'Car Wash For Data': Best Practice for Information & Configuration Management of an industrial Facility.

‘Getting engineering data ready for digital twins’

Why, How, and What

Leo van Ruijven Croonwolter&dros BV; The Netherlands

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023

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Biography

dr. ing. L.C. (Leo) van Ruijven MSc; Principal Systems Engineer

- **> 25 years employee of TBI in the Netherlands (EPC contractor in building and construction) Responsible for systems engineering and supporting information management of major infrastructure projects.**
- **> 20 years Chairman Dutch standards committee NC 181184 'Information integration and Interoperability'.**
- **Member of ISO TC 184/SC4 (Industrial Data), initiator and editor of ISO 15926-11:2023.**
- **Member Executive Committee USPI, a Dutch foundation for data standards within process industry.**
- **PhD on Collaboration, Systems Engineering, and Information Management in building and construction (2018).**
- **Initiator and architect of the 'non-graphical data' part of the CDE in the Pallas Project.**

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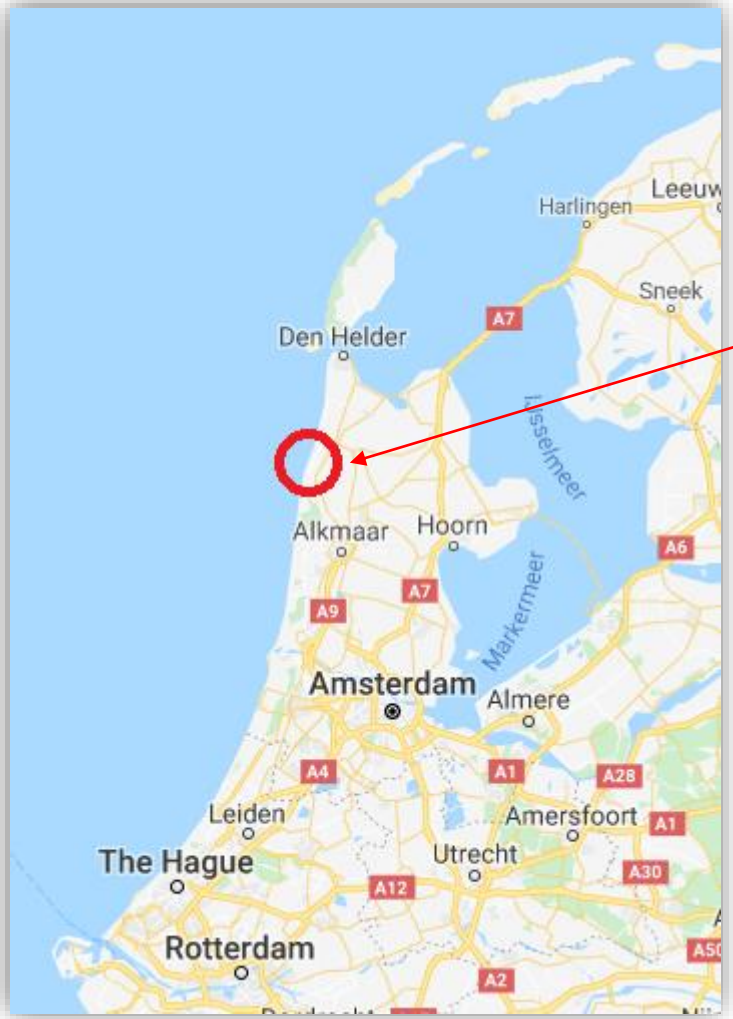
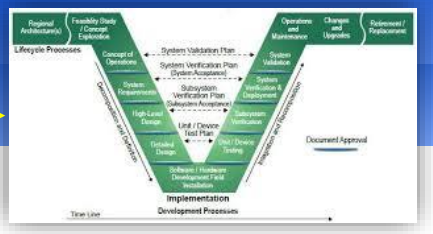
PALLAS is replacing the ageing High Flux Reactor (HFR) producing medical isotopes at location Petten, the Netherlands. Goal: data driven operation and asset management.



The challenge of Information Management in (one off) projects

based to a greater or lesser extent on SE



ISO 15288
"System Life Cycle Processes'

Design & construct process & tooling

information

Engineering company

Architect

Fragmentation over involved disciplines and or parties

Design & construct process & tooling

Design & construct process & tooling

Specialty engineer

Client / investor

Design & construct process & tooling

Sub contractor / supplier

Main contractor

Based on semantic data standards

The challenge of Configuration Management over the total life cycle (Concept of a Digital Twin)

Fragmentation over time

"As required" configuration of a facility (**Why**)
(what required is to be there, including it's behavior)

Equilibrium triangle defined by the International Atomic Energy Agency (IAEA)

Changes

Design Basis

Must be compliant with (traceable)

In practice the Why, How and What of systems / facilities are islands.
Nature of the interoperability barriers (ISO 11354):

- Organizational
- Technological
- Semantically

Must be compliant with (traceable)

Changes

Design information

Operational information

Maintenance information

Must be compliant with (traceable)

Changes

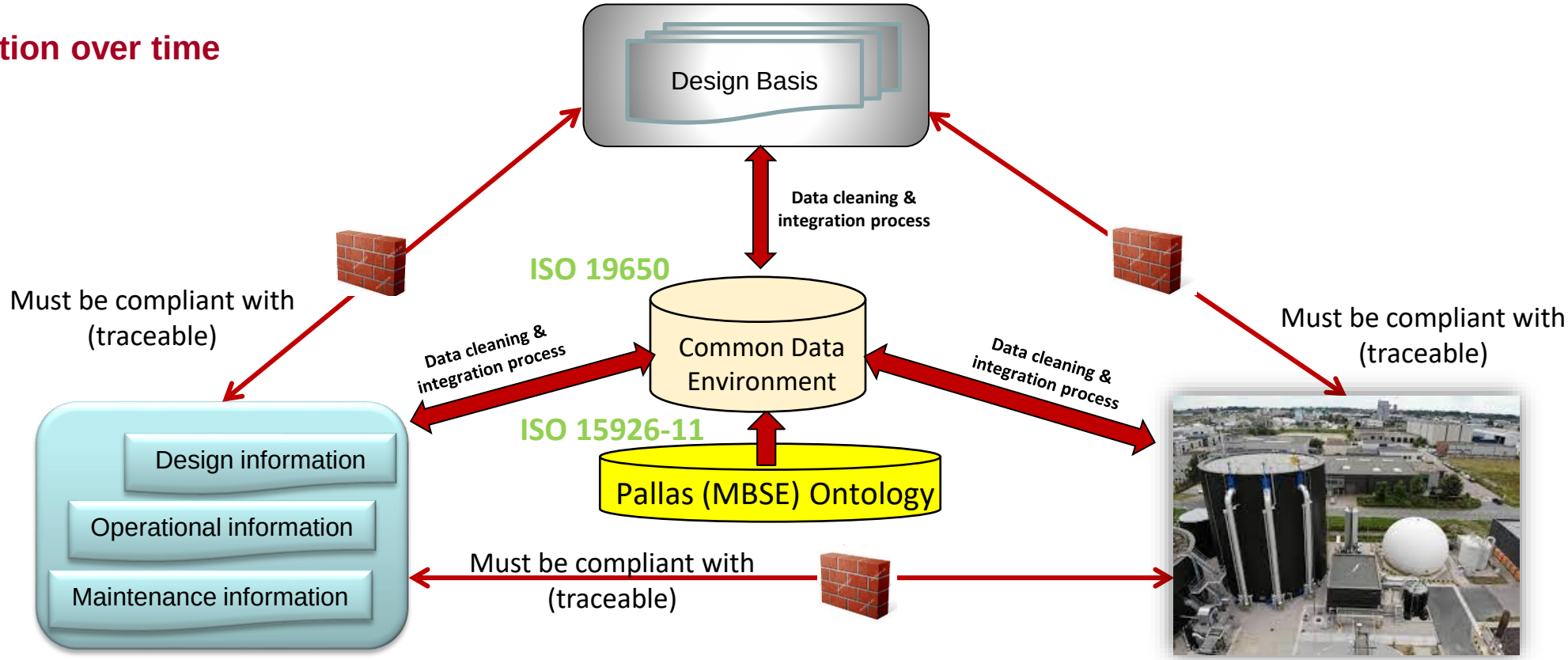
"As designed" configuration documentation **(How)**
(what we say that there is and say how it behaves)

