

Semantic Information Data Model Interoperability

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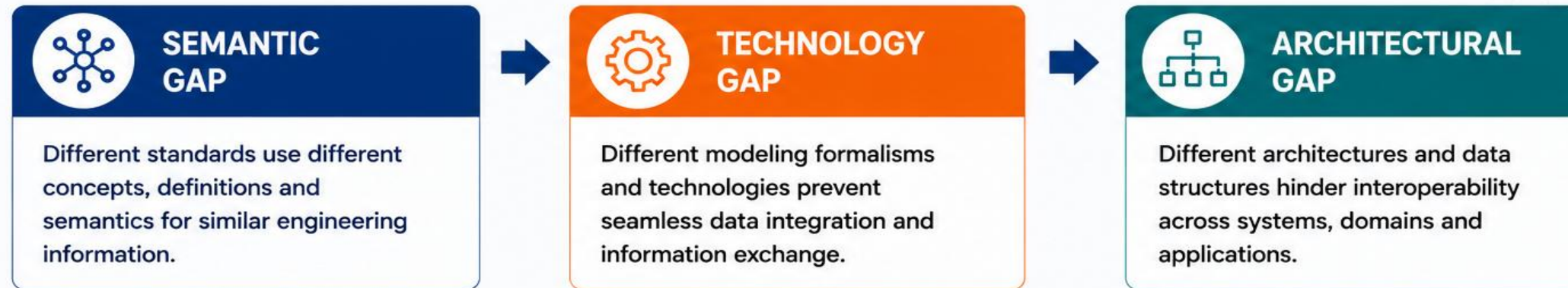
Carl Borngrund, LTU

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MAJOR ENGINEERING STANDARDS

Major standards are developed and maintained within their own contexts, each with distinct semantics and employing different modeling technologies and architectures.



EXAMPLES OF MAJOR INDUSTRIAL ENGINEERING STANDARDS



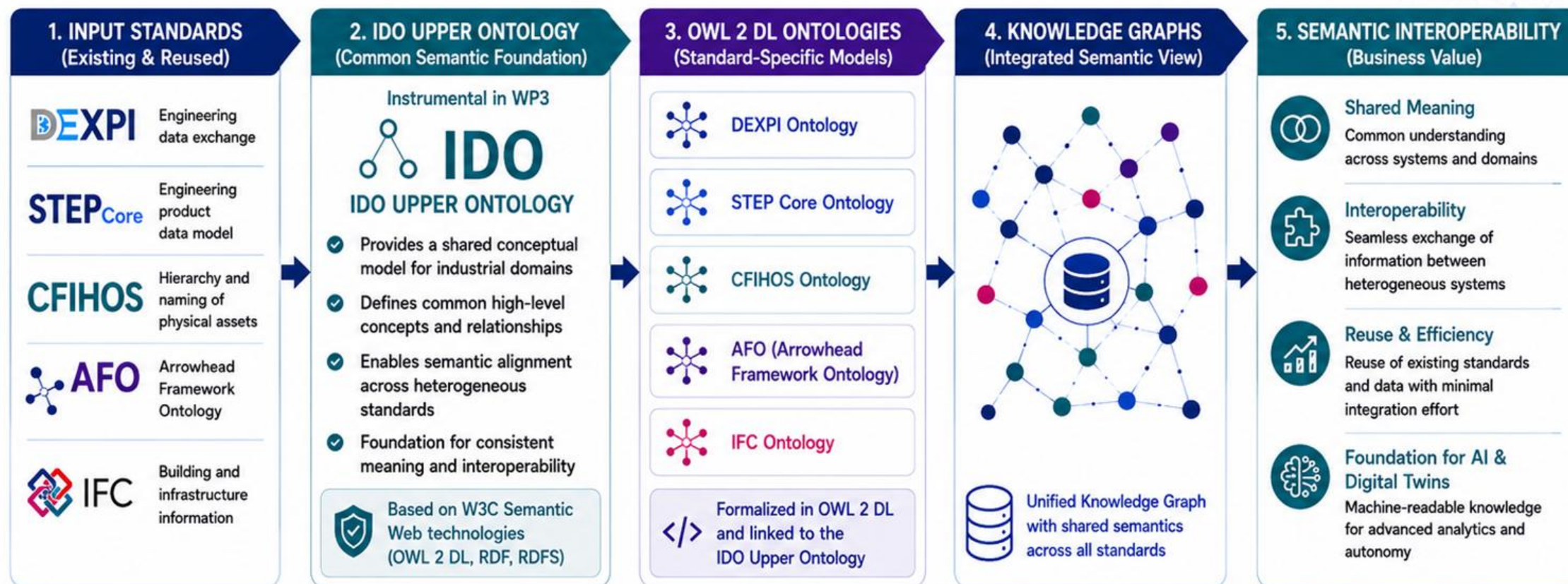
These gaps lead to data silos, custom integrations, high engineering cost, and limited reuse of valuable industrial information.



WP3 addresses these gaps by enabling semantic lifting of existing standards into a common **OWL 2 DL** semantic representation.

WP3 TRANSFORMS EXISTING INDUSTRIAL STANDARDS INTO SEMANTIC ASSETS FOR INTEROPERABILITY

WP3 does not create new standards – we reuse and semantically enable existing ones.



WP3 VALUE PROPOSITION:

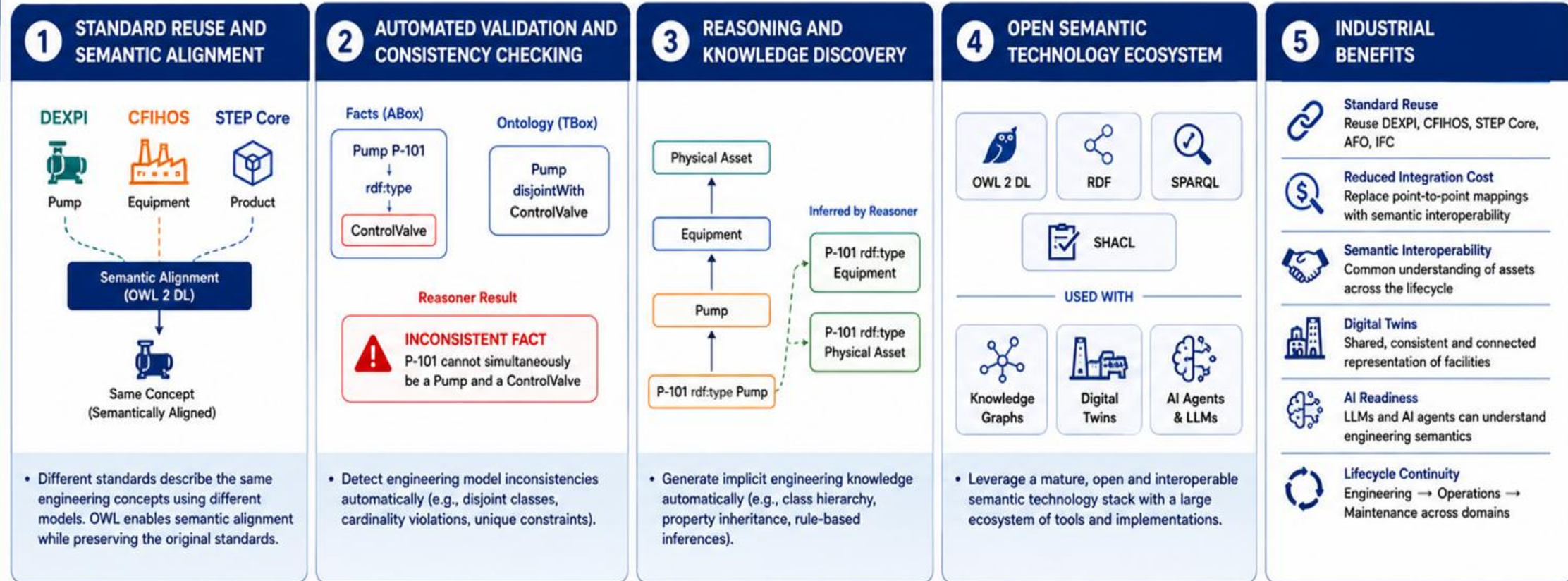
We reuse existing industrial standards and, with the **IDO Upper Ontology** as the semantic backbone, transform them into interoperable, machine-understandable assets for Digital Twins and AI-enabled industrial ecosystems.



NO NEW STANDARDS.
JUST SHARED SEMANTICS.

WHY OWL 2 DL?

OWL 2 DL provides the semantic foundation to connect, validate and reason over engineering standards.



INDUSTRIAL BENEFITS AT A GLANCE



Reuse
Leverage existing standards and investments



Reduce Cost
Lower integration and data management cost



Interoperate
Break data silos, enable seamless information flow



Digitize
Enable accurate and consistent digital twins



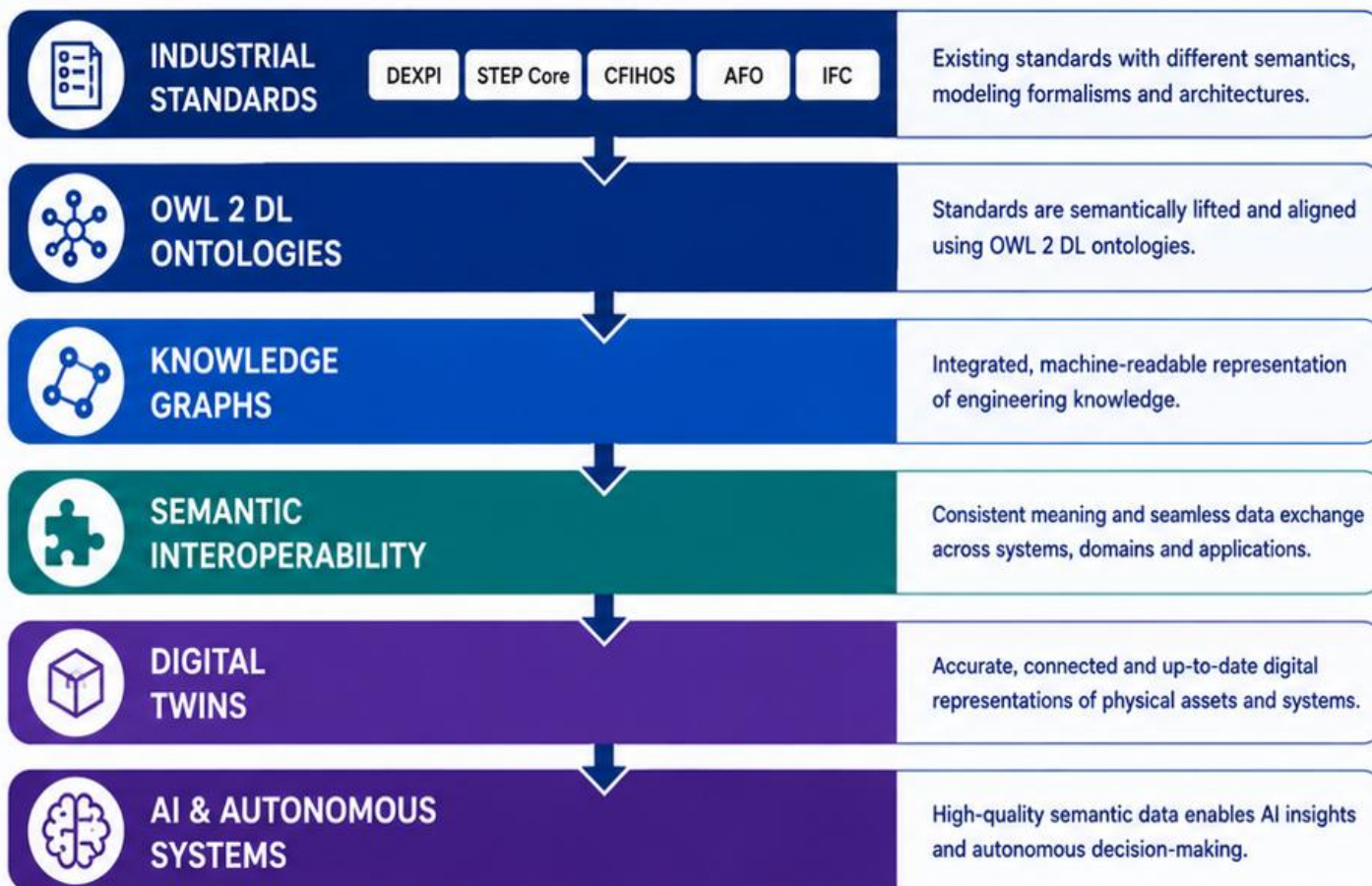
AI Ready
Empower AI/ML with trusted, semantic data



Across Lifecycle
Maintain continuity from design to operations

OUTCOME OF WP3

WP3 lifts existing industrial standards into a common semantic representation, enabling interoperability, digital twins and AI-driven value.



