

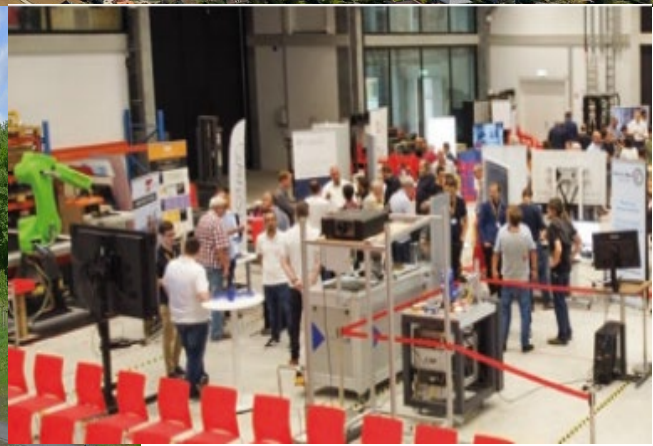
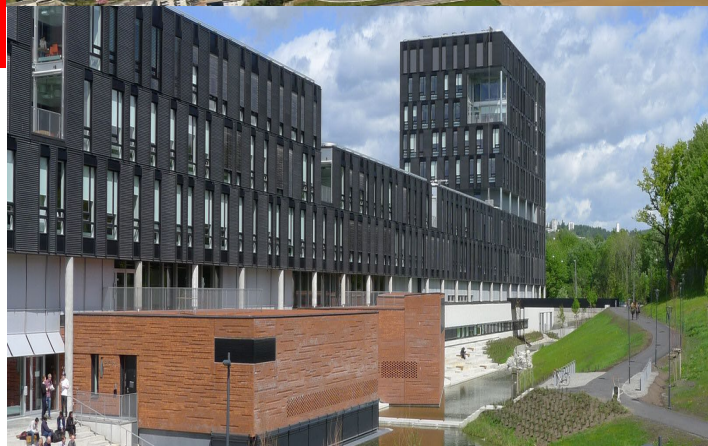
Information Modelling Framework for Cognitive Industrial Solutions

Dimitris Kyritsis (Kiritsis)

- Professor Emeritus of ICT for Sustainable Manufacturing, EPFL
- Senior Advisor, SIRIUS labs
Dept. of Informatics, UiO, Norway
- Senior Advisor, Swiss Smart Factory,
Biel/Bienne
dimitris.Kiritsis@epfl.ch

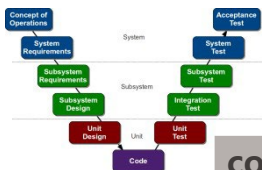
Arild Waaler

Professor, SIRIUS labs
Dept. of Informatics, UiO
arild@ifi.uio.no





Standards



Process



Business model

Electronic engineers



Software



Project managers



Mechanical Engineers



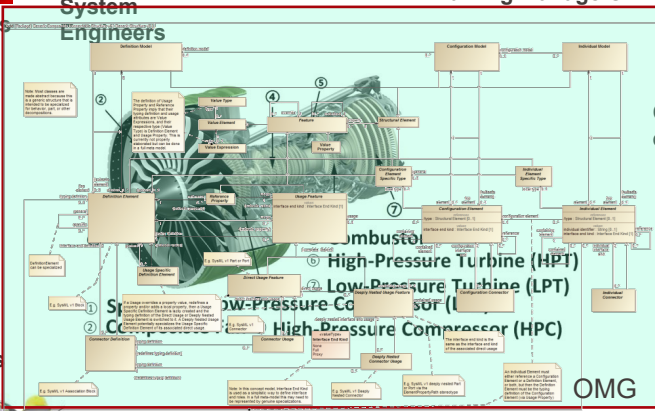
System Engineers



Testers



Training managers



Compressor

High-Pressure Turbine (HPT)

Low-Pressure Turbine (LPT)

High-Pressure Compressor (HPC)

OMG

Information



Data...



Model...

Knowledge



Quality engineers



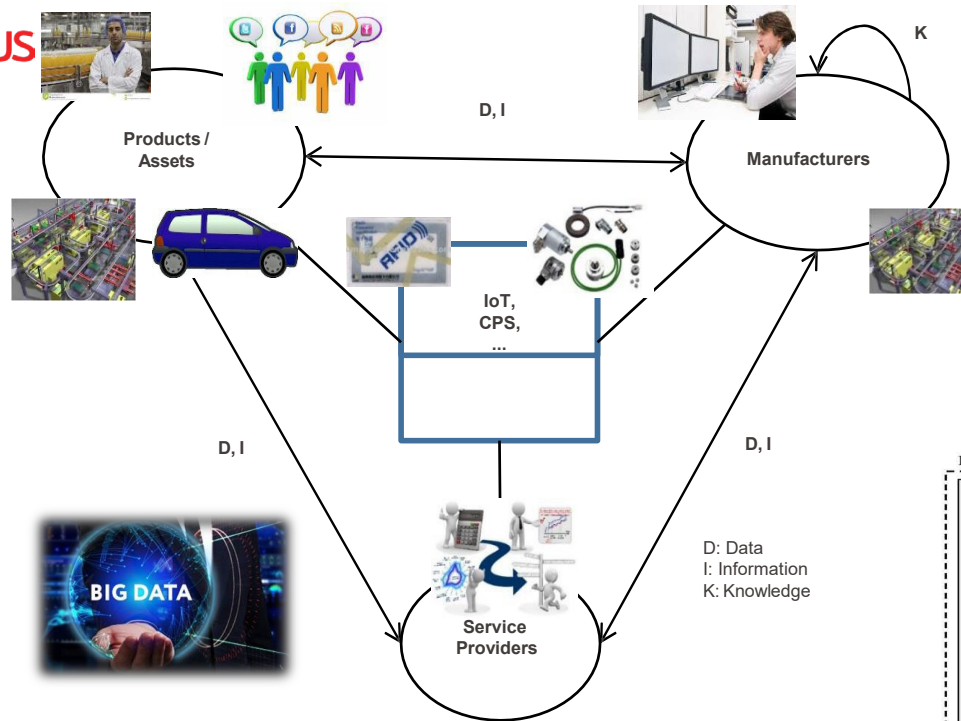
Safety engineers



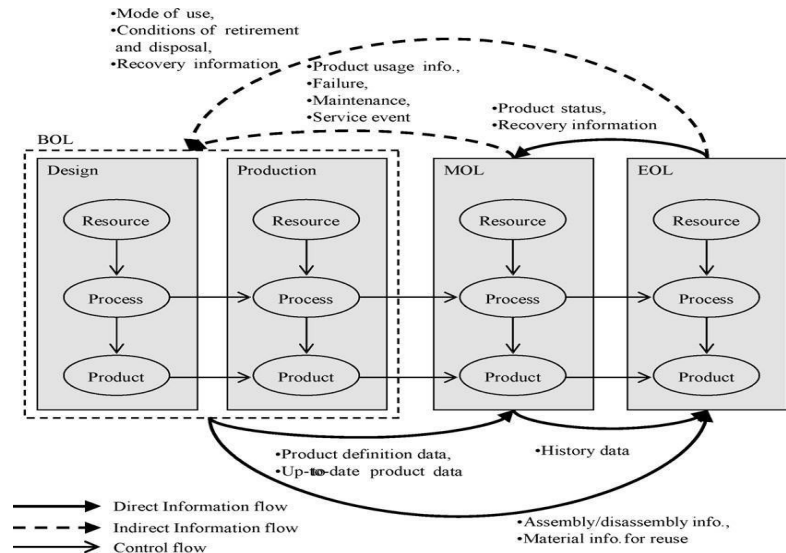
Stakeholders

Efficiency



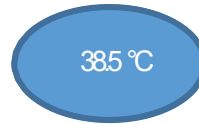


- Closed-Loop Life cycle
Data-Information-Knowledge Transformations
- Semantic Model-Based Systems
Engineering for Industrial Data Analytics



The Meaning of Data

Body
temperature



Oven
temperature

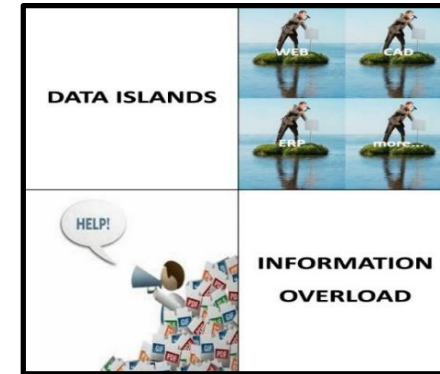


Ontologies allow the interpretation of the right meaning of data

Reasoning
Domain disambiguation
Data Silos

Capturing the Meaning of Data with Ontologies & KG

- Scattered data in several sources, systems and services
- Different actors with multidisciplinary skills



