Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME

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

D7.1 Functional Memorandum of Prototype

D7.2 Link to Current State of Prototype

D7.3 Short Description of Prototype

July 2022

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1 Introduction

The AMSfree project analyzed the architecture of Infrastructure Asset Management Systems (IAMSs) used by National Road Authorities (NRAs), as well as the asset information content in current IAMSs in order to establish detailed technical requirements for linking IAMS and Building Information Models (BIMs) as infrastructure asset databases on a macro and micro level. The analysis is performed on a range of BIM models utilized by designers and contractors, so the level of development (LOD) for the common infrastructure asset BIM can be agreed on. To allow full utilization of state-of-the-art data acquisition techniques (sensors and drones etc.), requirements for existing condition assessment techniques are established and documented in the information delivery manual (IDM) for the condition assessment of assets. Based on the national asset management system processes, a generic IAMS-Process approach was developed, and a related IAMS-oriented IDM was established. Based on these results, a prototype for linking legacy databases with IFC was developed and tested with three different use cases for pavements and bridges.

Information Container for linked Document Delivery (ICDD, ISO 21597) is the data structure for handling various interrelated documents. The documents in the container are organized, and the data is linked according to the ICDD specification. All the information stored in the container is contextualized by means of ontologies that also form part of a container. For the realization of the ICDD, a web-based ICDD-Platform is developed. For the organization of the data and the ICDD, the platform should give a function for creating projects and information containers. Furthermore, there must be the functionality to edit, modify and delete containers and container content. In the following chapters, the functionality of the prototype as a web-based platform will be declared.

2 Functional Memorandum of the Prototype

2.1 Scope of the Prototype

The prototype can be used to link IFC models and IAMS databases. Containers can be either uploaded to the Information Container Data Delivery (ICDD) Platform, extended or created. The users can then use the containers to link information in the prototype and create relations. In addition, IFC models are displayed in the IFC viewer, in which 3D-shapes can be clicked on to retrieve related information. The prototype can be used to synchronise changes in the IAMS and the BIM database so that reliable consistent data management can be realised.

The application of the prototype, See Figure 1is intended for the IAMS life cycle of pavement and bridges. This includes asset creation, condition assessment, maintenance planning and as-built models of implemented measures.

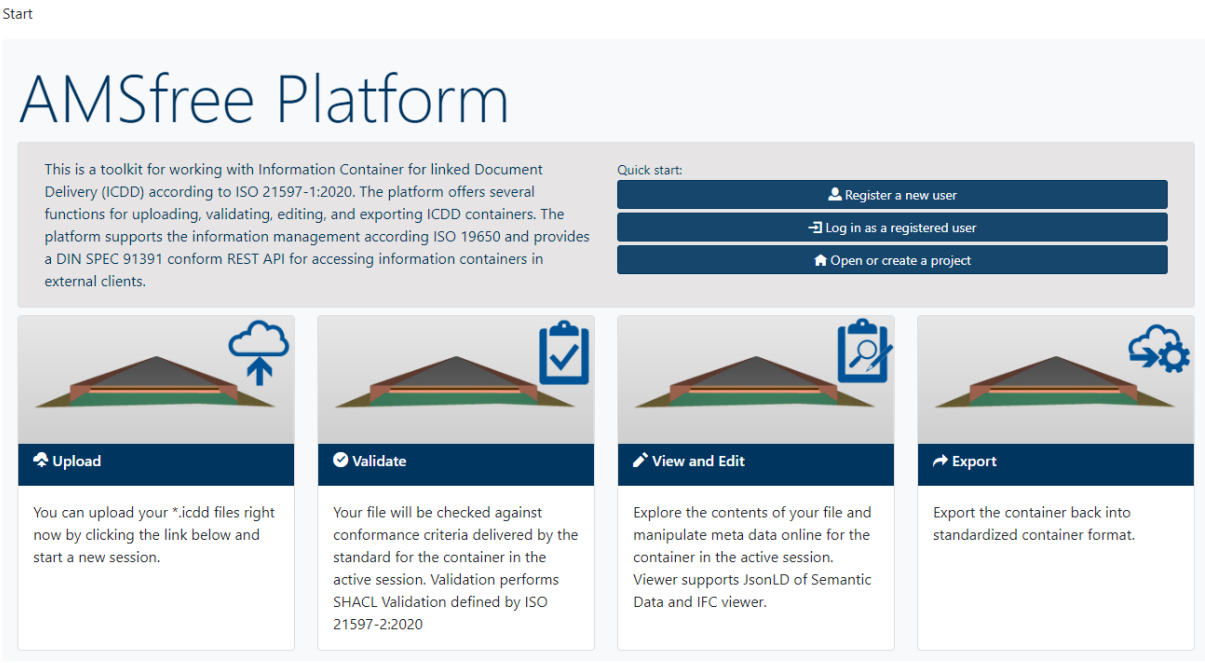

Figure 1 : Start screen of the prototype ICDD-Platform [RUB]

2.2 System architecture of the Prototype

The system architecture of the prototype to realize ICDD functions can be understood in three parts, shown in Figure 2. The created containers are recorded in the data repository for further use. The business & data access logic part provides the core processors for the functionalities of the ICDD. Furthermore, the data flow from the data repository to the presentation for the user is managed. The container processor provides the functionality to create, edit and delete content in the container. Other processors related to the container processor retrieve or send container-related data. The IFC Processor is processing IFC-files shown within the Web User Interface with the geometry and spatial hierarchy of the IFC model.

Moreover, IFC models can be converted into RDF-based datasets within the platform using the IFCtoLBD converter. The SPARQL and SHACL processors provide to retrieve data of container requested and validate data based on the defined constraints. The R2RML Processor realizes the data integration from the external database into ICDD with predefined mapping rules. The created RDF triples and links are stored in the container. The Web User Interface provides an interface for presenting and interacting with all provided functionalities in the business & data access logic part. Additionally, through the IFC viewer, it is able to create queries related to selected IFC objects in the container with little or no SPARQL expertise .

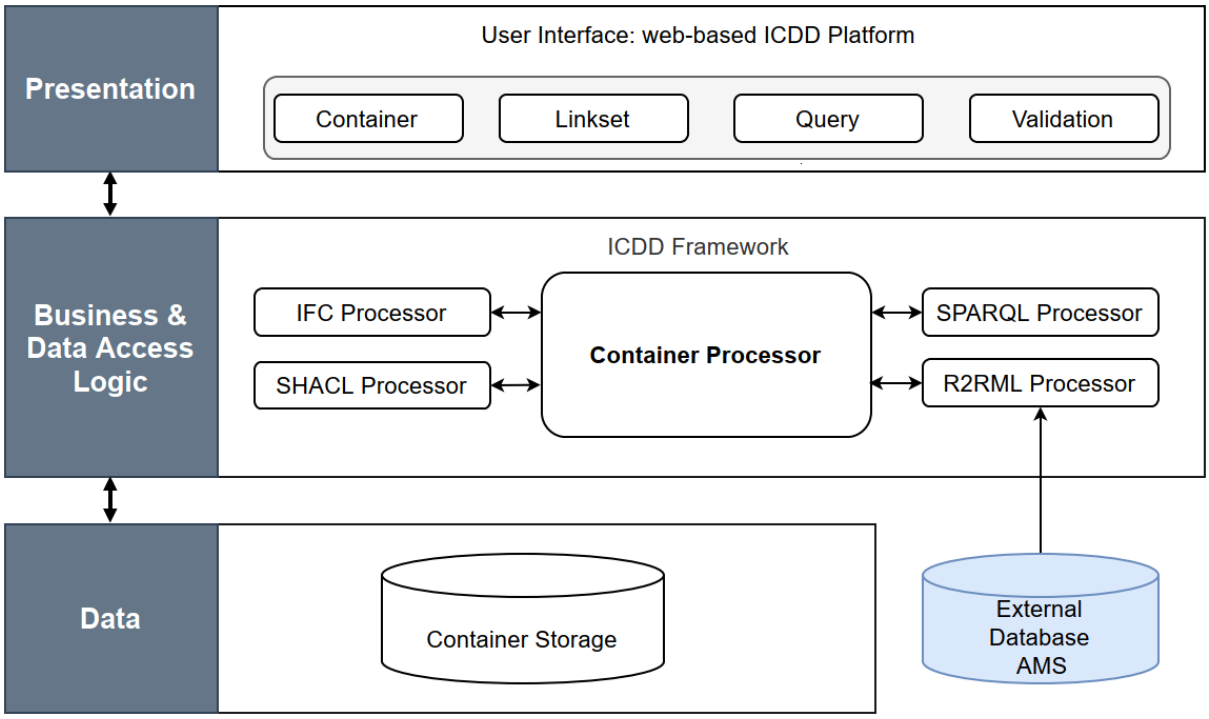

Figure 2 : System architecture of the prototype ICDD-Platform – core functionalities with ICDD

2.3 Function of the Prototype

2.3.1 General

The application and the general interrelationships that are important for the users are described in the guideline report 6.1. The aim of the report is to provide potential users of Building Information Modelling (BIM) from National Road Authorities (NRA) with a guideline to implement approaches developed in the AMSfree project. This document includes a instructions for exchanging linked data between Infrastructure asset management systems (IAMS) and BIM by using information containers, the development of a transformation concept for data exchange between different IAMS systems and a procedure for the systematic integration of existing asset data in different NRA by means of ontologies. This includes the description of the proposed approach, including use cases, the software and data/file formats used as well as an illustrative application of the developed concepts on the example of a road section and a bridge. It gives a detailed explanation of how to proceed as a user in updating the AMS database to mirror physical reality – this will serve as the basis for the engineering application. In the following, the function of the prototype is explained in detail.

The application starts with a login or registration as a user, which must be confirmed by project partner RUB. The login window is shown in Figure 1. The basic functionalities are as follows:

Upload:

The user can easily upload existing ICDD files

Validate:

The uploaded file can be checked against conformance criteria delivered by the standard for the container in the active session. The validation will perform SHACL Validation defined by ISO 21597-2:2020.

View and Edit:

The contents of the file can be explored, and meta data can be manipulated online for the container in the active session. The Viewer supports JsonLD of Semantic Data and IFC Viewer.

Export:

The container can be exported back into the standardized container format.

2.3.2 Project Management

2.3.2.1 Create Project

First, a project must be created on the ICDD Platform. This can be found in the "Project List" (see Figure 3). By clicking on the name, the project is opened. Several information containers can be created in a project, either directly on the website or by uploading them. Templates for Asset Management Maintenance and Inspection are stored on the website and can be selected when creating the project.

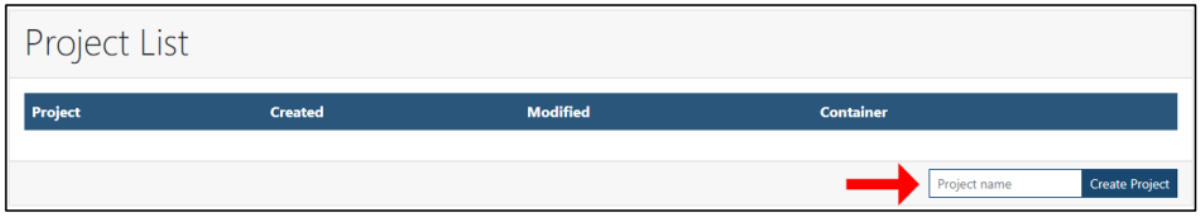

Figure 3: Create project

2.3.2.2 Edit Project

To open a project and therefore be able to edit it, one can either click on the name of the project or the magnifying glass icon (see Figure 4). The following screen will show the project properties and its containers (see Figure 5).

