Modelling Geometric Objects with ISO 15926

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Actual problems Oil and Gas Industry

- Scenarios are replaced in 3-4 years
- Projects lifecycle last more then 10 years

Owner, Manufactures, Engineering Contractors and Operators may use different Platforms

- Different project tools
- High-cost migration

NIST

US$15.8 billions for interoperability costs

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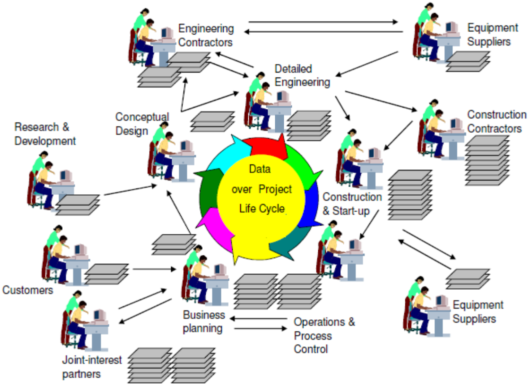
ISO15926 - Industrial automation systems and integration–Integration of life-cycle data for process plants including oil and gas production facilities

Why use ISO 15926?

- Life-cicle description
- Flexibility and Extensibility
- Information context
- Validation

ASU Arizona State University
AREVA
CoSign by arx
atlas RFID solutions
Autodesk
AVEVA
avolve software
BECHTEL
Bentley Sustaining Infrastructure
BLACK & VEATCH
BURNHAM
Burns and Roe
Carnegie Mellon University
CH2MHILL
CIFE Center for Integrated Facility Engineering
CLEMSON UNIVERSITY
CCC
THE CONSTRUCTION SCIENCES RESEARCH FOUNDATION, INC.
CREATING A COMMON LANGUAGE
COREWORX
CrossInnovation
DASSAULT SYSTEMES
DOW
Drexel UNIVERSITY CONSTRUCTION MANAGEMENT Build the World
EMERSON
EPRI ELECTRIC POWER RESEARCH INSTITUTE
ExxonMobil
FLUOR
Georgia Tech
GlencoIS
HAL
HATCH
Honeywell
IFS
INTERGRAPH
INTELLIWAVE TECHNOLOGIES
JACOBS
KAISER PERMANENTE
KAIST KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY SINCE 1971
Loughborough University
MADCAD.com
Meridian SYSTEMS
METALFORMING Architectural Machines
MYONGJI UNIVERSITY
NIST National Institute of Standards and Technology
Noumenon Consulting Ltd
OB ENGINEERING LTD
ORACLE AUTOVUE
PANPROJECTS Panalpina Group
S&B
Systemation Solutions
SIEMENS
SOLIBRI
Systemation
TARGET
Pontifícia Universidade Católica
Tecgraf
TEEC Software Solutions
A&M
THOMAS industrial network
Trimble
TVA
University of Alberta
UNIVERSITY OF CALGARY
THE UNIVERSITY OF MICHIGAN 1817
THE UNIVERSITY OF QUEENSLAND AUSTRALIA
University of Salford A Greater Manchester University
THE UNIVERSITY OF TEXAS AT AUSTIN
UNIVERSITY OF WASHINGTON
University of Waterloo
ВНИИАЭС
VTT
WorleyParsons resources & energy
ZACHRY

Data over Project Life Cycle (modified from Pawsey, 2012)



Nowadays…

Part 1: Overview and fundamental principles

Part 2: DataModel, it that represent information common to users and process plants. In Natural Language: Grammar

Part 3: Geometry and topology

Part 4: Reference Data Library (RDL). In Natural Language: The dictionary

Part 7: Templates. In Natural Language: It is equivalent to a phrase book

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Part 8: OWL implementation of the Templates. In Natural Language: It is like paper in a book, or a computer file

Part 9: Implementation standards, with the focus on Façades, standard web servers, web services, and security

Part 10: Formally named Implementation Methods for the Integration of Distributed Systems: Abstract Test Methods (draft)

Part 11: Industrial Usage Guidelines

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Defining objects

Template methodology

Complex objects must be defined as templates.

Part 3

A huge library of **basic** geometric terms.

Defining objects

Template methodology

Complex objects must be defined as templates.

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A huge library of **basic** geometric terms.

