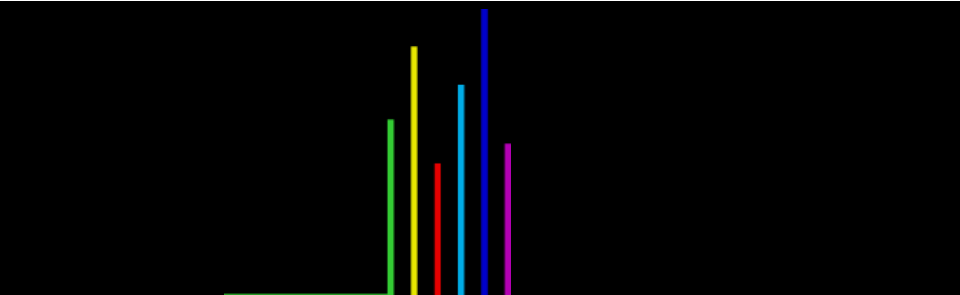


Linked Data for Structural Diagnostics: A Semantic Framework for Sustainable Infrastructure Management

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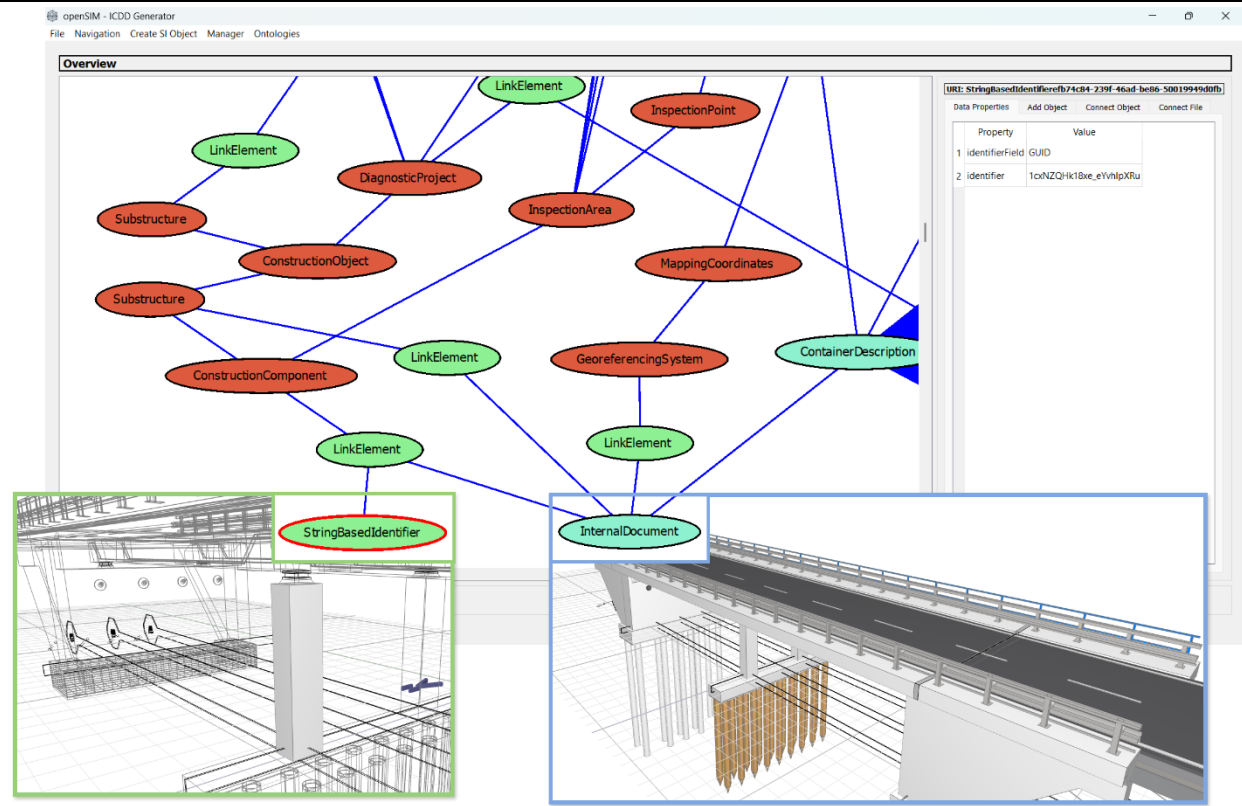


