

AutomationML Techday  
2021-09-22

# <AutomationML/>

## **Basics of AutomationML**

**Motivation, Architecture,  
Innovations, Navigation**

Prof. Dr.-Ing. Rainer Drath

# **This talk is for you if**

- you are new to AutomationML or**
- you need to discuss AML with others**

# Overview

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## Navigator for dicussions about AutomationML with others

How to avoid confusions in discussion with with software developers, data modelers, engineers, lead engineers, managers, external partners

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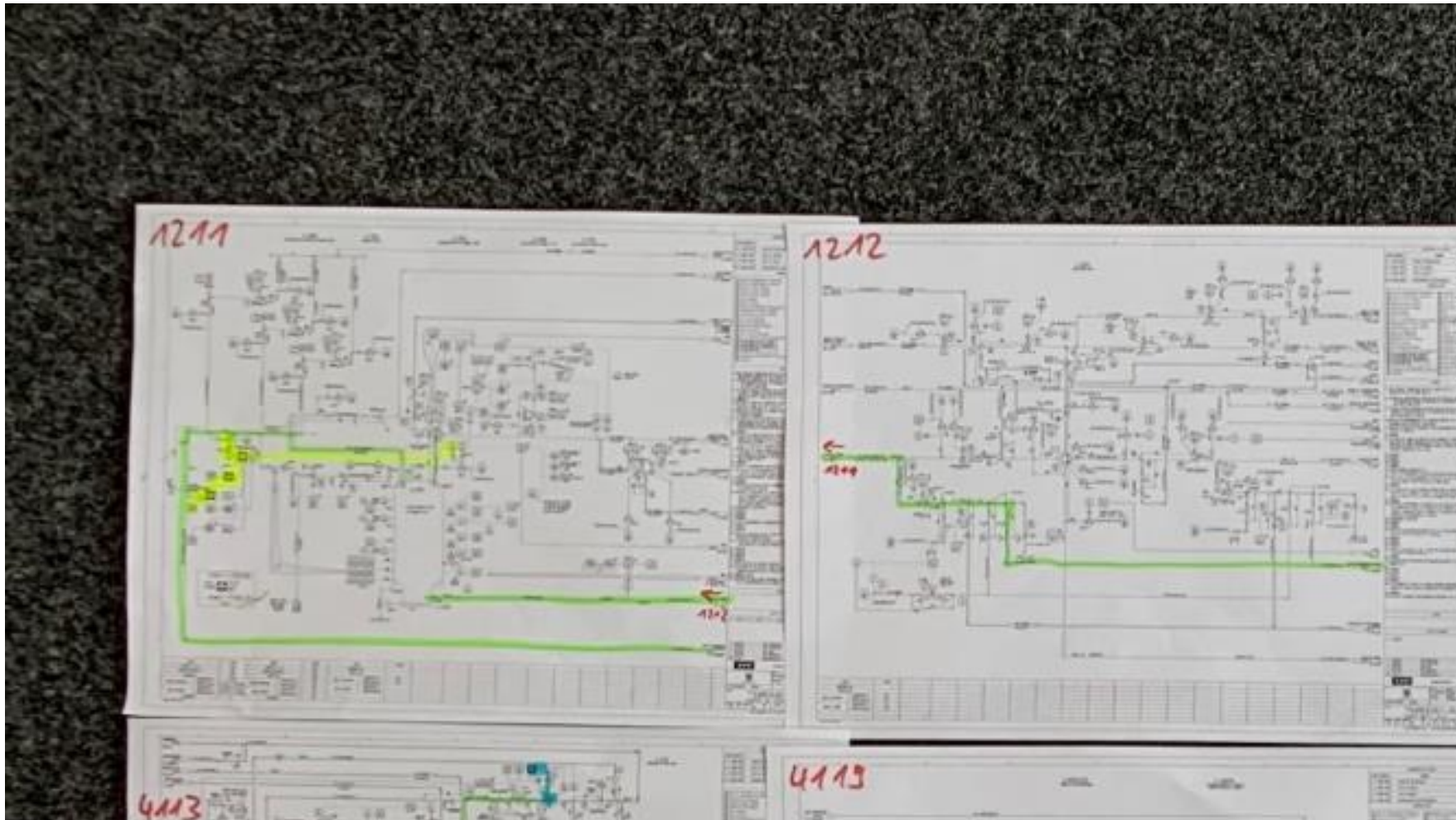
HS PF 

