2024-04-23: CE Forum

Accelerating Circular Economy Transition through Achieving Data Model Standardization and Interoperability
データモデルの国際標準化と相互運用性の実現：循環型経済推進における重要性と展望

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International Electrotechnical Commission

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4. Interoperability achieved through data models
   - Examples from standardization activities
5. Conclusions

Self introduction

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○BACKGROUND
data modelling, ontology, interoperability, system architecture, system engineering

ISO: International Organization for Standardization
IEC: International Electrotechnical Commission

○ Picked up standardization activities
- chairperson of IEC SC3D
  leading IEC 61360, IEC CDD data modelling methodology
- IEC TC111/JahG22 (CFP Digitalization): Convenor
- IEC SG12 (Digital transformation and systems approach): expert
- IEC MSB white paper: “Semantic Interoperability: Challenges in the digital transformation ages”: author
- ISO/IEC JTC1/SC41(IoT and Digital Twin)
  - project leader of ISO/IEC 21823-4 : IoT syntactic interoperability
  - Expert of ISO/IEC 21823-3: IoT semantic interoperability
- Liaison representative to IEC TC 65 (AAS), TC111 etc.

01

Background

Backgroud1 : DPP (Digital Product Passport) to facilitate Circular Economy

Interoperability among heteregenous systems are required for DPP

(1) ESPR specifies that DPP is mandatory for products.

- ESPR:Ecodesign for Sustainable Products Regulation
- enters into force: first harf of 2024

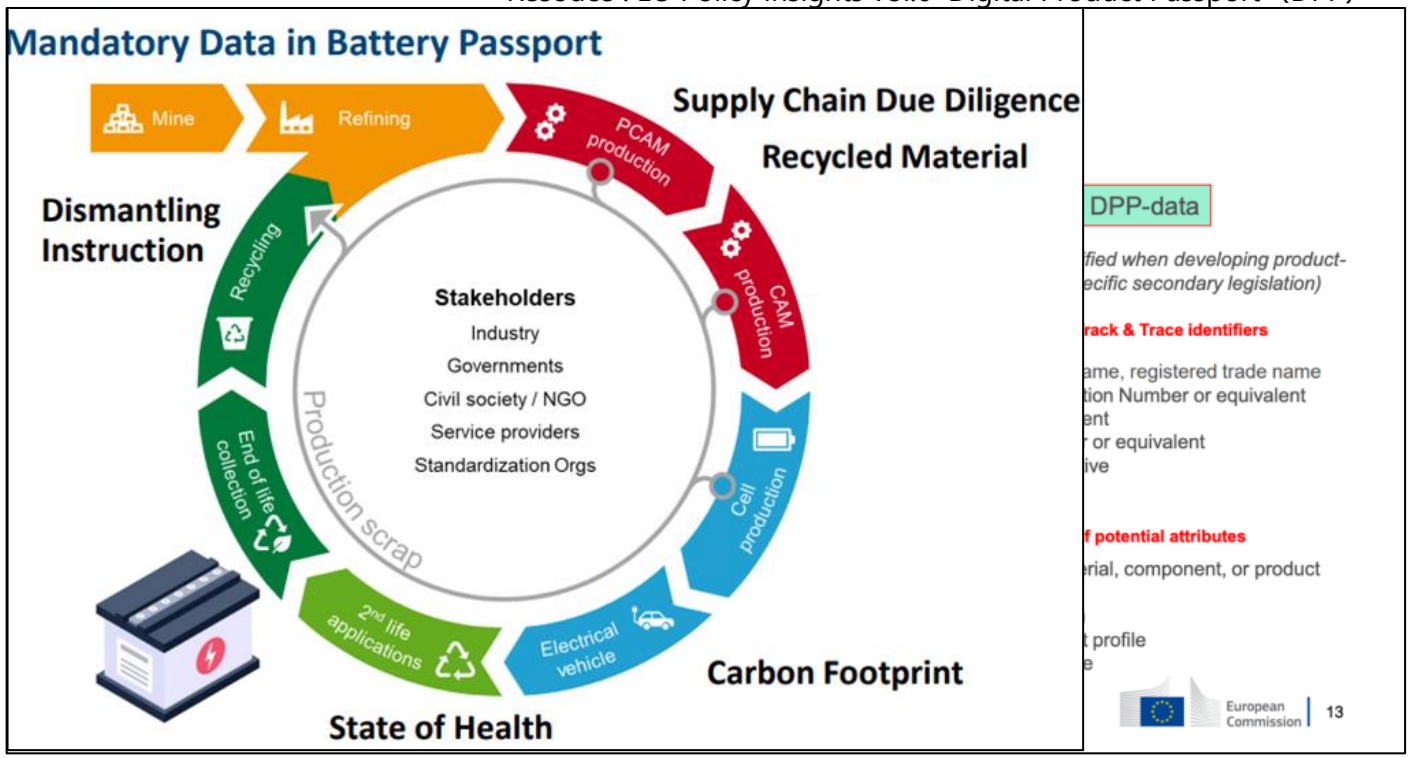
(2) Three leading domains (Battery/Textile/Electronics)

- https://cirpassproject.eu/wp-content/uploads/2023/07/D2.1_July_2023.pdf
-Battery regulation entered into force on Aug. 17th, 2023

(3) DPP Data throughout lifecycle

- Product Carbon Footprint is the highest priority

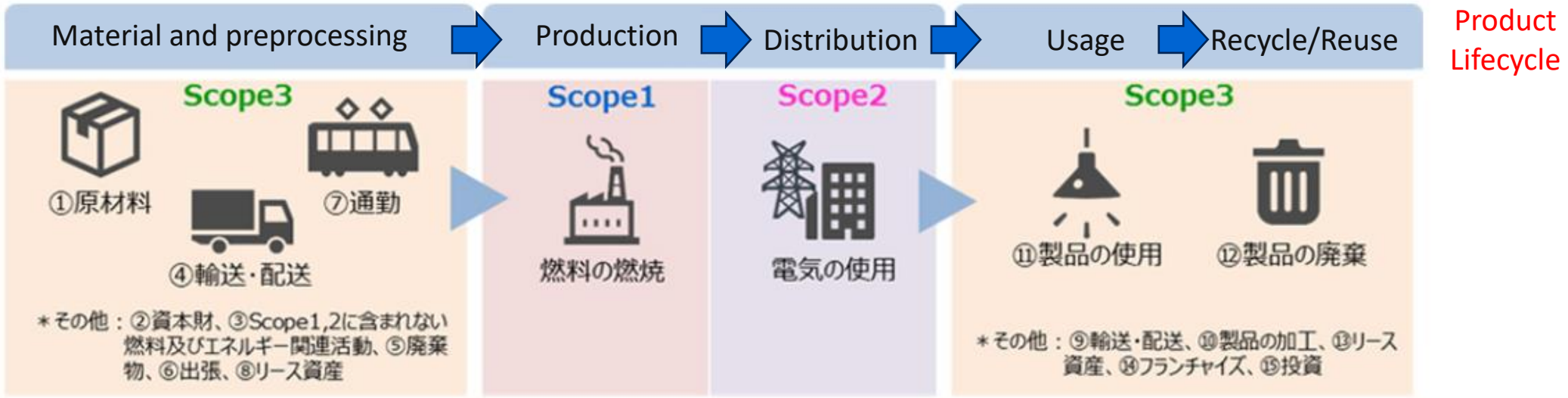
Resouce : EU Policy Insights vol.6 Digital Product Passport（DPP）



Resource: Conclusion about Evaluation of Standardization Request for digital product passport

Background2 : Products CO_2 emission calculation and exchange

Interoperability required for Product CO_2 calculation and data exchange



1. Rule-making and standardization of CO_2 emission calculation of materials, parts, and products
2. Common data model for sharing data between different systems
   - E.g., WBCSD PACT*: CFP Data Exchange Model
3. Interoperability with data platforms in standardized approaches

