Challenges in Standards-Based Interoperability for Digital Twins

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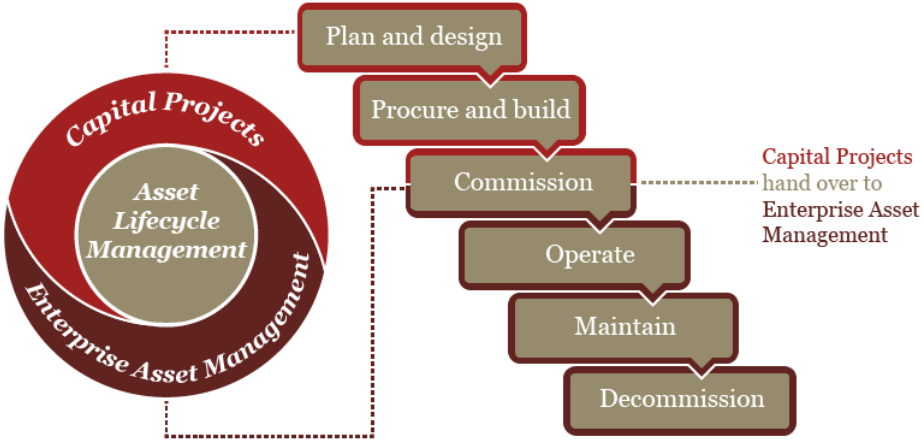
Support for Lifecycle in Asset Management



https://www.pwc.com/ca/en/services/consulting/operations/asset-life-management.html

- Start at planning and design
- Up to the point where asset is decommissioned
- In our context: asset “life” much longer than information systems (30+ years)
- In Digital Twins: often focus on operate and maintain

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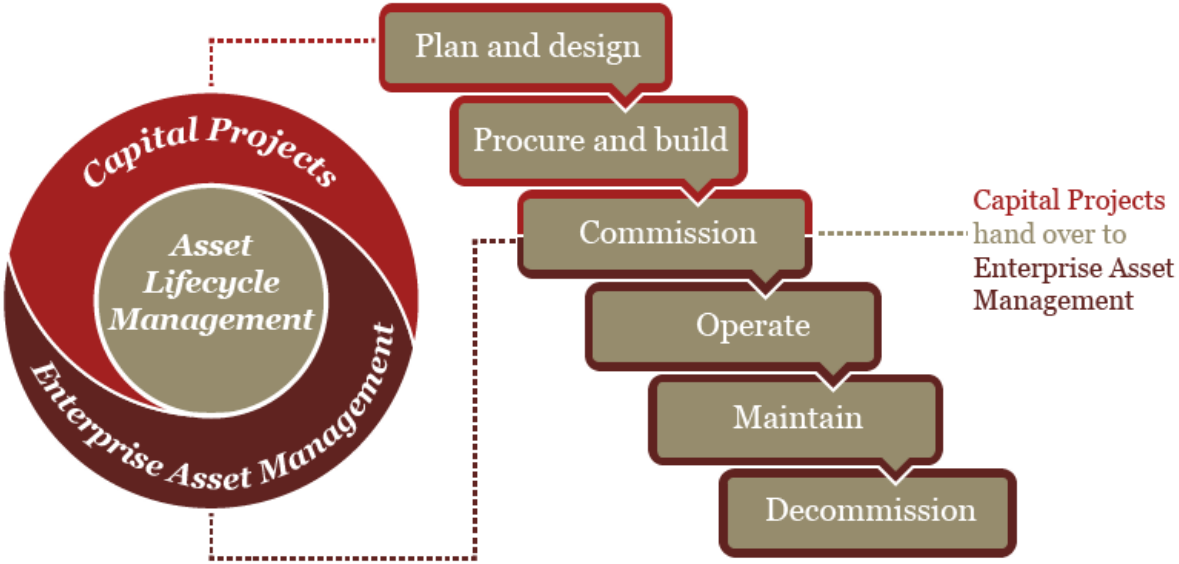
The need for interoperability

