conditionassessment#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

<http://amsfree.eu/ontology/conditionassessment>
  rdf:type owl:Ontology ;
  rdfs:comment "Creator: Liu Liu" ;
  rdfs:label "Condition Assessment Ontology" ;
  owl:versionInfo "Created with TopBraid Composer" ;
.
coas:ConditionGradeGeneral
  rdf:type owl:DatatypeProperty ;
  rdfs:domain coas:GradeOfCondition ;
  rdfs:label "Level of condition in general"@en ;
  rdfs:range xsd:integer ;
  owl:propertyDisjointWith coas:ConditoinGradeDK ;
.
coas:ConditoinGradeDK
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "Condition grade of construction element in Denmark. It is between 0-5
where 0 means no damage and 5 means the highest severity of damange {@en]" ;
  rdfs:domain coas:GradeOfCondition ;
  rdfs:label "Condition grade Denmark {@en]" ;
  rdfs:range [
      rdf:type rdfs:Datatype ;
      owl:oneOf (
          ""
          "1"
          "2"
          "3"
          "4"
          "5"
        ) ;
    ] ;
  owl:propertyDisjointWith coas:ConditionGradeGeneral ;
.
coas:Description
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "General description for special inspection, safey risk or maintenance
suggested"@en ;
  rdfs:domain coas:RoutineMaintenance ;
  rdfs:domain coas:SafetyRisk ;
  rdfs:domain coas:SpecialInspection ;
  rdfs:label "Description" ;
  rdfs:range xsd:string ;
.
coas:GradeOfCondition
  rdf:type owl:Class ;
  rdfs:subClassOf owl:Thing ;
.
coas:RoutineMaintenance
  rdf:type owl:Class ;
  rdfs:comment "If a routine maintennace be carried out at the time of inspection."@en
;
  rdfs:label "Routine maintenance at inspection needed"@en ;
  rdfs:subClassOf owl:Thing ;
```

```
.
coas:RoutineMaitenanceDK
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "If a need exists for carrying out routine maintenance works at the time
of inspection, indicate with '-', otherwise '+'"@en ;
  rdfs:domain coas:RoutineMaintenance ;
  rdfs:label "Routine maintenance carried out at inspection"@en ;
  rdfs:range [
      rdf:type rdfs:Datatype ;
      owl:oneOf (
          "+"
          "-"
        ) ;
    ] ;
.
coas:SafetyRisk
  rdf:type owl:Class ;
  rdfs:comment "Matters involving a safety risk - whether caused by damage or
inadequate design"@en ;
  rdfs:label "Safety risk of structural element"@en ;
  rdfs:subClassOf owl:Thing ;
  rdfs:subClassOf [
      rdf:type owl:Restriction ;
      owl:cardinality "1"^^xsd:nonNegativeInteger ;
      owl:onProperty coas:safetyDK ;
    ] ;
.
coas:SpecialInspection
  rdf:type owl:Class ;
  rdfs:comment "If the damage needs a special inspection."@en ;
  rdfs:label "Special inspection needed"@en ;
  rdfs:subClassOf owl:Thing ;
.
coas:SpecialInspectionDK
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "There are two types of special inspection Denmark. Need for technical
and economic special inspection or economic inspection must be indicated with 'A' and
'B', respectively"@en ;
  rdfs:domain coas:SpecialInspection ;
  rdfs:label "Type of special inspection Denmark"@en ;
  rdfs:range [
      rdf:type rdfs:Datatype ;
      owl:oneOf (
          "A"
          "B"
        ) ;
    ] ;
.
coas:safetyDK
  rdf:type owl:DatatypeProperty ;
  rdfs:comment "It allows to determine, whether a matter involves a safety risk"@en ;
  rdfs:domain coas:SafetyRisk ;
  rdfs:label "Matter of safety"@en ;
  rdfs:range [
      rdf:type rdfs:Datatype ;
      owl:oneOf (
          "s"
          ""
        ) ;
    ] ;
.
