



Semantics for PI Application Profiles

White Paper Cooperation PI and ECLASS

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may: indicates flexibility of choice with no implied preference.

should: indicates flexibility of choice with a strongly preferred implementation.

shall: indicates a mandatory requirement. Designers **shall** implement such mandatory requirements to ensure interoperability and to claim conformance with this specification.

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Revision Log

Version	Originator	Date	Change Note / History / Reason
0.1	JWG PI ECLASS	25.Feb. 20	Initial version
0.2		08. Mar. 20	Improved version after JWG discussion
0.3		30. Jun. 20	PNO C3 preview distribution
0.4		26. Sept. 20	JWG internal review, without XML update
0.5		08. Dec. 20	including all review comments from JWG, without XML update
0.9		22. Feb. 21	Final review version for JWG
1.0		09. Mar. 21	released

1 Motivation

The intelligent manufacturing networks of digital factories will only become reality with machineprocessable, standardized information, because they have to interact over different communication technologies, different companies and even across industry boundaries. PROFIBUS & PROFINET International (PI) sees its role in creating the necessary basis for this fact, especially in view of Industrie 4.0.

7 This has been accomplished by providing device-related expertise for PI technologies – for 8 instance, in the form of parameters in the open device profiles or other specifications for the 9 application layer, like for an asset management record. However, in order for these to be used as 10 the basis for a machine-processable flow of data across the various systems – from sensor to 11 cloud – the data that is already available today must be transformed into clearly usable information 12 by means of semantic standards.

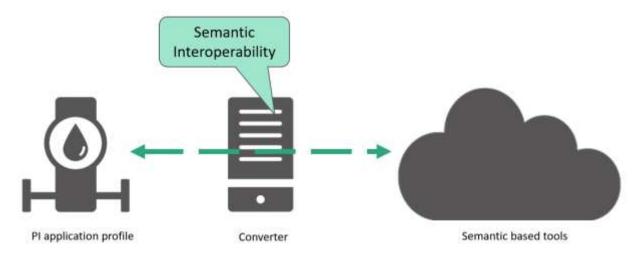
ECLASS e.V. is playing an increasingly important role in industrial automation and especially for Industrie 4.0. In cooperation with ECLASS e.V. existing PI specifications will be expanded by semantic identifiers. In a first step, PI application profiles (e.g., PA Profile) were selected, having the best preconditions for this endeavor.

17 The results form a significant basis for the automated interaction of various systems and 18 components from different manufacturers are essential for business processes to run optimally 19 between end users, suppliers, customers, etc. in systems of the Industrie 4.0 generation.

1 Management Summary - Scope of this Document

23 This white paper presents the results from the joint working group PI and ECLASS.

It describes how to extend already existing PI Application Profiles (e.g., PA Profile, PROFIdrive)
 with standardized semantic information.



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Figure 1: Overview

- 28 A converter can provide the necessary transformation
- from standardized data defined by PI Application profiles
- to fieldbus neutral technologic oriented semantic information
- The PI application profiles itself do not need to be changed. They are extended with a generic approach to support semantic interoperability.
- Today not all data provided by PI application profiles already have such a semantic information, it is future work to provide a complete set of information.
- The concept supports primarily ECLASS, nevertheless also other semantic standards like IEC CDD (common data dictionary) or semantic web will be supported.
- In context with Industrie 4.0, the above-mentioned converter can also provide the content for theasset administration shell.

40 **2** Related documents and references

41 **2.1 Related documents**

- 42 [1] PI "Identification & Maintenance Functions" 43 Profile Guidelines Part 1, Order No.: 3.502
- 44 [2] PI "Data types, Programming Languages, and Platforms"
 45 Profile Guidelines, Part 2, Order No: 3.512
- 46 [3] PI "Profile for Process Control Devices", Order No: 3.042
- 47 [4] PI "Topology and Asset Discovery for PROFINET Guideline", Order No. 7.182

48 2.2 References

- 49 [100] ECLASS Wiki: <u>https://wiki.eclass.eu/wiki/Main_Page</u>
- 50 [101] ECLASS white paper "Toward smart manufacturing with data and semantics"
- 51 [105] IEC Common Data Dictionary: <u>https://cdd.iec.ch/</u>
- 52 [110] <u>https://schema.org/</u>
- 53 [111] <u>http://iotschema.org/</u>

54 **3 Definitions and Abbreviations**

- 55 3.1 Definitions
- 56 3.1.1 Block
- 57 Blocks are a means to structure properties in a convenient and task related way (from IEC 61360-1).

58 3.1.2 COMDO

59 ECLASS, IEC and ISO - want to provide a Common Data Repository for Smart Manufacturing, 60 Industrie 4.0 and other domains for classifying and describing things (products, services, 61 procedures) along the process life cycle - based on high quality ISO/IEC Standards - to enable 62 electronic data transfer in an unambiguous way and to support digitalization of business by all 63 international market participants.

64 Since October 1, 2020 COMDO is a project as the 3 partiers (ECLASS, IEC and ISO) support the 65 preparation and signing of an agreement (so-called MoU).

66 **3.1.3 Data**

representation of information in a formalized manner suitable for human or automatic processing
 (source: <u>http://www.electropedia.org/iev/iev.nsf/display?openform&ievref=171-01-02</u>)

69 **3.1.4 TUF – Transaction Update Files**

ECLASS provides the Transaction Update Files (TUF) containing all information that is needed for a semi-automated ECLASS version update (e.g., migration from version 11.1 to version 12.0)

72 3.1.5 IEC CDD

IEC Common Data Dictionary. See [105]. Actually, IEC CDD offers data structures (classification
 and associated properties) in 3 technical areas based on international standards:

- Electric/Electronic Components (IEC 61360-4)
- Process Automation (IEC 61987)
- Low voltage switchgear and controlgear (IEC 62638)

78 3.1.6 Information

79 Knowledge concerning objects, such as facts, events, things, processes, or ideas (including 80 concepts) that, within а certain context. has а particular meaning (source: http://www.electropedia.org/iev/iev.nsf/display?openform&ievref=171-01-01) 81

82 3.1.7 Ontology

83 An ontology is a way of showing the properties of a subject area and how they are related, by 84 defining a set of concepts and categories that represent the subject (source: 85 <u>https://en.wikipedia.org/wiki/Ontology_(information_science</u>))

86 **3.1.8 OWL**

87 Web Ontology Language is a family of knowledge representation languages for authoring 88 ontologies. Source: <u>https://en.wikipedia.org/wiki/Web_Ontology_Language</u>

89 3.1.9 Property

A property describes a characteristic of a product (e.g., material, colour, article number) [100].
 Source: IEC 61360-1 Chapter 6 "Property".

92 3.1.10 Value

A property has values which determine the characteristics. A value can be a numerical quantity with or
 without a unit, or a text that describes a subject in more detail (e.g., property: colour, value: red;
 property: length, value: 25 mm). Source: IEC 61360-1 Chapter 6 "Property".

96 **3.1.11 Variable**

- 97 A PI application profile standardizes variables. They can be
- Parameters (how to parametrize the device)
- Measured values (can be transported cyclic or acyclic)
- Enumerations (e.g., Unit, sensor type)
- 101 Diagnosis information
- 102 Variables consist of two main parts
- 103 The value itself
- The access to the value (addressing)

106 3.2 Abbreviations

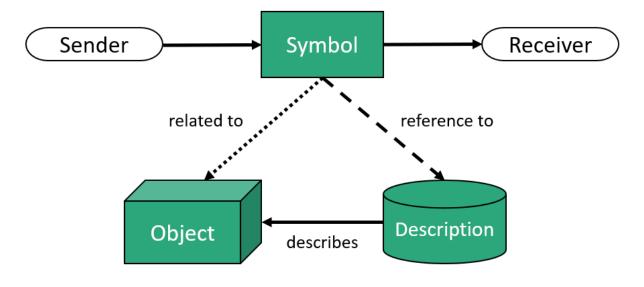
- 108 IRDI International Registration Data Identifier, based on ISO 29002-5
- 109 JWG Joint Working Group
- 110 LOP List Of Properties
- 111 W3C World Wide Web Consortium

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113 4 Semantic introduction

114 Goal of this white paper is to describe ways how machines can interact with each other. But first, we 115 look to humans. The science which applies to study of human language is linguistics.

