

# Inter@pera

Digitale Interoperabilität in kollaborativen  
Wertschöpfungsnetzwerken der Industrie 4.0

Patrick Sapel

## Technical Data for Injection Molding Final Results Presentation

17.11.2023

Ein Projekt gefördert vom



Bundesministerium  
für Wirtschaft  
und Klimaschutz

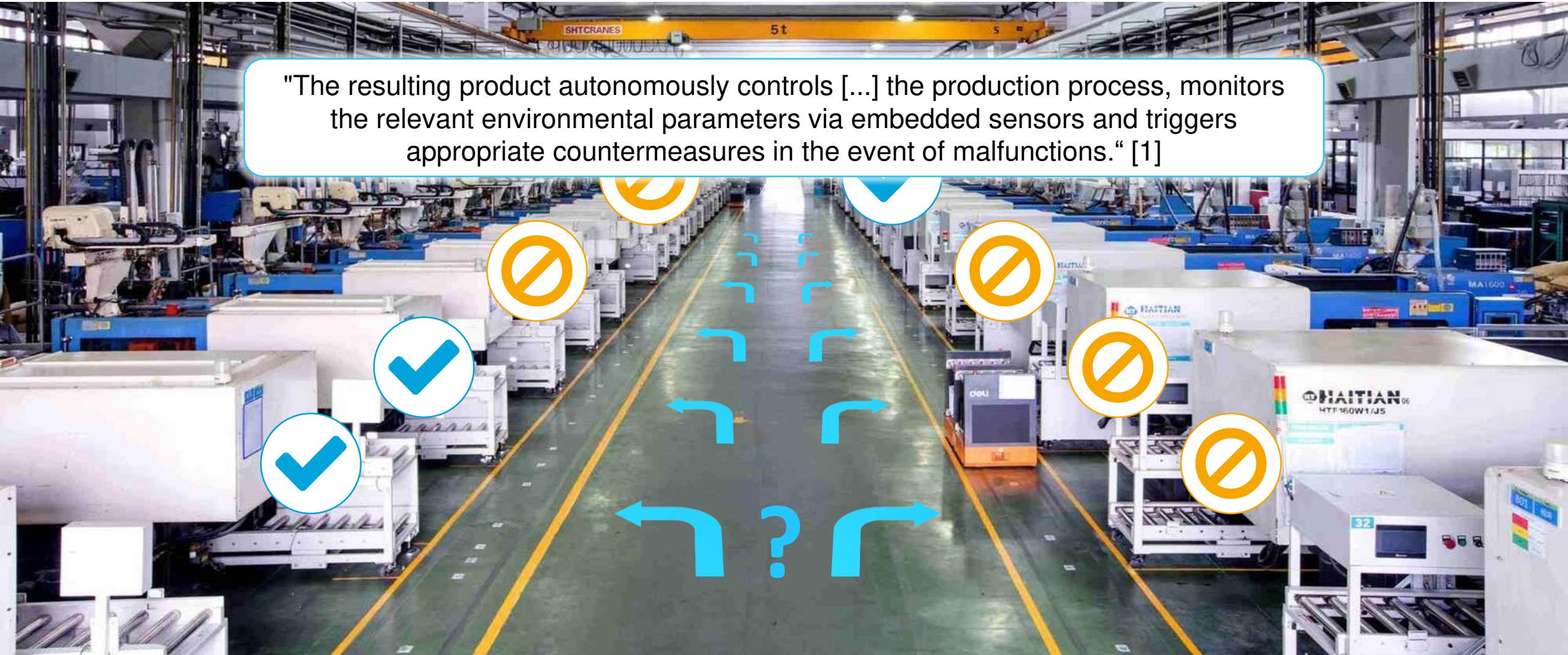
Durchgeführt von



# Motivation

One focus of Industrie 4.0 is autonomous production

"The resulting product autonomously controls [...] the production process, monitors the relevant environmental parameters via embedded sensors and triggers appropriate countermeasures in the event of malfunctions." [1]