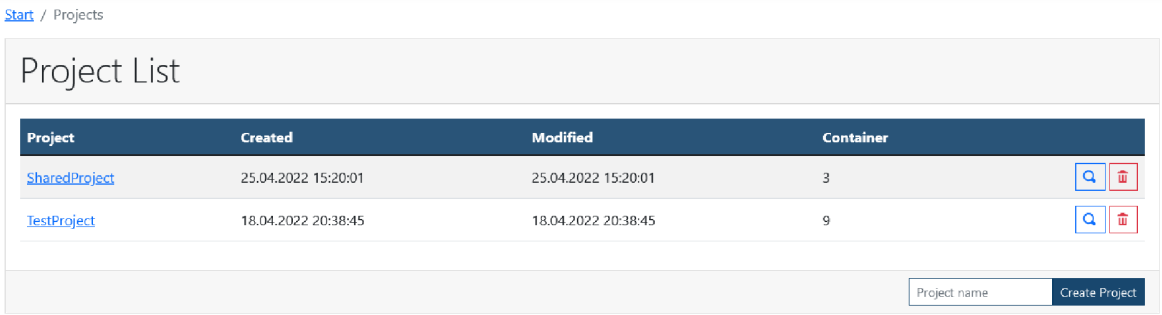

Figure 4: Project list

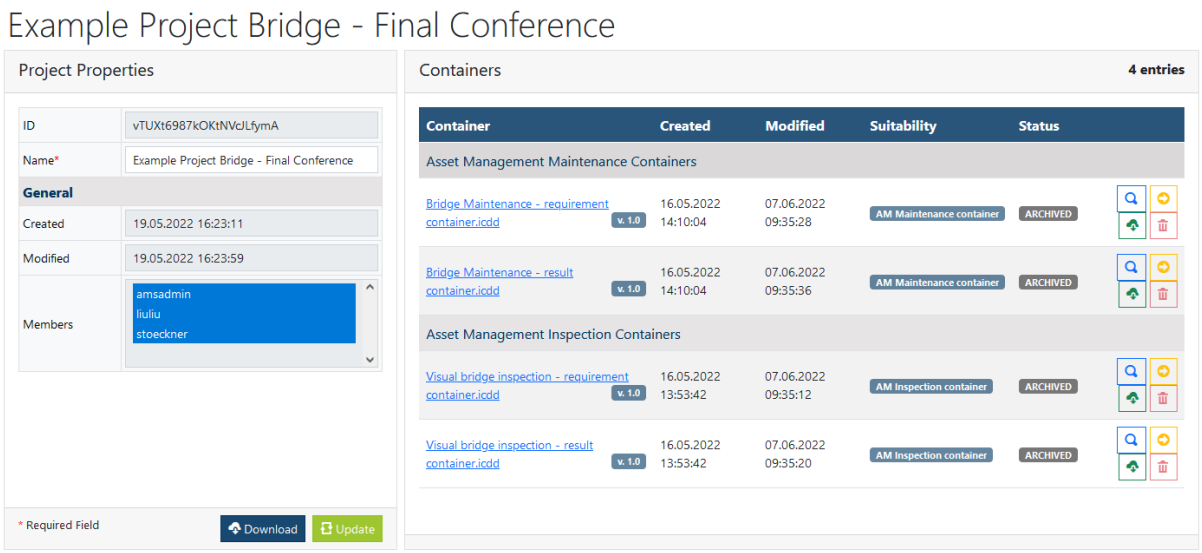

Figure 5: Project details

2.3.2.3 Delete Project

To delete a project, one can click on the red trash icon (see Figure 4). Another page will open, asking to delete the chosen project. Click on the “Delete”-Button (see Figure 6) to delete the project. The project and all its containers including their contents will be permanently deleted. This action cannot be undone.

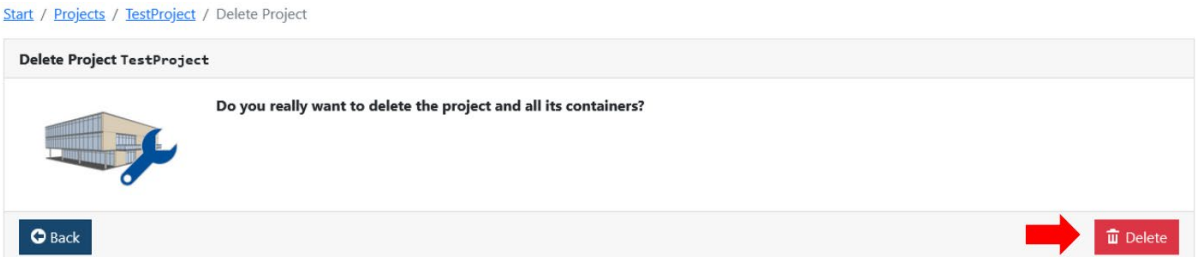

Figure 6: Delete project [RUB]

2.3.3 Container Management

After creating a project, the information container can now be generated, uploaded and modified. For that, the container must be opened. The structure of the container can be found in the area of user interface called explorer. The content window contains the content of the files and the container dashboard with information about the container. In addition, it offers five options for editing the container content, including uploading. With “Participants”, contributors can be added who are working on the container. An ontology or a payload triple can be added to ontologies by entering a web URL or uploading a file. The documents field offers the possibility to add internal documents, external documents, database connections and folders. With “Add Linkset” a new linkset can be created in the payload triples folder; only a name has to be entered. This linkset can be extended in the Payload triples folder. A SPARQL query can be

written under “Query”. The properties contain the metadata of the container, which was specified when the container was created, and further information. The metadata can be changed and updated here. In addition to the properties that are displayed within the container, there is also the IFC viewer. The IFC viewer displays the models.

2.3.3.1 Create a Container

There are two ways to create a container (see Figure 7):

- Upload a Container (A)
- Create new Container (B).

To open a container either click on the name or the magnifying glass. To create a new version of a pre-existing container, use the yellow arrow icon. To download a container, click on the cloud icon. To delete a container from the list of containers, the trash button can be used.

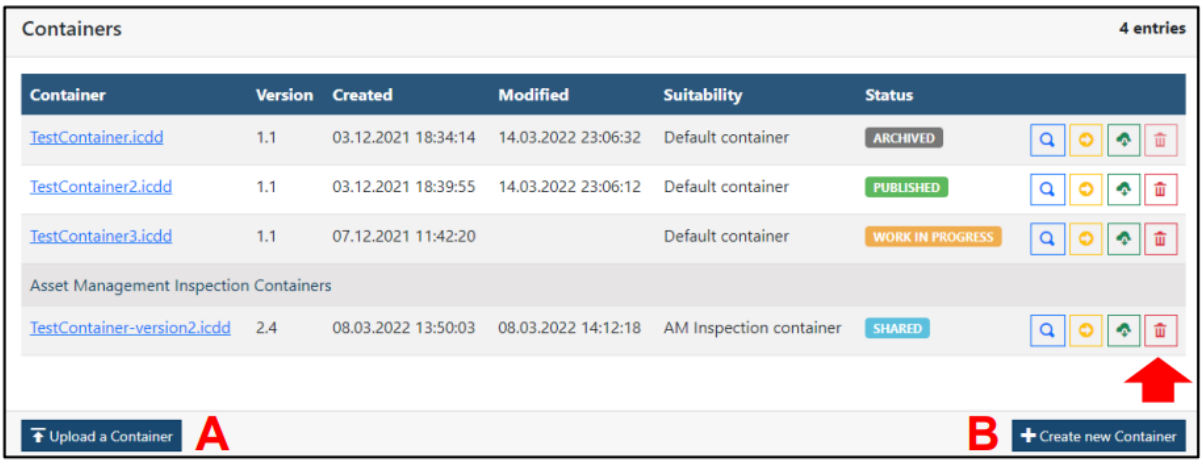

Figure 7: Container list [RUB]

To upload a container a file, a suitability and a status must be chosen (see Figure 8). To create a new container in addition to choosing the suitability and status (see Table 1), a name, description, and revision must be chosen.

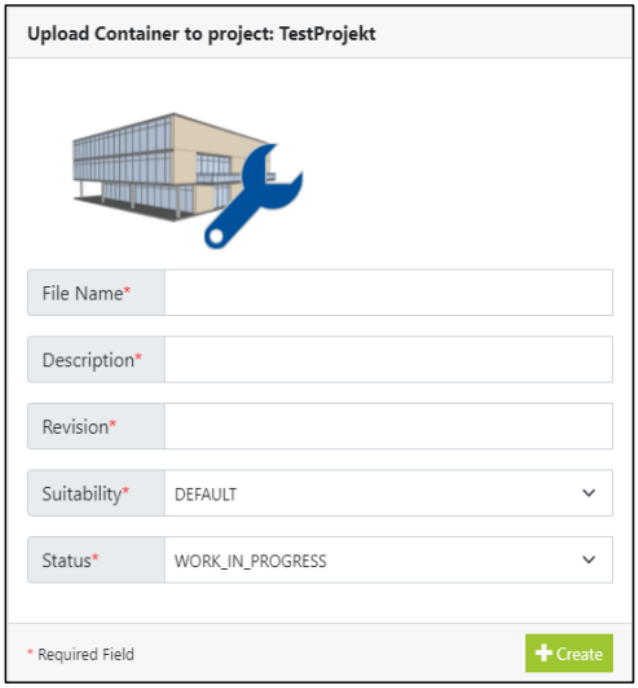

Figure 8: User interface while uploading a container file

Table 1: Suitability and status codes

Suitability	**Status**
- Default - Suitable for Coordination - Suitable for Information - Suitable for Internal Review and Comment - Suitable for Construction Approval - Suitable for Manufacture - Suitable for PIM Authorization - Suitable for AIM Authorization - Suitable for Costing - Suitable for Tender - Suitable for Contractor Design - Suitable for Manufacture Procurement - Suitable for Construction - Suitable for AM inspection - Suitable for AM Maintenance - Suitable for Requirements	- Work in Progress - Shared - Published - Archived*

Note *: Once the status “Archived” is chosen the container cannot be edited anymore and the status cannot be changed again

2.3.3.2 Delete and Export Containers

There are two different ways to delete and export a container

- in the container list of an open project (see Figure 9)
- under the explorer in an open container using ”Remove“ or “Export“ (see Figure 10)