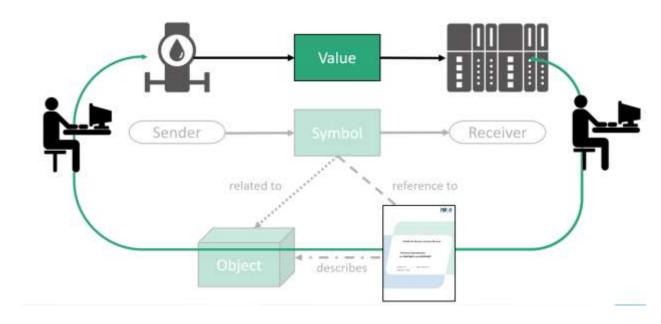


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Figure 2: Semiotic triangle

The semiotic triangle (also known as the triangle of meaning or the triangle of reference) is a model of how linguistic symbols are related to the objects they represent (from Wikipedia "Triangle of reference"). The sender and receiver can understand each other if both use the same symbol for the related object and have the same description of the object in mind. The description explains the object. To ensure this, the symbol references to a description of the object as well.



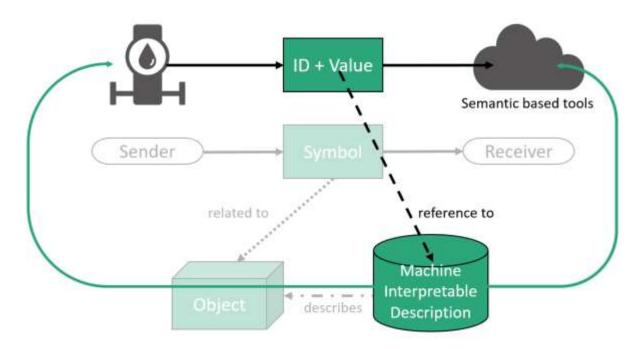
124

123

Figure 3: Semiotic triangle for PI application profiles

Today PI application profiles provide in the context of field devices such a "description" for different
 types of devices. But this description is made for humans: The meaning of the "symbols" is known
 by the programmers and coded in the software of the devices and controllers.

128 In future scenarios, e.g., smart manufacturing and Industrie 4.0 machines are directly talking with 129 each other. To understand each other, the exchange of the value itself is not enough, an additional 130 identification (ID) to specify the value transferred is necessary. The "symbol" in this case is a 131 combination of ID and value and the ID now references to a machine interpretable description.



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Figure 4: Semantics for PI application profiles

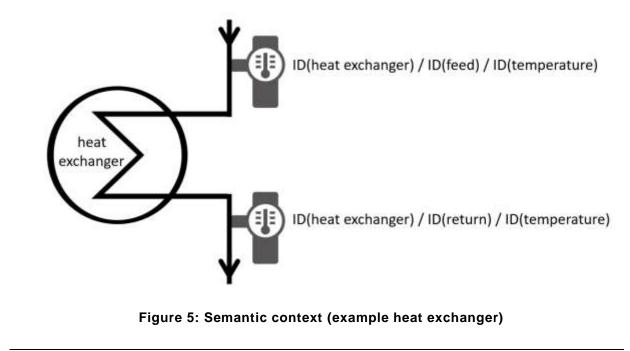
134 This concept can be used for machine-to-machine communication and / or any semantic based 135 tools analysing information. The additional ID needed is called the semantic identifier.

We all know, that there is not only one single device used in a plant but many devices even of the same type measuring different technological values. Semantic also provides a concept to handle this problem. This is called the "context". The context describes the application area and is again represented by a semantic identifier.

140 The concatenation of the semantic identifiers for the context(s) and for the symbol(s) result in a

141 complete technological description. The next figure illustrates this concatenation, building up a

142 path of semantic identifiers.



146 **5 Use cases for semantics**

- 147 The following use cases were discussed during the various meetings of JWG PNO ECLASS. They148 do not claim to be complete but provide an overview on possibilities of using semantics.
- 149 All these use cases rely on an international, standardized description of semantic identifier.

150 **5.1 Engineering Workflow**

151 The engineering workflow is characterized by offline scenarios, in which the instance of the device 152 itself is not present or accessible.

153 **5.1.1 UC1: Selection of devices**

During the engineering phase the plant engineer decided, where a pump, a valve, a flowmeter or a temperature measurement device is needed. Later the engineer has more detailed data for the plant like the flow and the pressure of the pump, the materials, which are resistant against the process demands, the minimal and maximal range of flow and the temperature range, the process will have.

With this information it is possible to start a request to the device supplier to ask for a quotation of a full specified device. Due to the huge number of variants, a pump, a valve, a flowmeter can be manufactured, the supplier provides a web configuration tool to consider all technical data to be able to provide a quotation for a device. After the selection, the supplier can calculate the price, the delivery time, the exact dimensions and weight etc. At the same time, when the engineer gets these data, he can use all the available (technical) product information to work with these (real) data in the engineering and construction software at the earliest possible time.

166 **5.1.2 UC2: Ordering devices**

The procurement of an engineering company has the task to compare and to buy the specified devices (or services) for the best price. For this, the buyer has to compare the quotations of several manufacturers to find the most suitable product (depending on his/her internal guidelines like price, durability, accuracy, service or spare part expenses, etc.). With a detailed specification of the demand, it is possible to get a high-quality quotation with all relevant or mandatory information to select the most suitable product by using a (semiautomatic) selection tool for the ranking.

173 **5.1.3 UC3: Offline parametrization of devices**

During the engineering phase and after the selection of a device (see UC1) the (technical) product
information is available. The engineer can now start to define the parametrization of the devices'
technological variables like min. / max. flow or any other.

177 The device itself doesn't need to be present at this time, only a list of the supported variables and 178 their standardized meaning is needed as input. If the device supports a PI application profile, PI 179 can provide so called mapping tables, which supply these informations.

180 **5.1.4 UC4: Offline parameter migration**

181 If a device must be replaced, then the new device may have a newer version or may be from a 182 different vendor. In this case the parameter set for the device needs also to be replaced. For the 183 transfer of the parameter content from the old device onto the parameter set of the new device, 184 the semantic information can be used to match corresponding parameters and to adapt parameter 185 contents to the semantic of the parameters of the new device.

186 **5.2 Runtime Workflows**

187 Runtime workflows are characterized by having an established online communication to the188 instance of the device. This is typically true during commissioning and operation phase.

189 **5.2.1 UC5: Inventory list**

- 190 PI devices support an electronic faceplate, called "Identification and Maintenance Information". [1]
- Access to this information is different due to e.g., different communication systems like PROFIBUS or PROFINET.

The PI mapping table "hides" the access and provides the electronic faceplate in a semantically standardized manner. An online scan over all active devices [4] connected to the network provides an inventory list of all devices with their name, manufacturer, order number, serial number, hardware and software revision available in a plant.

197 **5.2.2 UC6: Download parametrization**

- 198 The offline parametrization (see UC 3) can be downloaded to the device instance to ensure the 199 proper functionality.
- PI mapping table supports this download by defining the refence between technological value and
 write access within the device. Of cause the parameter download can also be done by a device
 specific tool.
- Note: Typically, more devices instances of the same type are used in a plant. Make sure to identify
 the desired device instance first.

205 **5.2.3 UC7: Check parametrization**

206 Over time the parametrization of device instances may be changed (temporarily or not). Goal of 207 this use case is to detect differences between the engineering phase (planning) and the real 208 configuration which is active in the field.

The PI mapping table supports this comparison by defining the reference between technological value and read access within the device

211 **5.2.4 UC8: Provide information for analytics**

- Typically, PI devices use internally more information from additional sensors built in to provide the right value for the control system.
- Goal of this use case is to provide this already available not time critical information for analytics.
- PI mapping tables offer a technology oriented and standardized way to get this information out of the devices to be used directly as input for any analytics.
- 217

218 6 Introduction Semantic Organizations

This chapter gives an overview on semantic organizations already specifying semantic identifiers. They provide a neutral technological definition of e.g., product data. The scope of product data may cover catalogue information, parameter and actual values of devices including their engineering, their diagnostic information or other needed information.

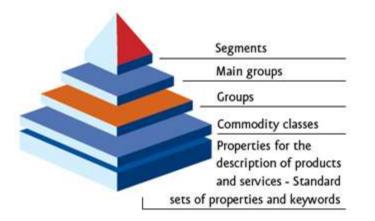
223 This technological definition is independent from any underlying communication system.

There are several independent organisations worldwide supporting such semantic identifiers. This chapter gives a short overview of selected organisations (we do not claim a full worldwide view). The content and examples shown, will focus on PI technology wherever possible, not every other aspect is covered.

228 6.1 ECLASS

ECLASS is most developed worldwide ISO/IEC-compliant data standard for goods and services¹.
 ECLASS contains tens of thousands of product classes and unique properties. This standardizes
 procurement, storage, production, and distribution activities in and between companies - across
 sectors, countries and languages.

