



BSI Standards Publication

Power systems management and associated information exchange — Interoperability in the long term

Part 102: CIM — IEC 61850 harmonization

National foreword

This Published Document is the UK implementation of IEC TS 62361-102:2018.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2018
Published by BSI Standards Limited 2018

ISBN 978 0 580 89477 0

ICS 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2018.

Amendments/corrigenda issued since publication

Date	Text affected

TECHNICAL SPECIFICATION



**Power systems management and associated information exchange –
Interoperability in the long term –
Part 102: CIM – IEC 61850 harmonization**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-8322-5454-7

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	11
3 Terms, definitions and abbreviated terms	11
3.1 Terms and definitions.....	12
3.2 Abbreviated terms.....	12
4 Use case summary	13
4.1 General.....	13
4.2 SCADA/EMS/DMS configuration from IEC 61850 SCL	13
4.3 Importing SCADA/EMS/DMS requirements into IEC 61850 SCL.....	14
4.3.1 General	14
4.3.2 Recommendation for harmonization: SCL Process/Substation/Line section.....	14
4.4 SCADA commissioning use case	14
4.5 Volt Var control use case	15
4.6 Wide Area Monitoring, Protection and Control (WAMPAC) for transient stability	16
5 Mapping SCL to SCADA/EMS/DMS relevant CIM	16
5.1 Business requirements.....	16
5.2 Profiles	17
5.3 IEC 61850 modelling principles	17
5.3.1 Introduction	17
5.3.2 System Configuration description Language (SCL)	17
5.3.3 Logical Devices and Logical Nodes	17
5.3.4 SCL sections	18
5.4 Mapping overview	18
5.4.1 SCL Document Types	18
5.4.2 General mapping principles	19
5.5 SCL Substation section mapping.....	22
5.5.1 Overview	22
5.5.2 SCL elements and CIM classes mapping	26
5.6 Equipment types and codes	29
5.6.1 General	29
5.6.2 Equipment type code mapping.....	29
5.6.3 Recommendation for harmonization: SCL Equipment Type codes.....	31
5.6.4 Recommendation for harmonization: SCL PSRType	33
5.6.5 Recommendation for harmonization: CIM BusbarSection and Junction	34
5.6.6 Recommendation for harmonization: CIM Fan, Motor, Batteries and charging systems.....	34
5.7 Naming and identification mapping	34
5.7.1 General	34
5.7.2 Naming and identification example	35
5.7.3 Recommendation for harmonization: SCL naming and identification	36
5.7.4 Recommendation for harmonization: CIM naming and identification:.....	36
5.8 Voltage mapping.....	36
5.8.1 General	36

5.8.2	Voltage mapping example.....	37
5.8.3	Voltage level additional attributes	37
5.9	Connectivity modelling	37
5.9.1	SCL Connectivity (single line diagram) modelling.....	37
5.9.2	Recommendation for harmonization: SCL unconnected terminals	39
5.9.3	Connectivity and Terminal example	39
5.9.4	Transformation of current transformer models.....	42
5.10	Phase modelling	42
5.10.1	General	42
5.10.2	Phase mapping example.....	44
5.10.3	Recommendation for harmonization: SCL Phase modeling	47
5.10.4	Recommendation for harmonization: CIM SinglePhaseKind	47
6	Extension syntax for drawing layout coordinates.....	47
6.1	General.....	47
6.2	Recommendation for harmonization: Drawing layout syntax	47
7	Logical Node mapping	48
7.1	Logical Node containers.....	48
7.2	CIM Measurement associations	48
7.2.1	General	48
7.2.2	Recommendation for harmonization: CIM SCADA package.....	49
7.3	Logical Node classes relevant to CIM	50
8	Measurement mapping	53
8.1	General.....	53
8.2	CIM Measurement Types – Logical Node and Data Object mapping.....	53
8.2.1	General	53
8.2.2	Recommendation for harmonization: CIM Measurement types	55
8.3	Measurement associations.....	56
8.4	CSWI or XSWI/XCBR as source of switch position information.....	56
8.5	Direction of positive flow	56
8.5.1	General	56
8.5.2	Recommendation for harmonization: SCL power flow direction	57
8.5.3	Recommendation for harmonization: CIM power flow direction.....	57
8.6	CIM Extensions for Distribution – Metering Model and Reading Types	57
9	Real time data exchange mapping	58
9.1	Measurement identification	58
9.2	Common Data Class mapping	58
9.3	Common Data Class mapping to IEC 60870 and CIM Measurements	59
9.4	Common Data Class mapping to IEEE1815 and CIM.....	62
9.5	Data Attribute mapping	62
9.5.1	General	62
9.5.2	Quality flag mapping	63
9.5.3	Non-real time measurement attribute mapping.....	64
9.5.4	Recommendation for harmonization: CIM measurement classes	64
10	Control Model	64
10.1	CIM Control Modelling.....	64
10.1.1	General	64
10.1.2	Recommendation for harmonization: CIM control model	65
10.1.3	Recommendation for harmonization: CIM CONTROL TYPES.....	66

10.2	Automated control sequences	66
11	Protection modelling	66
12	Communication model	68
13	Settings and attributes	68
Annex A (informative)	Use case details	80
A.1	SCADA/EMS/DMS configuration from IEC 61850 SCL – Description	80
A.1.1	Name of use case	80
A.1.2	Scope and objectives of use case	80
A.1.3	Narrative of use case	80
A.1.4	General remarks	82
A.2	Use case diagrams	82
A.3	Technical details	86
A.3.1	Actors: People, systems, applications, databases, the power system, and other stakeholders	86
A.3.2	Preconditions, assumptions, post condition, events	89
A.3.3	References / Issues	89
A.3.4	Further Information on the use case for classification / mapping	90
A.4	Step by step analysis of use case	90
A.4.1	Pre-conditions	90
A.4.2	Steps – Normal	91
A.4.3	Steps – Alternative, error management, and/or maintenance/backup scenario	93
A.5	Information exchanged	94
A.6	Common terms and definitions	94
Annex B (informative)	Use case details	95
B.1	Wide Area Monitoring, Protection and Control system (WAMPAC) for Transient stability	95
B.1.1	Name of Use Case	95
B.1.2	Scope and objectives of use case	96
B.1.3	Narrative of use case	103
B.2	Use case diagrams	105
B.3	Technical details	106
B.3.1	Actors: People, systems, applications, databases, the power system, and other stakeholders	106
B.3.2	Preconditions, assumptions, post condition, event	107
B.3.3	References / issues	107
B.3.4	Further information on the use case for classification / mapping	108
B.4	Step by step analysis of use case	108
B.4.1	Overview of scenarios	108
B.4.2	Steps – Alternative, error management, and/or maintenance/backup scenario	109
B.5	Information exchanged	111
Annex C (informative)	Recommendations	115
C.1	Recommendations for IEC 61850	115
C.2	Recommendations for CIM based standards, particularly IEC 61970-301	116
C.3	Recommendations for joint working groups	117
Bibliography		118

Figure 1 – IEC 61850 and CIM data flows	15
Figure 2 – Mapping for Wide Area Monitoring Protection and Control.....	16
Figure 3 – Equipment mapping	21
Figure 4 – Example of equipment and status measurement mapping	22
Figure 5 – UML class diagram of SCL entities showing inheritance	24
Figure 6 – UML class diagram of SCL entities showing inheritance and containment	25
Figure 7 – UML class diagram of SCL equipment connectivity and phase information	26
Figure 8 – Composite Switch example.	33
Figure 9 – Substation section connectivity example	40
Figure 10 – Three-phase (left) and single-phase control (right)	43
Figure 11 – Unbalanced phase switching example	45
Figure 12 – Current CIM SCADA package.....	49
Figure 13 – Revised SCADA package	50
Figure 14 – Signal identification as defined in IEC 61850-7-2	58
Figure 15 – UML model of MV, DEL and WYE data classes	59
Figure 16 – Current CIM Control Model.....	65
Figure 17 – Proposal for revised CIM Control Model	66
Figure 18 – Present IEC 61970 Protection Model.....	67
Figure A.1 – Activity diagram part 1 – Create and review system specification description	83
Figure A.2 – Activity diagram part 2 – Create and review system configuration description	84
Figure A.3 – Sequence diagram	85
Table 1 – Overview of SCL and CIM counterparts	19
Table 2 – Mapping between SCL data types and CIM classes	27
Table 3 – Equipment type codes	29
Table 4 – Equipment type codes – proposed modified descriptions	32
Table 5 – Equipment type codes – proposed additional codes	33
Table 6 – Name mapping	35
Table 7 – Proposed CIM NameType class naming conventions	36
Table 8 – Base voltage mapping	37
Table 9 – Attributes for terminal.....	38
Table 10 – Attributes for ConnectivityNode	39
Table 11 – Comparison of IEC 61850 and CIM Phase values.....	44
Table 12 – Breaker mapping scenarios	44
Table 13 – Mapping IEC 61850 Logical Nodes to CIM classes	51
Table 14 – IEC 61850 DataObjects vs Current CIM measurement types	54
Table 15 – IEC 61850 DataObjects for non-three phase measurements	55
Table 16 – IEC 61850 DataObjects for CIM control types.....	55
Table 17 – Mapping IEC 61850 Common Data Classes to IEC 60870 information objects and CIM classes	60

Table 18 – Mapping IEEE1815 data point types to CIM classes	62
Table 19 – Mapping IEC 61850 real time data attributes to CIM classes/attributes	63
Table 20 – Mapping IEC 61850 Non-real time data attributes to CIM classes/attributes	64
Table 21 – Mapping SCL Communication elements.....	68
Table 22 – Mapping IEC 61850 settings to CIM attributes	70

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION
EXCHANGE – INTEROPERABILITY IN THE LONG TERM –****Part 102: CIM – IEC 61850 harmonization**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62361-102, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/1706/DTS	57/1948/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62361 series, published under the general title *Power systems management and associated exchange – Interoperability in the long term*, can be found on the IEC website.