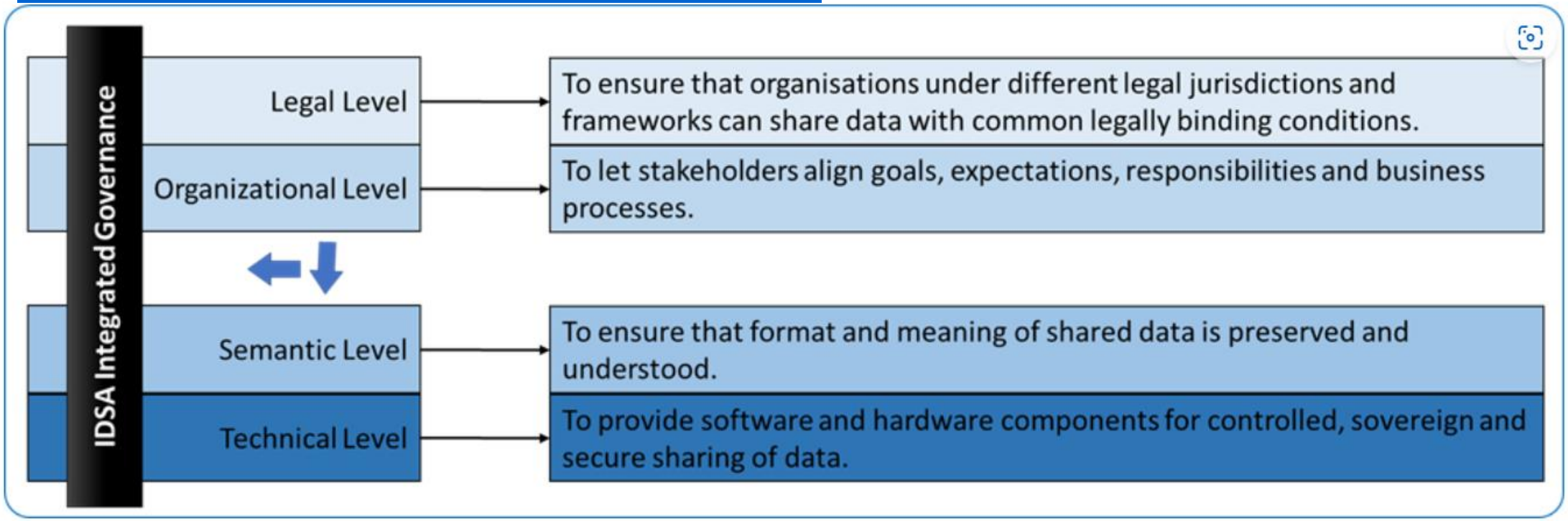
*WBCSD: World Business Council For Sustainable Development
PACT: Partnership for Carbon Transparency

Background 3: Interoperability

Interoperability: ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged

異なるシステムを接続し、相互の情報・データ（形式や意味など）を理解し、利活用をする

Interoperability for Data Spaces



Resource: 4.3.8 Data Space Instances | IDS-RAM 4 | IDS Knowledge Base (internationaldataspaces.org)

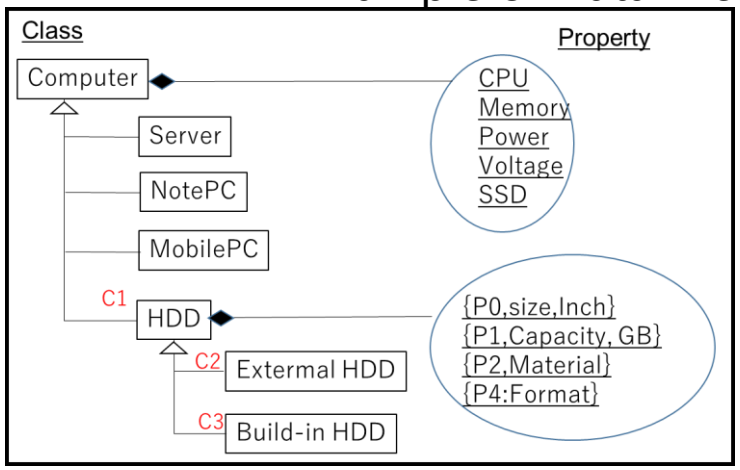
02

IEC CDD : Standard data modelling activities

Background：DX Issues to be solved by IEC SC3D standards

Digital World

Example of Data Dictionary



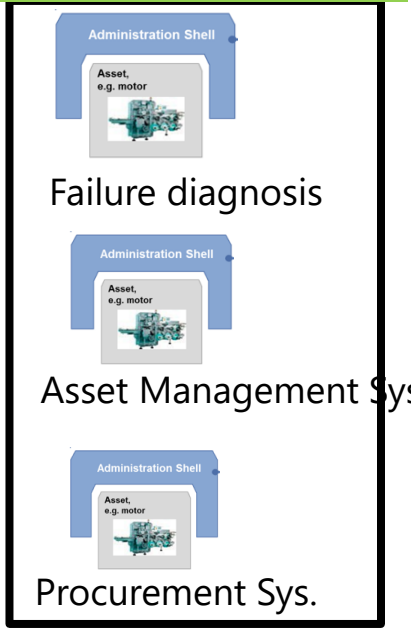
Standardized Data models

IEC CDD

②Common Data Dictionary
（IEC CDD of IEC SC3D）

③Exchange data with various stakeholders

System/Application/Modules

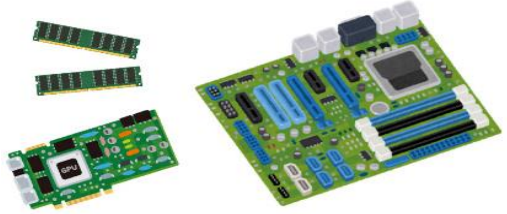


Physical World

①Data modelling methodology for digital representation of device information
（IEC 61360/IEC SC3D）

PC Maker A

PC Maker B



Component Maker X

Component Maker Y

L. YAMASHITA

Background：Interoperability issues to be solved with IEC SC3D standards

PC Maker A

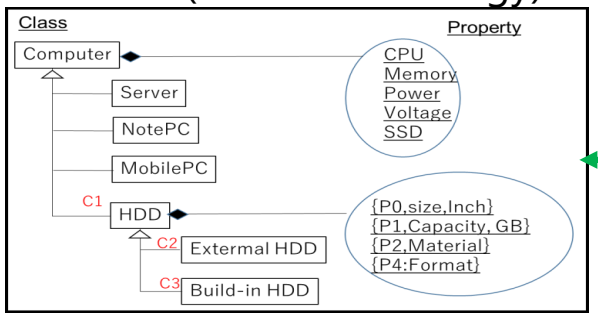
Can we use HDD of Maker B?

HDD：256G
Material：Glass
HDD Type：Build-in

HDD Maker B

Capacity: 256G
Material：Glass
Type：Build-in

IEC CDD(Product Ontology)



HDD: P1
Material: P2
HDD Type: C3

Capacity：P1
Material：P2
Type：C3

・Each entity is assigned with an identifier so that the semantic differences caused by different terms can be systematically solved
・Data exchange can be achieved with consideration of product ontology structures and relationships such as is-a, has-a, dependency.

Semantic Interoperability is supported

Modelling example: How to model physical devices in IEC CDD?