ECLASS is a hierarchical classification system for grouping materials, products and services according to an agreed, systematic structure. All products and services can be described by product-specific and standard-compliant properties, which are identified by IRDI's. They are assigned to the four-level numerical ECLASS class structure. The 4th level of the hierarchical classification is always the level that carries all structures and properties for the exact description of the product type or product instance (depending on the use case).



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Figure 6: ECLASS – classification scheme

Since ECLASS release 7.0, a BASIC Application Class (BASIC AC) and an ADVANCED
 Application Class (ADVANCED AC) coexist in the same classification system.

The BASIC Application Class is mainly used for e-business catalogues, where people with a limited number of properties can compare and select the device or service they are looking for in a flat list.

246 The ADVANCED Application Class can be used to provide a detailed description of any device

- 247 with an almost unlimited number of properties in a hierarchical list with blocks and other
- structure elements. It is used for engineering and (in the future) for Industrie 4.0 [101]
- applications, where machines will exchange data without any human interaction.
- 250 For the use with PI only the Advanced application classes can be used.

¹ The term "services" in context of ECLASS has a much broader scope than the PI technical term

ECLASS covers various segments of product types. Segment 27 contains "Electric engineering, automation, process control engineering" definitions.



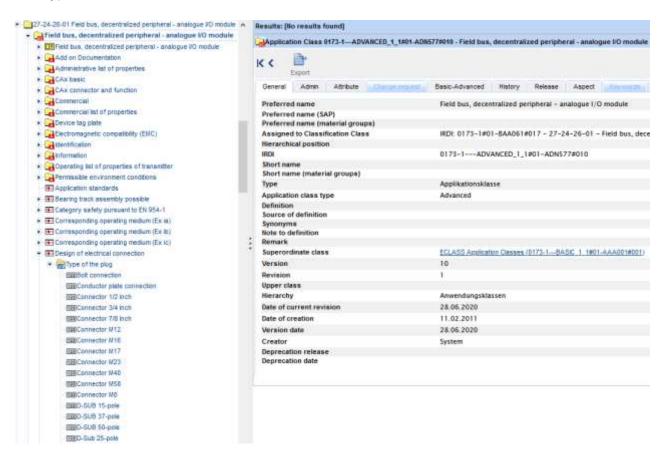
- 255 The list below covers the most relevant main groups and groups relevant for PI technology:
- 256 19-17 Network technology (computer communication) • 27-02 Electrical drive 257 • 258 27-20 Measurement technology, process measurement technology 259 27-21 Signal processing 27-23 Process control system (PCS) 260 261 27-24-22 Programmable logic control (SPS) 262 27-24-26 Field bus, decentralized peripheral •

253

- 27-32 Industrial weighing technology
- 27-37 Low-voltage switch technology
- 37-01-10 Valve (with actuator)

266
267 Let's make an example: We choose application class 27-24-26-01: Field bus, decentralized
268 peripheral - analogue I/O module.

269 This type of module has the Identifier "0173-1---ADVANCED_1_1#01-ADN577#010".



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Figure 8: ECLASS – example: fieldbus, analogue I/O module

The figure above shows on the right side the definition and identification of the I/O module type. On the left side, the properties listed there are characterizing the I/O module.

We select the property "design of electrical connection", with its identifier 0173-1#02-BAD831#012.

EProperty 0173-1#02-BAD831#012 - Design of electrical connection

Overview General Admin Format Attribute Change request History Values Release Alternative Preferred name Design of electrical connection 0173-1#02-BAD831#012 0173-1#02-BAD831#012 0173-1#02-BAD831#012 Abstract property false 0173-1#02-BAD831#012 0173-1#02-BAD831#012 Definition mechanical design of the electrical connection to the operating of	
IRDI 0173-1#02-BAD831#012 Abstract property false Definition mechanical design of the electrical connection to the operating of the electric	e units
Abstract property false Definition mechanical design of the electrical connection to the operating Quantity Connection to the operating	
Definition mechanical design of the electrical connection to the operating i Quantity Connection is a second sec	
Quantity	
	resource
Value list (Type of the plug)	
1-3-1	
Type of property Non-dependent	
Valency type Univalent	
Definition class eCl@ss (0173-1#01-RAA001#001)	
Property data type String	
Class type code A58 - Product geometry, shape, and size	
Property Original Identifier BAD831001	
Date of creation 27.09.2004	
Version date 11.06.2019	
Creator System	

275

276

Figure 9: ECLASS – example: Design of electrical connection

This property has a value list "type of the plug", containing in this case 39 different types of plugs (ECLASS11.1).

<					
Genera	A	dmin Attribute	Change red	History	Used value
Value	15				
	er qui anced a	ery saich +	Pearch		
2	0	0173-1#07-WAA	967#001	Conductor plate	connection
3	0	0173-1007-WAA(066#002	Soldering lug co	nnection
4	0	0173-1#07-WAA(965#003	Screw connection	on
5	0	0173-1#07-DAA4	04#005	Push-in connect	ion
6	0	0173-1007-DAA3	10//004	crimp connectio	ñ

279

280 Figure 10: ECLASS – example: excerpt of value list "type of the plug"

281 This example shows how to characterize product features of an I/O module.

The same ideas is used to characterize variables (e.g., actual values, parameters or diagnosis information) of PI application profile compliant devices. This allows a technologic oriented standardized access to information.

Access by humans to ECLASS elements (via ECLASS internet page) is free of charge but a license is required to download ECLASS data structures, to assign data to ECLASS elements and to exchange data. 288 ECLASS and its service providers supply professional IT support, transaction- and version management and a fast-track procedure (ECLASS ACCELERATED) to get ECLASS elements 289 (classes, properties, ...) defined quickly. 290

291 6.2 IEC CDD

292 IEC Common Data Dictionary (IEC CDD) [105] is an International Standard (IEC 61360-4 DB) and 293 serves as a common repository of concepts for industrial/technical domains. It is based on the 294 methodology and the information model of IEC 61360 series, and provides [105]:

- 295 unambiguous identification of classes and properties, and their relations
- commonly accepted terminology and definitions based on accepted sources such as IEC 296 International Standards, other International Standards, Industry Standards, or Public 297 Authorities 298
- 299 hierarchies of concepts enabling users to appropriately characterize their products and services 300
- 301 all kind of data element types and concepts like classes, properties, value lists, values, 302 cardinality, polymorphism, blocks, conditions, qualifiers, conditions, constraints, 303 relations, ...
- 304 technical representation of concepts including units and data types and their identification
- IEC CDD actually supports the following domains: 305
- 306 IEC 62683 (low voltage switch gears)
- 307 IEC 61360 (electric / electronic components)
- 308 IEC 61987 (process automation) •
- 309 IEC 61987 covers process automation topics in detail. The following picture shows an overview of 310 supported transmitters.



International Electrotechnical Commission

IEC 61987 - SC 65E/WG 2 - Common Data Dictionary (CDD - V2.0014.0016)

Domain: Process automation (IEC 61987 series) • Open all | Close all Process automation (IEC 61987 series) E G 0112/2///61987#ABA000 - Equipment for industrial-process a 🖻 😋 ABV000 - Characterization 🖻 😋 ABA001 - Measuring instrument 🗄 🦳 ABA643 - Gauge ABA684 - Measuring assembly 🗄 🦳 ABA689 - Sight indicator 🕀 🧰 ABA697 - Switch 🖻 😋 ABA751 - Transmitter - ABA752 - Accelerometer - ABA753 - Current transmitter 庄 🛅 ABA754 - Density transmitter 🗄 🧰 ABA761 - Flow transmitter ABA803 - Level transmitter ABA831 - Pressure transmitter 🖻 🧰 ABA835 - Temperature transmitter ABA839 - Velocity transmitter 🗄 🛅 ABA842 - Weight transmitter

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Figure 11: IEC CDD – transmitter overview

313 Unlike in ECLASS, IEC CDD already provides semantic definitions for device parameters, which 314 in this case can be mapped to PA Profile [3]. This example shows the parameter low flow cut-off.

Properties tree:	0112/2///61987#ABH691 - Low flow cut-off
Open all	0112/2///61987#ABH692 - type of low flow cut-off
Close all	0112/2///61987#A8H693 - set low flow cut-off
	-0 0112/2///61987#ABH694 - value of mass flow low flow cut-off
	0112/2///61987#ABH695 - value of normalized volume flow low flow cut-or
	0112/2///61987#ABH696 - value of actual volume flow low flow cut-off
	0112/2///61987#ABJ724 - value of low flow cut-off in units of span

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Figure 12: IEC CDD – example property list

- 317 The exact parameter definition is given in the following picture. The identifier (IRDI), the description
- and the unit in which the parameter value is shown.

