Aibel's MMD Ontology

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SIRIUS
Centre for Scalable Data Access
in the Oil and Gas Domain
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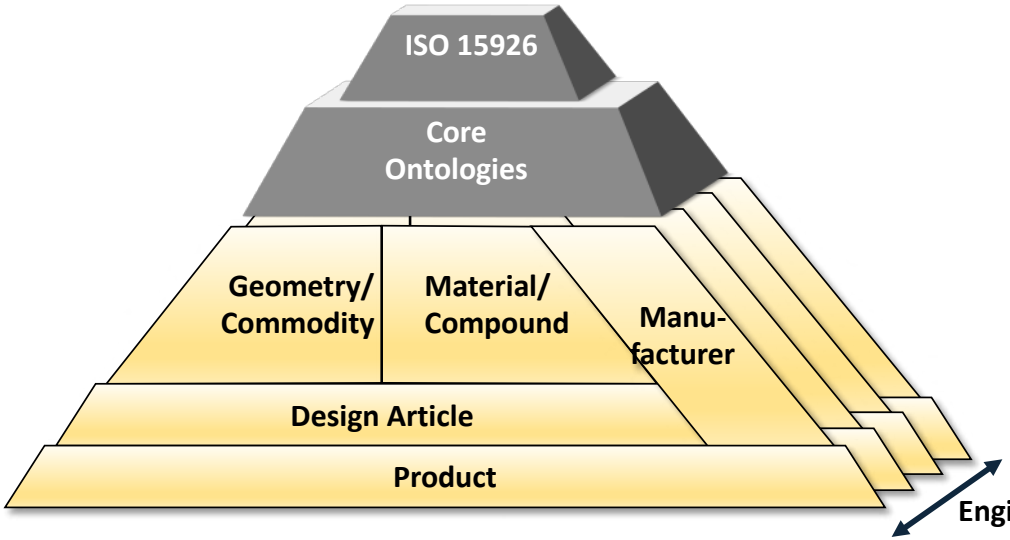
1. Material Master Data (MMD)



Key Figures

Axioms	1.840.769
Logical axioms	535.512
Declaration axioms	106.674
Class count	98.133
Object property count	135
Data property count	723
Individual count	20.412
SubClassOf	505.376
EquivalentClasses	745
DisjointClasses	27
AnnotationAssertion	1.198.266

The World's Largest Industrial Ontology…?

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2. Application domain of MMD

- Bulk material
- Structural steel
- Piping commodity

- Ongoing extensions:
  - Ontologies that span all engineering domains
  - Capture current asset model objects and their functions

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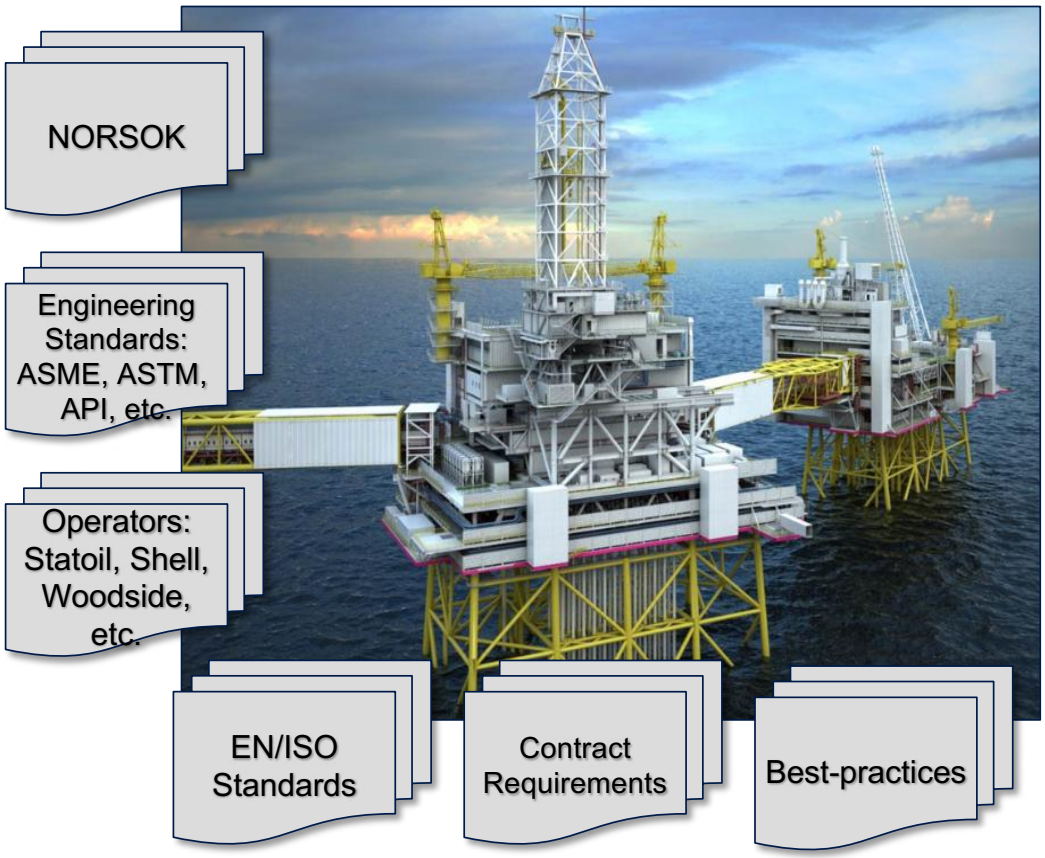
3. Intended purpose of MMD