Product specifications: IEC CDD

Physical device

Sensor products classification

- AAA103 - sensor
  - AAA104 - humidity sensor
  - AAA105 - light sensor
  - AAA106 - magnetic field sensor
  - AAA107 - nuclear sensor
  - AAA108 - pressure sensor
  - AAA109 - proximity sensor
  - AAA110 - temperature sensor

Sensor properties

- 0112/2///61360_4#AAA103 - sensor
  - 0112/2///61360_4#AAE892 - sensor input quantity
  - 0112/2///61360_4#AAE893 - sensor working principle
  - 0112/2///61360_4#AAE001 - main class of component
  - 0112/2///61360_4#AAE002 - category EE component
  - 0112/2///61360_4#AAE007 - terminal shape
  - 0112/2///61360_4#AAE008 - terminal placement
  - 0112/2///61360_4#AAE022 - outside diameter
  - 0112/2///61360_4#AAE023 - terminal diameter
  - 0112/2///61360_4#AAE024 - terminal pitch
  - 0112/2///61360_4#AAE072 - terminal length
  - 0112/2///61360_4#AAE257 - power dissipation
  - 0112/2///61360_4#AAE259 - shape/size code BSI
  - 0112/2///61360_4#AAE347 - CECC specification
  - 0112/2///61360_4#AAE540 - current rms
  - 0112/2///61360_4#AAE633 - lacquered length
  - 0112/2///61360_4#AAE634 - terminal material
  - 0112/2///61360_4#AAE683 - temperature type
  - 0112/2///61360_4#AAE685 - temperature

- Products classifications
  - Hierarchical relationship/Composition relationship are supported
- A set of properties for a product class
  - Catalogue information, operational information, monitoring information etc.
- Typical units/values can be assigned to each property
- Property relationships

IEC TC 3/SC 3D: Product properties and classes and their identification

SC 3D Scope

https://www.iec.ch/ords/f?p=103:7:616475896896878::::FSP_ORG_ID,FSP_LANG_ID:1345,25

Standardization for representation of technical information along the life cycle of a product including service, device, system, software or plant, covering rules, principles and methods associated with the machine sensible representation of the technical information. This refers to:

- definition, structuring and identification of classes and properties
- structural design of product data dictionaries and ontologies
- consistent methodology for the purpose of structuring technical information and its exchange
- support for the design of classes and properties in all domains/industries and their publication in IEC Common Data Dictionary (IEC CDD)
- maintenance and quality control of the IEC Common Data Dictionary (IEC CDD)
- Supporting semantic interoperability

Horizontal function related to the methodology, design, architecture and interface for supporting product data dictionaries.

- Data modelling methodology for unambiguous product specifications and their relations as Common Data Dictionary (IEC CDD)
  - Product data dictionary/domain ontology/product ontology

IEC SC3D standards support IEC CDD

➢IEC 61360-1/ISO 13584-42 provides methodology to construct product data dictionaries in various industrial domains

- Syntax for product data dictionaries is specified and formalized.
- E.g., structures of the entity, relations among entities, value/format constraints for entities.

➢Data formats supported

-IEC 61360-2: a formal EXPRESS format
-IEC 62656-1: a formal spreadsheet format
-IEC 62656-3: a RDF and XML format included
-IEC 62656-8: a JSON/XML format included

➢Selected IEC CDD in industries

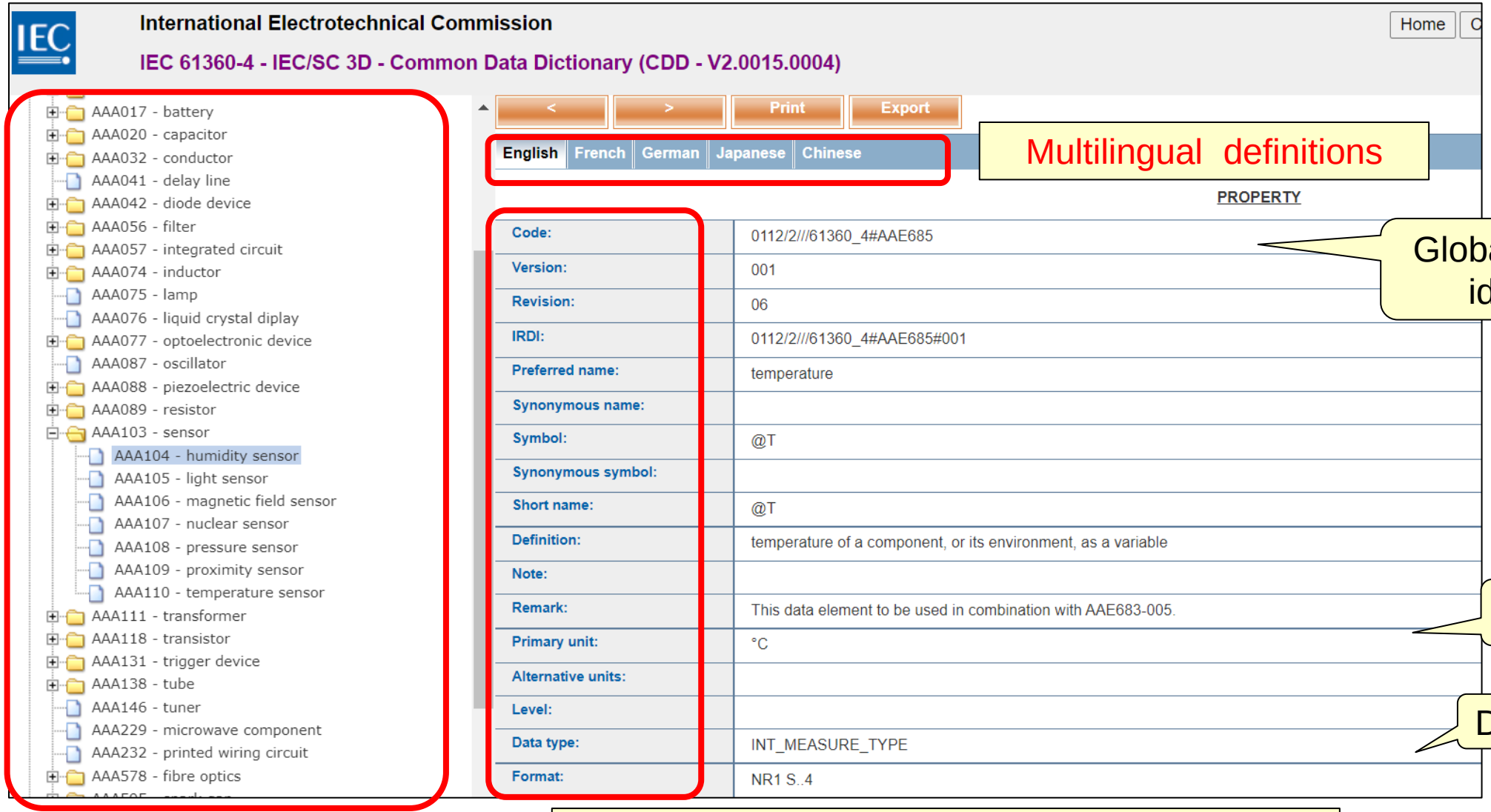
- IEC 61987 (IEC TC65): CDD for process automation
- IEC 62683 (IEC TC121): CDD for low voltage switchgear and controlgear
- IEC 61360-4(IEC SC3D): CDD for Electric/Electronic components

➢ Online management system

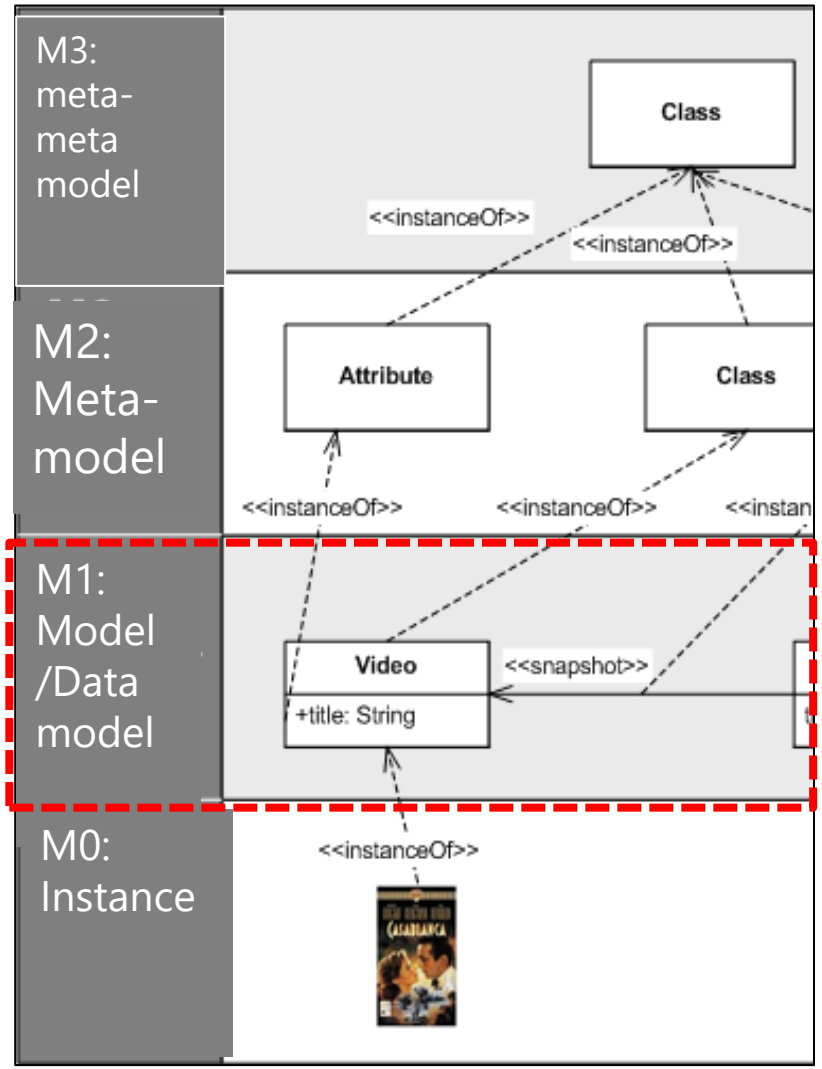
- https://cdd.iec.ch

IEC CDD example in electrical and electronic domains

https://cdd.iec.ch



IEC CDD modelling methodology：MoF (Model-Object Facility)