"As-is" Actual physical and operational configuration **(What)**
(what there actually is and how it really behaves)

Solution direction PALLAS, based on ISO and W3C data integration and semantic standards

Fragmentation over time

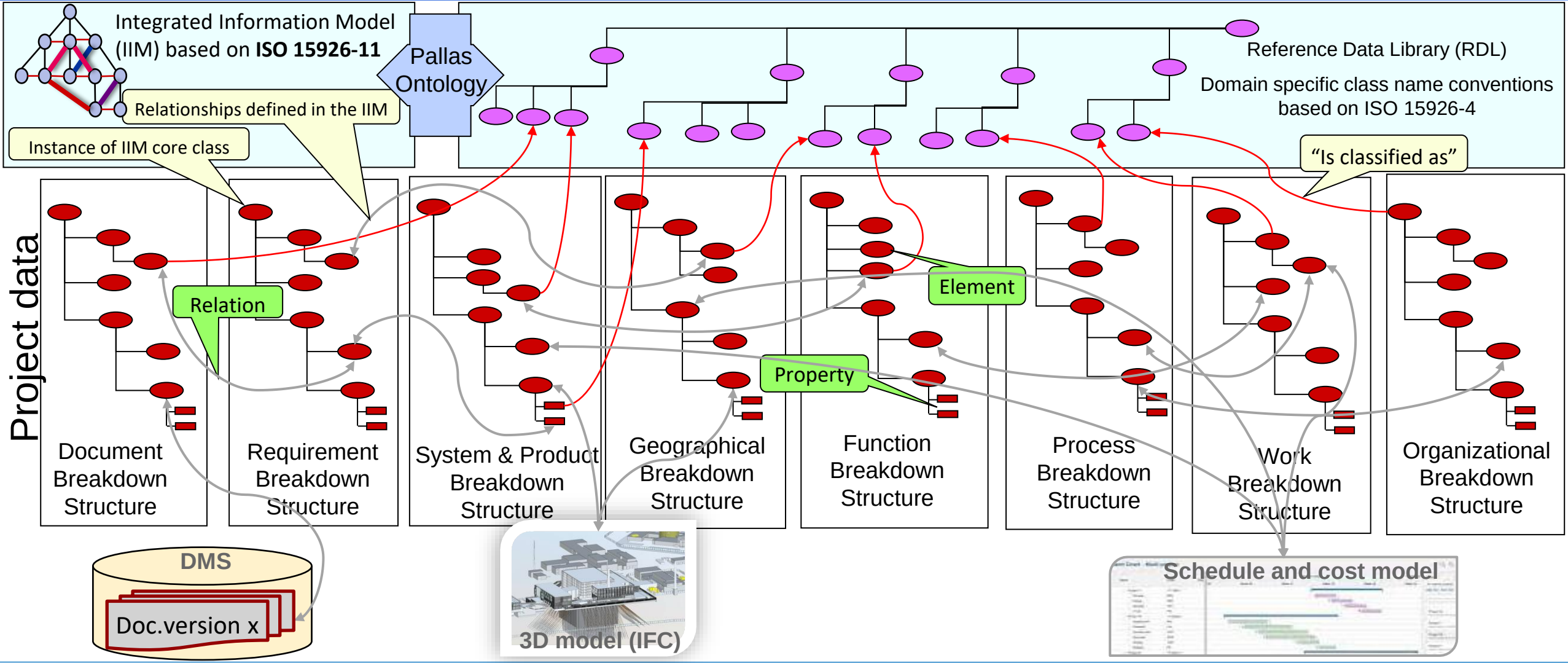
"As required" configuration of a facility (**Why)**
(what required is to be there, including it's behavior)



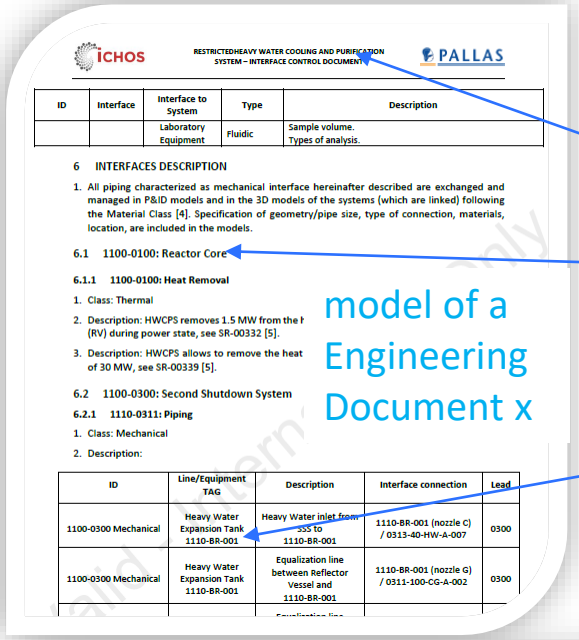
"As designed" configuration documentation **(How)**
(what we say will be there and how it will behave)

"As-is" Actual physical and operational configuration **(What)**
(what there actually is and how it really behaves)

Breakdown structures are the basis of a project and the content of the CDE (ISO / IEC 81346)



Examples of “models” from which data is represented by nodes in the breakdown structures


ICHOS — RESTRICTED HEAVY WATER COOLING AND PURIFICATION SYSTEM – INTERFACE CONTROL DOCUMENT — PALLAS

ID	Interface	Interface to System	Type	Description
		Laboratory Equipment	Fluidic	Sample volume. Types of analysis.