LDAC2025 – Linked Data in Architecture and Construction



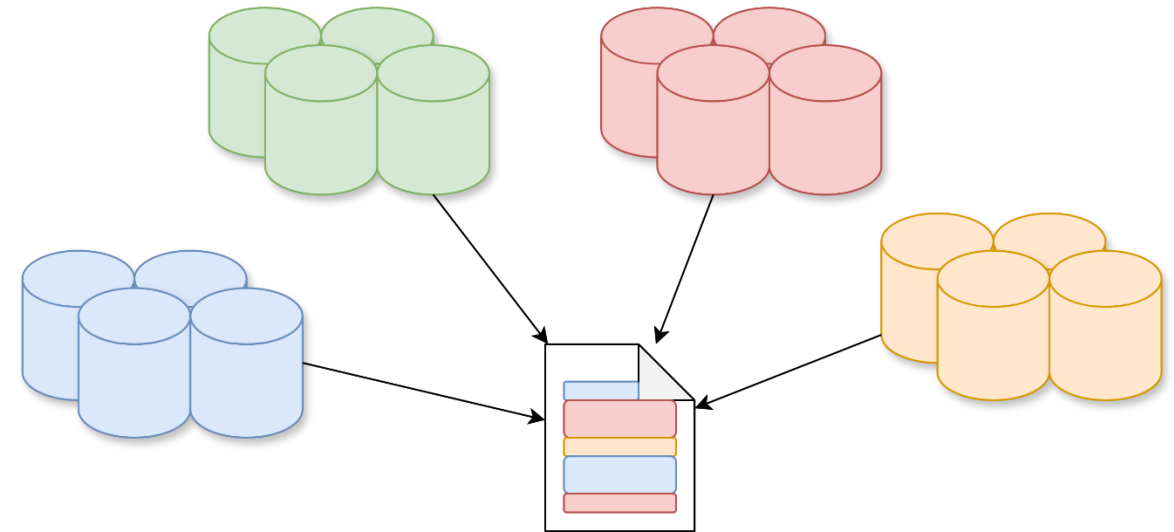
Paul-Christian Schuler Abdullah Al Mohammad
Mahsa Mirboland Christian Koch
Yannic Stark

10.07.2025
Faculdade de Engenharia da
Universidade do Porto



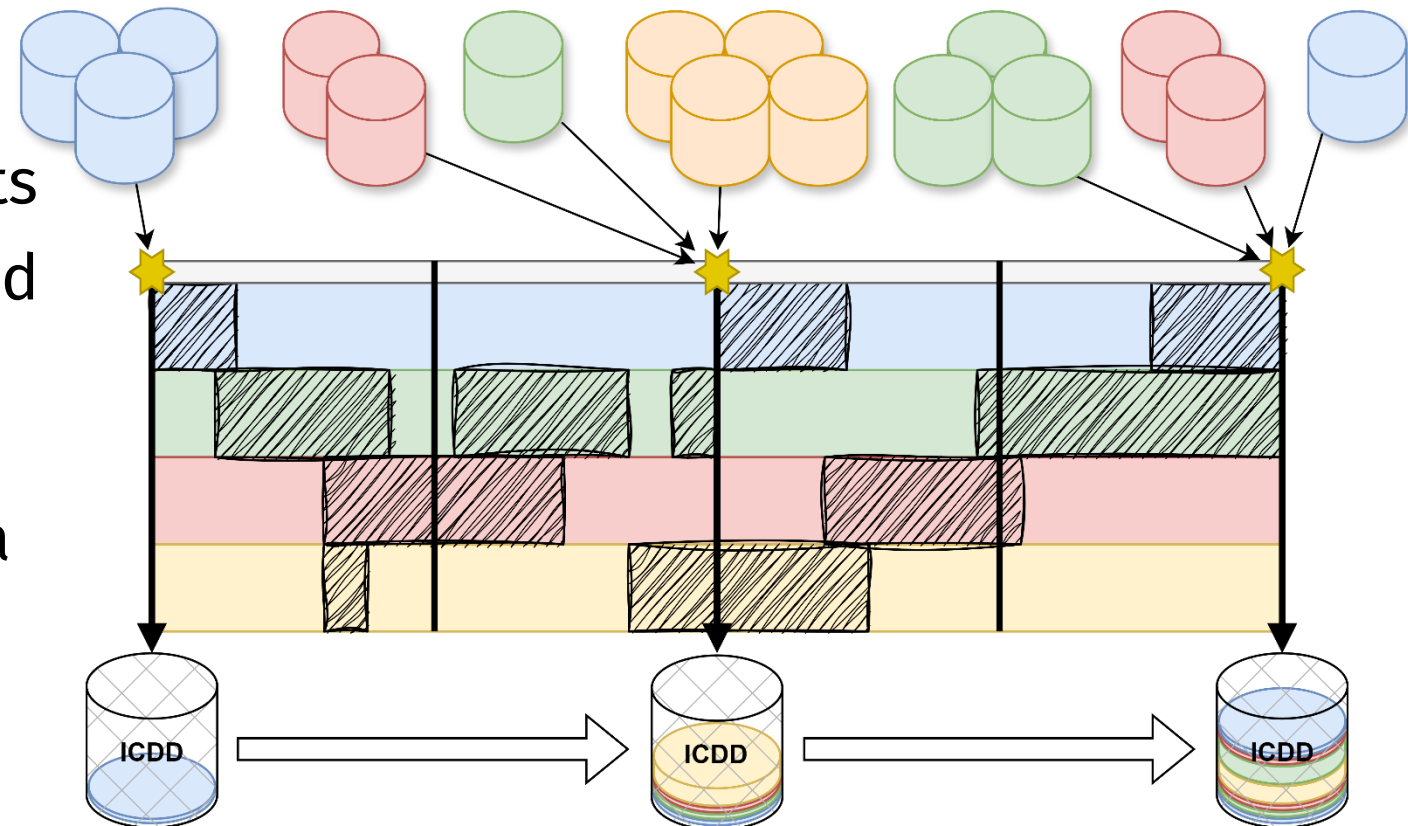
Challenges in Structural Data Management

- openSIM Project¹
- Development of a Building Information Modeling (BIM) workflow for inspection projects
- Heterogeneous data is collected during a project
- Data silos are created
- Client receives information at a high aggregation level