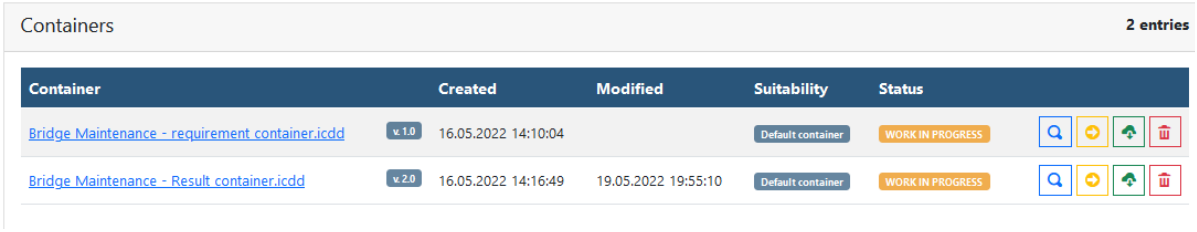

Figure 9: Container list with the icons to remove (red icon “Delete”) and export (green icon “Download”) containers

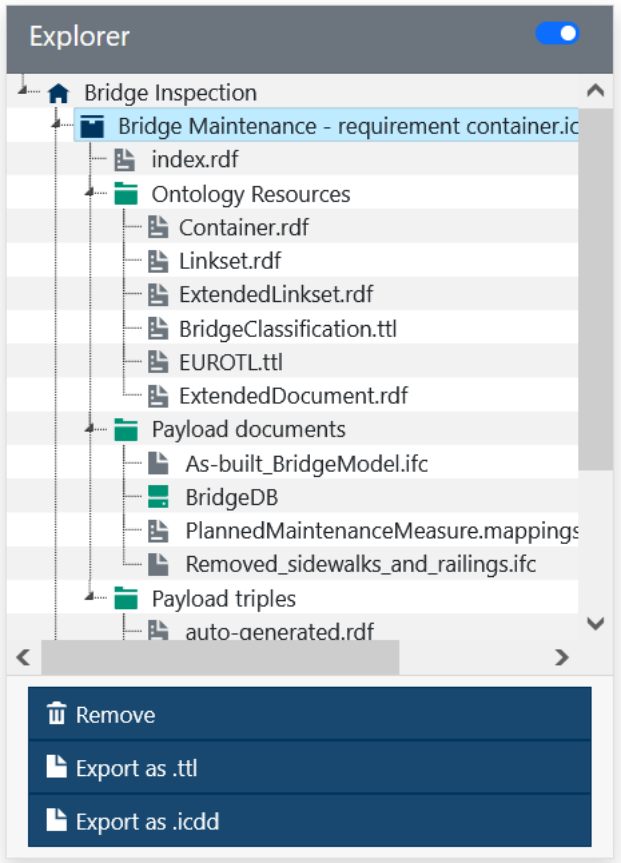

Figure 10: Explorer with the options to remove and export containers

2.3.3.3 Add new Container Version

To add a new version to a container, click on the yellow arrow icon of the chosen container (see Figure 11). The container and its contents will be duplicated, and the resulting new container will be added to the container list. Its container version will be increased by one.

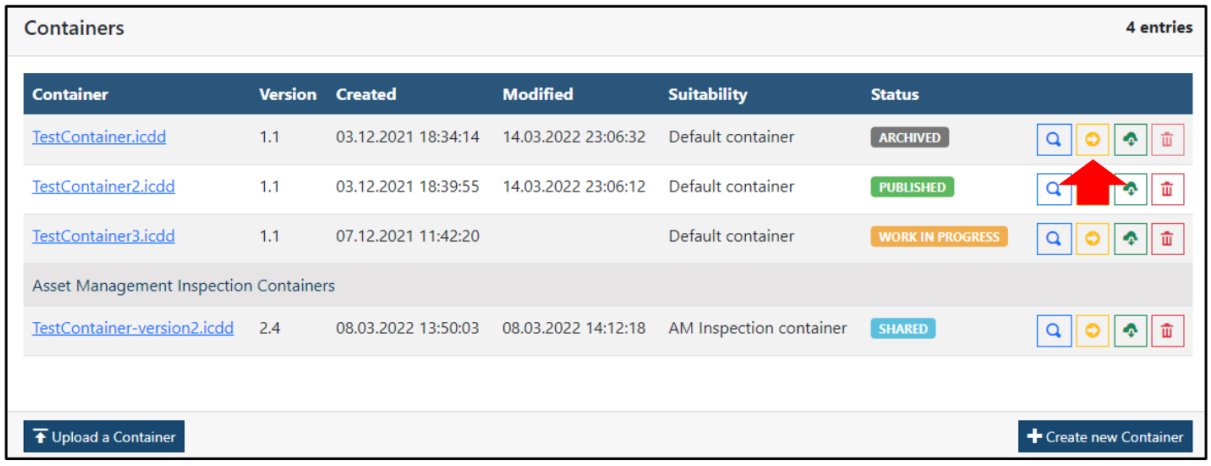

Figure 11: New container version [RUB]

2.3.3.4 Edit Container

In the container tab details of the container can be edited. The container details are divided into three sections.

- Explorer (left)
- Content (center)
- Properties / IFC Viewer (right)

Explorer

The explorer gives an overview of the structure of the container with its three folders Ontology Resources, Payload documents and Payload triples and each of its contents. The explorer can be hidden or unhidden with the controller in the far-right corner (see Figure 12). To get back to the dashboard click on the name of the container. At the bottom of the currently open container, other containers that belong to the same project are listed. To switch to one of those, click on the name.

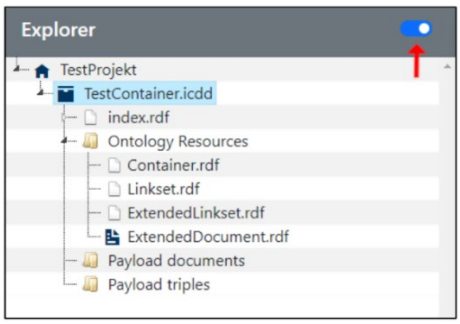

Figure 12: Explorer and Controller [RUB]

Content

Within the content window are the contents of the files and the container dashboard with information about the container. The container dashboard offers 5 ways to edit the container contents (see Figure 13).

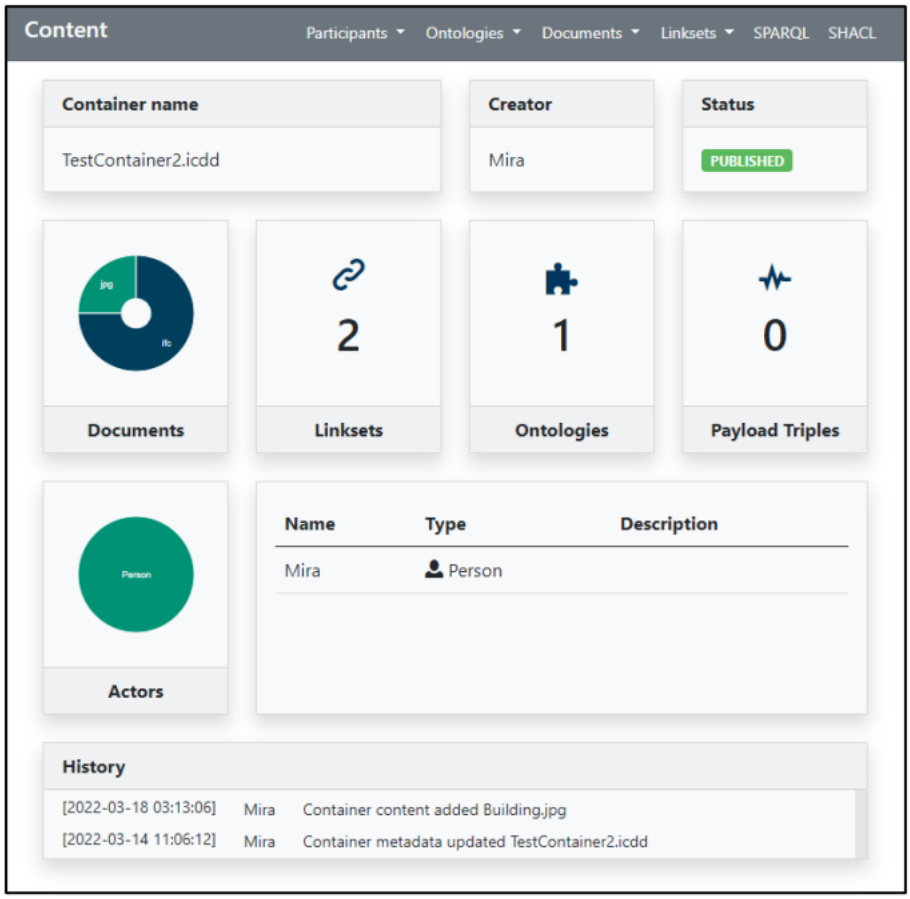

Figure 13: Container dashboard [RUB]

Properties

The metadata of the container (selected when creating the container) and further information can be found in Properties. In Properties the metadata can be changed and updated.

IFC-Viewer

Additionally, to the properties, the IFC-Viewer can be found in “Properties” in the upper right corner (see Figure 14). The IFC-Viewer shows the IFC models in the container, the label and GUID of selected Elements. The models can be activated and deactivated with the “Visibility” controller. To make the model transparent, use the “Transparency mode” Button, and the Button “Reset viewer” resets the model to its original point of view.

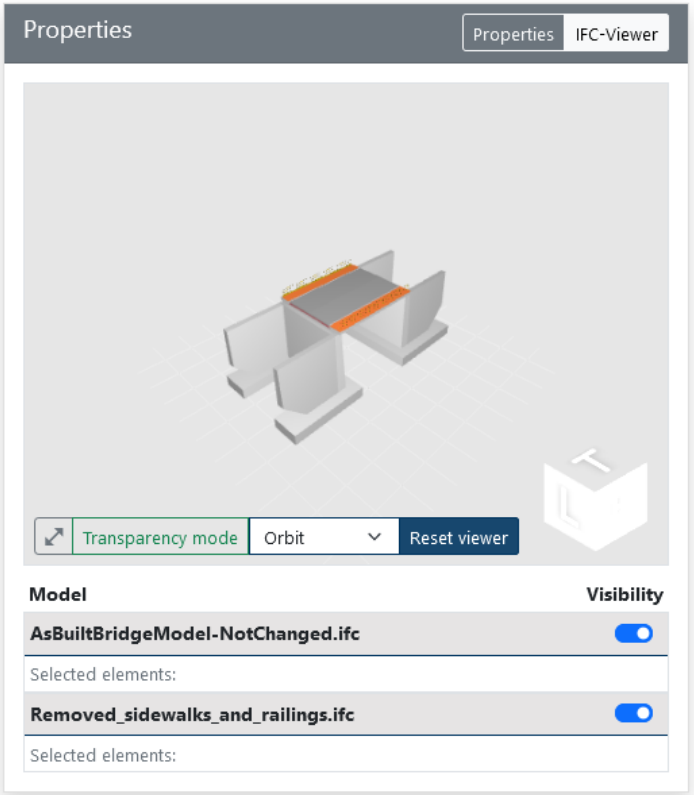

Figure 14: IFC viewer [RUB]

The operating instructions of the mouse functions in the IFC viewer are the following:

Rotate model:	Cube or hold left mouse key
Move entire model:	Right mouse key
Zoom in and out:	Mouse wheel
Activate/deactivate:	Visibility controller
Select model element:	Click on it with left mouse key
Back to starting position:	Button “Reset viewer”

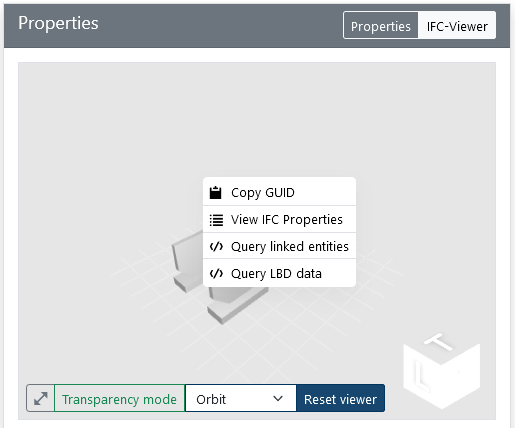

Figure 15: Pop-up menu IFC viewer

To open the pop-up menu for an element, click on the element in the IFC-Viewer using a right mouse click. The option “Copy GUID” copies the Guid of the chosen IFC element. “View IFC Properties" directs one to the specific element in the .ifc file. Using “Query linked entities" or “Query LBD data”, the SPAQRL query feature opens up with a query to find linked entities or LBD data.

