IEC 61968-1

Edition 3.0   2020-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Application integration at electric utilities – System interfaces for distribution management –
Part 1: Interface architecture and general recommendations

Intégration d'applications pour les services électriques – Interfaces système pour la gestion de la distribution –
Partie 1: Architecture des interfaces et recommandations générales

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

IEC 61968-1

Edition 3.0   2020-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Application integration at electric utilities – System interfaces for distribution management –
Part 1: Interface architecture and general recommendations

Intégration d'applications pour les services électriques – Interfaces système pour la gestion de la distribution –
Partie 1: Architecture des interfaces et recommandations générales

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

**APPLICATION INTEGRATION AT ELECTRIC UTILITIES –
SYSTEM INTERFACES FOR DISTRIBUTION MANAGEMENT –**

Part 1: Interface architecture and general recommendations

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.

International Standard IEC 61968-1 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) update of IRM section, which has been out of date since the 2nd edition;

b) update to IRM model using ArchiMate modelling language;

c) addition of missing business functions and business objects;

d) alignment with newly released documents from the technical committee;

e) alignment with IEC 61968-100;

f) update of annexes.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/2174/FDIS	57/2186/RVD

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

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

A list of all parts in the IEC 61968 series, published under the general title *Application integration at electric utilities – System interfaces for distribution management*, can be found on the IEC website.

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

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

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

IEC 61968 is a series of standards:

IEC 61968 part	Title
1	Interface architecture and general recommendations
2	Glossary
3	Interface for network operation
4	Interface for records and asset management
5	Interface standard for operational planning and optimisation
6	Interface for maintenance and construction
7	Interface standard for network extension planning [1]
8	Interface standard for customer support
9	Interface for meter reading and control
11	Common information model (CIM) extensions for distribution
13	CIM RDF model exchange format for distribution
100	Implementation profiles

The IEC 61968 series is intended to facilitate inter-application integration, as opposed to intra-application integration of the various distributed software application systems supporting the management of utility electrical distribution networks. Intra-application integration is aimed at programs in the same application system, usually communicating with each other using middleware that is embedded in their underlying runtime environment. Additionally, the intra-application integration tends to be optimized for close, real-time, synchronous connections and interactive request/reply or conversation communication models. The IEC 61968 series by contrast, is intended to support the inter-application integration of a utility enterprise that needs to connect disparate applications that are already built or new (legacy or purchased applications) each supported by dissimilar runtime environments. Therefore, the IEC 61968 series is relevant to loosely coupled applications with more heterogeneity in languages, operating systems, protocols, and management tools. The IEC 61968 series is intended to support applications that need to exchange data on an event driven basis. The IEC 61968 series is also intended to be implemented with middleware services that broker messages among applications and complementing, but not replacing, utility data warehouses, database gateways, and operational stores.
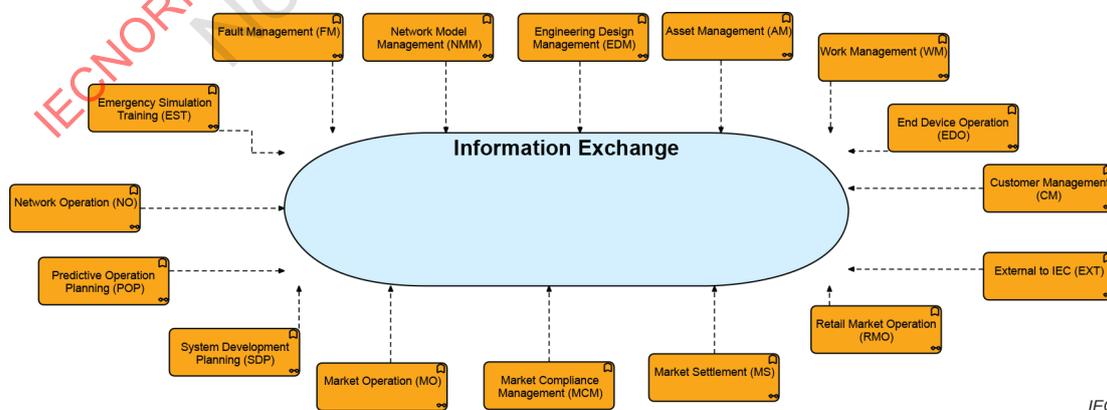
Figure 1 – High-level IEC IRM business functions

---

1 Under consideration.

Figure 1 clarifies the scope of IEC IRM in terms of business functions.

As used in the IEC 61968 series, distribution management consists of various distributed application components for the utility to manage electrical distribution networks. These capabilities include monitoring and control of equipment for power delivery, management processes to ensure system reliability, voltage management, demand-side management, outage management, work management, and network model management. The distribution management system could also be integrated with premise area networks (PAN) through an advanced metering infrastructure (AMI) network. Standard interfaces are to be defined for each class of applications identified in Clause 3, Interface Reference Model (IRM), except for those in the group EXT (External to IEC).

In the distribution management domain it is important to keep in mind the basic meaning of the following terms:

- management: effective regulation and direction;
- automation: working without human participation in accordance with pre-defined rule sets;
- system: a set of organized operations working to support a particular activity (set of applications). Generally, a system in the context of this work is a computer-based technology.

In the world of integrated systems, systems can also be a subset of a larger system, a system of systems or a set of federated systems. A system composed of coordinating subsystems may support activities more efficiently than the subsystems operating independently.

As the size of an organisation increases so does the complexity of the tasks and information exchange associated with the tasks. Furthermore, the deeper the data structure is within a system the less transparent it is to the end user. This suggests the need for data stewardship to avoid:

- errors arising from multiple points of data entry;
- lack of consistency with software interfaces;
- expensive changes with new or upgraded software;
- loss of governance of authorised data.

The standardisation of data facilitates the reduction of errors, reduced time for data entry, and improved process control.

The IEC 61968 series recommends that the semantics (domain model) of system interfaces of a compliant utility inter-application infrastructure be defined using Unified Modelling Language (UML).

The Extensible Markup Language (XML) is a data format for structured document interchange, particularly on the Internet. One of its primary uses is information exchange between different and potentially incompatible computer systems. XML is currently recommended to define grammar/syntax for profiles of a compliant utility inter-application infrastructure. A CIM profile, in accordance with IEC TR 62361-103, is derived from the CIM canonical model, which is maintained in the form of a logical information model using UML. Once defined, the profile can be used to generate an associated schema definition, most commonly (but not exclusively) as an XML Schema (XSD) or Resource Description Framework Schema (RDFS). The instance data for given information exchange must then conform to the schema defined for the profile in order to be valid. This can take into account additional restrictions that are defined for the profile over what is defined by the CIM, as almost everything is otherwise optional in the CIM by virtue of its role as a logical information model. Where applicable, IEC 61968-3 to -9 and -13 will define the information recommended for 'message payloads'. Message payloads will be formatted in accordance with industry requirements and technology development such as XML Schema for IEC 61968-3 to -9 and RDF Schema for IEC 61968-13 with the intent that these payloads can be exchanged using common integration technologies such as SOAP,

JMS, RESTful HTTP, or Web Services (WS). It is the intent of the IEC 61968 series to be leveraged by Service-Oriented Architectures (SOA) and to encourage the usage of Enterprise Service Buses (ESB). In the future, it is possible that payload formats other than XML could be officially adopted by the IEC 61968 series for specific parts or information exchanges.

The organization of IEC 61968-1 is described in Table 1.

Table 1 – Document overview for IEC 61968-1

Clause	Title	Purpose
1.	Scope	Scope of IEC 61968-1.
2.	Normative references	Documents that contain provisions which, through reference in this text, constitute provisions of this International Standard.
3.	Terms and definitions	The terms and definitions relevant to IEC 61968 series is described.
4.	Interface reference model	The domain relevant to IEC 61968 series is described. For each relevant business function, a list of abstract components is provided, which is described by the functions performed by the component. Parts IEC 61968-3 to -9 define interfaces for these abstract components.
5.	Interface profile	Utility inter-application integration environmental requirements are described. Abstract message passing services are defined and are available for applications to communicate information to other applications, including publish and subscribe services.
6.	Information exchange model	Requirements and recommendations are provided for information exchange between applications/functions listed in the IRM.
7.	Component reporting and error handling	Recommendations for audit trails and error message handling authentication necessary to support utility inter-application integration are described.
8.	Security and authentication	Recommendations for security and authentication necessary to support utility inter-application integration are described.
9.	Maintenance aspects	General maintenance recommendations are specified.
Informative Annex A	Use of IEC 61968 series	The methodology used to determine interface architecture recommendations for utility inter-application integration is described.
Informative Annex B	Inter-application integration performance considerations	Some typical performance recommendations necessary to support utility inter-application integration are described. These recommendations are of a general nature as specific implementation requirements will vary by utility.
Informative Annex C	Views of data in a conventional electric utility	This annex describes some of the underlying principles of defining the reference data dictionary of IEC 61968-11.
Informative Annex D	Relevant ArchiMate Definitions for IRM	This annex describes the ArchiMate notations used in the IEC 61968-1 IRM modelling.
Informative Annex E	61968:ED2 Interface profile mapping to ArchiMate	This annex provides the mapping between the 61968-1:2012 ED2 Interface profile and ArchiMate 3.0 from Open Group Standard that is used for this Edition (ED3).

**APPLICATION INTEGRATION AT ELECTRIC UTILITIES –
SYSTEM INTERFACES FOR DISTRIBUTION MANAGEMENT –**

Part 1: Interface architecture and general recommendations

1 Scope

This part of IEC 61968 is the first in a series that, taken as a whole, defines interfaces for the major elements of an interface architecture for power system management and associated information exchange.

This document identifies and establishes recommendations for standard interfaces based on an Interface Reference Model (IRM). Subsequent clauses of this document are based on each interface identified in the IRM. This set of standards is limited to the definition of interfaces. They provide for interoperability among different computer systems, platforms, and languages. IEC 61968-100 gives recommendations for methods and technologies to be used to implement functionality conforming to these interfaces.

As used in IEC 61968, distribution management consists of various distributed application components for the utility to manage electrical distribution networks. These capabilities include monitoring and control of equipment for power delivery, management processes to ensure system reliability, voltage management, demand-side management, outage management, work management, network model management, facilities management, and metering. The IRM is specified in Clause 3. The IRM defines the high-level view of the TC 57 reference architecture and the detailed in the relevant 61968 series, 61970 series or 62325 series. The goal of the IRM is to provide a common relevant context view for TC 57 that covers domains like transmission, distribution, market, generation, consumer, regional reliability operators, and regulators.

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 61968-3, *Application integration at electric utilities – System interfaces for distribution management – Part 3: Interface for network operations*

IEC 61968-4, *Application integration at electric utilities – System interfaces for distribution management – Part 4: Interfaces for records and asset management*

IEC 61968-5, *Application integration at electric utilities – System interfaces for distribution management – Part 5: Distributed energy optimization*[2]

IEC 61968-6, *Application integration at electric utilities – System interfaces for distribution management – Part 6: Interfaces for maintenance and construction*

IEC 61968-8, *Application integration at electric utilities – System interfaces for distribution management – Part 8: Interfaces for customer operations*

---

[2] Under preparation. Stage at the time of publication: IEC/AFDIS 61968-5:2019.

IEC 61968-9, *Application integration at electric utilities – System interfaces for distribution management – Part 9: Interfaces for meter reading and control*

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

IEC 61968-13, *Application integration at electric utilities – System interfaces for distribution management – Part 13: CIM RDF Model exchange format for distribution*

IEC 61968-100, *Application integration at electric utilities – System interfaces for distribution management – Part 100: Implementation profiles*

IEC 62351-11, *Power systems management and associated information exchange – Data and communications security – Part 11: Security for XML documents*

IEC TR 62361-103, *Power systems management and associated information exchange – Interoperability in the long term – Part 103: Standard profiling*

3   Terms and definitions

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

Where there is a difference between the definitions in this standard and those contained in other referenced IEC standards, then those defined in IEC 61968-2 shall take precedence over the others listed, and those defined in IEC 61968-1 shall take precedence over those defined in IEC 61968-2.

3.1
DMS
Distribution Management System
system consisting of various distributed application components for the utility to manage electrical distribution networks

Note 1 to entry: These capabilities include monitoring and control of equipment for power delivery, management processes to ensure system reliability, voltage management, demand-side management, outage management, work management, automated mapping and facilities management.

3.2
IRM
Interface Reference Model
standard interfaces for TC 57 cover domains like transmission, distribution, market, generation, consumer, regional reliability operators, and regulators defined using The Open Group ArchiMate standard

Note 1 to entry: The high-level view defined in 61968-1 Interface Architecture and General Requirements, defines the Business Layer context model using Business Function and Business Objects.

3.3
profiles
subset of the CIM used to define a specific message in a given context

3.4
use case
specification of a set of actions performed by a system which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system.

Note 1 to entry: There are two types of Use Cases:

- Business Use Cases describe how Business Roles interact to execute a business process. These processes are derived from services, i.e. business transactions which have previously been identified.
- System Use Cases describe how System and/or Business Roles of a given system interact to perform a Smart Grid Function required to enable / facilitate the business processes described in Business Use Cases. Their purpose is to detail the execution of those processes from an Information System perspective.

Note 2 to entry: Since a Smart Grid Function can be used to enable / facilitate more than one business process, a System Use Case can be linked to more than one Business Use Case.

[SOURCE: SG-CG/M490/E:2012-12]

3.5   Abbreviated terms

CIM   Common Information Model

DER   Distributed Energy Resource(s)

DERMS   Distributed Energy Resources Management System

DMS   Distribution Management System

EMS-API   Energy Management System Application Program Interface

RDF   Resource Description Framework

UML   Unified modelling language

XML   eXtended Markup Language

XSD   XML Schema Definition

4   Interface reference model

4.1   Domain

Within this document, the distribution management domain covers all aspects of management of utility electrical distribution networks. A distribution utility will have some or all of the responsibility for monitoring and control of equipment for power delivery, management processes to ensure system reliability, voltage management, demand-side management, outage management, work management, network model management, facilities management, and metering.

The distribution management domain may be organised as two inter-related types of business, electricity supply and electricity distribution. Electricity supply is concerned with the purchase of electrical energy from bulk producers for sale to individual consumers. Electricity distribution covers the management of the physical distribution network that connects the producers and consumers. In some countries, the responsibility of organisations may be legally restricted and certain sections of the document will be inapplicable.

A utility domain includes the software systems, equipment, staff and consumers of a single utility organisation, which could be a company or a department. It is expected that within each utility domain, the systems, equipment, staff and consumers can be uniquely identified. When information is exchanged between two utility domains, then identifiers may need extending with the identity of the utility organisation in order to guarantee global uniqueness.

4.2 Business functions

Various departments within a utility co-operate to perform the operation and management of a power distribution network; this activity is termed distribution management. Other departments within the organisation may support the distribution management function without having direct responsibility for the distribution network. This segmentation by business function[3] is provided in the Interface Reference Model (IRM), which is described in detail in 4.3.

The use of a business-related model should ensure independence from vendor-produced system solutions. It is an important test of the viability of this document that the IRM be recognisable to utility staff as a description of their own distribution network operation and management.

Major utility business functions and sub-functions of the IRM are shown in Figure 2. Note that not all the functionalities listed are relevant to a given utility but all are relevant for different utilities. Since IRM covers the IEC TC 57 context, not all interfaces are relevant for a distribution utility. However, it is noteworthy that more and more inter-application interfaces are becoming intra-application interfaces. With the increase amount of intermittent resources (Distributed Energy Resource (DER)) in distribution network, the distribution utility becomes more dependent on traditional transmission business functions. Distribution is also more dependent on traditional market business functions.
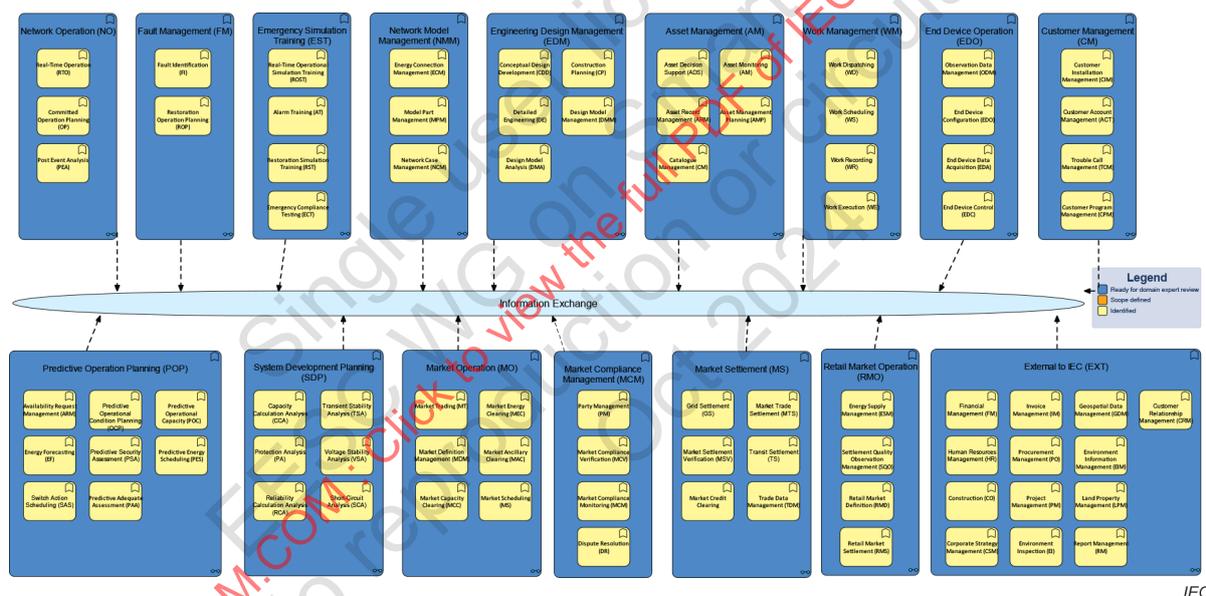
Figure 2 – Defined business function for Interface Reference Model (IRM)

4.3 Interface reference model

4.3.1 General

The Common Information Model (CIM) Interface Reference Model (IRM) utilizes The Open Group ArchiMate Modelling language to describe the business functions, business objects and business roles involved in the different major business systems that build up the power utility business capabilities.

_____

3   The work of the CIRED Working Group on Distribution Automation, published in 1996, is fully acknowledged in the segmentation.

The major business functions and business objects are listed in Subclauses 4.3.2 to 4.3.17. These business functions and objects describe the business layer that provides the business input for developing the data objects that represent the CIM profile (logical representation of the schemas) in the application layer.

The goal is to create and maintain a common IRM for IEC TC 57 that cover domains like transmission, distribution, market, generation, consumer, and regional reliability operations.

The IRM provides a business context for the profiles defined in IEC TC 57. Vendor-produced system solution will have different coverage the IRM. It has not been the intention to describe the current functionality delivered by those systems, but rather develop a generic context view that will not need to be changed based on new types of offerings by vendors, nor changes in regulation or technology.

The IRM ArchiMate model is not intended to replace the existing UML modelling, but rather complement it for addressing architecture issues.

The modelling strategy for creating the IRM is to identify the relevant business objects that are being realised through one or more data objects (IEC 61968-3 to -9, -13), also called CIM profiles. The relevant business functions that consume or produce the business objects have been identified to create the relevant context for the business objects and to describe their purpose. The major business functions are used to identify the high-level context that CIM is addressing. These business functions are then broken down to sub-business functions. However, only the business functions that access certain business objects are modelled. Note that some valid business functions are not modelled as sub-business functions due to the reason that they do not access any business objects other than those accessed by the top business function. All business objects that are accessed by a top business function are also accessible by the sub-business function. All business objects are allocated to one major business function but can be accessed by multiple functions. The colour scheme of the business object in the all diagrams for Subclause 4.3 indicate if the business object belongs to the business function modelled in the same diagram or others.

The use of access relationship (arrow from business function) does not indicate information flow, e.g. if the business object is produced or consumed by the business function. The use of the arrow is just for showing the business object's responsibility. IRM does not define any business process or link to any data object. This information will be maintained in the different standards that use the IRM. The ArchiMate notation used in IRM is listed in Annex D.

4.3.2   Asset Management (AM)

4.3.2.1   General

The Asset Management (AM) package in the CIM IRM defines the business functions and business objects involved in balancing of costs, opportunities and risks against the desired performance of assets, to achieve the organisational objectives. The relationships between the business functions and business objects are described in Figure 3.

This package is interlinked with Work Management (WM), Engineering Design Management (EDM), Network Model Management (NMM) and Network Operation (NO) packages.

The Institute of Asset Management (IAM) defines the scope of Asset Management to include the following concepts:

- organisational strategy plan;
- organisation and people;
- asset knowledge;
- asset management decision making;
- asset management strategy and planning;

- lifecycle delivery including acquire/design, operate, maintain and dispose;

- risk and review.

CIM, in Asset Management, is focusing on creating an information model and document messages (CIM profiles) that support the management of (primarily) the physical assets lifecycle including design/acquisition, operations, maintenance and renewal/disposal to ensure safe, secure, cost-effective (value-for-money) operation of power systems.