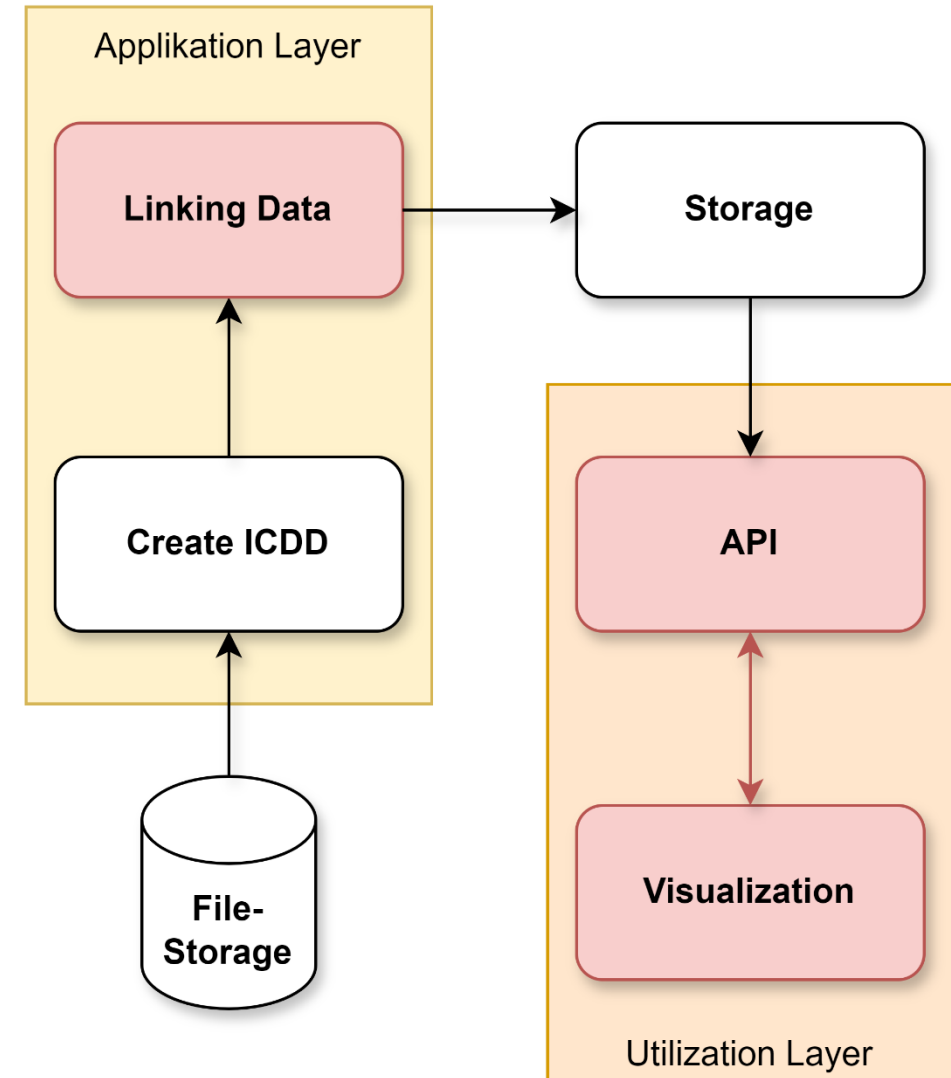


Challenges in Structural Data Management

- openSIM Project¹
 - Development of a Building Information Modeling (BIM) workflow for inspection projects
 - Heterogeneous data is collected during a project
 - Data silos are created
 - Client receives information at a high aggregation level
- Goal: Long-term data storage and availability

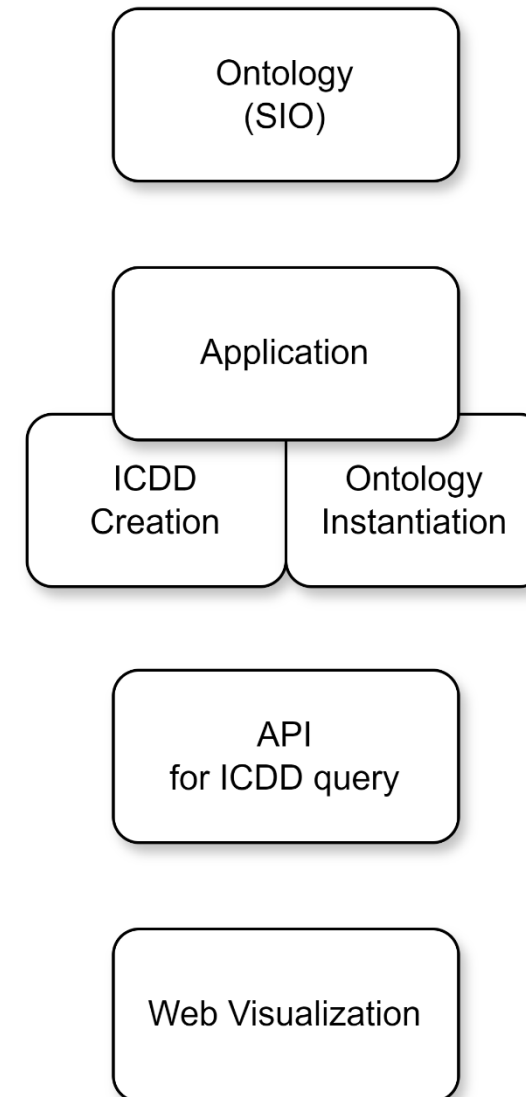


- ISO 21597²
- RUB ICDD Platform³
- Advantage of Linking Data/ Files
 - ICDD helps improve understanding of the data
- Link creation showed individual variations
- Files not semantically labeled