In this publication, the following print types are used:

– *Associations: in italic type.*

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IEC focuses primarily on specifying the payload of various functionally oriented messages or file exchanges. This concept includes configuration files like those developed in all IEC power systems management standards. The different smart grid initiatives in the USA, Europe and Asia have all recognized the necessity to establish solid standards for communicating between all the "smart" devices. For interoperability purposes, it has been recognized, at an early stage, that widely shared semantics would be necessary. Unfortunately, the semantic models used by the technical groups have differed from the start due to the different needs for information exchange within substations and information exchange within control centres. This has led to some gaps between the models within different standards, even though they reflected the same power system entities. Various institutions have requested that we narrow the gaps:

- NIST has recommended harmonization as a mechanism to decrease cost of integration in the Smart Grid.
- CEN/CENELEC/ETSI Smart Grid Coordination Group report states: "Harmonized electronic data model and description language are missing" and strongly recommends the study of "Harmonized glossary, semantic & modelling between CIM and IEC 61850".
- ENTSO-E letter states: "There is also a need to perform a harmonization between IEC 61850 and IEC CIM (Common Information Model) Standards [...] There are applications which use both set of standards and significant improvements on interoperability and data exchange between the applications should take place."

A number of studies and reports have already been produced on the subject of Harmonization as listed in the Bibliography.

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE – INTEROPERABILITY IN THE LONG TERM –

Part 102: CIM – IEC 61850 harmonization

1 Scope

This part of IEC 62361, which is a Technical Specification, outlines a technical approach for achieving effective information exchange between power system installations governed by IEC 61850 and business systems integrated with IEC CIM standard data exchanges, based on a selected specific set of use cases, but also with the goal of creating a framework that will extend successfully to other use cases in the future. This document includes proposals to 'harmonize' the two standards by adapting or extending existing information models and/or defining new models, where such changes will enable more effective communication. Both current and future directions of models will be considered. The report will take into account existing standards for semantics, services, protocols, system configuration language, and architecture.

It was intended to be coordinated with IEC 61850 and all affiliated subgroups as well as IEC 61968 and IEC 61970. This edition of the document was prepared based on Edition 2 of IEC 61850-6 (2009), IEC 61850-7-3 and IEC 61850-7-4 and has been updated to match the forthcoming Edition 2.1. Mapping to other parts of IEC 61850 is incomplete. Mapping has been considered for the CIM classes defined in IEC 61970-301. The mapping to CIM classes defined in IEC 61968-11 and other standards is incomplete.

This document suggests a technical approach by which two of the leading standards for software interoperability that serve the electric utility industry (the Common Information Model, CIM, and the IEC 61850 model) can cooperate in order to enable effective data exchanges between the domains covered by these standards. Both of these standards are maintained by the International Electrotechnical Committee (IEC).

A number of studies and reports have already been produced on the subject of harmonization as listed in the Bibliography.

The work leading to this Technical Specification has considered how exchanges required by commonly understood use cases might be mapped between the standard models in order to determine the harmonizing changes suggested for the relevant models. The report references any papers, reports or other documents that provided data for this harmonization.

The approach is to define a transformation of the data governed by IEC 61850 SCL XSD to data governed by CIM UML. The transformations in this document are defined based on the use cases presented in this document. Only SCL data relevant to these use cases is transformed.

The aim is to allow the development of tools that perform automatic transformation from an SCL instance file into a CIM based instance model that can then be exported using existing standards such as IEC 61970-552: CIMXML Model exchange format.

These transformations will result in CIM-side processes that can distribute the information as needed for configuration of specific CIM applications. It is also presumed that the result of this exchange will be to enable creation of real-time CIM-side clients for IEC 61850 system data.

The heart of the SCL to CIM transformation specification defined in this document is a mapping between the two information models. Wherever this mapping has been judged to be unnecessarily complex, changes have been recommended to the existing information models.

A major objective, however, has been to define a solution that does not change either SCL or CIM UML without a mechanism to supply backward compatibility.

The transformation specification is only for structural modelling. IEC 61970-301 states “CIM entities have no behaviour.” IEC 61850-5 states “the behaviour of the functions itself are ... outside the scope of this standard”.

This document is a Technical Specification – not a standard. Paragraphs introduced by the word Recommendation are recommendations for revisions to some of the IEC 61850 and CIM standards. It is anticipated that if these recommendations are accepted, then this report can be revised and elevated to a standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-6:2009, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-3, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-4, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC TS 61850-80-1:2009, *Communication networks and systems for power utility automation – Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104*

IEC 61968-11, *Application integration at electric utilities – System interfaces for distribution management – Part 11: Common information model (CIM) extensions for distribution*

IEC TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*

IEC 61970-301:2013, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

IEC 61970-452:2015, *Energy management system application program interface (EMS-API) – Part 452: CIM static transmission network model profiles*

IEC 81346-1, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC TS 61850-2, IEC 61850-6 and IEC TS 61970-2 and the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

NOTE The following terms and definitions are critical to the understanding of this document and are repeated here for convenience.

3.1 Terms and definitions

3.1.1

Common Information Model

CIM

abstract model that represents all the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility, which includes public classes and attributes for these objects, as well as the relationships between them

Note 1 to entry: The objects represented in the CIM are abstract in nature and may be used in a wide variety of applications. The use of the CIM goes far beyond its application in an EMS. This document should be understood as a tool to enable integration in any domain where a common power system model is needed to facilitate interoperability and plug compatibility between applications and systems independent of any particular implementation.

Note 2 to entry: IEC 61970-301 defines the CIM Base set of packages which provide a logical view of the functional aspects of an Energy Management System including SCADA. Other functional areas are standardized in separate IEC documents that augment and reference this base CIM standard. For example, IEC 61968-11 addresses distribution models and references this base CIM standard. While there are multiple IEC standards dealing with different parts of the CIM, there is a single, unified information model comprising the CIM behind all these individual standards documents.

[SOURCE: IEC 61970-301:2016, Introduction]

3.1.2

System Configuration description Language

SCL

file format for describing communication-related IED (Intelligent Electronic Device) configurations and IED parameters, communication system configurations, switch yard (function) structures, and the relations between them, the main purpose of which is to exchange IED capability descriptions and SA system descriptions between IED engineering tools and the system engineering tools of different manufacturers in a compatible way

3.2 Abbreviated terms

In general, the abbreviations defined in IEC TS 61850-2 or IEC TS 61970-2 apply. The following abbreviations are particularly useful for understanding this document and are repeated here for convenience:

CDC	Common Data Class [IEC 61850]
CIM	Common Information Model
DA	Data Attribute [IEC 61850]
DMS	Distribution Management System
DO	Data Object [IEC 61850]
EMS	Energy Management System
ICD	IED Capability Description [IEC 61850]
IID	Instantiated IED Description [IEC 61850]
IED	Intelligent Electronic Device [IEC 61850]
LD	Logical Device [IEC 61850]
LN	Logical Node [IEC 61850]

SCADA	Supervisory Control and Data Acquisition
SCD	System Configuration Description [IEC 61850]
SCL	System Configuration description Language [IEC 61850]
SCT	System Configuration Tool
SED	System Exchange Description [IEC 61850]
SSD	System Specification Description [IEC 61850]
UUID	Universally Unique Identifier

4 Use case summary

4.1 General

A number of use case titles were proposed. As the subject is complex, it was decided to concentrate on the use case SCADA/EMS/DMS configuration from IEC 61850 SCL. This is based on the top-down approach to substation automation design described in IEC 61850-4 and IEC 61850-6.

It is expected that the mapping rules determined by mapping from IEC 61850 to CIM will be a good base for developing mappings for other use cases that take information from CIM to IEC 61850.

The following use cases have been considered. For further details, see Annex A, Use case details.

4.2 SCADA/EMS/DMS configuration from IEC 61850 SCL

NOTE This use case is written using the example of a transmission substation automation system, but the general steps are applicable to any power system related local automation system.

- The use case starts with requirements specification determined by a planning department e.g. following a request for a new connection or a review of assets or load growth. In this use case the requirements are expected to be defined in paper form, not in a CIM electronic format. [Managing requirements in electronic format is another use case]

The next few steps of the use case use the top-down engineering process described in more detail in IEC 61850-4 and IEC 61850-6. IEC 61850-6 refers to a number of different types of software tool for creating and editing different types of SCL file. In this document the term System Configuration Tool (SCT) is used as a generic term for multi-function software tools that are capable of system specification and system configuration.

- The System Configuration Tool (SCT) is used by a System Engineer to model any SCL defined installation, for example an electrical substation. The process starts by creating a formal specification of the system requirements. The engineer inputs information on primary equipment types, names and connectivity, typically based on the station's single line diagram. The required monitoring, protection, local automation and other functions may be described as template Logical Nodes that are allocated to the equipment or container instances.
- This formal model can be exported from the System Configuration Tool as a System Specification Description (SSD) file.
- This SSD file can then be transformed and/or imported into a CIM based modelling tool for review. If necessary, comments may be provided on paper or verbally for the System Engineer to update the model in the SCT. The review cycle may be repeated several times.
- In the next phase of the design process, the System Configuration Tool is used to import descriptions of the capabilities of specific Intelligent Electronic Devices (IEDs). The System Engineer extends the automation system model by redefining the required Logical

Nodes with specific instances of Logical Nodes with specific types of IEDs. The final phase of the automation system design is to define the communication configuration.

- At any stage during this process, the automation system model can be exported as a System Configuration Description (SCD) file.
- IEC 61850-6 describes how this SCD file is used as an input to IED tools in order to provide the IED specific configuration including the configuration of the communication between IEDs.