6 INTERFACES DESCRIPTION

1. All piping characterized as mechanical interface hereinafter described are exchanged and managed in P&ID models and in the 3D models of the systems (which are linked) following the Material Class [4]. Specification of geometry/pipe size, type of connection, materials, location, are included in the models.

6.1 1100-0100: Reactor Core

6.1.1 1100-0100: Heat Removal

1. Class: Thermal
2. Description: HWCPS removes 1.5 MW from the h (RV) during power state, see SR-00332 [5].
3. Description: HWCPS allows to remove the heat of 30 MW, see SR-00339 [5].

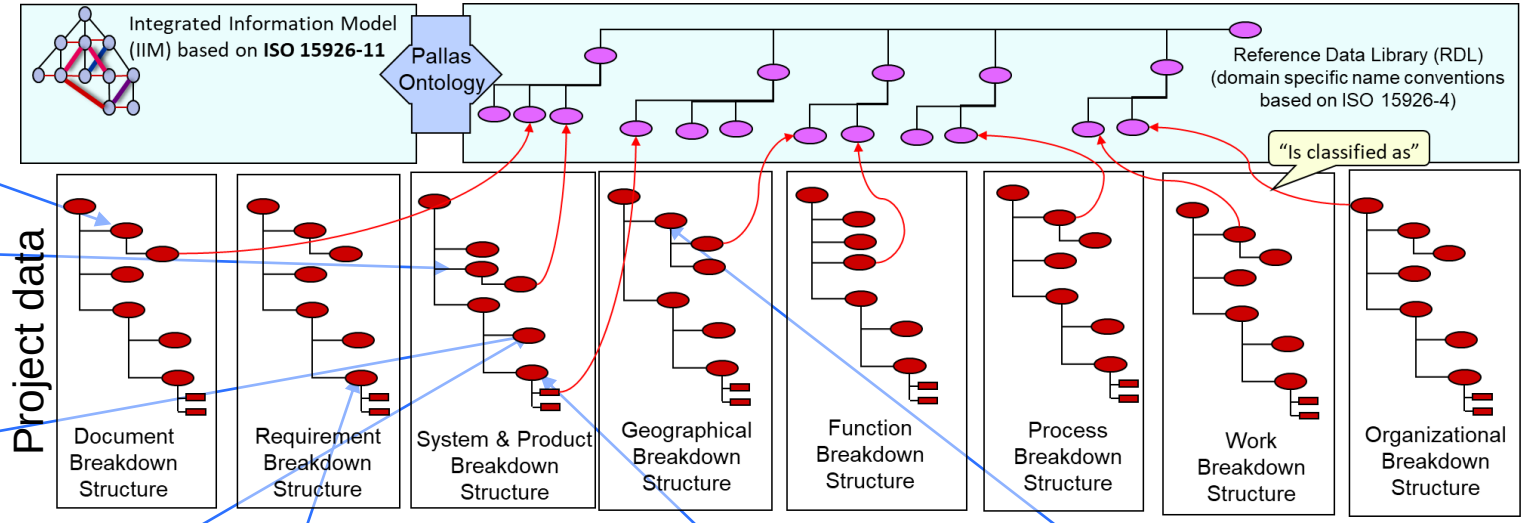
6.2 1100-0300: Second Shutdown System

6.2.1 1110-0311: Piping

1. Class: Mechanical
2. Description:

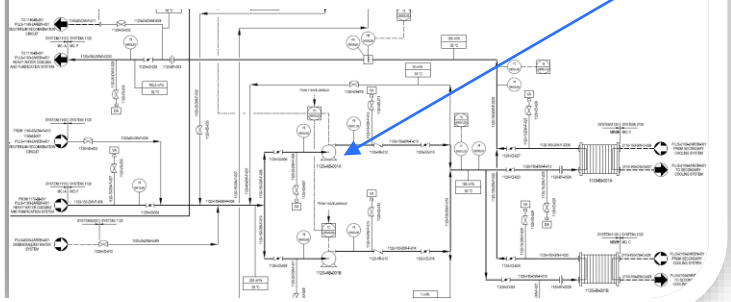
ID	Line/Equipment TAG	Description	Interface connection	Lead
1100-0300 Mechanical	Heavy Water Expansion Tank 1110-BR-001	Heavy Water inlet from SSS to 1110-BR-001	1110-BR-001 (nozzle C) / 0313-40-HW-A-007	0300
1100-0300 Mechanical	Heavy Water Expansion Tank 1110-BR-001	Equalization line between Reflector Vessel and 1110-BR-001	1110-BR-001 (nozzle G) / 0311-100-CG-A-002	0300

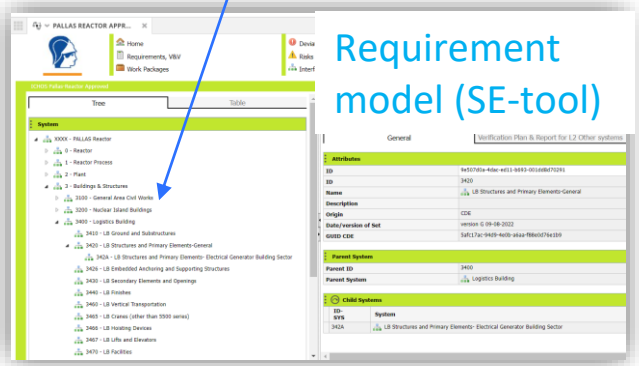
model of a Engineering Document x



Content CDE

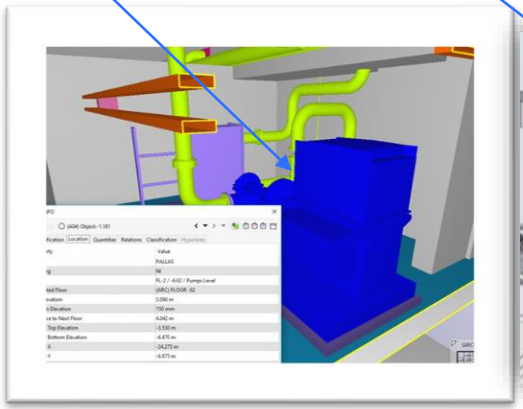
Logical model (2D P&ID)



