



AUTOMATIONML TECHDAY 2021

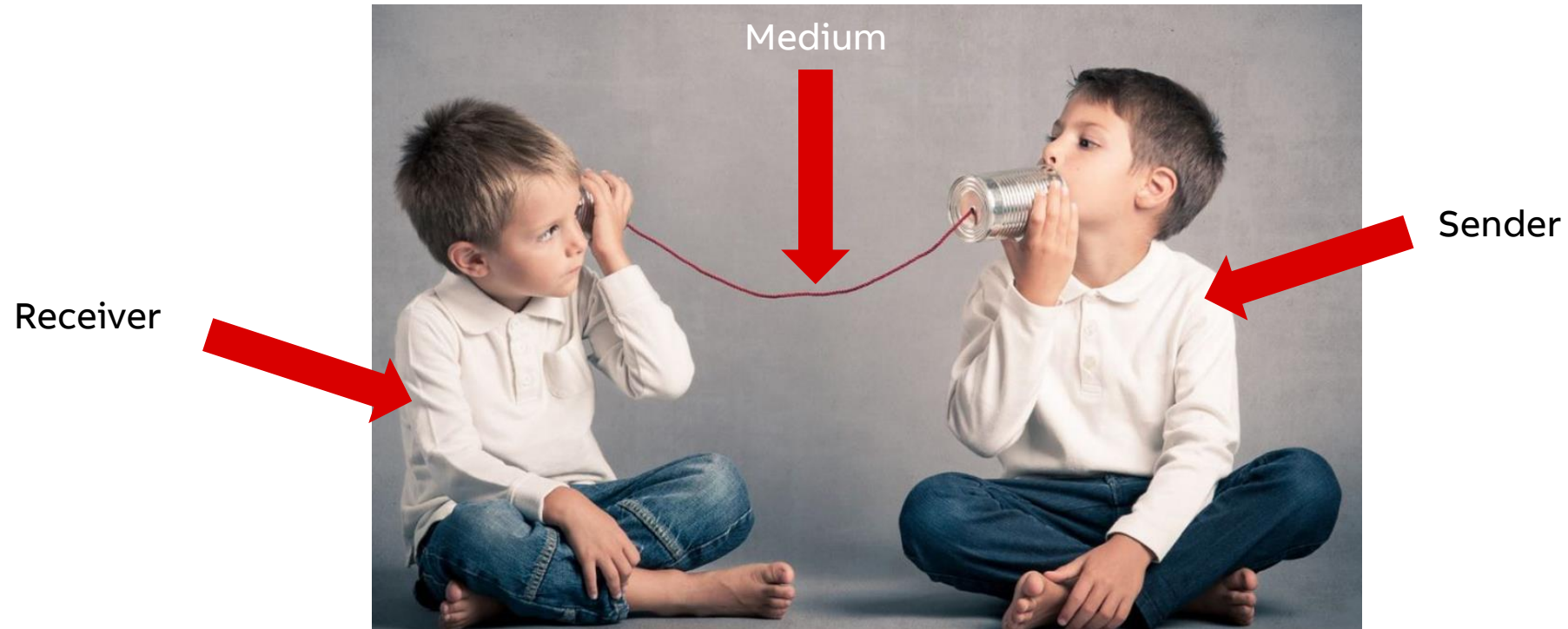
# Semantic Integration

Managing semantic heterogeneity of engineering tools

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## Message Exchange: Child's Play?



