Model driven integration architecture for IO G2 information

Reference Semantic Model alignment to ISO 15926

Integrated Operations in the High North – Joint Industry Project

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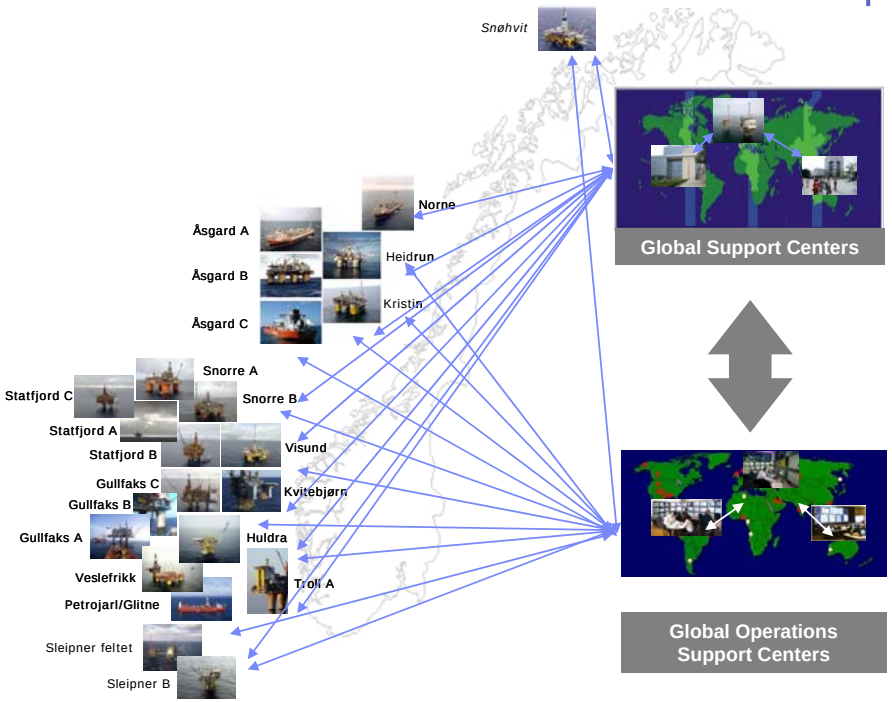
Content

- Background
  - Owner / operator requirements
- Reference Architecture
  - Conceptual Reference Architecture for IO G2
  - The IBM Integrated Information Framework
- Reference Semantic Model
  - Integrating information model for the oil&gas industry
- RSM alignment to ISO15926
  - RSM as a Reference Data Library module
  - Providing ISO15926 data from the IIF/RSM

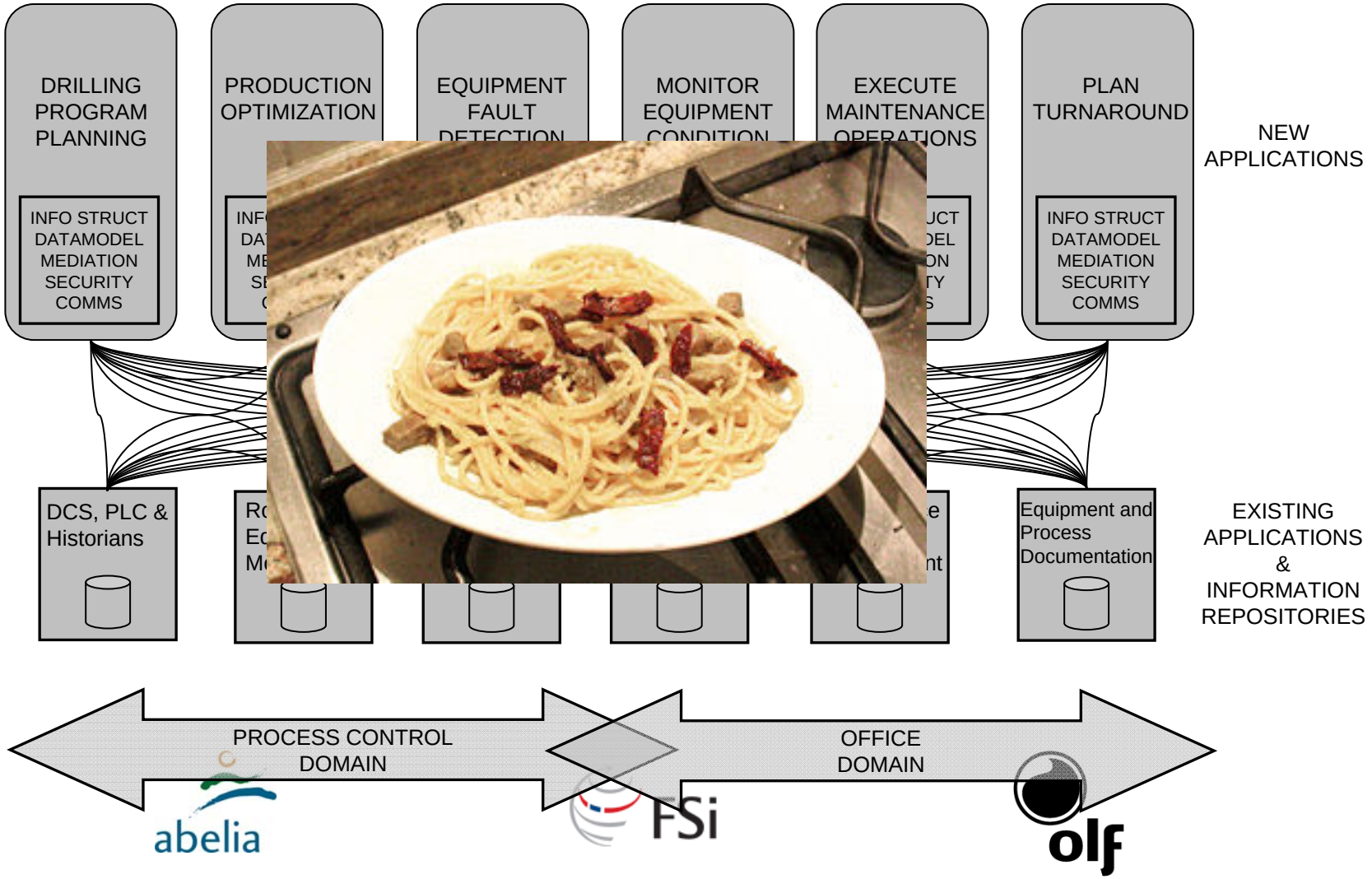
StatoilHydro TAIL-IO R&D Programme - Operational reality

- Large number of different applications. Each instance with own unique reference and data model. Example:
  - Real Time historians / IMS Systems - One for each asset
  - Hydro Carbon Accounting systems - One for each asset / license
- Complex views spanning divisions/plants/process areas requires new “one-off” application developments.

- Challenges
  - Lost volumes
  - Inefficient operation & maintenance
  - Incidents
  - Reduced IT ROI



The current situation – complexity is increasing



Draft Reference Architecture for OLF Integrated Operations Generation 2 Version 1.0 *)

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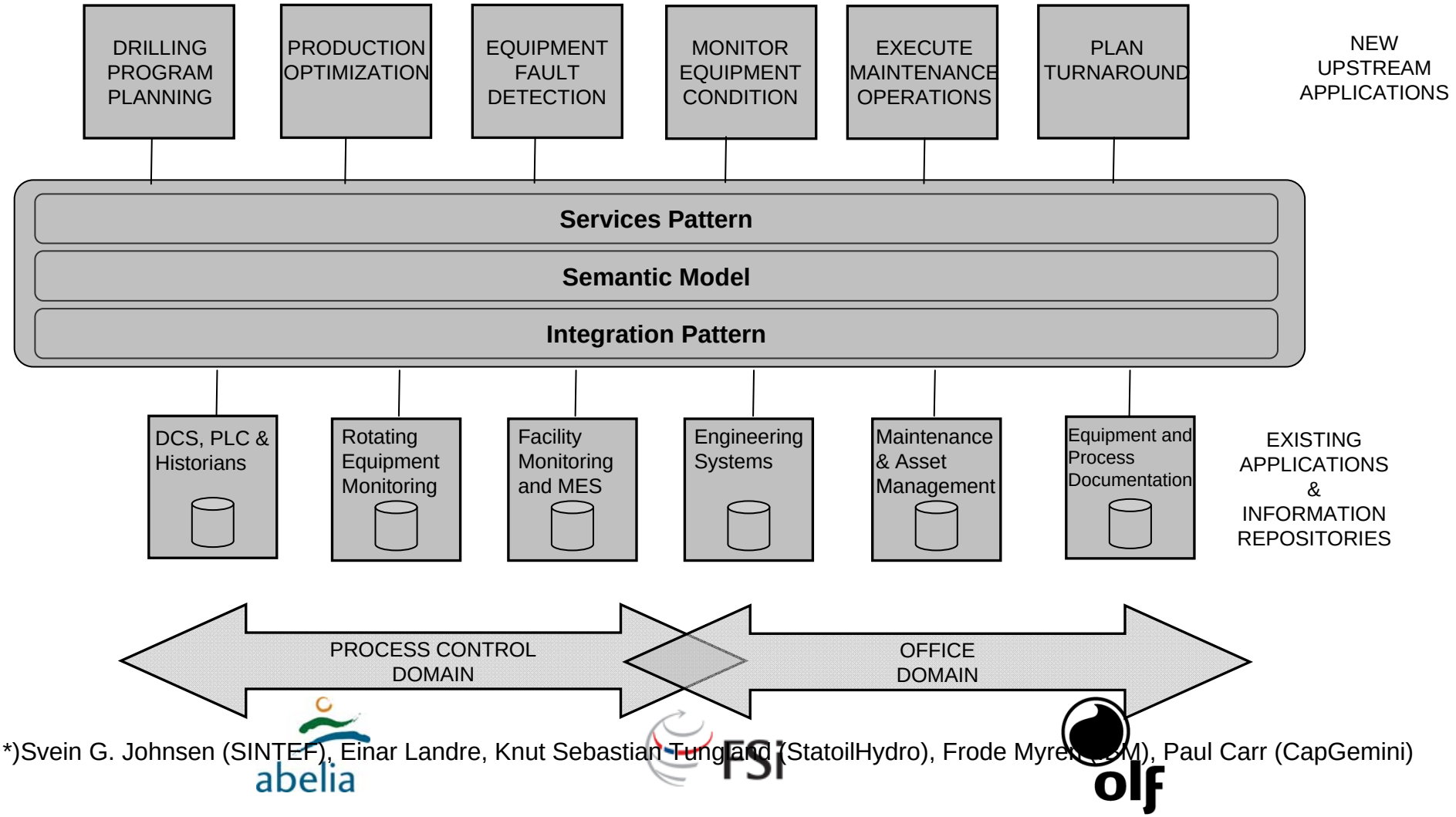
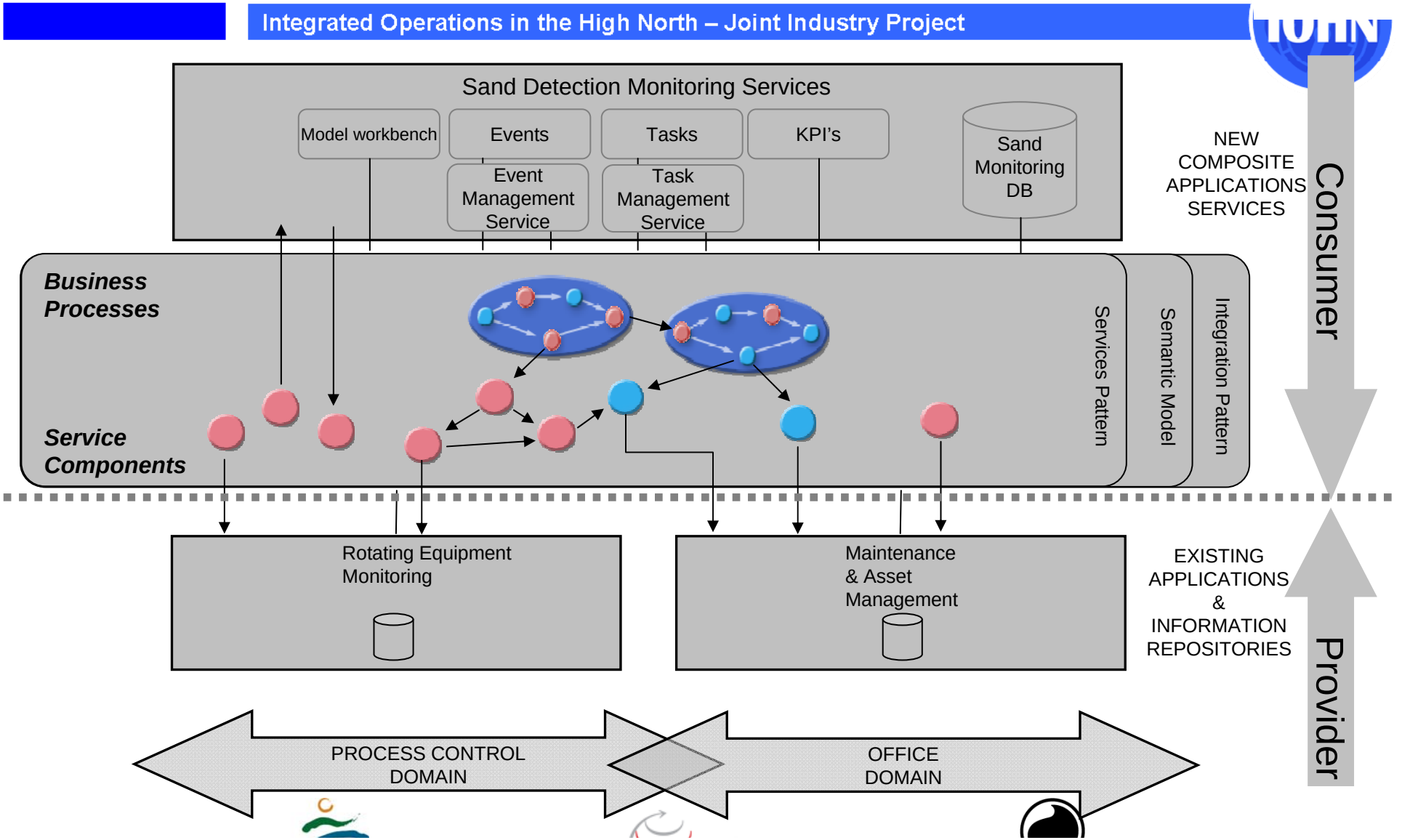
•Current EAI/ESB technologies are inadequate



*)Svein G. Johnsen (SINTEF), Einar Landre, Knut Sebastian Tungland (StatoilHydro), Frode Myren (ABB), Paul Carr (CapGemini)

The Service patterns



http://www.computer.org/portal/cms_docs_itpro/itpro/homepage/2007/may_june/f3010.pd

IEEE S3: A Service-Oriented Reference Architecture, Arsanjani et al.

The Integration pattern within the architecture

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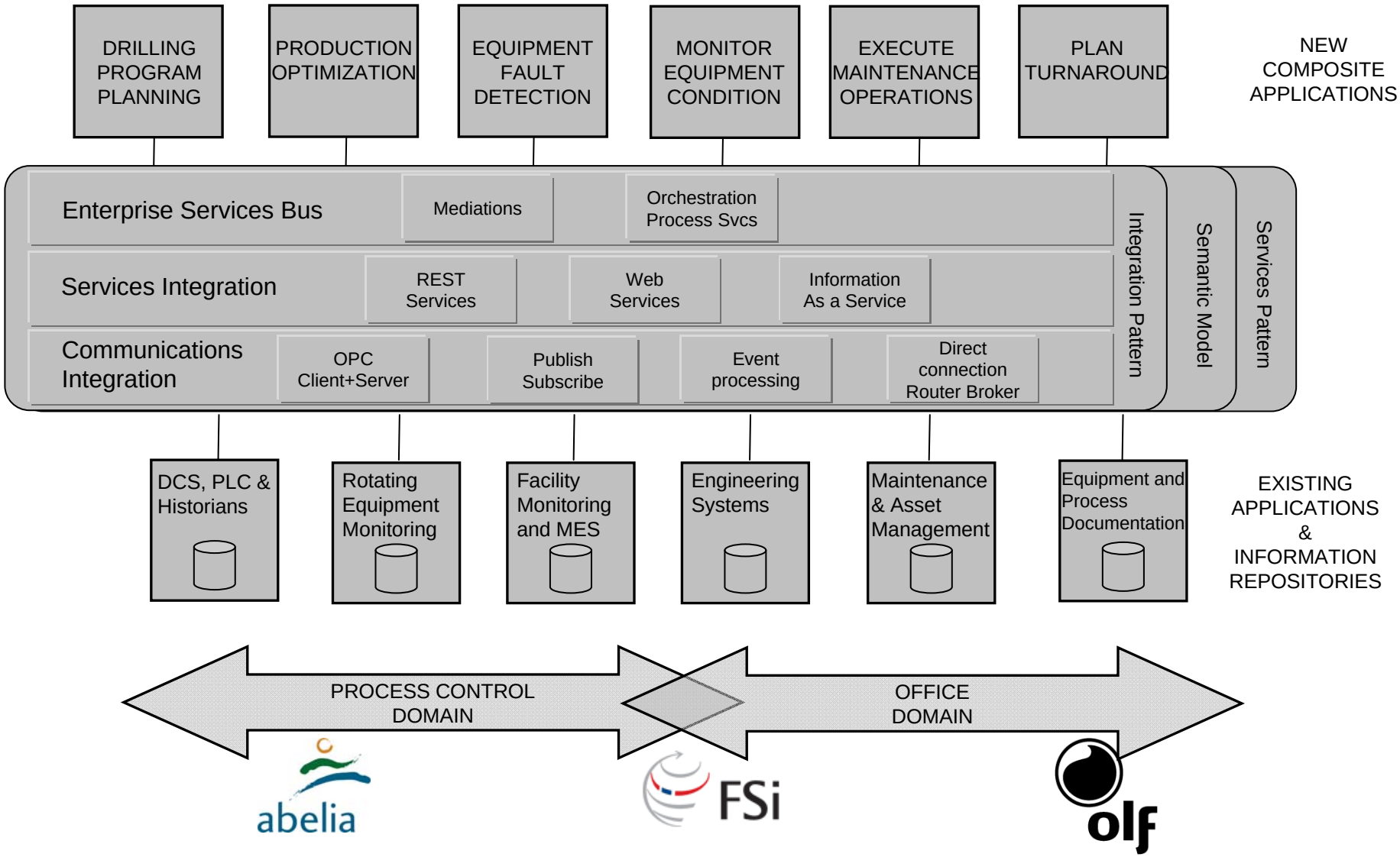
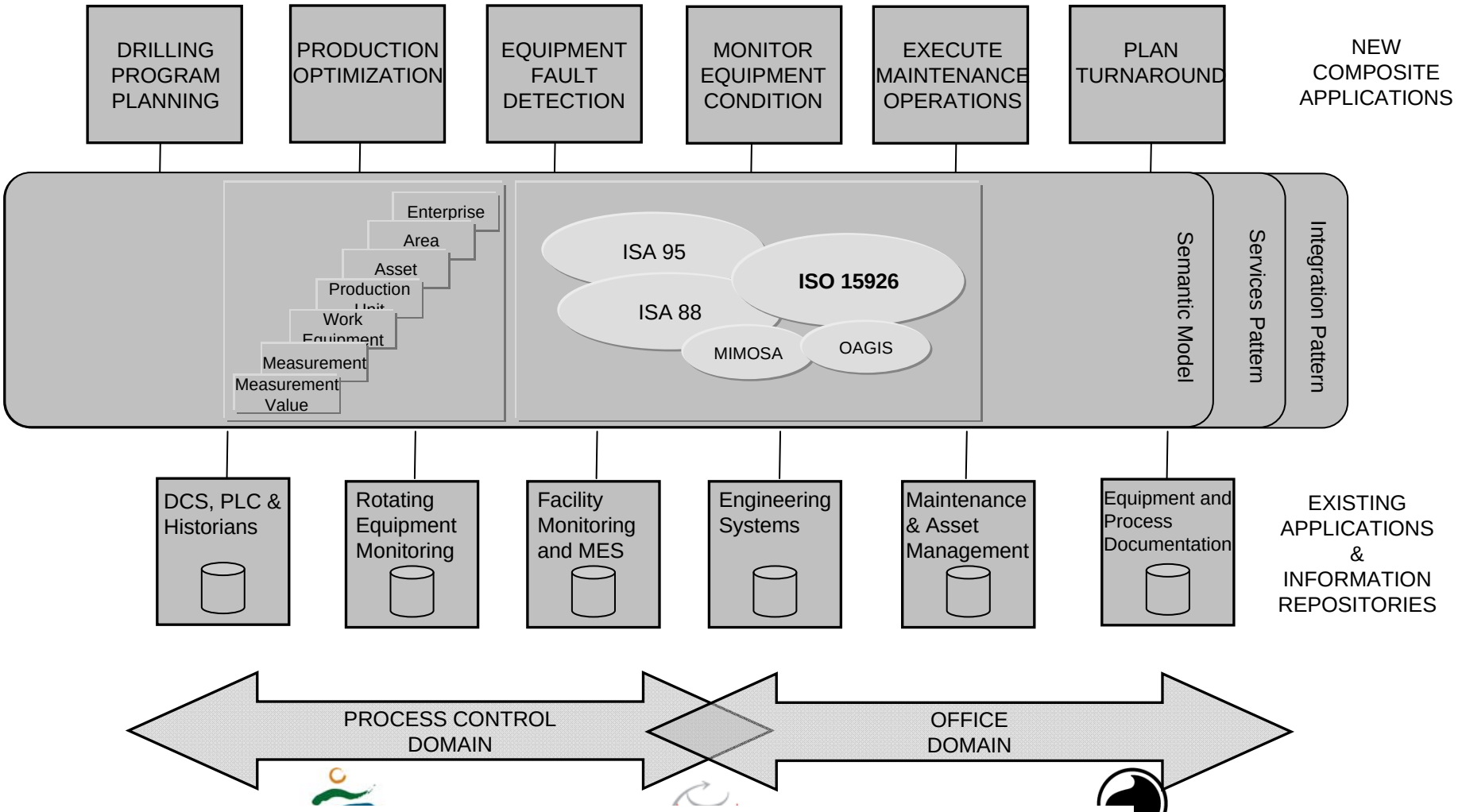