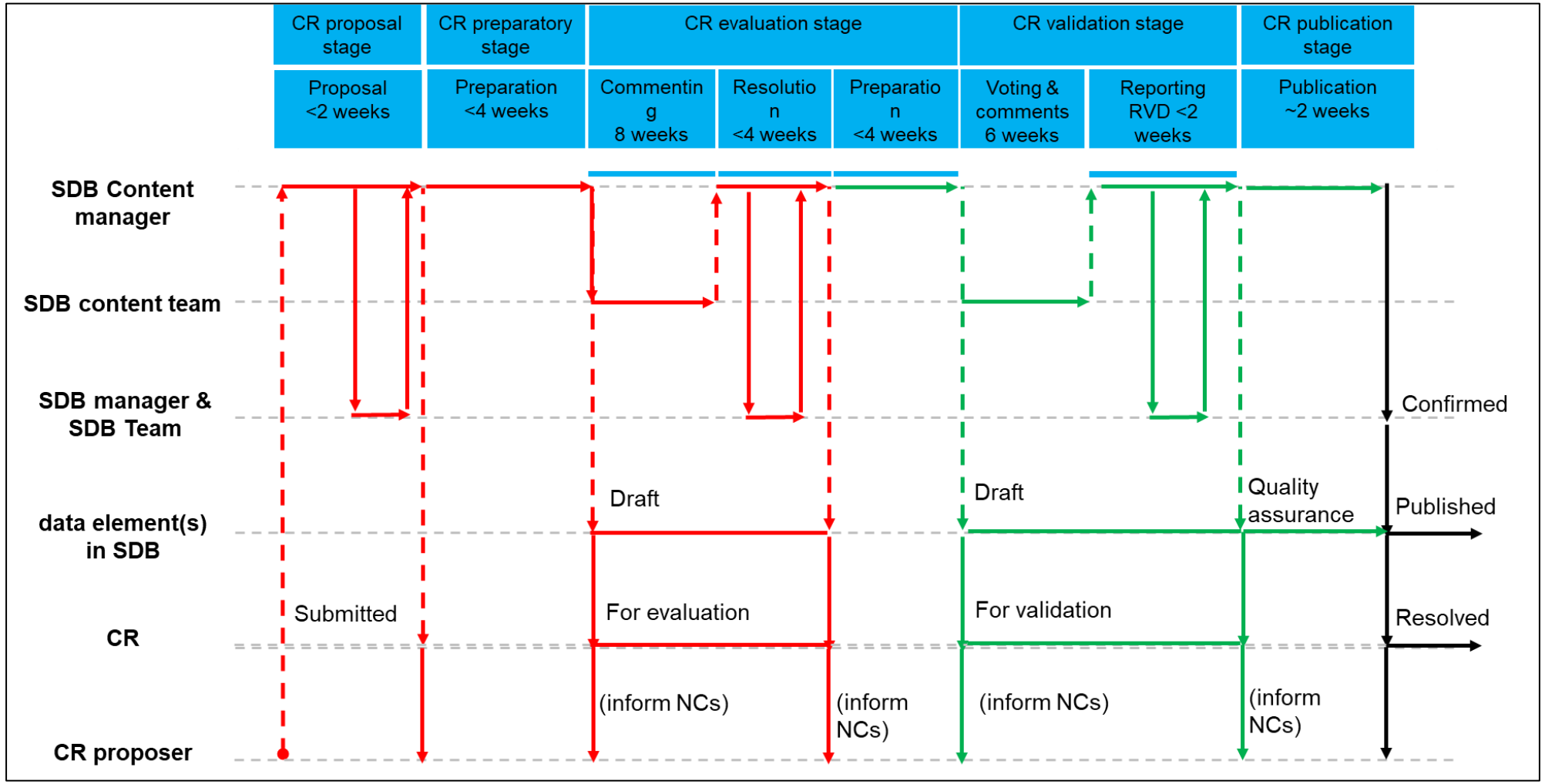


- The IEC CDD data modelling methodology aligns with MoF
- A meta-model (M2) and detailed specifications for IEC CDD data model (M1)
- Standardized data models is located at M1
  - IEC CDD data model
  - CFP Calculation data model
    - E.g., IEC 63369, IEC 63372, IEC 63058, GLEC
  - CFP exchange data model
    - E.g., PACT, ECLASS CFP, ZVEI AAS CFP

Resource: ISO/IEC 19502:2005 Information technology -- Meta Object Facility (MOF)

Procedure for digitalized standard development (under discussion)

IEC CDD can be developed in 6 months



Relevant fundamental terms and definitions

➢Information model(*1): a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse.

➢Data model(*2): graphical and/or lexical representation of data, specifying their properties, structure, and inter-relationships

[1] Y. Tina Lee, "Information modelling from design to implementation," National Institute of Standards and Technology., 1999.
[2] [SOURCE:ISO/IEC 11179-1:2015, 3.2.7]

- Information model : conceptual understanding, abstract
- Data model: focus on data, concrete
- Sometimes be used interchangeables

IEC CDD and Ontology

- Ontology(*1): An ontology is an explicit specification of a conceptualization.
  - An ontology is a set of concepts and categories in a subject area or domain that shows their properties and the relations between them.
  - knowledge sharing among AI software
- Ontology definition adopted in IEC SC3D
  - Specification of concrete or abstract things, and the relationships among them, in a prescribed domain of knowledge (*2)
    - ✓ Note 1 to entry: The specification should be computer process-able

- IEC CDD and Ontology
  - IEC CDD: ontology for unambiguous specifications and relations of products/system/service etc.
    - ✓ Data model, data dictionary, data catalog, domain ontology

(*1) Tom Gruber http://www-ksl.stanford.edu/kst/what-is-an-ontology.html
*DARPA:Defense Advanced Research Projects Agency 米国・防衛高等研究計画局
(*2) ISO/IEC 19763-3:2010

03

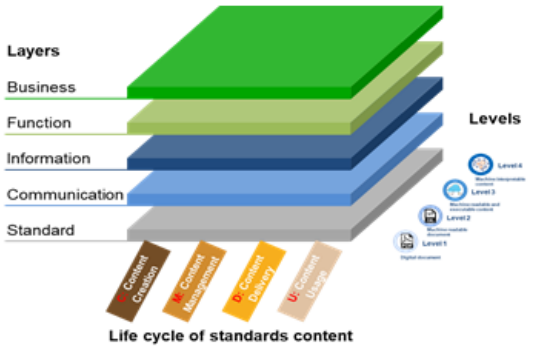
Digital transformation of standards ~SMART: Standards Machine Applicable, Readable and Transferable

IEC/SG12: Digital transformation and system approach (ongoing)