```

7.7 XML-Schema of an inspection report for Germany

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema targetNamespace="http://amsfree.eu/inspectionReport"
    elementFormDefault="qualified"
    xmlns="http://amsfree.eu/inspectionReport"
    xmlns:mstns="http://amsfree.eu/inspectionReport"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
>
  <xs:element name="inspectionReport" type="inspectionReportType"/>

  <!--definition of meta data bridge and inspection-->
  <xs:complexType name="headerType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="landesbetrieb"/>
      <xs:element type="xs:string" name="teilBauwerkNr"/>
      <xs:element type="xs:string" name="bauwerkAbschnitt"/>
      <xs:element type="xs:string" name="strasse"/>
      <xs:element type="xs:string" name="niederlassung"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="metadataBauwerkType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="bauwerksName"/>
      <xs:element type="xs:string" name="teilbauwerksName"/>
      <xs:element type="xs:string" name="landesbetrieb"/>
      <xs:element type="xs:string" name="bauwerksOrt"/>
      <xs:element type="xs:string" name="bauwerksRichtung"/>
      <xs:element type="xs:string" name="bauwerksArt"/>
      <xs:element type="xs:string" name="tragfaehigkeit"/>
      <xs:element type="xs:short" name="bauJahr"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="metaDataInspektionType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="pruefRichtung"/>
      <xs:element type="xs:string" name="prufPerson"/>
      <xs:element type="xs:string" name="startDate"/>
      <xs:element type="xs:string" name="endDate"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="headlineType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:short" name="inspektionJahr"/>
      <xs:element type="metadataBauwerkType" name="metadataBauwerk"/>
      <xs:element type="metaDataInspektionType" name="metaDataInspektion"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="bauwerksZustandType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:decimal" name="bauwerksNote"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="titelPageType">
    <xs:sequence>
      <xs:element type="headerType" name="header"/>
      <xs:element type="headlineType" name="headline"/>
      <xs:element type="bauwerksZustandType" name="bauwerksZustand"/>
    </xs:sequence>
  </xs:complexType>
```

```
<!--defintion of damage description and assessment each structure element-->
<xs:complexType name="zustandsBewertungType" mixed="true">
  <xs:sequence>
    <xs:element type="xs:byte" name="standsicherheitWert"/>
    <xs:element type="xs:byte" name="verkehrssicherheitWert"/>
    <xs:element type="xs:byte" name="dauerhaftigkeitWert"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="schadenErfassungType" mixed="true">
  <xs:sequence>
    <xs:element type="xs:string" name="bauteilBeschreibung"/>
    <xs:element type="xs:string" name="material"/>
    <xs:element type="xs:string" name="schadenUmfang"/>
    <xs:element type="xs:string" name="schadenArt"/>
    <xs:element type="xs:string" name="schadenGroesse"/>
    <xs:element type="xs:string" name="schadenUnit"/>
    <xs:element type="xs:string" name="schadensOrt"/>
    <xs:element type="xs:byte" name="massnahmeID" minOccurs="0"/>
    <xs:element type="xs:string" name="schadenBild" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="schadenVonBauteilType" mixed="true">
  <xs:sequence>
    <xs:element type="zustandsBewertungType" name="zustandsBewertung" minOccurs="0"/>
    <xs:element type="xs:string" name="bspID" minOccurs="0"/>
    <xs:element type="schadenErfassungType" name="schadenErfassung" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute type="xs:byte" name="schadenID" use="optional"/>
</xs:complexType>
<xs:complexType name="bauteilType" mixed="true">
  <xs:sequence>
    <xs:element type="schadenVonBauteilType" name="schadenVonBauteil" maxOccurs="unbounded" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute type="xs:string" name="bauteilName" use="optional"/>
</xs:complexType>
<xs:complexType name="schadensBeschreibungType">
  <xs:sequence>
