# ETSI EN 303 760 V1.1.1 (2024-10)

EUROPEAN STANDARD

## SmartM2M;
## SAREF Guidelines for IoT Semantic Interoperability;
## Develop, apply and evolve Smart Applications ontologies

Reference

DEN/SmartM2M-303760

Keywords

application, application layer, artificial intelligence,
interoperability, IoT, IoT platforms, methodology,
ontology, SAREF, semantic

*ETSI*

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

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# Contents

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# Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

| **National transposition dates** | |
|---|---|
| Date of adoption of this EN: | 25 September 2024 |
| Date of latest announcement of this EN (doa): | 31 December 2024 |
| Date of latest publication of new National Standard or endorsement of this EN (dop/e): | 30 June 2025 |
| Date of withdrawal of any conflicting National Standard (dow): | 30 June 2025 |

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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# Introduction

Fragmentation of the IoT ecosystem in terms of standardization, architectures and available technologies and IoT service platforms targeting specific applications or application domains impede the sharing of information between the resulting silos. An increasing number of IoT devices located in different IoT networks generate greater quantities of data to be shared across the IoT. Therefore, more and more devices and applications need to interoperate. Manufacturers of IoT devices are faced with many standards and protocols to choose from. Consumers invest in smart IoT products. In order to combine products from different vendors according to their needs, consumers want to make sure that these products are interoperable with each other.

All of this underscores the need for open and standardized interfaces for products of different brands to interoperate and to avoid vendor-lock in. Interoperability offers the business benefit, to unlock new added value services for consumers from data integration, while manufacturers and other commercial parties can still maintain their competitive advantage in offering their solutions (not everything needs to become open and interoperable).

In the past, interoperability used to be addressed at the technical communication level.

EXAMPLES:

- by using one agreed single data model, but nowadays there is too big fragmentation in existing data models/protocols to choose from;
- by implementing ad-hoc translations between different data models/protocols, which turns to be very expensive when there are so many standards/protocols that can be translated into each other.

In recent years, the interoperability challenge has been raised to the information level, where the common concepts for all existing data models/protocols can be incorporated in an ontology (i.e. a common vocabulary). This captures the meaning of a concept (i.e. semantics) rather than the specific data format in which the concept is encoded for data exchange at the underlying communication layer.

The Smart Applications REFerence ontology (SAREF) developed and maintained by ETSI since 2015 provides a mature, sustainable and standardized framework of ontologies for IoT that enables different parties to interoperate with each other at the semantic level.

The present document brings together widely considered good practices in semantic interoperability for IoT smart applications in a set of high-level outcome-focused provisions. The objective of the present document is to support all parties involved in the development and manufacturing of IoT smart applications and products with guidance on making them interoperable in compliance to the SAREF framework. The provisions give organizations and companies the flexibility to innovate and implement SAREF-compliant semantic interoperability solutions appropriate for their products and applications.

The present document is not intended to specify the technical details of SAREF, which are evolving further dynamically in the respective ETSI Standards, and which it refers to. Rather, it describes a methodology to apply SAREF in products/solutions and how to show SAREF compliance according to the present SAREF EN and optionally how to contribute to a new SAREF extension (if what Users need is not yet in the SAREF framework).

The provisions in the present document have been developed following a review of published standards, recommendations and guidance on semantic interoperability and SAREF, including:

- "SAREF: the Smart Applications REFerence ontology" [i.7]
- ETSI TS 103 673 [1]
- ETSI TS 103 264 [2]
- ETSI TS 103 548 [3]
- ETSI TS 103 410-1 [4]
- ETSI TS 103 410-2 [5]
- ETSI TS 103 410-3 [6]
- ETSI TS 103 410-4 [7]

- ETSI TS 103 410-5 [8]
- ETSI TS 103 410-6 [9]
- ETSI TS 103 410-7 [10]
- ETSI TS 103 410-8 [11]
- ETSI TS 103 410-9 [12]
- ETSI TS 103 410-10 [13]
- ETSI TS 103 410-11 [14]
- ETSI TS 103 410-12 [16]

As IoT applications and products become increasingly interoperable, it is envisioned that future revisions of the present document will mandate provisions that are currently recommendations in the present document.

# 1 Scope

The present document gives guidance and provisions for making IoT smart applications and products interoperable at the semantic level in compliance to the SAREF framework. It contains provisions about how to use SAREF, points to the relevant existing Technical Reports and Technical Specifications and specifies a methodology to follow for showing SAREF compliance according to the present SAREF EN. Further on, it describes how to contribute optionally to a new SAREF extension (if what Users need is not yet in the SAREF framework).

The present document addresses parties involved in the development and manufacturing of IoT smart applications and products, who might take different roles in their organization like:

- executives and product owners, who decide on to invest in a SAREF-compliant product;
- developers, who will implement a SAREF-compliant product as non-ontology experts or even ontology experts.

Different roles imply different intentions and expectations when reading the present document according to their tasks in the organization. The present document considers this by its implemented structure. Clause 4 provides guidance about how to go throughout the present document in order to judge, which clauses might be essential for the special role of the reader and which ones might be skipped.

The present document is structured as follows:

- **Clauses 1 to 3** set the scene and provide references as well as definitions of terms, symbols and abbreviations, which are used in the present document.
- **Clause 4** defines the motivation and principles shared by those who are reading the present document also serving as a checkpoint whether the reader is in the right place or not. It includes a brief reading guide as not everyone needs to read every part of the present document, depending on the reader's role and expertise.
- **Clause 5.1** provides guidance about the best practice of specifying use cases as the important basis for deriving requirements from them.
- **Clause 5.2** provides guidance/provisions about identifying core elements from the use cases defined in clause 5.1.
- **Clause 5.3** describes, how to get acquainted with SAREF.
- **Clause 5.4** provides guidance /provisions about ensuring that the correct (latest) versions of the relevant SAREF modules/patterns/extensions are selected. It illustrates, how to document the version of those SAREF modules, which the product, application, or possible ontology extension is compliant to.
- **Clause 6.1** provides guidance/provisions about the translation of data into SAREF.
- **Clause 6.2** gives guidance about testing "SAREF-compliant data" in one example application of interoperability exchange with another organization/manufacturer/brand.
- **Clause 7.1** provides guidance/provisions about creating a new SAREF extension (or pattern).
- **Clause 7.2** provides guidance/provisions about checking SAREF compliance of a new created SAREF extension without going (yet) to an official standardization contribution to ETSI.
- **Clause 8** describes the process of incorporating a new created SAREF extension according to clause 7 in the official standardization process in ETSI, which will then result in a new official extension/pattern (SAREF4abcd) under the ETSI SAREF namespace.
- **Annex A** contains an example of a possible use case to provide context to clause 5.1.
- **Annex B** contains examples of relevant core elements from use cases to provide context to clause 5.2.
- **Annex C** contains examples of translating data into SAREF-compliant data to provide context to clause 6.1.
- **Annex D** contains examples of testing SAREF data to provide context to clause 6.2.

- **Annex E** provides a short summary of SAREF ontology development methodology with figures and different phases.
- **Annex F** provides a mechanism for the User of the present document (who is expected to be an entity involved in the development and manufacturing of IoT smart applications and products) to give information about the implementation of the provisions within the present document.
- **Annex G** provides an example of how to enhance the SAREF core with its extensions to give context to clause 7.

# 2 References

## 2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 673: "SmartM2M; SAREF Development Framework and Workflow, Streamlining the Development of SAREF and its Extensions".

[2] ETSI TS 103 264: "SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping".

[3] ETSI TS 103 548: "SmartM2M; SAREF reference ontology patterns".

[4] ETSI TS 103 410-1: "SmartM2M; Extension to SAREF; Part 1: Energy Domain".

[5] ETSI TS 103 410-2: "SmartM2M; Extension to SAREF; Part 2: Environment Domain".

[6] ETSI TS 103 410-3: "SmartM2M; Extension to SAREF; Part 3: Building Domain".

[7] ETSI TS 103 410-4: "SmartM2M; Extension to SAREF; Part 4: Smart Cities Domain".

[8] ETSI TS 103 410-5: "SmartM2M; Extension to SAREF; Part 5: Industry and Manufacturing domains".

[9] ETSI TS 103 410-6: "SmartM2M; Extension to SAREF; Part 6: Smart Agriculture and Food Chain Domain".

[10] ETSI TS 103 410-7: "SmartM2M; Extension to SAREF; Part 7: Automotive Domain".

[11] ETSI TS 103 410-8: "SmartM2M; Extension to SAREF; Part 8: eHealth/Ageing-well Domain".

[12] ETSI TS 103 410-9: "SmartM2M; Extension to SAREF; Part 9: Wearables Domain".

[13] ETSI TS 103 410-10: "SmartM2M; Extension to SAREF; Part 10: Water Domain".

[14] ETSI TS 103 410-11: "SmartM2M; Extension to SAREF; Part 11: Lift Domain".

[15] ETSI Labs: SAREF extensions online.

[16] ETSI TS 103 410-12: "SmartM2M; Extension to SAREF; Part 12: Smart Grid Domain".

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the User with regard to a particular subject area.

[i.1] ETSI Labs: SAREF pipeline SW.

[i.2] Poveda-Villalón, M., Fernández-Izquierdo, A., Fernández-López, M., & García-Castro, R. (2022). LOT: An industrial oriented ontology engineering framework. Engineering Applications of Artificial Intelligence, 111, 104755.

[i.3] Linked Open Terms (LOT) methodology website.

[i.4] ETSI TR 103 411: "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.5] IEC 62559: "Use case methodology".

[i.6] EN 50631-1: "Household appliances network and grid connectivity - Part 1: General Requirements, Generic Data Modelling and Neutral Messages" (produced by CENELEC).

[i.7] ETSI SAREF portal.

[i.8] EN 50491-12-2: "General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 12-2: Smart grid - Application specification - Interface and framework for customer - Interface between the Home / Building CEM and Resource manager(s) - Data model and messaging" (produced by CENELEC).

[i.9] ETSI Labs: Sources of the SAREF Extensions.

[i.10] ETSI Labs: SAREF-portal repository.

[i.11] Chávez-Feria, Serge, Raúl García-Castro, and María Poveda-Villalón. "Chowlk: from UML-Based Ontology Conceptualizations to OWL." The Semantic Web: 19th International Conference, ESWC 2022, Hersonissos, Crete, Greece, May 29-June 2, 2022, Proceedings. Cham: Springer International Publishing, 2022.

[i.12] W3C® Recommendation 27 September 2012: "A Direct Mapping of Relational Data to RDF".

[i.13] W3C® Recommendation 27 September 2012: "R2RML: RDB to RDF Mapping Language".

[i.14] Declarative RDF graph generation from heterogeneous (semi-)structured data: A systematic literature review, Journal of Web Semantics, Volume 75, January 2023, 100753.

[i.15] Common JUnit XML Format & Examples, JUnit project.

[i.16] W3C® Recommendation 21 March 2013: "SPARQL 1.1 Query Language".

[i.17] ETSI TS 103 735: "SmartM2M; Smart Lifts IoT System".

[i.18] EN 627: "Specification for data logging and monitoring of lifts, escalators and passenger conveyors", 1995 (produced by CEN).

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 673 [1] apply:

**cleansing plan:** data cleansing is the process of fixing or removing incorrect, corrupted, incorrectly formatted, duplicate, or incomplete data within a dataset which improves data quality and helps provide more accurate, consistent and reliable information

**ETSI Labs:** platform where ETSI members and others on invitation can collaborate and experiment with code around ETSI standardized technologies, developing demos, prototypes and proofs of concept

NOTE: As specified in ETSI Labs: SAREF pipeline SW [i.1].

**ontology:** formal specification of a conceptualization, used to explicitly capture the semantics of a certain reality

**SAREF actor:** role that a person can play when using or contributing to SAREF

**SAREF core:** versioned reference ontology for the IoT developed by ETSI SmartM2M

NOTE: As specified in ETSI TS 103 264 [2].

**SAREF development framework:** actors, software, and infrastructure that support the SAREF development workflows

NOTE: As specified in ETSI TS 103 673 [1].

**SAREF development workflows:** specification of a lifecycle of SAREF project versions, where SAREF actors interact in a codified manner

NOTE: For example their creation, development, and release ETSI TS 103 673 [1].

**SAREF extension:** versioned ontology extending SAREF core for a certain domain

NOTE: SAREF extensions are documented in ETSI Technical Specifications ETSI TS 103 410-1 [4], ETSI TS 103 410-2 [5], ETSI TS 103 410-3 [6], ETSI TS 103 410-4 [7], ETSI TS 103 410-5 [8], ETSI TS 103 410-6 [9], ETSI TS 103 410-7 [10], ETSI TS 103 410-8 [11], ETSI TS 103 410-9 [12], ETSI TS 103 410-10 [13], ETSI TS 103 410-11 [14] and ETSI TS 103 410-12 [16].

**SAREF extension acronym:** SAREF extension is named **SAREF4ABCD**, where ABCD is the **SAREF extension acronym**, and is any sequence of four letters

NOTE: This acronym is unique for each extension.

**SAREF pipeline:** software on ETSI Labs that can check the conformance of one or more SAREF project versions with respect to ETSI TS 103 673 [1], and generate part of the SAREF public portal [i.7]

NOTE: The SAREF pipeline may be run manually by a SAREF actor, or automatically by a continuous integration and continuous deployment service. See ETSI Labs: SAREF pipeline SW [i.1] for instructions.

**SAREF project:** SAREF core, or any SAREF extension

**SAREF project version:** SAREF project has several **versions**, each being numbered by a **version number** v*x*.*y*.*z*

NOTE 1: The first number x is the **major version**. The second number y is the **minor version**. The third number z is the **patch version**.

NOTE 2: The version numbering system for SAREF projects is different from the ETSI version numbering system.