SMART: Standards Machine Applicable, Readable and Transferable

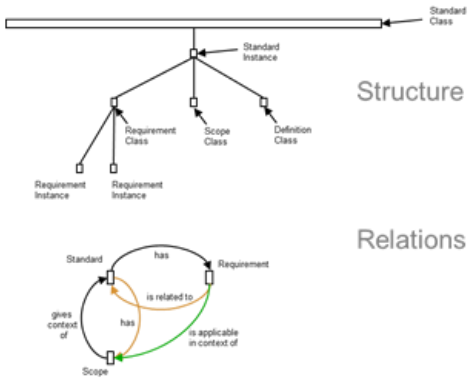
SMART Standards

Foundation 1
Standardization Architecture Model
SAM



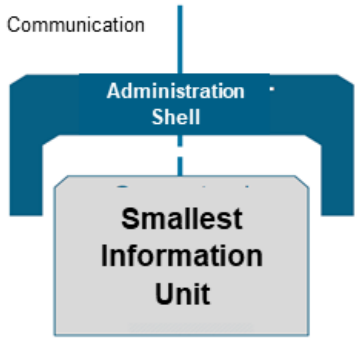
- SAM is a Service Oriented Architecture
- SAM combines all elements in a layered, life cycle model
- SAM provides a common language

Foundation 2
Standard Information Model
SIM



- SIM describes the SIU (smallest information unit) of a standard that still enables a certain function or action in an application
- SIM decomposes standards into re-usable elements/classes

Foundation 3
Standard Administration Shell
SAS



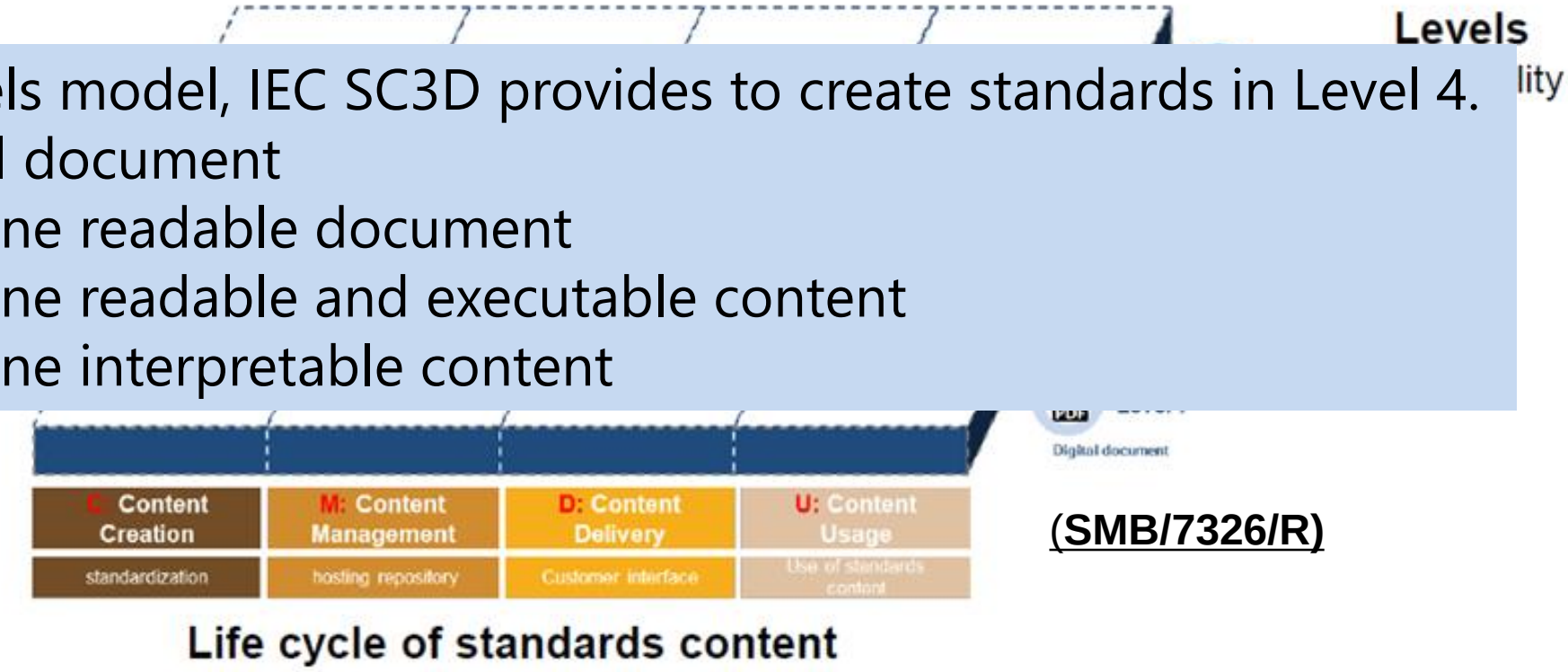
- Service Access Point: A conceptual location how and where to find, identify and request the capabilities/functions of a standard resp. its SIM
- In this sense it represents the registry of services of SMART STANDARDs

IEC CDD provides methodology to create standardized data models in Level 4

IEC CDD = Digitalized and standardized data models

In the Four-Levels model, IEC SC3D provides to create standards in Level 4.

- Level 1: digital document
- Level 2: machine readable document
- Level 3: machine readable and executable content
- Level 4: machine interpretable content



(SMB/7326/R)

One example of SMART: JAHG22(CFP Digitalization)

JAHG 22

Investigation and standardization proposal for "digitalization and data exchange of Carbon Footprint of Products (CFP)

linked to SC 3D

Objective of the JahG: jointly develop a new work item proposal (NWIP) for an IEC project on digitalization of carbon footprint of product data as per SMB Decision 175/6. The standard would be published as a data model in the IEC CDD (IEC Common Data Dictionary available under https://cdd.iec.ch) with a guidance document on how to use the data model.

The following tasks were identified for the JahG CFP digitalization [lead TC is based on subject matter expertise] :

Task1
- Assessing environmental impacts (e.g. climate change) for digitalization of carbon footprint of products (CFP) [TC111 lead] 3D/399/Q ® Registered trademark of the International Electrotechnical Commission

Task2
- Investigating standardization projects and standards on carbon footprint calculation and representation [TC111 lead] Note: this should leverage results originally provided to ahG94

Task3
- Identifying data models (structured concepts with classes and properties) for data exchange ensuring interoperability. [SC3D lead]

Task4
- Develop NWIP for data model (to be included in CDD) and guidance document

JAHG 22 Convenor & Members

Convenor	National Committee
Ms Lijie Xu	CN
Mrs Lan YAMASHITA	JP

- IEC SC3D, in collaboration with IEC TC111 (Environmental Standardization), established a JahG to facilitate the CFP digitalization
  - CFP calculation models
  - CFP data exchange models
- 30 experts from 9 NCs(CA, NL, JP, FI, FR,GB, DE, CN、KR) had been nominated
- Participants
- Siemens, NXP, Schneider, Rockwell, Hitachi, Yokokawa, Mitsubishi heavy, NEC, Canon, Azbil, JEMA, JEITA, Toshiba, etc.