This use case describes additional steps

- The same SCD file is also used as an input for a CIM based modelling tool. If necessary, the model may be updated in the SCT and the review cycle repeated.
- CIM information which is required for EMS or DMS applications, but which is not present or derived from information in the SCD file, is added within a CIM based modelling tool.
- The output of the CIM model tool is an incremental update that can be applied to SCADA/EMS/DMS control centre systems.

NOTE The mapping is independent of whether the SCL describes a proxy view of the data as presented by a gateway device, or the more detailed view of the physical IEDs.

IEC TR 61850-90-2 states "... a logical node that appears in the data model of the Proxy/Gateway includes all mandatory data and those optional data of the respective logical node of the IED, which are used by the control centre." It should be noted that some of the data items defined as mandatory by IEC 61850 are not relevant for control centre communications.

4.3 Importing SCADA/EMS/DMS requirements into IEC 61850 SCL

4.3.1 General

Requirements may be expressed in a CIM based electronic format. The translation into a human readable format or automatic translations into a format that can be imported into the IEC 61850 System Configuration Tool are considered as a separate use case to that of translating SCL to CIM.

The CIM based electronic format would be used to define that part of the SCL "Substation / Line / Process: [that] describes the primary process related functions and devices, electrical connections on single line level (topology), and the designation of equipment and functions."

The information of the Substation/Line/Process section is usually not used within IEDs. It is usually used only within system configuration tools.

4.3.2 Recommendation for harmonization: SCL Process/Substation/Line section

Recommendation R1: In the medium to long term, investigate the mapping for the transformation of CIM models into SCL. It may be possible to generate the SCL Process/Line/Substation section with an XML schema directly generated from an appropriate CIM profile or profiles. It may be necessary to consider extensions to the CIM in order to model additional types of assets, functions and equipment, and/or IEC 61850 model features such as Logical Nodes.

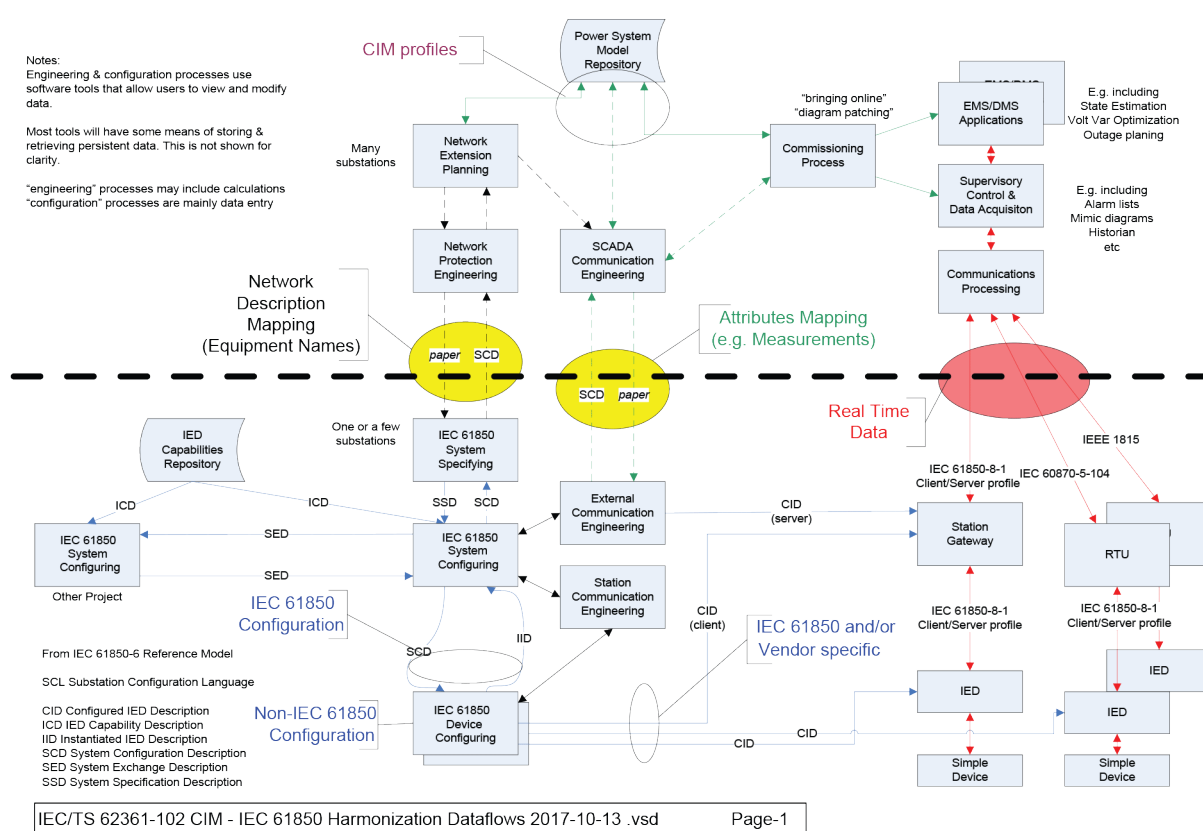
4.4 SCADA commissioning use case

The final step of the SCADA/EMS/DMS commissioning use case is "Perform Test and Validation to turn on SCADA and receive IEC 61850 data, and execute commands". This can also be considered as part of the SCADA Commissioning Use Case. The CIM update information will be incorporated into the online SCADA and the new measurements and controls commissioned. Bi-directional real time end-to-end data transfer between IEDs and the control centre can then take place.

Commissioning requires that the configuration of the communication links in the control centre is consistent with the configuration of the communication links with the IEDs in the field. The communication with the IEDs may be direct or via proxy or gateway devices. The communication messages may use IEC 61850 client-server services for all communication or they may use other standard or proprietary communication protocols for some of the communication links.

Typical engineering data exchanges used in the configuration and commissioning use cases are shown in Figure 1. The upper half of the diagram shows the CIM based control centre processes and the lower half of the diagram shows the IEC 61850 based processes.

The left side of the diagram shows the engineering data exchanges required for engineering design and configuration. The right side of the diagram shows the real-time data communication that can take place after all the systems have been correctly configured.



IEC

Figure 1 – IEC 61850 and CIM data flows

Substation to control centre communication via IEC 61850-8-1 is expected to use the guidelines from IEC TR 61850-90-2. Communication via IEC 60870-5-104 is expected to use the mapping guidelines defined in IEC TS 61850-80-1.

4.5 Volt Var control use case

This use case builds on the configuration and real time data use cases. Coordinated volt var control requires that the control centre has a consistent view of not only the network equipment and its measurements as described in the configuration use case, but also appropriate information about the equipment parameters, the remote control capabilities and settings used by local automation. This use case was considered relevant but was not examined in detail due to time constraints. The particular issues for volt-var control including the modelling of distributed energy resources (DER) will be addressed in detail in a future document.

For an example, see Tanaka, T; Tsuchiya, T; Katayama, S; Serizawa, Y; Fujikawa, F; Otani, T, "Basic Concept and Verification of Distributed Real-time Computer Network Architecture for Power systems", CIGRE 2004, D2-105, 29 August-3 September 2004.

4.6 Wide Area Monitoring, Protection and Control (WAMPAC) for transient stability

This is a particular example of using a model of the power system network with specific status and analog measurements as shown in Figure 2. Details of the use case are given in Annex B.

To maintain the transient stability, a high-speed control architecture is required. Hierarchical WAMPAC can be utilized as a last-resort control system, which executes the minimum required control action defined by CE in order to minimize the impact to power grid and to maintain the transient stability.

In addition, power grid operators are required to mitigate possible severe consequences by taking minimum required control actions every time when they face severe operating conditions. As a mitigation measure, hierarchical WAMPAC can provide the preventive control or enhancement control by shifting an operating point.

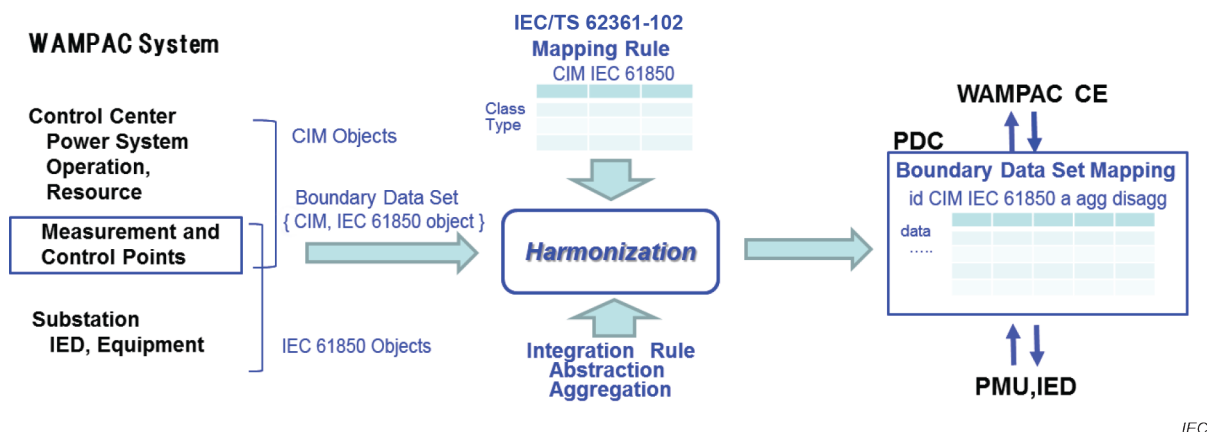


Figure 2 – Mapping for Wide Area Monitoring Protection and Control

NOTE CE: Central Equipment, PDC: Phasor Data Concentrator, PMU: Phase Measurement Unit, IED: Intelligent Electric Device.

5 Mapping SCL to SCADA/EMS/DMS relevant CIM

5.1 Business requirements

The use case gives the context for some high level business requirements for transformation and mapping. There are two main variants, create a new CIM model, or update an existing CIM model.