**SAREF project release:** SAREF project version whose documentation is exposed on the SAREF public portal

**SAREF project repository:** git repository that consists of **git branches**, which consist of sequences of **git commits**

NOTE: Git commits have a unique identifier. There are four types of branches in a SAREF project repository: **issue branches**, **develop branches**, **pre-release branches**, and **release branches:**

- issue branches are named `issue-w`, where w is an issue number of the SAREF project;
- develop branches are named `develop-vx.y.z`, where v*x.y.z* is a SAREF project version number;
- pre-release branches are named `prerelease-vx.y.z`, where v*x.y.z* is a SAREF project version number;
- release branches are named `release-vx.y.z`, where v*x.y.z* is a SAREF project version number.

**SAREF project sources:** git repository called **the SAREF project repository**, an associated **public issue tracker**, and a **continuous integration and continuous deployment service**

**SAREF ETSI Labs:** software development and git-based source code web platform managed by the ETSI Secretariat

NOTE: The SAREF ETSI Labs contains the **SAREF projects sources**. The entry point to the SAREF public ETSI Labs is https://labs.etsi.org/rep/saref/ [i.9].

**SAREF public portal:** web server hosted on an **ETSI server** and managed by the ETSI Secretariat [i.7]

NOTE: It exposes the documentation of SAREF and the SAREF projects to the public. The entry point to the SAREF public portal is https://saref.etsi.org/. The SAREF public portal contains the documentation of all the SAREF projects for different **SAREF project releases**.

**user:** stakeholder, who wants to apply SAREF in his products/solutions

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

| | |
|---|---|
| AI | Artificial Intelligence |
| BER | Bit Error Rate |
| CD | Continuous Deployment |
| CI | Continuous Integration |
| CLI | Command Line Interface |
| CSV | Comma Separated Values |
| DL | Description Logics |
| EN | European Standard |
| FoaF | Friend-of-a-Friend |
| GUI | Graphical User Interface |
| HTML | Hyper Text Markup Language |
| IoT | Internet of Things |
| IPR | Intellectual Property Right |
| IRI | Internationalized Resource Identifier |
| LOT | Linked Open Terms (methodology) |
| NAN | Not A Number |
| ORSD | Ontology Requirements Specification Document |
| OWL | Web Ontology Language |
| QUDT | Quantities, Units, Dimensions, and Types Ontology |
| R2RML | RDB to RDF Mapping Language |
| RDB | Relational Data Base |
| RDF | Resource Description Framework |
| RSSI | Radio Signal Strength Indicator |

| | |
|---|---|
| SAREF | Smart Applications REFerence ontology |
| SCD | SAREF-Compliant Data |
| SHA | Secure Hash Algorithm |
| SHACL | Shapes Constraint Language |
| SPARQL | SPARQL Protocol and RDF Query Language |
| SPINE-IoT | Smart Premises Interoperable Neutral-message Exchange protocol |
| STF | Specialist Task Force |
| TR | Technical Report |
| TS | Technical Specification |
| URI | Uniform Resource Identifier |
| URL | Universal Resource Locator |
| UTF-8 | Unicode Transformation Format (the 8-bit form) |
| W3C® | World Wide Web Consortium |
| WSDB | Web Service Data Broker |
| YAML | YAML Ain't Markup Language |

# 4 Motivation

The present document addresses parties involved in the development and manufacturing of IoT smart applications, services and products, which want to make their applications, services and products interoperable with each other and with those of other different parties. The Smart Applications REFerence ontology (SAREF) developed and maintained by ETSI since 2015 provides a mature, sustainable and standardized framework of ontologies for IoT that enables different parties to interoperate with each other at the semantic level.

The present document provides a decision support for the implementation of SAREF, a commonly agreed and standardized ontology with many extensions in different IoT domains, a shared model of consensus that facilitates the matching of existing assets in the smart applications. Once decided to apply SAREF, the present document describes all steps to be taken in order to be SAREF-compliant by fulfilling the documented provisions.

As the reader of the present document might take different roles in his organization like:

- executives and product owners, who decide on to invest in a SAREF-compliant application, service or product;
- developers, who will implement a SAREF-compliant product as non-ontology experts or even ontology experts.

Different roles imply different intentions and expectations when reading the present document according to the specific tasks in the reader's organization, the present clause gives some guidance about how to go throughout the present document in order to judge, which clauses might be essential for the special role of the reader and which ones might be skipped.

Figure 4-1 illustrates the steps, which are necessary to get a SAREF-compliant data set for usage in an interoperable IoT product, application or service and which are mandatory (some are optional) to perform for being compliant with the present document.

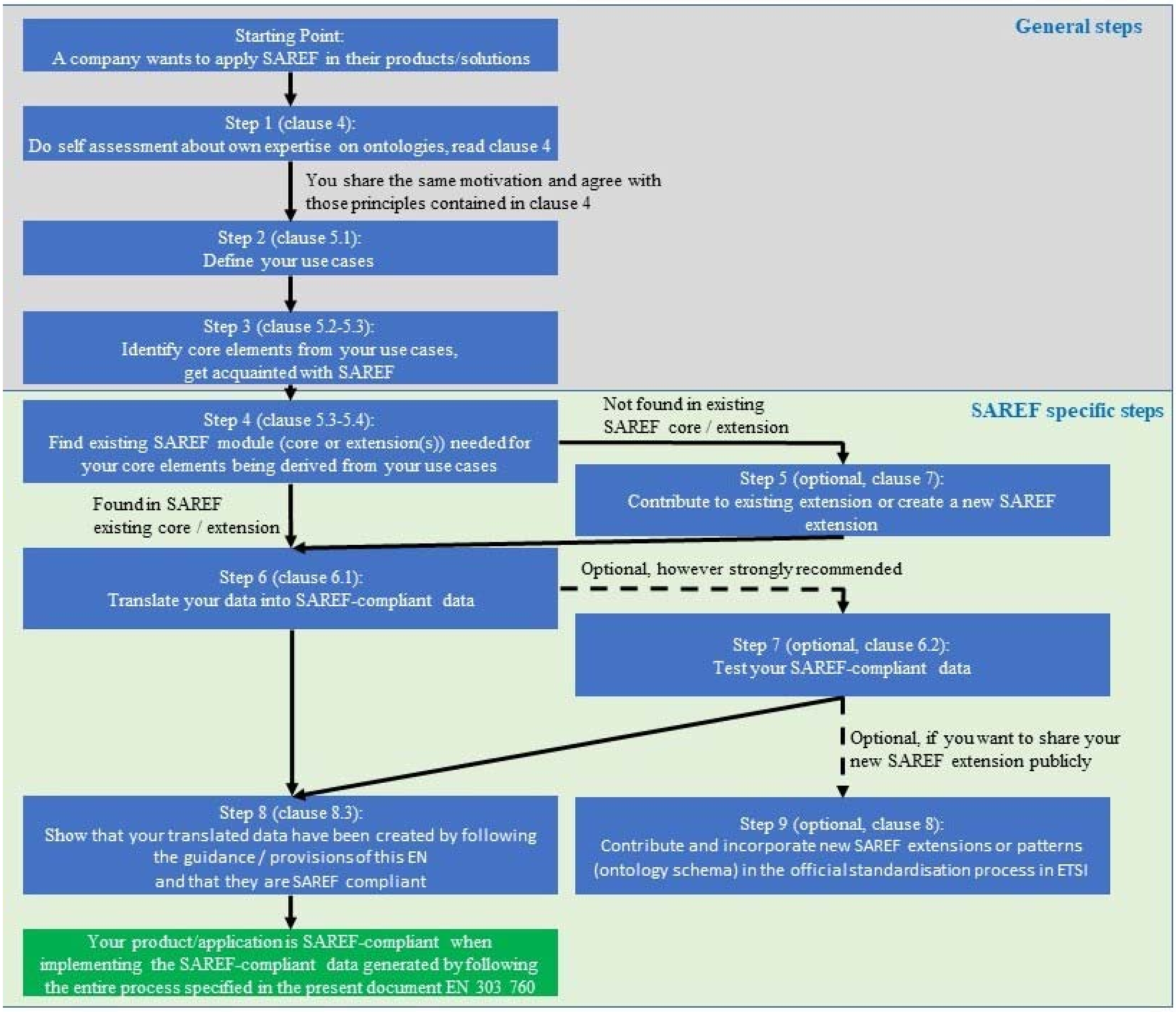

General steps
Starting Point:
A company wants to apply SAREF in their products/solutions
Step 1 (clause 4):
Do self assessment about own expertise on ontologies, read clause 4
You share the same motivation and agree with those principles contained in clause 4
Step 2 (clause 5.1):
Define your use cases
Step 3 (clause 5.2-5.3):
Identify core elements from your use cases, get acquainted with SAREF
SAREF specific steps
Step 4 (clause 5.3-5.4):
Find existing SAREF module (core or extension(s)) needed for your core elements being derived from your use cases
Not found in existing SAREF core / extension
Step 5 (optional, clause 7):
Contribute to existing extension or create a new SAREF extension
Found in SAREF existing core / extension
Step 6 (clause 6.1):
Translate your data into SAREF-compliant data
Optional, however strongly recommended
Step 7 (optional, clause 6.2):
Test your SAREF-compliant data
Optional, if you want to share your new SAREF extension publicly
Step 8 (clause 8.3):
Show that your translated data have been created by following the guidance / provisions of this EN and that they are SAREF compliant
Step 9 (optional, clause 8):
Contribute and incorporate new SAREF extensions or patterns (ontology schema) in the official standardisation process in ETSI
Your product/application is SAREF-compliant when implementing the SAREF-compliant data generated by following the entire process specified in the present document EN 303 760

**Figure 4-1: Steps to SAREF Compliance**

- **Starting point**:
  A company wants to apply SAREF in their products/solutions and show SAREF compliance according to the present document and optionally contribute to a new SAREF extension if what they need is not yet in the SAREF framework.

- **Step 1** (clause 4):
  The present clause 4 shall be read first before the following clauses, since it describes the principles of being compliant with the present document.
  It also recommends to perform an initial self-assessment of the reader's expertise on ontologies, as this could lead to different paths in using the present document as well as different roles of the reader (e.g. decision maker, traditional developer not experienced in semantic technology, ontology expert, etc.) may also take advantage of it.

- **Step 2** (clause 5.1):
  Defining use cases is a sound basis for selecting, implementing and applying an ontology. Therefore clause 5.1 provides a description of best practice to define use cases as a way to clarify requirements and identifying core elements from them.
  Based on this information, the User shall formulate and describe his use case, e.g. short natural language description like as described in IEC 62559 [i.5] or following a certain different standard.

- **Step 3** (clauses 5.2 and 5.3):
  Clauses 5.2 to 5.3 provide guidance and provisions for this step 3, which requests the identification of core elements from the use cases, which have been described by performing step 2.
  Before exploring, which SAREF modules/extensions can be relevant, Users shall get acquainted with the SAREF framework in general, so that in the next step 4 they can keep focus on getting more acquainted with the relevant parts of SAREF only.

- **Step 4** (clauses 5.3 and 5.4):
  After in step 3 the Users have got acquainted with the SAREF framework in general, step 4 requests to identify which existing SAREF modules/extensions can be relevant for the core elements being derived from the use cases. These are the ones to keep focus on getting acquainted with in more in detail. It is important to ensure using the latest version of the SAREF ontology/extensions.
  If there is no existing SAREF modules/extensions being relevant for the core elements, step 5 will be the next one.

- **Step 5** (optional, clause 7):
  If there is no existing SAREF modules/extensions being relevant for the core elements derived from the use cases (from step 4), clause 7 provides guidance/provisions about extending the existing SAREF ontology or creating a new SAREF extension. The pipeline on the SAREF portal [i.1] is supporting this step as well.

- **Step 6** (clause 6.1):
  Having identified existing SAREF modules/extensions being relevant for the core elements or having created a new SAREF extension (step 5), step 6 requests to translate the User's data into SAREF-compliant data. Clause 6.1 provides respective guidance/provisions to use SAREF in practice for this purpose.
  Testing of the produced SAREF-compliant data according to interoperability is strongly recommended. Therefore, the optional step 7 is the next one. Otherwise step 8 continues the process.

- **Step 7** (optional, clause 6.2):
  This optional step includes a test of the generated "SAREF-compliant data" in one example application of interoperability exchange with another organization/manufacturer/brand that speaks a different language/protocol (therefore interacting with it via SAREF).

- **Step 8** (clause 8.3):
  This step requests to show that and to demonstrate how the generated SAREF data have been created by following the guidance/provisions of the present document and that they are SAREF-compliant. Using table F-1 in Annex F supports to prove compliance with the present document.

- **Step 9** (optional, clause 8):
  Once having extended the existing SAREF ontology or created a new SAREF extension for implementing it in a product or application, it makes a lot of sense to share it publicly with other Users by evolving the SAREF standard. For this purpose, the optional step 9 includes the contribution of a new extension to be submitted to ETSI as part of the official SAREF framework. This step supported by guidance/provisions given in clause 8 includes the contribution and incorporation of new SAREF extensions or pattern (ontology schema) in the official standardization process in ETSI.

**Provision 4-1** In order to prove compliance with the present document, the User shall perform at least all steps listed in clause 4, which are not optional.

NOTE 1: The product/application is SAREF-compliant when implementing the SAREF-compliant data generated by following the entire process (steps 1 to 9) specified in the present document.
Table F-1 can provide a mechanism for the User of the present document (who is expected to be an entity involved in the development or manufacturing of IoT systems and/or devices and/or applications) to give information about the implementation of the provisions within the present document.

NOTE 2: As one example, suppose one department or company team has produced a working system that one or more other departments could readily use. Defining a shared ontology facilitates and unifies the sharing of this system, all the more so if direct database or system access is problematic. Data silos are often deeply separated because of substantial technical and language differences. A similar situation is the employment of sub-contractors, particularly in terms of industrial quality.

# 5 Getting started

## 5.1 Define use cases

The definition of use cases allows Users to write down their requirements and at the same time, to have a clear idea of how SAREF can be useful for their purposes. As "use case", a natural language description of the main aspects of the scenarios covering Users' activities is intended.

To describe use cases, the Users are not asked to provide such descriptions through the adoption of specific standards (e.g. IEC 62559 [i.5] or EN 50631-1 [i.6]), but they are invited to adopt the following schema enabling the provision of a simple but complete overview of each use case.

Such overview may guide the creation of the contents samples within Annexes A, B, C and D. Below, it is provided the list of the provisions a User shall consider defining each use case.