IEC 61968-4 defines the document messages (i.e. CIM profiles) for asset management. The asset management system does not need to support the business layer defined in this package for being CIM compliant. The compliance is defined by the support of the document message (i.e. CIM profile). However, vendors and utilities are encouraged to link application function requirement or capability to the business function defined in this package.
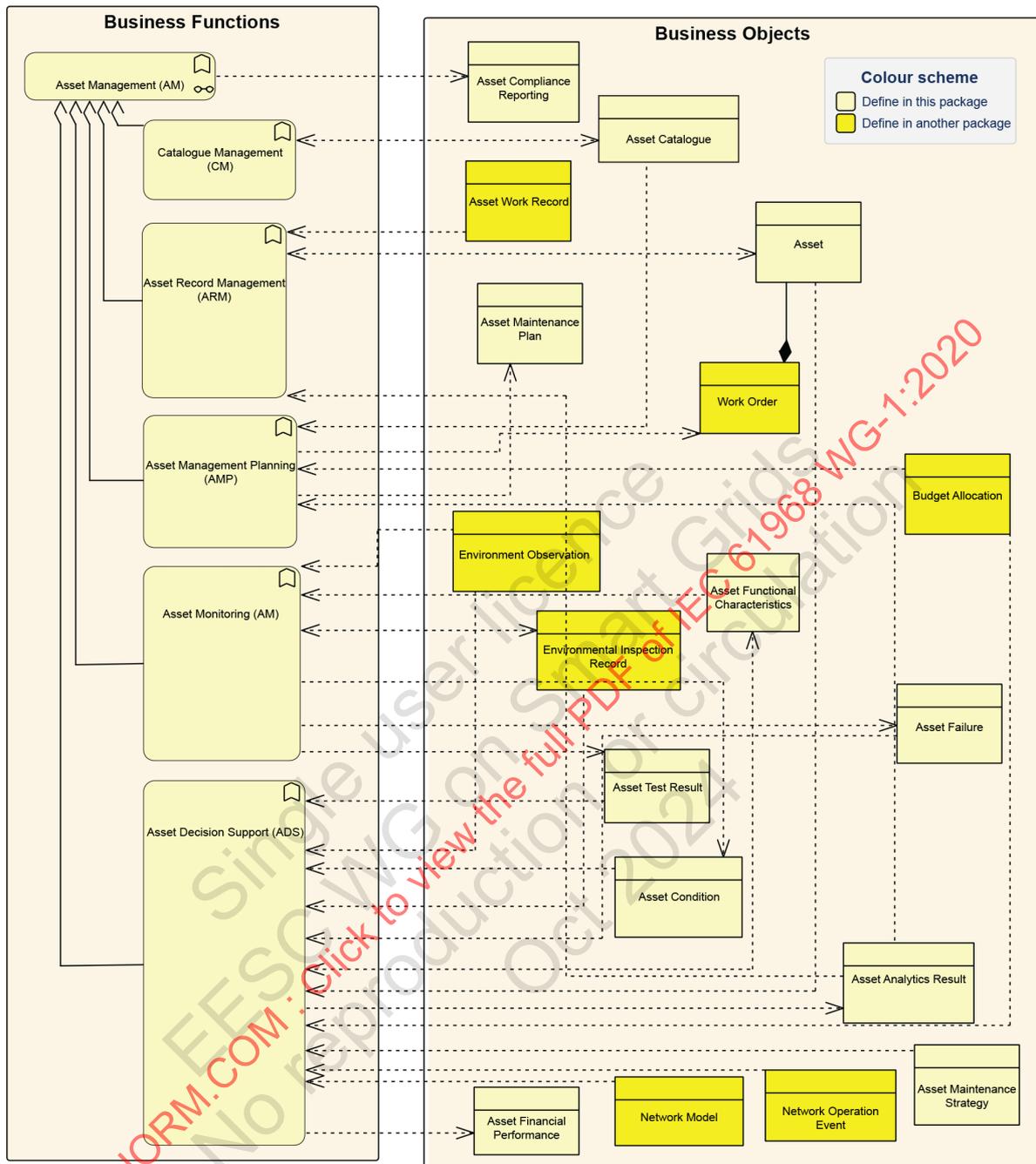
Figure 3 – Asset management business functions and business objects

4.3.2.2 Business functions

Name		Description
Asset Management (AM)		The Asset Management (AM) business function coordinates activities of an organisation to realise value from assets. Assets are in general considered to be items, things or entities that have potential or actual value to an organisation. This business function is focused on physical assets in the power system. Asset Management involves the balancing of cost, opportunities and risks against the desired performance of assets, to achieve the organisational objectives (see ISO 55000).
	Asset Decision Support (ADS)	The Asset Decision Support (ADS) business function involves strategy definition and prioritization, maintenance strategy planning, risk management, programme management and decision-making. The central aspect of asset decision support is analytics. It drives the condition, configuration, performance, operating costs, and flexibility of the asset base, with the aim of maximising value. The Asset Decision Support (ADS) business function involves also the following business functions: • Asset Criticality Analysis (ACA) The business function of developing an understanding of the role of each asset to deliver the required function, and the risk associated with operating a particular asset. • Failure Mode Effect Analysis (FMEA) The business function to determine the potential failures of systems, subsystems, equipment, component and their consequences with the goal of mitigating or reducing the risks associated with the identified failures to safely and reliably operate those assets. This will also assist to identify the best strategies to maintain these assets throughout their lifecycle.
	Asset Management Planning (AMP)	The Asset Management Planning (AMP) business function involves the specification of the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organization's asset management objectives. Reliability trends and the evaluation of corrective actions needs to be performed. The grouping of assets may be by asset type, asset class, asset system or asset portfolio. An asset management plan is derived from the strategic asset management plan.
	Asset Monitoring (AM)	The Asset Monitoring (AM) business function involves inspection, testing, measurement, and monitoring of the assets in order to understand, assess and manage their condition and performance.
	Asset Record Management (ARM)	The Asset Record Management (ARM) business function involves the registration and maintenance of the legal (e.g. ownership), commercial (e.g. supplier), financial (e.g. different type of cost), technical and managerial information for: • Substation and Network Assets The electrical substation and network assets that a utility owns, or for which it has responsibility, maintained in an accurate asset register developed around an asset hierarchy that supports advanced asset management functions. • Energy Resource Asset Record of the Energy Resource, including Distributed Energy Resource (DER), that can be aggregated to provide power necessary to meet demand. These resources refer to distributed generation, storage, load management, combined heat and power and other sources involved in electricity supply, both in stand-alone and interconnection applications.

Name		Description
		• Non-Electrical Grid Asset The non-electrical assets (e.g. poles, cross-arms, etc.) that a utility owns, or for which it has responsibility, maintained in an accurate asset register that supports advanced asset management functions. • Non-Grid Asset The non-grid assets (e.g. tools, vehicle, etc.) that a utility owns or responsibility for that is not related directly to the network grid.
	Catalogue Management (CM)	The Catalogue Management (CM) business function involves the maintenance of the collection of information regarding available types of products and materials that are used to design, build or install, maintain or to operate assets. Asset having common characteristics that distinguish those asses as a group or class are defined into asset type. Management of manufacturer product specification for given asset types and management of the engineering design asset type specification.

4.3.2.3   Business objects

Name	Description
Asset	The Asset business object includes legal (e.g. ownership), commercial (e.g. supplier), financial (e.g. different type of cost), technical and managerial information for substation and network, energy resource (including distributed energy resource (DER), and non-electrical assets. Identification numbers (specification number, product number, serial number) are central items that allow for collection of additional information associated with the asset.
Asset Analytics Result	The Asset Analytics Result business object includes various analytic scores for the asset, asset type or group of asset (e.g. breakers from a given manufacture) that describe the criticality to the organisation, performance targets or standards, non-conformance criteria, operating cost, replacement value, downtime impact and health assessment.
Asset Catalogue	The Asset Catalogue (AC) business object includes the information of asset grouping with relevant specification to provide information on a given set of generic asset material to be used in strategic planning, design/acquisition, operations, maintenance and renewal/disposal.
Asset Compliance Reporting	The Asset Compliance Reporting business object describes compliance to organisation realisation of asset management in regard to value, efficiency and effectiveness, integrity, execution and leadership against regulatory, standard and business requirements. This could include reporting on compliance to maintenance strategy, maintenance execution, deliverables, and continual improvement. Reporting can be done on individual asset, asset type and asset group in regard to operational, reliability and security standards and regulations. It can also include their impact on the environment in regard to government regulation.
Asset Condition	The Asset Condition business object describes a given asset or asset type key performance indicators for given operational condition, performance targets or standard, operational safety and reliability assessment.
Asset Failure	The Asset Failure business object describes the failure history or statistics associated with a given asset, asset type or asset group (e.g. breakers from a given manufacturer). This includes burnout and accidents.

Name	Description
Asset Financial Performance	The Asset Financial Performance business object includes the evaluation of return-on-investment (ROI) for a given asset, asset type or asset group by comparing resource investment and cost for lifecycle management against performance and availability.
Asset Functional Characteristics	The Asset Functional Characteristics business object describes the combination and interdependencies of asset data (technical information), engineering data, design parameters, environment conditions (both static and dynamic), asset condition data and asset maintenance strategy to form the safe operational space and operational constraints. For example, inherent/permanent thermal rating of assets deployed in the network including changes in electrical asset performance limits based on temperature, wind speed and solar radiation, which set the frame for a variety of actual operational limits on network elements.
Asset Maintenance Plan	The Asset Maintenance Plan business object specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organization's asset management objectives and prevent expected impact of asset failure.
Asset Maintenance Strategy	The Asset Maintenance Strategy business object describes the business and compliance requirements in regard to value provided to stakeholders, such as safety, return on investment, return on assets, return on equity and service levels. The organisation's appetite for risk (safety, financial, environment and reputational) and its performance goal need to be explicitly stated or be possible to be derived. Asset maintenance is a key lever to deliver business outcomes and the strategy defines the alignment and combination of technical and financial management to provide equipment/assets that are "fit for purpose", "safe to use" and "financially sustainable" over the short and long term. This includes the asset lifecycle of design/acquisition, operations, maintenance and renewal/disposal.
Asset Test Result	The Asset Test Result business object describes the result of monitoring, inspections, a formal evaluation task, and built-in self-test (BIST) activities. This is the result of measurements, tests and gauges applied to certain characteristics in regard to an item/thing or activity. The results are usually compared to specified requirements and standards for determining whether the item or activity is in line with these targets. Standard Inspection Procedures ensure consistent checking and interpretation of the result. These include results from laboratory work.
Asset Work Record	The Asset Work Record business object describe the job completion including close work orders (time and material consumption), post-work documentation needed for updating/cleaning-up the asset record. As part of work execution, additional business objects such as Failure Record, Asset Test Result, Asset Condition Data and Asset Analytics Result can be produced.

4.3.3   Customer Management (CM)

4.3.3.1   General

The Customer Management (CM) package in the CIM IRM defines the business functions and business objects involved in the management of customer data and records, customer trouble calls, customer installation, customer agreements and settlement (creating the billing components that are aggregated as part of the billing process) and the development of new products. The relationships between the business functions and business objects are described in Figure 4.

This package is interlinked with End Device Operation (EDO), Predictive Operation Planning (POP), Retail Market Operation (RMO), Work Management (WM), Fault Management (FM), External to IEC (EXT) and Network Operation (NO).
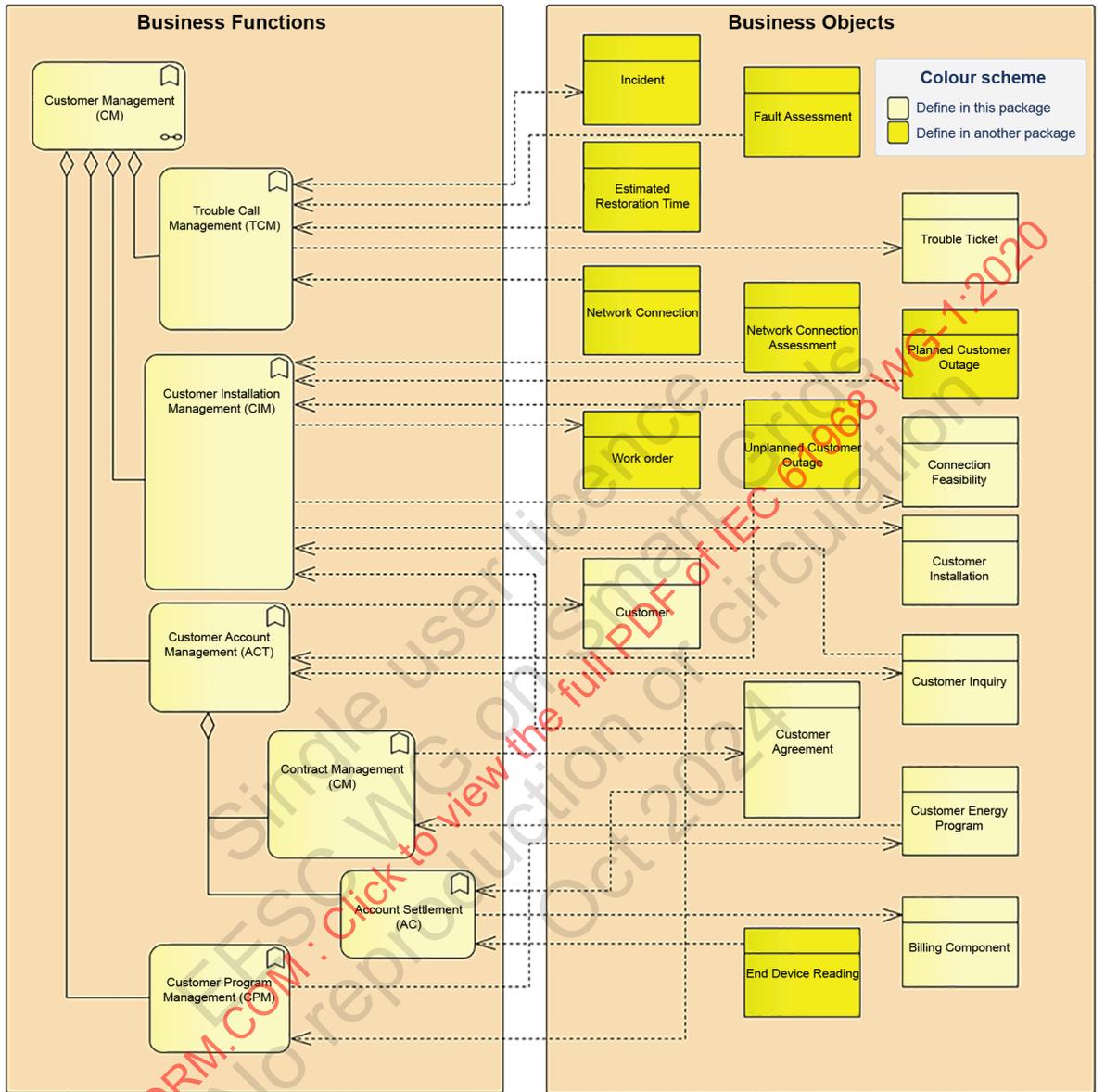
Figure 4 – Customer management business functions and business objects

4.3.3.2 Business functions

Name	Description
Customer Account Management (ACT)	The Customer Account Management (ACT) business function includes the creation, ongoing management (including responding to customer inquiries relative to their account), account billing, and account closing.
Account Settlement (AC)	The Account Settlement (AC) (or Billing Management or Customer Settlement Management) business function involves the settlement calculation based on the customer agreement and the Settlement Quality observation (typically through a meter reading). This produces the items, statements or billing components that are used in the billing process for invoicing the customer.
Contract Management (CM)	The Contract Management (CM) (or Contract Administration) business function involves the management of contracts/agreements with customer in regard to services to the customer installation, maintenance and creation of new customer installation.
Customer Installation Management (CIM)	The Customer Installation Management (CIM) business function is managing the information related to the customer installation and connection to the grid. This includes line extension, fuse and capacity description, inspection and survival, meter installation and interconnection of additional devices (e.g. solar panels through an inverter) to the grid. This also includes the work definition, work task breakdown and request for a schedule of the work.
Customer Programme Management (CPM)	The Customer Programme Management (CPM) business function involves the creation and maintenance of programs made available to customers such as various rate options or programs which will affect their usage/billing (e.g. demand response (DR)).
Trouble Call Management (TCM)	The Trouble Call Management (TCM) business function manages the receipt of information from and communications to customers or other observation related to service to one of more customers. This involves the matching up of previous reported trouble ticket, know incident (in the related area) or unplanned (some cases planned) outages.

4.3.3.3   Business objects

Name		Description
Billing Component		The Billing Component (or Settlement Statement, Customer Settlement Statement or Customer Billing Statement) business object describes the line items that constitute the charges and payment created as part of settling the contract signed with the customer. This provides some of the input to invoicing were pay and receivable and payment agreement is not included.
Connection Feasibility		The Connection Feasibility business object described the result of a feasibility study for connection.
Customer		The Customer business object describes an individual person or business that has or has had an agreement with the utility in regard to provide goods or services.
Customer Agreement		The Customer Agreement (or Customer Contract) business object describes the commitment between the service provider and a customer. The agreement describes the aspects of the service in regard to quality, availability and responsibilities.
	Energy Agreement	The Energy Agreement (or Energy Contract) business object is a specialisation of Customer Agreement where the commitment is in relation to the delivery of energy to or from a given customer installation and customer. In some cases, this could also describe agreement in regard to active power that is delivered or consumed as well.
	Grid Connection Agreement	The Grid Agreement (or Grid Contract) business object is a specialisation of Customer Agreement where the commitment is in relation to the connection into the grid, distribution or transmission.
	Network Extension Agreement	The Network Extension Agreement (or Network Extension Contract) business object is a specialisation of Customer Agreement where the commitment is in relation to extending an existing customer installation or the creation of a new customer installation.
Customer Energy Programme		The Customer Energy Programme business object describes the product that a customer can be entered into agreement with. It normally describes a way for a utility to control the customer installation as a reserve for balancing the grid in regard to demand (or in some cases production surplus). The customer is compensated for providing the flexibility and when the flexibility is activated. This could be a demand response product or other power effect control program.
Customer Inquiry		The Customer Inquiry business object describes the inquiries from a given customer.
Customer Installation		The Customer Installation business object describes the content of the installation on the customer premises in regard to installation, premise, point of delivery and device (e.g. a meter for meter reading) and their location (directly or relative to the connection to the grid).
Trouble Ticket		The Trouble Ticket business object describes the event and/or symptoms that may or may not affect the grid that is reported by a customer or third-party observer. The trouble ticket might be linked to an Incident, Unplanned Customer Outage or in some cases a Planned Customer Outage.

4.3.4   Emergency Simulation (ES)

4.3.4.1   General

The Emergency Simulation (ES) package in the CIM IRM defines the business functions and business objects involved in training, planning and simulation of emergency situations. The relationships between the business functions and business objects are described in Figure 5.

The emergency simulation includes training and planning for both internal enterprise and external cross utility/entity corporation. Both are in the horizontal and vertical domain, e.g. TSOs-TSOs and TSOs-DSOs coordination.

This package is interlinked with Network Model Management (NMM) and Network Operation (NO) packages.
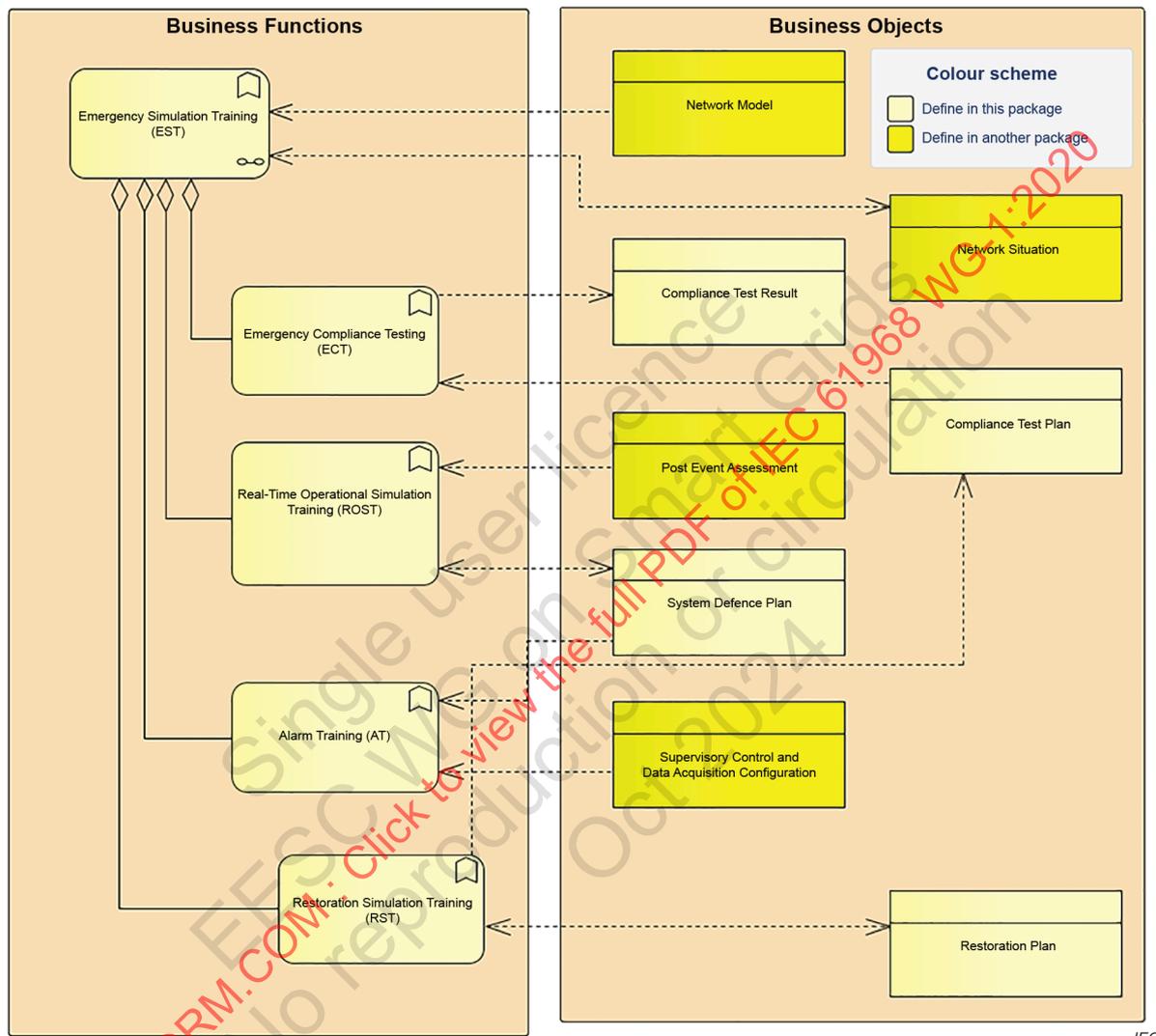
Figure 5 – Emergency simulation training business functions and business objects

4.3.4.2   Business functions

Name	Description
Emergency Simulation (ES)	The Emergency Simulation (ES) business function involved operational training and operational planning with the use of network and situation simulation to prepare for emergency situations.
Alarm Training (AT)	The Alarm Training business function involves training in interpreting alarms and how to change the network operation so that the alarm situation is resolved.
Emergency Compliance Testing (ECT)	The Emergency Compliance Testing business function involves the formal verification of equipment and capabilities relevant for the system defence plan and the restoration plan.
Real-Time Operational Simulation Training (ROST)	The Real-Time Operational Simulation Training business function involves the training of operators in real-time operating environment such as control centres to operate a plant, facility or grid.
Restoration Simulation Training (RST)	The Restoration Simulation Training business function involves the training of executing defence and restoration plans, e.g. restoration from blackout.

4.3.4.3   Business objects

Name	Description
Compliance Test Plan	The Compliance Test Plan business object includes legal (e.g. ownership), commercial, (e.g. supplier), financial (e.g. different type of cost), technical and managerial information for substation and network, energy resource (including distributed energy resource (DER)), and non-electrical asset that are included and used in a defence and restoration plan.
	Identification of the network function and the physical assets are central items that allow for the retrieval of additional information associated with the asset and its network function.
Compliance Test Result	The Compliance Test Result business object includes the identification of the asset and network function that has passed the compliancy test.
Restoration Plan	The Restoration Plan business object includes the all technical and organisational measures necessary for the restoration of the system back to normal state.
System Defence Plan	The System Defence Plan business object includes the identification of critical grid elements and their relevant roles, e.g. operator of significant production, the conditions under which the system defence plan is activated. It needs to include the list of measurements that is implemented and can be active on the installations that are deemed critical.
	This includes a protection schema as:
	• automatic under-frequency control scheme;
	• automatic scheme against voltage collapse.
	And defence procedures for:
	• frequency deviation;
	• voltage deviation;
	• power flow management;
	• demand disconnection.

4.3.5   End Device Operation (EDO)

4.3.5.1   General

The End Device Operation (EDO) package in the CIM IRM defines the business functions and business objects for configuration, control and acquisition of information from end devices. The relationships between the business functions and business objects are described in Figure 6.

End device is defined as the item that provides the source of the information and the destination of any control. The business function action is normally triggered by other business function, e.g. a meter reading that is triggered by billing or a device control triggered by a demand response programme. This is not preventing the underlying technology to be real-time based. The control signal for changing the temperature setting on an air condition is an example of a control that is triggered by the Network Operation business function. End device operation are independent of technology, ownership or type of device.

