IEC SRD 63456

Edition 1.0   2023-10

SYSTEMS REFERENCE DELIVERABLE

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Navigation tools for smart manufacturing

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NAVIGATION TOOLS FOR SMART MANUFACTURING

FOREWORD

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IEC SRD 63456 has been prepared by IEC systems committee SM: Smart Manufacturing. It is a Systems Reference Deliverable.

The text of this Systems Reference Deliverable is based on the following documents:

Draft	Report on voting
SyCSM/81/DTS	SyCSM/89/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Systems Reference Deliverable is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document aims to describe external requirements in terms of navigation tools for smart manufacturing to assist the development of manufacturing systems and international standards through linking reference models, use cases, architecture, and standards. Some of the requirements mentioned in this document (including annexes) refers to additional IEC internal IT support.

With this motivation, this document contains the following clauses; Clause 5 describes an outline of the navigation tool for smart manufacturing. Clause 6 presents a view of relationships between the navigation tool and related IT resources in IEC. And Clause 7 defines external requirements. Besides, annexes show a practical example of an IT tool having similar characteristics to the navigation tool, prior works as IT tools developed in IEC, an example of a practical development scheme of IT tool in IEC, and an outline of a potential development scheme for the navigation tool through a comparative analysis with the Mapping Platform.

NAVIGATION TOOLS FOR SMART MANUFACTURING

1 Scope

This document describes requirements in terms of navigation tools for smart manufacturing.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/

- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
aspect
labelled designation for a collection of concepts in a particular context

[SOURCE: IEC 63339:–, 3.1.1, modified – The example and notes to entry have been omitted.]

3.2
business
series of processes, each having a clearly understood purpose, involving more than one person, realised through the exchange of information and directed towards some mutually agreed upon goal, extending over a period of time

[SOURCE: ISO/IEC 15944-20:2015, 2.2]

3.3
concern
matter of relevance or importance to a *stakeholder* (3.10) regarding a manufacturing system or element thereof

[SOURCE: ISO/IEC/IEEE 42010:2022, 3.10, modified – In the definition, "regarding a manufacturing system element thereof" has been added.]

3.4
dimension
coherent collection of *aspects* (3.1) relevant to a *manufacturing domain* (3.7)

[SOURCE: IEC 63339:–, 3.1.7, modified – Note 1 to entry has been omitted.]

3.5
facet
framework composed of one or more *dimensions* (3.4)

[SOURCE: IEC 63339:–, 3.1.9]

3.6
manufacture
any or all of the activities in the design, procurement, construction, commissioning, deployment, screening, testing, production, storage, labelling, packaging or distribution of products and production systems

[SOURCE: IEC 63339:–, 3.1.12]

3.7
manufacturing domain
portion of a *business* (3.2) dealing with the *manufacture* (3.6) of products

[SOURCE: IEC 63339:–, 3.1.13]

3.8
reference model
framework for understanding significant relationships among the entities of some environment, and for the development of consistent standards or specifications supporting that environment

[SOURCE: ISO 19165-1:2018, 3.30]

3.9
use case
technique for capturing potential functional requirements

[SOURCE: IEC TS 62443-1-1:2009, 3.2.132]

3.10
stakeholder
role, position, individual, organization or classes thereof, having an interest, right, share, or claim, in an entity of interest

[SOURCE: ISO/IEC/IEEE 42010:2022, 3.17]

4   Abbreviated terms

ahG	ad hoc Group
GUI	graphical user interface
IEC	International Electrotechnical Commission
IEV	International Electrotechnical Vocabulary
IS	International Standard
ISO	International Organization for Standardization
JWG	Joint Working Group
MP	Mapping Platform
MPIP	Master Plan Implementation Plan
NT	navigation tool
OF1	Open Forum 1

OSS	open source software
SDK	software development kit
SDO	standards development organization
SEG	Systems Evaluation Group
SM2TF	Smart Manufacturing Standard Map Task Force
SM	smart manufacturing
SMB	Standardization Management Board
SMRM	Smart Manufacturing Reference Model
SRG	Systems Resource Group
SyC	systems committee
TC	technical committee
UCMR	use case management repository
URM-MM	Unified Reference Model – Map and Methodology
URMSM	Unified Reference Model for Smart Manufacturing

5 Navigation tool

5.1 Objective

Navigation tools aim to assist in the configuring of smart manufacturing systems by utilizing relevant ISs and existing products/solutions, including open source software, and the smart manufacturing example described in use cases.

5.2 Definition

In order to clarify the external requirements of navigation tools, a navigation tool is defined as follows:

"A set of software functions to navigate the development of smart manufacturing systems through exploiting information related to reference models, use cases, architecture and standards, which are stored in the accessible repositories."

5.3 Expected value

Navigation tools provide access to related reference models, use cases, architecture and standards based on the needs of standard developers and smart manufacturing system developers in the development and implementation of smart manufacturing systems.

5.4 Related information

There are some prior studies and activities related to navigation tools, such as Unified Reference Model – Map and Methodology (URM-MM) (see Annex A), Smart Grid Standards Map (see Annex B), and Mapping Platform (see Annex C).

6 Relationships among related activities developing IT tools in IEC

6.1 General

Subclause 6.1 describes the relationships among individual IT resources involving related committees within IEC. Figure 1 shows an example of an assumed IEC service system configuration, which allows IEC to deliver services to end users through its own platform. A navigation tool provides a functionality as a domain-specific function by exploiting functionalities provided as domain-neutral functions and repositories.
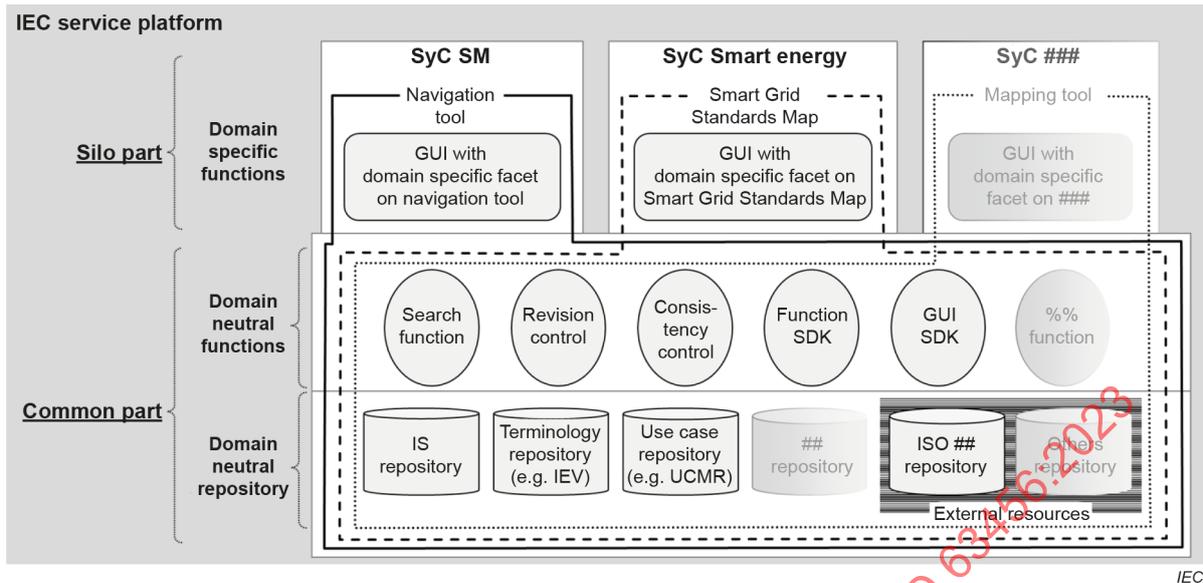
Figure 1 – Example of an assumed IEC service system configuration

6.2   Categorization of functionalities

Subclause 6.2 describes the categorization of functionalities provided through the IEC service system. According to the assumed configuration depicted in Figure 1, a typical system configuration is composed of two parts: a silo part composed of individual domain-specific functions, and a common part composed of domain-neutral functions and repositories. The common part will be utilized from multiple domain-specific functions at the silo part. As domain-neutral functions, the common part also provides a software development kit (SDK) for developing domain-neutral functions and for domain-specific functions, respectively. Domain-neutral repositories are to be provided by relevant groups not only in the IEC but also by those external to the IEC. Moreover, the common part allows the IEC to provide domain-specific functions such as a navigation tool, which may utilize multiple domain-neutral functions and/or refer to related repositories of the common part, as necessary, to end users via the Internet. To understand how IEC proceeds with IT tool development, Annex D provides a case of practical IT tool development in IEC. Besides, to consider practical implementation approaches for navigation tools, Annex E describes similarities and differences between the case of Mapping Platform and the case of a navigation tool.

7   Requirements for navigation tools

Clause 7 describes the functional requirements and non-functional requirements from a user's point of view. Moreover, it also describes the expectations for interfaces between navigation tools and domain-neutral functionalities. Table 1 shows the list of functional requirements of navigation tools.