**Provision 5.1.1** The User shall provide a general description of the use case, including domain specification and the problems to be solved. Here, it is expected to find the main purposes of the use case including the mention to each element of interest that may be linked to conceptual entities already defined within SAREF Core or existing SAREF extensions. Alternatively, such elements of interest may represent the main concepts of a further SAREF extension proposed by the User. In this case, a detailed description of each element of interest is required to better understand its context and try to define a candidate model.

**Provision 5.1.2** The User shall provide the list of the actors that are part of the use case. Through a precise definition of the actors it is possible to gather specific information that may be included in the possible future conceptual model.

**Provision 5.1.3** The User shall describe the existing context in which the use case is defined. Such a description allows to have a broad landscape of how the knowledge necessary to manage the use case may be linked with existing SAREF concepts (both Core and its extensions), if any. Indeed, through the analysis of the use case the need to define new concepts and/or properties linking existing SAREF concepts with a candidate new extension.

**Provision 5.1.4** The User shall provide a use case workflow by describing how each task is performed and how the entities described evolve through time.

**Provision 5.1.5** The User should provide any further information about the use case that is not included in the previous provisions.

NOTE: IEC 62559 [i.5] may be used as an optional standard for describing use cases.

## 5.2 Identify core elements

This clause provides guidance via a set of provisions to identify the core elements of the use case in questions. These core elements will in the following sections inform the user to which extent SAREF and its extensions can cover their use cases.

**Provision 5.2-1** The User shall identify the core elements of the use cases.

**Provision 5.2-2** The User should categorize the list of core elements according to their type, e.g. objects, attributes, datatypes, code list elements, and more.

EXAMPLE 1: In an example use case covering a flexible start for white goods, the main concepts could be the appliance, its energy usage configuration options, the User preferences, as well as instructions from an energy management system. The appliances would be the main objects. The User preferences and the energy usage would be the attributes. The relevant datatypes could be gathered from the attributes.

**Provision 5.2-3** The User should identify the questions that the semantic model should be able to answer, potentially in collaboration with a use case tool.

EXAMPLE 2: In the flexible start for white goods use case, the main questions that would have to be answered could be:

- What is the allowed possible start time?
- What is my power consumption profile?
- What is the forecasted energy production and consumption throughout the relevant period?
- At which moment should the white goods start its program execution?

NOTE: Some questions can be directly answered by the data employing the semantic model, whereas in other cases semantic model only facilitates the answering. The question of which types of energy flexibility a device exposes can be directly answered, whereas the question of which energy flexibility configuration is optimal would be facilitated by the ontology but would still require an external component.

**Provision 5.2-4** The User shall identify which, if any, existing standards could be relevant to the use case.

EXAMPLE 3: For an energy flexibility use case, energy usage flexibility standards such as SPINE-IoT (EN 50631-1 [i.6]) and EN 50491-12-2 [i.8] can be identified as relevant.

## 5.3 Get acquainted with SAREF

### 5.3.1 Introduction

The SAREF framework of ontologies conveys a rich expressivity. This expressivity, however, can be overwhelming for end-Users who are trying to become acquainted with these ontologies. Nevertheless, it is important to note that not all parts of SAREF are relevant for everyone. Therefore, Users should prioritize the initial focus on learning how to identify the specific modules of interest when becoming familiar with the tools and documentation available. The present clause provides a step-by-step guide to assist the readers in this process.

### 5.3.2 Get Familiar with SAREF Core

**Provision 5.3.2-1** Users should acquire proficiency in SAREF Core by referring to the official technical specification published by ETSI TS 103 264 [2].

To gain a comprehensive understanding of modelling information using SAREF framework of ontologies, Users are advised to follow a systematic approach. The initial step involves consulting the official technical specification of SAREF Core ontology, which is published by ETSI and accessible on the ETSI portal for SAREF (see [i.7]). ETSI TS 103 264 [2] serves as a valuable resource for gaining familiarity with the core ontology.

### 5.3.3 Define the Domain of the Information that Require Structuring

**Provision 5.3.3-1** Users shall delineate the precise domain of information necessitating structuring before choosing the relevant SAREF extension that aligns with their objectives.

The SAREF Framework of ontologies comprises several extensions, each covering a specific domain. The extensions specify the scope of SAREF providing domain-specific vocabulary terms and concepts tailored to the requirements of Users in various sectors. They are built upon SAREF Core and consequently enhance its expressiveness. The extensions of interest should be chosen by Users based on their specific requirements and the domain of the information that they seek to define.

### 5.3.4 Get Familiar with the Selected SAREF Extensions

**Provision 5.3.4-1** Users should acquire proficiency in the selected SAREF extensions by referring to the official technical specification published by ETSI.

The SAREF Framework of ontologies encompasses various extensions according to ETSI Labs: SAREF extensions online [15], each dedicated to a specific domain. These extensions include at the moment:

- SAREF4AGRI: Extension for the agriculture domain. It facilitates the modelling of information regarding agricultural devices, crops, weather conditions, and farming processes according to ETSI TS 103 410-6 [9].
- SAREF4ENER: Extension for the energy-related applications. It provides concepts to describe energy-related devices, measurements, profiles and flexibility management according to ETSI TS 103 410-1 [4].
- SAREF4BLDG: Extension for building automation and management. It provides the expressivity to describe building-related devices according to ETSI TS 103 410-3 [6].
- SAREF4CITY: Extension for smart city applications. It facilitates the modelling of urban infrastructures and services according to ETSI TS 103 410-4 [7].

- SAREF4ENVI: Extension to describe information regarding environmental devices, sensors, and measurements according to ETSI TS 103 410-2 [5].
- SAREF4INMA: Extension for the industry and manufacturing domains. It enables the modelling of industrial processes, machines and sensors according to ETSI TS 103 410-5 [8].
- SAREF4AUTO: Extension for the automotive domain. It facilitates the representation of vehicles, sensors, and actuators according to ETSI TS 103 410-7 [10].
- SAREF4EHAW: Extension for the eHealth/Aging-well domain. It supports the modelling of medical devices, and health-related measurements according to ETSI TS 103 410-8 [11].
- SAREF4WEAR: Extension for the wearables domain. It facilitates the representation of wearable devices and associated measurements according to ETSI TS 103 410-9 [12].
- SAREF4WATR: Extension for the water domain. It enables the modelling of water-related devices and measurements according to ETSI TS 103 410-10 [13].
- SAREF4LIFT: Extension for the smart lift domain. It facilitates the description of lift-related devices and measurements according to ETSI TS 103 410-11 [14].
- SAREF4GRID: Extension for the smart grid domain. It focuses on extending SAREF in order to create a common core of general concepts for smart grid data oriented to the IoT field according to ETSI TS 103 410-12 [16].

Users aspiring to organize data using the SAREF framework of ontologies are encouraged to acquaint themselves with the specific SAREF extension(s) they intend to utilize. This can be achieved by consulting the official technical specifications of the extensions, which are made available by ETSI.

### 5.3.5 Enhance SAREF Core with its Extensions

**Provision 5.3.5-1** To effectively leverage the SAREF framework of ontologies, Users are required to structure data in accordance with the standardized patterns established within both SAREF Core and its extensions.

NOTE: The standardized patterns of the SAREF family of ontologies are defined in the technical specifications of SAREF Core and its extensions published by ETSI.

Users have the flexibility to combine vocabulary terms from SAREF Core with those outlined in their chosen SAREF Extensions (Annex G). However, it is crucial that Users structuring data within the SAREF framework of ontologies adhere diligently to the standardized patterns delineated in SAREF Core and its extensions. These patterns are comprehensively delineated in the technical specifications published by ETSI, and demand strict observance for effective implementation.

## 5.4 Ensure use of correct SAREF version

As SAREF is specified in the ETSI technical documents, it uses *Semantic Versioning*. Each module of the ontology has a distinct version composed of three numbers: a MAJOR, a Minor, and a patch. The increase in MAJOR indicates a break in backward compatibility. The increment in Minor indicates the addition of features. The increment in the patch indicates the correction of a bug.

EXAMPLE 1: The IRI of the latest version of SAREF Core is https://saref.etsi.org/core/. This IRI redirects to the current latest version IRI of SAREF Core.

EXAMPLE 2: The IRI of the latest version of SAREF Core compatible with MAJOR version 3 is https://saref.etsi.org/core/v3. This IRI redirects to the latest version of SAREF Core that is backward compatible with V3.1.1.

EXAMPLE 3: The IRI of the version V1.1.2 of the SAREF4SYST extension is https://saref.etsi.org/saref4syst/v1.1.2/. This ontology version should remain stable.

EXAMPLE 4: The IRI of the latest version of SAREF4SYST compatible with MAJOR version 1 and Minor version 1 is https://saref.etsi.org/saref4syst/v1.1. This IRI redirects to the latest version of SAREF Syst that is compatible with V1.1.1.

**Provision 5.4-1** SAREF Users should use SAREF Core and SAREF extensions in a specific MAJOR version.

EXAMPLE 5: SAREF Core may be used in an extension through the owl:imports statement such as owl:imports <https://saref.etsi.org/core/v3.1.1/>.

**Provision 5.4-2** Extra care shall be taken when migrating to a new MAJOR version of a SAREF project.

EXAMPLE 6: Some terms and axioms from SAREF Core V2 were deleted when migrating to SAREF Core V2.

**Provision 5.4-3** SAREF projects shall import other SAREF projects with a specific version.

EXAMPLE 7: SAREF4LIFT V1.1.1 imports SAREF V3.1.1, SAREF4SYST V1.1.2, and SAREF4BLDG V1.1.2.

# 6 Use and instantiation of SAREF (data)

## 6.1 Map data to SAREF-compliant data

It is useful to map all data that is input into and output from a Device to SAREF in order to maximize data interoperability. The W3C provides two documents for mapping existing customer data to SAREF-compliant-data:

1) A Direct Mapping of Relational Data to RDF [i.12], where the mapping takes as input the data and schema of a relational database and generates a direct RDF graph.

2) R2RML: RDB to RDF Mapping Language [i.13], a language for customizing mappings from relational databases to RDF datasets.

In addition, the 2023 paper "Declarative RDF graph generation from heterogeneous (semi-)structured data: A systematic literature review" [i.14] provides an overview of the existing approaches for generating knowledge graphs from heterogeneous (semi-)structured data.

Most open source and commercial graph database vendors also provide tools for translating and ingesting existing relational data into RDF triple graph databases. However, for large Internet of Things (IoT) sensor data streams stored directly into a purpose-built IoT database, custom transformation monitor programs are often written.

Metadata can additionally be translated to make SAREF-compliant, such that it provides a basis for data set comparison, composition, and inference. Metadata nearly always includes data summary statistics such as standardized units, numeric minimum, maximum, mean, standard deviation, mode, and cardinality, the number of non-null values, and so on.

The SAREF extensions provide concrete examples of useful metadata. The SAREF4ENVI and SAREF4AUTO extensions declare several Classes and ObjectProperties that facilitate the comparison and composition of data sets. These entities include UnitOfMeasure, FrequencyUnit, FrequencyMeasurement, Confidence, hasConfidenceUnitOfMeasure, hasConfidence. Each of these properties enhance the interoperability of data measurements.

Finally, an absolutely necessary translation task is data cleansing or curating. Cleansing is very time-consuming, tedious, and error-prone. Fortunately, free open source tools are available designed specifically for working with messy data; cleaning it, transforming it from one format into another, extending it with web services, and linking it with external data.

Some best practices for translating data into SAREF-compliant data include:

- Formulate a data cleansing plan.
- Justify the modelling approach taken.
- Decide which type of database will store the data.
- Decide what to do with missing and duplicate data.
- Decide beforehand upon a closed-world or open-world modelling assumption.

- Agree on standard measurement units for data; for example, those defined in QUDT.
- Temporally align the data if possible.
- Add characteristic metadata properties to the ontology that support further inference.
- Recognize when to reuse and link other ontologies.
- Add public online ontology documentation and diagrams.
- Ensure the ontology is consistently and coherently loaded by an ontology editor (e.g. Protégé).

These best practices suggest some provisions for translating any types of data into SAREF-compliant data:

**Provision 6.1-1** The User shall ensure that all SAREF-compliant data semantically conform to SAREF guidelines given in the present document.

**Provision 6.1-2** The User may formulate a cleansing plan for SAREF-compliant data.

**Provision 6.1-3** The User shall ensure that all SAREF-compliant data conforms to standard units of measurement that do not conflict with or override existing SAREF definitions.

EXAMPLE 1: The open source QUDT ontology provides data standard measurement units. See https://www.qudt.org/.

EXAMPLE 2: The open source Ontology of Measurement provides standard measurement units. See GitHub - HajoRijgersberg/OM: Ontology of units of Measure.

**Provision 6.1-4** The User should add characteristic metadata properties.

EXAMPLE 3: The User adds hasDistribution, hasEquation, isComparableTo, hasNumericPrecision, or isAlignedTimeseries properties to an ontology class.

**Provision 6.1-5** The User shall only reuse, import, incorporate, or link non-SAREF ontologies that do not conflict with or override existing SAREF definitions.

An example of SAREF-compliant device data for the SAREF building extension is given in Annex C.

## 6.2 Test SAREF-compliant data

Once the SAREF-compliant data become available, the first step in testing that data is to load it into a graph database or an ontology editor. Tools are available on the market to test an ontology's inference and functional requirements.

Provisions for testing SAREF-compliant data include:

**Provision 6.2-1** The User shall test and ensure that the SAREF-compliant data is logically consistent and coherent when verified by an ontology reasoner.

**Provision 6.2-2** The User should test and ensure that the SAREF-compliant data declares up-to-date web addresses without any dead links.

**Provision 6.2-3** The User shall test and ensure that the SAREF-compliant data uses the correct version of references SAREF entities.

**Provision 6.2-4** The User may use functional and inference requirements to systematically test the ontology.

**Provision 6.2-5** The User may use SPARQL queries, CONSTRUCT statements, or SHACL constraints to test the SAREF-compliant data for validity.