Text



The need for interoperability

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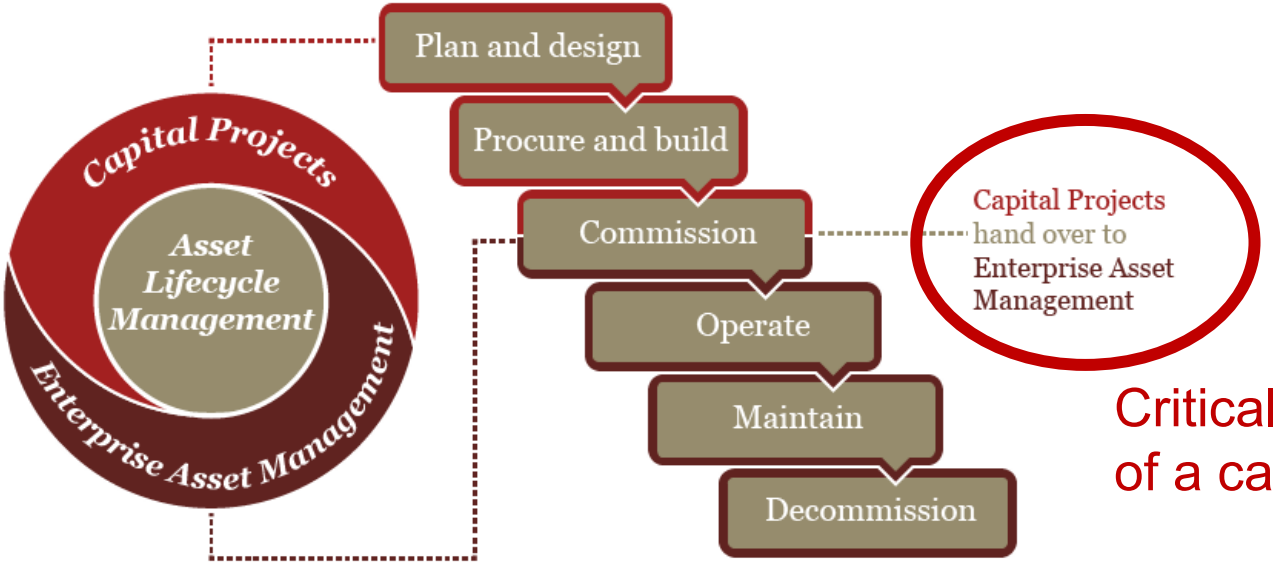
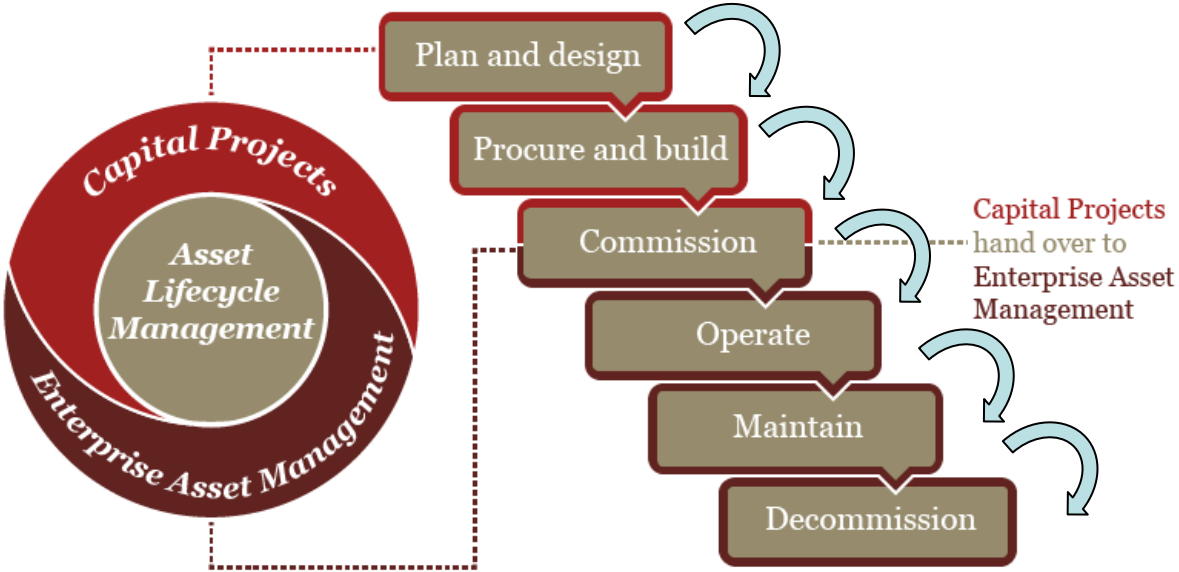


Critical to the success of a capital project!