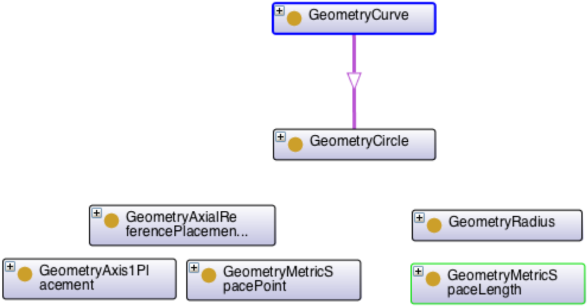
Identifying Part 3 elements

Circle definition in Part 3

An object is a ***circle*** *if and only if: 1-it is* ***curve****; 2-it lies in a* ***plane****; 3- there is a centre point that is equi-distant from each point in the curve.*

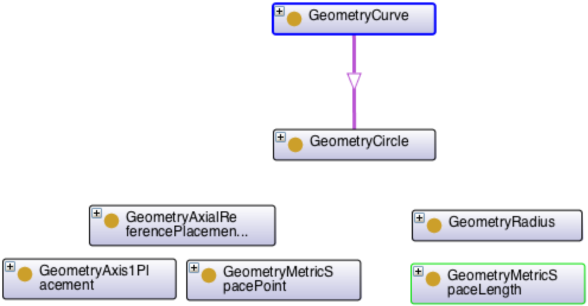
NOTE 2 A ***circle*** *has the geometric properties: radius; center and plane. These properties can be given for a* ***circle*** *by a* ***axial_reference_placement*** *and a* ***radius****. A* ***circle*** *has two alternative values for the* ***axial_reference_placement*** *corresponding to opposite directions for the normal.*

Identifying classes



Which templates are necessary?

Identifying classes



Which templates are necessary?

Modeling process steps

Definition of the signature, that describes the elements that compound the relationship;

Signature

Order	Rule	Type
1	hasProperty	Property
2	valPropertyValue	ExpressReal
3	hasScale	Scale

Modeling process steps

Definition of Axioms/Sentences in First Order Logic (FOL), that describes the semantics through the relations between the elements presented in the signature.

Axiom

$$\begin{aligned}
&\mathrm{RealMagnitudeOfProperty}(x_1, x_2, x_3) \leftrightarrow \\
&\quad \mathrm{property}(x_1) \wedge \mathrm{ExpressReal}(x_2) \wedge \mathrm{scale}(x_3) \wedge \\
&\quad \exists u\ (\mathrm{MagnitudeOfProperty}(x_1, u, x_3) \wedge \\
&\qquad \mathrm{IdentificationByNumber}(x_2, u))
\end{aligned}$$

RealMagnitudeOfProperty

The template **RealMagnitudeOfProperty** is used to connect a concept classified as a **property** with a numeric value and a **scale**.

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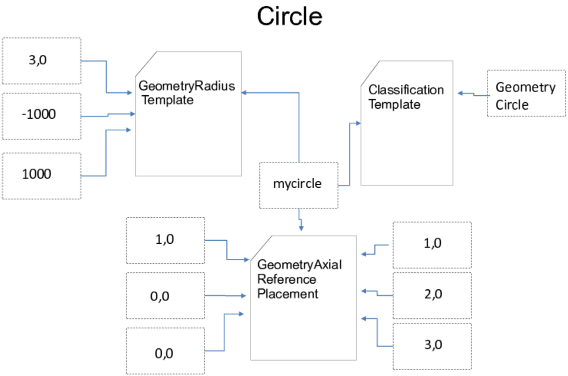
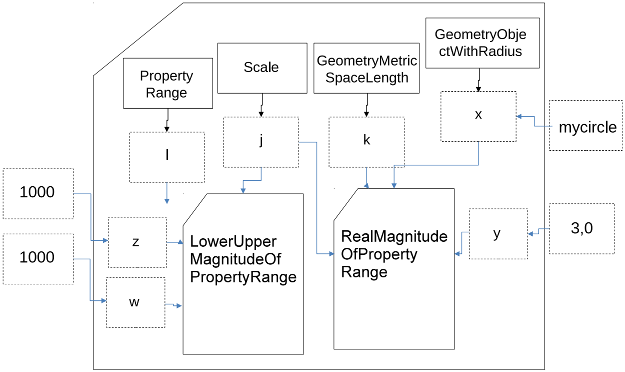