NOTE 1: See W3C® Rec: "SPARQL 1.1 Query Language" [i.16] https://www.w3.org/TR/sparql11-query/ about SPARQL queries and CONSTRUCT statements.

NOTE 2: See https://www.w3.org/TR/shacl/ for a description of the Shapes Constraint Language (SHACL).

EXAMPLE 1: Annex D provides a SPARQL GROUP BY query to find products with multiple barcodes.

EXAMPLE 2: Annex D provides a sample SPARQL CONSTRUCT statement.

EXAMPLE 3: Annex D provides a working SHACL constraint that tests whether a Friend-of-a-Friend (FoaF) Person has a valid 3-piece SHA public key. SHACL constraints can also be used to test for the existence of specific graph patterns.

Clearly, a plan should be implemented to systematically test at least some enriched SAREF data. The tests mentioned in Provision 6.2-5 are often included in the data cleansing process to test the data for missing elements or gaps and "duplicate" data elements (even though RDF is defined as a logical set of triples implying there are no duplicates by definition).

**Provision 6.2-6** The User may publicly document their SAREF-compliant data online according to SAREF standards.

**Provision 6.2-7** Placeholder for provision about suggested W3C schema/pattern group. The User should advertise the application profile of the SAREF-compliant data as described in ETSI TS 103 264 [2].

**Provision 6.2-8** The User may implement content negotiation by profile to expose SAREF-compliant data along with other SAREF-compliant data UML-Based Ontology Conceptualizations to OWL [i.11].

# 7 Extension of SAREF

## 7.1 Create a new SAREF extension

**Provision 7.1-1** Before proposing a new extension, the User, shall check that none of the existing SAREF extensions available in [15] cover the domain to be modelled in the new extension.

**Provision 7.1-2** In case the domain for the new potential extension is already modelled in an existing SAREF extension but the ontology does not cover the new requirements, an update of the existing extension shall be proposed instead following clause "7.2 Proposing a new change request" in ETSI TS 103 673 [1].

**Provision 7.1-3** To propose a new SAREF extension, the User proposing the extension should follow the workflow in clause 8.2.

NOTE 1: All roles defined in the same clause can propose extensions.

**Provision 7.1-4** When a new SAREF extension is proposed, or new requirements for existing extensions arise, the User should follow well-known ontology engineering practices, adopt web practices and reuse exiting tools.

For the case of the SAREF family of ontologies the Linked Open Terms (LOT) methodology has been followed since 2014 as reported in ETSI TR 103 411 [i.4]. LOT is an overall and lightweight methodology to build ontologies based on existing methodologies and best practices. This methodology is based on a core workflow of four phases that are divided in specific activities. These phases are:

1) **ontology requirements specification:** the goal of this phase is to state why the ontology is being built and to identify and define the requirements the ontology should fulfil;

2) **ontology implementation:** the goal of this phase is to obtain the OWL code modelling the identified requirements;

3) **ontology publication:** The goal of this phase is to provide an online ontology accessible both as a human-readable documentation and a machine-readable file from its URI; and

4) **ontology maintenance:** The goal of this phase is to update and add new requirements to the ontology that are not identified in the ORSD, to identify and corrects errors or to schedule a new iteration for ontology development.

NOTE 2: Main references describing the methodology and related resource in detailed are available at LOT methodology [i.2] and LOT methodology website [i.3].

## 7.2 Ensure compliance of an extension to SAREF

The specific provisions that describe how an extension should comply with SAREF are given in clauses 8.3.1 (1 provision), 8.3.2 (18 provisions), and 8.3.3 (1 provision) of the present document. Those Users who have developed their own extension and simply want to manually verify its compliance to SAREF under their own namespace should follow the guidelines in clause 9 of ETSI TS 103 673 [1], particularly the ontology specification in clause 9.4.

**Provision 7.2-1** The Users who want to manually verify an extension's compliance to SAREF under their own namespace shall follow the development guidelines of clause 9 in ETSI TS 103 673 [1].

# 8 Contribution to ETSI SAREF suite of ontologies

## 8.1 Introduction

Although the SAREF framework of ontologies provides a wide range of expressive capabilities, there may be scenarios where the existing SAREF extensions do not fully meet the specific requirements of Users. In such cases, Users have the opportunity to actively contribute to the development process of SAREF extensions and bring new use cases into the SAREF framework of ontologies. The following clause outlines the process that Users can follow to actively participate in the development activity of SAREF framework of ontologies.

## 8.2 Actors and workflow for starting the development of a new SAREF extension

**Provision 8.2-1** The actors involved in the SAREF extensions should belong to the following categories: Steering actors, Development actors, and Community actors The roles defined for each category are described in the list below summarizing the description provided in ETSI TS 103 673 [1].

NOTE 1: The SAREF ETSI Labs allows defining Users with the following roles: Guest, Reporter, Developer, Maintainer, and Owner; each with its own permissions.

NOTE 2: One person may play the role of many actors at a time, and potentially different roles for different SAREF projects.

- **Steering** actors:
    - **Steering Board member:** A Steering Board member belongs to the group of persons in charge of steering the SAREF development, including SAREF core and SAREF extensions:
        - Steering Board members may have at least the role of Reporter in the SAREF ETSI Labs.
        - The Steering Board is composed by the SmartM2M Chairman, Vice-Chairman, and Technical Officer, and experts nominated by SmartM2M.
    - **Technical Board member:** A Technical Board member belongs to the group of persons in charge of maintaining the SAREF public ETSI Labs and the SAREF public portal:
        - Technical Board members may have at least the role of Maintainer in the SAREF ETSI Labs.
        - The Technical Board is composed by the ETSI Secretariat and experts nominated by SmartM2M.
- **Development** actors:
    - **Project leader:** A project leader is the person in charge of the SAREF project who carries out the project management tasks:
        - A project leader shall have experience in ontology development projects.
        - Project leaders may have at least the role of Maintainer in the ETSI Labs.

  - There should exist at least one project leader for SAREF core and at least one for each SAREF extension.

- **Ontology developer:** An ontology developer is a member of the ontology development team who has high knowledge about ontology development and rights to modify the ontology and interact in the development cycle. Ontology developers create and modify the different development artefacts, provide new requirements to the ontology and validate whether they are satisfied or not when implemented, and have decision rights about what contributions can be included in the ontology.

  - Ontology developers may have at least the role of Developer in the ETSI Labs.

- **Community** actors:

  - **Contributor:** A contributor is a person knowledgeable about the ontology domain and proposes contributions:

    - Contributors have an account on the SAREF ETSI Labs.

    - The role of contributor is not assigned beforehand, it is obtained when submitting some contribution.

  - **Ontology user:** An ontology user is someone interested in any of the SAREF projects or in proposing a new SAREF project:

    - Ontology users do not necessarily have an account on the SAREF ETSI Labs.

    - Ontology users include potential end users of the ontology, software developers that will make use of the ontology within their applications, industry users, researchers, domain experts, etc.

**Provision 8.2-2** New SAREF project versions proposals should represent:

a) new versions of SAREF core;

b) new versions of existing SAREF extensions; or

c) initial versions (V1.1.1) of new SAREF extensions.

NOTE 3: The workflow depicted in Figure 8.2-1 supports the creation of new SAREF project proposals. The workflow and detailed information about the processes involved are defined in ETSI TS 103 673 [1].

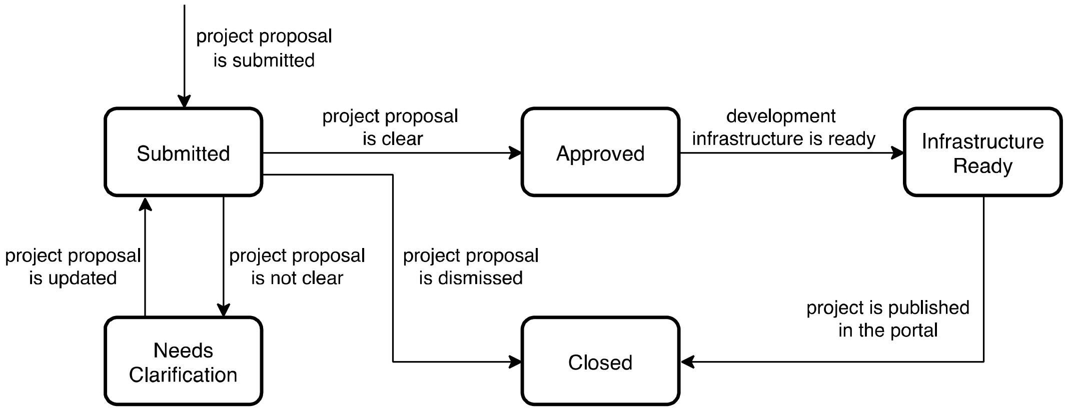

project proposal is submitted
Submitted
project proposal is clear
Approved
development infrastructure is ready
Infrastructure Ready
project proposal is updated
project proposal is not clear
project proposal is dismissed
project is published in the portal
Needs Clarification
Closed

**Figure 8.2-1: Different states of a new SAREF project version proposal and the transitions among them (Source: ETSI TS 103 673 [1])**

**Provision 8.2-3** New SAREF project versions proposals may go through different states, which can be one of the following:

- **Submitted:** This state is used for new SAREF project version proposals that have been submitted but the decision has not been taken yet on whether to approve them or to dismiss them:
    - Any contributors may propose new SAREF project versions. Steering Board members should review new SAREF project version proposals:
        - If the proposal is clear, the Steering Board should change the status to "**Approved**".
        - It the proposal is not clear, the proposal status is changed to "**Needs Clarification**" and Steering Board members interact with contributors to clarify the proposal until it is either clear and declared "**Approved**" or it is dismissed, then declared "**Closed**".
- **Needs Clarification:** This state is used for new SAREF project version proposals that do not clearly describe the project itself:
    - Steering Board members interact with contributors to clarify the proposal.
- **Approved:** This state is used for new SAREF project version proposals that have been approved for creation:
    - The Steering Board is responsible for the selection of the project leader and the team of ontology developers.
    - The Technical Board and the project leader are responsible for setting up the project version development infrastructure and publishing the project to the portal (see ETSI TS 103 673 [1], clause 6.4). The proposal status should then be changed to "Infrastructure Ready".
- **Infrastructure Ready:** This state is used for new SAREF project version proposals whose sources on the SAREF ETSI Labs have been set up:
    - Once the infrastructure is ready, the project leader and steering board add the new SAREF project version to the portal. The new proposal is then set to "**Closed**".
- **Closed:** This state is used for new SAREF project version proposals that have been dismissed, or that have been approved, set up, and added to the portal.

# 8.3 SAREF development framework and SAREF pipeline

## 8.3.1 Introduction

ETSI TS 103 673 [1] defines how SAREF project versions are specified and documented in the SAREF ETSI Labs. The accompanying SAREF pipeline software enables to automatically check the conformance of SAREF project versions with respect to the present document. The accompanying SAREF public portal enables to browse the documentation of SAREF project versions and engage the community of users.

The SAREF pipeline, and the SAREF public portal, enable the SAREF developers to speed up the development of SAREF and its extensions as well as the SAREF community of users to actively contribute to the development. They provide an efficient and robust support infrastructure for the Continuous Integration and Delivery of SAREF.

**Provision 8.3.1-1** SAREF Projects may correspond to SAREF Core or a SAREF Extension. Each SAREF Extension is assigned an identifier that is based on a four letter code.

EXAMPLE: The four letter code for the SAREF Extension for Smart Lifts is LIFT, and the extension name is SAREF4LIFT.

SAREF Projects are hosted in a git repository on the public ETSI Labs [i.9]. Release branches are used instead of tags to identify releases, thus allowing continuous evolution of the documentation or examples after the ontology version is published. SAREF project repositories therefore have four different types of branches: `issue-x` branches to work on an issue, `develop-vx.y.z` branches to work on a version, `prerelease-vx.y.z` branches to work on the final validation of the ontology, and `release-vx.y.z` branches for published versions. Protection rules are defined to prevent ontology developers from directly pushing their changes to `development-vx.y.z` branches or from directly accepting merge requests in `prerelease-vx.y.z` branches.

In addition, the SAREF-portal repository [i.10] contains the static resources of the SAREF public documentation portal, and a file `.saref-repositories.yml` that references each of the SAREF projects whose documentation needs to be generated on the portal.

### 8.3.2 SAREF Project Version Specification and Documentation

Clause 9 in the ETSI TS 103 673 [1] outlines the rules to which each SAREF project repository shall comply. All these rules, summarized below, are automatically checked by the SAREF Pipeline.

**Provision 8.3.2-1** SAREF project versions shall conform to Clause 9 of ETSI TS 103 673 [1]. Provisions 8.3.2-2 to 8.3.2-18 below summarize this clause.

**Provision 8.3.2-2** (Summary of ETSI TS 103 673 [1], Clause 9.2) The SAREF project version directory shall contain a `README.md`, a `LICENSE` file, and folders requirements, ontology, tests, examples, documentation.

**Provision 8.3.2-3** (Summary of ETSI TS 103 673 [1], clauses 9.3.1 and 9.3.2). The requirements directory should contain a file `requirements.csv`. If present, this file shall be a UTF-8 encoded CSV file with specific delimiter, quote character, and specific header row.

**Provision 8.3.2-4** (Summary of ETSI TS 103 673 [1], clause 9.4.1). The ontology directory shall contain the ontology document of the project version `saref.ttl` for SAREF Core, `saref4abcd.ttl` for SAREF extension SAREF4ABCD. This file shall contain the sources of a consistent OWL2 DL ontology in the Turtle 1.1 format.

**Provision 8.3.2-5** (Summary of ETSI TS 103 673 [1], clause 9.4.2). If the ontology document contains a base or prefix declarations, they shall conform to the ones given in ETSI TS 103 673 [1], clause 9.4.2.

**Provision 8.3.2-6** (Summary of ETSI TS 103 673 [1], clause 9.4.3.1). Specific ontology series IRI and ontology version IRI shall be used, version-related metadata such as `owl:versionInfo`, `vann:preferredNamespacePrefix`, `vann:preferredNamespaceUri`, and `owl:priorVersion` shall be defined if applicable.