# Why we need AutomationML?

# Reason #1: Engineering data is often just paper, it requires human eyes, education and interpretation



## Reason #1: Engineering data is often just paper, it requires human eyes, education and interpretation



## Reason #2: large heterogeneous tool landscape

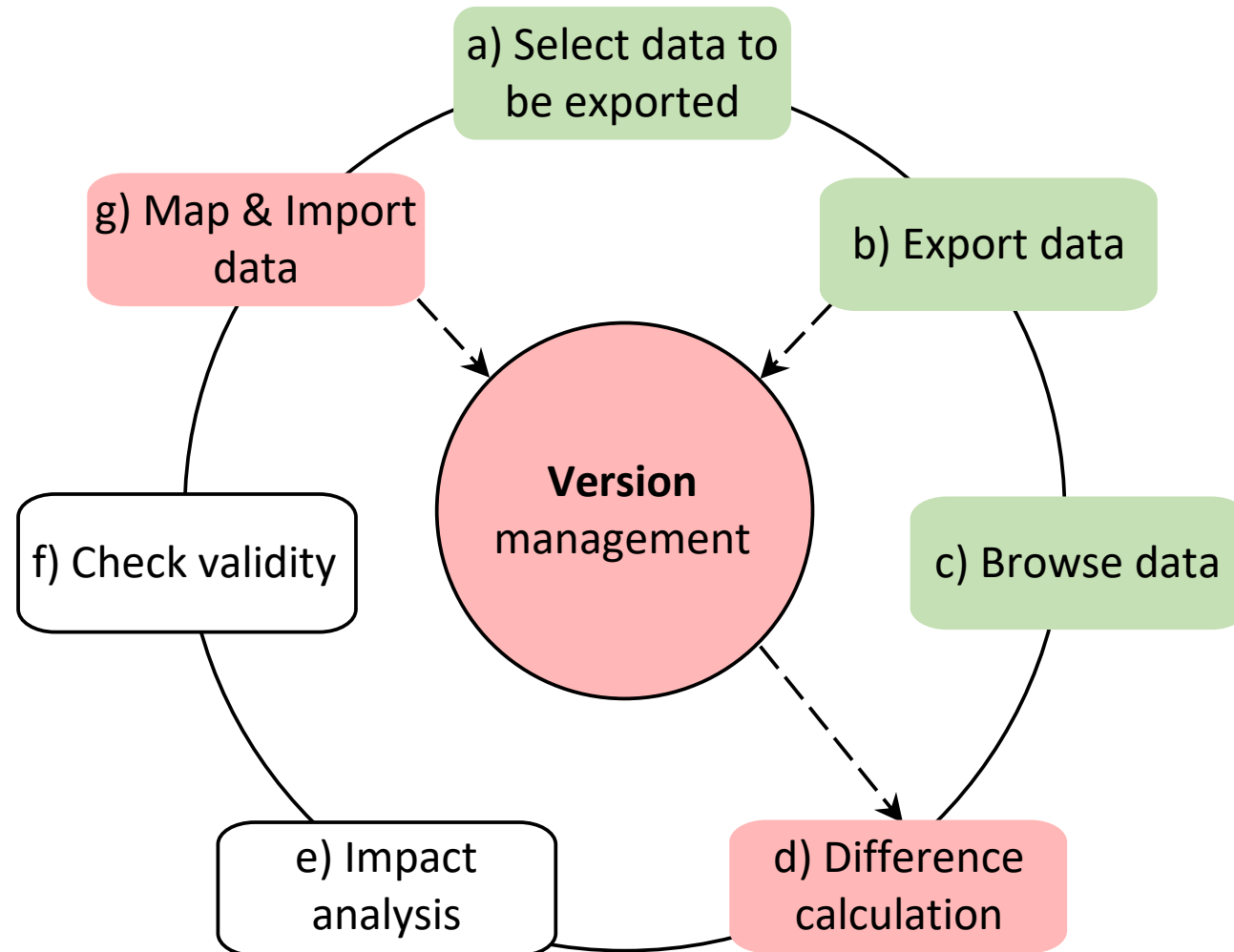
Domain		Tool (examples)
CAD		<ul style="list-style-type: none"> <li>•CATIA v4, v5</li> <li>•AutoCAD</li> <li>•NX</li> <li>•SolidWorks</li> <li>•MicroStation</li> <li>•Maya</li> </ul>
Simulation	Material Flow Simulation	<ul style="list-style-type: none"> <li>•Plant Simulation</li> <li>•Witness Horizon</li> <li>•INOSIM</li> </ul>
	Robot Simulation	<ul style="list-style-type: none"> <li>•Gazebo Simulator</li> <li>•RoboDK</li> <li>•V-REP</li> </ul>
	Process Simulation	<ul style="list-style-type: none"> <li>•ANSYS</li> </ul>
	Electrical Simulation	<ul style="list-style-type: none"> <li>•LTspice</li> <li>•Oregano</li> <li>•Multisim</li> </ul>
Office	Text Processing	<ul style="list-style-type: none"> <li>•Word</li> <li>•OpenOffice</li> </ul>
	Spreadsheet Analysis	<ul style="list-style-type: none"> <li>•Excel</li> <li>•OpenOffice</li> </ul>
	Presentation	<ul style="list-style-type: none"> <li>•Powerpoint</li> <li>•OpenOffice</li> </ul>
	Databases	<ul style="list-style-type: none"> <li>•Access</li> <li>•Oracle</li> <li>•MySQL</li> </ul>
	Communication	<ul style="list-style-type: none"> <li>•Email</li> </ul>
Project Management		<ul style="list-style-type: none"> <li>•Project</li> <li>•Asana</li> </ul>
Product Data Management (PDM)		<ul style="list-style-type: none"> <li>•TeamCenter</li> <li>•PDM Studio</li> <li>•ENOVIA</li> <li>•SmarTeam</li> </ul>
Product Lifecycle Management (PLM)		<ul style="list-style-type: none"> <li>•Fusion Lifecycle</li> <li>•3DEXPERIENCE</li> </ul>