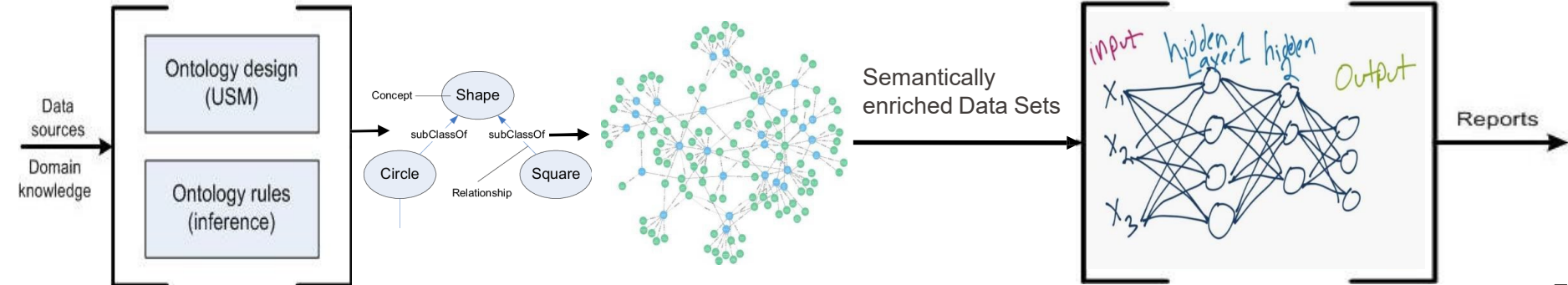
Semantic modelling

Ontology

Knowledge Graph



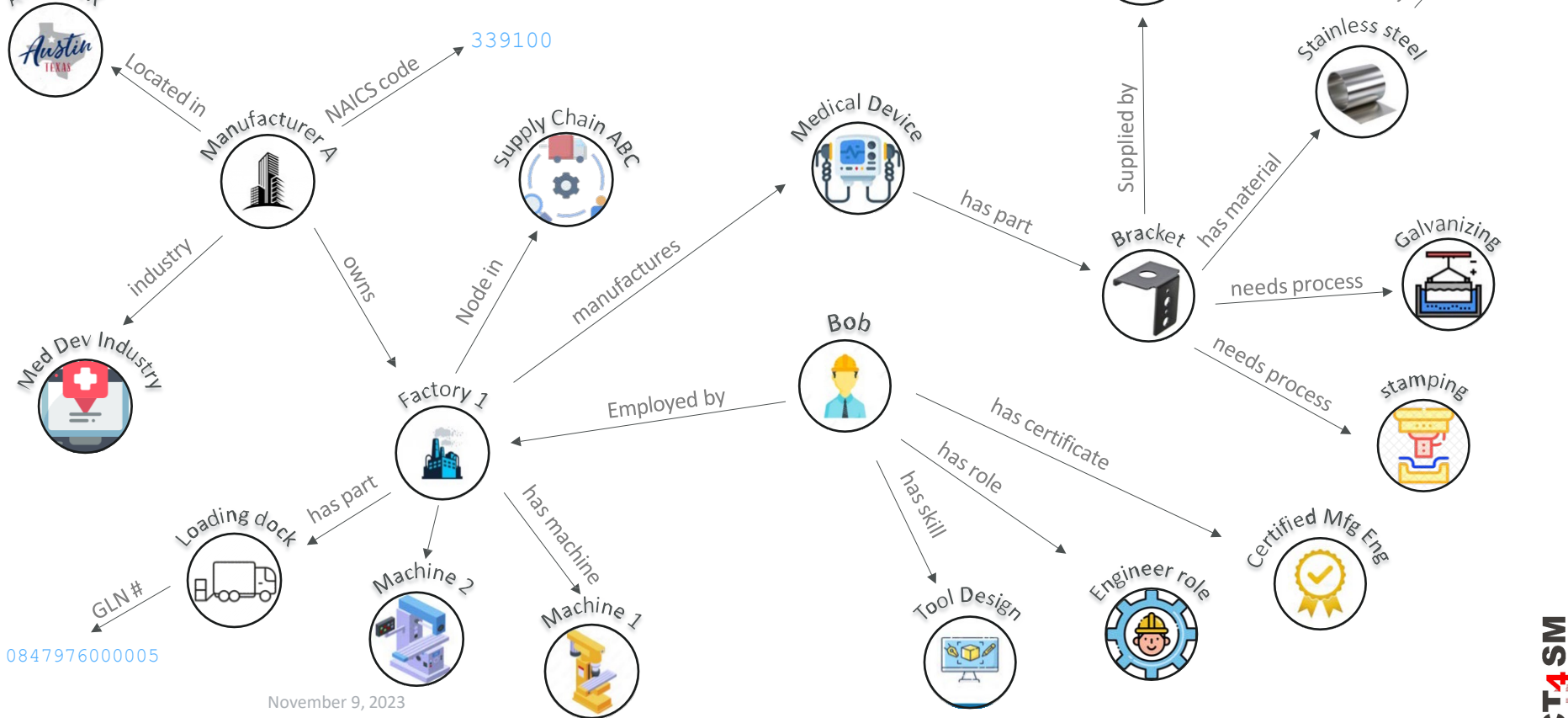
Data Mining+Analytics module:
on context and on purpose



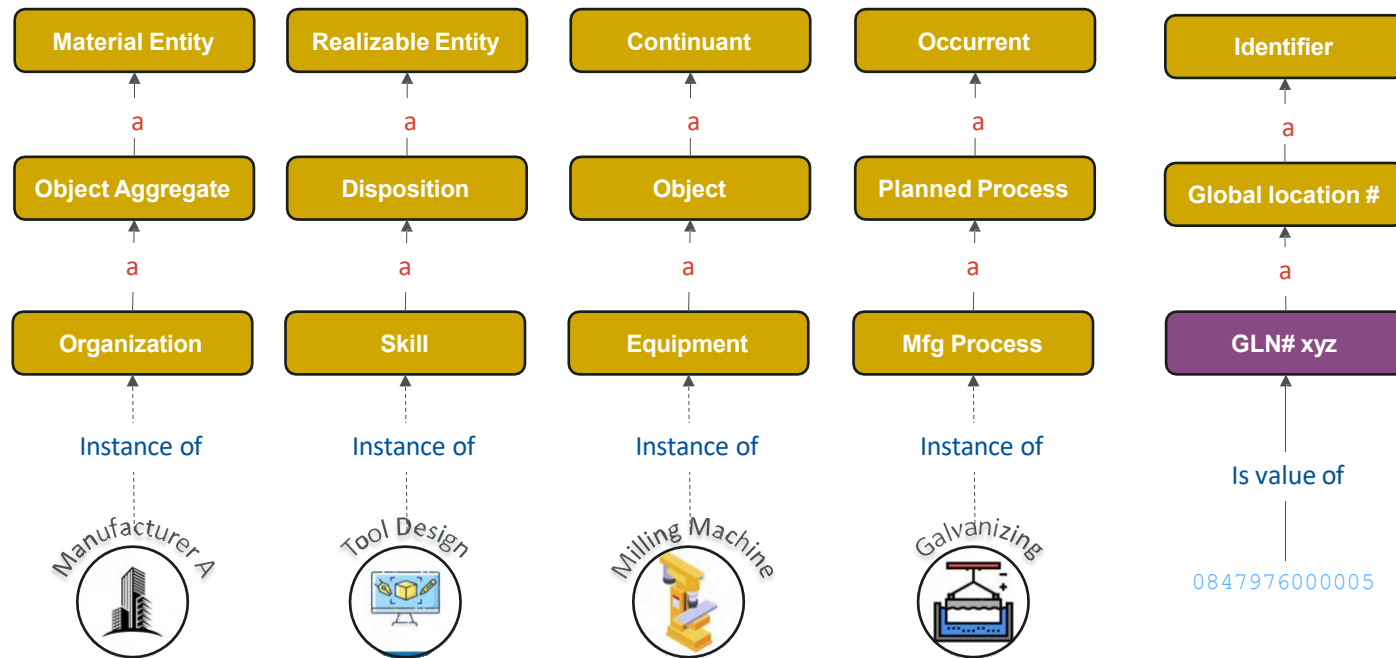


Uio: Example KG

EPFL

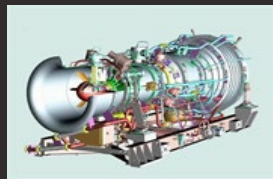


November 9, 2023





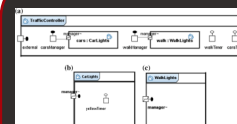
interface



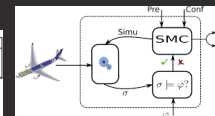
CAD



FEM models

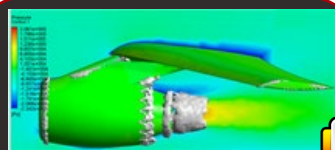


Model checking models

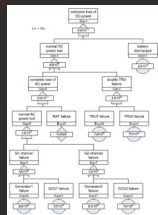


Realtime model...

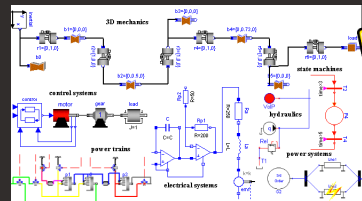
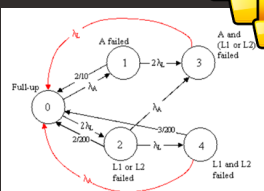
Testing models



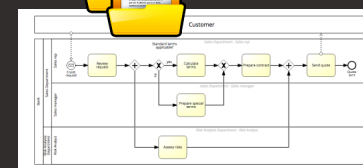
CFD models



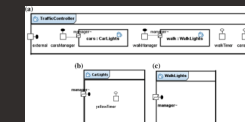
Analysis Models



Performance models



Process models...