**Provision 8.3.2-7** (Summary of ETSI TS 103 673 [1], clause 9.4.3.2). This clause specifies, which specific ontology metadata shall, should, or may be defined. In general the use of Dublin Core terms is enforced. Supporting ontologies are imported by their version IRI and not by the ontology series identifier.

NOTE: Ontology imports are often a source of versioning problems. This provision effectively avoids imported ontology versioning issues.

EXAMPLE: For example, SAREF4LIFT V1.1.1 imports SAREF Core V3.1.1, SAREF4SYST V1.1.2, and SAREF4BLDG V1.1.2.

**Provision 8.3.2-8** (Summary of ETSI TS 103 673 [1], clause 9.4.3.3). This clause defines who can be considered a creator or a contributor to the SAREF project version, and how they may be described in the ontology. In general persons are described using IRIs or blank nodes, which then shall be instances of `schema:Person` and further described using a `schema:givenName` and `schema:familyName`. Affiliations shall be described as instances of `schema:Organization`.

**Provision 8.3.2-9** (Summary of ETSI TS 103 673 [1], clause 9.4.4.1). Specific namespace shall be used for terms defined in the ontology document, and specific naming convention shall be used for classes and properties.

**Provision 8.3.2-10** (Summary of ETSI TS 103 673 [1], clause 9.4.4.2). metadata `rdfs:label` and `rdfs:comment` shall be defined for terms, and should at least have one `rdf:langString` datatype with the `en` language tag.

**Provision 8.3.2-11** (Summary of ETSI TS 103 673 [1], clause 9.4.5). The ontology shall satisfy the OWL2 DL profile, with the exception that unknown datatypes may be used. It shall be consistent, it should not present ontology development pitfalls as per the OntOlogy Pitfall Scanner! (OOPS!) (see https://oops.linkeddata.es), and every declared class should be satisfiable.

**Provision 8.3.2-12** (Summary of ETSI TS 103 673 [1], clauses 9.5.1 and 9.5.2). The tests directory should contain a file `tests.csv`. If present, this file shall be a UTF-8 encoded CSV file with specific delimiter, quote character, and given header row.

**Provision 8.3.2-13** (Summary of ETSI TS 103 673 [1], clause 9.6.1) The `examples` directory should contain example documents that illustrate how the ontology can be used in practice. Every example document shall be a consistent OWL2 DL ontology in the Turtle 1.1 format. Main classes and properties should be illustrated with at least one example.

**Provision 8.3.2-14** (Summary of ETSI TS 103 673 [1], clause 9.6.2). Specific prefixes and base declarations should be used in examples.

**Provision 8.3.2-15** (Summary of ETSI TS 103 673 [1], clause 9.6.3). The example document shall be declared as a `dctype:Dataset`. It shall be asserted to conform to (`dct:conformsTo`) the SAREF project version IRI. It additionally may conform to other SAREF project specific versions, or some ontology published by international Standard Development Organizations. Additional metadata elements shall be used.

**Provision 8.3.2-16** (Summary of ETSI TS 103 673 [1], clause 9.6.4). The RDF graph in the example document, when augmented with an ontology declaration that imports all the ontologies the example conforms to, shall satisfy the OWL2 DL profile, with the exception that unknown datatypes may be used, and shall be consistent.

**Provision 8.3.2-17** (Summary of ETSI TS 103 673 [1], clause 9.7.1). The documentation directory should contain documentation sources to provide human-readable documentation for the ontology and how it can be used in practice. These documentation sources are for creators, contributors, abstract, description, examples, references, acknowledgements. They shall be a HTML snippet and have the extension `.html` or be a markdown snippet and have extension `.md`.

**Provision 8.3.2-18** (Summary of ETSI TS 103 673 [1], clause 9.7.2). Diagrams should be included in a directory documentation/diagrams, and adopt graphical notations from UML-Based Ontology Conceptualizations to OWL [i.11].

### 8.3.3 Quality Control and Requirements Verification with the SAREF Pipeline

The SAREF Pipeline software verifies the conformance to the specification summarized in clause 8.3.2, and generates the HTML documentation of SAREF. It can be run on a SAREF project repository, or on the SAREF portal repository [i.10] for verifying all the SAREF projects and generating the complete documentation of SAREF to be deployed on the public SAREF community portal. The present clause describes how this software is used.

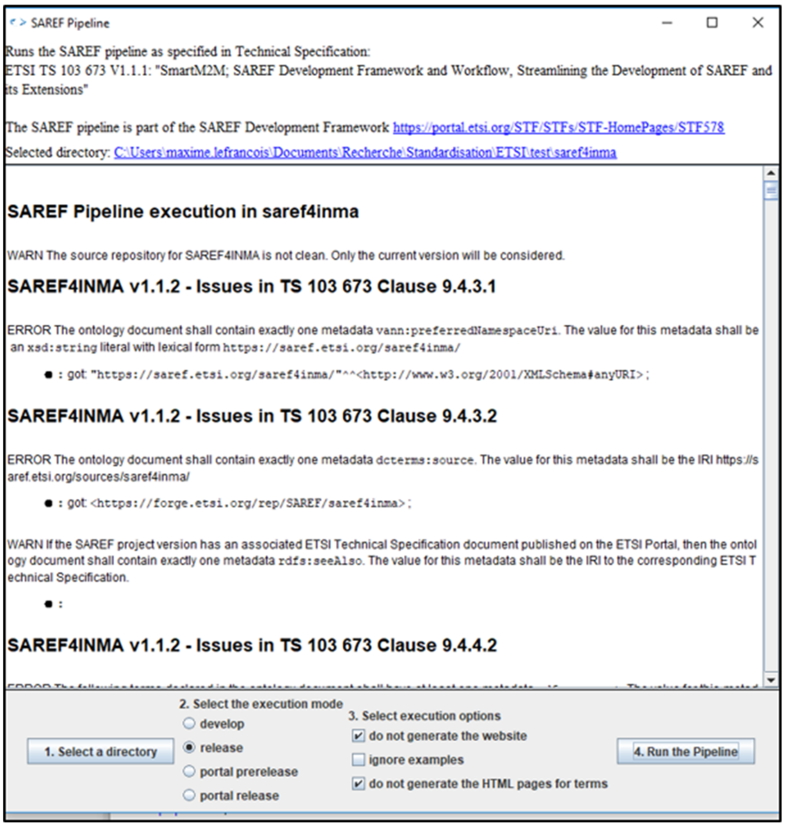
**Provision 8.3.3-1** SAREF project version developers should check the conformance of their work using the SAREF pipeline software [i.1].

NOTE 1: The SAREF Pipeline is openly available under an open BSD-3-Clause license at https://saref.etsi.org/sources/saref-pipeline/ [i.1]. It has already been used to accelerate the development of version 3 of SAREF and the 12 published SAREF extensions, and to generate the contents of the public SAREF community portal.

The SAREF Pipeline operates in either a graphical mode (see figure 8.3.3-1) or a command line interface (see figure 8.3.3-2) depending upon the ontology developer's preference. Choosing an execution mode determines the thoroughness and coverage of the pipeline tests and usually depends on the development stage:

- **develop** some metadata such as version numbers are not checked;
- **release** thorough check of the repository which shall be clean (contain no tracked and modified files);
- **portal pre-release** run on the SAREF portal repository to operate a strict check and generate the documentation for all pre-release and release branches of the source repositories;
- **portal-release** same as above, but only considers release branches.

The ontology engineer may also choose to skip some tasks such as the analysis of examples, the generation of the HTML documentation for terms, or the generation of the HTML documentation altogether.



Runs the SAREF pipeline as specified in Technical Specification:
ETSI TS 103 673 V1.1.1: "SmartM2M; SAREF Development Framework and Workflow, Streamlining the Development of SAREF and its Extensions"

The SAREF pipeline is part of the SAREF Development Framework https://portal.etsi.org/STF/STFs/STF-HomePages/STF578
Selected directory: C:\Users\maxime.lefrancois\Documents\Recherche\Standardisation\ETSI\test\saref4inma

**SAREF Pipeline execution in saref4inma**

WARN The source repository for SAREF4INMA is not clean. Only the current version will be considered.

**SAREF4INMA v1.1.2 - Issues in TS 103 673 Clause 9.4.3.1**

ERROR The ontology document shall contain exactly one metadata `vann:preferredNamespaceUri`. The value for this metadata shall be an `xsd:string` literal with lexical form `https://saref.etsi.org/saref4inma/`

- : got `"https://saref.etsi.org/saref4inma/"^^<http://www.w3.org/2001/XMLSchema#anyURI>` ;

**SAREF4INMA v1.1.2 - Issues in TS 103 673 Clause 9.4.3.2**

ERROR The ontology document shall contain exactly one metadata `dcterms:source`. The value for this metadata shall be the IRI https://saref.etsi.org/sources/saref4inma/

- : got `<https://forge.etsi.org/rep/SAREF/saref4inma>` ;

WARN If the SAREF project version has an associated ETSI Technical Specification document published on the ETSI Portal, then the ontology document shall contain exactly one metadata `rdfs:seeAlso`. The value for this metadata shall be the IRI to the corresponding ETSI Technical Specification.

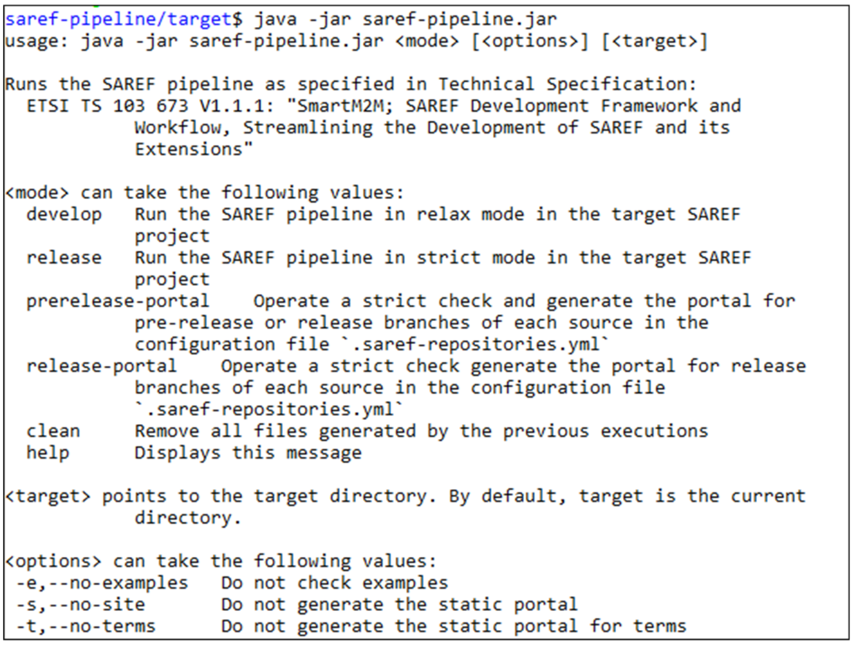
- :

**SAREF4INMA v1.1.2 - Issues in TS 103 673 Clause 9.4.4.2**

2. Select the execution mode
○ develop
● release
○ portal prerelease
○ portal release

3. Select execution options
☑ do not generate the website
□ ignore examples
☑ do not generate the HTML pages for terms

Figure 8.3.3-1: Graphical User Interface (GUI) of the SAREF Pipeline [i.1]



```
saref-pipeline/target$ java -jar saref-pipeline.jar
usage: java -jar saref-pipeline.jar <mode> [<options>] [<target>]

Runs the SAREF pipeline as specified in Technical Specification:
  ETSI TS 103 673 V1.1.1: "SmartM2M; SAREF Development Framework and
            Workflow, Streamlining the Development of SAREF and its
            Extensions"

<mode> can take the following values:
  develop   Run the SAREF pipeline in relax mode in the target SAREF
            project
  release   Run the SAREF pipeline in strict mode in the target SAREF
            project
  prerelease-portal    Operate a strict check and generate the portal for
            pre-release or release branches of each source in the
            configuration file `.saref-repositories.yml`
  release-portal    Operate a strict check generate the portal for release
            branches of each source in the configuration file
            `.saref-repositories.yml`
  clean     Remove all files generated by the previous executions
  help      Displays this message

<target> points to the target directory. By default, target is the current
            directory.

<options> can take the following values:
 -e,--no-examples    Do not check examples
 -s,--no-site        Do not generate the static portal
 -t,--no-terms       Do not generate the static portal for terms
```

Figure 8.3.3-2: Command Line Interface (CLI) of the SAREF Pipeline [i.1]

The SAREF Pipeline provides a detailed but easy-to-read global view of all the identified warnings and errors. Violation of shall clauses trigger errors, while violation of should clauses trigger warnings. The logs are formatted in HTML in the GUI and markdown in the CLI, which is convenient to create nicely formatted issues rapidly to collaboratively deal with problems. In addition, a log file in the JUnit report format [i.15] is generated, which can be used by GitLab to provide an overview of the issues in Merge Requests.

The SAREF Pipeline is configured to run using the Continuous Integration and Continuous Deployment (CI/CD) features of the ETSI Labs. Each SAREF project repository is configured such that the SAREF Pipeline is run in different modes and with different options depending on the type of branch where a commit is pushed:

- **Issue and develop branches.** run `java -jar saref-pipeline.jar develop -s` (relaxed mode without generating the static portal), then publish an HTML report file to the snapshot area of the SAREF portal (deleted after one day) at https://saref.etsi.org/snapshot/$CI_PIPELINE_ID/report.html, even if the pipeline identified errors.

- **Pre-release branches.** run `java -jar saref-pipeline.jar release -t` (do not generate the static portal for terms) then publish the generated report and partial static portal to the snapshot area of the SAREF portal at https://saref.etsi.org/snapshot/$CI_PIPELINE_ID/report.html, even if the pipeline identified errors.

- **Release branches.** run `java -jar saref-pipeline.jar release -t` and, if successful, trigger the CI/CD pipeline on the master branch of `saref-portal.`

The CI/CD process on the master branch of the saref-portal project is a three stage process:

1) Run `java -jar saref-pipeline.jar release-portal`.

2) Publish the generated report and static portal to the staging area of the SAREF portal (deleted after one week) at https://saref.etsi.org/staging/$CI_PIPELINE_ID/.