3 Examples and Use Cases

3.1 Pavement

In the beginning, the user selects which use case or which data is to be considered. This selection is made by clicking on the corresponding container in the container list (see Figure 16). This selects the corresponding ontology and loads the IFC model.

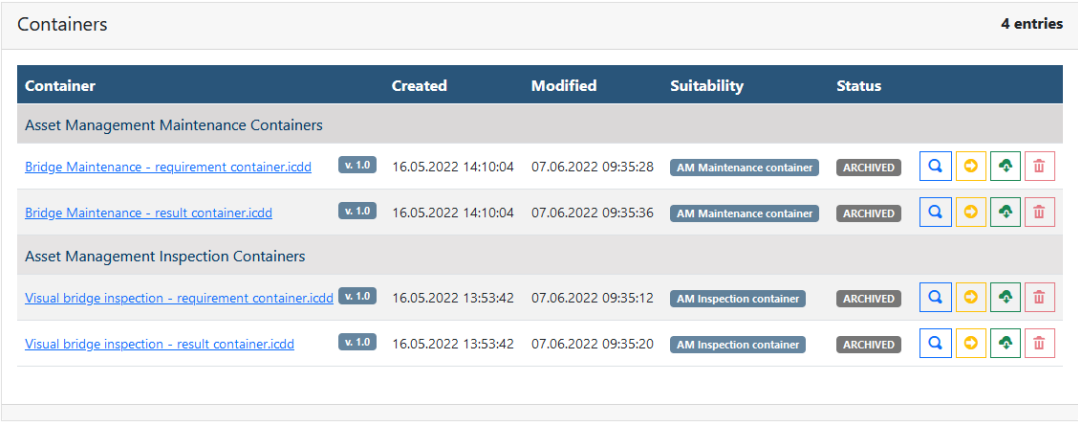

Figure 16 : Container list / Pavement

An overview page is displayed, which is divided into three windows (see Figure 17); the explorer, the content window and the properties window, in which it is possible to switch between properties and the IFC viewer.

The explorer window displays the stored files and their folder structure. Files can be selected here for closer observation. It is also possible to switch between the various containers for different use cases.

In the content window, an overview of the containers is displayed at the beginning, with the number of linksets, ontologies and payload triples contained. When a file is selected in the explorer window, the metadata of the file and its structure are displayed in the content window.

An IFC model exists for the roadway, which was loaded onto the platform. In addition, the platform provides containers for condition assessment, maintenance planning and modification of the as-built model. All containers receive a roadway model, a container RDF, a linkset RDF and an object-type library.

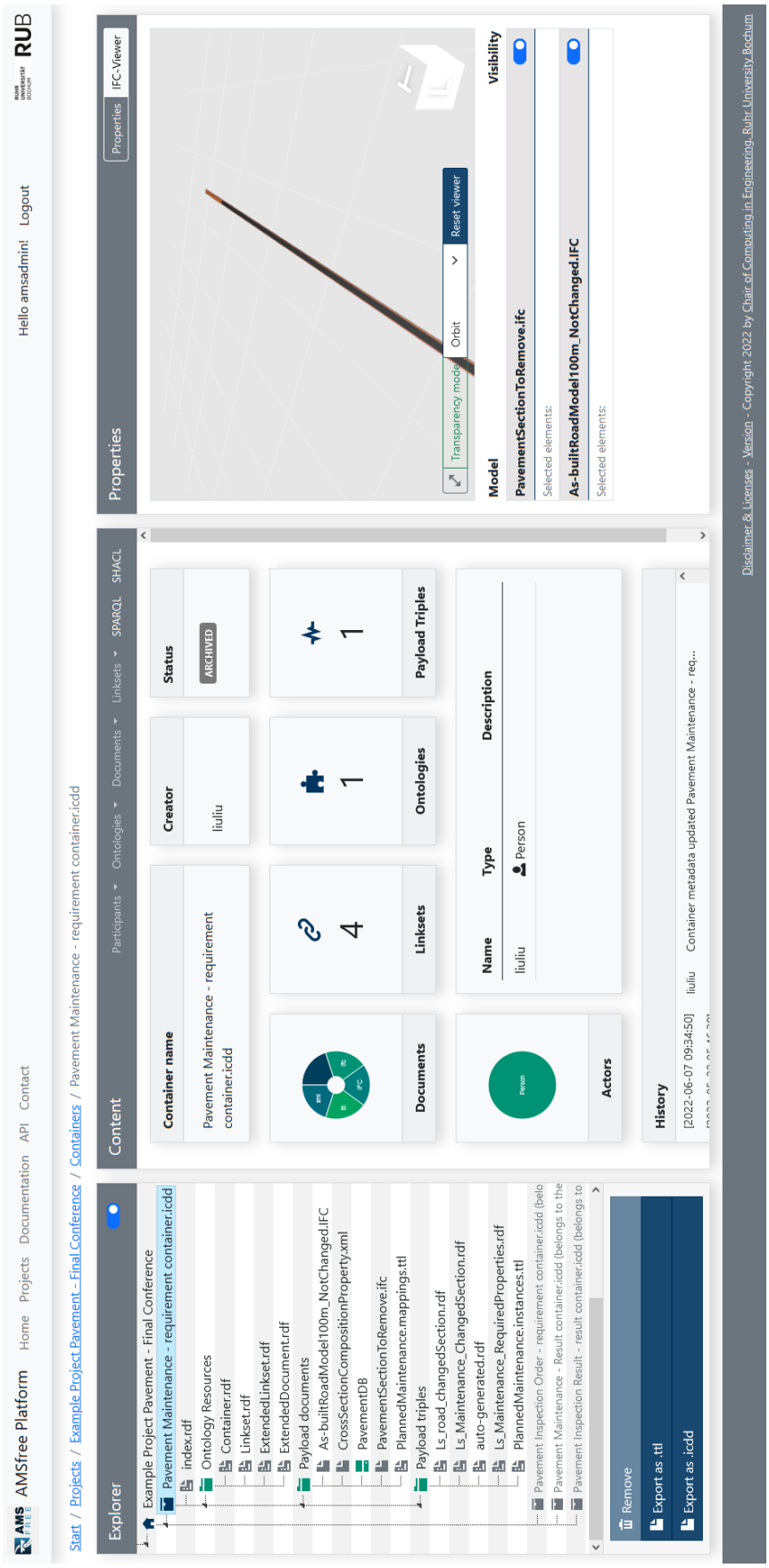

Figure 17: Overview page for example "pavement"

3.1.1 View S&A

The aim of this use case is to query and display the results of the condition survey and assessment (S&A) of road sections.

Workflow:

The user selects the survey file in the explorer window. The information is now displayed in the content window. The list in the content window contains road sections that are surveyed and the results of drill cores.

Now the user can select a section. The IFC viewer opens, and the selected section is displayed as a marker in the IFC model (see Figure 18). Below the IFC viewer, the status information of the selected road section is displayed in tabular form.

Furthermore, it is possible for the user to select the route sections in the IFC viewer. The information is also displayed in a table under the IFC viewer of the selected road section. In addition, the selected road section is highlighted and displayed in the content window.

Requirements:

What data is accessed? → A result file of the condition data from S&A campaign.

Which feature groups are updated / exchanged?

- General information on the S&A campaign, e.g. time of implementation, person who recorded the data, scope of recording:
    - Campaign
    - Subproject
- Results of the survey, i.e. standardised condition values:
    - Asphalt condition values
    - Concrete condition values
    - Partial and aggregate values

Which data format is available?

- For providing the general information and results of the survey
    - IFC – digital model
    - PFD, image format (e.g. JPG) – paper-based documents
    - XML, CSV – semantic information
    - RDF, TTL – semantic information (retrievable with SPARQL)
- For exporting the selected data of result with SPARQL:
    - CSV

The results of the condition recording are attached to a virtual layer by means of property groups and properties. The location of the areas must be done by specifying the start and end points. The width and length of the surface elements are to be calculated from the geometry of the profile or the grid length of the condition survey.