Property models





UiO:

Digital Twins: *enablers of integrated solutions*

EPFL

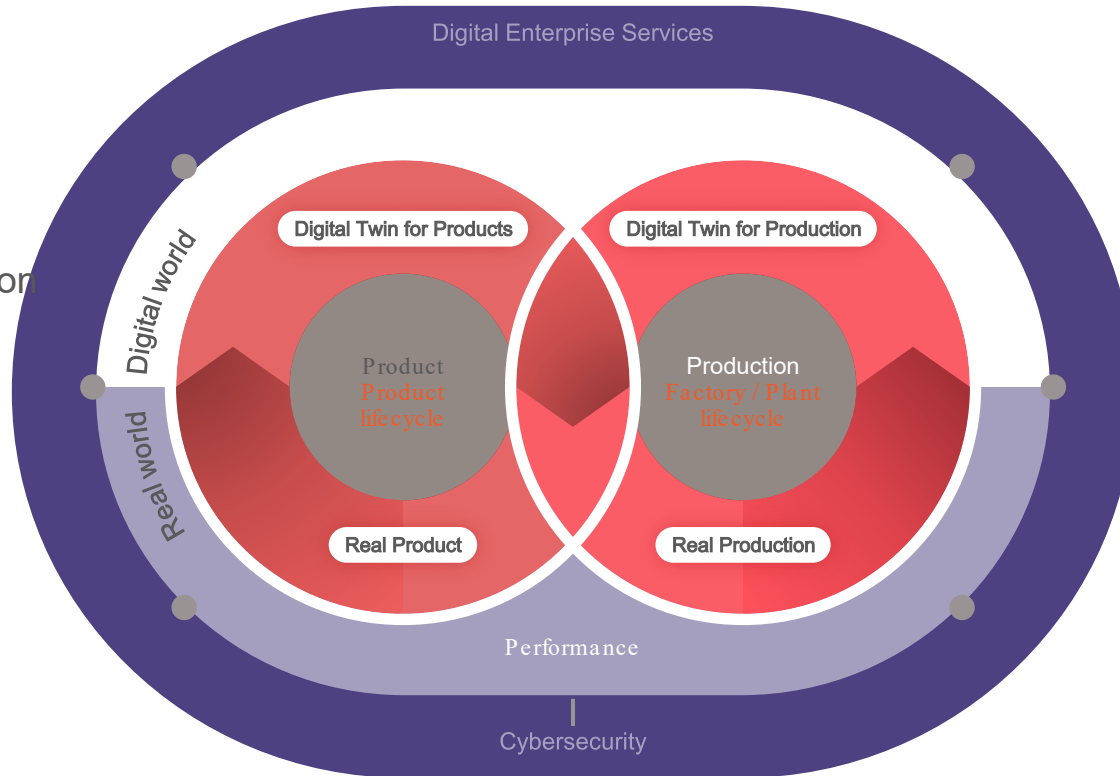


RE4DY

MANUFACTURING DATA NETWORKS

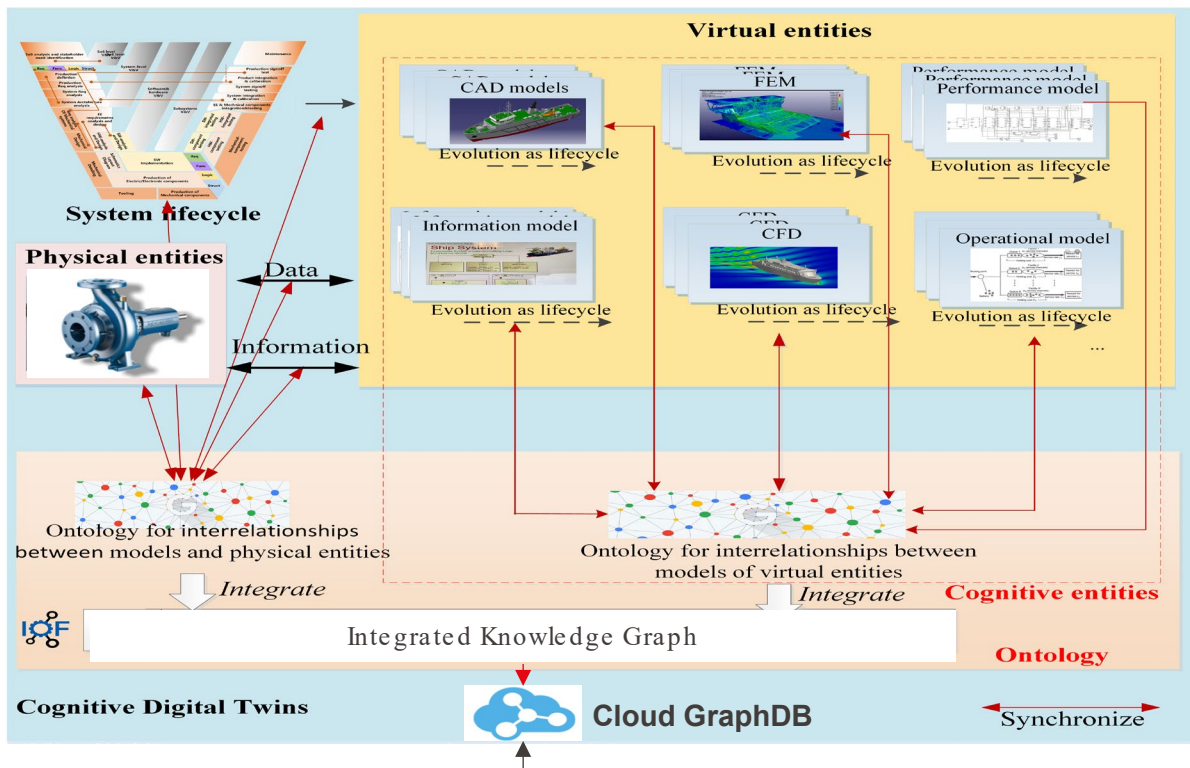
<https://re4dy.eu/>

The comprehensive Digital Twin approach allows the realistic simulation and validation of products, machines, lines and complete plants



They're the foundation for flexible and efficient manufacturing

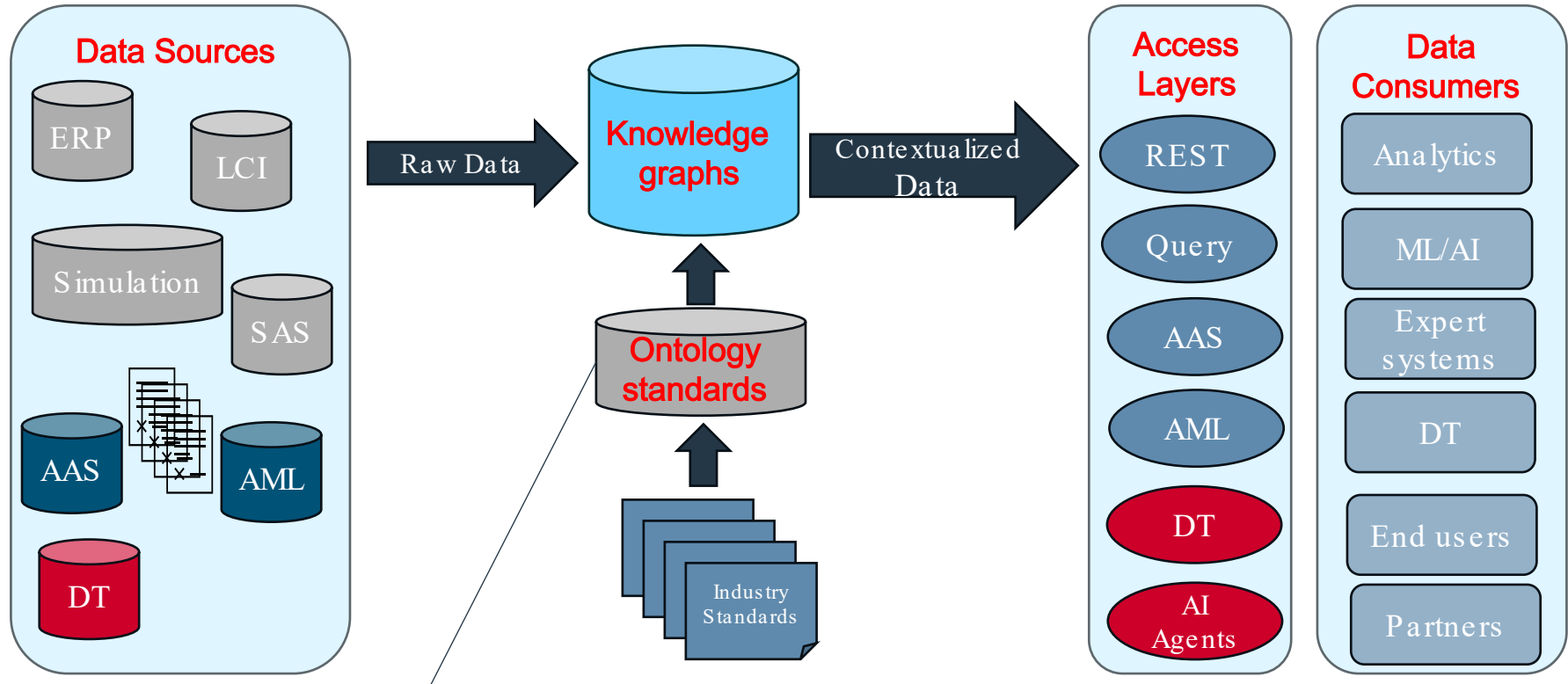
Cognitive Digital Twin: a digital representation of a physical system augmented with **cognitive capabilities** and enables **autonomous activities**; comprises **semantically interlinked digital models** related to **different lifecycle phases**; **continuously evolves** with the physical system across the entire lifecycle.