WP3 DOES NOT CREATE ANOTHER INDUSTRIAL STANDARD.



WP3 ENABLES EXISTING INDUSTRIAL STANDARDS TO WORK TOGETHER in a common semantic environment.



KEY MESSAGE

WP3 delivers the semantic foundation that unlocks interoperability, digital twins and AI across the Arrowhead-EP value chain.



WP3 is the semantic bridge from today's industrial standards to tomorrow's intelligent, autonomous and interoperable value networks.

WHAT TO REMEMBER

WP3 demonstrated that existing industrial standards can be reused in a semantic environment.



WP3 does not create another industrial standard

Existing standards such as DEXPI, STEP Core, CFIHOS, AFO, and IFC are preserved and reused.



Semantic interoperability replaces complex point-to-point integrations

Shared meaning becomes more important than data translation.



Large business value can be achieved with limited initial effort

A small number of semantic alignments can unlock significant interoperability benefits.



The first alignments deliver the highest return

Often, 5–10% semantic alignment provides a majority of the achievable business value.



Benefits grow continuously

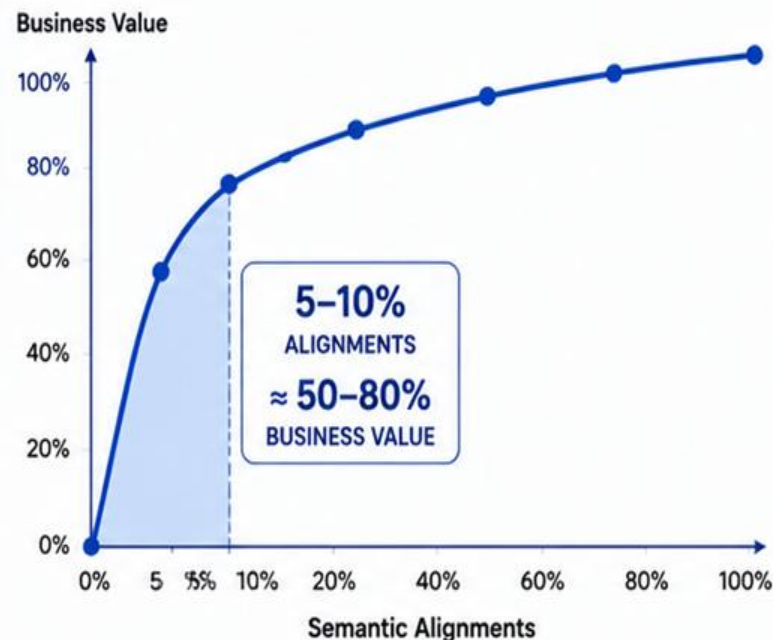
Every additional ontology, system, and data source increases the value of the Knowledge Graph ecosystem.



Knowledge Graphs provide the foundation for Digital Twins and AI

Creating machine-readable engineering knowledge that can be reused across the entire lifecycle.

INTEROPERABILITY VALUE GROWS WITH ALIGNMENTS



SHORT TIME • LOW COST • LARGE INTEROPERABILITY GAINS

High business value can be achieved quickly with minimal alignments and investment.



**5–10%
SEMANTIC ALIGNMENT
→ 50–80%
OF BUSINESS VALUE**



INDUSTRIAL STANDARDS



OWL 2 DL ONTOLOGIES



KNOWLEDGE GRAPHS



INTEROPERABILITY



DIGITAL TWINS



AI & AUTONOMOUS SYSTEMS



START SMALL • DELIVER VALUE EARLY • SCALE CONTINUOUSLY

A practical and low-risk path to interoperability where substantial benefits can be achieved quickly, while long-term value grows as more standards and systems are connected.

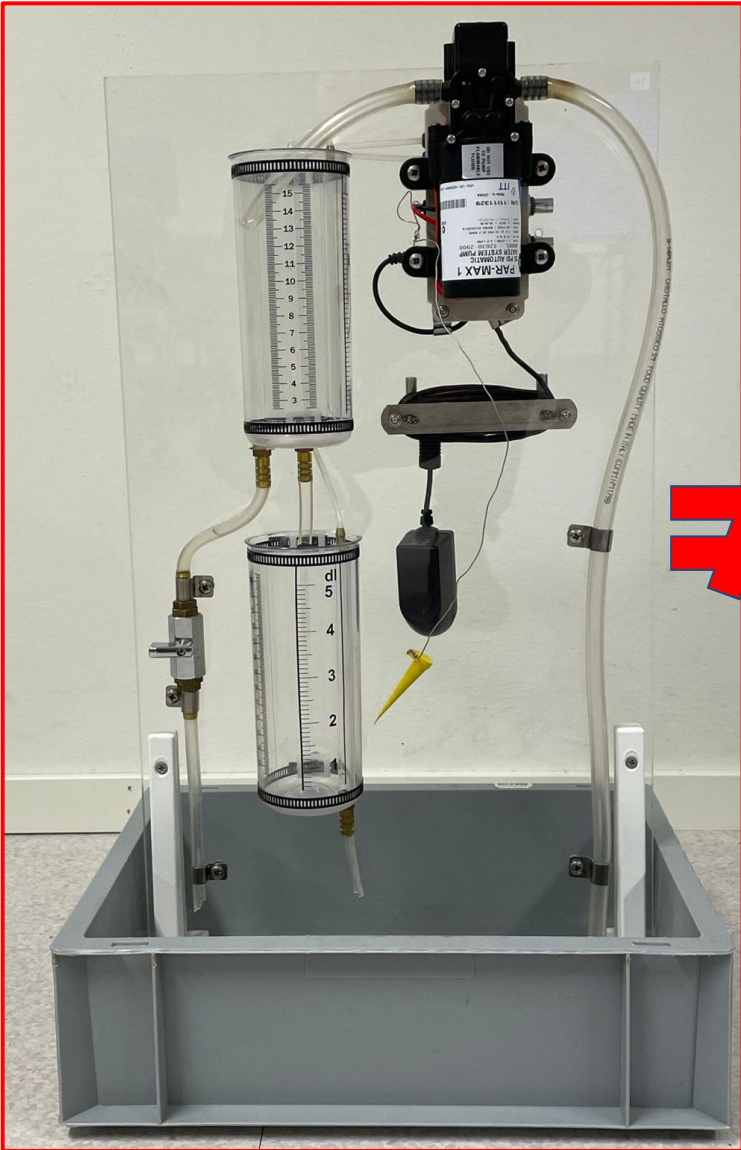


ARROWHEAD
FPVN

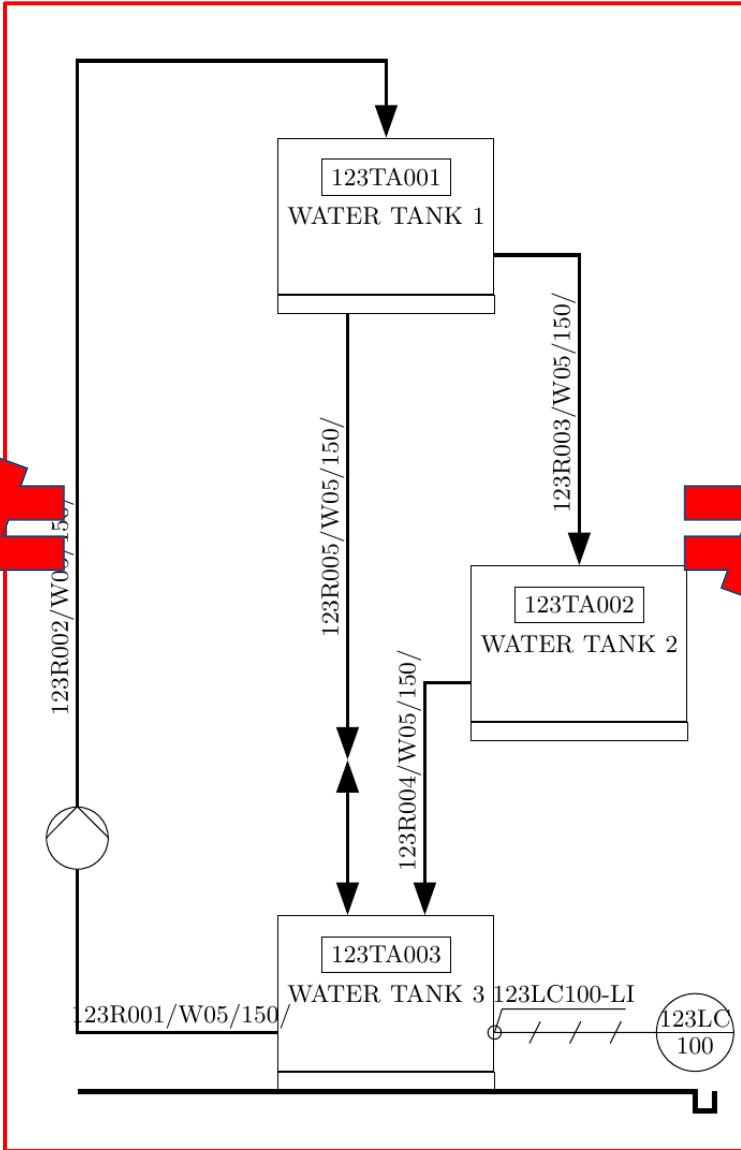
Semantic Foundation
for Interoperable
Engineering