Domain		Tool (examples)
Enterprise Resource Planning (ERP)		<ul style="list-style-type: none"> <li>•SAP S/4HANA</li> <li>•Oracle PeopleSoft</li> <li>•Dynamics Navision</li> </ul>
Reporting		<ul style="list-style-type: none"> <li>•Cognos</li> <li>•Crystal Reports</li> <li>•BIRT</li> </ul>
Visualization	Mock-up	<ul style="list-style-type: none"> <li>•Axure RP</li> </ul>
	Plant Visualization	<ul style="list-style-type: none"> <li>•EZPlantView</li> <li>•M4 PLANT</li> <li>•OpenFlight</li> </ul>
	HMI	<ul style="list-style-type: none"> <li>•WinCC</li> <li>•InTouch HMI</li> <li>•VisiWin7</li> </ul>
Control Programming	PLC	<ul style="list-style-type: none"> <li>•STEP 7</li> <li>•RSLinx</li> <li>•CoDeSys</li> </ul>
	Robot Control	<ul style="list-style-type: none"> <li>•RobotStudio</li> <li>•KUKA.Sim</li> <li>•3D Onsite</li> </ul>
CAE		<ul style="list-style-type: none"> <li>•RUPLAN</li> <li>•EPLAN Electric P8</li> <li>•EAGLE</li> <li>•Target 3001!</li> </ul>
Process configuration		<ul style="list-style-type: none"> <li>•BOS 6000</li> </ul>
Facility Management		<ul style="list-style-type: none"> <li>•Speedykon</li> <li>•TRICAD MS</li> <li>•AutoCAD Architecture</li> </ul>
Computerized Maintenance Management System (CMMS)		<ul style="list-style-type: none"> <li>•Maximo</li> <li>•Datastream 7i</li> <li>•API PRO</li> </ul>
Authoring		<ul style="list-style-type: none"> <li>•Adobe Acrobat</li> <li>•Illustrator</li> <li>•Sharepoint</li> <li>•MacroMedia</li> </ul>
Functional Engineering		<ul style="list-style-type: none"> <li>•AutomationDesigner</li> <li>•COMOS</li> <li>•Automation Framework</li> </ul>

- Heterogeneous tool landscape
  - many tools from different vendors,
  - many engineering aspects
  - different interpretation

# Reason #3: Iteration support

Domain	Tool (examples)	Domain	Tool (examples)
CAD	• CATIA v4, v5 • AutoCAD • NX • SolidWorks • MicroStation • Maya	Enterprise Resource Planning (ERP)	• SAP S/4HANA • Oracle PeopleSoft • Dynamics Navision
Material Flow Simulation	• Plant Simulation • Witness Horizon • WDSIM	Reporting	• Cognos • Crystal Reports • BIET
Robot Simulation	• Gazebo Simulator • RoboDK • v-REP	Mock-up	• Azure RP • EPlantView • 3D Plant • OpenFlight
Process Simulation	• ANSYS	Plant Visualization	• WinCC • InTouch HMI • iLogWin
Electrical Simulation	• ETAP • Orcad • Multisim	HMI	• STEP 7 • HMIline • GDSys
Text Processing	• Word • OpenOffice	PLC	• RobotStudio • KUKA Sim • 3D Onsite
Spreadsheet Analysis	• Excel • OpenOffice	Robot Control	• TURTLE • EPLAN Electric P8 • EASLE • Target 3001
Presentation	• Powerpoint • OpenOffice	CAE	• BOS 6000 • SolidWorks • TRICAD MS • AutoCAD Architecture
Databases	• Access • Oracle • MySQL	Process configuration	• SIMATIC Manager
Communication	• Email	Facility Management	• Maximo • Datastream 7i • JAP PRO
Project Management	• Project • Asana	Computerized Maintenance Management System (CMMS)	• Adobe Acrobat • Illustrator • Sharepoint • MacroMedia
Product Data Management (PDM)	• TeamCenter • PDM Studio • ENOVIA • SmartTeam	Authoring	• COMOS • Automation Designer • Automation Framework
Product Lifecycle Management (PLM)	• Fusion Lifecycle • SOLIDEXPERIENCE	Functional Engineering	



# Therefore: AutomationML aims for digital workflows



- AML is a neutral file format for engineering.
- AML is a modelling language.
- AML is IEC standard (IEC62714)
- AML is XML
- AML allows the modelling and storage of
  - Object structures with classes, instances, attributes, interfaces, relations, geometry and kinematics
  - Geometry and kinematics
  - Signals and discrete control behaviour
- AML is object-oriented
- AML combines established industrial sub-standards
- AML is free and lean
- The AML association provides software components to simplify first steps

# Who is behind AutomationML?

# Who is behind AutomationML?



# Values of AutomationML

# Values of AutomationML

## Value 1

Extensible and flexible  
by design

## Value 2

Human and machine  
readable

## Value 3

No standardization  
deadlocks

## Value 4

Acceptance by reusing  
established standards

## Value 5

Continued use of  
company standards

## Value 6

Compatibility to other  
semantic standards

## Value 7

Identification and  
exploration of semantics

## Value 8

Identification and manage-  
ment of unknown data

## Value 9

Standard

## Value 10

Suitable for changing  
lifecycle data

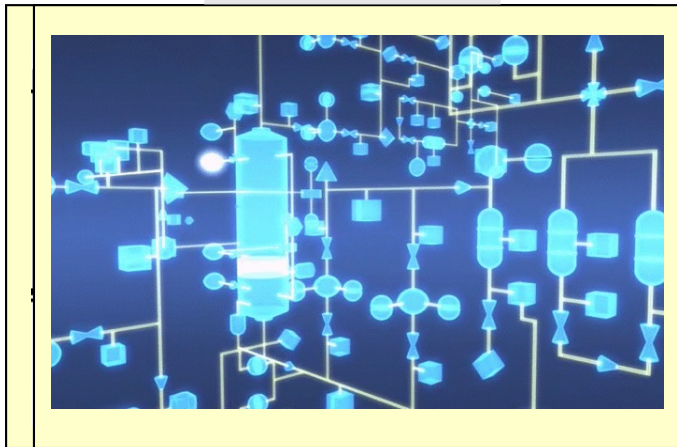
## Value 11

Variability in abstraction

# Algorithmic accessibility of data unleashes new potentials



Object model



Algorithms run through the object model and do useful things: quality check, completeness check, check for compliance with rules, pattern search, error search, generate control code, user interfaces, interlocks, simulation models