Table 1 – Functional requirements of navigation tools

#	Usage purpose	In	Process	Out
	[General]			
1	Find relevant use case(s)	Keyword(s) for use cases	Search use cases in a repository	Relevant use case(s)
2	Find relevant IS(s)	Keyword(s) for IS(s)	Search IS(s) in a repository	Relevant IS(s)
3	Protect privacy of usage data	Data input by a user	Authenticate users to access data and prohibit the access of data for other users	Output generated from the data of the user
	[User interface]			
4	Create contents	Name as a character string for identifying the contents stored in file system	Create new contents in the file system	The contents created in the file system
5	Manage contents created using the navigation tool	Name as a character string for identifying the contents stored in a file system	Manage the contents in the file system	The contents saved or retrieved through the file system
6	Edit contents created using the navigation tool intuitively	GUI manipulation	Edit design contents of the navigation tool	Corresponding operations such as Undo, Redo, Cut, Copy, and Paste
7	Search a keyword	Keyword	Identify the location of the keyword in design contents	Highlight the keyword on the navigation tool
	[Navigation functionality]			
8	Identify relevant international standards	Relevant keywords (e.g. CDD)	Derive model-contents from URMSM specified in ISO/TC 184 – IEC TC 65 Joint Working Group 21	List of relevant international standards

Table 2 shows the list of non-functional requirements of navigation tools.

Table 2 – Non-functional requirements of navigation tools

#	Usage purpose	In	Process	Out
	[Usability]			
1	Access universally from any terminal	Interactions through a terminal	Recognize features of the terminal and adjust presentation of contents	Appropriate presentation of contents
2	Access universally from any region	Interactions through a terminal in any region	Recognize features of the region (such as language) and adjust presentation of contents	Appropriate presentation of contents
3	Interact intuitively	Key input and/or GUI manipulation	Follow conventional GUI manners	Visual contents and feedback
	[Security]			
4	Protect confidentiality	Data input by a user	Authenticate a user and allow operations based on their access privilege	Output generated from the data of the user
5	Authorize access	Data input by a user	Authenticate a user and allow operations based on their access privilege	Output generated from the data of the user

Table 3 shows the list of expectations for interfaces between navigation tools and domain-neutral functionalities.

**Table 3 – Expectations for interfaces between navigation tools
and domain-neutral functionalities**

#	Usage purpose	In	Process	Out
1	Search use case(s) using the reference model concept	Concern as a keyword	Search use cases in use case repository	Relevant use case(s)
2	Search IS(s) using the reference model concept	Aspect as a keyword	Search IS(s) in IS repository	Relevant IS(s)
3	Find relevant term	Term	Search a term in terminology repository	Relevant term(s)
4	Search SMRM(s) for SM	Keyword(s) such as aspect(s), dimensions(s), and/or facet(s)	Search SMRM(s) referable from the navigation tool	SMRM(s)

Annex A
(informative)

Unified Reference Model – Map and Methodology (URM-MM)

A.1 Background

Through the survey and the discussions on a unified model for smart manufacturing at several SDOs, URM-MM is proposed as a guideline, which supports users in developing their manufacturing systems as open-ecosystems by supporting the selection of an appropriate reference model for representing use cases and supporting the creation of relevant design information through a phased process.

URM-MM is one of the most important outcomes in Germany–Japan cooperation in relation to Industrial IoT and Industrie 4.0.

Clauses A.2 to A.5 introduce URM-MM as an example of a navigation tool.

NOTE   Annex A includes examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these products.

A.2 Overview

To represent each use case by utilizing existing reference models and architecture, URM-MM defines two axes, one including multiple existing reference models and the other presenting possible design processes on practical manufacturing systems for smart manufacturing.
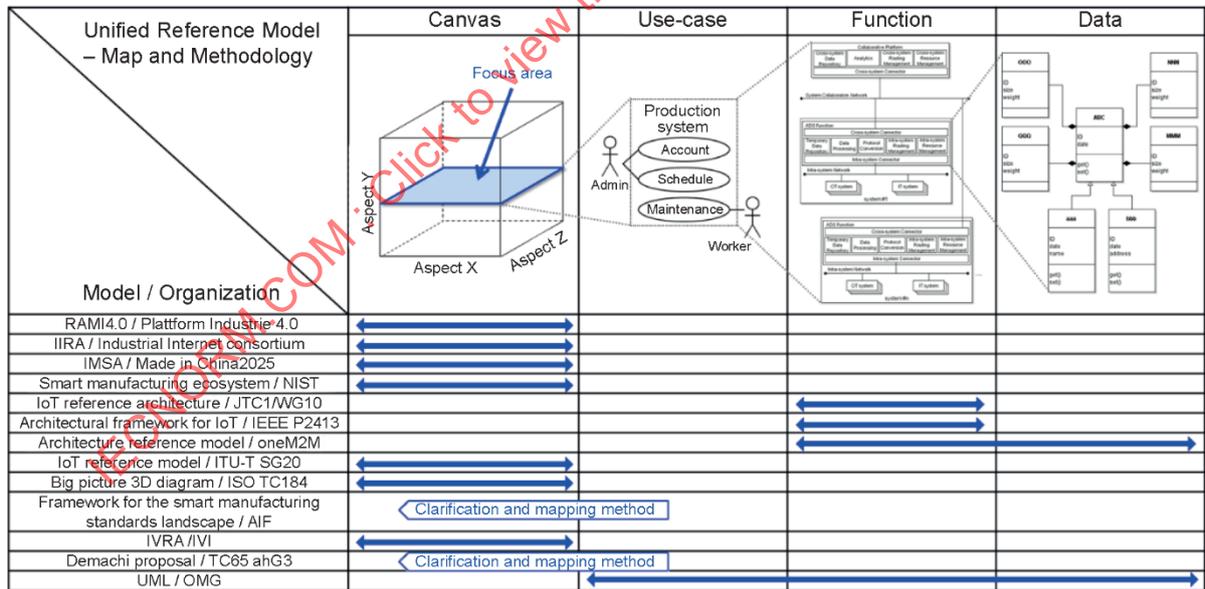
Figure A.1 – Unified Reference Model – Map and Methodology (URM-MM)

URM-MM defines four divergent phases as design processes: "Canvas", "Use-case", "Function", and "Data". A guideline is provided to describe individual use cases to utilize appropriate existing reference models or architectures, categorized into "Canvas", "Use-case", "Function", and "Data" for presenting related international standards.

"Canvas" provides a space as a "Focus area" that has appropriate aspects such as domain, hierarchy, and life cycle in order to draw a physical structure of implementing use cases, which is composed from field equipment to Manufacturing Execution System (MES). In "Canvas", it is supposed that those drawings present related international standards and de-facto products such as industrial Ethernet (e.g. Profibus, EtherNet/IP), communication protocols (e.g. AMQP, MQTT, CoAP), and Web service interfaces (e.g. RESTful, SOAP).

"Use-case" provides a space for drawing behaviour diagrams of whole use cases in order to define main actions, which are performed by subjects, and express interactions with external actors as stakeholders. In "Use case" it is supposed that those drawings present international standards related to system-wide issues such as system architectures (e.g. IEC 62264, IEC 61512), security, safety, privacy (e.g. IEC 62443, ISO/IEC 27000), and national and international regulations (e.g. trade restrictions, international procurement). Typical use cases related to smart manufacturing have been discussed at some initiatives such as Plattform Industrie 4.0, IIC, and IVI.

"Function" provides a space for drawing logical functional blocks, which implement necessary and characterizing features of each use case, and visualized relationships among those functional blocks. In "Function", it is supposed that those drawings present related international standards, de-facto products, and de-facto open source software (OSS) such as virtualization software (e.g. Docker, KVM, Vmware), database (e.g. PostgreSQL, MongoDB), data processing infrastructures (e.g. Hadoop, Spark). Figure A.1 shows an example of a notation of "Function".

"Data" provides a space for drawing data models, which are defined and utilized in each use case. In "Data", we suppose that those drawings present related international standards such as business indexes (e.g. ISO 22400), engineering data (e.g. IEC 62714, IEC 61131), and dictionary data (e.g. IEC 61360, eCl@ss).

A.3 Usage

By walking through development processes defined in URM-MM, users can make open-ecosystem development easier, guided by relevant international standards and/or de-facto standards and products for each development process. Iterative operations of the following three steps at four development phases, from "Canvas" through to "Data", is a typical usage of URM-MM.

- Step 1: Select an appropriate reference model or architecture for describing a use case by referring to the lower table summarizing the features of individual reference models/architectures.

- Step 2: Draw the use case visually by leveraging the selected reference model at appropriate scales and granularity to have common understandings among diversified stakeholders which have interests from various aspects.

- Step 3: Map relevant international standards and/or de-facto standards and products by delivering interoperability and interchangeability onto the drawn use-case precisely for supporting open-ecosystem developments that allow complicated system integrations.