Demonstrator: Pump Station

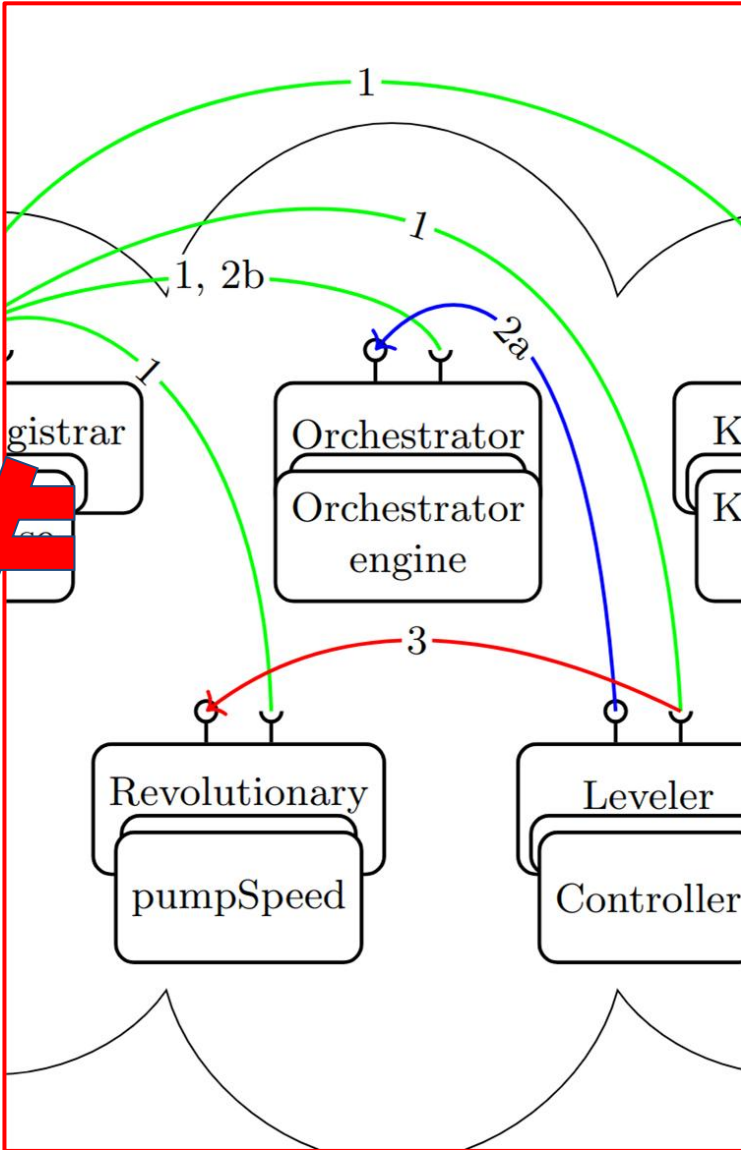
Lifecycle



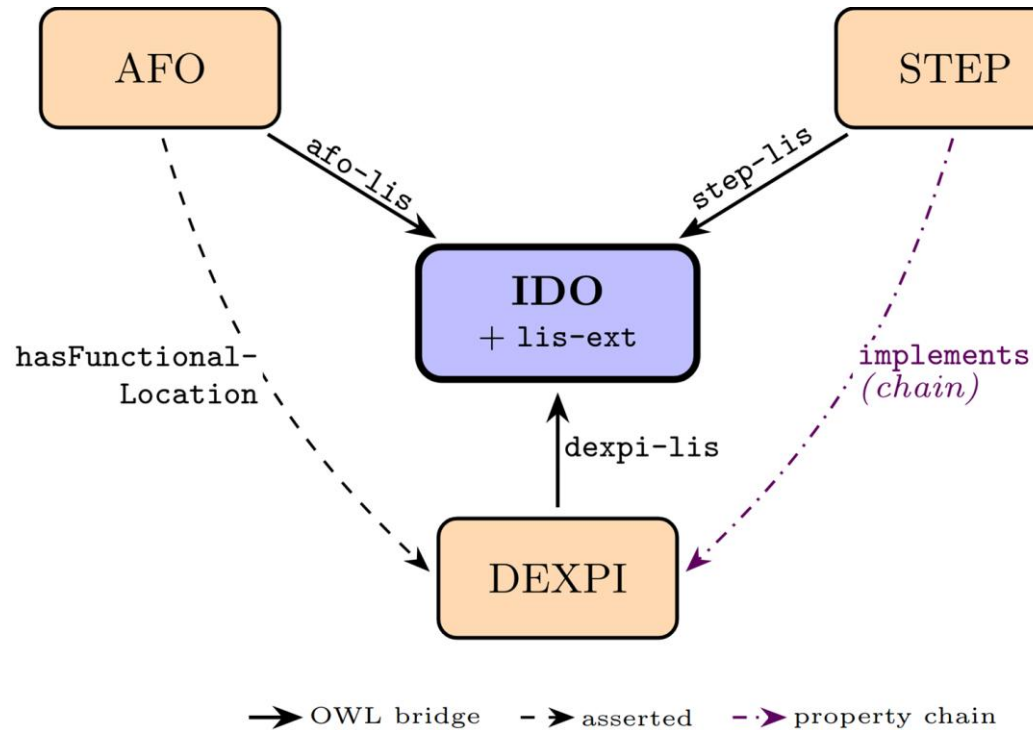
Plant design



Runtime



IDO-Mediated Alignment Architecture



Connecting design, lifecycle, and runtime

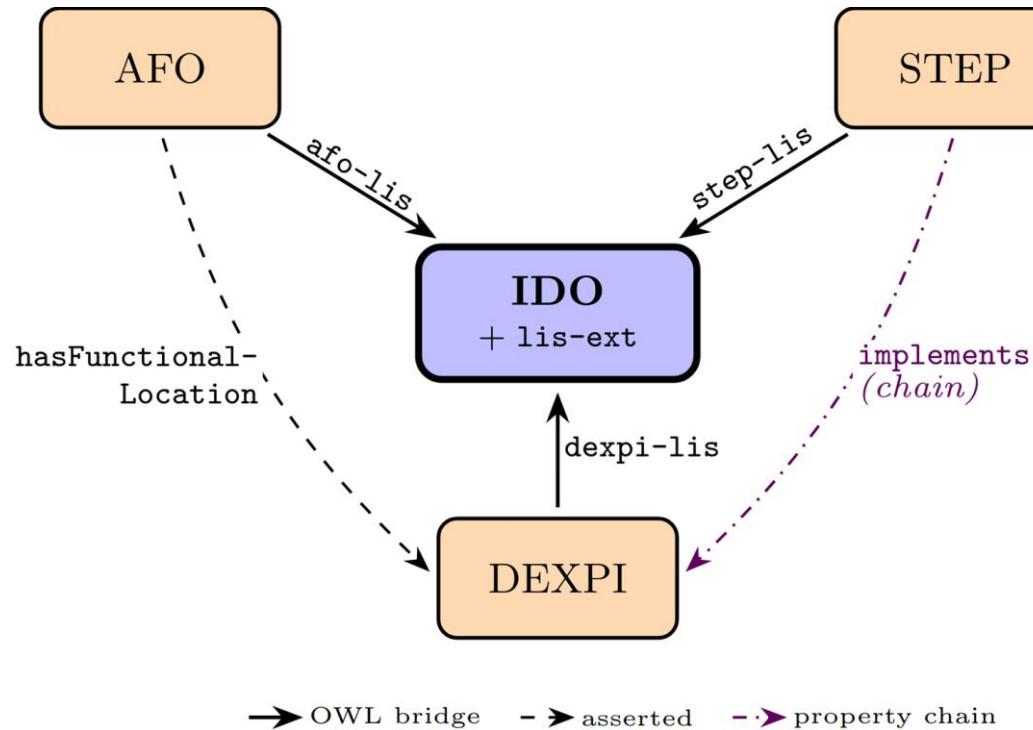
Align independently developed models through shared semantics

- **DEXPI** → plant design
- **STEP** → lifecycle
- **AFO** → runtime
- **IDO** → shared semantic reference

Benefits:

- Reusable mappings
- Cross-domain querying
- Preserve source semantics

Alignment Ontologies



Alignment ontologies:

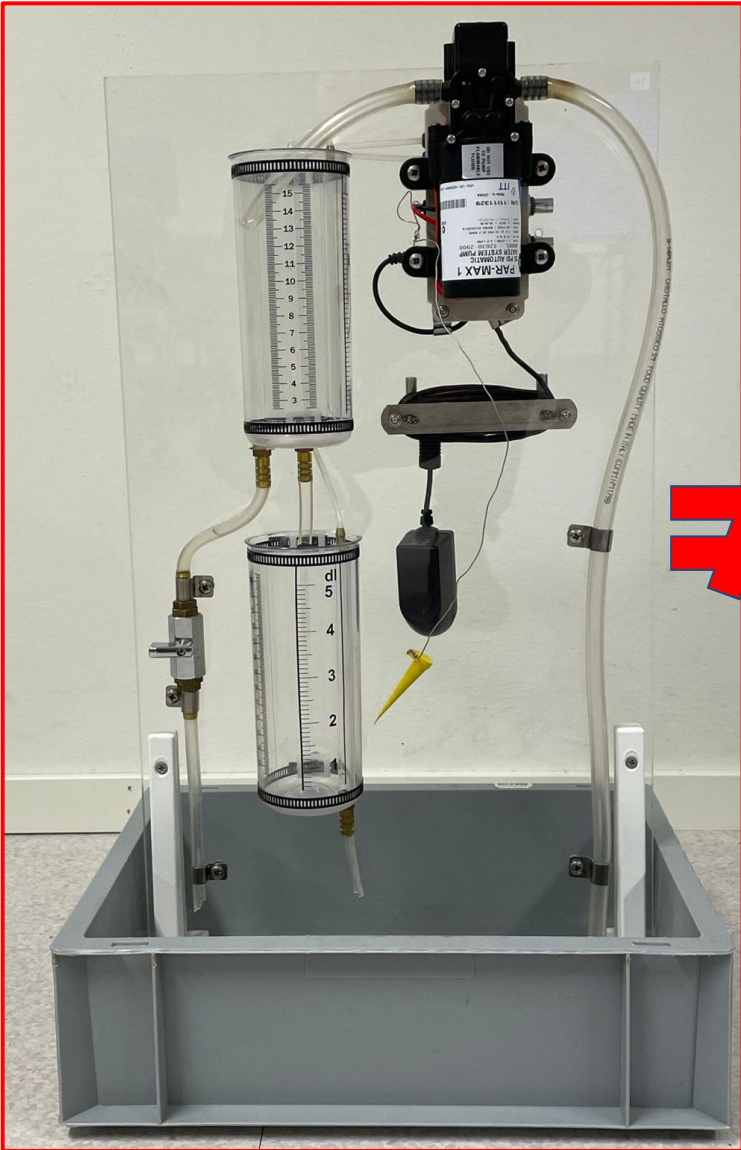
- AFO ↔ **afo-lis** ↔ IDO
- DEXPI ↔ **dexpi-lis** ↔ IDO
- STEP ↔ **step-lis** ↔ IDO

Reasoning derives:

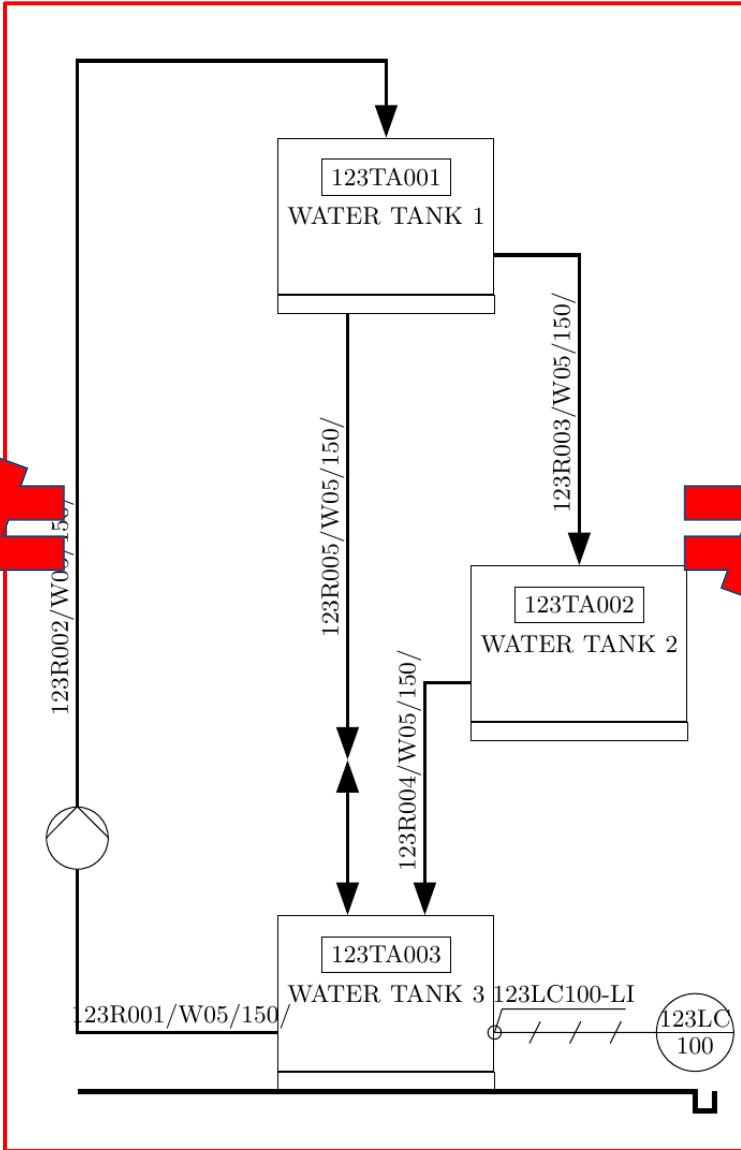
- Shared interpretation
- Cross-domain traceability
- Unified querying