This package is interlinked with Customer Management (CM), Work Management (WM) and Network Operation (NO) packages.
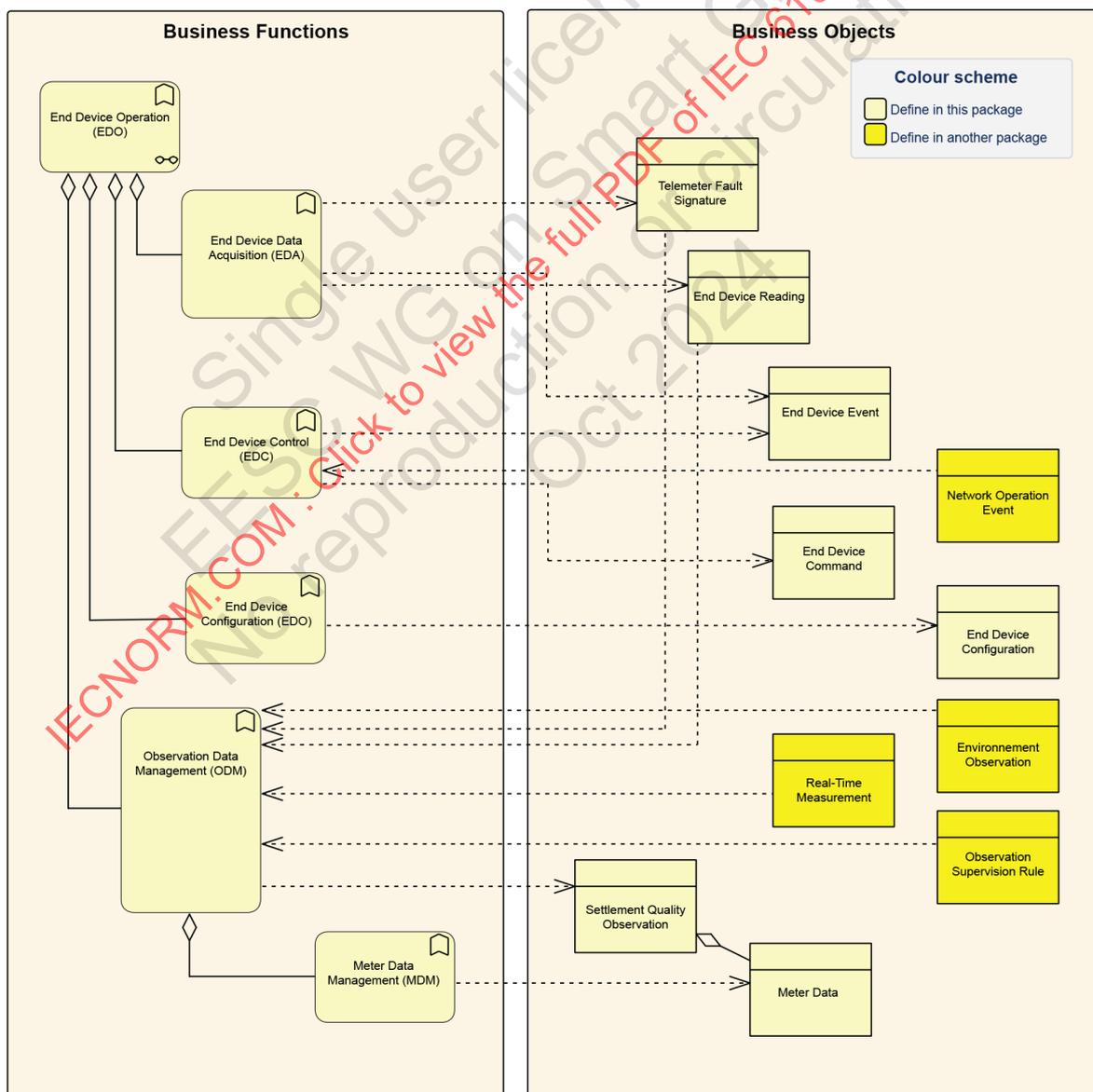
Figure 6 – End device operation business functions and business objects

4.3.5.2   Business functions

Name	Description
End Device Configuration (EDO)	The End Device Configuration (ECO) business function focuses on configuration of an end device including communication settings, establishing unique identification, control settings, acquisition setting in regard to measurement, accuracy, sampling rate and quality monitoring.
End Device Control (EDC)	The End Device Control (EDC) business function includes the ability to control the end device in regard to meet new configuration settings, operations (e.g. enabling demand response) or other controls of the system services by network operation.
End Device Data Acquisition (EDA)	The End Device Acquisition (EDA) business function includes all activities that gather non-real-time data from an end device, e.g. a meter, Phasor Measurement Unit (PMU), or fault recorder. This includes data such as: – analogue data such as meter reading; – discrete data such as on and off; – status; – control results.
Meter Data Management (MDM)	The Meter Data Management (MDM) business function collects, validates, stores and distributes readings and event-related data from meters and other end devices to other enterprise functions and systems. The meter data management function supports diverse end-use applications including but not limited to billing, load management, load forecasting, demand response, outage management, asset management and distribution network planning and maintenance. The function may perform validating, editing, and estimating (VEE) according to rules established by the appropriate supervising regulatory agency.
Observation Data Management (ODM)	The Observation Data Management (ODM) business function validates readings and other observation measurement against agreed quality rules. Observation that does not meet the requirement can be user edited or estimated bases on rules. The appropriate supervision rules for validating, editing and estimating (VEE) are normally defined by the relevant supervising regulatory agency.

4.3.5.3   Business objects

Name	Description
End Device Command	The End Device Command business object represent the command communicated to the end device, e.g. change temperature setting on the air condition.
End Device Configuration	The End Device Configuration business object describe the configuration of the end device. This can include communication settings, establishing unique identification, control settings, acquisition setting in regard to measurement, accuracy, sampling rate and quality monitoring.
End Device Event	The End Device Event business object is information provided by the end device based on the end device configuration and represents the occurrence of an event that has been under monitoring. Meter tampering and grounding error are examples of end device events.
End Device Reading	The End Device Reading business object represents the data that have been acquired by the end device. A meter reading that provides the cumulative kWh value recorded by a meter device from a previous reading, or a meter reading on an hourly resolution for a period are examples of end device readings. A fault reading from a remote fault recorder is also an example of an end device reading.
Meter Data	Meter data that are integrated over a period of time before being presented for billing or other purposes.
Settlement Quality Observation	The Settlement Quality Observation business object describes the data that meets the quality required by the settlement function defined in the Market Rules. For example, a meter reading can include the cumulative kWh value that needs to have the previous meter reading subtracted to calculate the consumption from previous billing components. The consumption value could be considered as settlement ready data that meets the requirement defined in the market rules.
Telemeter Fault Signature	The Telemetered Fault Signature business object includes one or more remotely monitored measurements from sensors that are used to identify the location of a Predicted Fault Event. The Telemetered Fault Signature could be waveform data from a fault recording device, fault passage and direction from fault passage indicator devices, fault distance from a relay, fault current from a relay, the open/close status of a switch or an analogue voltage/flow measurement.

4.3.6   Engineering Design Management (EDM)

4.3.6.1   General

The Engineering Design Management (EDM) package in the CIM IRM defines the business functions and business objects involved in creating and maintaining detailed design (e.g. blueprints) of all the structures that constitute the relevant grid elements. These include substation engineering, transmission line engineering, distribution engineering, generation engineering, and so on. Engineering design includes both electrical and non-electrical aspects at the level of detail necessary to support construction and maintenance activity, and typically identifies catalogue specifications that are associated with parts of the design. Detailed schematics are common, and the content describes how asset positions are to be connected (either mechanically or electrically). Engineering design functions are usually limited to owned parts of the grid. Engineering design connects the functional requirements to asset requirements and evolves from the generic requirement on the type of asset to the documentation of the specific asset. The relationships between the business functions and business objects are described in Figure 7. The breakdown of the detailed engineering and detailed design can be found in Figure 8.

This package is interlinked with Work Management (WM), Asset Management (AM) and Network Model Management (NMM) packages.

For the following domain area; legal, commercial, financial, managerial and organisational informational model will be harmonised with other exiting standards and information models, such as the Building Information Model (BIM).

As an example, this means that CIM does not intend to support Procurement & Supply Chain Management but provide input in regard to requirements for asset design, operations, maintenance and monitoring as well as evaluating the delivered or build solution.

The Building Information Modelling (BIM) lifecycle view includes:

- programming (e.g. project and functional requirements);
- conceptual design;
- detailed design;
- analysis;
- documentation;
- fabrication;
- construction 4D/5D (4D adding time to 3D, 5D adding of cost);
- construction logistics;
- operation and maintenance;
- demolition/renovation.

IEC 61968-6 defines the current document messages/CIM profiles for Engineering Design.

Engineering Design system does not need to support the business layer defined in this package to be CIM compliant. The compliance is defined by the support of the document message/CIM profile. However, the vendor and utility companies are encouraged to link application function requirements or capabilities to the business function defined in this package. Since power systems are considered part of the critical infrastructure and its operation and maintenance involves a high level of personal safety risk, the CIM standard has extra focus on information security and personal safety.
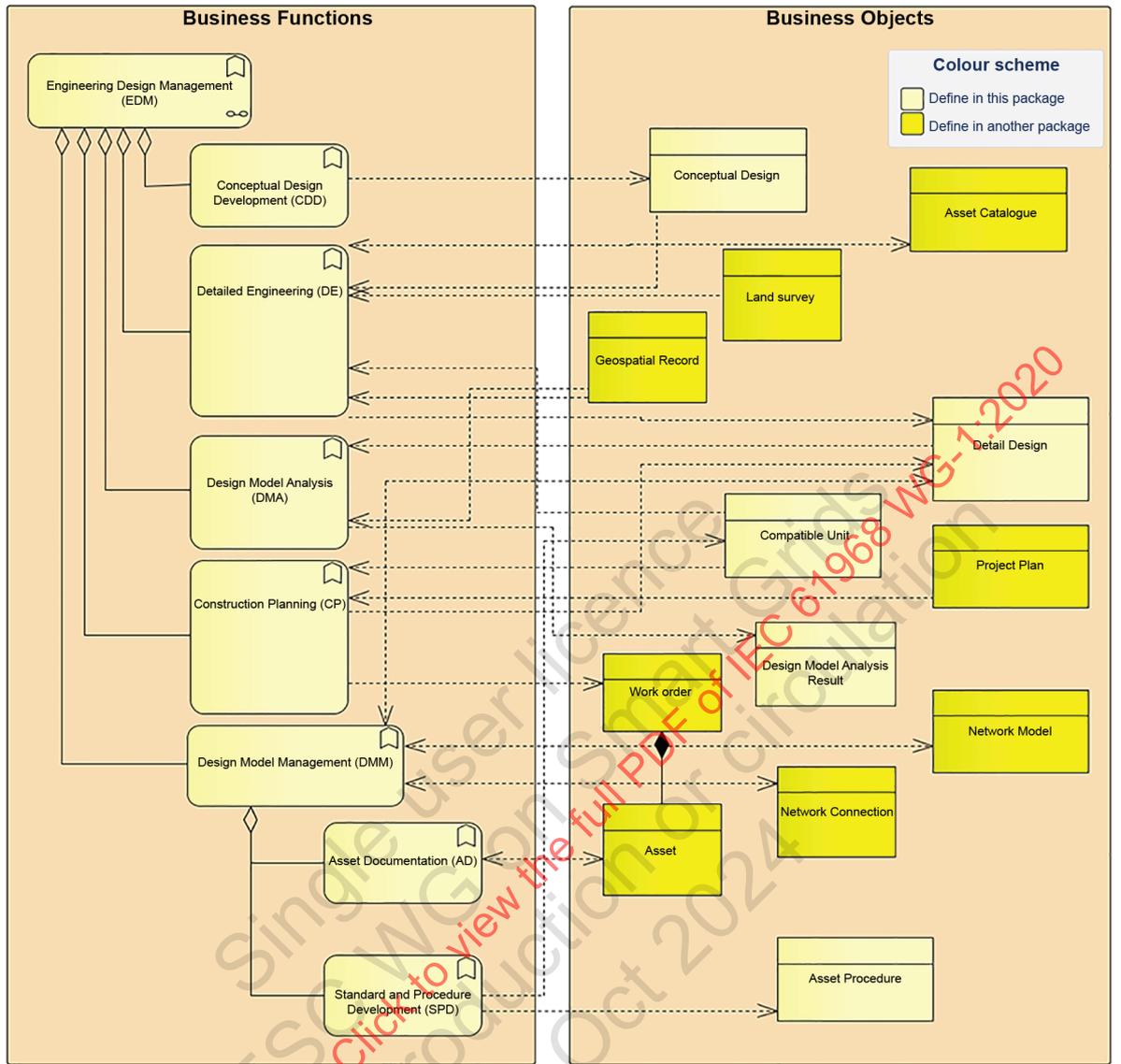
Figure 7 – Engineering design management business functions and business objects
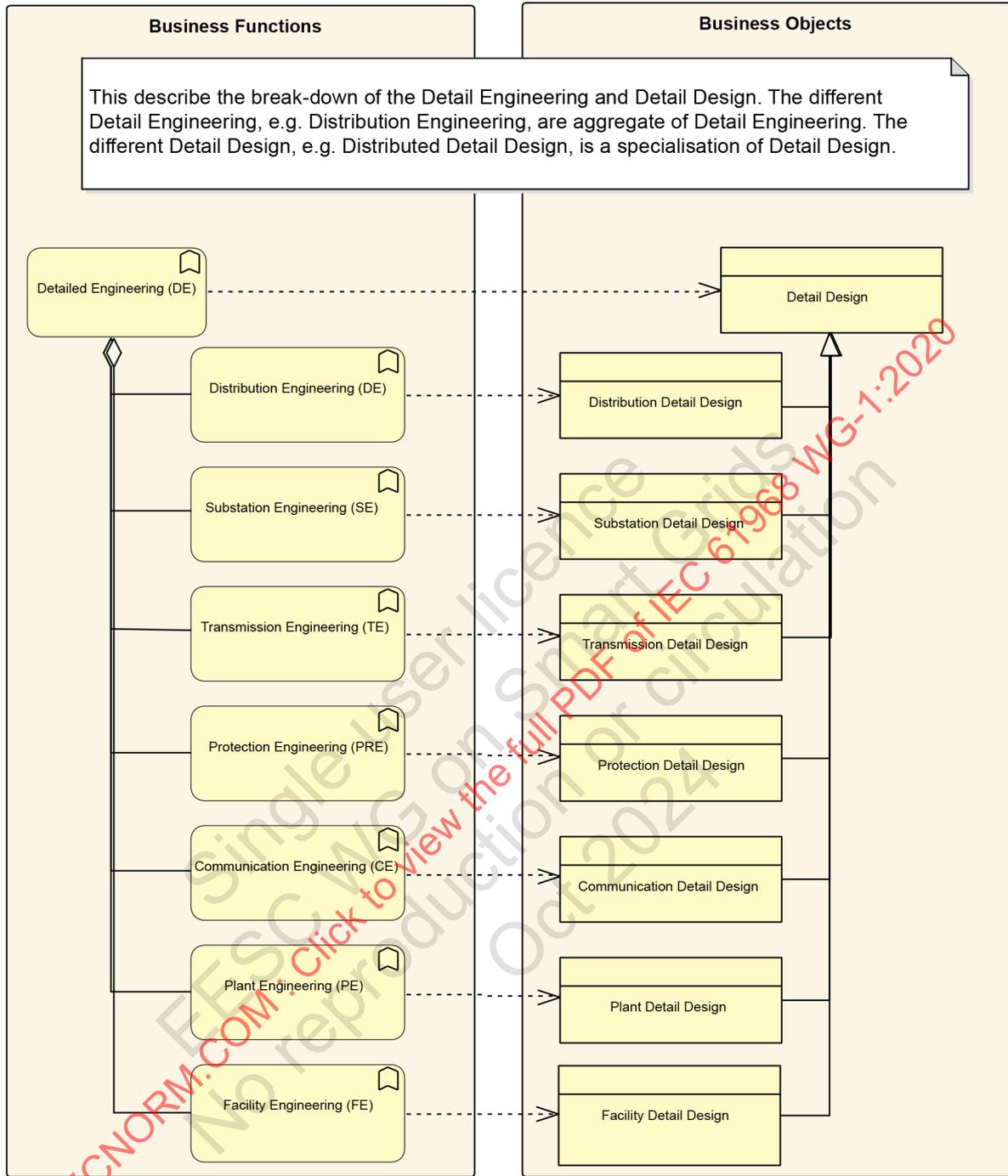
Figure 8 – Break down of detail engineering and detail design

4.3.6.2   Business functions

Name	Description
Conceptual Design Development (CDD)	The Conceptual Design Development (CDD) business function involves producing ideas and taking into account the pros and cons of implementing those ideas. It is also referred to as Font-End Engineering (FED), or Front-End Engineering Design (FEED). The purpose is to minimize the likelihood of error, manage costs, assess risks, and evaluate the potential success of the intended project construction. The overall system configuration is defined, and schematics, diagrams, and layouts of the construction project may be in an early configuration. The following are example on consideration that is done: • degree of automation; • rates and levels (e.g. performance range); • material specifications (e.g. compatible units); • standards and guidelines; • assumptions, exclusions, and potential problems.
Construction Planning (CP)	The Construction Planning (CP) business function involves the definition of work order and the relevant sequence task based on the detail design. Construction planning is the necessary forerunner to scheduling. In this planning, defining work tasks, technology and construction methods is typically done either simultaneously or in a series of iterations.
Design Model Analysis (DMA)	The Design Model Analysis (DMA) business function involves the analysis to simulate the performance of the asset structure based on the detail design. The detail design could represent the structure and/or building in different stages, as-planned, as-designed, as-built or as-operated. The simulation of measure-based performance is done as part of Network Operation (NO) for real-time and System Development Planning (SDP) or other functional area after the fact simulation. Relevant power electronic analysis are: • small signal stability analysis; • dynamic simulation; • geomagnetic induced currents (GIC); • short-circuit calculation; • line properties calculation; • electromagnetic transients (EMT); • protection simulation; • cost calculation; • reliability.

Name	Description
Design Model Management (DMM)	The Design Model Management (DMM) business function involves the management of information through the whole life cycle of a built asset. It delivers value by underpinning the creation, collation and exchange of shared models and corresponding intelligent structured data.
	The focus being the support for:
	• provision a "single source of truth" for asset data and information for all parties to share during design, construction, and throughout the operational phase of assets;
	• bringing design and operational engineers, processes, information and technology closer together;
	• sharing data and information in a way to ensure traceability and a high level of accuracy.
	The generic compatible unit in the conceptual design is replaced by individual assets or physical objects through the procurement process.
Asset Documentation (AD)	The Asset Documentation (AD) business function involves the documentation of the built asset by providing a "single source of truth" for asset data throughout the whole lifecycle for the build asset.
	The documentation is guided by the asset management policy and strategy.
Standard and Procedure Development (SPD)	The Standard and Procedure Development (SPD) business function involves the development and documentation of standard operating procedures or work instructions that detail all of the steps involved in a procedure or process.
	The development of standard operating procedures is central for TQM (Total Quality Management), HACCP (Hazard Analysis Critical Control Points), ISO 9000 (International Organization for Standardization), and Six Sigma for helping companies maintain process and quality control.
	The establishment of measurable conditions and performance of assets and how they are employed. Characteristics or attributes of a standard describe its required level of performance, which typically describes "how much", "of what nature" and "how frequently". Often, engineering and design standards reference industry standards and manufacturing specifications.

Name	Description
Detailed Engineering (DE)	The Detailed Engineering (DE) business function involves the detailing to provide a complete description through solid modelling, drawings as well as specifications. Solid modelling is a consistent set of principles for mathematical and computer modelling of three-dimensional solids. Solid modelling, together with geometric modelling, forms the foundation of computer-aided design for supporting creation, exchange, visualisation, animation, interrogation, and annotation of digital models or physical objects. The following elements are considered as part of detailed engineering to provide necessary information for manufacturing/fabrication/construction: • operating parameters; • operating and non-operating environmental stimuli; • test requirements; • external dimensions; • maintenance and testability provisions; • materials requirements; • reliability requirements; • external surface treatment; • design life; • packaging requirements; • external marking.
	Communication Engineering (CE)	The Communication Engineering (CE) business function is a specialisation of Detail Engineering with a focus on designing communication and IT infrastructure.
	Distribution Engineering (DE)	The Distribution Engineering (DE) business function is a specialisation of Detail Engineering with a focus on designing the distribution system including feeder, fuses, etc.
	Facility Engineering (FE)	The Facility Engineering (FE) business function is a specialisation of Detail Engineering with a focus on designing microgrid or collection of one or more production, consumption and storage entities that has a common control and forecast mechanism. This would include the engineering of Distributes Energy Resources (DER).
	Plant Engineering (PE)	The Plant Engineering (DE) business function is a specialisation of Detail Engineering with focus on designing production, consumption or storage plant.
	Protection Engineering (PRE)	The Protection Engineering (PRE) business function is a specialisation of Detail Engineering with a focus on designing protection schemes, SIPS (SPR/RAS), configuration of components (e.g. relay, disturbance-monitoring).
	Substation Engineering (SE)	The Substation Engineering (SE) business function is a specialisation of Detail Engineering with a focus on designing substation including transformation, switching and direct current transition.
	Transmission Engineering (TE)	The Transmission Engineering (TE) business function is a specialisation of Detail Engineering with a focus on designing transmission lines and connections to distribution, bulk production and industry.

4.3.6.3   Business objects

Name	Description
Asset Procedure	The Asset Procedure business object includes the step-by-step work instruction for operating, maintaining, testing and inspecting the asset.
Communication Detail Design	The Communication Detail Design business object is a specialisation of Detail Design for communication and IT infrastructure. E.g. Field Area Networks (FAN) that include communication with end-devices. Another example is Premise Area Network (PAN) communication.
Compatible Unit	The Compatible Unit (PU) business object is a standardised assembly unit defined for general use by designers, crews and accounting personnel. A compatible unit is made up of labour tasks, vehicle/equipment hours, materials, accounting information, attachments, default contract/contractors.
Conceptual Design	The Conceptual Design business object includes the definition of the overall system configuration, and schematics, diagrams, and layouts of the detail design in an early configuration. Conceptual designs can be made up of individual line items or by a set of "Compatible Units" or CUs. Line items and Compatible Units are associated with a design diagram location and/or with a geospatial location.
Design Model Analysis Result	The Design Model Analysis Result business object includes detailed and complete description of the analytic result of the analysis that is done on the detail design.
Detail Design	The Detail Design (DD) business object includes detailed and complete description of the construction solution through solid models, drawings as well as specifications. The object provides the necessary information for manufacturing, fabrication, construction and maintenance.
Distribution Detail Design	The Distribution Detail Design business object is a specialisation of Detail Design for distribution system including feeder, fuses, etc. This includes, among others, geographical information, connectivity and ratings.
Facility Detail Design	The Facility Detail Design business object is a specialisation of Detail Design for microgrid or collection of one or more production, consumption and storage entities that has a common control and forecast mechanism. This would include the design of Distributed Energy Resources (DER).
Plant Detail Design	The Plant Detail Design business object is a specialisation of Detail Design production, consumption and storage plant.
Protection Detail Design	The Protection Detail Design business object is a specialisation of Detail Design for protection schemes, SIPS (SPR/RAS), component (e.g. Relay, disturbance monitoring) configuration.
Substation Detail Design	The Substation Detail Design business object is a specialisation of Detail Design for substation including transformation, switching and transition (DC).
Transmission Detail Design	The Transmission Detail Design business object is a specialisation of Detail Design for transmission line and connection to distribution, bulk production and industry.

4.3.7   Fault Management (FM)

4.3.7.1   General

The Fault Management (FM) package in the CIM IRM defines the business functions and business objects involved in fault identification and fault restoration planning using The Open Group ArchiMate modelling language. The relationships between the business functions and business objects are described in Figure 9.

Fault Management gets notifications regarding faults in the electrical network and analyses those notifications in order to estimate the location of the fault. Fault Management tracks the fault through the stages of actual location, minimizing the area impacted by the fault, restoring service to all impacted parts of the network and coordinating permanent repairs. Fault Management ensures that fault durations and restoration times are correctly captured for regulatory reporting purposes.