A.4 Practical use case

Figure A.2 shows an example of a production system having a production plan dynamic optimization capability by leveraging simulation. The production controller aggregates real-time process status information in order to update the production plan. The maintenance controller monitors and manages the production capacity and availability in all the stations. It is focused on production planning self-optimization and the continuous improvement of the line operational efficiency based on 4M (man–machine–material–method) information.
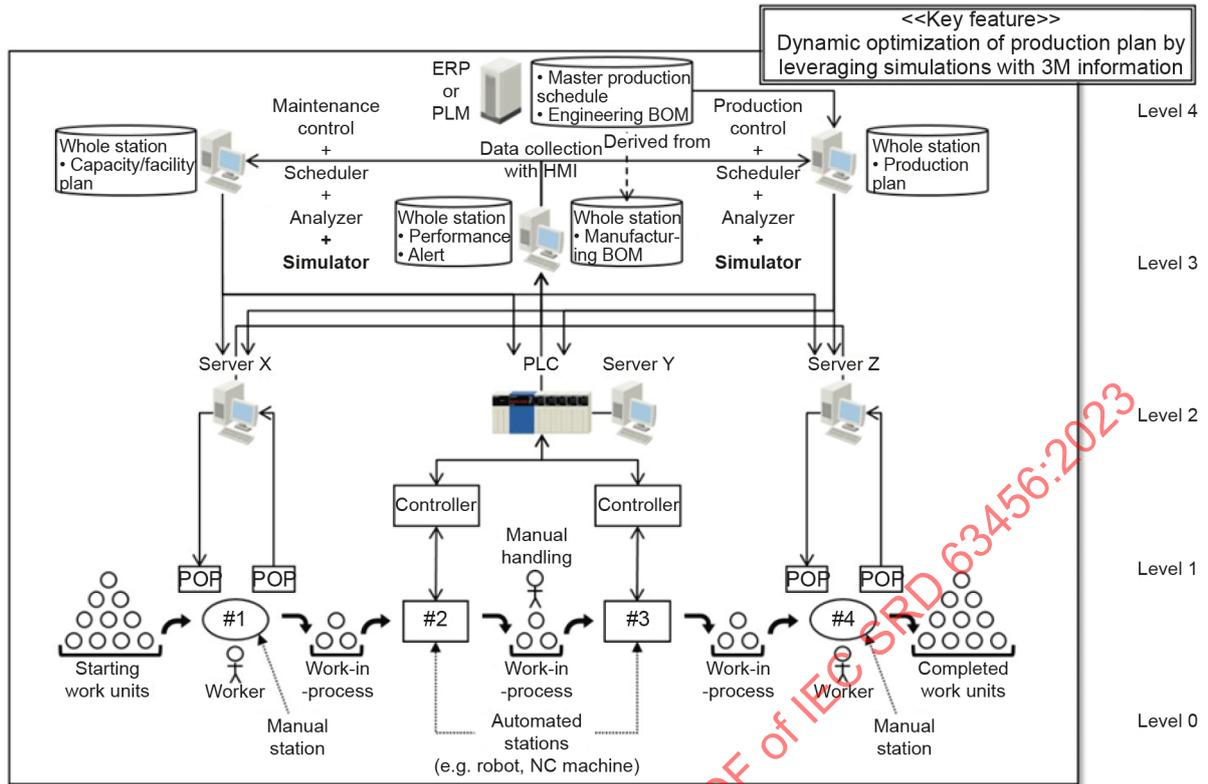
ERP: Entreprise resource planning, MES: Manufacturing execution system, PLC: Programmable logic controller, POP: Point of production

**Figure A.2 – Diagram of Canvas of an example production
system with dynamic optimization**

Figure A.3 shows a drawing of the manufacturing system at Use-case of URM-MM.
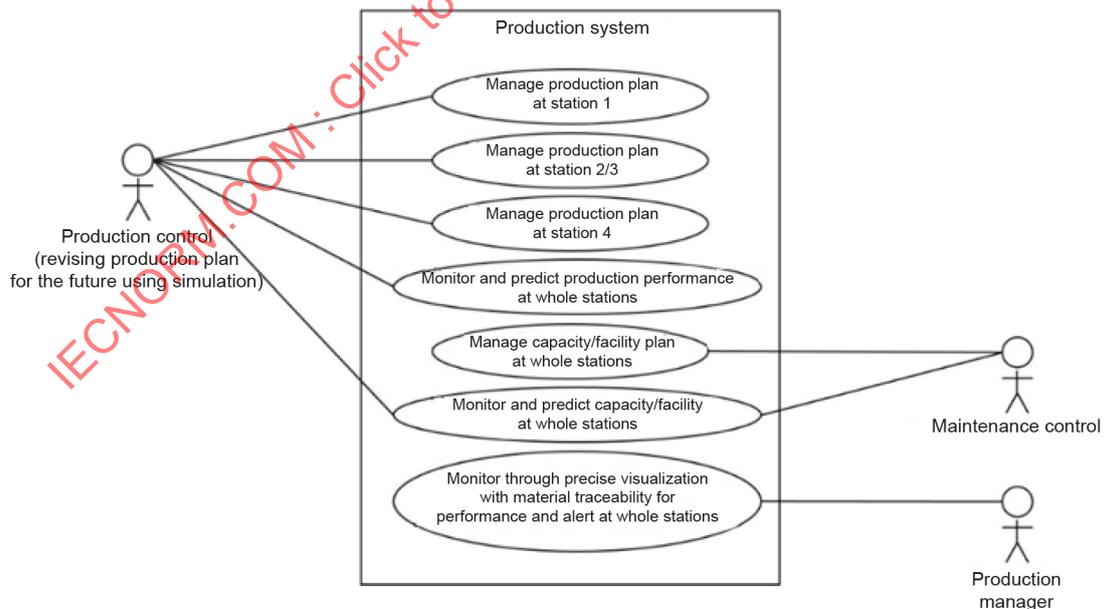
**Figure A.3 – Diagram of Use-case of an example production
system with dynamic optimization**

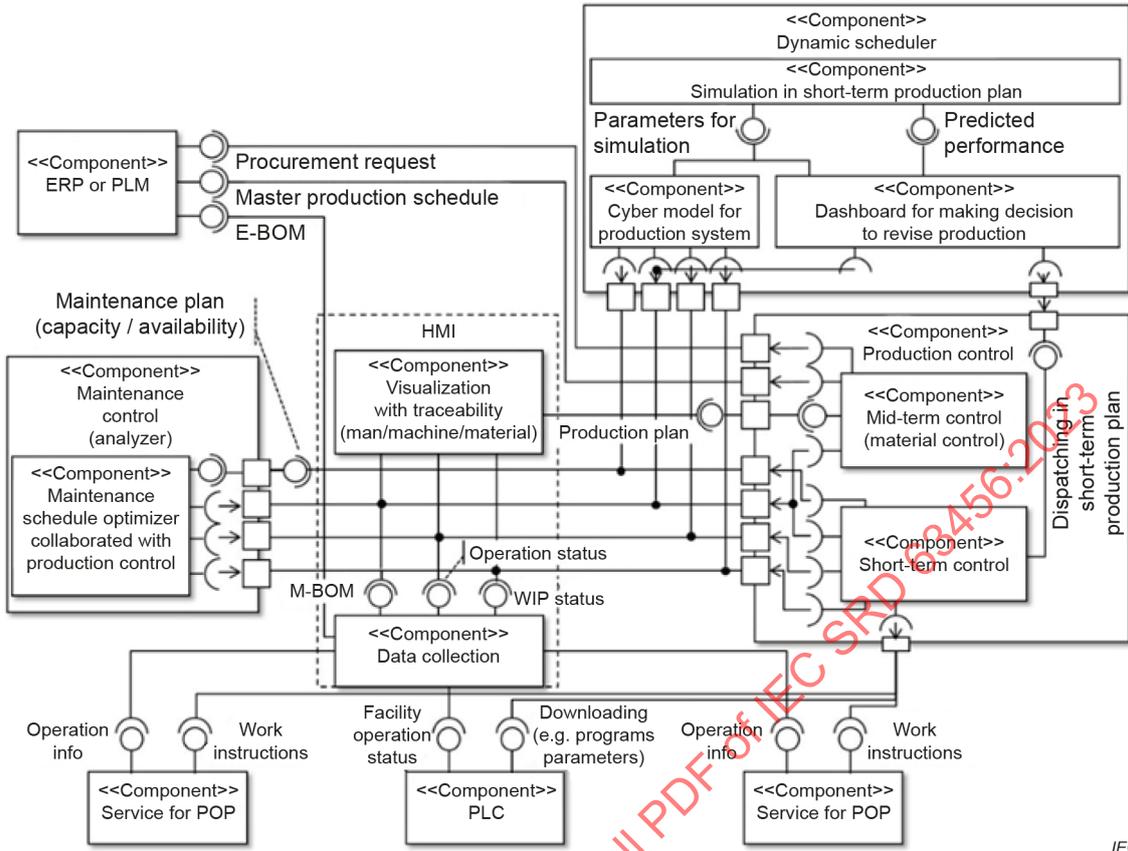Figure A.4 shows a drawing of the manufacturing system at Function of URM-MM.