Demonstrator

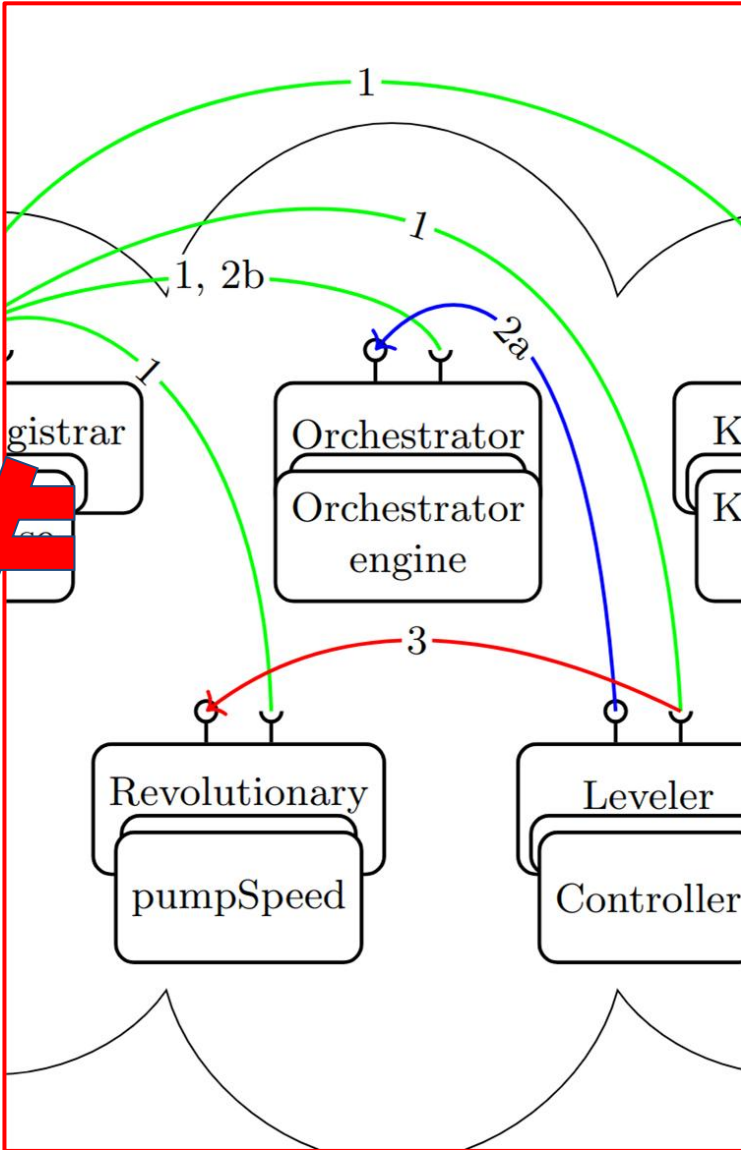
Lifecycle



Plant design

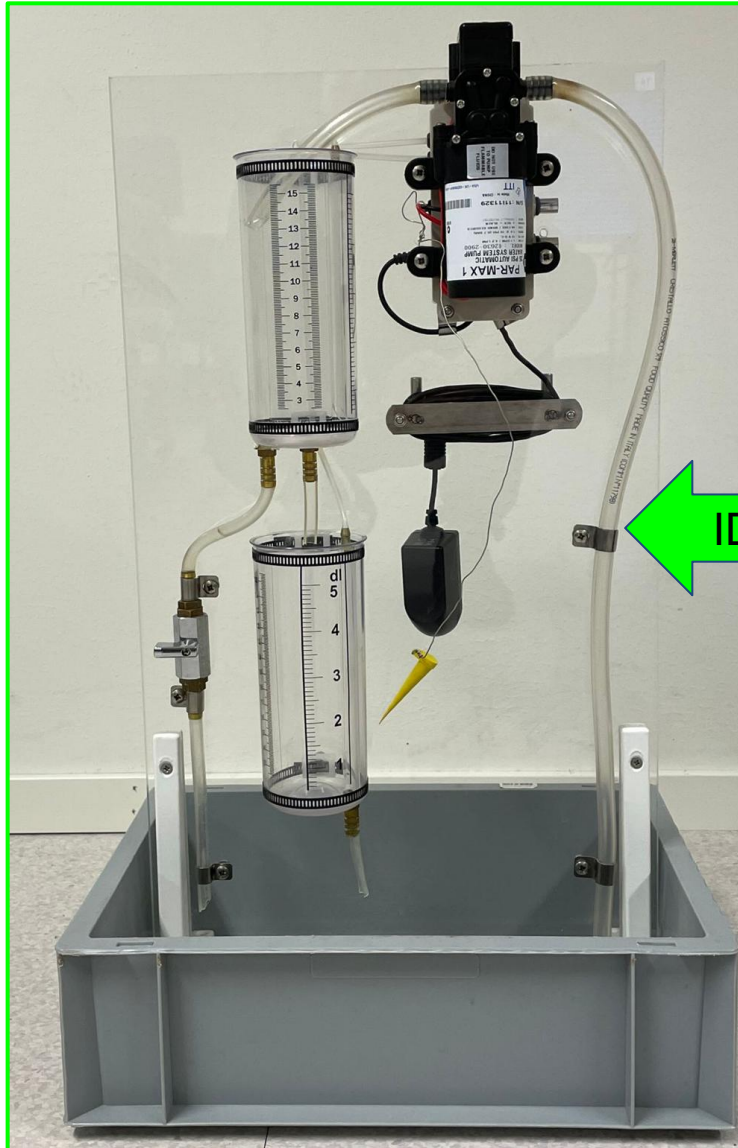


Runtime

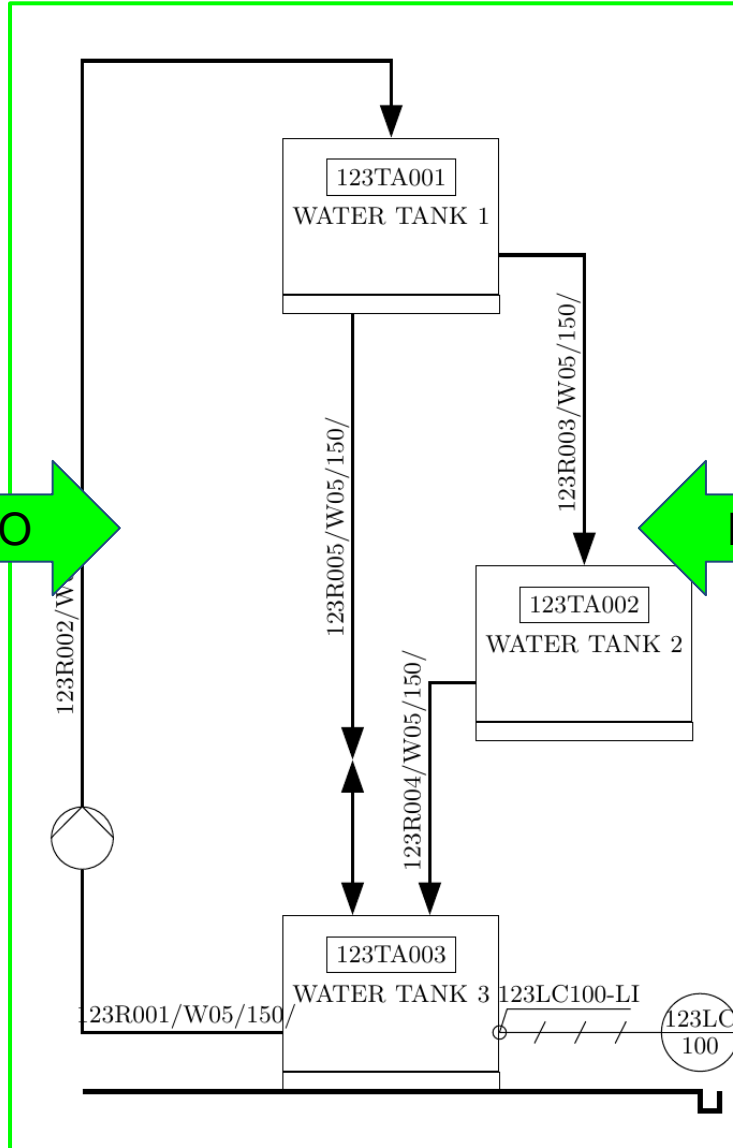


Demonstrator

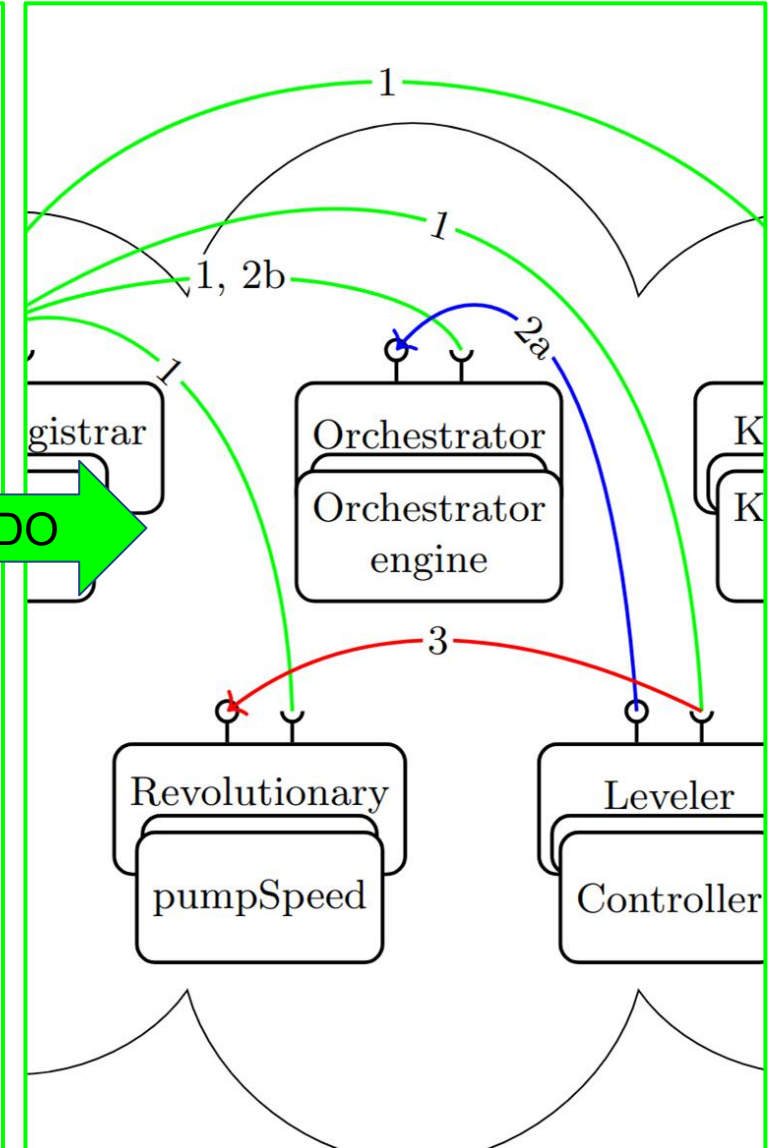
Lifecycle



Plant design



Runtime

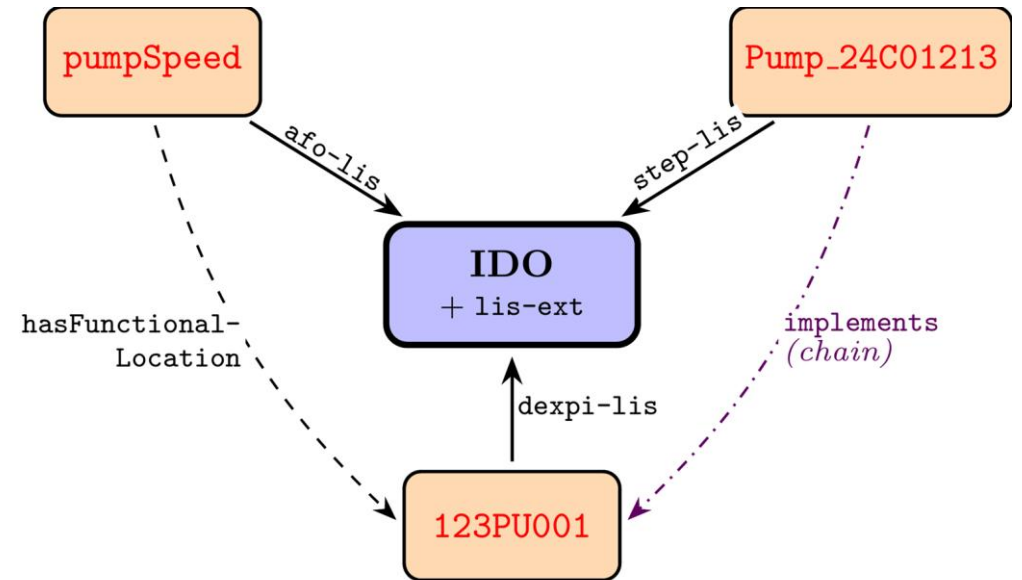