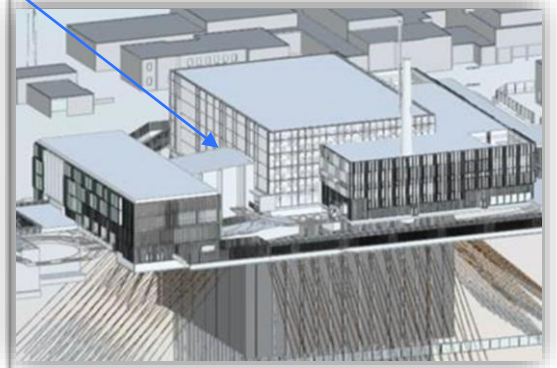


Requirement model (SE-tool)

Equipment within 3D models (IFC)



Spatial objects within 3D architectural models (IFC)



The life cycle model of Product Breakdown Structure elements performing a ‘process unit operation’

- *Compliant with ISO 55001, ISO 15926-11, EN 17632*
- *Supports the equilibrium triangle defined by the IAEA*

process design

has input

has output

Stream 001

Inlet port

Pumping Unit Operation

Outlet port

Stream 002

Following principles of MBSE

Planned Entity

Actual Entity

performs

Functional Design

Functional Entity

realizes

Asset performance representation

Data Analytics'