This package is interlinked with Work Management (WM) and Network Operation (NO) packages.
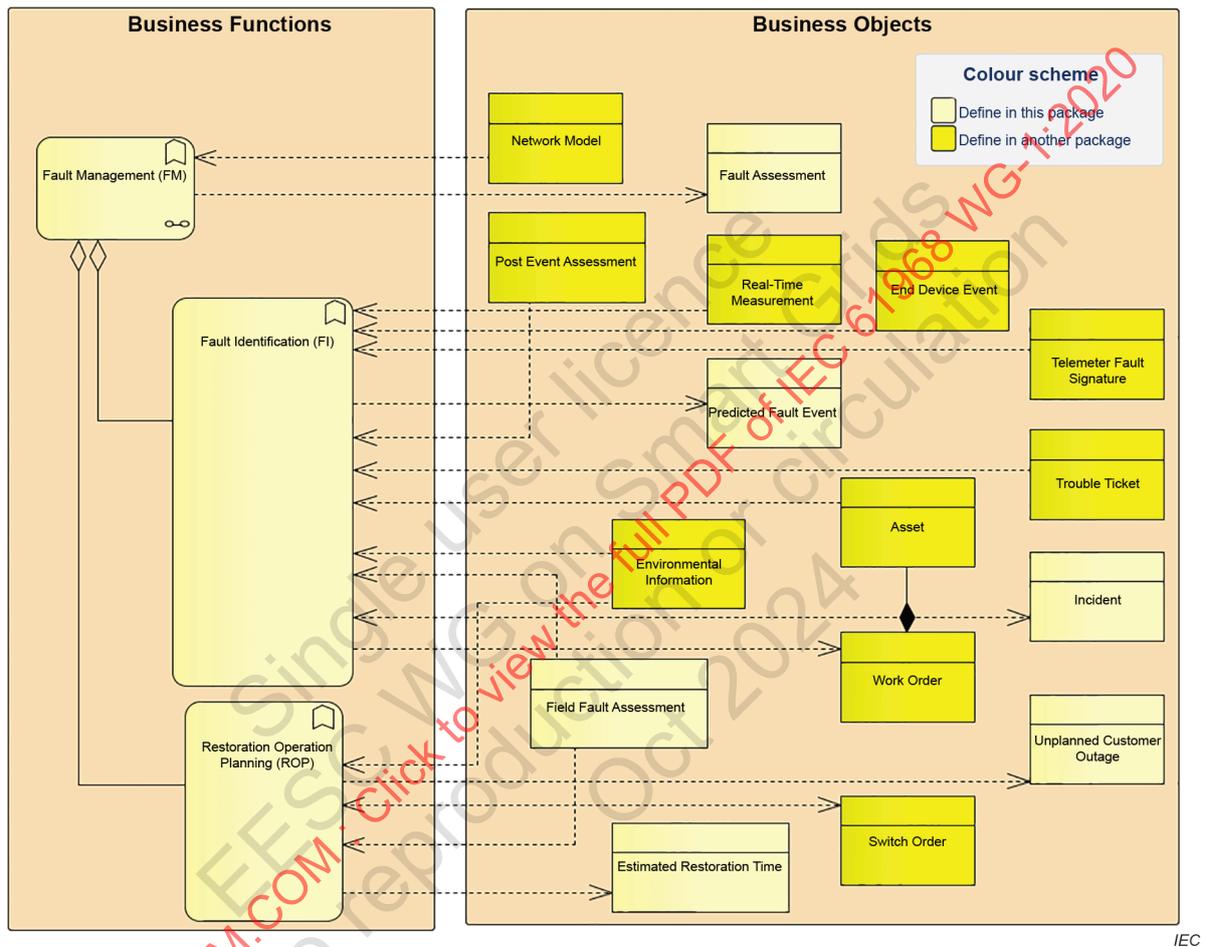
Figure 9 – Fault management business functions and business objects

4.3.7.2 Business functions

Name	Description
Fault Management (FM)	The Fault Management (FM) business function receives notifications regarding faults in the electrical network and analyses those notifications in order to estimate the location of the fault. Fault Management tracks the fault through the stages of actual location, minimizing the area impacted by the fault, restoring service to all impacted parts of the network and coordinating permanent repairs. Fault Management ensures that fault durations and restoration times are correctly captured for regulatory reporting purposes.
	Fault Identification (FI)	The Fault Identification (FI) business function uses a variety of inputs in order to identify where the real fault has occurred. It will also identify the cause of the fault, where known.
	Restoration Operation Planning (ROP)	The Restoration Operation Planning (ROP) business function create a plan for handling unplanned or forced outage to recover to an acceptable operation state. It also includes a plan to restore the network to its pre-fault condition after repairs have been made.

4.3.7.3 Business objects

Name	Description
Estimated Restoration Time	The Estimated Restoration Time business object is the time and date that service is expected to be restored for a particular fault. Estimated Restoration Time can be calculated automatically or can be based on estimates provided by field crews assigned to repairing the fault. The accuracy of Estimated Restoration Time can vary through the course of the lifecycle of each fault.
Fault Assessment	The Fault Assessment business object includes the result of analyses data received about the fault, in order to estimate the probable location of the fault.
Field Fault Assessment	The Field Fault Assessment business object includes the information that is provided by a field crew sent to a predicted fault event. The field crew travels to the predicted location and determines if this is the actual location. If the predicted fault location is confirmed, then the assessment is complete. If the predicted fault location is incorrect, the field crew investigates other possible fault locations and reports the actual fault location, completing the assessment. The field crew may also subsequently report the cause of the fault, if the cause can be determined.
Incident	The Incident business object describes an occurrence in the field that impacts or may impact the network grid. An incident may be reported as part of a trouble ticket. It may or may not be associated with an outage.
Predicted Fault Event	The Predicted Fault Event business object includes the result of Fault Identification analysing input data, such as telemetered values, Trouble Tickets, End Device Events and field Fault Assessment data. The Predicted Fault Event is described by location, faulty equipment and phases.
Unplanned Customer Outage	The Unplanned Customer Outage business object describes an unplanned event and the related failure of delivery the customer the committed service in accordance with the customer agreement. The customer may or may not be compensated.

4.3.8   Compliance Management (CO)

4.3.8.1   General

The Compliance Management (CO) package in the CIM IRM defines the business functions and business objects involved in definition of the rules and regulations that govern a market or inter-party operation. The compliance of the parties to the market rules and overall performance of the market are also included. The relationships between the business functions and business objects are described in Figure 10.

This package is interlinked with Market Operation (MO), End Device Operation (EDO) and Customer Management (CM) packages.
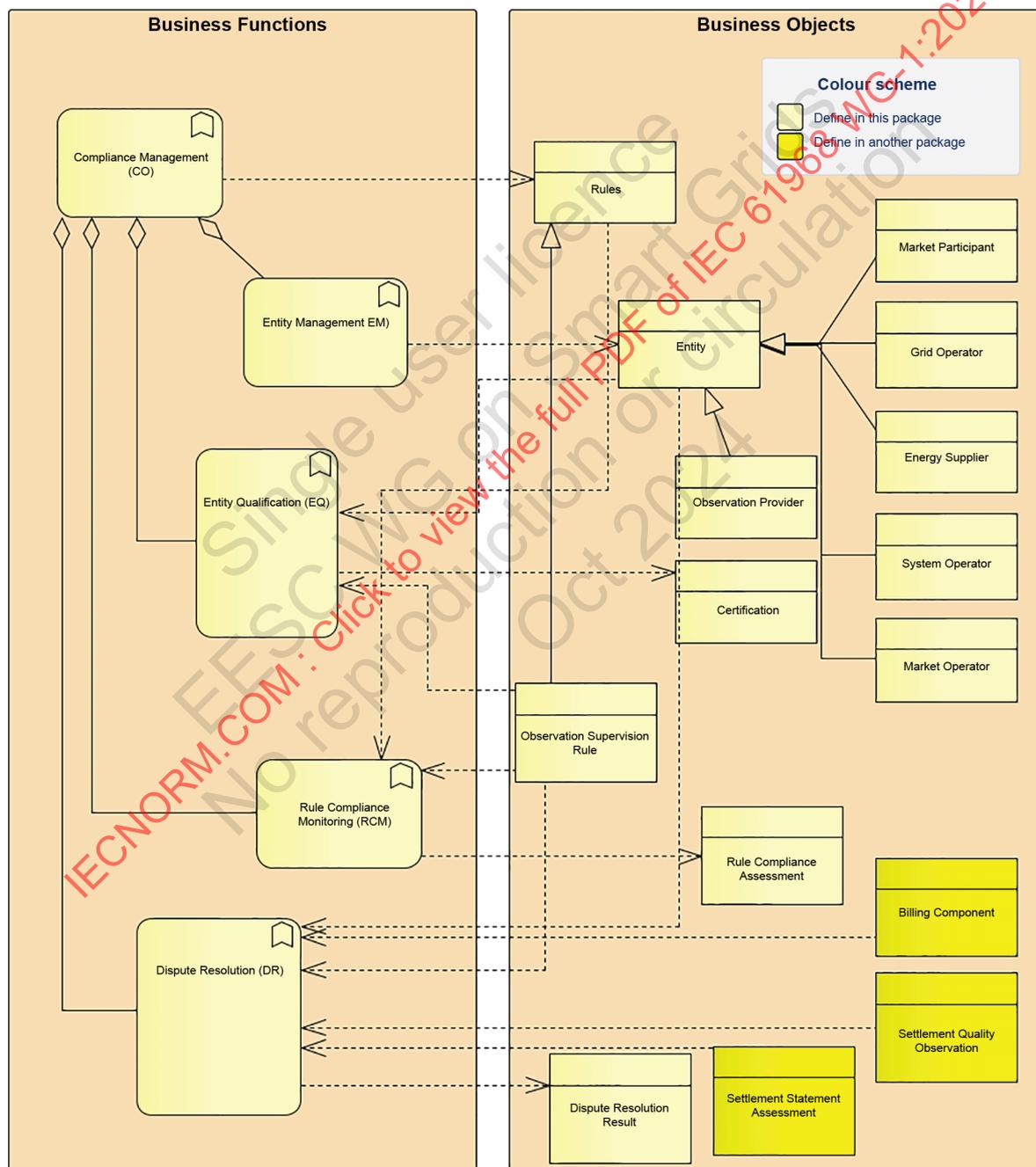
Figure 10 – Compliance management business functions and business objects

4.3.8.2 Business functions

Name		Description
Compliance Management (CM)		The Compliance Management (CM) business function involves the definition of the rules and regulations that shall govern any specific market area were one or more parties are operating.
	Dispute Resolution (DR)	The Dispute Resolution business function involves the handling of resolution of disputes opened by one party with regards to billing components information that is calculated from settlement quality observation data. Typically, this could be resolving a dispute of a charge included in an invoice (or billing component/settlement statement as supporting documentation to the invoice) that does not reflected the same observation understanding by the receiver of the charges as the one issuing the invoice.
	Rule Compliance Monitoring (RCM)	The Rule Compliance Monitoring (RCM) business function involves the monitoring, inspection and testing of a party for its compliance to the market rules. These rules require the party to provide market transparency data in a timely manner with required data quality. The European Transparency platform is an example of a system that supports this business function.
	Compliance Verification (CV)	The Compliance Verification (CV) business function involves the verification and in some cases certification of a given party's compliance with a set of market or supervision rules. An example rule is the testing and verification of communication links and compliance of metering data to quality standards.
	Entity Management (EM)	The Entity Management (EM) business function involves the registration and maintenance of the information of the entities and their roles in the area that is under compliance governance.

4.3.8.3 Business objects

Name	Description
Dispute Resolution Result	The Dispute Resolution Result business object includes interim data about the dispute and data about the final resolution of the dispute.
Energy Supplier	The Energy Supplier business object is a specialization of Party that describes an entity who is responsible for providing the energy to a customer in a retail energy market according to the customer energy agreement.
Grid Operator	The Grid Operator business object is a specialization of Party that describes an entity who is responsible for operating a power grid that provides connection for a customer through a customer connection agreement. The grid operator may operate a high-voltage grid, a distribution-voltage grid, micro-grid or any combination.
Certification	The Certification business object describe a given entity's compliance with one or more market or supervision rules. An example is the certification of meeting the requirement for acting in the role of metering data provider.
Compliance Assessment	The Compliance Assessment business object describes the entity's compliance to one or more market rules.
Market Operator	The Market Operator business object is a specialization of Party that describes an entity who is responsible for operating one or more market places by matching bids and offers and that confirms a trade and/or market prices.
Market Participant	The Market Participant business object is a specialization of Entity that describes an entity who participates in one or more markets through buying, selling, transmission, or distribution of energy, capacity or ancillary services into, out of, or through one or more areas of the power grid.

Name	Description
Rules	The Rules business object describes the rules that applies to all entities in a given market or inter-party operation. It describes the different roles that can be performed by the different parities to meet the covered compliance.
Observation Provider	The Observation Provider business object is a specialization of Entity that describes an entity who is responsible for providing observation data that meets settlement quality requirements to other relevant parties that is operating under the same governance rules.
Observation Supervision Rule	The Observation Supervision Rule business object is a specialization of the Rules that describes the rules which observations that are going to be exchanged need to follow between parties in a compliance market.
Entity	The Entity business object describes the role that is governed by compliance.
System Operator	The System Operator business object is a specialization of Entity that describes an entity who is responsible for a stable and balanced power system operation for a given part of the power grid.

4.3.9   Market Operation (MO)

4.3.9.1   General

The Market Operation (MO) package in the CIM IRM defines the business functions and business objects involved in market trading, market definition and market operations, and market monitoring. The relationships between the business functions and business objects are described in Figure 11.

This package is interlinked with Customer Management (CM), Predictive Operation Planning (POP), End Device Operation (EDO), External to IEC (EXT), Network Operation (NO), Market Settlement (MS), Retail Market (RM), Compliance Management (CO) and Network Model Management (NMM).

The Market Operation business function includes energy trading by market participants as part of their business strategy and tactics to achieve their business goals.

Market operation can be split into energy markets and capacity markets. Capacity markets provide a market-based procurement of transmission and generation capacity. It can also handle capacity in relationship to the balancing energy market and/or emergency restoration capacity (e.g. black start).

Energy markets can be split into financial markets that are used for hedging against price risk and risk of energy delivery, spot trading (e.g. day-ahead or intra-day energy marked) to handle short to medium-term balancing of supply and demand and real-time balancing of demand and supply in the presence of prediction inaccuracy or forced unavailability of equipment.

The CIM currently supports many types of market implementations. The IRM provides a set of business functions and objects to describe common implementation of market operation but not necessarily complete for all markets at the moment.

Market Operation (MO) provides the operation instruction to Network Operation (NO) that is responsible for reliable operations of the power grid. It also provides forecasts or pattern-based instructions to Predictive Operation Planning (POP) in regard to price inelastic units, so that a maximum utilisation of the network can be performed in the future without compromising the operational security of the network. Predictive Operation Planning (POP) provides Market Operation (MO) with market constraints, that in most cases are derived from

the underlying grid constraints (e.g. line unavailability), in regard to the expected future operation.
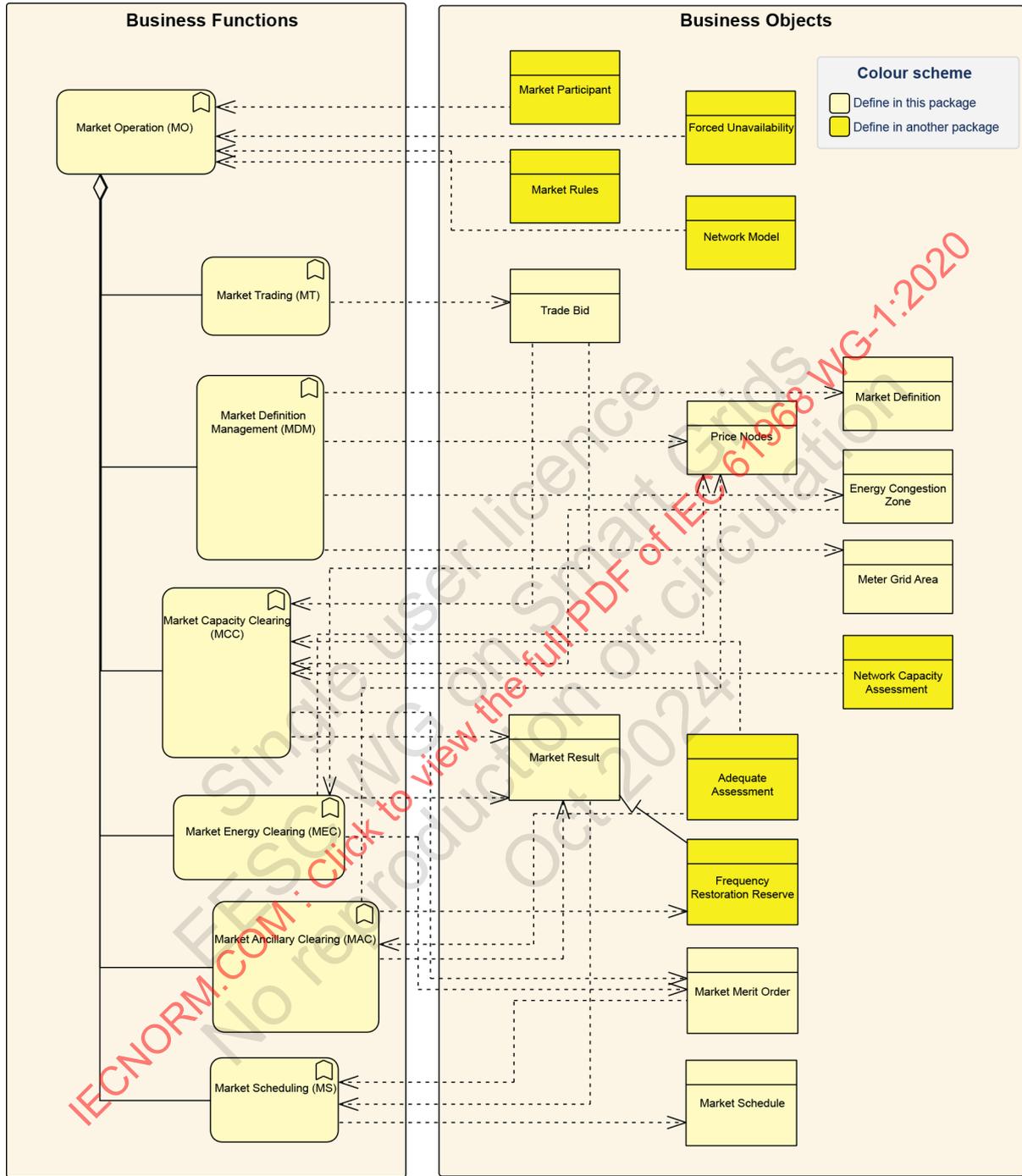
Figure 11 – Market operation business functions and business objects

4.3.9.2 Business functions

Name	Description
Market Operation (MO)	The Market Operation (MO) business function involves the provision of a market-based allocation of energy, capacity and ancillary services based on bid-based market clearing. Market Operations produce schedules and balancing dispatch instructions that are feasible considering market and grid constraints.
Market Ancillary Clearing (MAC)	The Market Ancillary Clearing (MAC) business function includes provision of ancillary service based on clearing bids and offers for the volumes of ancillary service required to maintain the defined grid security and reliability.
Market Capacity Clearing (MCC)	The Market Capacity Clearing (MCC) business function includes provision of generation and transmission capacity based on bids and offers for the same capacity product. Options for allocation of transmission include explicit auctions, secondary trading of transmission rights, and implicit auctions. Long-term generation capacity can involve bilateral market mechanism or centrally run auction market.
Market Definition Management (MDM)	The Market Definition Management (MDM) business function provides a definition of the market products, and the market timelines including gate closures. For the European style market, this would include the definition of the energy congestion zone (e.g. Bidding Zone).
Market Energy Clearing (MEC)	The Market Energy Clearing (MEC) business function includes provision of energy based on clearing all the bids and offers for energy.
Market Scheduling (MS)	The Market Scheduling (MS) business function includes the creation of schedules based on a market result trade for energy, transmission, and ancillary services.
Market Trading (MT)	The Market Trading (MT) business function involves the market participant's decision making, strategic and tactical, for creating bid and offers on market products.

4.3.9.3 Business objects

Name	Description
Energy Congestion Zone	The Energy Congestion Zone business object includes the description of the board of the delivery of energy and capacity market products. Market participants' bids and offers can be cleared without congestion constraints. This is used in a zonal-based market, such as the European-style market.
Market Definition	The Market Definition business object describes the market definition, including products and pricing.
Market Merit Order	The Market Merit Order business object is a collection of market bids ordered by economic priority for a given market service. Each underlying market offer is related to market resource.
Market Result	The Market Result business object describes the matched and cleared result of the trading. It includes the identification of resource, product and matched price.
Market Schedule	The Market Schedule (MS) business object includes the market resource allocation for a given product based on the Market Result. If multiple market resources can provide the product, the Market Merit Order is used to distinguish. For ancillary services, this could mean the providing reserve capacity.
Meter Grid Area	The Meter Grid Area business object includes the description of an electrical area that has metered flow in and out of the area. Only a single entity is responsible for the metering of the area.

Name	Description
Unified Pricing Location	The Unified Pricing Location business object is a set of network nodes at which energy is injected or withdrawn from the network. The price of energy and ancillary services at each node within a pricing location is the same. The price of energy and ancillary services may be unique at different pricing locations. This is used in a nodal-based market, such as the North American-style market.
Trade Bid	The Trade Bid business object can be a bid or an offer on an identified resource and product with a price dependency. The bid/offer can be a curve of quantity of product offered or demanded at different price levels.

4.3.10   Market Settlement (MS)

4.3.10.1   General

The Market Settlement (MS) package in the CIM IRM defines the business functions and business objects involved in the settlement of market contracts for energy and capacity: including energy, ancillary services and the deployment of reserve for real-time balancing of supply and demand. It includes the settlement of bilateral contracts (non-standard contracts) and the settlement for the use of the transmission and distribution network. The relationships between the business functions and business objects are described in Figure 12.

This package is interlinked with Customer Management (CM), End Device Operation (EDO), External to IEC (EXT), Network Operation (NO), Market Operation (MO), Compliance Management (CO) and Network Model Management (NMM).

CIM currently supports two styles of markets: North American and European-style markets. Some business functions, roles and objects may only apply to a particular style of market.