End-to-End Traceability

We can query across engineering domains:

```
SELECT ?service ?tag ?IndividualPartView WHERE {...
```

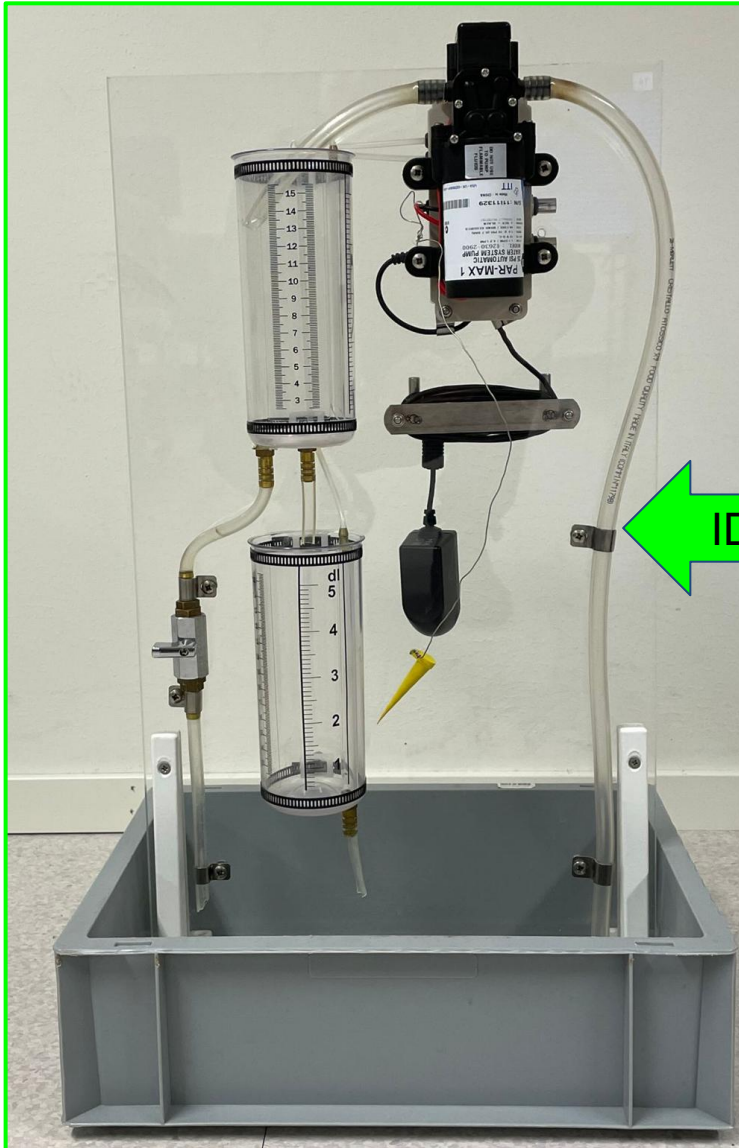
service	tag	IndividualPartView
pumpSpeed	123PU001	Pump_24C01213



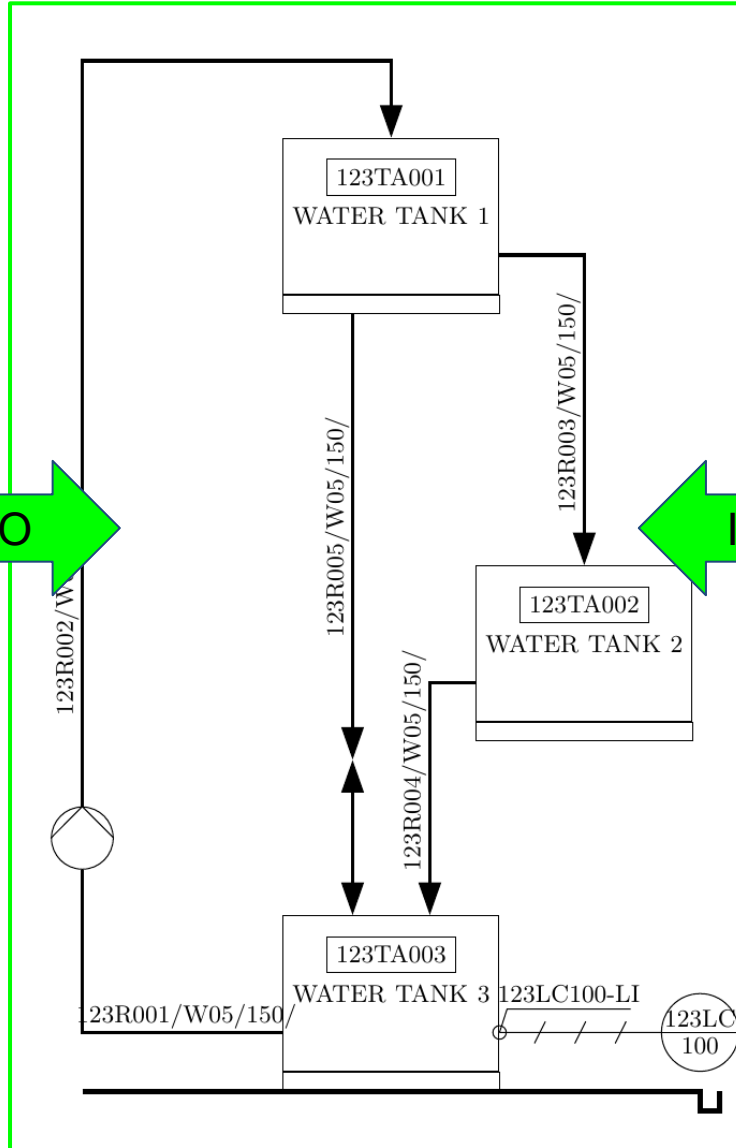
→ OWL bridge - -> asserted - · -> property chain