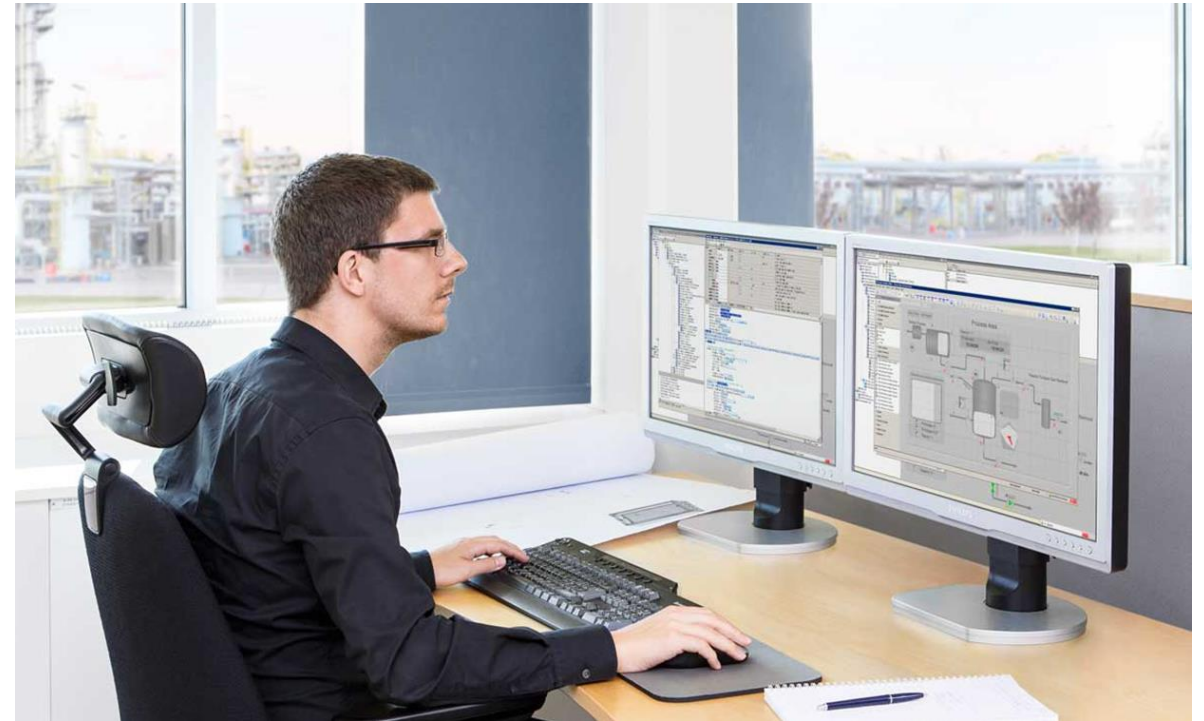
Success requires clear speech and hearing!

# Message Exchange in Engineering

Engineering of industrial products typically involves

- **multiple phases** such as design, configuration, simulation and commissioning
- **multiple disciplines** such as mechanical, electrical and control engineering
- **specialized, multi-vendor tools** with different data models for the different activities

Success requires not only verbal communication among engineers but also engineering tool **interoperability!**



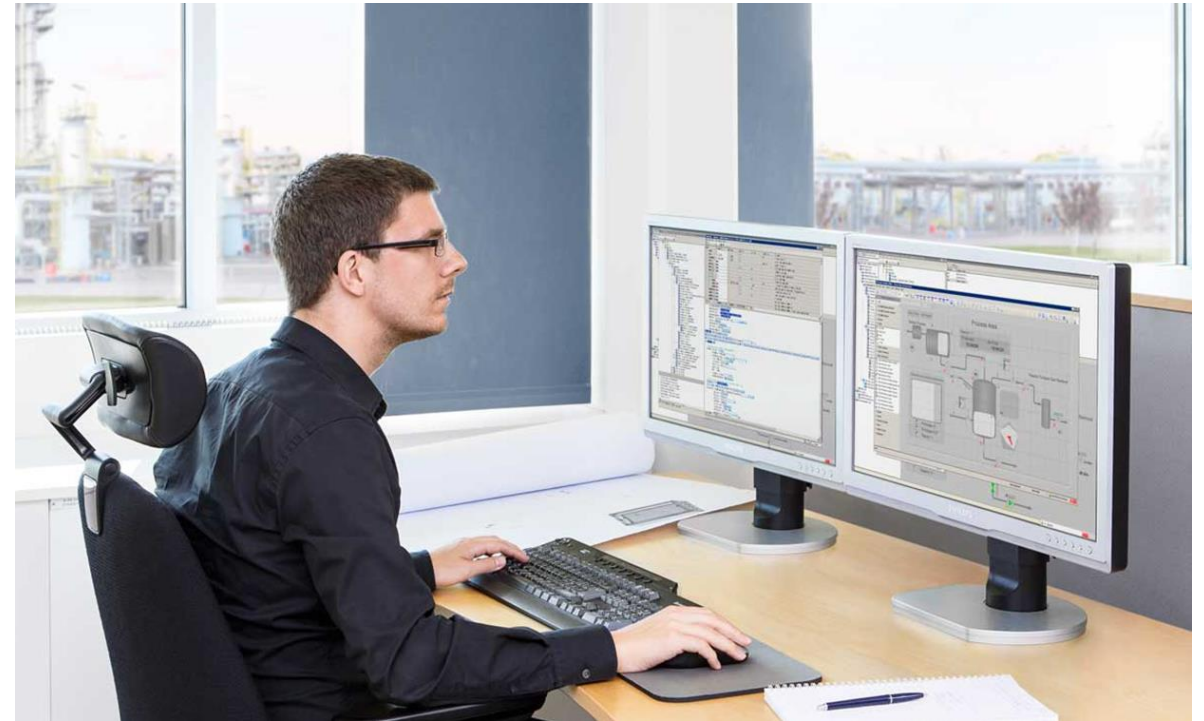
Success requires interoperability of engineering tools!

