Semantic Interoperability Centre Europe

Quality Framework for Interoperability Assets

This document has been prepared by

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PREFACE

ABOUT SEMIC.EU

SEMIC.EU (Semantic Interoperability Centre Europe) is an EU project to support the data exchange for pan-European eGovernment services. Its goal is to create a repository for interoperability assets that can be used by eGovernment projects and their stakeholders. SEMIC.EU offers the following services for the public sector in Europe:

- SEMIC.EU will provide access to interoperability assets that have been developed in previous governmental projects.
- A clearing process will safeguard specific rules and standards to assure the quality of published assets.
- Community features will be available on the platform, e.g. a forum to discuss best practices for the use of assets.
- SEMIC.EU will invite stakeholders to seminars and workshops that are related to its activities.
- SEMIC.EU offers coaching services for the creation and/or reuse of interoperability assets.

More information on SEMIC.EU can be found at http://www.semic.eu.

SEMIC.EU is an endeavour of IDABC. Contracted technical service providers for the project are]init[(main contractor), Fraunhofer ISST, GEFEG, and France Telecom R&D.

ABOUT IDABC

IDABC (http://ec.europa.eu/idabc) stands for Interoperable Delivery of European eGovernment Services to Public Administrations, Business, and Citizens. It takes advantage of the opportunities offered by information and communication technologies to encourage and support the delivery of cross-border public sector services to citizens and enterprises in Europe and to improve efficiency and collaboration between and among European public administrations.

The programme also provides financing to projects addressing European policy requirements, thus improving cooperation among administrations across Europe. National public sector policymakers are represented in the IDABC programme's management committee and in many expert groups, making the programme a unique forum for the coordination of national eGovernment policies.

TYPOGRAPHICAL CONVENTIONS

The type styles shown below are used in this document to emphasize parts of the text.

Times New Roman 11 pt. Normal: Standard body text

Times New Roman 11 pt. Italic: Citations

The requirements level indicators are fully aligned to "*RFC2119 - Key words for use in RFCs to Indicate Requirement Levels*" and are used as follows:

MUST means, that this rule or requirement is to be fulfilled unexceptionally.

SHOULD indicates an optional rule / requirement which may be fulfilled if desired.

GRAPHICAL NOTATIONS

The notations listed below are used in this document to visualize concepts. The notation is explained briefly in the document's Appendices. These illustrations are intended to support readers' understanding; however, they do not replace any specification or tutorial. For further information on this topic, please refer to the relevant documentation. The figure notes clearly indicate the specific notation used:

BPMN – Business Process Modelling Notation from the Object Management Group

FMC – Fundamental Modelling Concept from the Hasso Plattner Institute, Potsdam, Germany

MANAGEMENT SUMMARY

This document defines the quality framework for SEMIC.EU covering all quality-related aspects:

- minimum quality criteria for publishing an asset
- quality criteria for assets and their artefacts according to stakeholder requirements
- assessing the quality of assets and their artefacts
- assignment of quality criteria to assets and the quality assessment of assets
- improving the quality framework itself

The document gives a short overview of quality related terms as they are used throughout the document to establish a common understanding of "quality". Common definitions are aligned to the special needs and goals of SEMIC.EU.

Based on these terms the requirements stated by SEMIC.EU's quality framework are compiled. The requirements are based on good practices from existing approaches.

The key decisions concerning SEMIC.EU's quality framework are the following:

- In order to allow the interested community to participate and cooperate even in an early development stage of an asset, only minimum quality criteria have to be fulfilled in order to publish an asset on the platform.
- The quality of an asset and its artefacts is basically expressed and evaluated via measurable quality indicators, e.g. the percentage of documented logical units in a specification.
- Additional quality indicators that have to be provided, are soft indicators such as community ratings and vitality measures like the number of downloads of an asset, etc. Furthermore soft indicators have to be measurable, i.e. have to be mapped to numerical values.
- To get manageable information about the quality of an asset, quality labels are used to aggregate quality information. Being awarded a quality label indicates that the results of related quality indicators have reached certain thresholds.
- The overall development stage of an asset is indicated by a progress level which comprises the information of related quality labels. Reaching a certain progress level indicates that related quality labels have been awarded. Whereas quality indicators and labels apply to assets and artefacts, progress levels only apply to entire assets.
- The definition and assignment of the quality criteria is part of the development of the asset and its artefacts. Therefore the asset owner has to provide an asset together with its quality criteria. The asset community that is interested in the development and reuse of that asset, should not only participate in the development of the asset itself, but also in the development and refinement of its quality criteria. For "conform assets" minimum quality criteria have to be defined by domain experts appointed by the SEMIC.EU Advisory Group.

In the future, i.e. not planned yet for the launch of the SEMIC.EU platform, the improvement of the quality framework should be considered, following the CMM/CMMI[1] approach of maturity levels for software development processes.

After introducing the quality framework an outline of its implementation in the SEMIC.EU platform is provided. This implementation is mainly a refinement of the specific tasks of the clearing process without changing its overall structure. As the quality framework only defines how quality has to be implemented, the implementation of the quality framework requires further specific definitions, e.g. the definition of artefact types, the definition of specific quality criteria for these artefact types. Last but not least guidelines have to be provided to support asset providers and tools for the automatic evaluation of indicators including soft indicators and vitality measures have to be developed that preferably should be integrated in the SEMIC.EU platform.

[1] Capability Maturity Model / Capability Maturity Model Integration (see Appendix B.2)

1. INTRODUCTION

One major goal of SEMIC.EU is to provide interoperability assets of high quality. Interoperability assets – with all the artefacts they consist of – are technical specifications like syntactic (e.g. XML schemas) and semantic assets (e.g. ontologies) needed for semantic interoperability as a basis for cross-border eGovernment services. To achieve high quality assets, SEMIC.EU implements a clearing process consisting of three dedicated stages. It is promoted that at each stage, the quality of the interoperability asset will increase.

In the first stage, the registration process, assets, and even "asset candidates" can be uploaded and registered on SEMIC.EU without unnecessary barriers. In practice, this means that those assets only need to meet basic requirements in terms of their stage of development and quality.

After an asset has been developed adequately and specific quality criteria have been met, the asset may be brought into the second stage: the maturity process. In this process, the current development (maturity) of an asset is evaluated, particularly in relation to the asset's potential for reuse in other projects. If successful, a new, mature release of the asset is published.

At the final stage, a semantic interoperability asset will be introduced into the conformance process. One prerequisite for a conformance request is that the asset has already passed the maturity process. Furthermore, it has to have reached acceptable levels of development, quality, and completeness of documentation, and it must demonstrate significant potential for reusability. Conform assets are branded with an outstanding level of quality that has been evaluated in detail and formally assessed by domain experts.

1.1. The Purpose of this Document

This document provides a definition of the quality framework for SEMIC.EU and outlines its implementation in SEMIC.EU's clearing process. This framework comprises all issues related to quality in SEMIC.EU.

The quality framework does not define concrete quality criteria for particular types of assets, but it provides the requirements and regulations for developing quality criteria for assets and artefacts. An exception of that is a set of the minimum quality criteria. In accordance with an approach that does not restrict assets to a predefined structure with predefined types of artefacts, there should also be no predefined quality criteria, except the minimum criteria. The assignment of the quality criteria to an asset and its artefacts is part of the development of the asset itself.

In detail the quality framework consists of:

- a set of minimum quality criteria that have to be met for publishing an asset and its artefacts on the platform
- requirements for the development of quality criteria for assets and their artefacts
- an appropriate structure and representation of these quality criteria
- assigning appropriate quality criteria to assets and their artefacts regarding the requirements of all stakeholders
- requirements for assessing, preferably by measuring, the quality of assets and their artefacts
- the quality process, i.e. the assignment of quality criteria to assets and the quality assessment
- requirements for the future improvement of the quality framework itself

SEMIC.EU's quality framework does not cover all areas addressed by quality management models such as ISO 9000 ff and CMM /CMMI (see Appendix B.2). CMMI addresses areas such as project planning, project monitoring and control, and quantitative project management. These are constituents of the software- and systems-development process. These areas are beyond the scope of SEMIC.EU and therefore not considered in the SEMIC.EU quality framework.

1.2. Approach and Structure of the Document

The quality framework is intended to comprise all quality-related aspects of SEMIC.EU. Therefore, it determines the process of defining and assessing quality, however the concrete quality criteria and measures are to be specified in later documents. The structure of the approach is detailed in the following sections.

In the second section, quality-related terms are introduced in order to achieve general understanding. These terms are based on common terms that can be found in quality-related publications, but they have been aligned to the SEMIC.EU context.

The third section defines the quality framework by presenting all quality-related requirements of SEMIC.EU. These requirements are aligned with good practices from existing quality models and processes (see Appendix B) and are based on design decisions already specified in the document "Vision of the Clearing Process"[2]. Therefore, a requirement may have a "design character", e.g. it is not required to have an aggregated representation of the various quality measures, but it is required to have a quality label mechanism that represents the aggregation of a number of quality measures in the form of a label.

The forth section elaborates the SEMIC.EU quality model, i.e. the implementation of the quality framework concerning quality characteristics related to assets and artefacts.

The fifth section defines the quality process for SEMIC.EU, which is primarily the embedding of configuring and assessing quality into the clearing process.

An example of a quality criterion and related measures for a particular type of artefact and a survey of existing quality models and processes conclude the document.

1.3. Audience

The audience for this document comprises:

- providers of assets who want to provide high-quality assets
- potential asset users who want to know whether an asset of interest fulfils their quality needs and expectations
- the clearing process manager, who has to ascertain that quality requirements have been met
- the conformance committee, i.e. technical experts appointed by the advisory board, as they have to assess and decide whether an asset meets the quality criteria according to SEMIC.EU's conformity standards

These comprise most of the stakeholders identified in the document "Vision of the Clearing Process".

[2] http://www.semic.eu/semic/view/documents/vision-of-the-clearing-process.pdf

2. DEFINITIONS OF QUALITY TERMS

The purpose of the following section of the document is to develop a general and common understanding of quality related terms in respect to their use in this paper.

The following descriptions and definitions are based on common definitions that can be found in quality-related literature, e.g. quality standards. However, an alignment to the special needs and goals of SEMIC.EU constitutes part of the definition work.