Demonstrator

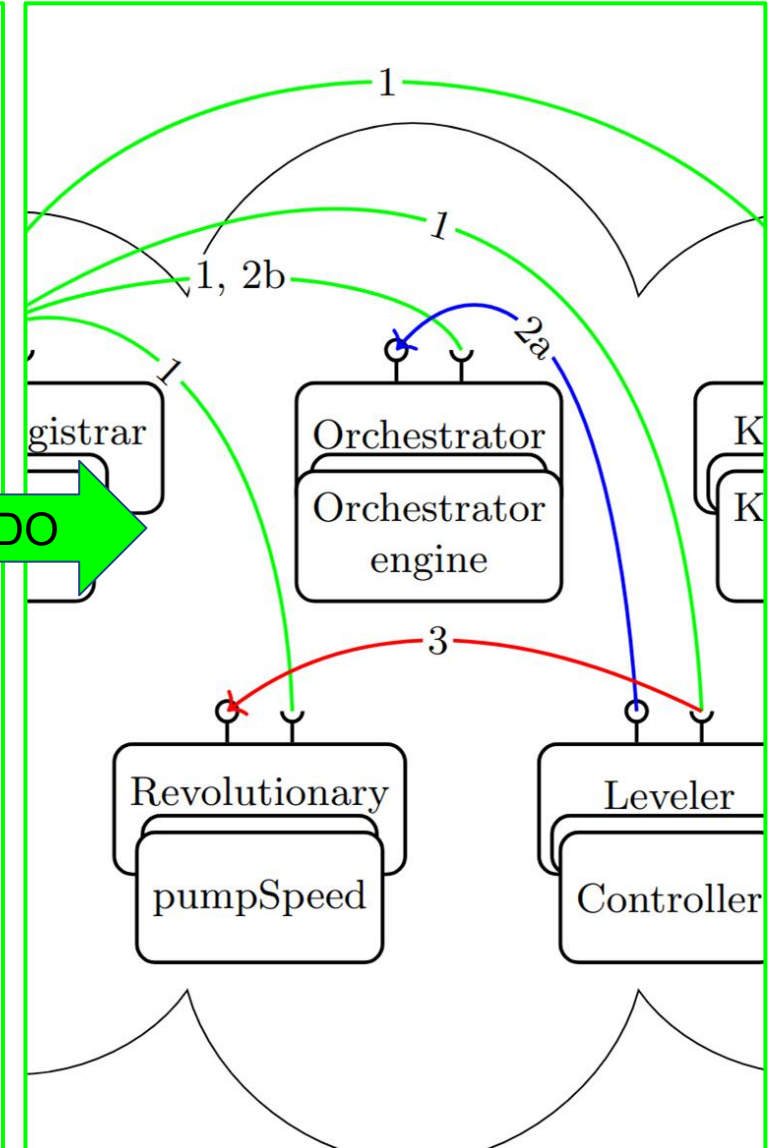
Lifecycle



Plant design

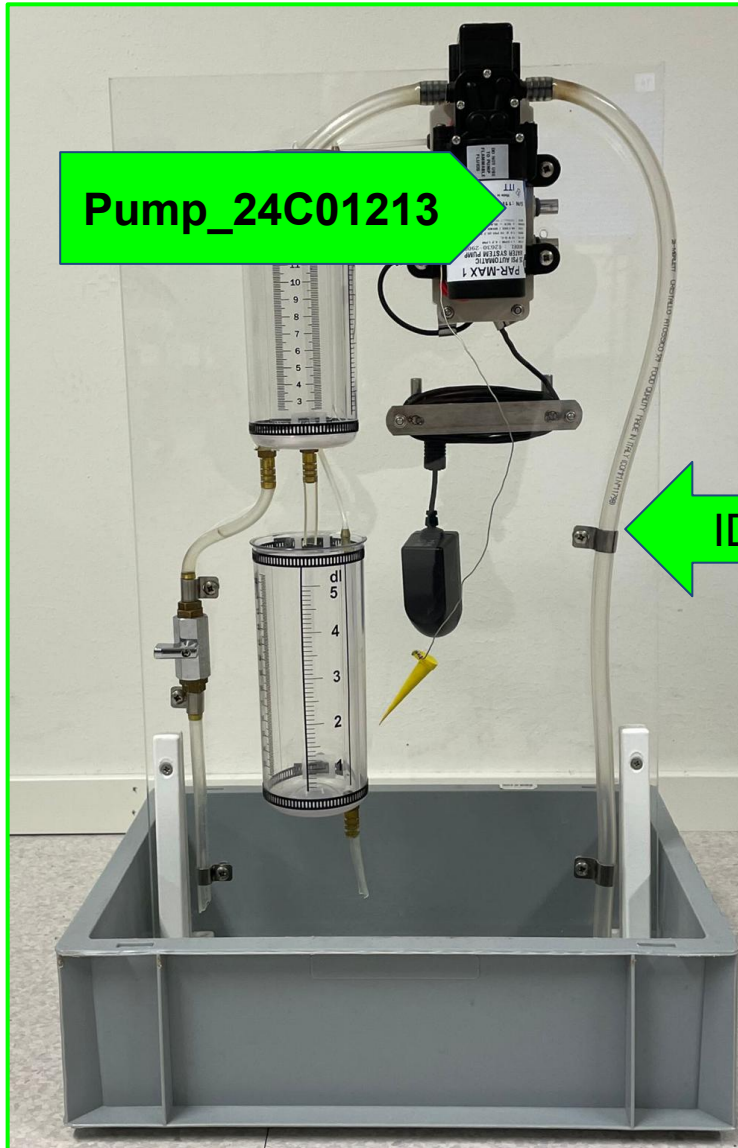


Runtime

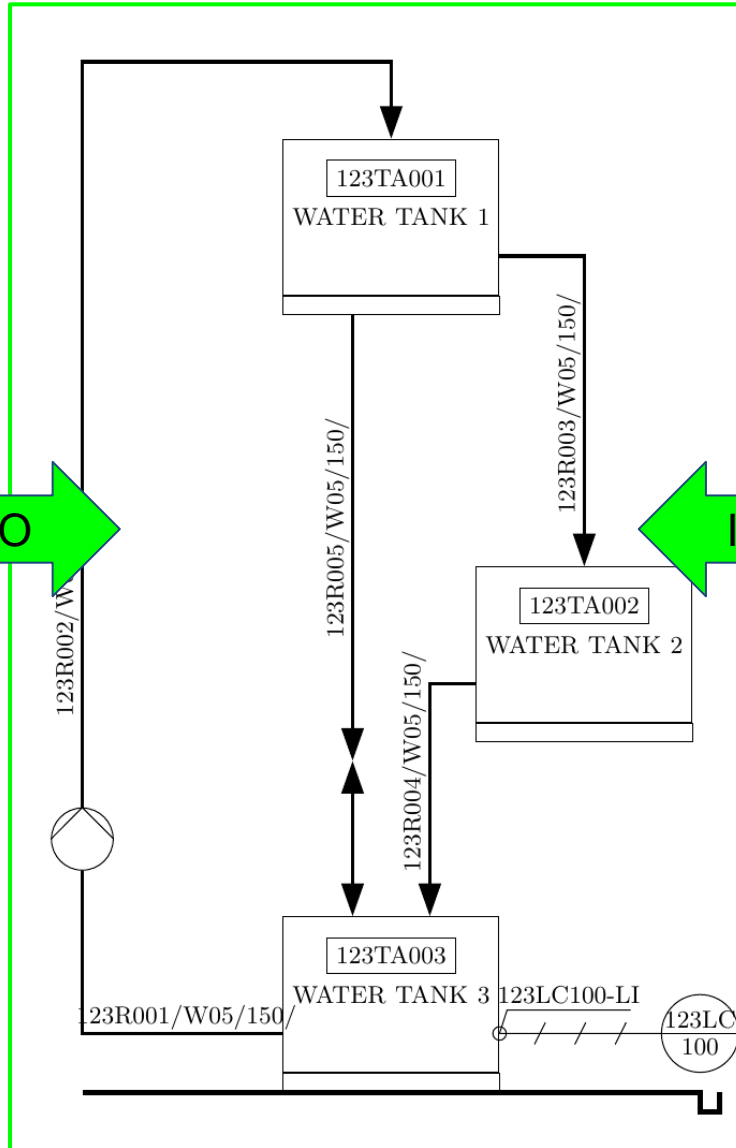


Demonstrator

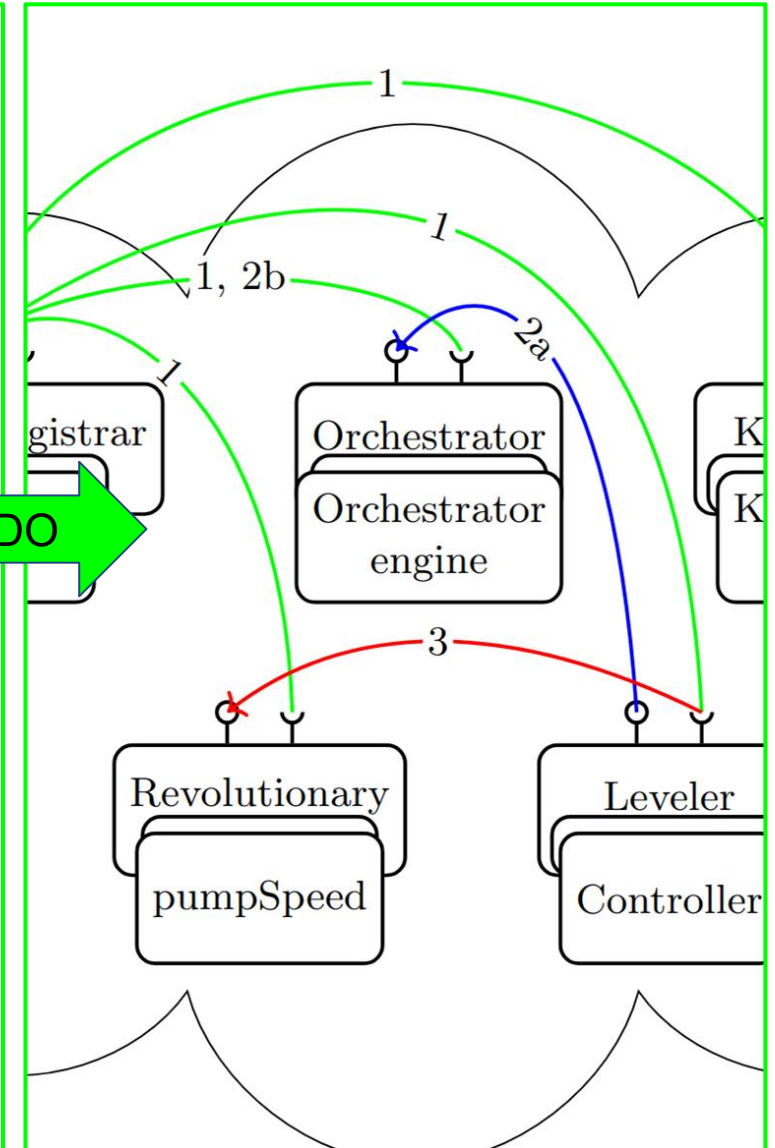
Lifecycle



Plant design

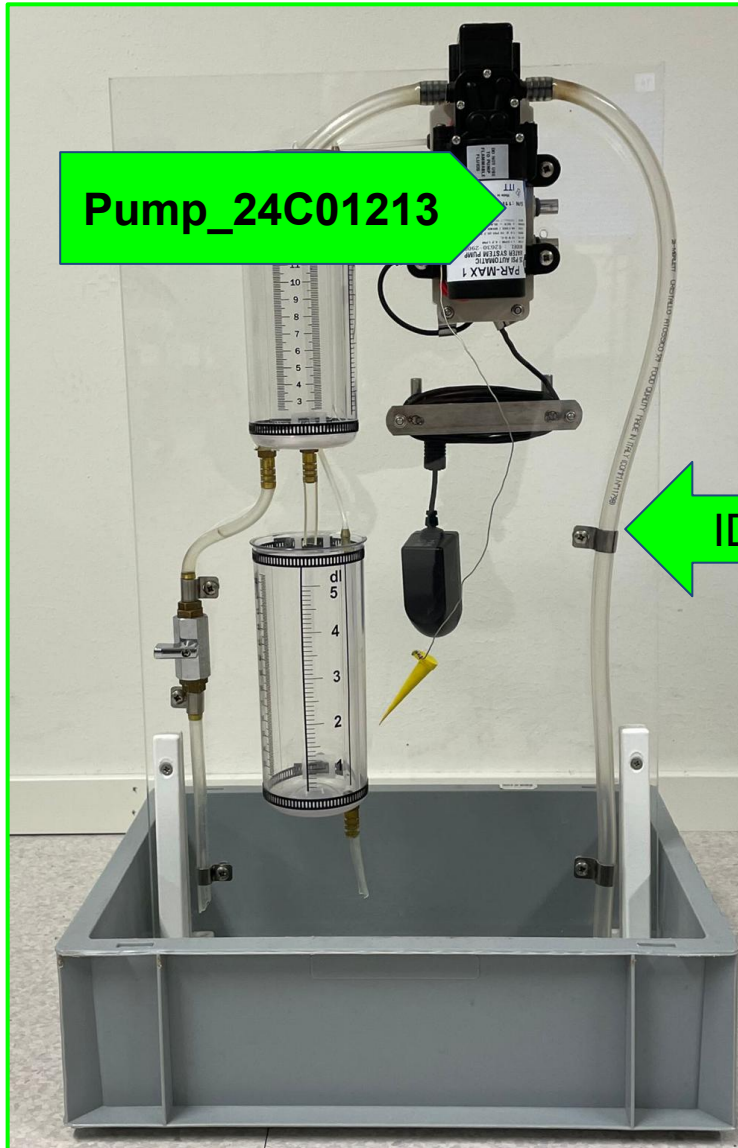


Runtime

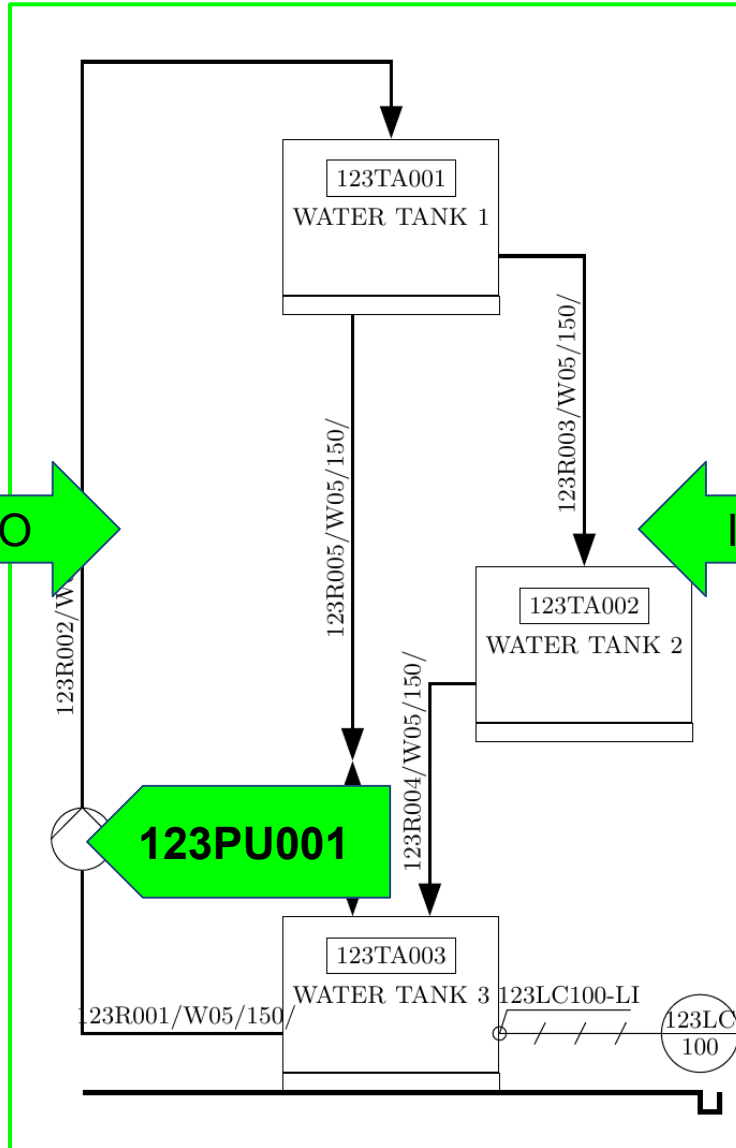


Demonstrator

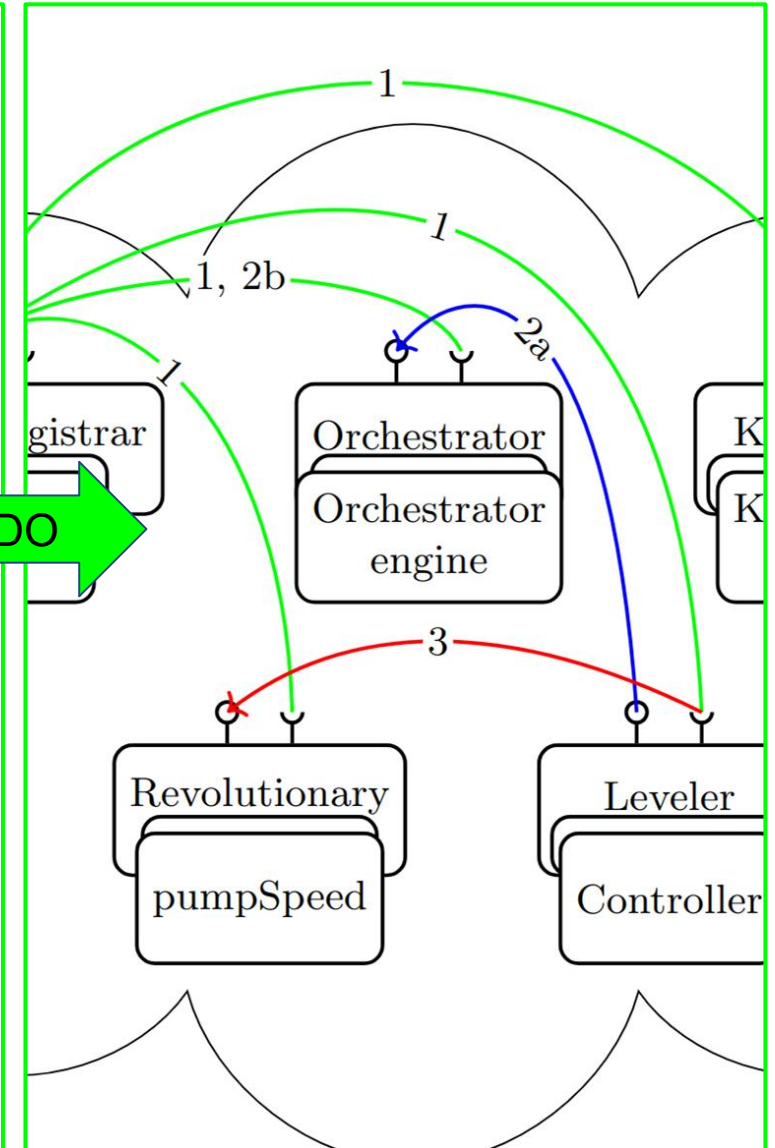
Lifecycle



Plant design

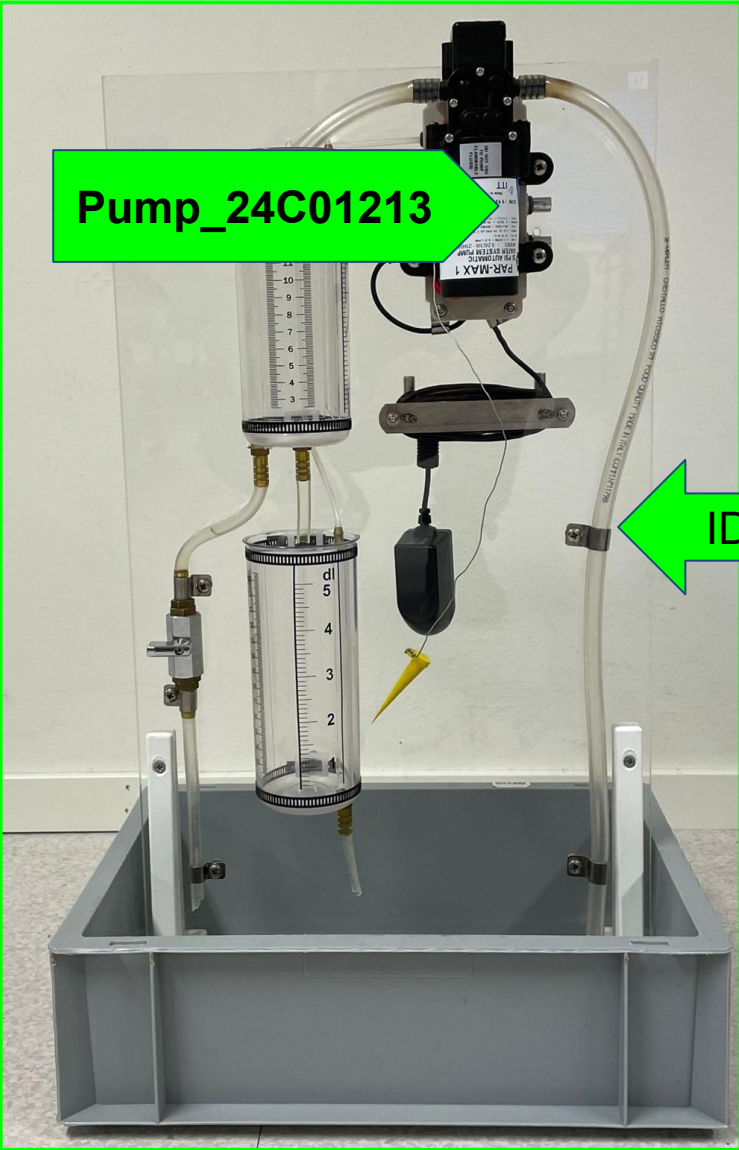


Runtime

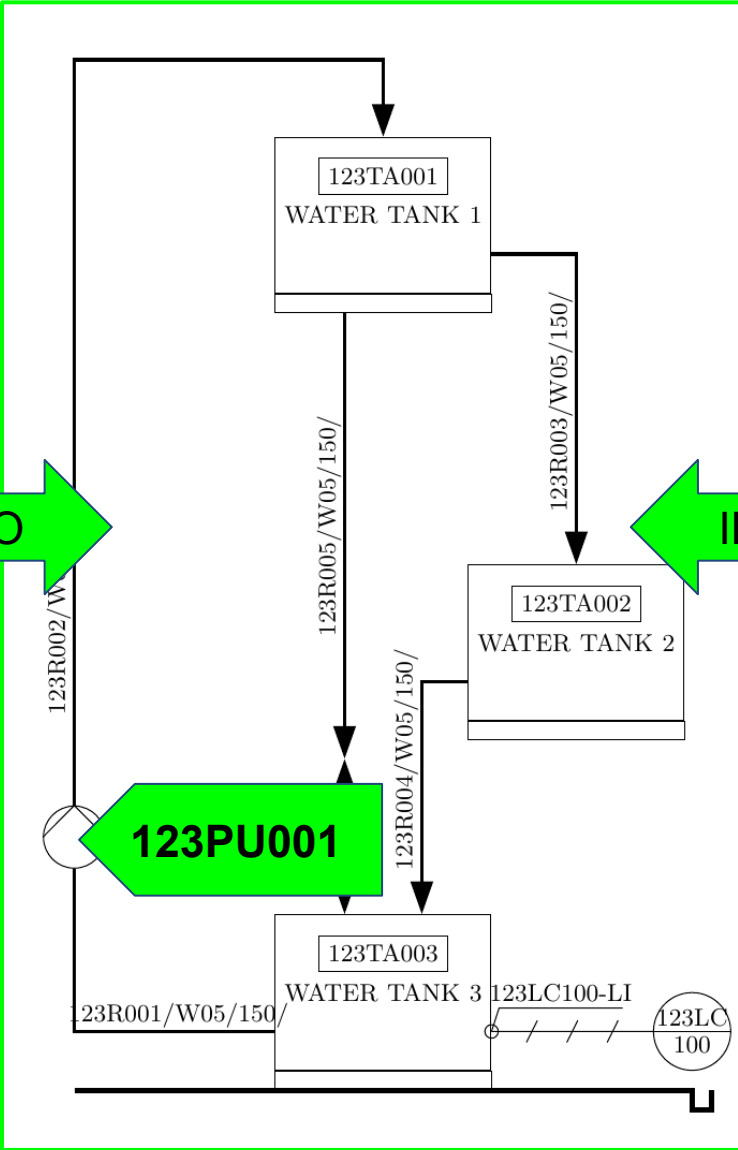


Demonstrator

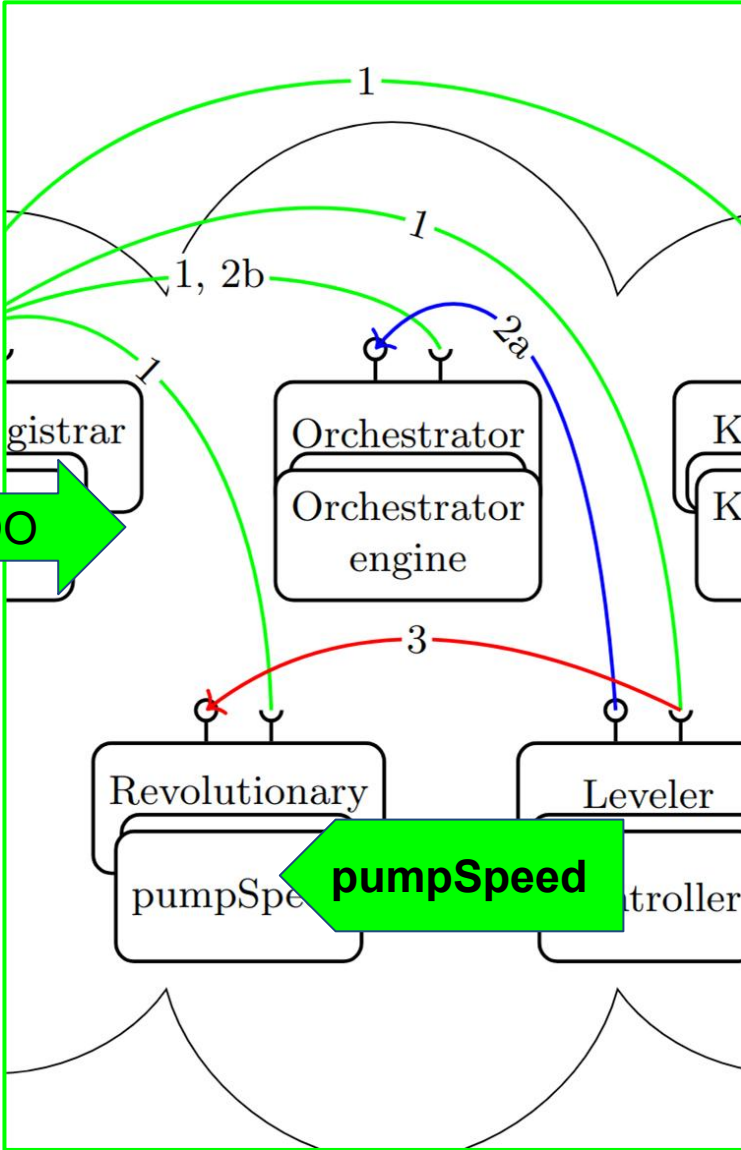
Lifecycle



Plant design



Runtime



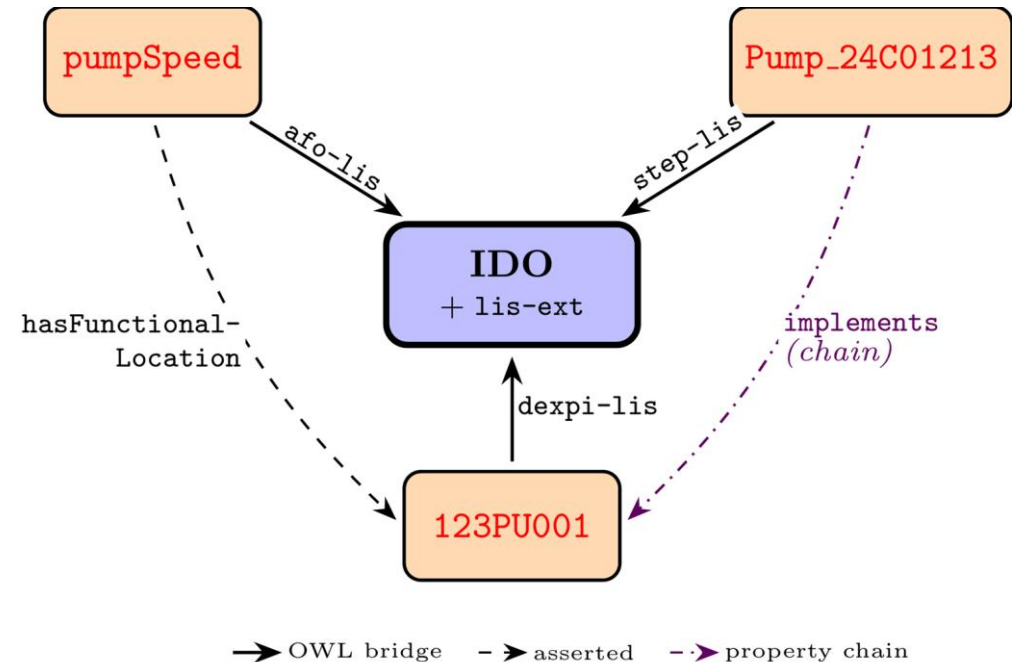
End-to-End Traceability

We can query across engineering domains:

```
SELECT ?service ?tag ?IndividualPartView WHERE {...
```

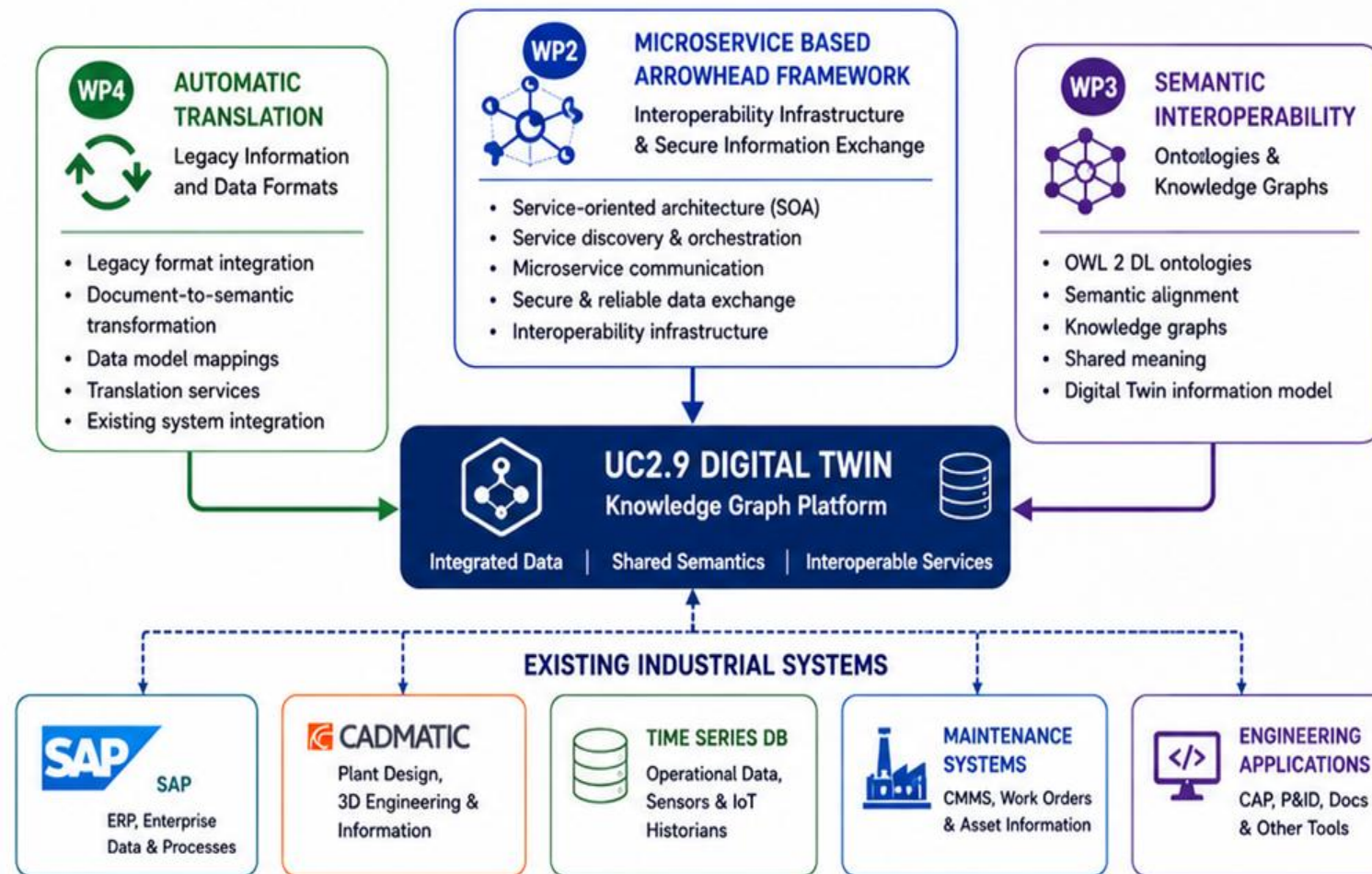
service	tag	IndividualPartView
pumpSpeed	123PU001	Pump_24C01213

No single data source or data domain could answer this independently



UC2.9 LIVE DEMONSTRATION - THURSDAY

How Arrowhead-EP Technologies Work Together



ON THURSDAY, UC2.9 WILL SHOW:

WP2

WP2 provides the **secure interoperability infrastructure** based on the microservice Arrowhead framework.

WP3

WP3 provides the **semantic interoperability** foundation through ontologies and Knowledge Graphs.

WP4

WP4 provides **automated translation** and integration of legacy information and data formats.