# Motivation

One focus of Industrie 4.0 is autonomous production

## 2030 VISION FOR INDUSTRIE 4.0

Shaping Digital Ecosystems Globally

 More Information



DE | EN

# Motivation

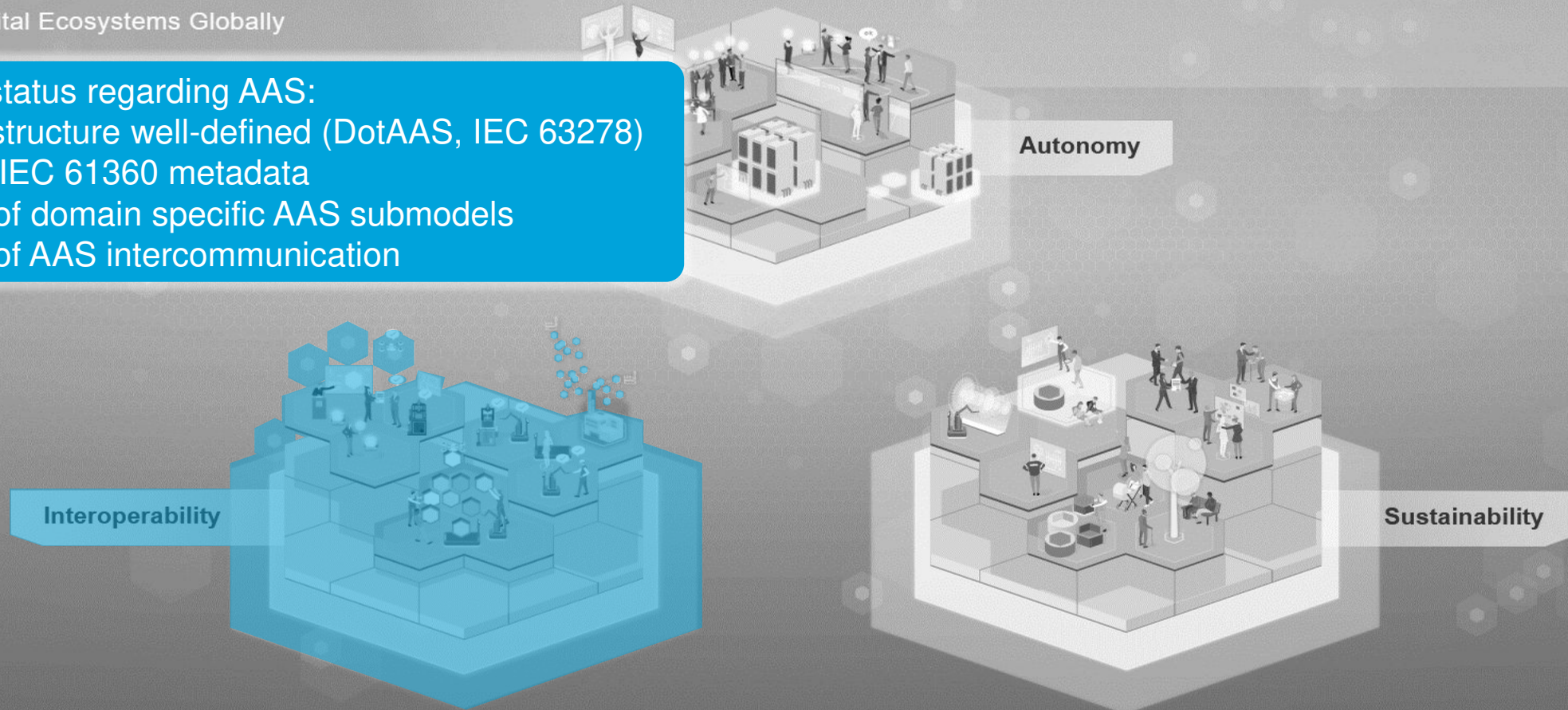
InterOpera directly contributes to Interoperability by providing submodels

## 2030 VISION FOR INDUSTRIE 4.0

Shaping Digital Ecosystems Globally

Current status regarding AAS:

- AAS structure well-defined (DotAAS, IEC 63278)
- Uses IEC 61360 metadata
- Lack of domain specific AAS submodels
- Lack of AAS intercommunication



# Agenda

- 1 | Motivation
- 2 | Brief introduction to InterOpera
- 3 | Submodel „Technical Data for Injection Molding“
  - 3.1 | Initiating Use Case
  - 3.2 | Working group
  - 3.3 | Overview of the submodels
  - 3.4 | Technical Data for Injection Molding Machine
  - 3.5 | Technical Data for Injection Mold
  - 3.6 | Technical Data for Temperature Control Unit
  - 3.7 | Technical Data for Hot Runner Device
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- 4 | Exemplary real-world application
- 5 | Conclusion and Outlook

# Brief introduction to InterOpera

## Introduction of the project consortium



### Steinbeis Europa Zentrum (Coordinator)

- **Role:** Coordination and network development
- **Major Contribution:** Network development for Industry 4.0 through by establishing value creation networks and submodel projects



### Fraunhofer IPA

- **Role:** Scientific assistance
- **Major Contribution :** Validation of the processes as AAS experts, support in the selection of idea sketches, interface with IDTA and other AAS stakeholders



### Standardization Council Industrie 4.0

- **Role:** Connection to standardization activities
- **Major Contribution :** Implementation, rollout, and transfer to standardization

# Brief introduction to InterOpera

## Introduction of the project consortium



- Development of specific, practicable, and interoperable submodels of the asset administration shell (AAS) for multiple business processes
- Expanding the strategic framework for implementing digital business models in Germany and Europe with this and by transferring partial models to standardization in the long term
- Spreading knowledge about AAS and raising companies' awareness of the benefits of AAS
- Increasing the number of technical experts who can create submodels

Deliverable:

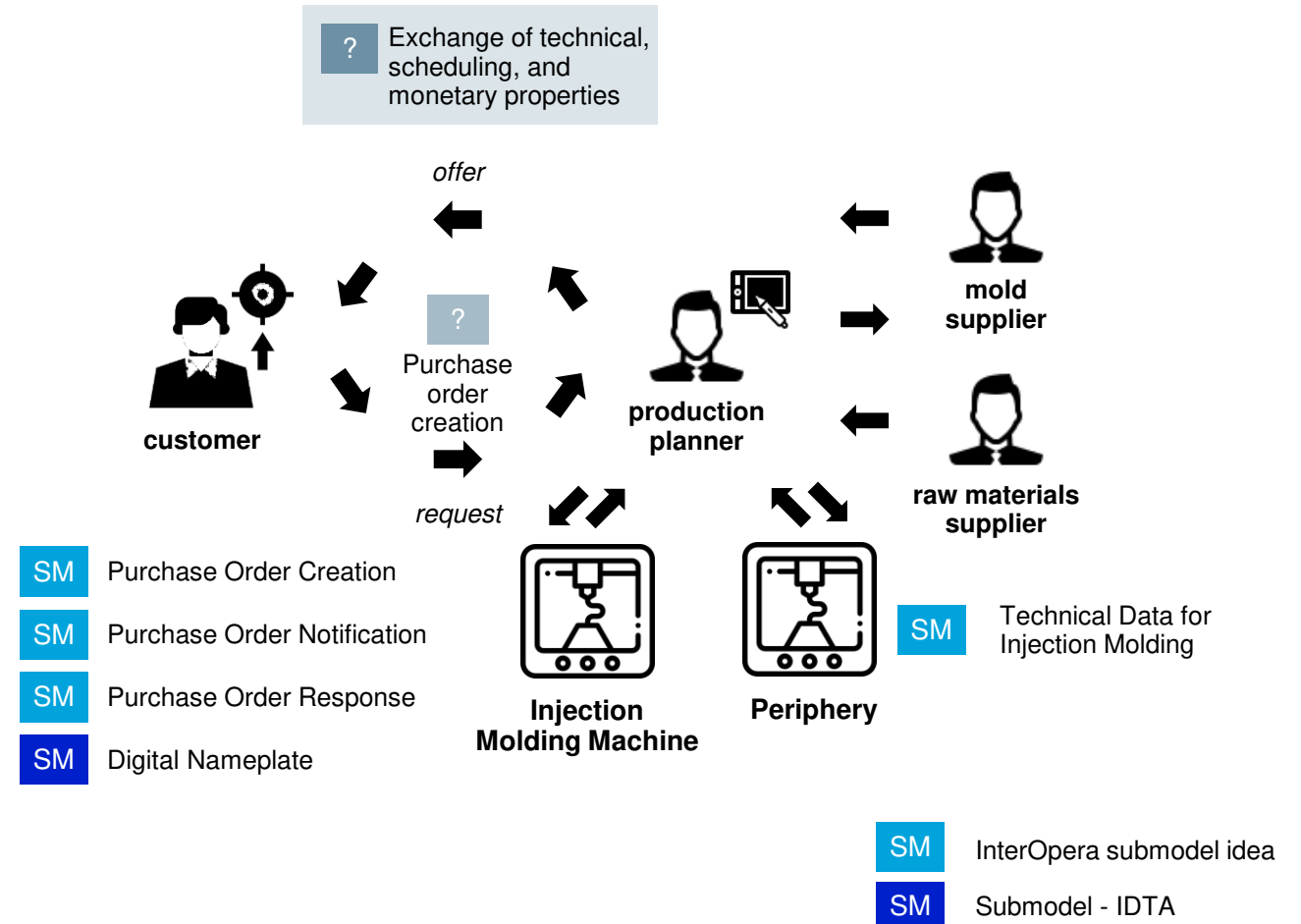
- ➔ Dictionaries, comprising the assets properties plus metadata