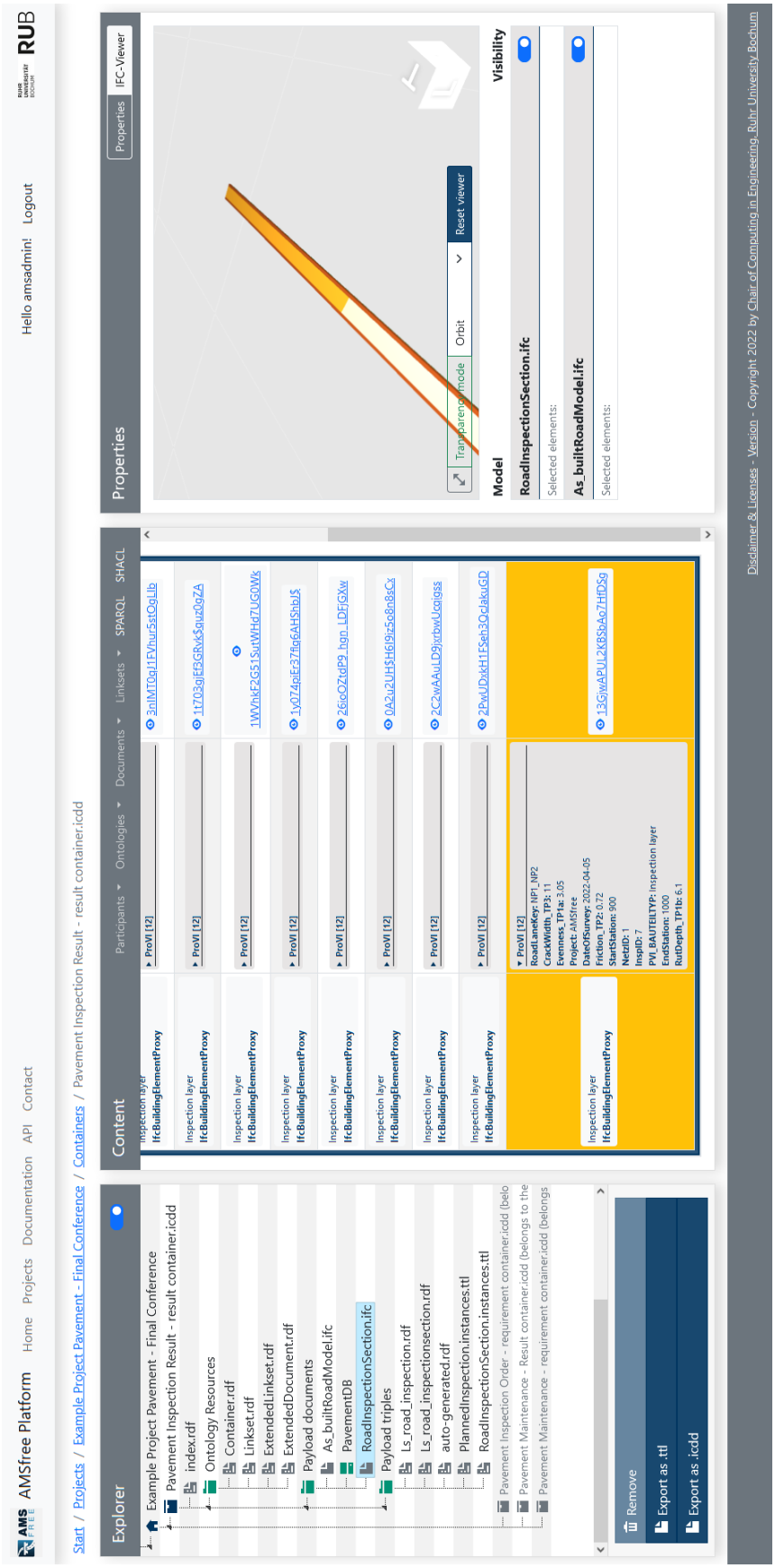

Figure 18: Example of a selected road section in survey

3.1.2 View Maintenance Plan

The purpose of the use case is to query and graphically display the results of maintenance planning. The planned maintenance sections, including information on the type of measure, costs and time, which were previously generated with a PMS, will be displayed.

Workflow:

The user selects a specific road section for analysis via the content window. The related model is then loaded and displayed in the IFC viewer and the properties of the section and the maintenance planning are displayed in the properties window under the IFC viewer (see Figure 19).

The maintenance planning is colour-coded according to the type of measure in the IFC viewer. The user can identify directly whether it is maintenance or replacement.

The user can see further maintenance sections via the IFC viewer and click on them to obtain more detailed information. The information (condition data) attached to this surface layer is displayed in the properties window under the IFC viewer.

Requirements:

The results are collected using ICDD. The maintenance units are linked to the output of the PMS calculations. The results ICDD are saved by the asset owner separately.

- What data is accessed? Output from PMS calculations, i.e. list of measures.
- Which groups of characteristics are updated / exchanged?
    - Type of measure
    - Cost of the measure
    - Year of measure
    - Explanation of reason/trigger of measure
- Which data format is available?
    - For providing the general information and the results
        - IFC – digital model
        - PFD, image format (e.g. JPG) – paper-based documents
        - XML, CSV – semantic information
        - RDF, TTL – semantic information (retrievable with SPARQL)
    - For exporting the selected data of result with SPARQL:
        - CSV

The information to be represented by means of property groups and properties is attached to a virtual layer in the IFC model.

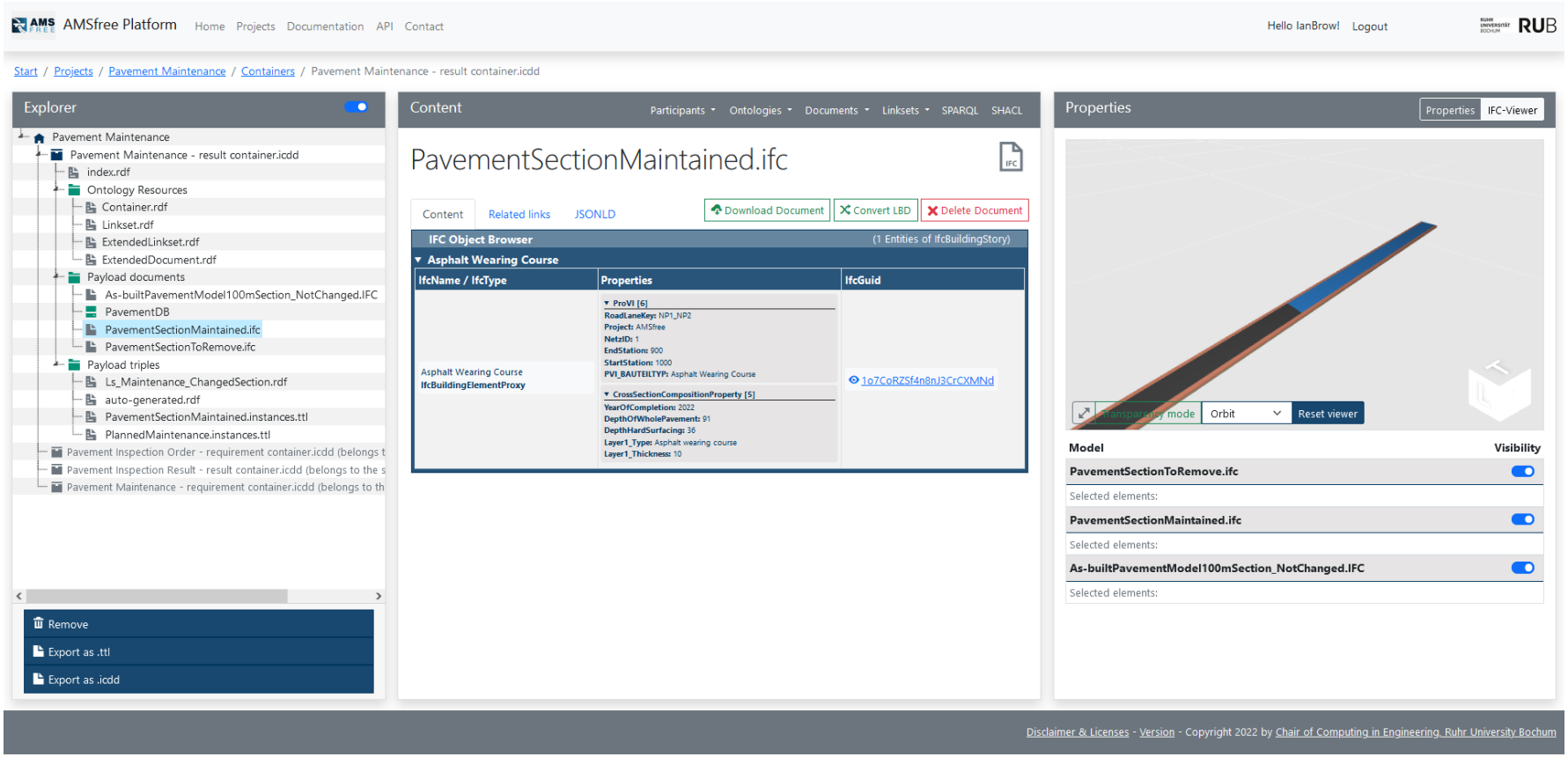

Figure 19: Maintenance plan for a selected road section

3.1.3 As-built View

The purpose of this use case is to import as built data from the construction phase and to query and graphically display this information. Here, the following two features are of particular relevance:

- Changes in the geometry of the structure (e.g., changes in the layout).
- Location of individual drill cores
- Display of information on material properties on drill cores.

Workflow:

The user has to select an element by clicking on it. Then, the information attached to the element is displayed.

The position of the individual drill cores is displayed to the user in the IFC viewer. To locate the drill cores, they must be located by reference.

The user can get information about the drill core in a new window by clicking on the marked drill core locations. When selecting the drill cores, the information obtained from the material inspections (acceptance test) should be displayed. The model element is highlighted in the IFC viewer.

Requirements:

- What data is accessed? → Planning documents, reports of the acceptance tests.
- Which groups of characteristics are updated / exchanged?
    - Layer general
    - aggregate control test
    - Binder control test
    - Asphalt mix control test
    - Concrete mix control test
    - Asphalt surface layer control test
    - Concrete surface layer control test
    - Asphalt binder layer control test
    - Pavement bound Control test
    - Pavement unbound Control test
    - Paving conditions
    - Photo of the drill core
- Which data format is available?
    - For providing the general information and the results
        - IFC – digital model
        - PFD, image format (e.g. JPG) – paper-based documents
        - XML, CSV – semantic information
        - RDF, TTL – semantic information (retrievable with SPARQL)
    - For exporting the selected data of result with SPARQL:
        - CSV

The information to be presented based on property groups and properties is attached directly to the drill core location in the results. For updating the model (as-built model), the corresponding information is attached to the individual layers and the geometry is adjusted if necessary.

Changes in the geometry:

Example: Replacement of a surface layer

In Example 1, a surface layer of the same thickness is replaced as part of a maintenance measure. The individual layer thicknesses remain the same, so that only the feature groups need to be updated. Therefore, no changes in geometry are necessary.

The geometric changes must also be adjusted in the geometry of the model. For this purpose, existing elements are removed and replaced by new geometric elements. The as-built properties are attributed to the new elements. The properties of the previous element are linked to the new element for reproducibility.

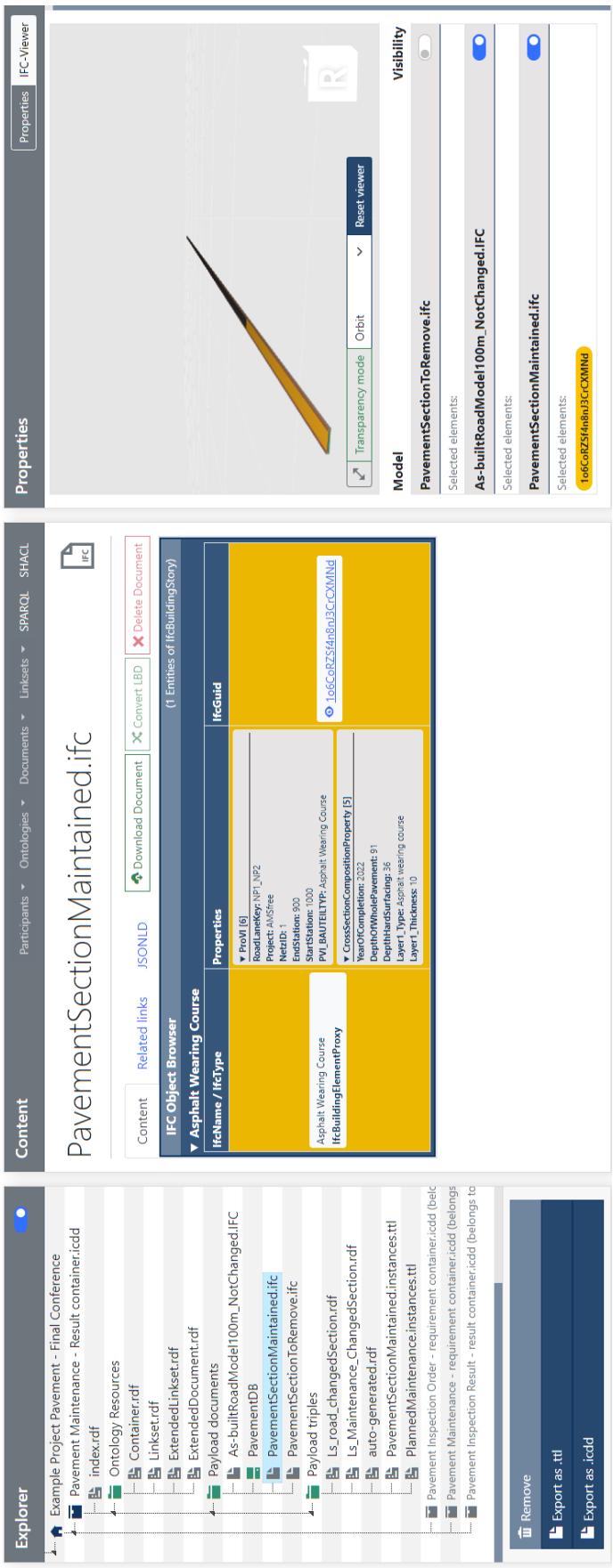

Figure 20: Maintenance with the road section replaced by the work

3.2 Bridge

The prototype includes the following three use cases; condition assessment, maintenance plan, and as-built view.