    <xs:element type="bauteilType" name="bauteil" maxOccurs="unbounded" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

<!--defintion of condition description and assessment for whole bridge-->
<xs:complexType name="standsicherheitType" mixed="true">
  <xs:sequence>
    <xs:element type="xs:byte" name="standsicherheitWert"/>
    <xs:element type="xs:string" name="zustandsBesZuS"/>
    <xs:element type="bauteilType" name="bauteil"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="verkehrssicherheitType" mixed="true">
  <xs:sequence>
    <xs:element type="xs:byte" name="verkehrssicherheitWert"/>
    <xs:element type="xs:string" name="zustandsBesZuS"/>
    <xs:element type="bauteilType" name="bauteil" maxOccurs="unbounded" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="dauerhaftigkeitType" mixed="true">
  <xs:sequence>
    <xs:element type="xs:byte" name="dauerhaftigkeitWert"/>
    <xs:element type="xs:string" name="zustandsBesZuS"/>
    <xs:element type="bauteilType" name="bauteil"/>
```

```
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="gesamtBewertungType" mixed="true">
    <xs:sequence>
      <xs:element type="standsicherheitType" name="standsicherheit"/>
      <xs:element type="verkehrssicherheitType" name="verkehrssicherheit"/>
      <xs:element type="dauerhaftigkeitType" name="dauerhaftigkeit"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of maintenance suggestion-->
  <xs:complexType name="massnahmeType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="LeistungArt"/>
      <xs:element type="xs:short" name="leistungMenge"/>
      <xs:element type="xs:byte" name="leistungKosten"/>
      <xs:element type="xs:string" name="kostenUnit"/>
      <xs:element type="xs:string" name="leistungDringlichkeit"/>
      <xs:element type="xs:string" name="leistungFix"/>
      <xs:element type="xs:string" name="projektBez"/>
      <xs:element type="xs:string" name="leistungBem"/>
      <xs:element type="schadenVonBauteilType" name="schadenVonBauteil" maxOccurs="unbounded" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute type="xs:byte" name="massnahmeID"/>
  </xs:complexType>
  <xs:complexType name="empfehlungenSanierungType" mixed="true">
    <xs:sequence>
      <xs:element type="massnahmeType" name="massnahme"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of visual inspection report according DIN1076-->
  <xs:complexType name="inspectionReportType">
    <xs:sequence>
      <xs:element type="titelPageType" name="titelPage"/>
      <xs:element type="schadensBeschreibungType" name="schadensBeschreibung"/>
      <xs:element type="gesamtBewertungType" name="gesamtBewertung"/>
      <xs:element type="empfehlungenSanierungType" name="empfehlungenSanierung"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

7.8 XML-Schema of an inspection report for Denmark

```xml
<?xml version="1.0" encoding="utf-8"?>
<xs:schema targetNamespace="http://amsfree.eu/inspectionReport"
    elementFormDefault="qualified"
    xmlns="http://amsfree.eu/inspectionReport"
    xmlns:mstns="http://amsfree.eu/inspectionReport"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
>
  <xs:element name="inspectionReport" type="inspectionReportType"/>

  <!--definition of meta data bridge-->
  <xs:complexType name="metadataStructType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="adminAuthority"/>
      <xs:element type="xs:string" name="registNr"/>
      <xs:element type="xs:string" name="structureID"/>
      <xs:element type="xs:string" name="structureDesign"/>
      <xs:element type="xs:gYear" name="constructionYear"/>
      <xs:element type="xs:string" name="structTypeMaterial"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of meta data inspection-->
  <xs:complexType name="metaDataInspektionType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:string" name="inspectionEng"/>
      <xs:element type="xs:string" name="inspectionDate"/>
      <xs:element type="xs:string" name="weatherCondition"/>
      <xs:element type="xs:string" name="genComments"/>
      <xs:element type="xs:gYear" name="nextInspectionDate"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="headerType" mixed="true">
    <xs:sequence>
      <xs:element type="xs:gYear" name="inspektionJahr"/>