The Role of the Semantic Model within the integration architecture



RSM: Part of real time transactional integration platform

ISO15926: Master data definitions and structures

The Purdue Reference Model – Enterprise – Operation – Control
Applicable standards for integration

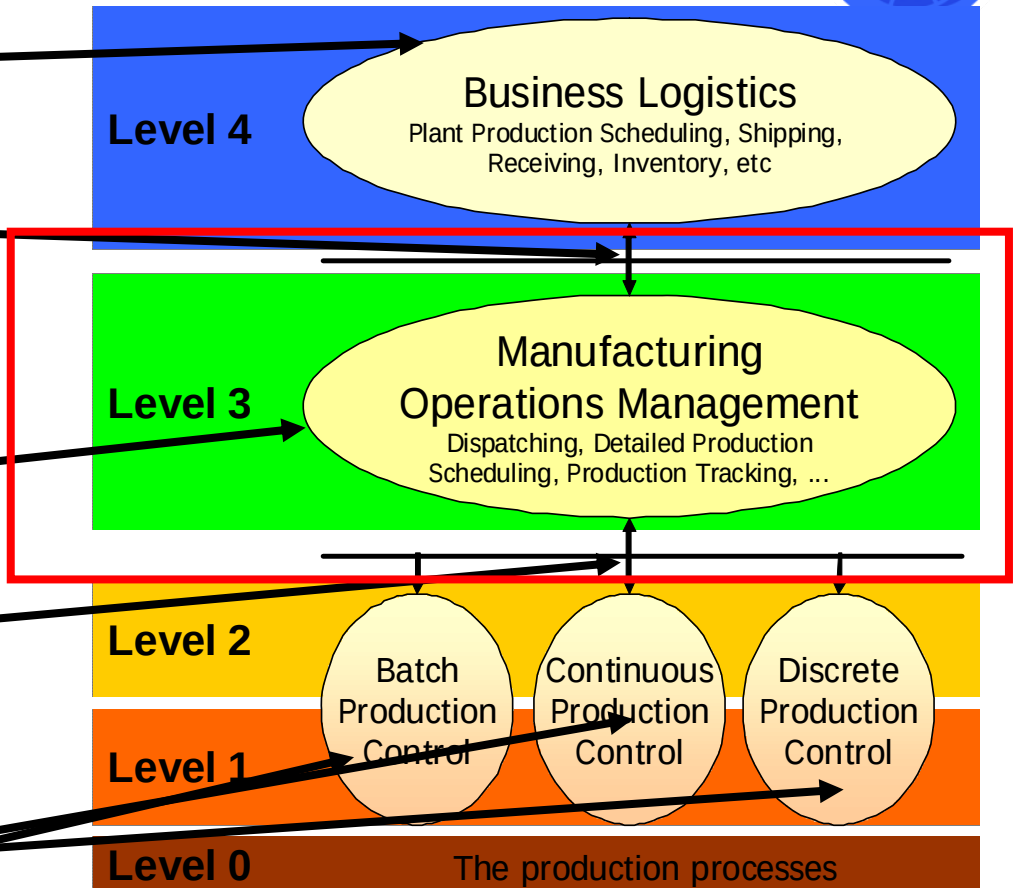
OAGIS (Supply chain)

ISA S95 Parts 1, 2, and 5 and B2MML

ISA S95 Parts 3 and 4

OPC UA, MIMOSA and IEC and ISO standards

ISA S88, BatchML, IEC and ISO standards



StatoilHydro TAIL-IO R&D Programme
→F0B GODI Full Scale Pilot project context

IBM C&P Integrated Information Framework

STID/SAP/PIMS Intergraph SPF

Energy Components

SAP PM

Security

Systems Monitoring

Model Management

Engineering Design Systems

Well Production Information

Production Management (PM) & Condition Monitoring (CM)

Enterprise Asset Management (EAM)

WS/ SQL

WS/ OPC

WS/ BAPI

OFFICE DOMAIN

Global Operations Data Integration

Reference Semantic Model

Business Workflow Processing
Event Processing
Enterprise Service Bus
Model Awareness / Model mgmt

OPC

OPC

WS

Plant Integration & mobile ICT

Historian

WS

WS/ OPC

OPC TCPIP

Asset Management (incl field worker)

Asset Monitoring

Other Subsystems

Vibration Subsystem

Distributed Control System

PROCESS CONTROL DOMAIN

© IBM

Statfjord A

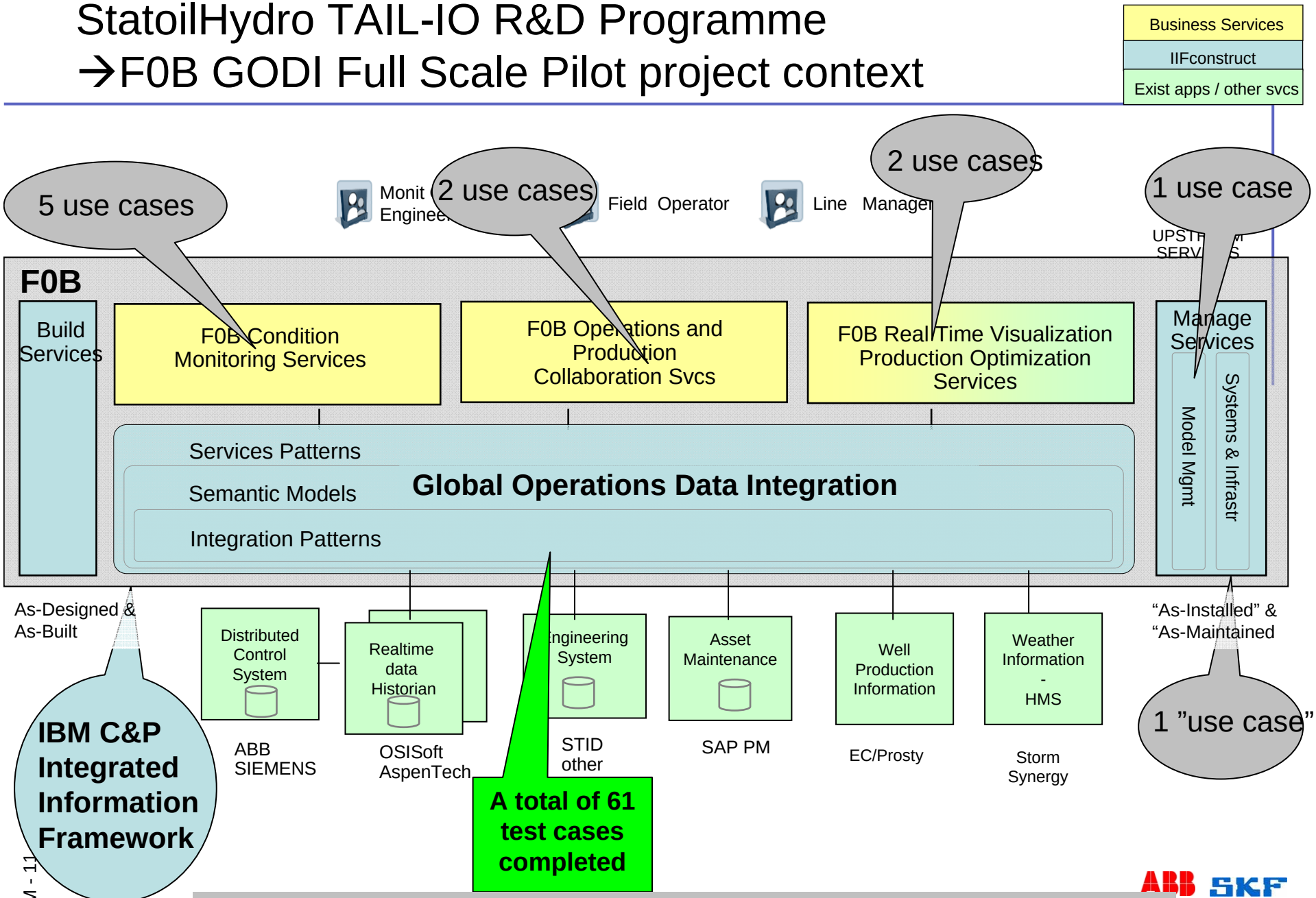
PI, Prosty, SAP, STID, Storm, Synergi

Oseberg FC

IP21, Proff, SAP, Storm, Synergi

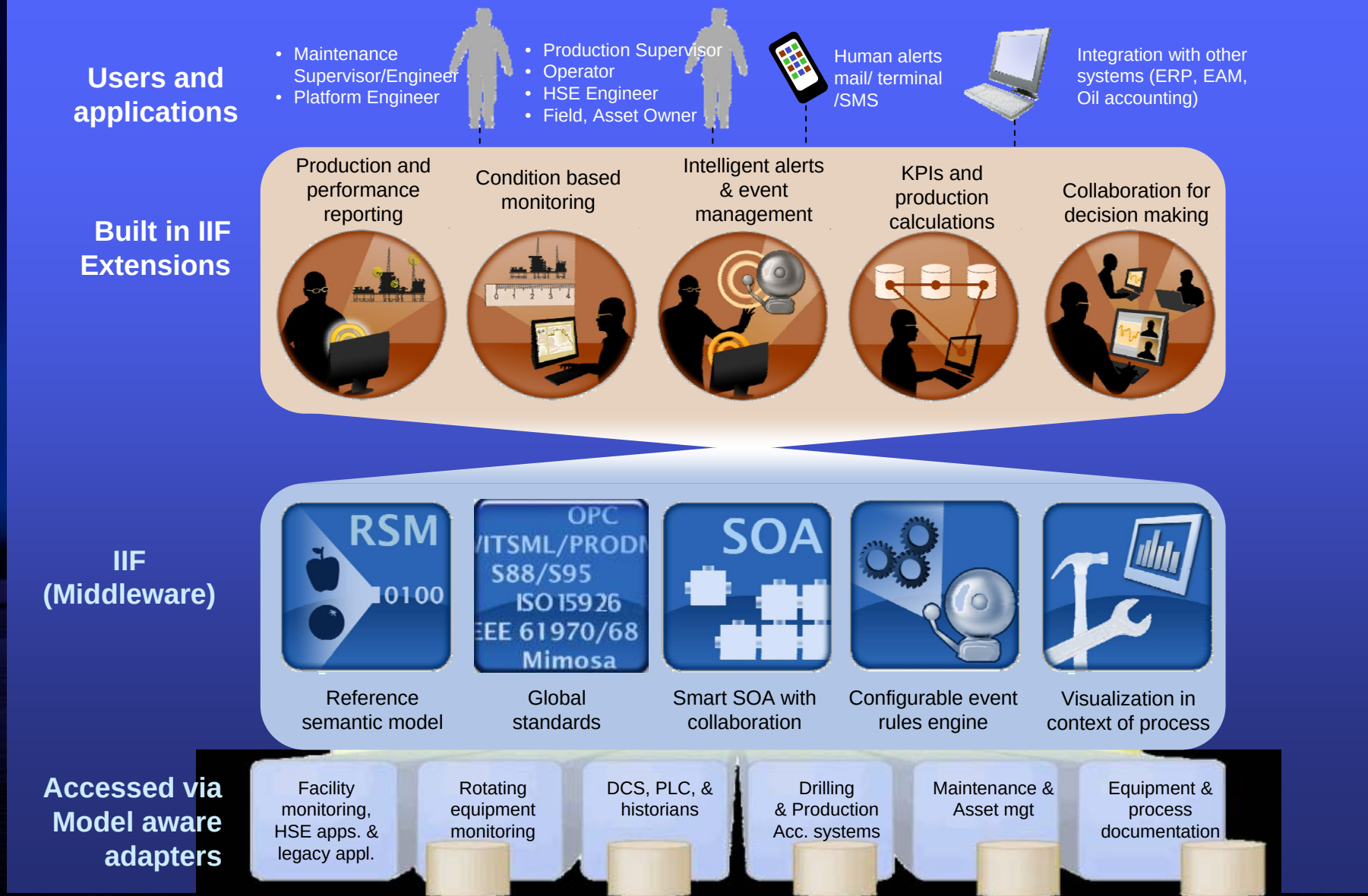
ABB SKF StatoilHydro IBM AkerSolutions

StatoilHydro TAIL-IO R&D Programme
→F0B GODI Full Scale Pilot project context



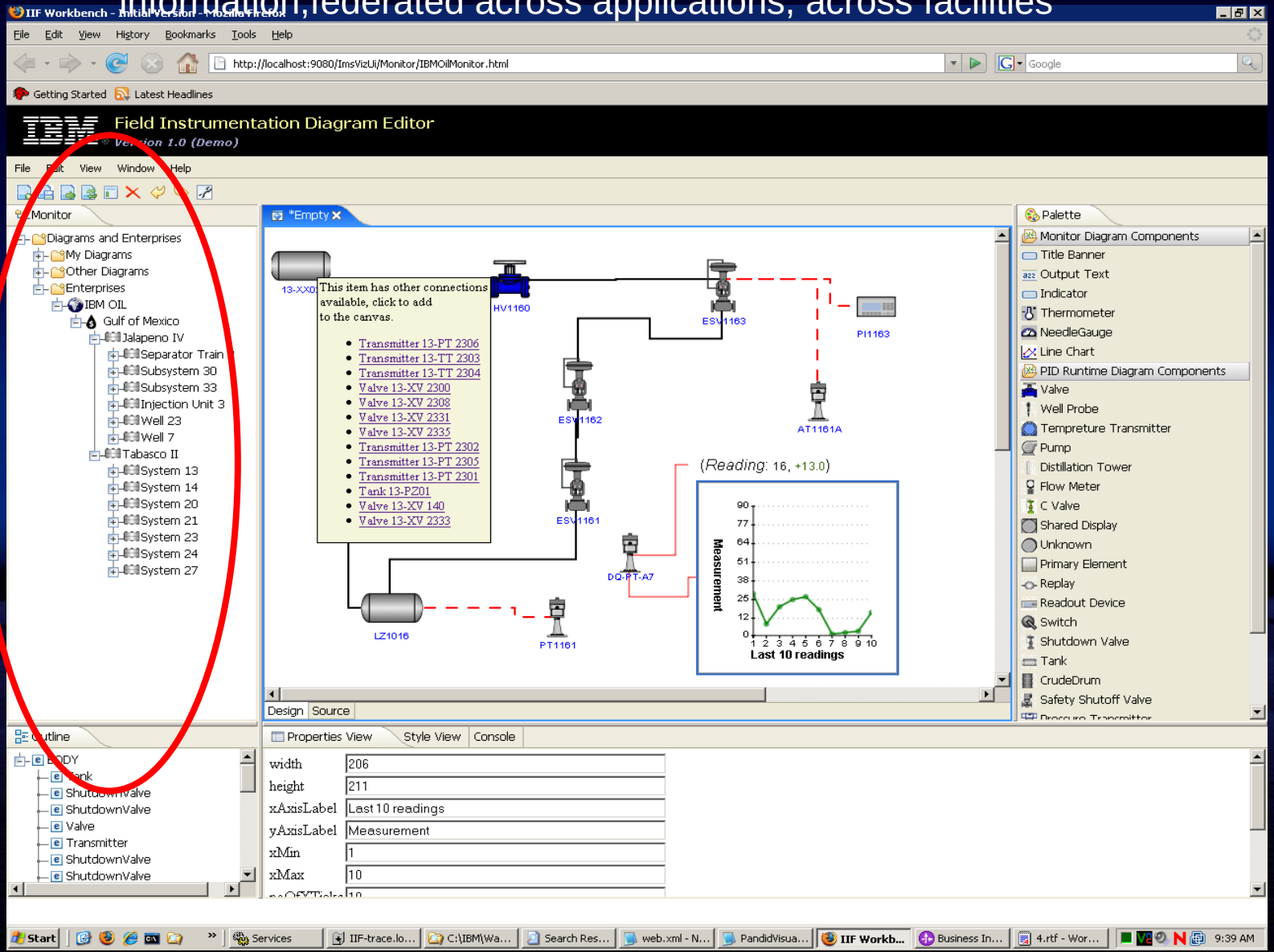
- Verification of flexibility & scalability wrt work processes and data access
- Verification of performance, availability, security, usability

IBM C&P Integrated Information Framework, extending IBM WebSphere



IIF Solution Studio

Facilitates exchange of measurements, equipment, planning information,federated across applications, across facilities



IOHN Activity 2 has the architecture focus

To establish a digital platform infrastructure across domains

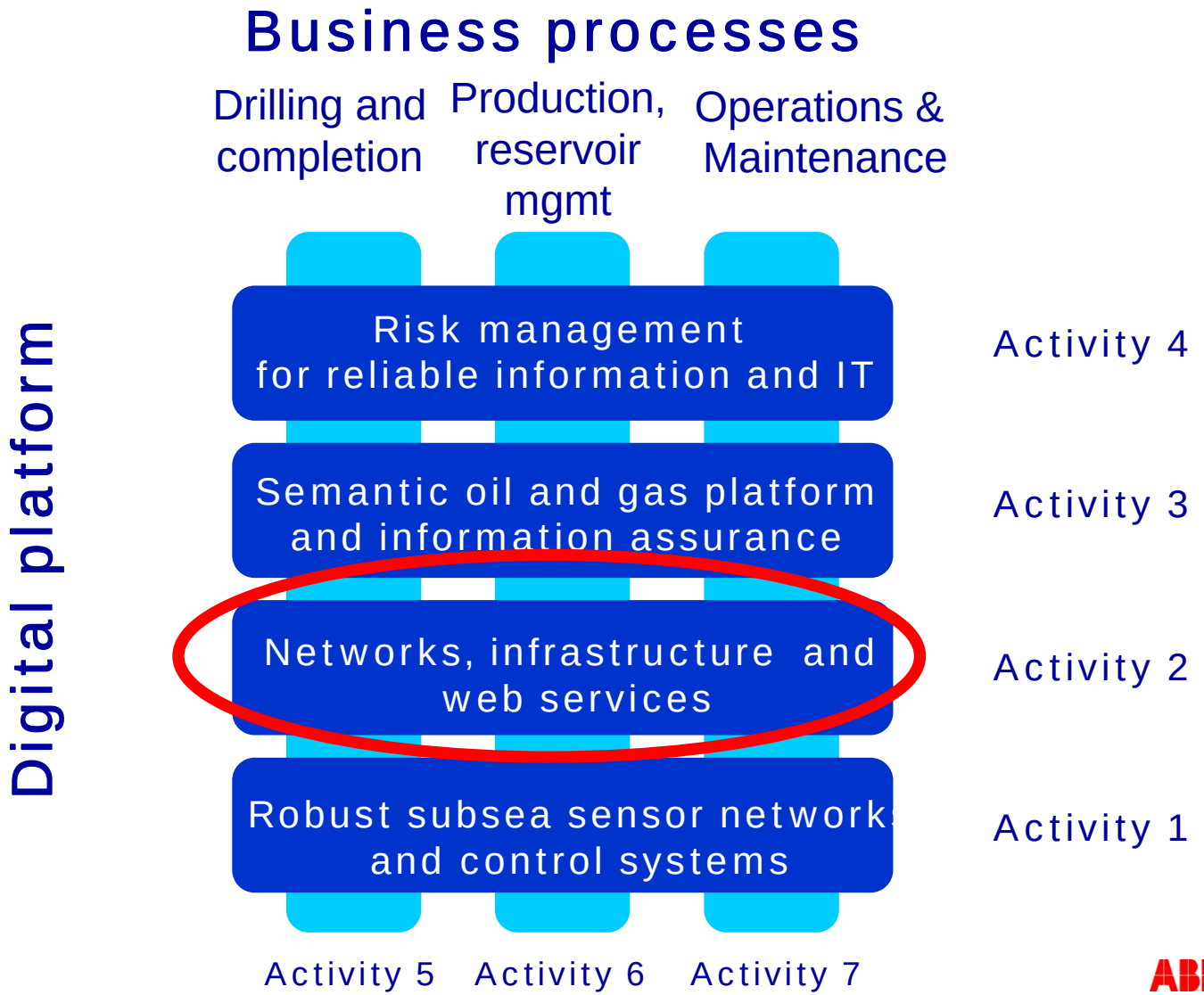
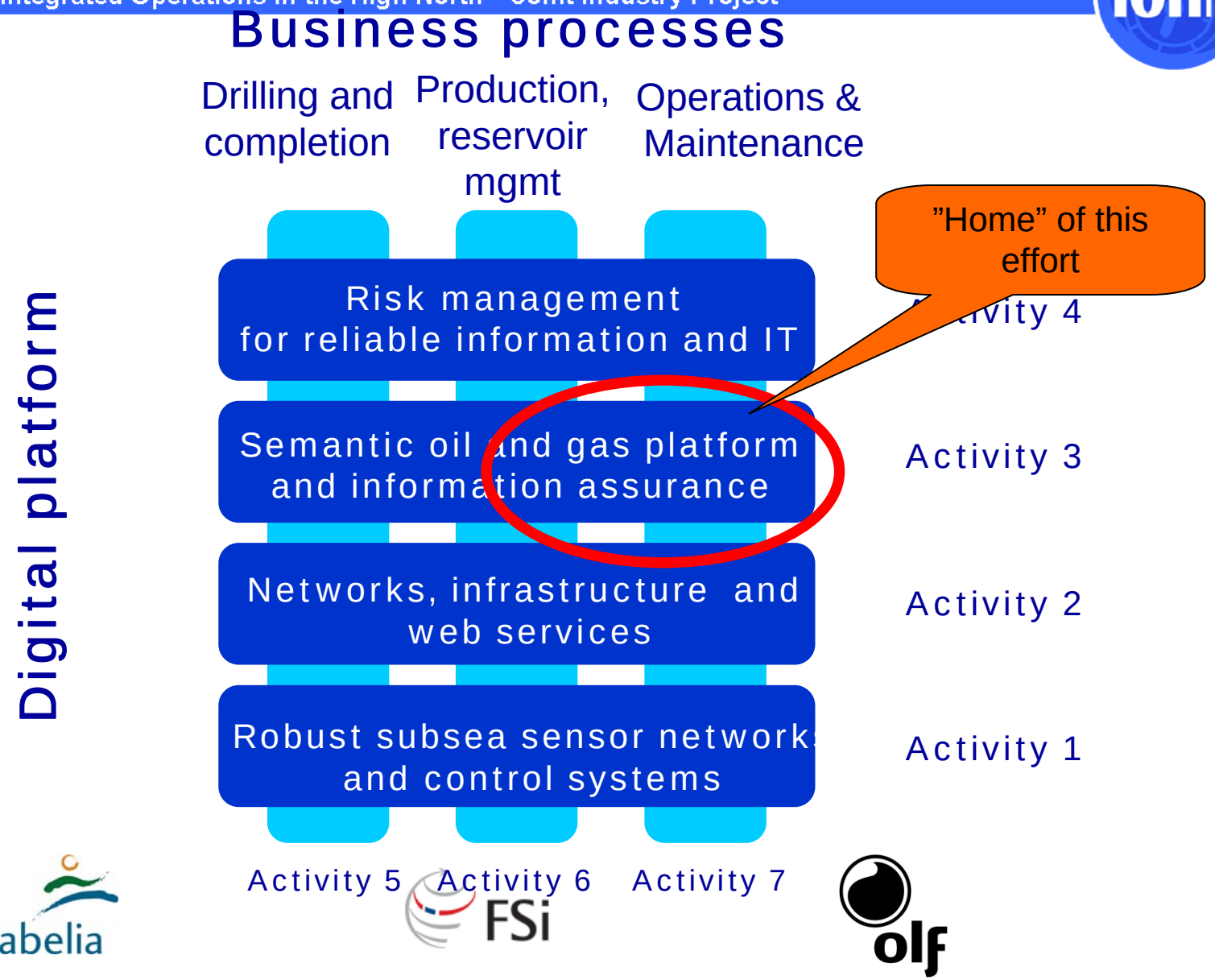