2.1. Quality

Throughout the literature, quality is an intensively discussed concept, and a term whose definition and meaning are highly dependent on the observed field of interest. Many approaches to the definition of quality exist. They often refer explicitly to products, processes, and costs and benefits, as well as to users or customers.

Common definitions that mainly refer to products and processes describe quality as the *"degree to which a set of inherent characteristic fulfils requirements"*[3], as *"conformance to requirements"*[4] or just as *"fitness for use"*.[5]

All the above-mentioned definitions focus primarily on requirements that are often not identical with the needs and expectations of the user. To correct this, more user-oriented descriptions have been developed. The IEEE[6] defines quality in its Standard Glossary as *"the degree to which a system, component, or process meets customer or user needs or expectations."*[7]

In the context of SEMIC.EU, it is important to find a pragmatic definition that corresponds to the goals and requirements of the project as well as the expectations of the user community. Based on the IEEE definition, in this project the term "quality" is defined as follows:

"The degree to which assets and corresponding artefacts meet the needs and expectations of the user community within the goals of SEMIC.EU."

2.2. Quality Model

The term "quality" as such is not directly applicable to the assets and artefacts managed by SEMIC.EU. Additional concepts are needed to make quality measurable and assessable. Those concepts are expressed in quality models.

Quality models are used for the evaluation of quality, and they therefore provide the basis for successful quality management. They consist of a set of quality characteristics and the relation between them, which provide the basis for specifying quality requirements and evaluating quality.[8]

The principal components of the SEMIC.EU quality model and their relationships are described in the following sections.

2.3. Quality Factors / Criteria /Attributes

The definition of quality as such is not adequate when it is applied to the managed content of SEMIC.EU. Therefore, it is necessary to derive sub-terms that are more specific and serve as a feature or detailed characterisation of the asset's or artefact's quality in respect to community expectations and project intentions.

[3] ISO 9000:2005 Quality management systems – Fundamentals and vocabulary
[4] Philip B. Crosby, Quality is free: the art of making quality certain, New York 1979
[5] Joseph M. Juran, Juran's Quality Handbook, New York 2000
[6] Institute of Electrical and Electronics Engineers
[7] IEEE Std 610.12 1990 (R2002) IEEE Standard Glossary of Software Engineering Terminology
[8] ISO/IEC 9126 Software Engineering – Product Quality Standard (2001 – 2003)

These sub-terms are called quality factors, quality criteria, or quality attributes. They are often used as synonyms, but when applied in a hierarchical structure, it is common to call the higher-level attributes "quality factors" and the lower-level ones "quality criteria". Quality attributes are only abstract characterisations; they can never be measured directly.

In the SEMIC.EU quality model, quality factors and criteria are only used to derive corresponding quality indicators and quality labels (see figure 2-1 and definitions below). The step of defining quality factors and criteria is helpful for a more detailed description of an asset's or artefact's quality.

2.4. Quality Indicators

For each quality criterion, it is necessary to find quality indicators that make quality criteria measureable and assessable. They should provide "*a quantitative measure of the degree*"[9] to which an item possesses a given quality criterion.

Quality indicators have to be defined by a metric, i.e. a measurement method and a measurement scale.[10] The measurement method will often be a function whose input in the context of SEMIC.EU consists of certain artefacts and whose output is a single value that can be interpreted as the degree to which an artefact or class of artefacts meets a given quality criterion. The scale depends on the kind of function used.

A distinction can be made between hard and soft indicators. Hard indicators are exact measurement functions where the return value does not change if the input parameters stay the same. Soft indicators are based on rather blurred measurement methods like ballots or ratings. Measurement results can vary even if the input measured stays the same.

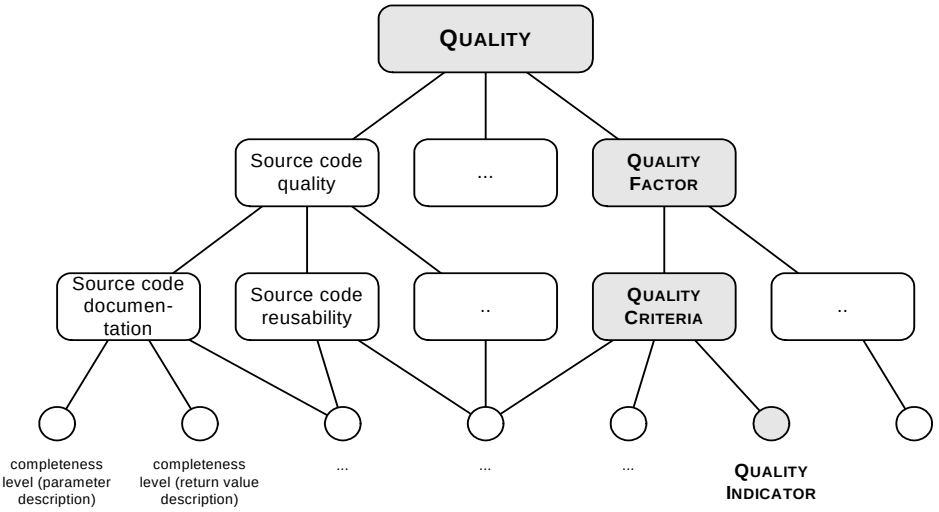

Figure 2-1: Correlations between Quality Factors, Criteria and Indicators

2.5. Quality Labels

One of the major challenges of SEMIC.EU is to develop precise statements that express the degree to which user expectations and needs are met. A solution suggested by the SEMIC.EU quality model is the introduction of quality labels.

Quality labels designate predicates that relate to one or more quality indicators. They are comparable to labels that confirm the conformity of a product to certain standards, e.g. TCO'06 (low-emission standard for computer displays) or the EU Eco-Label (reduced environmental impacts of products and services). With reference to SEMIC.EU, quality labels state the conformity to predefined user expectations. They can be awarded to both assets and artefacts.

[9] IEEE Std 610.12 1990 (R2002) IEEE Standard Glossary of Software Engineering Terminology
[10] ISO/IEC 9126 Software Engineering – Product Quality Standard (2001 – 2003)

Quality labels can be arranged in quality label groups (see figure 2-2). Each label in a group is based on the same indicators as the other labels in it.

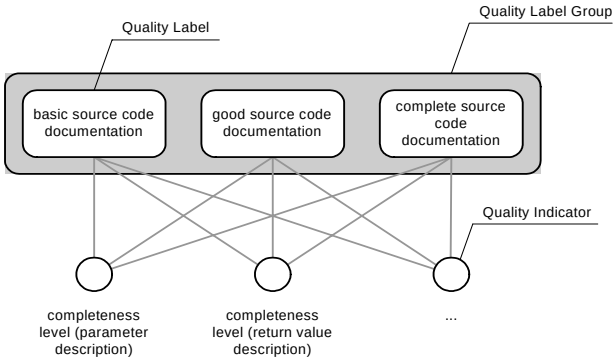

Figure 2-2: Composition of Quality Labels and Quality Label Groups

2.6. Quality Progress

The quality progress is a measure that shows the asset's overall quality improvement to the user community; it is done by defining progress levels. The asset owner associates specific quality labels with each progress level (see figure 2-3). When all the labels associated with the level have been awarded to the asset and its artefacts, the quality progress level has been reached.

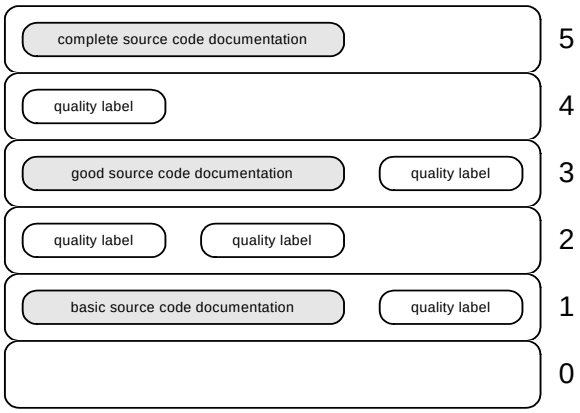

Figure 2-3: Example for Progress Levels

2.7. Quality Process

The quality process in the context of SEMIC.EU is the aggregation of three quality sub-processes. These sub-processes are the quality configuration, the quality assessment, and the quality improvement process.

The quality configuration process refers to a system of activities that is focused on the configuration of the quality model with regard to the needs and expectations of the asset owner and the user community.

The quality assessment process focuses on the assessment of the quality model for the assets that are part of the clearing process managed by SEMIC.EU.

In addition to configuration and assessment, it is necessary to define a quality improvement process. This process concentrates on the improvement of the quality model and the quality process itself.

2.8. Quality Framework

The quality framework consists of requirements for a quality model and a quality process for SEMIC.EU comprising (see previous section):

- minimum quality criteria that have to be met for publishing an asset and its artefacts on the platform
- requirements for the definition of quality criteria for assets and their artefacts
- an appropriate structure and representation of these quality criteria
- assigning these quality criteria to assets and their artefacts according to stakeholder requirements
- requirements for assessing, preferably measuring the quality of assets and their artefacts
- the quality process, i.e. the assignment of quality criteria to assets and the quality assessment
- requirements for the future improvement of the quality framework itself

3. QUALITY FRAMEWORK

This section explains all the SEMIC.EU requirements stipulated by the quality framework. All of these requirements in form of numbered mandatory rules must adhere to the quality framework, as stated by the use of MUST in their phrasing.

A distinction is made among the requirements based on:

- the interoperability assets and artefacts, i.e. the quality model for assets and artefacts
- the configuration and the assessment of the quality of interoperability assets and artefacts, i.e. the quality process
- the quality framework itself, i.e. the continuous improvement of the quality model and the quality process

The quality framework establishes and adapts, as far as they are in the scope of SEMIC.EU, process areas of the CMMI approach (for a correspondence of these process areas to the quality framework see Appendix B.2).

In the following, the requirements are described in detail in terms of this structure.