3) If the portal in the staging area seems fine, this step can be manually triggered to publish the generated static portal to https://saref.etsi.org/ [i.7].

# Annex A (informative): Example of a use case

Use Case Example: Predictive Maintenance on Smart Lifts

Description:

This use case focuses on how maintenance companies and technicians can use the available information within a SAREF extension modelling the Smart Lifts domain to set a predictive maintenance program for the lift, and how they can use the remote connection with the lift to fix the faults or the problems.

Predictive maintenance is the "new" trend in lift industry even if it has been applied in several industrial sector for ages. The scope of predictive maintenance is to anticipate the event of a fault, evaluating the fault rate of the single components based on the number of runs of the lift. So, the maintenance companies can substitute the components before the fault arise and they can reduce the out of service for the lift.

With the remote connection between the lift and the technicians of the control cabinet supplier, the maintenance technicians can fix the fault very quickly (by an e-mail report or by a message sent automatically by the lift).

Furthermore, there are some faults very hard to discover and that require a long time to be fixed, so the capability for the maintenance technician to have the direct and real-time support by the control cabinet's technician could drastically reduce the out of service necessary to fix the fault.

A typical problem is that a fault appears but - when the maintenance technician is on site - the lift runs properly; this is a typical case of misuse by the users that some time smash the manual landing doors and the consequence is that the locking devices work sometimes well and sometimes badly.

In this case for the maintenance technician it is very hard to discover the fault; the best solution is that the technician of the control cabinet supplier connects the lift from the remote position and analyses the faults; by the history of the faults recorded and the capability of analysing the single input and output of the main board, the technician can very quickly identify which landing door causes the fault and understand why the fault appears.

With predictive maintenance the system sends a message to the maintenance company that the lifetime of a component (for example: wheel of the doors, push button, etc.) has expired; the maintenance company can send a technician to substitute the component with a new one, so the time of substitution could be very short and the possible out of service of the lift avoided.

Actors:

- Maintenance companies, which can automatically monitor the status of all smart lift installations and to check if there are potential undesired situations on some of them.
- Maintenance technicians, which can receive a notice about a potential undesired event and can perform a preventive intervention over the smart lift installation.
- Supplier technicians (especially of control cabinet), which can be involved in the maintenance operations based on the outcome of the data processing operation.
- System.
- Data user/consumer: Maintenance companies.

Context:

- The IoT devices and IoT service platforms are deployed and in operational condition.
- The data collection services are up and running.
- The Smart Lift is operational.

- The smart lift component has been fixed or replaced and the data processing service does not alert about any possible undesired event.

Normal Flow:

- The smart lift IoT ecosystem provides data to the remote central control unit installed within the Maintenance Company premises.
- The remote central control unit AI component detects a data pattern that, with a probability higher than a specified threshold, can lead to a possible fault or to an undesired event.
- The Maintenance Technicians are alerted about the undesired event together with the related explanation.
- The Maintenance Technicians check if the smart lift installation can be fixed by their own or if it is necessary to involve any Supplier Technicians team.
- The smart lift component is fixed or replaced.
- The smart lift installation restarts to work and the alert within the remote central control unit disappeared.

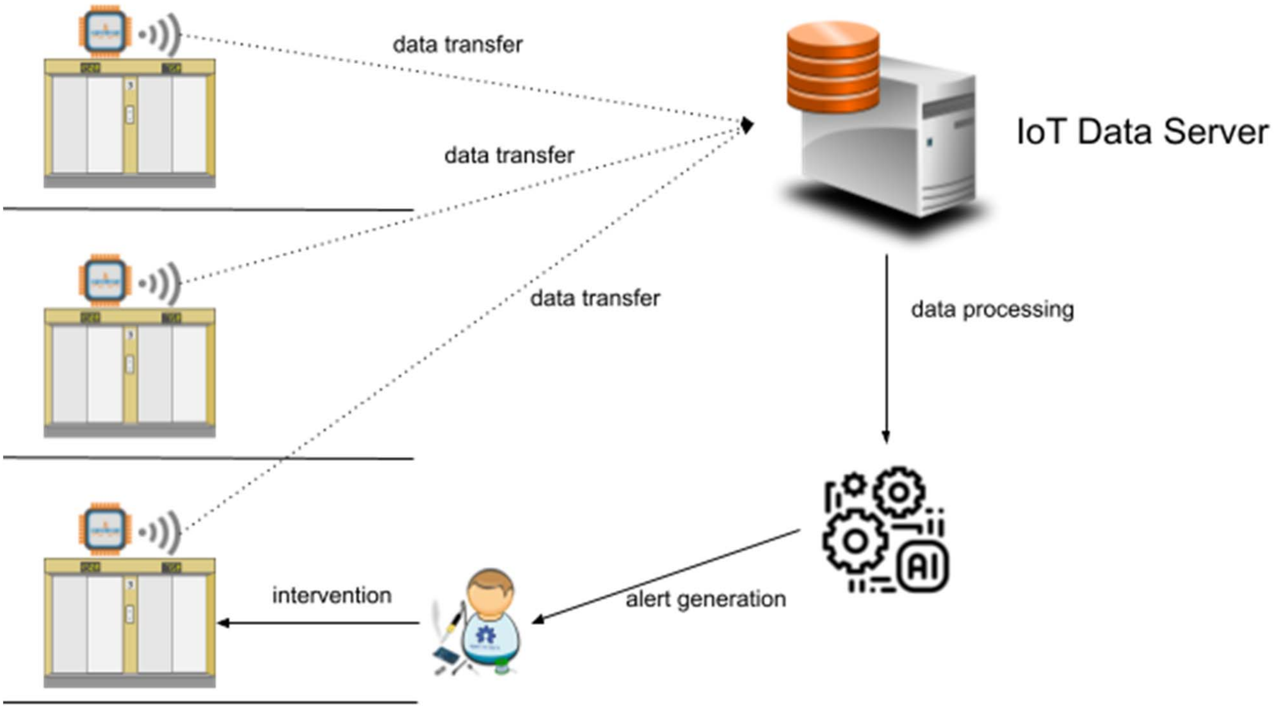


**Figure A-1: Overall concept of the Use Case related to the Predictive Maintenance of Smart Lifts**

Further analysis and considerations:

A typical problem is that a fault appears but, when the maintenance technician is on site, the lift runs properly. This is a typical case of misuse by the users who sometimes smash the manual landing doors and as a consequence the locking devices sometimes work well and sometimes are faulty.

In this case for the maintenance technician, it is very hard to discover the fault. The best solution is that the technician of the control cabinet supplier connects the lift from the remote position and analyses the faults; by the history of the faults recorded and the capability of analysing the single input and output of the main board, the technician can very quickly identify which landing door causes the fault and understand why the fault appears.

With predictive maintenance, the system sends a message to the maintenance company that the lifetime of a component (for example: wheel of the doors, pushbutton, etc.) has expired; the maintenance company can send a technician to substitute the component with a new one, so the time of substitution can be very short and the possible out of service of the lift avoided.

The whole predictive maintenance activity relies on the quality of the data provided by the IoT ecosystem to the main server. Any fault during the collection of such data (e.g. wrong read, network issue) can compromise the output of the AI-based predictive system by making it not usable for addressing the predictive maintenance task.

# Annex B (informative):<br>Example of relevant core elements from a use case

The requirements presented in this annex have been derived from the previously presented use. The associated requirements have been grouped in different categories and are presented from Table B-1 to Table B-11.

**Table B-1: Requirements for the "Car Signal" category**

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-1 | Which is the car position? | (Floor Number i.e. -2, -1, 0, 1) |
| LIFT-2 | What is the lift direction? | Upwards, Downwards, Standstill |
| LIFT-3 | Is the car in an unlocking zone? | Yes/No |
| LIFT-4 | Is there a test ride in execution? | Yes/No |
| LIFT-5 | Is there any fault? | Yes/No |
| LIFT-6 | Is the lift overloaded? | Yes/No |
| LIFT-7 | Are there ongoing inspection operations? | Yes/No |
| LIFT-8 | Are there fire operations? | Yes/No |
| LIFT-9 | Is the alarm in the car activated? | Yes/No |
| LIFT-10 | Is the car empty? | Yes/No |
| LIFT-11 | What is the limit load of the lift? | 90 kg |
| LIFT-12 | What is the power supply voltage of the lift? | 380 volts |
| LIFT-13 | What is the value of the standard power supply of the lift? | 12 volts |
| LIFT-14 | How many car stops has the lift? | 8 |
| LIFT-15 | How many doors are installed in the lift? | 2 |
| LIFT-16 | How many car services are available in the lift? | 8 |

**Table B-2: Requirements for the "Bidirectional Communication System Signal" category**

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-17 | Signal related to the periodic test run every 24h has been received. | |
| LIFT-18 | The bidirectional communication system signal has been received. | |
| LIFT-19 | Which is the received signal strength/quality? | % of coverage, i.e. 87 |
| LIFT-20 | Which is the home network operator of the lift? | 289-88 |
| LIFT-21 | The types of signals that can be sent by the Bidirectional Communication System are:<br>• timeOfLastPeriodicTest72hAttempt;<br>• timeOfConfirmationOfLastPeriodicTest72hAttempt;<br>• registeredNetworkOperator, networkQualityRSSI; and<br>• networkQualityBER. | |
| LIFT-22 | Examples of network technologies supported by the Bidirectional Communication System of the lift are: Fixed_line, 2G, 3G, 4G or 5G. | |
| LIFT-23 | Which is the telephone number of the lift? | +3975528568888 |
| LIFT-24 | Which are the primary emergency numbers of the lift? | +3975528568889 |
| LIFT-25 | Which are the secondary emergency numbers of the lift? | +3975528568890,<br>+3975528568891 |

**Table B-3: Requirements for the "Power Supply Signal" category**

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-26 | Is the emergency power supply signal active? | Yes/No |
| LIFT-27 | Is the standard power supply signal active? | Yes/No |
| LIFT-28 | Which is the voltage of emergency power? | Voltage value, i.e. 330 volts |

### Table B-4: Requirements for the "System Status Signal" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-29 | Is the lift out of service? | Yes/No |
| LIFT-30 | Is the lift overloaded? | Yes/No |
| LIFT-31 | Are there ongoing inspection operations? | Yes/No |
| LIFT-32 | Are there fire operations? | Yes/No |

### Table B-5: Requirements for the "Fault Signal" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-33 | The lift has a major fault. | |
| LIFT-34 | The lift has a minor fault. | |
| LIFT-35 | The lift has an audio fault. | |

### Table B-6: Requirements for the "Statistic Signal" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-36 | How many times the lift has been called during its lifetime? | 245 |
| LIFT-37 | How many upward travels the lift did during its lifetime? | 167 |
| LIFT-38 | How many downward travels the lift did during its lifetime? | 153 |
| LIFT-39 | Which is the total number of floors covered during its lifetime? | 94 |
| LIFT-40 | How many times have been executed the reset sequence during its lifetime? | 26 |
| LIFT-41 | How many times the lift adopted the reversal direction during its lifetime? | 4 |
| LIFT-42 | How many times the door has been opened during its lifetime? | 362 |
| LIFT-43 | How many times the lift has been called from the floor X during its lifetime? | 46 |
| LIFT-44 | How many times the fault event X occurred during its lifetime? | 12 |

### Table B-7: Requirements for the "Alarms" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-45 | Alarm button has been pressed for X seconds. | |
| LIFT-46 | Alarm call has been initiated. | |
| LIFT-47 | Alarm voice communication has been activated. | |
| LIFT-48 | Alarm in the well is active. | |
| LIFT-49 | Alarm in the car is active. | |
| LIFT-50 | Flood alarm is active. | |
| LIFT-51 | Emergency power alarm is active. | |

### Table B-8: Requirements for the "Commands" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-52 | A command can call the car to a specific floor. | |
| LIFT-53 | A command can set the lift to out of service. | |
| LIFT-54 | The lift is subject to inspection operation. | |
| LIFT-55 | Which is the opening door time? | 4 seconds |
| LIFT-56 | Which is the closing door time? | 3 seconds |
| LIFT-57 | A command can test the emergency number. | |
| LIFT-58 | A command can test the proper functioning of the lift. | |
| LIFT-59 | A command can start the real time mode. | |
| LIFT-60 | What is the emergency number? | +1-555-1589 |
| LIFT-61 | Which is the current absolute counter of operating hours? | 1 634 hours |
| LIFT-62 | A command can initiate the board reset. | Yes/No |
| LIFT-63 | There are four emergency battery power status: good, warn, critical and insufficient. | |

### Table B-9: Requirements for the "Smart Lift System" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-64 | A Smart Lift Installation is contained into a Smart Lift System. | |
| LIFT-65 | A Smart Lift Edge Control Unit hosts the different Smart Lift modules. | |
| LIFT-66 | Examples of Smart Lift modules are signals or bidirectional communication systems. | |

### Table B-10: Requirements for the "Smart Lift identification" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-67 | Each Smart Lift Installation should be globally and uniquely identified. | |
| LIFT-68 | Each Smart Lifts Group should be globally and uniquely identified. | |
| LIFT-69 | Which is the manufacturing lift company? | Company1 |
| LIFT-70 | Which is the installer lift company? | Company2 |

### Table B-11: Requirements for the "Smart Lift administrative information" category

| Id | Competency Question/Statement | Answer |
|---|---|---|
| LIFT-71 | Which is the maintenance lift company? | Company1 |
| LIFT-72 | Who is the building manager of the lift? | Company2 |
| LIFT-73 | Who is the legal owner of the lift? | Company3 |
| LIFT-74 | A lift is installed in a geographic location. | |
| LIFT-75 | The lift geographic location is provided by the geographic location validator. | |
| LIFT-76 | Examples of types of use of a lift are Lift, Goods lift, Goods only lift, or Fireman lift. | |

By starting from the list of requirements, the figure below shows the diagram representing the concepts extracted from the analysis of the use case about Smart Lifts shown within Annex A.