Figure A.4 – Diagram of Function of an example production system with dynamic optimization

Figure A.5 and Figure A.6 show drawings of the manufacturing system at Data of URM-MM.
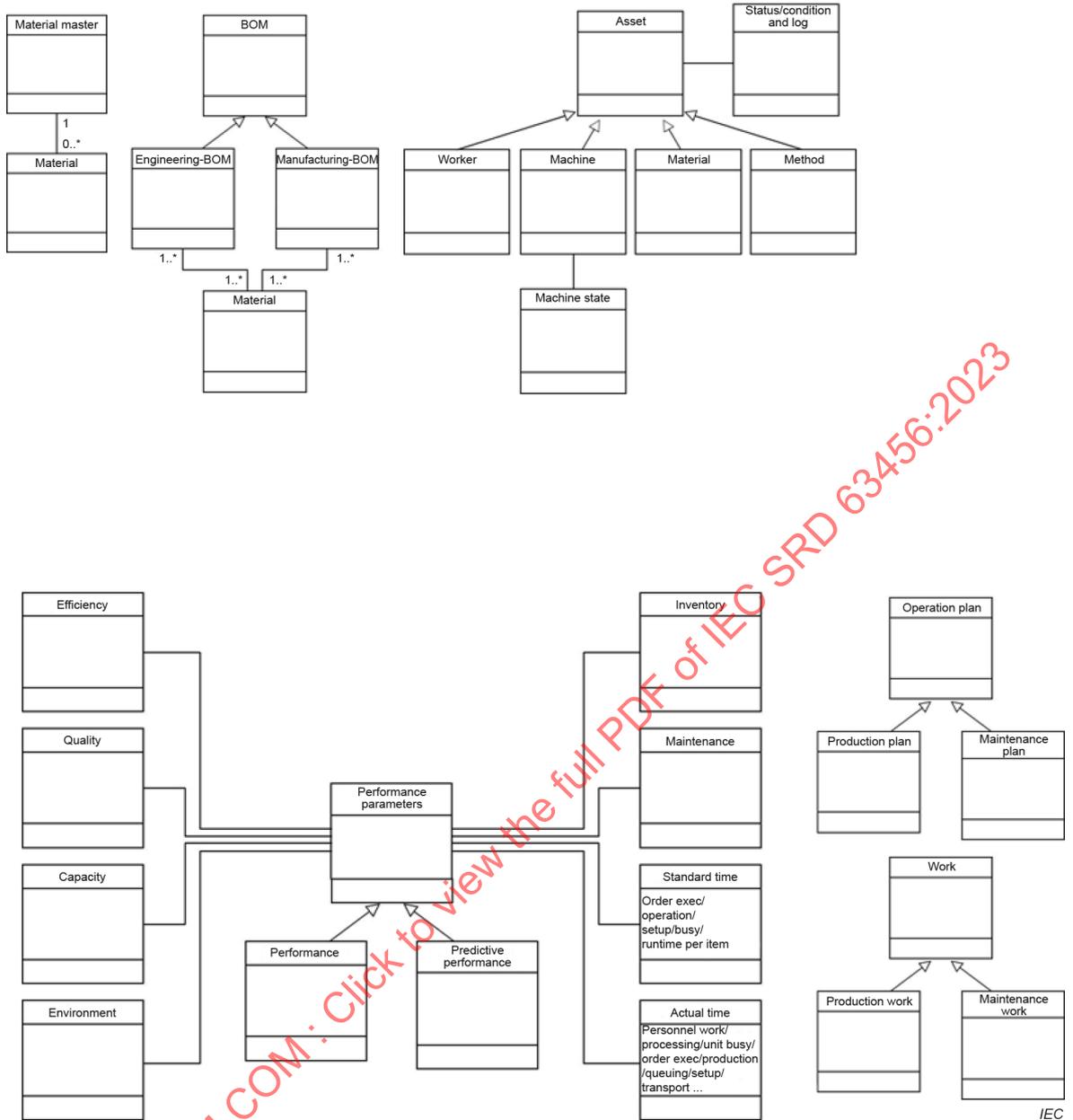
Figure A.5 – Diagram of Data of an example production system with dynamic optimization (first half)
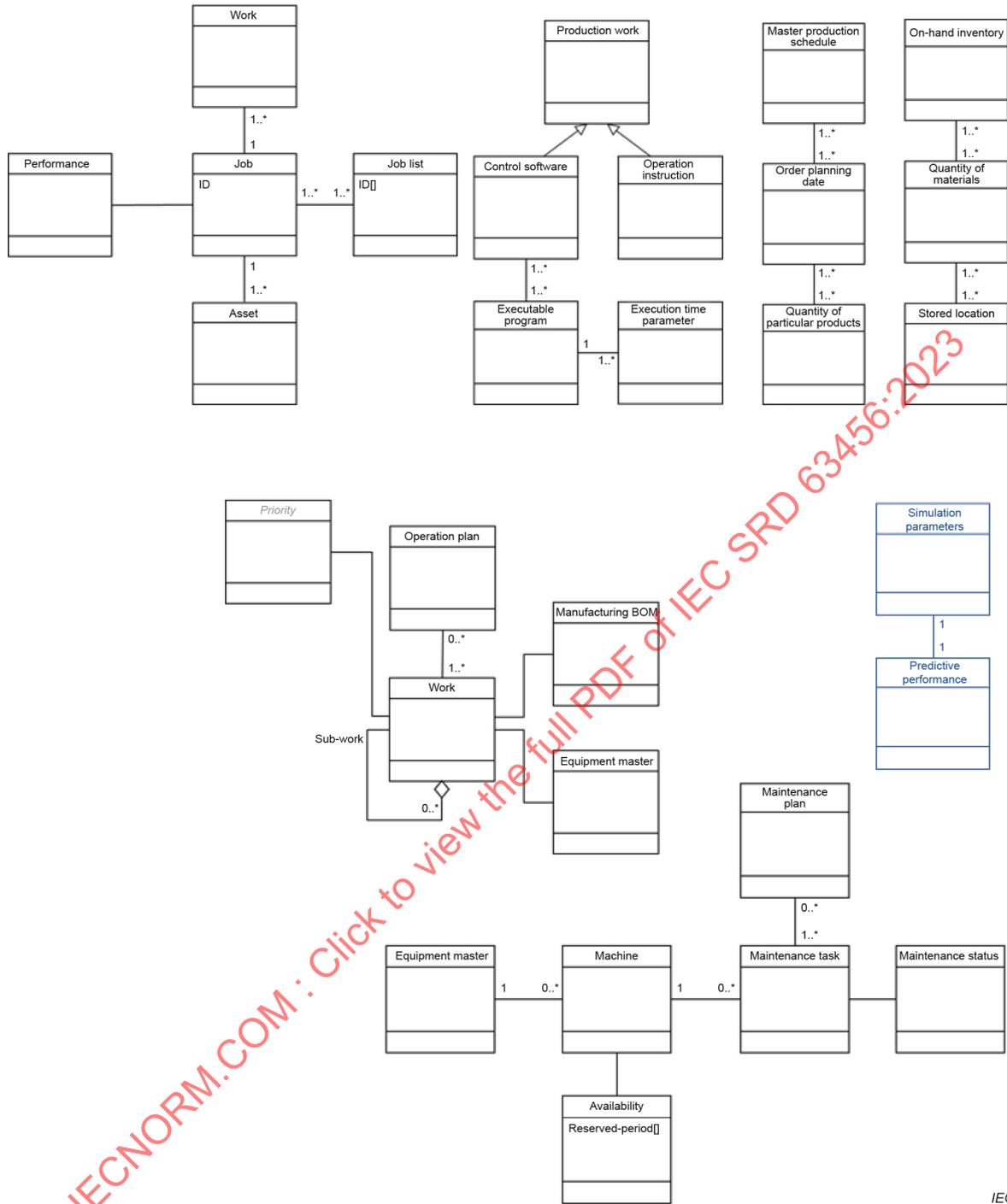
**Figure A.6 – Diagram of Data of an example production
system with dynamic optimization (second half)**