Market Settlement includes the calculation of payments and charges for ancillary services as well as payments or charges (penalties) for following (or not following) the instructions issued by the Market Operator for balancing the power grid in real-time.
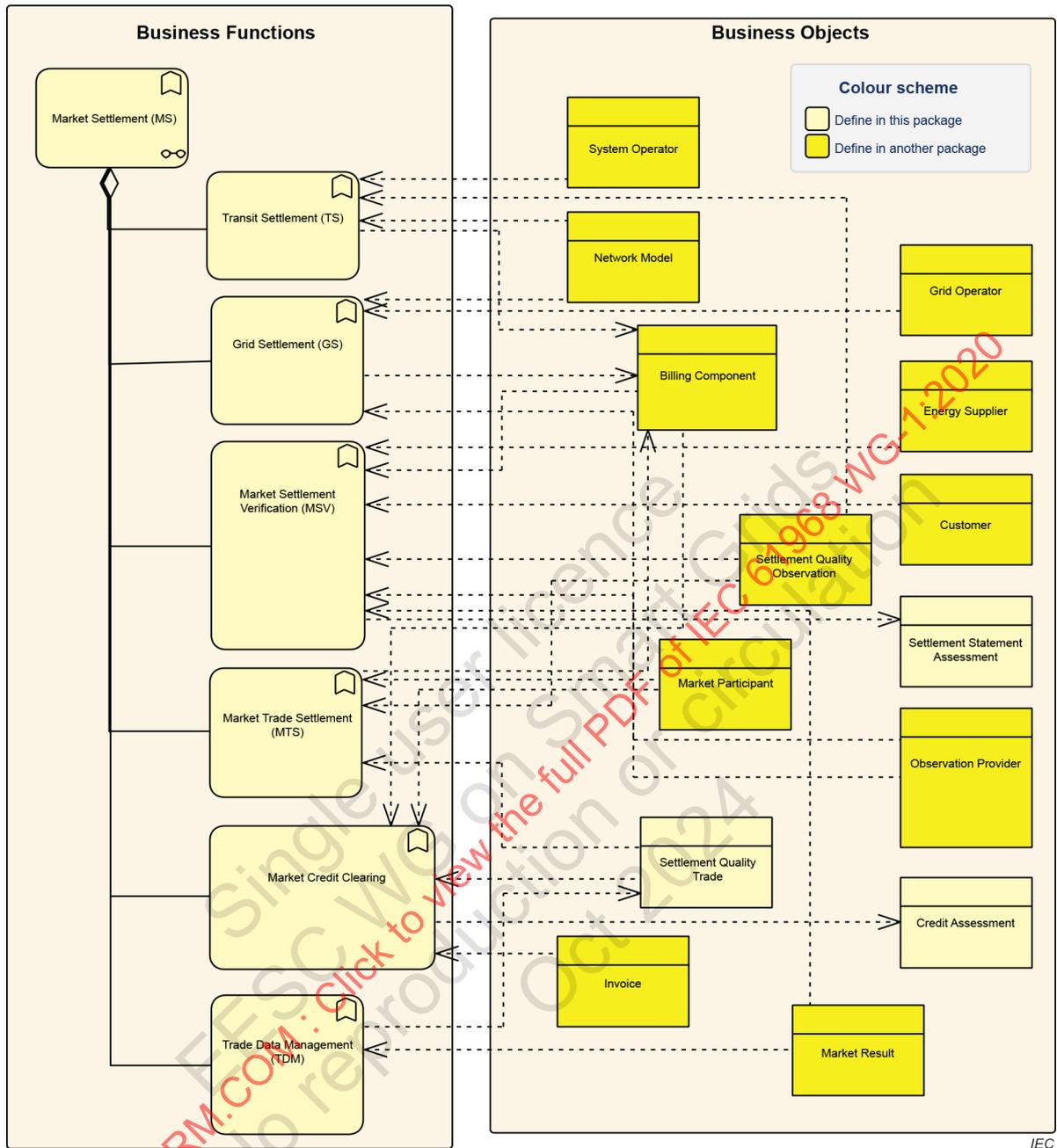
Figure 12 – Market settlement business functions and business objects

4.3.10.2 Business functions

Name		Description
Market Settlement (MS)		The Market Settlement (MS) business function includes the settlement of market contracts for energy and capacity: including energy, ancillary services, and the deployment of reserves for real-time balancing of supply and demand. It includes the settlement of bilateral contracts (non-standard contracts) and the settlement for the use of the transmission and distribution network.
	Grid Settlement (GS)	The Grid Settlement (GS) business function includes the settlement for the use of the transmission and distribution network.
	Market Credit Clearing	The Market Credit Clearing (MC) business function involves the calculation of the total loans by borrowers and total supply of loans from lenders. The totally exposure can include trade that is not settled, trade settled but not invoiced, and trade invoiced but not paid. In some markets, the clearing is done by separate financial institution that net the exposure in all different markets.
	Market Settlement Verification (MSV)	The Market Settlement Verification (MSV) business function includes the verification of the market settlement statements payment and charges. It is sometimes referred to as "Shadow Settlement". This could provide the input to dispute resolution. The business function might also include the calculation of shares of the payment and charges to the organizational partners.
	Market Trade Settlement (MTS)	The Market Trade Settlement (MTS) business function includes the settlement of standard market products that are traded on a market place. The products include energy, capacity, ancillary service and deployment of reserves for real-time balancing.
	Trade Data Management (TDM)	The Trade Data Management (TDM) business function involves validation and aggregation of cleared trade data and creates settlement quality data defined by the market rules.
	Transit Settlement (TS)	The Transit Settlement (TS) business function includes settlement of the use of the grid for wheeling transactions between third parties that are outside of the footprint served by the grid.

4.3.10.3 Business objects

Name	Description
Credit Assessment	The Credit Assessment business object describes the result of calculating the total debt or financial obligation exposure of a given party.
Settlement Quality Trade	The Settlement Quality Trade business object describes the data that meets the quality required by the settlement function defined in the Market Rules.
	Settlement data may include the measurement of energy produced and consume, instructions issued by market operators to resources, and the response of market resources to these instructions.
Settlement Statement Assessment	The Settlement Statement Assessment business object describes the result of comparing the billing components/Settlement Statement from another party with the internal calculation based on observation and trading records.

4.3.11 Network Model Management (NMM)

4.3.11.1 General

The Network Model Management (NMM) package in the CIM IRM defines the business functions and business objects for establishing and maintaining the functional description of the network grid that is provided by the currently installed asset (as-built model), the planned installed asset (future model) or the potential installation (what-if/hypothetical model). The relationships between the business functions and business objects are described in Figure 13.

The focus is to provide a mathematical model of the network grid that can be used in different analysis of the grid, including, but not limited to, steady-state power flow, state estimation, contingency analysis as part of security assessment and stability analysis.

It maintains the main representations of the power system for network analysis functions, so that all analyses share the same source information.

Network Model Management (NMM) handles both internal enterprise elements and cross-entities, both in the horizontal and vertical domain, e.g. TSOs-TSOs and TSOs-DSOs coordination.

This package represents the business layer that provides the business input for developing data objects that represent the CIM profiles in the application layer.

This package is interlinked with the Network Operation (NO), Engineering Design Management (EDM), System Development Planning (SDP) and Predictive Operation Planning (POP) packages.
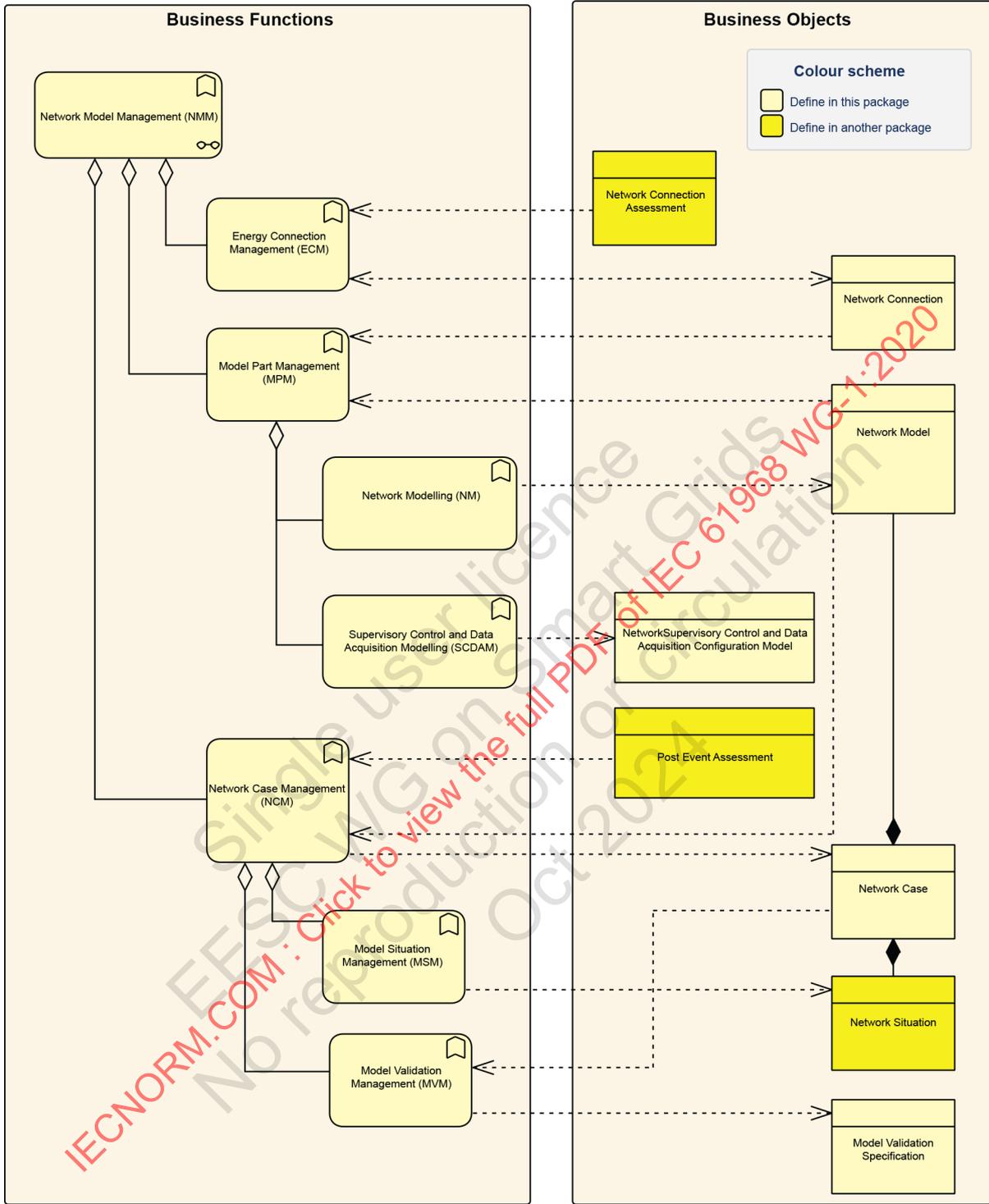
Figure 13 – Network model management business functions and business objects

4.3.11.2 Business functions

Name	Description
Energy Connection Management (ECM)	The Energy Connection Management (ECM) business function involves the coordination of the relevant connection data and the documentation of the conditional approval of connecting power system elements to the network grid. This includes, but is not limited to, power-generating facilities, transmission system, high-voltage direct current cables, distribution system and demand facilitates.
Model Part Management (MPM)	The Model Part Management (MPM) business function involves the governance of the master set of models and model parts so they are fit for analytic purpose. This includes model coordination and configuration (versioning), build, and release management, timeline management for handling past, current and future models. Provide synchronisation with the external Model Part Management function from other model authorities.
	Network Modelling (NM)	The Network Modelling (NM) business function provides the means to maintain a network model as a master repository for the power system resources that are part of the model responsibility area. The repository should provide means for accessing network models for the past situation, current as-built and future situations. The network models represent the functional description of the power system needed for supporting different analyses. The functional model may differ from the functional representation given by the asset that is providing the functionality.

Relevant modelling fragments are:

- Substation modelling
- Transmission network modelling
- Distribution network modelling
- Production and consumption modelling
- Market modelling
- Electrical diagram modelling
- Transient/dynamic modelling
- Short-circuit modelling
- Protection modelling
- System Integrity Protection Scheme (SIPS)
- Role and actor modelling
- Pattern and hypothesis situation modelling
- Training simulation modelling |
	Supervisory Control and Data Acquisition Modelling (SCDAM)	The Supervisory Control and Data Acquisition Modelling (SCDAM) business function includes the modelling of alarm setting and monitoring, acquisition configuration, measurement and signalling structure and quality constrains.
Network Case Management (NCM)	The Network Case Management (NCM) business function involves the establishment and maintenance of the situation and validation description of the network grid. This includes management of the test cases for the validation.
	Model Situation Management (MSM)	The Model Situation Management (MSM) business function involves the establishment and maintenance of representative situations that can be taken as historical events or statistical analyses to be used in the validation of the model and in different analysis. The situation includes a description of the operational condition, operational settings and estimated injections on the network.
	Model Validation Management (MVM)	The Model Validation Management (MVM) business function involves the testing and validation of the network model to see if it is fit for purpose and can be used by the intendent analysis. The quality of the model is established by running it against predefined test cases.

In the cases where the as-build model is used in a state estimation, the model evaluation should then be managed by this function to improve the model as possible. |

4.3.11.3   Business objects

Name	Description
Model Validation Specification	The Model Validation Specification business object includes the validation rules and criteria for model validation.
Network Case	The Network Case business object includes the Network Model and the Network Situation that together with test case settings defined a Network cases used for analytic and validation of the model.
Network Connection	The Network Connection business object describes the conditional requirement for connecting equipment to the network grid.
Network Model	The Network Model business object includes the functional description of the network grid that used in one or more network analysis.
Supervisory Control and Data Acquisition Configuration	The Supervisory Control and Data Acquisition Model business object includes the necessary information to support Supervisory control and data acquisition of the equipment that is controlled by the utility.

4.3.12   Network Operation (NO)

4.3.12.1   General

The Network Operation (NO) package in the CIM IRM defines the business functions and business objects involved in monitoring and operating the power grid as a whole system or the entities responsible for part of the whole system. The relationships between the business functions and business objects are described in Figure 14.

This package is interlinked with Fault Management (FM), Predictive Operation Planning (POP), End Device Operation (EDO), External to IEC (EXT), Market Operation (MO) and Network Model Management (NMM).

The Network Operation business function includes real-time operation, which handles the execution of planned actions in addition to ensuring that the power grid is operating in a secure and balanced state. It also includes obligated operation planning that handles the "look-ahead" function to ensure that the "near future" operation based on committed schedules is an operation in a secure and balanced state.

That a system is in secure and balanced state means that there is balance between supply and demand and that the system can handle pre-defined unanticipated loss of system equipment without violating operational requirements in regard to voltage, frequency, and operational stability limits.

The instruction on balancing of demand and supply are solved outside Network Operation (NO). In the area of Market Operation (MO), this instruction will be provided by the market. In the case of no market, the same business object needs to be provided. The instruction could be cost based, and in that case the operating costs need to be provided.

The Network Operation business function also includes the post event analysis to evaluate a historical incident or situation of interest for identify a root cause of a fault or create training or plans for preventing similar occurrence in the future.
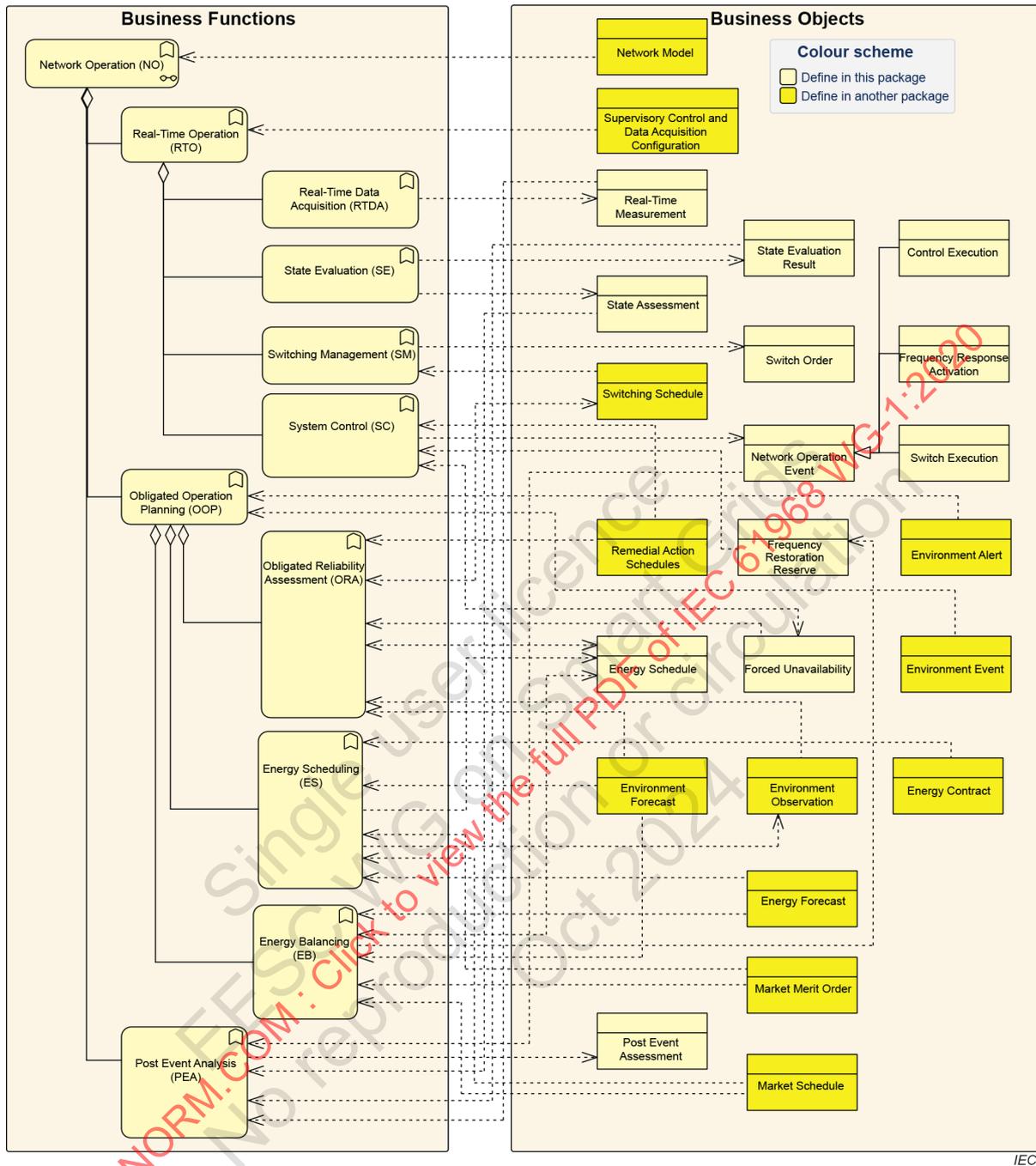
Figure 14 – Network operation business functions and business objects

4.3.12.2   Business functions

The Network Operation (NO) function includes business activity directly involved with monitoring and operating the power grid as a whole system or the entities responsible part of the whole system.

Name	Description
Obligated Operation Planning (OOP)	The Obligated Operation Planning (OOP) business function involves the "look-ahead" function to ensure that the "near future" operation, based on committed schedules is operation in a secure and balanced state. That a system is in a secure and balanced state means that there is balance between supply and demand and that the system can handle pre-defined unanticipated loss of system equipment without violating operational requirements in regard to voltage, frequency, and operational stability limits. In the case of a violation, predefined remedial action is applied.
	Energy Balancing (EB)	The Energy Balancing (EB) business function involves the evaluation of the balancing instruction that is prepared as part of planning activity that ensures that energy supply meets energy demand.
	Energy Scheduling (ES)	The Energy Scheduling business function involves the establishment and commitment to a given energy schedule for consumption, production, direct current and area inter-exchange. This also includes energy scheduling for intermittent or price inelastic production that is part of Distributed Energy Resources (DER). The Energy Scheduling (ES) business function is: • involved in optimising production; • cost based; • involved in schedule-marked energy purchases /agreements; • season based; • involved in predictive analysis based on historical logs; • involved in the establishment of the most realistic energy forecast possible with relevant uncertainty. Power import scheduling and optimisation aims to minimise the cost of imported power by keeping the average imported power close to the contracted value, making use of peak plants, load switching or load shedding. This business function includes scheduled energy quantities, such as: • market outcomes; • unit schedules; • net or bilateral interchange schedules; • direct current tie schedules; • phase-shifter schedules.
	Obligated Reliability Assessment (ORA)	The Obligated Security Assessment business function is the "look-ahead" analysis based on current network operation state and the committed schedules to assess if future network operation is in a secure and balanced state. That a system is in a secure and balanced state means that there is balance between supply and demand and that the system can handle pre-defined unanticipated loss of system equipment without violating operational requirements in regard to voltage, frequency, operational stability limits. In the case of a violation, predefined remedial action is applied. It is particularly relevant to perform this prior to taking equipment out of service.
Post Event Analysis (PEA)	The Post Event Analysis (PEA) business function includes the evaluation historical incident or situation of interest to identify the root cause and taking steps to prevent a similar occurrence in the future. Training, remedial action plans or other prevention schemes could be created based on a post event analysis.

Name	Description
Real-Time Operation (RTO)	The Real-Time Operation (RTO) business function includes the execution of the planned action in regard to changing the network operational state. In addition, it monitors the current state of the network to ensure that the power grid is operating in a secure and balanced state. Predefined and activated remedial action will be executed when the pre-condition is met. That a system is secure and balanced state means that there is balance between supply and demand and that the system can handle pre-defined unanticipated loss of system equipment without violating operational requirements in regard to voltage, frequency, and operational stability limits.

	Name	Description

	Real-Time Data Acquisition (RTDA)	The Real-Time Data Acquisition business function includes the collection and validation of measurements and observations that are used to determent the present state of the system that is under the entities' control. This could include acquisition of measurements and observations that are outside the entity's responsibility, but where the equipment that is defined as relevant to determine the state of the responsible system. The measurements and observations could include:
		• traditional SCADA points and analogues;
		• manually collected and entered data;
		• phasor data;
		• data generated by other systems, such as:
		  – generating plants;
		  – IEC 61850 systems;
		  – lower or higher-level operations' activities.
		The common denominator for this data is that it is sampled data treated as raw input, as opposed to a setting or instruction or request received from some other system. In other words, the source of the data is completely ignorant of the acquisition and use of the data. It is not a coordinated integration of peer intelligence.

	State Evaluation (SE)	This State Evaluation business function includes all activity that evaluates the current state of the grid. In general, this involves analytical processes that use acquired data and network models as input, and that generate evaluations of the grid from varying perspectives, such as: • topology analysis, feeder tracing, island detection; • state estimation; • contingency analysis; • dynamic stability analysis; • alarms; • reserve calculations; • dynamic limit calculations.
	Switching Management (SM)	The Switching Management business function includes all activity involved in supervising execution of switching orders and outage restoration. • Execution of switching steps can involve remote operations of devices via SCADA and/or modifying settings on system controls. • Execution incorporates critical safety procedures. • Wherever there is concern about the impact of switching on the grid, analytical evaluation of the security of the state that switching will establish is usual. The types of analysis are similar to real-time state evaluation except that power flow or optimal power flow replaces state estimation.

Name		Description
	System Control (SC)	The System Control business function includes any activity (other than Switching Management) which issues instructions to field controls in order to change the state of the grid. These controls may be closed loop or man-in-the-loop. Controls can be divided into active and reactive domains and generally use either raw measurements or the evaluated state as the input to control logic, which then develops a proposed change. Such control logic can be quite complex, even involving analyses based on algorithms such as optimal power flow. Control functions also may include follow-up logic to confirm that an issued control was in fact executed in the field and/or to assess whether the impact of the control was as predicted.

Controls are important to model in analytical simulations, and a key distinguishing characteristic is whether the control can be represented by standard block diagram components or whether one has to incorporate the control software in order to simulate.

Active controls include:
- AGC, LFC;
- active reserve management;
- controllable load management;
- remedial action scheme settings;
- security constrained dispatch.

Reactive controls include:
- reactive reserve management;
- Volt-VAr optimization;
- DER settings;
- FLISR. |

4.3.12.3 Business objects

Network Operation business objects are listed in this subclause.

Name	Description
Energy Contract	The Energy Contract business object includes the conditions for demand response and provision of ancillary services or any other energy contract that is relevant for operational control.
Energy Schedule	The Energy Schedule business object includes the schedule for consumption (conformed or non-conformed, including demand response), production (primarily intermittent or price inelastic production), direct current and area inter-exchange. This also includes the energy forecast for intermittent or price inelastic production that is part of Distributed Energy Resources (DER).
Forced Unavailability	The Forced Unavailability business object includes the description of a piece of equipment's unavailability by the utility owing to operating constraints or in the course of restoring an unplanned outage in the same part of the network.
Frequency Restoration Reserve	The Frequency Restoration Reserve business object is a specialisation of Market Result that describes: - aFRR – automatic frequency restoration reserve; - mFRR – manual frequency restoration reserve; - nFCR – frequency containment reserve – normal situation; - dFCR – frequency containment reserve – disturbed situation.