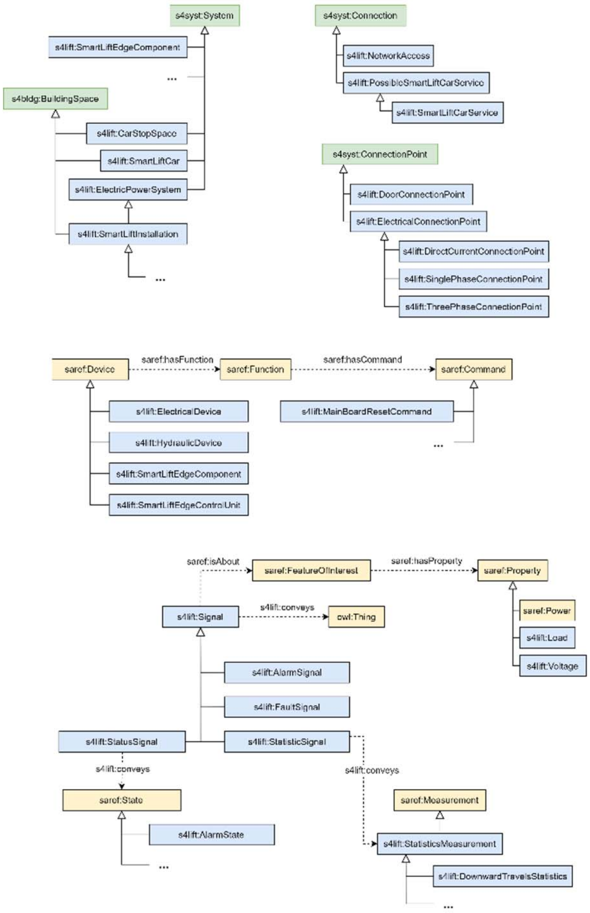


**Figure B-1: Conceptual model containing the new concepts defined through the use case analysis and their relationships**

The text below shows two examples of SAREF-compliant data coming from the use case about Smart Lifts described within Annex A.

```
@prefix ex: <https://saref.etsi.org/saref4lift/v1.1.1/example/TS103735_Clause_6_14_BCSAlarms/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix saref: <https://saref.etsi.org/core/> .
@prefix s4syst: <https://saref.etsi.org/saref4syst/> .
@prefix s4bldg: <https://saref.etsi.org/saref4bldg/> .
@prefix s4lift: <https://saref.etsi.org/saref4lift/> .
@prefix dctype: <http://purl.org/dc/dcmitype/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix cdt: <http://w3id.org/lindt/custom_datatypes#>.


<https://saref.etsi.org/saref4lift/v1.1.1/example/TS103735_Clause_6_14_BCSAlarms#> a dctype:Dataset
;
  dcterms:license <https://forge.etsi.org/etsi-software-license> ;
  dcterms:conformsTo <https://saref.etsi.org/saref4lift/v1.1.1/> ;
  dcterms:title "Bidirectional Communication System alarms example"@en ;
  dcterms:description "Example demonstrating how to represent information from group name BCSAlarms
as in ETSI TS 103 735, Clause 6.14"@en .


# alarmInTheCar


ex:car1 a s4lift:SmartLiftCar .
```

```
_:AlarmInTheCarState a s4lift:AlarmInTheCarState .
_:AlarmInTheCarState saref:isAbout ex:car1 .
_:AlarmInTheCarState saref:hasTimestamp "2021-03-15T12:00:00Z"^^xsd:dateTime .


# s4lift:AlarmSignal can convey alarm state


_:AlarmInTheCarSignal a s4lift:AlarmSignal .
_:AlarmInTheCarSignal saref:isAbout ex:car1 .
_:AlarmInTheCarSignal s4lift:conveys _:AlarmInTheCarState .




# alarmInTheWell


<mailto:lift.1415@company1.com> a s4lift:SmartLiftInstallation .
_:AlarmInTheWellState a s4lift:AlarmInTheWellState .
_:AlarmInTheWellState saref:isAbout <mailto:lift.1415@company1.com> .
_:AlarmInTheWellState saref:hasTimestamp "2021-03-15T12:00:00Z"^^xsd:dateTime .




# alarmInTheRoof


_:AlarmInTheRoofState a s4lift:AlarmInTheRoofState .
_:AlarmInTheRoofState saref:isAbout <mailto:lift.1415@company1.com> .
_:AlarmInTheRoofState saref:hasTimestamp "2021-03-15T12:00:00Z"^^xsd:dateTime .




# alarmInTheMachinery


_:AlarmInTheMachineryState a s4lift:AlarmInTheMachineryState .
_:AlarmInTheMachineryState saref:isAbout <mailto:lift.1415@company1.com> .
_:AlarmInTheMachineryState saref:hasTimestamp "2021-03-15T12:00:00Z"^^xsd:dateTime .


@prefix ex: <https://saref.etsi.org/saref4lift/v1.1.1/example/TS103735_Clause_6_9_FaultSignals/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix saref: <https://saref.etsi.org/core/> .
@prefix s4syst: <https://saref.etsi.org/saref4syst/> .
@prefix s4bldg: <https://saref.etsi.org/saref4bldg/> .
@prefix s4lift: <https://saref.etsi.org/saref4lift/> .
@prefix dctype: <http://purl.org/dc/dcmitype/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix cdt: <http://w3id.org/lindt/custom_datatypes#>.


<https://saref.etsi.org/saref4lift/v1.1.1/example/TS103735_Clause_6_9_FaultSignals#> a
dctype:Dataset ;
  dcterms:license <https://forge.etsi.org/etsi-software-license> ;
  dcterms:conformsTo <https://saref.etsi.org/saref4lift/v1.1.1/> ;
  dcterms:title "Fault Signals example"@en ;
  dcterms:description "Example demonstrating how to represent information from group name
FaultSignals as in ETSI TS 103 735 [i.17], Clause 6.9"@en .


# The fault signals describe some faults.


<mailto:lift.1415@company1.com> a s4lift:SmartLiftInstallation .
<mailto:lift.1415@company1.com> saref:hasState _:FloodInTheWellState .
_:FloodInTheWellState a s4lift:FloodInTheWellState .
```

```
_:FloodInTheWellState rdfs:comment "example of a s4lift:FloodInTheWellState of a
s4lift:SmartLiftInstallation"@en .
_:FloodInTheWellState saref:hasTimestamp "2021-03-15T12:00:00Z"^^xsd:dateTime .


_:FloodInTheWellSignal a s4lift:StatusSignal , s4lift:FaultSignal .
_:FloodInTheWellSignal rdfs:comment "example of a fault signal that conveys a
s4lift:FloodInTheWellState of a s4lift:SmartLiftInstallation"@en .
_:FloodInTheWellSignal saref:isAbout <mailto:lift.1415@company1.com> .
_:FloodInTheWellSignal s4lift:conveys _:FloodInTheWellState .




# faults from EN 627:1995 [i.18]


## s4lift:SmartLiftInstallationFaultState is a faulty state of a smart lift. The fault rdf:label
should be one of the values defined in EN 627:1995 [i.18], (e.g.: "01xx" broken security chain).


<mailto:lift.1415@company1.com> a s4lift:SmartLiftInstallation .
<mailto:lift.1415@company1.com> saref:hasState _:fault .
_:fault a s4lift:SmartLiftInstallationFaultState .
_:fault rdfs:label "01xx" .
_:fault saref:hasTimestamp "2020-05-03T12:00:00Z"^^xsd:dateTime .
_:faultSignal a s4lift:StatusSignal , s4lift:FaultSignal .
_:faultSignal s4lift:conveys _:fault .
```

# Annex C (informative): Example of data translated into SAREF-compliant data

### Example of use for the SAREF extension for building devices.

```
@prefix : <https://saref.etsi.org/saref4bldg/v1.1.2/example/example1BLDG/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix prov: <http://www.w3.org/ns/prov#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix saref: <https://saref.etsi.org/core/> .
@prefix s4bldg: <https://saref.etsi.org/saref4bldg/> .
@prefix s4ener: <https://saref.etsi.org/saref4ener/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix wurvoc: <http://www.wurvoc.org/vocabularies/om-1.8/> .
@prefix dctype: <http://purl.org/dc/dcmitype/> .
@base <https://saref.etsi.org/saref4bldg/v1.1.2/example/example1BLDG/> .


<https://saref.etsi.org/saref4bldg/v1.1.2/example/example1BLDG#> a dctype:Dataset ;
  dcterms:creator <http://purl.org/net/mpoveda> ,
                  <http://www.garcia-castro.com/foaf.rdf#me> ;
  dcterms:license <https://forge.etsi.org/etsi-software-license> ;
  dcterms:conformsTo <https://saref.etsi.org/saref4bldg/v1.1.2/> ;
  dcterms:conformsTo <https://saref.etsi.org/saref4ener/v1.1.2/> ;
  dcterms:title "Example of use for the SAREF extension for building devices"@en ;
  dcterms:description "Example of use for the SAREF extension for building devices"@en .


geo:SpatialThing a owl:Class .
geo:long a owl:DatatypeProperty .
geo:lat a owl:DatatypeProperty .


:Compressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , s4bldg:Compressor ;
  s4bldg:compressorSpeed :CompressorSpeedCompressor001SIERRA02-0434C3 ;
  s4bldg:idealCapacity :IdealCapacityCompressor001SIERRA02-0434C3 ;
  s4bldg:impellerDiameter :ImpellerDiameterCompressor001SIERRA02-0434C3 ;
  s4bldg:isContainedIn :RefrigerationStoreComputerScienceBuilding1 ;
  s4bldg:nominalCapacity :NominalCapacityCompressor001SIERRA02-0434C3 ;
  geo:location :LocationCompressor001SIERRA02-0434C3 ;
  s4ener:exposes :PowerProfileCompressor001SIERRA02-0434C3 ;
  s4bldg:hasHotGasBypass "false"^^xsd:boolean ;
  s4bldg:powerSource "MotorDriven"^^xsd:string ;
  s4bldg:refrigerantClass "HFC"^^xsd:string ;
  saref:hasManufacturer "SIEMENS"^^xsd:string ;
  rdfs:label "CompressorSIERRA02-0434C3"@en .


:CompressorSpeedCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , saref:Measurement ;
  saref:isMeasuredIn :cyclesPerSecond ;
  saref:hasValue "3.0"^^xsd:float ;
  rdfs:label "Compressor speed of compressor001 SIERRA02-0434C3"@en .


:ComputerScienceBuilding1 rdf:type owl:NamedIndividual , s4bldg:Building ;
  geo:location :LocationComputerScienceBuilding1 ;
  rdfs:label "Computer Science Building 1"@en .


:IdealCapacityCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , saref:Measurement ;
  saref:isMeasuredIn wurvoc:watt ;
  saref:hasValue "1800.0"^^xsd:float ;
  :label "Ideal capacity of compressor001 SIERRA02-0434C3"@en .


:ImpellerDiameterCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , saref:Measurement ;
  saref:isMeasuredIn wurvoc:inch-international ;
  saref:hasValue "5.9"^^xsd:float ;
  rdfs:label "Impeller diameter of compressor001 SIERRA02-0434C3"@en .


:LocationCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , geo:SpatialThing ;
  geo:lat "40.405155" ;
  geo:long "-3.839203" ;
  rdfs:label "Location of compressor001 SIERRA02-0434C3"@en .


:LocationComputerScienceBuilding1 rdf:type owl:NamedIndividual , geo:SpatialThing ;
  geo:lat "40.405013" ;
  geo:long "-3.839349" ;
  rdfs:label "Location of Computer Science Building 1"@en .


:LocationRefrigerationStoreComputerScienceBuilding1 rdf:type owl:NamedIndividual , geo:SpatialThing
;
  geo:lat "40.405152" ;
  geo:long "-3.839209" ;
  rdfs:label "LocationRefrigerationStoreComputerScienceBuilding1"@en .


:NominalCapacityCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , saref:Measurement ;
  saref:isMeasuredIn wurvoc:watt ;
  saref:hasValue "680.0"^^xsd:float ;
  rdfs:label "Nominal capacity of compressor001 SIERRA02-0434C3"@en .


:PowerCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , saref:Measurement ;
  saref:isMeasuredIn wurvoc:watt ;
  saref:hasValue "902.0"^^xsd:float ;
  rdfs:label "Power of compressor 001 SIERRA02-0434C3"@en .


:PowerProfileCompressor001SIERRA02-0434C3 rdf:type owl:NamedIndividual , s4ener:PowerProfile ;
  rdfs:label "Power profile of compressor 001 SIERRA02-0434C3"@en .


:RefrigerationStoreComputerScienceBuilding1 rdf:type owl:NamedIndividual , s4bldg:BuildingSpace ;
  s4bldg:isSpaceOf :ComputerScienceBuilding1 ;
  geo:location :LocationRefrigerationStoreComputerScienceBuilding1 ;
  rdfs:label "Refrigeration store of Computer Science Building 1"@en .


:cyclesPerSecond rdf:type owl:NamedIndividual , saref:UnitOfMeasure ;
  rdfs:label "cycles per second"@en .


wurvoc:inch-international rdf:type owl:NamedIndividual , saref:UnitOfMeasure ;
  rdfs:label "inch international"@en .


wurvoc:watt rdf:type owl:NamedIndividual , saref:PowerUnit .
```

# Annex D (informative): Example of testing SAREF data

### Example of a SHACL constraint that tests whether a Friend-of-a-Friend (FoaF) person has a valid 3-piece SHA public key.

```
@prefix dash: <http://datashapes.org/dash#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix schema: <http://schema.org/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix sh: <http://www.w3.org/ns/shacl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix bibo: <http://purl.org/ontology/bibo/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix ical: <http://www.w3.org/2002/12/cal/ical#> .
@prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#> .


schema:IoTUserShape
    a sh:NodeShape ;
    sh:targetClass foaf:Person ;
    sh:property [
        sh:path foaf:name ;
        sh:datatype xsd:string ;
        sh:name "First and last name" ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
    ] ;
    sh:property [
        sh:path foaf:Organization ;
        sh:datatype xsd:string ;
        sh:name "Organization" ;
        sh:minCount 1 ;
    ] ;
    sh:property [
        sh:path foaf:mbox ;
        sh:datatype xsd:string ;
        sh:name "Email address" ;
        sh:minCount 1 ;
    ] ;
    sh:property [
        sh:path foaf:sha1 ;
        sh:datatype xsd:string ;
        sh:name "3-piece SHA public key" ;
        sh:minCount 1 ;
    ] .


schema:PersonalProfileDocumentShape
    a sh:NodeShape ;
    sh:targetClass foaf:PersonalProfileDocument ;
    sh:property [
        sh:path foaf:maker ;
        sh:name "Unique IRI" ;
        sh:minCount 1 ;
        sh:maxCount 1 ;
    ] ;
    sh:property [
        sh:path foaf:primaryTopic ;
        sh:name "Same value as maker" ;
        sh:minCount 0 ;
        sh:maxCount 1 ;
    ] .
```