04

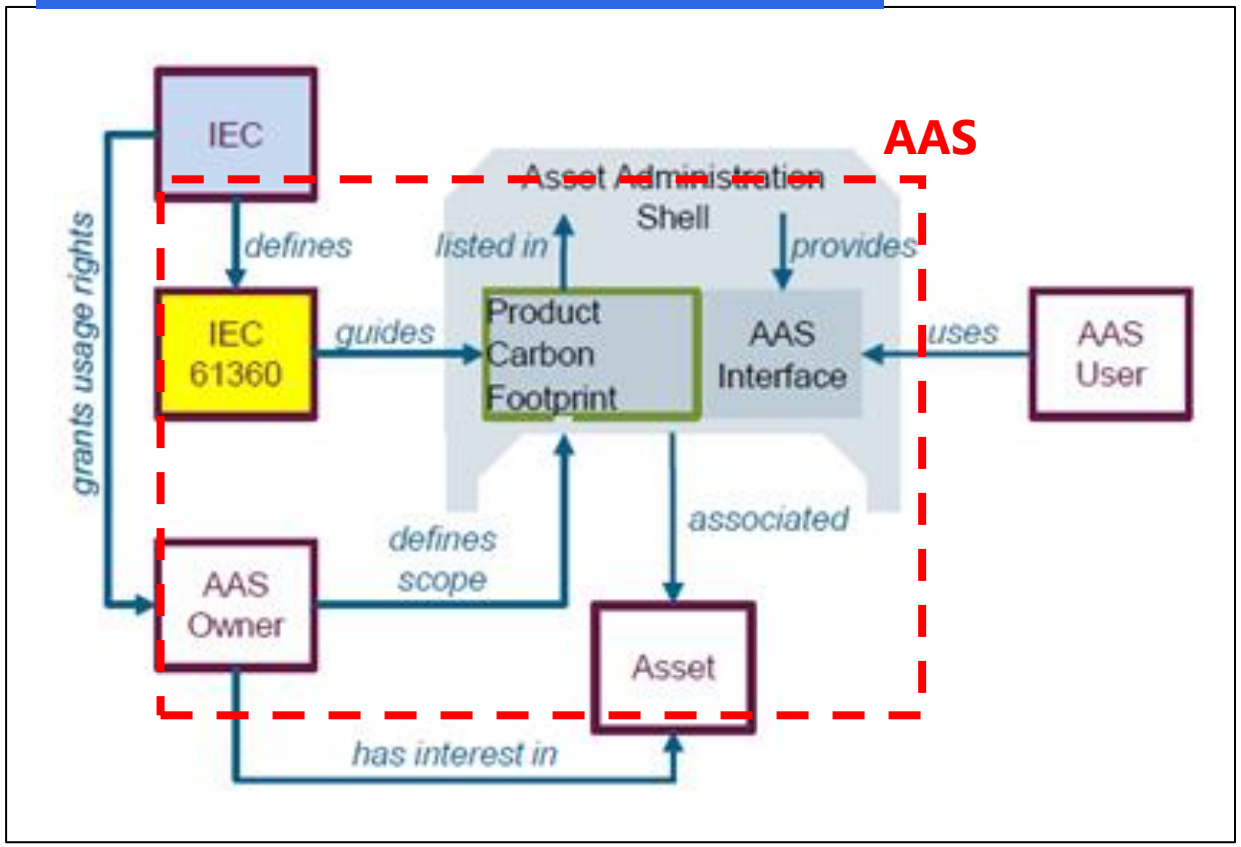
Interoperability achieved through data models

～Examples from standardization activities

AAS standardized data models to support CPF and DPP

AAS data models for CFP and DPP (Ongoing)

IEC CDD and CPF in AAS



Resource: SMB_7552e_INF

ECLASS for CFP and DPP in AAS

Identification, description and properties as well as environmentally relevant information as submodels of the AAS.

Submodel	ECLASS Designation Submodel	Properties
Identification	AAS Submodel Nameplate	Manufacturer name
		Address
		Serial number
		Year of manufacture
		Markings
		Number of markings
		Markings
		Label name
		...
Description and characteristics	AAS Submodel *technical data* (via ECLASS classification) [Aspect - AC].	Size
		Form
		Material
		Functions
		...
Environmentally relevant information	AAS Submodel *Environmental Footprint*	Carbon footprint
		Number of PCF methods
		Number of TCF methods
		Product Carbon Footprint (PCF)
		PCF calculation method
		PCF CO2eq
		PCF reference value for the calculation
		PCF quantity specification for the calculation
		PCF life cycle phase
		...

TCF: Transport Carbon Footprint; PCF: Product Carbon Footprint

Resource: ECLASA e.v.(2023)

Digital nameplate and IEC CDD for DX/DT interoperability

IEC CDD

AAA160 - motor
AAA161 - linear motor
AAA162 - linear ac motor
AAA163 - linear dc motor
AAA164 - linear stepping motor
AAA165 - linear universal motor
AAA166 - rotational motor
AAA167 - rotational ac motor
AAA168 - rotational dc motor
AAA169 - rotational stepping motor
AAA170 - rotational universal motor

プロパティ

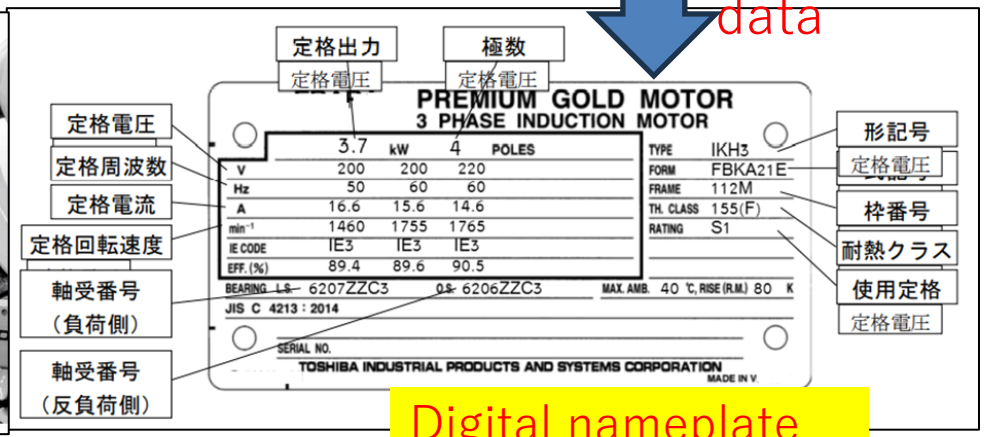
定格電圧
定格周波数
定格回転速度
・・・

② AAS refer to property

Administration Shell
Asset, e.g. motor
Prop "ManufacturerName"
Prop "ManufacturerProductDesignation"
SMC "PhysicalAddress" (5 elements)
Prop "ManufacturerProductFamily"
Prop "SerialNumber"
Prop "BatchNumber"
Prop "ProductCountryOfOrigin"
Prop "YearOfConstruction"
SMC "Marking_CE" (2 elements)
Prop "CEQualificationPresent"
File "File"
SMC "Marking_CRUUS" (2 elements)
SMC "Marking_RCM" (2 elements)

①Connect digital nameplate with standardized property

③detailed/latest data



Digital nameplate

Integrate data from different systems

Systems/App.