- Increase data quality of the engineering database by removing **duplicate classes:**
  - 2010: more than 300.000 duplicates
  - Today: none

- Support complex engineering processes
  - Selection of product classes that match design constraints
  - Requirements management

Managing Complex Requirements



- Types
- Geometry
- Pressure classes
- Fire classes
- Explosion ratings
- Materials
- Certificates
- Manufacturers
- Revisions
- +++

?

Cost Estimates
Material Catalogs
Interchangeability
Efficiency
Digitalization
Reuse
Data Exchange
Master Data
Automation

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4. Representation of the world

- There is currently no temporal dimension in the ontology
- The ontology is designed for statements about a single “point of space”, i.e. there is currently no notion of space in the ontology

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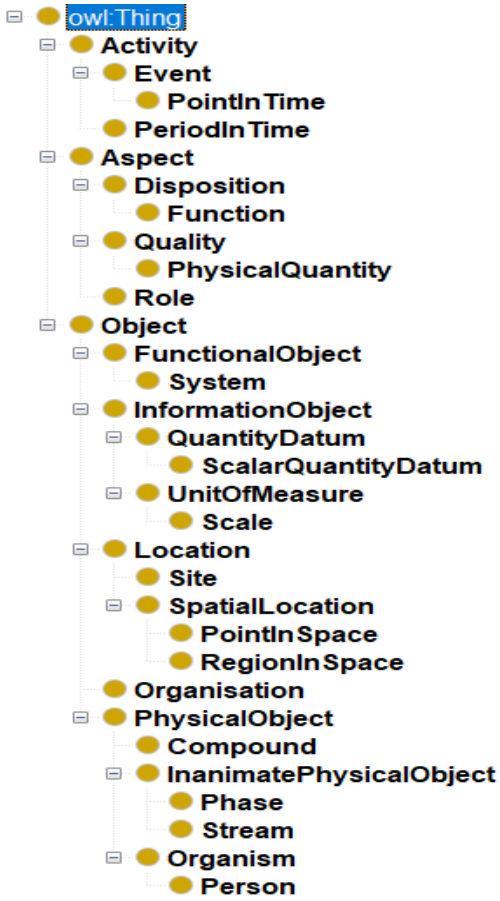
5. Concepts in the upper level ontology



- The upper level ontology is now proposed for publication as ISO/TR 15926 Part 14.

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6. Industrial use cases of MMD

- Improving quality of materials catalogue
- Improve accuracy of weight estimates
- Management of stock items
  - Purchases in error significantly reduced
- Restrict product types allowed to be selected
- Check validity of components
- Ensure interchangeability of components
- Design of a digital twin, sharing of data along the supply chain
  - Operator – EPC contractor – supplier

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How is the MMD ontology used?

- Ontologies are used to capture domain knowledge in a hierarchy that stretches from generic types down to industry compliant product types.
  - Alternatives to this approach is building such hierarches in specialized applications in combination with repetitive interpretations of industry standard content.
- Product type specification is supported by ontologies;
  - This allows information to be captured once and reused many times.
- Ontologies provide a consistent and high quality result
  - because the ontologies are subjected to domain expert quality control.
- Ontologies support rule based design
  - because the product type semantics can be reused to determine that a product type is suitable for performing a function in an asset

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7. Overlaps with other ontologies

- Upper level is partly overlapping with BFO
- PCA RDL (Reference Data Library based on ISO 15926) has been a source of inspiration
  - The PCA RDL was not adopted as is because the Aibel MMD had to be designed so as to make use of automated reasoning

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8. Main relations in MMD

- Connectivity:
  - Ex: has flanged face
- Breakdown structure:
  - partOf and sub-relations
- Subclassing

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9. The knowledge that MMD represents

- Vocabularies used in relevant industrial standards
  - Relevant subset for process plant engineering
  - Knowledge expressed in industry standards
- Aibel's best practice
  - Covering engineering experience

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10. Relations between different granularity views

- MMD covers standard requirements at different levels of granularity
- In the design process, objects are gradually enriched with more information.
  - From functional objects to physical objects