	PROPERTY
Code:	0112/2///61987#ABJ724
Version:	002
Revision:	01
IRDI:	0112/2///61987#ABJ724#002
Preferred name:	value of low flow cut-off in units of span
Synonymous name:	
Symbol:	
Synonymous symbol:	
Short name:	Low flow cut off
Definition:	value of flow cut-off in units of span
Note:	If the span is not defined the range-limit is to be used instead.
Remark:	
Primary unit:	%
Alternative units:	
Level:	
Data type:	REAL_MEASURE_TYPE
Format:	
Definition source:	
Value source:	
Property data element type:	NON_DEPENDENT_P_DET
Drawing:	
Formula:	
Value list code:	
Value list:	
DET class:	
Applicable classes:	0112/2///61987#ABH691 - Low flow cut-off
Definition class:	0112/2///61987#ABA000
Code for unit:	0112/2///62720#UAA000 - percent
Codes for alternative units:	
Code for unit list:	0112/2///61987#ABT533 - Percentage
Status level:	Standard
Published in:	IEC 61987

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Figure 13: IEC CDD – example property content

Access by humans to IEC CDD (via internet page) is free of charge. IEC also offers so-called "free attributes" to enable electronic data exchange free of charge. Download and distribution of elements and concepts with the full set of attributes requires a license from IEC.

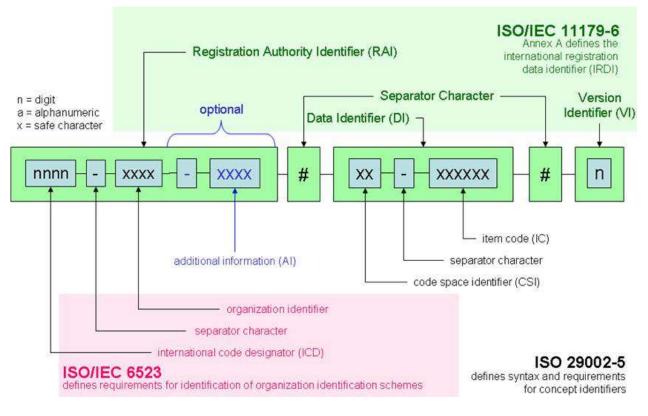
IEC SC3D offers support for IEC TCs/SCs to model and implement concepts in IEC CDD. IEC CDD
 offers version management for each and every data element (not for the total database). It covers
 only a few numbers of product types, but being an international standard, the definition depth is in
 parts deeper compared to ECLASS.

328 6.3 Harmonization IEC CDD – ECLASS

- An international cooperation between the IEC and ECLASS e.V. was signed in 2016. Under this Cooperation Agreement the content for mapping belongs to
- IEC 61987, Industrial-process measurement and control Data structures and elements in process equipment catalogues;
- IEC 61360, Standard data element types with associated classification scheme for electric components; and
- ECLASS Segment 27: Electric engineering, automation, process control engineering.
- For the benefit of ECLASS and IEC CDD users, common content shall be identified and easily accessible in a harmonized form. Actual status see COMDO in section definitions.
- It can be expected that for several standards (IEC, ISO, ECLASS) several identifiers (IRDI's) will
 be defined for the same semantic topic.

340 6.4 International Registration Data Identifiers (IRDI)

- 341 IEC CDD and ECLASS both rely on the same basic definition of semantic identifiers, the IRDI.
- 342 The structure and syntax of IRDI is defined in ISO/TS 29002-5.



```
344
```

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Figure 14: IRDI structure [100]

345 To reach the goal of globally unique identifiers each publishing organization defining IRDI's requests

an ICD (International Code Designator) at the relevant registration authority to globally identify the

347 organization and the OI (Organisation Identifier) if specified.

- 348 Examples: ECLASS: 0173-1; ISO: 0112/1; IEC: 0112/2
- Note: As the separator is not specified in ISO/TS 29002-5 the organisations are using different separators. Separator examples: ECLASS: "-"; ISO and IEC: "/"

Data element	IRDI
Dictionary: IEC CDD	<u>0112/2///61360 4#AAH011#003</u>
Domain: Electric/electronic components (IEC 61360-4)	
Data element: designation of IP protection	
Dictionary: IEC CDD	0112/1///ICS# SAB156 #002
Domain: International Classification for Standards (ISO ICS)	
Data element: Printed circuits and boards	
Dictionary: ECLASS	0173-1#02- BAG975 #013
Data element: degree of protection	

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Table 1: Examples for IRDI's

The item code (IC) - marked bold in the table above - unambiguously identifies a specific data element in the dictionary.

354 One advantage of the IRDI is language neutrality. The name and the semantic definition of a data 355 element can be translated in every language worldwide without changing the semantic meaning.

356 **Note**: IEC CDD uses the number of the standard (IEC or ISO) as an additional information (AI) to 357 distinguish between different domains and their different semantic definitions.

359 6.5 Thing description

360 Schema.org [110] is a collaborative, community activity with a mission to create, maintain, and 361 promote schemas for things (structured data) on the Internet, on web pages, in email messages, 362 and beyond. Schema.org provides a collection of shared vocabularies webmasters can use to mark 363 up their web pages in ways that can be understood by the major search engines: Google, Microsoft, 364 Yandex and Yahoo!

365 Actually schema.org does not provide semantic definitions relevant for PI technologies.

366 6.6 IoT thing description

iotschema.org [111] is an extension of schema.org for Internet of Things. The goal is to enable
 web applications to interact with the physical world based on machine interpretable information.
 iotschema.org enables semantic interoperability for connected things across diverse IoT
 ecosystems.

The further development in this direction should be monitored carefully. PI shall not only rely on IRDI's but also have the possibility to support definitions like iotschema.org in future as well.

373 6.7 Summary

Actually, ECLASS is the most promising semantic organization to work with. Reasons are as follows:

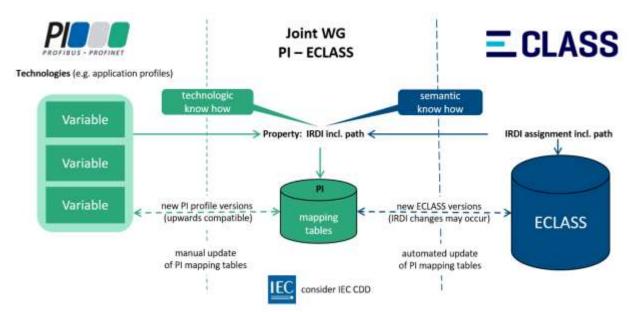
- ECLASS today mainly supports properties for product catalogues. That means, ECLASS
 today already supports use cases UC1 and UC2
- Scope of ECLASS is extended towards Industrie 4.0 [101]. Industrie 4.0 uses ECLASS.
- Professional IT support
- Transaction update management of versions
- Well established version- and change management
- Has fast track procedure getting new properties defined
- Curated long-term specification
- Supports the full life cycle of property definition
- For international applications other semantic database standards like IEC CDD needs to be considered.

388 **7 Working model JWG PI – ECLASS**

In the near future, PI and ECLASS e.V. expect a great value mapping semantically well-defined
 product classes / properties to PI technologies. Therefore, a joint working group was established
 to work out the technical details to support this mapping automatically executed by machines.

PI brings in the technological know-how of the devices used in automation, ECLASS adds it's
 semantic know how. This unique combination offers a significant step towards smart manufacturing
 and Industrie 4.0.

395 The working model is shown in the next figure.



396

397

Figure 15: Working model PI – ECLASS

398 Goal of the JWG is to define fieldbus neutral technologic oriented semantic information.

399 **7.1 Current status**

At first, the discussions were focused on the semantic organizations ECLASS e.V. and IEC CDD.
 The chapter "Introduction Semantic Organizations" provides technical background, similarities and
 differences.

403 Second the JWG focused on the technical details, e.g., how to map data types and so on. The 404 results of this discussion and technical solution proposals can be found in chapter "mapping 405 model".

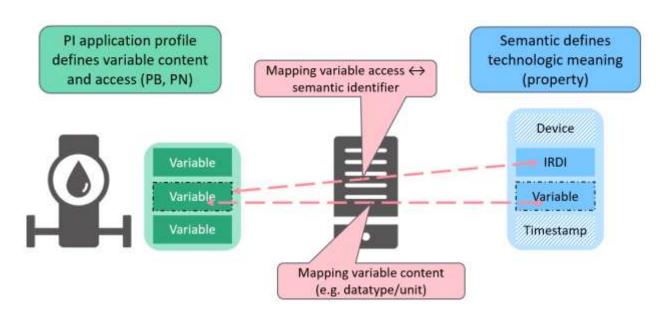
Finally, a meta model was built up how to add semantics to PI Application profiles resulting in a
 first version of an XML scheme for the mapping tables. This includes a conceptional verification of
 the XML scheme by considering several aspects of existing PI application profiles.