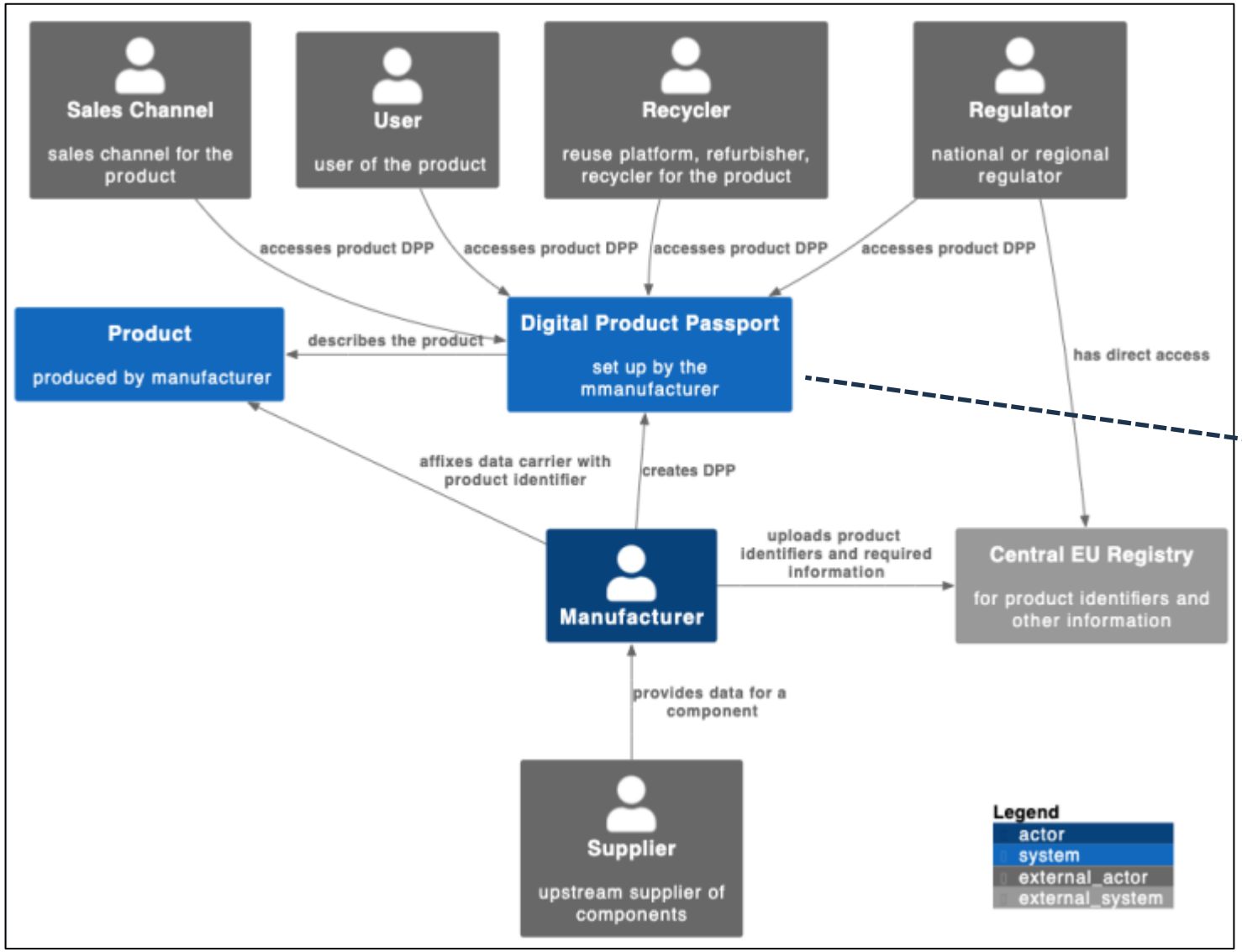
Failure diagnosis

Asset Plan

Procure

monitoring

Interoperability among different actors in DPP system

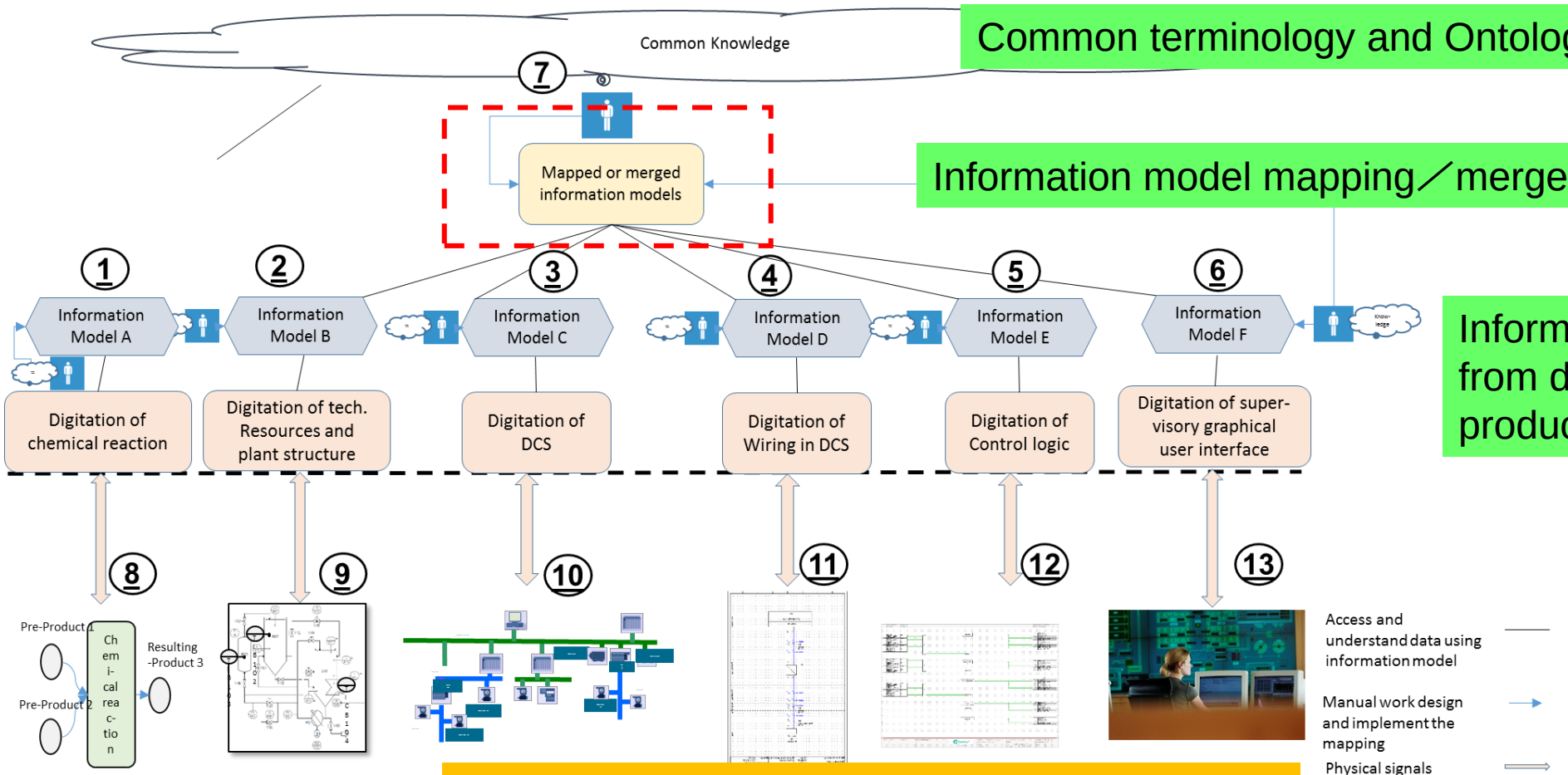


- Common data understanding among different actors are required
- Standardization of data models and APIs are in progress

Resource: 2023-12_Discussion_Paper_DPP4.0_Architecture_v1.1.pdf (zvei.org)

IEC MSB white paper: “Semantic Interoperability: Challenges in the digital transformation ages”

https://www.iec.ch/basecamp/semantic-interoperability-challenges-digital-transformation-age



Common terminology and Ontology

Information model mapping／merge

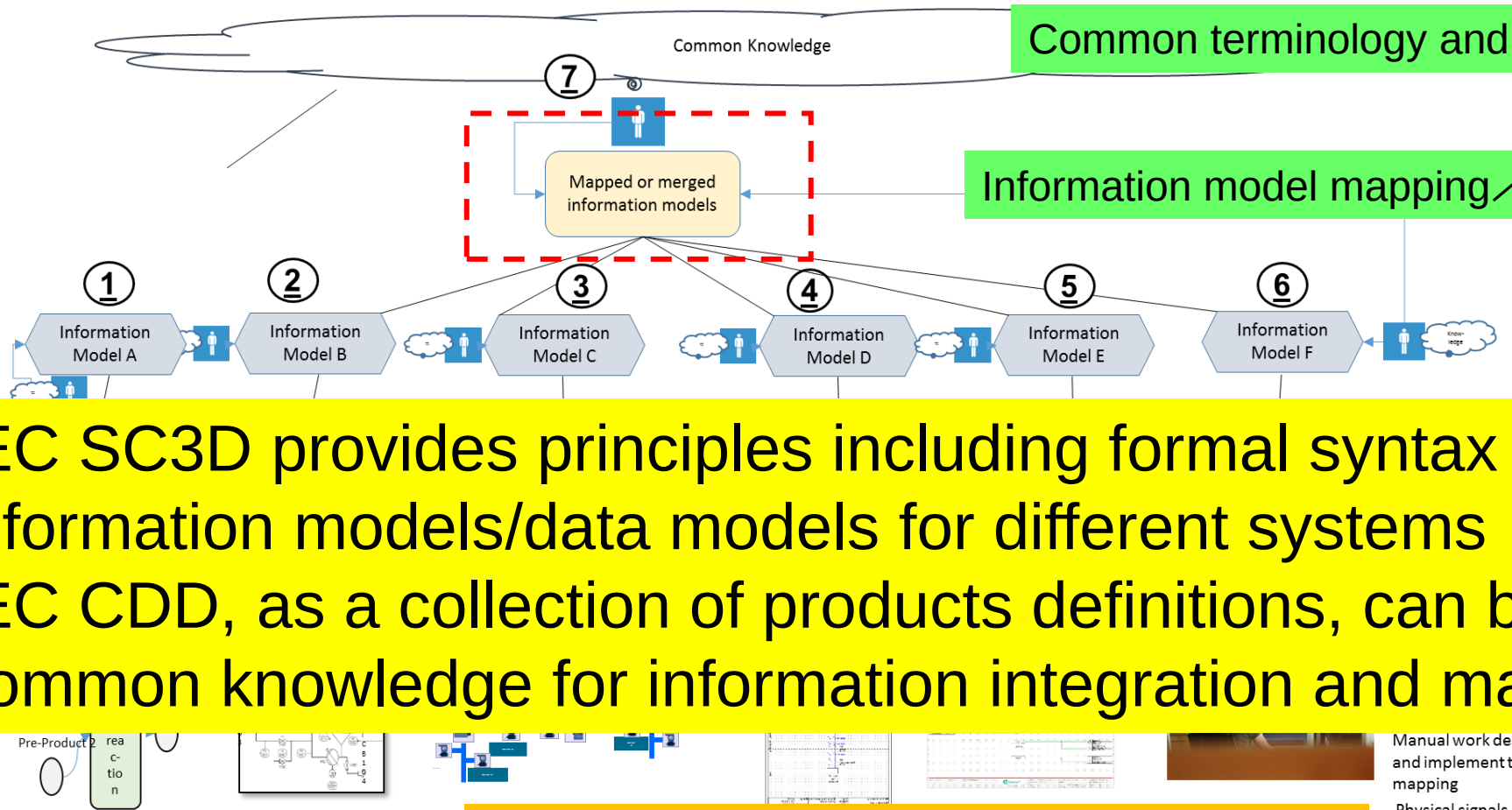
Information models from different product aspects