      <xs:element type="metadataStructType" name="metadataStruct"/>
      <xs:element type="metaDataInspektionType" name="metaDataInspektion"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of condition description and assessment-->
  <xs:complexType name="pictureType">
    <xs:simpleContent>
      <xs:extension base="xs:string">
        <xs:attribute type="xs:string" name="picID" use="optional"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <xs:complexType name="structElementType">
    <xs:sequence>
      <xs:element type="xs:string" name="structDescription"/>
      <xs:element type="pictureType" name="picture" maxOccurs="unbounded" minOccurs="0"/>
      <xs:element name="conditionGrad">
        <xs:simpleType>
          <xs:restriction base="xs:integer">
            <xs:enumeration value="0"/>
            <xs:enumeration value="1"/>
            <xs:enumeration value="2"/>
            <xs:enumeration value="3"/>
            <xs:enumeration value="4"/>
            <xs:enumeration value="5"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:element>
```

```
      <xs:element name="specialInspection" minOccurs="0" maxOccurs="1">
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:pattern value="[AB]"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:element>
      <xs:element type="xs:string" name="safety" minOccurs="0" maxOccurs="1" fixed ="S"/>
      <xs:element name="routineMaintenance" minOccurs="0" maxOccurs="1">
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:pattern value="[+-]"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:element>
      <xs:element type="xs:string" name="recommendRepairWorks"/>
      <xs:element type="xs:gYear" name="recommendYear"/>
      <xs:element type="xs:decimal" name="recommendPrice"/>
      <xs:element type="xs:string" name="recommendPriceUnit"/>
    </xs:sequence>
    <xs:attribute type="xs:byte" name="structElementID" use="optional"/>
    <xs:attribute type="xs:string" name="structElementName" use="optional"/>
  </xs:complexType>
  <xs:complexType name="damageType">
    <xs:sequence>
      <xs:element type="structElementType" name="structElement" maxOccurs="unbounded" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="tableType">
    <xs:sequence>
      <xs:element type="damageType" name="damage"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of damage images-->
  <xs:complexType name="pictureCollectionType">
    <xs:sequence>
      <xs:element type="pictureType" name="picture" maxOccurs="unbounded" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>

  <!--definition of principal inspecition report-->
  <xs:complexType name="inspectionReportType">
    <xs:sequence>
      <xs:element type="headerType" name="header"/>
      <xs:element type="tableType" name="table"/>
      <xs:element type="pictureCollectionType" name="pictureCollection"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

7.9 Damage types and locations of a real inspection report

S	V	D	BSP-ID	Schadensbeschreibung	*Damage description*	Bridge element	DamageArea	Classified Damage
0	0	2	002-09	Platte, Betonoberfläche, Stellenweise, Feuchte Stelle, Gesamter Überbau, Unterseite, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, - stw. mit Aussintenmgen; - Zurn Zeitpunkt der HP größtenteils trocken,	*Slab, Concrete surface, In places, Damp spot, Entire superstructure, Underside, Old damage not repaired, See last main inspection, - stw. with Aussintenmgen; - At time of HP mostly dry,*	Platte http://server.bim-q.de/258#Platte_130011131110000	all elements, in places, underside	Moisture
1	2	3	002-04	Balken, Vollquerschnitt, Bügel, An allen Bauteilen, Freiliegend, Gesamter Überbau, Unterseite, Alter Schaden nicht behoben, - Stw. ist beg. Querschnittsschwächung vorhanden; - Mehrfach sind Querrisse erkennbar, die auf rosttreibende. Bügelbewehrung schliessen lassen; Sichtprüfung durchgeführt	*Beams, Full cross-section, Brackets, On all components, Exposed, Entire superstructure, Underside, Old damage not repaired, - Stw. is beg. Cross-section weakening present; - Transverse cracks are visible on several occasions, indicating rust-driving. Visual inspection carried out.*	Balken, Vollquerschnitt http://server.bim-q.de/258#Balken_Vollquerschnitt_130011131120000	all elements, underside	ExposedTransverseReinforcement ReinforcementCorrosion TransverseCrack