409 **7.2 Proposed next steps**

410 Define concrete mapping for selected PI application profiles and refine XML scheme if necessary.

412 8 Mapping model

- 413 The mapping model provides the necessary reference between
- the variable (content and access) defined by PI application profiles
- the technologic meaning by using semantic identifiers (e.g., IRDI paths) without knowledge
 of the underlying communication protocol
- 417



418

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Figure 16: Mapping model overview

420 The mapping model covers the device types defined by PI application profiles only.

421 Concrete mapping implementations use instances of these device types. The figure above shows
 422 additional instance related information indicated by the dashed fields. This example contains e.g.,
 423 the instance name of the device and a timestamp when the variable was read.

424 8.1 Mapping requirements

The mapping is an add on to a PI application profile. It is recommended not to reference semantic identifier directly in the application profile because semantic identifier may be changed asynchronously by semantic organizations.

There is no single PI mapping table. PI will provide mapping tables for each application profile or even for each device type defined within an application profile. This allows an incremental approach and later a flexible handling of updates.

To support different semantic organizations and their identifiers the mapping provides the possibility to use different types of identifier (e.g., IRDI) for the same variable.

PI application profiles support different underlying communication protocols like PROFINET or
 PROFIBUS and use specific methods to access variables. The mapping shall support different
 types of access methods for the same variable.

A variable consists of a value and for several data types of a unit (e.g., °C) and/or a status (e.g., 437 good / bad). This fact shall be supported by the mapping.

PI application profiles often use tables in which a numeric value relates to a selection. Example is
the unit code table provided by the PA Profile, the decimal value 1001 relates to °C (degree
Celsius) and has the ECLASS IRDI 0173-1#05-AAA567#004. The mapping shall support the
generic use of tables.

A property may be related (belong) to another property resulting in a series of variables. This is
modeled by IRDI paths representing the series and shall be supported by the mapping. Example:
One property damping belongs to mass flow signal, or the property damping belongs to density
signal.

446 **8.2 Preconditions for using the mapping**

- The use of the semantic mapping requires for the runtime use cases only some preconditions inthe communication environment.
- A discovery mechanism used to identify the devices connected to the network. See [4].
- A communication connection to the devices is established
- To detect devices / slots following any PI application profile, the PROFILE_ID (and optional the PROFILE_SPECIFIC_TYPE) supported by I&M functions can be used. See [1] for further details.

Using this basic communication information, the semantic access to the devices' information is possible. The mapping table describes the link between semantic identifier (e.g., IRDI) and their associated access and data already standardized by PI application profiles.

457 8.3 Mapping of data types

PI application profiles support constrained devices. This is the reason why much more data types
[2] than of other concepts are used to save device resources. Example: there are data types for
integer with different lengths: int8, int16, int32 and int64.

461 Semantic definitions do not need this restriction. They typically support native data types e.g., the 462 data type integer. Combining data type and data format, restrictions can be defined as well.

However, the different data types must be converted to ensure the right values to be used. There
is almost no conversion problem reading information from a device. Writing to a device requires
an online check whether the given value from outside can be correctly transferred to the device or
not.

- 467 The mapping table provides the data type used by the device to perform this check.
- 468 Hint 1: There is no unsigned data type in ECLASS yet. Reading may cause problems when data
 469 type unsigned64 is used and the values exceed 2³². In this case a wrong negative value is
 470 assumed.
- 471 Hint 2: PI data types use big endian coding. Typically, PC data types use little endian coding. In
 472 case of need, the byte order has to be exchanged. See [2] for further information.

473 8.4 Mapping units

474 Units are also coded as IRDI's. IEC/TS 62720 "Identification of units of measurement for computer-475 based processing" provides the definition for IEC CDD. ECLASS provides own IRDI's based on

476 UnitsML. There is a 1:1 relationship between units for IEC and units for ECLASS.

Searchi (* OK			and the second second	Print Export	
Tut:	Classes.		English French German Japanese Chinese		
	 Value lists Units 	 Value terms Lists of Units DET classification 	UNIT		
	 Relations All kind of items 		Code:	0112/2///62720#UAA903	
	Sector and a sector		Version:	001	
			Revision:	02	
	2///62720#UAA900	milliroentgen equivalent ir	IRDE	0112/2///62720#UAA903#001	
SU. 655	2///62720=UAA902	, 2015, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2017, 2	Preferred name:	nanofarad	
0112/	2///62720=UAA903	nanofarad	Synonymous name:		
0112/2///62720#UAA904 nanofarad per metre 0112/2///62720#UAA905 nanohenry 0112/2///62720#UAA906 nanohenry per metre			Short name:	nF	
			Definition:	0,000 000 001-fold of the SI derived unit farad	
A conclusion		nanosiemens per centimel	Note:		
		nanosiemens per metre	Remark:	UN/ECE code: C41	
0112/	2///62720#UAA909	nanotesla	Definition source:		
1.55.57	2///62720=UAA910		Definition class:		
	2///62720#UAA914		Unit structure:	m ⁻² kg ⁻¹ s ⁴ A ²	
	2///62720#UAA916	nuid ounce (US) ounce (avoirdupois) per ci	Unit in text:	nanofarad	
		cunce (avairdupois) per ci	the state of the second second		



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Figure 17: Example unit nanofarad from IEC TS 62720

479 For practical reasons, ECLASS assumes units to be fixed. This means the version information will not be used, especially for ECLASS updates. 480

Depending on the definition of the PI application profile, a unit of a variable can be fixed or read / 481 written from / to the device. Due to constrained resources, the PI devices deliver a coded number 482 483 instead of a string or IRDI.

Value	Symbol	Description	Equivalence
1244	μV	microvolt	= 10 ⁻⁶ V
1245	F	farad	= 1 C/V
1246	mF	millifarad	= 10 ⁻³ F
1247	μF	microfarad	= 10 ⁻⁶ F
1248	nF	nanofarad	= 10 ⁻⁹ F
1249	pF	picofarad	= 10 ⁻¹² F
1250	F/m	farad per meter	
1251	nE/m	microfarad per meter	

484

microfarad per meter

485

Figure 18: Example unit code nanofarad from PA Profile

486 In this example, the coded number for unit "nanofarad" is 1248. The IRDI for "nanofarad" is 487 0112/2///62720#UAA903#001. A special transformation table for units is necessary to automatically map coded number for unit to IRDI. 488

Hint: PI needs different unit transformation tables depending on the different application profiles 489 490 supported.

491 **Hint**: The transformation tables should support ECLASS and IEC CDD identifiers for units.

492 8.5 Mapping using transformations

Constrained devices often do not support strings directly. Therefore, often lists with value - string 493 494 pairs are defined in PI Application profiles. Examples:

495 Manufacturer ID - company name https://www.profibus.com/IM/Man_ID_Table.xml

- 496 These lists shall be converted in machine readable format to perform the automated transformation497 from value to string.
- 498 The second type of lists defines triples: value string IRDI's. Example:
- 499 Type of linearization
 500 PA Profile 4.0 value 119 string RTD Ni100 IRDI (CDD) ABB088/ABK987
- ECLASS (AAT180 defines type of RTD sensor)
 PA Profile 4.0 value 119 string Ni100 IRDI (ECLASS) 07-AAX026
- 503 **Hint**: in contradiction to units, transformations in general are version depended.

504 8.6 Proof of concept: electronic faceplate

- 505 PROFINET and PROFIBUS DP V1 devices support the PI wide standardized identification and 506 maintenance data (I&M).
- 507 One part of the I&M data is the electronic faceplate. The following table shows the mapping by 508 adding the ECLASS semantic identifiers and their data types.

PROFINET / PROFIBUS	Offset, length	Data type	ECLASS device identification	ECLASS IRDI path	ECLASS data type
MANUFACTURER_ID	0, 2	unsigned 16	Manufacturer name	/:ADN228/AAQ373/AAO677	String_ translatable
ORDER_ID	2, 22	visible string 20	Product article number of manufacturer	/:ADN228/AAQ373/AAO676	String_ translatable
SERIAL_NUMBER	22, 38	visible string 16	Serial number	/:ADN228/AAQ373/AAM556	String_ translatable
HW Revision	38, 54	visible string 16	Hardware version	/:ADN331/AAN270	String_ translatable
SW Revision	54, 70	visible string 16	Firmware version	/:ADN331/AAM985	String_ translatable

509

Table 2: Mapping electronic faceplate

- 510 This proof of concept shows the general idea works. Using an ECLASS IRDI can be mapped to a 511 standardized data access in a device.
- 512 This example also shows the use of transformations. The MANUFACTURER_ID represents the 513 name of the manufacturer. PI provides a list transforming ID's to name, see 514 https://www.profibus.com/IM/Man ID Table.xml.
- 515 **Note:** Keep in mind that the transformation Manufacturer \rightarrow name to ID is not 1:1. There might be 516 several entries for one manufacturer due to mergers and acquisitions over time.