A.5   Illustration of relevant international standards mapping

Clause A.5 shows how URM-MM allows users to identify relevant international standards using drawings as practical examples at individual scales and granularities (i.e. Canvas, Use-case, Function, Data). This usage is presented here using "Canvas" and "Data" drawings as easy understandable examples for importance in terms of interoperability and interchangeability. Figure A.7 shows an example of "Canvas" mapping of relevant international standards and de-facto technologies in the manufacturing industry. "Canvas" mapping allows users to identify relevant standards and technologies, which are applied to interfaces between the physical components of a target system.
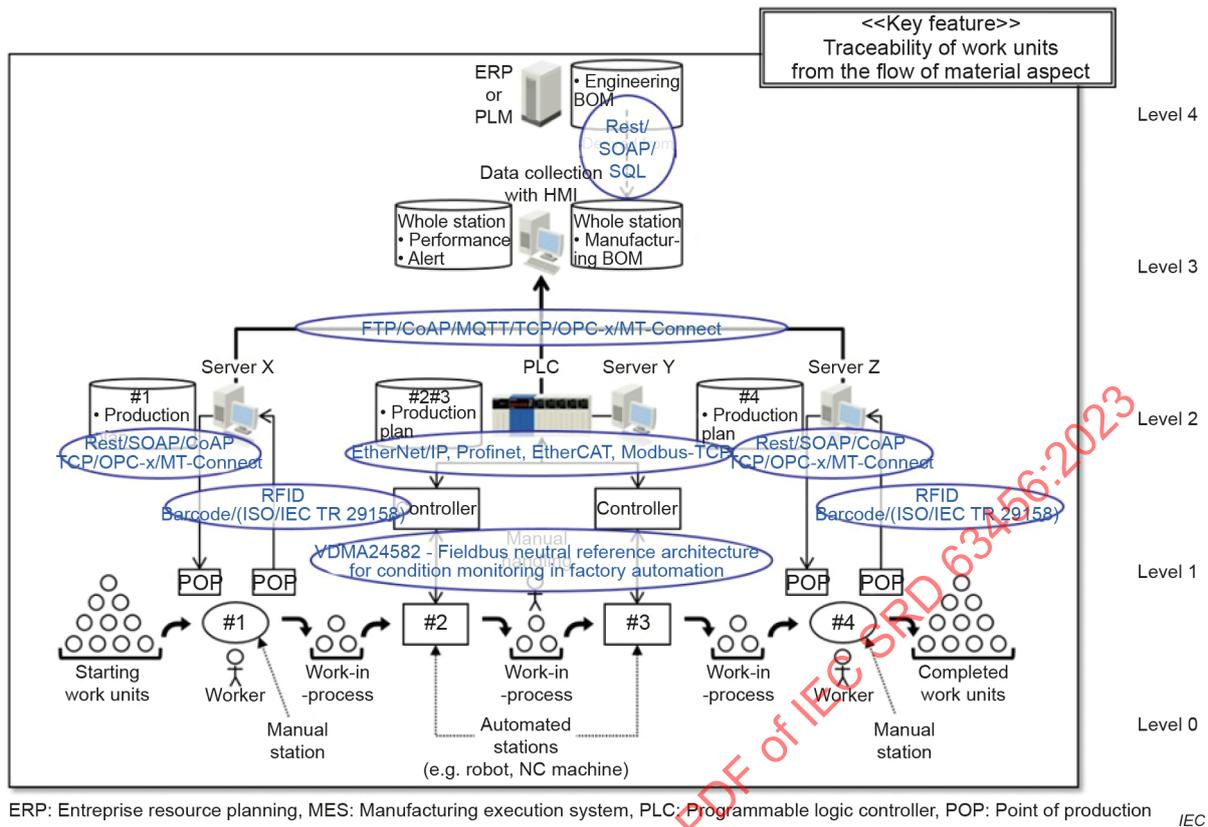
Figure A.7 – Example of "Canvas" mapping of relevant International Standards

Moreover, Figure A.8 also shows an example of "Data" mapping of relevant international standards. "Data" mappings allow users to identify relevant standards, which are applied to interfaces between logical components of a target system.
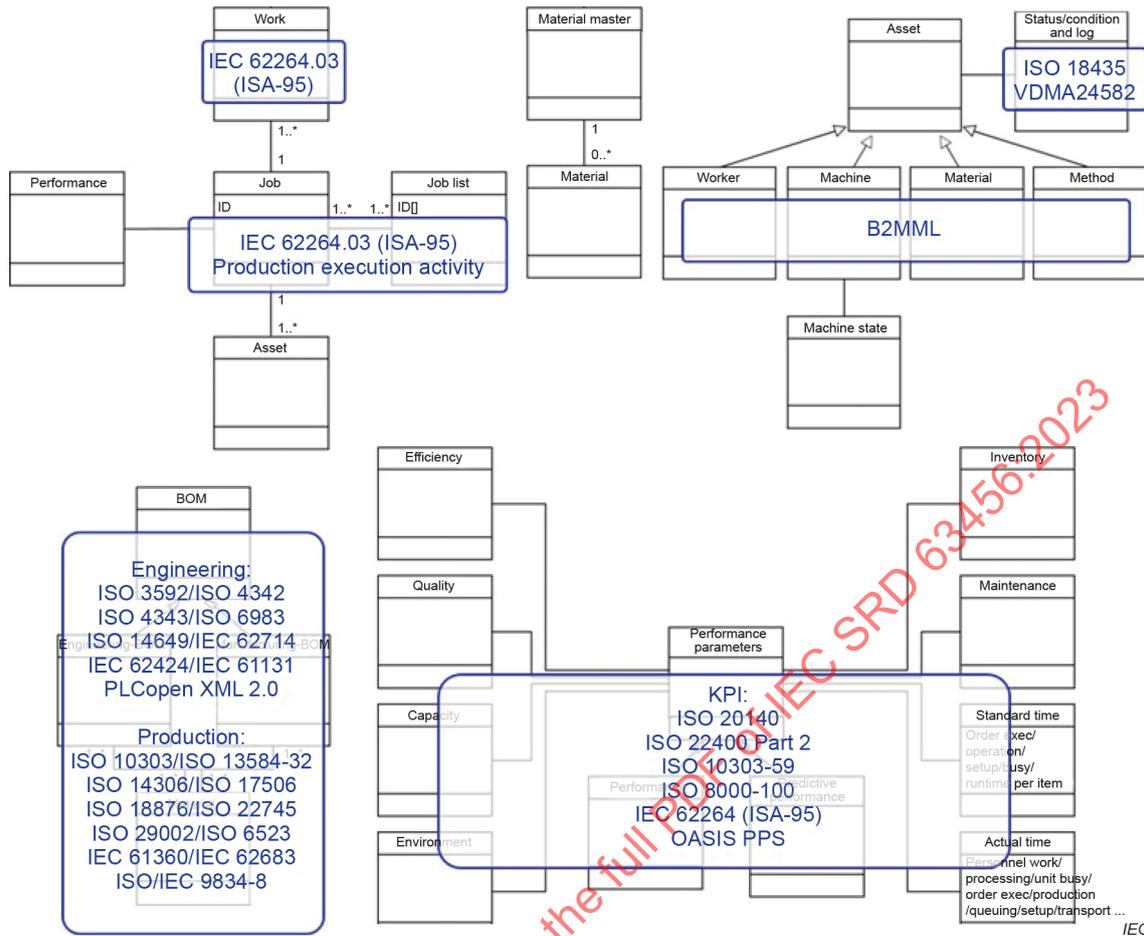
Figure A.8 – Example of "Data" mapping of relevant International Standards

Therefore, these "Canvas" and "Data" mappings are quite important for implementing interoperability and interchangeability in a system. Even though "Use-case" and "Function" mapping examples are not shown here, "Use-case" mappings provide the capability to present relevant information about system-wide issues such as system architectures, security, safety, privacy, and national and international regulations, and "Function" mappings provide the capability to present relevant information about necessary and characterizing features for implementation, such as virtualization software, database, and data processing infrastructures.

URM-MM mappings at all scales and granularities are helpful to build systems as open ecosystems.

Annex B
(informative)

Smart Grid Standards Map

B.1 Overview

1) Background

Provided by IEC Secretariat in order to support information sharing in relation to IEC work with people. It is one of deliverables from IEC SyC Smart Energy and is intended to promote the committee's work for the smart grid. This Annex B reports an overview of this activity according to [1][1].

2) Benefits

Allows identifying the right standards that are needed for any components of the smart grid through an online tool on a web browser.

3) Tool users

- Smart grid practitioners (grid integrators, grid operators)
- Standard developers

4) Tool developer and maintainer

IEC Secretariat developed the Smart Grid Standards Map as an IEC tool and continues its maintenance activities, such as adding new relevant standards regularly.

5) Functionality

The smart grid standards mapping tool defines relationships between components and standards of the smart grid. It provides two approaches to finding the smart grid standard you need.

6) Architecture view

The smart grid architecture view provides a pictorial overview of the grid. It includes clusters that form the generic smart grid landscape. Components of the grid are located in topological communities grouped into systems, or so-called "functional clusters". Figure B.1 shows an appearance of the architecture view of the Smart Grid Standards Map.

_____

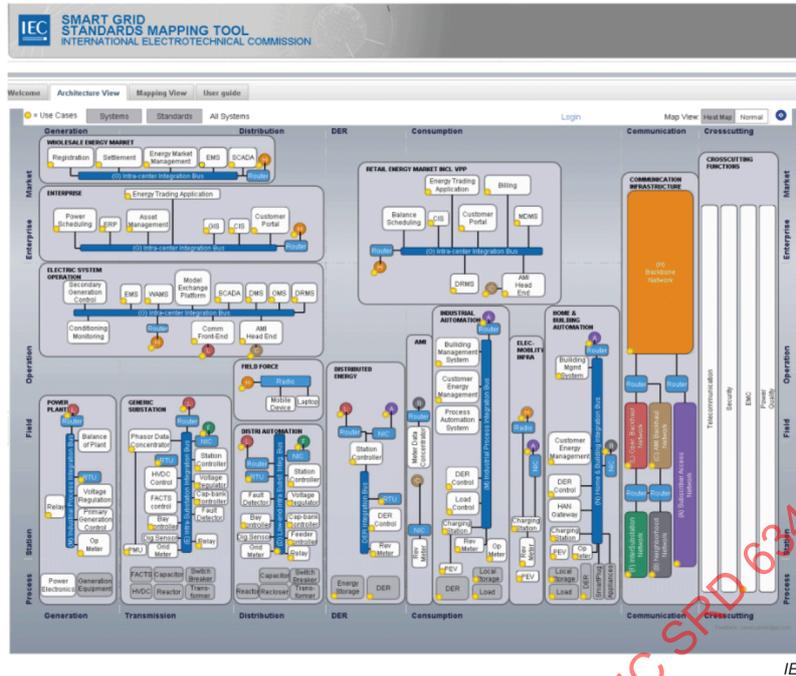1   Numbers in square brackets refer to the Bibliography.