pump system

Date B

is installed as

is installed as

implements

replaces

has temporal part

Technical Engineering

Asset

Date A

Technical Entity

realizes

CMMS

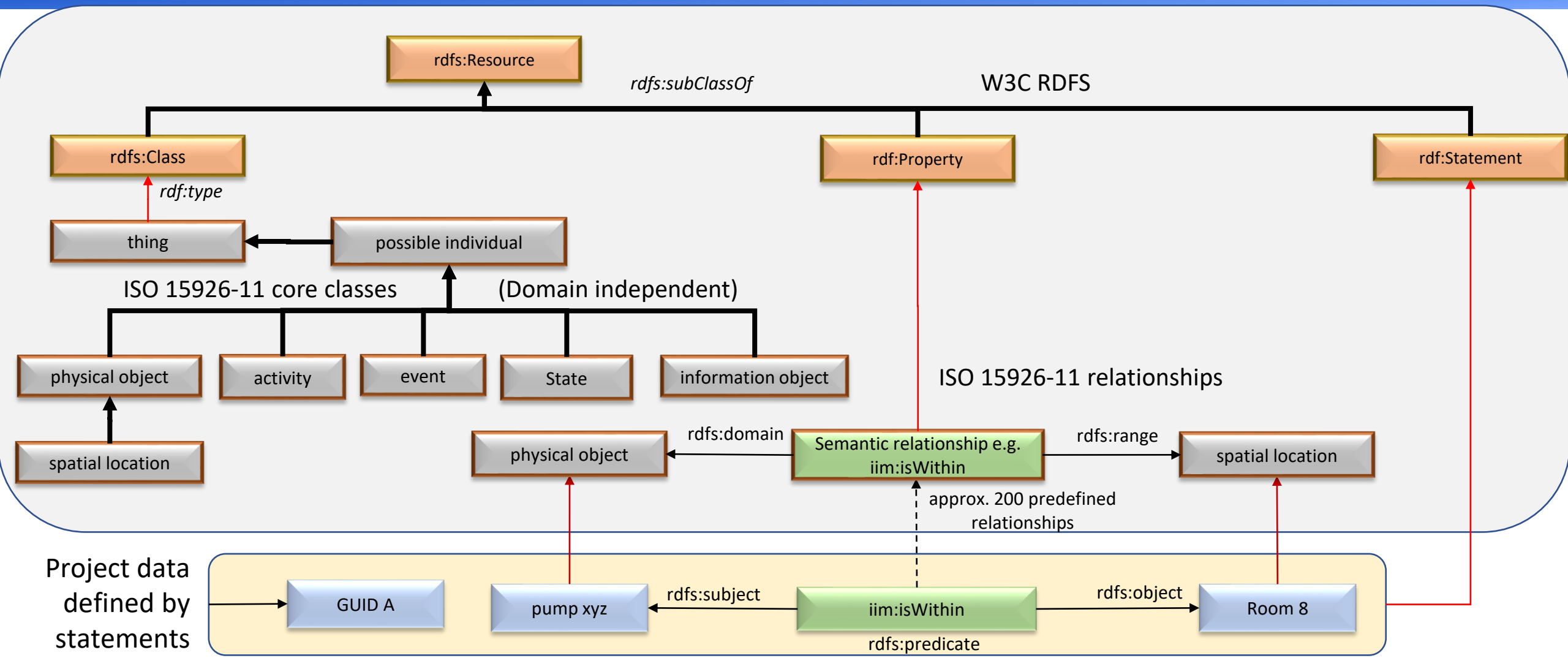
SCADA

IoT

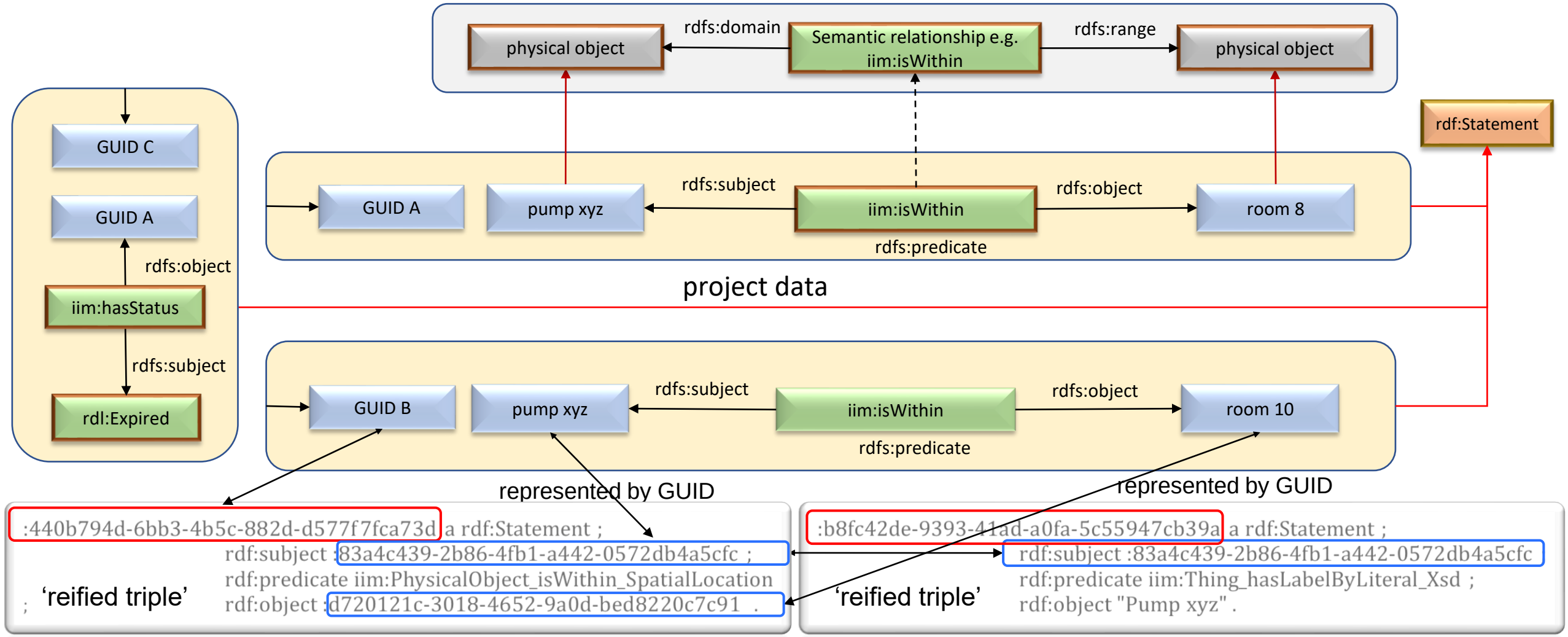
Warren model S210
Serial WQ234516

Kishor model QW24
Serial PU637773

Structure of the Pallas ontology (compliant with ISO 15926-11:2023)



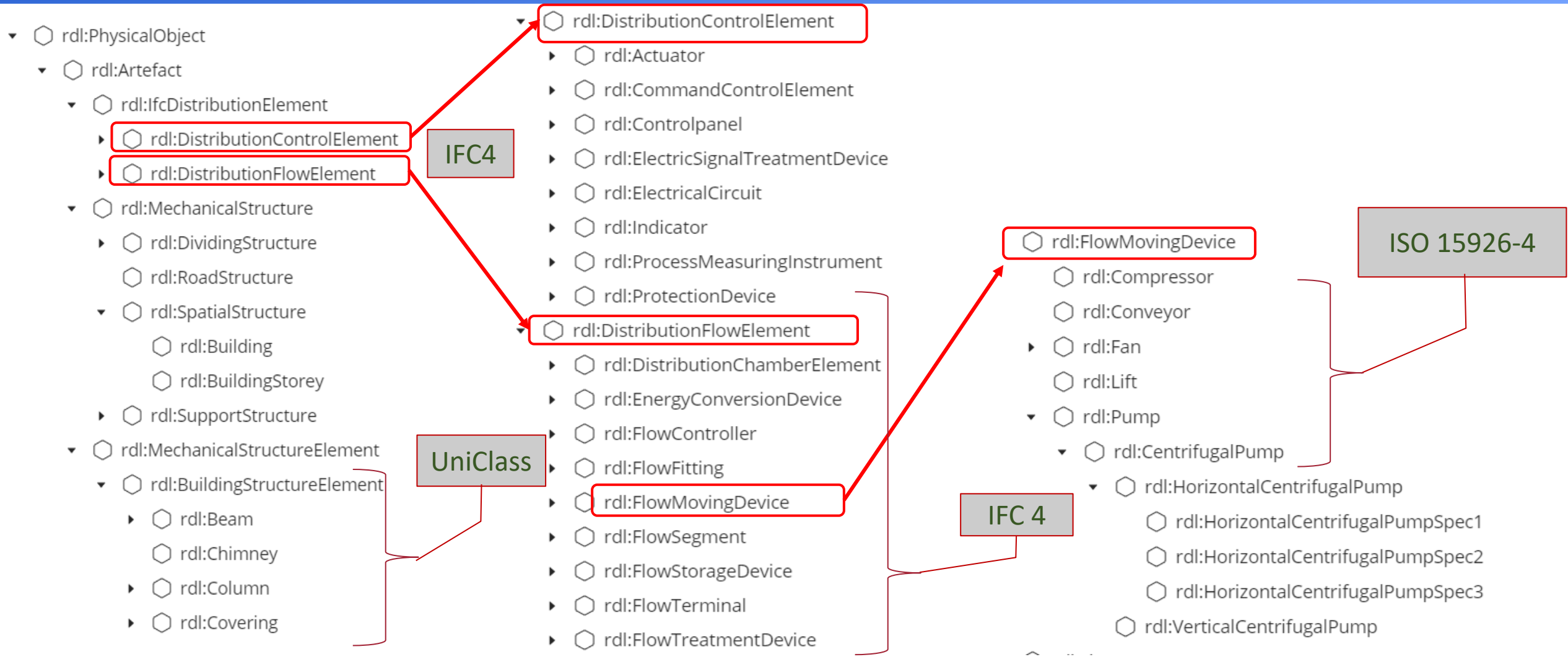
‘Statements’ form the basis for implementation of the ontology and for configuration management



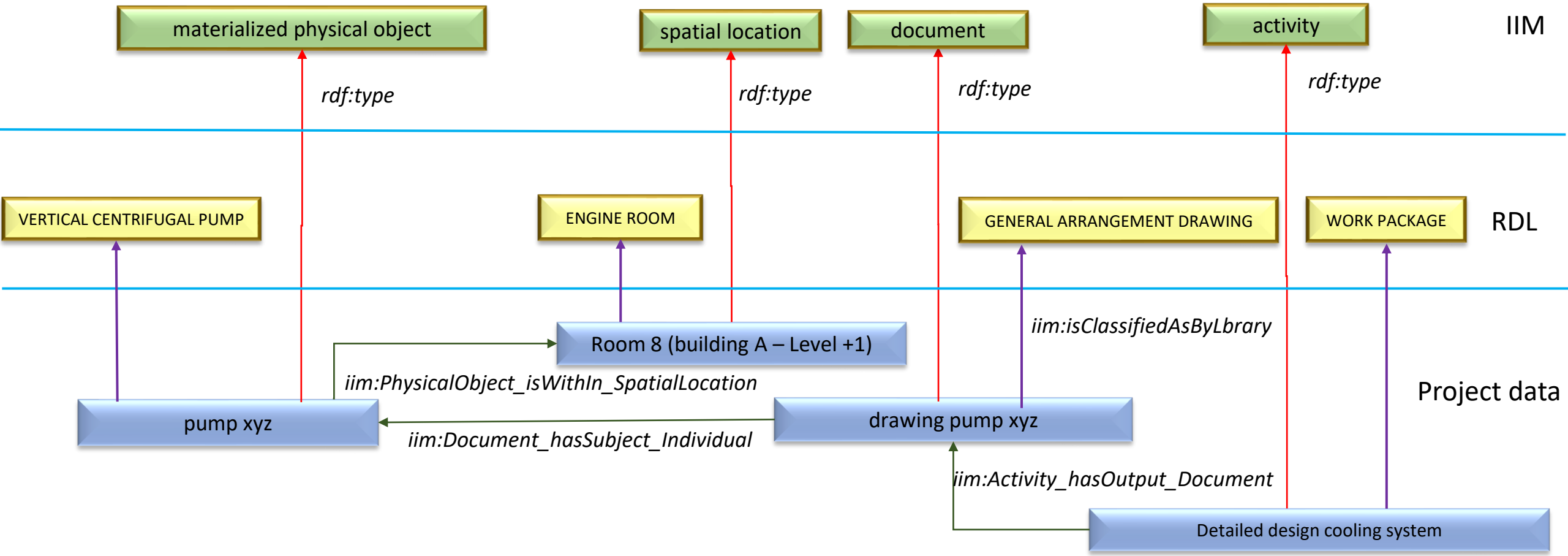
Fragment of the relationships defined in the IIM (compliant with the ontology of ISO 15926-11:2023) supporting multi domain MBSE, digital twins, and asset life cycle management