# Initiating Use Case

Checking the technical capability requires technical data of assets

## Goals:

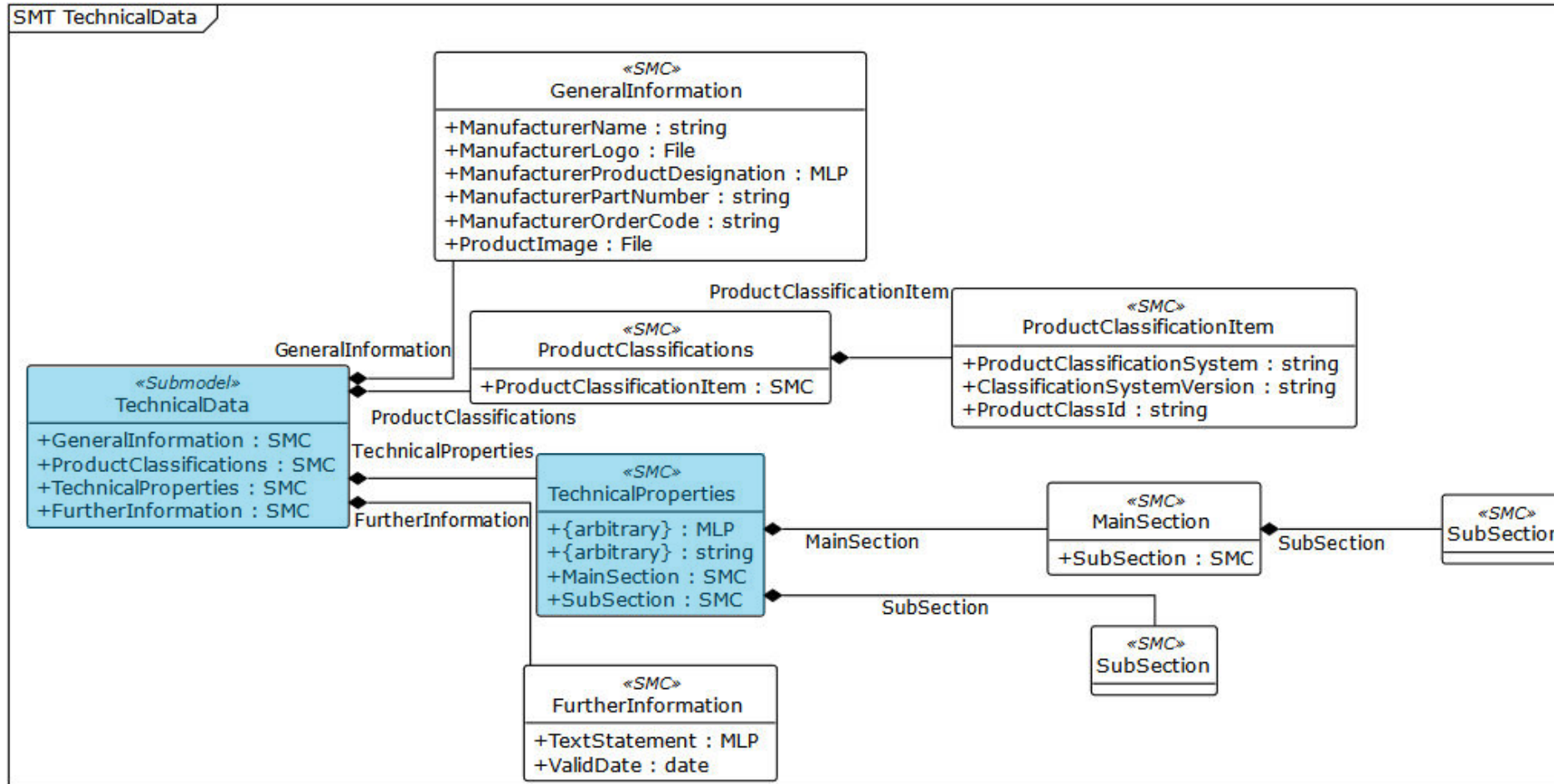
- Common definition and understanding of technical data in the IM domain
- AAS compliant submodel and specification
- Performing data-based capability checks (production planning)