ABB SKF StatoilHydro IBM AkerSolutions

IOHN Activity 3 focus for this effort

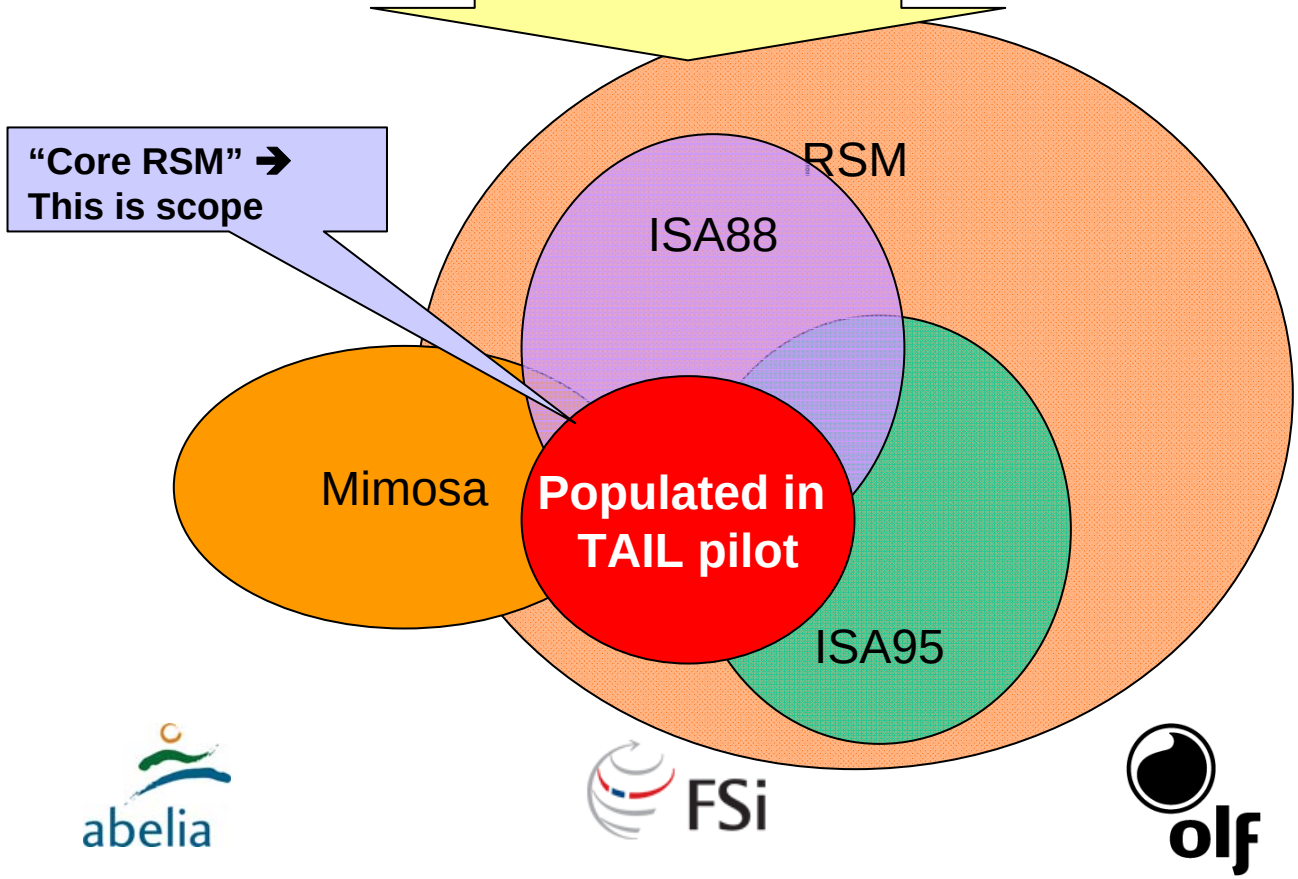
To establish a semantic platform



Mission and scope

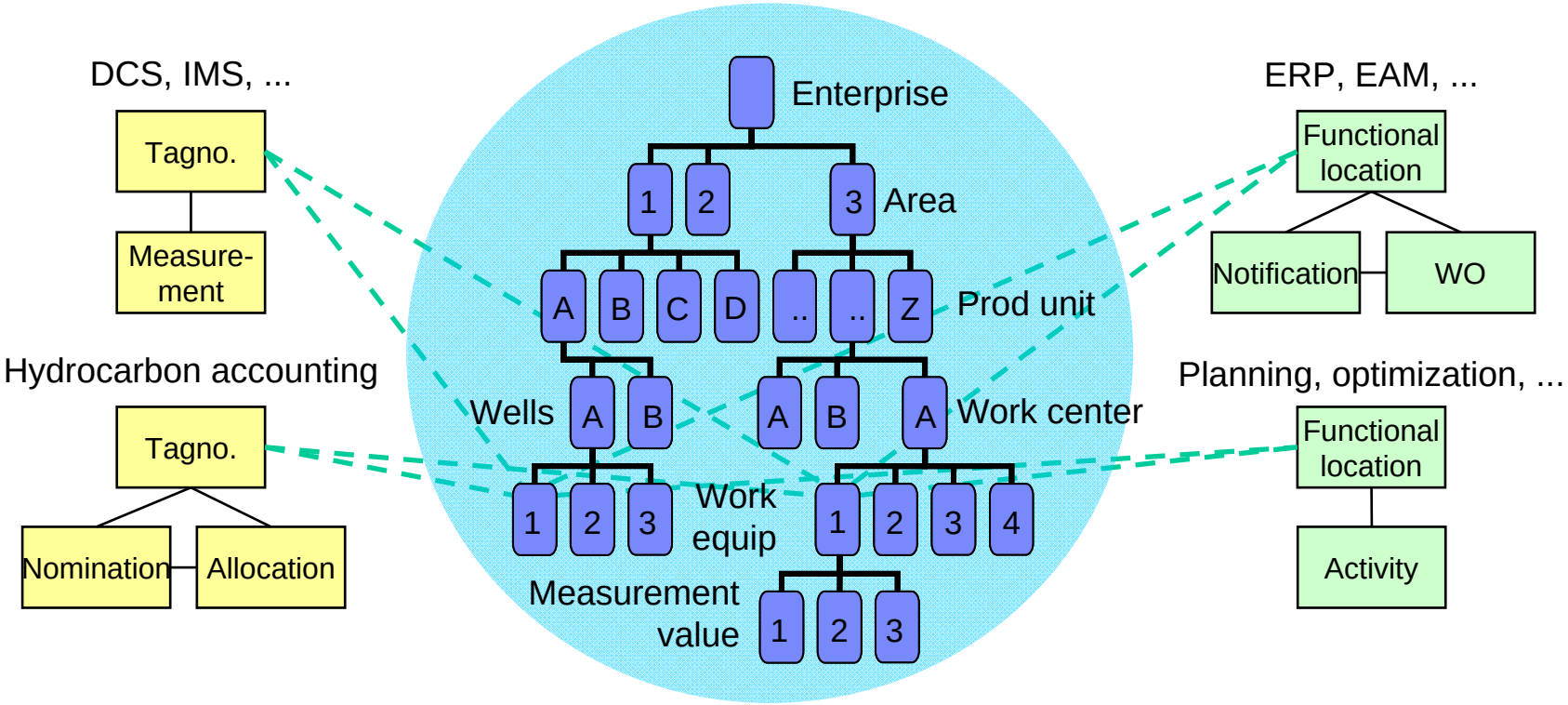
Represent the Reference Semantic Model (RSM) in ISO15926

This scope: Represent in ISO15926 the scope of the Reference Semantic Model (RSM) currently exploited by the F0B/GODI (TAIL) project



Examples of challenges targeted by the RSM and the IIF framework

- Part of real time transactional integration platform
- Access to information concerning the same object(s) even if the information is dispersed across many facilities and many applications
- An instance model providing a naming context for measurements across facilities



Reference Semantic Model

- An integrating information model for the oil & gas industry

Integrated Operations in the High North – Joint Industry Project

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Overview

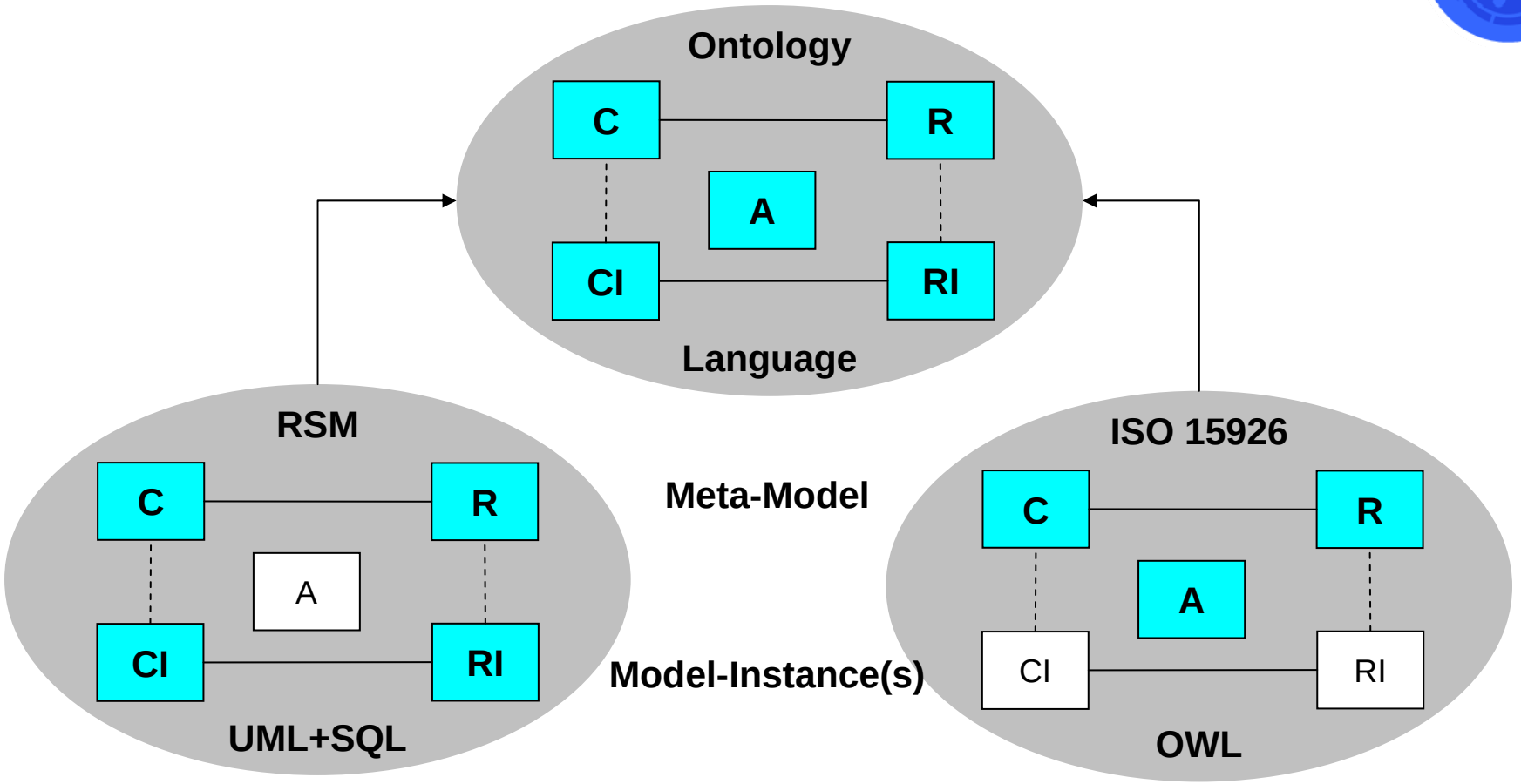
- **Why the Reference Semantic Model**

- Main elements of Refence Semantic Model
- Summary

Main aspects of the Reference Semantic Model

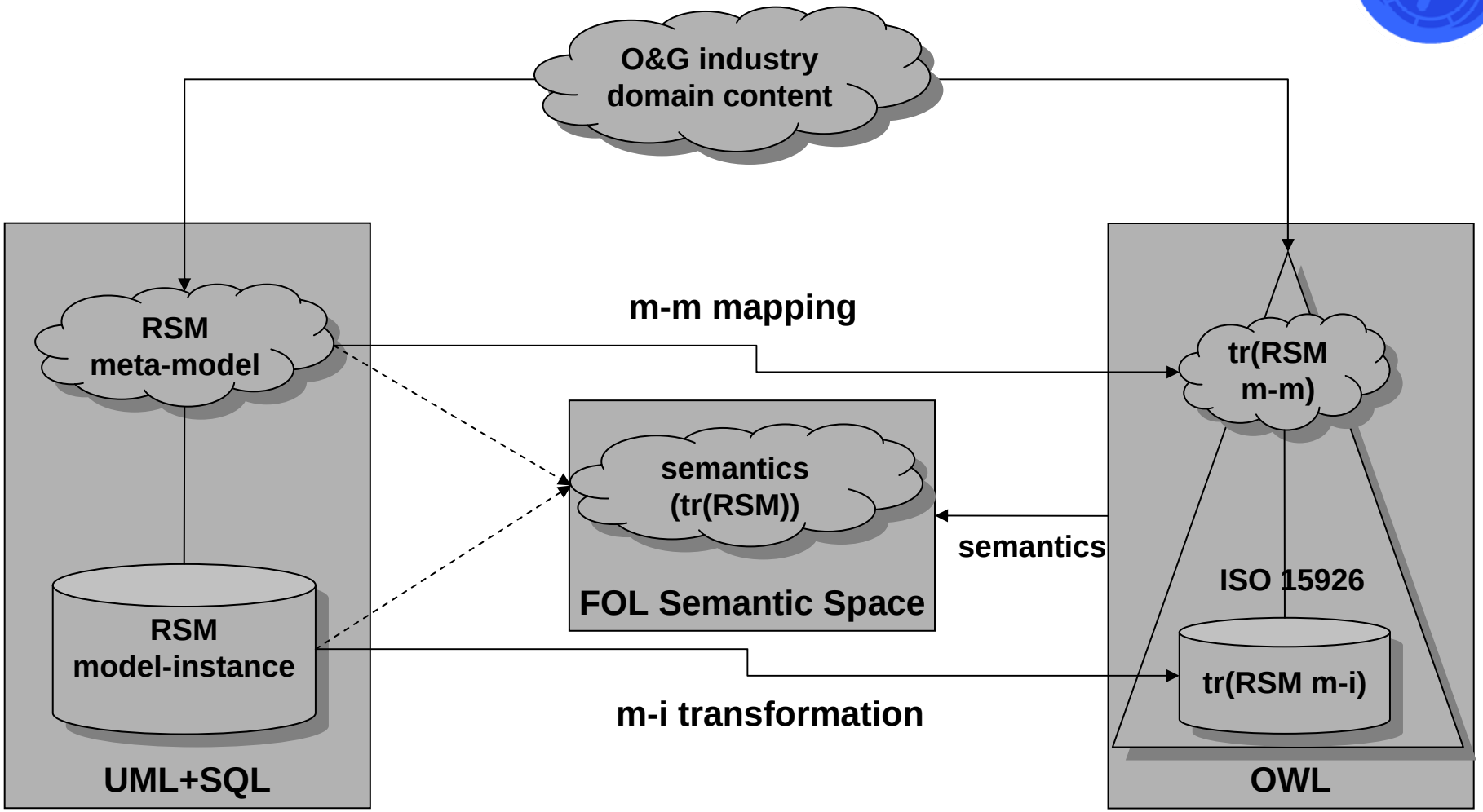
- Uniform representation of data/information flowing through the IIF
- Supports information needs of different applications
- Is a blend of different information model standards like ISA S88, S95, MIMOSA, ISO 15926
- The RSM is
  - defined as a UML meta-model
  - implemented as a relational database for storing model instance data

Clarifying terms and how they are used in RSM and ISO 15926



C = class, R = relation, A = axiom, CI = class instance, RI = relation instance

Semantics for RSM: by translation into ISO 15926



Why the term ‚Reference Semantic Model‘?

