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Report

Long Term Development Statement (LTDS)
Grid Modelling Annex 2: Data Exchange Specifications

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This document outlines the information model, profile and serialisation requirements for data supplied under the Grid Modelling section of the Long Term Development Statement (LTDS) Form of Statement.

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1 Contents

2 Introduction

This document provides detailed information regarding the requirements for the CIM-based exchange of LTDS grid model data. It overviews the information model underlying all data exchange definitions and describes the LTDS profiles and serialisation requirements in detail. It is intended primarily as a resource for developers of data exchange interfaces. It may also be a useful reference for grid modellers interested in understanding exchanged data in more detail.

The foundation of LTDS grid model data exchange is provided by the CIM and the IEC standards which leverage it. The CIM is an information model that defines a common industry structure for a broad range of data critical to electric utilities, including grid model data. IEC CIM standards provide guidance on how the CIM information model can be used to enable data exchange. The CIM information model is described in IEC 61970-301[1]. CIM profile standards are defined by IEC 61970-452[2], IEC 61970-453[3], IEC 61970-456[4], 61970-457[5], and IEC 61968-13[6], along with IEC 61970-600-1[7] and IEC 61970-600-2[8], which together are known as CGMES (Common Grid Model Exchange Standard).

The CIM information model and IEC CIM-based profiles, as well as the LTDS information model and LTDS profiles are expressed in a data modelling language call Unified Modelling Language (UML). More can be learned about the use of UML by CIM from Section 4 of EPRI's Common Information Model Primer: Eighth Edition[9].

When the CIM is used to support data exchange among applications, data is referenced at three levels:

- The underlying canonical information model provides the data structure for all exchanges.
- Data exchange definitions describe a type of data exchange and are comprised of:

[1] IEC 61970-301:2020+AMD1:2022 CSV | IEC Webstore
[2] IEC 61970-452:2021 | IEC Webstore
[3] IEC 61970-453:2014+AMD1:2018 CSV | IEC Webstore
[4] IEC 61970-456:2021 | IEC Webstore
[5] IEC 61970-457:2021 | IEC Webstore
[6] IEC 61968-13:2021 | IEC Webstore
[7] IEC 61970-600-1:2021 | IEC Webstore
[8] IEC 61970-600-2:2021 | IEC Webstore
[9] Common Information Model (CIM) Primer: Eighth Edition | EPRI

    - A profile which prescribes the structure of the type of data exchange using a subset of the classes, attributes and associations of the information model and
    - A set of constraints which describe rules for the content of the type of data exchange
- Exchanged data is an instance of data whose structure conforms to a profile, whose data content complies with constraints, and which is expressed using a specific serialisation method.

In line with those levels, this document is divided into three main sections:

- Section 3 LTDS Information Model describes the information model which underlies all LTDS data exchanges and outlines the approach used in its definition.
- Section 4 LTDS describes the profiles and constraints which govern the structure and content of specific sets of LTDS grid model data and the approach used in their definition.
- Section 5 LTDS Serialisation provides information on the serialisation of LTDS grid model data into CIM XML (the serialisation method currently defined by the International Electrotechnical Commission (IEC) CIM standards).

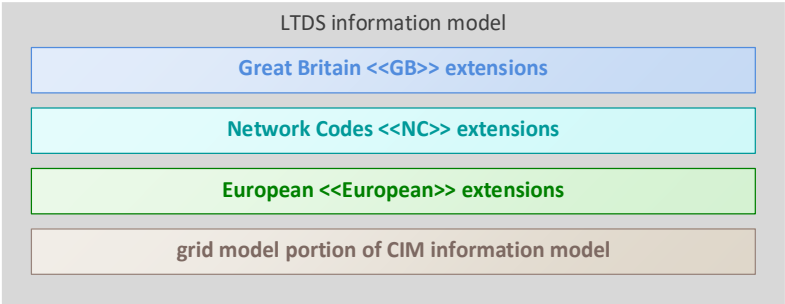
Additional reference information is provided in a collection of Appendices.

3 LTDS Information Model

3.1 LTDS layered information model

When used as the basis for a specific data exchange implementation, like LTDS, the CIM information model typically needs to be extended to meet local requirements. A standard approach to defining information model extensions is described in the ENTSO-E CGMES Profiling User Guide v1.0[10] and has been followed in creating the LTDS information model.

Because ongoing alignment with the IEC 61970 family of standards is key to the long-term usefulness of LTDS data, several "layers" of extensions are employed in the definition of the LTDS information model:



The CIM information model, expressed in UML, is maintained using a structured, collaborative process sponsored by UCA International[11] (UCAI). Its content is periodically snapshotted and published as the IEC 61970-301 standard, the current version of which is IEC 61970-301:2022. The CIM information model forms the base on which a set of extensions (the European <<European >> and Network Codes <<NC>> extensions) developed by the European Network Transmission System Operator for Electricity (ENTSO-E) are layered. Together those layers form the base for the Great Britain <<GB>> extensions required to support data exchanges in Great Britain, including (but not limited to) LTDS.

3.2 LTDS information model diagrams

The scope of the CIM information model is broad and the grid model portion of CIM includes numerous classes not currently relevant to LTDS grid model data exchange (though such

[10] CGMES profiling User Guide (entsoe.eu)
[11] Home - UCAIug

classes be of interest in the future as LTDS is enhanced to meet changing industry needs). The classes outside the LTDS area of interest fall into the following general categories:

- Classes describing dynamic (sub-cycle) transient behaviours of generators, loads and protection equipment.
- Classes describing HVDC equipment
- Classes describing measurements and measurement values
- Classes which support the description of schedules

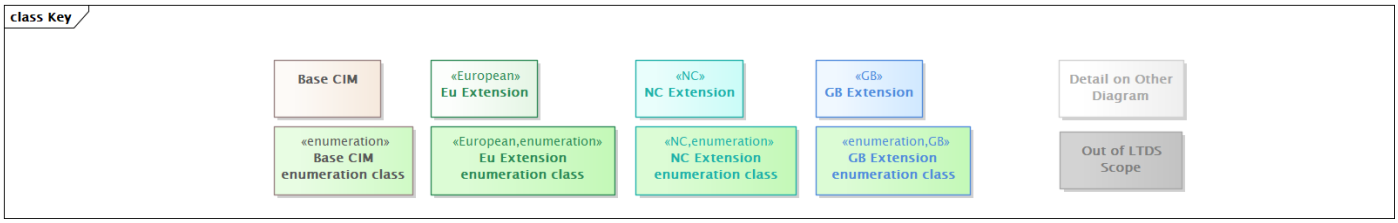
The UML class diagrams below cover the only the portions of the CIM information model relevant to LTDS (leaving aside classes of the categories listed above). Each of the diagrams contains a group of related classes which model a particular type of grid equipment or a particular type of grid-related data. The diagrams appear in the following order:

- Diagrams of groups of classes describing the physical grid and its operating state:
  - Building block classes
  - General equipment, control and external modelling classes
  - Switch-related classes
  - Circuit-related classes
  - Transformer-related classes
  - Transformer tap changer-related classes
  - Load-related classes
  - Generation-related classes (2 diagrams)
  - Shunt and static VAr compensator-related classes
  - Limits-related classes
  - Containment-related classes (grouping of grid equipment by facility and region)
  - Geospatial location-related classes
- A diagram of the classes which describe system capacities and connection activity at the bus-group level
- A diagram of the groups of classes describing the results of power flow analysis, including those describing grid topology (output of topology processing) and power flow solutions
- A diagram of the set classes which support display layout definitions

Each diagram contains classes from the underlying CIM information model along with related European, Network Codes and Great Britain extension classes. The diagrams are copied from

Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML and the path of the diagram within the UML model is noted below each diagram.

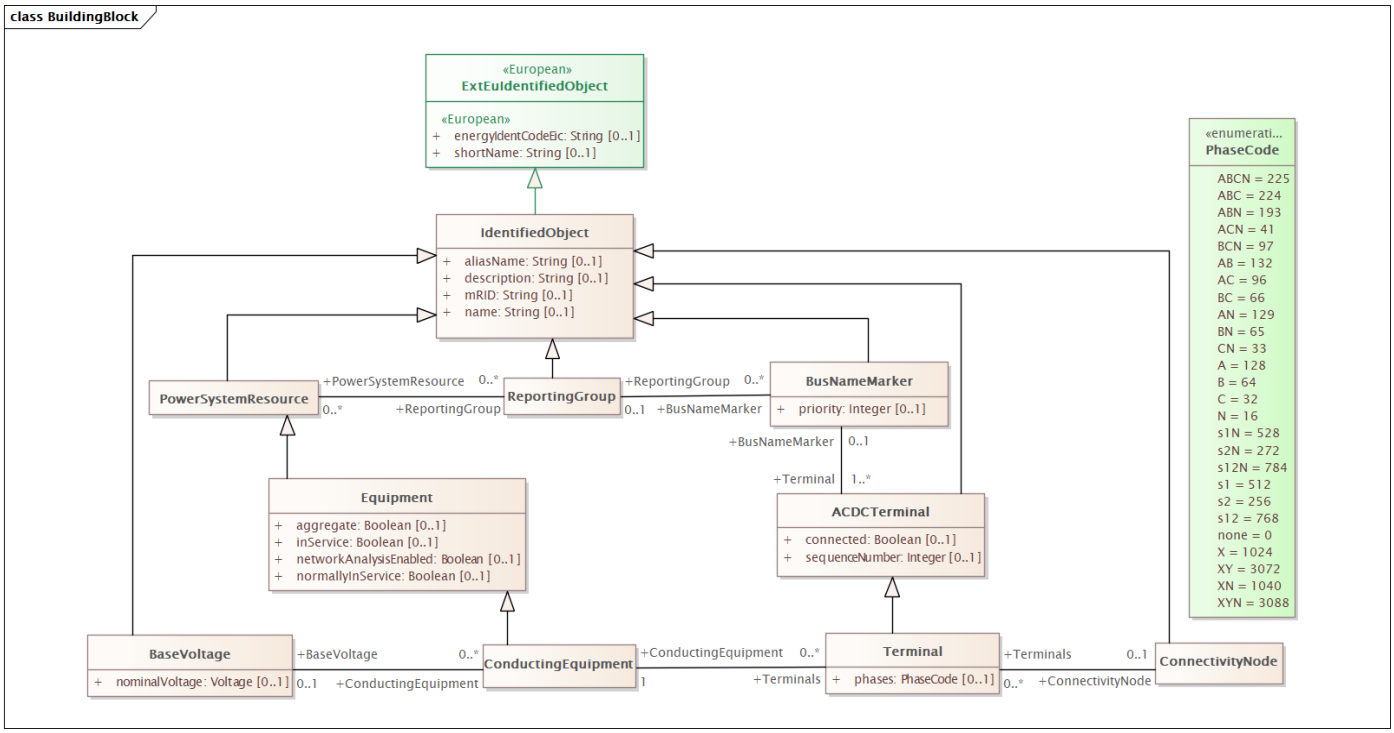
The class colouring convention followed in the UML class diagrams is illustrated below:



Diagrams of classes describing the physical grid and its operating state

The Building Block diagram includes:

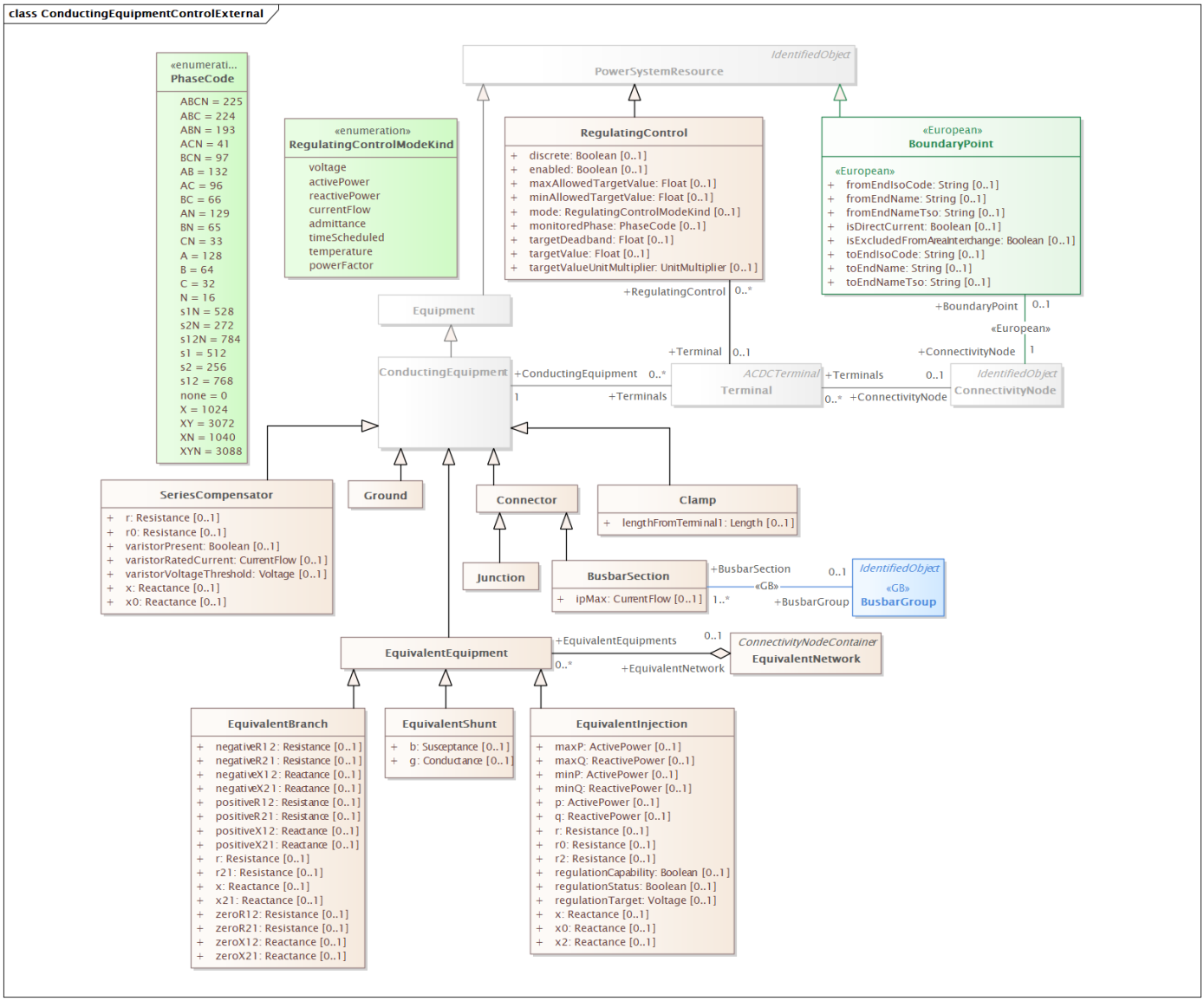
- The foundational CIM classes (e.g., Identified Object, PowerSystemResource, ConductingEquipment, Terminal, ConnectivityNode, BaseVoltage)
- Two classes used for grouping and naming (e.g., ReportingGroup, BusNameMarker)



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>BuildingBlock

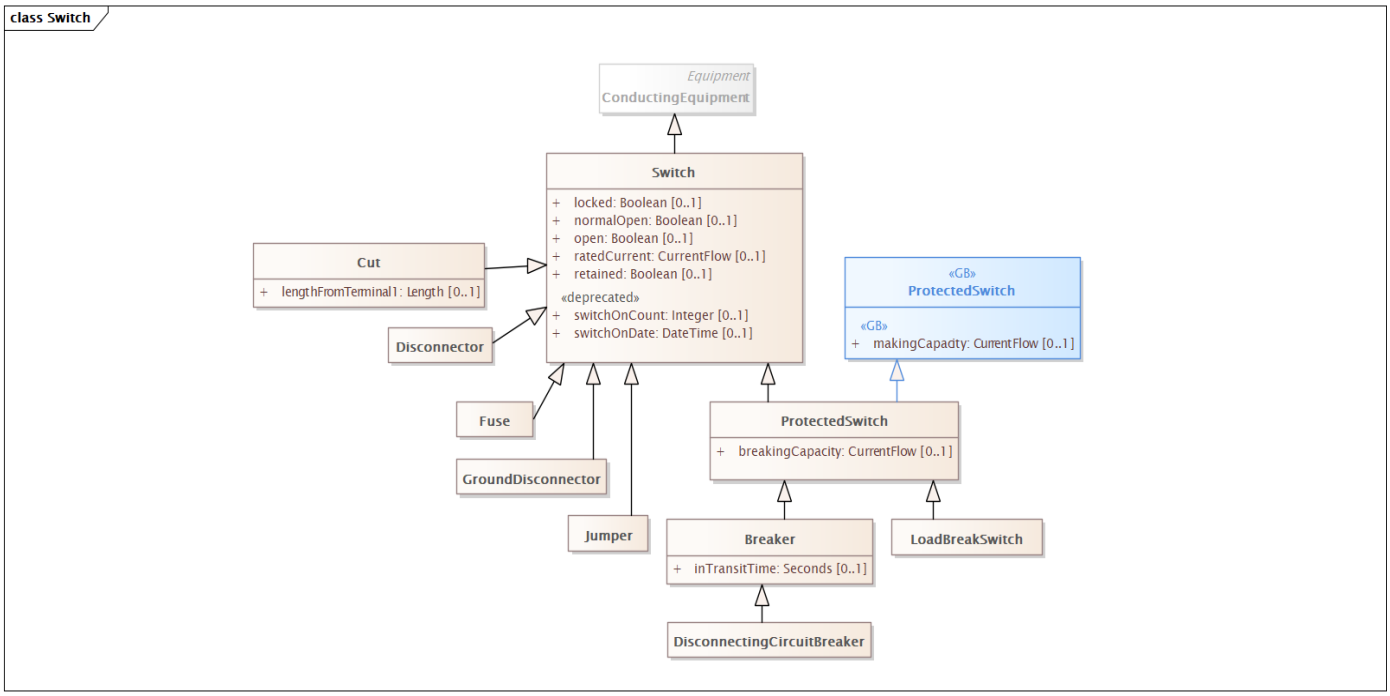
The ConductingEquipment RegulatingControl and External diagram includes:

- The RegulatingControl class (which is referenced by classes that support generator, tap changer and shunt compensator modelling)
- The CIM classes used to support external network modelling (BoundaryPoint and ExternalInjection)
- The BusbarSection and BusbarGroup classes
- Several ConductingEquipment subtype classes which have no additional associated objects (e.g., SeriesCompensator, Ground, Junction, Clamp)



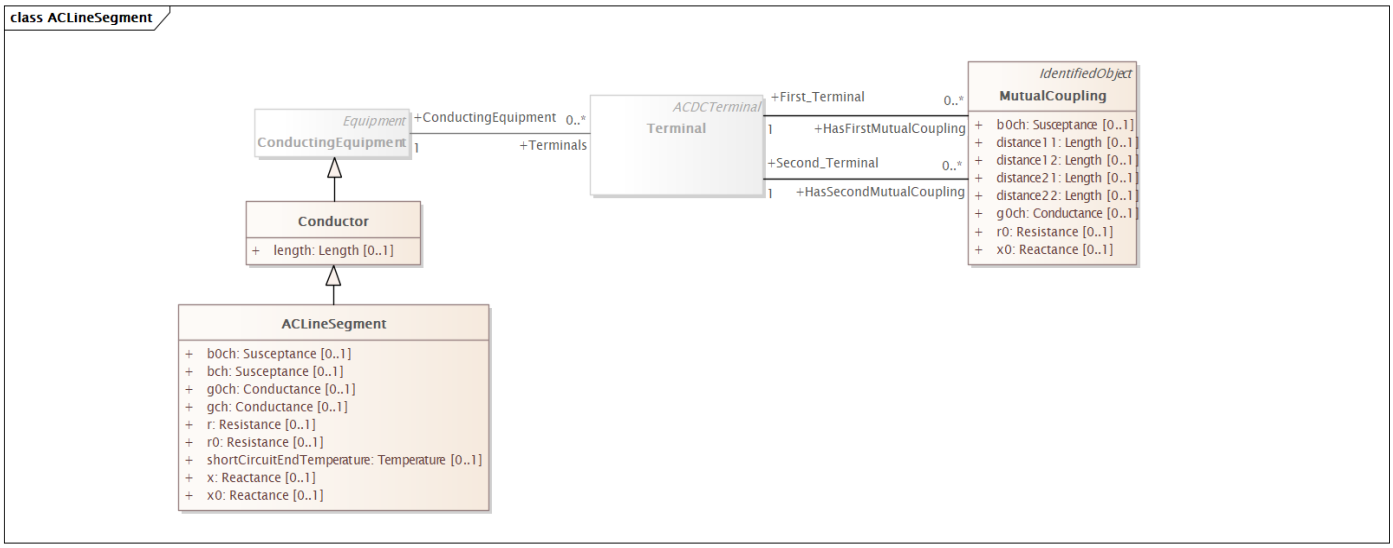
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>ConductingEquipmentControlExternal

The Switch diagram shows the CIM classes which support switching device modelling:



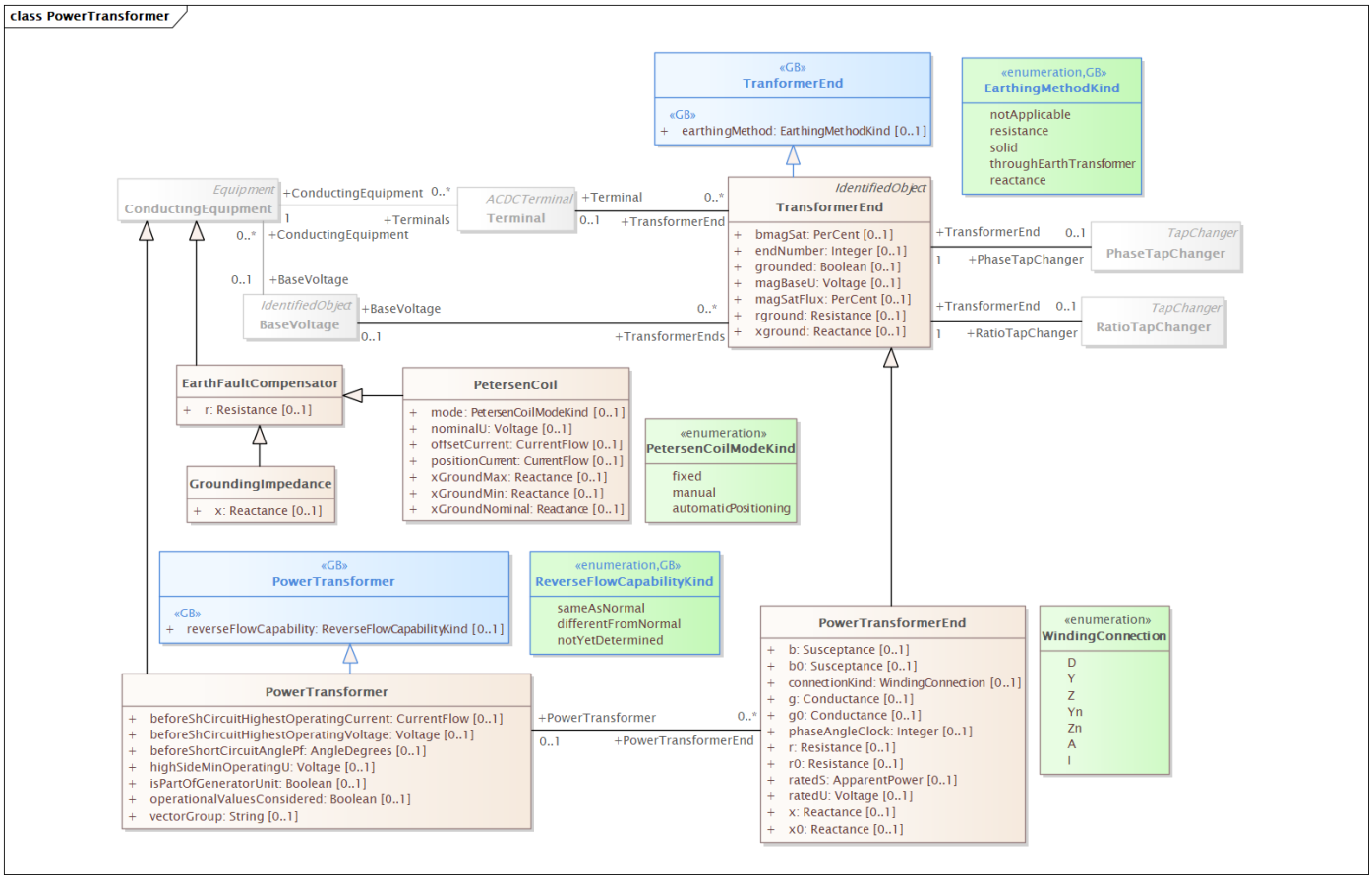
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>Switch

The ACLineSegment diagram shows the CIM classes which support circuit modelling:



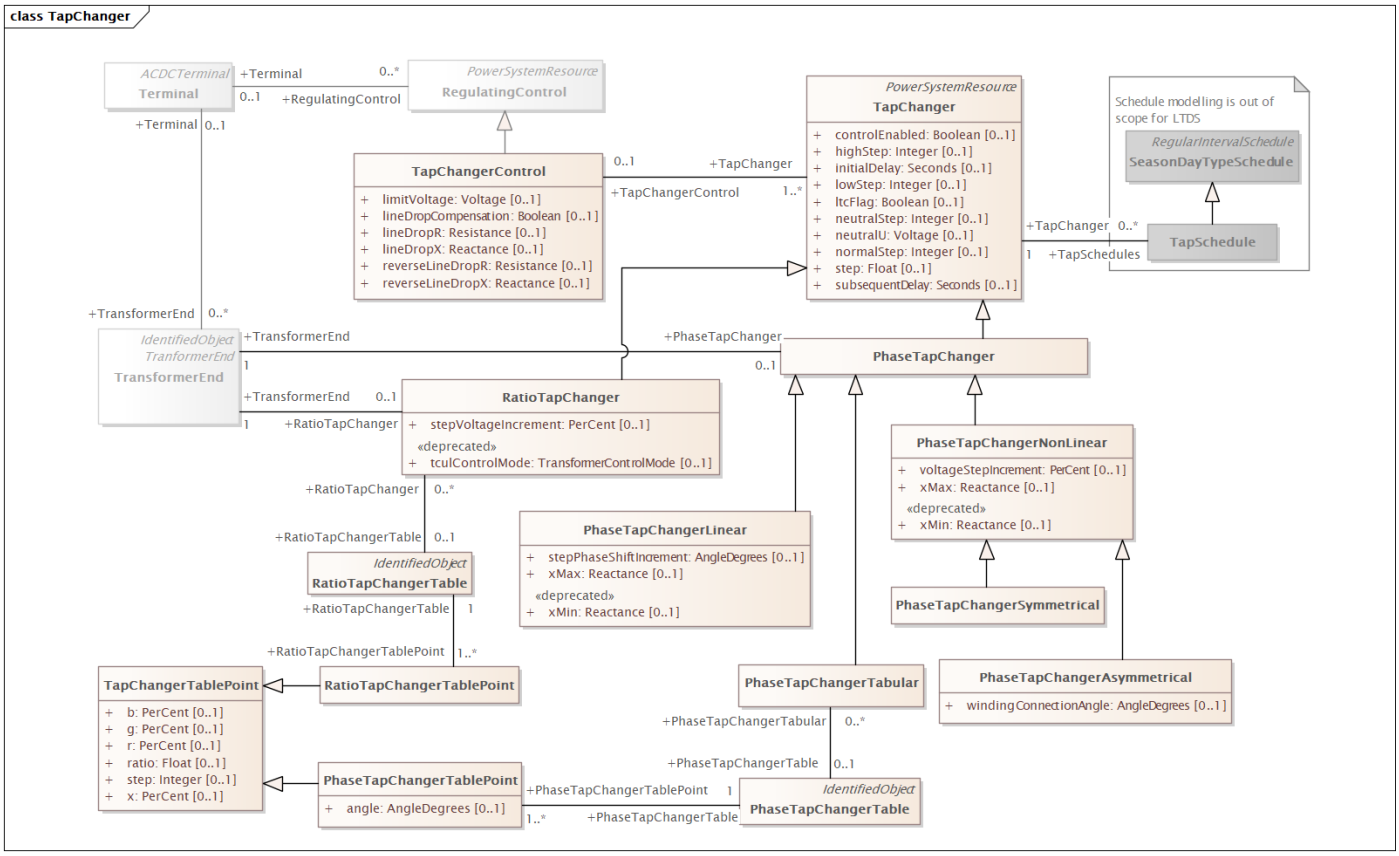
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>ACLineSegment

The PowerTransformer diagram shows the CIM classes which support transformer modelling:



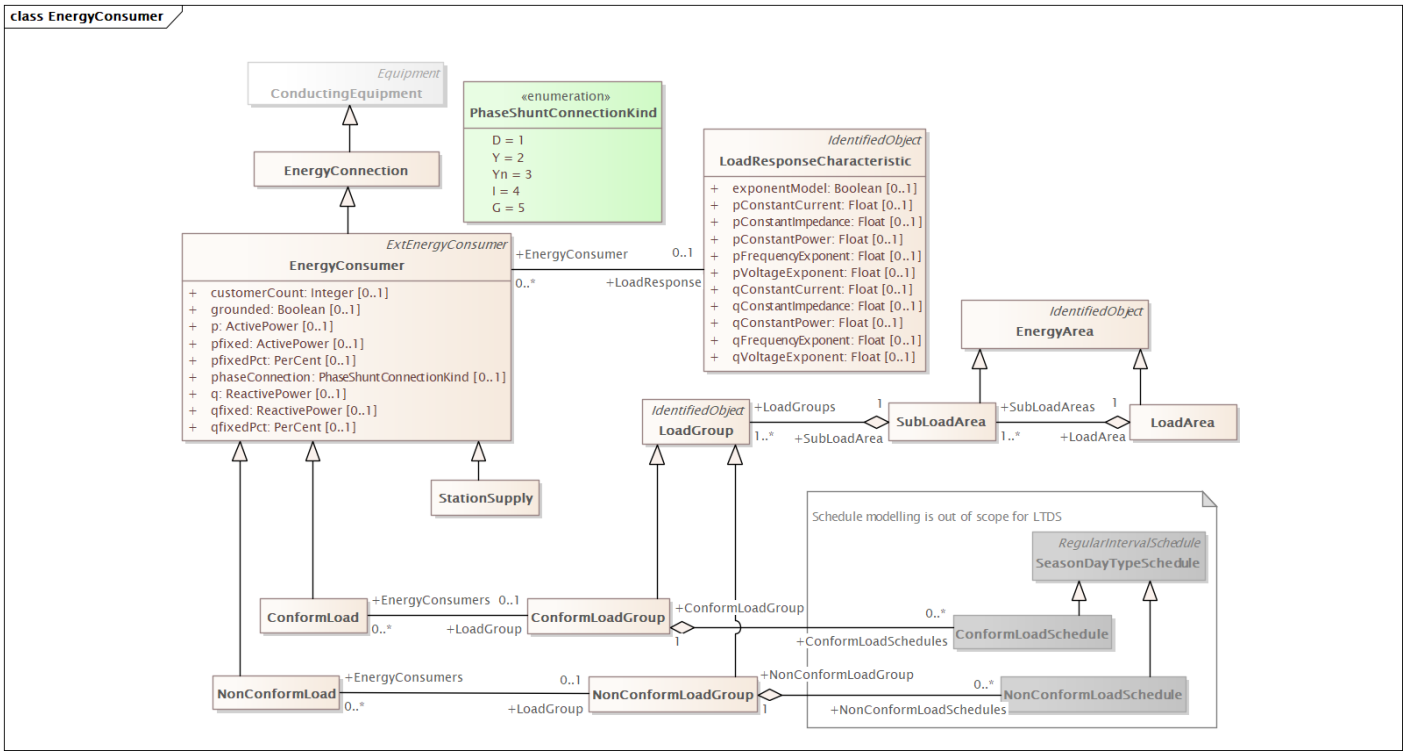
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>PowerTransformer

The TapChanger diagram shows the CIM classes which support transformer tap changer modelling:



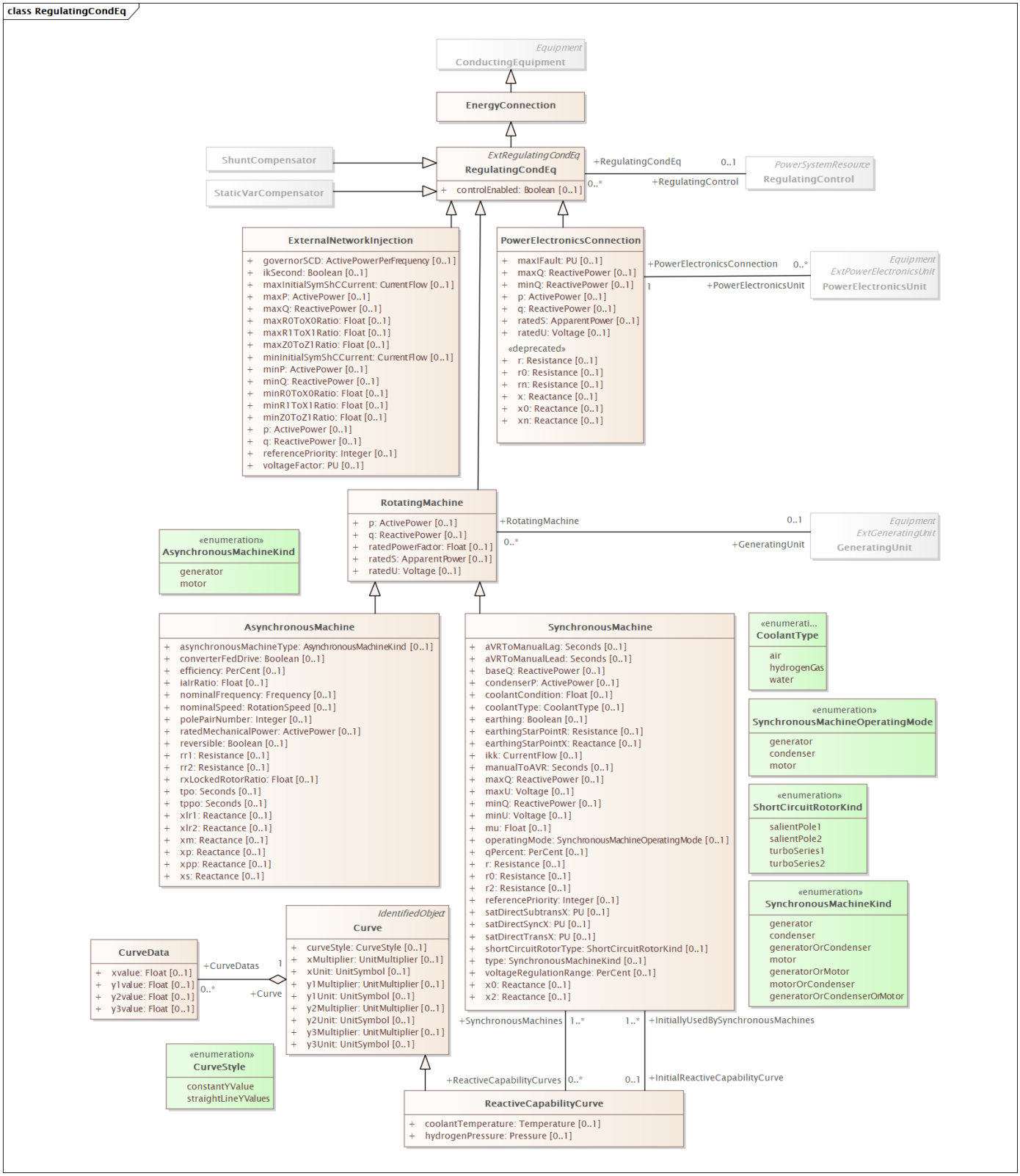
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>TapChanger

The EnergyConsumer diagram shows the CIM classes which support load modelling:



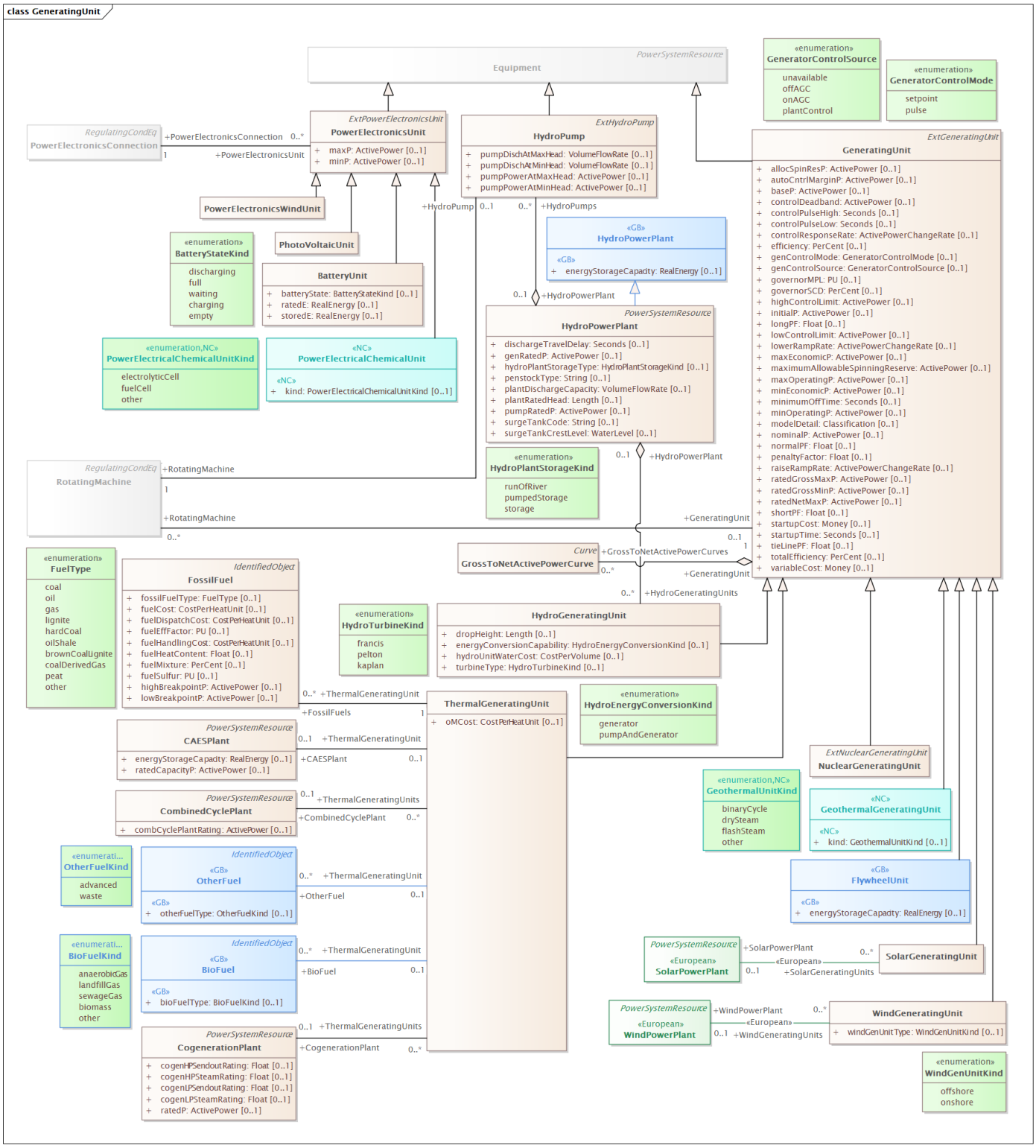
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>EnergyConsumer

The RegulatingCondEq diagram shows the foundational CIM classes which support generation modelling:



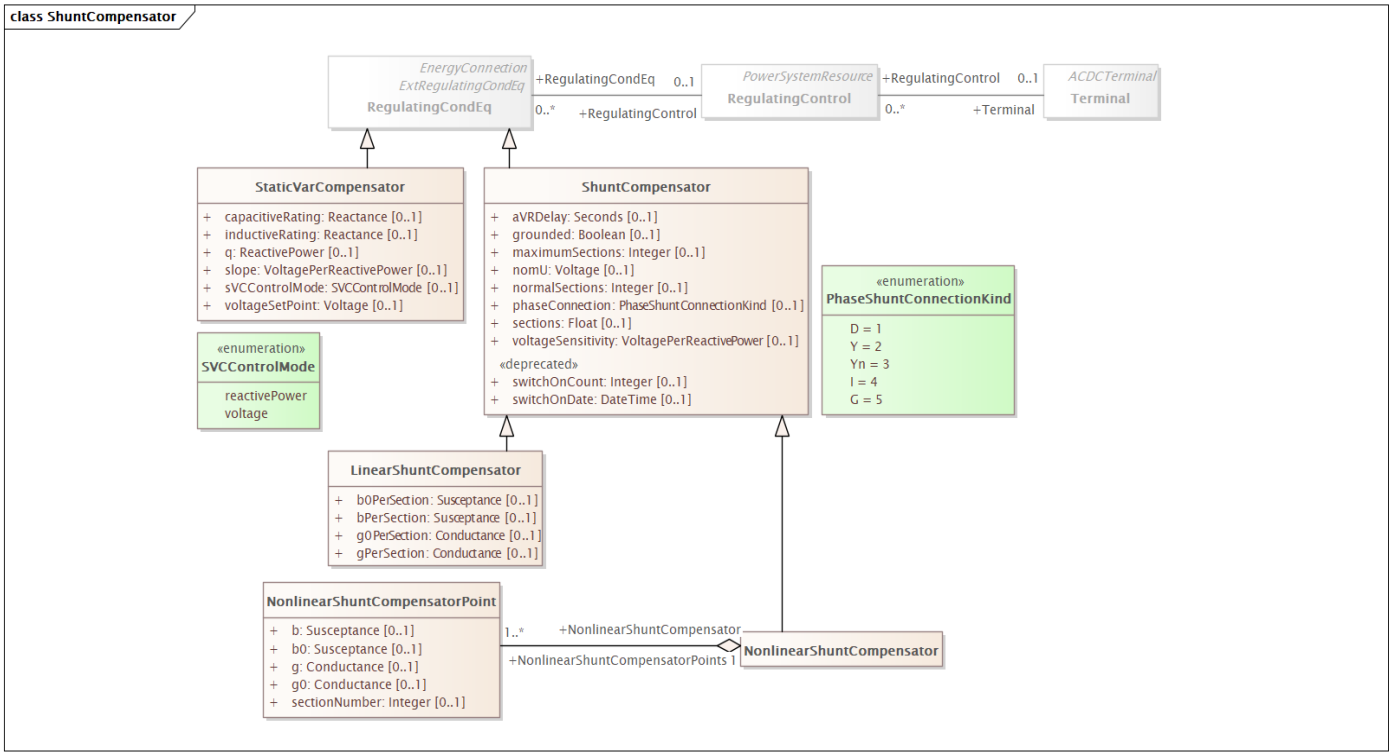
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>RegulatingCondEq

The GeneratingUnit diagram shows the classes that supply additional detail for generation modelling by providing generator physical characteristics:



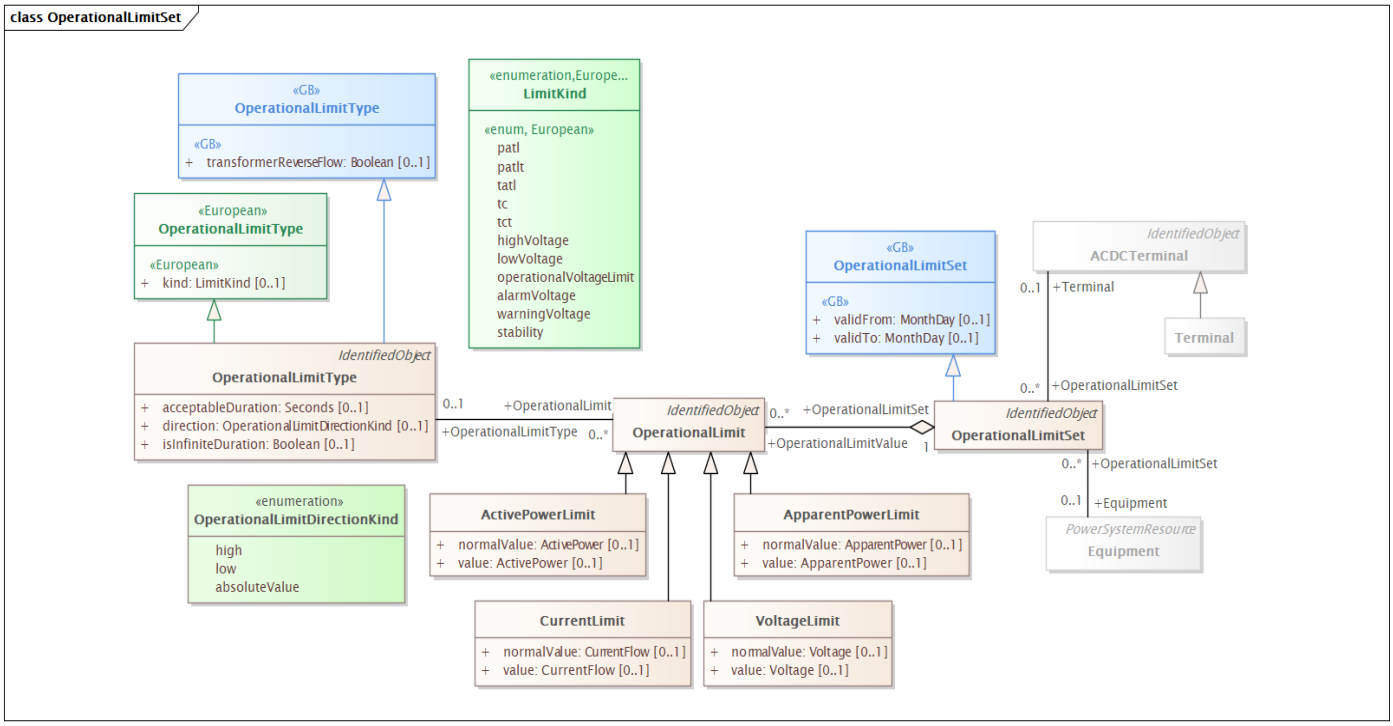
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>GeneratingUnit

The ShuntCompensator diagram shows the CIM classes which support shunt compensator and static VAr compensator modelling:



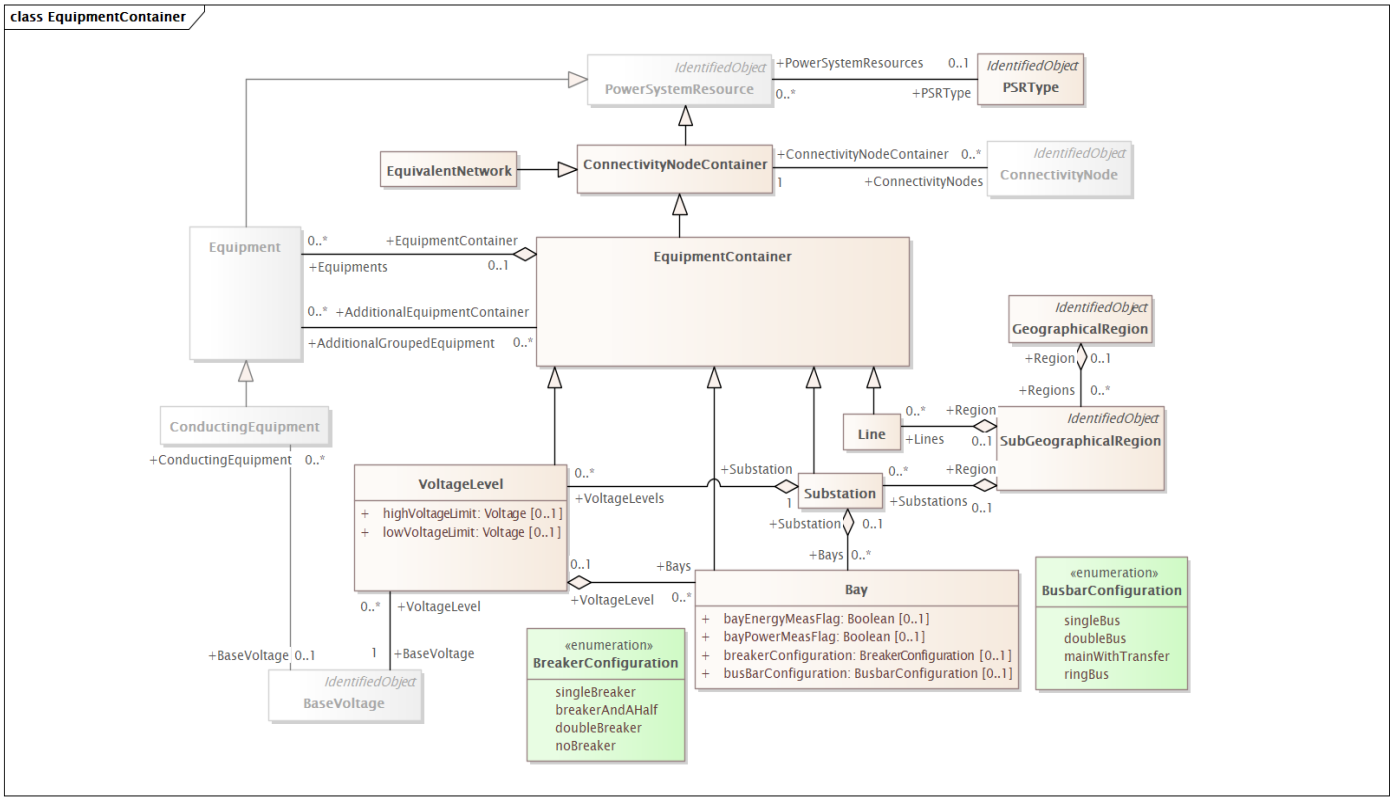
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>ShuntCompensator

The OperationalLimitSet diagram shows the CIM classes which support the modelling of limits:



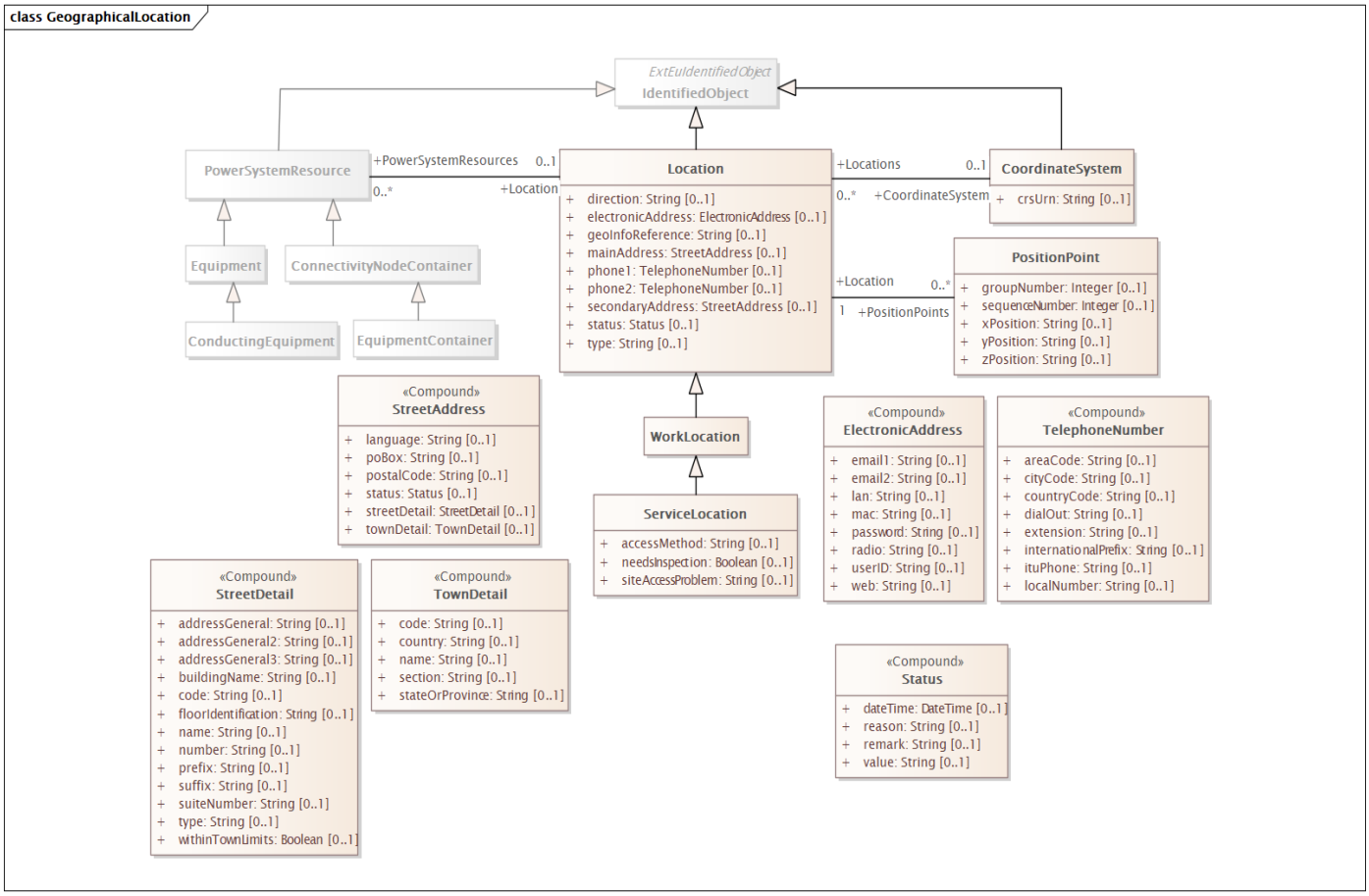
Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>OperationalLimitSet

The EquipmentContainer diagram shows the CIM classes which support the containment of grid equipment and connectivity nodes in facilities and regions:



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>EquipmentContainer

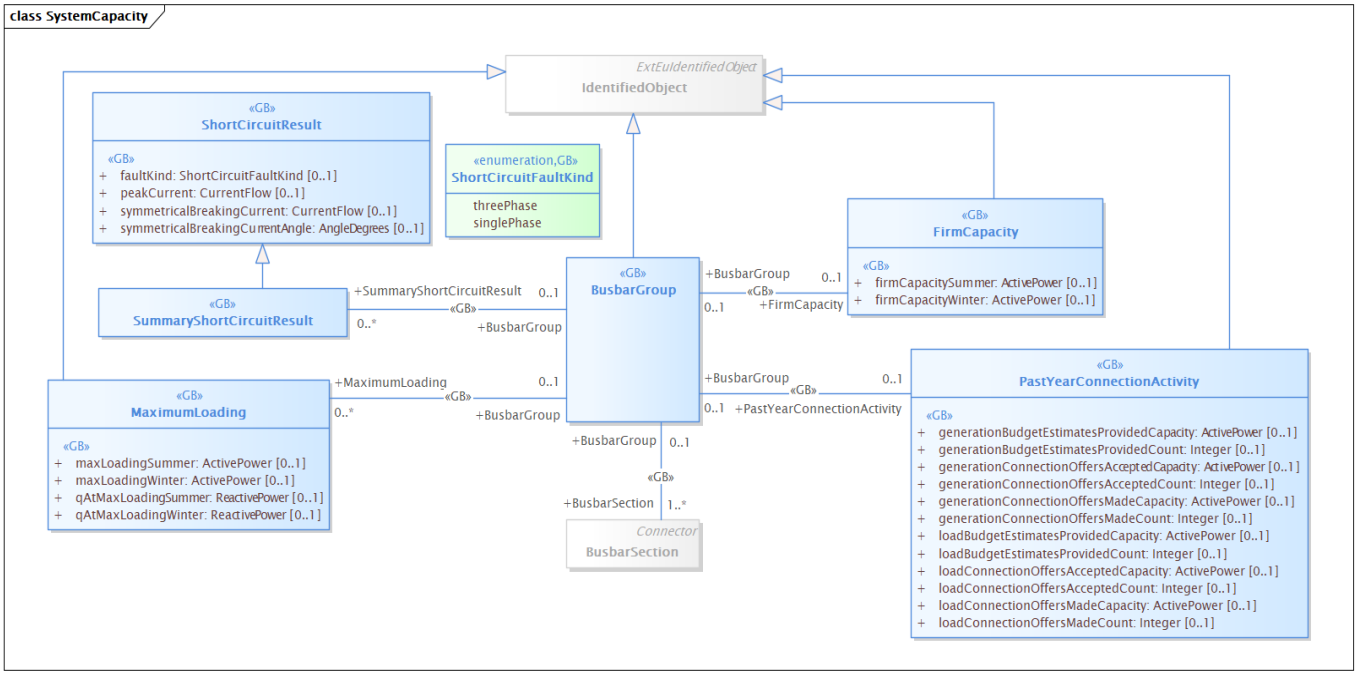
The GeographicalLocation diagram shows the CIM classes which describe the geospatial location of grid equipment and facilities:



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>GeographicalLocation

Diagram of classes describing system capacities

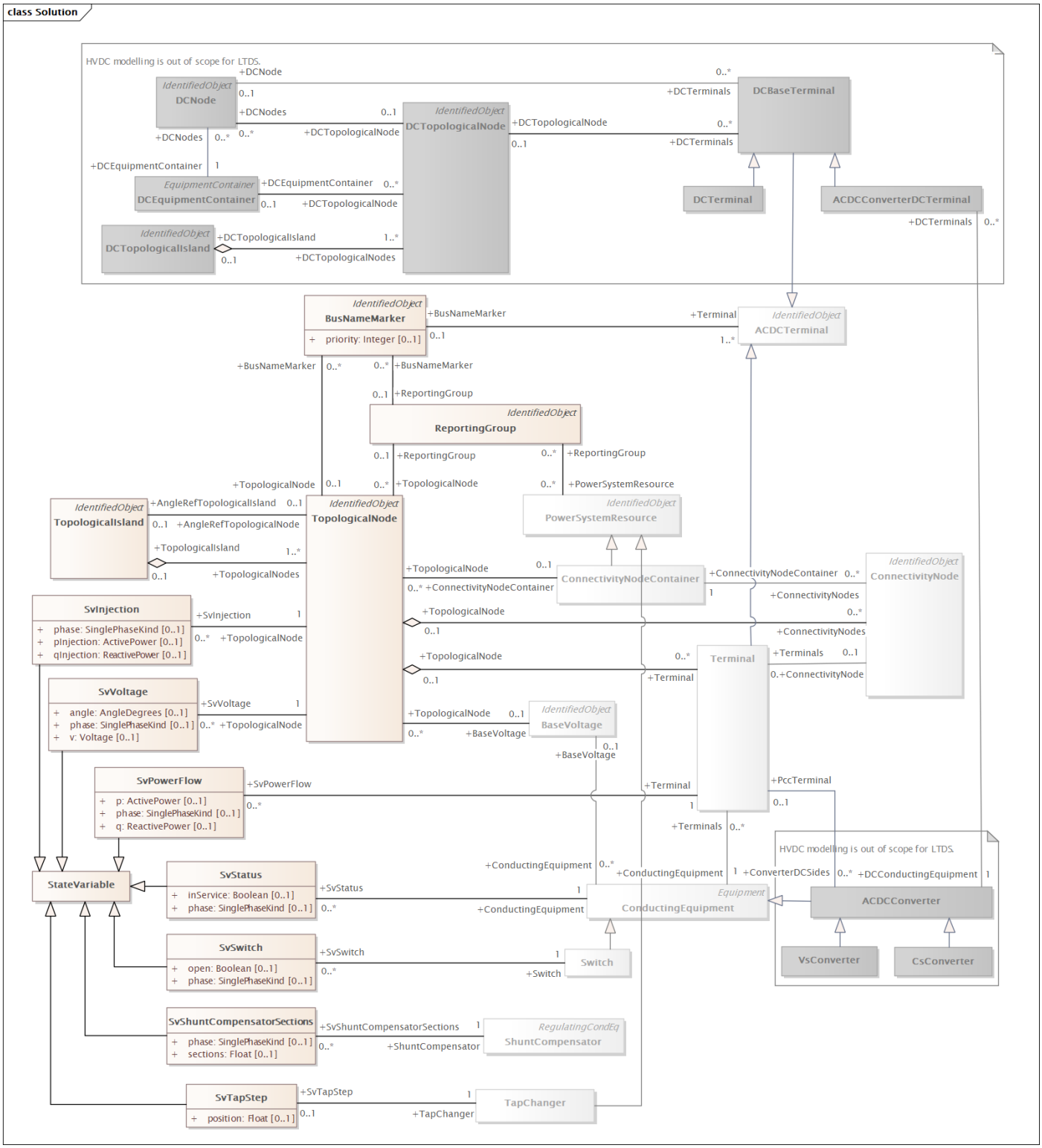
The SystemCapacity diagram shows the CIM classes which support the modelling of various types of capacity information and connection activity:



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>SystemCapacity

Diagram of classes describing power flow results

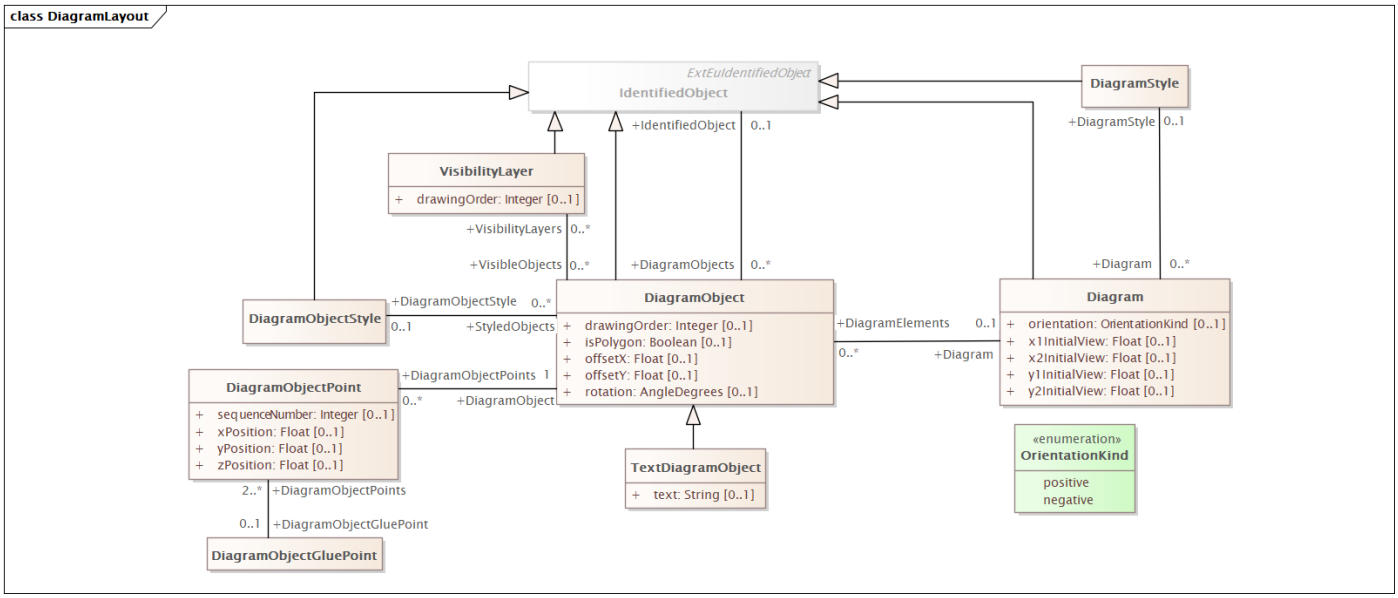
The Solution diagram shows the CIM classes which describe the outputs of topology processing and of power flow analysis:



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>Solution

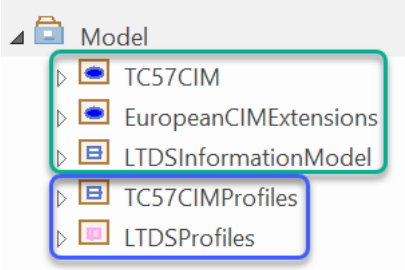
Diagram of classes describing display layout

The DiagramLayout diagram shows the CIM classes which describe the layout of CIM objects on diagrams:



Source: Appendix 1, LTDSInformationModel>LTDSInformationModelDiagrams>DiagramLayout

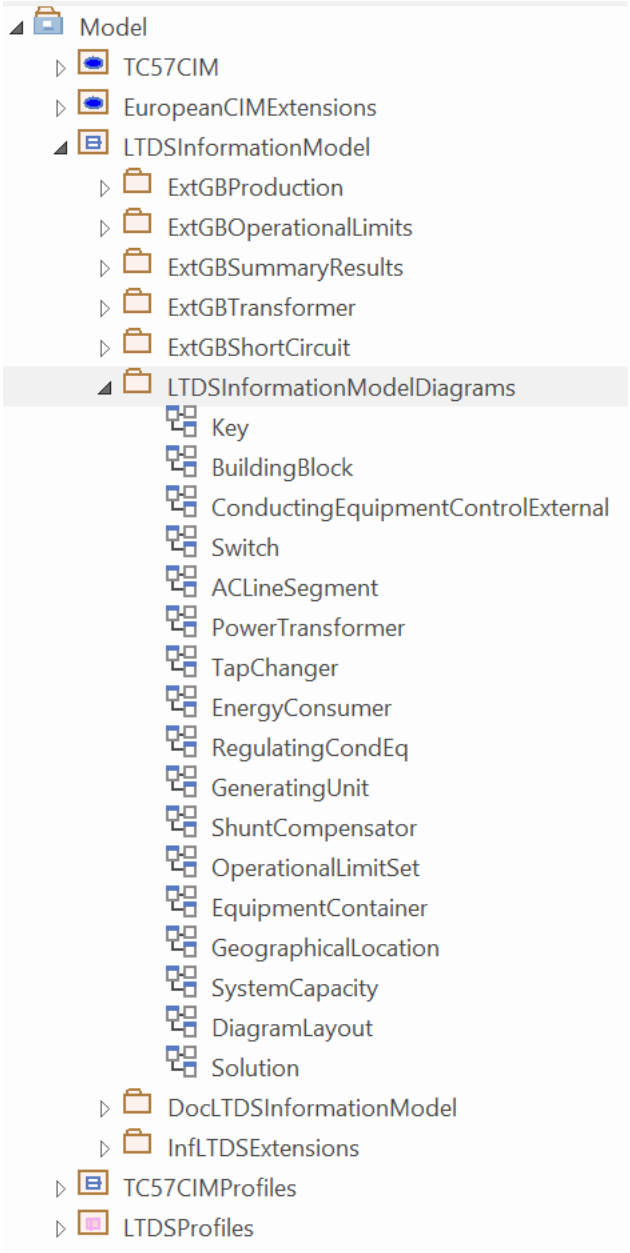
The CIM UML information model is maintained using Sparx System's Enterprise Architect tool[12]. The complete LTDS information model (including the underlying CIM information model, along with related European, Network Codes and Great Britain extensions) is provided as *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML.* It is an Enterprise Architect file which contains not only the LTDS information model, but also the LTDS profile in subpackages under the main Model:



The top three packages (boxed in green) comprise the information model, the lower 2 packages make up the profiles. In the green box, the TC57CIM package contains the underlying CIM information model, the EuropeanCIMExtensions package contains European and Network Codes extensions and the LTDSInformationModel package contains the Great Britain extensions defined for LTDS.

[12] Enterprise Architect | Sparx Systems

The diagrams pictured above are located in LTDSInformationModelDiagrams sub-package of the LTDSInformationModel package:



4 LTDS Data Exchange Definitions

4.1 CIM grid model profiles

CIM generally defines a profile as "a subset of the classes, attributes and associations of the information model". CIM exchanges of grid model data refine that definition a bit further and consider a profile to be "a non-overlapping subset of CIM classes, attributes and associations defined to organise grid model data and support its exchange". CIM grid model profiles organise grid model data primarily for the purpose of studies which involve power flow calculation, i.e., they describe exchanges which provide power flow inputs such as the physical model and the grid operating state as well as separate exchanges which provide power flow outputs.

The CIM grid model profiles, like the grid model-related portion of the CIM information model, contain a broader scope of information than is required by LTDS. The CIM profiles of relevance to LTDS and their groupings are as follows:

- The **Physical group** of profiles describes the grid itself, providing information about the behaviour, connectivity, and geospatial location of the equipment that makes up the electrical system. Profiles in the Physical group are:
  - The Equipment profile which describes basic equipment and connectivity and provides the foundation on which the data of the other Physical profiles are layered.
  - The Short Circuit profile which describes equipment electrical behaviour characteristics essential to the execution of short circuit studies.
  - The Geographical Location profile which describes the geospatial location of equipment, facilities, and load and generation.
- The **Situation group** of profiles describes a grid operating state and is used, in conjunction with foundational Physical data, as input to network analysis. It has a single profile:
  - The Steady State Hypothesis profile which represents load and generation injections, the operating state of the switching equipment and control settings.
- The **Solution group** of profiles describes the output resulting from a successful power flow execution. It has two profiles:
  - The Topology profile which describes the output of topology processing which eliminates closed switches and zero impedance branches.

- The State Variables profile which describes the output of a power flow calculation, including node voltage and angle and active and reactive power flows.

An additional profile, the Diagram Layout profile, describes the layout of CIM objects for visualisation on a display. It can reference objects and attributes from any of the other profiles.

4.2 Approach to LTDS profile development

IEC standard profiles of relevance to LTDS grid model data exchange are defined by the 61970-45x set of standards[13,14,15], the IEC 61968-13 standard[16], and the IEC 61970-600-2[17] standard. The usual approach to the definition of profiles for a specific implementation of CIM-based data exchange (like LTDS) is to start with a set of relevant IEC standard profiles and modify them as necessary to meet local requirements. The LTDS profile development process followed this philosophy, but did so using an unusually rigorous methodology, in which each LTDS profile was defined as a "delta" from an underlying CGMES v3.0 standard profile. As a result, developers and data modellers using the LTDS profiles are provided with a clear, concise identification of changes from a known existing profile. This approach is intended to ease initial implementation efforts and facilitate longer term solution evolution.

The standard CGMES v3.0 exchange profiles – as expressed in IEC 61970-600-2 - were selected as the underlying standard profiles for a variety of reasons:

- The CGMES v3.0 profiles align very closely with the IEC 61970-45x set of standards and incorporate relevant modelling (primarily related to geographical location) from IEC 61968-13.
- There is continuous ongoing CIM and CGMES alignment activity occurring within IEC with support from ENTSO-E community via the established formal liaisons.
- The CGMES standards are intended to meet the requirements specified in European Network Codes.
- CGMES v3.0 is the most recent, approved version of the CGMES standard, correcting a number of issues present in earlier versions.

[13] IEC 61970-452:2021 | IEC Webstore
[14] IEC 61970-453:2014+AMD1:2018 CSV | IEC Webstore
[15] IEC 61970-456:2021 | IEC Webstore
[16] IEC 61968-13:2021 | IEC Webstore
[17] IEC 61970-600-2:2021 | IEC Webstore

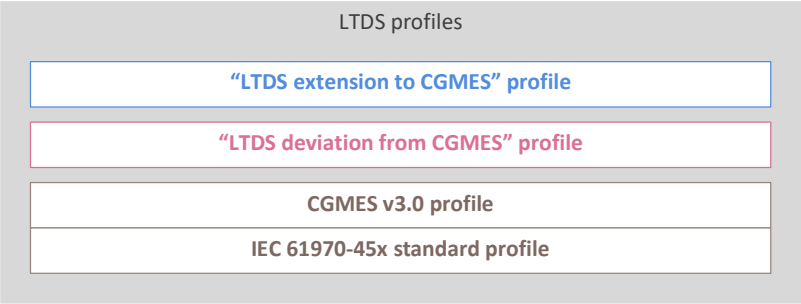
- Interfaces based on CGMES v3.0 are implemented on several vendor tools (and the clear expression of differences will enable those tools to more easily accommodate LTDS data).
- The use of CGMES v3.0 enables the future evolution of LTDS to take advantage of European advancements.

It is hoped that expressing LTDS profiles as deltas from CGMES v3.0 profiles will set a precedent for the definition of other local CIM-based profiles, particularly in the United Kingdom. If used widely, this approach to profile definition has the potential to make data more accessible and tools more interoperable across Europe.

The definition of LTDS profiles as deltas to CGMES v3.0 is accomplished via a "layered" approach not unlike the layered approach to information model definition described above. Two LTDS "difference" profiles are defined for each CGMES v3.0 profile:

- An "LTDS deviation from CGMES" profile, which describes differences from the data structure defined in a CGMES v3.0 profile.
- An "LTDS extension to CGMES" profile, which describes additional data structures not defined by a CGMES v3.0 profile.

The complete profile stack (including the CIM standard profiles on which CGMES v3.0 profiles are based) looks like this:



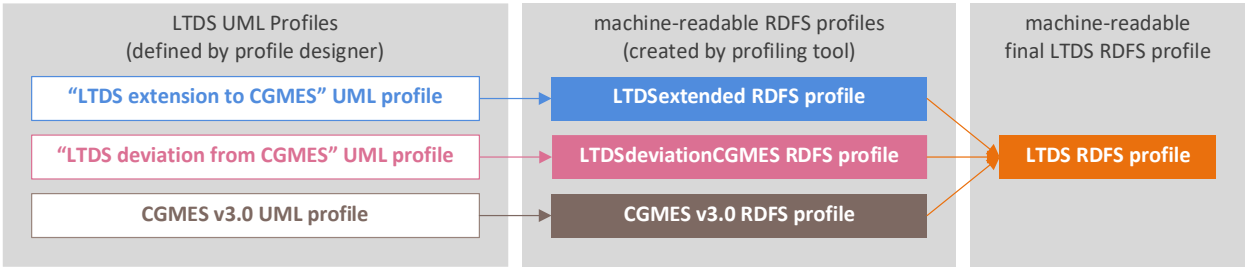
While the layered approach offers significant benefits, it is not an approach that has been used elsewhere, so tooling has not (yet) been specifically developed to support it. The LTDS layered profiles were defined primarily using existing tooling, but there is an area where future tool development would be useful. A bit of background information is necessary to understand where the additional tooling support is needed.

Several profiling tools, among them CimConteXtor[18], use UML as the mechanism by which a profile designer specifies the information model subset comprising a profile. (CimConteXtor

[18] CimContextor | Zamiren

is the most widely used profiling tool in Europe and is an add-in to the Sparx Enterprise Architect application.) Other profiling tools leverage mechanisms other than UML to express profile design. Regardless of the mechanism used for design, once profile design is complete, the profiling tool produces a machine readable version of the profile expressed in Resource Definition Framework Schema (RDFS). (As an example, after a profile is designed in CimConteXtor, an RDFS description of it is created by a companion tool called CimSyntaxGen[19].) The IEC 61970-501 standard[20] describes the mapping of CIM grid model profiles expressed in UML to their RDFS equivalents.

In LTDS profile definition, the three individual profiles (CGMES v3.0, LTDS deviation from CGMES, and LTDS extension to CGMES) are first defined in UML and then each is expressed in RDFS. The rules regarding the changes to be made to the underlying RDFS profile by applying the two "difference" RDFS profiles are clear and can be implemented by a "profile merging" software tool. A beta version of a profile merging tool (called CimPal and available here: https://github.com/griddigit/CimPal) has been created and was used to produce a complete set of final LTDS RDFS profiles.



The final merged LTDS RDFS profiles are included, along with the CGMES v3.0 RDFS profile and the two difference RDFS profiles, in Grid Modelling Appendix 3 – LTDS Profiles in RDFS .

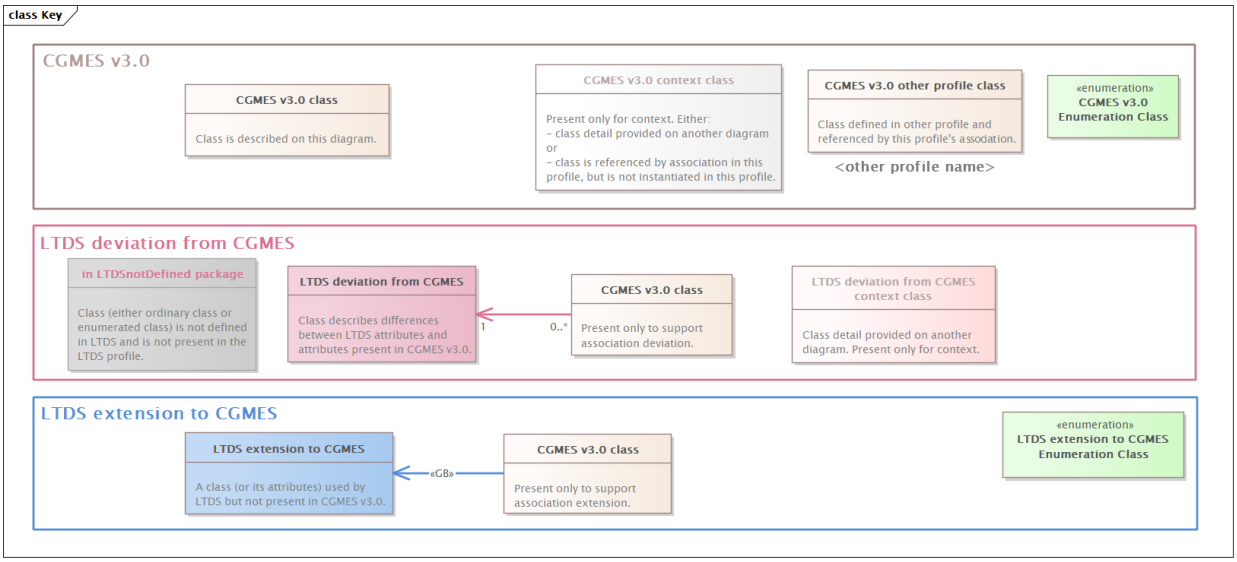
The expression of merged LTDS profiles in UML is the area where additional tooling support would be useful. The beta profile merging software works sufficiently well to support the use of LTDS profiles in LTDS grid model data exchanges, but a means of creating a merged profile in UML would be helpful. It would provide a human-understandable profile definition which could then be used as the direct source for a machine-generated final RDFS profile.

[19] CimSyntaxGen | Zamiren
[20] IEC 61970-501:2006 | IEC Webstore

4.3 LTDS layered profiles in UML

This section contains a set of UML diagrams which detail the layered profiles used to structure LTDS data exchanges. Because UML does not exist for merged profiles, each diagram shows the related portions of all layers, to allow the reader to envision the content of the merged profile.

Each diagram illustrates a base CGMES v3.0 UML profile (or portion of a profile) along with its two corresponding LTDS "difference" profiles (LTDS deviation from CGMES and LTDS extension to CGMES). The diagram layers are illustrated in the Key diagram below.



The upper layer shows the CGMES v3.0 profile classes, attributes and associations. The middle layer shows the LTDS deviations from the upper layer:

- Classes (of any kind, including <<enumeration>> classes) which are eliminated completely in creating the merged LTDS profile are shown in grey. Eliminating a class eliminates all of its associations, whether or not the association is shown.
- Classes where CGMES v3.0 attribute requirements are modified when the merged LTDS profile is created are shown in pink. Modifications take one of three forms:
    - Attribute exists in CGMES v3.0 and is not defined in LTDS (these are indicated with an <<LTDSnotDefined>> stereotype)
    - Attribute is required in CGMES v3.0 and is optional in LTDS (the usual convention of [0..1] after the attribute name indicates this)
    - Attribute is optional in CGMES v3.0 and is required in LTDS (the usual convention of nothing after the attribute name indicates this)

The lower layer shows the LTDS extensions to the upper layer, with classes and/or attributes to be added in creating the merged LTDS profile indicated in blue. Associations to be added are indicated by blue association lines.

The UML profile diagrams below describe the complete set of LTDS layered profiles. The diagrams are copied from *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML* and the path of the diagram within the UML model is noted below each diagram.

The diagrams appear in the following order:

- Diagrams of the Physical profile group:
  - Equipment and Short Circuit profile diagrams of building block classes
  - Equipment and Short Circuit profile diagrams of general equipment, control and external modelling classes
  - Equipment and Short Circuit profile diagrams of switch-related classes
  - Equipment and Short Circuit profile diagrams of circuit-related classes
  - Equipment and Short Circuit profile diagrams of transformer-related classes
  - Equipment profile diagram of transformer tap changer-related classes
  - Equipment profile diagram of load-related classes
  - Equipment and Short Circuit profile diagrams of generation-related classes (3 diagrams)
  - Equipment and Short Circuit profile diagram of shunt and static VAr compensator-related classes
  - Equipment profile diagram of limits-related classes
  - Equipment profile diagram of containment-related classes
  - Geographical Location profile diagram of geospatial location-related classes
- Diagrams of the Situation profile group:
  - Steady State Hypothesis profile diagram of building block classes
  - Steady State Hypothesis profile diagram of control and external modelling classes
  - Steady State Hypothesis profile diagram of switch-related classes
  - Steady State Hypothesis profile diagram of transformer tap changer-related classes
  - Steady State Hypothesis profile diagram of load-related classes
  - Steady State Hypothesis profile diagrams of generation-related classes (2 diagrams)
  - Steady State Hypothesis profile diagram of shunt and static VAr compensator-related classes
  - Steady State Hypothesis profile diagram of limits-related classes
- Diagrams of the Solution profile group:
  - A Topology profile diagram of classes describing the output of topology processing

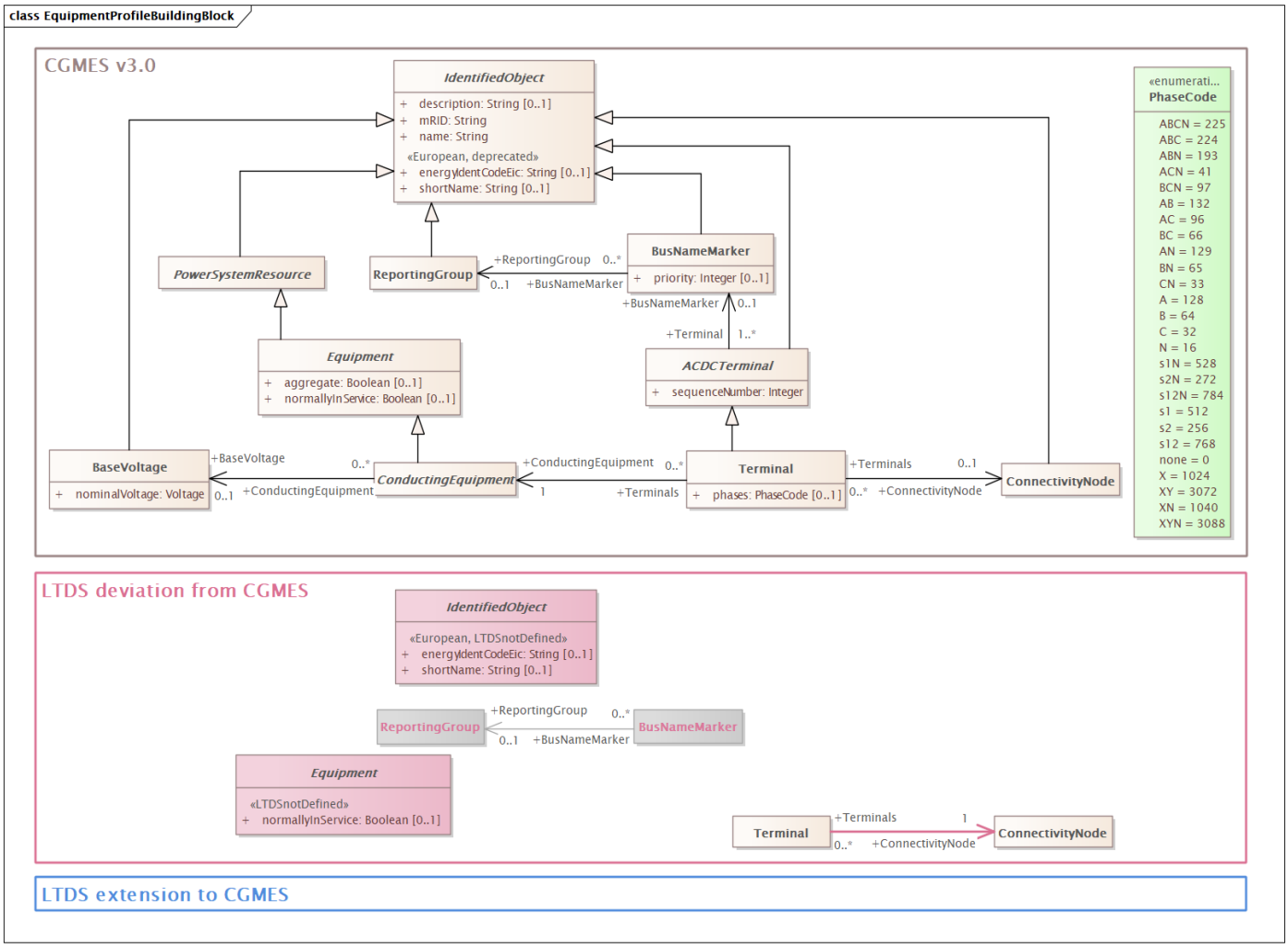
- A State Variables profile diagram of power flow solution-related classes

- A diagram of the System Capacity profile (an LTDS-extension profile with classes describing system fault levels, loadings and capacities, along with connection activity)
- A diagram of the Diagram Layout profile classes

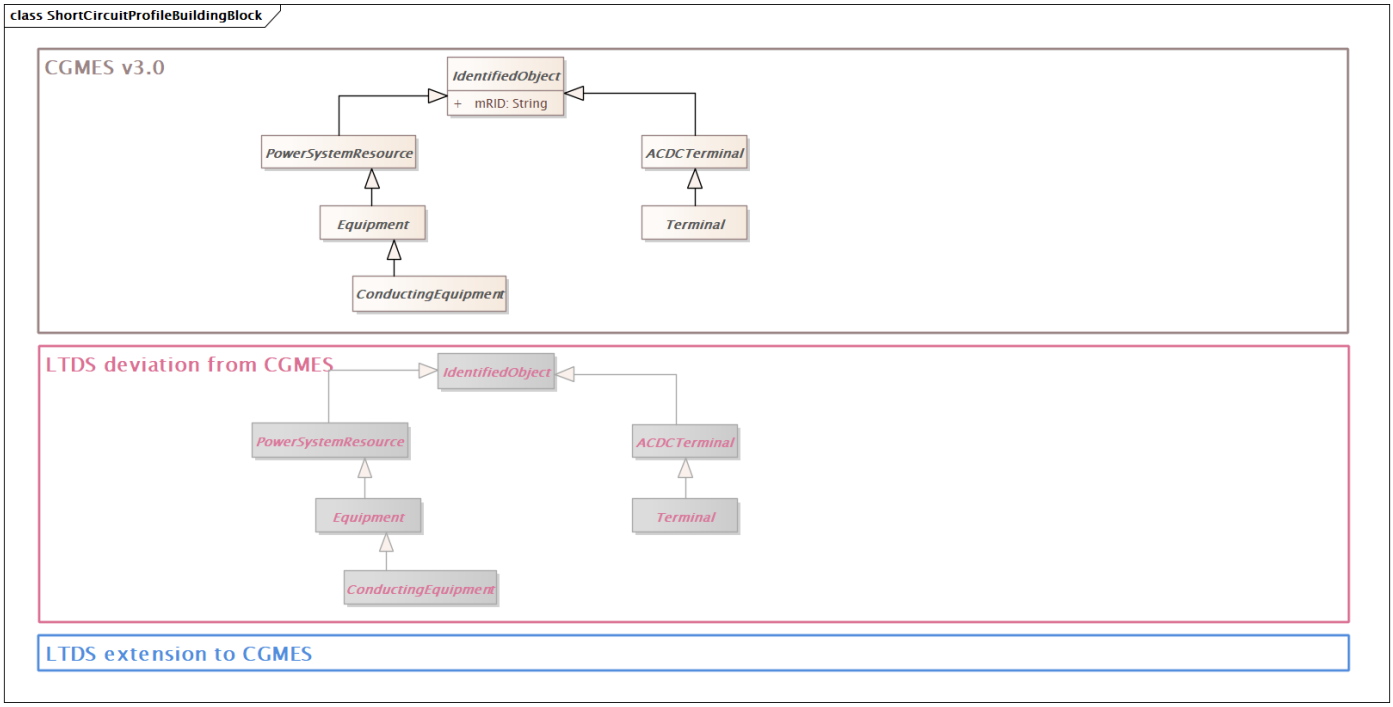
4.3.1 Physical profile group

Taken as a whole, the 20 diagrams of this section describe the LTDS Equipment, Short Circuit and Geographical Location profiles.