basic semantic relationships	specialized relationship (rdfs:subPropertyOf)	rdfs:domain	rdfs:range
iim:Thing_isConditionFor_Thing	iim:Condition_isConditionFor_Process	iim:Condition	iim:Process
iim:Thing_isConditionFor_Thing	iim:Condition_isConditionFor_Transition	iim:Condition	iim:Transition
iim:Thing_isConditionFor_Thing	iim:StateOfIndividual_isConditionFor_Transition	iim:StateOfIndividual	iim:Transition
iim:Thing_isCoveredBy_Thing	iim:PhysicalObject_isCoveredBy_PhysicalObject	iim:PhysicalObject	iim:PhysicalObject
iim:Thing_isCreatedBy_Thing	iim:Statement_isCreatedBy_Party	iim:Statement	iim:Party
iim:Thing_isDefinedBy_Thing	iim:Baseline_isDefinedBy_Milestone	iim:Baseline	iim:Milestone
iim:Thing_isDerivedFrom_Thing	iim:Requirement_isDerivedFrom_Objective	iim:Requirement	iim:Objective
iim:Thing_isDerivedFrom_Thing	iim:Requirement_isDerivedFrom_Statement	iim:Requirement	iim:Statement
iim:Thing_isDerivedFrom_Thing	iim:Statement_isDerivedFrom_Document	iim:Statement	iim:Document
iim:Thing_isDerivedFrom_Thing	iim:Statement_isDerivedFrom_DocumentSection	iim:Statement	iim:DocumentSection
iim:Thing_isFulfilledBy_Thing	iim:PhysicalObject_isFulfilledBy_PhysicalObject	iim:PhysicalObject	iim:PhysicalObject
iim:Thing_isGuidedThrough_Thing	iim:Stream_isGuidedThrough_SpatialLocation	iim:Stream	iim:SpatialLocation
iim:Thing_isHierarchicallySubordinate	iim:Requirement_isHierarchicallySubordinatedTo_Requirement	iim:Requirement	iim:Requirement
iim:Thing_isImplementedBy_Thing	iim:PhysicalObject_isImplementedBy_PhysicalObject	iim:PhysicalObject	iim:PhysicalObject
iim:Thing_isInitiatedBy_Thing	iim:Interaction_isInitiatedBy_Activity	iim:Interaction	iim:Activity
iim:Thing_isInitiatedBy_Thing	iim:Interaction_isInitiatedBy_Stream	iim:Interaction	iim:Stream
iim:Thing_isInitiatedBy_Thing	iim:Requirement_isInitiatedBy_PartyRoleAndDomain	iim:Requirement	iim:PartyRoleAndDomain
iim:Thing_isInstalledAs_Thing	iim:PhysicalObject_isInstalledAs_PhysicalObject	iim:ActualMaterialisedPhysica	iim:DesignedFunctionalPhysicalObject
iim:Thing_isInvolvedIn_Thing	iim:Individual_isInvolvedIn_Risk	iim:PossibleIndividual	iim:Risk
iim:Thing_isMadeOf_Thing	iim:PhysicalObject_isMadeOfByClass_TypeOfMatter	iim:PhysicalObject	iim:ClassOfMatter
iim:Thing_isManufacturedBy_Thing	iim:ManufacturerModel hasManufacturer Partv	iim:ManufacturerModel	iim:Party

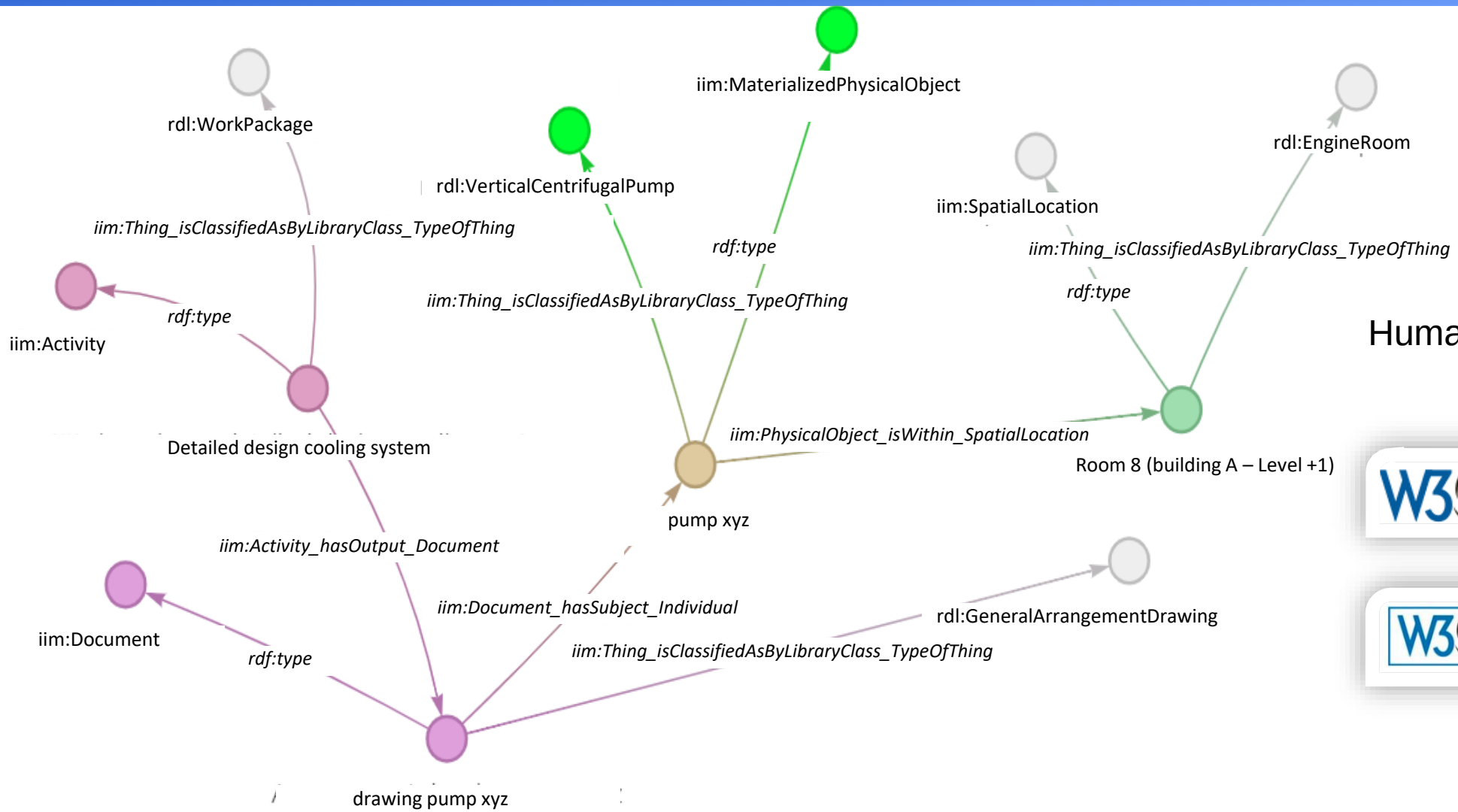
Fragment of the structure of the domain specific Pallas RDL (physical object part)