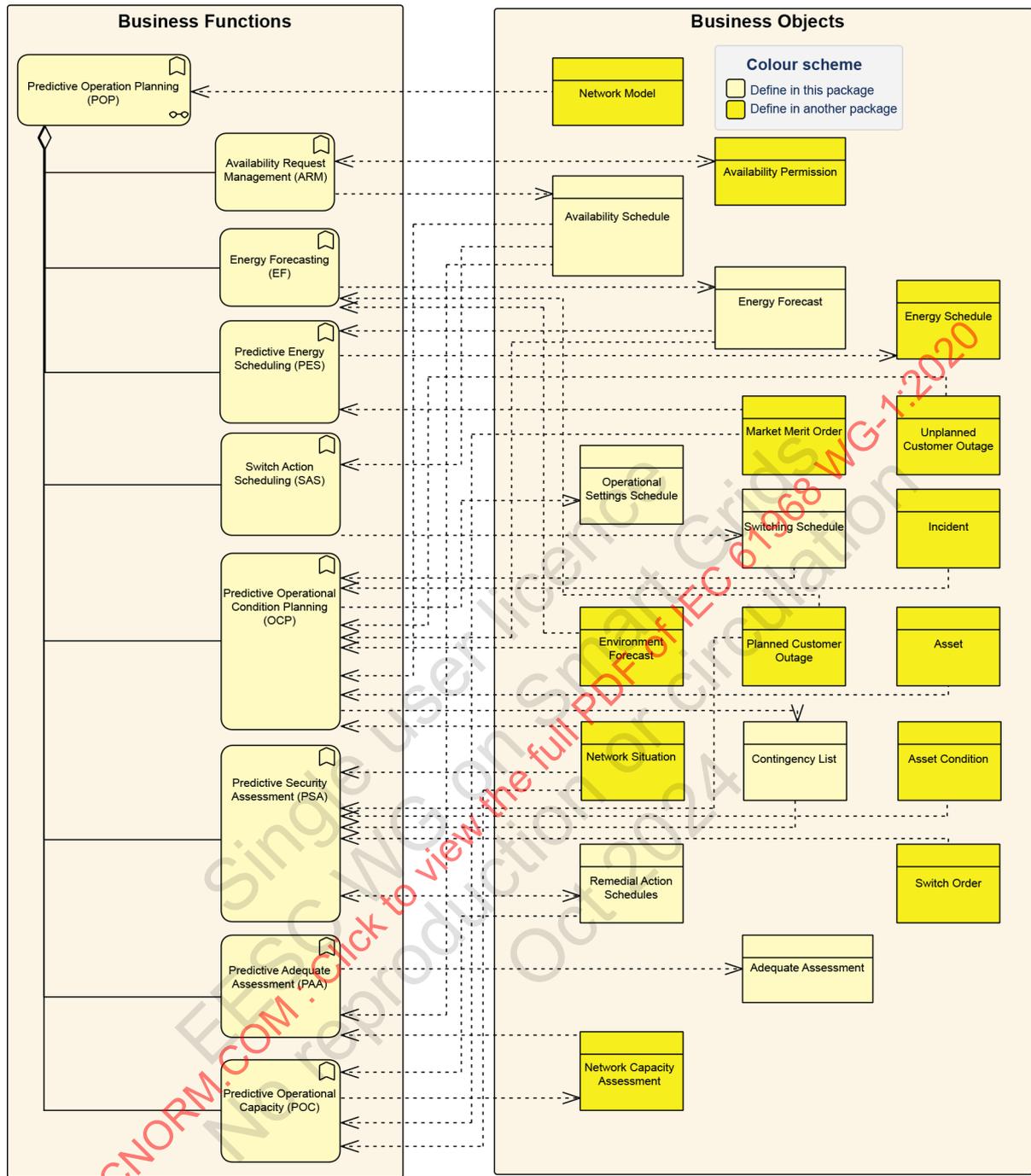| Name		Description
Network Operation Event		The Network Operation Event business object include: • event logs that capture outage and other relevant information; • records for equipment to ascertain the cause of its incorrect operation; • planned and unplanned maintenance data including root cause and repair/replacement details.
	Control Execution	The Control Execution business object includes the control commands to remotely operated devices and monitors the responses back to ensure correct operation or create an alarm if the operation fails.
	Frequency Response Activation	The Frequency Response Activation business object includes the description of activation of frequency reserve in regard to correct an over or under frequency event.
	Switch Execution	The Switch Execution business object includes the description of the act of manually opening or closing a switch by a field crew, rather than via remote control.
Post Event Assessment		The Post Event Assessment business object describes the results of post-event analysis.
Real-Time Measurement		The Real-Time Measurement business object includes measurements from any source. Examples include: – RTU; – PMU; – ICCP; – AMI; – smart devices; – protection; – IEC 61850.
State Assessment		The State Assessment business object includes: • alarms to indicate system failure and response required; • load estimation calculated on a more granular basis than load forecasts, based on specified conditions, weather and other events; • load flow/voltage profile of the network by analysing operating conditions and predicting and preventing voltage problems; • protective relay setting that can be adjusted based on conditions such as weather and operational conditions; • protective relay analysis to coordinate protective schemes such as opening a breaker after a high current is detected; • weather data to predict impacts on the electrical networks, especially where outages are likely to occur due to heavy storm activity. Temperature and wind speed are sometimes used to calculate dynamic load limits on electrical network assets.
State Evaluation Result		The State Evaluation Result business object includes the solved power flow or state estimator results for the network model being evaluated.

Name	Description
Switch Order	The Switch Order business object includes a sequence of switch open/close operations, tagging operations, device setting changes, other network operations and safety procedures to change the configuration of the network to achieve a particular business goal. The business goal could be to isolate part of the network in order to allow crews to work safely, to isolate a fault or to optimize the network based on various criteria, for example. Switch Orders can also be used to coordinate live line work safely.
	The switch order records the result of the switching operations, including who performed the switching and when the switching operation was performed. Both the control room operator and field crews, if any, are recorded with the switch order.
	This information:
	• includes a view of all incoming work on the systems. Work details are recorded for each set of switching actions (examination of manual and remote-controlled operations, work characteristics, and crews involved in the work);
	• provides a view of all switching states in addition to the open or closed state of the switch or device. This includes operational tags used to prevent device operations and safety documents to transfer authority between the control room and field crews.

4.3.13 Predictive Operation Planning (POP)

4.3.13.1 General

The Predictive Operation Planning (POP) package in the CIM IRM defines the business functions and business objects involved in predicting the operational condition based on forecast, operational pattern (e.g. season-based operation) and different scheduling options. The different operational conditions are evaluated against the target for transfer capacity, operational security (e.g. support for N-1) and availability scheduling. The Predicative Operation Planning (POP) could be seen as an optimisation between these three contradicting requirements. However, not all utilities or business processes include all of the relevant business functions and business objects. The relationships between the business functions and business objects are described in Figure 15.

This package is interlinked with Network Operation (NO), Market Operation (MO), Work Management (WM), Asset Management (AM), Network Model Management (NMM) and System Development Planning (SDP) packages.

Figure 15 – Predictive operation planning business functions and business objects

4.3.13.2   Business functions

Name	Description
Predictive Operation Planning (POP)		The Predictive Operation Planning (POP) business function is involved in forecasting future operation situations with an acceptable level of reliability, the inclusion of what-if scenarios and risk assessment. This includes adequate management that requires system operators and planners to take into account scheduled and reasonably expected unscheduled availability of equipment, while maintaining a constant balance between supply and demand.
	Availability Request Management (ARM)	The Availability Request Management (ARM) business function involved the management of request for making grid elements available or unavailable for the network operation. This includes, but is not limited to, requesting for: • taking a grid element out-of-service for maintenance or other work; • setting a grid element in-to-service after work or new construction; • coordination with other entities that have system responsibility and would be affected by the change of availability; • coordinating with the Work Management to establish a schedule for the availability; • coordinating with Market Operation to inform the market or to minimise the impact to the market; • inform relevant entities about forced unavailability or customer outage; • coordinating the resolution of forced unavailability or customer outage planned and schedule. Different scheduling alternatives might be created to evaluate their impact on the transfer capacity and the operational security of the grid.
	Predictive Operational Condition Planning (OCP)	The Predictive Operational Condition Planning (OCP) business function involved the scheduling of: • device status (switch status, tap position, shunt bank position); • control settings (voltage regulation, flow regulation); • monitoring (operational limit determination, critical grid elements, topology limitation (power transfer corridors) and stability limits. This also includes planning and optimisation for Distributed Energy Resources (DER) in regard to power characteristics settings.
	Predictive Adequate Assessment (PAA)	The Predictive Adequate Assessment (PAA) business function is involved in evaluations of the forecasts and schedules for consumption, production capacity, direct current capacity and area inter-exchange to assess the capacity adequacy. This includes the evaluation of sufficient resources to provide customers with a continuous supply of electricity of the proper voltage and frequency through all time periods. Resources refer to a combination of electricity generating and transmission facilities that produce and deliver electricity, and demand-response programmes that reduce customer demand for electricity.

Name		Description
	Predictive Operational Capacity (POC)	The Predictive Operational Capacity (POC) business function involves the calculation of cross-zonal capacity and congestion management in regard to where potential congestion needs to be resolved though changes in the energy schedules. In areas where a balancing market is in place, this will be solved as part of operation. However, as part of predictive operation planning, this business function needs to use predictive merit order of the energy connection to simulate the price inelastic.
	Predictive Security Assessment (PSA)	The Predictive Security Assessment (PSA) business function involves coordination with dependent system operators or regional security coordinators for assessing different predicted grid situation abilities to withstand sudden, unexpected disturbances, such as short circuits or unanticipated loss of system equipment owing to natural causes. The extended assessment would also involve withstanding disturbances caused by manmade physical or cyber-attacks.

Typically, the assessment is done using an N-1 criterion, where loss of any one given equipment will still leave the grid operating inside the defined operational limits. However, other methods, such as probabilistic assessment, can also be used. |
	Switch Action Scheduling (SAS)	The Switch Action Scheduling (SAS) business function is involved in the scheduling and all relevant coordination of switching action. This includes the creation of switching schedules for remote control switches and for switches that requires the dispatch of crews. Different schedules alternatives can be created to be used in an assessment process.
	Energy Forecasting (EF)	The Energy Forecasting business (EF) function involves the forecasting of one or more of the items consumption (load), production (primarily intermittent or price inelastic production), direct current and area inter-exchange. This also includes energy forecasts for intermittent or price inelastic production that is part of the Distributed Energy Resources (DER).
	Predictive Energy Scheduling (PES)	The Predictive Energy Scheduling (PES) business function involves the establishment of predictive energy schedule for consumption, production, direct current and area inter-exchange. This also includes predictive energy scheduling for intermittent or price inelastic production that is part of Distributed Energy Resources (DER).

4.3.13.3   Business objects

Name	Description
Adequate Assessment	The Adequate Assessment business object includes the assessment of expected consumption compared to available production and transmission capacity.
Availability Schedule	The Availability Schedule business object includes the time intervals during which a grid element is available or not. For grid elements normally in service, the focus is on the period that the grid element will not be available to provide functionality to the network. For grid elements normally out of service, or that have been forced out of service through network constrains or faults, the focus would be on when it is back in service. For grid elements in test mode, the focus is on the period during which it will be in service.
Contingency List	The Contingency List business object includes the list of grid elements that should be included as part of contingency assessment.
Energy Forecast	The Energy Forecast business object includes forecast for consumption (conformed or non-conformed including demand response), production (primarily intermittent or price inelastic production), direct current and area inter-exchange. This also includes energy forecasts for intermittent or price inelastic production that is part of Distributed Energy Resources (DER).
Operational Settings Schedule	The Operational Settings business object includes the schedule for: • device status (switch status, tap position, shunt bank position); • control settings (voltage regulation, flow regulation); • monitoring (operational limit determination, critical grid elements, topology limitation (power transfer corridors) and stability limits.
Planned Customer Outage	The Planned Customer Outage business object describe a planned event and the related information in regard to not being able to deliver the customer the committed service according to the customer agreement. The customer may or may not be compensated. The customer is informed in advance of planned outages. The reason for the outages is normally related to new construction, maintenance or repair either directly on the customer installation or to a nearby part of the Customer Installation connected to the grid.
Remedial Action Schedules	The Remedial Action Schedules business object includes the description of preventive, curative and restorative remedial action and the schedule for the activation. System Integrity Protection Scheme (SIPS) would be part of the network model. However, activation and arming of existing SIPS would be part of remedial action schedules. In addition, it includes proposals for new SIPS as part of system development planning.
Switching Schedule	The Switching Schedule business object includes the schedule and sequence for the opening and closing of switches.

4.3.14   Retail Market Operation (RMO)

4.3.14.1   General

The Retail Market Operation (RMO) package in the CIM IRM defines the business functions and business objects involved in the execution and monitoring of transparent retail markets that enable efficient handling of the choice of supplier, contractual arrangements, commitment to customers, data exchange and settlement rules, data ownership and metering responsibility. The relationships between the business functions and business objects are described in Figure 16.

This package is interlinked with Customer Management (CM), Predictive Operation Planning (POP), End Device Operation (EDO), External to IEC (EXT), Network Operation (NO), Market Settlement (MS), Market Operation (MO) and Network Model Management (NMM).

The Retail Market business function includes the possibility to handle energy supply and energy delivery by separating the network connection contract and energy contract. In both cases, the metering responsibility and data exchange are crucial for a retail market that works well. In the case of long-term energy contracts, the change of supplier process needs to be efficient.

CIM currently supports two styles of markets: North American and European-style markets. It should be noted that while there are some examples of successful retail markets, in most jurisdictions, retail markets are still in a formative stage.
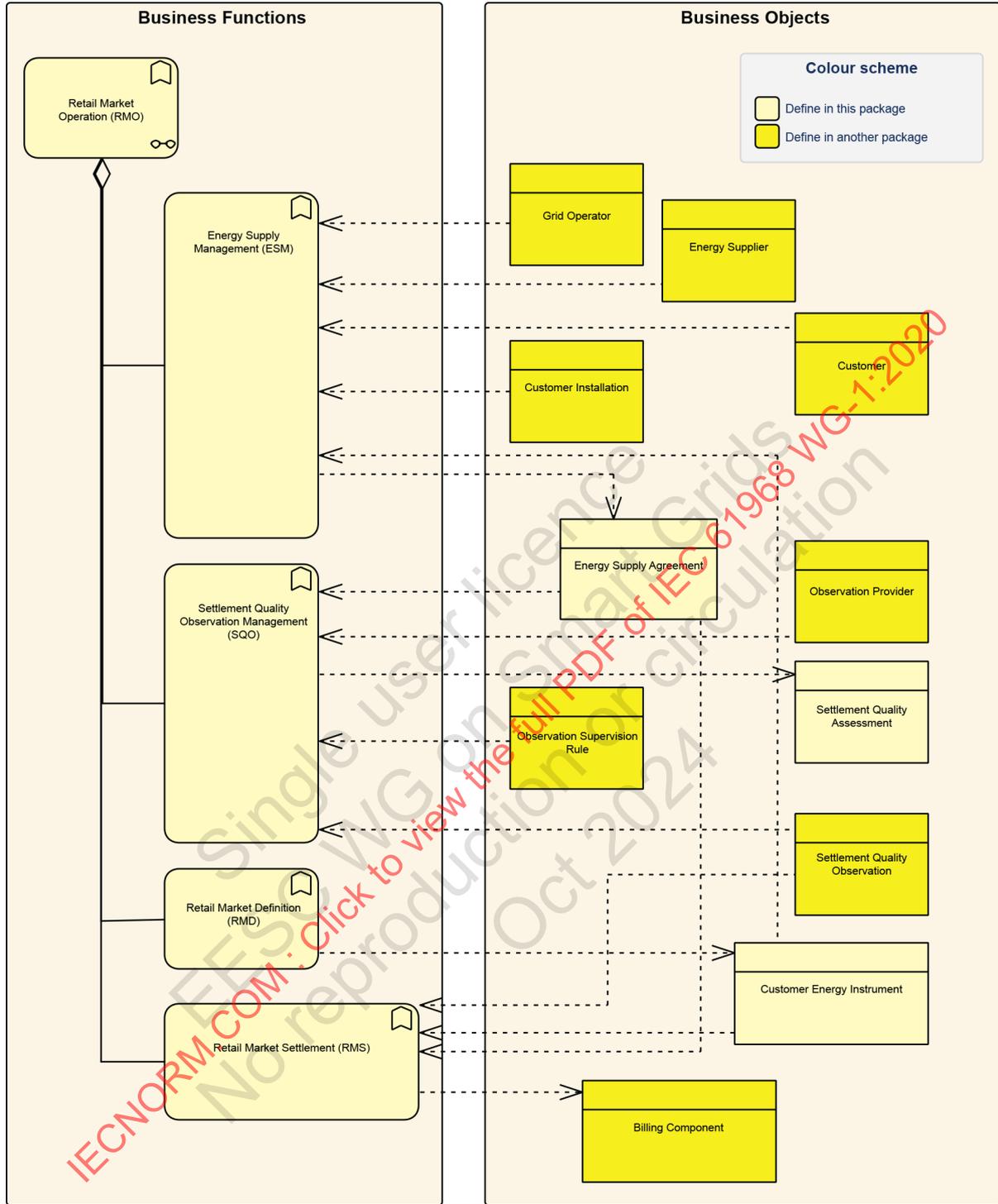
Figure 16 – Retail market operation business functions and business objects

4.3.14.2 Business functions

Name	Description
Retail Market Operation (RMO)	The Retail Market Operation (RMO) business function provides the execution and monitoring of transparent retail markets that enable efficient handling of the choice of supplier with respect to contractual arrangements, commitment to customers, data exchange and settlement rules, data ownership and metering responsibility.
	Energy Supply Management (ESM)	The Energy Supply Management (ESM) (Retail Supply Management) business function provides alignment of the supply agreement between grid operator and (energy) supplier or the Customer Installation for a given customer.
	Retail Market Definition (RMD)	The Retail Market Definition (MD) business function provides a definition of the retail market products and the retail market timelines.
	Retail Market Settlement (RMS)	The Retail Market Settlement (RMS) business function includes the settlement calculation of standard customer energy instruments/retail market products (tariff elements) for which the customer can chose the supplier. The most normal product is energy supply, but they could include different types, like fixed price, market price, etc.
	Settlement Quality Observation Management (SQO)	The Settlement Quality Observation Management (SQO) business function includes processes that provide settlement quality data for the billing functions. These processes typically include measurement of energy, correction of errors and resolution of disputes.

4.3.14.3 Business objects

Name	Description
Customer Energy Instrument	The Customer Energy Instrument (Retail Market Instrument/Product) business object describes the products (tariff elements) that are included in the contract and should be settled. The normal product is energy supply, but they could include different types, like fixed price, market price, etc.
Energy Supply Agreement	The Energy Supply Agreement business object is a specialization of Customer Agreement that defines the term of the contract between the parties involved providing the retail customer with an energy service.
Settlement Quality Assessment	The Settlement Quality Assessment business object describes the compliance with the observation supervision rules to see if the data is fit for purpose.

4.3.15 System Development Planning (SDP)

4.3.15.1 General

The System Development Planning (SDP) package in the CIM IRM defines the business functions and business objects for network development and long-term planning including extension planning for utilities that do not have system operational responsibilities. The relationships between the business functions and business objects are described in Figure 17.

The network development and long-term planning handle both the internal enterprise elements and the cross entities, both in the horizontal and vertical domain, e.g. coordination of TSOs-TSOs and TSOs-DSOs.

This package is interlinked with Network Model Management (NMM), Engineering Design Management (EDM) and Predictive Operation Planning (POP) packages.
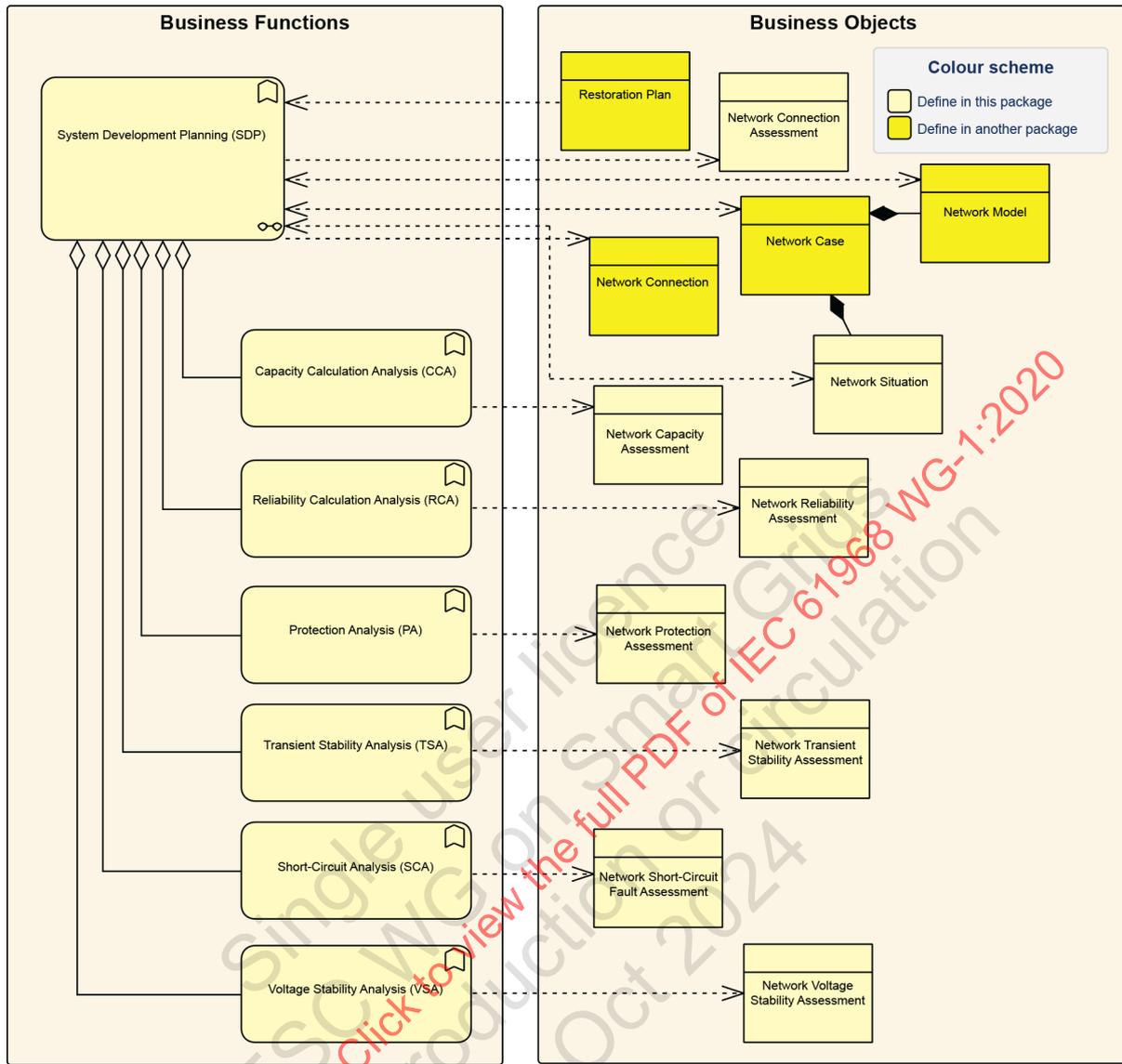
Figure 17 – System development planning business functions and business objects

4.3.15.2 Business functions

Name	Description
System Development Planning (SDP)	The System Development Planning (SDP) business function involves network development and long-term planning. The business function support cooperation and coordination to develop a secure, environmentally sustainable and economic network system aimed at an adequate grid for the purpose of a well-functioning network operation and market operation. This is done through good planning with focus on future infrastructure characteristics, efficient asset management, critical infrastructure protection and system operability perspective.
	Capacity Calculation Analysis (CCA)	The Capacity Calculation Analysis business function involves the establishment of the maximum secure capacity of intact network grid.
	Protection Analysis (PA)	The Protection Analysis business function involves the establishment of the necessary protective devices and their configuration to ensure necessary protection of critical network elements.
	Reliability Calculation Analysis (RCA)	The Reliability Calculation Analysis business function involves the establishment of the necessary equipment, system protective configuration to meet the required reliability and operational goal of new construction.
	Short-Circuit Analysis (SCA)	The Short-Circuit Analysis business function involves the establishment of the necessary equipment features to meet the steady-state operational requirement for supporting different fault conditions.
	Transient Stability Analysis (TSA)	The Transient Stability Analysis business function involves the establishment of the necessary equipment features to meet the transient stability operational requirement for supporting different fault conditions.
	Voltage Stability Analysis (VSA)	The Voltage Stability Analysis business function involves the establishment of the necessary equipment features to meet the voltage stability operational requirement for supporting different fault conditions.