# Message Exchange in Engineering

**Interoperability** is *the ability of two or more systems or components to exchange information and to use the information that has been exchanged.\**

**Information** is data with its meaning attached  
→ Interoperability is about alignment on meaning and usage of exchanged data.

**Semantic integration** is combining of heterogeneous data with meaning alignments.



Interoperability requires meaning and usage alignments

# Approaches for Engineering Data Exchange

Options 1-5 as described in 'AutomationML – A Practical Guide'\*

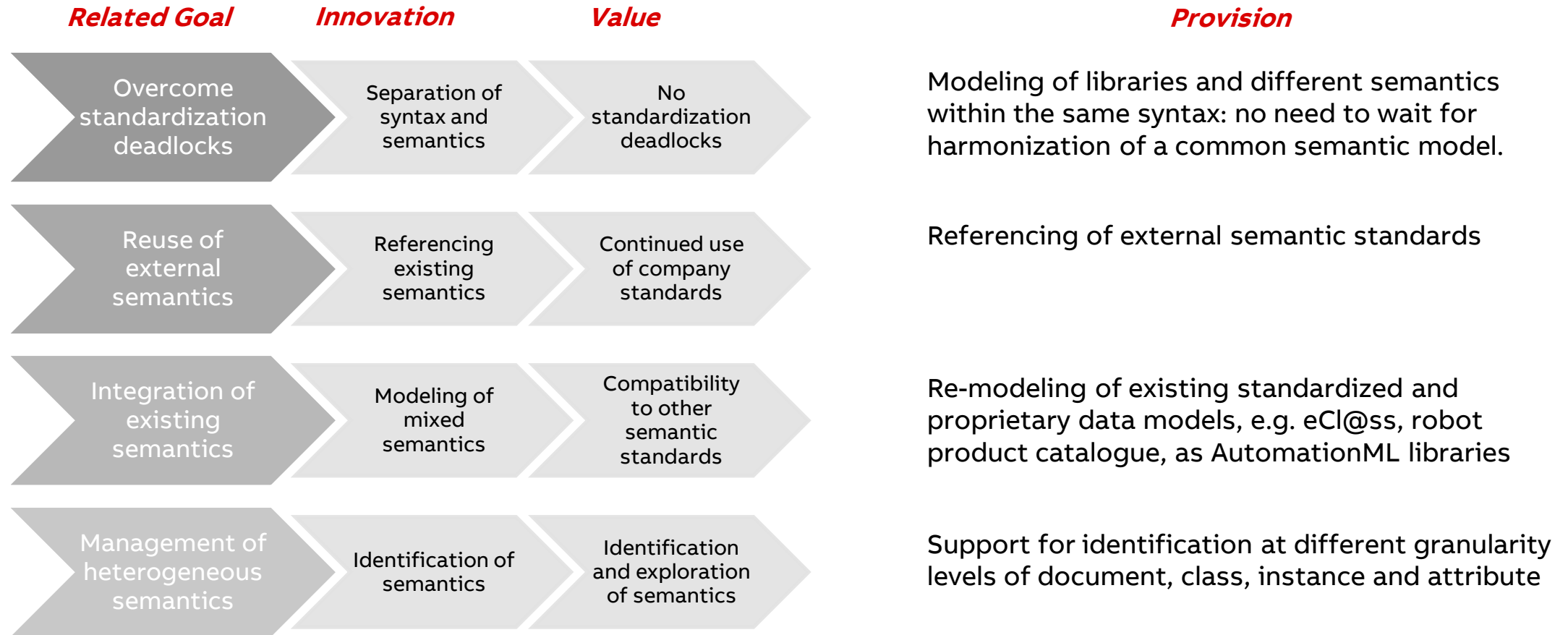
Address semantic integration

Options	1. Harmonization of engineering tools	2. Simple file-based data exchange	3. Common tool-suite	4. Harmonization of data models	5. Alignment of heterogeneous data models
Criteria					
Data synchronization		+	+	+	+
Multiple iteration support	+		+	+	+
Independent tool innovation	+	+			+
Best-in-class tool usage		+		+	+
Reuse of proven know-how		+		+	+
Low tool costs		+		+	+
Low interface development effort	+		+		+
Low governance requirement	+	+	+		+
Low maintenance	+		+		
Suitable for	Small projects	Small or medium projects	Large projects	Centralized data infrastructures	Distributed data infrastructures

+ denotes fulfillment

# Semantic Integration Support from AutomationML

Related Goals, Innovations, Values and Provisions<sup>[1]</sup>