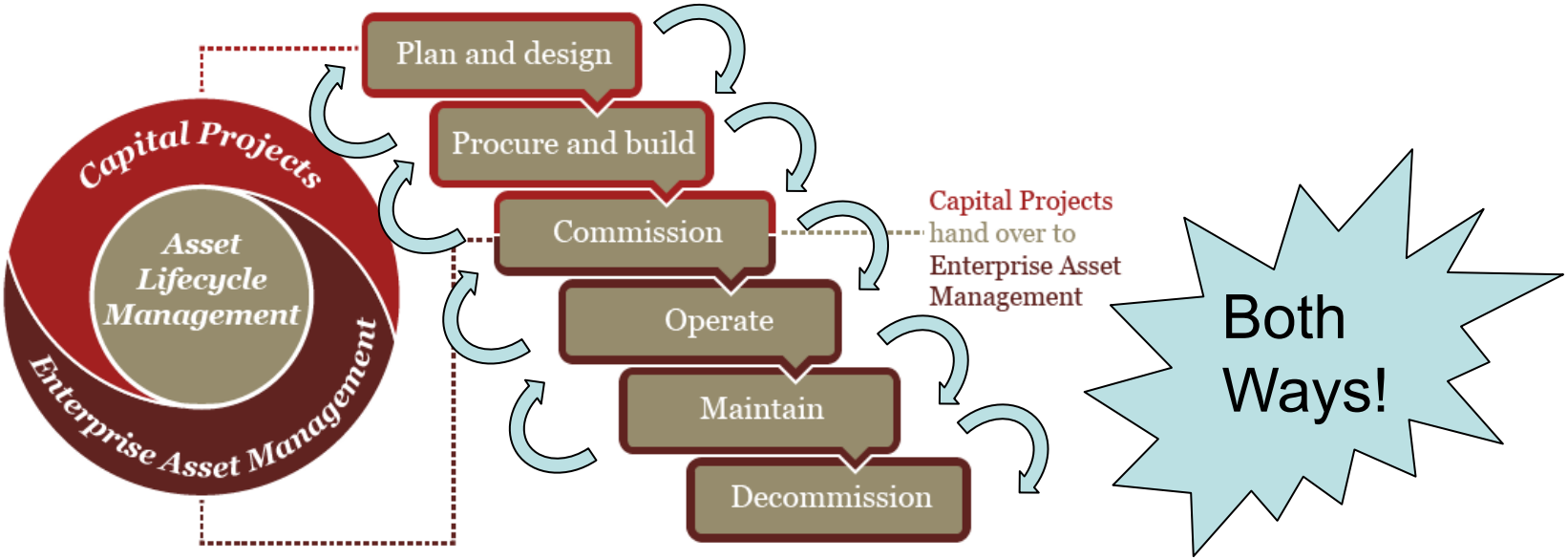
The need for interoperability – semantics!