4.3.15.3 Business objects

Name	Description
Network Capacity Assessment	The Network Capacity Assessment business object includes assessment of the maximum secure capacity of an intact network grid.
Network Connection Assessment	The Network Connection Assessment business object describes the result of the evaluation of the Network Connection and includes any dependent modification that is needed to the network grid to support the evaluated Network Connection.
Network Protection Assessment	The Network Protection Assessment business object involves the assessment of the necessary protective devices and their configuration to ensure necessary protection of critical network elements.
Network Reliability Assessment	The Network Reliability Calculation Assessment business object includes the assessment of the necessary equipment, system protective configuration to meet the required reliability and operational goal of new construction.
Network Short-Circuit Fault Assessment	The Network Short-Circuit Fault Assessment business object includes the assessment of the necessary equipment features to meet the steady-state operational requirement for supporting different fault conditions.
Network Situation	The Network Situation business object includes the description of the operational condition, operational settings and estimated injections on the network. Different situations are defined that should be used in training, simulation/analysis and validation.

Name	Description
Network Transient Stability Assessment	The Network Transient Stability Assessment business object includes assessment of the necessary equipment features to meet the transient stability operational requirement for supporting different fault conditions.
Network Voltage Stability Assessment	The Network Voltage Stability Assessment business object includes the assessment of the necessary equipment features to meet the voltage stability operational requirements for supporting different fault conditions.

4.3.16   Work Management (WM)

4.3.16.1   General

The Work Management (WM) package in the CIM IRM defines the business functions and business objects involved in tracking field service orders through request, schedule, dispatch, execution and completion. The focus is on efficient use of available resources to meet work requirements in regard to time and quality. The relationships between the business functions and business objects are described in Figure 18.

This package is interlinked with Asset Management (AM), Engineering Design Management (EDM), Customer Management and Network Operation (NO) packages.

CIM, Work Management (WM) is focusing on creating an information model and document messages (CIM profiles) that support the management of resources for executing work in regard to customer requests, asset maintenance and inspection, asset repair and construction in regard to operation of a power system.

For legal, commercial, financial, managerial and organisational informational requirements, CIM focuses on harmonising with other exiting standards and information models, like the Building Information Model (BIM).

As an example, this means that CIM for Work Management (WM) is not intended to support the full scope of building and construction but focus on the part that is relevant for resource management on internal employees and for in-house equipment.

IEC 61968-6 defines the existing document messages/CIM profiles for Work Management. The Work Management system does not need to support the business layer defined in this package to be CIM compliant. The compliance is defined by the support of the document message/CIM profile. However, vendors and utilities are encouraged to link the application function requirement or capability to the business function defined in this package.

Since power systems are considered part of critical infrastructure and operating and maintenance of it involves a high level of personal safety risk, the CIM standard has extra focus on information security and personal safety.
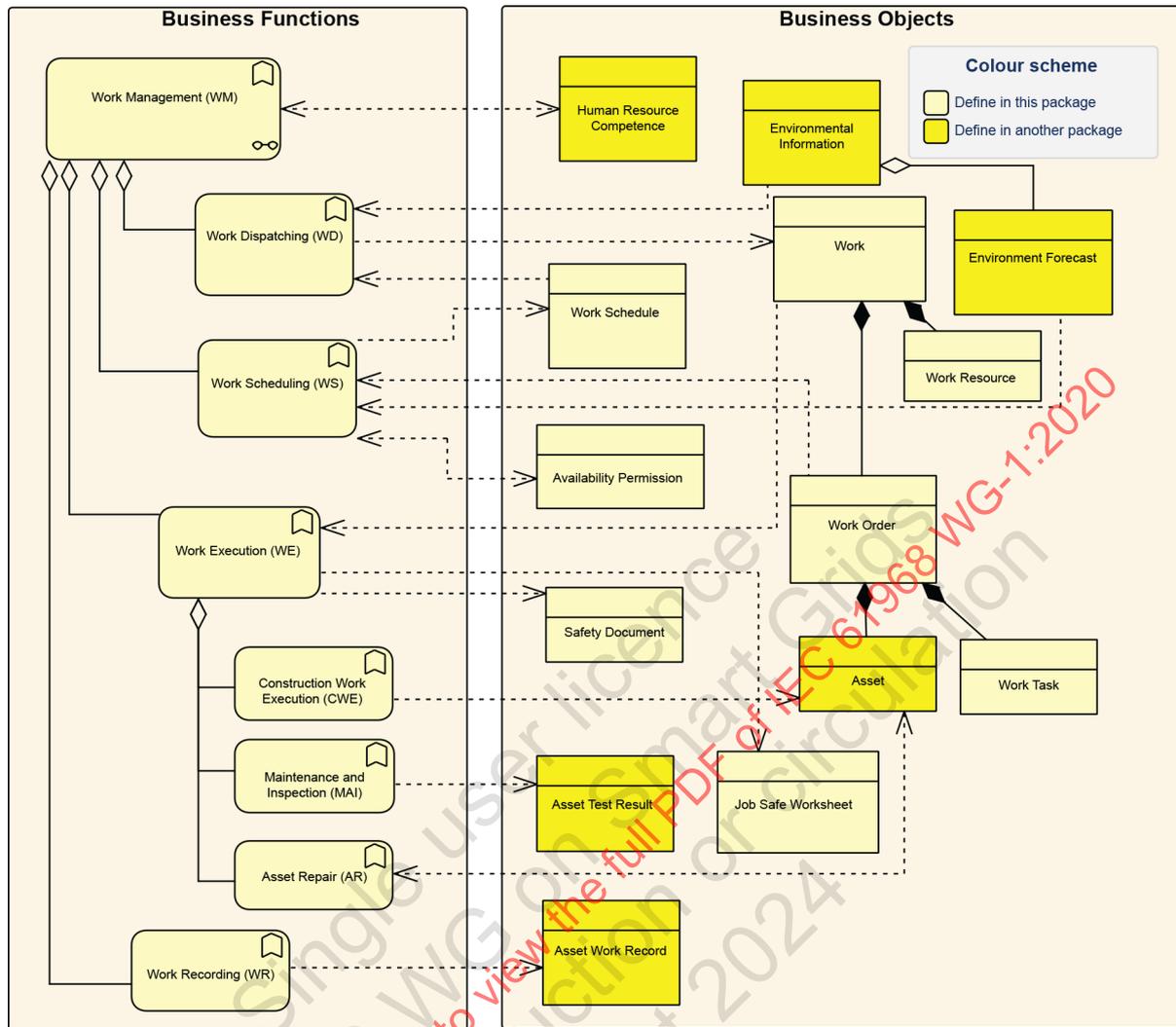
Figure 18 – Work management business functions and business objects

4.3.16.2   Business functions

Name	Description
Work Dispatching (WD)	The Work Dispatch (WD) business function involves prioritisation and allocation of specific resources, crew, vehicle, equipment and materials to ensure an efficient work execution based on current resource availability.
	This is real-time work assignment, work execution and crew status monitoring and management.
Work Execution (WE)	The Work Execution (WE) business function involves the disciplined execution of work tasks to ensure that assets fulfil their function reliability, effectively and will be available when required.
	Part of the work execution could be a systematic step-by-step work evaluation in regard to safety by evaluating all the risk elements of any physical work operation. Measures to remove or reduce the elements of risk are documented.
Asset Repair (AR)	The Asset Repair (AR) business function involves disciplined execution of work related to repair asses after failure or breakdown or when asset breakdown is imminent. The asset is repaired to assure that assets fulfil their function reliability, effectively and will be available when required.
Construction Work Execution (CWE)	The Construction Work Execution (CWE) business function involves the work that is normally governed by a construction project and executed on a construction site and connected to a structure (e.g. mast, tower, power line and substation). This is normally work that builds or constructs new, alters existing or removes/de-commissions asset behaviour and functionality.
Maintenance and Inspection (MAI)	The Maintenance and Inspection (MAI) business function involves the combination of all technical and administrative actions, including supervision actions, intended to retain an asset in, restore an asset to (e.g. adjustment), or replace an asset so that it can perform a required function and/or extend its service life. It also includes inspections that constitute an organized examination or formal evaluation task that involves the measurements, tests, and gauges applied to certain characteristics in regard to an object or activity. The results are usually compared to specified requirements and standard for determining whether the item or activity is in line with these targets, often with a standard inspection procedure in place to ensure consistent checking. Inspections are usually non-destructive.
	Example of maintenance work are routine oil changes and painting. Examples of inspection work are pole inspections, vault inspections and substation inspections.
Work Recording (WR)	The Work Recording (WR) business function involves the job completion or closing of work orders by documenting time and material consumed, creating post-work documentation, recording failures, recording collected data and measurements, analysis and follow-up of work orders and measurement of work management/execution performance.
Work Scheduling (WS)	The Work Scheduling (WS) business function involves work planning, priority and capacity scheduling, supply of parts, tools and instruments to ensure an efficient work order execution. The focus is to ensure that all the tasks that need to be done will be done in the required time and quality with little or no waste of human and material resources.
	For power system work, safe access to assets is important and can involve scheduling of access permits and shutdown/de-energising of conducting equipment.

4.3.16.3 Business objects

Name	Description
Availability Permission	The Availability Permission business object includes the reservation and allowance for supply of parts, tools and instruments to ensure an efficient work order execution. This can also involve getting access permits and shutting down/de-energising conducting equipment to ensure safe working conditions.
Job Safe Worksheet	The Job Safe Worksheet business object includes a documentation of risk assessment that is developed through the Job Safe/hazard analysis. Each step or task of the work/job identifies potential hazards or risk and a recommended safest way to do the job.
Safety Document	The Safety Document business object includes the restriction or authorising of works on electrical equipment (for example, a permit to work, sanction for test, limitation of access, or certificate of isolation), defined based upon organisational practices.
Work	The Work business object includes the schedule for the allocation of specific resources, crew, vehicle, equipment and materials and work orders (one or more work tasks) to one or more assets.
Work Order	The Work Order business object includes the identity of the asset, schedule constraints (e.g. done by), prioritisation, work-breakdown-structure (WBS), crew skill requirement, procedure reference, material, tools, services, testing, etc. Here are some Work Order types: • request for maintenance, maintenance order, e.g. refurbish a given power transformer; • request for construction work, e.g. line extension or construction, substation extension or construction; • request for service, service order, e.g. meter reading, meter replacement, turn-on, turn-off; • work request, e.g. forest clearing/thinning; • emergency work, that could be triggered by trouble ticket, or switch request given by network operation.
Work Resource	The Work Resource business object includes specific resources, crew, vehicle, equipment and materials that are needed for executing the work.
Work Schedule	The Work Schedule business object includes the collection of work orders and schedules that specify the generic or specific allocation of vehicle, crew, equipment and materials. Normally, the scheduling is done on the generic type; type of vehicle, type of crew, type of equipment and type of materials to enable the allocation to be done as close as possible to the work execution.
Work Task	The Work Task business object describes the activity that needs to be accomplished within a defined period of time or by a deadline for completion. One or more assignments on a task puts the task under execution. A work task can have dependency to other tasks.

4.3.17   External to IEC

4.3.17.1   General

The External to IEC package in the CIM IRM defines the business functions and business objects involved in the interacting with business functions and business objects that are defined in other packages in the IEC CIM IRM. These functions are defined or shared/harmonized with other standards that are defined outside the scope of the IEC, e.g. ISO. The relationships between the business functions and business objects are described in Figure 19.

Even if the business function and business object are defined to be managed externally to the IEC, it does not mean that a profile is not created to handle data exchange between applications that service a business function external to the IEC and a business function defined in the other IRM package.
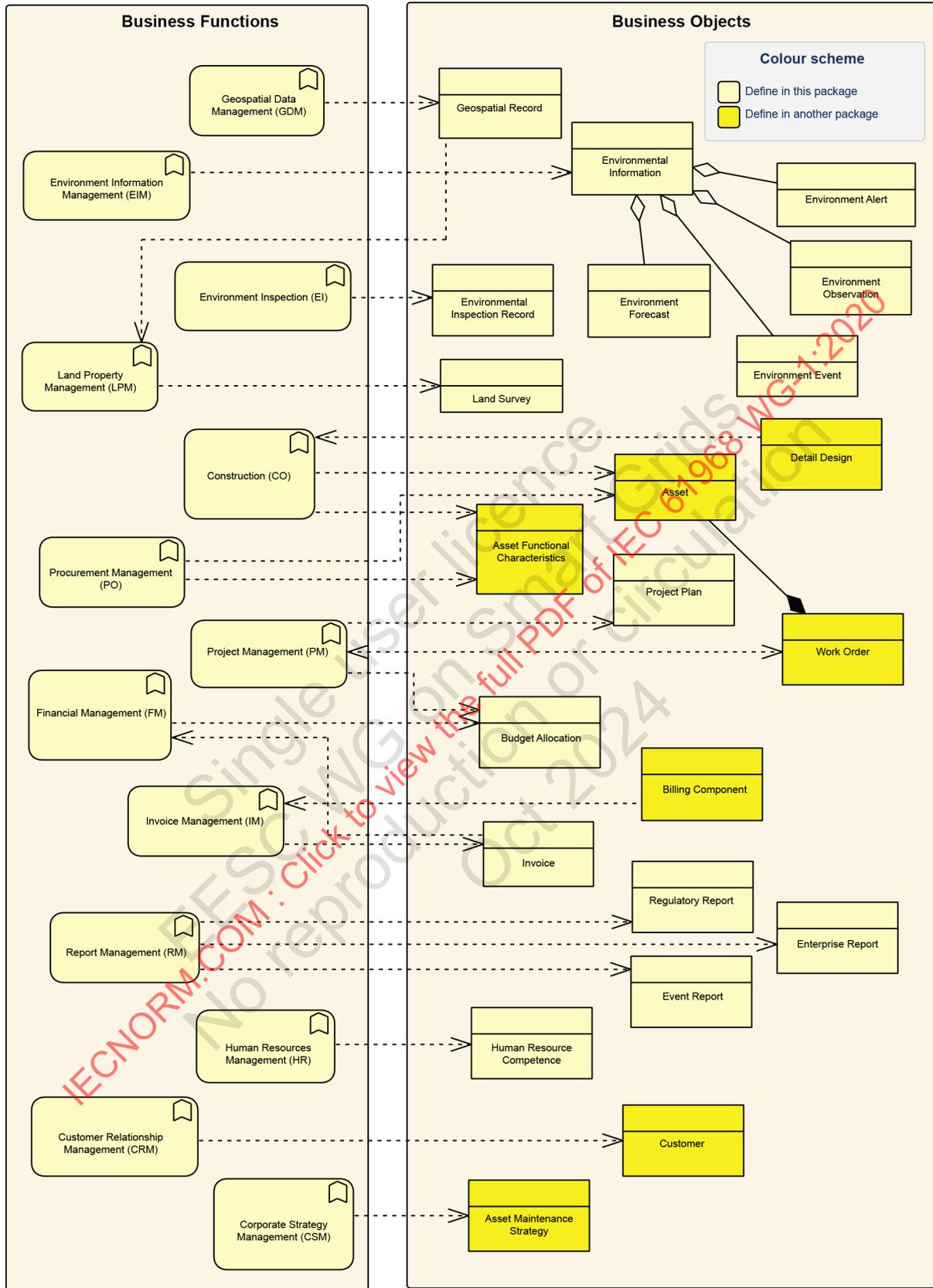
Figure 19 – External to IEC business functions and business objects

4.3.17.2 Business functions

Name	Description
Construction (CO)	The Construction (CO) business function includes the production and construction of the product that satisfies the client requirements based on the detail design and the execution of the construction. It also includes a follow-up to ensure sound engineering practices and compliance to all applicable engineering standards and government regulations during construction.
Corporate Strategy Management (CSM)	The Corporate Strategy Management (CSM) business function describes the overall scope and direction of the corporation and the way in which various businesses work together to archive particular goals.
Customer Relationship Management (CRM)	The Customer Relationship Management (CRM) business function involves the practices and strategies used to manage and analyse customer interactions and data throughout the customer's lifecycle, with the goal of improving customer service relationships and assisting in customer retention and driving sales growth. This includes marketing campaigns, programmes, promotions, etc.
Environment Forecasting (EF)	The Environment Forecasting business function are estimating the intensity, nature, and timing of the external forces that may affect the construction, operation and maintenance of power utility asses or function in regard to performance, firms, disrupt or force changes to existing plans and strategies. For power utilities, this is relevant for weather warnings and real-time data for load forecasting.
Environment Information Management (EIM)	The Environment Information Management (EIM) business function has a multidisciplinary perspective where the environment management goal is to provide the necessary environmental data, including atmospheric, hydrospheric, and geospheric, to the relevant business functions that provide the impact assessment and analysis. This includes creating environment models that are used for forecast and hindcast. Hindcast are commonly used in hydrology for training models based on observation.
Environment Inspection (EI)	The Environment Inspection (EI) business function involves inspection of the environmental condition of an area in regard to constructing, operating or maintaining power utility assets. This is less comprehensive than Land Surveying and is often done in closer cooperation with inspection of the assets that are located in the same area. This is typically relevant for inspecting transmission lines where, for example, tree height or environmental obstacles are also inspected.
Financial Management (FM)	The Financial Management (FM) business function involves the efficient and effective management of financial assets in such a manner as to accomplish the objectives of the organisation. This includes the evaluation of investments in capital projects, maintenance, and operations. These processes include risk and benefit costs and impact on levels of service. The business function includes tracking of amounts owed to utility for services provided to its customers and other relevant parties, for example use of its facilities in energy markets, joint use of its structures and rights of ways. The business function also includes managing future budgets and adjustments to existing budgets, which are based on current and forecasted financial commitments and prioritized needs. Budgeting is also included to support the transfer of budget amounts between all possible source applications throughout their enterprise and a general ledger or budget application.

Name		Description
	Credit Assessment (CS)	The Credit Assessment (CS) business function assesses the customer's credit based on predetermined terms, such as interest rates that apply per period since the billing amount became due. Collection is a relevant function that refers to the procedures that a utility follows to ensure that bill payments are made along with procedures followed in non-payment scenarios as indicated by the terms of the customer agreement. Credit Assessment and Collection are important components of revenue protection.
Geospatial Data Management (GDM)		The Geospatial Data Management (GDM) business function involves the creation and management of information that is directly or indirectly associated with a location relative to the Earth. This is normally done in cooperation with other design and graphical technology to update graphic and non-graphic information. In addition, it can support services such as: • location-based services; • simple feature access (ISO 19125) that specifies a common storage and access model of mostly two-dimensional geometries (point, line, polygon, multi-point, multi-line, etc.); • reference model support (abstract framework or domain-specific ontology (including power engineering)); • spatial and temporal schemas (exchange profiles); • geospatial metadata (ISO 19115, ISO 19139); • map images (Web Map Service (WMS)). The following geospatial information is relevant for the management of power systems: • topographical land data for road network, place names, administrative/property boundaries and addresses; • land property cadastre data (real estate and land ownership and access right information); • domain-specific data (hydrographic, power system (e.g. power line, substation, generators), environment).
Human Resources Management (HR)		The Human Resource Management (HR) business function involves maximizing employee performance at the service of an employer's strategic objectives. The primary focus is the management of people in regard to company policies and systems (e.g. benefits, training). The basic functions are staffing, training and development, motivation and retention. The Human Resource Management business function is responsible for overseeing the design of employee benefits, employee recruitment, training and development, performance appraisal, and rewards (e.g. managing pay and benefit systems). HR handle organisational changes and industrial relations as well as governmental requirements in regard to employee-based system and competence management.
Invoice Management (IM)		The Invoice Management (IM) business function involves the creation of invoice bases on billing components (or account settlement statements) by applying discount, sales tax or VAT (if applicable), terms of sales and method of payment. The total charges provided by the billing components are aggregated. In the case, market settlement, where the utility creating the invoice is neutral, the invoice management function aggregates both payments and changes in the created invoice.

Name	Description
Land Property Management (LPM)	The Land Property Management business function contains two aspects in the IRM model: Land Surveying and Address Management. The Land Surveying involves the technique, profession, and science of determining the terrestrial and positions of points to establish maps and boundaries for ownerships, locations of construction and ground or other environmental conditions.
	The following are relevant surveys for the power utility industry:
	• easement and right-of-way surveys;
	• pipeline surveys;
	• topographic surveys;
	• boundary surveys;
	• control surveys;
	• construction staking;
	• plats and exhibits;
	• legal descriptions;
	• transmission line location;
	• transmission line mapping;
	• utility corridors;
	• plan and profile preparation;
	• realignment surveys;
	• ROW surveys;
	• rebuild\as-built;
	• route studies;
	• substation surveys;
	• locating tower sites;
	• subsurface utility engineering (SUE).
	Right of Way Survey – Survey performed for the purpose of laying out an acceptable route for an easement or right-of-way for a road, pipeline, utility or transmission line. This survey would include the establishment of all boundary lines and road crossings along the route.
	Topographic Survey – Graphic representation of physical features of the land depicting natural and man-made features, such as fences, buildings, utilities, hills, valleys, streams, lakes and roads.
	Construction Survey – Construction staking to establish the correct location of proposed structures shown on engineering design plans for constructing roads, pipelines, buildings and other improvements.
	The Address Management tracks relevant addresses for service locations, billing, organisations, etc.
Procurement Management (PO)	The Procurement Management (PO) business function involves selecting products and vendors, establishing payment terms, strategic vetting, selection, the negotiation of contracts and actual purchasing of goods.
	Management of assets and material items from the time their procurement is planned to the time that the asset or material items are installed or used.
	Logistics are also included in this business function, which tracks and manages inventory (assets and material items) that are stored for later use.

Name	Description
Project Management (PM)	The Project Management (PM) business function or discipline involving initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria. A project is a temporary endeavour designed to produce a unique product, service or result with a defined beginning and end, being time, funding or deliverable constrained, undertaken to meet unique goals and objectives.
Report Management (RM)	The Report Management (RM) business function coordinates activity of an organisation to prepare, make, or submit a report of something observed, investigated, or the like. The following type or report might be relevant: • structure reporting; • schedule reporting; • event reporting; • real-time reporting.