AI & DS Agents – Digital Twins – Apps – other software

AI: Artificial Intelligence
DS: Decision Support

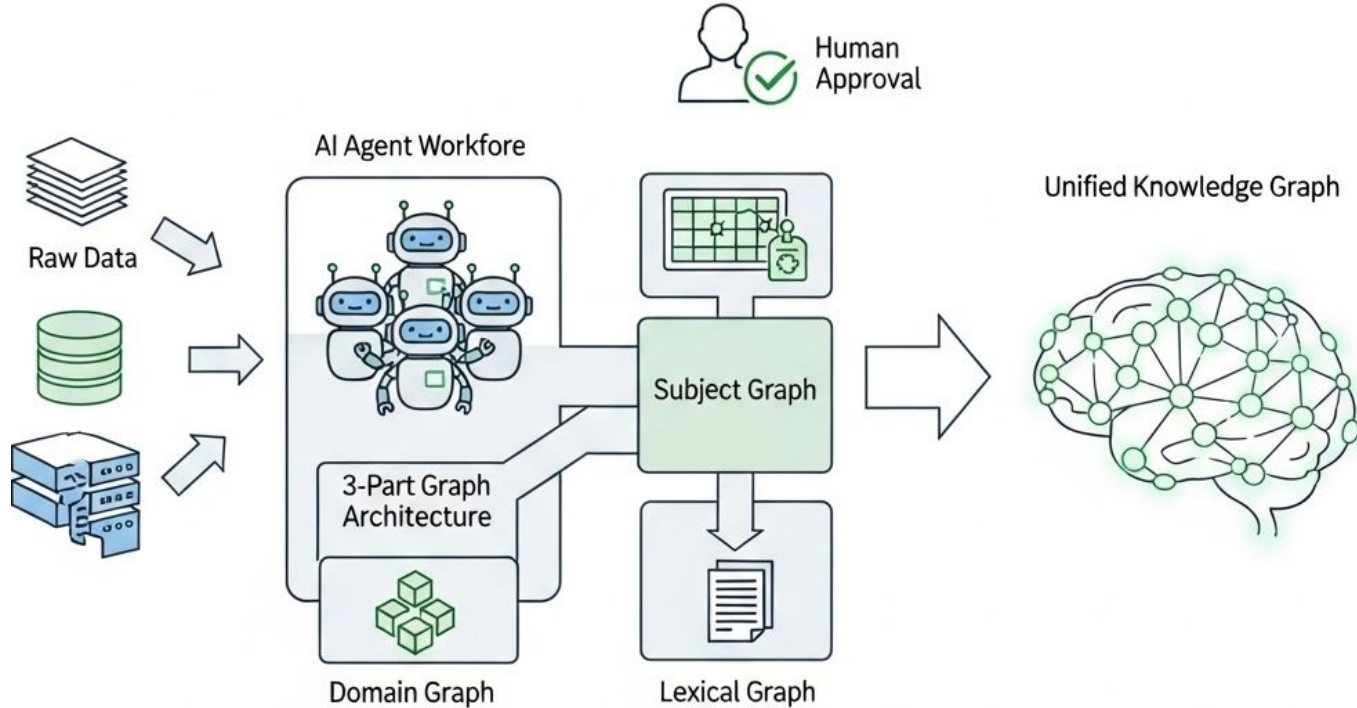
NEED FOR STANDARDS



IOF: <https://oagi.org/pages/industrial-ontologies>
IDO: <https://rds.posccaesar.org/ontology/lis14/>
KGA: <https://www.kg-alliance.org/>

Starting directly with data models does not allow to capture the knowledge of the data owners

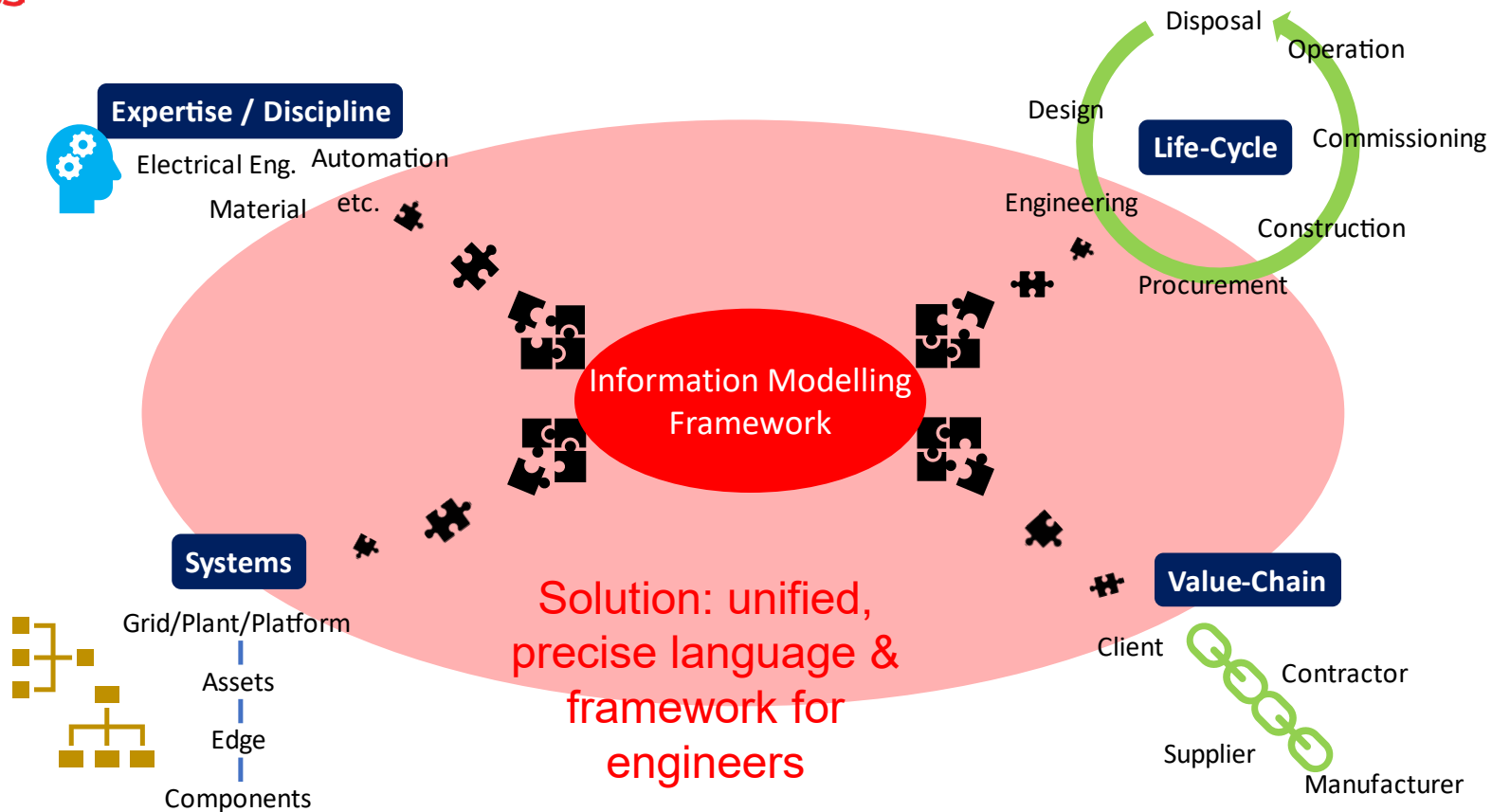
NO MODEL HERE !



SOLUTION: Model Based Systems Engineering - MBSE

How to create an Integrated KG of a Twinned System?

Connecting Fragmented System Elements



- Information modelling **language** and **framework**
 - Last version of IMF material available here: <https://www.imfid.org/>
- Language for identifying and describing objects of **industrial assets** in different **aspects**
- Language for integrating across ...
 - different **domain** and **discipline** specific descriptions
 - different **ontologies** and **domain standards**
 - descriptions using different **abstraction** levels
 - the complete **asset lifecycle**
- Designed to be used and understood by **subject matter experts**
- Based on
 - ideas from **systems engineering**, ISO/IEC 81346*'s aspect concept
 - **formal logic**, **semantic web** technologies
 - **graph data** formats

DNV-RP-0670 | Based on **ISO IEC RDS 81346** standards

<https://www.dnv.com/digital-trust/recommended-practices/asset-information-modelling-dnv-rp-0670/>

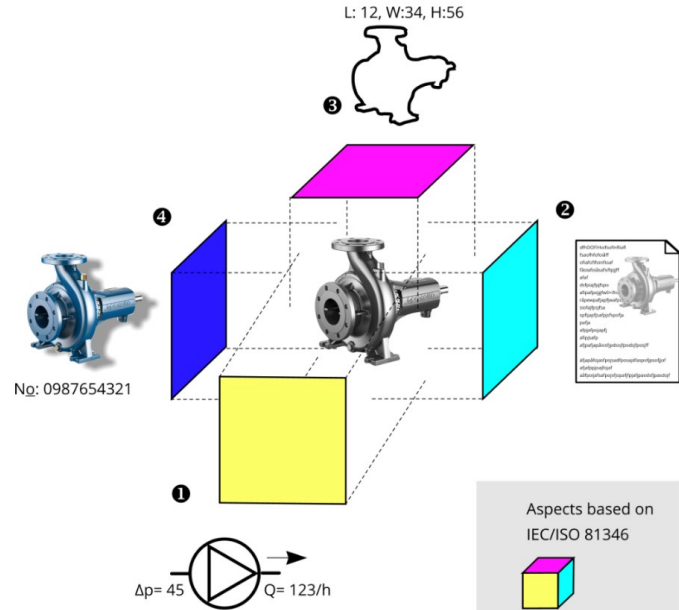
*Industrial systems, installations and equipment and industrial products – structuring principles and reference designations