- Reference Semantic Model aims at
  - **richer content quantity** =/= higher content quality through
    - expanding the industry domain modeling scope
    - unification of relevant information models like S95, S88, MIMOSA
  - richer content quantity =/= **higher content quality** through
    - Reviews of UML master model
    - (semantics-defining) transformation to ISO 15926
    - exploiting semantics of OWL used as modeling language for ISO 15926

Overview

- Why a Reference Model
- **Main elements of Refence Semantic Model**
- Summary

Standards around RSM and IIF

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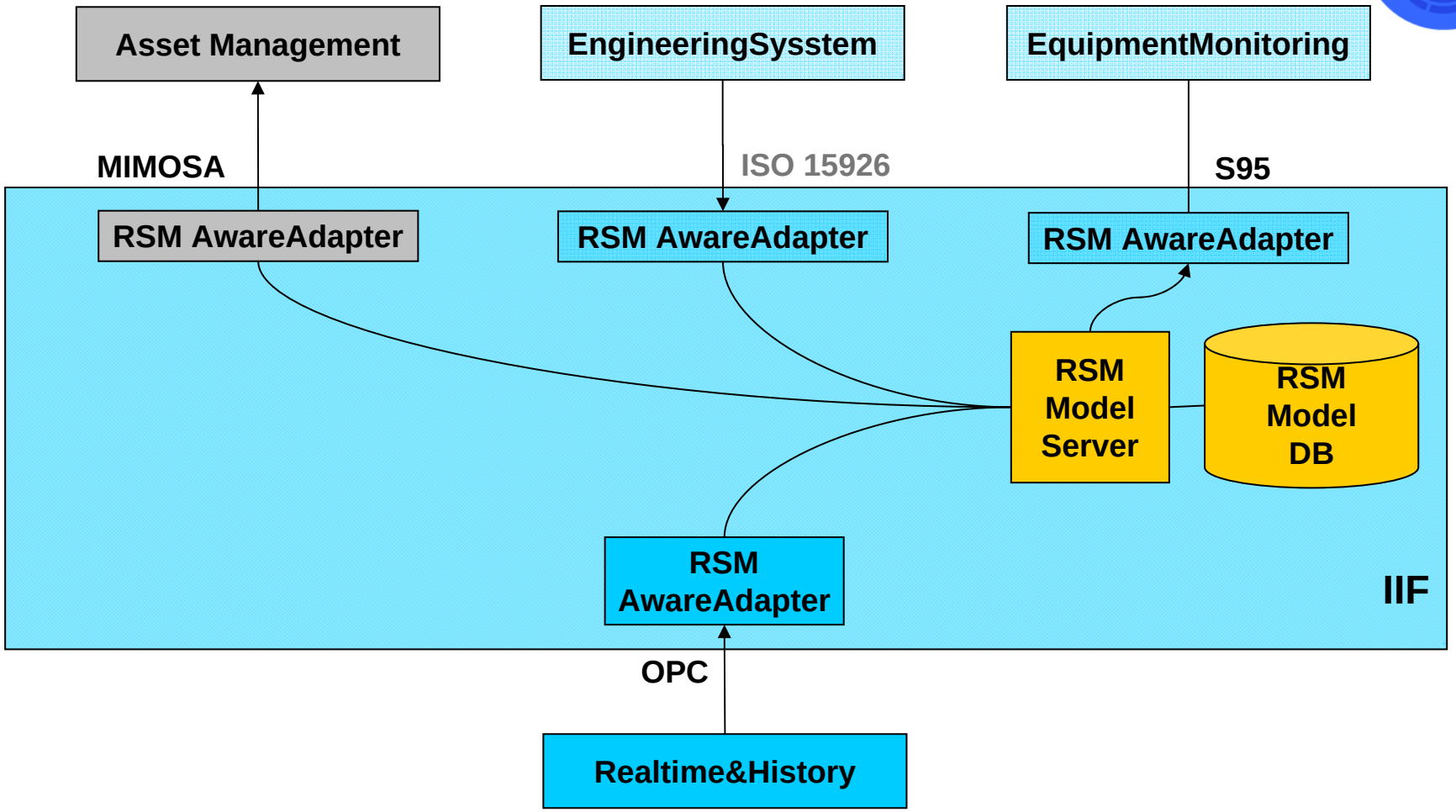

Standards around RSM and IIF

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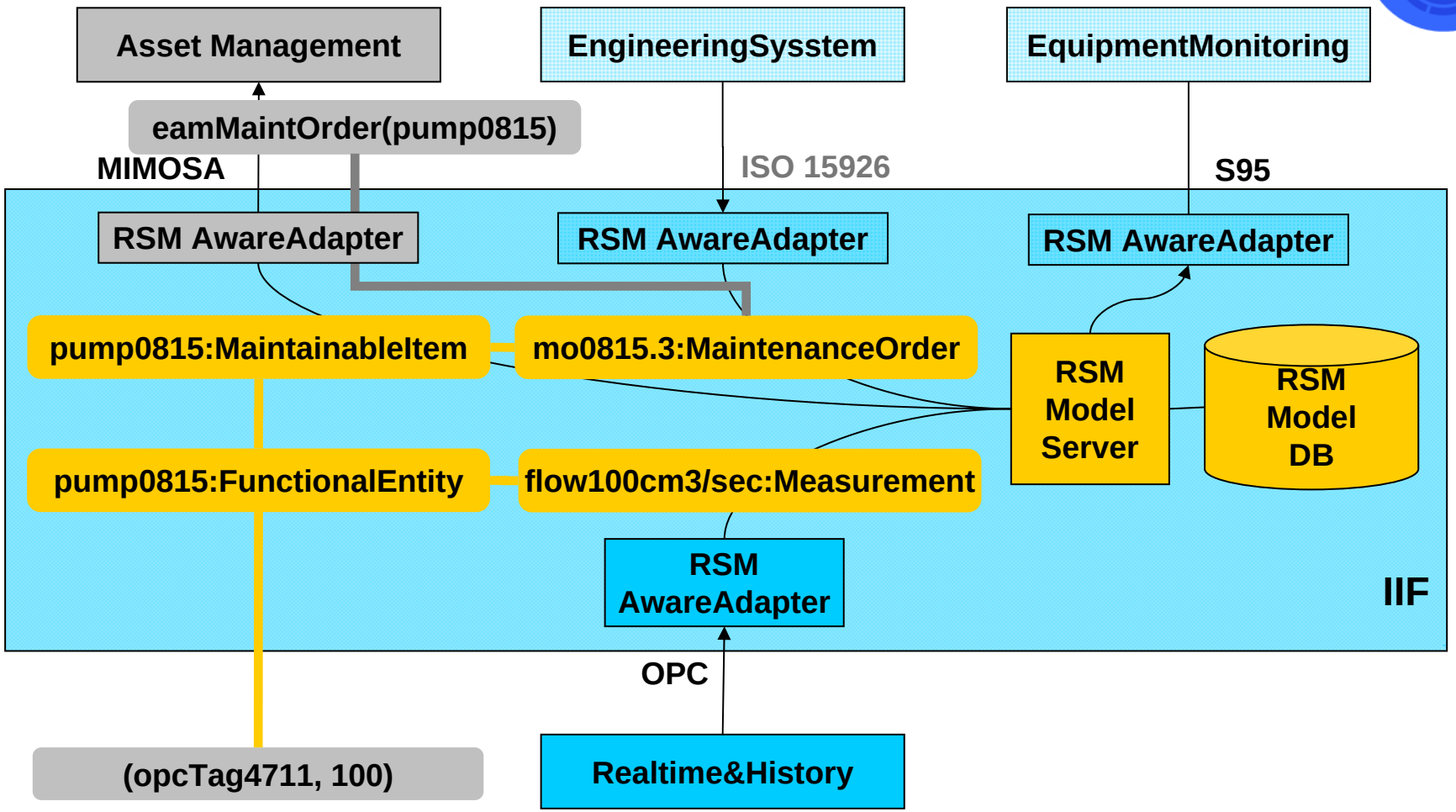
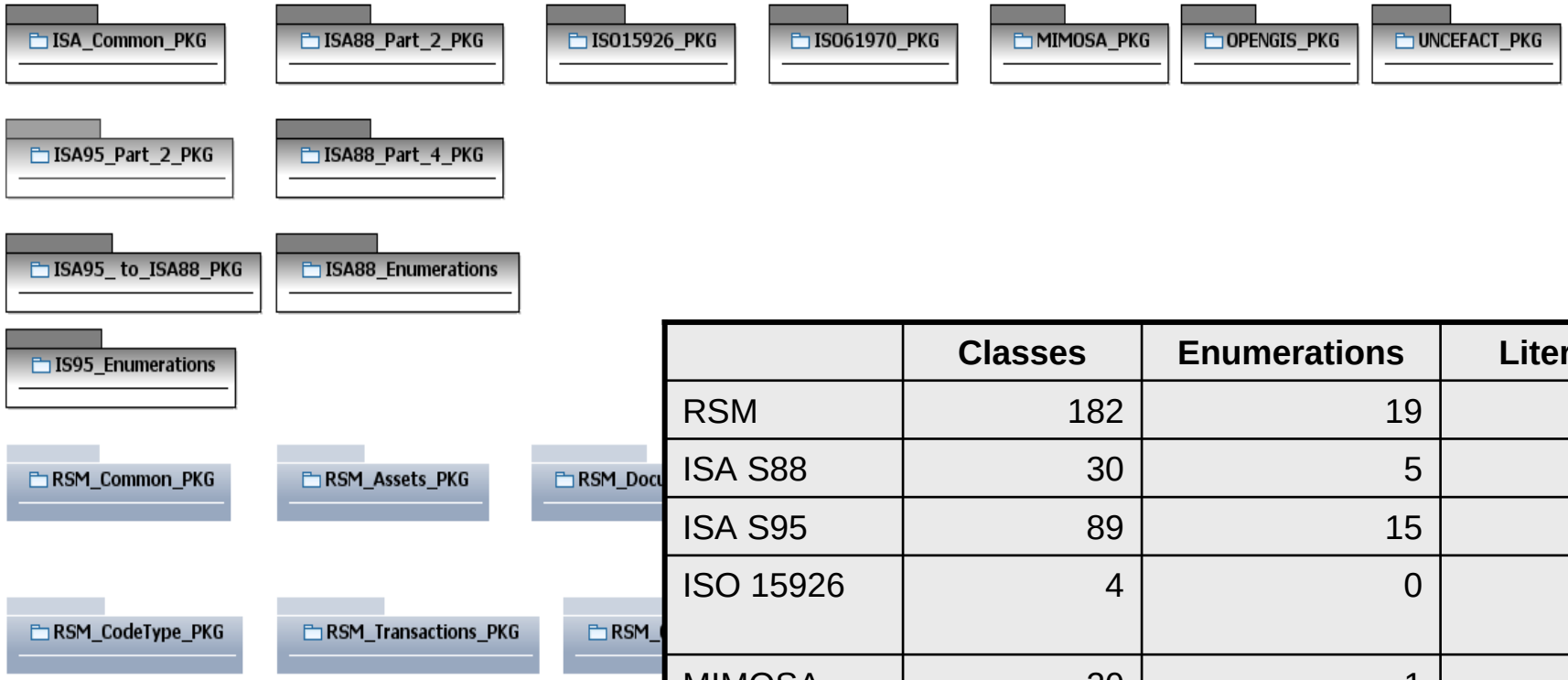


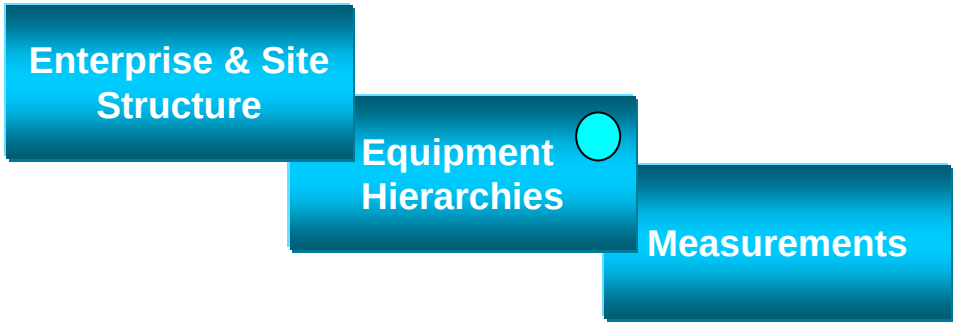
RSM main package collection



	Classes	Enumerations	Literals
RSM	182	19	~ 100
ISA S88	30	5	~ 100
ISA S95	89	15	~ 100
ISO 15926	4	0	0
MIMOSA	20	1	3
OPENGIS	38	6	~ 50
UNCEFACT	2	3	~ 800
Total	**365**	**49**	**1208**

Key aspects of O&M for oil & gas enterprises in RSM

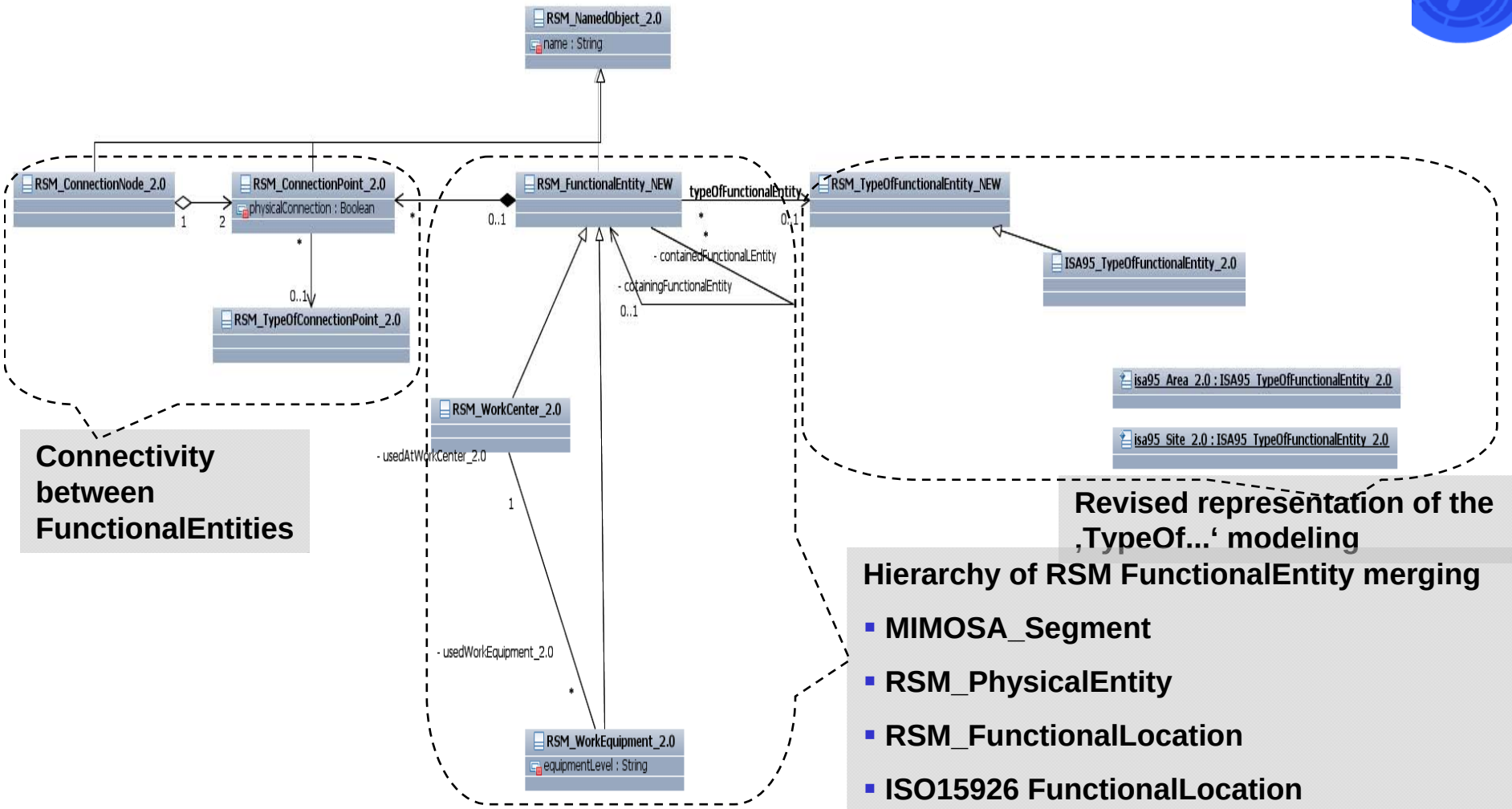
- Currently most exploited parts of RSM
- Main areas of RSM subject for ISO 15926 alignment
- Alignment means
  - Position RSM more precisely in the ISO 15926 ontology
    - ➔ RSM classes as subclasses of ISO 15926 classes
  - Import equipment classifications from ISO 15926 into RSM
    - ➔ ISO 15926 classes as subclasss of RSM classes
    - ➔ ISO 15926 classes as instances of RSM classes



Functional enterprise structure

- Objectives of the RSM and ISO 15926 alignment effort
  - The intended representation aimed at capturing
    - the functional entities in an enterprise
    - the accountable assets – including a view of the physical specimen
  - Unify RSM, ISA, ISO 15926, and MIMOSA terminology
  - Capture a notion of connectivity between functional entities
  - Simplify RSM modeling to eliminate redundancies
  - Adapt the ‚TypeOf...‘ representations for better alignment with ISO 15926

Functional enterprise structure



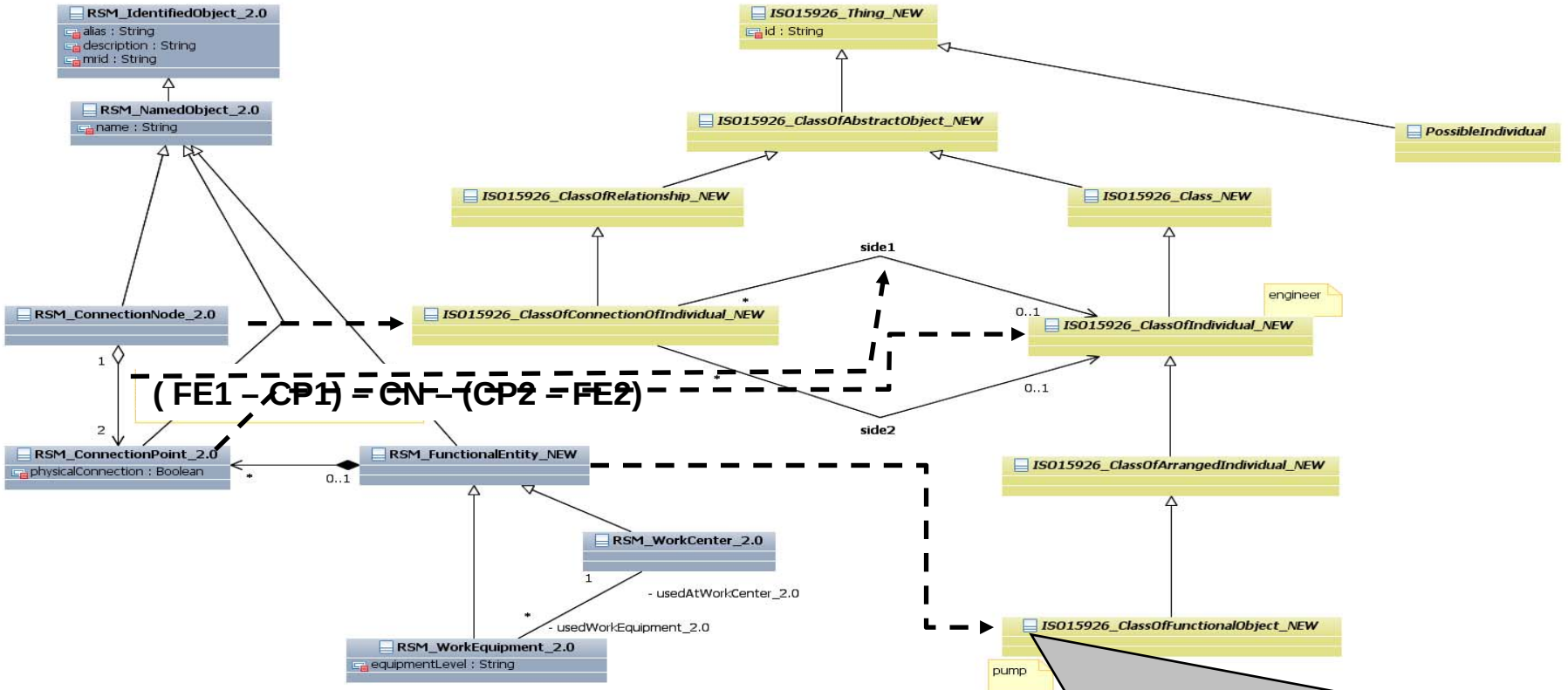
Connectivity between FunctionalEntities

Revised representation of the ‚TypeOf...‘ modeling

Hierarchy of RSM FunctionalEntity merging

- **MIMOSA_Segment**
- **RSM_PhysicalEntity**
- **RSM_FunctionalLocation**
- **ISO15926 FunctionalLocation**

ISO 15926-to-RSM alignment for functional entities



Both models have detailed model elements for functional structure
➔ close links are possible ➔ better mechanical translations

The ‚TypeOf...' construction - I

- In the RSM there are many different types of
  - OrganizationalEntity
  - **FunctionalEntity**
  - Asset
  - . . .
- In ISO 15926 those types of ... are represented as classes in the meta-model
- Adopting this approach for RSM
  - is highly highly interesting, since it allows for exploiting ISO 15926 equipment classification
  - has to be done with care, because, e.g.,
    - ISO 15926 has 10.000+ equipment types represented as OWL classes
    - Representing each such OWL class per equipment type as a UML class in RSM would lead to 10.000+ sparsely populated DB tables

Equipment type modeling:
- instances vs subclasses – original RSM approach

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Meta-model

Equipment
tOE : TypeOfEquipment

TypeOfEquipment
rdlURL : String

motor:TypeOfEquipment

pump:TypeOfEquipment

valve:TypeOfEquipment

instances

Database

Equipment		
name	**desc**	**type**
motor1		motor
...		motor
m10000		motor
pump1		pump
...		pump
p10000		pump
valve1		valve