This is a SPARQL GROUP BY query to find products with multiple barcodes. Note that using the SPARQL DISTINCT keyword does not remove "duplicate" elements from the database.

```
SELECT ?product WHERE {
  ?product rdf:type product:Product .
   optional { ?product product:barcode ?barcode . }
} GROUP BY ?product
```

```
HAVING (COUNT(?barcode) > 1)
```

This is a SPARQL CONSTRUCT statement that returns the existence of a NamedIndividual whose particular properties have been satisfied with any value. This CONSTRUCT can also be modified to simply return the COUNT of such individuals for another verification.

```
PREFIX s4agri: <https://saref.etsi.org/saref4agri/>
PREFIX saref: <https://saref.etsi.org/core/>
CONSTRUCT { ?s s4agri:hasName ?p . } WHERE {
    { ?s s4agri:hasMember ?p . }
    UNION
    { ?s s4agri:hasID ?p . }
    UNION
    { ?s s4agri:hasDeploymentPeriod ?p . }
    UNION
    { ?s saref:hasValue ?p . }
    UNION
    { ?s s4agri:hasBirthDate ?p . }
}
```

# Annex E (informative): SAREF methodology

The LOT methodology [i.2] provides guidelines about the activities to be carried out during the ontology development process including additional resources, recommendations, resources and tools to support them. This methodology is structured in four main phases as depicted in figure E-1. Such figure also includes information about roles involved in each phase and the expected outcomes. These phases are:

- **Ontology requirements specification:** The goal of this phase is to state why the ontology should be built and to identify and define the functional and non-functional requirements the ontology should fulfil. This phase takes as input the documentation and data provided by domain experts and users. Then, the ontology development team generates a first proposal of ontological requirements written in the form of competency questions or natural language statements.

- **Ontology implementation:** The goal of this phase is to build the ontology using a formal language, more precisely OWL, based on the ontological requirements identified previously. After defining the first set of requirements, the ontology implementation phase is carried out through a number of sprints. The ontology is built by the development team in an iterative way, implementing only a certain number of requirements in each iteration or sprint. The output of each iteration is a new version of the ontology written in OWL code.

- **Ontology publication:** The goal of this phase is to provide an online ontology accessible both as a human-readable documentation and a machine-readable file from its URI and registered in the ETSI SAREF ontologies portal.

- **Ontology maintenance:** The goal of this phase is to update and add new requirements to the ontology that might have not been identified in the current version of the requirement specification document. This is the mechanism provided to identify and corrects errors or to schedule a new iteration for ontology development.

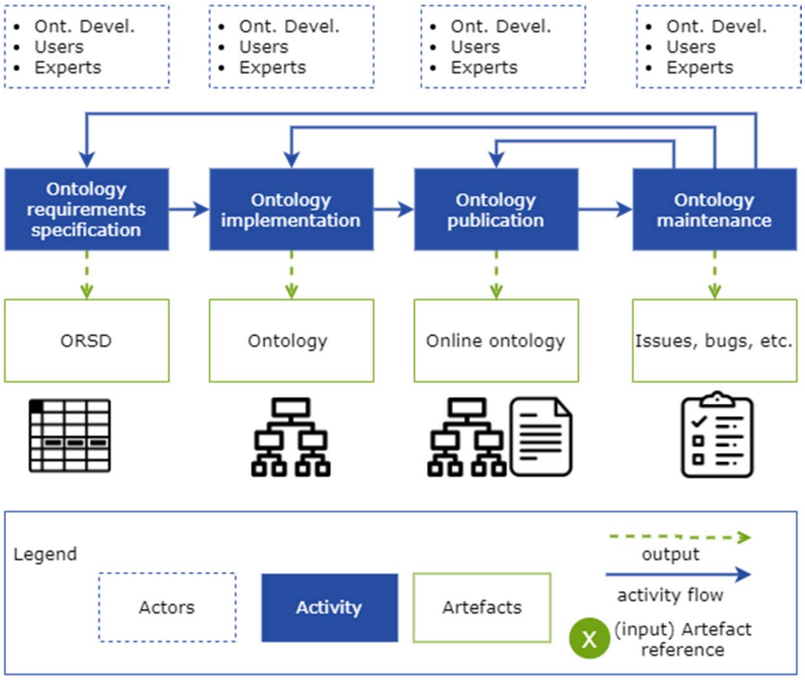


Figure E-1: LOT methodology main phases. Figure taken from [i.2]

# Annex F (informative): Implementation conformance statement pro forma

Notwithstanding the provisions of the copyright clause related to the text of the present document, ETSI grants that Users of the present document can freely reproduce the pro forma in the present annex so that it can be used for its intended purposes and can further publish the completed annex including table F-1.

Table F-1 can provide a mechanism for the User of the present document (who is expected to be an entity involved in the development or manufacturing of IoT systems and/or devices and/or applications) to give information about the implementation of the provisions within the present document.

The reference column gives reference to the provisions in the present document.

The status column indicates the status of a provision. The following notations are used:

M the provision is a mandatory requirement

R the provision is a recommendation

M C the provision is a mandatory requirement and conditional

R C the provision is a recommendation and conditional

NOTE: Where the conditional notation is used, this is conditional on the text of the provision. The conditions are provided at the bottom of the table with references provided for the relevant provisions to help with clarity.

The support column can be filled in by the User of the present document. The following notations are used:

Y supported by the implementation

N not supported by the implementation

N/A the provision is not applicable (allowed only if a provision is conditional as indicated in the status column and if it has been determined that the condition does not apply for the product in question)

The detail column can be filled in by the User of the present document:

- If a provision is supported by the implementation, the entry in the detail column is to contain information on the measures that have been implemented to achieve support.
- If a provision is not supported by the implementation, the entry in the detail column is to contain information on the reasons why implementation is not possible or not appropriate.
- If a provision is not applicable, the entry in the detail column is to contain the rationale for this determination.

**Table F-1: Implementation of provisions for ETSI EN 303 760**

| **Clause number and title** | | | |
|---|---|---|---|
| **Reference** | **Status** | **Support** | **Detail** |
| **4 Motivation** | | | |
| Provision 4-1 | M | | |

| Clause number and title | | | |
|---|---|---|---|
| **Reference** | **Status** | **Support** | **Detail** |
| **5.1 Define use cases** | | | |
| Provision 5.1-1 | M | | |
| Provision 5.1-2 | M | | |
| Provision 5.1-3 | M | | |
| Provision 5.1-4 | M | | |
| Provision 5.1-5 | R | | |
| **5.2 Identify core elements** | | | |
| Provision 5.2-1 | M | | |
| Provision 5.2-2 | R | | |
| Provision 5.2-3 | R | | |
| Provision 5.2-4 | M | | |
| **5.3 Get acquainted with SAREF** | | | |
| Provision 5.3.2-1 | R | | |
| Provision 5.3.3-1 | M | | |
| Provision 5.3.4-1 | R | | |
| Provision 5.3.5-1 | M | | |
| **5.4 Ensure use of correct SAREF version** | | | |
| Provision 5.4-1 | R | | |
| Provision 5.4-2 | M | | |
| Provision 5.4-3 | M | | |
| **6.1 Translate data into SAREF-compliant data** | | | |
| Provision 6.1-1 | M | | |
| Provision 6.1-2 | R | | |
| Provision 6.1-3 | M | | |
| Provision 6.1-4 | R | | |
| Provision 6.1-5 | M | | |
| | | | |
| **6.2 Test SAREF-compliant data** | | | |
| Provision 6.2-1 | M | | |
| Provision 6.2-2 | R | | |
| Provision 6.2-3 | M | | |
| Provision 6.2-4 | R | | |
| Provision 6.2-5 | R | | |
| Provision 6.2-6 | R | | |
| Provision 6.2-7 | R | | |
| Provision 6.2-8 | R | | |
| **7.1 Create a new SAREF extension** | | | |
| Provision 7.1-1 | M | | |
| Provision 7.1-2 | M | | |
| Provision 7.1-3 | R | | |
| Provision 7.1-4 | R | | |
| **7.2 Ensure compliance of an extension to SAREF** | | | |
| Provision 7.2-1 | M | | |
| **8.2 Actors and workflow for starting the development of a new SAREF extension** | | | |
| Provision 8.2-1 | R | | |
| Provision 8.2-2 | R | | |
| Provision 8.2-3 | R | | |
| **8.3.1 Introduction** | | | |
| Provision 8.3.1-1 | R | | |
| **8.3.2 SAREF project version specification and documentation** | | | |
| Provision 8.3.2-1 | M | | |
| Provision 8.3.2-2 | M | | |
| Provision 8.3.2-3 | R | | |
| Provision 8.3.2-4 | M | | |
| Provision 8.3.2-5 | M | | |
| Provision 8.3.2-6 | M | | |
| Provision 8.3.2-7 | M | | |
| Provision 8.3.2-8 | M | | |
| Provision 8.3.2-9 | M | | |
| Provision 8.3.2-10 | M | | |
| Provision 8.3.2-11 | M | | |
| Provision 8.3.2-12 | R | | |
| Provision 8.3.2-13 | R | | |

| **Clause number and title** | | | |
|---|---|---|---|
| **Reference** | **Status** | **Support** | **Detail** |
| Provision 8.3.2-14 | R | | |
| Provision 8.3.2-15 | M | | |
| Provision 8.3.2-16 | R | | |
| Provision 8.3.2-17 | R | | |
| Provision 8.3.2-18 | R | | |
| **8.3.3 Quality Control and Requirements Verification with the SAREF Pipeline** | | | |
| Provision 8.3.3-1 | R | | |
| **Conditions**<br>1) text of condition #1;<br>2) text of condition #2;<br>3) text of condition #3. | | | |

# Annex G (informative): Example of how to enhance SAREF Core with its Extensions

Example annex G.A presents patterns that showcase the organization of device-related information using the ontology. In the given example, a thermal buffer responsible for measuring water temperature in degree Celsius is described by specifying details such as the measurement value, manufacturer, model, serial number, and the unit of measure employed. It is important to note that the presented patterns only demonstrate a fraction of the expressivity offered by SAREF Core which additionally comprises vocabulary terms to describe, among others, commodities, commands, feature of interests, and states of devices. The prefixes used in the examples Annex G.A and Annex G.B are provided in table G-1. The examples are written in extensive Turtle syntax.

**Table G-1: Prefixes Used in Examples G.A and G.B**

| Prefix | Namespace |
|---|---|
| ex | http://www.example.org/ |
| rdf | http://www.w3.org/1999/02/22-rdf-syntax-ns# |
| saref | https://saref.etsi.org/core/ |
| S4ener | https://saref.etsi.org/saref4ener/ |

**Example Annex G.A. Lines 1-12**

```
1   ex:TermalBuffer rdf:type saref:Device.
2   ex:TermalBuffer saref:hasManufacturer "Manufacturer X"^^xsd:string.
3   ex:TermalBuffer saref:hasModel "T X-5000"^^xsd:string.
4   ex:TermalBuffer saref:serialNumber "1234DAX "^^xsd:string.
5   ex:TermalBuffer saref:makesMeasurement ex:measurementX.
6   ex:measurementX rdf:type saref:Measurement.
7   ex:measurementX saref:hasvalue "15"^^xsd:integer.
8   ex:measurementX saref:hasTimestamp "2021-12-30T00:00:00Z"^^xsd:dateTime.
9   ex:degreeCelsius rdf:type saref:TemperatureUnit.
10  ex:measurement saref:isMeasuredIn ex:degreeCelsius.
11  ex:celsiusTemperature rdf:type saref:Temperature.
12  ex:measurement saref:relatesToProperty ex:celsiusTemperature.
```

To illustrate the complementary use of SAREF Core and its extensions, example annex G.A gets enriched with a few vocabulary terms from the SAREF4ENER module. By incorporating the definition of the profile associated with the thermal buffer into the existing patterns, the expressivity provided by the extension can be leveraged.

Lines 13-14 describe the profile of the thermal buffer by using vocabulary terms coming from SAREF Core, including saref:hasProfile, as well as from SAREF4ENER, such as s4ener:FillRateBasedProfile. Furthermore, by utilizing the same module, values for flexibility offers created by energy providers can be defined, as presented at lines 15-23 of example annex G.B.

**Example Annex G.B. Lines 13-23**

```
13 ex:FillRateBasedProfileX rdf:type s4ener: FillRateBasedProfile.
14 ex:TermalBuffer saref:hasProfile ex:FillRateBasedProfileX.
15 ex:FlexOfferX rdf:type s4ener:FlexOffer.
```

```
ex:FlexOfferX s4ener:includes ex:FillRateBasedProfileX.
ex:FlexOfferX s4ener:validFrom "2021-13-30T00:00:00Z"^^xsd:dateTime.
Ex:FlexOfferX s4ener:ValidTo "2021-13-30T00:00:00Z"^^xsd:dateTime.
ex:FlexOffer s4ener:includes ex:price.
Ex:price rdf:type s4ener:DataPoint.
Ex:price saref:hasValue "2"^^xsd:decimal .
Ex:price saref:isMeasuredIn ex:Euro.
Ex:Euro rdf:type saref:Currency.
```

# History

| Document history | | |
|---|---|---|
| V1.1.0 | June 2024 | EN Approval Procedure AP 20240925: 2024-06-27 to 2024-09-25 |
| V1.1.1 | October 2024 | Publication |
| | | |
| | | |
| | | |