Existing industrial systems such as SAP, CADMATIC and operational systems collaborate within a **single interoperable Digital Twin environment**.

EXPECTED OUTCOMES



Seamless Information Exchange



Shared Semantic Understanding



Reuse of Existing Systems



Digital Twin Integration



Foundation for AI & Advanced Analytics



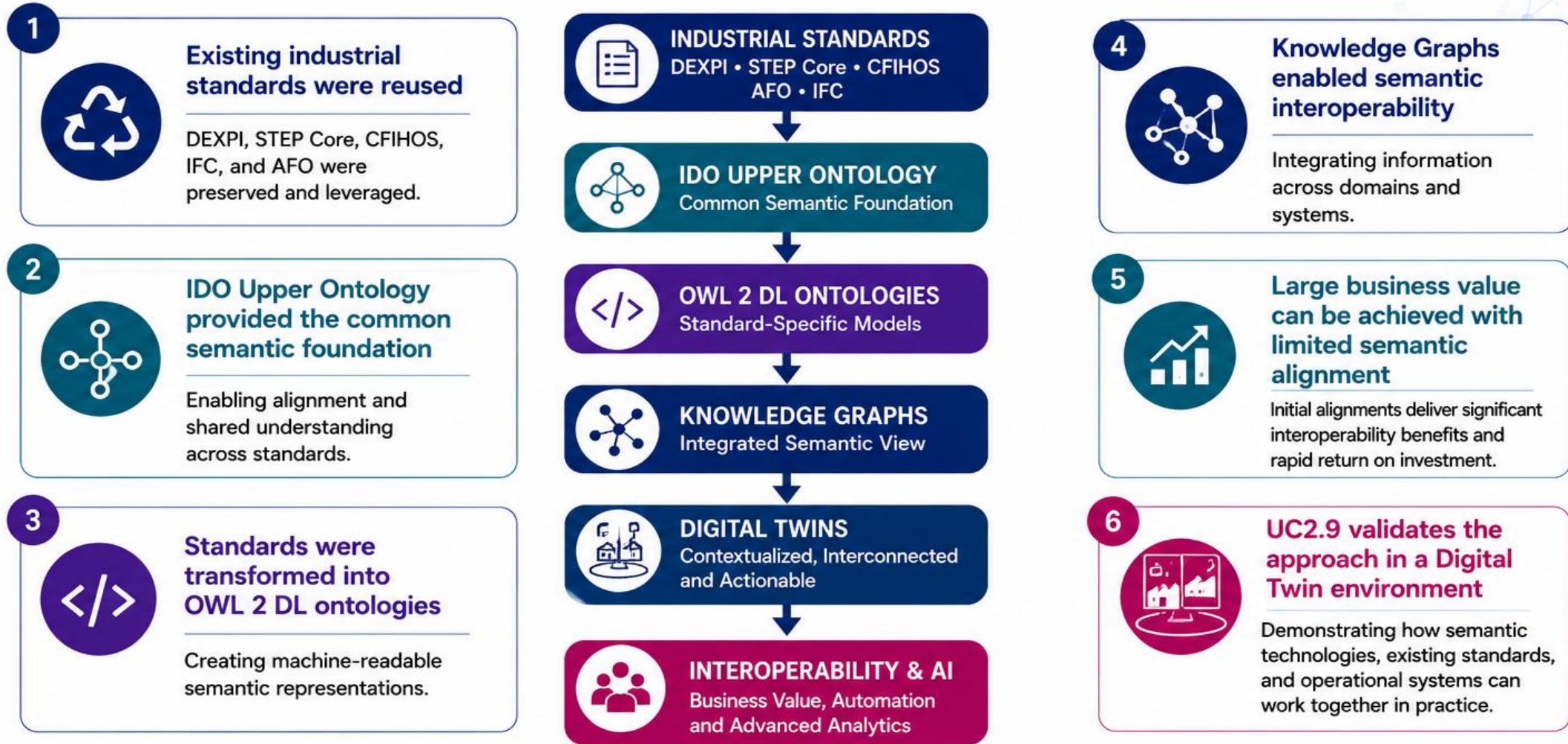
UC2.9 DEMONSTRATES THAT INTEROPERABILITY IS ACHIEVED BY COMBINING COMMUNICATION (WP2), MEANING (WP3), AND TRANSLATION (WP4) AROUND EXISTING INDUSTRIAL SYSTEMS.



JOIN US ON THURSDAY
for the UC2.9 Live Demonstration!

WHAT TO REMEMBER

WP3 Demonstrated a Practical Path to Industrial Interoperability



NO NEW STANDARDS. JUST SHARED SEMANTICS.



**Start Small.
Deliver Value Early.
Scale Continuously.**