One big table:
many queries run against large amounts of data

original RSM

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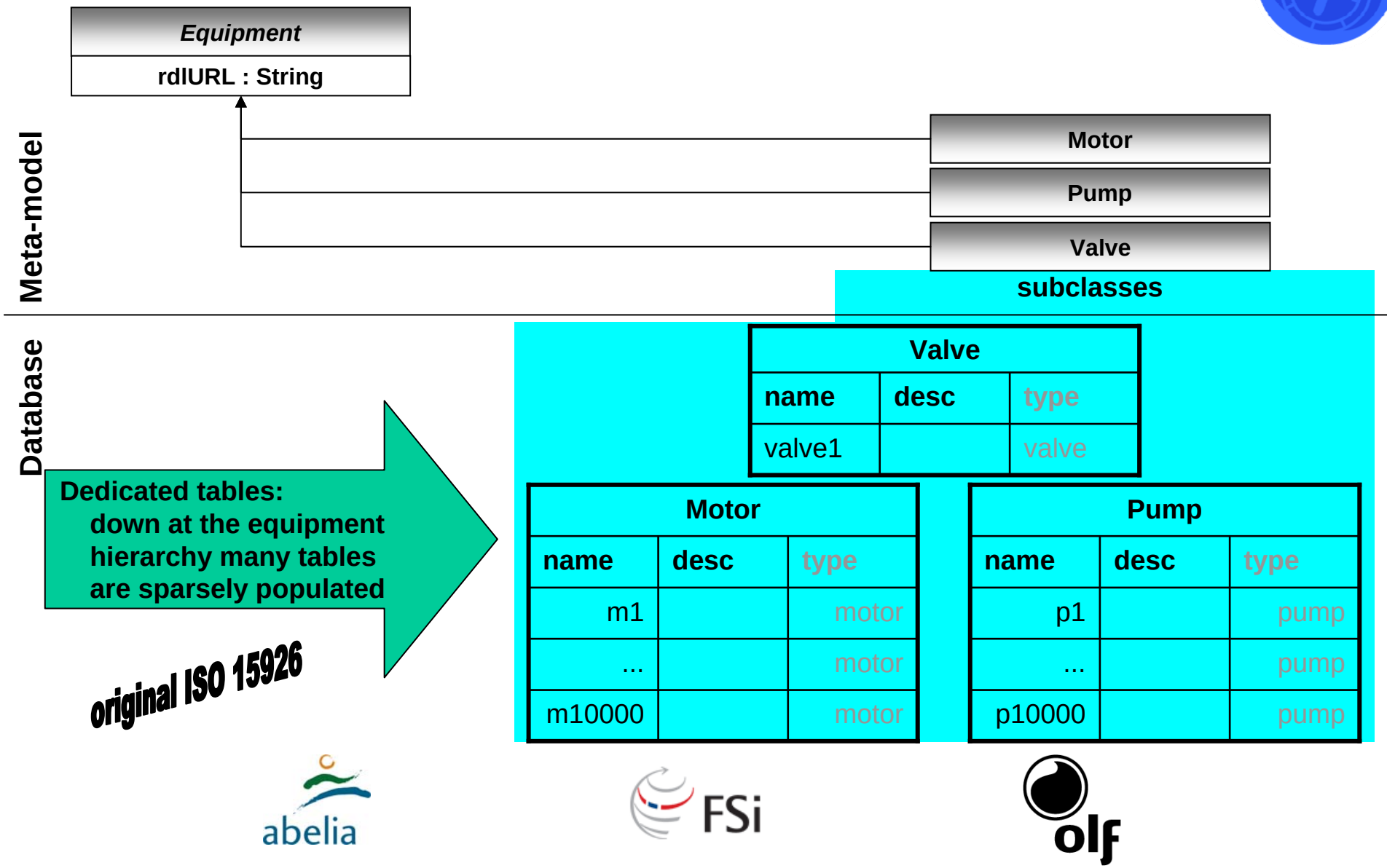
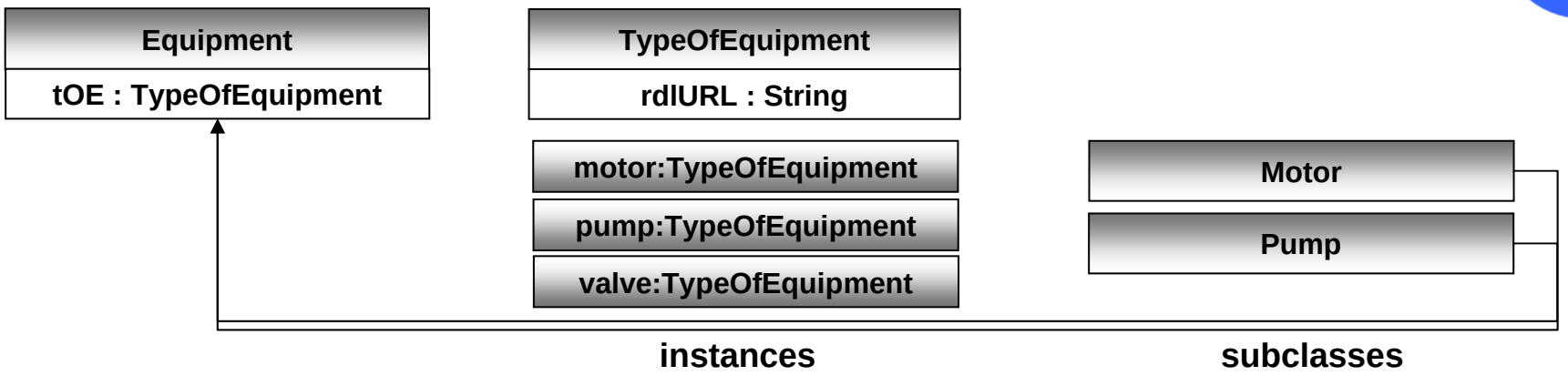
Equipment type modeling:
- instances vs subclasses – original ISO 15926 approach

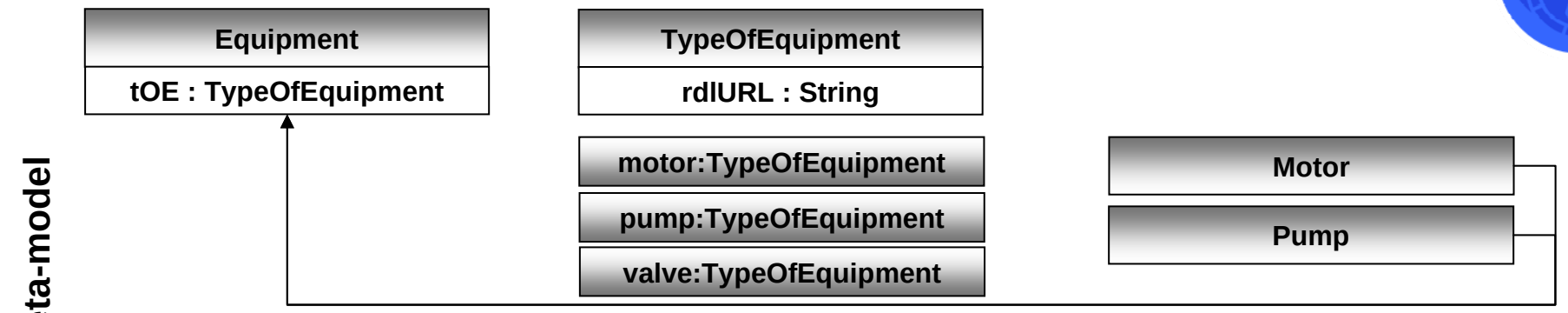


Equipment type modeling:
- instances vs subclasses recommendation



ISO 15926 and RSM alignment allows for a combined ‚TypeOf...' modeling approach
- ➔ **subclassses for equipment types with high population**
- ➔ **just type instances for equipment types with low population**

Equipment type modeling:
- instances vs subclasses as recommended



Database

instances

Equipment		
name	**desc**	**type**
valve1		valve

subclasses

Motor		
name	**desc**	**type**
m1		motor
...		motor
m10000		motor

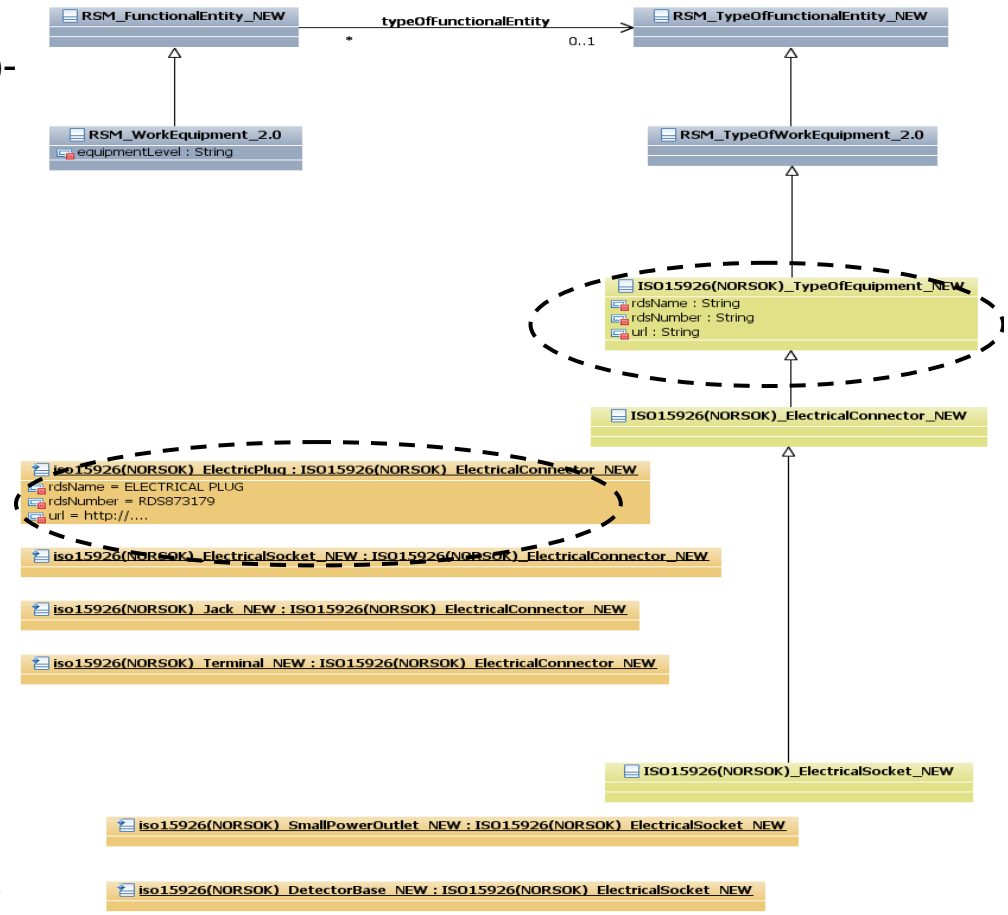
Pump		
name	**desc**	**type**
p1		pump
...		pump
p10000		pump

The ‚TypeOf...' construction - II

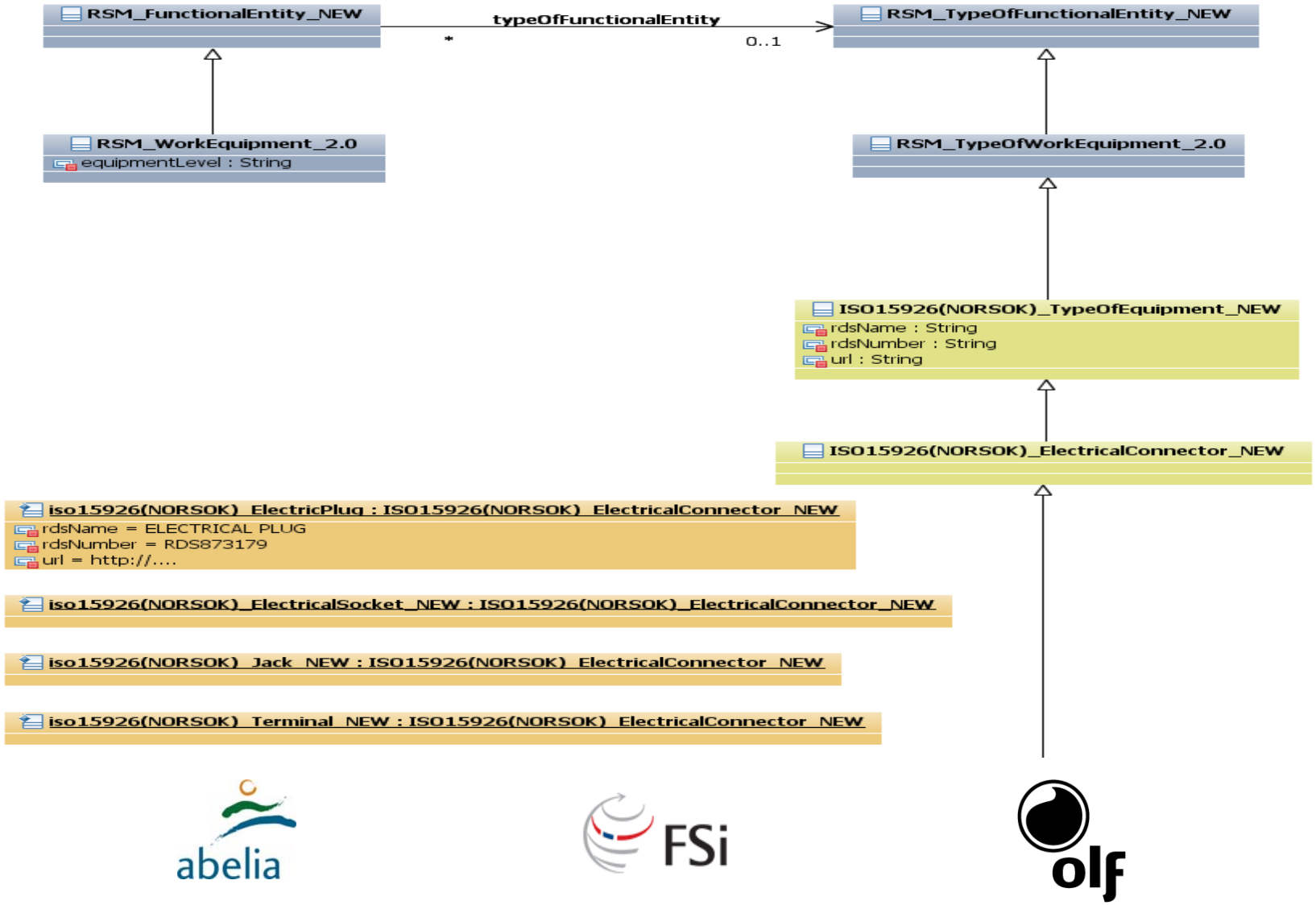
- Adopting the ISO 15926 modeling approach strictly for RSM, the equipment types are sub-classes of RSM_WorkEquipment

- The chosen approach for RSM 2.0 is more flexible in the sense of
  - Modeling the ISO 15926 equipment type hierarchy through RSM classes ‚down to a reasonable' level of detail
    - ➔ if large numbers of certain equipments suggest separate tables per equipment type

  - Modeling ISO 15926 equipment types as instances of class RSM_TypeOfWorkEquipment
    - ➔ if small numbers of certain equipment types suggest a single table for equipment of different types



Detailed UML diagram view



Overview

- Why a Reference Model
- Background Reference Semantic Model
- Main elements of the Refence Semantic Model

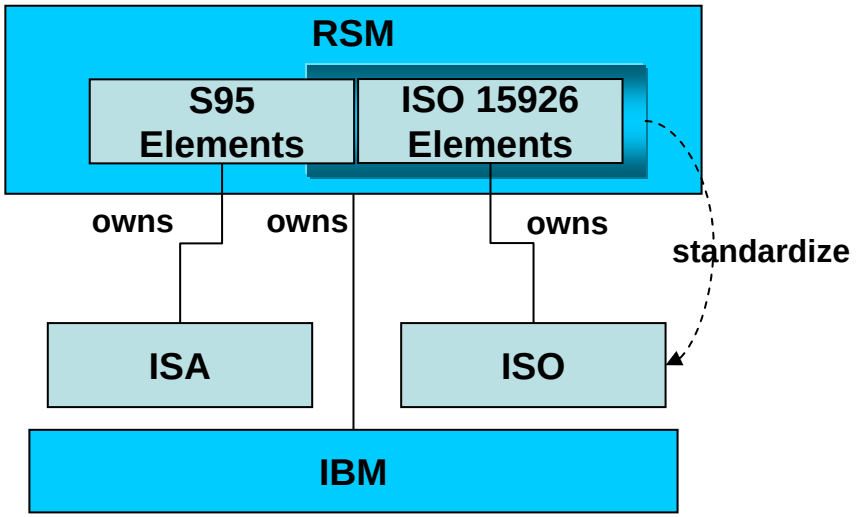
- **Summary**

Two interesting threads to bring RSM forward

- Gain acceptance for RSM through established standardization bodies
  - The standards integration approach of RSM considered meaningful
- Expand the scope of RSM to provide improved integration support through IIF
  - Understand integration and information model alignment needs along the processing chain

RSM and its parent standards

- Parent standards are established as industry standards
- RSM is not yet standardized
- Its nature as a mesh-model combining other standards implies
  - **Portions of RSM ‚close enough' to parent standard could be standardized by the organization owning the parent standard**
  - Standardizing RSM may also trigger parent organizations cross-accepting other standard's models



Standardize RSM

➔ to obtain acceptance of RSM based applications by POSC Caesar and ISO
➔ to assure better interoperability with systems based on RSM parent standards

Number of existing standards prohibitively high to incorprate all of them into RSM

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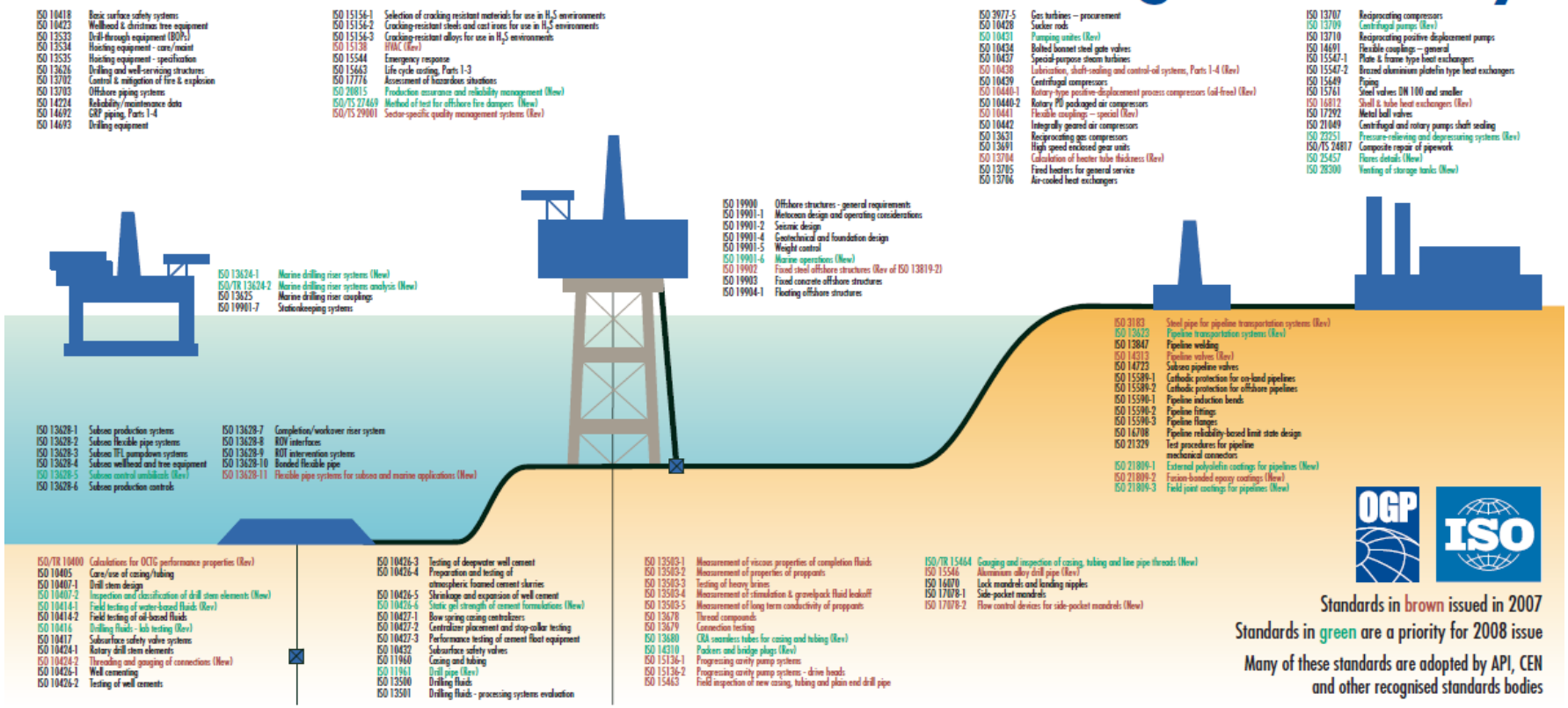
ISO Standards for use in the oil & gas industry