3.1. Quality Requirements for Assets and Artefacts

In the document "Vision of the Clearing Process", the following overall levels for an asset's quality are defined, ordered from lowest to highest quality:

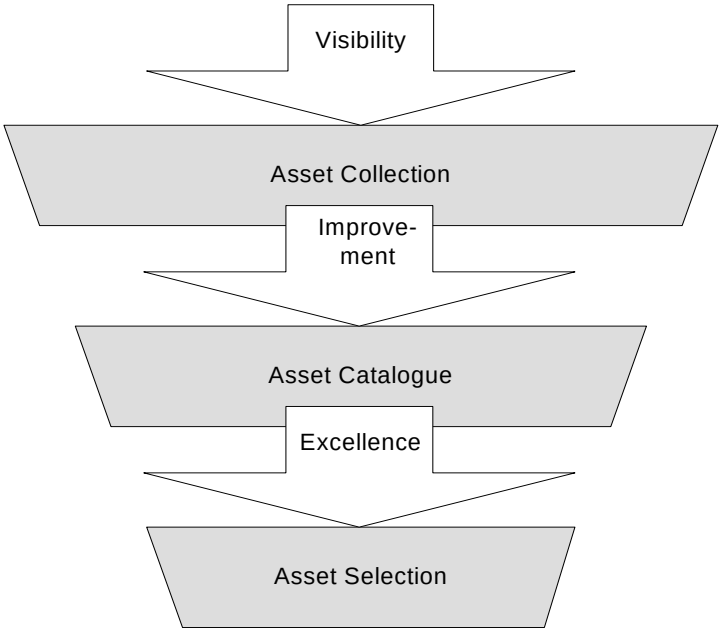

Figure 3-1: Goals for the Clearing Process

- *VISIBILITY*
  Interoperability assets can be registered on the platform with only a small set of requirements that have to be fulfilled. Even an idea for an interoperability asset with a minimum of documentation may be made known to the interested community, thus providing an opportunity to participate and cooperate, even at an early stage of development.
- *IMPROVEMENT*
  As the development proceeds, the maturity of an asset should increase in terms of its quality and suitability for reuse in other projects. Specific quality criteria are assessed and documented in a quality report. A branding of the asset indicates the fulfilment of dedicated quality criteria.

- *EXCELLENCE*
  Mature assets whose development has been finalised achieve an outstanding level of quality that is recognized by their being awarded a conformance statement approving the quality goals of SEMIC.EU.

In accordance with the clearing process and its goals (see figure 3-1), the quality requirements for assets and artefacts can be structured in quality requirements for:

- *REGISTERED ASSETS*
- *MATURE ASSETS*
- *CONFORM ASSETS*

3.1.1. Quality Requirements for Registered Assets

To achieve visibility of assets, even at an early development stage, only minimal quality criteria have to be fulfilled when registering an asset. These criteria, denoted as rules, are:

Rule 1 Each asset – or more precisely, each release of an asset (see document "Vision of the Clearing Process") – MUST contain a manifest comprising at least the core metadata of the asset and all of its artefacts.

Proposed core asset metadata are:

- unique identifier
- title
- purpose
- abstract
- etc. (see document "Vision of the Clearing Process" and the SEMIC.EU specification for a complete list.)

Rule 2 For each artefact of an asset, at least one authoritative licence MUST be provided (see document "License Framework for Interoperability Assets"[11]). For non-English licences, an English translation MUST be provided.

As registering an asset shall be possible even for ideas for an asset, it is not required that an asset as to contain at least one artefact.

Rule 3 Each document MUST be provided in at least one of the representation formats supported by SEMIC.EU, e.g. as a PDF document.

Rule 4 The attribute values and the artefacts of the attributes MUST obviously be what they claim to be.

For example, a document presented as an English translation of a license but which is not written in English cannot be an English translation. This requirement prevents an incorrect document from accidentally being uploaded to the platform.

Rule 5 The values of the attributes, e.g. the abstract, as well as the artefacts themselves, MUST NOT contain discriminating contents.

Whereas all asset providers, in particular the asset owner, are responsible for delivering content that fulfils all of these requirements, it is the role of the clearing process manager to supervise this. The supervision may be supported by tools, but at least the fulfilment of the last two requirements has to be assured "manually" by the clearing process manager or authorized SEMIC.EU staff (see document "Vision of the Clearing Process").

[11] http://www.semic.eu/semic/view/documents/licensing-framework.pdf

These minimum requirements do not apply to assets being registered but apply to each publishing of content on the SEMIC.EU platform, i.e. for each release of an asset (see document "Vision of the Clearing Process") in further development stages.

Rule 6 The set of minimum requirements for registered assets MUST be adhered to in order to allow the publishing of each release of an asset.

3.1.2. Quality Requirements for Mature Assets

Evaluation process

To evaluate the quality of an asset and its artefacts during the maturity process, three levels of quality assessments are required for SEMIC.EU. These are:

- quality indicators
- quality labels
- progress levels

Quality Indicators

Quality indicators apply to an artefact or a number of artefacts. An example of an indicator applied to one artefact is the completeness of documentation for a given artefact.

Because SEMIC.EU is not restricted to fixed types of artefacts, an open approach has to be chosen concerning the quality criteria as well as the quality indicators of assets and artefacts. There are no predefined quality criteria and quality indicators related to mature assets except those required for registration (see above).

The definition of the quality criteria for an asset and its artefacts has to be part of the development of the asset itself and has to be provided by the asset owner. However, the assignment of quality criteria to an asset and its artefacts should be supported by predefined collections of quality criteria for predefined artefact types. These types have to be defined first to be provided as predefined ones on the platform. These predefined quality criteria could be taken as default or could be tailored by the asset owner when assigning the quality criteria to an asset and its artefacts (see below).

In addition guidelines should be provided on the platform that support the asset provider in choosing appropriate quality indicators to an asset and its artefacts.

Rule 7 The asset owner MUST provide appropriate quality indicators to the assets published on the platform.

As sources for developing the predefined quality criteria, existing quality models as ISO and means for defining quality models as the Goal Question Metric Approach (GQM) should be considered (see Appendix B.1).

In the long term for each kind of artefact there should be predefined quality criteria. The usual way of defining the appropriate quality for an asset should consist of selecting predefined quality criteria for the artefacts of an asset, in some cases tailoring them, but only as an exception defining specific quality indicators.

Types of Indicators

There are *STRICT QUALITY INDICATORS* that can be measured objectively, e.g., the number of logical units of a specification that are documented.

SOFT QUALITY INDICATORS, e.g. the readability and comprehensibility of the documentation, have to be assessed by the asset's community.

A third kind of indicator is *VITALITY MEASURES* that indicate the degree of user awareness and interaction. At least these different types of quality indicators have to be supported by SEMIC.EU.

It is stated that all indicators have to be defined by a metric, i.e. a measurement method and a measurement scale (see section 2.4). This also applies to soft indicators which implies that ratings have to be mapped to a scale and numerical values.

Only the first kind of quality indicators are a responsibility of the asset owner and only when not predefined quality criteria are used – these have to be measurable as well – the following requirement applies:

Rule 8 Quality indicators assigned to an asset by the asset owner MUST be measurable.

Quality Labels

Quality labels abstract from single indicators and subsume the results of several quality indicators. A quality label can be awarded if a corresponding predicate evaluates to the Boolean value "true". In the terminology of "Vision of the Clearing Process", the awarding of a quality label is called "branding".

In contrast to quality indicators that only apply to artefacts, quality label may apply to assets as well. As in the case of quality indicators, for predefined artefact types predefined quality labels should be provided as well as guidelines to support the asset owner

Rule 9 The asset owner MUST provide appropriate quality labels to the assets published on the platform.

As in the case of quality indicators the usual way is selecting predefined quality labels for an asset and its artefacts.

Versioning of quality indicators, criteria and labels

Since quality indicators, quality criteria and, in particular, quality labels may be adjusted during the development process of an asset and its artefacts, all of those have to be subjected to versioning. If, for instance, a new quality label is assigned to an asset, former releases of this asset should not be reassessed. It should be indicated, however, which versions of the quality criteria and labels the assessments of former releases were based on.

Progress Level

As opposed to the registration and conformance processes, the maturity process is cyclic. An asset usually will pass through the maturity process several times during its lifecycle (see document "Vision of the Clearing Process"). Hence, there is not one level of maturity; instead, there is progress in the asset's fulfilment of the quality criteria that is denoted as "quality progress" for that asset.

A potential user of an asset receives a brief overview of the current level of fulfilment of the quality indicators. To do this, the progress, following the approach of maturity levels as defined in CMMI (see Appendix B), has to be indicated by a specific quality label that indicates the quality progress of an asset. These specific quality labels, called progress levels, abstract from single quality labels. Particular quality labels are associated with each progress level. In order to reach a specific progress level, an asset has to hold the quality labels associated with it (see section 2.6). The asset owner is in charge of assigning the quality labels to the progress levels.

Rule 10 The asset owner MUST relate the quality labels of an asset to progress levels.

3.1.3. Quality Requirements for Conform Assets

A special quality branding is the conformance designation that is granted to assets that traversed the conformance process.

Assets assigned as "conform assets" should have reached a high progress level, but, as in the case of maturity, there are no predefined quality criteria for conformance. The assignment of conformance quality criteria to an asset and its artefacts should be supported by providing collections of quality criteria for specific artefact types. In particular, domain specific quality criteria should be contributed

by the domain experts that are involved in the conformance process. As in the maturity process, these quality criteria could be taken as default or could be tailored by the asset owner.

In principle, there is no difference in the mechanisms for quality criteria between mature assets and conform assets except that the defining the quality criteria for conform assets and the quality assessment is performed by domain experts from the Member States appointed by the SEMIC.EU Advisory Group (see document "Vision of the Clearing Process").

Rule 11 Quality criteria for conform assets MUST be provided by domain experts from the Member States.

3.2. Quality Requirements for the Quality Process

Configuring Quality Criteria

The need for specific quality criteria of an asset strongly depends on the intended application context. An asset developed in a national project, for example, and hence only available in one language, does not meet the quality criterion "multilingualism" that need to be fulfilled for reuse of the asset in a pan-European context. E.g. if only an Austrian project is interested in reusing a German asset, from the language point of view, the asset fulfils the requirements for reuse (apart from differences between "national instances" of the German language).

As described above, the initial definition of the quality criteria for an asset and its artefacts has to be part of the development of the asset itself.

Rule 12 The asset owner MUST assign the initial quality criteria to the asset and its artefacts.