Example of the use of the IIM and RDL (based on ISO 15926-11:2023)

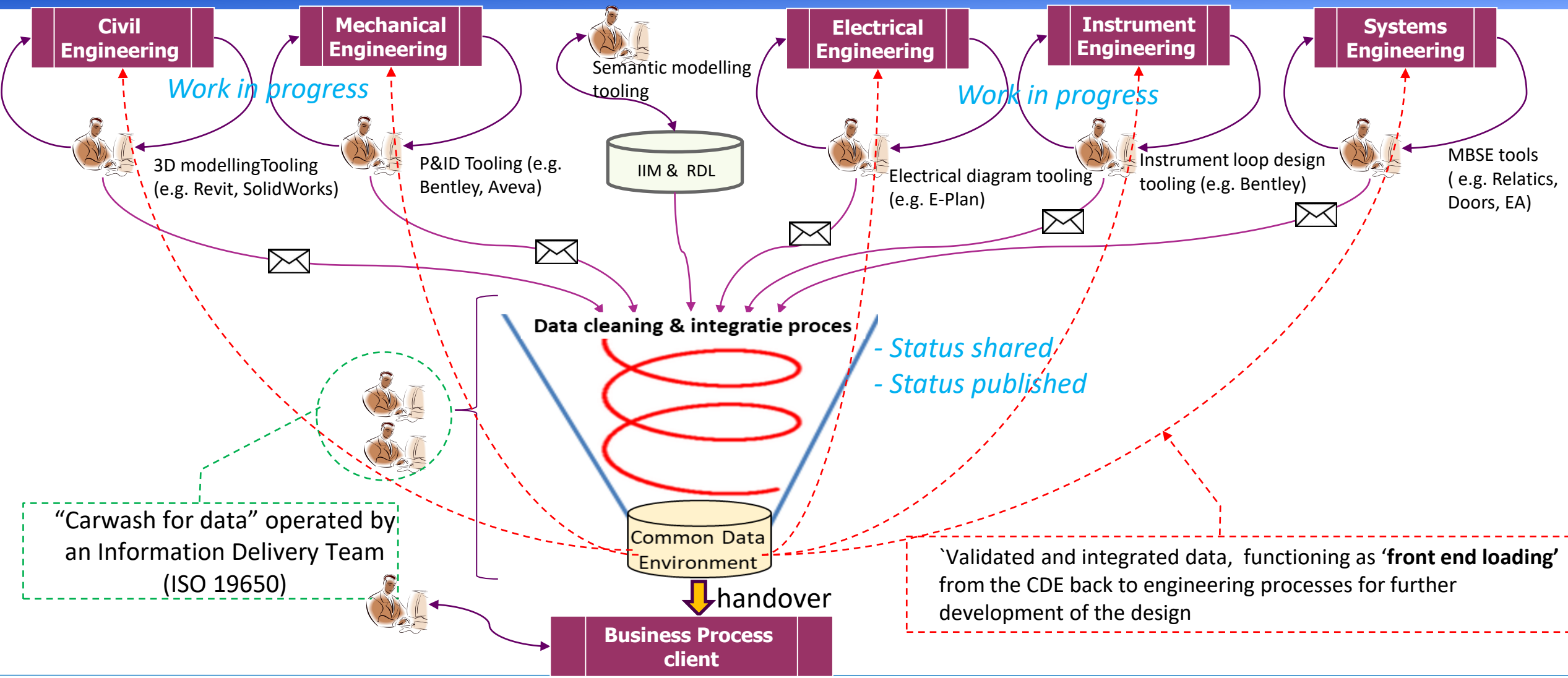


The previous example implemented by a Named Graph in the Graph Database of the CDE



Human AND machine readable

Information Management: controlling information input and output of engineering processes



Data cleaning and mapping process (based on ISO 8000 Data Quality): Assuring reliability and integrity for acceptance of the CDE as a Single Source of Truth

"Similar carwash for cleaning IFC 3D models"

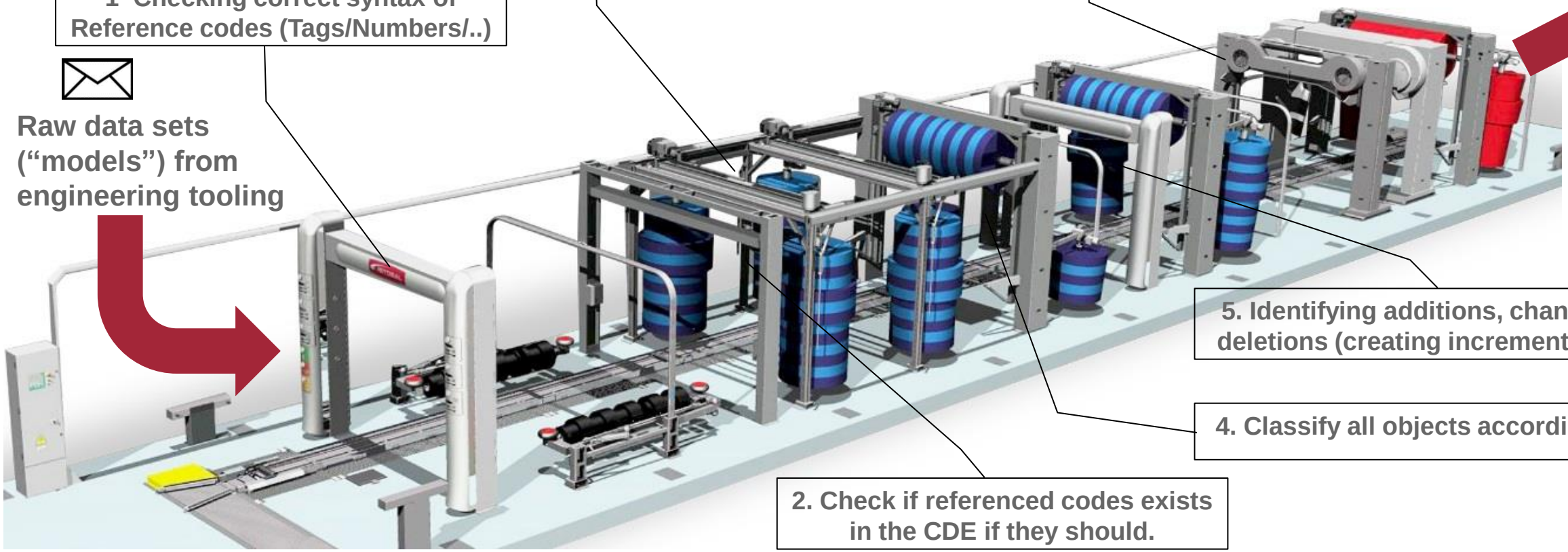
3 Harmonize semantics according to the Integrated Information Model (IIM)