3	2	3	002-07	Balken, Vollquerschnitt, Tragbewehrung, Mehrfach, Freiliegend, Gesamter Überbau, Unterseite, - Die Längsbewehrung an der Unterseite der Längsbalken weist tw. Slattrostbildung mit beginnender Querschnittsschwächung auf (umlaufend ca. 1.5 mm); - mehrfach sind größere Hohlstellen vorhanden; in den ausgeplatzten Stellen ist Rosttrieb und mangelnder Verbund zwischen Beton und Bewehrung sowie lockere Betonstruktur erkennbar; nur Sichtprüfung möglich	*Beams, full cross-section, load-bearing reinforcement, multiple, exposed, entire superstructure, underside, - The longitudinal reinforcement on the underside of the longitudinal beams shows partial slat rust formation with incipient weakening of the cross-section (approx. 1.5 mm all around); - Larger cavities are present in several places; rust sprouting and poor bond between concrete and reinforcement as well as loose concrete structure can be seen in the burst areas; only visual inspection possible*	Balken, Vollquerschnitt http://server.bim-q.de/258#Balken_Vollquerschnitt_130011131120000	all elements, underside	ExposedLongitudinalReinforcement ReinforcementCorrosion
2	1	3	002-03	Balken, Vollquerschnitt, Beton, Zahlreich, Abgeplatzt, Gesamter Überbau, Unterseite, Alter Schaden nicht behoben, - Die Längs und Querbewehrung an der Unterseite und der Seitenflächen der Längsbalken sowie an der Unterseite der Plattenbereiche ist zu gering mit Beton überdeckt, ca. 5 bis 25 mm; - An den Abplatzungen ist ebenfalls zu geringe Betonverdichtung erkennbar (lockere Komstruktur); nur Sichtprüfung durchgeführt	*Beams, Full section, Concrete, Numerous, Spalled, Entire superstructure, Underside, Old damage not repaired, - Longitudinal and transverse reinforcement on the underside and sides of the longitudinal beams and on the underside of the slab areas is insufficiently covered with concrete, approx. 5 to 25 mm; - Insufficient concrete compaction is also visible at the spalled areas (loose com structure); only visual inspection carried out*	Balken, Vollquerschnitt http://server.bim-q.de/258#Balken_Vollquerschnitt_130011131120000	all elements, underside	InsuficientConcreteCompaction Spalling

S	V	D	BSP-ID	Schadensbeschreibung	*Damage description*	Bridge element	DamageArea	Classified Damage
0	0	2	006-01-03	Balken, Vollquerschnitt, Betonoberfläche, An allen Bauteilen, Querriss, Breite 0.3 mm, Gesamter Überbau, Unterseite, tw. umlaufend in die Seitenflächen; - Die Rißweiten betragen 0.1 - 0.3 mm und beginnen punktuell in Abplatzungen über zugehen; - Das Schadensbild weist auf rosttreibende Bügelbewehrungan an den Unterseiten und an den Seitentlachen der Balken hin;- zum Teil mit Aussinterungen; nur Sichtprüfung möglich	*Beams, full cross-section, concrete surface, on all components, transverse crack, width 0.3 mm, entire superstructure, underside, partly running around into the side surfaces; - The crack widths are 0.1 - 0.3 mm and are beginning to spall off at points; - The damage pattern indicates rust-driving stirrup reinforcement on the undersides and on the side flats of the beams; - Partly with sintering out; only visual inspection possible.*	Balken, Vollquerschnitt http://server.bim-q.de/258#Balken_Vollquerschnitt_130011131120000	all elements	TransverseCrack ReinforcementCorrosion Sintering-inducedWaterDrain
1	1	2	002-03	Kragarm, Betonoberfläche, Zahlreich, Hohlstelle, Gesamter Überbau, Beidseitig, Unterseite, - Der Schaden befindet sich unter anderem im Bereich der Pfeiler; - Tw. sind Abplatzungen sowie freiliegende Querbewehrung vorhanden;	*Cantilever, Concrete surface, Numerous, Hollow spot, Entire superstructure, Both sides, Underside, - The damage is among others in the area of the piers; - Tw. spalling as well as exposed transverse reinforcement are present;*	Kragarm http://server.bim-q.de/258#Kragarm_130011131160000	all elements, both sides, underside	Spalling ExposedTransverseReinforcement