518 8.7 Verification of mapping using PA Profile V 4.0

519 To verify this general concept, we used the PI application profile "PA Profile" V4.0 [3]. One reason 520 is being a real complex example, the other reason is that there are already IRDI definitions by IEC 521 CDD available.

522 8.7.1 Support different device types within a profile

523 PA Profile [3] defines different types of devices (so called transducer blocks) for e.g., flow or 524 temperature transmitter. Interesting problem here is that a flow transducer block also supports a 525 temperature but the address is different (slot 3 vs. slot 1) compared with temperature transducer 526 block.

ECLASS	🔞 Do you have quest	ions?	
11.1 (BASK) 🔄 💻 📑 🚺 🔚 🛛 🕼 CLASS ADVANCED	Scarch in: Classificatio	n v lan Santhar_ Switch	
ECLASS Version 11.1 (m)	Transforma		
2 (122 Millionini ((morig)	 Classification: 	27-24-26-02 Field hus, decentralized peripheral - analogue	
27-23 Process control system (PCI)	and and an an	Field birt, do entrollo d'anticher d'anticher d'anticher d'alle mont de	
27-24 Cantrol, Process Control System (PCS)	Preferred name:	Field bus, decentralized peripheral - analogue I/D module	
27-24-96 PC-based controls	Definitios:		
 27-24-36 Hard-wired control with (VPS) 			
27-24-20 Motion control (gengremmable motion control)	Naywords:	Add-on module Analog module Analog input Analog octpu	
- 10 17/24-21 hC (numerical control) - 10 27/24-22 Program matter logic control (SPS)		Beldbus - input/output module Decentralized compact and	
- 27-24-22 Programmatic eggs control (proj - 27-24-23 Querate and Observe (Hill)		module Desentralized compact digital I/O module	
In 17-24-25 Operate and Outprise (1980)	Properties		
- Se 27-24-26 Field bus, decentralized peripheral O	Properties		
27-24-25-01 Field bus, decentralized perphanal - analogue VD module O	0173-1202-44/48112001-148	of the product	
27/24-20-02 Field bus, decentralized pertpheral- analogue/digital I/D roodule O	0173-1002-ANVELID01-GLN of manufacturer		
27-24-26-03 Field Itun, decevit-alized peripheral - module carrier 0			
-27-24-26-64 Field hus, decentralized peripheral - digital I/O module 0	0173-1002-6AZ8500901 - Use	of customs tariff number	
- 27-24-28-65 Field hun, decentralized peripheral - function-dechnology module 9	0173-1402-AA29494001 - Typ	e of customs tariff number	
27-24-29-67 Field bun, decentralized peripheral - basic device O	0173-1402-6AZ8004001 - Cen	doms tart# number	
- 27-24-26-06 Field hus, determinized peripheral - communizations module 0	0173-1202-A428514001-HS	Code of the WCD	
27-24-26-69 Field hun, decentralized peripheral - power module, motor sailtch 8	0173-0403-4403624004-04	untry of customs tariff number	
27-24-26-10 Peld but, decentralized peripheral - level and segment module ()	0173-1#02-64D931#006 - cut		
27-34-36-11 Pielz bus, decentralized pertoheral - power supply module ()	To the second strength and the second s		
-27-24-26-13 field bus, decembral pertpheral - preumatics module ()	0173-1802-AAD2642002 - Rej	pon of customs tariff number	
-17-24-28-18 Interface (PCS) 0	0173-1#02-AAD342#002 - Bits	ind	
27-24-26-17 Output mupling link	0173-1402-ARDE77#002 - Ma	hufacturer name	
- 27-24-26-20 Pield bus, decentralized pertahenel (unspectived) ()	0173-1202-A4U7712001-Ma	sufacturer product ben fir	
17/24-26-01 Field bus, decentralized perioheral (parts) 0	0173-1=02-44Z485#001 - Sur		
- 17-24-16-92 Field box, decentralized peripheral (accessories) O		New York Control of Co	
- 27-24-32 Centrel compensat	0173-1#02-AAM486#304 - an		
- 80 27 24 40 Control for specific applications	0173-1802-6499136001 - 51.8	f of supplier	
- 27-34-96 Continui (other)	0173-1#02-AAD500#002- No	mber of HW Interfaces serial R5232	
- I7-26 Component (electronic)	0173-1402-AAMS514002 - Su	aplier product designation	
27-27 Binary sensor technology, safety-related sensor technology 0	0173-1#02-640729#001-8on		
27-28 Identification		inclan antier from adeptates for mans.	

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Figure 19: Example different ECLASS device types

Flow mass_flow (function block 1 = Slot 1)
density (function block 2 = Slot 2)
temperature (function block 3 = Slot 3)
Temperature temperature (function block 1 = Slot 1)

529

530

Figure 20: Example different PA Profile device types

531 Solution:

532 The mapping file must be specific for the device type used. That means, there is a mapping table 533 for the device type flow transmitter and another mapping table for temperature. PA profile e.g., 534 specifies device type with the help of online readable information. To select the right file, the file 535 name must include such device type information.

536 8.7.2 Variable names are used multiple times

537 In the example shown, the variable damping is used several times. In fact, the device supports for 538 each primary variable (e.g., mass flow) an own value for damping. This requires that not only the 539 variable but also the context is necessary.

> Flow mass_flow (function block 1 = Slot 1) damping density (function block 2 = Slot 2) damping temperature (function block 3 = Slot 3) damping Temperature temperature (function block 1 = Slot 1) damping

540

541

Figure 21: Example context

542 Solution:

- 543 Instead using the IRDI for damping ABH526 (from CDD) the IRDI path which indicates this is the 544 damping for e.g., the variable mass flow shall be used. This link shall be explicitly modelled within
- 545 the mapping file to avoid time and processing power consuming searches.

546 **8.7.3 Unit Codes need transformation**

547 The chapter "Mapping Units" already describes the principle. A transformation is used to convert 548 PI application profile unit codes to IRDI's and vice versa.

549 8.7.4 Shown display language

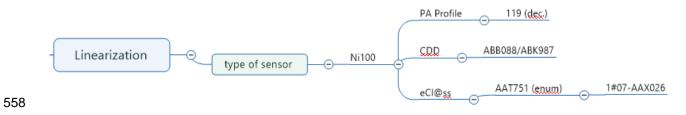
550 PA devices support different languages on their local display. ECLASS supports a list of all 551 supported display languages (AAT401). There is up to now no ECLASS identifier which language 552 is actually shown on the display.

553 Solution:

554 Add a new IRDI in ECLASS.

555 8.7.5 Different types of linearization

556 PA Profile [3] Table 240 provides a list "Type of linearization", supporting e.g., different 557 temperature sensor types (e.g., PT 100, Ni 100).



559

Figure 22: Example linearization

Courts	: A58068	OK	Data type:	ENUM CODE TYPE(0112/2///61987#ABJ760)	
In:	Classes	* Properties	Format	. Later _ court_, in Eler in an eler in an appendent	
	Value lists	Volue terms Usts of Units DET classification	Definition source:		
	Units Relations		Value source:		
	All kind of items		Property data element type:	DEPENDENT P DET	
			Drawing:	and property () Cores	
hit	Export selected	Select all Deselect all	Formula		
■ 0112/2///61987#ABB088 type of RTD sensor		Value list code	0112/2//61987#ABJ760		
		Value list:	0112/2/061987#ABK976 - Cu1000 0112/2/061987#ABK977 - Cu25 0112/2/061987#ABK975 - Ni100 0112/2/061987#ABK975 - Ni100 0112/2/061987#ABK986 - Ni120 0112/2/061987#ABK986 - Ni20 0112/2/061987#ABK986 - P110 0112/2/061987#ABK986 - P120 0112/2/061987#ABK986 - P120 0112/2/061987#ABK986 - P120 0112/2/061987#ABK986 - P120 0112/2/061987#ABK986 - P120 0112/2/061987#ABK986 - P150 0112/2/061987#ABK988 - P160 0112/2/061987#ABK988 - P160 0112/2/061987#ABK988 - P160		
			DET class:		
			Applicable classes:	0112/2///61987#ABC570 - RTD input 0112/2///61867#ABF398 - RTD/tusistance measurement 0112/2///61987#ABF418 - RTD	
			Definition class.	0112/2/061967#ABA000	