6. Apply validation rules IIM and RDL

Cleaned, signed data sets for import in CDE (signed Named Graphs)

1 Checking correct syntax of Reference codes (Tags/Numbers/..)

Raw data sets ("models") from engineering tooling

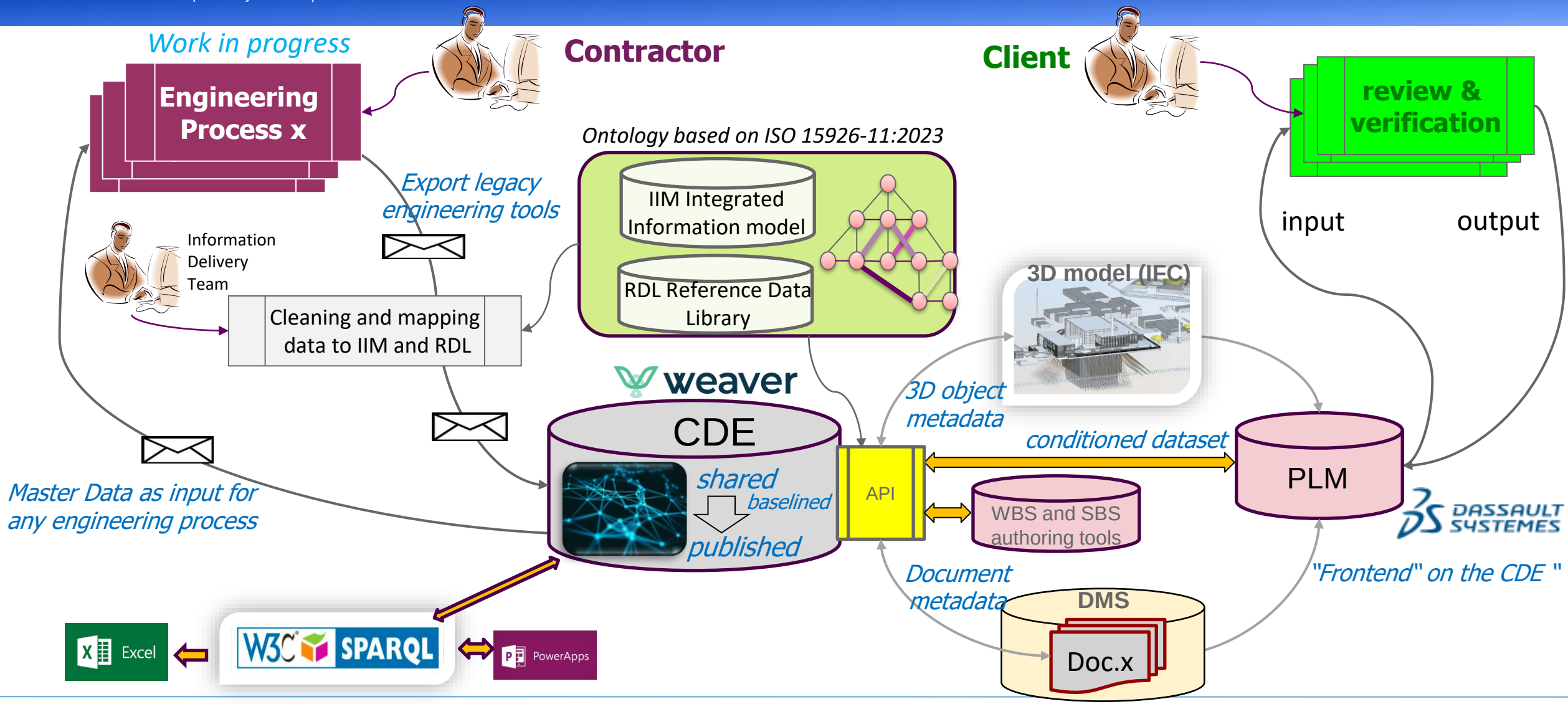


5. Identifying additions, changes and or deletions (creating incremental data set)

4. Classify all objects according the RDL

2. Check if referenced codes exists in the CDE if they should.

Recap of the PALLAS digital eco system for managing of engineering & facility life cycle data



Recap CDE approach PALLAS project (ontology driven rather than document driven)

Information:

- Select, tailor, and implement **data standards**, develop iterative an **IIM and RDL ("project ontology")**
- Focus on life cycle **information streams**, the models behind them and their owners and stakeholders.
- Agree on **data exchange requirements** with the engineering environment (for tool export compliancy).
- Apply principles of ISO 8000: **syntactic, semantic and pragmatic Data Quality.**

Technology:

- Use **semantic modeling technology** to cope with the richness of **Systems Engineering** data
- Select a flexible **'linked data'** platform, capable of handling **Named Graph with reified triples**.
- Use **data standards** and **open-source technology** to ensure seamless migration for decades to come.
- The PALLAS project succeeded in its mission by limiting itself to using only **RDFS combined with SPARQL**.

Human and organization:

- Clear **vision** and visual support from **senior management / leadership.**
- Availability of required (new) **competences and new roles** acknowledged.
- Succeeded in **bridging the gap** between ontology, engineering environment and engineering tooling.
- Organized **integration** of domain knowledge, semantic modeling knowledge, and IT.

Adoption of the Pallas concept: It is not an “one fits all” solution

However, it can be tailored and scaled with respect to:

- **the ambition level of digitalization and**
- **an appropriate balance between documents and data**

Considering:

- Partners in a project consortium all have their own methods, standards and tools
- Partners has different maturity in the practice of data quality and data modeling skills
- Contracts in many cases don’t take explicit into count data quality and data exchange
- The vision and support of senior management is crucial for what can be achieved
- IT platforms and software supporting full data integration are still in development
- In general, within companies there is lack of knowledge of data integration standards
- The gap between ontology developers and knowledge of implementation in industry is huge

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Q&A

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