Descriptions are categorized by **aspects**

Aspects are distinct perspectives on entities

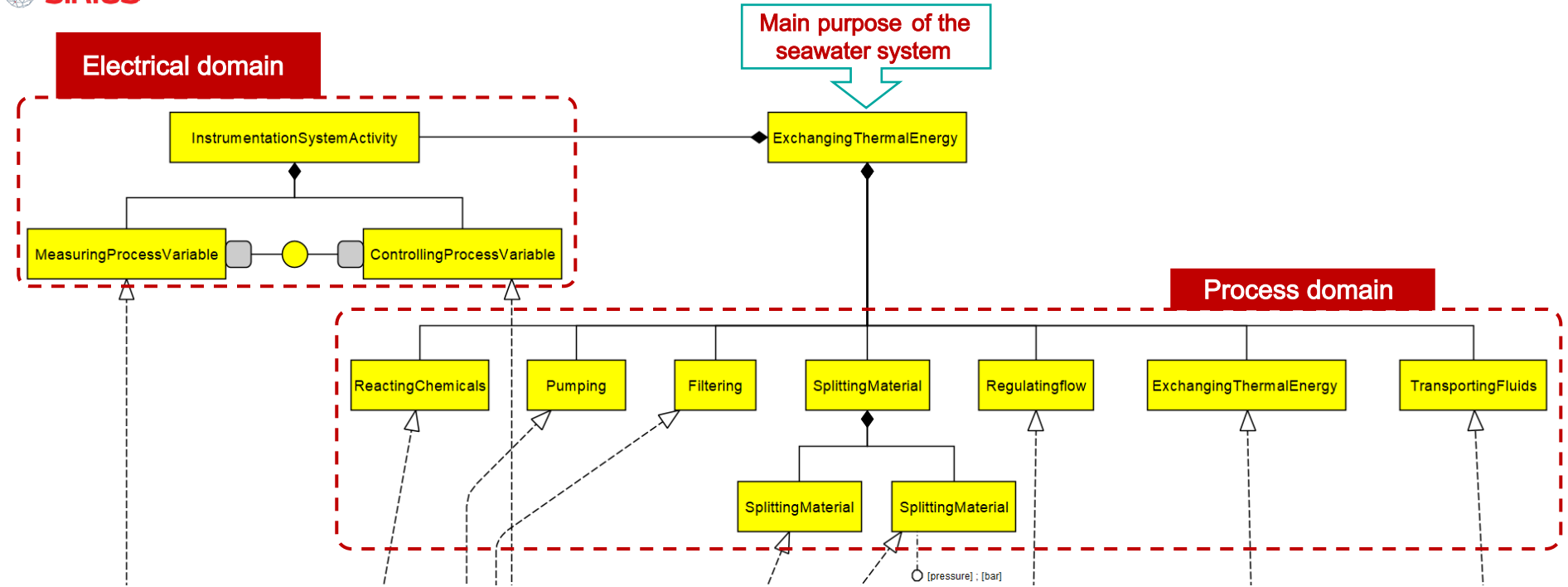
Example:

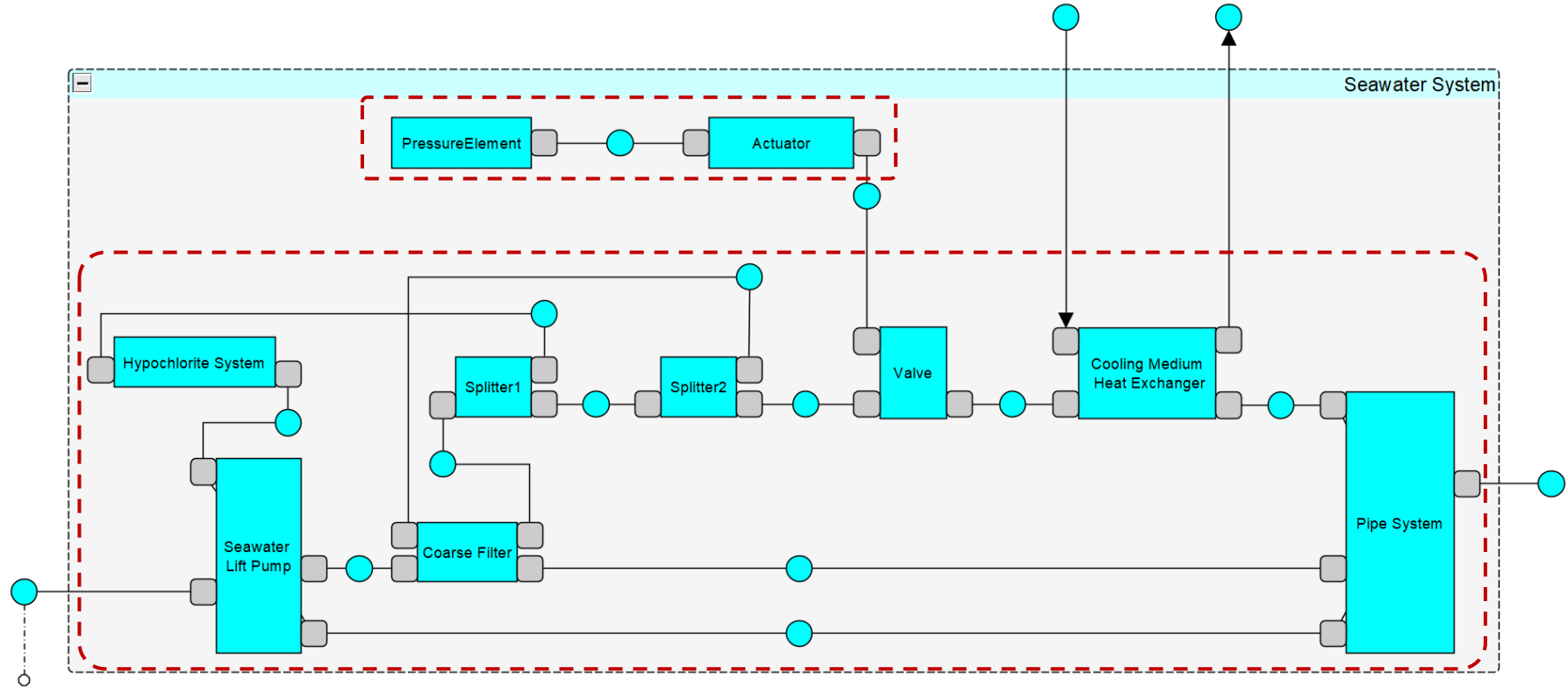
- Function aspect (Yellow) ① is about the intended activity, providing information about required activity, perform
- Product aspect (Cyan) ② is about the specification, perform the activity, in this example the specification
- Location aspect (Magenta) ③ is about the spatial e specified pump and the requirements imposed by th
- Installed aspect (Dark blue) ④ is about information about the actual pump, with information such as serial number, run hours, and status.



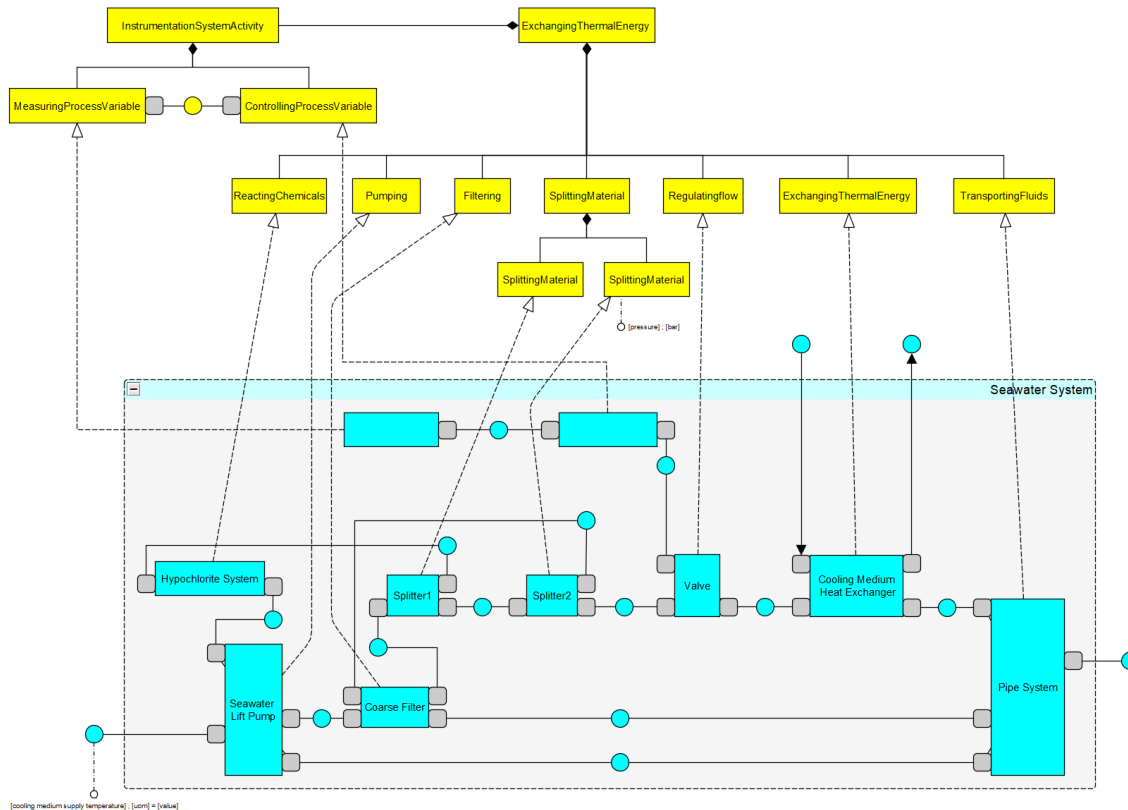
Aspects based on
IEC/ISO 81346

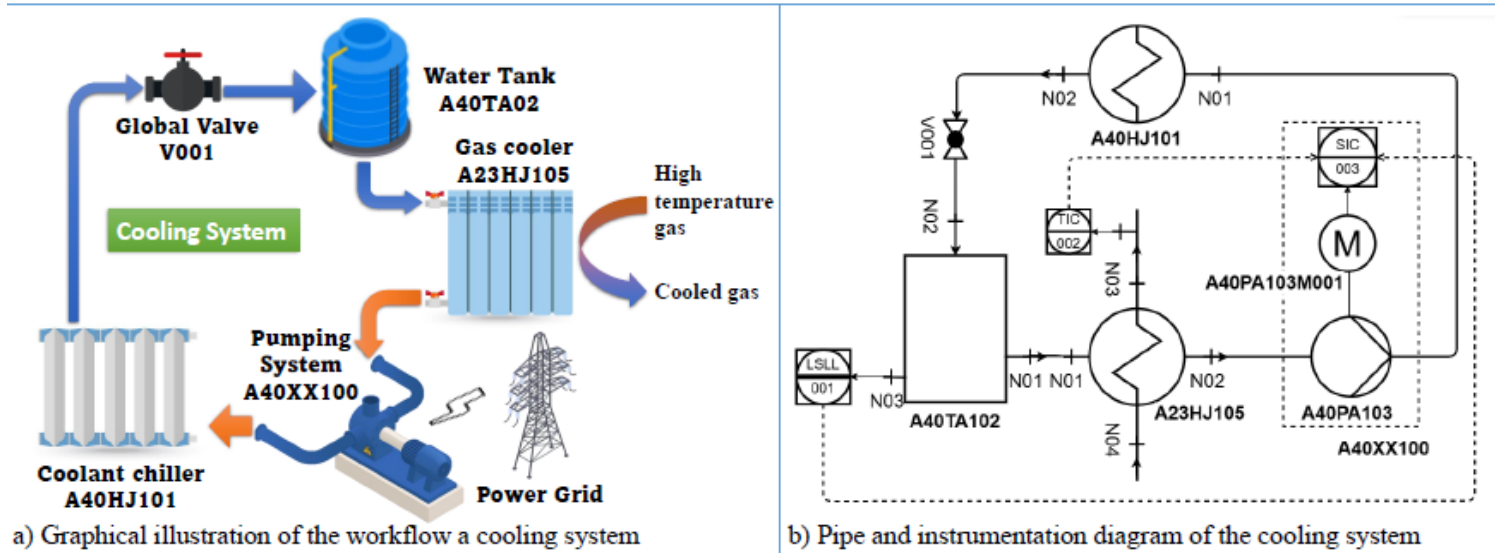






[cooling medium supply temperature] : [uom] = [value]