As this above example shows, the requirements and the quality criteria to be met, also depend on the community of an asset and particularly its potential (re)users. Therefore, the entire asset community should be involved in customizing and enhancing the initial quality criteria for an asset and its artefacts.

In particular, this applies to the definition of the quality criteria for conform assets in which the conformance committee has to be involved. In contrast to mature assets, the quality criteria for conform assets has to be defined or at least confirmed by the domain experts from the Member States.

Rule 13 The quality criteria for conform assets MUST be defined or those assigned by the asset owner MUST be confirmed by domain experts appointed by the SEMIC.EU Advisory Board.

Quality Assessment

The quality of an asset and its artefacts is assessed by applying the related quality indicators, quality labels and by calculating the progress level.

Rule 14 The quality of assets and artefacts MUST be evaluated by applying the related or assigned quality indicators, i.e. applying the measurement method defined for the quality indicator (see previous section). The clearing process manager is in charge of this task.

Rule 15 Based on the evaluation of the indicators of an asset or an artefact, the quality labels related to these indicators MUST be evaluated. The clearing process manager is in charge of this task.

To support the assessment, tools or platform functions should be available.

The quality labels of all artefacts of an asset have to be aggregated in an appropriate way. This requires suitable mathematical functionality to calculate the quality label of an asset from the corresponding quality labels of its artefacts. Simple functions, such as constructing the median from the quality labels of the artefacts, may not suffice to yield the expected result.

Functionality for calculating the progress levels is needed as well. For the calculation of quality labels and progress levels appropriate tools or platform functions should be available.

Quality Reporting

For each artefact of an asset and for the asset itself, the quality of each criterion and its indicators has to be collected in a clearly arranged representation, e.g. in a quality matrix. This representation supports the asset developers in identifying strengths and weaknesses appropriately.

Rule 16 The measures of all indicators of an artefact MUST be represented in an easily readable format. Appropriate representations of the quality labels of an asset as well as for the quality labels of artefacts MUST be provided. The clearing process manager is in charge of these tasks.

Appropriate platform functions should support the clearing process manager in performing these tasks.

3.3. Quality Requirements for the Quality Framework Itself

As in level five of CMMI (see Appendix B.2) that has its focus on optimizing the software-development process itself, SEMIC.EU quality framework, i.e. the quality criteria for assets and artefacts as well as the quality process, should be subjected to a self-improving process.

For the quality criteria for artefacts and assets, partly the criteria may be applied to themselves, e.g. the soft quality criterion “completeness of documentation” may be applied to the formulation of quality criteria. Quality indicators applying to the quality process could be measuring the duration of quality assessments or other subprocesses of the clearing process.

As for the quality criteria for assets and artefacts, the SEMIC.EU community should be involved in the improvement of SEMIC.EU’s quality framework. This may involve the use of soft indicators as similar to the ones to those applied to assets and artefacts, e.g. ratings.

4. THE SEMIC.EU QUALITY MODEL

The following two sections outline the implementation of the quality framework in the SEMIC.EU platform starting with general considerations about the increase of quality during the clearing process.

Normally, it is assumed that with each publication and at each development stage, the quality of the interoperability asset increases (see figure 4-1).

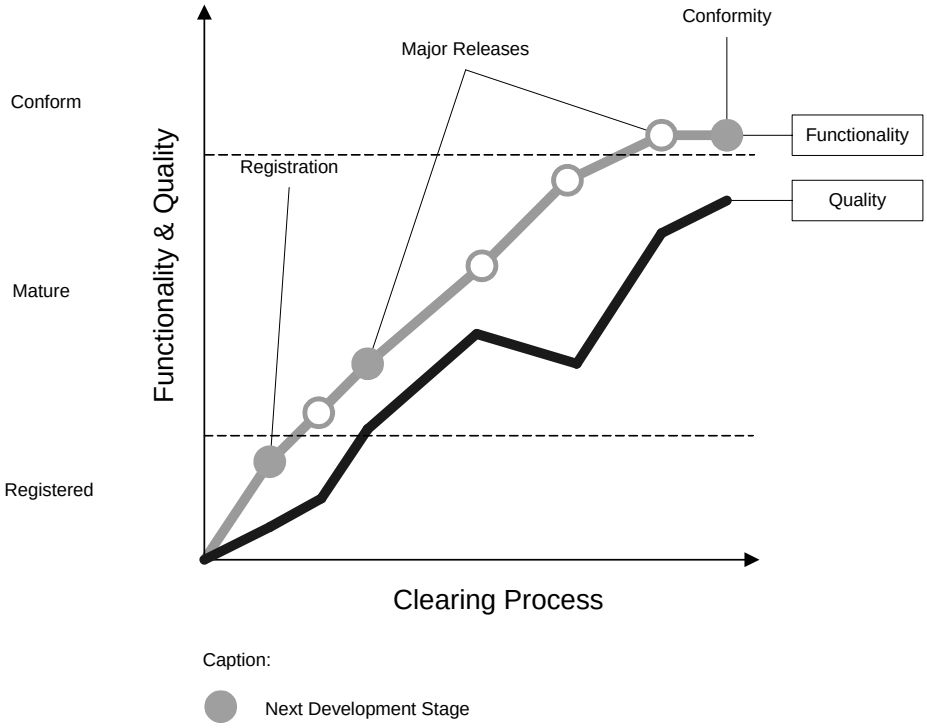

Figure 4-1: Example of the Quality Growth over the Clearing Process

In the first development stage, after the first publication of the interoperability asset in the registration process, it becomes visible to the asset's community. The asset owner should have personal interest that even this publication is valuable to the public and that the interoperability asset follows common conventions regarding its quality.

Thus, a registered asset could be of minimal quality, but this is not measured using common criteria. After an interoperability asset has passed the maturity process the first time and reaches the second development stage, it is reviewed by the asset's community, which evaluate it using the predefined minimum-quality criteria.

The maturity branding only indicates that an interoperability asset can be used in practical applications. This does not mean that the interoperability asset fully implements the required functionality or that all quality criteria have been fulfilled and have reached a maximum level. The intention is only that each time an interoperability asset passes the maturity process upon publication of a new major release, its functionality (completeness) and quality increases.

In two cases the quality of a minor release could decrease in comparison to that of the previous release. In the former case the quality may decrease because new functionalities and changes have been implemented that have a minor quality. In the latter case due to requirements of the asset audience new quality criteria may have been added or existing ones may have been replaced by stronger ones. In the latter case the decrease of quality is not absolute, but relative to the increase or tightening of the quality criteria.

If an interoperability asset passes the third and final development stage – conformity – the requested functionality has to be completely implemented and the quality must achieve a high or very high level in reference to its specific targets.

This shows that the statements about the quality of an asset using the development stages are possible but somewhat imprecise. Therefore, SEMIC.EU should provide a quality model that allows measurement of the quality of an interoperability asset in order to provide comparable results.

To document the overall improvement of an asset, a progress meter is needed that shows the quality progress level for an interoperability asset on a scale. This provides an asset user with an easy way to see the development state of an interoperability asset from the quality perspective. The quality progress level has to summarise the quality in a linear value relative to the final quality targets.

If a user wants to see the strengths and weaknesses of an interoperability asset, a quality report should be available. The detailed quality analysis should be based on various quality criteria. Furthermore, it should also be possible to identify the critical artefacts by looking at the evaluation of the quality criteria for each single artefact. The quality report comprises the results of a quality analysis, i.e. providing the results for each quality indicator, as well as in an aggregated form, i.e. providing the quality labels and the progress level.

This section introduces the quality model for SEMIC.EU, outlining how the quality criteria are measured using quality indicators for each artefact or a group of artefacts. The quality model includes a systematic approach to sum up the results for all artefacts using quality labels to present analysis details for an asset, showing the overall result for all quality criteria and calculating the quality progress level (see figure 4-2). This should give the SEMIC.EU audience a convenient overview of the quality of an interoperability asset as well as hints regarding what has to be improved. In the following the constituents of the quality model will be described in detail.

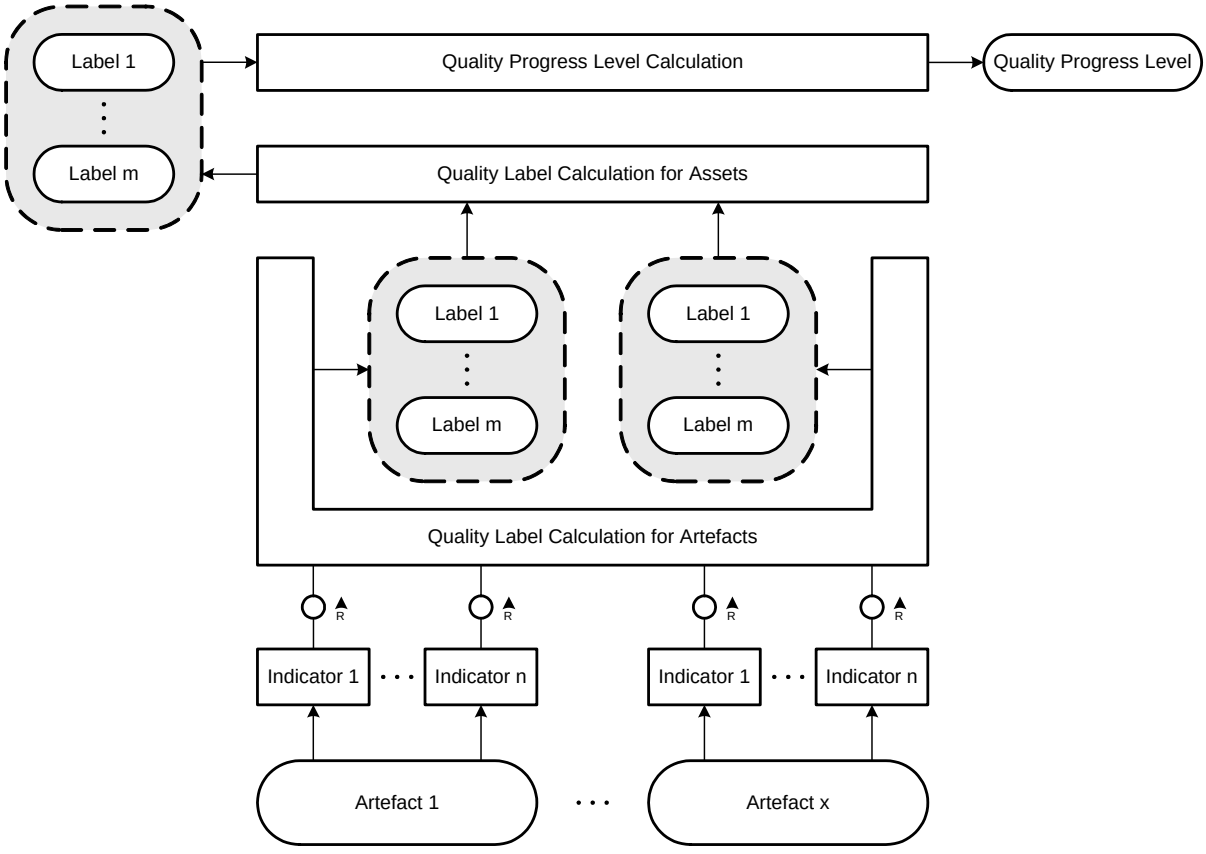

Figure 4-2 – FMC block diagram: Overview of the Quality Model

4.1. Quality Criteria and Indicators

Before an overall statement about the quality of an interoperability asset can be calculated, quality criteria need to be identified, measured, and evaluated. Several quality indicators of a quality criterion exist that define how to measure it in practice. All quality indicators of an interoperability asset are collected in a quality matrix.