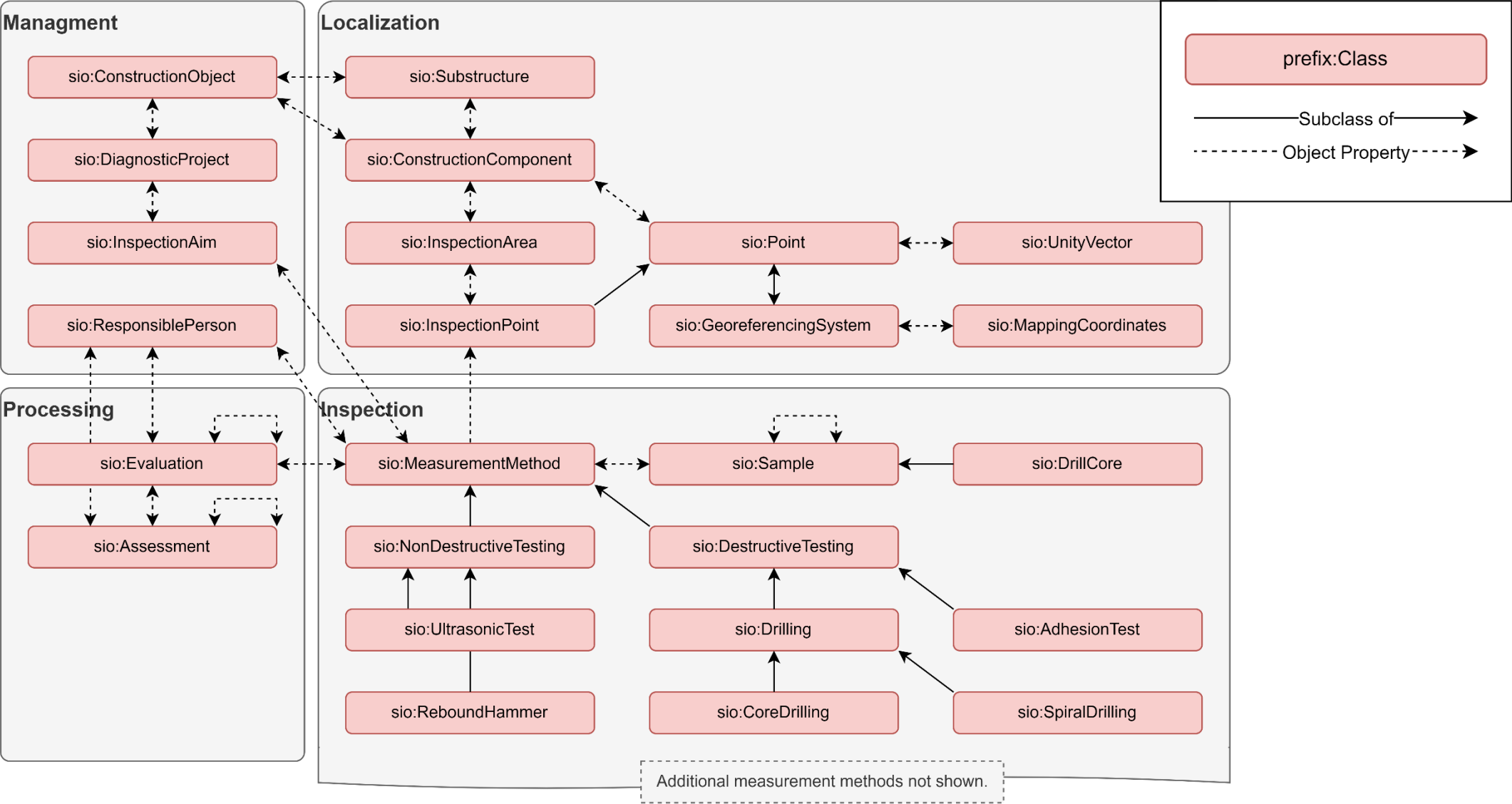


Objective

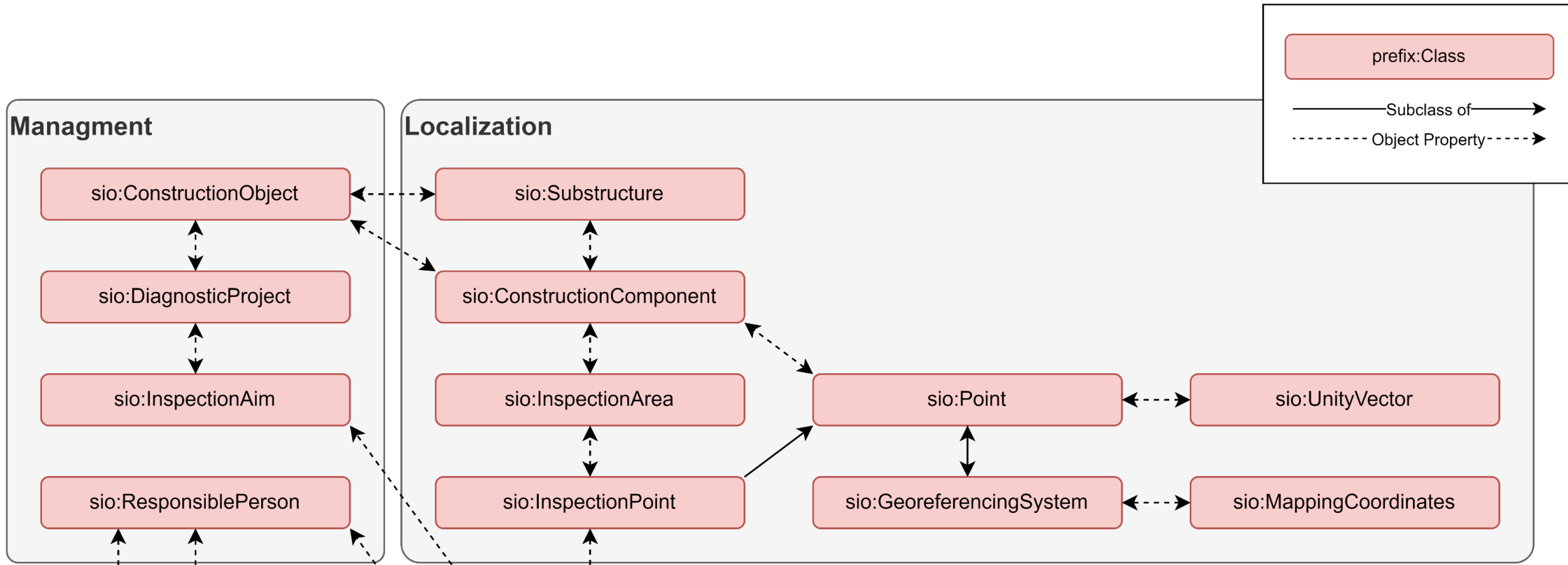
- Structural Information Ontology (SIO)
 - Represent data in graph format
 - Provide schema for users
- ICDD Application
 - Graphical User Interface