- Importing and transforming an SSD or SCD file with minimal, partial or full logical node details into a CIM based SCADA/EMS/DMS modelling tool (see Appendix A for more on modelling tools) to create a new CIM model for review and/or subsequent processing.
- Importing and transforming an SSD or SCD file with partial or full logical node details into a CIM based modelling tool to create, delete or update the relevant instances and associations within an existing CIM model.

A CIM based modelling tool should allow CIM information not modelled in the SSD or SCD file to be added to an imported and transformed model. As far as practical, the tool should preserve this additional information during any updates.

5.2 Profiles

This Technical Specification provides a general mapping but does not define whether data elements are mandatory or optional. It is expected that subsets of the mappings, including definitions of mandatory data, may be specified in the form of profiles that apply either to the SCL or the CIM models.

5.3 IEC 61850 modelling principles

5.3.1 Introduction

The initial scope of the IEC 61850 series was communication in substation automation systems. This included the definition of communication services, data models and a configuration description language. The initial application use cases were concerned with protection, control and monitoring. From 2009 and onwards the IEC 61850 series has been updated and extended for other domains. Edition 2 also redefined the models for statistical and historical data handling.

The concepts defined in IEC 61850 have been applied beyond the substation domain including modelling automation systems for hydropower plants, distributed energy resources, and wind turbines. Work is in progress for other applications such as distribution feeder automation.

Subclauses 5.3.2 to 5.3.4 are a summary of the key features of the IEC 61850 System Configuration description Language.

5.3.2 System Configuration description Language (SCL)

IEC 61850-6 specifies a file format for describing communication and parameters related to IED (Intelligent Electronic Device) configurations, communication system configurations, switchyard (function) structures, and the relations between them. The main purpose of the format is to exchange IED capability descriptions, and system level descriptions between engineering tools of different manufacturers in a compatible way.

The file format language is called System Configuration description Language (SCL).

It provides a way of describing the following:

- Primary system equipment and connectivity (single line) description,
- Communication connection description,
- Intelligent Electronic Device (IED) capabilities,
- Allocation of logical nodes within physical IEDs to the corresponding primary equipment or container.

5.3.3 Logical Devices and Logical Nodes

IEC 61850 is concerned with automation systems that consist of one or more Intelligent Electronic Devices (IEDs) connected by a communication system. Typically, IEDs are communication servers. The IED model is also used for clients, routers or clock sources.

The principle use case for this document is concerned only with IEDs that are servers providing data that may be of interest in the control centre. The following summary is an overview of the data models for these types of IED.

- An Intelligent Electronic Device is a physical device
- Each IED/physical device contains one or more instances of Logical Devices (LD)
- Each Logical Device contains at least one instance of a Logical Node (LN)

- Each Logical Node is a standardised set of related Data Objects (DO)
- Data Objects have standard types called Common Data Classes (CDC)
- Common Data Classes define a set of Data Attributes (DA)
- Data attributes can be
 - Status information (digital values)
 - Substituted values
 - Measurands (analogue values)
 - Operation or control requests
 - Settings
 - Description
 - Configuration
 - Name space definitions

Some of the IEC 61850 data attributes correspond to traditional SCADA digital, analogue and counter objects. Controls are modelled as services that can be applied to relevant Data Objects.

Compared to the data point lists of traditional SCADA protocols, IEC 61850 allows systems to be designed and configured using fewer but more complex objects.

5.3.4 SCL sections

The SCL as defined in IEC 61850-6 has a number of sections:

- a) **Substation / Line / Process Section:** describes the primary process related functions and devices like a switch yard in the functional view according to IEC 81346-1, electrical connections on single line level (topology), and the designation of equipment and functions
- b) **IED Section:** describes the capabilities or configuration of each IED in terms of communications and logical nodes. It may also define the default or configured values for individual data objects.
- c) **Communications Section:** contains communication-related object types such as subnetworks and communication access points, and describes the communication connections between IEDs as a base for communication paths between logical nodes as clients and servers.
- d) **Data Type Templates section:** defines instantiable logical node types. A logical node type is an instantiable template of the data of a logical node. A LN type is referenced each time that this type is or shall be instantiated within an IED. A logical node type template is built from data objects (DO) elements, which have a DO type. DOTypes consist of attributes (DA) or other defined DO types. The data attributes (DA) can either have a basic type, be an enumeration, or a structure of a DAType built from basic types or other defined DA types.

In the SCL context the term “logical node container” means the primary equipment or substation/line/process that is *associated* with zero or more logical nodes.

Technically, the Logical Nodes are software entities contained within physical IEDs.

5.4 Mapping overview

5.4.1 SCL Document Types

Different subsets of the SCL language are used at different stages of the design, installation and commissioning processes. Mapping to the CIM is concerned with the following document types:

- **System Specification Description (SSD).** This describes the primary equipment, single line diagram and functions of the substation, plus the required logical nodes. It must contain a substation description section and may contain the needed data type templates and logical node type definitions.
- **System Configuration Description (SCD).** This file contains the substation description section; the IED description section including the data flows and Data Type Templates; plus, a section to describe the local communication configuration.

5.4.2 General mapping principles

Table 1 shows an overview of the main categories of data within SSD or SCD documents, together with their main CIM counterparts. The details are considerably more complex and are described in Subclauses 5.4 to 5.9.

Table 1 – Overview of SCL and CIM counterparts

SCL Section	SCL Description	CIM
Header	SCL schema version and document revision history	No equivalent
Substation / Line / Process	Equipment, SubEquipment Function, SubFunction = primary process related functions and devices	Substation, Plant, Lines or other location containers Voltage Level Bay PowerSystemResources
Substation / Line / Process	Terminals, ConnectivityNodes = electrical connections on single line level (topology)	Terminals, Connectivity Nodes & associations
Diagram coordinates (optional – see note below)	coordinates to draw a single-line diagram corresponding to the electrical connectivity	Diagram layout
IED Instances	Containers for Logical Devices and Logical Nodes.	Remote Unit or EndDevice
IED instances containing specific types of Logical Nodes, Data Objects, Data Attributes	Analogue Measurands, Status and Controllable objects	CIM measurements (analogs, discretes, accumulators) & controls (commands, setpoints)
IED instances containing specific types of Logical Nodes, Data Objects, Data Attributes	Settings and Parameters	CIM object attributes or associations
Communication	Description of the communication configuration	CommunicationLink or classes from IEC 61968-11

Each of these data categories requires a set of mapping and/or transformations.

SCL files include a header section which can be used to define the revision history or version management information of the contents. At present the core IEC 61970-301 model does not define any specific model for version management. A generic method for modelling proposed or implemented changes for any CIM based application is currently under discussion.

The Substation / Line / Process section describes the primary system equipment and therefore has considerable overlap with the CIM. This section may also describe the one-line connectivity. Whilst both models have classes for Terminals and Connectivity Nodes, the treatment of phase information in the SCL and CIM models is different.

IEC 61850 defines an informative i.e. optional extension format to allow diagram coordinates and symbol orientation to be defined for the primary equipment and/or for the communications system. However, it is not as rich as the CIM diagram layout model; for instance, it does not define how to define symbol scaling.

All equipment and equipment containers defined in the Substation / Line / Process section can have associated Logical Nodes. Within a SSD document, these Logical Nodes are template types. Within a SCD document, the Logical Nodes are specific instances within specific IEDs.

IEC 61850-7-4 defines a set of Data Objects for each type of Logical Node. IEC 61850-7-3 defines standard Data Attributes for Data Objects. Many of these Data Objects or Data Attributes are optional. The IED and Data Type Template sections of the SCL file are used to define the types or instances of Data Objects and Data Attributes for each type or instance of Logical Nodes for specific IEDs.

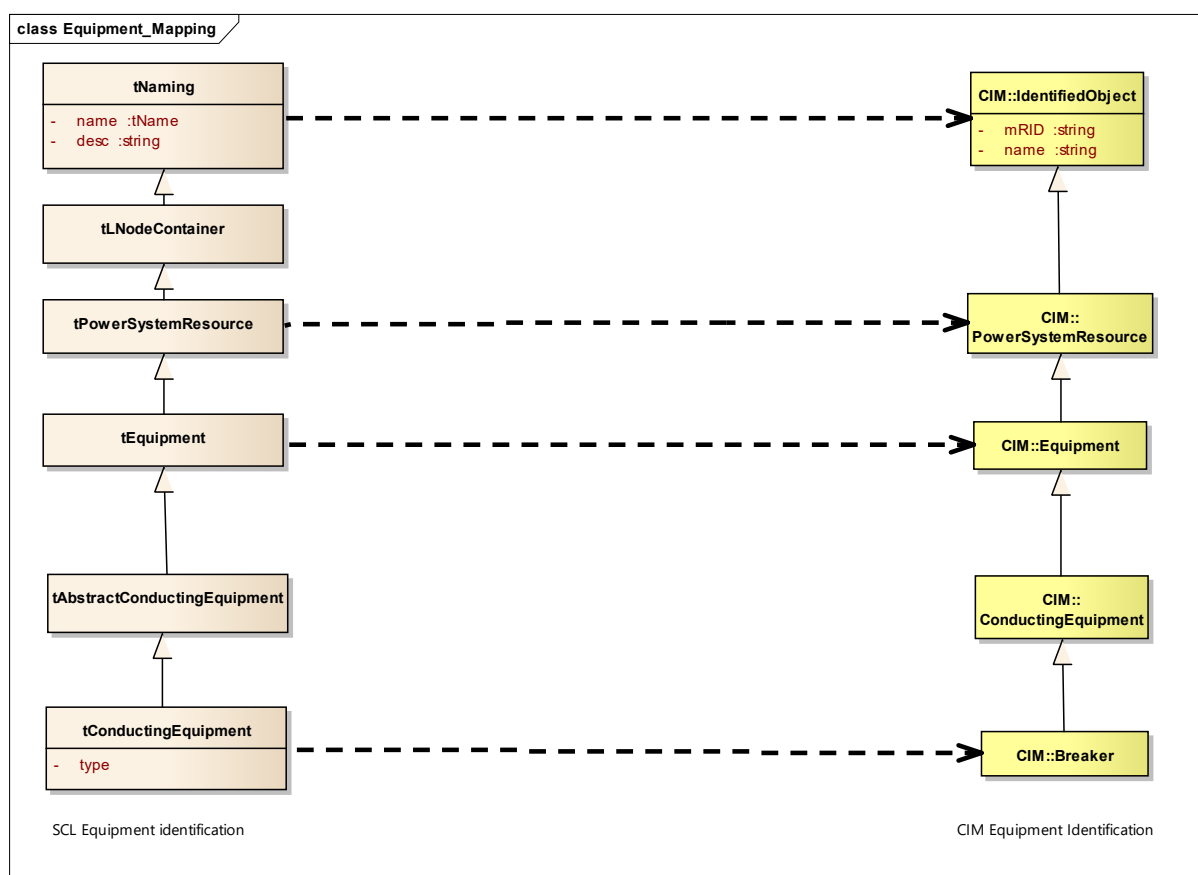
Some of these Data Objects / Data Attributes correspond to CIM Measurements. In these cases, the association {*Equipment* → *Logical Node* → *Data Object* → *Data Attribute*} is equivalent to the CIM association of {*Power System Resource* → *MeasurementValue* or *Asset* → *MeasurementValue*}.