Text

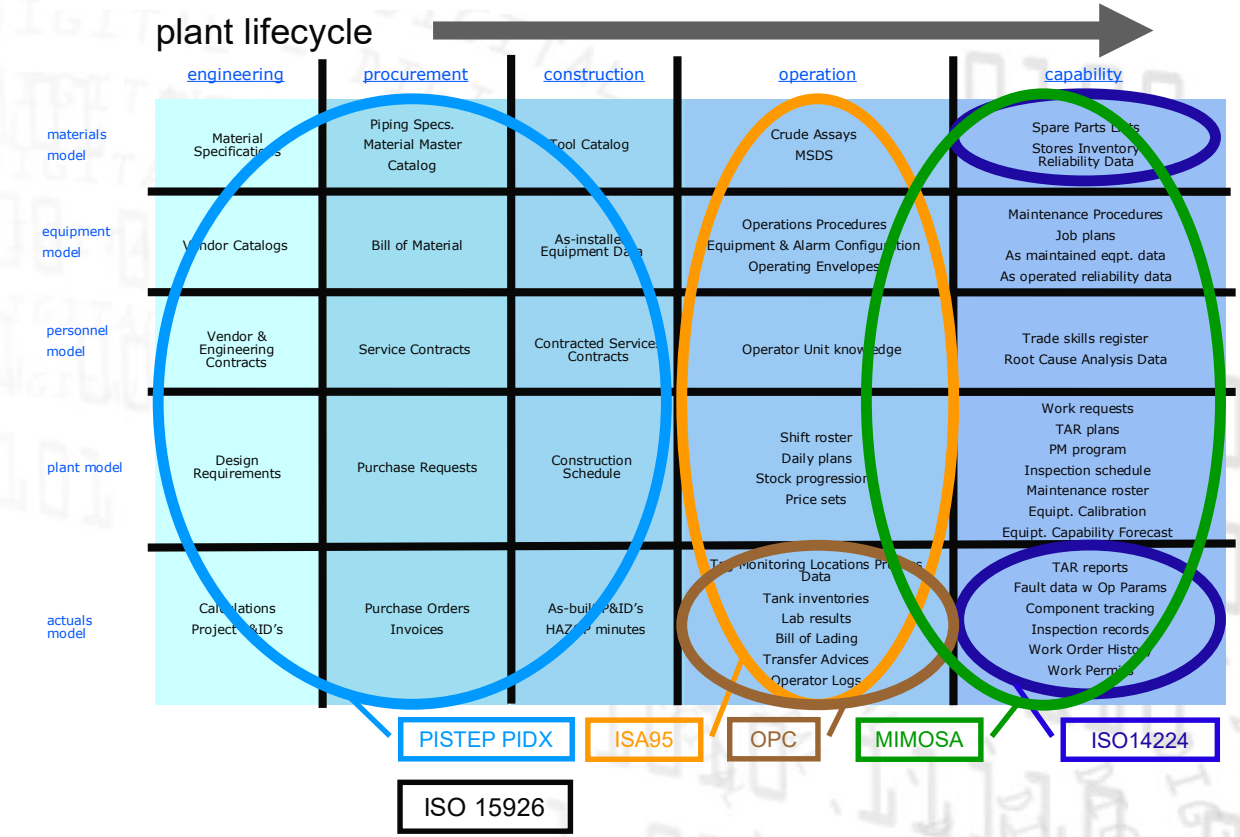


The need for interoperability – semantics!

Text



Standards Landscape



Standards Landscape for Digital Twins

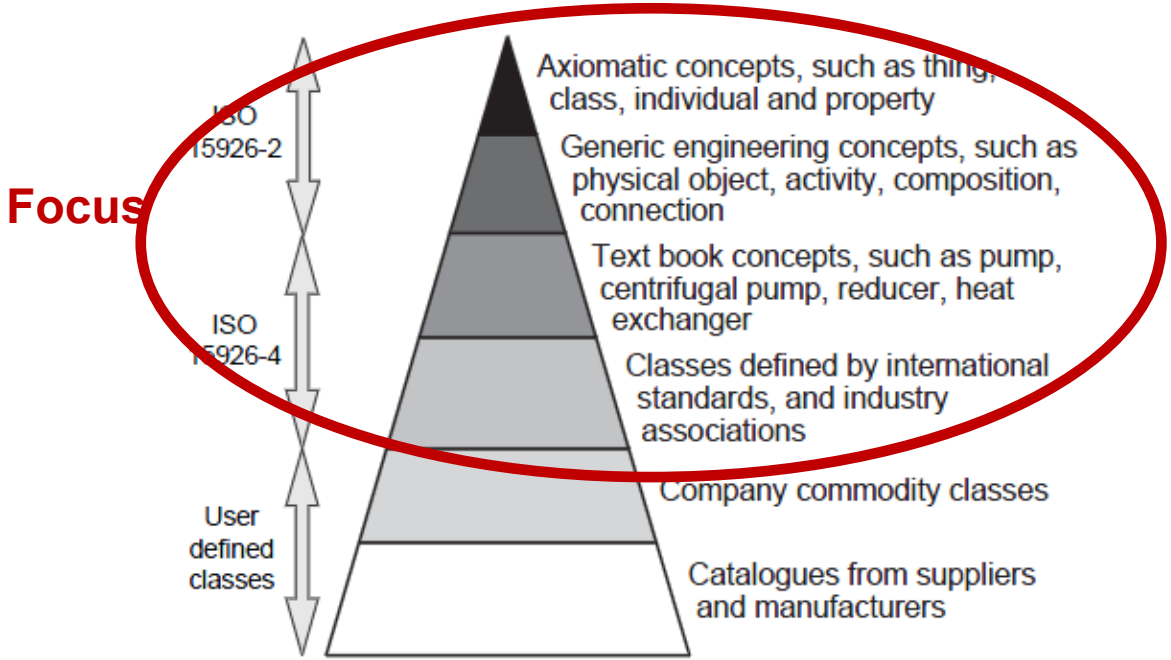
	AAS	DTDL	NGSI-LD	OData	STA	WoT
Resource Description						
Resource Term	Asset	Interface	Entity	Entity	Thing	Thing
Model Type(s)	Meta	Meta	Meta Cross-Domain	Meta	Cross-Domain	Meta
Resource Identification	IRI IRDI custom	DTMI	URI	URL custom	URL custom	URI
Type System (based on)	XSD	custom	JSON GeoJSON JSON-LD	custom	JSON SWE-standards	JSON JSON Schema
Resource Interlinking	X	X	X	X	- [a]	X
Semantic Annotation	X	O [b]	X	-	O [c]	X
Resource Elements						
Properties	X	X	X	X	X	X
Services	X	X	-	O [d]	O	X
Events	X	X	O [e]	-	O [e]	X
Serialization Format	JSON RDF XML OPC UA AutomationML	JSON RDF Avro Protobuf	JSON RDF	JSON XML	JSON	JSON RDF
Supported Kind of Data						
geo-spatial	-	-	X	X	X	-
temporal	-	-	X	X	X	-
historical	-	-	X	-	O [f]	-