# Initiating Use Case

## Enrichment of Generic Frame for Technical Data (IDTA 02003)



# Working Group

Diverse industry partners gave their valuable input and form the results



# Overview of the submodels

Overall, we have created four comprehensive submodels

## Technical Data for Injection Molding

298 Elements\*

38 SubElementCollections | 164 Properties | 22 Enumerations | 74 Values

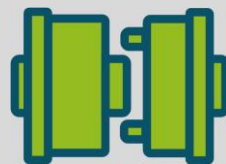
### Injection Molding Machine

16 SMC  
79 Properties  
17 Enumerations  
35 Values



### Injection Mold

12 SMC  
35 Properties  
12 Enumerations  
29 Values



### Temperature Control Unit

8 SMC  
34 Properties  
11 Enumerations  
19 Values



### Hot Runner Device

5 SMC  
30 Properties  
4 Enumerations  
10 Values



IEC 61360-1 data specification

\* without duplicates

# Semantics enabling FAIR data for the IM domain

SMC and properties are described with metadata acc. to IEC 61360-1



**F**indable – **A**ccessible – **I**nteroperable – **R**eusable

## Property:

### Submodel Element (Property)

#### Referable:

idShort: MaxClampingForce  
displayName: [en] Maximum clamping force  
[de] Maximale Schließkraft  
category:  
description: [en] The maximum clamping force is the maximum force applied by the clamping unit of an injection moulding machine  
[de] Die maximale Schließkraft ist die maximale Kraft, die von der Schließenheit einer Spritzgießmaschine aufgebracht wird

#### HasExtension:

#### Semantic ID:

semanticId: (GlobalReference) <https://iop.rwth-aachen.de/IM/cd/1/1/maxClampingForce>

#### Supplemental Semantic IDs:

#### Qualifiable:

##### Qualifier 1

semanticId: (GlobalReference) <https://admin-shell.io/SubmodelTemplates/Cardinality/1/0>  
kind: TemplateQualifier  
type: SMT/Cardinality  
valueType: xs:string  
value: One

#### HasDataSpecification (Reference):

#### Property

valueType: xs:double  
value:

# Semantics enabling FAIR data for the IM domain

SMC and properties are described with metadata acc. to IEC 61360-1



**F**indable – **A**ccessible – **I**nteroperable – **R**eusable

Concept Description:

## ConceptDescription

### Referable:

idShort: MaxClampingForce  
displayName: [en] Maximum clamping force  
[de] Maximale Schließkraft  
category:  
description: [en] The maximum clamping force is the maximum force applied by the clamping unit of an injection moulding machine  
[de] Die maximale Schließkraft ist die maximale Kraft, die von der Schließenheit einer Spritzgießmaschine aufgebracht wird

### HasExtension:

### Identifiable:

id: <https://iop.rwth-aachen.de/IM/cd/1/1/maxClampingForce>  
id (Base64): aHR0cHM6Ly9pb3Aucnd0aC1hYWNoZW4uZGUvSU0vY2QvMS8xL21heENsYW1waW5nRm9yY2U=

### administration:

version: 1  
revision: 1

### isCaseOf:

reference[0]: (GlobalReference) 0173-1#02-AAJ507#002

# Semantics enabling FAIR data for the IM domain

SMC and properties are described with metadata acc. to IEC 61360-1



**F**indable – **A**ccessible – **I**nteroperable – **R**eusable

IEC61360 data specification (within Concept Description):

## HasDataSpecification (records of embedded data specification):

### dataSpec.[0] / Reference:

dataSpec.[0]: (GlobalReference) <http://admin-shell.io/DataSpecificationTemplates/DataSpecificationIEC61360/3/0>

### dataSpec.[0] / Content:

#### Data Specification Content IEC61360:

preferredName: [en] Maximum clamping force  
[de] Maximale Schließkraft

shortName: [en] Max closing force  
[de] Max Schließkraft

unit: kN

sourceOfDef.: EUROMAP 7

symbol: F\_cl,max}

dataType: REAL\_MEASURE

definition: [en] The maximum clamping force is the maximum force applied by the clamping unit of an injection moulding machine  
[de] Die maximale Schließkraft ist die maximale Kraft, die von der Schließeinheit einer Spritzgießmaschine aufgebracht wird

valueFormat: NR2..4.2

value:

levelType:  min  max  nom  typ

## Property

valueType: xs:double

value:

# Technical Data for Injection Molding Machine

Existing standards and guidelines are considered



DIN 24450	Maschinen zum Verarbeiten von Kunststoffen und Kautschuk; Begriffe
DIN EN ISO 472	Kunststoffe - Fachwörterverzeichnis
EUROMAP 1	Description of injection moulding machines
EUROMAP 2	Injection moulding machines - Mould fixing and connection dimensions
EUROMAP 4	Injection moulding machines - Determination of the actual injection efficiency
EUROMAP 5	Injection moulding process - Determination of important production data - Manufacturing Report
EUROMAP 6	Injection Moulding Machines - Determination of the duration of the dry cycle
EUROMAP 7	Injection moulding machines - Determination of the maximum clamping force
EUROMAP 8	Determination of the nominal opening force of injection moulding machines
EUROMAP 60.1	Determination of machine related energy efficiency class
EUROMAP 77 (VDMA 40077)	OPC UA interfaces for plastics and rubber machinery – Data exchange between injection moulding machines and MES
EUROMAP 83 (VDMA 40083)	OPC UA interfaces for plastics and rubber machinery – General Type definitions
EUROMAP 86 (VDMA 40086)	Material Supply Systems - Order Management