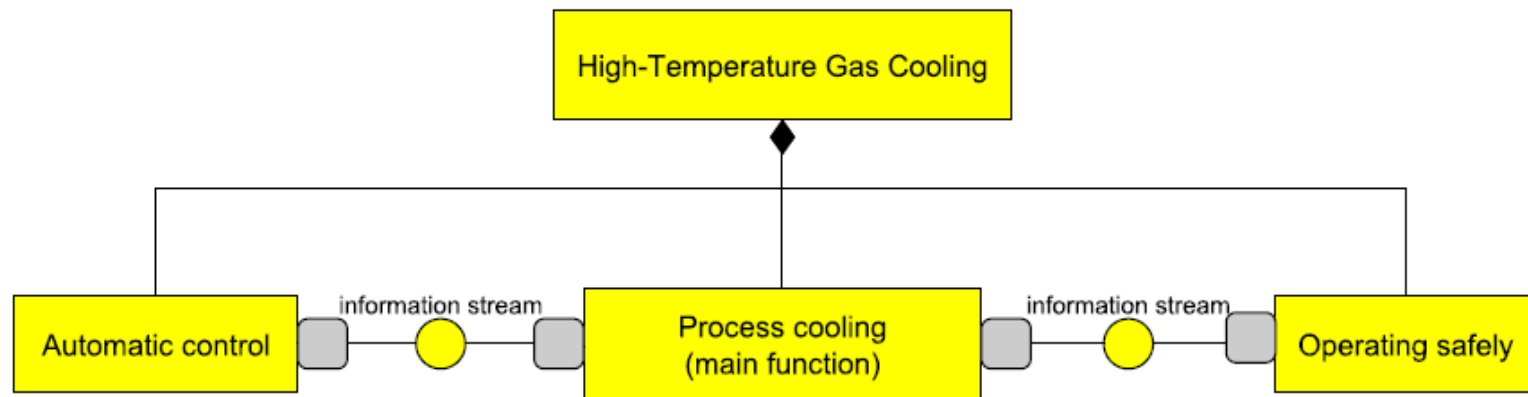
Example: cooling system

work breakdown structure

<https://tec4maases.eu>

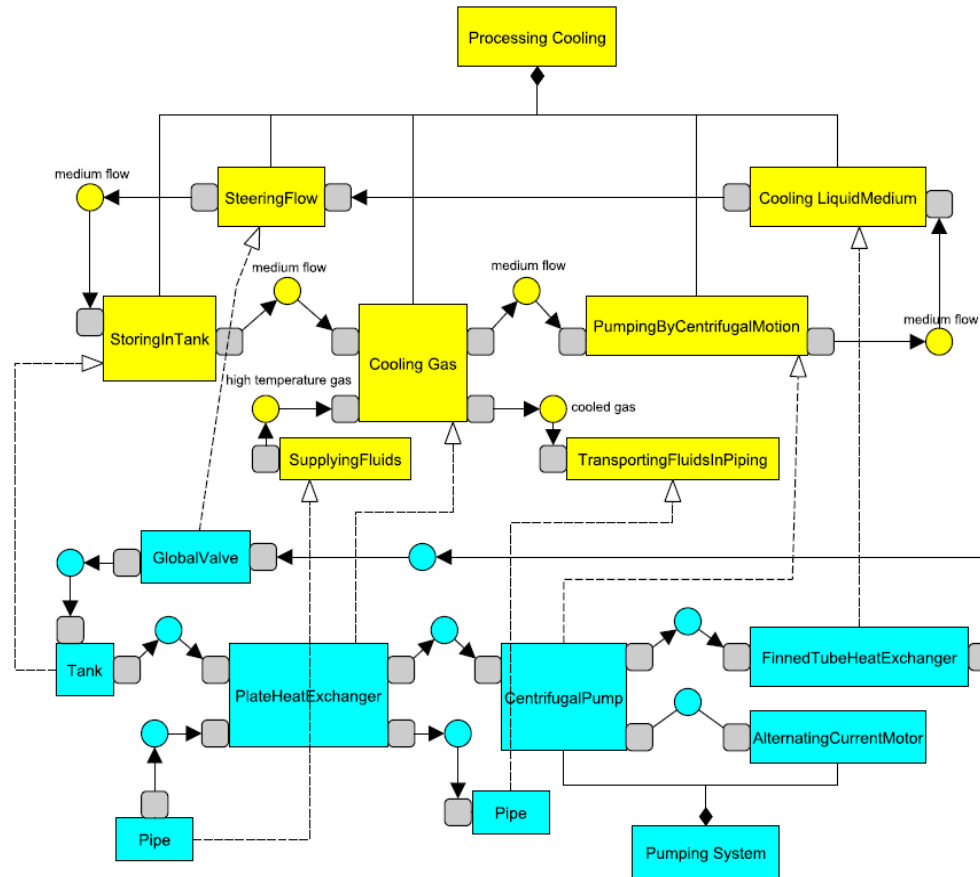
<https://sm4rtenance.eu>

20



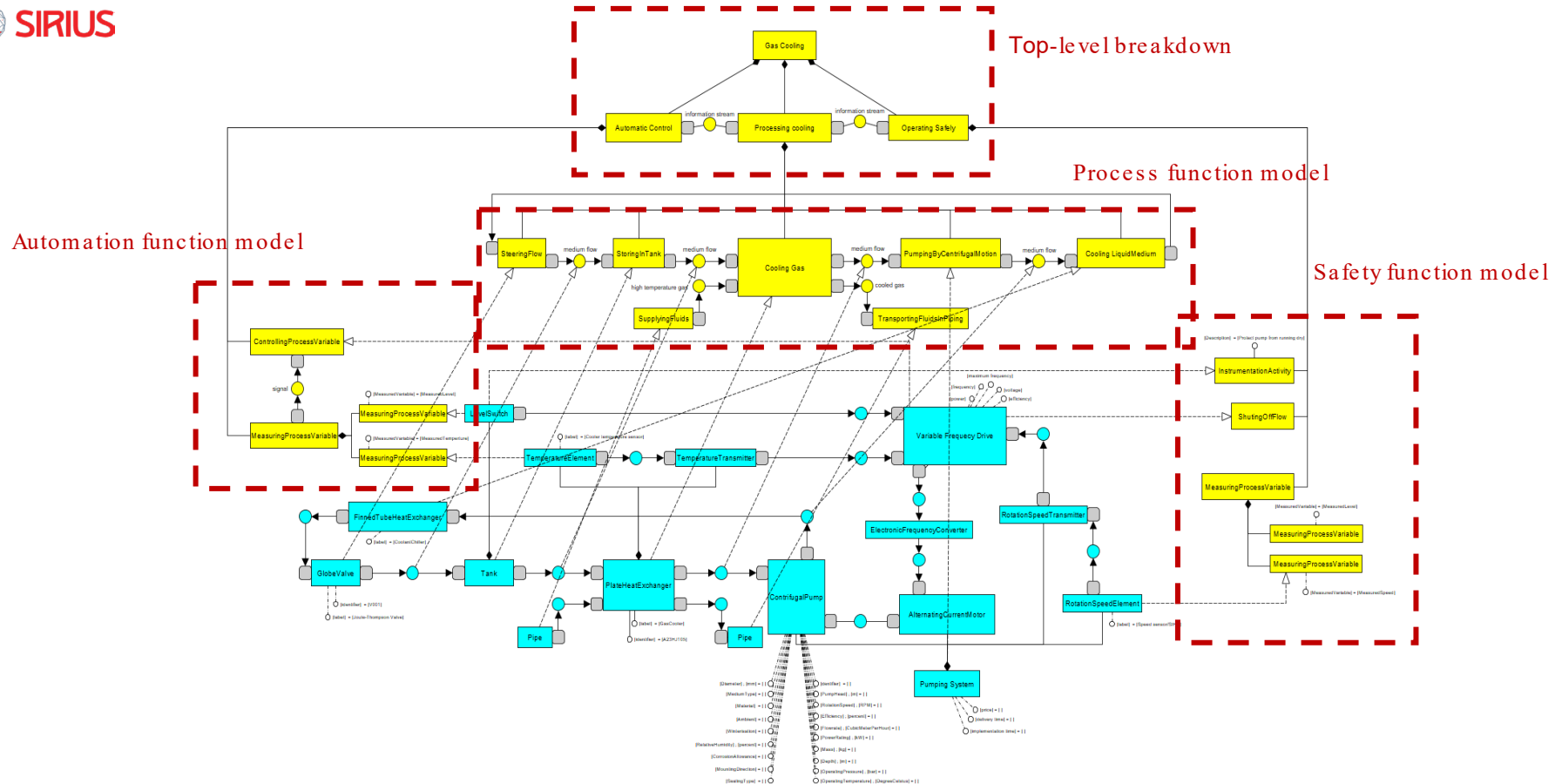
Example: cooling system

IMF model of cooling system