 - Create Links
 - Instantiate Ontologies
- API
 - Query data from ICDD
- Web Visualization
 - User-based visualization of data
 - Navigation through data in the ICDD

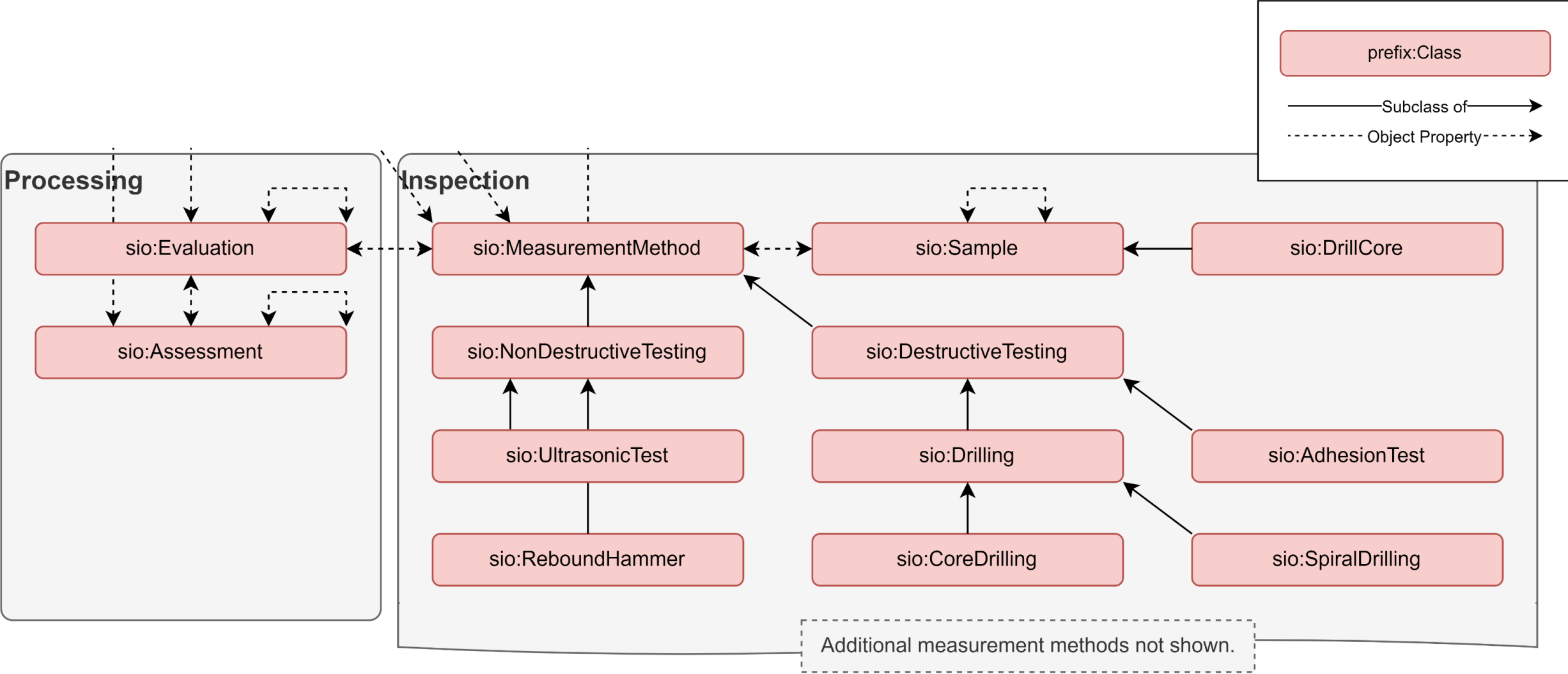


Structural Information Ontology (SIO)