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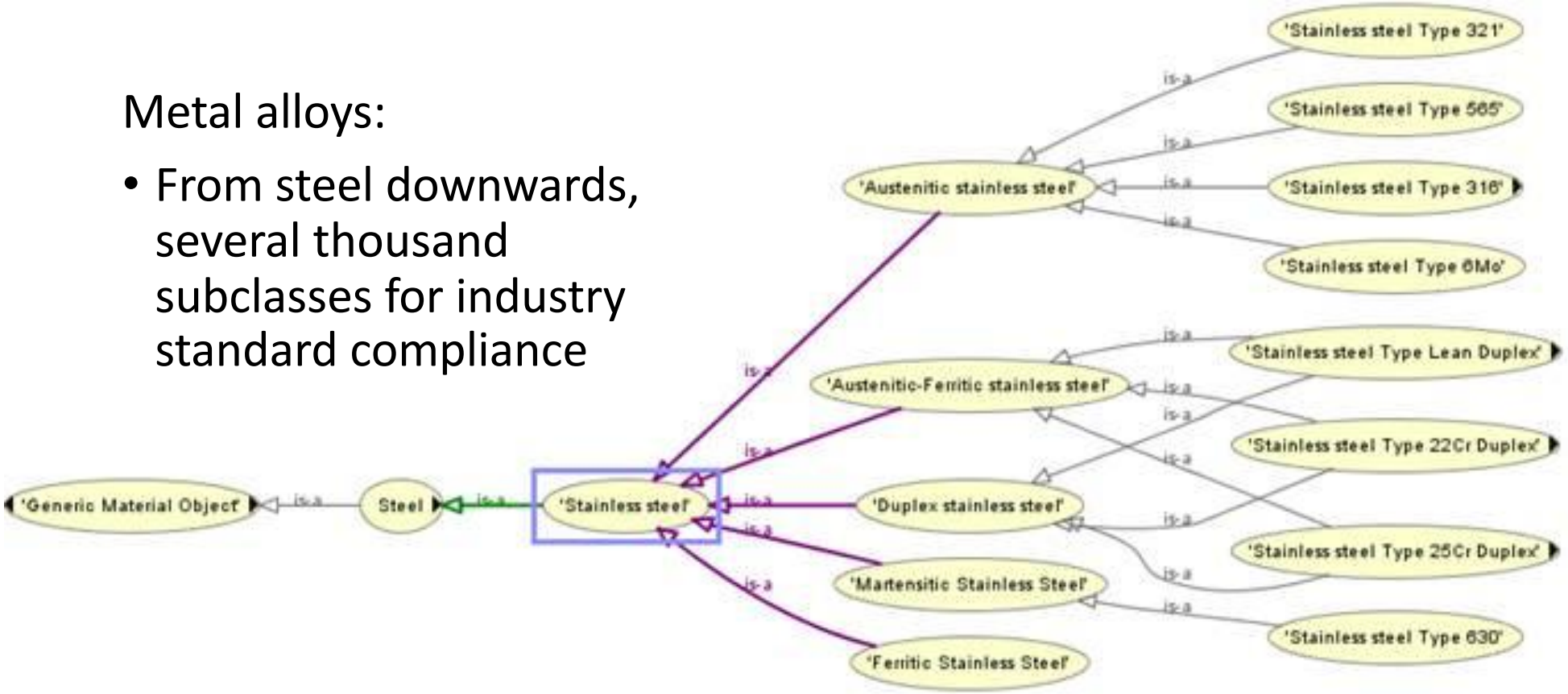
11. Representation of materials

Metal alloys:

- From steel downwards, several thousand subclasses for industry standard compliance



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12. Type of processes?

- Work processes
- Weld procedures
- Weld qualification records
- Welder qualifications

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13. Representation of manufacturing

- MMD is about requirements to manufacturing from design

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14. Physical properties, materials models and measurement

- MMD does not capture measurements
- It represents nominal values for use in design
- Max and min design requirements, limit values in a design, normal operating values, …
- Values taken from standards

Table 330.1.1 Preheat Temperatures

Base Metal P-No. or S-No. [Note (1)]	Weld Metal Analysis A-No. [Note (2)]	Base Metal Group	Nominal Wall Thickness		Specified Min. Tensile Strength, Base Metal		Min. Temperature			
							Required		Recommended	
			mm	in.	MPa	ksi	°C	°F	°C	°F
1	1	Carbon steel	< 25	< 1	≤ 490	≤ 71	...	...	10	50
			≥ 25	≥ 1	All	All	...	...	79	175
			All	All	> 490	> 71	...	...	79	175
3	2, 11	Alloy steels, Cr ≤ ½%	< 13	< ½	≤ 490	≤ 71	...	...	10	50
			≥ 13	≥ ½	All	All	...	...	79	175
			All	All	> 490	> 71	...	...	79	175
4	3	Alloy steels, ½% < Cr ≤ 2%	All	All	All	All	149	300	...	...
5A, 5B, 5C	4, 5	Alloy steels, 2¼% ≤ Cr ≤ 10%	All	All	All	All	177	350	...	...
6	6	High alloy steels martensitic	All	All	All	All	...	...	149[4]	300[4]
7	7	High alloy steels ferritic	All	All	All	All	...	...	10	50
8	8, 9	High alloy steels austenitic	All	All	All	All	...	...	10	50

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15. Representation language and logic

- Ontology represented in OWL 2
  - Direct semantics based on Description Logic
  - Reasoning support from Hermit has been essential for the MMD project
  - Main service implemented using DL queries and reasoning