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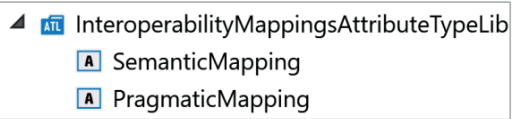
# Alignment of heterogeneous data models

Addressed in Chapter 23 of 'AutomationML – The Industrial Cookbook'

# Semantic and Pragmatic Interoperability Mappings

As described in Chapter 23 of ‘AutomationML – The Industrial Cookbook’

## Interoperability Mappings Attribute Type Library

AML Attribute Type Library	Attribute Type Name	Description
	SemanticMapping	Attribute for semantic alignment. Value corresponds to required transformation.
	PragmaticMapping	Attribute for pragmatic alignment. Value corresponds to required transformation with usage context specification.

### Interoperability Mapping Attribute Types

- used to align data from heterogeneous data models for meaning and usage via an AutomationML metamodel
- formed at class-level and made available to all participating tools via the AutomationML metamodel

## Semantic Mapping Attribute Type

Attributes of SemanticMapping Attribute Type:

- **refCAEXAttribute**: attribute mirrors a CAEX attribute
- **Language**: language of applicable transformation
- **Direction**: direction of data transfer for mapping

## Pragmatic Mapping Attribute Type

In addition to above attributes, PragmaticMapping Attribute Type also contains:

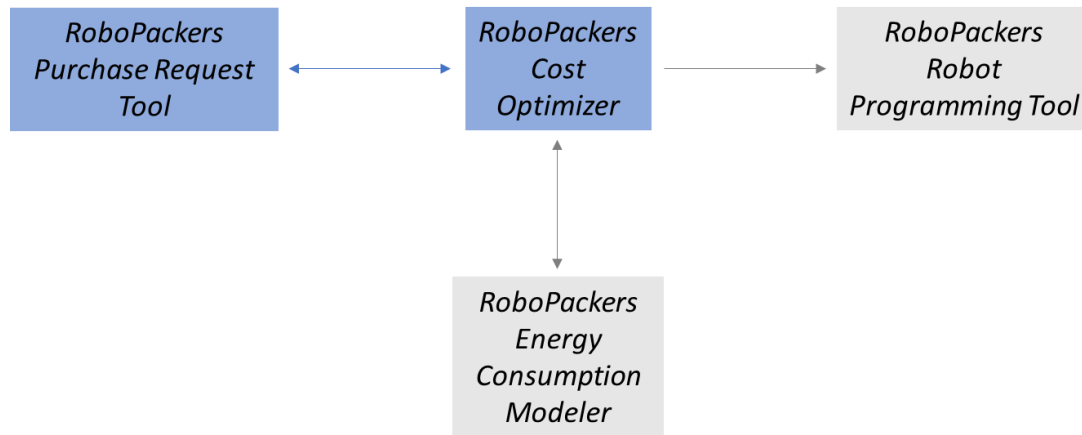
- **UsageContext**: Condition of usage for mapping
- **UsageContext/refCAEXAttribute**: mirrors corresponding CAEX attribute