# Technical Data for Injection Molding Machine

## Submodel structure based on EUROMAP 1





# Technical Data for Injection Mold

- SMC "TechnicalProperties" (10 elements) @SMT/Cardinality=One
  - SMC "DimAndWeight" (2 elements) @SMT/Cardinality=One
    - SMC "InjectionMold" (9 elements) @SMT/Cardinality=One
    - SMC "MoldInsert" (3 elements) @SMT/Cardinality=One
  - SMC "MoldConcept" (3 elements) @SMT/Cardinality=One
  - SMC "MaterialAndSurface" (1 elements) @SMT/Cardinality=One
  - SMC "EjectorSystem" (4 elements) @SMT/Cardinality=OneToMany
  - SMC "GuidingAndCentering" (2 elements) @SMT/Cardinality=OneToMany
  - SMC "SprueSystem" (7 elements) @SMT/Cardinality=One
  - SMC "TemperingSystem" (5 elements) @SMT/Cardinality=One
  - SMC "MachineMountingAndForcelntake" (1 elements) @SMT/Cardinality=One
  - SMC "Cavity" (4 elements) @SMT/Cardinality=One
  - SMC "EnergyTransportAndSensors" (2 elements) @SMT/Cardinality=One

Number	Title
DIN 24450	Maschinen zum Verarbeiten von Kunststoffen und Kautschuk; Begriffe
DIN EN ISO 472	Kunststoffe - Fachwörterverzeichnis
EUROMAP 2	Injection moulding machines - Mould fixing and connection dimensions
EUROMAP 5	Injection moulding process - Determination of important production data - Manufacturing Report
EUROMAP 77 (VDMA 40077)	OPC UA interfaces for plastics and rubber machinery – Data exchange between injection moulding machines and MES
EUROMAP 83 (VDMA 40083)	OPC UA interfaces for plastics and rubber machinery – General Type definitions

# Technical Data for Temperature Control Unit

- SMC "TechnicalProperties" (16 elements) @Cardinality=One
- ▷ SMC "Channels" (3 elements) @SMT/Cardinality=OneToMany
- ▷ SMC "DimAndWeight" (4 elements) @SMT/Cardinality=One
- ▲ SMC "Connections" (4 elements) @SMT/Cardinality=OneToMany
  - ▷ SMC "MainAndReturnLine" (4 elements) @SMT/Cardinality=One
  - ▷ SMC "CoolingWaterAndSeparateSystemWater" (7 elements) @SMT/Cardinality=One
  - ▷ SMC "CompressedAir" (6 elements) @SMT/Cardinality=One
  - ▷ SMC "Drain" (2 elements) @SMT/Cardinality=One
- ▷ SMC "ControlAndIT" (3 elements) @SMT/Cardinality=One

Number	Title
DIN 24450	Maschinen zum Verarbeiten von Kunststoffen und Kautschuk; Begriffe
EUROMAP 82.1 (VDMA 40082-1)	OPC UA interfaces for plastics and rubber machinery – Peripheral devices – Temperature control devices

# Technical Data for Hot Running Device



- SMC "TechnicalProperties" (18 elements) @Cardinality=One
  - SMC "DimAndWeight" (4 elements) @SMT/Cardinality=One
  - SMC "MoldConnection" (1 elements) @SMT/Cardinality=One
    - SMC "ConnectorPlugArrangement" (2 elements) @SMT/Cardinality=One
      - SMC "FeelerAndHeaterSeparated" (8 elements) @SMT/Cardinality=ZeroToOne
      - SMC "FeelerAndHeaterMerged" (4 elements) @SMT/Cardinality=ZeroToOne

Number	Title
DIN EN ISO 472	Kunststoffe - Fachwörterverzeichnis
EUROMAP 82.2 (VDMA 40082-2)	OPC UA interfaces for plastics and rubber machinery – Peripheral devices – Hot runner devices

# Conventions, Challenges, Best Practices, and the connection to EUROMAP



## Conventions:

- IRI-Typ: <https://iop.rwth-aachen.de/IM/{Typ}/1/1/{idShort}> → wird später zu IRDI, z. B. 0173-1#02-AAJ507#003
- Min/Max as prefix

## Challenges:

- Reusing properties:
  - Multiple options, e.g., 7x clamping force in ECLASS
  - Mostly not fully specified with IEC 61360 metadata
    - new `ConceptDescription` *isCaseOf* existing `ConceptDescription`
- Different philosophies for definition
  - Providing two options with multiplicity 0..X so user can decide

### isCaseOf:

reference[0]:

(GlobalReference) 0173-1#02-AAJ507#002

## EUROMAP connection:

- Rebuild submodel structure from EUROMAP as far as possible
- Reusing names
- Submodels not in competition to EUROMAP

# Exemplary real-world application

## Checking the technical capability of injection molding assets



Company A			Company B		
Asset	Property		Asset	Property	
Mold	MinRequiredClampingForce	<=	IMM	MaxClampingForce	
Mold	ShotVolume	<=	IMM	MaxPlasticizingCapacity	
Mold	GreaterMoldDimension	<=	IMM	GreaterClearDistanceBetweenColumns	
Mold	SmallerMoldDimension	<=	IMM	SmallerClearDistanceBetweenColumns	
Mold	RequiredOpeningStroke	<=	IMM	MaxOpeningStroke	
Inquiry	RequiredHandlingType	=	HandDev	HandlingDevice	
Mold	Coolant	=	TCU	Coolant	

### Pairwise comparison based on AAS properties

Mold	MinRequiredClampingForce	1000	<=	IMM 1	MaxClampingForce	1200
Mold	ShotVolume	270	<=	IMM 1	MaxPlasticizingCapacity	500
Mold	GreaterMoldDimension	400	<=	IMM 1	GreaterClearDistanceBetweenColumns	600
Mold	SmallerMoldDimension	350	<=	IMM 1	SmallerClearDistanceBetweenColumns	500
Mold	RequiredOpeningStroke	800	<=	IMM 1	MaxOpeningStroke	900
Mold	MinRequiredClampingForce	1000	<=	IMM 2	MaxClampingForce	900
Mold	ShotVolume	270	<=	IMM 2	MaxPlasticizingCapacity	600
Mold	GreaterMoldDimension	400	<=	IMM 2	GreaterClearDistanceBetweenColumns	450
Mold	SmallerMoldDimension	350	<=	IMM 2	SmallerClearDistanceBetweenColumns	400
Mold	RequiredOpeningStroke	800	<=	IMM 2	MaxOpeningStroke	800

Inquiry (customer)

machinery (manufacturer)

```

AAS IMM_1 (23-11-14 21:18:34.760)
├── Sub Nameplate
├── Sub TechnicalData
│   ├── Coll DesignFeatures #3
│   │   ├── Prop ClampingUnitDesignFeatures @QUALIFIERS
│   │   ├── Prop InjectionUnitDesignFeatures @QUALIFIERS
│   │   └── Prop DimAndWeight @QUALIFIERS
│   ├── Coll TechnicalProperties #2
│   │   ├── Coll ClampingUnitTechnicalProperties #2
│   │   │   ├── Coll BasicData #2
│   │   │   │   ├── Prop MaxClampingForce = 1200.00
│   │   │   │   └── Prop MaxOpeningStroke = 900.00
│   │   │   └── Coll MoldMounting #2
│   │   │       ├── Prop GreaterClearDistanceBetweenColumns = 600.00
│   │   │       └── Prop SmallerClearDistanceBetweenColumns = 500.00
│   └── Coll InjectionUnitTechnicalProperties #1
│       └── Prop MaxPlasticizingCapacity = 500.00
├── Coll ProductClassifications #1
├── Coll ProductClassificationItem #3
│   ├── Prop ProductClassificationSystem
│   ├── Prop ClassificationSystemVersion
│   └── Prop ProductClassId
    
```

- AASX Server: Accessible via REST
- Deploy AAS as OPC UA server – read values, e.g., via python

# Conclusion and Outlook



- Four new submodels for „Technical Data in Injection Molding“ are developed
- Injection Molding Machine, Injection Mold, Temperature Control Unit, and Hot Runner Device
- Enhanced with semantics regarding IEC 61360-1
- Concomitant to EUROMAP



- In cooperation with IDTA: publish submodel specification
- VDMA: Consideration of transferring results into new EUROMAP specification(s)
- Using submodels for establishing asset to asset communication

# Danke für Ihr Kommen!

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Research Assisitant

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