Other Data Objects correspond to CIM Controls. In these cases, the association {*Equipment* → *Logical Node* → *Data Object* → *Data Attribute*} is equivalent to the CIM association of *Power System Resource* → *Control* or *Asset* → *Control*.

The Substation / Line / Process section only defines the basic types, names and descriptions for the primary system equipment. A limited number of attributes are available such as the nominal voltage and nominal frequency. In the IEC 61850 model, settings and configuration parameters may be defined within associated Logical Nodes. For some (but not all) of the settings the associations {*Equipment* → *Logical Node* → *Data Object* → *Data Attribute*} may map to attributes belonging to the CIM object classes.

Some of the general mapping principles described above are shown in Figures 3 and 4. Figure 3 shows a simplified representation of the main equipment hierarchy in the SCL and in CIM.

The inheritance hierarchy of the SCL is similar but not the same as that of the CIM. Within SCL, the type of conducting or non-conducting equipment is defined by a type code, whilst in the CIM the equipment type is defined by a concrete class.



IEC

Figure 3 – Equipment mapping

Figure 4 shows a correspondence between Data Objects in the SCL and some of the CIM classes in the Measurement package. Comparing the measurement models, equipment in SCL is associated with zero or more Logical Nodes, whereas in the CIM, Equipment, or more generally, PowerSystemResources, are associated with zero or more Measurement instances.

Note that in IEC 61850 the term Measurand is used for some types of Data Object that contain analogue values, whereas the CIM Measurement class is a generic class that may have discrete, analogue or accumulator subclasses.

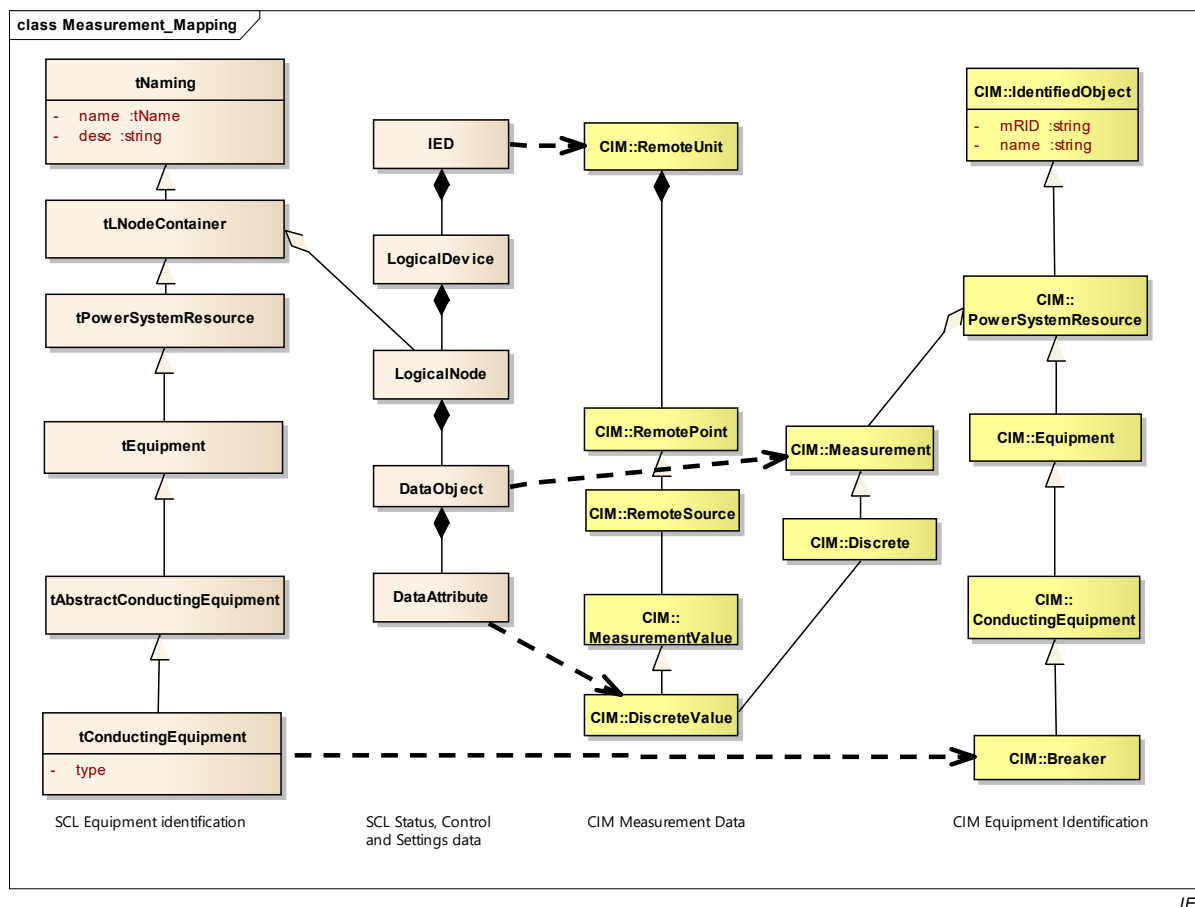


Figure 4 – Example of equipment and status measurement mapping

5.5 SCL Substation section mapping

5.5.1 Overview

The following text is reproduced from IEC 61850-6:

The Process model is an object hierarchy based on the functional structure of the primary process. Special primary processes are the Substation and the Line, which have their own SCL elements. [The generic Process element shall be used] ... to model any additionally needed structuring levels of a power grid above the substation ... Although each object is self-contained, its reference designation is derived from its place in the hierarchy. Because LNs perform functions within the complete context of the Process / Substation, they can be attached as functional objects at each function level. Typically, a switch controller LN is attached to a switching device, while a measuring LN is attached to the bay, which delivers the measurands, and transformer-related LNs are attached to the appropriate transformer.

The purpose of the process model is

- *to relate a logical node and its function to a process function (substation, process or line part or equipment or sub-equipment);*
- *to derive a functional designation for the logical node from the substation structure.*

Logical nodes (LNode) can be attached at each level of the structure (i.e., substation, voltage level, bay, equipment, subequipment respective function, subfunction). Power transformers (PowerTransformer) can also be attached at the structure levels substation, voltage level and bay. Conducting equipments (ConductingEquipment) can only be attached to the bay level. Logical node instances at the same level shall have different identifications.

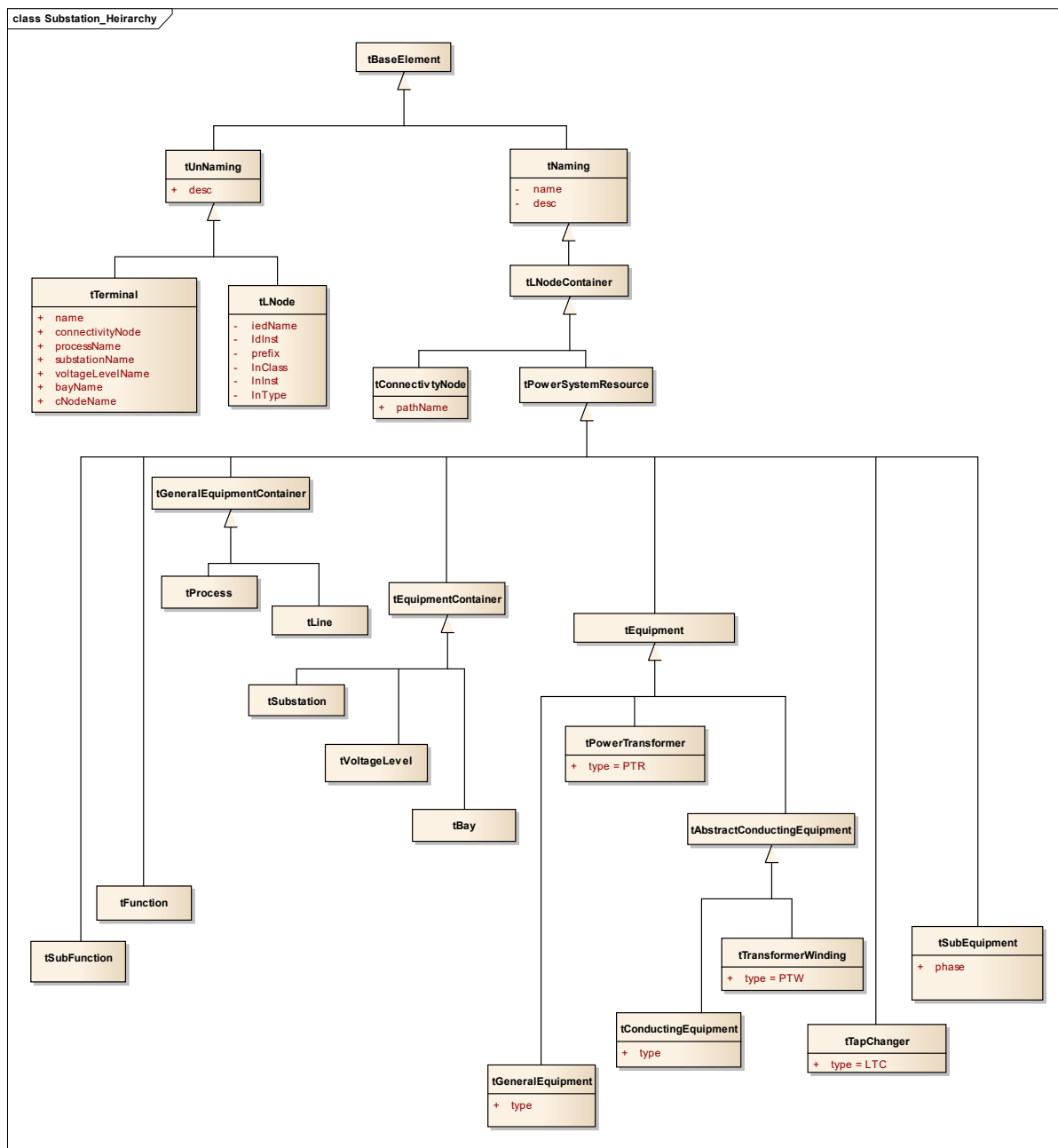
NOTE 1 In the first paragraph “function” is used in the general sense and not the specific SCL element type called function.