These diagrams show the basic building block portions of the Equipment and Short Circuit profiles:

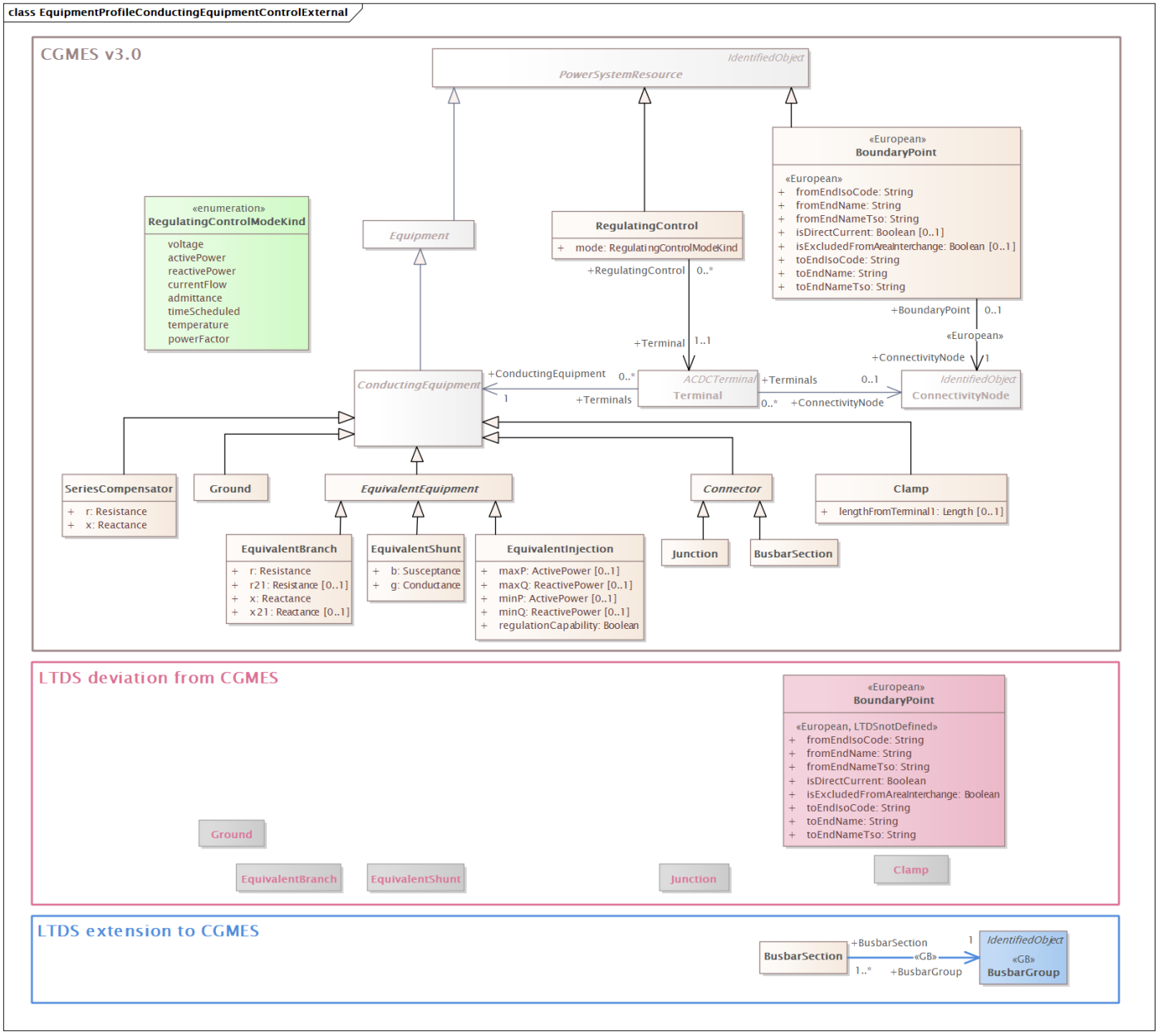


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileBuildingBlock

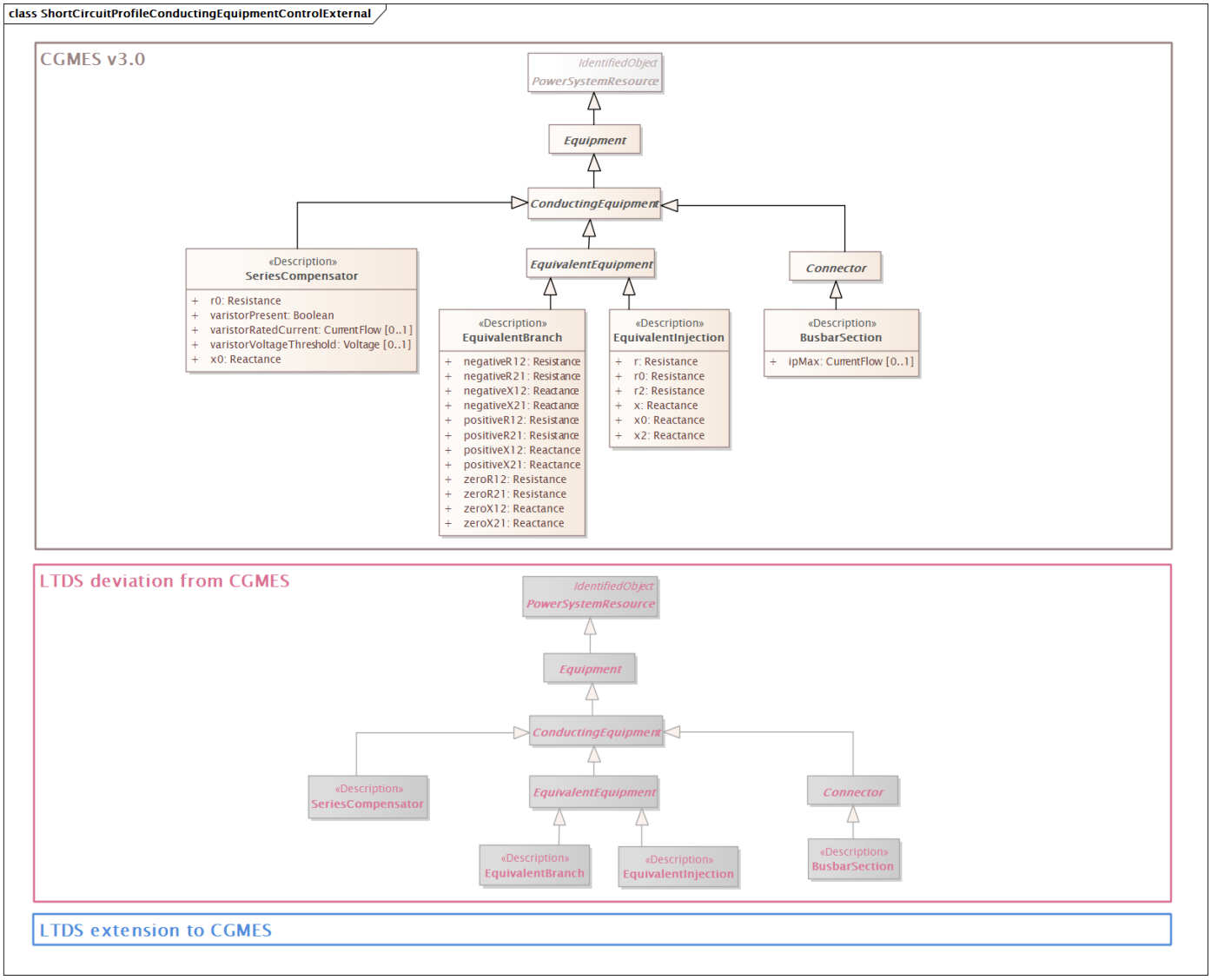


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileBuildingBlock

These diagrams show the portions of the Equipment and Short Circuit profiles which support general equipment, control and external modelling:

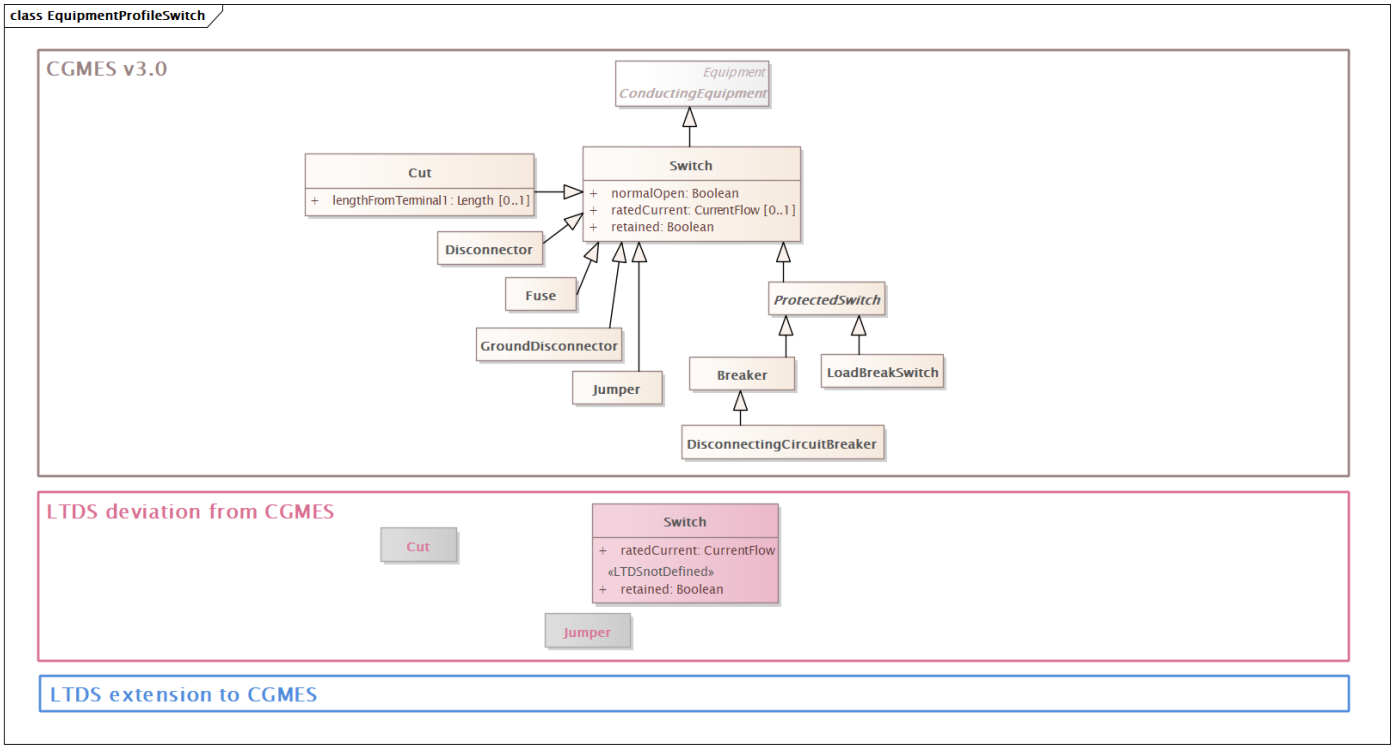


Source: Appendix 1,
LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileConductingEquipmentControlExternal

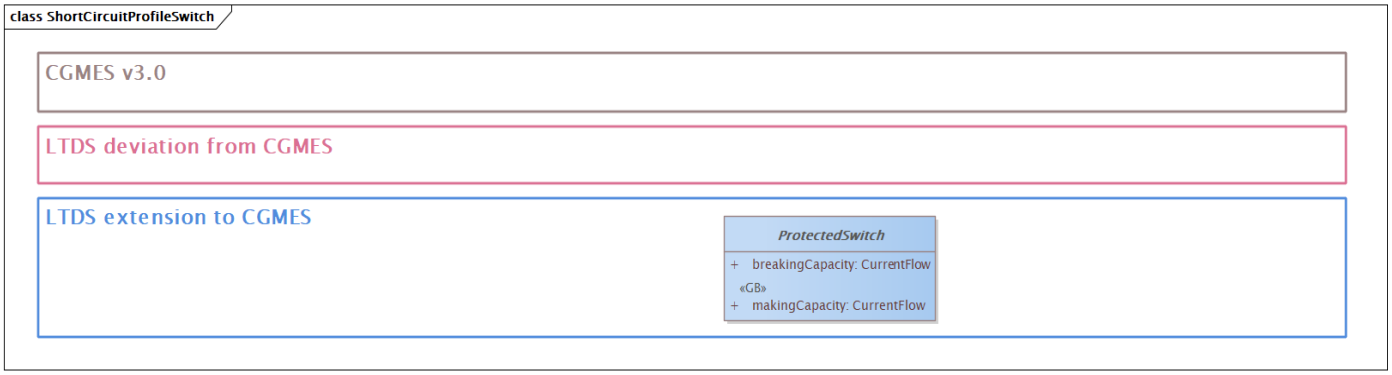


Source: Appendix 1,
LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileConductingEquipmentControlExternal

These diagrams show the switching device-related portion of the Equipment and Short Circuit profiles:

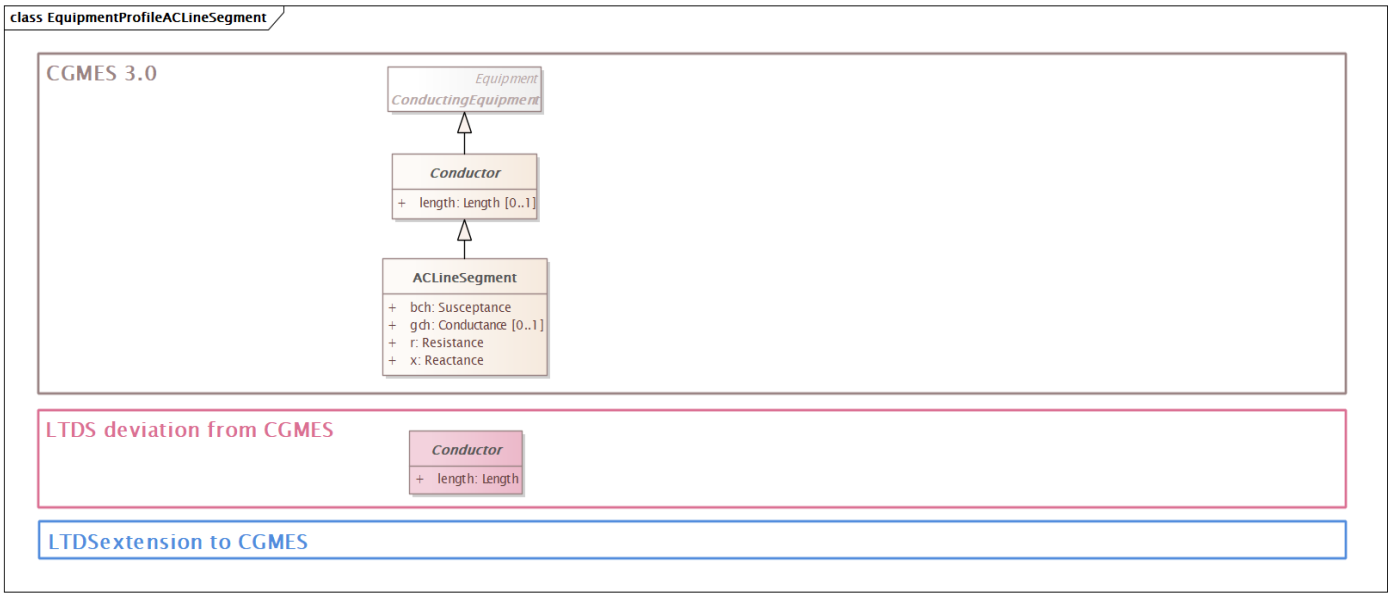


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileSwitch

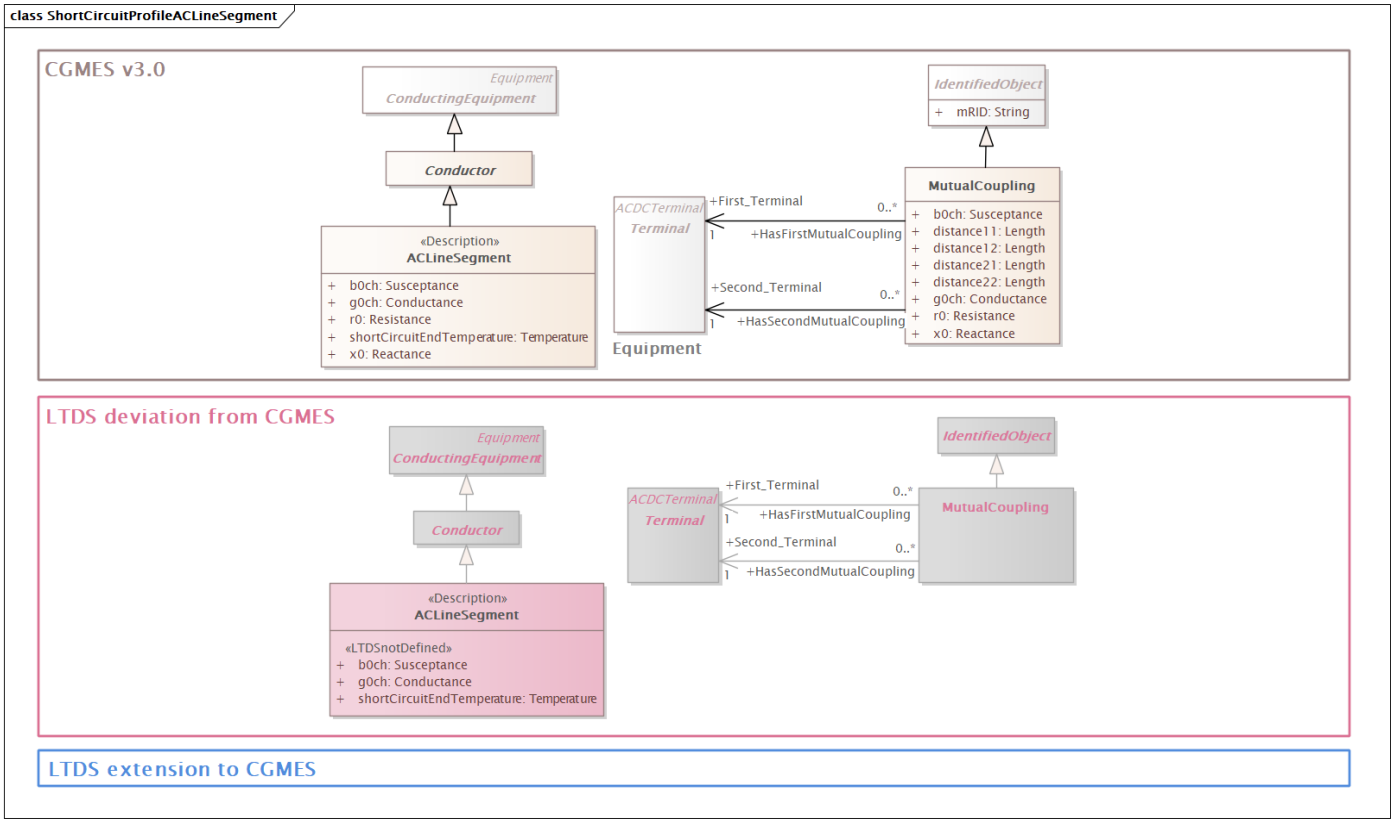


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileSwitch

These diagrams show the circuit-related portion of the Equipment and Short Circuit profiles:

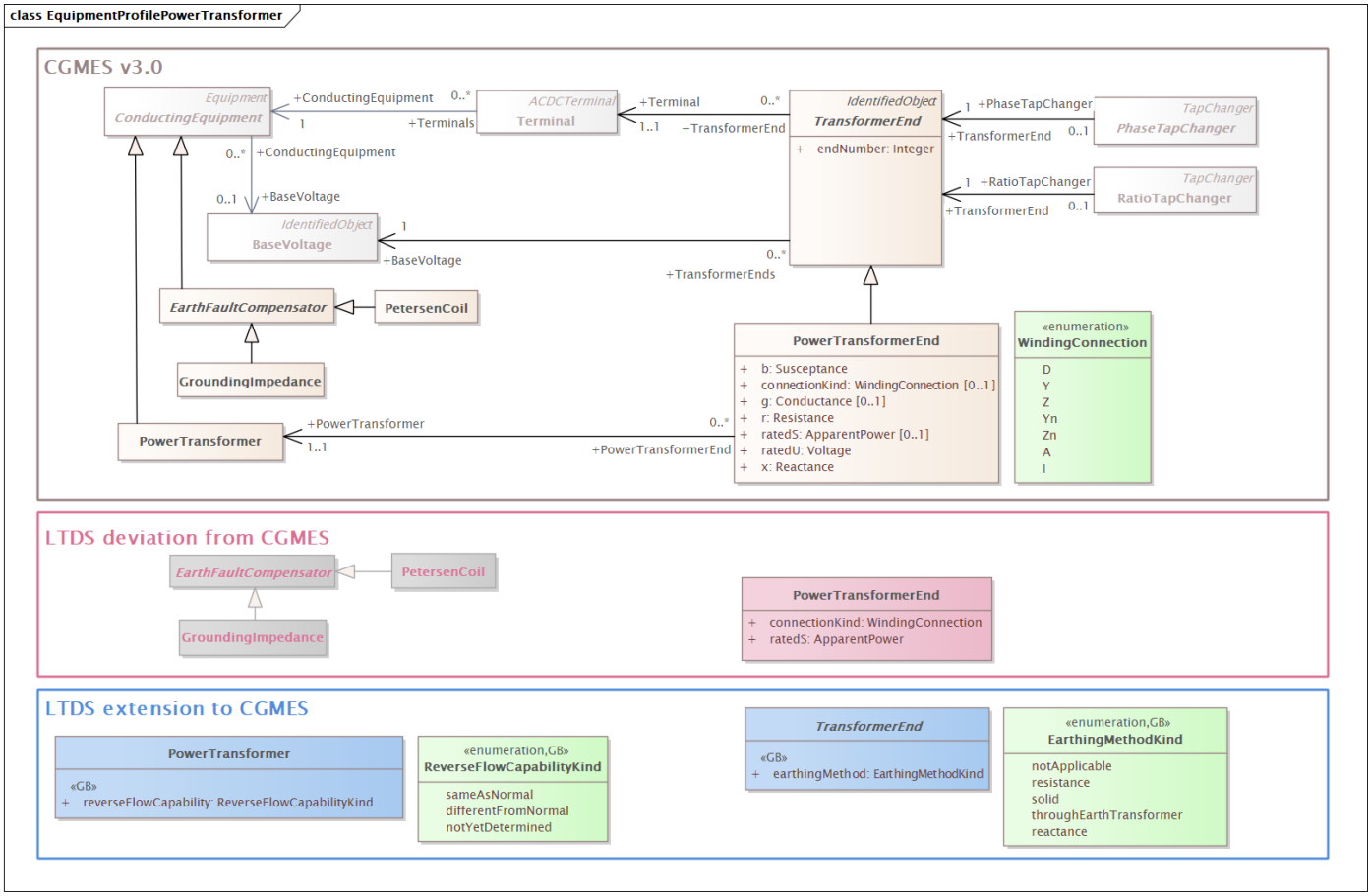


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileACLineSegment

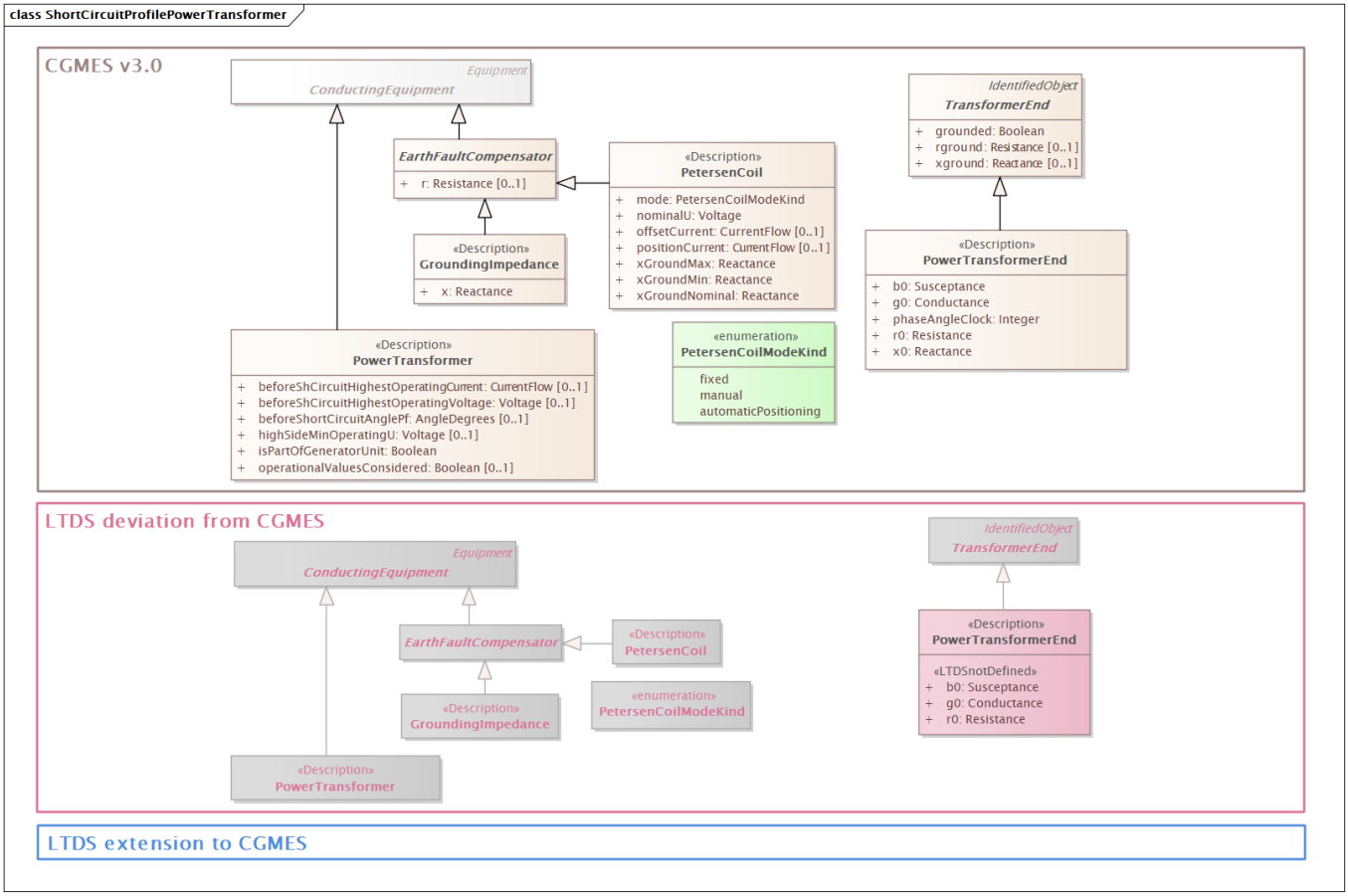


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileACLineSegment

These diagrams show the transformer-related portion of the Equipment and Short Circuit profiles:

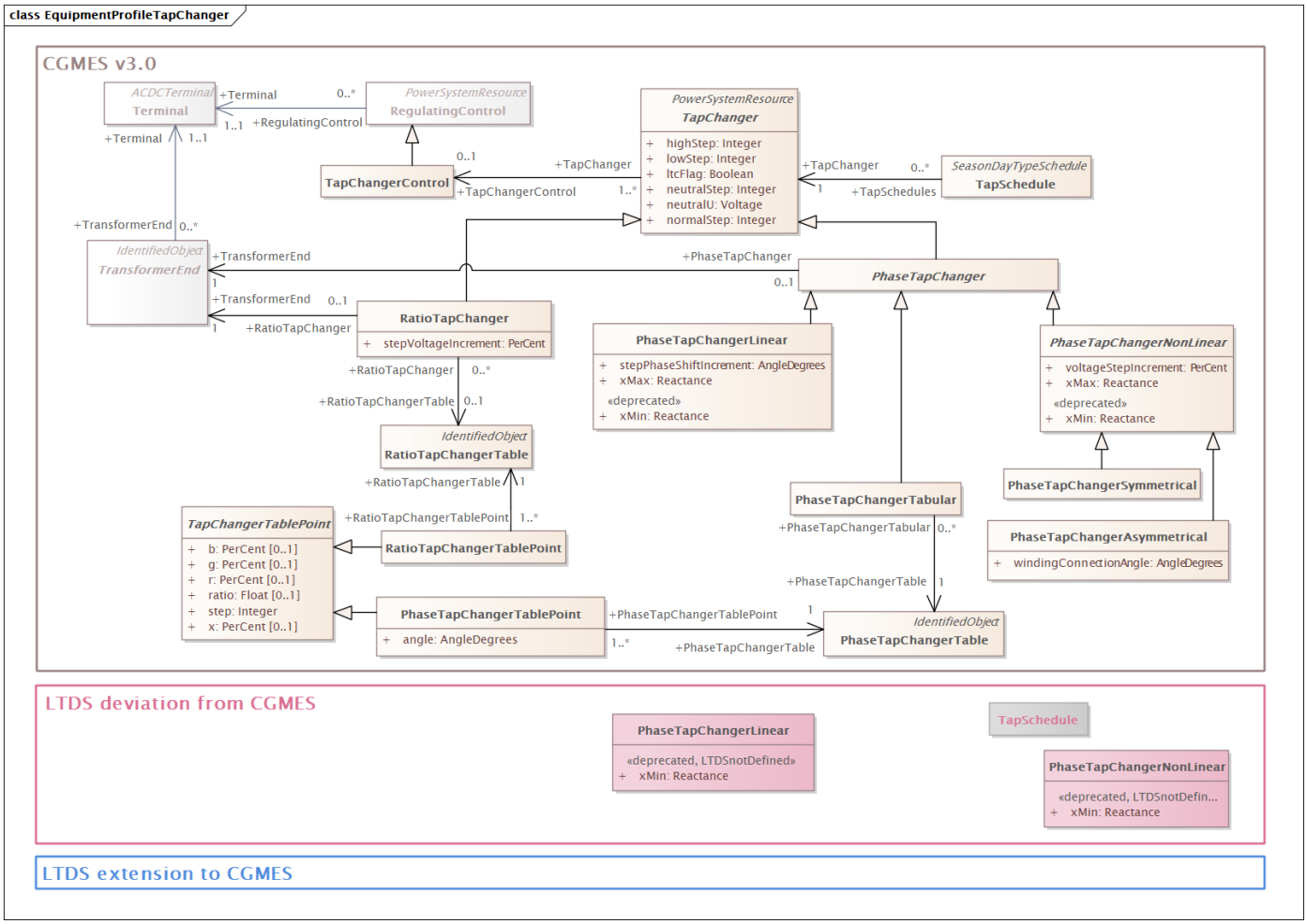


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfilePowerTransformer



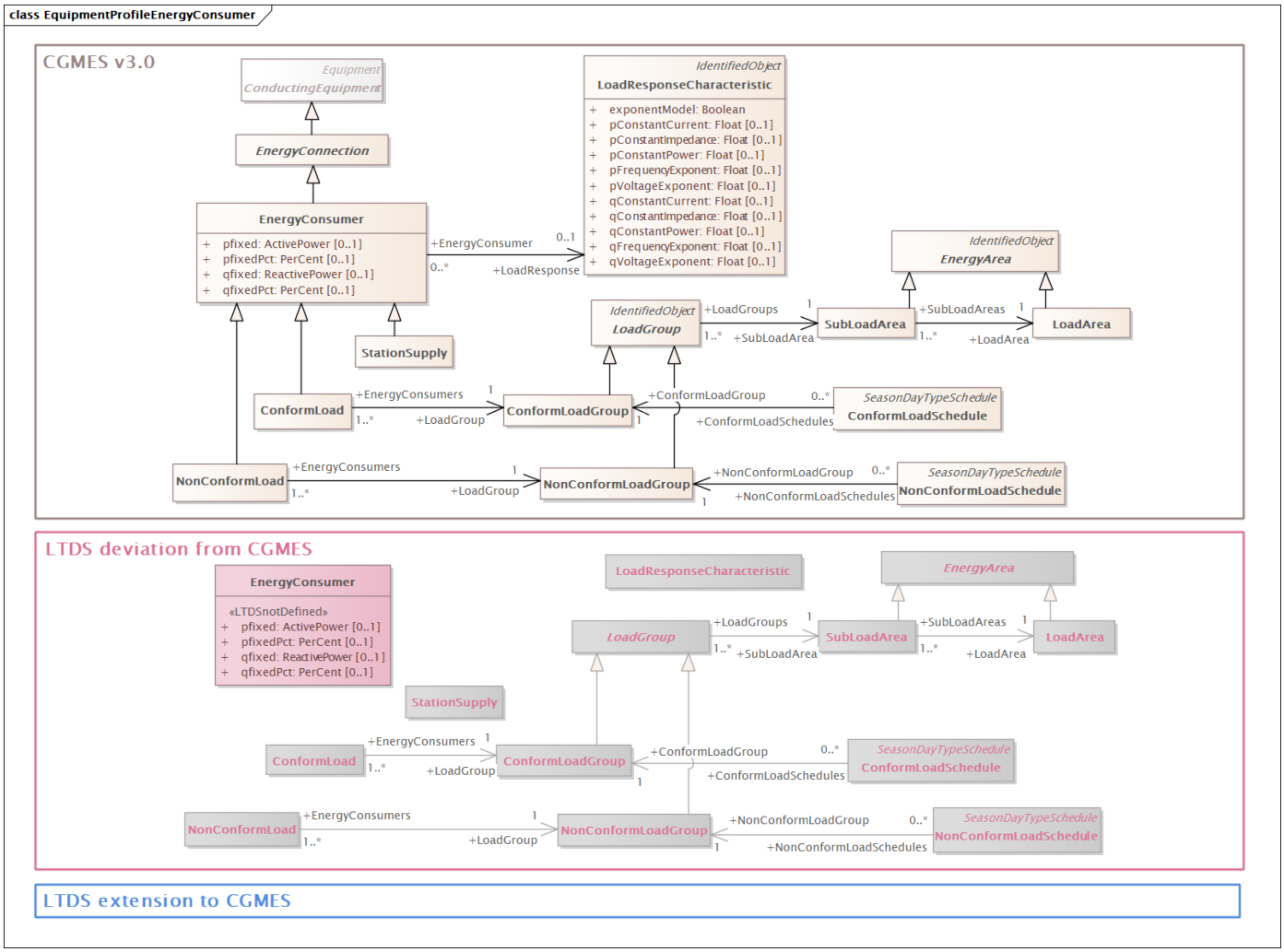
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfilePowerTransformer

This diagram shows the transformer tap changer-related portion of the Equipment profile:



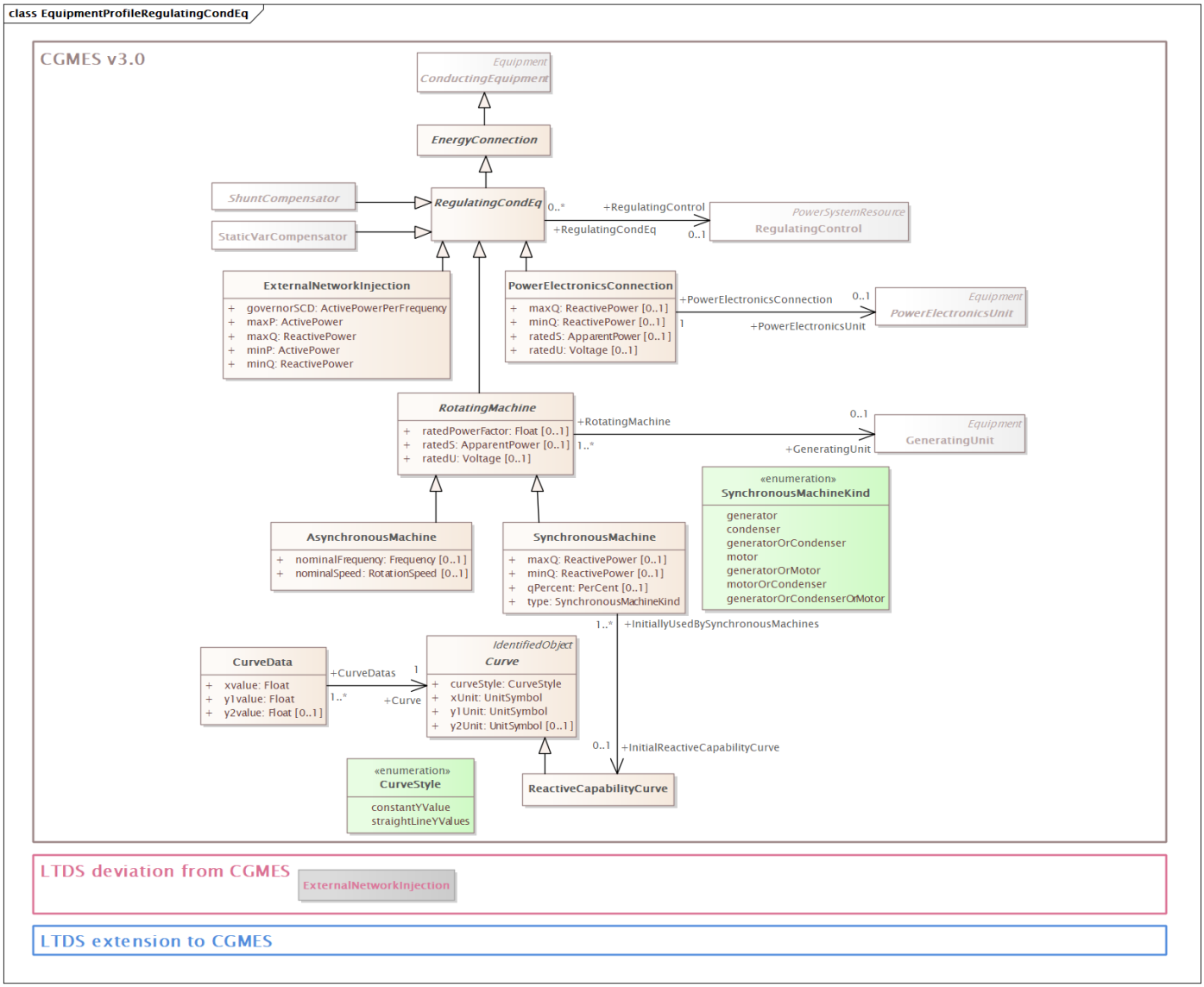
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileTapChanger

This diagram shows the load-related portion of the Equipment profile:

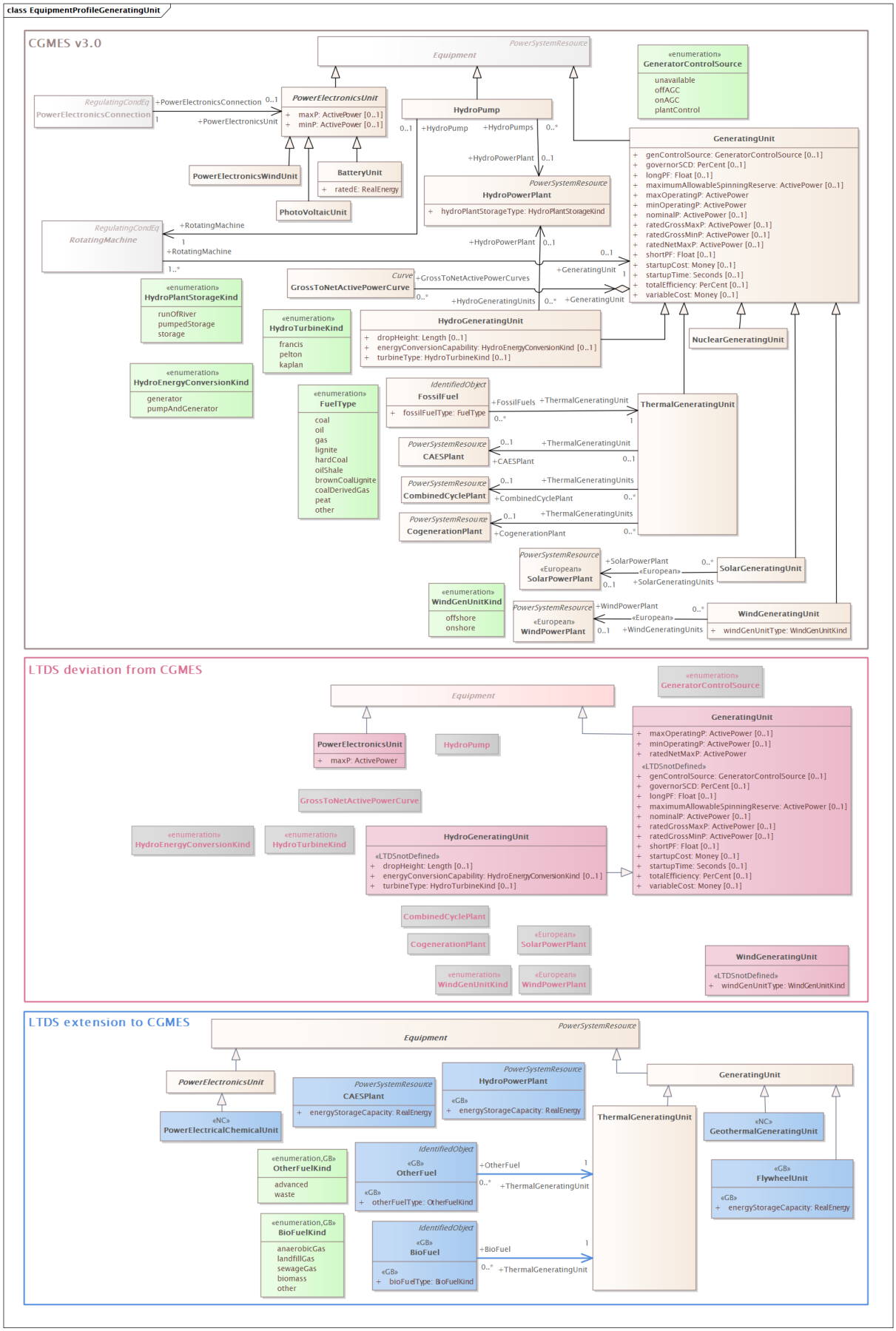


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileEnergyConsumer

These diagrams show the generation-related portion of the Equipment profile:

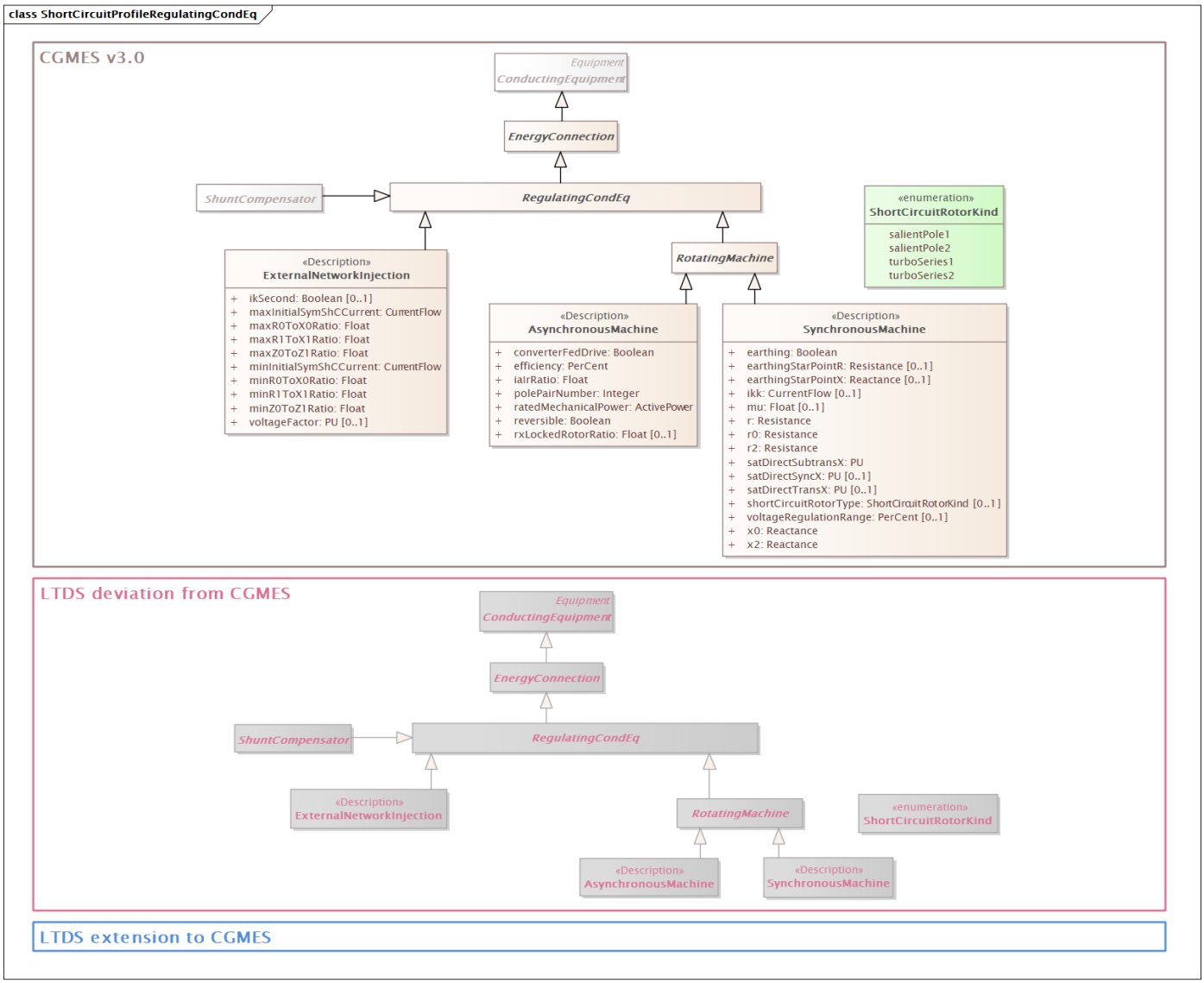


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileRegulatingCondEq



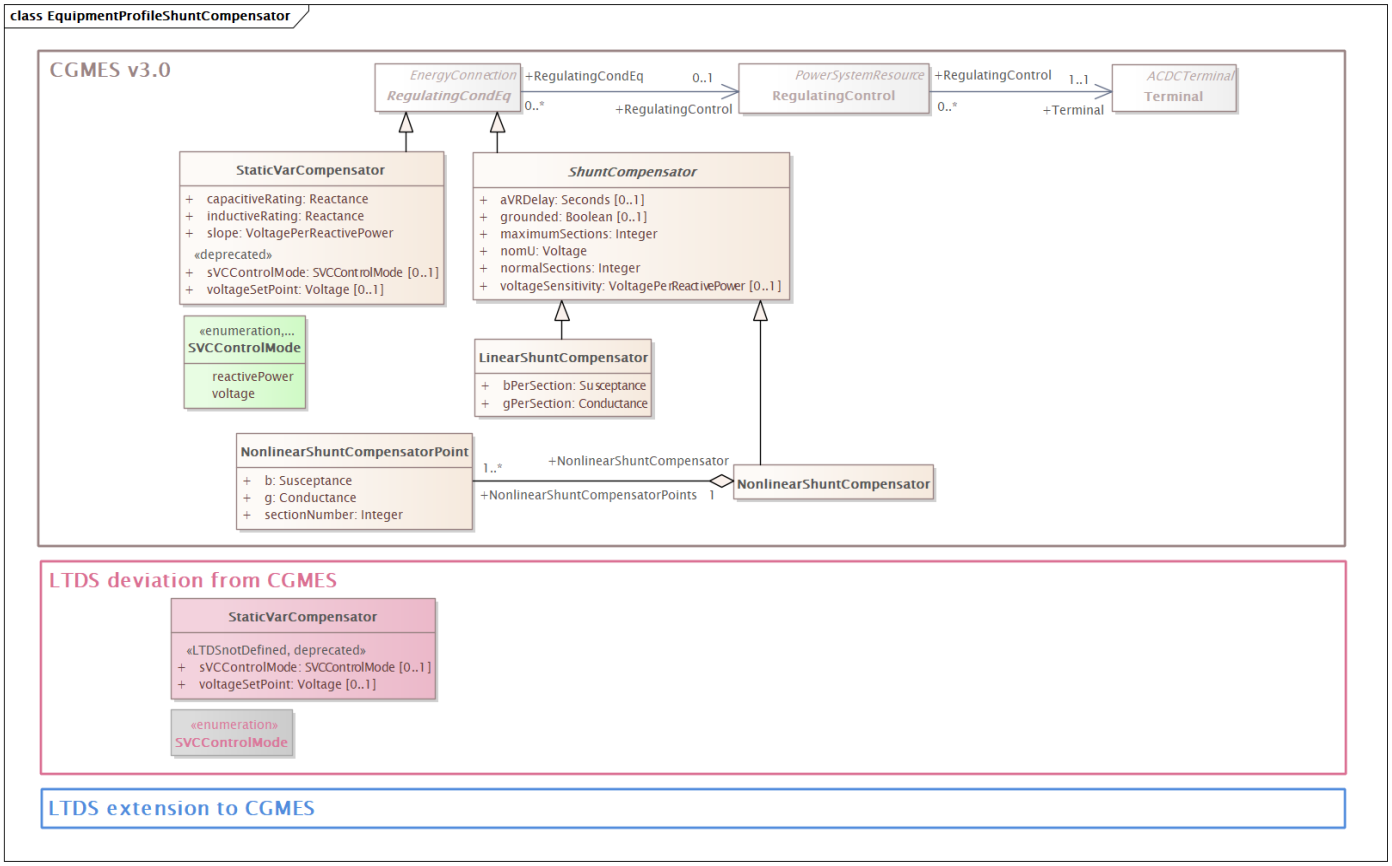
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileGeneratingUnit

This diagram shows the generation-related portion of the Short Circuit profile:

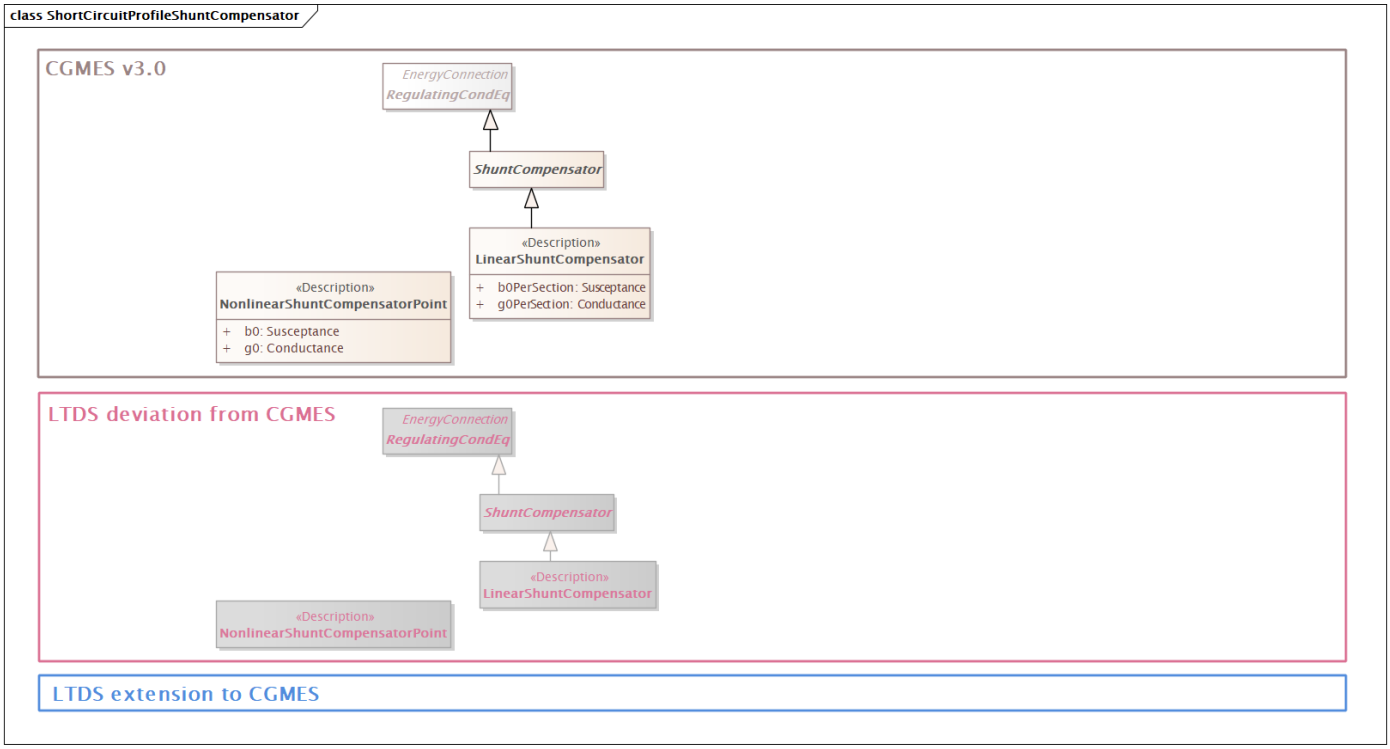


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileRegulatingCondEq

These diagrams show the shunt and static VAr compensator-related portions of the Equipment and Short Circuit profiles:

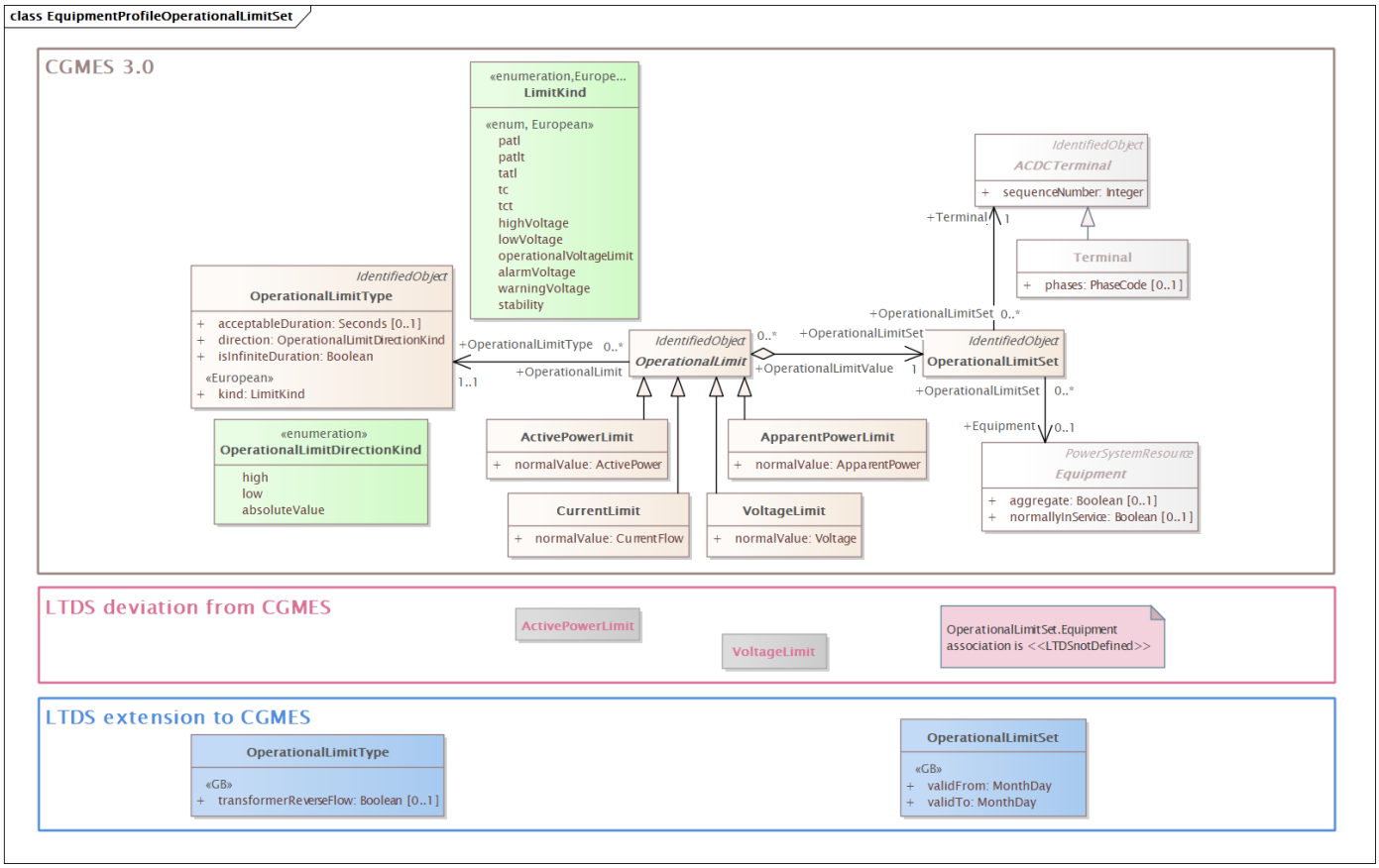


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileShuntCompensator



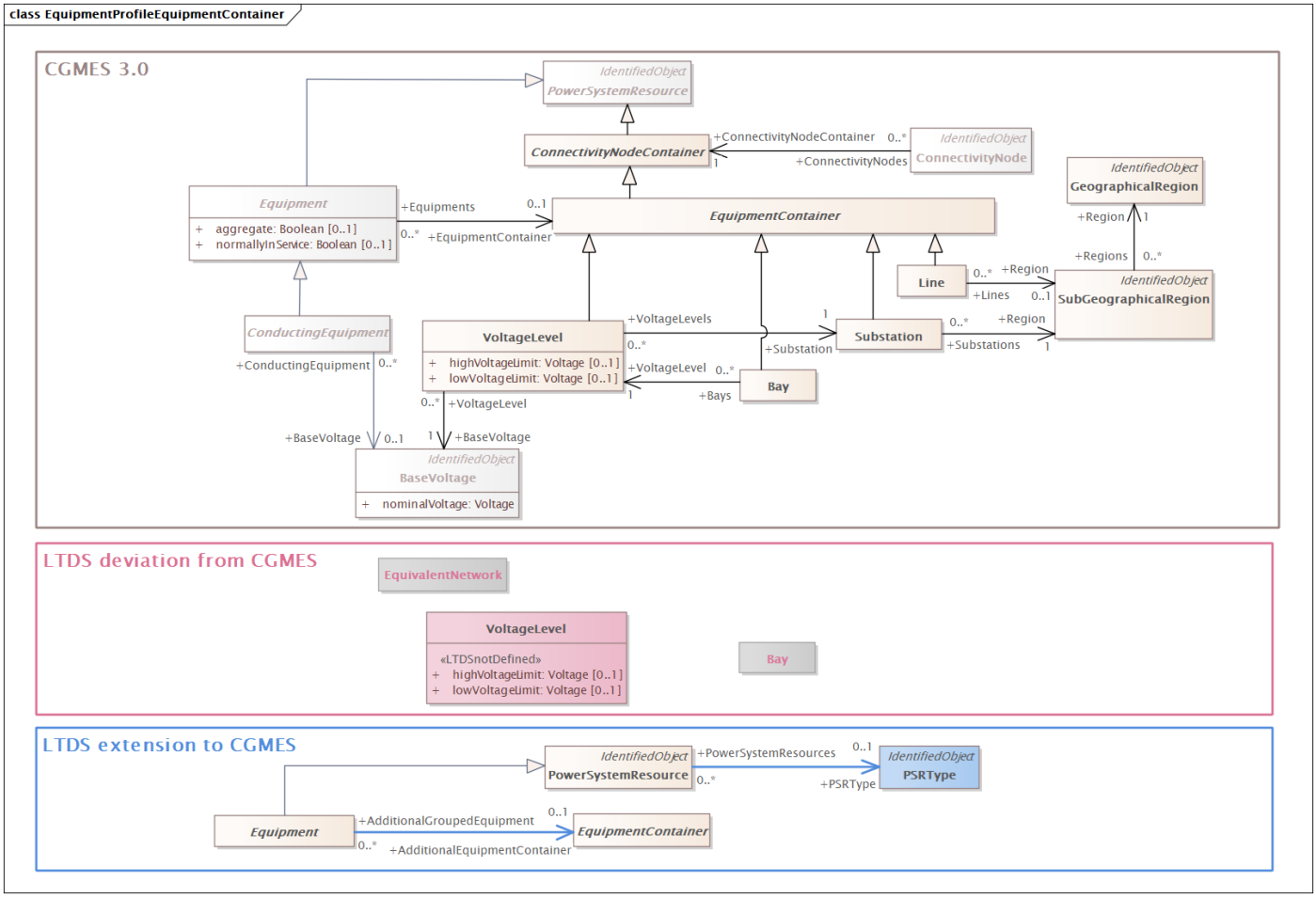
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>ShortCircuitProfileShuntCompensator