IEC

Figure B.1 – Architecture view of Smart Grid Standards Map

B.2   Usage

Clause B.2 provides a brief introduction to the mapping tool and Smart Grid Standards Map. See https://mapping.iec.ch/#/maps/1.

1) Architecture view

   The smart grid architecture view provides a pictorial overview of the grid. It includes clusters that form the generic smart grid landscape. Components of the grid are located in topological communities grouped into systems, or so-called "functional clusters". Figure B.1 shows an example of the architecture view of the tool.

2) Mouse-over a component inside a cluster to open a new view that provides a list of publication numbers of international standards that apply to that component. Click a publication number to expand the publication number to a detailed list of links to a page of individual international standards of IEC or ISO.

Annex C
(informative)

Examples of maps developed using the Mapping Platform

C.1 Overview

Many maps developed using the Mapping Platform are released including beta versions at the IEC web page (https://mapping.iec.ch/#/maps). Figure C.1 shows a front-page collecting the maps developed using the Mapping Platform.
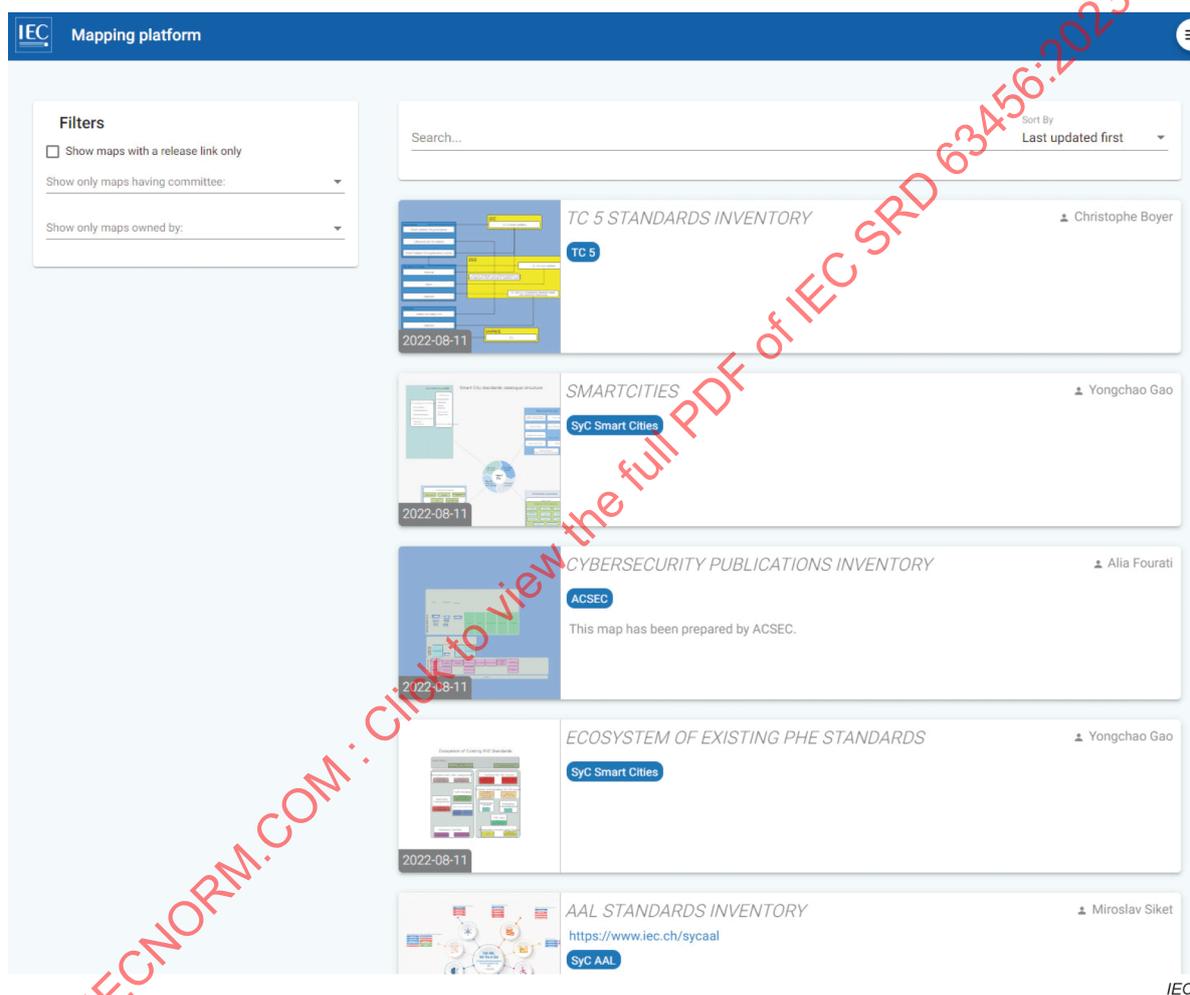

Figure C.1 – Collection of released maps as developed using the Mapping Platform

C.2 IEC 61850

The map (Figure C.2) shows an overview of the IEC 61850 series by presenting not only 67 publications of TC 57 but also many extensions and parts not developed by TC 57.
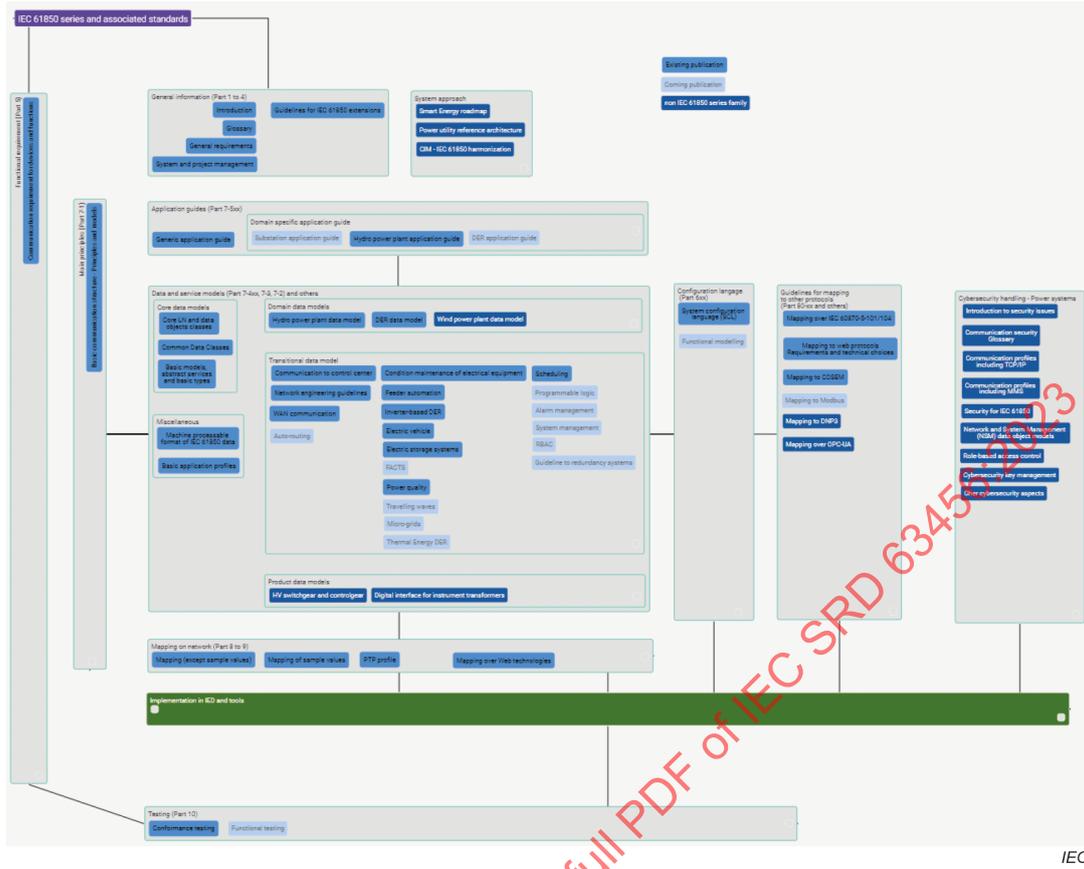
IEC