Workflow to start the described use cases:

1. In the prototype, all structures are listed for selection.

2. The user selects a structure for further information display.

3. After selecting the structure, the user can choose between "view condition assessment", "view maintenance plan" and "as-built view".

4. After selecting the use case, the procedures are described accordingly.

3.2.1 View Inspection

Purpose: The user wants to view the condition of a specific structure.

Workflow:

The user selects the structure and the as-built model is loaded into the embedded IFC viewer of the prototype and displayed.

The existing inspections with meta-information (year, inspector, elements of the structure) are to be read from the database and displayed in the prototype for the year selected.

The meta-information of the latest inspection is displayed as the default information. The user can select the inspection according to the year of execution.

By clicking on the button "Show detail", the inspection data of all bridge elements of the selected year are read from the database and displayed as a table in the Prototype.

When clicking on an element in the IFC-Viewer, the corresponding element information is highlighted in the table.

The same behaviour applies when clicking a row in the table, the element is highlighted in the IFC Viewer.

If images are available for a component, a "bracket" symbol is displayed in the table. It is highlighted at the beginning of each element and table row.

When clicking on the "bracket" symbol, the damage image from the data storage is read out and displayed (see Figure 21). The element and the location of the image are highlighted in the IFC Viewer.

Requirements:

1. The mapping between IFC element and bridge element from database should be available as ontology. (IFC element ID ↔ ID bridge element).
2. An ontology for the relevant inspection data from database shall be predefined.
3. The location of the damage photo

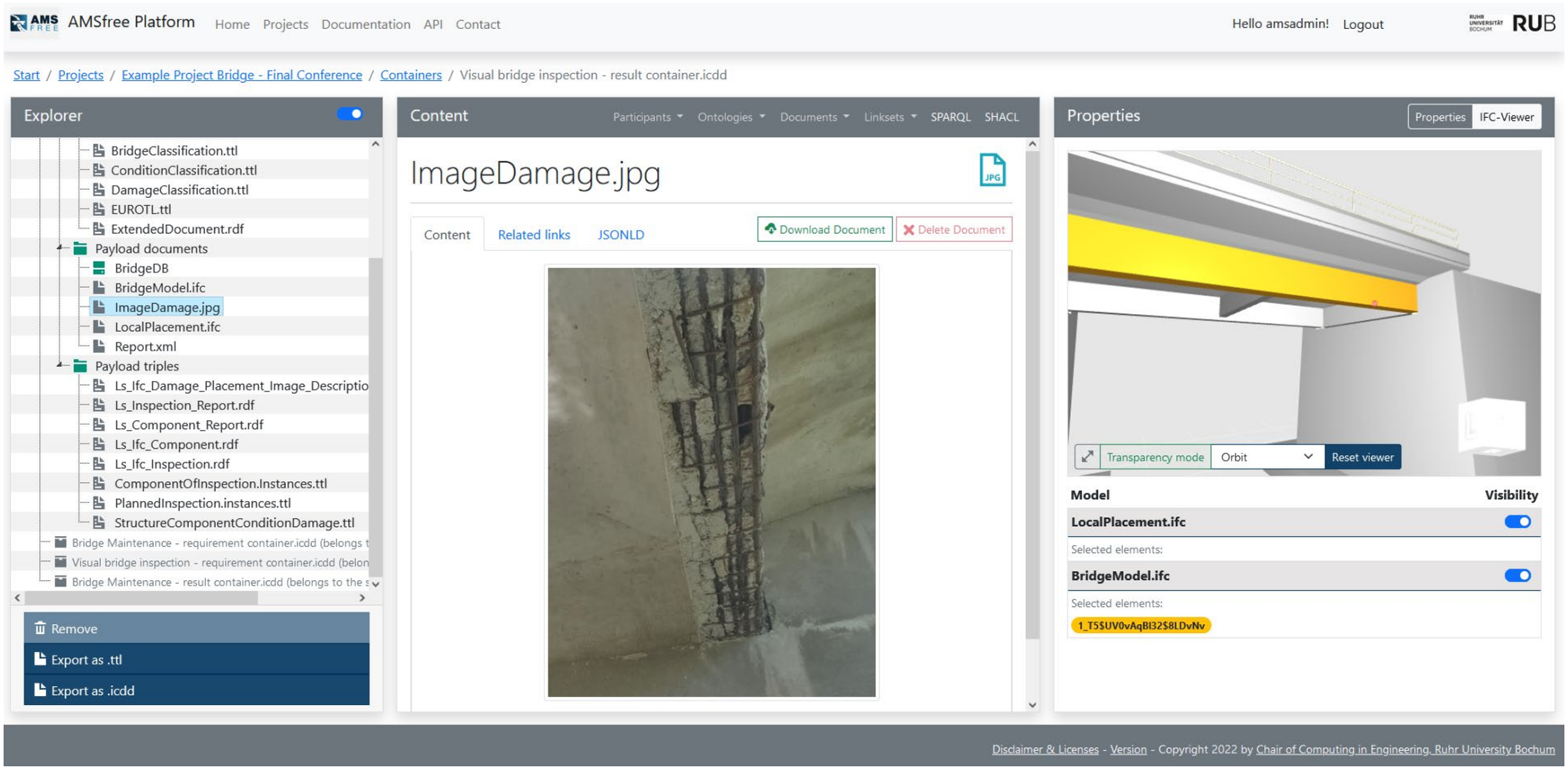

Figure 21: Image of a damage from a selected structure element

3.2.2 View Maintenance Plan

Purpose: The user wants to view the maintenance plan of a structure from a specific inspection year.

Workflow:

The user selects the structure and the as-built structure model is loaded and displayed in the embedded IFC viewer of the prototype.

The year of construction is preselected as the default value. The meta-information of the structure is displayed in Prototype.

The user can select or change the maintenance year.

The information of the measures is read from the database and displayed in Prototype for selecting the year.

The maintenance model / partial model of the selected maintenance year is uploaded to IFC-Viewer at the same time as the as-built model. The maintenance information is displayed in Prototype (see Figure 22).

Requirements:

The meta / construction information of the building is read from the database. In the corresponding predefined ontology, this data should be imported as entities.

The maintenance information of the building should be read from the database and imported into the corresponding predefined ontology.

For each measure a model of the maintained structure elements should be created and stored.

A geometric change is not taken into account during the measure.

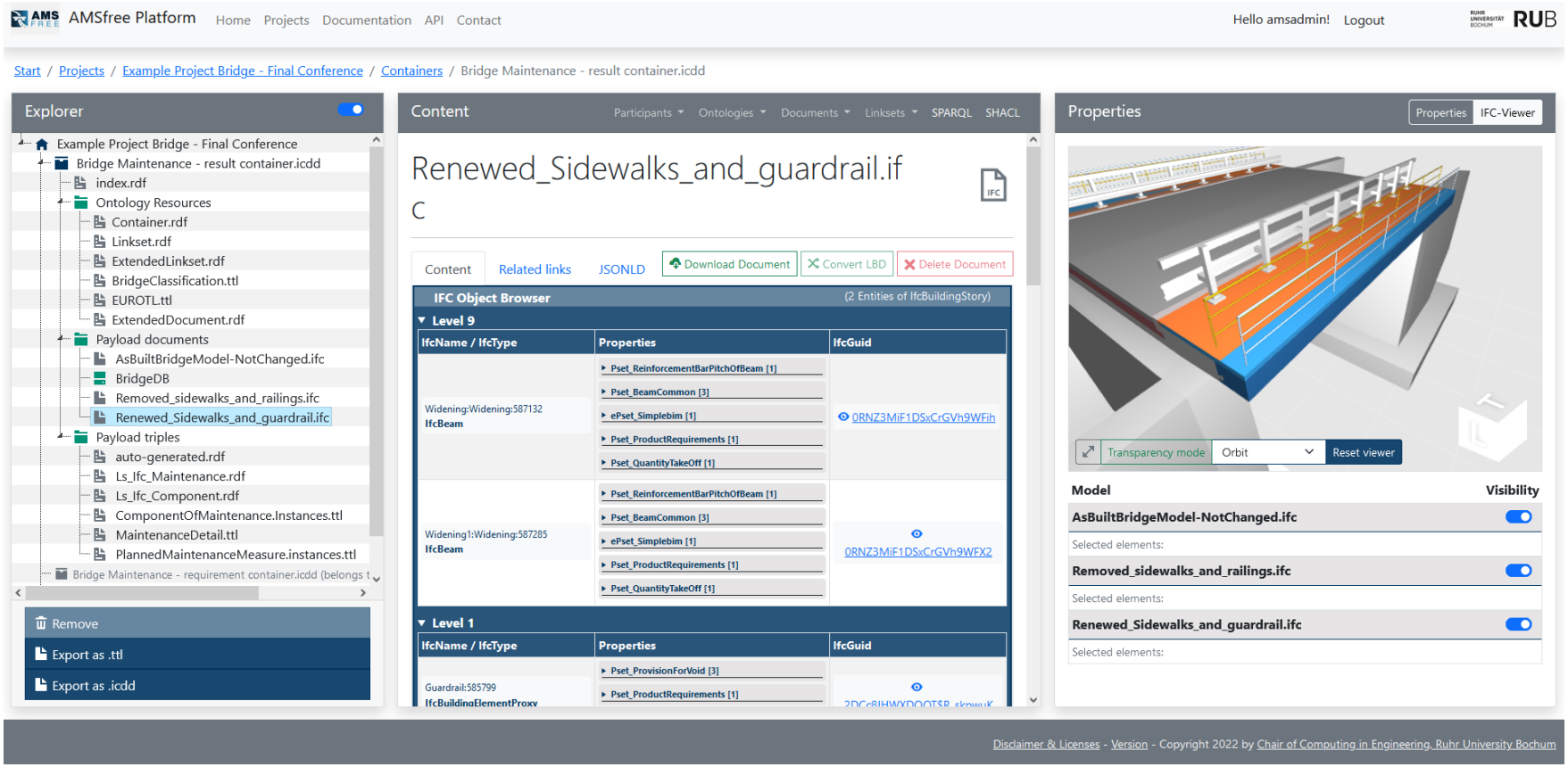

Figure 22: The maintenance information in the content list and color-coded IFC model

3.2.3 As-built View

Purpose: The purpose of this use case is to import structure material data from the construction process and to query and graphically display this information. Here, the following two features are of particular relevance:

- Display of information on material properties
- Changes in the geometry of the structure (e.g., extension of the width).