An example could be the quality criterion “completeness of the documentation”. This quality criterion can be applied to artefacts using a formal notation like an XML schema. There could be several quality indicators to measure the completeness in practice:

- the ratio between the tag and attribute definitions and the related comment tag
- the ratio between the size of the document and the number of characters that make up its comments
- the ratio between the number of defined identifiers and how many of these occur in comments
- the opinion of the community members, assessed by means of a ballot

The first three examples show that there are indicators that can be measured in an objective way using semantic analyses. These are hard quality indicators (see 2.4). The last example is based on a more subjective opinion. The result of the related balloting depends on the people who take part and their assessments, which could change if the balloting were repeated; the result is not generally reproducible. This is an example of a soft quality indicator.

If indicators are objectively measurable, they should be reproducible and will not change over time as long as the measurement method or input does not change. Typically, these “hard indicators” can be measured automatically by implementing syntactical and semantic analysis which may be supported by software tools.

A quality criterion can be applied to a single artefact or a group of artefacts. If one wants to measure “the ratio between the number of defined requirements and the number of implemented requirements”, the requirement documents and all related implementation artefacts have to be analysed, e.g. using references as an indicator that point to the corresponding requirement.

A quality criterion can be domain independent like the previous examples, and the implementation of its indicators depends mainly on the artefact type. This kind of quality criterion should primarily be used in the maturity process since it makes improvement of the assets and their artefacts possible without restricting the asset owner, keeping the intentions of the owner in mind. There are also domain-dependent quality criteria, such as taking the existing standards obligatory for a domain into account, e.g. using HL7[12] for representation formats in the medical area.

The quality criteria are the core of the quality model. They can be measured using quality indicators that deliver characteristic values based on an automatic analysis or opinions from reviewers like the asset community or the conformance committee. The quality indicators depend on the artefact types and the domain, so there is no limit to the number of quality criteria and indicators. As a result, the concrete specification of the quality criteria and indicators are not part of this paper. The concrete specification of the quality criteria and indicators will be defined as separate interoperability assets. This will be explained later as part of the quality configuration process. In Appendix A an example is given.

4.2. Quality Labels

In general, it is possible to provide a quality report to the asset user and provider that includes a quality matrix showing the measures of all quality indicators grouped by the related quality criterion for each artefact and the entire interoperability asset. However, this report will not be very convenient if the number of indicators grows, so a branding system has been introduced that combines several quality criteria and their related quality indicators as a group of quality labels. A quality label is the

[12] See www.hl7.org

name of a predicate. The predicate is a complex Boolean expression that defines the condition to be validated for all quality indicators the predicate depends on. Each quality label in a group depends on the same indicators, but they have different conditions.

A simple example can be derived from the discussion of "completeness of the documentation" above. Based on the related quality indicators, four related quality labels are defined:

- The source code comments are completely available.
- The source code comments are generally available.
- The source code comments are partially available.
- The source code comments are hardly available.

This example shows that only one quality label of the group should be shown to the user at a time, e.g. if the comments are complete, they are generally available, too, but only the first label should be shown. Thus, the quality labels have an order, e.g. the first has the highest priority. However, the most important factor is whether there should be a strict boundary between the predicates. The four predicates could also be defined as:

- ratio between the tag and attribute definitions and the related comment tags > 95% and …
- 95% > ratio between the tag and attribute definitions and the related comment tags > 80% and …
- 80% > ratio between the tag and attribute definitions and the related comment tags > 30% and …
- 30% > ratio between the tag and attribute definitions and the related comment tags and …

This example shows that a strict boundary defined by the conditions could lead to volatile behaviour. A suggested solution might be to use a linear value. There could be predicates using a set of distinct values as a quality indicator, like available languages in the comments, with the following predicates:

- pan-European
- international
- multinational
- national

and the following conditions:

- Number of languages == 23 and …
- English is in languages
- Number of languages > 1
- Number of languages == 1

The special condition "English is in languages" shows the advantages of using distinct quality labels representing vague-but-easy statements. Instead of presenting tables with all measured values for the quality indicators in the quality report result, a limited list of derived quality labels is shown for each artefact.

Summing up the results for all the artefacts of an asset, results in a statement about the entire asset. This means the values for each label group have to be summed up from the artefacts, resulting in a single label assigned to the asset itself. This operation is difficult to define using the standard Boolean logic, where a statement is either "true" or "false". E.g. what is the result of having two artefacts with the quality label "Pan-European" and one artefact with the quality label "International", is the asset "Pan-European" or "International"? Do we need a less precise logic? Instead of using standard Boolean logic, "Fuzzy Logic"[13] (which enables linear functions to implement Boolean operations and instead of binary values, employs the closed interval from 0 to 1) may be a promising candidate for use in deriving the quality labels. A simpler but not necessarily better approach might be the possibility to calculate the predicate for the asset by applying the indicator not only to a single

[13] Zadeh, Lofti A.: Fuzzy Sets. Information and Control 1965 and Hellmann, Martin: Fuzzy Logic Introduction. Epsilon Nought Radar Remote Sensing Tutorials, 2001.

artefact, but to the aggregation of all concerned artefacts. Which approach is more general and comprehensible for the derivation of quality labels for assets has to be examined and verified in practice.

Quality labels allow combining quality indicators using a predicate function. The quality label is a property characterizing each artefact and the interoperability asset as a whole. The quality labels should be used in the quality report to outline the quality of the interoperability asset and its artefacts.

4.3. Quality Progress Level

To get a quick overview, a simple indicator that shows the actual quality of an interoperability asset is required for each asset. However, interoperability assets are hard to compare as they usually have different intentions and use different artefacts. Although there could be common quality criteria and indicators, the quality goals could always differ, e.g. some interoperability assets are developed for a pan-European target group, and others for international asset users.

The general quality indicator can only show the quality level relative to the individual quality goals assigned to an interoperability asset. Therefore, the indicator should show the "quality progress level" of an interoperability asset. This quick indicator should be simple to read and understand, like filling-level meter. The filling-level meter can be precisely scaled and should be used to indicate the overall quality of an interoperability asset (see figure 4-3).

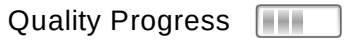

Figure 4-3: Level Meter

The quality labels that combine the quality indicators were introduced in subsection 4.2. In the overall context of an interoperability asset, a quality label of an interoperability asset represents a certain quality goal. The definition of the quality progress level is directly based on the quality goals represented by the quality labels.

There should be six quality-progress levels[14] - from zero to five - available to have an applicable system. For each level, the asset owner, in consultation with the asset community or the conformance committee, can assign multiple quality labels that have to be fulfilled to reach that specific quality progress level. A higher quality progress level can only be reached if the lower quality progress level is reached. It is not required that a quality label is assigned to each quality progress level. If this is done, however, the calculation of the quality progress level should be based on imprecise logic, too. There should be no leaps if a quality progress level has an empty set of assigned quality labels. Instead, the level should be reached when the higher quality level has reached a specific degree.

The quality goals as defined by the quality labels will originally be assigned by the asset owner to the quality progress levels. Therefore, a problem might arise in that the quality progress levels between interoperability assets are not comparable if an interoperability asset owner sets low quality goals. The clearing process supports this case, as the asset community has the opportunity to use their review option to demand changes to the definition of the quality progress levels and to specify the quality indicators to be used. This follows the principles of a self-regulating process.

The quality-progress level is a quick indicator to show how many of the quality goals represented by the quality labels have been reached by the interoperability asset. The quality-progress level can be used in search results and abstracts to give the user an overview. The detailed rules for the calculation of the quality progress level from the assigned quality labels will be defined in the detail specifications.

[14] This is a common number of levels used to describe hit rates in search results of search engines and electronic libraries.

5. THE SEMIC.EU QUALITY PROCESS

As outlined in section four the quality framework for SEMIC.EU implements three quality processes to support the widely accepted maturity model (CMM/CMMI) defined by the Carnegie Mellon University (see Appendix B.2):

- The quality assessment process describes the use and integration of the quality model into the clearing process.
- The quality configuration process describes the development and maintenance of the quality labels, criteria, and indicators.
- The quality improvement process describes the continuous evolution of the quality framework and its related quality model and quality processes.

This section explains how to implement these different quality processes. Implementing of these processes mainly consists of refining SEMIC.EU's clearing process.

5.1. Quality Assessment Process

Each time an interoperability asset passes through the maturity or conformance process its quality has to be evaluated.

Figure 5-1 and 5-2 outline the implications for the clearing process defined in the document "Vision of the Clearing Process", especially its sub-processes "maturity process" and "conformance process". The related quality tasks are assigned to the existing subtasks of the clearing process. The quality tasks only refine these subtasks.