NOTE 2 In practice measurement logical nodes may be attached to any of the elements that inherit from `tlNodeContainer` including `ConnectivityNodes`. However logical nodes cannot be allocated to terminals.

Figures 5 to 7 show UML class diagrams that correspond to the entities in the IEC 61850 SCL Process/Line/Substation section. For clarity, this is presented as several diagrams and the classes `EqFunction` and `EqSubFunction` have been omitted.

Figure 5 shows the main inheritance structure for equipment and equipment containers. Equipment may be either `GeneralEquipment` without electrical connectivity; or conducting equipment with terminals that connect to connectivity nodes. Power transformers, windings and tap changers have specific entities.

The SCL inheritance hierarchy is similar but not the same as that of the CIM. Within the SCL, the type of equipment is defined by a type code whilst in the CIM the equipment type is defined by its concrete class.



IEC

Figure 5 – UML class diagram of SCL entities showing inheritance

Figure 6 shows both the inheritance structure and the containment associations for equipment.

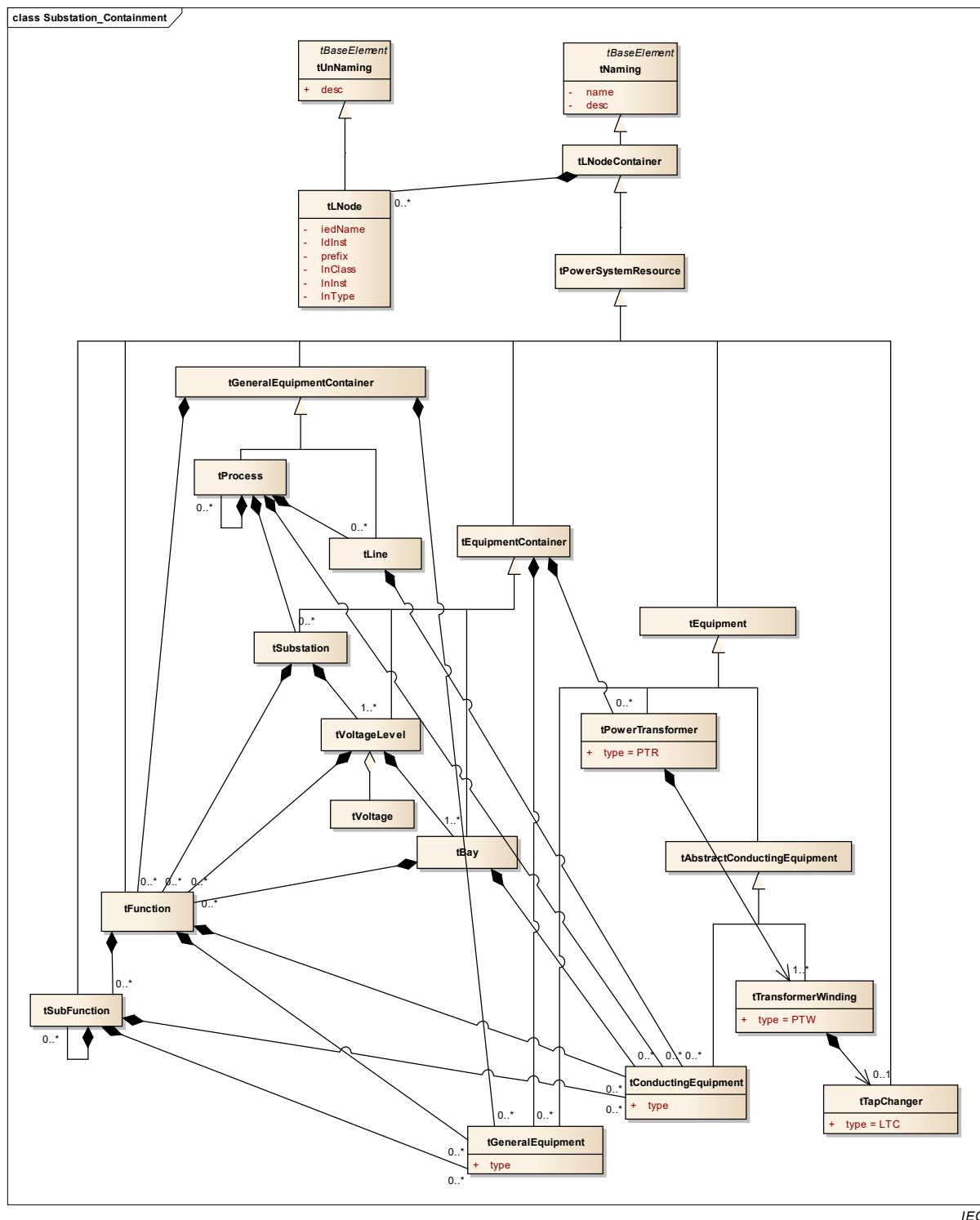
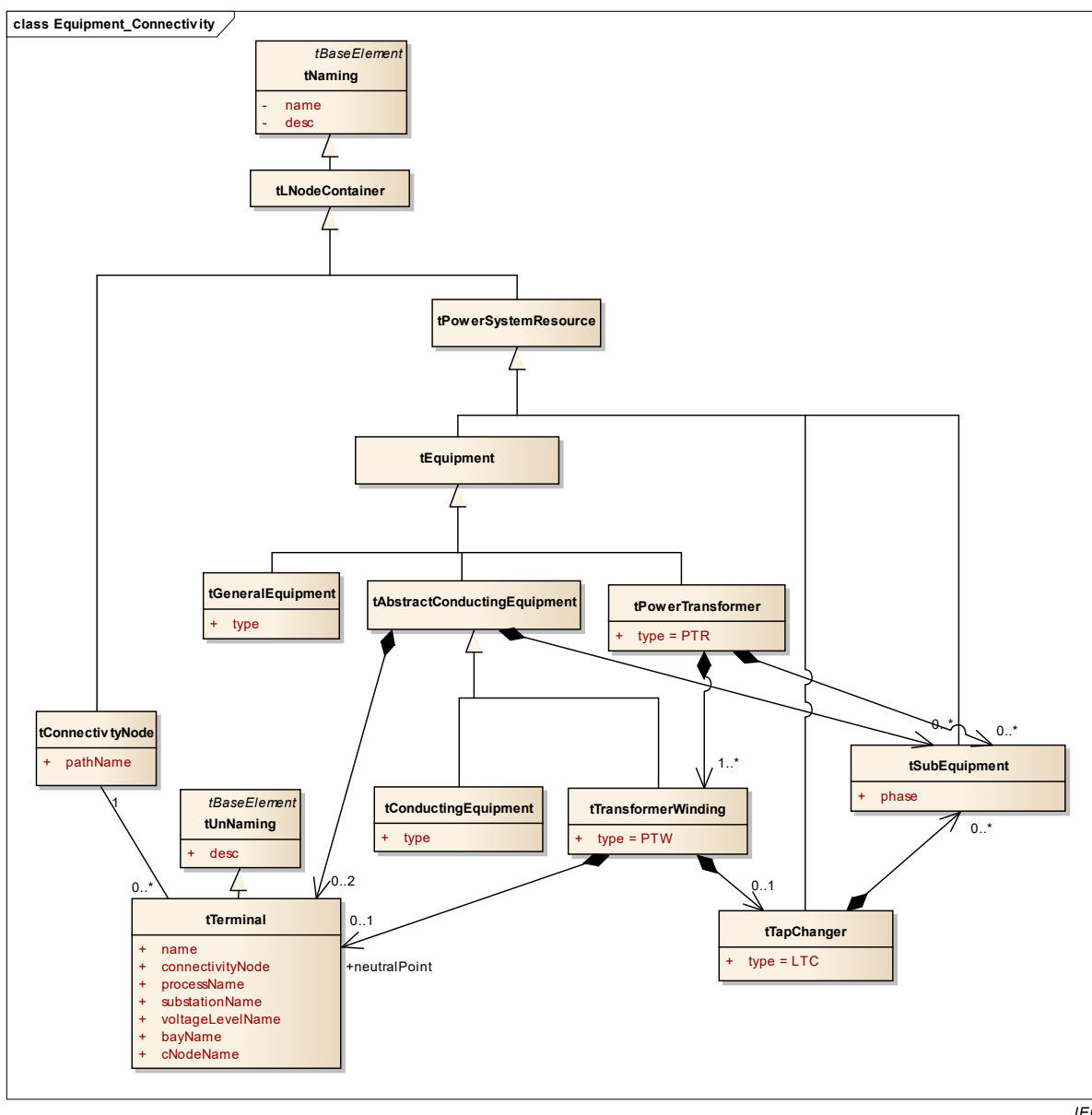


Figure 6 – UML class diagram of SCL entities showing inheritance and containment

Figure 7 shows the connectivity modelling using Terminals and ConnectivityNodes. It also shows that phase information may be defined in SubEquipment instances associated with power transformers, windings, tap changers and all other types of ConductingEquipment.