Jacoby and Uslaender in *Appl. Sci.* **2020**, *10*(18), 6519; https://doi.org/10.3390/app10186519

Need for Model-Driven Engineering Approach

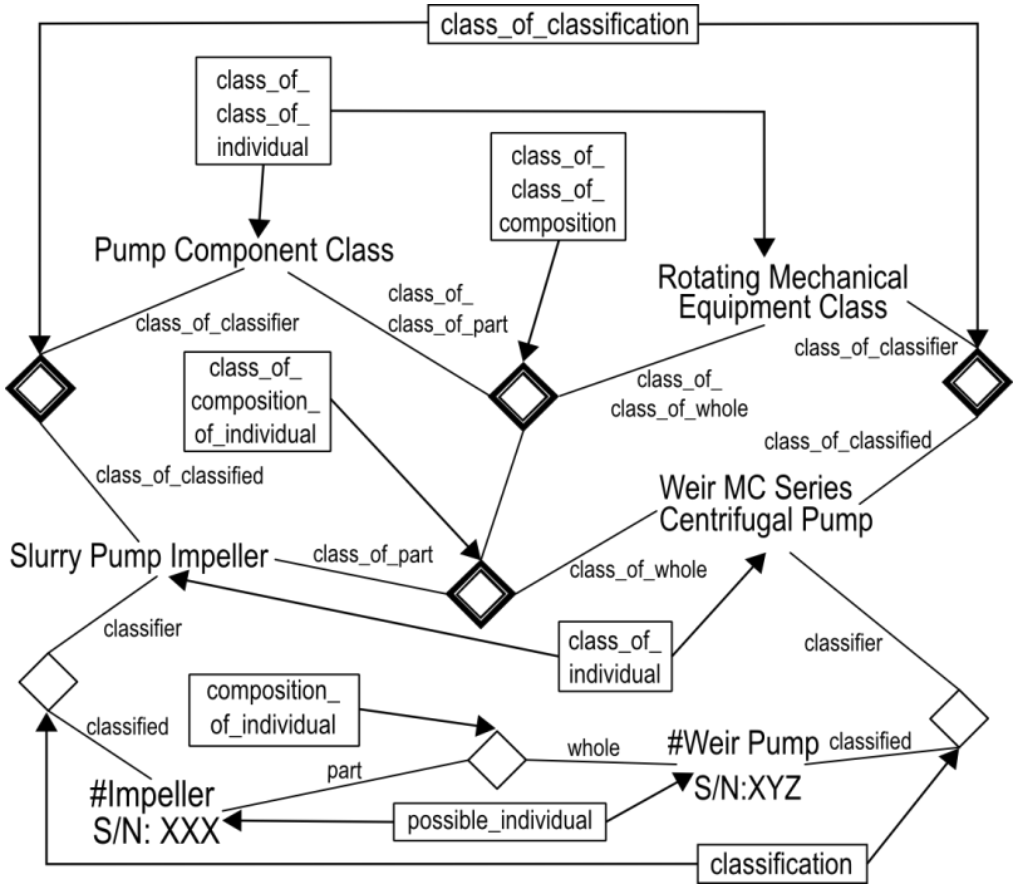
- Understanding
- Abstraction
- Specify a common ground for interoperability
- Verification
- Reasoning