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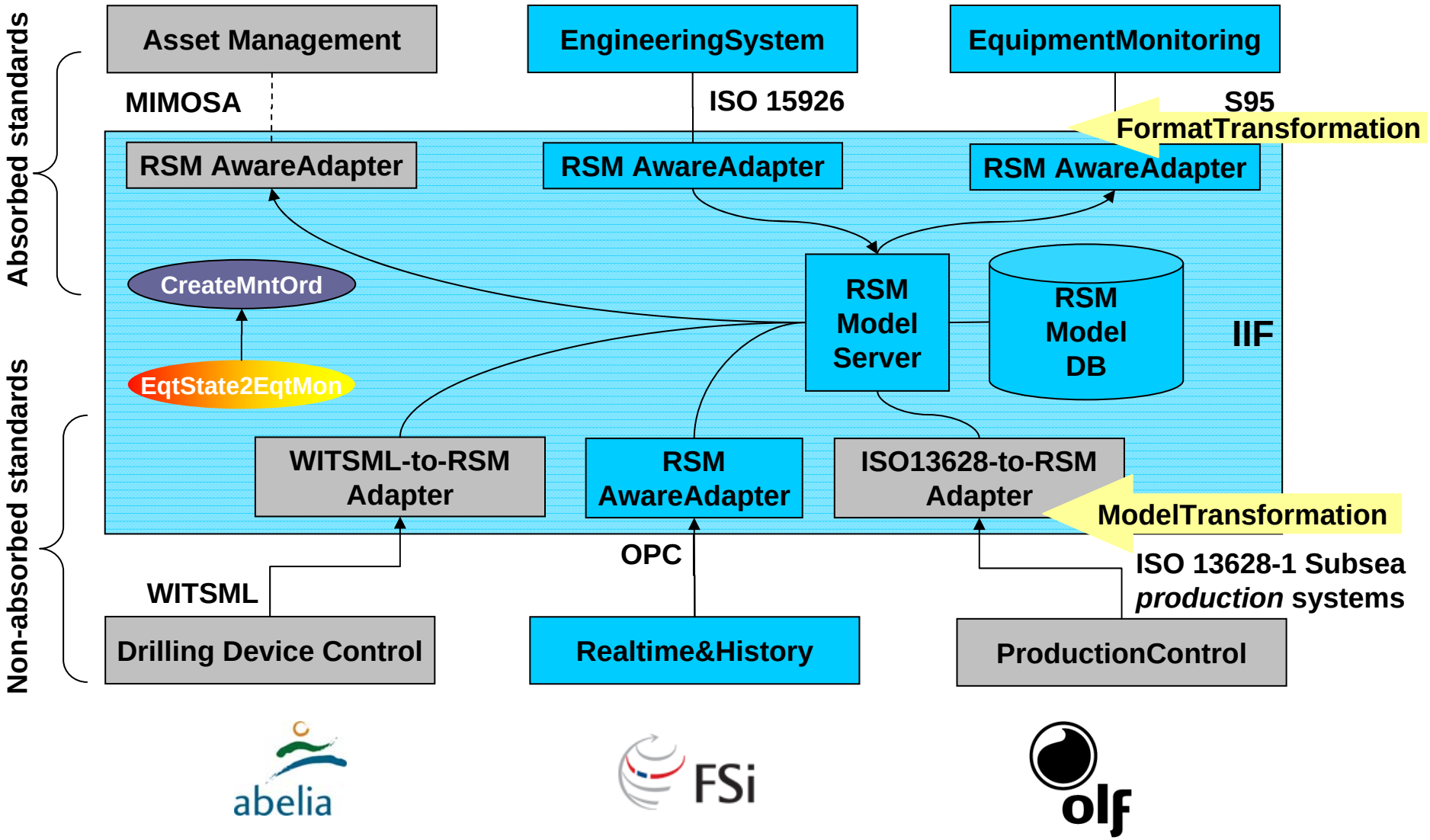
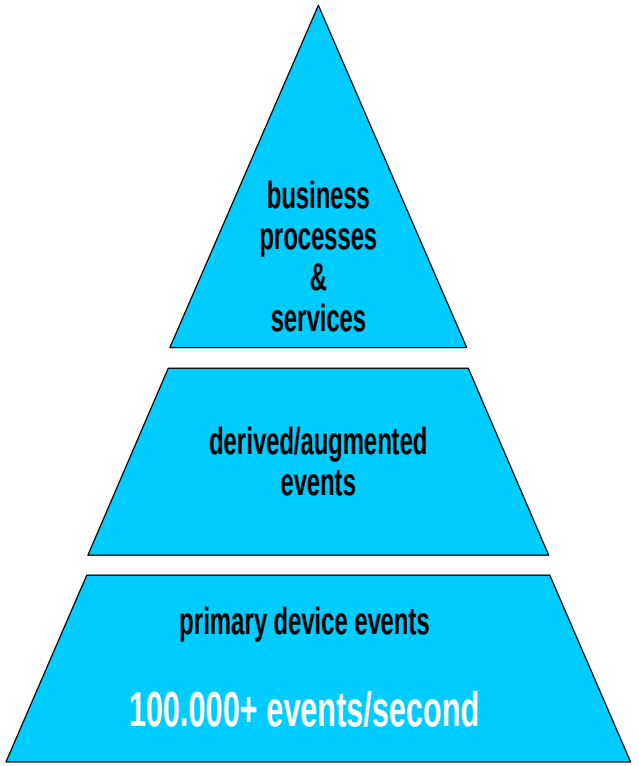
Standards around RSM and IIF



‚To absorb' or ‚Not to absorb'?

- (Partially) absorbed parent standards
  - Allow for simpler transformation between IIF and applications relying on parent standard
    ➔ format transformation in adapters
  - ‚Absorption' means static model alignment
- Non-absorbed (further) parent standards
  - Require more complex transformations
    ➔ model transformation inside adapters
  - ‚Non-absorption' requires dynamic model transformation
- Expand parents standard integration for applications that exchange information with IIF at the bottom of the event processing pyramid
  - good candidates are PRODML/WITSML



Exploitation and evolution of RSM

- StatoilHydro TAIL project
  - Gain practical experience and prove applicability
- Streamline RSM content and align with ISO 15926
  - Gain acceptance through established standardization bodies
- Absorb elements from further standards
  - Assure wider scope of usage

Alignment to ISO 15926

Integrated Operations in the High North – Joint Industry Project

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IOHN Activity 3 overall objective

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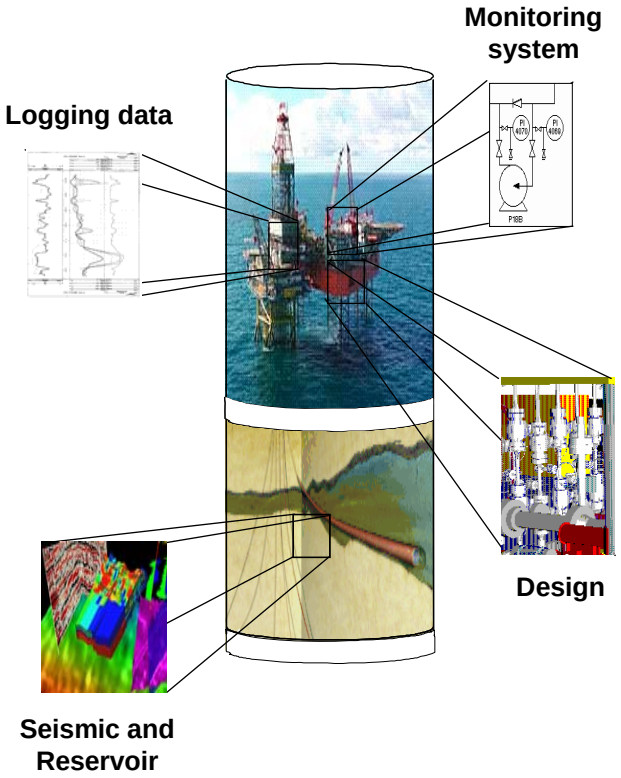

Based on requirements from the pilot projects and project participants:

- Extend and improve the content and quality of the ISO 15926 Reference Data Library (RDL)
- Develop a prototype information validation service

ISO 15926 – *Integration of life-cycle data for process plants including oil and gas production facilities.*

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Domain specific reference data

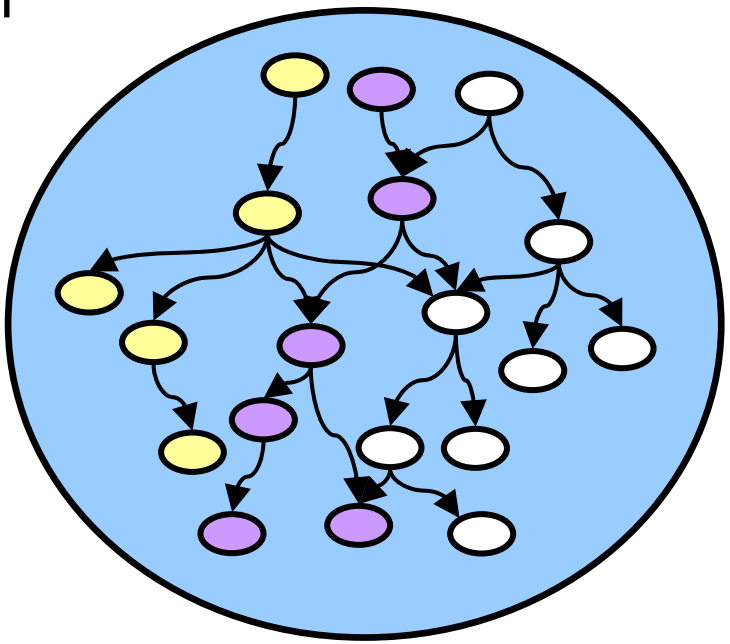
Domain specific nomenclatures

- Drilling
- Production and Reservoir
- Operations and Maintenance

ISO 15926*

Structure and add to ISO 15926 Reference Data Library (RDL)

Oil and gas ontology (Reference Data)



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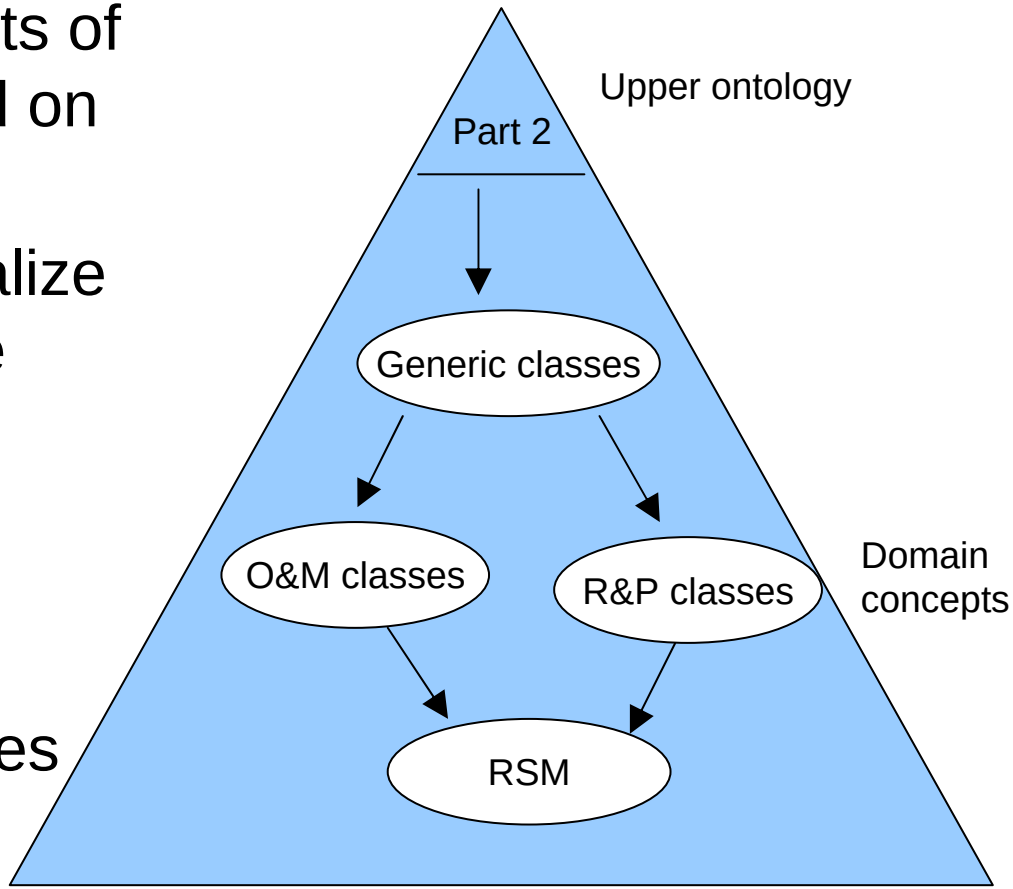
‘RSM in ISO 15926’ means two things

- The RSM UML model in ISO 15926 Reference Data Library
  - Represented as an ISO 15926 ontology
  - RSM classes are mainly specializations of O&M, P&R classes

- Export/import data between IIF/RSM systems and ISO 15926 format
  - RSM content provided with RDL classification
  - On demand production of exchange-friendly instance data

RSM *model* in the ISO 15926 RDL hierarchy

- Domain-specific parts of the PCA RDL depend on generic parts
- RSM classes specialize RDL classes from the IOHN Activity 3 information scope
- The RSM model representation effort introduced new classes to the RDL



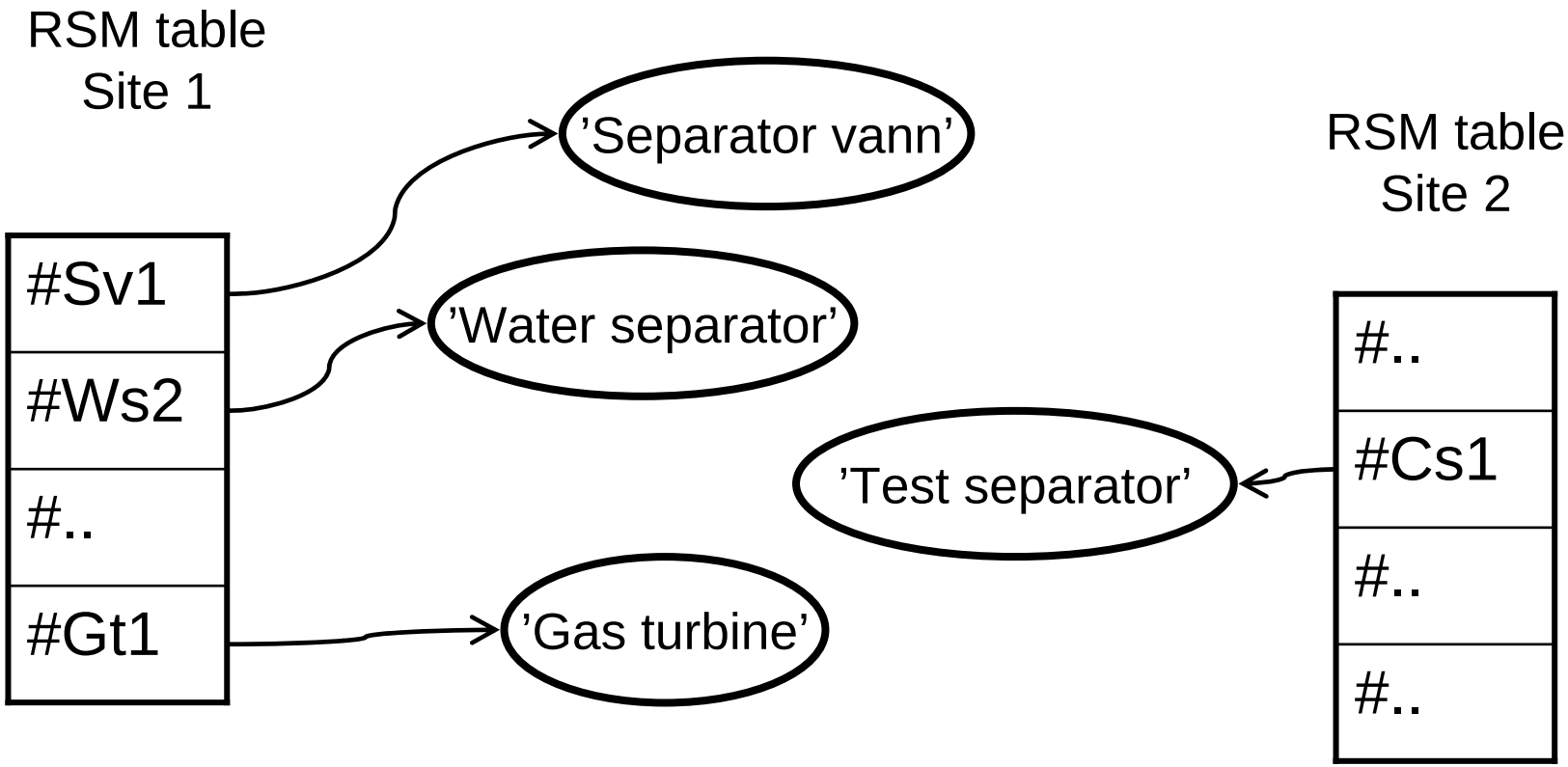
Work carried out in IOHN Activity 3

- Modelling using Protégé OWL workbench and Rational Software Architect
- RSM UML model entities represented as RDL classes and relations
- Complex mappings expressed in ISO 15926-7 templates
- Mappings tested using Template Expander tool
- The RSM classes uploaded to the RDL

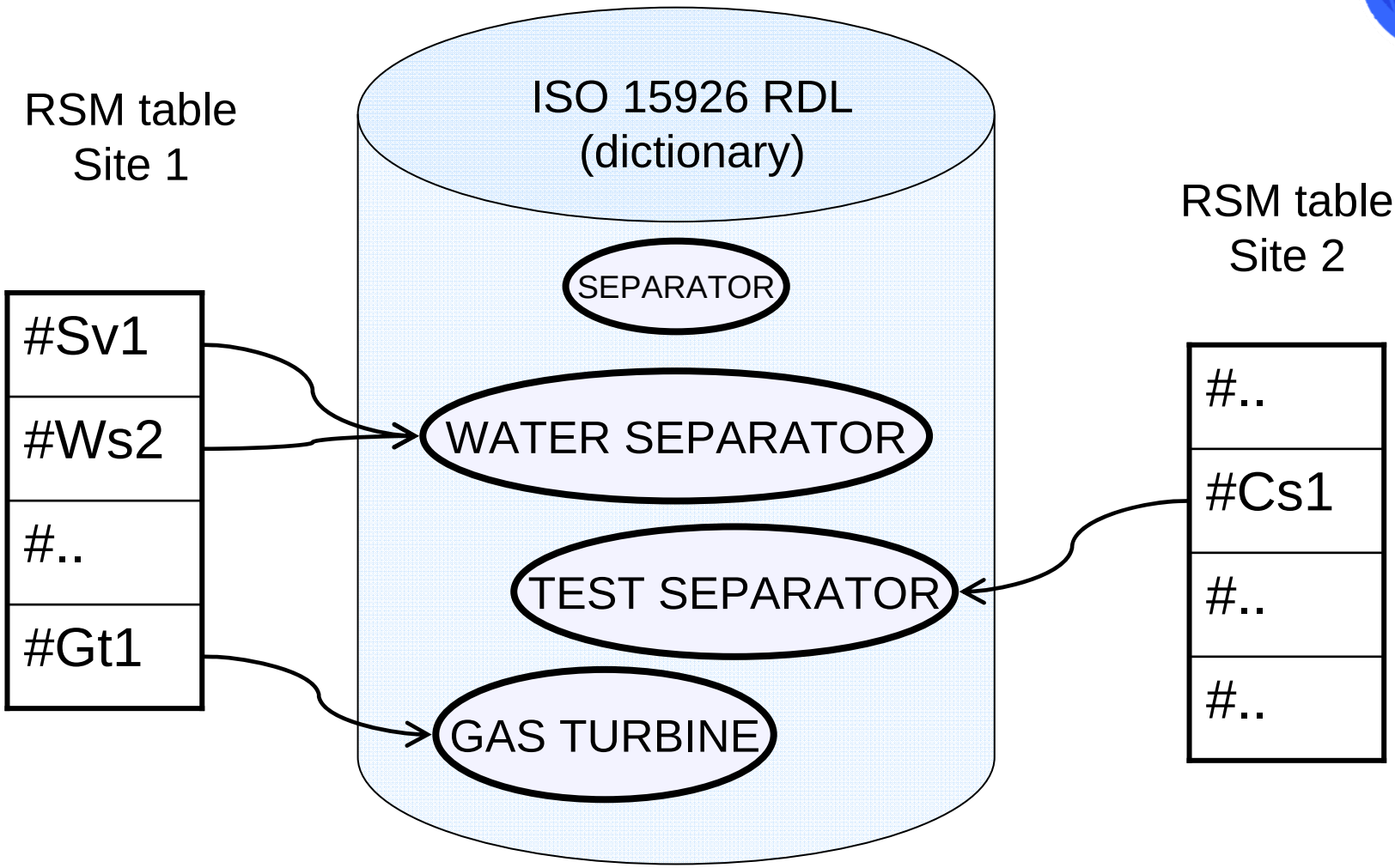
Three generic levels of *data* alignment

- Dictionary: Explanation
  - *apply reference definition to things*
- Taxonomy: Aggregation
  - *generic/specific categories of things*
- Ontology: Relation
  - *identify things that are related in various ways*