IEC

Figure 7 – UML class diagram of SCL equipment connectivity and phase information

5.5.2 SCL elements and CIM classes mapping

The high-level mapping between SCL elements and CIM classes is shown in Table 2. Some elements such as Process or Function map to more than one CIM class. In these cases, any SCL to CIM implementation must use local mapping rules, for example based on the element names.

Table 2 – Mapping between SCL data types and CIM classes

SCL element	SCL description	CIM Class
Process	the whole or part of a primary process. Parts of power grids containing several substations or lines. a logical node container, which can be used for other processes than substations, or to group several substations into parts of a power grid. For the first purpose, it can also contain equipment elements. It can be recursively used	Plant GeographicalRegion SubGeographicalRegion
Line	a power line connecting several substations. a logical node container, which can be used to model lines between substations of a power grid. It can contain equipment elements modelling line segments, general equipment and connectivity nodes	Line
Substation	the object identifying a whole substation	Substation
VoltageLevel	an identifiable, electrically connected substation part having an identical voltage level.	VoltageLevel
Voltage	states the voltage used at a voltage level	BaseVoltage
Bay	an identifiable part or subfunction of the switch yard (substation) within one voltage level.	Bay
Equipment	an apparatus within the switch yard, for example circuit breaker, disconnector, voltage transformer, power transformer winding etc. Equipment has an attribute 'type' which is an enumerated code.	See the descriptions for ConductingEquipment and GeneralEquipment
ConductingEquipment	Subclass of Equipment for equipment that forms part of the primary power system.	Subclass of AuxiliaryEquipment e.g. SurgeArrester or subclass of ConductingEquipment
GeneralEquipment	Subclass of Equipment for auxiliary equipment	Subclass of AuxiliaryEquipment or subclass of ConductingEquipment e.g. AsynchronousMachine
SubEquipment	a part of an Equipment, which might especially be one phase of a three-phase equipment.	ACLineSegmentPhase SwitchPhase EnergyConsumerPhase ShuntCompensatorPhase TransformerTankEnd
ConnectivityNode	the (electrical) connectivity node object connecting different primary devices. Typical connectivity node examples are: connecting nodes within a bay, bus bars connecting several bays in the same voltage level, lines connecting bays in different substations.	ConnectivityNode plus BusbarSection or Junction

SCL element	SCL description	CIM Class
Terminal	an electrical connection point of a primary apparatus at single line level. A terminal can be connected to a ConnectivityNode. Within SCL terminals can be explicitly named, or exist implicitly.	Terminal
Function	allows additional functions at substation, voltage level or bay level, either independent from the basic switch yard functionality like firefighting or building supervision, or as part of the switch yard like main 1 protection and main 2 protection.	AuxiliaryEquipment ProtectionEquipment AssetFunction Contained logical nodes may be mapped to the measurements associated of the parent equipment class.
SubFunction	a hierarchical subpart of a Function or SubFunction, e.g. earth fault protection as subpart of the main 1 function.	As Function
EqFunction	allows additional functions at or below Equipment level, e.g. redundant functions on the same equipment. Contained by tConductingEquipment, tGeneralEquipment, tSubEquipment, tPowerTransformer, tTransformerWinding, tTapChanger.	As Function
EqSubFunction	a hierarchical subpart of an EqFunction or EqSubFunction.	As Function
PowerTransformer	special equipment, which can hierarchically be located below Substation, VoltageLevel or Bay. It contains Transformer windings as equipment, which might again have a relation to a tap changer. A power transformer usually connects between two or more voltage levels.	PowerTransformer
TransformerWinding	Part of a PowerTransformer	TransformerEnd PowerTransformerEnd TransformerTankEnd
TapChanger	Part of a PowerTransformer	TapChanger PhaseTapChanger RatioTapChanger

Some equipment such as extra high voltage switch gear and transformers may be physically separate equipment per phase. This may be represented in the SCL as one instance of the three-phase equivalent equipment with three instances of sub-equipment, one for each of the phases. Depending on the application of the CIM model, the CIM model could be either the three-phase equivalent or the three single-phase equipments. For more details, see 5.10, Phase modelling.

IEC 61850-6 has the definition of Function/SubFunction that represents application aggregates of PowerSystemResources and/or LogicalNodes. Currently, there are no clear corresponding entities within CIM for mapping this concept.

5.6 Equipment types and codes

5.6.1 General

Within the SCL, the type of equipment is defined by a type code whilst in the CIM the equipment type is defined by its concrete class.

5.6.2 Equipment type code mapping

Table 3 shows all the type codes defined in IEC 61850-6:2009 Table 5 and Table 9 with a correspondence to one or more CIM classes defined in IEC 61970-301. It also includes some CIM classes that are used in IEC 61970-452, but do not have corresponding type codes in IEC 61850.

If details of network connectivity are not required e.g. for condition monitoring, then equipment can be mapped to instances of CIM Asset.

Table 3 – Equipment type codes

Type Code	IEC 61850 Meaning	Number of terminals	CIM (IEC 61970-301) class
AXN	Auxiliary Network	None	No corresponding CIM class
BAT	Battery [and charging system]	1 (Note 1)	No corresponding CIM class
BSH	Bushing	2	Connector
CAB	Power cable	2	ACLineSegment DCLineSegment
CAP	Capacitor bank	1/2	ShuntCompensator SeriesCompensator
CBR	Circuit Breaker	2	ProtectedSwitch Breaker Recloser
CON	Converter	1/2	FrequencyConverter
CTR	Current Transformer	2	CurrentTransformer
DIS	Disconnecter or earthing switch	2	Switch Disconnecter Fuse Jumper LoadBreakSwitch GroundDisconnecter Sectionalizer
EFN	Earth Fault Neutralizer (Petersen coil)	1	PetersenCoil
FAN	Fan	0 or 1 (Note 1)	No corresponding CIM class
FIL	Filter	0 or 1 (Note 1)	No corresponding CIM class
GEN	Generator	1	GeneratingUnit
GIL	Gas Insulated Line (or line segment)	2	ACLineSegment DCLineSegment

Type Code	IEC 61850 Meaning	Number of terminals	CIM (IEC 61970-301) class
IFL	Infeeding line; substation limiting object; models a possibly infeeding power network line outside the substation at the single line border	1	ACLineSegment DCLineSegment EquivalentBranch
LIN	Power overhead line or line segment	2	ACLineSegment DCLineSegment
LTC	Load Tap Changer	Part of winding	TapChanger RatioTapChanger PhaseTapChanger
MOT	Motor	0 or 1 (Note 1)	AsynchronousMachine
PMP	Pump	0 or 1 (Note 1)	No corresponding CIM class
PSH	Power Shunt (bypass for transformer star point grounding resistor)	2	GroundingImpedance
PTR	Power Transformer	Implicit via windings	PowerTransformer
PTW	Power Transformer Winding	1/2	TransformerEnd PowerTransformerEnd TransformerTankEnd
REA	Reactor	1/2	ShuntCompensator SeriesCompensator
RES	Neutral resistor	2	EarthFaultCompensator
RRC	Rotating reactive component	1	SynchronousMachine
SAR	Surge arrester	1	SurgeArrester
SCR	Semiconductor controlled rectifier	2	ACDCCConverter
SMC	Synchronous Machine	1	SynchronousMachine
TCF	Thyristor controlled frequency converter	2	FrequencyConverter
TCR	Thyristor controlled reactive component	2	StaticVarCompensator
TNK	Tank	0	TransformerTank
VLV	Valve	0 or 1 (Note 1)	No corresponding CIM class
VTR	Voltage Transformer	1	PotentialTransformer
Note 2	Bus bar section	1	BusbarSection
Note 2	Identified connection point that is not a bus bar (see 5.6.5 below)	1	Junction
Note 2	Identified connection point to ground	1	Ground

NOTE 1 IEC 61850-6 allows equipment of type codes AXN, BAT, MOT, FAN, PMP, VLV to be defined as general equipment without terminals, or as conducting equipment with terminals. Equipment such as filters and pumps may be monitored by a central SCADA or asset management system. Their status may be useful for assessing operational limits.

NOTE 2 IEC 61850-6 does not model bus bar sections or junctions as identified equipment, but simply as connectivity nodes.

In some cases, it is possible to use other information from the SCL in addition to the type code to define a more complex mapping to the appropriate CIM class. For example, if one of the terminals for a SCL switch is connected to a SCL connectivity node called “grounded”, then the CIM switch type is a “GroundDisconnecter”.

Within SCL, DC lines can be modelled with equipment of type LIN/GIL/CAB within (or connected to) a voltage level with nominal frequency 0. However, for control centre applications, there are fundamental differences between AC and DC equipment. The CIM therefore uses different sets of classes for AC lines and for DC lines

The SCL is intended to describe the power system such that the primary equipment type does not depend on the associated logical nodes. However, if logical node information is available it may allow the CIM model to be refined. This additional information could simply be the logical node class type as listed in Table 13, or it could be the configured value for a data object within the logical node. For example, the XSWI logical node has a data object that defines the sub-type of the associated switch equipment. See Table 22.

IEC 61850 has no special modelling for temporary equipment which will be installed to provide safety during maintenance or erection work. Temporary equipment must be pre-defined in the SCL in the same way as permanent equipment.