rules



Algorithm

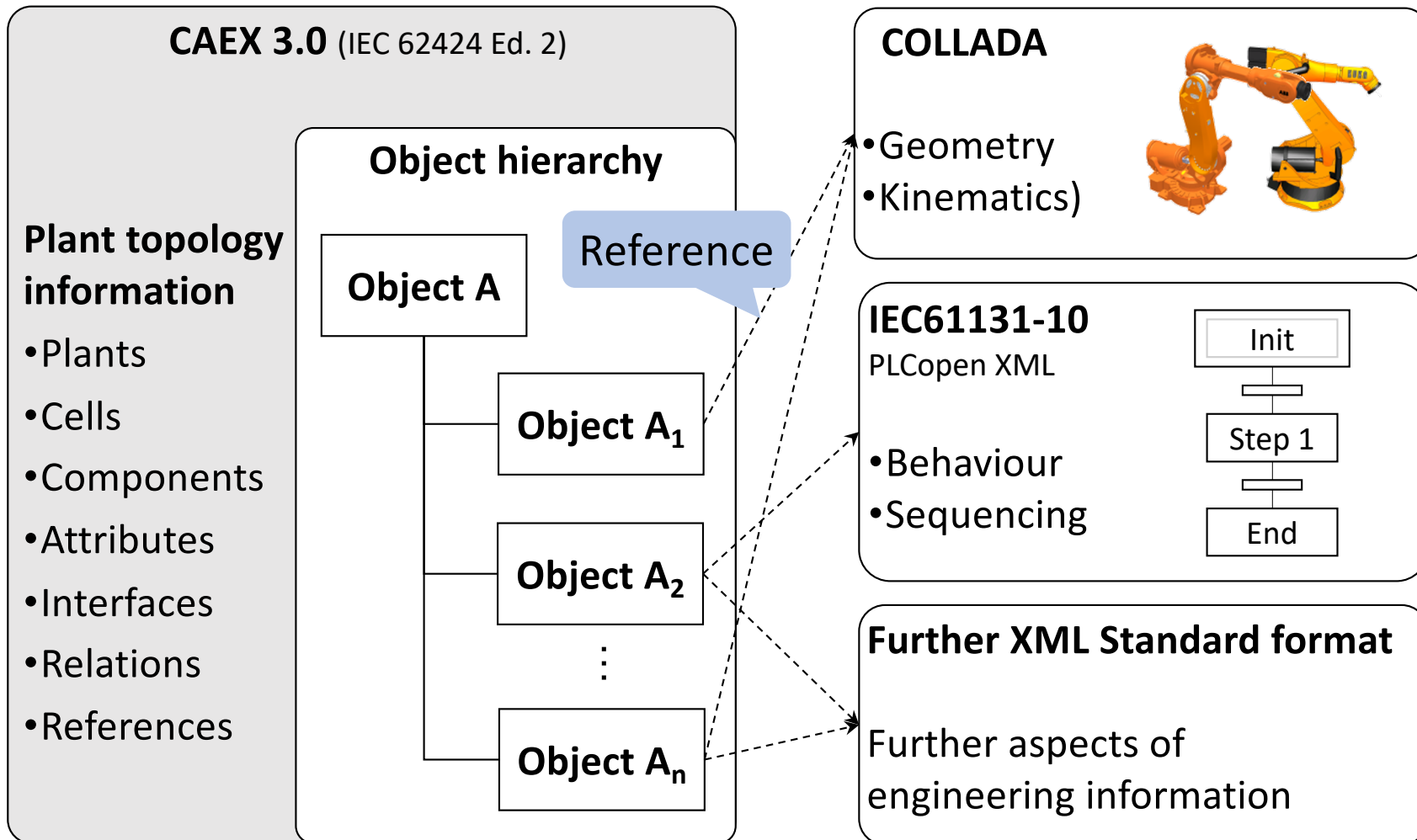
Automation code

IF Tank empty ...  
... THEN switch pump off

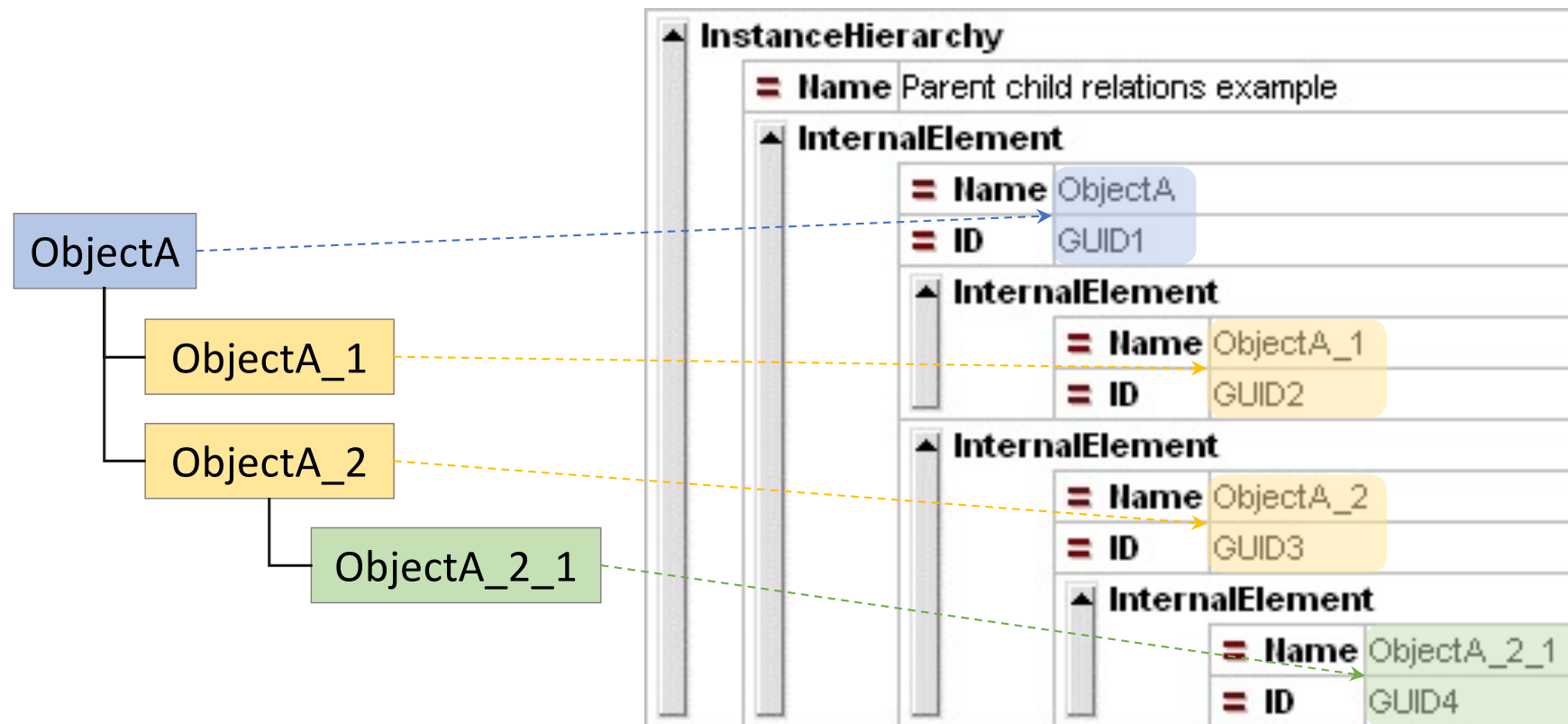
# Complexity of AutomationML

AutomationML architecture

# Architecture



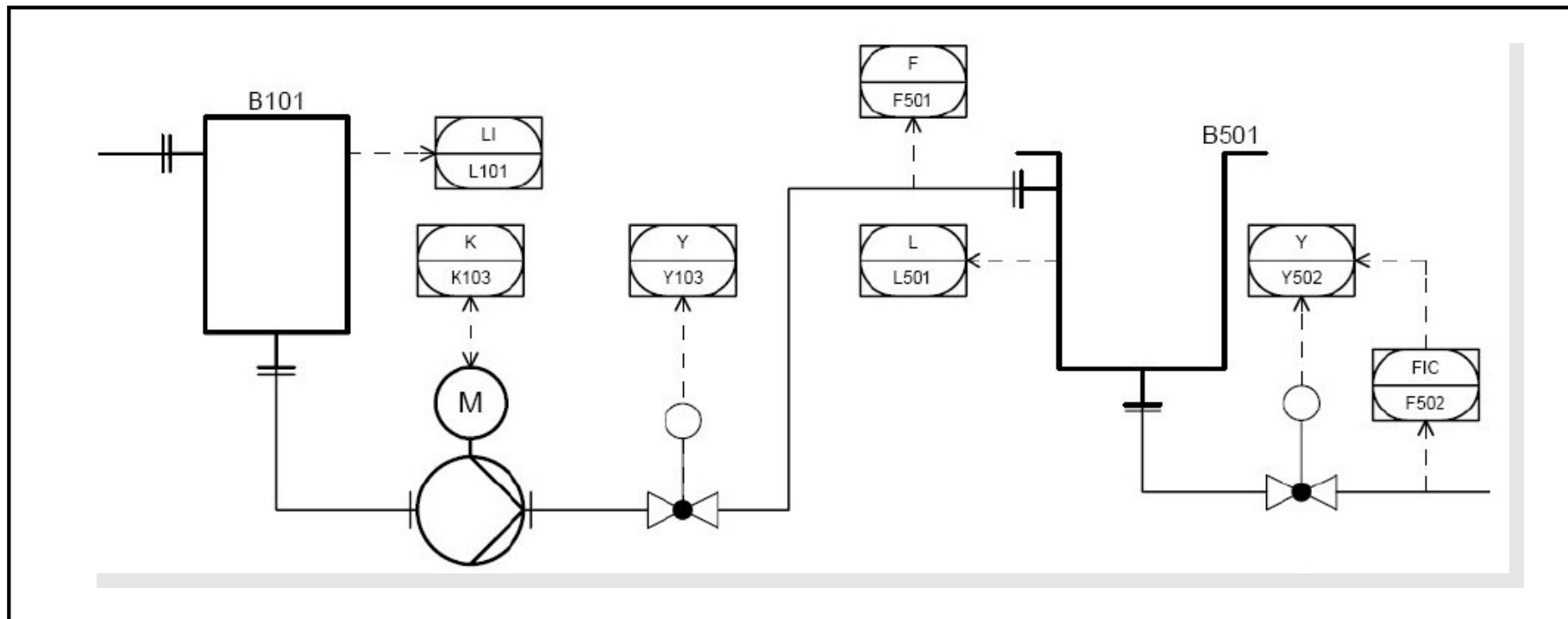