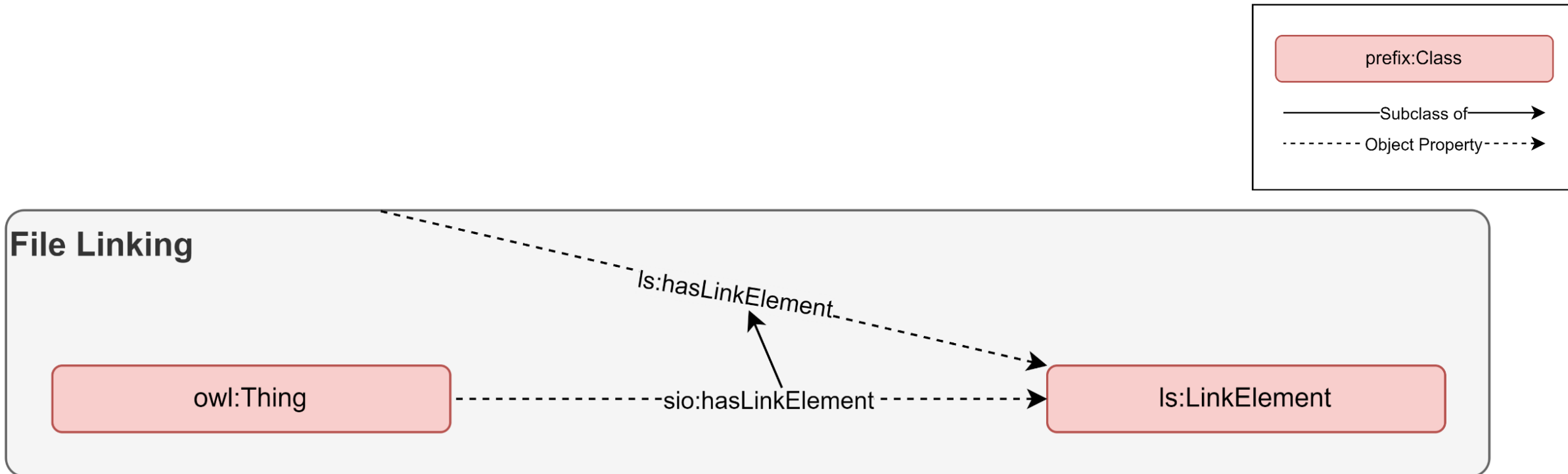


Structural Information Ontology (SIO)





Structural Information Ontology (SIO)



ICDD data query via API

Listing 1: Representation of an inspection point in Turtle format.

```

1 @prefix sio: <http://www.openSIM.org/0.10.24/SIO#> .
2 @prefix prj: <http://BUW-ITD.org/openSIM/Diagnostics#> .
3 @prefix idx: <http://BUW-ITD.org/openSIM/index#> .
4 @prefix ls: <https://standards.iso.org/iso/21597/-1/ed-1/en/Linkset#> .
5 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
6 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
7
8 prj:InspectionPoint5436e0e7-b292-4f54-98f7-e08cedc2a3f1
9   a sio:InspectionPoint ;
10   sio:Name "1.3"^^xsd:string ;
11   sio:X "-2.54979361828466"^^xsd:string ;
12   sio:Y "8.782499999999999"^^xsd:string ;
13   sio:Z "5.20020638171526"^^xsd:string ;
14   sio:inGeoreferencingSystem prj:GeoreferencingSystemc668bbce-4c11-4aff-8
      d9b-3f2f4f923350 ;
15   sio:inInspectionArea prj:InspectionArea3b5cd8c3-05a9-4589-991e-
      e4afcddb59 ;
16   sio:hasLinkElement [
17     a ls:LinkElement ;
18     ls:hasDocument idx:InternalDocumentffeb0194-02b6-47b0-b64c-64
      a5f4b02a2f
19   ] .