Figure C.2 – Draft IEC 61850 map

C.3   Cybersecurity publications inventory

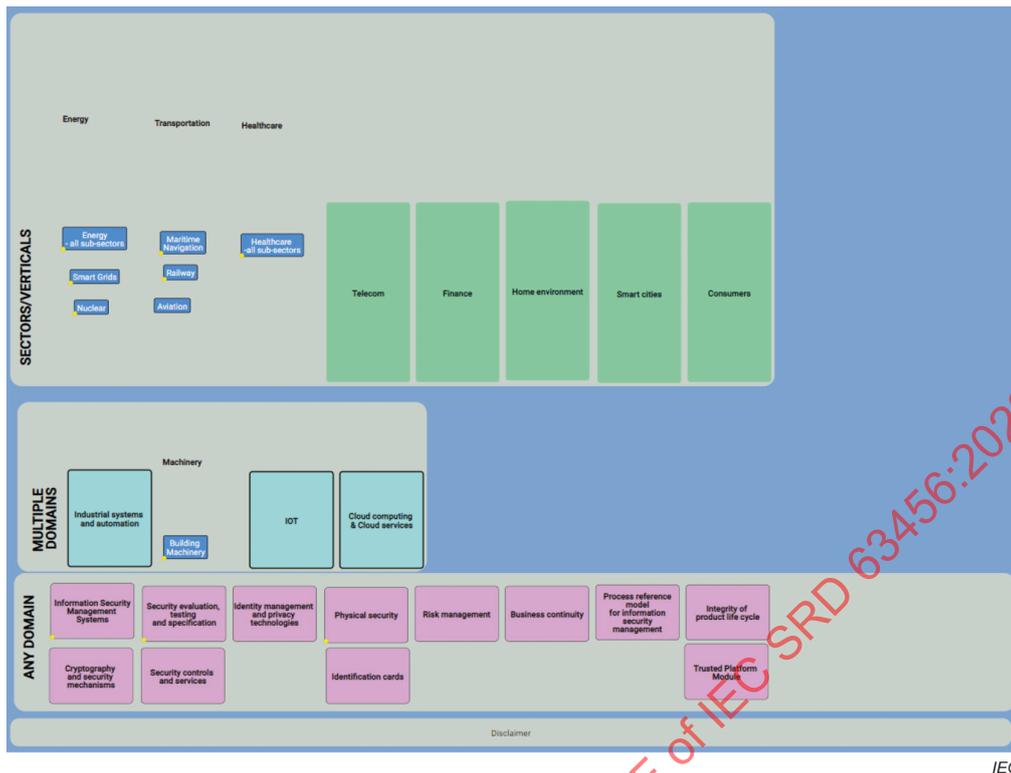The draft ACSEC map (Figure C.3) presents security related IEC publications (300 documents) by domain.

IEC

Figure C.3 – Draft ACSEC map

C.4   TC 5 standards inventory

The map (Figure C.4) shows an overview of standards for steam turbines (e.g. IEC 60045) produced by IEC TC 5.
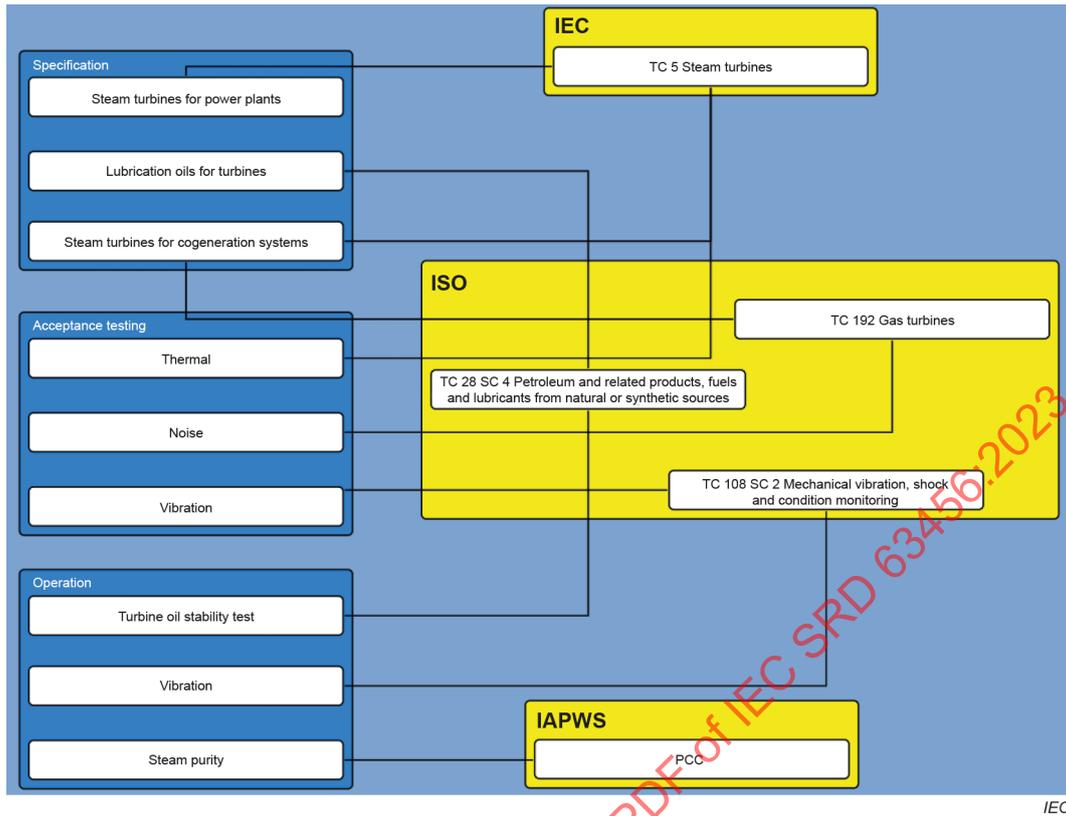
Figure C.4 – Draft TC 5 standards inventory

C.5   Smart grid map

This map (Figure C.5) shows an overview of standards for the smart grid, which provides a Smart Grid Standards Map-like appearance.
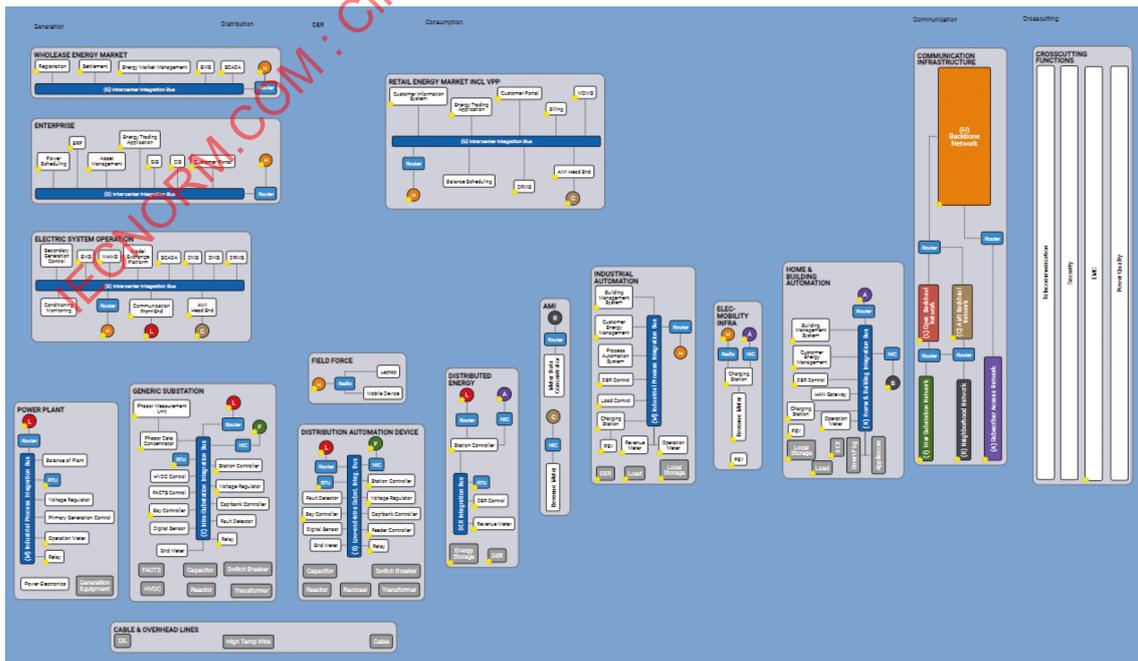

Figure C.5 – Smart grid map

Annex D
(informative)

Example of practical development scheme of IT tool

D.1   General

Clause D.1 introduces two relevant activities which were executed in ahG 76 and ahG 86 under the SMB, respectively, which are related to navigation tools as IT tools, discussed in SyC SM, and explains our analysis of relationships among the navigation tools and such groups. Figure D.1 shows the SMB Ad-Hoc Groups as of 2020-10-21. The depicted ahGs were disbanded after finishing their work.
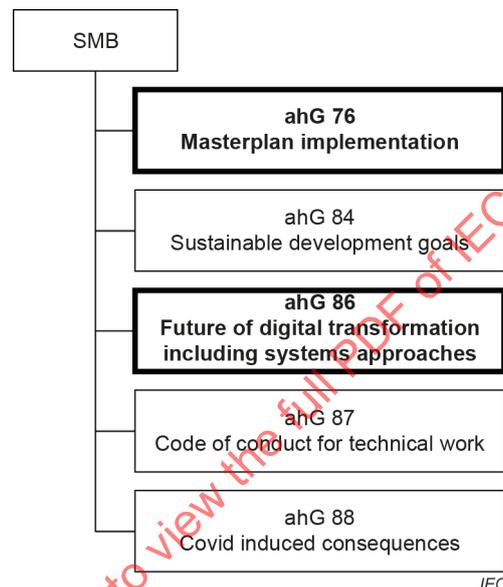

Figure D.1 – The SMB Ad-Hoc Groups (as of 2020-10-21)

Clause D.2 presents an outline of the relevant activities in ahG 86 and Clause D.3 presents an outline of other relevant activities in ahG 76.