1	0	3	002-10	Kragarm, Betonoberfläche, Großflächig, Durchfeuchtet, Gesamter Überbau, Beidseitig, Unterseite, - Zum Zeitpunkt der HP waren die Feuchtstellen trocken; - Stw. sind Quer und Langsrisse sowie kleinere Abplatzungen vorhanden (rosttreibende Sewehrung); - Die Betonobertlache beider Kragarme ist stark verwittert und im Feld 2 (Gleisfeld) zusätzlich verrußt; nur Sichtprüfung durchgeführt	*Cantilever arm, Concrete surface, Large area, Soaked, Entire superstructure, Both sides, Underside, - At the time of the HP, the wet spots were dry; - Stw. transverse and longitudinal cracks as well as minor spalling are present (rust-driving soiling); - The concrete surface of both cantilever arms is heavily weathered and additionally sooted in bay 2 (track field); only visual inspection carried out*	Kragarm http://server.bim-q.de/258#Kragarm_130011131160000	all elements, both sides, underside	Moisture TransverseCrack LongitudinalCrack Spalling
0	0	2	002-02	Platte, Betonoberfläche, Gering, Abplatzung mit freiliegender Bewehrung, Gesamter Überbau, Unterseite, Siehe letzte Hauptprüfung	*Slab, Concrete surface, Minor, Spalling with exposed reinforcement, Entire superstructure, Underside, See last main inspection.*	Platte http://server.bim-q.de/258#Platte_130011131110000	underside	Spalling ExposedReinforcement
0	0	3	025-08	Widerlager, Betonoberfläche, Häufig, Gerissen, Widerlager hinten, Alter Schaden nicht behoben, Siehe Skizze, - Im Bereich der Betonierfugen, stw. bis 0.5 mm tw. mit Aussinterungen;	*Abutment, Concrete surface, Frequent, Cracked, Abutment rear, Old damage not repaired, See sketch, - In the area of the concreting joints, stw. to 0.5 mm tw. with sintering out;*	Widerlager http://server.bim-q.de/258#Widerlager_130011910000000	West	Crack Sintering-inducedWaterDrain

S	V	D	BSP-ID	Schadensbeschreibung	*Damage description*	Bridge element	DamageArea	Classified Damage
1	0	3	025-08	Widerlagerwand, Betonoberfläche, Mehrfach, Längsriss, Breite 3.5 mm, Hinten am Bauwerk, Links, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, Siehe Skizze, - Die Rßbreiten betragen 0.2 mm bis 3.5 mm; - Vereinzelt weisen die Rißbereiche Kantenausplatzungen auf; - siehe Rißüberwachung an den Unterbauten von der Gesellschaft f. Baudiagnose und Schadensanalyse mbH - keine Rissbewegung festzustellen	*abutment wall, concrete surface, multiple, longitudinal crack, width 3.5 mm, rear of structure, left, old damage not repaired, see last main inspection, see sketch, - crack widths range from 0.2 mm to 3.5 mm; - isolated crack areas show edge chipping; - see crack monitoring on substructures by Gesellschaft f. Baudiagnose und Schadensanalyse mbH - no crack movement detected*	Wand http://server.bim-q.de/258#Wand_130011911000000	West	LongitudinalCrack
1	0	2	025-05	Widerlagerwand, Beton, Ein Stück, Längsriss, Breite 2.0 mm, Widerlager vorn, 4.6 m vom rechten Bauteilrand, Durchgehend, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, - Riß führt senkrecht in den Entwässerungsablauf; - siehe Rißüberwachung an den Unterbauten durch Gesellschaft f. Baudiagnose und Schadensanalyse mbH vom 09.12.2005;	*Abutment wall, concrete, One piece, longitudinal crack, width 2.0 mm, abutment front, 4.6 m from right edge of component, Continuous, Old damage not repaired, See last main inspection, - Crack leads vertically into drainage drain; - See crack monitoring on substructures by Gesellschaft f. Baudiagnose und Schadensanalyse mbH dated 09.12.2005;*	Wand http://server.bim-q.de/258#Wand_130011911000000	4.6 m from right edge of component	LongitudinalCrack Sintering-inducedWaterDrain
0	0	2	021-06	Widerlagerwand, Betonoberfläche, Bereichsweise, Durchfeuchtet, Beide Widerlager, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung	*Abutment wall, Concrete surface, In areas, Soaked, Both abutments, Old damage not repaired, See last main inspection.*	Wand http://server.bim-q.de/258#Wand_130011911000000	in places	Moisture
0	0	2	021-03	Auflagerbank, Betonoberfläche, Stellenweise, Schmutzablagerung, Beide Widerlager, Oberseite, Alter Schaden nicht behoben, - Die Fuge zwischen hinterer Kammerwand und Hinterfllillung ist offen, dadurch sickert Sand auf die Auflagerbank;	*Support bench, Concrete surface, In places, Dirt buildup, Both abutments, Top, Old damage not repaired, - Joint between rear chamber wall and backfill is open, causing sand to seep onto support bench;*	Auflagerbank http://server.bim-q.de/258#Auflagerbank_130011913000000	top side, in places	Soiling