# Example object topology



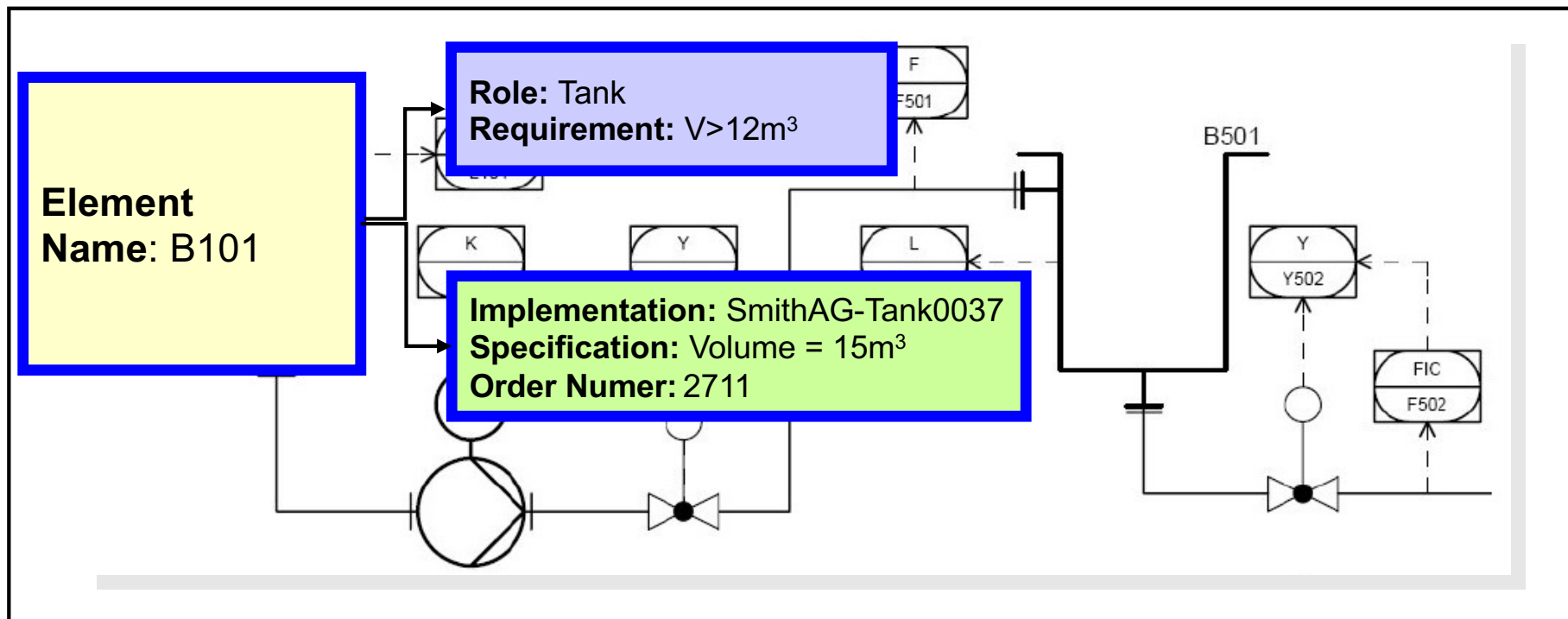
# Key innovations of AutomationML

What makes AutomationML innovative and future proof?

# Innovation #1: the role concept



# Innovation #1: the role concept

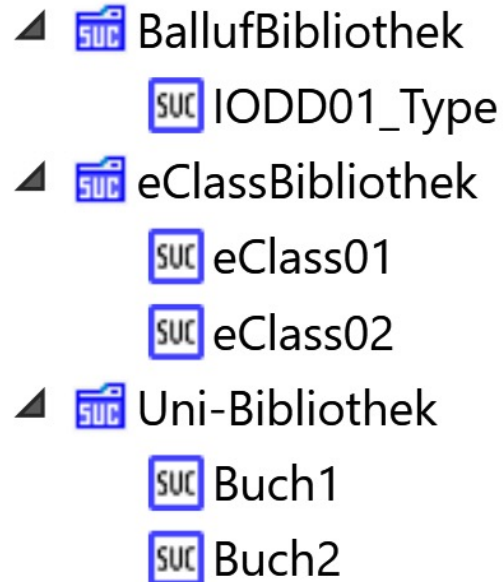


# Innovation #2: AutomationML can be updated

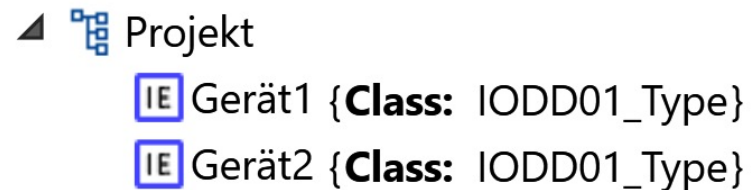
(similar to over-the-air-updates for recent cars)

- AutomationML (CAEX) is an *object oriented data modelling language*
- For a new domain or semantic standard, just create a new AML library and model it without changing the AML metamodel