# Example Problem

Need for interoperability alignments

## Example Problem Scenario

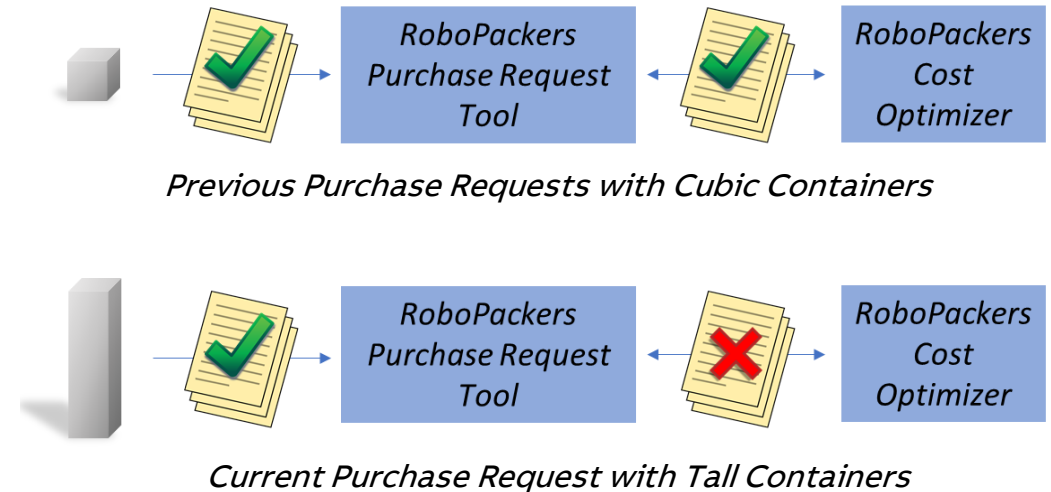
*RoboPackers* is a hypothetical company using industrial robots for filling and packaging hand-sanitizer containers.



*RoboPackers engineering tool chain*

## Data Exchange Problem

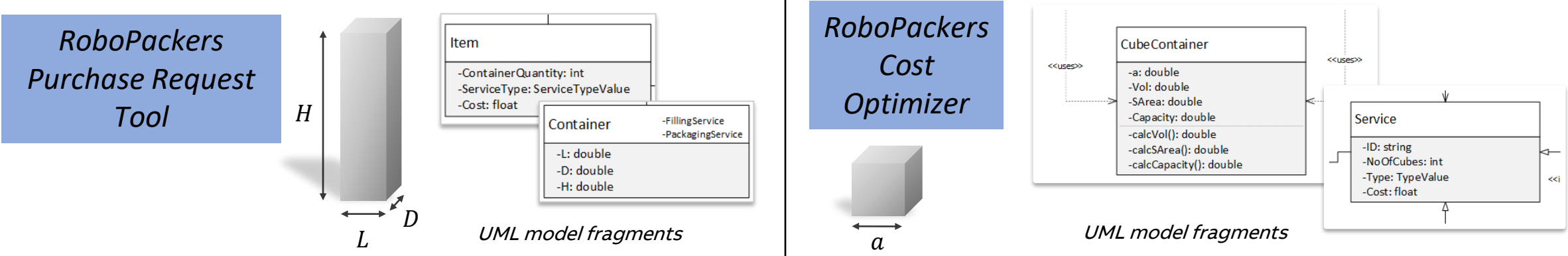
Legacy tool *CostOptimizer* only supports cube containers – problematic for new order with rectangular containers:



Q: How can data be exchanged automatically, without internal tool changes or common data model development?