Workflow:

The user needs to select an element by clicking on it. The information attached to the element is then displayed.

The model element is highlighted in the IFC viewer (see Figure 23).

When the element is selected, the information obtained from the material tests (acceptance test) is displayed.

Requirements:

What data is accessed? → Planning documents, reports of acceptance tests.
Which groups of properties are updated / exchanged?
Mixed material_concrete_inspection test
Substrate _Control test
Construction conditions
Images of the structure
Which data format is available? → PDFs

Changes in the geometry:

The geometric changes must be adjusted in the geometry of the model. For this purpose, existing elements are removed and replaced by new geometric elements. The as-built properties are attributed to the new elements. The previous elements can be linked to the new element for reproducibility.

The information to be displayed based on property groups and properties is attached directly to the element in the results. For updating the model (as-built model), the corresponding information is attached to the individual elements and the geometry is adjusted if necessary.

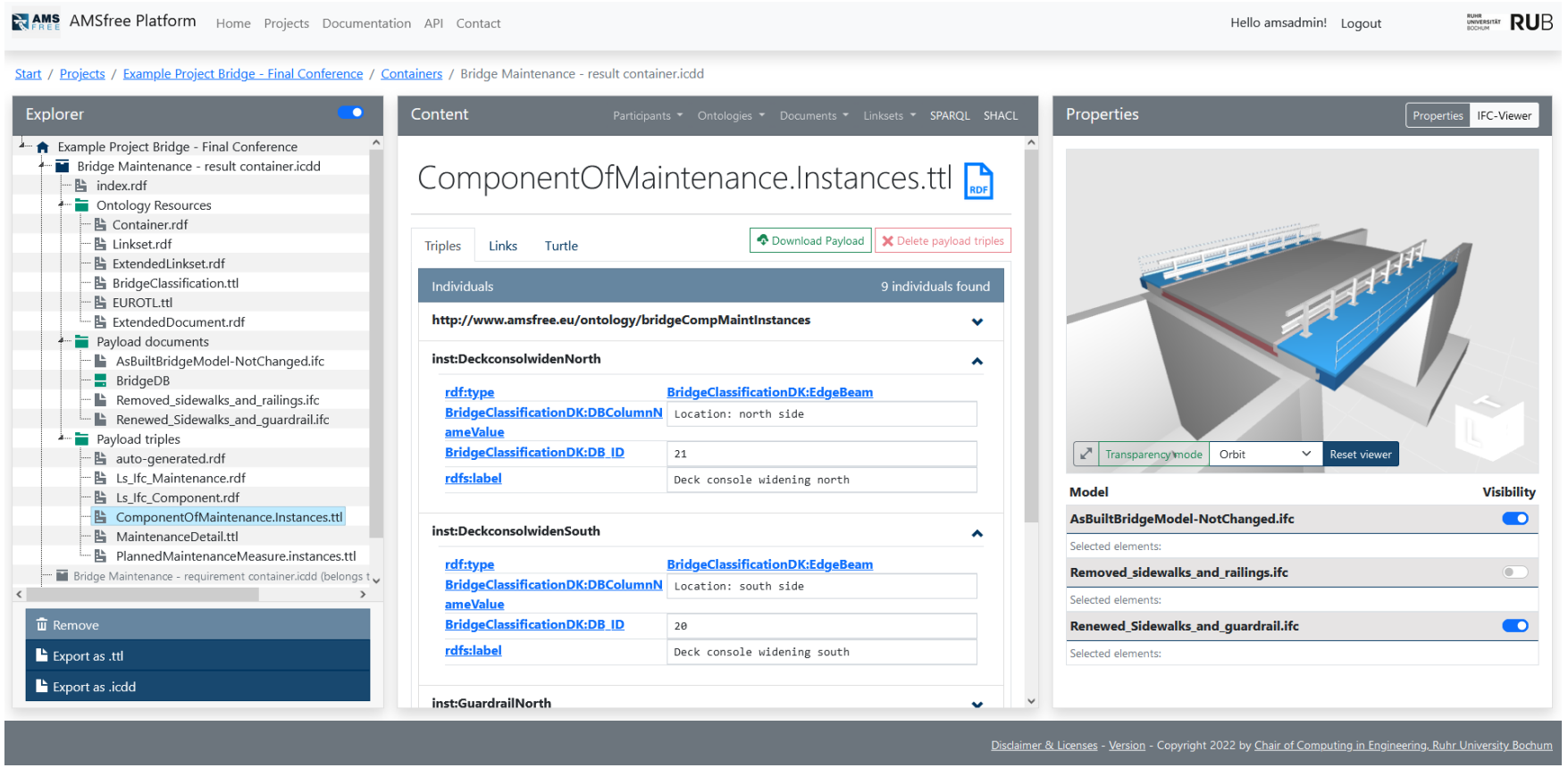

Figure 23: The as-built model after a measure

4 D7.2 – Link to Current State of the Prototype

The prototype described above can be reached at the following link:

https://icdd.vm.rub.de/amsfree/

A user account with simple containers for viewing and downloading is provided as following:

Login: amsadmin

password: l0&X6B(K

For testing and using the platform, the user should register with an own account.

5 D7.3 – Short Description of Prototype

A brief description and overview of the prototype was presented on a summary poster (see Figure 24). The poster can be downloaded from the following link:

http://www.amsfree.eu/documents

Three use cases were described for the prototype. These were also summarised in a poster (see Figure 26 to Figure 28), which can be downloaded from the following link:

http://www.amsfree.eu/documents

Figure 25: Summary poster of the prototype

Exchange and Exploitation of Data from Asset Management Systems using Vendor Free Format

AMS FREE

Project Summary

The aim of the AMSfree project is to develop a new approach based on information containers to combine asset management systems and BIM. Therefore, the processes and procedures existing within asset management systems as well as the related data flows were analysed and described by using process and data flow models. Three typical use cases were identified, and their data exchange was described. The interoperability and the connection with already existing databases or information systems are considered. Based on the example of a road section and a bridge, the consistency of the BIM concept and the implementation of rights of use are demonstrated. It is shown how existing national data formats (e.g., OKSTRA) for the management of road and bridges are linked to the IFC format during the entire life span. The approach differentiates between data that is directly contained in BIM and data that is linked to external databases.

Introduction

Planning, construction, operation, and maintenance of infrastructure require a significant commitment of both economic and human resources. For a targeted allocation of financial resources determined according to objective criteria, asset management systems (AMS) are used. One of the key aspects of asset management covered by most of these road authorities is the condition evaluation of assets and the assessment of related risks. While the condition-related data and data on inventory and traffic are stored in national asset management databases, data on materials from the maintenance planning and construction phase are often included in BIM models, documented as PDF or hosted in external databases. The exchange and update of these data are often time-consuming and error-prone. To combine the advantages of AMSs and BIM, a methodology based on standardized information containers was developed and tested.

Methodology

Based on the previously described potential to combine AMS with BIM, concepts for the integration of data from AMSs into BIM are introduced. First, the stakeholders within the context of asset management and its processes are described by using a process map. Three relevant update steps were defined on which an asset manager interacts with external contractors such as a inspector, a tender preparation team and a construction team. Based on the process analysis, the related data that needs to be exchanged at each update step and the national data formats are analyzed. The approach involves linking and transferring different data sources, models, or formats. This challenge cannot be solved in a universally valid way. The SWT is used to define ontologies for the description of domain-specific semantic information and link data from different data sources. It is shown how existing national data formats for managing road assets during the whole life span are linked with the IFC format. The approach was tested and validated in the context of use cases.

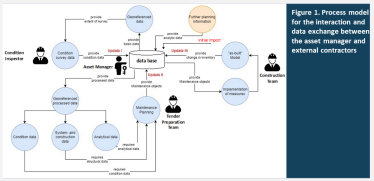

Figure 1. Process model for the interaction and data exchange between the asset manager and external contractors

ICDD Container

A prototype was developed to evaluate the proposed concepts of sharing, exchanging and visualization of data between the asset manager and external contractors by using information containers. The ICDD provides an environment for capturing and linking data from different formats. File-based documents can be linked in this information container. Figure 2 shows the idea of using standardized information containers for the data exchange between an asset manager and external contractors.

Figure 2. Using standardized Information Containers for the data exchange between the asset manager and external contractors

Use Cases

Assignment of the 3D Geometry to the Structure Elements
It is essential to consider the finest granularity of the asset management database to be able to link BIM with the different data models. For instance, Germany's ASB-ING's object classification is a hierarchical catalogue with a huge number of object type categories. The model is disassembled, and each bridge element and sub-element is associated with the corresponding ASB-ING catalogue type. The IFC entity types are exemplary shown in Figure 3.

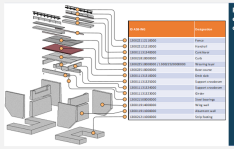

Figure 3. Disassembled bridge model with its elements associated with the corresponding objects from the ASB-ING catalogue

1. Inspection
As part of the structural inspections for engineering structures, condition changes to the infrastructure objects are recorded in the asset management database. Update 1 as shown in Figure 1 includes the implementation of results of visual inspections into BIM. The condition of the infrastructure objects and their individual elements can be integrated into BIM.

2. Maintenance Plan
Update 2 includes the implementation of results of maintenance planning into BIM. One can then access specified data for type of maintenance measure, the timeframe, estimated costs and the cause for maintenance activity. Also, bundles of measures, which contain several assets, can be combined and exported together for the program planning and processed correspondingly.

3. Maintenance Measures
Update 3 includes the implementation of an updated "as-built" model into BIM. As a result of the documentation of the construction work achieved, it includes all properties of the maintained elements of a bridge/road section.

Conclusion

In this project a new approach based on information containers was presented to combine AMSs and BIM. The processes and procedures existing within AMSs as well as the related data flows were analyzed. Afterwards, typical use cases were identified, and their data exchange was described. The interoperability and the connection with already existing databases or information systems were considered. Based on the example of a road section and a bridge, the consistency of the BIM concept is demonstrated. It is shown how existing national data formats for the management of road and bridges are linked to the IFC format during the entire life span. The approach differentiates between data that is directly contained in BIM and data that is linked to external databases. The benefits of connecting asset management processes with BIM are enormous. The combination and visualization of material related data within BIM its temporal classification and precise localization offer the possibility for a multitude of new analysis.