This diagram shows the limit-related portion of the Equipment profile:



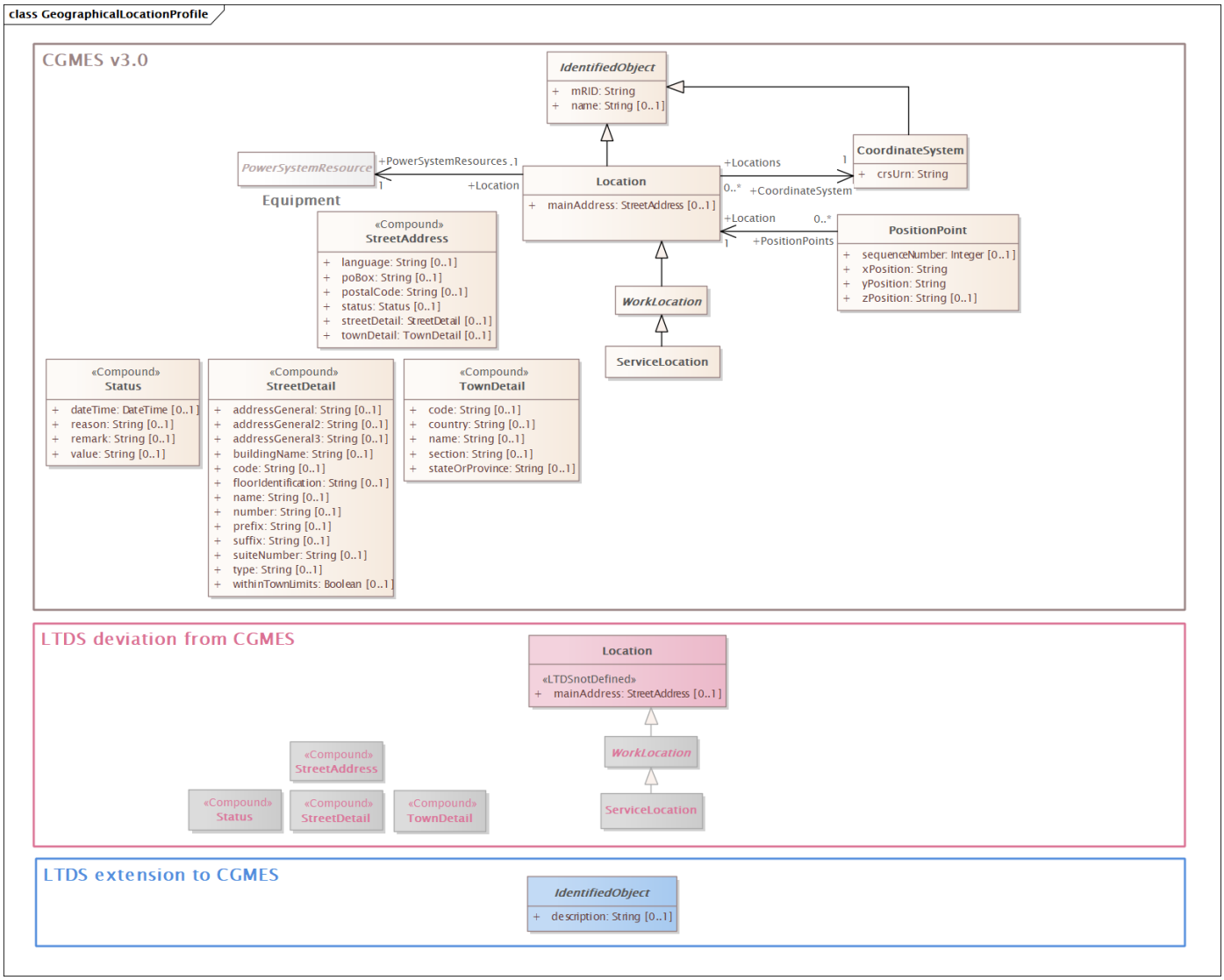
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileOperationalLimitSet

This diagram shows the portion of the Equipment profile which supports the containment of grid equipment and connectivity nodes in facilities and regions:



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>EquipmentProfileEquipmentContainer

This diagram shows the Geographical Location profile:

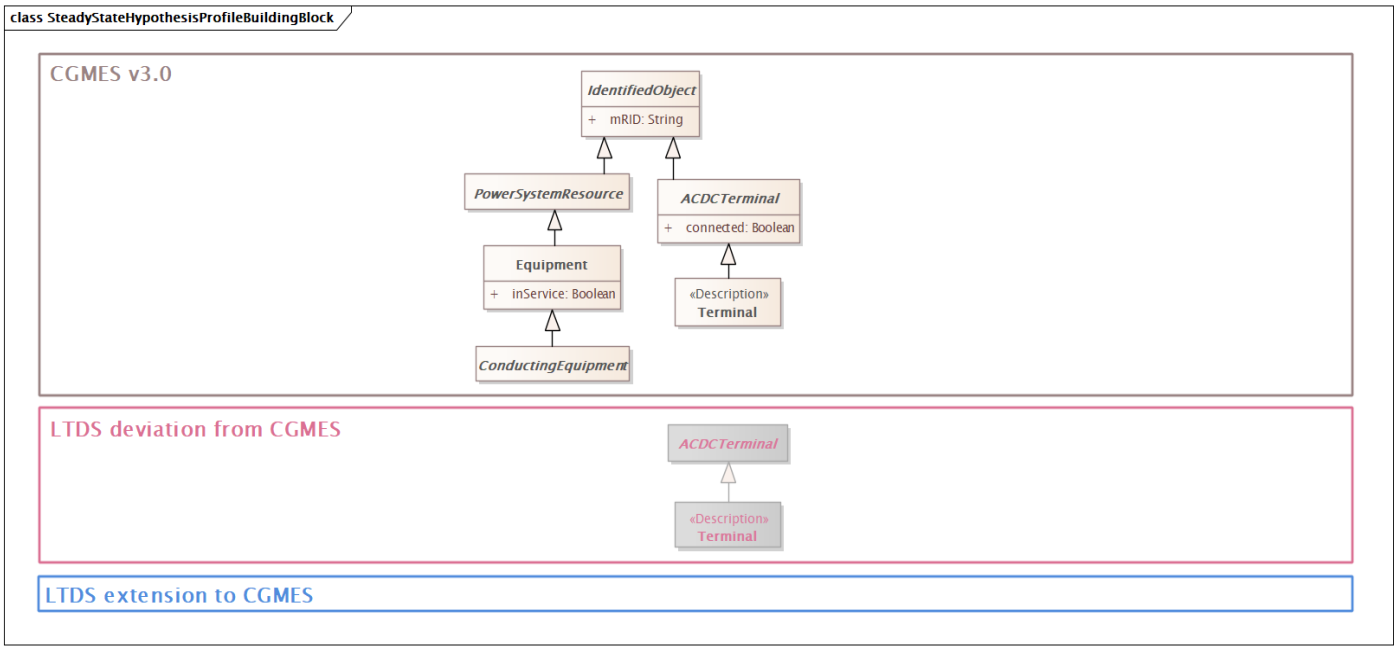


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>GeographicalLocationProfile

4.3.2 Situation profile group

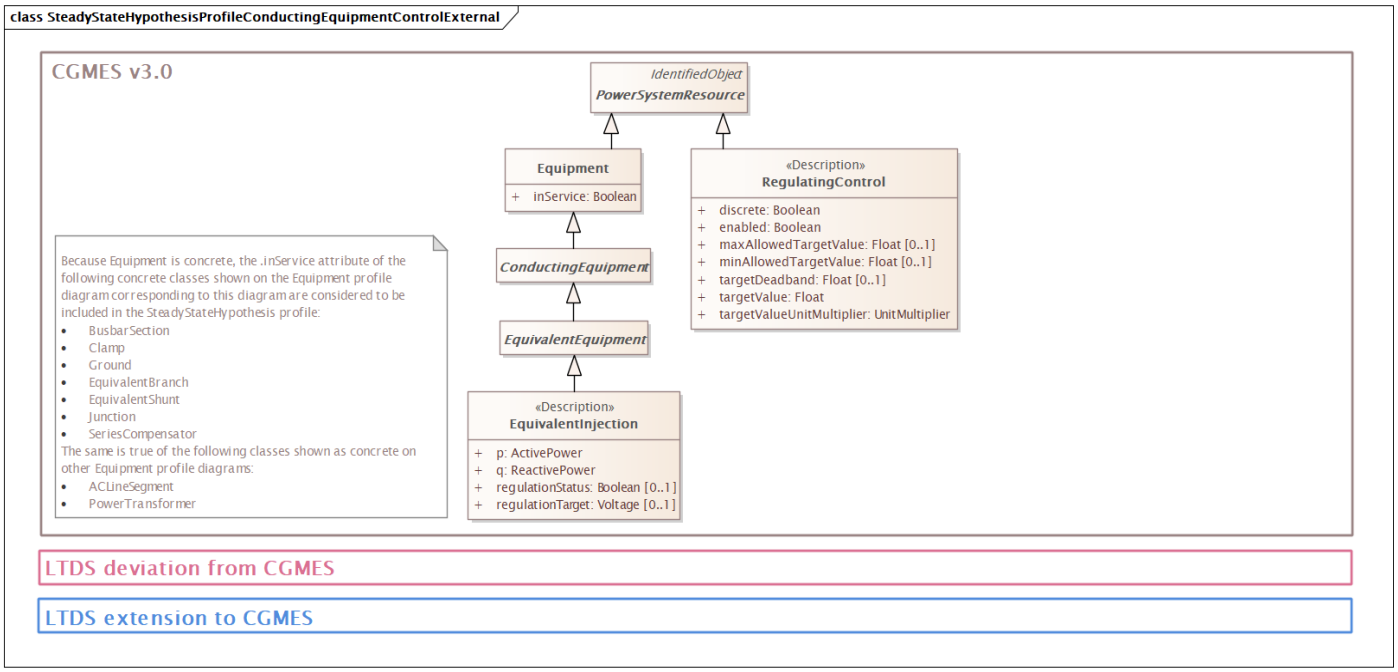
Taken as a whole, the 9 diagrams of this section describe the LTDS Steady State Hypothesis profile. Note that an anomaly in CIM and CGMES profiling has left multiple Equipment subtype classes out of the Steady State Hypothesis UML profile. All Equipment subtype classes should be present in the Steady State Hypothesis profile and should inherit the required cim:Equipment.inService attribute. Notes have been put on diagrams to identify these classes.

This diagram shows the building block-related portion of the Steady State Hypothesis profile:



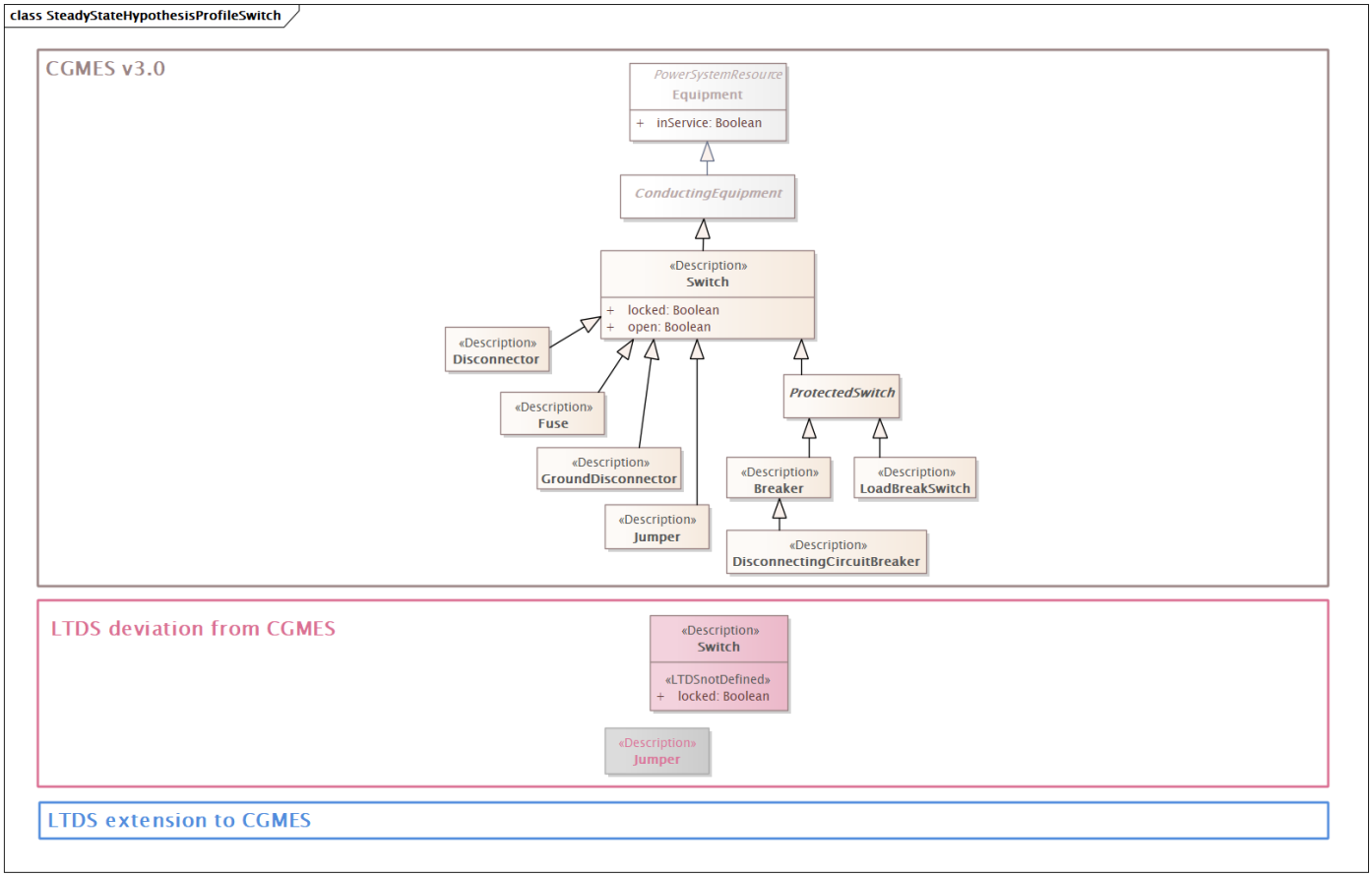
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileBuildingBlock

This diagram shows the portion of the Steady State Hypothesis profile which relates to conducting equipment, control and external modelling:



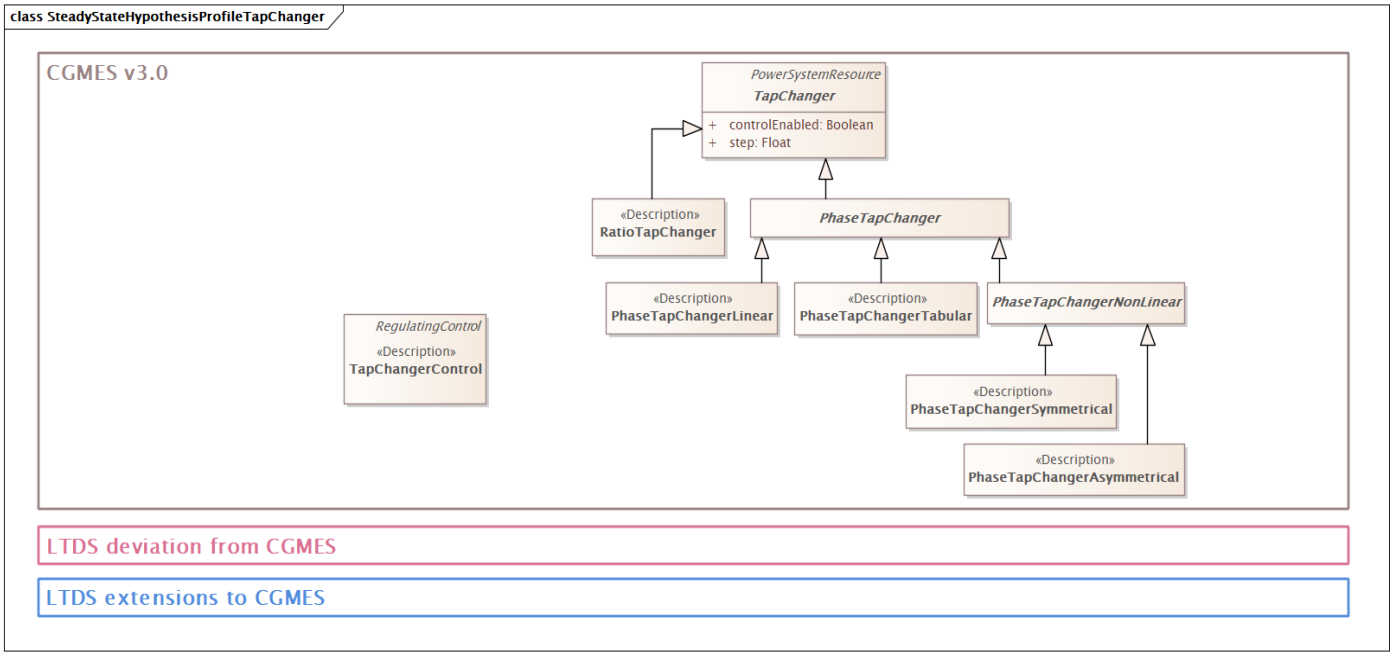
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>PhysicalThreeLayers>SteadyStateHypothesisProfileConductingEquipmentControlExternal

This diagram shows the switching device-related portion of the Steady State Hypothesis profile:



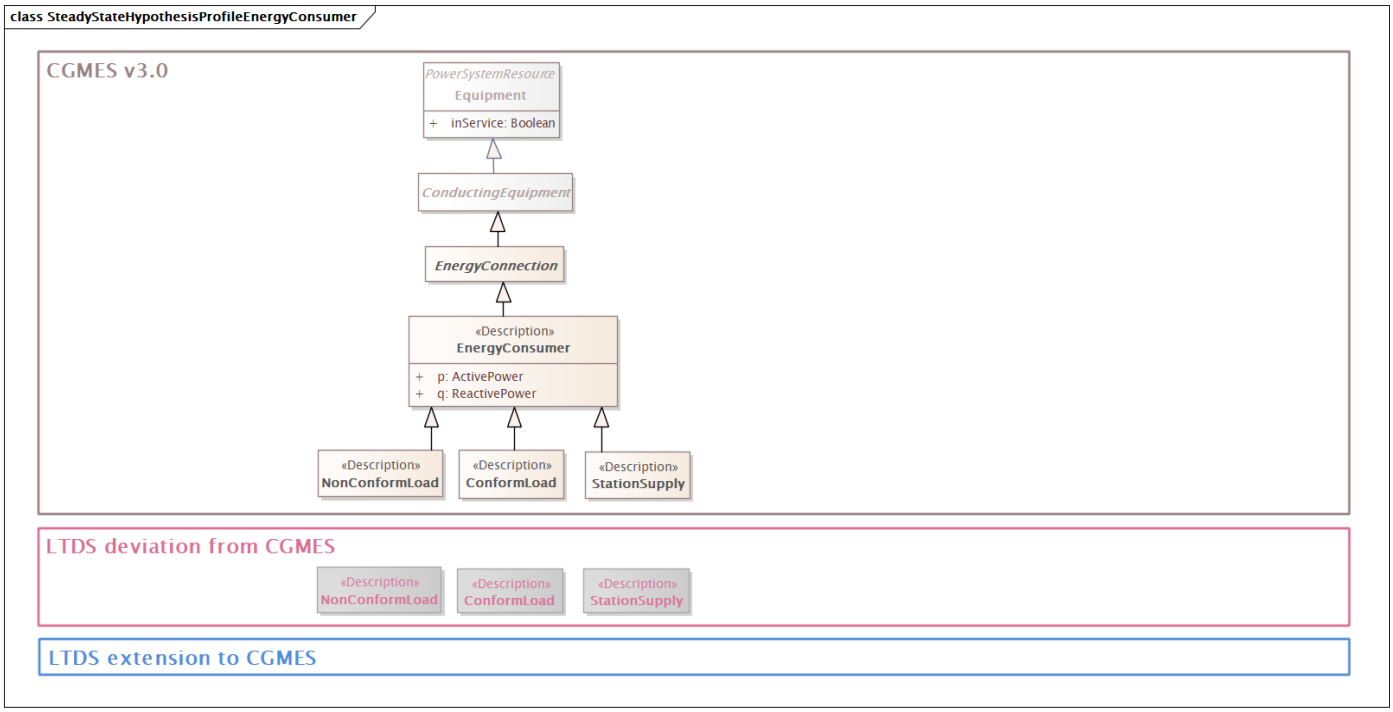
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileSwitch

This diagram shows the transformer tap changer-related portion of the Steady State Hypothesis profile:



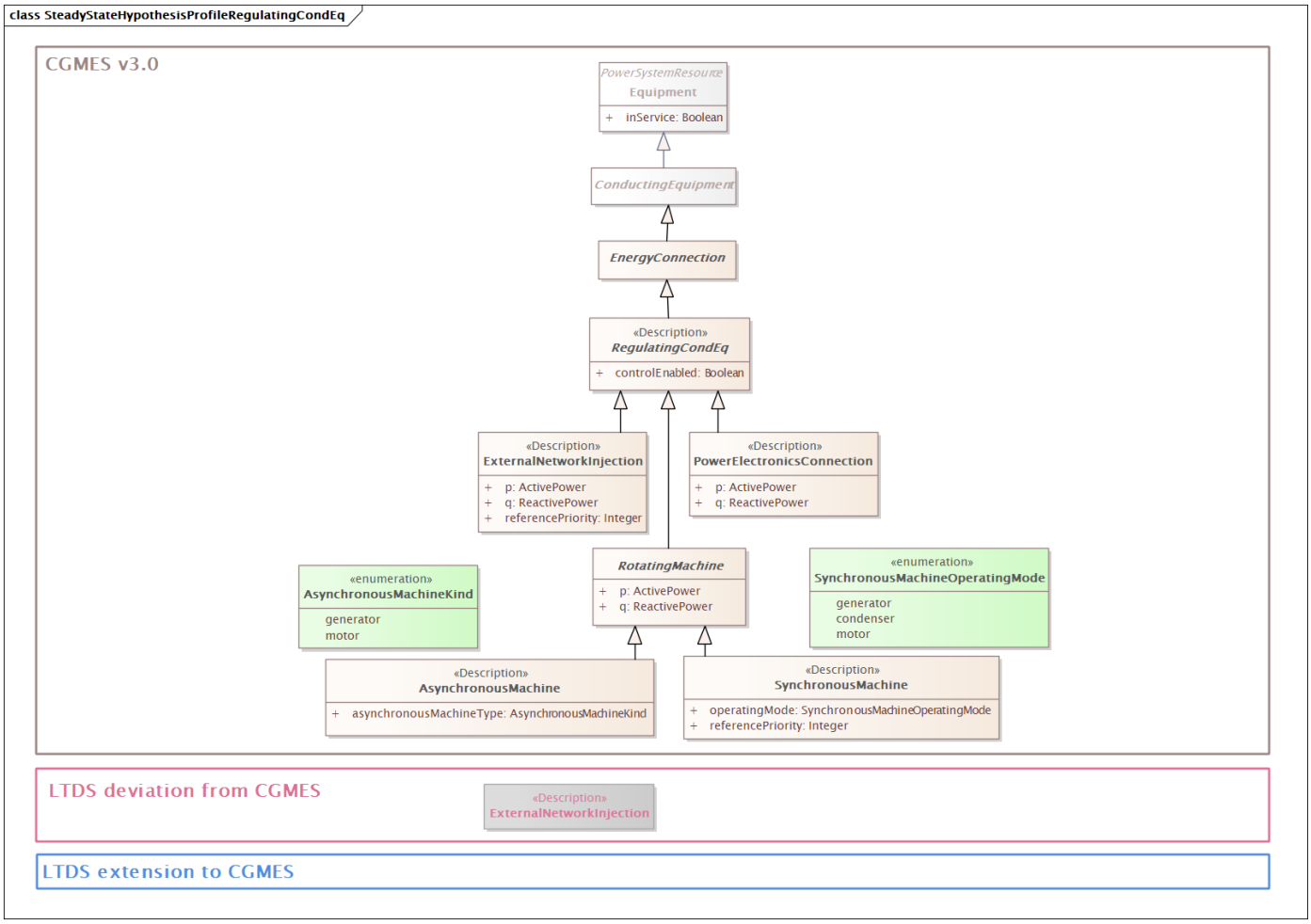
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileTapChanger

This diagram shows the load-related portion of the Steady State Hypothesis profile:

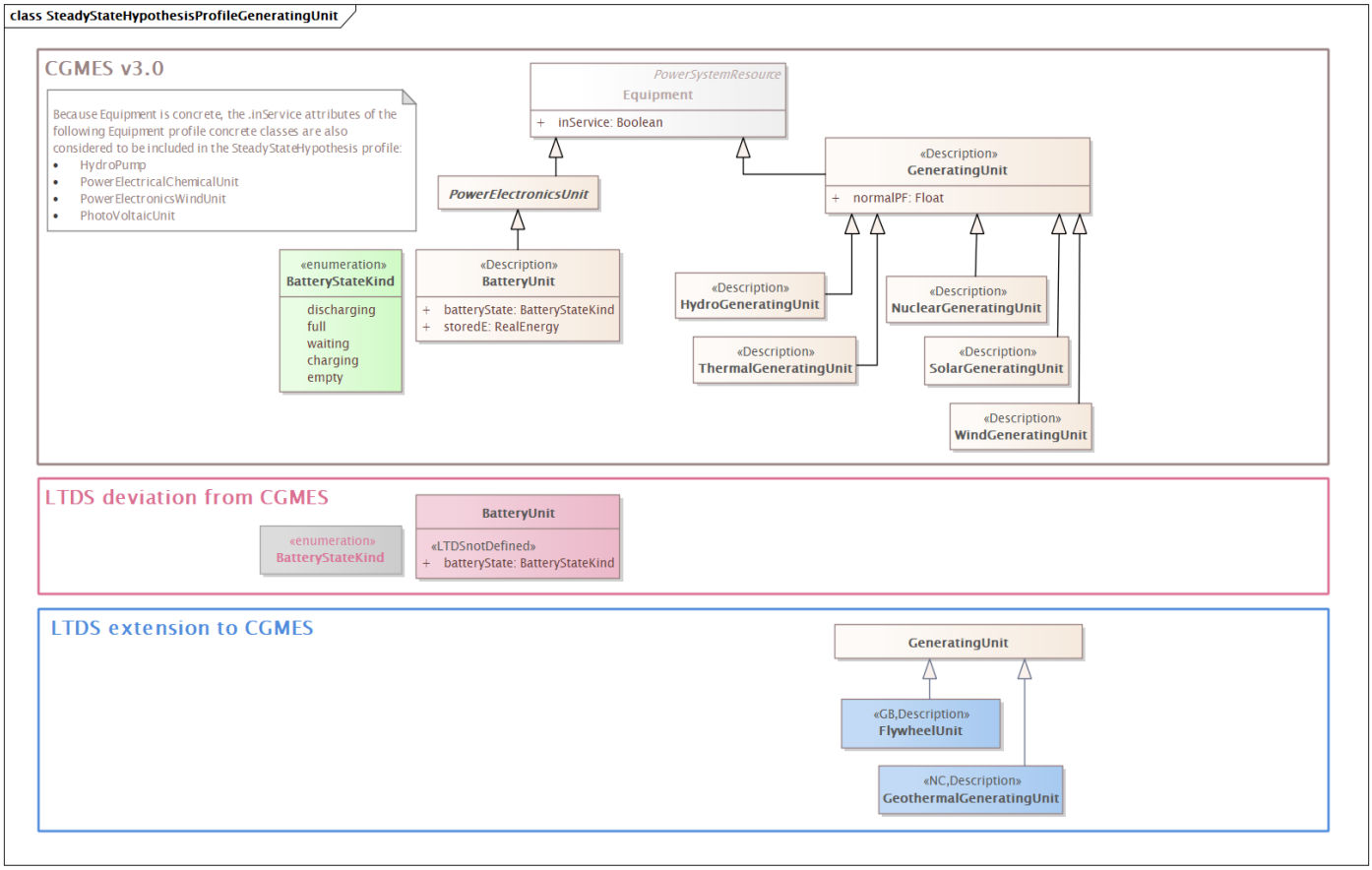


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileEnergyConsumer

These diagrams show the generation-related portion of the Steady State Hypothesis profile:

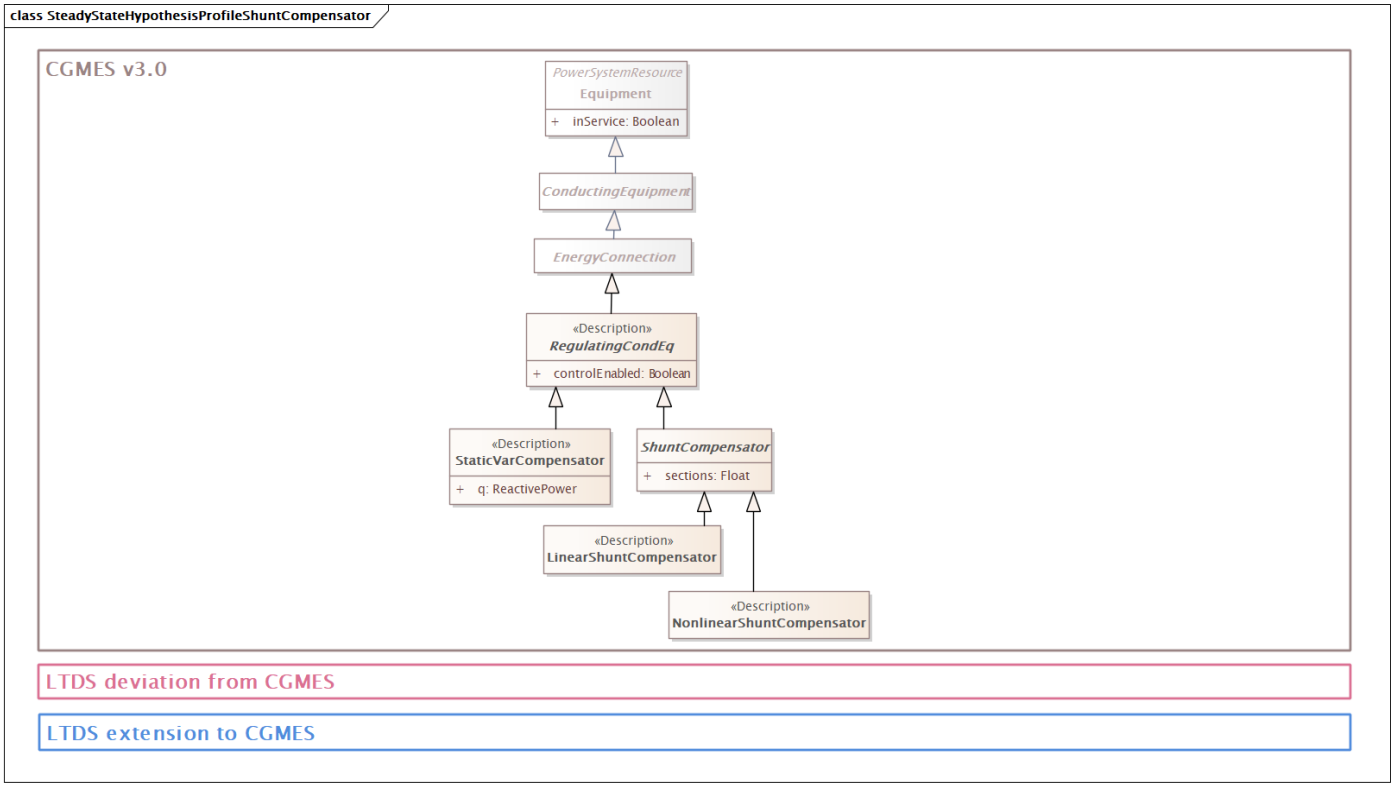


Source: Appendix 1,
LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileRegulatingCondEq



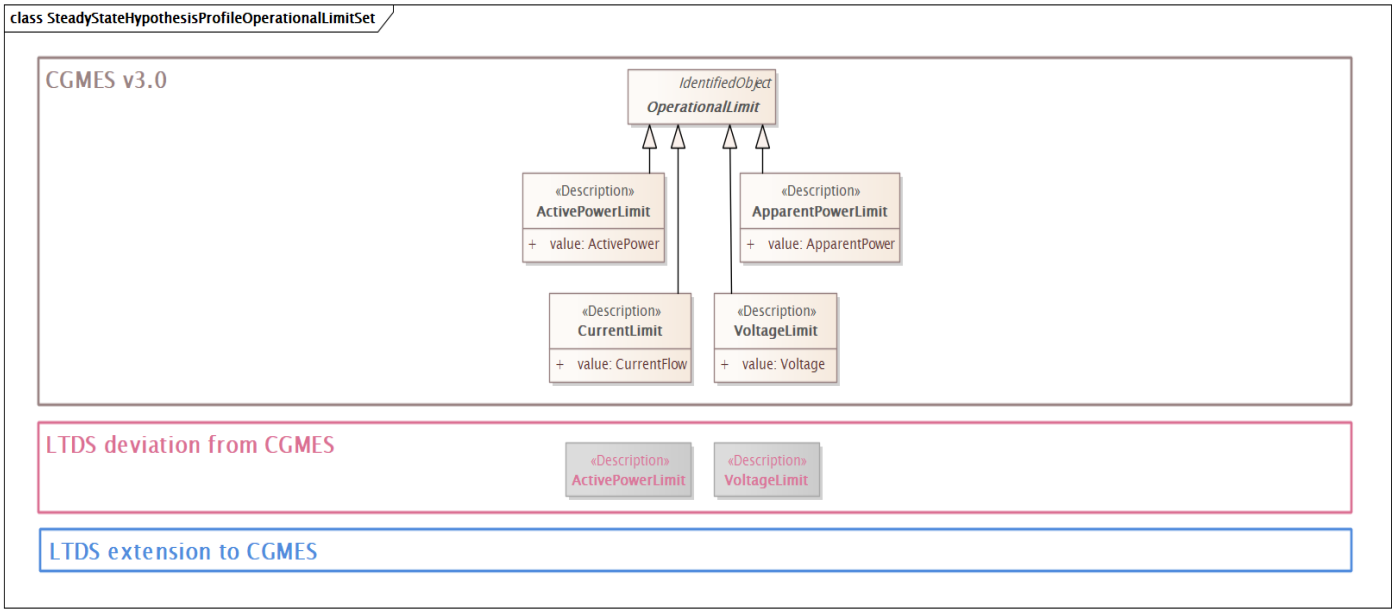
Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileGeneratingUnit

This diagram shows the shunt and static VAr compensator-related portions of the Steady State Hypothesis profile:



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileShuntCompensator

This diagram shows the limit-related portion of the Steady State Hypothesis profile:

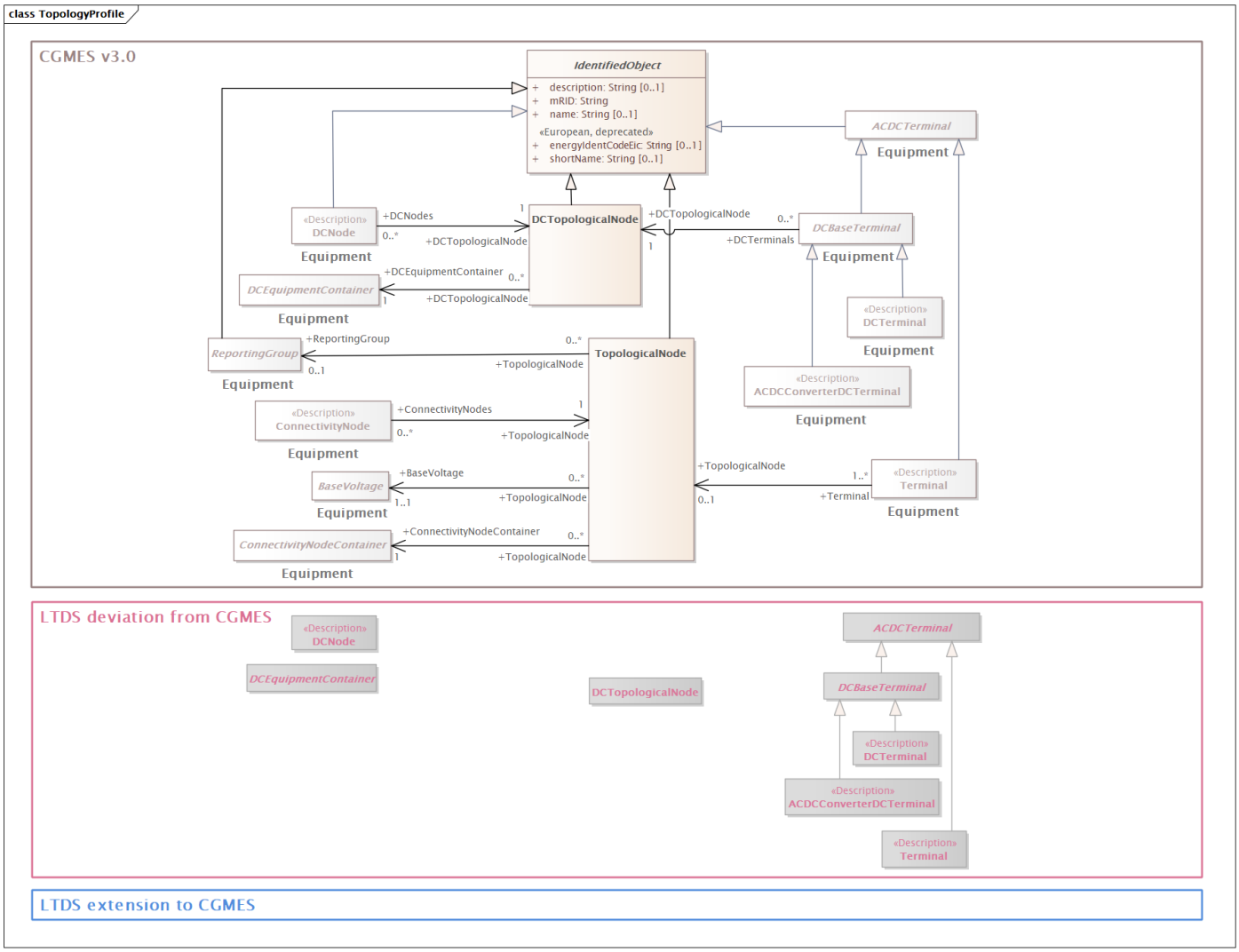


Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SituationThreeLayers>SteadyStateHypothesisProfileOperationalLimitSet

4.3.3 Solution profile group

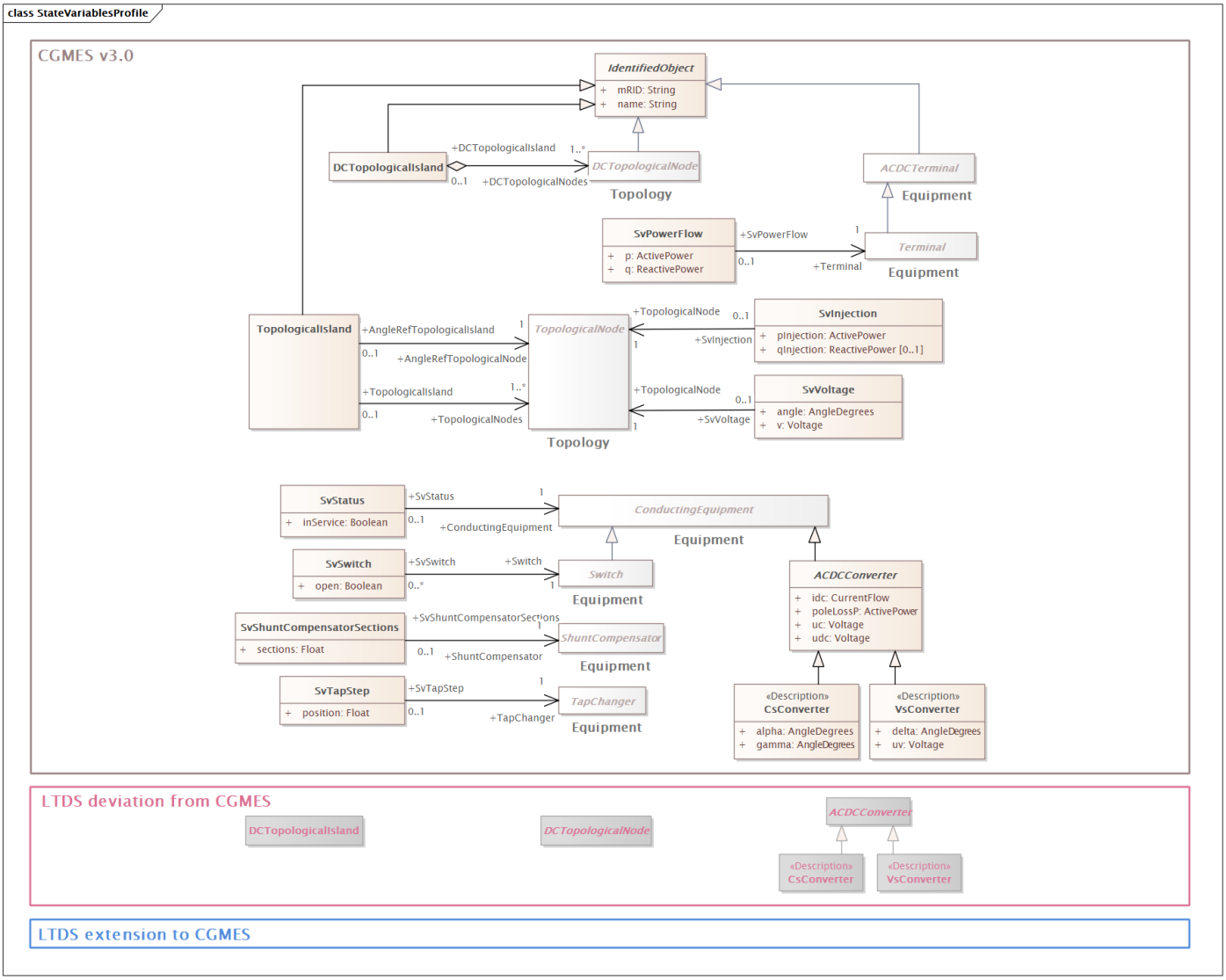
The two diagrams of this section describe the LTDS Topology profile and the LTDS StateVariables profile.

This diagram shows the Topology profile:



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SolutionThreeLayers>TopologyProfile

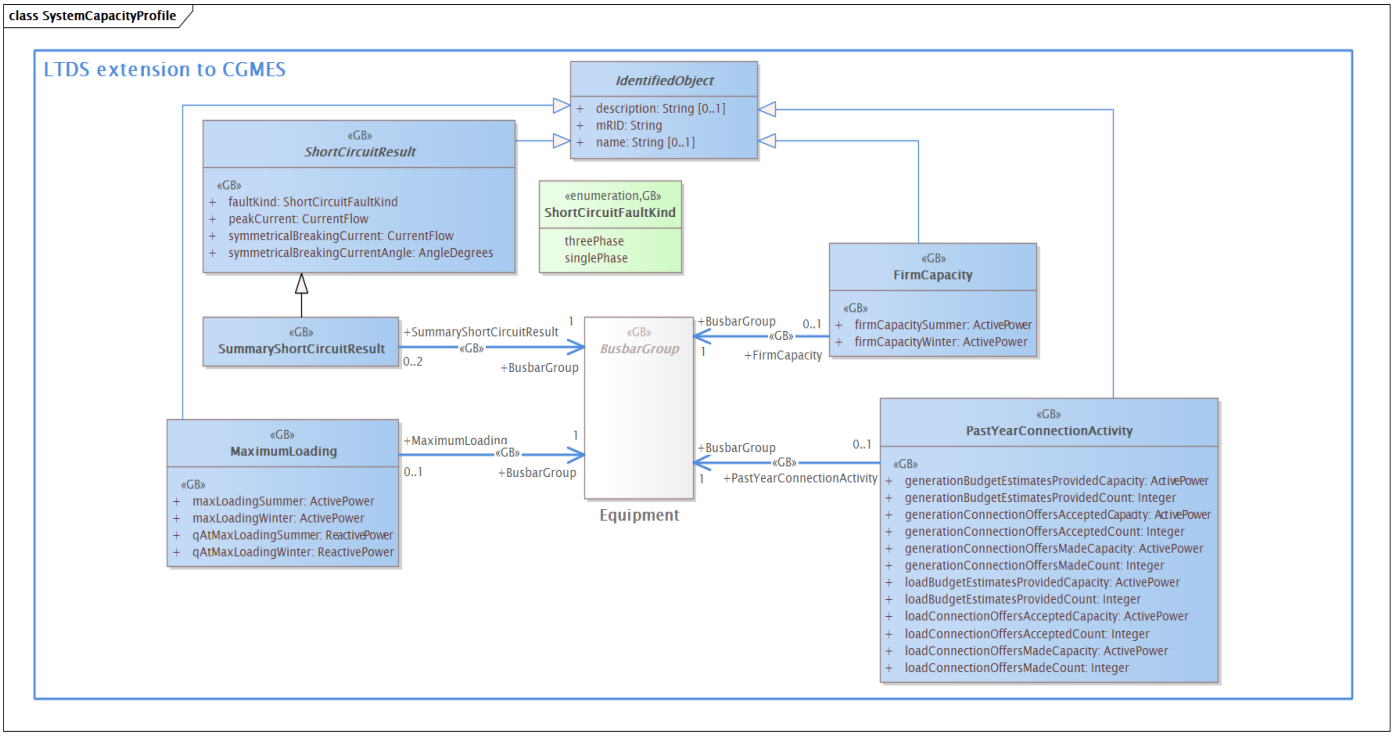
This diagram shows the State Variables profile:



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SolutionThreeLayers>StateVariablesProfile

4.3.4 System Capacity profile

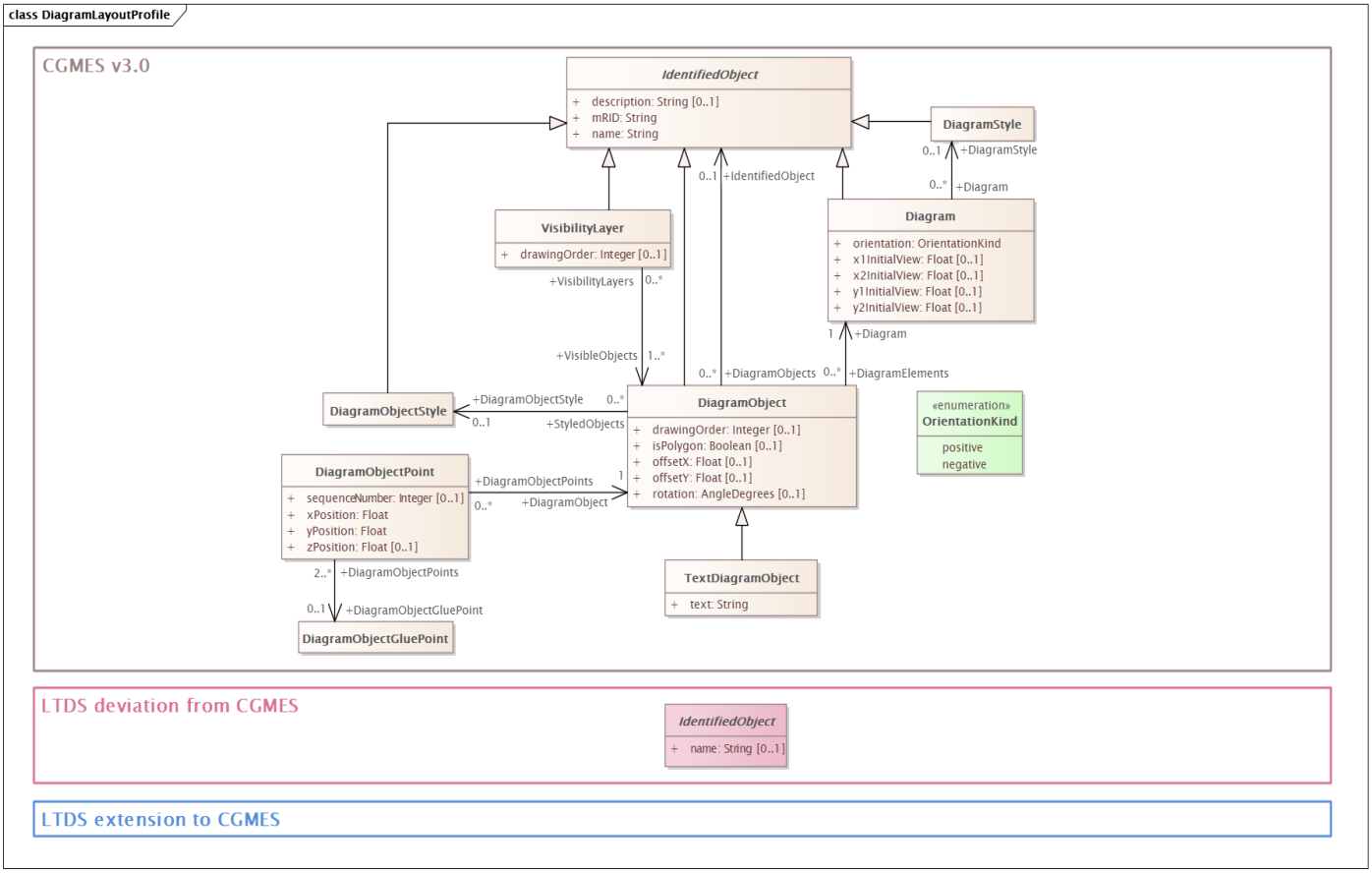
This diagram describes the LTDS System Capacity profile. It is an LTDS extension profile.



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>SystemCapacityProfileThreeLayers>SystemCapacityProfile

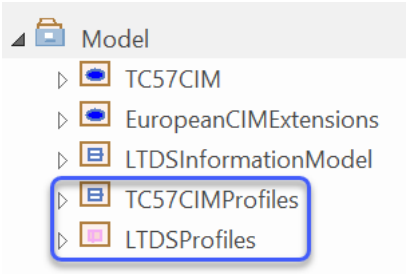
4.3.5 Diagram Layout profile

This diagram describes the LTDS Diagram Layout profile.



Source: Appendix 1, LTDSProfiles>ProfileDiagrams>DiagramLayoutProfileThreeLayers>DiagramLayoutProfile

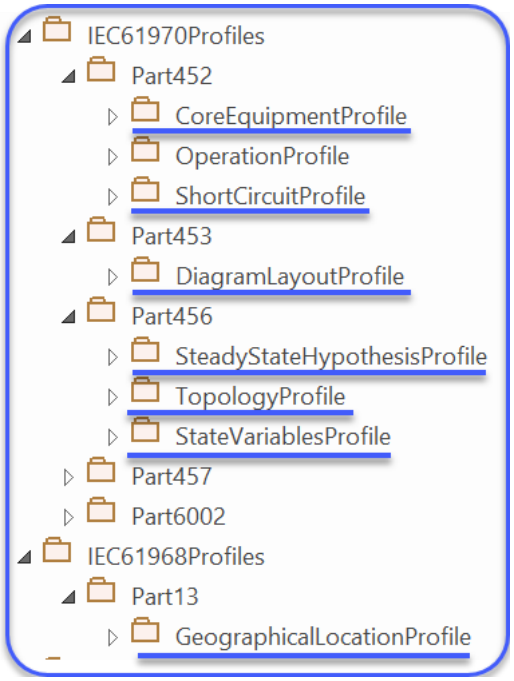
As has been noted, the layered UML profiles are maintained in the .eap file which comprises *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML*. The profile descriptions are contained in the two packages boxed in blue in the diagram below.



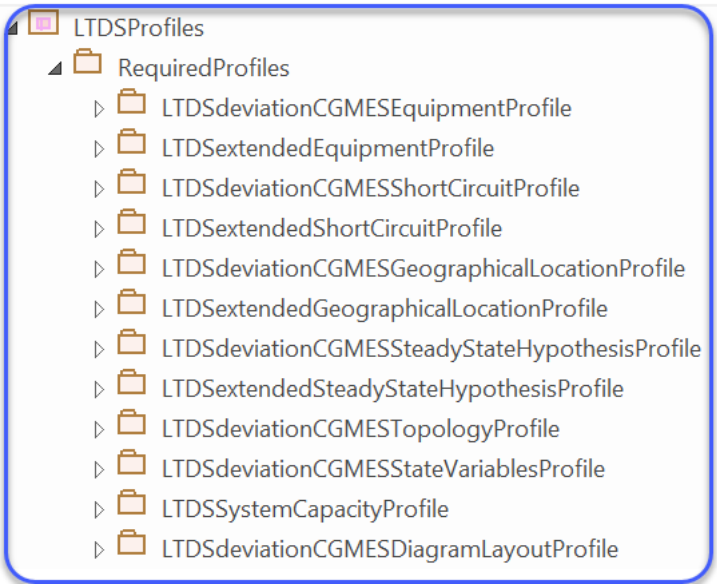
The packages have the following content:

- The CGMES v3.0 profiles are in the TC57CIMProfiles package
- The two LTDS "difference" profiles are in the LTDSProfiles package

The underlined sub-packages of the IEC61970Profiles package contain the UML profile definitions used by CGMES v3.0:



The LTDS "difference" profiles (LTDS deviation from CGMES and LTDS extension to CGMES) are defined in the RequiredProfiles sub-package of the LTDSProfiles package:



4.4 LTDS merged profiles

The LTDS merged profiles provide the definitions of LTDS data exchanges against which interfaces are developed and exchanged data is validated. As was noted in 4.2 Approach to

LTDS profile development, merged profiles currently exist only in RDFS form. Their RDFS forms are included, along with those of the CGMES v3.0 RDFS profiles and the two difference RDFS profiles, in *Grid Modelling Appendix 3 – LTDS Profiles in RDFS* .

4.5 LTDS profile identifiers

Each profile (merged and layered) has a unique version identifier. The version identifier is part of the profile resource definition contained in the profile's RDFS file. They are provided below for convenience.

Version identifiers for CGMES v3.0 profiles are:

http://iec.ch/TC57/ns/CIM/CoreEquipment-EU/3.0
http://iec.ch/TC57/ns/CIM/ShortCircuit-EU/3.0
http://iec.ch/TC57/ns/CIM/GeographicalLocation-EU/3.0
http://iec.ch/TC57/ns/CIM/SteadyStateHypothesis-EU/3.0
http://iec.ch/TC57/ns/CIM/Topology-EU/3.0
http://iec.ch/TC57/ns/CIM/StateVariables-EU/3.0
http://iec.ch/TC57/ns/CIM/DiagramLayout-EU/3.0

They are also documented in the IEC 61970-600-2 standard and can be found in the <<owl>><profile name>_Ontology class of each profile package in *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML.*

Version identifiers for LTDS deviation from CGMES v3.0 profiles are:

Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationEQ/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationSC/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationGL/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationSSH/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationTP/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationSV/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DeviationDL/1.0

They are also documented in *Grid Modelling Appendix 4 – LTDS Difference Profile Definitions and Diagrams* and can be found in the <<owl>><profile name>_Ontology class of each profile package in *Modelling Appendix 1 – LTDS Information Model and Profiles in UML.*

Version identifiers for LTDS extended profiles are:

Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/ExtendedEQ/1.0

Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/ExtendedSC/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/ExtendedGL/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/ExtendedSSH/1.0

They are also documented in *Grid Modelling Appendix 4 – LTDS Difference Profile Definitions and Diagrams* and can be found in the <<owl>><profile name>_Ontology class of each profile package in *Modelling Appendix 1 – LTDS Information Model and Profiles in UML.*

The version identifier for the LTDS extension profile is:

Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/SYSCAP/1.0

It is also documented in *Grid Modelling Appendix 4 – LTDS Difference Profile Definitions and Diagrams* and can be found in the <<owl>><profile name>_Ontology class of each profile package in *Modelling Appendix 1 – LTDS Information Model and Profiles in UML.*

Version identifiers for LTDS merged profiles are:

Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/SteadyStateHypothesis/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/Topology/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/StateVariables/1.0
Version IRI: http://ofgem.gov.uk/ns/CIM/LTDS/DiagramLayout/1.0

They are only documented here and in the applicable profile RDFS file.

4.6 Constraints

CIM RDFS profiles are critical to the definition of the structure of the data to be exchanged, but their capability to support validity checking of exchanged data is fairly limited.

RDFS profiles are good for defining a scope of data that has understood, shared meaning and providing the structure to which that data must conform. An RDFS profile can:

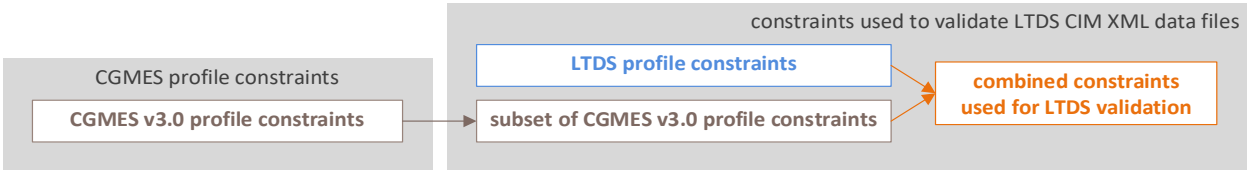
- Specify the classes, attributes and associations for which there is a defined meaning
- Specify allowed attribute values for certain datatypes (booleans, enumerations)
- Specify that an attribute must be populated (i.e., it is required) or may be populated (i.e., it is optional)
- Specify that an association must exist

- Specify an upper bound on the number of instances of an association that may exist
- Require that an object exists, but only by means of a required association.

There are many other types of requirements that RDFS profiles cannot express. They include:

- The allowed value (or value range) for an attribute
- The conditions under which an optional attribute must be populated
- The conditions under which an optional association must be present
- The number of associations (within the allowed multiplicity range) that must or may be present and under what conditions
- The number of objects of a given class must be present in a data exchange

The ability to specify these more involved data requirements is an essential pre-requisite to validating exchanged grid model data. Constraint languages – like Shapes Constraint Language (SHACL) or Object Constraint Language (OCL) – are the vehicle by which these more specific, more complex data requirements are described. Typically, constraints are defined in conjunction with every profile, both standard profiles and local implementation profiles. Constraints are also described for combinations of profiles, which are used in validating models containing data conforming to multiple profiles. The set of constraints to be used in validating LTDS grid model data exchanges currently includes a selected subset of CGMES v3.0 constraints, and ultimately will include both those and a set of LTDS-specific constraints:



A note on CGMES current practice for SHACL constraints: To allow all cardinality and value validation to be done using one rule source, CGMES v3.0 includes SHACL constraints which duplicate the RDFS definitions regarding attribute and association cardinality and attribute datatype. These constraints are generated from the RDFS profile definitions. This practice will be followed when the LTDS constraints are defined.