```

Listing 2: Result of Querying for an Inspection Point named 1.3 in OData-JSON format.

```

1 {
2   "@odata.context": "$metadata#InspectionPoint",
3   "value": [
4     {
5       "name": "1.3",
6       "comment": [],
7       "description": [],
8       "x": "-2.54979361828466",
9       "y": "8.782499999999999",
10      "z": "5.20020638171526",
11      "hasDirection": null,
12      "inInspectionArea": [
13        {
14          "name": "UB1",
15          "id": "InspectionArea3b5cd8c3-05a9-4589-991e-e4afcddb59",
16          "type": "InspectionArea"
17        }
18      ],
19      "inGeoreferencingSystem": {
20        "name": "IFC Local System",
21        "id": "GeoreferencingSystemc668bbce-4c11-4aff-8d9b-3f2f4f92330",
22        "type": "GeoRefSystem"
23      },
24      "hasLinkElement": [
25        {
26          "name": "inspectionpoint.png",
27          "filename": "images\\inspectionpoint.png",
28          "filetype": ".png",
29          "identifier": null,
30          "identifierField": null,
31          "id": "LinkElement3c1131aa-b48b-4dcd-b20f-7fcd60109da0",
32          "type": "LinkElement"
33        }
34      ],
35      "id": "InspectionPoint5436e0e7-b292-4f54-98f7-e08cedc2a3f1",
36      "type": "InspectionPoint"
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13  sio:Z "5.20020638171526"^^xsd:string ;
14  sio:inGeoreferencingSystem prj:GeoreferencingSystemc668bbce-4c11-4aff-8
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15  sio:inInspectionArea prj:InspectionArea3b5cd8c3-05a9-4589-991e-
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25        {
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30          "identifierField": null,
31          "id": "LinkElement3c1131aa-b48b-4dcd-b20f-7fcd60109da0",
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34      ],
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36      "type": "InspectionPoint"
37    }
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ICDD data query via API

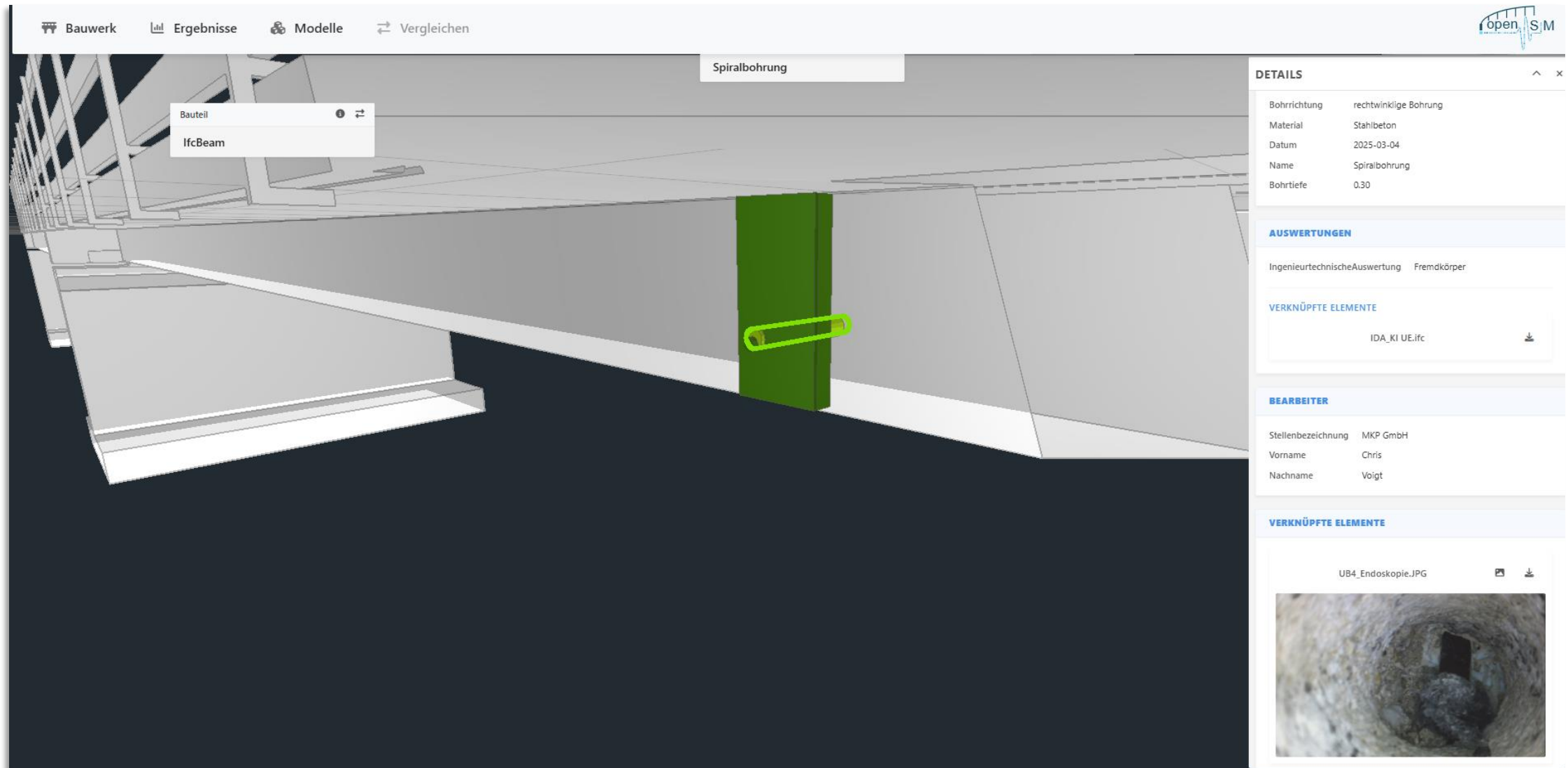
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16   sio:hasLinkElement [  
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22 | | | "hasLinkElement": [  
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24 | | | | | "name": "inspectionpoint.png",  
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27 | | | | | "identifier": null,  
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30 | | | | | "type": "LinkElement"  
31 | | | | }  
32 | | | ],
```