4.3.17.3   Business objects

Name	Description
Budget Allocation	The Budget Allocation business object includes cost allowance (and potential revenue) for design/acquisition, operations, maintenance and renewal/disposal (e.g. replacement). In addition to cost, it can also include resource planning people, supporting equipment such as vehicles, equipment (such as machinery, measuring instruments and other tools), consumables and supplies and subcontracts.
Enterprise Report	The Enterprise Report business object includes the collection of valuable data to support efficient and timely decision making in the organisation by the management. The data is structured and rendered in a way that essential information is highlighted. The report generally takes the form of graphs, text and tables. The data and information can be rendered as a document or provided as web pages on enterprise portals.
Environment Alert	The Environment Alert business object includes the notice of unusual or potentially dangerous or difficult circumstances that is typically issued based on the severity and timing of an environmental event. It includes warnings and watches.
Environment Event	The Environment Event business object is an activity that is associated with an observation of a thing that happens that can influence or affect the behaviour of an asset. This includes events such as major natural events and manmade disasters.
Environment Forecast	The Environment Forecast business object includes the estimation of the intensity, nature, and timing of the external forces that may affect the performance of individual assets in the grid or the grid as a whole. This includes forecast or hindcast on: • space (solar flares); • atmospheric conditions (wind speed gust, humidity etc.); • geospheric conditions (fire, earthquake etc.); • hydrospheric conditions (flood level, water temperature, surface temperature etc.).
Environment Observation	The Environment Observation business object describes the recorded environmental data.
Environmental Information	The Environmental Information business object includes records of observed and forecasted environmental data that directly or indirectly influences the asset or grid behaviour. It can also be information needed for planning work done to the asset or the grid.

Name	Description
Environmental Inspection Record	The Environment Inspection Record business object describes the result of the inspection in regard to environmental information. This could include three levels in relationship to transmission line, icing, snow depths.
Event Report	The Event Report business object includes the collection of relevant data to support efficient and timely reporting of an event after its occurrence. An event report could also identify areas for future tuning and improvements.
Geospatial Record	The Geospatial Record (GR) business object includes information having implicit or explicit association with a location relative to the Earth. The following geospatial information is relevant for power systems management: • topographical land data for road network, place names, administrative/property boundaries and addresses; • land property cadastre data (real estate and land ownership and access right information); • domain specific data (hydrographic, power system (e.g. power line, substation, generators), environment. Geospatial data and information is defined in ISO/TC 211 standard series.
Human Resource Competence	The Human Resource Competence business object contains personal information for each employee or contractor. It includes data such as job code, employee status, department or place in the organisation, and job-related skills and certification.
Invoice	The Invoice business object, also called "bill of sale" or "contract of sale", is a statement given by a seller to a buyer itemizing the sale and demanding payment. It includes the identification of instruments, products or services that are provided by the seller with the associated quantities and price of the items sold, billing or settlement components/statements. It can also include discounts, applicable sales tax or VAT, or terms of sales and methods of payment.
Land Survey	The Land Survey business object describes the result of the land surveying execution and also describes the terrestrial and positions of points to establish maps and boundaries for ownerships, locations of construction and ground or other environmental conditions. This includes environmental conditions that impact the construction, operation and maintenance of the asset. This includes ground conditions, wind, salt corrosion, ice, solar radiation, water, sand, etc.
Project Plan	The Project Plan business object describes how and when a project's objectives are to be achieved, by showing the major products, milestones, activities and resources required on the project.
Regulatory Report	The Regulatory Report business object includes the collection of valuable data to support the monitoring of compliance to one or more regulatory rules. The following type or reporting can be relevant: • record keeping reporting; • complaints handling reporting; • processes and procedures reporting; • training reporting.

4.4 General

IEC 61968-1 describes utility inter-application infrastructure recommendations necessary to integrate components distributed throughout the enterprise. The services and functionalities described are independent of the underlying integration infrastructure. In the recommendations listed in this clause, an "event" is a unit of information exchange which is issued asynchronously by its source ("push"). A "component" is a module of application software, which could be a component of the integration bus as either a publisher or subscriber (receiver) of an information exchange.

The business process begins by identifying the information to be exchanged and the components involved. This typically involves one publisher that has the information and initiates the exchange, and zero or more subscribers that will receive the information.

The IEC 61968 series recommends that a compliant utility inter-application infrastructure:

a) should allow components to exchange information of arbitrary complexity;

b) should be able to be implemented using various forms of integration technology (e.g. web services, Java EE, message brokers, message-oriented middleware, databases, or others);

c) should provide an information exchange model facility that users employ to describe the information to be exchanged. This facility presents the user with the models of events and the components to which they relate, and it allows the new exchange to be added to the old, so that a comprehensive corporate exchange model, tailored to a utility's specific needs, can be built rather than a collection of independent models;

d) should allow publisher and/or subscriber component to be deployed by system administrators independently of other components as far as interfaces remain the same;

e) should ensure that, once a given type of event is published, additional subscribing components can be configured to receive the event without having to make any changes or additions to the publisher's component.

4.5 Requirements analysis methodology

To help solve the problem of effectively sharing information across electric utility departments and systems, a common modelling notation or language is needed. A modelling language extends natural language by adding formal constructs to aid in communication by reducing ambiguity. By using a common modelling language across the utility, utilities can better define what information needs to be shared across departments.

The chosen modelling language should be rich enough to detail the requirements, graphically oriented (visual diagrams) to make it easy to use, widely accepted, and supported by reasonably priced tools. Refer to Annex A for further information regarding this methodology that has been used for the development of the IEC 61968 series.

5 Interface profile

5.1 General

Clause 5 is organised in accordance with the interface profile shown in Figure 20.

| 5.2	Business function
5.3	Application adapter
5.4	Interface specification
5.5	Middleware adapter
5.6	Middleware service
5.7	Communication service
5.8	Platform environment

IEC

Figure 20 – Overview of the interface profile and corresponding subclause numbers

The recommendations for all the individual parts in this interface profile are explained in 5.2 to 5.8.

5.2   Business function

Business functions and their accessible objects are defined in the IRM, which can be used for use cases and data objects defined in IEC 61968-3 to -9, and -13. The following example shows a use of the IRM business functions in a business use case (Figure 21). In this use case, four IRM business functions (WS, WD, WE, and WR) are involved in a "Manage Work" business process that is triggered by a "Work Requested" Business Event in ArchiMate terminology. Note that several business objects are involved in this process as well. These business objects are further realized by Data Objects in the Application Layer that will be described in the next section.
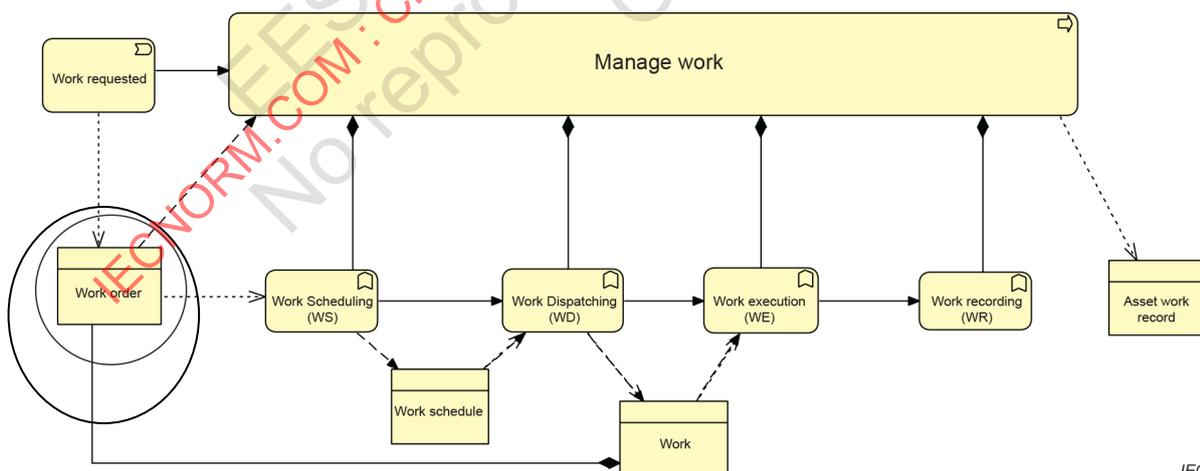
IEC

Figure 21 – Manage Work Business Process Example

The message exchange of the Work Orders (circled) in this business process can be further detailed using an UML sequence diagram. This will be presented in the Application Layer in the following section.

The business functions can be viewed as logical functionalities. A physical function based on a logical function can be executed such as being invoked remotely for data exchange. For example, an application function can be a classic, procedural application (also referred to as a legacy application) or a fully object-oriented application built around the latest technology. Also, application functions can be distributed across the network (LAN, Intranet, private corporate WAN or even the public Internet), enabling flexible deployment of DMS applications in the utility-wide information and communication (ICT) architecture.

Today's DMS applications may have its own application architecture, its own API, and its own mechanism of interfacing the application with other products. However, many of their applications are based on common logical functions, such as the common Network Operation function. For that reason, the common business functions are provided in this document. The IEC 61968 series recommends that applications should implement at least one of the common top business functions as specified in the relevant series of documents from IEC 61968-3 onwards.

5.3   Application adapter

An application adapter in the context of the IEC 61968 series is a CIM profile compliant software that enables a non-compliant software application to expose the services. A CIM profile is basically a Data Object in an Application layer using the ArchiMate concept. As such, the component adapter only goes as far as necessary to make the application conformant to one or more specific interface specifications in the series IEC 61968-3 onwards.

A Business Object can be realized by one or more Data Object(s) defined in CIM as Profile(s). For example, the "Work Order" Business Object described in the previous subclause can be realized by a "WorkRequests" data object in the Application Layer in an ArchiMate model (Figure 22).
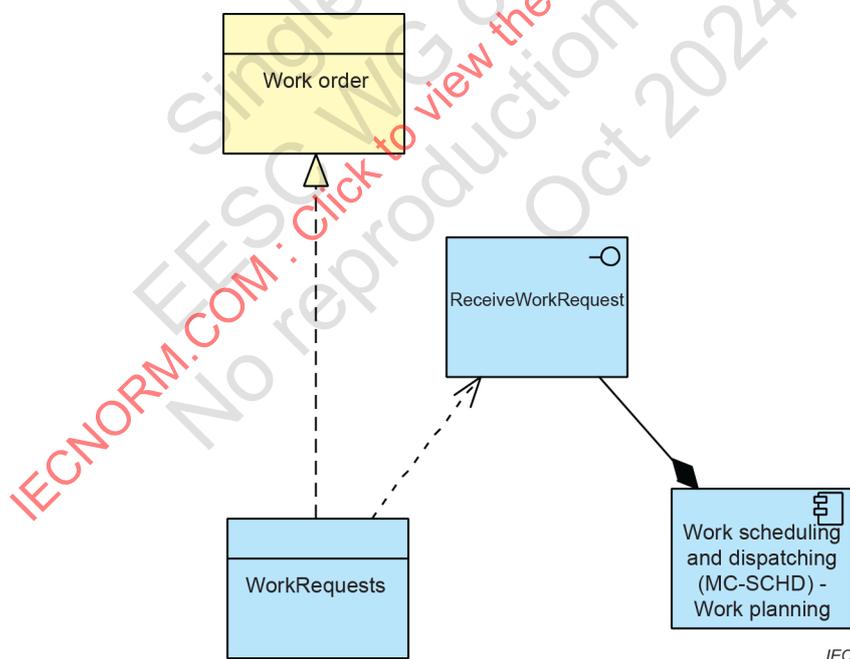

IEC

Figure 22 – WorkRequest Data Object Example

The "WorkRequests" message can be exchanged between the "Customer Support" and "Work Scheduling & Dispatching" components. Here is an example to present the message exchange in a UML sequence diagram that is typically used in 61968-3 to -9 (Figure 23). The process is triggered by a Work Requested followed by the "WorkRequest" message exchange. After the "Work Scheduling & Dispatching" component process the request, a "WorkOrder" message is sent back to the requester, Customer Support (CS) component.
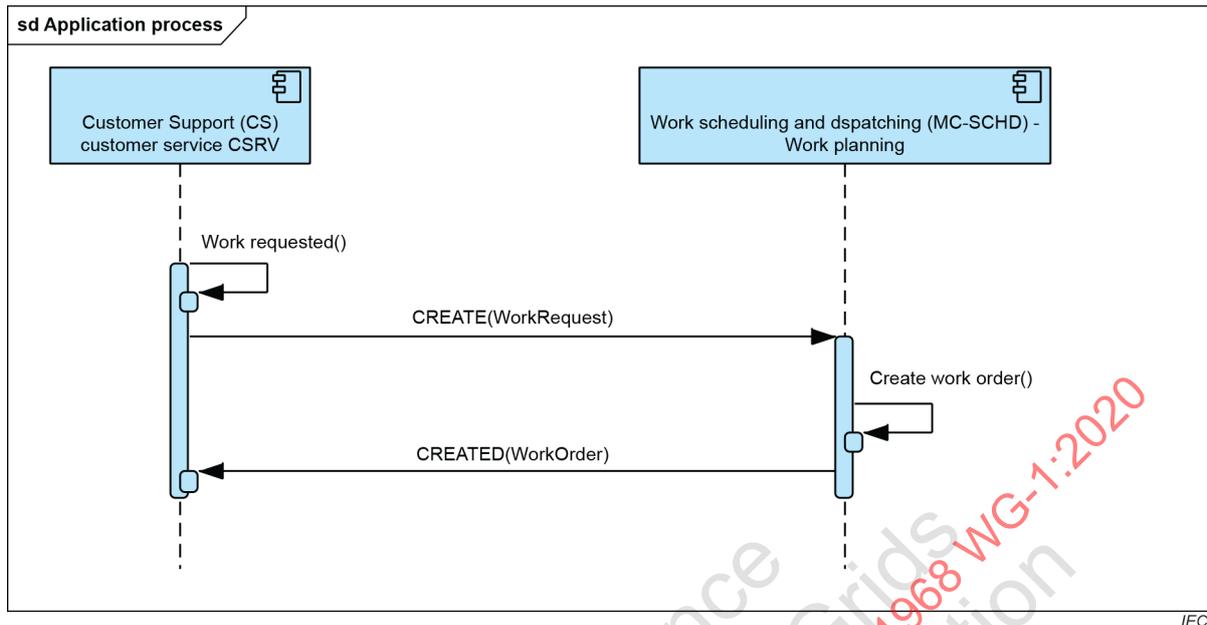
Figure 23 – Application Process Sequence Diagram Example

5.4   Interface specification

The IEC 61968 series interface specification recommendations consist of two parts: CIM profile specifications and services specifications, which are common in a distributed computing environment based on components. Individual IEC 61968 CIM profile specifications for functional areas (see the Interface Reference Model in Clause 3) are available in the IEC 61968 series (IEC 61968-3 through -9 and -13). Service specifications are described in IEC 61968-100.

Using the ArchiMate terminology, an interface can be described using Application Layer: Application Interface notation which describes how the functionality of a component can be accessed by other elements.

For all parts in an IEC 61968 interface specification, it should:

a) be declarative, containing attributes, methods and parameters as needed for all the service exchanges that are part of the specific interface specification;

b) be programming-language neutral;

c) emphasize the separation of logical interface and its implementation;

d) be middleware-agnostic.

Recommendations for interface specifications are standard-based. Common service patterns are provided in IEC 61968-100.

5.5   Middleware adapter

A middleware adapter in IEC 61968 series is a CIM profile compliant software that augments existing middleware services to ensure a utility's inter-application infrastructure supports recommended services and patterns. As such, the middleware adapter only goes as far as necessary to make the used set of middleware features conformant to the requirements of one or more available interface specifications in IEC 61968-3 through -9. In this context the middleware services represent not one single interface, it represents a set of interfaces enabling a set of corresponding services for components.

Using the ArchiMate terminology, a middleware adapter can be described using the Technology Layer: System Software which represents software that provides or contributes to an environment for storing, executing, and using software or data deployed within it.

For example, each vendor's component may use internally any middleware (or no middleware at all) that is appropriate for the needs of the specific business function. A utility cannot assume that two arbitrary components will always use the same implementation of middleware services that are used by the utility. A middleware adapter is needed that is able to act as a middleware "gateway" for IEC 61968 exchanges produced by one component over the implemented middleware services into the other component(s) (which may be based on other middleware).

IEC 61968-3 to -9 define the services (see 5.4) that are recommended to be present in the architectural implementation supporting and governing component implementation. However, different implementations of middleware services will introduce heterogeneous service implementations and different operating environments. This situation may provide some properties implicitly and recommend that others be added by the middleware adapter. If the middleware services implementation does not provide a specific profile-compliant feature, the middleware adapter should provide it.

This implies that:

- for a middleware service implementation that provides the service, the middleware adapter should provide a mapping to it;

- when a non-compliant middleware services implementation is used in an IEC 61968 environment, at least one middleware adapter is present for that middleware services implementation to make it IEC 61968-compliant. It can also be the case that more than one middleware adapter is used to make a single middleware service implementation compliant with the services (e.g. one middleware adapter for each required IEC 61968 interface service);

- for those middleware services that are non-compliant, each middleware adapter is custom-made for that specific middleware services implementation because it depends heavily on the architecture and implementation of the middleware services implementation. It also runs in a specific, possibly distributed hardware/operating system (HW/OS) environment. Therefore, the triple set middleware services implementation, (set of) middleware adapter(s) and HW/OS are fully dependent on each other;

- the middleware adapter (in theory) is reusable for multiple IEC 61968 interface services running over the same middleware services implementation in the same computing environment.

5.6   Middleware service

Information exchanged among components can be performed within the same process (in process), across processes on the same machine (local) and across machines (remote). Middleware providers usually support different communication patterns, e.g. synchronous and asynchronous interaction. Subscription refers to the ability to read or modify objects at cyclic or event-driven times. Messaging addresses the features of today's messaging middleware, such as store-and-forward, persistence of messages and guaranteed delivery.

Using the ArchiMate terminology, a middleware service can be described using the Technology Layer: Technology Interface which specifies how the technology services of a node can be accessed by other nodes.

The middleware services should provide a set of APIs and allow the previous layers in the interface profile to:

a) transparently locate and interact with other applications or services across the network;

b) exist independently of communication profile services;

c) be reliable and available;

d) modify transaction capacity without losing functionality;

e) provide the ability to support business-to-business (B2B) transactions where needed.

As an example, in Java EE the JMS supplies some of the basic middleware services for life cycle and registration.

5.7 Communication service

Integrating two components requires a connection between them. A computing infrastructure shall be managed to support multiple network types and different resources presenting different protocols, such as a JMS transport and HTTP. To connect multiple components, an integration system shall seamlessly reconcile network and protocol differences to support component communication. In general, services should be provided independently to the underlying platform, language, and integration tool or technology.

Using the ArchiMate terminology, a communication service can be described using the Technology Layer: Technology Service which exposes the functionality of a node to its environment.

5.8 Platform environment

Services can be deployed on various hardware and software platforms. A utility may need to manage different hardware and operating system platforms from different vendors. This means that a utility may have to make modifications depending on the hardware and software that is deployed. The specific adaptations that may be required for a particular implementation are outside the scope of this document.

Using the ArchiMate terminology, a platform environment can be described using the Technology Layer: Node which represents a computational or physical resource.

6 Information exchange model

6.1 General requirements

This document defines requirements and recommendations for an Interface Reference Model (IRM) for distribution management where components distributed over the communication network exchange information using IEC 61968 services. Only functionality and services required to support information exchange are enumerated in this clause.

However, since the initial release of IEC 61968-1, the term 'CIM Profile' has come into common use. A CIM profile is simply some formal subset of the CIM, in terms of classes, attributes and relationships that may have additional restrictions imposed (e.g. some elements are required). The term IEM has effectively been replaced with the term CIM Profile. The normative contents of IEC 61968-3 through -9 and -13 are effectively the definition of CIM Profiles. The use of the IEC CIM as the basis for the information exchange model has been enhanced through the effective merging of distribution with transmission models within the CIM, as realized by IEC 61970-301 and IEC 61968-11, as well as the definition of naming and design rules.

IEC 61968 series recommends that a compliant utility inter-application infrastructure should:

- support both integrations with or without an integration layer such as an ESB,

- provide interoperability for information exchange between components.

The IEC 61968 profiles are effectively a set of payload definitions that can be used within messages. The realization of message payloads occurs using one of two XML formats:

a) XML documents that conform to an XML Schema are derived from the CIM. This is the approach used for IEC 61968-3 to -9;

b) XML documents that conform to an RDF Schema that is derived from the CIM. This is the approach used for IEC 61968-13.

The use of XML schema also raises several issues related to the derivation of a specific XML Schema from a model defined using UML. The issues of concern include:

- specification of required vs. optional elements;

- specification of relevant associations (from the perspective of what is or is not relevant to the specific message of interest);

- the means to uniquely identify specific elements;

- the means to relate one element to another element;

- the use of XML attributes vs. XML elements.

As a result, a mapping of UML to XML schema should follow IEC 62361-100, and a mapping to RDF schema should follow IEC 61970-501.

6.2 Message structures

6.2.1 General

IEC 61968 series recommends the use of a standard message envelope structure in addition to technology specific message envelope structures such as JMS and SOAP header definitions. The basic understanding of each message defined requires:

- a verb, to identify the type of action being taken;

- a noun, to identify the type of the payload;

- the payload, which contains the data relevant to the information exchange as defined using a profile.

Detailed information on the recommended message structure is provided in IEC 61968-100.

6.2.2 Compliance philosophy

6.2.2.1 General

The IEC 61968 series defines the names of message types and fields within message types. Compliance can be assessed separately for each message type payload.

If a message type has an XML Schema Definition (XSD) defined within IEC 61968 parts, compliance shall be made at the physical XSD level syntactically. Explicit compliance guidelines in the IEC 61968 series should be followed if provided. Note that the IEC 61968 defines standards for compliance but does not define guidelines and tests to certify interoperability.

The CIM Compliance Testing Task Force defines four levels of CIM Compliance based on the TOGAF Levels of Architecture Conformance.

6.2.2.2 Irrelevant

The implementation under consideration supports none (0 %) of the profiles identified in applicable IEC CIM Profile Standards so the question of compliance or conformance does not arise.

6.2.2.3   Compliant

The implementation under consideration supports some percentage (> 0 %, < 100 %) of the profiles identified in applicable IEC CIM Profile Standards and all supported profiles are implemented in accordance with the applicable IEC CIM Profile Standards. A compliant implementation under consideration will either: 1) contain other interface functionality that is not in the scope of IEC CIM Profile Standards; or 2) only contain interface functionality that is in the scope of IEC CIM Profile Standards.

6.2.2.4   Conformant

The implementation under consideration supports all (100 %) of the profiles in applicable IEC CIM Profile Standards and all supported profiles are implemented in accordance with the applicable IEC CIM Profile Standards. A conformant implementation under consideration will only contain interface functionality that is in the scope of IEC CIM Profile Standards.

6.2.2.5   Non-compliant

The implementation under consideration claims to support some percentage (≤ 100%) of the profiles identified in applicable IEC CIM Profile Standards; however, those profiles have not been implemented in accordance with the applicable IEC CIM Profile Standards.

6.2.3   Extension

Both CIM UML models and XSDs can be extended. Customer extensions to an UML model are recommended to be properly located and/or labelled in model for namespace management. Customer extensions to XSDs are recommended to not break CIM XSD backward compatibility if possible. Customer extensions should be submitted to related 61968 working groups to be considered for inclusion into the relevant part of the standard.

7   Component reporting and error handling

7.1   Component reporting

The IEC 61968 series recommends that a compliant utility inter-application infrastructure:

a) should provide a generic event history facility as a component. This allows all or selected information exchanges to be saved;

b) should provide the event history's schema based on the metadata provided by the information exchange model;

c) should provide the event history component to record the time at which the publishing component issued each event;

d) should be capable of supporting event information model versions and component versions (this allows a complete audit trail to be preserved which is capable of supporting rigorous reconstruction of history, if that should become a requirement);

e) should provide Inter-application Supervisor component that analyses the state of any application component interface connected to the utility services. It may be enabled and disabled, and has the capability to provide performance monitoring capabilities. Those elements will help to provide statistics in order to identify bottlenecks or areas subject to improvement in the future. The information helps the administrators configure information exchanged among components and to ensure availability;

f) should be able to support a component sending or requesting information without knowing where the receiving component is physically located or if it is currently connected. The receiver may be unreachable because of a network problem, or be naturally disconnected as in the case of mobile users who only connect periodically.