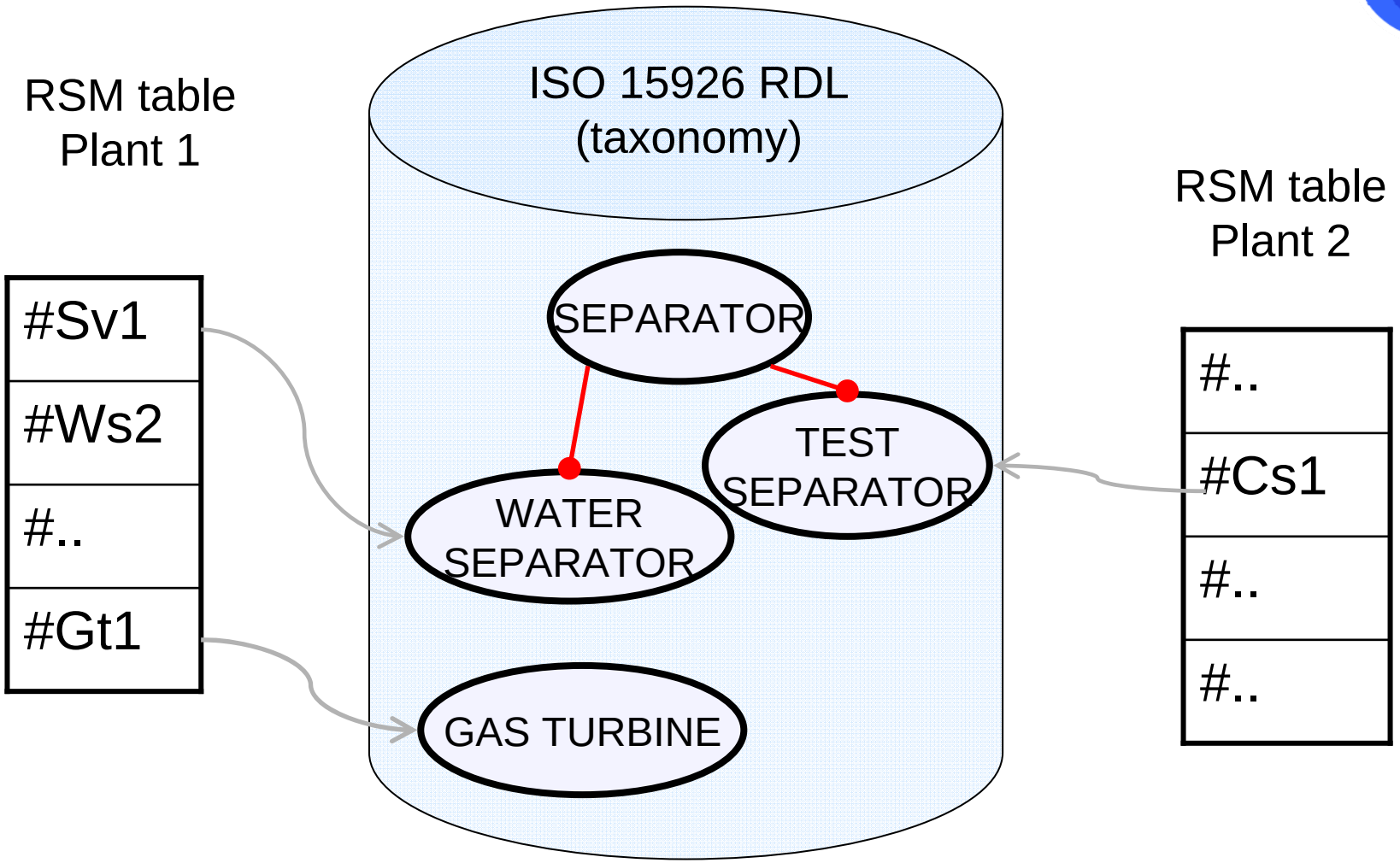
Current classification isn't uniform



Dictionary alignment:
Apply common terminology

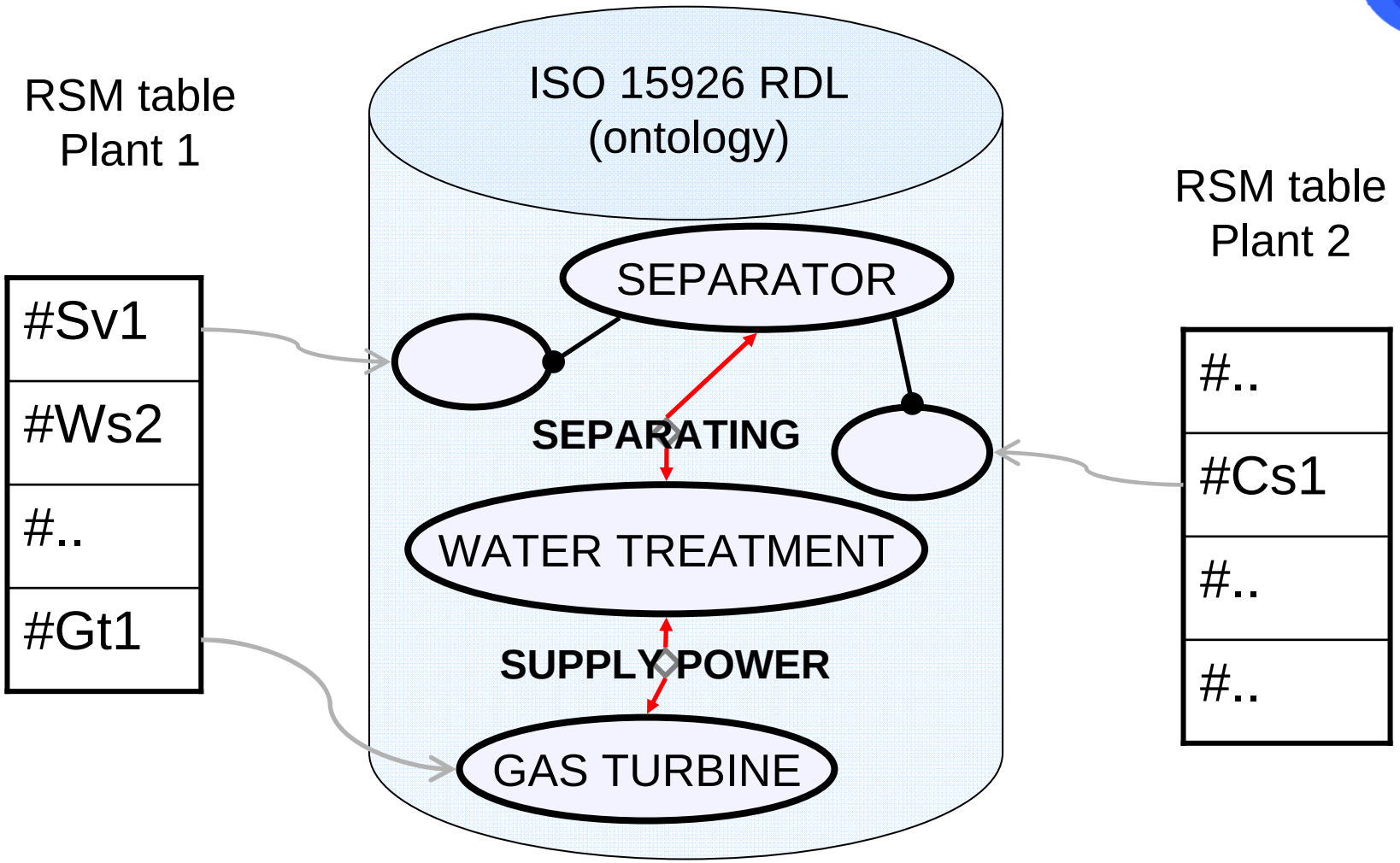


Taxonomy alignment:
Discover additional knowledge



Ontology alignment

Knowledge discovery along arbitrary dimensions



Mapping complex patterns

- Several constructions in the RSM scope require information assemblies of more than one element
  - *E.g. Connections, measurements, properties*
  - For a meaningful interpretation, several pieces of information have to be considered together.
  - The *dictionary*, *taxonomy*, *ontology* alignment levels apply also to patterns of information

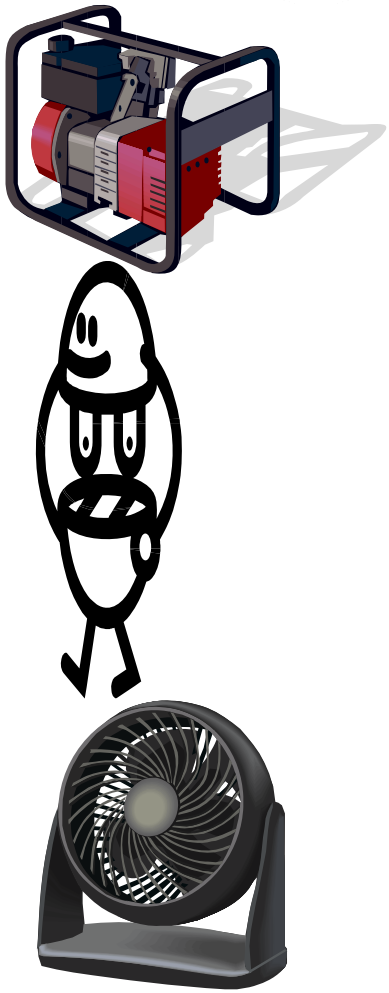
- RSM and ISO 15926 represent things differently

ISO 15926 Templates

- *Part 7* is a new addition to ISO 15926
- A template captures a pattern for stating facts
- Signature – Rule (Axiom):
  - The template signature specifies the input arguments
  - The template rule specifies what statement is made, expanding to explicit ISO 15926 format
  - Template rules allow for interpretation as first-order logic axioms

Example: Connections

- *Typical information in an RSM database: A generator is connected to power a fan.*
- *The general case is: Pieces of equipment are connected.*
- *We want to present such connection information in the ISO 15926 space as well.*

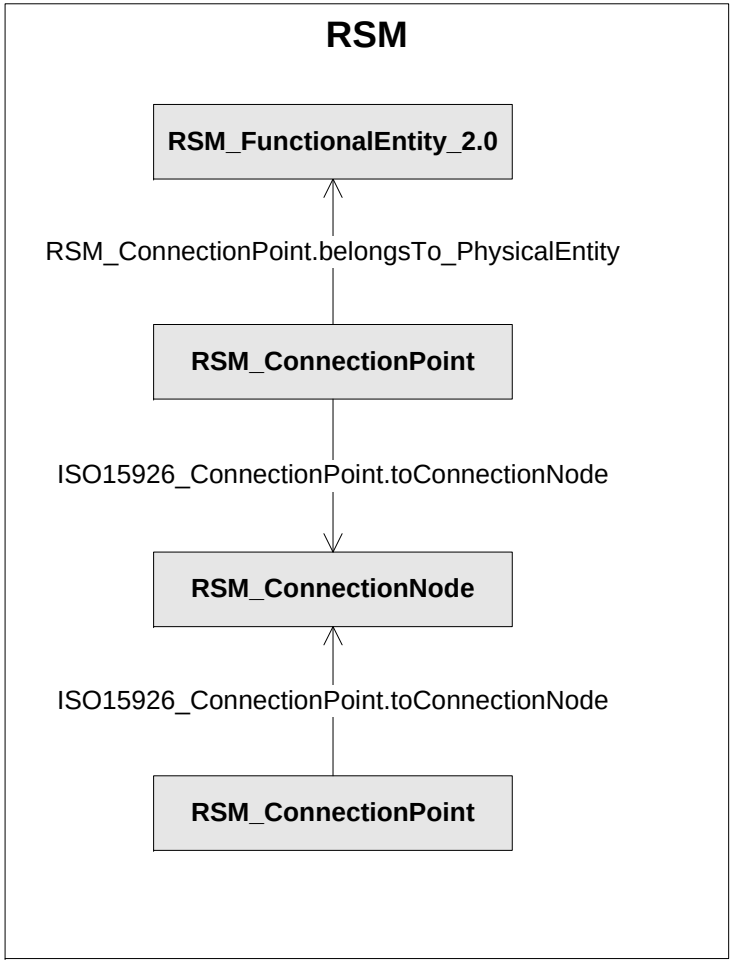


Connections in RSM

We need to consider the RSM classes

- Functional Entity
- Connection Point
- Connection Node

and relations between them.

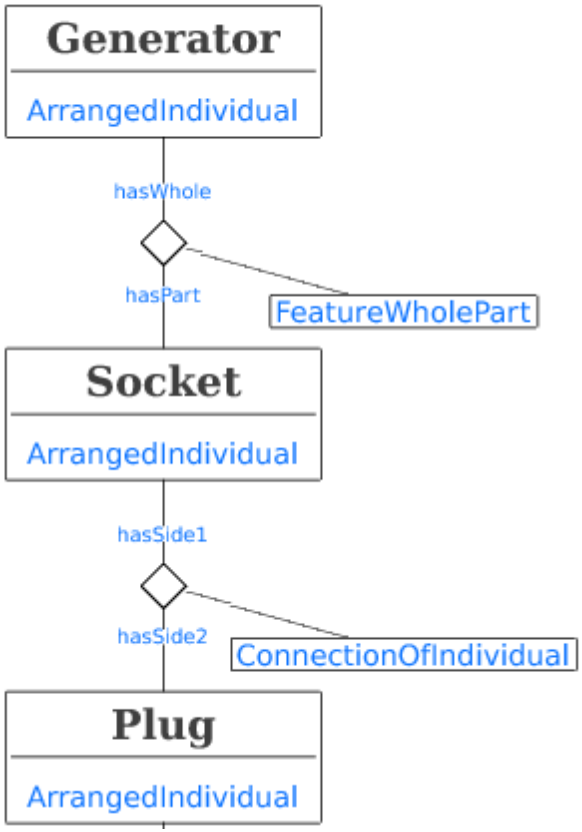


Connections in ISO 15926

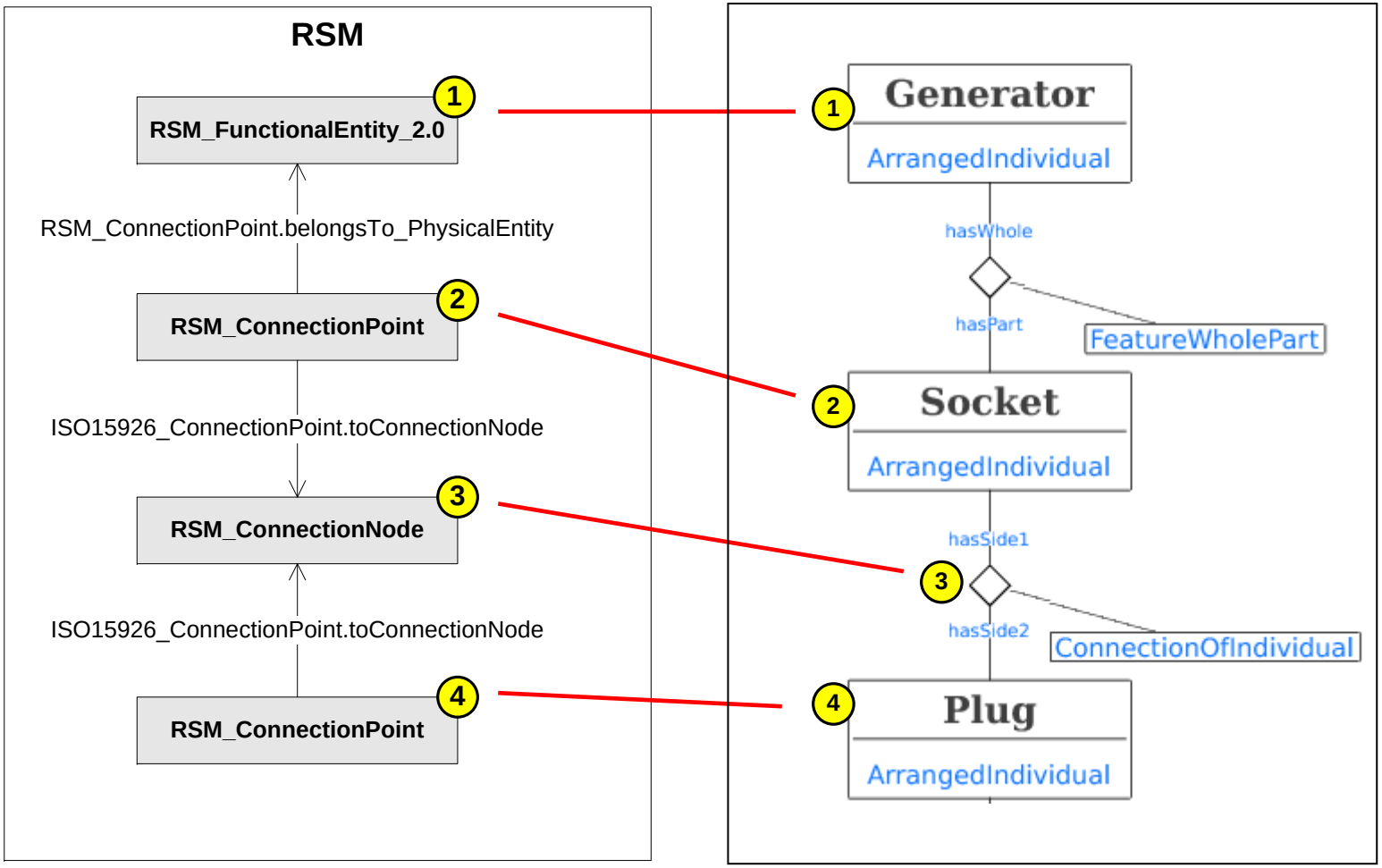
We need to consider the ISO 15926 entity types

- ArrangedIndividual
- FeatureWholePart
- ConnectionOfIndividual

and relations.

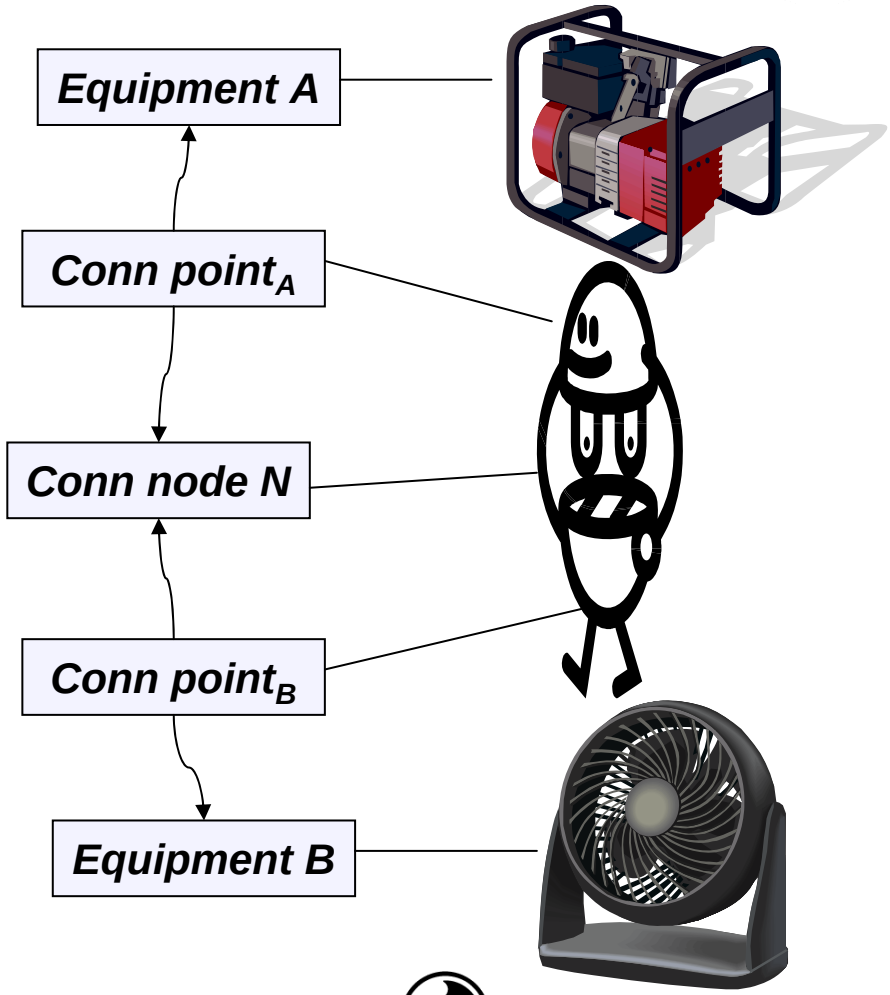


Alignment: Connections



Connections: RSM representation

- There are two pieces of equipment, *A* and *B*.
- There is a connection *N* between *A* and *B.*
- Connection points *CA*, *CB* represent equipment parts that participate in the connection
- *N* is the connection itself

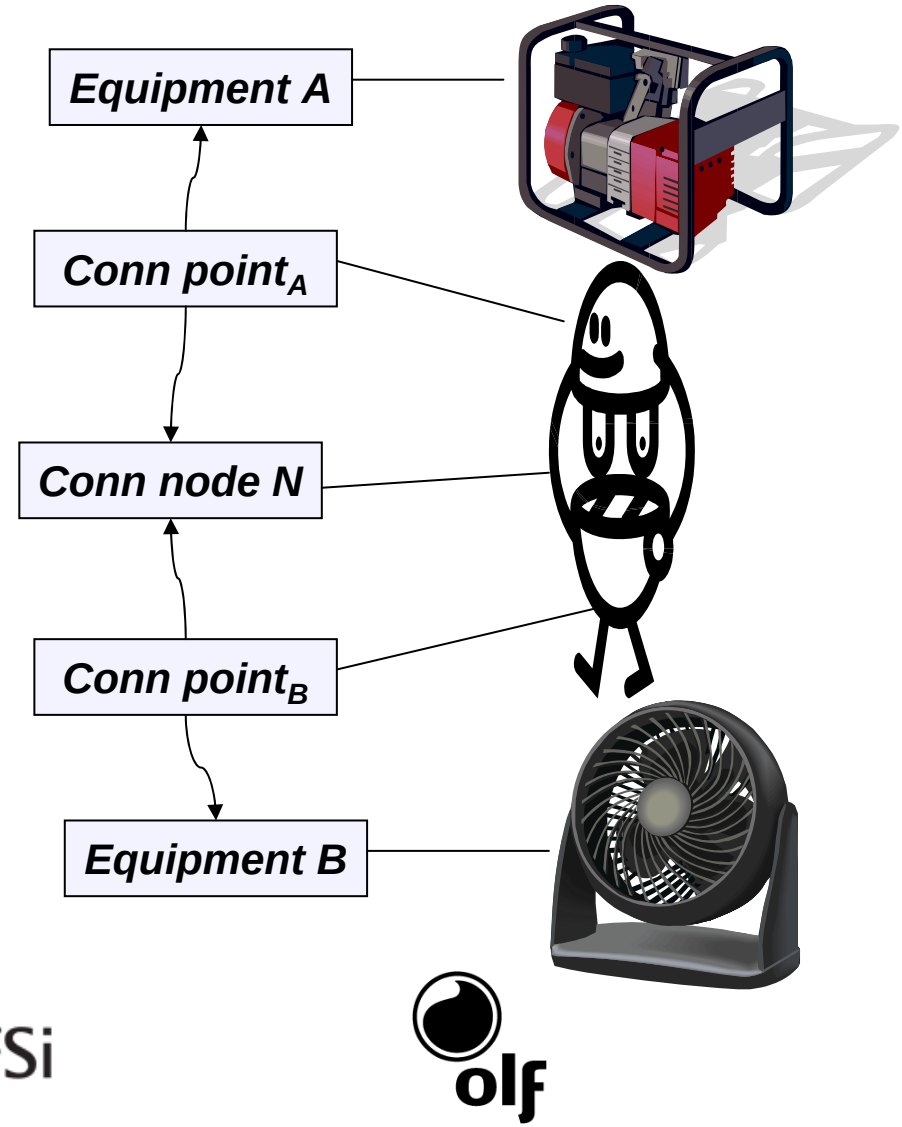


Template signature: Input arguments

RSMFunctionalEntityConnection

#	*Role*	*Type*
1	Entity 1	ArrangedIndividual
2	Entity 2	ArrangedIndividual
3	Conn. pt. 1	ArrangedIndividual
4	Conn. pt. 2	ArrangedIndividual
5	Connection	ConnectionOfIndividual

This signature defines a table for recording RSM connections.