Visualization example

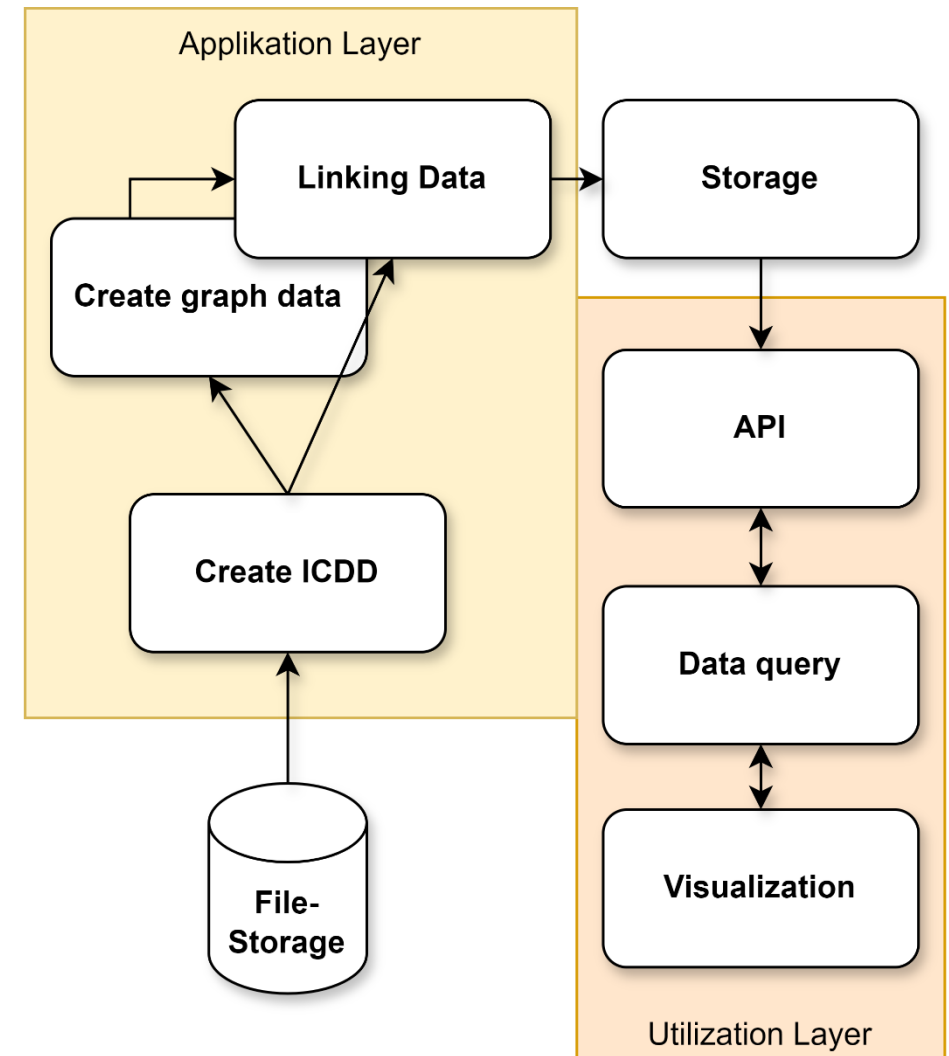
The screenshot displays a software interface for diagnostic investigations. The top navigation bar includes 'Bauwerk', 'Ergebnisse', 'Modelle', and 'Vergleichen'. The left sidebar, titled 'DIAGNOSTISCHE UNTERSUCHUNGEN', contains a search bar, 'AKTUELLE AUSWAHL' (Bauwerk), 'OpenLAB', 'UNTERSUCHUNGEN FILTERN' (listing 'IfcBeam' as Bauteil), and 'VERFAHREN UND ERGEBNISSE' (listing various methods like '#9', '#3', '#14', '#16', '#20', '#28', '#1', '#4', 'Profometer', and 'Spiralbohrung'). The central 3D model shows a building structure with a green door and callout boxes for 'Bauteil IfcBeam', 'Ultraschallmessung Bohrung', and 'Spiralbohrung'. The right sidebar, titled 'DETAILS', shows 'Ultraschallmessung' with properties: Name (Ultraschallmessung), Datum (2025-03-04), and Material (Stahlbeton C25/30). It also displays 'AUSWERTUNGEN' (IngenieurtechnischeAuswertung, Ultraschallauswertung) and 'VERKNÜPFT E ELEMENTE' (UB_4_6_Ultraschallmessung_Zuschnitt.png, UB_4_6_Ultraschallmessung.png) with a heatmap and a waveform graph.

Visualization example



Conclusion

- Framework for Linked Data: Storing & Utilizing Knowledge
- SIO: Maps Inspection Processes
- ICDD App: Container & Ontology Instantiation
- API: Reads ICDD Data
- Structured Data Delivery
- Long-term Usability
- Future Focus: Developing User-Friendly Tools for Wider Adoption

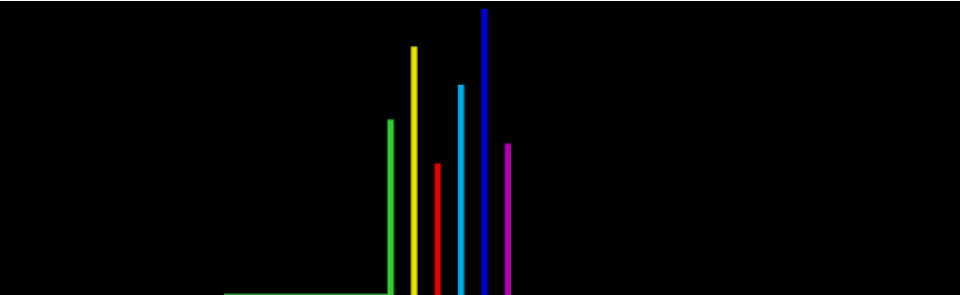


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← Hit me up with your questions



Check out our research project openSIM →

Sources and Links

1. <https://www.bmv.de/SharedDocs/DE/Artikel/DG/mfund-projekte/opensim.html>
2. ISO 21597-1, Information container for linked document delivery: Exchange specification - Part 1: Container, 1 ed., Standard, International Organization for Standardization, Geneva, Switzerland, 2020. URL: <https://www.iso.org/standard/74389.html>.
3. <https://icdd.vm.rub.de/ui>
4. <https://gitlab.uni-weimar.de/professur-intelligentes-technisches-design/opensim-icdd-tool>