0	0	1	021-06	Autlagerbank, Betonoberfläche, Großflächig, Durchfeuchtet, Widerlager hinten, Oberseite, - Zurn Zeitpunkt der EP trocken;	*Support bench, concrete surface, large area, soaked, abutment rear, top side, - dry at time of EP;*	Auflagerbank http://server.bim-q.de/258#Auflagerbank_130011913000000	West, top side	Moisture
0	0	2	025-07	Flügel, Beton, Stellenweise, Gerissen, Flügelwand vorn, Links, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, - Der Beton des Flügels ist in den Betonierfugen gerissen mit Feuchtigkeitsaustritt und Aussinterungen;	*Wing, Concrete, In places, Cracked, Front wing wall, Left, Old damage not repaired, See letzte Hauptprüfung, - The concrete of the wing is cracked in the concreting joints with moisture seepage and sintering out;*	Flügel http://server.bim-q.de/258#Flugel_130011914000000	North-East, in places	Crack Moisture Sintering-inducedWaterDrain

S	V	D	BSP-ID	Schadensbeschreibung	*Damage description*	Bridge element	DamageArea	Classified Damage
1	0	3	025-06	Flügel, Betonoberfläche, Häufig, Allgemeiner Riss mit Aussinterung, Vorne und hinten am Bauwerk, Rechts, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, - Die Risse verlaufen quer und längs - häufig in den Betonierfugen; - Die Rißweiten betragen zwischen 0.3 mm und 3.5mm, tw. mit Aussinterungen und Wasseraustritt aus den Betonierfugen ; - Unterhalb des Flügelgesimses vorn rechts be.findet sich ein horizontaler Riss bis 5 mm stw. mit Kantenausbrüchen;	*Wing, Concrete surface, Frequent, General crack with sintering out, Front and rear of structure, Right, Old damage not repaired, See last main inspection, - The cracks run transversely and longitudinally - frequently in the concreting joints; - The crack widths range between 0.3 mm and 3.5mm, tw. with sintering out and water seepage from the concreting joints ; - Below the wing cornice at the front right, there is a horizontal crack up to 5 mm stw. with edge breakouts;*	Flügel http://server.bim-q.de/258#Flugel_1300119140 00000	North-East, East, South-East	TransverseCrack LongitudinalCrack Sintering-inducedWaterDrain
0	0	3	025-08	Flügel, Betonoberfläche, Bereichsweise, Allgemeiner Riss mit Wasseraustritt und Aussinterung, Flügelwand hinten, Links, Alter Schaden nicht behoben, Siehe letzte Hauptprüfung, Die horizontalen Risse befinden sich in den Betonierfugen;	*Wing, Concrete surface, Area wise, General crack with water leakage and sintering out, Wing wall rear, Left, Old damage not repaired, See last main inspection, The horizontal cracks are in the concreting joints;*	Flügel http://server.bim-q.de/258#Flugel_1300119140 00000	North-East	Crack
2	0	3	025-08	Flügel, Betonoberfläche, Stellenweise, Schrägriss, Breite 9.0 mm, Flügelwand hinten, Links, Oben, Schadenserweiterung, Siehe letzte Hauptprüfung, - Rißmarkenablesung nicht möglich, Marke beschädigt; Rißüberwachung an den Unterbauten von der Gesellschaft f. Baudiagnose und Schadensanalyse mbH;-	*Wing, concrete surface, in places, diagonal crack, width 9.0 mm, Flügelwand rear, left, top, damage extension, See last main inspection, - crack mark reading not possible, mark damaged; crack monitoring on the substructures by the Gesellschaft f. Baudiagnose und Schadensanalyse mbH;-*	Flügel http://server.bim-q.de/258#Flugel_1300119140 00000	North-East, top, in places	DiagonalCrack
0	0	2	021-06	Flügel, Betonoberfläche, Bereichsweise, Durchfeuchtet, Vorne am Bauwerk, Beidseitig, Alter Schaden nicht behoben, mit Aussinterungen	*Wing, Concrete surface, Area by area, Soaked, Front of structure, Both sides, Old damage not repaired, With sintering out*	Flügel http://server.bim-q.de/258#Flugel_1300119140 00000	South-East	Moisture Sintering-inducedWaterDrain
0	0	2	241-07	Brücke, Fahrbahnbelag, Fugen längs allgemein, Stellenweise, Gerissen, Mitte quer, - Die Längsfugen im Fahrbahnbelag sind stw. bis 1.0 mm gerissen;	*Bridge, pavement, joints longitudinal general, in places, cracked, center transverse, - The longitudinal joints in the pavement are cracked stw. up to 1.0 mm;*	Fahrbahn http://server.bim-q.de/258#Fahrbahn_130022510000000	On the plate	Crack