IEC 61850-6 allows private type codes. To allow compatibility with future enhancements of the standard, they shall start with the character E, contain only capital letters, and have at least three letters. The mapping of private type codes requires local mapping rules.

5.6.3 Recommendation for harmonization: SCL Equipment Type codes

5.6.3.1 New and deprecated type codes

Recommendation R2: The list of device type codes in IEC 61850-6 should be extended to correspond better with the IEC 61970 / IEC 61968 Common Information Model, particularly to support applications related to distribution networks. This would allow the Substation section to be used to more fully describe the power system equipment and its connectivity without needing any details of Logical Nodes. The aim is that the type code indicates the fundamental nature of the physical equipment, not necessarily its usage within a particular software application.

Details:

- 1) Add new type codes for Busbar section and Junction. Conducting Equipment of these types would be defined within Bays together with their associated Terminal and ConnectivityNode.
- 2) Add new type codes to distinguish types of switch. DIS is ambiguous as it can be mapped to several different sub-types of CIM Switch.
- 3) It is confusing to have type codes for capacitor device types with a variable number of terminals. Add new type codes to distinguish series and shunt capacitors.
- 4) It is confusing to have type codes for reactor device types with a variable number of terminals. Add new type codes to distinguish series and shunt reactors.
- 5) It is not clear what the difference is between type code CON “converter” compared with the SCR “rectifier” and TCF “frequency converter”. The type code CON should be deprecated.
- 6) Add a new type code for Composite Switches i.e. a set of individual Switches normally enclosed within the same cabinet or cubicle, possibly with interlocks that restrict the combination of switch positions. These are typically found in medium voltage distribution networks or high-voltage gas insulated switchgear. The purpose is to allow the cabinet or cubicle to be represented as equipment with its own identity and status, in addition to its constituent switches.

- 7) The IFL type code should not be used for new designs. The differentiation with between outgoing and infeeding lines is not relevant in many transmission networks and is becoming artificial in distribution grids with high level of dispersed generation. The power flow direction may change in a few seconds. Allow LIN and CAB to be modelled with one terminal when they cross the substation or system border, and modelled with two terminals if the SCL models a full line.
- 8) For CIM applications, there are fundamental differences between AC and DC equipment. It is complex to distinguish AC lines and DC lines based on the association with a voltage level that has a frequency attribute with value zero. Add new type codes DLN and DCA.

These recommendations are summarized in Tables 4 and 5.

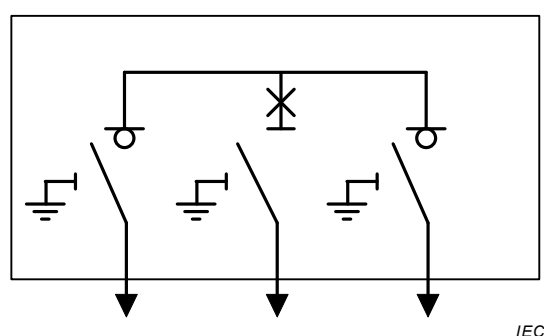
Table 4 – Equipment type codes – proposed modified descriptions

Type Code	Meaning	Number of terminals	CIM class
DIS	Disconnecter or earthing switch (generic) Deprecated – use SDC or SES	2	
CAP	Capacitor bank (generic) Deprecated – use CSE or CSH	1 or 2	ShuntCompensator if number of terminals =1 SeriesCompensator if number of terminals =2
REA	Reactor (generic) Deprecated – use RSE or RSH	1 or 2	ShuntCompensator if number of terminals =1 SeriesCompensator if number of terminals =2
CON	Converter (generic). Deprecated – use TCF or SCR as applicable	1 or 2	
IFL	Infeed line Deprecated – use CAB, LIN or GIL		

Table 5 – Equipment type codes – proposed additional codes

Type Code	Meaning	Number of terminals	CIM class
BUS	Busbar section – a low impedance conductor to which several instances of conduction equipment can be separately connected	1	BusbarSection
BJN	Junction – connection between two or more instances of conduction equipment	1	Junction
CSE	Capacitor bank – series	2	SeriesCompensator
CSH	Capacitor bank – shunt	1	ShuntCompensator
DLN	DC Line	2	DCLineSegment
DCA	DC Cable	2	DCLineSegment
RSE	Reactor – series	2	SeriesCompensator
RSH	Reactor – shunt	1	ShuntCompensator
CSW	Composite Switch (set of individual Switches normally enclosed within the same cabinet and possibly with interlocks that restrict the combination of switch positions) See example in Figure 8		CompositeSwitch
SWI	Switch – generic	2	Switch
SLB	Switch – Load break switch	2	LoadBreakSwitch
SDC	Switch – Disconnecter	2	Disconnecter
SES	Switch – Earthing switch	2	EarthingSwitch
SHS	Switch – High speed earthing switch	2	EarthingSwitch
SFS	Switch – Fuse	2	Fuse
SJP	Switch – Jumper	2	Jumper

Figure 8 shows a Ring Main Unit modelled as a composite switch containing several individual switches.

**Figure 8 – Composite Switch example.**

5.6.4 Recommendation for harmonization: SCL PSRType

In the CIM, instances of power system resources may be associated with zero or one instances of PSRType. This is used for “classifying instances of the same class, e.g. overhead and underground ACLineSegments. This classification mechanism is intended to provide flexibility outside the scope of this standard, i.e. provide customisation that is non-standard.”

This custom classification is particularly useful for modelling distribution network equipment, as a way of defining individual instances with reference to template or catalogue objects that contain sets of reference parameters.

It would also help mapping algorithms to choose the appropriate CIM class when there is a choice, e.g. a physical line could be modelled as an ACLineSegment, but for transmission network applications it could be modelled as an EnergyConsumer (a point of consumption on the power system model)

Recommendation R3: An optional string attribute `psrType` should be added to the SCL definition for `tPowerSystemResource`. It may be appropriate to use a specific namespace for this and other CIM related attributes.

5.6.5 Recommendation for harmonization: CIM BusbarSection and Junction

The CIM has two classes called `BusbarSection` and `Junction` which have the same attributes and associations. From a topology processing point of view clearly the two classes are equivalent.

Recommendation R4: Explanatory text should be added to IEC 61970-301 to explain the differences and where connectivity nodes are defined without either, e.g.

“For topology processing, a `BusbarSection` is identical to a `Junction`. The `BusbarSection` class is intended to represent physical parts of bus bars. It can be used to connect any number of equipment terminals.

The `Junction` class is intended for those cases where it provides a place to connect additional information for a connectivity node that is formed by connecting two or three equipment terminals such as a tee-point or the connection point between two switches.

Typically, `BusbarSections` and `Junctions` are represented by different symbols on diagrams.”

5.6.6 Recommendation for harmonization: CIM Fan, Motor, Batteries and charging systems

The IEC 61850 SCL allows fans, motors and battery systems to be defined either as types of general equipment or as types of conducting equipment. When defined as conducting equipment they will have terminals to allow modelling of their electrical supplies. There is no corresponding CIM class for these types of equipment within the connectivity model except the generic `EnergyConsumer` class.

Auxiliary equipment may be relevant for asset management purposes. The status and measured values for such equipment are defined in IEC TR 61850-90-3 and may be considered in a future edition of this document.

Recommendation R5: The business needs for modelling fans, motors and battery systems and similar types of auxiliary equipment in control centre applications should be considered.

5.7 Naming and identification mapping

5.7.1 General

The SCL and CIM models have different principles for naming and identification.

[From IEC 61850-6:2009, 8.5.2] *In case of the hierarchically structured objects of the substation structure and the product structure, both name and desc attributes for each object contain only that part which identifies the object within this level of the hierarchy. The full object reference is a pathname and consists of the concatenation of all name parts of higher hierarchy levels up to this level.*

NOTE *ConnectivityNode is an exception. It includes a full pathname that should be unique within the SCL file.*

IEC 61850-6:2009 defines two conventions for concatenating names. Subclause 8.5.2 recommends using a dot (.) as a separator, however Subclause 9.2.3 states “The separator “/” has been purposely selected, because the dot “.” might appear as part of the names at higher hierarchy levels, for example at bay level.”

Table 6 shows the mapping between name/identification attributes in SCL and the corresponding attributes in CIM.

Table 6 – Name mapping

Attribute	SCL Description	CIM Mapping
name	identification of each object within its container. Must be unique within the container. Must be unique within the file for top level objects	IdentifiedObject.name Name.name where Name is associated with a NameType “SCL.name”
desc	user oriented textual designation	IdentifiedObject.description
	pathname: concatenation of all name parts of higher hierarchy levels up to this level.	Name.name where Name is associated with a NameType “SCL.id”
□missing□	Master resource identifier issued by a model authority. The mRID is globally unique within an exchange context.	1. Generate a system unique object reference as per IEC 61850-6 Clause 8.5.2. The full object reference is a pathname and consists of the concatenation of all name parts of higher hierarchy levels up to this level. 2. Use the pathname as a key in some sort of registry to look up a UUID

5.7.2 Naming and identification example

ConnectivityNodes have an additional pathname attribute – this is discussed in more detail in Subclause 5.9.

If the SCL file contains the following:

```
<Substation name="S12" desc="Baden">
<VoltageLevel name="E1">
<Bay name="Q1">
<ConductingEquipment name="QA1" type="CBR">
```

using the existing SCL schema, it is possible to generate a CIM model using SCL pathnames as mRIDs. This satisfies the requirement for unique identifiers but does not satisfy the common business requirement that the same mRIDs are used even if the object names are changed.

```
Substation.name      = Baden
Substation.mRID      = S12

VoltageLevel.name    = E1
VoltageLevel.mRID    = S12E1

Bay.name             = Q1
Bay.mRID              = S12E1Q1

Breaker.name         = QA1
Breaker.mRID         = S12E1Q1QA1
```