Information in system engineering

*Resource: SMB/6793/DC

IEC MSB white paper: “Semantic Interoperability: Challenges in the digital transformation ages”

https://www.iec.ch/basecamp/semantic-interoperability-challenges-digital-transformation-age



Common terminology and Ontology

Information model mapping／merge

Information models from different

- IEC SC3D provides principles including formal syntax to construct information models/data models for different systems
- IEC CDD, as a collection of products definitions, can be utilized as common knowledge for information integration and mapping.

Information in system engineering

*Resource: SMB/6793/DC

Technologies for Interoperability between different data models

Model-based exchange rules

Syntactic and semantic rules

Formal expressions for data exchange rules

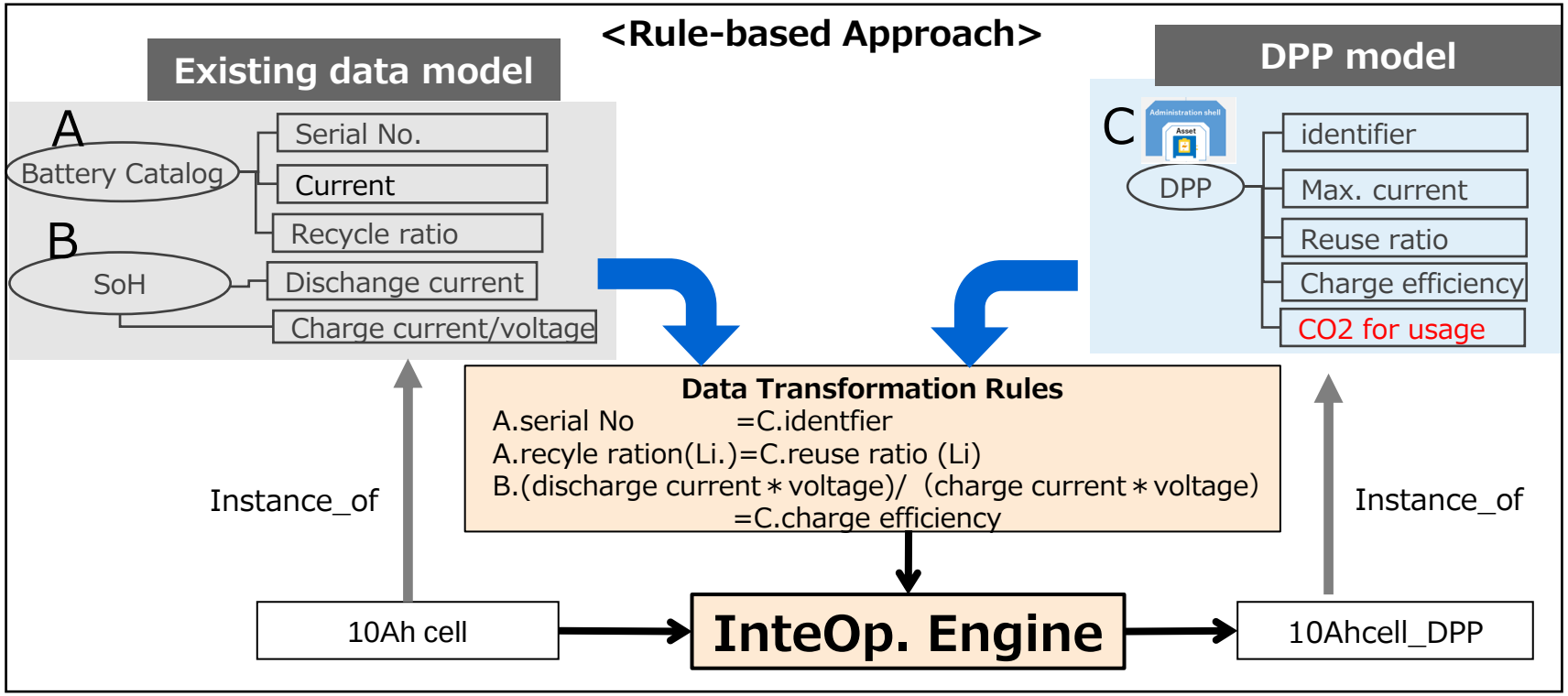
Approaches to support automatic generation of rules

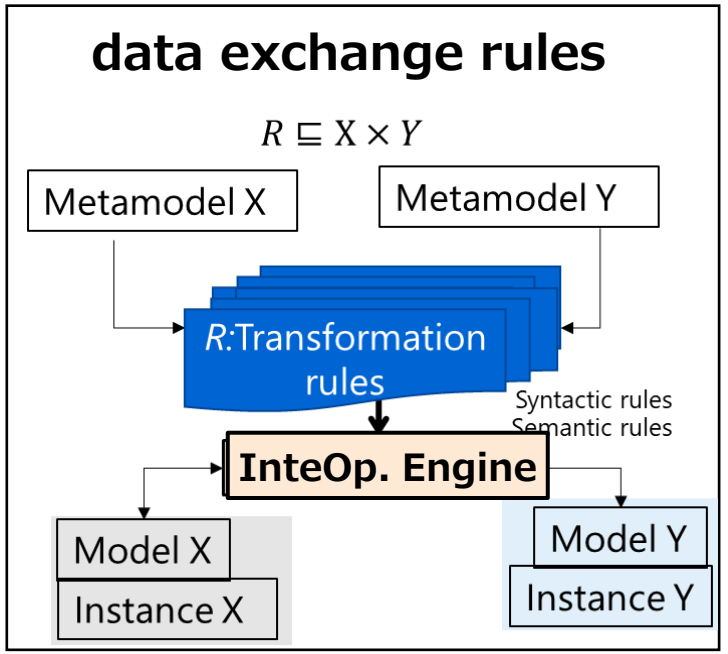
Standardized as ISO/IEC 21823-4

Use cases

Use cases for data exchange between AAS and CDD, FIWARE and Connected Car

https://github.com/21823-4/usecases





05

Conclusions

Conclusions

1. ISO and IEC is transiting from paper-based standards development to SMART: Standards Machine Applicable, Readable and Transferable.
2. IEC SC3D is supporting digitalized standards development as data models to accelerate application in industries.
   - collaborates with TC/SCs for domain data models development
3. To facilitate CE, data exchange and interoperability among different data ecosystems and data spaces are required. Standardized data models are underway. E.g.,
   - WBCSD PACT Pathfinder for CFP data exchange
   - DPP in AAS, RDF/OWL format

Thank you!