# Example Alignments

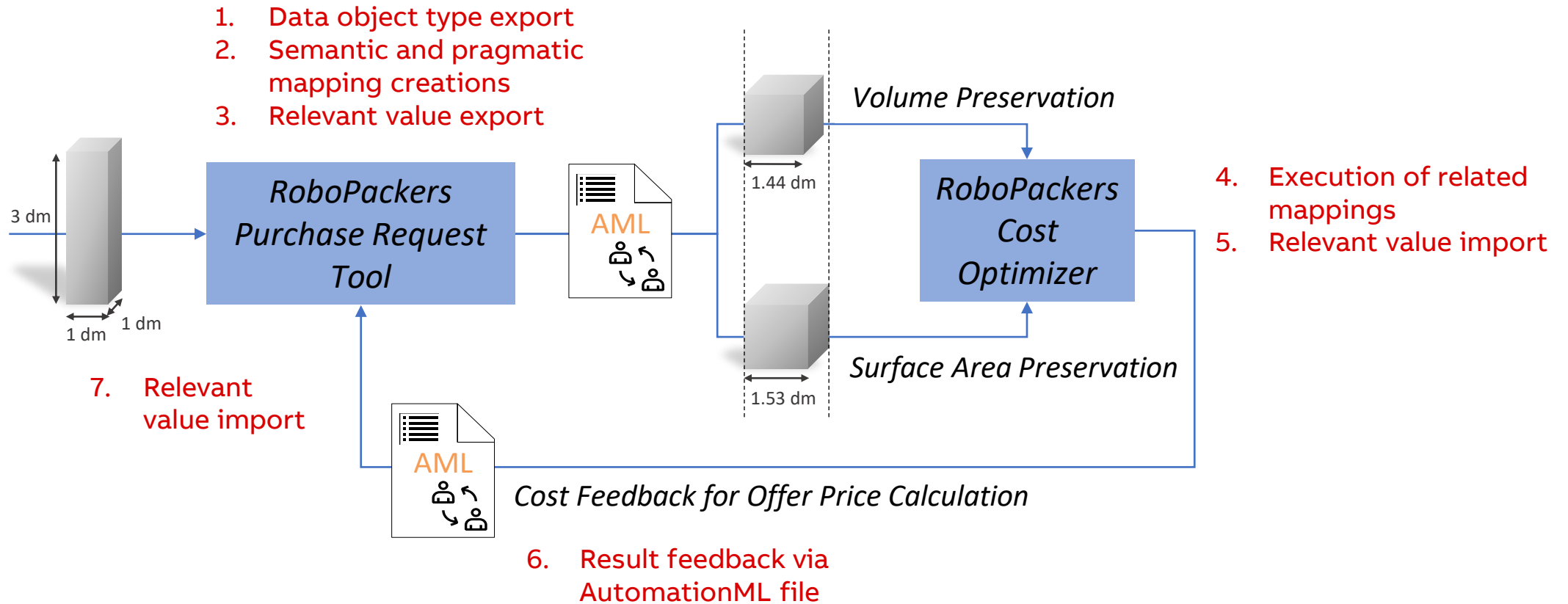
## Semantic and Pragmatic Interoperability Alignments



Simple Semantic Alignments: (direct)	$Item/ContainerQuantity$	$\longrightarrow$	$Service/NoOfCubes$
Complex Semantic Alignments: (transformation required)	$L * D * H$	$\longrightarrow$	$Vol$
	$2 * (L * D + D * H + L * H)$	$\longrightarrow$	$SArea$
Pragmatic Alignments: (usage-dependent):	$\sqrt[3]{L * D * H}$	$\longrightarrow$	$a$ if $Type.Value = "FillingService"$ (volume preservation)
	$\sqrt[2]{(L * D + D * H + L * H)/3}$	$\longrightarrow$	$a$ if $Type.Value = "PackagingService"$ (surface area preservation)

# Solution Overview

## Using Semantic and Pragmatic Interoperability Mapping Types



# Benefits of Interoperability Alignments Methodology

	Flexible	Feasible	User-Friendly
<i>Mapping Phase</i>	Complex meaning and usage alignments supporting flexible <b>multi-language, multi-step transformations</b>	Meaning alignments for transferred data <b>without high initial costs</b> associated with data model harmonization	<b>Discovery</b> of available data object types from different tools via a syntactically neutralized CAEX model
<i>Data Exchange Phase</i>	Generically programmable tool exporters and importers requiring <b>no knowledge of other tool data models</b>	Interoperability managed externally of participating software, <b>avoiding costly tool-internal code changes</b>	<b>Transparent, growing and reusable</b> set of interoperability mappings that are centrally available
<i>Overall</i>	Gradual development of semantic standards in a stepwise manner <b>avoiding standardization deadlocks</b>	Immediately implementable mappings for <b>fast return on investment</b> through quality and efficiency improvements	Automatic data exchange of only the <b>relevant and meaningfully aligned data</b>

**ABB**