Figure 23: Example linearization IEC CDD

Overview	General	Admin F	Format	Attribu	te Change request Values F	telease Alternate units Constra
• 100 Pt50	00		Value	es		
• 123 Pt50	(acc. JIS)				. 0	
• 128 Pt50)			ter quer		
• 120 Pt25	5		Adva	anced sea	arch 👻 Search	
• 00 Pt20	00		9	0	0173-1#07-AAX032#001	Pt10 (acc. JIS)
• 123 Pt10	000		5	0	0113-1#01700032#001	P110 (acc. 013)
• 125 Pt10	0 (acc. JIS)					
• 120 Pt10	00		10	\odot	0173-1#07-AAX033#001	Pt100
• 100 Pt10	(acc. JIS)					
• 03 Pt10)		11	0	0173-1#07-AAX034#001	Pt100 (acc. JIS)
• 100 Ni50)		10	<u> </u>		11100 (000, 010)
• 🖽 Ni25	5					
• 123 Ni12	20		12	0	0173-1#07-AAX035#001	Pt1000
• 125 Ni10	000		:			
• 123 Ni10	00		• 13	0	0173-1#07-AAX036#001	Pt200
• 123 Cu2	5					

562

563

Figure 24: Example linearization ECLASS

564 Solution:

565 Use triple transformation: **value** (from PI application profile), **string** (human readable), **IRDI** (from 566 ECLASS, IEC CDD)

567 Hint: Linearization is version dependent

568 8.7.6 Conclusion

- 569 From theoretical point of view, the semantic mapping of PA Profile with all its specifics is possible.
- 570

9 Recommended Actions

572 The recommended actions base on the discussions in the JWG PI – ECLASS. They will be 573 extended or refined if needed.

574 9.1 ECLASS

575 Delete PROLIST information within ECLASS. In ECLASS10.1 the PROLIST information is already 576 signed as "phased out".

577 Build up a definition which focusses on technology properties for PA devices only and align to IEC 578 CDD 61987-Series). Keep this definition as slim as possible. Do not introduce any communication 579 or fieldbus specific properties / information. Incorporate results from project COMDO.

580 Continue already started activities on ECLASS – OWL mapping to enable use of W3C semantic 581 tools (e.g., search engines) together with ECLASS semantic definitions.

Additional tool support is necessary: Simple export of complete path for use in PI mapping tables.
 This path shall be the same path as used in TUF file for ECLASS version updates. Support also
 value lists with its values.

585 **9.2 Pl**

586 Today not all data provided by PI application profiles already have such a semantic property 587 defined, it is future work to provide a complete set of information.

- 588 Up to the PG's to
- Select parameter / values defined by profile to be extended with semantic identifiers
- Support ECLASS IRDI's and other semantic identifiers (e.g., IEC CDD IRDI's) as well
- Provide XML file(s) for mapping
- Support ECLASS TUF update mechanisms

593 **9.3 JWG PI – ECLASS**

- 594 This white paper describes the results of the JWG PI ECLASS so far. Future work:
- Refine the meta model (and XML mapping file) when necessary
- Give support and advice to PI PG's working on semantic definitions for application profiles and beyond
- Evaluate PI goal to shorten IRDI paths vs. TUF update file
- 599 Support ECLASS version updates by providing updated mapping tables. Use ECLASS beta 600 versions to prepare XML files in advance for testing purposes.

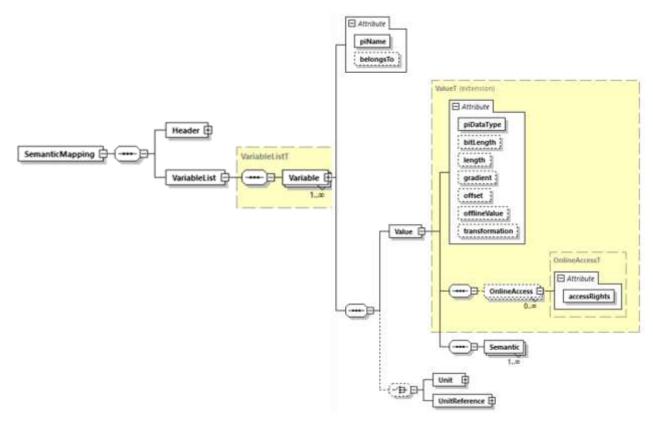
602 **10** Annex: XML Schema for Mapping table

The mapping table models how to access to information provided by PI application profiles using a given semantic identifier (e.g., IRDI path). The complete property definition of semantic organisations like ECLASS will not be part of the mapping table in order to avoid inconsistencies or double definitions.

607 This XML schema can be found in the attachments to this white paper, file name 608 "PI_ECLASS_SemanticMapping_1.0.xsd".

The XML schema contains type information only. The number of instances needed depends on the number of connected devices.

611 **10.1 Overview**



612

613

Figure 25: Overview XML mapping table

614 The SemanticMapping XML file consists of one Header and one VariableList for each device type.

615 The *VariableList* contains all *Variables* (e.g. PI data record elements) of this device type for which 616 a semantic definition is needed.

617 Each *Variable* has a *Value* and optional a *Unit* or *UnitReference*.

618 The *Value* is defined in the PI application profile with its piName, meaning, data type, online 619 access, The *Semantic* identifiers (e.g. IRDI path) are added. There may be different *Semantic* 620 identifiers from different semantic organizations or versions.

Beside the *Value* itself, the *Unit* is necessary (e.g. length 10 mm) to describe the complete information. The *Unit* may also be read from the device (like the *Value*) and has also a *Semantic* identifier. Alternatively, *UnitReference* refers to the unit of another *Variable*.

625 10.2 XML filename

The XML filename for a specific device type enables any mapping application to determine the right mapping table to be used for the connected device. The filename shall fulfill the following conventions

629 PI_SEM1.0-<profileID>-<profileSubID>-<releaseDate>

630 PI_SEM1.0

631 Indicates a PI semantic mapping table with the used schema version

632 <profileID>

633 Indicates the PI application profile e.g., 0x9700 for PA Profile.

634 <profileSubID>

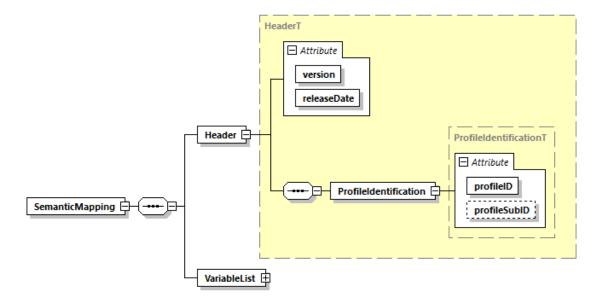
635 Indicates different device types supported by PI application profile

636 <releaseDate>

- 637 Indicates the date of the mapping table released. Format is yyyymmdd
- 638 Background: The online detection of devices delivers exactly the information, which profile and 639 profile sub type is supported. This can be easily used to open the corresponding XML file.
- 640 This definition supports the following Requirements
- Machine readable
- no additional information (see XML Header inside the file)
- global unique file names (one directory for all mapping files))
- contains version of XML scheme to optimize file open with the right scheme
- 645 Hints:
- For some PI profiles a specific logic is needed to determine the exact type of the device.
- IO-Link is currently not supported. Reason: One IO-Link device may support more than one profile ID.
- 649

650 10.3 Header

The *Header* within the XML file supports the same information that is given in the filename. This is intended to doublecheck eventual misuse of windows rename function.



653

654

Figure 26: XML Header

655 Version

656 Version of this XML schema for SemanticMapping

657 ReleaseDate

release date of the XML mapping file for the specific device type supported

659 ProfileID

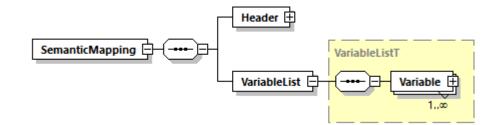
- 660 Profile ID defined by PI for each application profile, see I&M0 data
- 661 <u>https://www.profibus.com/IM/Profile_ID_Table.xml</u>

662 **ProfileSubID (optional)**

663 Specifies sub types of devices, see I&M0 data Profile Specific Type or IdentNumber

664 10.4 VariableList

665 The *VariableList* contains all *Variables* (e.g. PI data record elements) of this device type needing 666 a semantic definition.

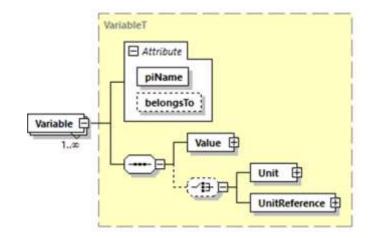


667

668

Figure 27: XML Variable List

- 669 VariableList
- 670 Container for all Variables defined
- 671 **10.4.1 Variable**
- 672 Each Variable has a Value and optional a Unit or UnitReference.