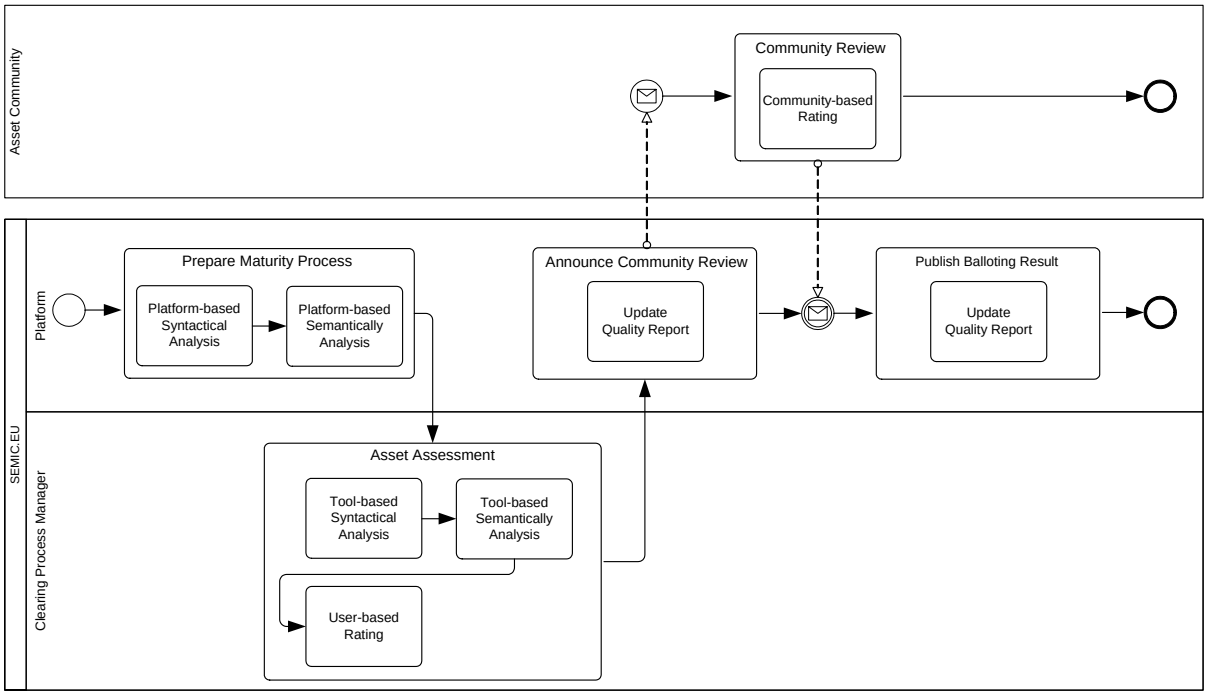

Figure 5-1 BPMN: Quality Assessment in the Maturity Process

The quality model for SEMIC.EU stipulates that the quality indicators have to be measured, the quality labels derived from the measured values of the quality indicators, and the overall quality progress level calculated.

All these results will be included in the quality report, which is part of the interoperability asset's manifest (see document "Vision of the Clearing Process"). The manifest only holds the latest quality report[15].

As the quality report is trusted information, it should be protected by a security hash to guarantee the information's integrity.

There are two possibilities to generate the quality report. An external option is for the asset provider or the clearing process manager to generate it using a quality assurance tool. This might present a problem if the asset community does not trust the asset provider. This should not present a major problem, however, since the results can be verified by each member of the asset community. It requires, though, that the quality assurance tools be widely – perhaps freely – available. Furthermore, if the clearing process manager has to provide the quality reports, he himself could become a bottleneck, and the quality reports would not immediately be available.

A more user-friendly option should integrate the automated quality analysis for hard indicators using syntactic and semantic analyses, the calculation of the quality labels, and the calculation of the quality progress level in a future release of the SEMIC.EU platform.

This should be implemented when the quality model has been fully developed, tested, and approved in practice. The soft indicators from ballots and user-based ratings can be inserted into the manifest by special platform functions, e.g. a balloting component or through the use of tools.

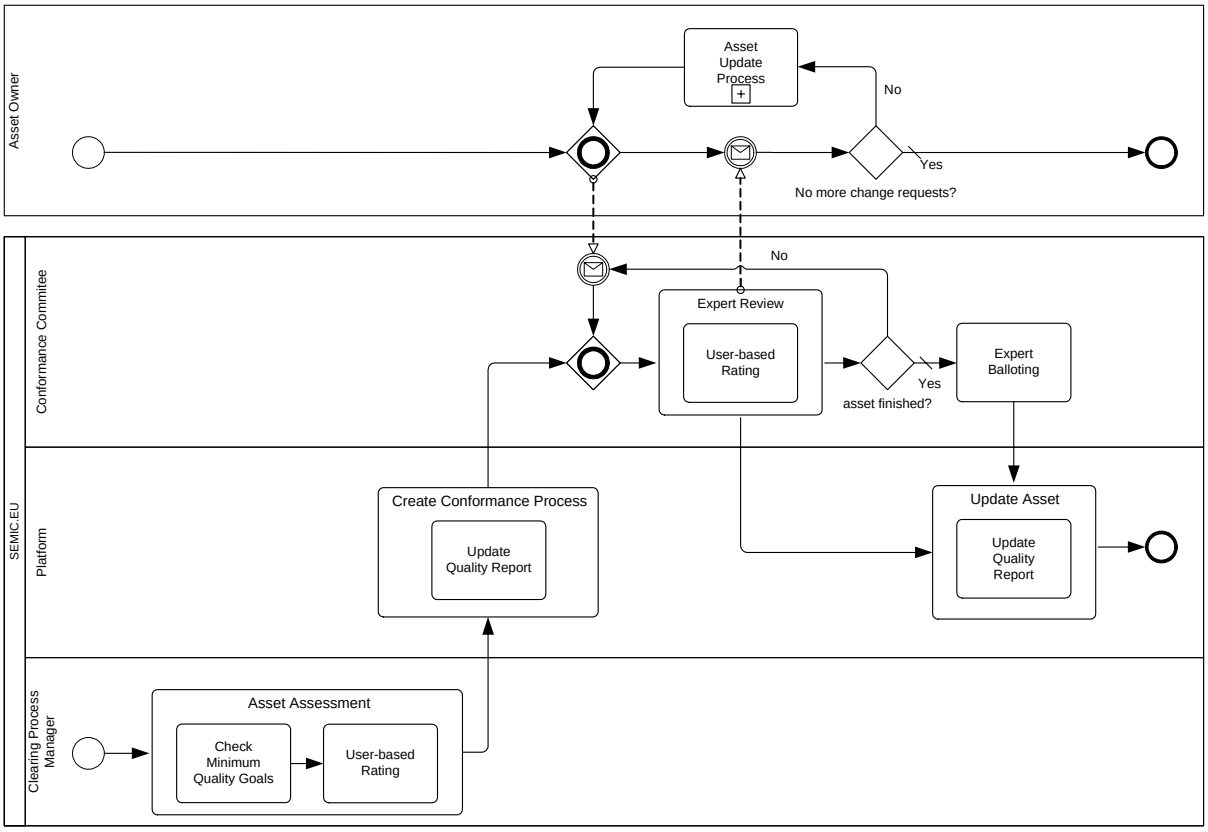

Figure 5-2 BPMN: Quality Assessment in the Conformance Process

As the quality report is part of the meta-information stored in the manifest, this file has to be extracted from the asset archive, updated, and written back into the archive.

The asset community will be able to see the quality report[16].

[15] If it is required to track the history of the quality reports, an additional file should be created that collects the history for further evaluations and presentations.

5.2. Quality Configuration Process

As mentioned previously, the quality framework and its quality model do not define the required quality criteria and quality indicators in detail. These depend on the artefact types and the application domain and will be improved and extended over time. Especially at the beginning, the required quality criteria and quality indicators need to be identified, and some experience is required to justify the quality indicators for practical use.

To support asset providers in developing quality criteria, SEMIC.EU should, based on a definition of artefact types, provide collections of quality criteria for artefact types, e.g. quality criteria for XML schemata as notation conventions etc. (see Appendix A). Therefore, to implement the quality framework in the SEMIC.EU platform, the following tasks have to be accomplished:

- definition of artefact types
- definition of quality criteria for artefact types
- definition of quality labels for artefact types
- definition of minimum quality goals or preferably quality objectives for mature and conform assets
- development of tools for the automatic evaluation of quality criteria that – in the long run – should be provided to the users
- elaboration of guidelines on how to choose and apply quality criteria to assets and artefacts

As for the development of interoperability assets, the SEMIC.EU community should be able to be involved and actively participate in these tasks.

5.3. Quality Framework Improvement

Due to the ongoing evolution of SEMIC.EU's goals and for the accommodation of the experience that is gained, SEMIC.EU's quality framework as well as the entire clearing process will be subject to improvement themselves. This approach also conforms to the CMM/CMMI maturity model.

As for the definitions related to the quality configuration process, the SEMIC.EU community should be able to be involved and actively participate in the improvement of the quality framework as well.

The improvement of the quality framework should be an ongoing target that is not in the focus of the first version of the SEMIC.EU platform.

[16] The quality report can be visualised by transforming the manifest using a style sheet that extracts the quality report and generates an output in HTML format. Charts can be generated using JavaScript libraries and functions.

Appendix A. EXAMPLE

The following section provides a basic example that is intended to explain the quality assessment for a given artefact type. The example focuses on XML schema representations and suggests a subset of quality criteria, quality indicators, quality labels, and progress level definition that might be applied to describe the overall quality of this artefact type.

It is not the intention of this section to provide a complete set of criteria, indicators, and labels; the goal is to communicate the idea of how quality can be made assessable.

A.1. Quality criteria

For the quality assessment of XML Schema artefacts, the following quality criteria can be identified:

VALIDITY
: The examined XML Schema representation is valid in reference to the W3C schema specification.

COMPLIANCE WITH NAMING CONVENTIONS
: The examined XML Schema representation is compliant to common naming conventions.

COMPLETENESS OF DOCUMENTATION
: The examined XML Schema representation is complete regarding the documentation of schema content.