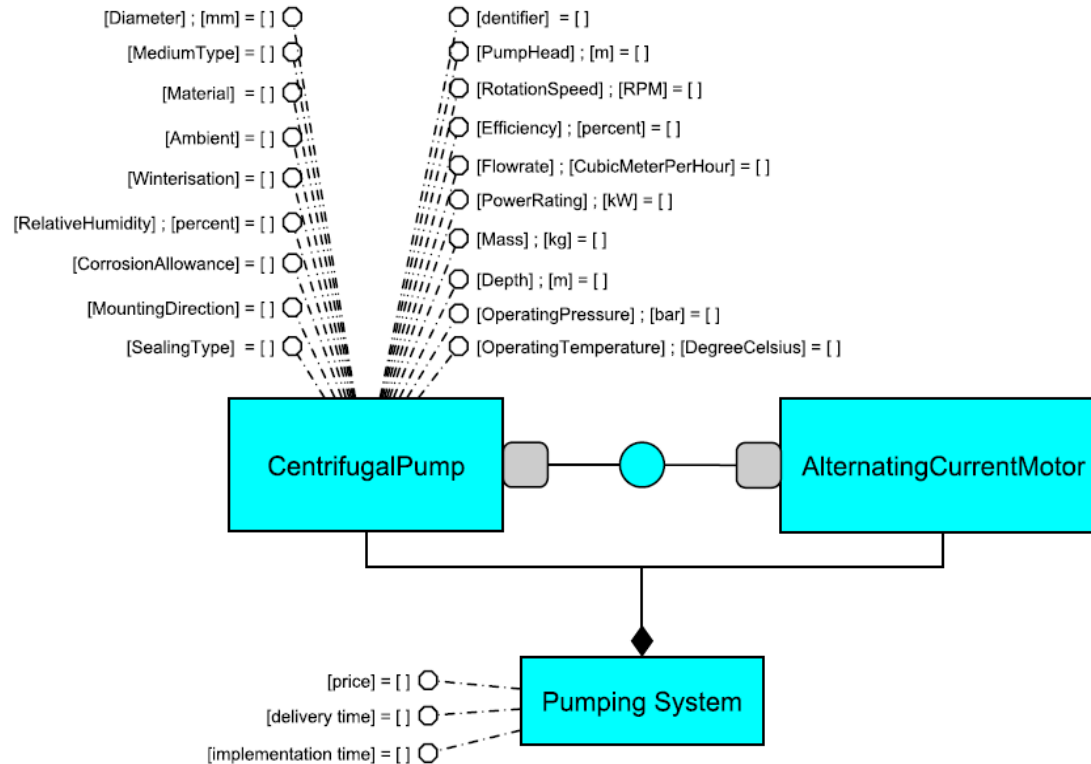
Example: cooling system

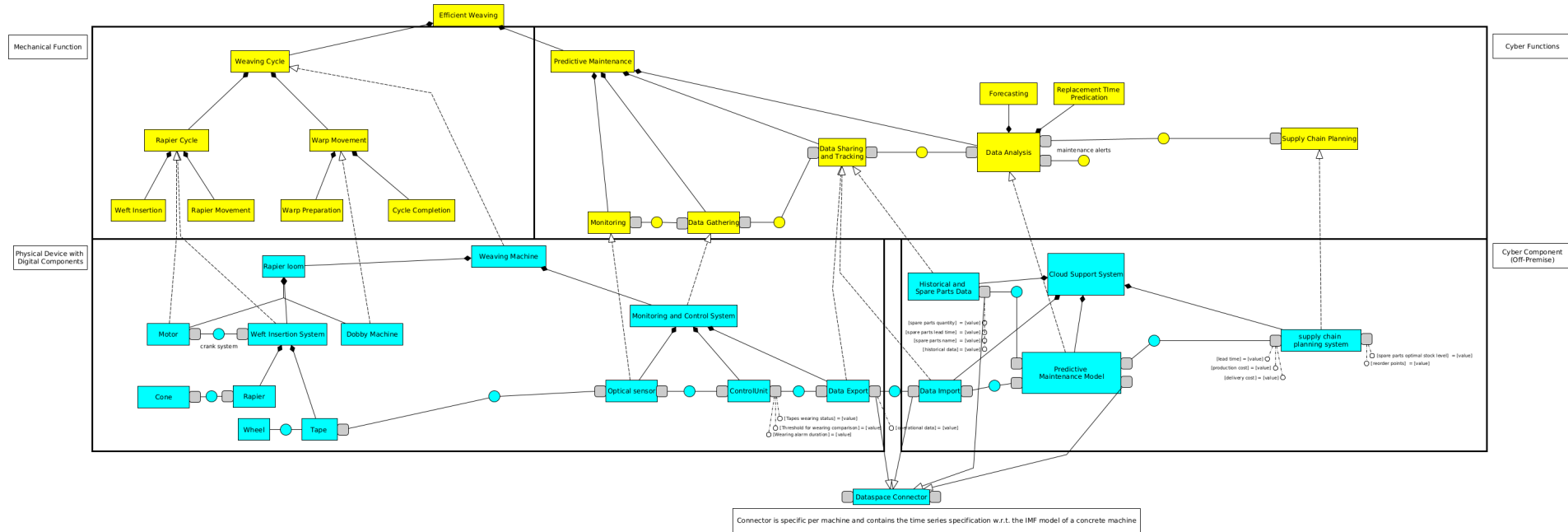
IMF model integration



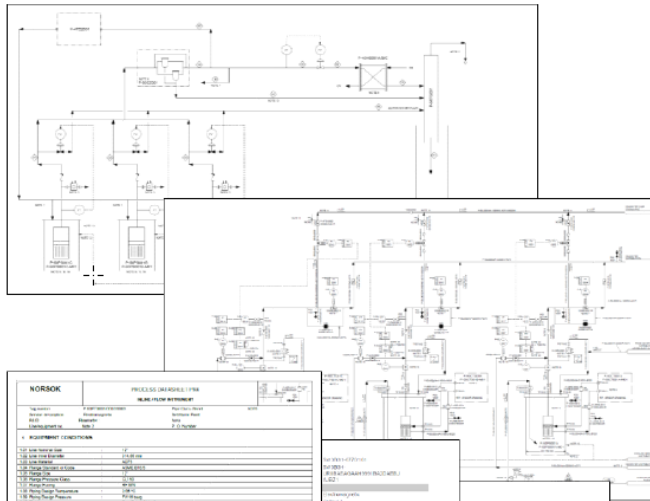
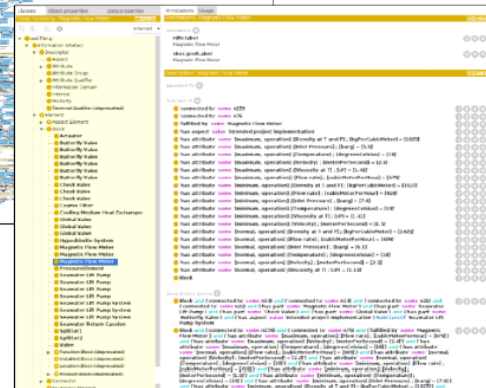
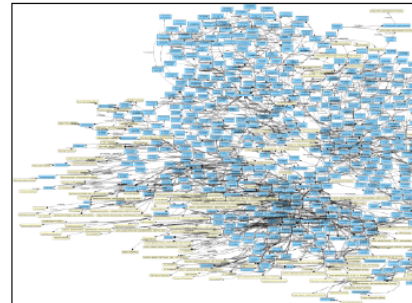
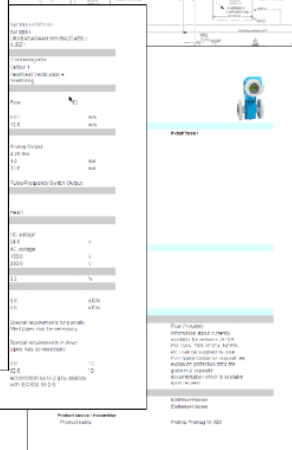
Example: cooling system