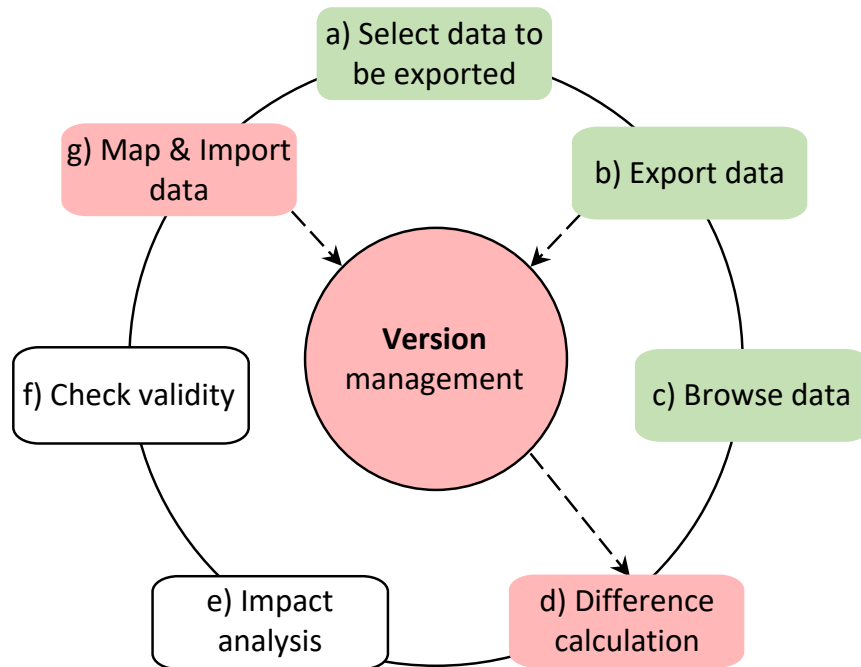
## Classes



## Instances



# Innovation #3: Separation of syntax and semantics



- Every software, which can
  - read, browse, manage versions, calculate and display differences, map and import data (the hard job of iterative engineering)
- can do this for any AML file, even if the semantics is unknown.
- Other data formats which change their format frequently as Excel or plain XML cannot.

# Innovation #4: Explicite semantic modelling

Semantic references to  
eCLASS or IEC CDD

▷ <A> SemanticSystems	InstallationMountingDimensions	IRDI:0112/2///62683#ACG121#001		Empty
▷ <A> Identification	Height	IRDI:0112/2///62683#ACE801#001	mm	xs:integer
▷ <A> InstallationMountingDimensions		IRDI:0173-1#02-BAD849#004		
<A> Height	Width	IRDI:0112/2///62683#ACE802#001	mm	xs:integer
<A> Width		IRDI:0173-1#02-BAD823#004		
<A> Length	Length	IRDI:0112/2///62683#ACE803#001	mm	xs:integer
<A> Diameter		IRDI:0173-1#02-BAD856#005		
<A> Mounting Position	Diameter	IRDI:0112/2///62683#ACE810#001	mm	xs:integer
<A> Housing Construction		IRDI:0173-1#02-BAD826#005		
▷ <A> GeneralTechnicalData	Mounting Position	IRDI:0112/2///62683#ACE810#001	code	xs:string
▷ <A> ControlAndAuxiliaryCircuits		IRDI:0173-1#02-BAD866#007		
▷ <A> ConnectionFacilities	Housing Construction	IRDI:0112/2///62683#ACE813#001	code	xs:string
▷ <A> ProductCertificatesAndStandards		IRDI:0173-1#02-BAD840#007		

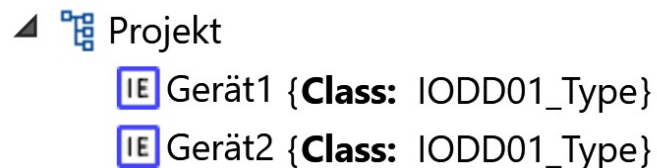
Attribute names  
become irrelevant

# Innovation #5: Mixed semantics

## Classes



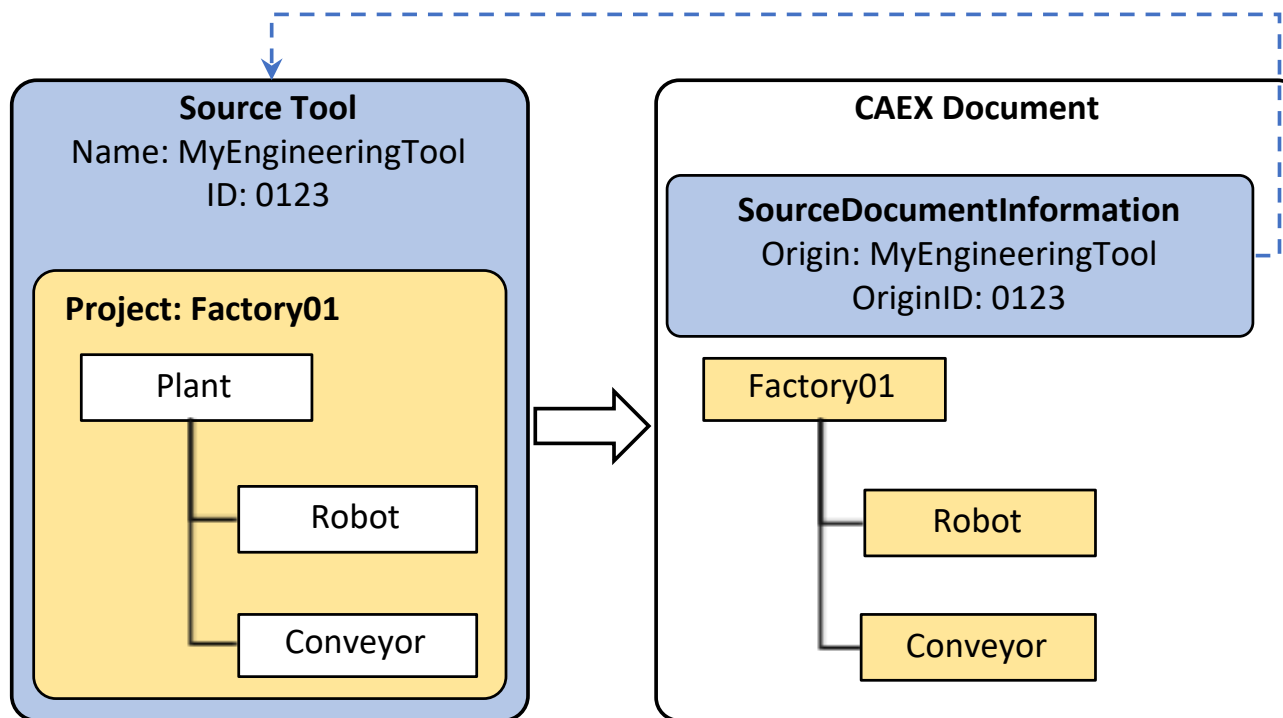
## Instances



- CAEX can hold and mix different domain libraries (proprietary versus standardized)
- Libraries and all classes are tagged: they know which semantic standard they belong to
- Crazy: we elegantly get explicit knowledge about unknowns (!)