Circle
3,0
-1000
1000
GeometryRadius Template
Classification Template
Geometry Circle
mycircle
1,0
0,0
0,0
GeometryAxial Reference Placement
1,0
2,0
3,0

GeometryRadiusTemplate



Property Range

Scale

GeometryMetric SpaceLength

GeometryObjectWithRadius

l

j

k

x

mycircle

1000

1000

z

w

LowerUpper MagnitudeOf PropertyRange

RealMagnitude OfProperty Range

y

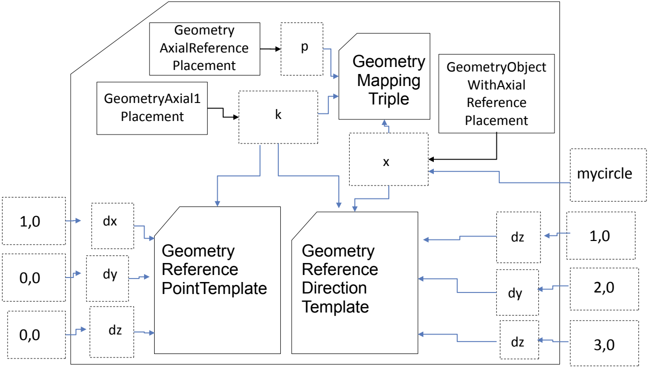
3,0

Order	Rule	Type
1	hasPossessor	ObjectWithRadius
2	hasRadius	RealNumber
3	hasLowerBound	RealNumber
4	hasUpperBound	RealNumber

$$
\begin{aligned}
&\mathrm{RadiusTemplate}(x, y, z, w) \leftrightarrow \\
&\quad \mathrm{ObjectWithRadius}(x) \wedge \mathrm{RealNumber}(y) \wedge \mathrm{RealNumber}(z) \wedge \\
&\quad \mathrm{RealNumber}(w) \wedge \exists m\ (\mathrm{radius}(m) \wedge \mathrm{hasEnd1}(m, x_1) \\
&\qquad \wedge\ \mathrm{hasEnd2}(m, k)) \wedge \\
&\quad \exists k\ (\mathrm{metric\_space\_length}(k) \wedge \exists j\ (\\
&\qquad \mathrm{Scale}(j) \wedge \exists \ell(\\
&\qquad\quad \mathrm{PropertyRange}(\ell) \wedge \\
&\qquad\quad \mathrm{LowerUpperMagnitudeOfPropertyRange}(\ell, j, z, w) \wedge \\
&\qquad\quad \mathrm{RealMagnitudeOfProperty}(k, y, j))) \wedge \\
&\qquad \exists p\ (\mathrm{MappingTriple}(m, x, k) \wedge \mathrm{radius}(p)))
\end{aligned}
$$

$$
\begin{aligned}
&\text{AxialReferencePlacementTemplate}(q, p_x, p_y, p_z, d_x, d_y, d_z) \leftrightarrow\\
&\quad \text{ObjectWithAxialReferencePlacement}(q) \land \exists k(\\
&\qquad \text{axis1\_placement}(k) \land\\
&\qquad \text{ReferencePointTemplate}(k, p_x, p_y, p_z) \land\\
&\qquad \text{ReferenceDirectionTemplate}(k, d_x, d_y, d_z) \land\\
&\qquad \exists p\ (\text{MappingTriple}(p, q, k) \land\\
&\qquad\quad \text{axial\_reference\_placement}(p)))
\end{aligned}
$$

GeometryAxialReference PlacementTemplate



Geometry AxialReference Placement

p

Geometry Mapping Triple

GeometryAxial1 Placement

k

GeometryObject WithAxial Reference Placement

x

mycircle

1,0

dx

0,0

dy

0,0

dz

Geometry Reference PointTemplate

Geometry Reference Direction Template

dz

1,0

dy

2,0

dz

3,0

Further work

- Implement tools:
  - for domain experts
  - for users
- Develop ISO 15926 research subjects

Tools

Template Expander expands FOL definitions to basic terms

iRing Tools interoperate data in a ISO 15926-like approach

.15926 an environment to build and manipulate ISO 15926 compliant data

15926:8 OWL visualization

FOL2OWL translates FOL template axioms to OWL

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