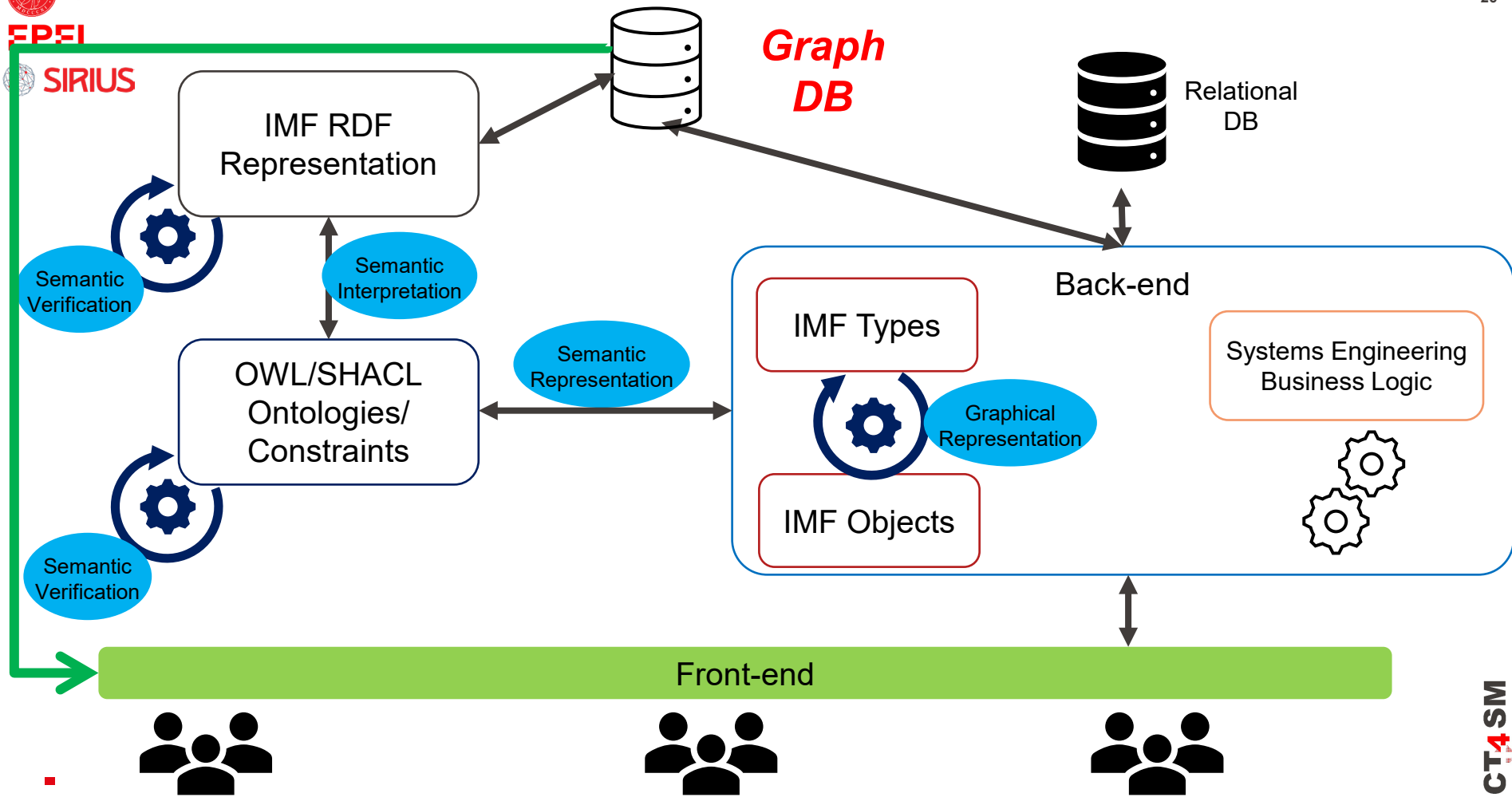
IMF attribute modelling (example of pumping system)





From Engineering Documents to IMF Models to IMF Knowledge Graphs

[illegible]



Information Modelling Framework: start with a System Model



Systems Engineer

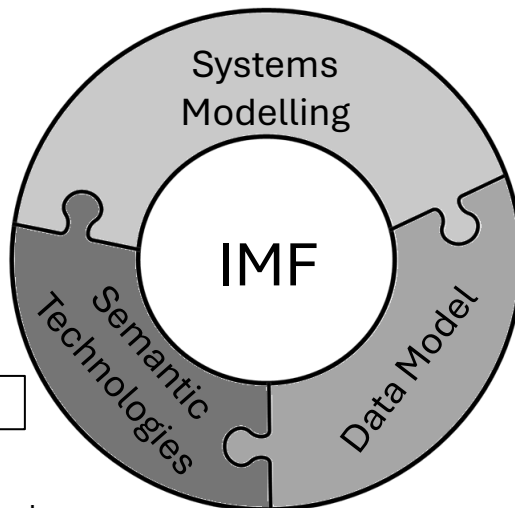
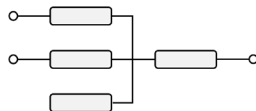
Model-Based Systems Engineering:
System modelling aligned with standards, best practices, and modelling templates

Role

Modelling and Validation

Task

Describe systems



Knowledge Engineer

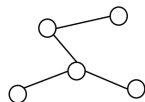
Semantics representation using ontologies and knowledge graphs
RDF/OWL/SHACL

Role

Verification and reasoning

Task

Knowledge representation/
Ontology & KG Engineering and management



Data exchange and software integration using, e.g., **Asset Administration Shell - AAS**

Role

Implementation/
Application
Information Flow

Task

Compose mappings/
Data transformations
Data exploration

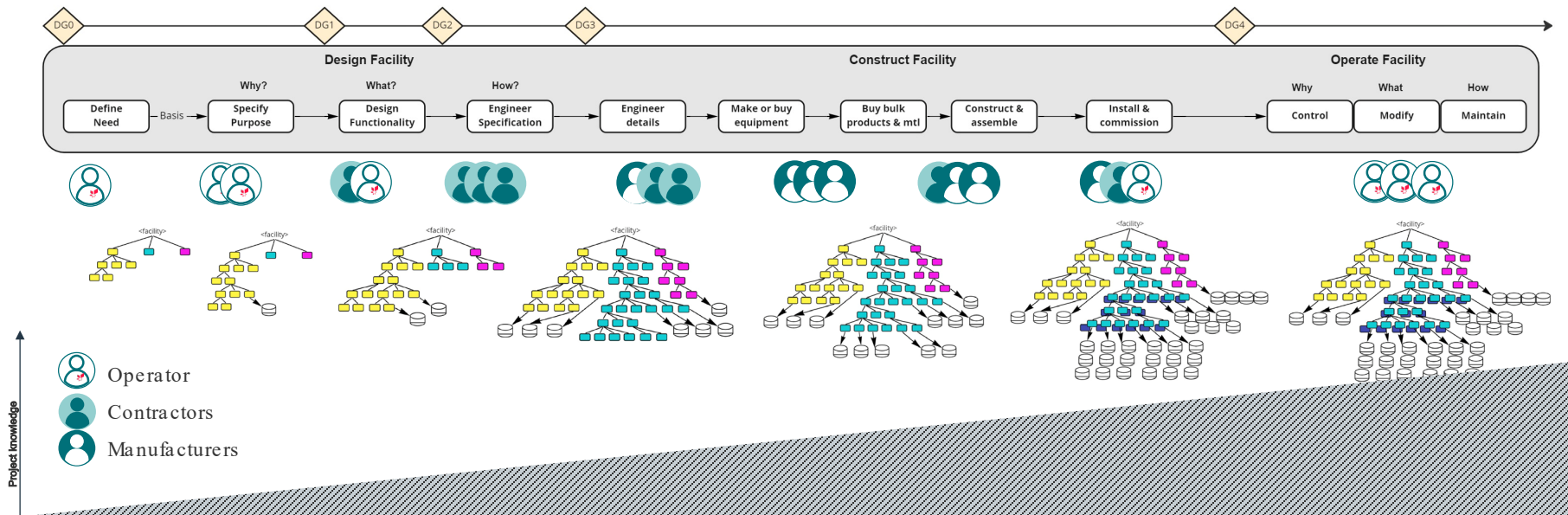


IT Expert



IMF provides an integrated semantic information model

The Vision and the Larger Picture



Added values:



Become more effective by hindering loss of information during handovers



Automation of manual procedures possible using machine integrable information models



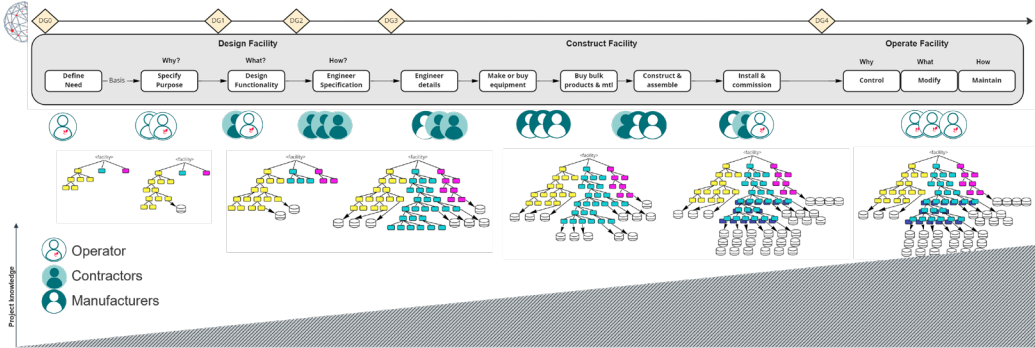
Reduce cost and time spent by the possibility of building in smartness



Improved safety and quality by better control of technical information

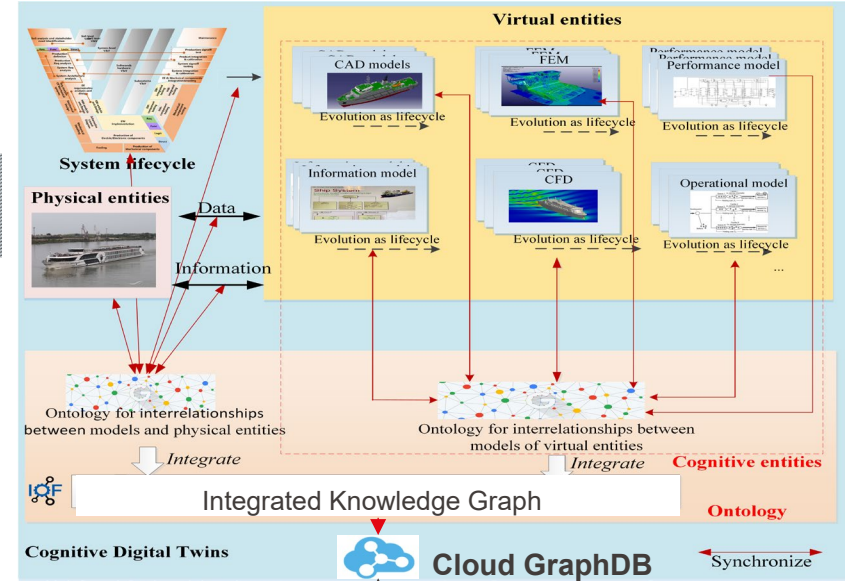


New business opportunities by combing information in new ways



Information Modeling Framework - IMF

Cognitive Digital Twin - CDT



AI & DS Agents – Digital Twins – Apps – other software

Thank you for your attention!



<https://people.epfl.ch/dimitris.kiritsis/?lang=en>



<https://www.linkedin.com/in/dimitris-kiritsis-07124/>



dimitris.kiritsis@epfl.ch