## Innovation #6: Iteration support via Source references

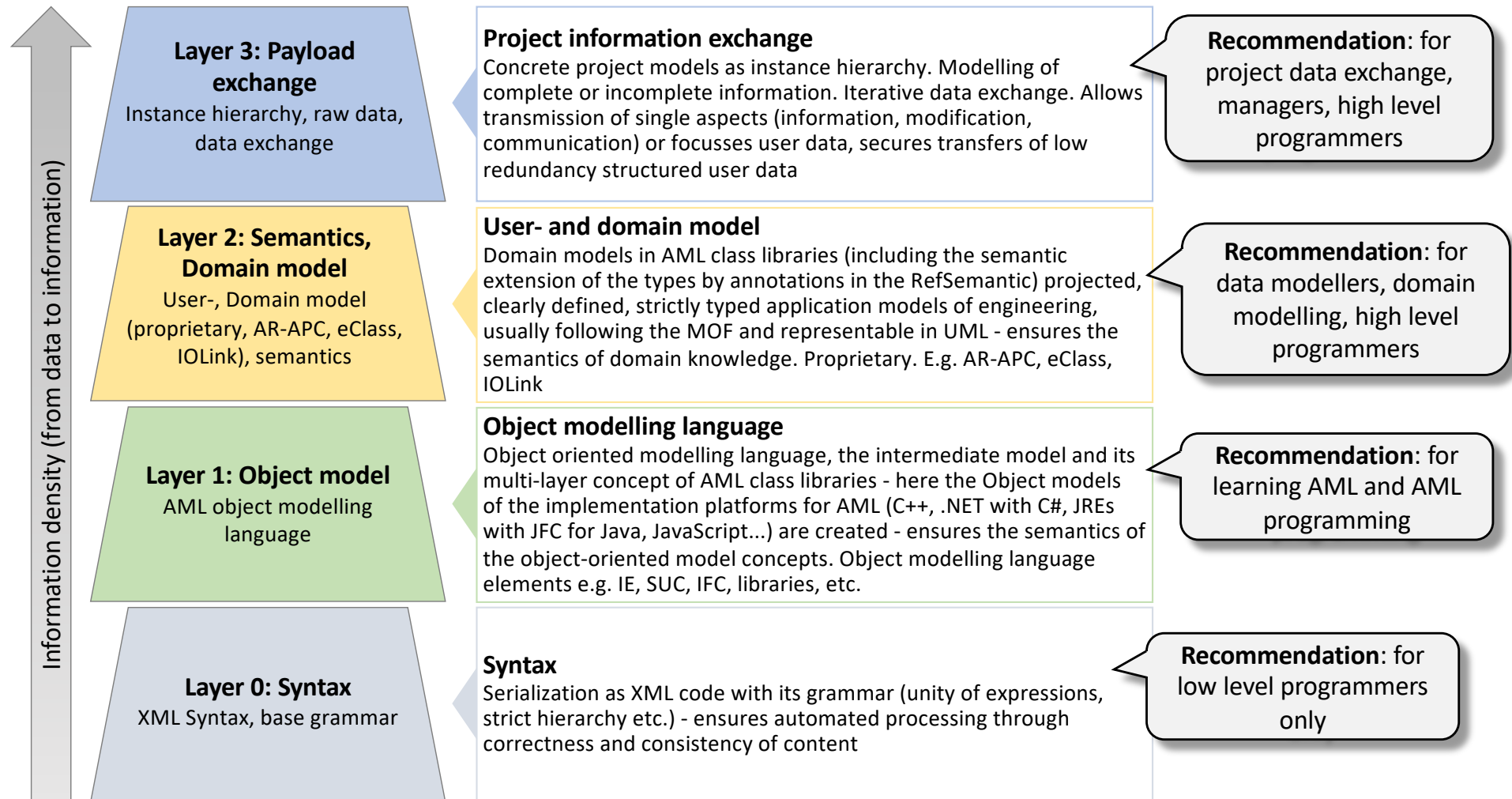
- Every AML file, every object, every attribute can explicitly model in detail from which source tool it comes from.
- This is very helpful in engineering tool chains.



# Navigator for dicussions about AutomationML with others

How to avoid confusions in discussion with with software developers, data modelers, engineers, lead engineers, managers, external partners

# 4 layers of abstraction



# 2021: New AutomationML Books

- beginners guide for base concepts
- industrial cookbook for concrete re-usable libraries and modelling patterns



# Summary: general values and limitations

## AutomationML enables

- digitalization of engineering data
- human and machine readable
- explicit modelling of semantics
- engineering data exchange
- digital product catalogues
- requirements models
- data access for algorithmic consistency and quality checking, transparent tracking of changes, version management
- Use engineering tools you are comfortable with instead of your customer tools

## AutomationML is no software, it cannot

- provide data base functionality as user authorization, data locking, multi user access
- Check the validity of the data (this happens in the source tool)

# Thank you