D.2   Discussion on digital transformation at IEC

At IEC, a digital transformation plan including IT tools has previously been discussed at the ahG 86. ahG 86 created a final report, SMB/7121/R [2], as its conclusions for reporting to the SMB.

In SMB/7121/R, the following four items were recommended to the SMB:

- Item 1: Approve the revised scope of SG 12 and its substructure.

- Item 2: Exceptionally allow a wide participation in the new SG 12 due to the importance and complexity of the topic.

- Item 3: Disband the Systems Resource Group (SRG).
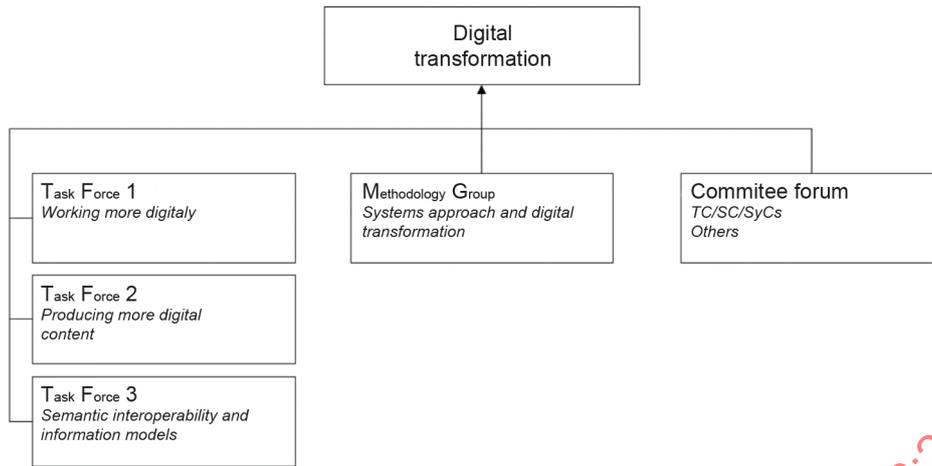
- Item 4: Disband ahG 86.

Figure D.2 – Organization of SG 12 recommended by ahG 86 [2]

In the recommendations, item 1 is most important for considering IT tools, because it defines the structure, organization, and scope of the SG 12 group, which is responsible for leading discussions on digital transformation. Figure D.2 shows the organization of SG 12 recommended by ahG 86.

As shown in Figure D.2, ahG 86 recommends the setting up of three Task Forces (TF1, TF2 and TF3), a Methodology Group, and a Committee Forum. SMB/7121/R [2] gives detailed information about each group of SG 12. According to the final report, SRG activities would be taken over by the Methodology Group. In this sense, the proposed scope of the Methodology Group is as follows.

- Develop a systems approach and digital transformation, as well as the synergies thereof, and apply them to standardization.

- Foster the uptake of a systems approach and digital transformation in all IEC committees.

- Act as an IEC competence centre for a systems approach and digital transformation methodology, architecture, and practice, and provide expertise and advisory services to all IEC committees.

- Develop best practice guidelines.

- Investigate and prioritize necessary IT developments by:

  – championing and coordinating IT tools for broad use in the IEC community; and

  – establishing and participating and/or leading reference groups on specific items.

As presented in items 3 and 4 of the final report, ahG 86 recommends the disbanding of ahG 86 itself and the SRG. Therefore, SyC SM/WG 3 needs to collaborate in terms of the system design of IT tools with the Methodology Group, as SyC SM/WG 3 is focusing on the requirement definitions of navigation tools as IT tools.

D.3 Mapping Platform supporting the development of mapping tools

D.3.1 General

Clause D.3 briefly introduces the Mapping Platform from both a technology and project perspective.

D.3.2   Technology overview

According to SMB/7088/R [3], a mapping tool is an IT tool which makes it easier to identify the involved standards, including terminologies or classifications and standard references. The mapping tool's role model is the Smart Grid Standards Map.

The Mapping Platform as a project was reported in SMB/7088/R [3]. Moreover, the IEC Academy provided a webinar about the Mapping Platform [4].

Here is a summary of the Mapping Platform project.

a) Goals:
   1) To develop and maintain maps of current and foreseen standardization projects and publications in the IEC and other SDOs (including consortia).
b) Objectives of the project:
   1) A generic mapping tool that will be used by technical and advisory bodies to better frame their activities including use cases in a graphical context.
   2) The maps will be used as browse facilities for customers and will also be available for National Committees for their own purposes.
c) Drivers for the project:
   1) An easy and appealing interface to provide information with one click.
   2) The interface shall significantly reduce the time to get the right information.

The Mapping Platform allows developers to create maps as applications similar to the Smart Grid Standards Map, presenting relevant information of international standards for the Smart Grid (Annex B). Through using the Mapping Platform, it will also be possible to design maps as visual representations of multiple objects, showing the relationships within a target domain. It will be possible to embed each object on a map with related information. Moreover, through using a map as an application based on the Mapping Platform, it will be possible for users to obtain a visual representation of relationships, such as:

- key information,
- the grouping of information,
- links between elements, and
- links with lists of the latest publications.

Each map is composed of an object, link, and tab. Figure D.3 shows examples of visual representations of objects.
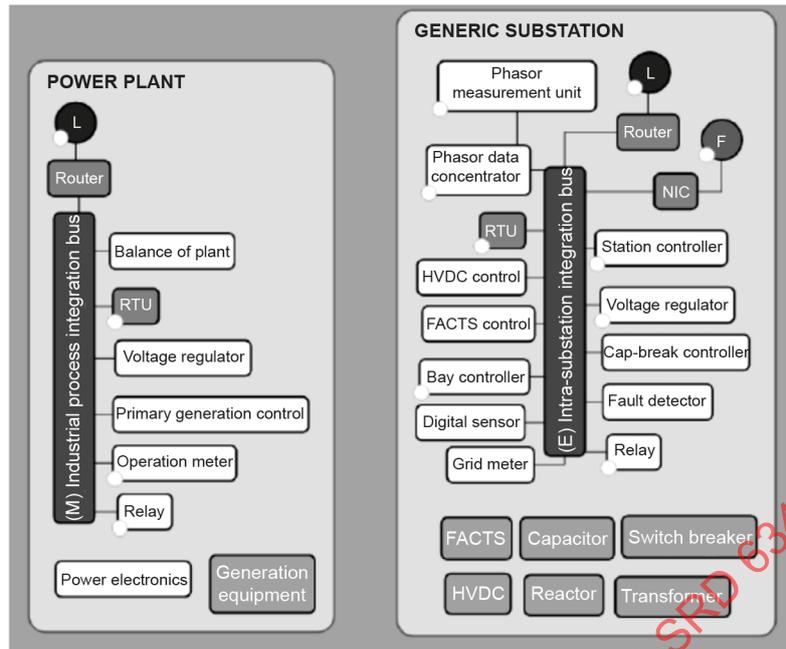

SOURCE: IEC Mapping Platform webinar [4].

Figure D.3 – Examples of visual representations of objects

Figure D.4 shows an example of the use of objects and links in the smart grid. Each link connects between two objects as a representation of the relationship between them.
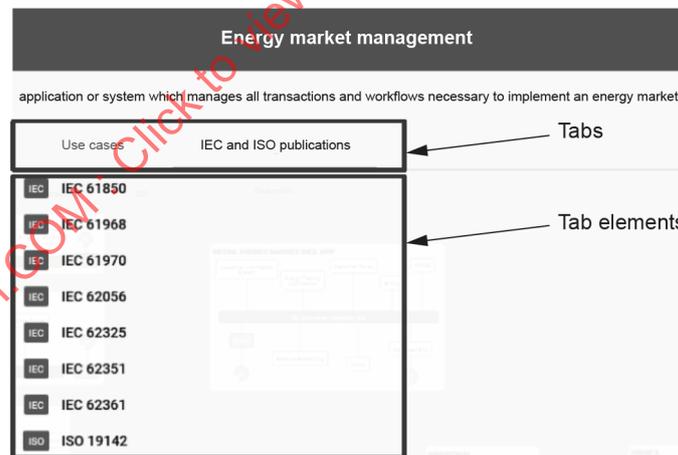
SOURCE: IEC Mapping Platform webinar [4].

Figure D.4 – Example of use of objects and links

Moreover, tabs represent a category of shown information, and elements in a tab present information categorized in the tab. Figure D.5 shows an example of the use of a tab and its elements in the smart grid.

SOURCE: IEC Mapping Platform webinar [4].

Figure D.5 – Example of the use of a tab and its elements

D.3.3   Project overview

As shown in Figure D.6, at IEC, the Council Board (CB) draws up masterplan implementation plans (MPIPs) and assigns each MPIP to the relevant board, such as the Standardization Management Board (SMB), the Conformity Assessment Board (CAB), and the Market Strategy Board (MSB). ahG 76 works to achieve MPIPs assigned to an SMB based on the decision of the CB.