Grid Modelling Appendix 7 – LTDS Subset of CGMES Constraints Descriptions provides a tabular description of the subsets of CGMES v3.0 profile constraints used by LTDS. Machine-readable versions of the constraints are provided in *Grid Modelling Appendix 6 – LTDS Subset of CGMES Constraints in SHACL*.

5 LTDS Serialisation

In CIM-based data exchanges, serialisation is the process of readying data for exchange. It includes:

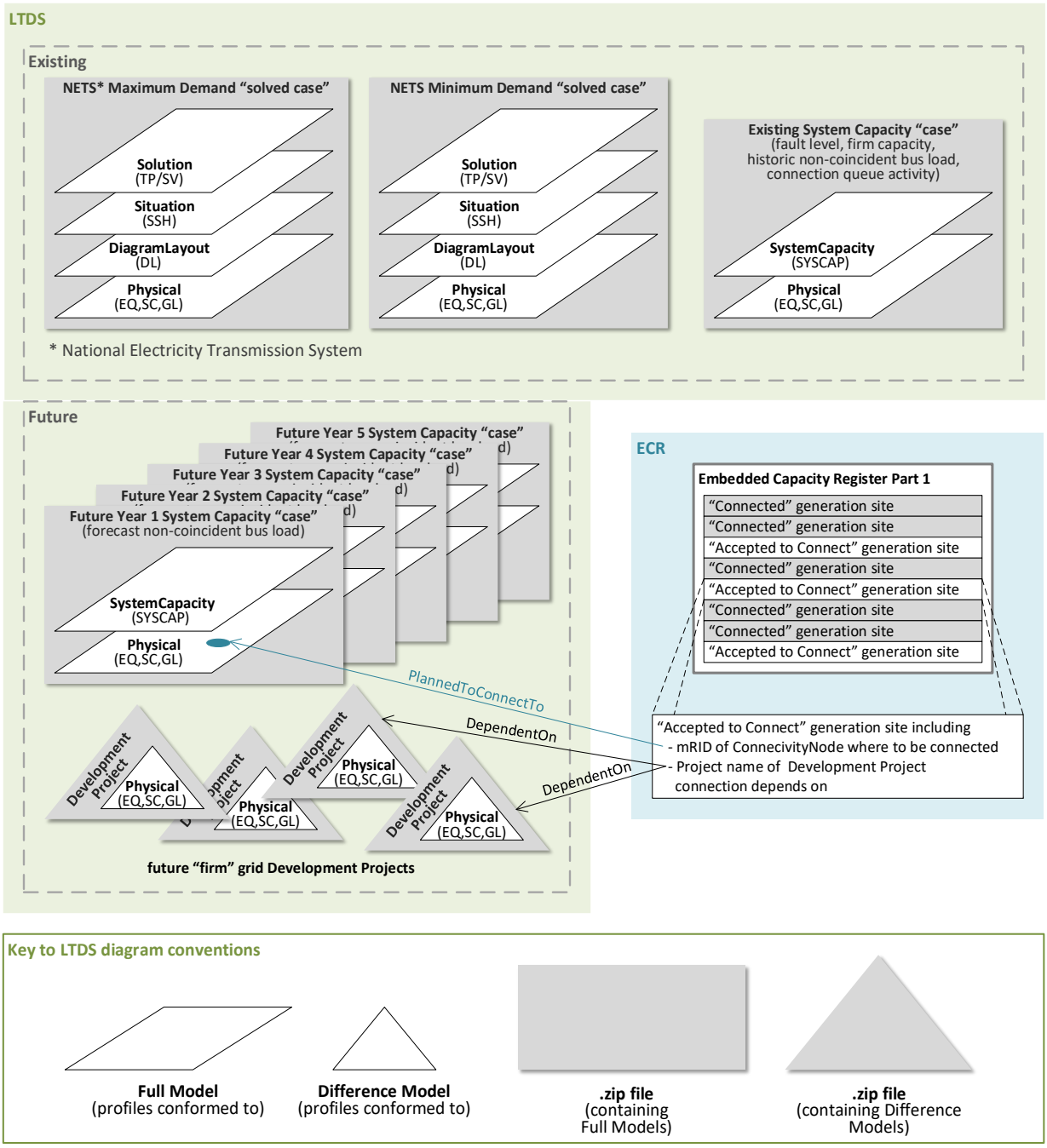
- Creating context information for the data being shared and
- Expressing data in a particular syntax (format)

The IEC 61970-552 standard[21] specifies serialisation conventions – for both context and syntax – to be used by CIM-based grid model data exchanges. The syntax called for by IEC 61970-552 is RDF/XML. Grid model data context is defined by IEC 61970-552 in the form of a header whose structure is described in UML.

The IEC 61970-552 standard is currently under revision, with the next version promising major improvement in the definition of context. The planned improvements will support accurate, detailed modelling of grid model context in machine-readable form. They will also implement the metadata features recommended by Ofgem[22] and others as data best practice. However, since details of the revision have not solidified, LTDS calls for organising and serialising its data exchanges according the existing IEC 61970-552 standard. The header described by IEC 61970-552 is used to supply some of the organisational information. A variety of other mechanisms are used to supply the remainder of the context required to organise LTDS data. They include:

- The grouping of files into .zip files
- .zip file naming conventions
- The presentation of collections of .zip files on websites.

[21] IEC 61970-552:2016 | IEC Webstore
[22] Consultation on updates to Data Best Practice Guidance and Digitalisation Strategy and Action Plan Guidance | Ofgem



Starting from the top and moving down into lower organisational levels, the context for the provision of LTDS grid model data is defined using the following:

- A web page location allows the LTDS data for a licence area to be identified. (This corresponds to the green area on the diagram above.)
- Within the web page, links to .zip files whose names follow specific naming conventions allow the identification of the following sets of grid model information:
  - The National Electricity Transmission System (NETS) Maximum Demand "solved case"
  - The NETS Minimum Demand "solved case"

    - The Existing System Capacity "case"
    - The five Future Year System Capacity "cases"
    - Planned grid Development Projects

  (The links to .zip files correspond to the solid grey shapes in the diagram above.)
- Within each .zip file, there is one or more CIM XML files. CIM XML files can be either Full Models (which are shown as white parallelograms with black borders in the diagram above) or Difference Models (shown as white triangles with black borders).
- Within each CIM XML file, the IEC 61970-552 header defines additional context information.

The conventions to be followed in describing the context of LTDS grid model data are defined below, with examples provided where appropriate.

.zip file naming

For the NETS Maximum Demand "solved case"

LTDS_<licence area>_<publication year>-<period>_GBMaximum_<date/time of maximum>h_v<version number>.zip

For the NETS Minimum Demand "solved case"

LTDS_<licence area>_<publication year>-<period>_GBMinimum_<date/time of minimum>h_v<version number>.zip

For the Existing System Capacity "case"

LTDS_<licence area>_<publication year>-< period>_SystemCapacity_Existing_v<version number>.zip

For the five Future Year System Capacity "cases"

LTDS_<licence area>_<publication year>-<period>_SystemCapacity_FY<yyyy>_v<n>.zip

For all "firm" future development projects

LTDS_<licence area>_<publication year>-<period>_<project ID>_v<version number>.zip

Where

- <licence area> is one of the following:
    - EELC (for East England operated by UK Power Networks)
    - EMEB (for East Midlands operated by National Grid Electricity Distribution)
    - LOND (for London operated by UK Power Networks)
    - MANW (for North Wales, Merseyside and Cheshire operated by SP Energy Networks)
    - MIDE (for West Midlands operated by National Grid Electricity Distribution)
    - NEEB (for North East England operated by Northern Powergrid)
    - NORW (for North West England operated by Electricity North West)
    - HYDE (for North Scotland operated by Scottish and Southern Electricity Networks)
    - SPOW (for South and Central Scotland operated by SP Energy Networks)

  - SEEB (for South East England operated by UK Power Networks)
  - SOUT (for Southern England operated by Scottish and Southern Electricity Networks)
  - SWAE (for South Wales operated by National Grid Electricity Distribution)
  - SWEB (for South West England operated by National Grid Electricity Distribution)
  - YELG (for Yorkshire operated by Northern Powergrid)
- <publication year> is the 4-digit year of the publication
- <period> is a 2-digit number reflecting the publication cycle number within the year
- <date/time of maximum> and <date/time of minimum> are expressed in yyyy-mm-dd_hhmm format
- <version number> is 1 for the .zip file initially published in a publication cycle and is incremented by 1 for any correction publication of the .zip file done thereafter in the cycle
- <yyyy> is a 4-digit future year
- <project ID> is a unique identifier, not longer than 24 characters, for the project. The project ID should persist through LTDS publication cycles.

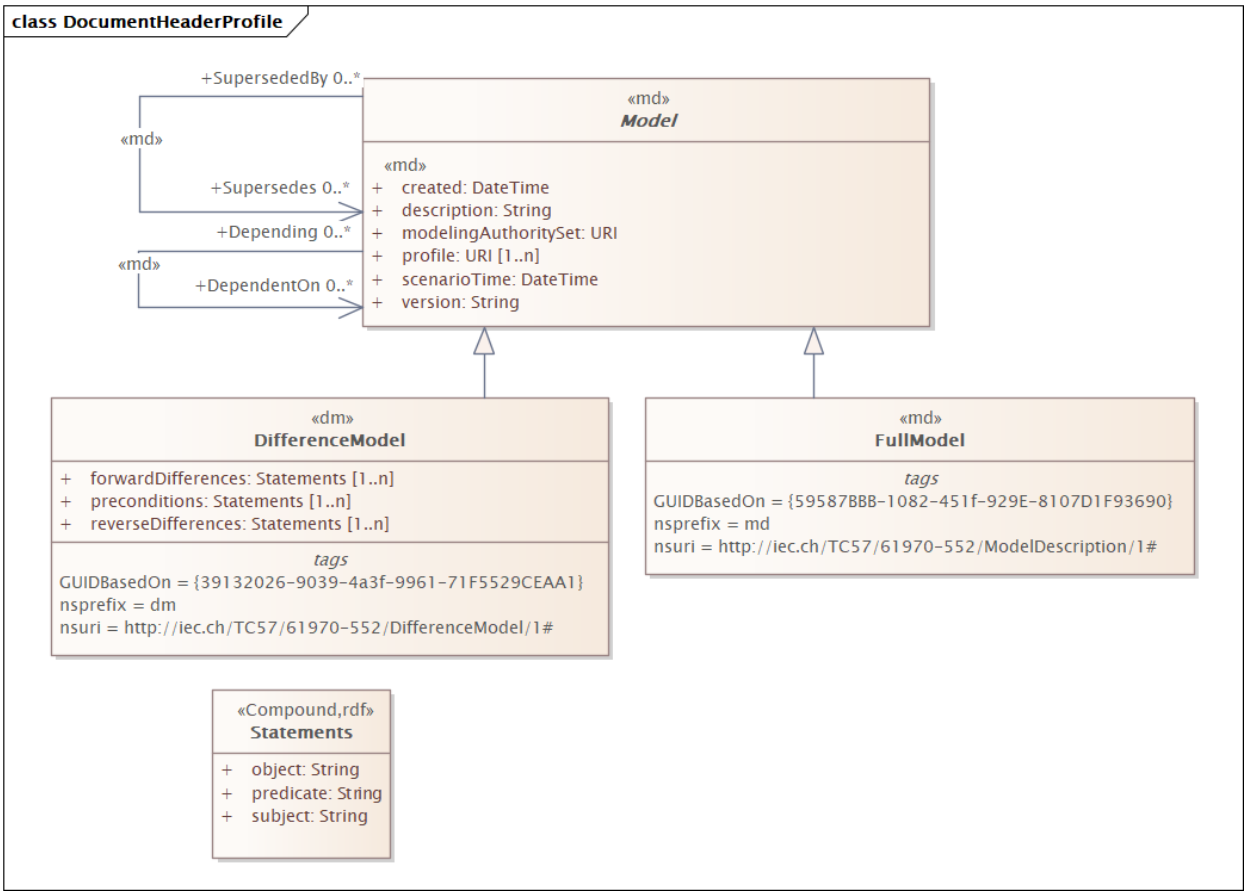
.zip file content

- The NETS Maximum Demand "solved case" and NETS Minimum Demand "solved case" .zip files each contain 4 CIM XML files with the following names and contents:
  - Physical.xml containing a Full Model with grid objects conforming to three merged LTDS profiles (Equipment, Short Circuit and Geographical Location)
  - DiagramLayout.xml containing a Full Model with grid objects conforming to the merged LTDS Diagram Layout profile
  - Situation.xml containing a Full Model with grid objects conforming to the merged LTDS Steady State Hypothesis profile
  - Solution.xml containing a Full Model with grid objects conforming to two merged LTDS profiles (Topology and State Variables)
- The Existing System Capacity "case" .zip file and each of the five Future Year System Capacity "case" .zip files each contain 2 CIM XML files with the following names and contents:
  - Physical.xml containing a Full Model with grid objects conforming to three merged LTDS profiles (Equipment, Short Circuit and Geographical Location)
  - SystemCapacity.xml containing a Full Model with grid objects conforming to the merged LTDS System Capacity profile
- Each planned grid Development Project .zip file contains one CIM XML file called Physical.xml which contains a Difference Model whose grid objects are those

defined in three merged LTDS profiles (Equipment, Short Circuit and Geographical Location).

CIM XML file content

The data described for the instance file header is based on CGMES v3.0. The CGMES v3.0 is using the definitions defined in the IEC 61970-552. The UML diagram presented below describes the header UML that is used by CGMES v3.0. The header information appears at the beginning of every CIM XML file.



Source: Appendix 1, TC57CIMProfiles>MetadataProfiles>CGMESDocumentHeaderProfile

The Model class defines the header information and the md:FullModel and dm:DifferenceModel objects used in exchanges inherit the Model attributes and associations. For LTDS it is defined that all the md:Model attributes, except .version, are required in both the md:FullModel and dm:DifferenceModel objects of LTDS data exchanges. The .version is attribute is considered optional. The md:Model.Supersedes association is not used by LTDS and the md:Model.DependentOn association is conditionally required.

A CIM XML file with a md:FullModel header supplies a "snapshot" of grid data reflecting a given moment or condition. Grid instance data, conforming to one or more profiles, follows immediately after the md:FullModel header object.

A CIM XML file with a dm:DifferenceModel header describes changes to grid data. The changes are described by of two sets of grid model instance data embedded in the dm:DifferenceModel header:

- One set of objects, and their attributes and associations, define items to be added to an existing Full Model – these are the Statements of the dm:DifferenceModel.forwardDifferences.
- A second set of objects, and their attributes and associations, define items to be deleted from an existing Full Model – these are the Statements of the dm:DifferenceModel.reverseDifferences.

Together they describe the net effect of a set of grid changes. The objects making up the forward differences and reverse differences are CIM grid objects which conform to the class, attribute and association structure defined by one or more profiles, although they cannot, on their own, be expected to conform to the multiplicity rules specified by the profiles.

Full Models

In LTDS grid model data exchanges, a Full Model CIM XML file contains the following statements:

```
<?xml version="1.0" encoding="UTF-8" ?>
<rdf:RDF
  xmlns:md="http://iec.ch/TC57/61970-552/ModelDescription/1#"
  xmlns:cim="http://iec.ch/TC57/CIM100#"
  xmlns:eu="http://iec.ch/TC57/CIM100-European#"
  xmlns:gb="http://ofgem.gov.uk/ns/CIM/LTDS/Extensions#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
 <md:FullModel rdf:about="urn:uuid:UUID">
  <md:Model.created>yyyy-mm-ddThh:mm:nn.nnnZ</md:Model.created>
  <md:Model.scenarioTime>yyyy-mm-ddThh:mm:00.000Z</md:Model.scenarioTime>
  <md:Model.description>FullModel or DifferenceModel description</md:Model.description>
  <md:Model.modelingAuthoritySet>DNO website URL/ltds/licence area</md:Model.modelingAuthoritySet>
  <md:Model.version>nn</md:Model.version>
  <md:Model.profile>Version IRI of profile</md:Model.profile>
  <md:Model.profile>Version IRI of profile</md:Model.profile>
  <md:Model.DependentOn rdf:resource="#_UUID"/>
 </md:FullModel>
  ... grid objects ...
</rdf:RDF>
```

The statements in grey are RDF and namespace definitions that appear in any CIM XML file containing a FullModel.

The statements in blue are the md:FullModel definition, where the light blue fields describe the following:

- In <md:FullModel rdf:about="urn:uuid:*UUID*">,

  UUID is the unique identifier of the FullModel expressed in Universally Unique Identifier (UUID) form.

- In <md:Model.created>*yyyy-mm-dd*T*hh:mm:nn.nnn*Z</md:Model.created>,

  *yyyy-mm-dd*T*hh:mm:nn.nnn* is the date/time that the Full Model was serialised.

- In <md:Model.scenarioTime>*yyyy-mm-dd*T*hh:mm*:00.000Z</md:Model.scenarioTime>,

  *yyyy-mm-dd*T*hh:mm* is the date/time that the Full Model represents. The conventions for its population in LTDS data exchanges are given in the table below.

- In <md:Model.description>*FullModel or DifferenceModel description*</md:Model.description>,

  FullModel or DifferenceModel description is a free form text field containing a locally meaningful description of the CIM XML file.

- In <md:Model.modelingAuthoritySet>*DNO website URL*/ltds/*licence area*</md:Model.modelingAuthoritySet>

  - *DNO website URL* is the URL of the DNO's main website.
  - *licence area* is one of the following (same list as for .zip file names):
    - EELC
    - EMEB
    - LOND
    - MANW
    - MIDE
    - NEEB
    - NORW
    - HYDE
    - SPOW
    - SEEB
    - SOUT
    - SWAE
    - SWEB
    - YELG

- In <md:Model.version>*nn*</md:Model.version>,

  nn is any text string a DNO chooses to use to represent a version. It is totally unrelated to the version number appearing in the .zip file name.

- In <md:Model.profile> *Version IRI of profile* </md:Model.profile>,

  Version IRI of profile is the appropriate LTDS merged profile (from 4.5 LTDS profile identifiers) or CGMES profile if a profile has no LTDS deviations or extensions. The specific Version IRIs for LTDS data exchanges are given in the table below. Note that there may be one, two or three md:Model.profile statements.

- In <md:Model.DependentOn rdf:resource=#*UUID*"/>,

  UUID is the unique persistent identifier of a Full Model on which this Full Model depends. The conventions for its population in LTDS data exchanges are given in the table below. Note that there may be zero to many md:Model.DependentOn statements.

.zip file	CIM XML file	Full or Difference Model	header .DependentOn is UUID of	header .scenarioTime represents	Version IRI of profile name (to which grid object content conforms)
NETS Maximum Demand "solved case"	Physical	Full Model	-none-	date/time of GB maximum demand	http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0
	DiagramLayout	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/DiagramLayout/1.0
	Situation	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/SteadyStateHypothesis/1.0
	Solution	Full Model	Physical and Situation Full Models in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/Topology/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/StateVariables/1.0
NETS Minimum Demand "solved case"	Physical	Full Model	-none-	date/time of GB minimum demand	http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0
	DiagramLayout	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/DiagramLayout/1.0
	Situation	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/SteadyStateHypothesis/1.0
	Solution	Full Model	Physical and Situation Full Models in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/Topology/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/StateVariables/1.0
Existing System Capacity "case"	Physical	Full Model	-none-	date/time for which SystemCapacity data is valid – a date close to the date of publication	http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0
	DiagramLayout	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/DiagramLayout/1.0
	SystemCapacity	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/SYSCAP/1.0
Future Year System Capacity "case"	Physical	Full Model	-none-	date/time for which SystemCapacity data is valid – a date in the appropriate future year	http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0
	DiagramLayout	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/DiagramLayout/1.0
	SystemCapacity	Full Model	Physical Full Model in same .zip file	same as Physical	http://ofgem.gov.uk/ns/CIM/LTDS/SYSCAP/1.0

Difference Models

In LTDS grid model data exchanges, a Difference Model CIM XML file contains the following statements:

```
<?xml version="1.0" encoding="UTF-8" ?>
<rdf:RDF
  xmlns:md="http://iec.ch/TC57/61970-552/ModelDescription/1#"
  xmlns:dm="http://iec.ch/TC57/61970-552/DifferenceModel/1#"
  xmlns:cim="http://iec.ch/TC57/CIM100#"
  xmlns:eu="http://iec.ch/TC57/CIM100-European#"
  xmlns:gb="http://ofgem.gov.uk/ns/CIM/LTDS/Extensions#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<dm:DifferenceModel rdf:about="urn:uuid:UUID">
  <md:Model.created>yyyy-mm-ddThh:mm:nn.nnnZ</md:Model.created>
  <md:Model.scenarioTime>yyyy-mm-ddThh:mm:00.000Z</md:Model.scenarioTime>
  <md:Model.description>description of the set of changes</md:Model.description>
  <md:Model.modelingAuthoritySet>DNO website URL/ltds/licence area</md:Model.modelingAuthoritySet>
  <md:Model.version>nn</md:Model.version>
  <md:Model.profile> Version IRI of profile</md:Model.profile>
  <md:Model.DependentOn rdf:resource="#_UUID"/>
  <md:Model.DependentOn rdf:resource="#_UUID"/>
  <dm:forwardDifferences parseType="Statements"
    … grid object additions …
  </dm:forwardDifferences>
  <dm:reverseDifferences parseType="Statements">
    … grid object deletions …
  </dm:reverseDifferences>
 </dm:DifferenceModel>
</rdf:RDF>
```

The statements in grey are RDF and namespace definitions that appear in any CIM XML file containing a Difference Model.

The statements in green are the Difference Model definition, where the light green fields describe the following:

- In <dm:DifferenceModel rdf:about="urn:uuid:*UUID*">,
  UUID is the unique identifier of the Difference Model expressed in Universally Unique Identifier (UUID) form.
- In <md:Model.created>*yyyy-mm-ddThh:mm:nn.nnn*Z</md:Model.created>,
  yyyy-mm-ddThh:mm:nn.nnn is the date/time that the Difference Model was serialised.

- In <md:Model.scenarioTime>*yyyy-mm-dd*T*hh:mm*:00.000Z</md:Model.scenarioTime>,

  *yyyy-mm-dd*T*hh:mm* is a date/time of relevance to the Difference Model. The conventions for its population in LTDS data exchanges are given in the table below.
- In <md:Model.description>*description of set of changes*</ md:Model.description>,

  description of set of changes is a free form text field containing a locally meaningful description of what the set of changes in the CIM XML file represents.
- In <md:Model.modelingAuthoritySet>*DNO website URL*/ltds/*licence area*</md:Model.modelingAuthoritySet>,
  - *DNO website URL* is the URL of the DNO's main website.
  - *licence area* is one of the allowed *licence area* values from the list outlined for the md:modelingAuthoritySet statement of a Full Model.
- In <md:Model.version>*nn*</md:Model.version>,

  nn is any text string a DNO chooses to use to represent a version. It is totally unrelated to the version number appearing in the .zip file name.
- In <md:Model.profile>*Version IRI of profile*</md:Model.profile>,

  Version IRI of profile is the appropriate LTDS merged profile (from 4.5 LTDS profile identifiers) or CGMES profile (from the ENTSO-E website) if a profile has no LTDS deviations or extensions. The specific Version IRIs for LTDS data exchanges are given in the table below. Note that there may be one, two or three md:Model.profile statements, depending on the nature of the grid change being described.
- In <md:Model.DependentOn rdf:resource="#_*UUID*"/>,

  UUID is the unique persistent identifier of a Difference Model on which this Difference Model depends. The conventions for its population in LTDS data exchanges are given in the table below. Note that there may be zero to many md:Model.DependentOn statements.

.zip file	**CIM XML file**	**Full or Difference Model**	**header .DependentOn is UUID of**	**header .scenarioTime represents**	**Version IRI of profile name** (to which grid object content conforms)
individual Development Project	Physical	Difference Model	other individual Development Project Difference Models, if any	anticipated Development Project in-service date/time	http://ofgem.gov.uk/ns/CIM/LTDS/Equipment/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/ShortCircuit/1.0 http://ofgem.gov.uk/ns/CIM/LTDS/GeographicalLocation/1.0

6 Terms, Definitions and Abbreviated Terms

Common Grid Model Exchange Standard (CGMES)

The CGMES is a CIM-based profile and usage standard developed by the European Network of Transmission System Operators for Electricity (ENTSO-E). Version 3.0 of CGMES (CGMES v3.0) is described by IEC 61970-600-1:2021 and IEC 61970-600-2:2021.

Common Information Model (CIM)

The CIM is an information model described by IEC 61970-301:2020 and expressed in UML. Its classes, attributes and associations provide the semantic model on which profiles are based.

Common Information Model in Extensible Markup Language (CIM XML)

CIM XML is CIM-based instance data expressed in Extensible Markup Language (XML). For grid model CIM XML, the RDF/XML syntax is typically used.

Difference Model

A Difference Model is an instance of a dm:DifferenceModel. It describes an update to a FullModel. It is composed of

- a header which provides limited context information and
- two sets of CIM grid instance data, both of which conform to the same profile(s). One set describes objects/attributes/associations to be added, the other set describes objects/attributes/associations to be deleted.

Distribution Network Operator (DNO)

A DNO is a company that owns, operates and maintains an electric distribution network in Great Britain.

European Network of Transmission System Operator for Electricity (ENTSO-E)

ENTSO-E is the European association for the cooperation of transmission system operators (TSOs) for electricity.

Full Model

A Full Model is an instance of a md:FullModel(which is a header which provides limited context information) along with a set of CIM grid instance data conforming to a profile or combination of profiles.

High Voltage Direct Current (HVDC)

HVDC is direct current used for the bulk transmission of power at voltages above 100kV.

International Electrotechnical Commission (IEC)

The IEC is an international standards organization that prepares and publishes international standards for electrical, electronic and related technologies.

Long Term Development Statement (LTDS)

The LTDS is a statement published by a DNO in Great Britain pursuant to provisions of paragraph 25.2 and 25.3 of the electricity distribution licence granted to it under section 6(1)(c) of the Electricity Act 1989.

National Electricity Transmission System (NETS)

NETS the transmission grid in Great Britain, consisting of high voltage electric lines owned or operated by transmission licensees within Great Britain, in the territorial sea adjacent to Great Britain and in any renewable energy zone, and used for the transmission of electricity from one generating station to a substation or to another generating station or between substations or to or from any interconnector.

Profile

A profile, in CIM-based grid model data exchange, is a non-overlapping subset of CIM classes, attributes and associations defined to organise grid model data and support a data exchange.

Resource Definition Framework / Extensible Markup Language (RDF/XML)

RDF/XML is a syntax, defined by the W3C, to express (i.e. serialize) an RDF graph (data expressed as triples) as an XML document. In CIM-based implementations of grid model data exchange, grid instance data is serialised into RDF/XML.

Resource Definition Framework Schema (RDFS)

RDFS is a W3C-defined language for representing the structure of a set of data.

Shapes Constraint Language (SHACL)

SHACL is a language for validating RDF graphs against a set of conditions. In CIM-based grid model data exchange, the RDF graph is grid instance data expressed in RDF/XML.

7 List of Grid Modelling Appendices

Grid Modelling Information Model

- *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML*
  This is the Enterprise Architect .eap file which includes LTDS information model and the profiles, both required and optional.

- *Grid Modelling Appendix 2 – LTDS Information Model Extension Definitions and Diagrams*
  This is a Word document with machine-generated diagrams from .eap showing the relevant portions of the underlying information models (base CIM, European extensions, Network Code extensions, and Great Britain extensions) with definitions for all Great Britain extension classes, attributes, associations.

Grid Modelling Profiles

- *Grid Modelling Appendix 3 – LTDS Profiles in RDFS*
  This is machine-generated information which represents the RDF schemas of all profiles. RDFS is generated for individual profiles i.e., LTDS deviation profiles and LTDS extended profiles as well as for merged profiles where the resulting RDFS is a merge of CGMES v3.0 RDFS, LTDS deviation profile and LTDS extended profile.

- *Grid Modelling Appendix 1 – LTDS Information Model and Profiles in UML*
  This is the Enterprise Architect .eap file which includes LTDS information model and the profiles, both required and optional.

- *Grid Modelling Appendix 4 – LTDS Difference Profile Definitions and Diagrams*
  This is a Word document with machine-generated content from .eap with diagrams explaining each LTDS deviation and extended profile (visually and in words) along with version information for each profile.

- *Grid Modelling Appendix 5 – LTDS Merged Profile Class and Attribute Lists*
  This is an Excel spreadsheet summarizing:
  - Classes and attributes used by LTDS
  - LTDS vs CGMES profile classes and enumerations.

Grid Modelling Constraints

- *Grid Modelling Appendix 6 – LTDS Subset of CGMES Constraints in SHACL*

This is machine-generated information of SHACL based constraints. These constraints are validating cardinalities of associations, attributes, their datatypes and relationship. SHACL constraints are generated only for the merged profiles.

- *Grid Modelling Appendix 7 – LTDS Subset of CGMES Constraints Descriptions*
  This is a Word document containing tables with descriptions of the relevant CGMES v3.0 constraints.

Additional CIM profile developed in conjunction with LTDS revision, but not required by Form of Statement

- *General Appendix 1 – Short Circuit Result Profile Definitions and Diagrams*
  This is a Word document with machine-generated content from .eap including diagrams and description of classes, attributes and associations of the short circuit result optional profile.