NOTE: *This list only represents a subset of all imaginable criteria (see figure A-1). The identification and definition of a complete catalogue has to be part of the quality configuration process.*

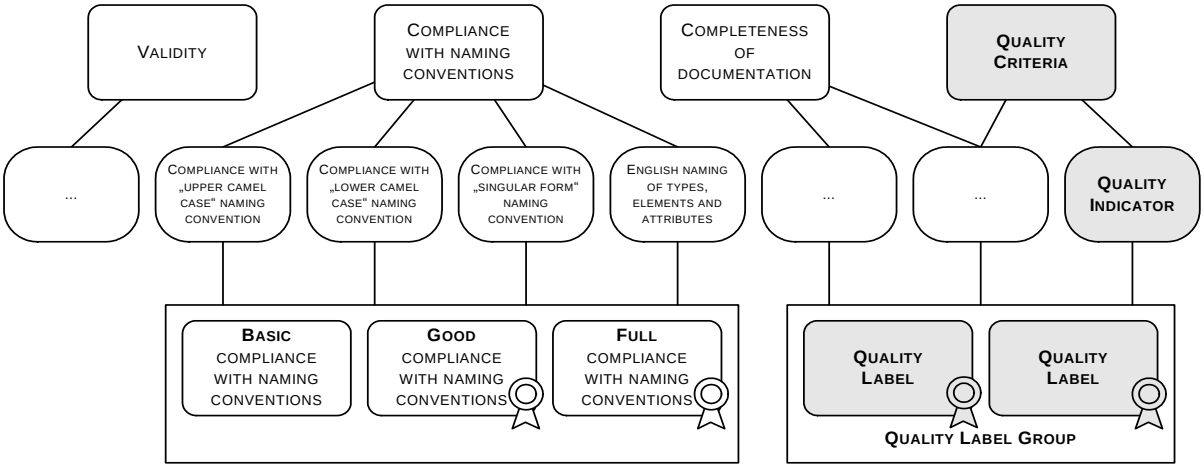

Figure A-1: Example for Quality Criteria, Indicators and Labels

Quality indicators

This subsection only refers to indicators that are connected to the "COMPLIANCE WITH NAMING CONVENTIONS" criterion. Most of the quality indicators are based on the "XML Naming and Design Rules" by UN/CEFACT[17].

[17] United Nations Centre for Trade Facilitation and Electronic Business

COMPLIANCE WITH "UPPER CAMEL CASE" NAMING CONVENTION How compliant is the naming of Elements and Types to the upper camel case (UCC) naming convention?	
Method:	Count the number of incorrect terms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:element name="**languageCode**"> → INCORRECT <xsd:element name="**LanguageCode**"> → CORRECT

Table A-1: Upper Camel Case

COMPLIANCE WITH "LOWER CAMEL CASE" NAMING CONVENTION How compliant is the naming of Attributes to the lower camel case (LCC) naming convention?	
Method:	Count the number of incorrect terms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:attribute name="**UnitCode**"> → INCORRECT <xsd:attribute name="**unitCode**"> → CORRECT

Table A-2: Lower Camel Case

COMPLIANCE WITH "SINGULAR FORM" NAMING CONVENTION How compliant is the naming of Types, Elements, and Attributes to the "singular form" naming convention?	
Method:	Count the number of incorrect terms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:element name="**ItemsQuantity**"> → INCORRECT <xsd:element name="**ItemQuantity**"> → CORRECT

Table A-3: Singular Form

AVOIDANCE OF ACRONYMS AND ABBREVIATIONS How compliant is the naming of Types, Elements, and Attributes to the naming convention that only permits use of a well-defined number of acronyms and abbreviations, e.g. ID?	
Method:	Count the number of terms with unknown acronyms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:element name="**ItemQnt**"> → INCORRECT <xsd:element name="**ItemQuantity**"> → CORRECT <xsd:element name="**ItemID**"> → CORRECT

Table A-4: Avoidance of Acronyms and Abbreviations

AVOIDANCE OF PERIODS, SPACES, AND OTHER SEPARATORS OR CHARACTERS NOT ALLOWED BY W3C XML 1.0 How compliant is the naming of Types, Elements and Attributes to the naming convention that only permits the a-z, A-Z character set?	
Method:	Count the number of incorrect terms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:attribute name="**unit_Code**"> → INCORRECT <xsd:attribute name="**unitCode**"> → CORRECT

Table A-5: Avoidance of Separators or Characteristics not Allowed by W3C XML 1.0

ENGLISH NAMING OF TYPES, ELEMENTS, AND ATTRIBUTES How compliant is the naming of Types, Elements and Attributes to the naming convention that only permits English terms?	
Method:	Count the number of unknown terms and compare it with the total number of terms.
Value range:	0 <= x <= 1
Interpretation:	The closer to 0, the more compliant
Source of input:	XSD-Representation
Example:	<xsd:attribute name="**produktNummer**"> → INCORRECT <xsd:attribute name="**productNumber**"> → CORRECT

Table A-6: English Naming of Types, Elements, and Attributes

A.2. Quality labels

Quality labels and quality label groups refer to certain quality criteria and indicators. The following subsection defines a quality label group based on the "COMPLIANCE WITH NAMING CONVENTIONS" criterion and its connected indicators.

NOTE: The following examplary quality-label group only refers to a single criterion and its indicators, but it is imaginable and intended to combine various quality criteria in one quality label (group).

The label group consists of the following quality labels/predicates:

BASIC COMPLIANCE WITH NAMING CONVENTIONS
: The value of each indicator is less than 0.05 (less than 5% of non-compliant naming).

GOOD COMPLIANCE WITH NAMING CONVENTIONS
: The value of each indicator is less than 0.02 (less than 2% of non-compliant naming).

FULL COMPLIANCE WITH NAMING CONVENTIONS
: Every quality indicator possesses the value 0 (fully compliant naming).

NOTE: Quality labels are awarded when the label-specific requirements are met. The calculation method presented in the above example is a simplification. A detailed method to determine if requirements have been met will be subject to further discussion.

A.3. Quality progress level

The assignment of quality labels to specific quality progress levels is one of the important features to make the quality of an asset visible to the user community. The following illustration shows the assignment of the above-defined labels to certain progress levels.

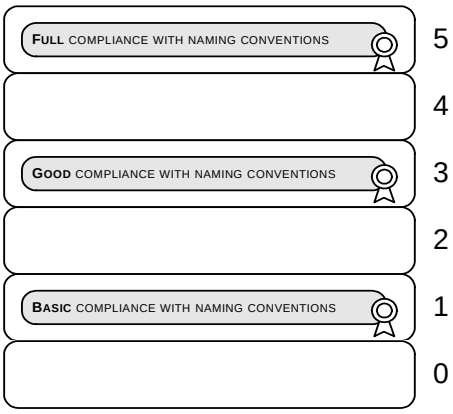

Figure A-2: Example for Progress Levels

The illustration may be interpreted as follows:

To reach the first quality progress level, the "*BASIC COMPLIANCE WITH NAMING CONVENTIONS*" label must have already been awarded to the asset and its artefacts (in our case, xml schemas). This means that all indicator values referred to by the quality label must be in the defined range (less than 5% of non-compliant naming). To reach the third progress level, higher naming-compliance requirements have to be met. These are represented by the "*GOOD COMPLIANCE WITH NAMING CONVENTIONS*" label. To achieve the highest quality progress level, the naming has to be fully compliant (represented by the "*FULL COMPLIANCE WITH NAMING CONVENTIONS*" label).

Appendix B. EXISTING QUALITY MODELS AND QUALITY PROCESSES

This examination of existing software-related quality models and quality processes is not providing a comprehensive investigation of existing models and processes, but selects the most important approaches in order to identify elements that could be incorporated in the SEMIC.EU quality framework.

B.1. Quality Models

Well-known software quality models include those by McCall[18], Boehm[19], the FURPS[20] (Functionality, Usability, Reliability, Performance, and Supportability) model developed at Hewlett Packard, and the ISO 9126[21] Software Engineering – Product Quality Standard (2001 – 2003). As ISO 9126 can be seen as an extension of the other models, they are not considered here.

Furthermore, an approach to defining quality models, the Goal Question Metric Approach, is taken into account.

ISO 9126 Software Engineering – Product Quality

ISO 9126 applies to the quality of a software product and covers the complete documentation of the product's development. ISO 9126 implements the Factor/Criterion/Attribute model (see section two "Quality Factor/Criterion/Attribute"). The quality model defined in ISO 9126-1 identifies the following six quality factors:

- functionality
- reliability
- usability
- efficiency
- maintainability
- portability

These factors are further subdivided into quality criteria. As an example, the factor usability is subdivided into understandability, learnability, operability, attractiveness, and usability compliance.

Examples of uses of the quality model defined in ISO 9126 are to:

- *"validate the completeness of a requirements definition;*
- *identify software requirements;*
- *identify software design objectives;*
- *identify software testing objectives;*
- *identify quality assurance criteria;*
- *identify acceptance criteria for a completed software product."*

Parts 2 - 4 of the standard propose internal, external, and quality-in-use metrics that apply to the product itself, the behaviour of the system, or the extent a product meets user needs, respectively.

Many of the assets that SEMIC.EU will contain in the future will not be complete software products. However, at least some of the quality criteria defined in ISO 9126 like understandability will apply to all kinds of assets and artefacts. Thus, the standard can be a source of selecting and deriving quality criteria as well as indicators for interoperability assets and artefacts.

[18] McCall J.A., Richards P.K., Walters G.F., Factors in Software Quality, Rome Air Development Center 1977
[19] Boehm B.W., Brown J. R., Kaspar H., Lipow M., MacLeod G.J., Merrit M.J., Characteristics of Software Quality, Amsterdam: North-Holland 1978
[20] Grady R.B., Caswell D. L., Software Metrics: Establishing a Company-Wide Program, Englewood Cliffs: Prentice Hall 1987
[21] ISO 9126 Software Engineering – Product Quality Standard (2001 – 2003)

The Goal Question Metric Approach

The Goal Question Metric (GQM) Approach provides a systematic procedure for defining specific quality models.

"GQM defines a measurement model on three levels:

- *Conceptual level (goal)*
  A goal is defined for an object for a variety of reasons, with respect to various models of quality, from various points of view, and relative to a particular environment.
- *Operational level (question)*
  A set of questions is used to define models of the object of study and then focuses on that object to characterize the assessment or achievement of a specific goal.
- *Quantitative level (metric)*
  A set of metrics, based on the models, is associated with every question in order to answer it in a measurable way."