673

674

Figure 28: XML Variable

675 piName

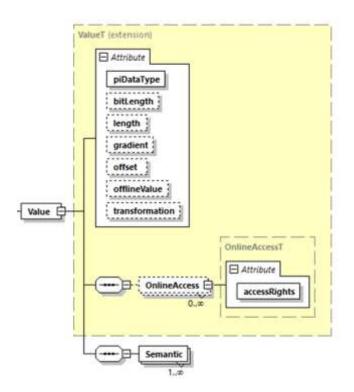
676 name of the *Variable* from PI application profile

677 belongsTo (optional)

- 678 Link to another Variable. Can be used e.g., for damping as reference to primary variable e.g.,
- 679 mass flow.

680 10.4.1.1 Value

- 681 The Value is defined in the PI application profile. The textual references to the data type, the online
- 682 access (for e.g., PROFINET and / or PROFIBUS), the referring *Unit* etc. and the *Semantic* identifier 683 are modelled for computerized use.



684

685

Figure 29: XML Value

686 piDataType

687 data type of the Value defined by PI application profile

688 bitLength (optional)

- 689 length of bits of PI data type. Only needed if not aligned to byte boundaries
- 690 length (optional)
- 691 length of octets of PI data type

692 gradient / offset (optional)

693 enables linearization of the Value if needed

694 offlineValue (optional)

695 predefined *Value* by PI application profile

696 transformation (optional)

- 697 Reference to a transformation with a keyword having input and output parameters. Each
- transformation has to be coded within the application. This is used for
- coding /decoding a list with "value ↔ string" tupels. E.g., useful for decoding manufacturer
 ID's to manufacturer names. This transformation could be indicated with the keyword
 "Manufacturer List"
- containing business logic. E.g. for IO-Link, the MinCycleTime ranges from 0.4 to 132.8 milliseconds with varying resolution, and is encoded in a single byte. It uses 6 bits multiplicator and 2 bits time base encoding, as specified in the IO-Link Interface and System Specification. This transformation could be indicated with the keyword "IO-Link 706 CycleTime"

707 **10.4.1.2 Online access (optional)**

Depending on the fieldbus and the application profile, different types to access the data from thedevice are needed.



710

711

Figure 30: XML OnlineAccessT

712 accessRights

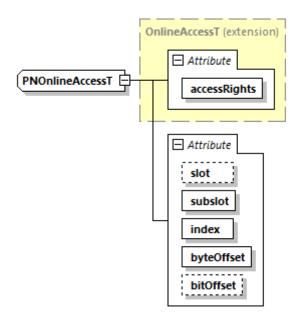
- 713 *Value* may be read only, read/write or write only. Defined by PI specifications.
- The standard access types for PI fieldbus communication technologies have to be coded within the application using the following definitions:
- PROFINET: *PNOnlineAccessT* native access type to data
- PROFIBUS: *PBOnlineAccessT* native access type to data
- PROFIBUS DS 255 call mechanism (see [1]): *PBCall255OnlineAccessT* access type for e.g. I&M data
- The XML model allows to add more than one *OnlineAccessT* for a *Value*, supporting the different PI fieldbus systems.
- These types can be extended for e.g.:
- PROFIdrive: PDOnlineAccessT and PDOnlineAccessUnit
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• PA Profile V3: PA3OnlineAccessT

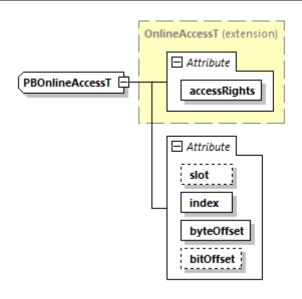
707

725 10.4.1.3 Online access PROFINET (optional)

726 Native data access type for PROFINET: PNOnlineAccessT



121	
728	Figure 31: XML PNOnlineAccessT
729	slot (optional)
730	the <i>slot</i> within the device. Defined by PI specifications. Needed e.g., for PA devices
731	subslot
732	the <i>subslot</i> to address within the device. Defined by PI specifications
733	index
734	the record number within the <i>subslot</i> to address. Defined by PI specifications
735	byteOffset
736	the byte offset within the record to address the value. Defined by PI specifications
737	bitOffset (optional)
738	The bit offset within the addressed byte. Defined by PI specifications
739	10.4.1.4 Online access PROFIBUS (optional)
740	Native data access type for PROFIBUS: PBOnlineAccessT



- 741
- 742

Figure 32: XML PBOnlineAccessT

743 slot (optional)

- the slot within the device to address. Defined by PI specifications
- 745 index
- the record number within the *slot* to address. Defined by PI specifications

747 byteOffset

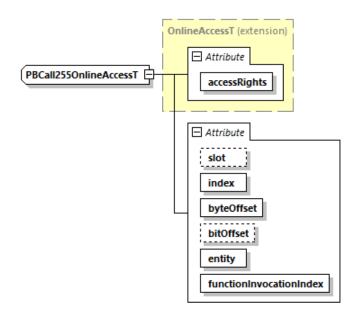
the byte offset within the record to address the Value. Defined by PI specifications

749 bitOffset (optional)

The bit offset within the addressed byte. Defined by PI specifications

751 10.4.1.5 Online access PROFIBUS Call 255 mechanism (optional)

Access type to data using PROFIBUS DS 255 call mechanism (see [1]). Needed e.g., for I&M data.



753

754

Figure 33: XML PBCall255OnlineAccessT

755 slot (optional)

756 the *slot* within the device to address

757 index

the record number within the *slot* to address

759 byteOffset

the byte offset within the record to address the Value

761 bitOffset (optional)

762 The bit offset within the addressed byte

763 entity

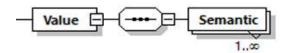
764 The sub-component within a *slot*

765 functionInvocationIndex

the communication service to use. See [1], table "Services of the Load Region state machine"

767 10.4.1.6 Semantic

For each *Value*, at least one semantic description is defined.



769

770

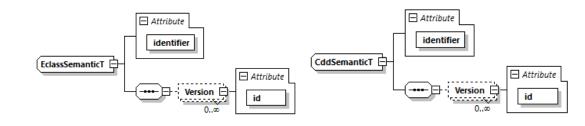
Figure 34: XML Semantic container

771 Semantic

container for all types of semantic identifier

There can be different types of semantic identifiers, supporting e.g., ECLASS or IEC CDD at the same time. In this version of XML semantic mapping, ECLASS and IEC CDD are different types to distinguish between both but the levent of the context is the context.

distinguish between both, but the layout of the content is the same.



776

777

Figure 35: XML SemanticT

778 identifier

the semantic identifier defined by the appropriate semantic organization. The IRDI path is included.

780 Version (optional)

container for all versions of the semantic organization the *identifier* is valid.

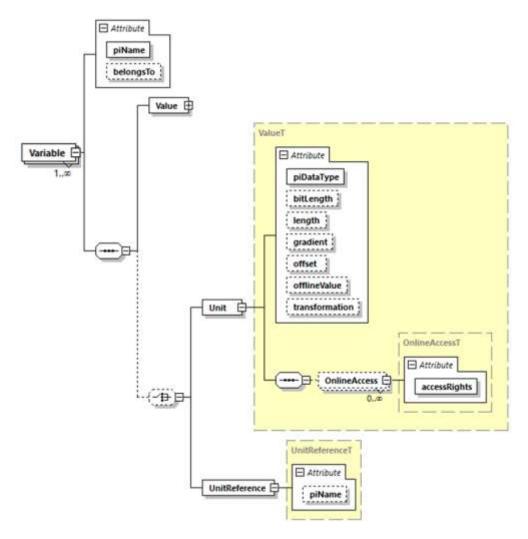
782 id

defines the version of the originator of the semantic *identifier*. E. g. ECLASS11.1

784 **10.4.2 Unit and UnitReference**

The *Unit* of a Variable can be fixed or read / written from the device, depending on the definition

of the PI specifications. Therefore, *Unit* is modeled in the same way as *Value*, with data types and
 onlineAccessT.



788

789

Figure 36: XML Unit and UnitReference

790 Due to constrained resources, the PI devices deliver a coded number instead of a string or IRDI 791 for units. A special *transformation* is needed to get the IRDI of the unit.

792 transformation

coding / decoding a list with "value ↔ string" tupels. In this case, a table with the coded number
 of the unit, the ECLASS IRDI and the CDD IRDI could be provided. This transformation could be
 indicated with the keyword "Unit List"

796 UnitReference

A Value may have a Unit or alternatively a UnitReference. The UnitReference supports the fact that not every Value has an own Unit defined. For example, a process value for pressure defines the unit itself, but upper and lower pressure limits (being also independent values with own semantics) always use the same unit definition as the process value.

801 piName

- 802 reference to the *Variable* from which the *Unit* has to be used
- 803





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