Introduction to ISO 15926



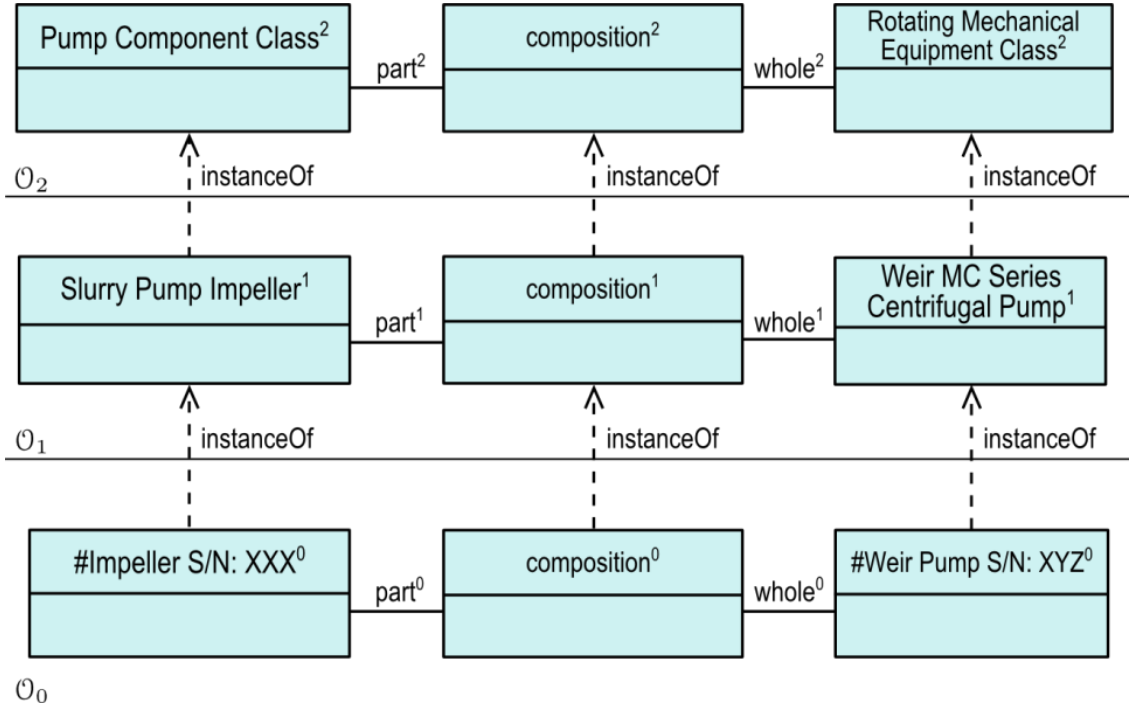
D. Leal, ISO 15926 "Life-cycle Data for Process Plant": An Overview.
Oil & Gas Science and Technology 60 (4) 2005, pp. 629 – 637.

Example on the right:
A Slurry Pump Impeller with serial number XXX is part of a Weir MC Series Centrifugal Pump with serial number XYZ.



Application of Multi-Level Modelling

Example:
A Slurry Pump Impeller with serial number XXX is part of a Weir MC Series Centrifugal Pump with serial number XYZ.



Benefits of an MDE Approach

- Simplify understanding of standards
- Identify inconsistencies from Software Engineering point of view
- Different end users: separation of concerns
- Matching: reducing the number of matching candidates
- Different languages: explicit representation through linguistic dim.
- Extensibility: simplified by separation of concerns

Challenges

- **Standards evolve over time**
  - Impact of change
  - Guidance in adapting change
  - Self-adaptive metamodels?

- **Traceability**
  - Temporal aspect
  - Keeping track of change
    - What happened when? Metamodel/Model/Data level

Thank you