Acknowledgements

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ICDD Platform

Use Case 1 – Inspection
Data Exchange by Using ICDD

Exchange and Exploitation of Data from Asset Management Systems using Vendor-free Format

The aim of the AMSfree project is to develop a new approach based on information containers to combine asset management systems and BIM. Therefore, the processes and procedures existing within asset management systems as well as the related data flows were analysed and described by using process and data flow models. Three typical use cases were identified, and their data exchange was described. The interoperability and the connection with already existing databases or information systems are considered. Based on the example of a road section and a bridge, the consistency of the BIM concept and the implementation of rights of use are demonstrated. It is shown how existing national data formats (e.g., OKSTRA) for the management of road and bridges are linked to the IFC format during the entire life span. The approach differentiates between data that is directly contained in BIM and data that is linked to external databases.

Activities for Inspection

The ***asset manager*** determines the need for an inspection on a bridge or road by an external contractor. For the inspection, the manager must provide necessary data to the contractor digitally.

The following data are required for this use case by using BIM:
- the IFC model
- the elements of the bridge/road to be inspected
- the applicable technical standard/guidelines
- the information requirement of result

To facilitate the recognition of mapping between the IFC model and the distributed data and to facilitate the data exchange between the different participants, the ICDD Prototype supplies a solution to collect the data linked in a whole package as a container named ***ICDD***.

Once the inspection is commissioned, the prepared data can be delivered from the ***asset manager*** to the ***external contractor*** using the ICDD container.

The ***external contractor*** uses the ICDD Prototype in preparation for the performing the work to:
- upload the delivered ICDD
- review the data
- derive a new version of the ICDD for the result on the platform.

The following data are required as a results of an inspection:
- the inspection report
- the image of damage
- the placement of the damage
- the links between the condition description and the elements of the model

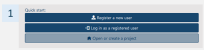
The results data are uploaded additionally to received data from the asset manager.

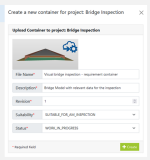
Once the inspection is finished, the results can be given back from the ***external contractor*** to the ***asset manager*** by using the ***ICDD*** container.

The ***asset manager*** can review the inspection result on the ***ICDD*** prototype. With certain query, the manager can select the specified data, such as damage images related to the bridge element or road section.

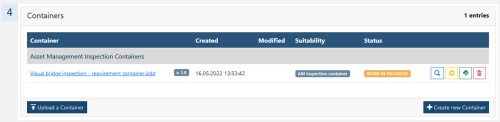
Realization of the Data Collection and Exchange with the ICDD Prototype

Screenshots show the user interface for:
1. Open or create a project
2. Create a container
3. View of container content in container explorer

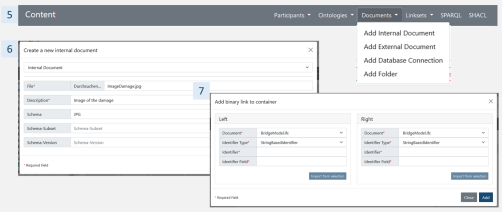




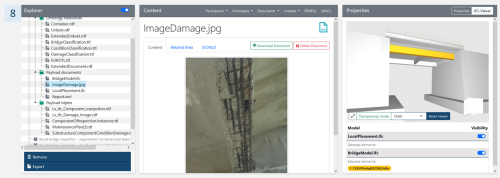
4. The user interface of the container management



The user interface for edition and modification of the container content with:
5. content menubar
6. a document form
7. linkset form



8. The user interface of the container content with IFC viewer and document viewer



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INGEO
Ruhr Universität Bochum
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Figure 26: Poster for the description of the use case inspection

ICDD Platform

Use Case 2 – Maintenance Plan
Data Collection by Using ICDD

Exchange and Exploitation of Data from Asset Management Systems using Vendor-free Format

The aim of the AMSfree project is to develop a new approach based on information containers to combine asset management systems and BIM. Therefore, the processes and procedures existing within asset management systems as well as the related data flows were analysed and described by using process and data flow models. Three typical use cases were identified, and their data exchange was described. The interoperability and the connection with already existing databases or information systems are considered. Based on the example of a road section and a bridge, the consistency of the BIM concept and the implementation of rights of use are demonstrated. It is shown how existing national data formats (e.g., OKSTRA) for the management of road and bridges are linked to the IFC format during the entire life span. The approach differentiates between data that is directly contained in BIM and data that is linked to external databases.

Activities for Maintenance Plan

The ***asset manager*** provides data on the results of the condition survey and assessment. These information are handed over to the team which is responsible for the detailed preparation of the tender.

The following data are required for this use case by using BIM:
- the IFC model
- the virtual layer with condition assessment or bridge element linked with condition data can be used for the maintenance plan
- the defined bridge/road elements to be maintained

To facilitate the recognition of mapping between the IFC model and the distributed data, and to facilitate the data exchange between the different participants, the ICDD Prototype supplies a solution to collect the data linked in a whole package as a container named ***ICDD***.

In order to define the type and amount of maintenance interventions by the ***tender preparation team***, the results of the condition survey and assessment are queried and output via a SPARQL query from the asset manager using the ***ICDD*** container. The data can now be used outside the model.

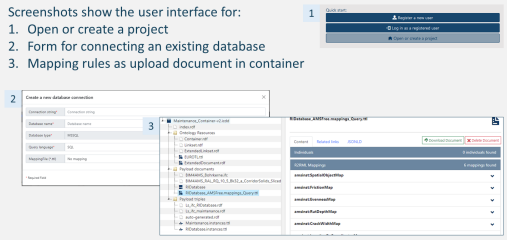
In addition to the general need for maintenance interventions, economic considerations and optimisations must then be applied. Thus, maintenance planning can be completed. The complete maintenance planning can now be linked to the model. Therefore, it is again necessary to apply the same reference to map the conservation planning onto the model.

Once the maintenance intervention plan is finished, the results can be given back from the ***external contractor*** to the ***asset manager*** by using the ***ICDD*** container.

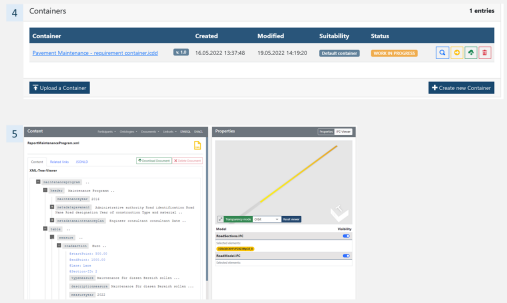
The ***asset manager*** can review the results of the detailed maintenance planning on the ***ICDD*** prototype. With defined queries, one can access the specified data for:
- type of maintenance measure
- timeframe
- estimated costs
- cause for maintenance activity

Realization of the Data Collection and Exchange with the ICDD Prototype

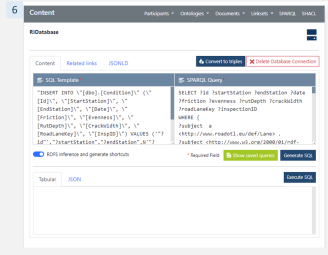
Screenshots show the user interface for:
1. Open or create a project
2. Form for connecting an existing database
3. Mapping rules as upload document in container



4. Container copy, download and upload
5. Uploaded maintenance plan related to the IFC element



6. Filter data with SPARQL Query
   Set the SQL Template
   Generate SQL query and import the data into database



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Project Website: http://www.amsfree.eu

Contact: icdd-plattform@ruhr-uni-bochum.de

Figure 27: Poster for the description of the use case maintenance plan

ICDD Platform

Use Case 3 – Maintenance Measures
Connection with Existing Databases by Using ICDD

Exchange and Exploitation of Data from Asset Management Systems using Vendor-free Format

The aim of the AMSfree project is to develop a new approach based on information containers to combine asset management systems and BIM. Therefore, the processes and procedures existing within asset management systems as well as the related data flows were analysed and described by using process and data flow models. Three typical use cases were identified, and their data exchange was described. The interoperability and the connection with already existing databases or information systems are considered. Based on the example of a road section and a bridge, the consistency of the BIM concept and the implementation of rights of use are demonstrated. It is shown how existing national data formats (e.g., OKSTRA) for the management of road and bridges are linked to the IFC format during the entire life span. The approach differentiates between data that is directly contained in BIM and data that is linked to external databases.

Activities for Maintenance Measures

The ***asset manager*** provides the contractor with a planning model for the maintenance measures to be carried out. For this purpose, he provides the IFC model with the elements to be replaced and their associated requirements on material properties.

The following data is required for the update in order to implement this use case in BIM:

- the IFC model
- the replaced elements after implementation of the measure
- the updated material properties of the elements

To facilitate the recognition of mapping between the IFC model and the distributed data, and to facilitate the data exchange between the different participants, the ICDD Prototype supplies a solution to collect the data linked in a whole package as a container named ***ICDD***.

Once the IFC elements are defined to be maintained, the prepared data can be delivered from the ***asset manager*** to the ***construction team*** using the ***ICDD*** container.

The ***construction team*** accesses the asset manager's prepared documents via the information container. The team uses the IFC model created by the asset manager as a basis for documenting the construction work achieved (scope of measures, installation quality, etc.).

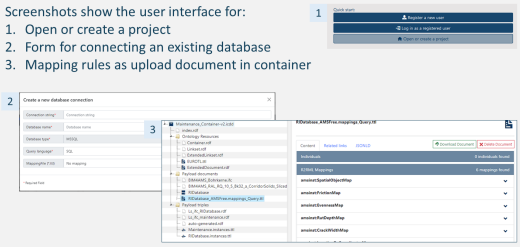
Once the team has integrated all the data relevant to the construction process into the IFC model, the updated data can be transferred to the asset manager using the information container.

As a result, the ***asset manager*** can access both the updated IFC model and all the associated updated material data and integrate it into its existing asset management database.

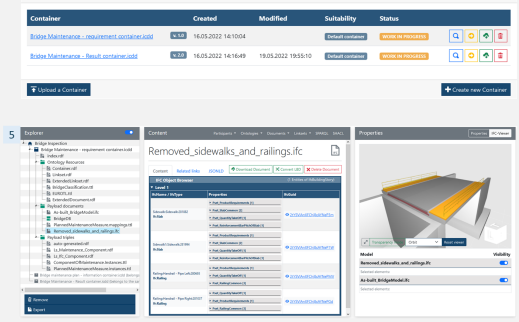
Realization of the Data Collection and Exchange with the ICDD Prototype

Screenshots show the user interface for:

1. Open or create a project
2. Form for connecting an existing database
3. Mapping rules as upload document in container



4. Container copy, download and upload
5. The defined IFC elements to be maintained



6. The updated IFC model

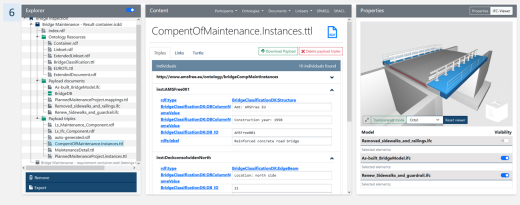


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Figure 28: Poster for the description of the use case maintenance measures