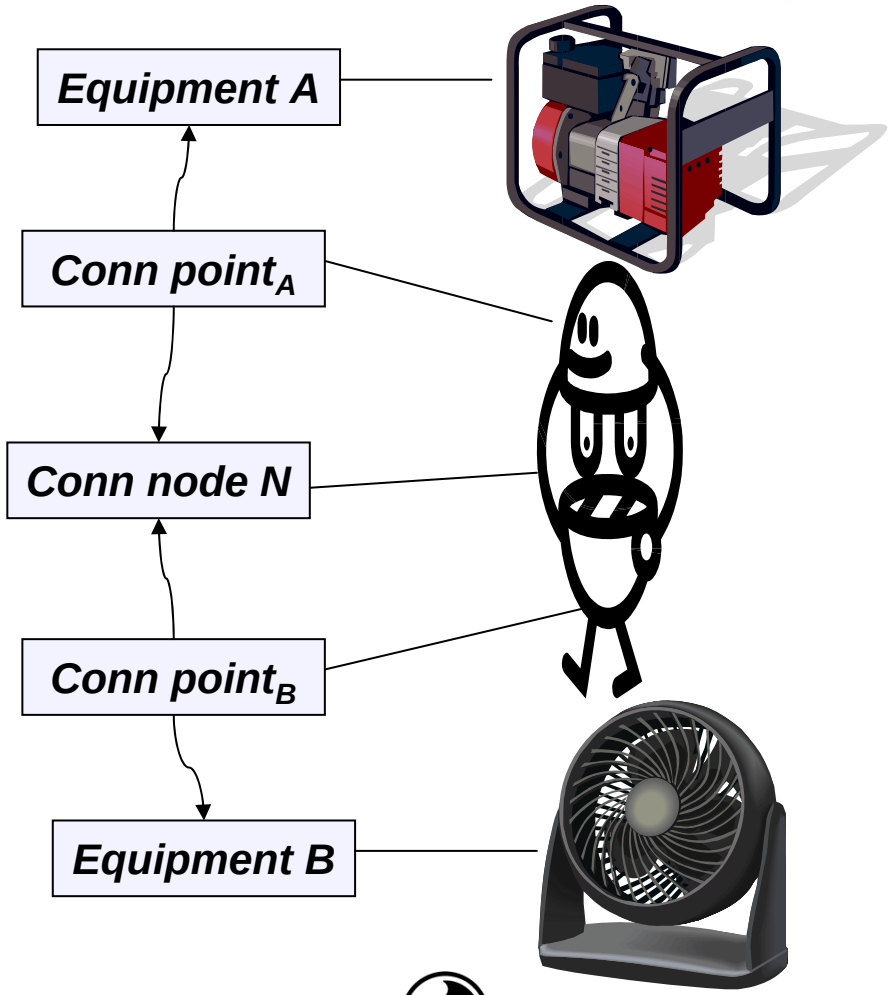
Rule: The ISO 15926 representation pattern

ISO 15926-7 template signature:

RSMFunctionalEntityConnection		
1	Entity 1	ArrangedIndividual
2	Entity 2	ArrangedIndividual
3	Conn. pt. 1	ArrangedIndividual
4	Conn. pt. 2	ArrangedIndividual
5	Connection	ConnectionOfIndividual

ISO 15926-7 template rule:

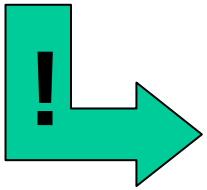
```
RSMFunctionalEntityConnection
                  (x1, x2, x3, x4, x5) <->
  ArrangedIndividual(x1) &
  ArrangedIndividual(x2) &
  ArrangedIndividual(x3) &
  ArrangedIndividual(x4) &
  ConnectionOfIndividual(x5) &
  FeatureWholePartTemplate(x3, x1) &
  FeatureWholePartTemplate(x4, x2) &
  DirectConnectionTriple(x5, x3, x4) .
```



Template expansion

ISO 15926-7 template instance

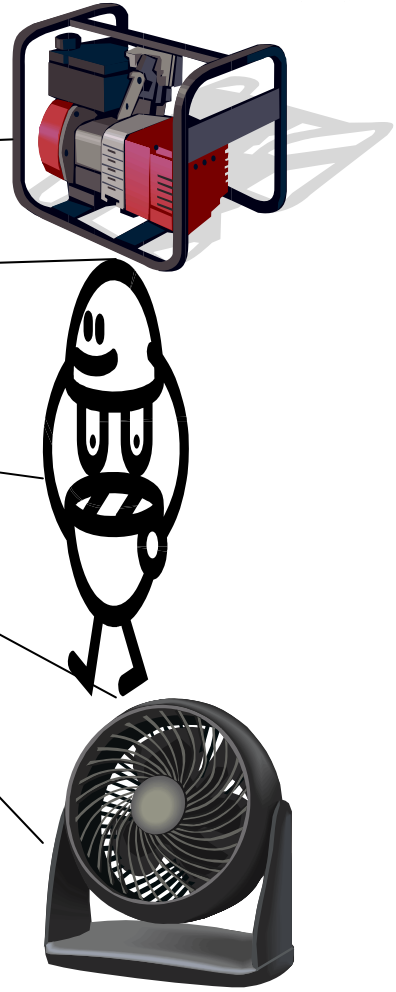
RSMFunctionalEntityConnection		
1	Entity 1	***Equipment A***
2	Entity 2	***Equipment B***
3	Conn. pt. 1	***Conn point$_A$***
4	Conn. pt. 2	***Conn point$_B$***
5	Connection	***Conn node N***



Expanded to explicit ISO 15926-2

```
 ArrangedIndividual(A)
& ArrangedIndividual(B)
& ArrangedIndividual(CA)
& ArrangedIndividual(CB)
& ConnectionOfIndividual(N)
```

This illustrates RSM to ISO 15926 model interchange for equipment connectivity.



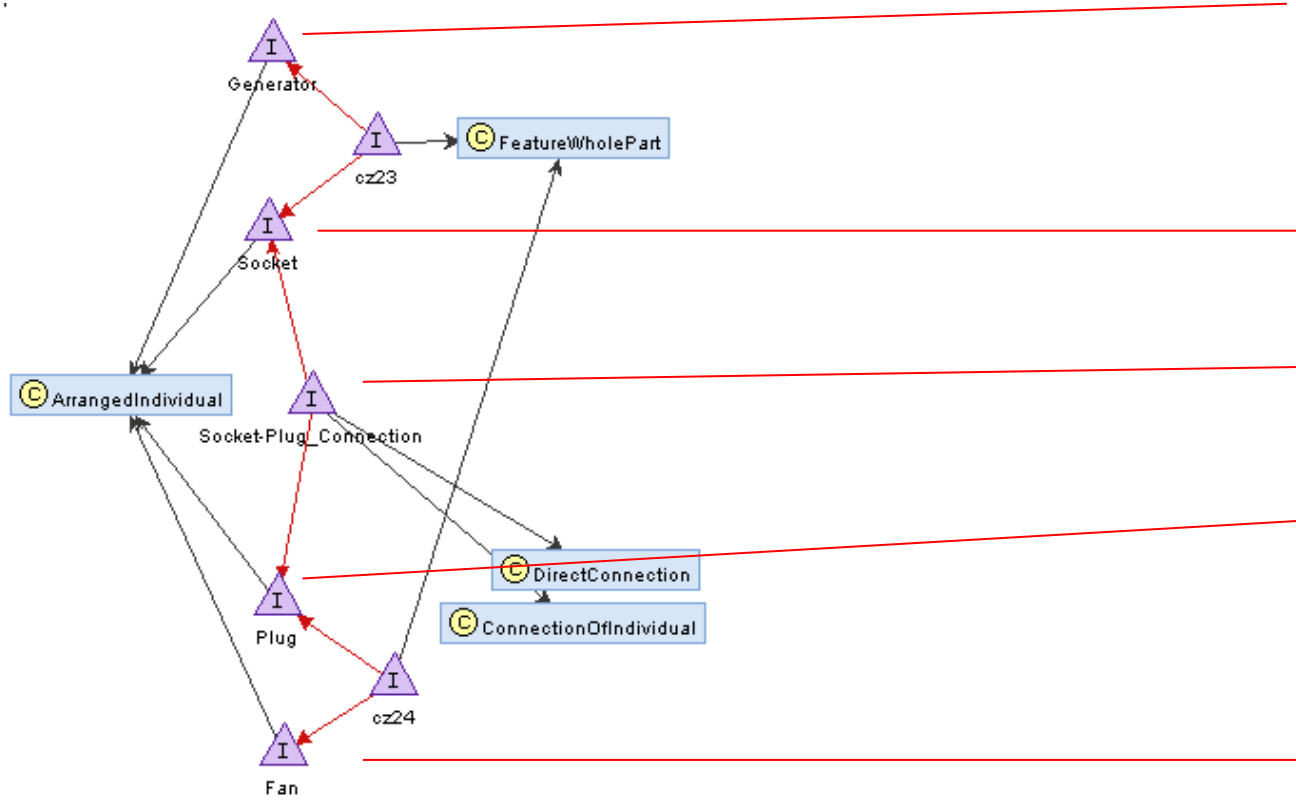
abelia

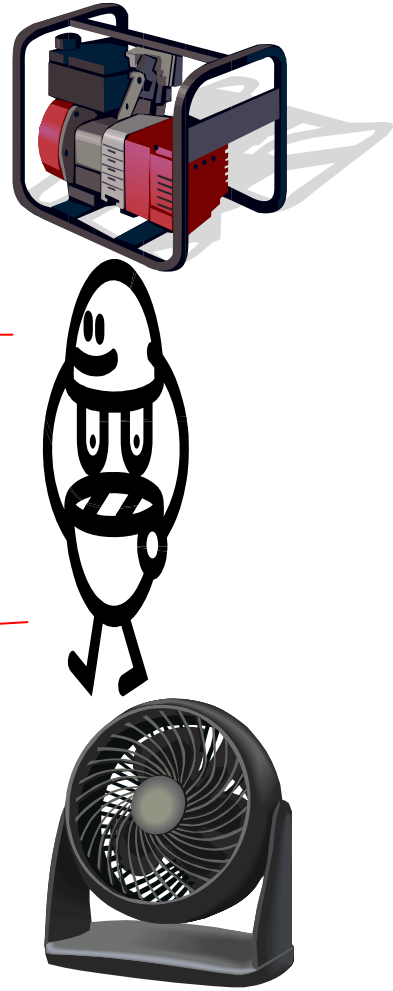
FSi

olf

The connection in ISO 15926-2

OWL representation





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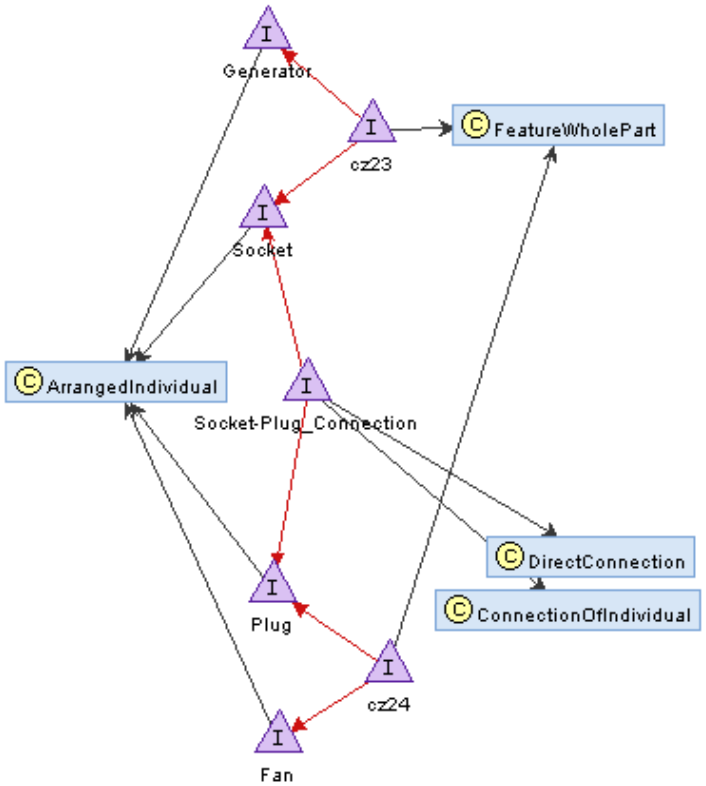
olf

Translation in two directions

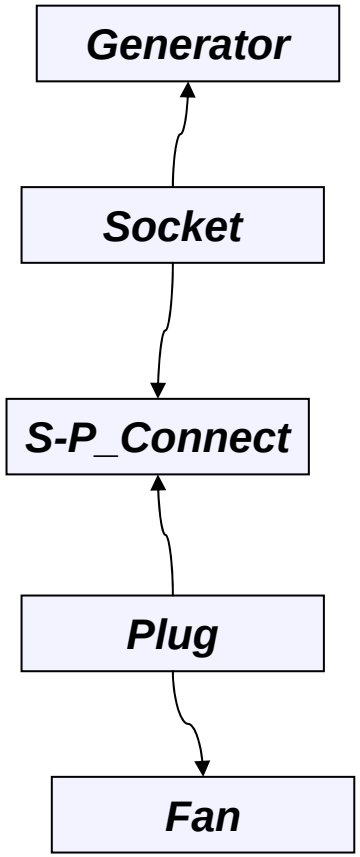
ISO 15926 data set



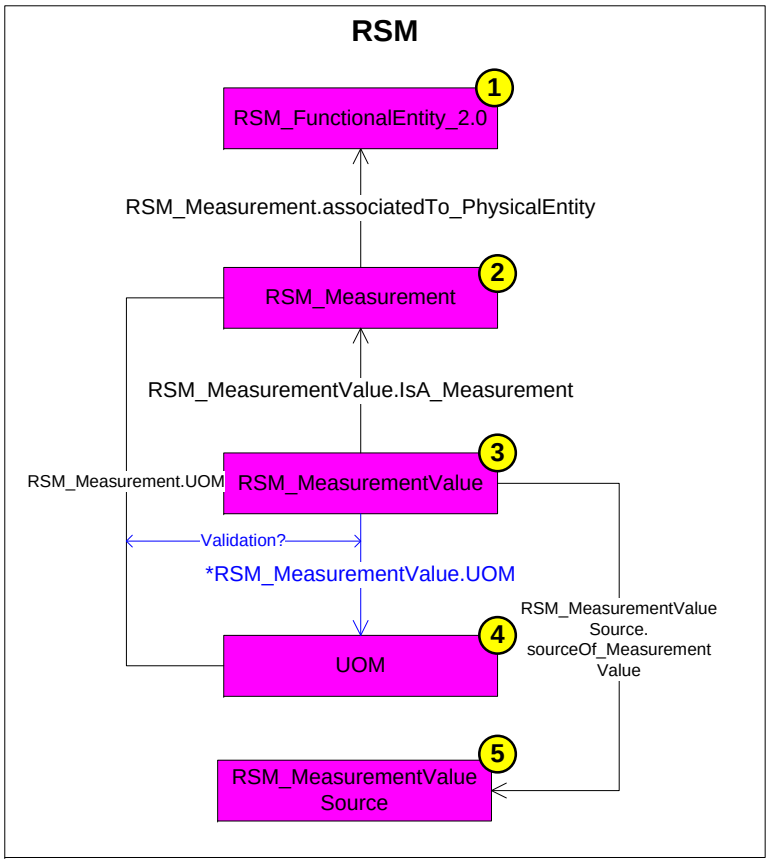
Expand

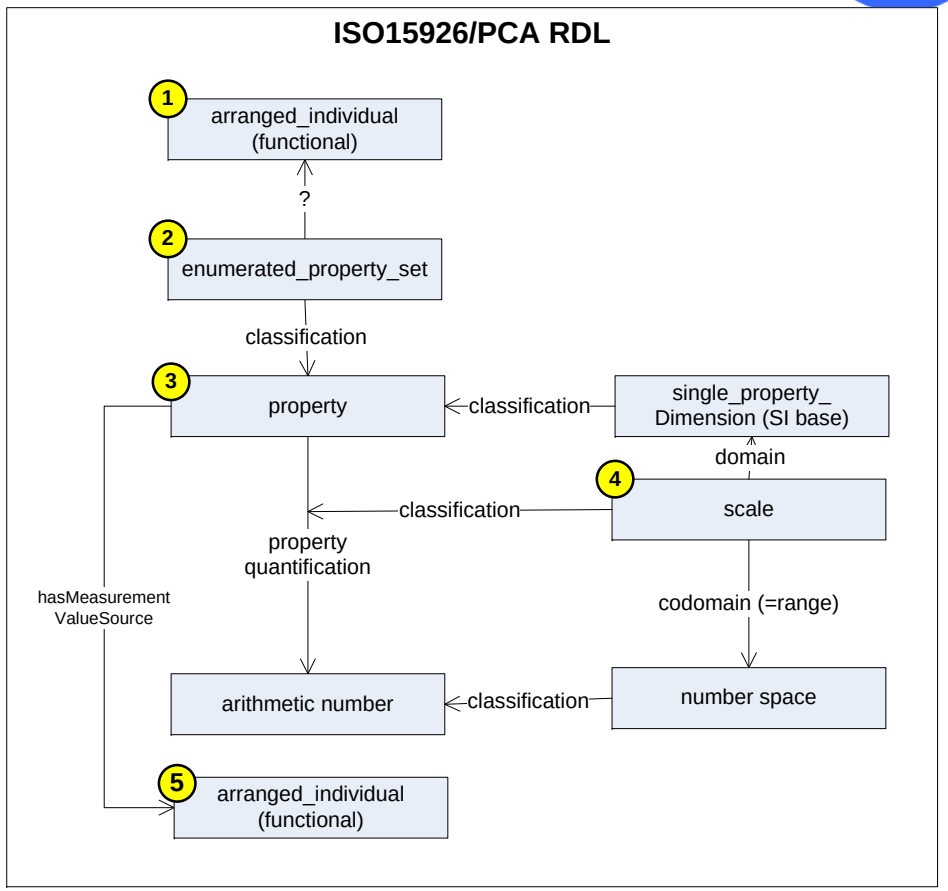
Query

RSM data set



Another complex mapping: Measurements





RSM model in RDL: Advantages

- We obtain a standardized representation of the model
- Documentation of the system structure is openly available
- Users and independent software vendors can investigate the model for alignment and integration

RSM data in ISO 15926: Advantages

- Dictionary alignment. *Apply common terminology*
- Taxonomy/ontology alignment. *Discover additional knowledge*

- Data quality. Content from various OPC sources is given a standard classification
- Integration. ISO 15926/reference data content is suitable for exchange
- Applications. The OWL/RDF format makes content available for semantic tools

Thank you!