The GQM approach could be used for the definition of appropriate quality criteria for specific assets which are not covered by ISO 9126.

B.2. Quality Processes

There are a number of quality management approaches with a much broader scope than that of SEMIC.EU. These approaches cover all aspects of SEMIC.EU's quality framework.

Quality management is a method to help ensure that all the activities necessary to design, develop, and implement a product or service are effective and efficient with respect to the system and its performance. Quality management can be considered to have three main components: quality control, quality assurance, and quality improvement. Quality management not only focuses on product quality, but also the means to achieve it. Quality management, therefore, uses quality assurance and control of processes as well as products to achieve consistent quality.

In practice, there are several methods for quality improvement: product improvement, process improvement, and people-based improvement.

- The product-based approach means that software product quality can be evaluated by measuring attributes.
- The process-based approach means to improve the quality of any of the lifecycle processes.
- The people-based approach means that the quality is defined by the product user (fitness for use).

Many techniques and concepts have evolved to improve product or process quality:

ISO 9000 ff

ISO 9000 – 9004[22] is an international standard family for quality management systems. It describes a general and organizational framework for quality management of products. A product, in terms of ISO, can mean a physical object, services, or software. To evaluate the quality of a product through various quantitative means, a set of quality characteristics that describe the product and form the basis for the evaluation is required.

TQM

As the name indicates, TQM (Total Quality Management)[23] seeks to achieve quality management in all of its aspects. As defined by the International Organization for Standardization (ISO): *"TQM is a management approach for an organization, centred on quality, based on the participation of all its*

[22]ISO 9000 ff Quality management systems

[23]There is not a single definitive source for TQM, but several concepts implement the principles of TQM, e.g. the EFQM Excellence Model promoted by the European Foundation for Quality Management (EFQM)

members, and aiming at long-term success through customer satisfaction and benefits to all members of the organization and to society."

The ISO 9000 family of standards as well as TQM guide quality management for entire organizations in both the software sector and in other branches. Therefore they are more general than CMM / CMMI that is focused on software and systems development, and SPICE that is focused on software development respectively. Hence ISO 9000 ff and TQM are not further taken into account.

CMM / CMMI

The Capability Maturity Model (CMM)[24] is a software process-improvement approach that provides organizations with the essential elements of effective processes. Its successor, Capability Maturity Model Integration (CMMI)[25], extends CMM's scope to software and systems development.

The approach can be used to guide process improvement across a project, a division, or an entire organization. CMMI helps integrate traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes.

At the heart of CMM / CMMI is the maturity model. This maturity model is a structured collection of elements that describe aspects of the maturity of the software- and systems-development process. CMM / CMMI define five maturity levels. *Maturity levels consist of a predefined set of process areas. The maturity levels are measured by the achievement of the specific and generic goals that apply to each predefined set of process areas.*

The process areas of CMMI that should be established in and adapted to SEMIC.EU, are

- *REQUIREMENTS MANAGEMENT*
  This process area corresponds to the configuration of quality criteria.
- *REQUIREMENTS DEVELOPMENT*
  This process area corresponds to customizing quality criteria.
- *PROCESS AND PRODUCT QUALITY ASSURANCE*
  This process area corresponds to the assessment of the quality of assets and artefacts.
- *MEASUREMENT AND ANALYSIS, VALIDATION AND VERIFICATION*
  These process areas corresponds to the fact that quality criteria should be measurable
- *ORGANISATIONAL INNOVATION AND DEPLOYMENT, CAUSAL ANALYSIS AND RESOLUTION*
  These process areas corresponds to optimizing quality model and quality process

SPICE

SPICE (Software Process Improvement and Capability Determination) is a framework for the assessment of software processes (ISO 15504[26]). The core of this norm is process improvement in a technology organization and the determination of the capability of potential suppliers to deliver software products.

SPICE provides similar process areas as CMM / CMMI. SPICE also incorporates the concept of optimizing the process as part of the process itself. In contrast to CMM, but analogue to CMMI in the so-called continuous representation, maturity is defined for single sub-processes and not for the overall process.

[24] http://www.sei.cmu.edu/cmm/
[25] CMMI for Development, Version 1.2, Technical Report CMU/SEI-2006-TR-008
[26] ISO/IEC Information technology – Process assessment

Appendix C. BUSINESS PROCESS MODELING NOTATION

The "Business Process Modelling Notation" (BPMN)[27] is standardised by the Object Management Group (OMG)[28].The Scope of BPMN is defined by the OMG as follows:

"The Business Process Management Initiative (BPMI) has developed a standard Business Process Modeling Notation (BPMN). The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation."

This short introduction to the BPMN only describes the core elements used in the graphs of this document. There are three kinds of flow elements: Activities, Events and Gateways. Activities (see figure C-1) are a generic term for work a process describes. A task describes rather detailed what should be done. Multiple tasks could be bundled as a sub-process. This is used in an overview of a process. In the detailed diagram the task is expanded and all details are included.

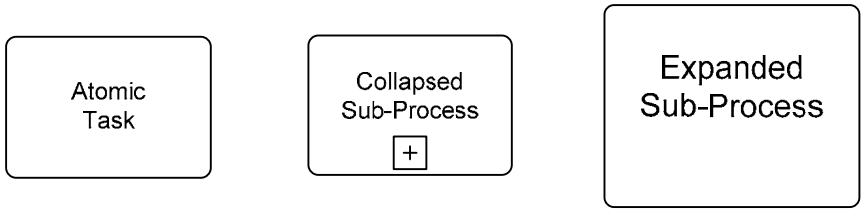

Figure C-1 – BPMN: Activities

Every process has one or more starting points and ending points. These are illustrated as events (see figure C-2). Intermediate results and waiting points are also represented as events. The type or trigger of an event can be highlighted by a symbol. An external "message" to start a process or symbolising the result is very common. A negative result is marked by a "cancel" event. A "link" is used if the process is to be continued by another process.

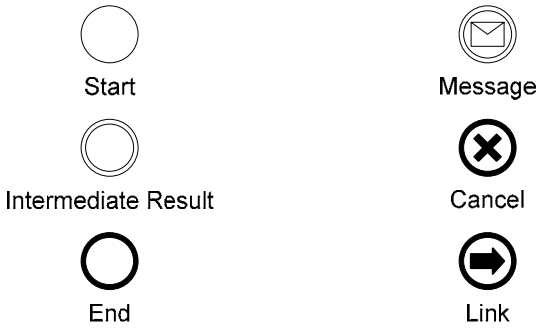

Figure C-2 – BPMN: Events

"A gateway is used to control the divergence and convergence of sequence flow" (see figure C-3). An important use case of gateways is concurrency (parallel sequence) and decisions points.

[27] http://www.bpmn.org/
[28] http://www.omg.org

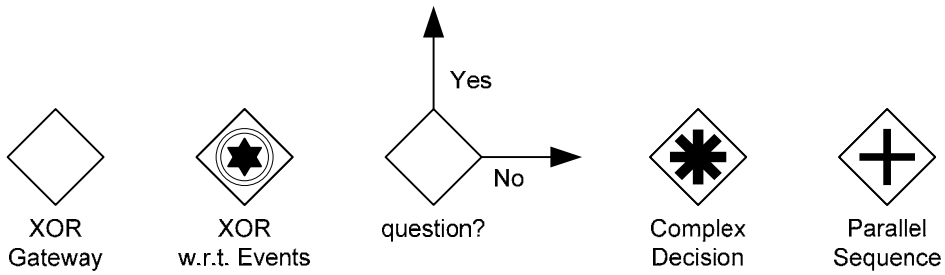

Figure C-3 – BPMN: Gateways

The events and activities are interconnected in order to illustrate the flow of information (see figure C-4). The most important connection is the sequence flow, which defines one or more paths from the starting to the ending points. The sequence flow specifies a continuous process inside a pool or a single lane. The message flow describes an external collaboration between two pools or single lanes. Artefacts are used to complement a message flow to signal the exchange of data objects.

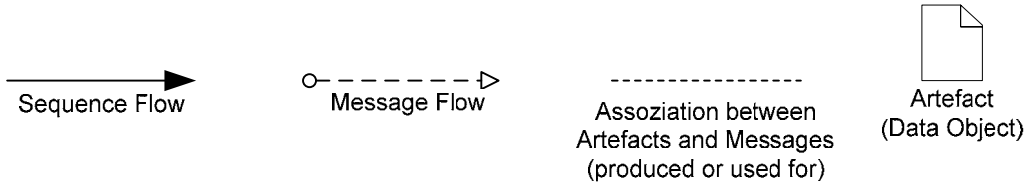

Figure C-4 – BPMN: Connections

The primary modelling elements are the lanes and the pools (see figure C-5) which are used to outline a process. A lane or pool is assigned to a role that may be a person, system or an abstract entity. A pool subsumes multiple roles and is typically a more abstract role like an organisation.

Figure C-5 – BPMN: Swim Lanes

Comments are written inside a square bracket (see figure C-6) and attached to the related graphical object.

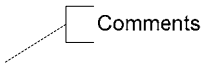

Figure C-6 – BPMN: Comments

Appendix D. FUNDAMENTAL MODELLING CONCEPTS

"Fundamental Modelling Concepts[29] (FMC) provide a framework to describe software-intensive systems. It strongly emphasizes the communication about software-intensive systems by using a semi-formal graphical notation that can easily be understood. FMC distinguishes three perspectives to look at a software system:

- *Structure of the system*
- *Processes in the system*
- *Value domains of the system*

FMC defines a dedicated diagram type for each perspective. FMC diagrams use a simple and lean notation. The purpose of FMC diagrams is to facilitate the communication about a software system, not only between technical experts but also between technical experts and business or domain experts.

Compositional structure diagrams depict the static structure of a system, and the relationships between system components. System components can be active or passive. Agents are active system components. They perform activities in the system. Storages and channels are passive components which store or transmit information."[30]

[29] http://www.fmc-modeling.org/
[30] http://en.wikipedia.org/wiki/Fundamental_modeling_concepts