

# ISO/IEC SQuaRE. The second generation of standards for software product quality

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## Abstract

*Quality needs for both customer and software supplier have become more complex and critical than ever. This paper presents the current ISO software products and process quality standards and our positioning of these standards as software quality engineering instruments, including the phases of product development to which they map. The first generation of these product-related and process-related standards are currently in their final ISO publication stage but, having been developed independently, their usage by practitioners will be particularly challenging. While ISO software experts are already at work defining strategies to develop the next generation of these standards, help is needed by practitioners to understand, deploy and leverage ISO standards that are now becoming available to them.*

*This paper addresses first the immediate need for integrating these process and product related standards in the development process through our quality engineering approach which maps them at the detailed level of the life cycle. Then, work in progress at the ISO level to develop the next generation of these software quality related standards is presented.*

## Key Words

Software product quality, software product life cycle, quality measurement, quality evaluation, ISO/IEC 9126, ISO/IEC SQuaRE

## 1. Introduction

The business value of a software product results from its quality as perceived by both acquirers and end-users. Therefore, quality is more and more often seen as a critical attribute of the software product, since its absence results in dissatisfied users and financial loss, and may even endanger lives. Increasing recognition of the importance of software quality causes a shift in the "center of gravity" of software engineering from creating a technology-centered solution toward satisfying the stakeholders. Software development organizations confronted with such a shift are, in general, not

adequately equipped to deal with it. Up until recently, they did not have at their disposal the quality-related measurement instruments that would allow (or "facilitate") the engineering of quality throughout the entire software product life cycle. To develop such quality-related measurement standards, the ISO/IEC working group six (WG6) of the software engineering subcommittee (SC7) has worked over the past ten years on the development of standards for software product quality; this ISO working group is now in the process of completing the publication of two series of standards: ISO/IEC 9126 - *Software product quality* [1] and ISO/IEC 14598 - *Evaluation of software products* [2]. Table 1 presents the unit standards included in these two series.

**Table 1.** List of ISO/IEC standards referenced

No.	Title
9126-1	Software Engineering – Product quality – Quality model
9126-2	Software Engineering - Product quality – External quality metrics
9126-3	Software Engineering - Product quality – Internal quality metrics
9126-4	Software Engineering - Product quality – Quality in use metrics
14598-1	Information Technology – Software product evaluation – General overview
14598-2	Information Technology – Software product evaluation – Planning and management
14598-3	Information Technology – Software product evaluation – Process for developers
14598-4	Information Technology – Software product evaluation – Process for Acquirers
14598-5	Information Technology – Software product evaluation – Process for Evaluators
14598-6	Information Technology – Software product evaluation – Documentation of evaluation modules
15288	Information Technology -- Life Cycle Management -- System Life Cycle Processes
15939	Information Engineering -- Software Measurement Process

Two years ago, the international members of WG6 carried out an analysis of what was then a 'work in progress' to verify the applicability and relevance of the series of standards being developed. This study highlighted the need for further improvements and led to two strategic decisions for the ISO subcommittee on software engineering:

- Complete for 2003 the publication of the work in progress on both the ISO/IEC 9126 and the ISO/IEC 14598 series,
- Reanalyze, prioritize and address all issues identified and initiate development of the second generation of the series of software quality standards:

*ISO/IEC 25000 SQuaRE – Software Product Quality Requirements and Evaluation*

In parallel, other ISO working groups developed other process related standards for the engineering of software, and in particular ISO 15288 on life cycle phases, and ISO 15939 on the software measurement process (Table 1). The first generation of these product-related and process-related standards are currently in their final ISO publication stage but, having been developed independently, their usage by practitioners will be particularly challenging. While ISO software experts are already at work defining strategies to develop the next generation of these standards, help is needed by practitioners to understand, deploy and leverage ISO standards that are now becoming available to them.

This paper addresses first the immediate need for integrating these process and product related standards in the development process through our quality engineering approach which maps them at the detailed level of the life cycle. Then, ISO work in progress to develop the next generation of these software quality related standards is presented.

In section 2, we use the software quality engineering approach to discuss software quality within the product development life cycle, and where current ISO/IEC quality product standards fit into the life cycle. Some of the integration challenges which have been identified by the ISO experts themselves, are included in the discussion. In section 3, the strategy designed to tackle these challenges is presented, including the design of the next generation of ISO quality product standards. A summary and the status of work in progress are presented in section 4.

## **2. Applying ISO/IEC quality engineering in the software product life cycle**

The topic of quality in the software product life cycle has been discussed for several years now, and from many distinct points of view [3, 4, 5, 6, 7, 8], among them the difficulty of finding the appropriate quality engineering mechanisms that could be applied in all phases of the life cycle of a software product [9]. For instance, while there are a number of ISO standards which can be used for product development and for products in use, none yet exists that applies to product definition itself (Figure 1). Moreover, here is no detailed mapping which specifies

precisely *how* the standards are used across all phases of the life cycle of a software product.

To define such a mapping, a generic life cycle model should be chosen to serve as a reference. We have chosen as the reference the recently published standard, ISO/IEC 15288 – *System life cycle processes* [10], which identifies all the generic phases of the development process (Figure 2). It is to be noted that, in ISO 15288, software development processes are referred to as 'technical processes'.

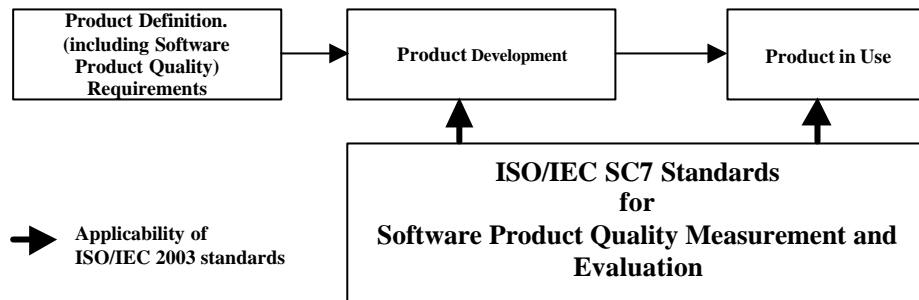
Figure 3 presents next the mapping between the broad product life cycle of our reference model from Figure 1 and the technical processes from the ISO/IEC 15288 software product life cycle phases.

The objective of software product quality engineering is to achieve the required quality of the product through the definition of quality requirements and their implementation, measurement of appropriate quality attributes and evaluation of the resulting quality. The ISO subcommittee on software engineering has already developed the first generation of software quality engineering standards for software products, that is, ISO/IEC 9126 – *Software Engineering – Product quality* and ISO/IEC 14598. ISO/IEC 9126 defines the quality model, characteristics, subcharacteristics and measures useful in the process of quality measurement, but does not offer guidance for quality evaluation. This guidance is provided through another series of standards aligned to ISO/IEC 9126: ISO/IEC 14598 -- *Evaluation of software products*. This latter series of standards provides both guidance and requirements for the evaluation process, and does so in three distinct contexts: development, acquisition and independent evaluation.

Both series of standards are based on the model described in Figure 4, where the quality of the process influences the internal quality of the software product, which in turn influences its external quality, and then its quality in use. In addition, ISO/IEC 9126 provides not only an inventory of candidate measures for each of these views, but also indicates from which phase of the life cycle these measures can be obtained. This is illustrated in Figure 5 with a mapping of ISO/IEC 9126 to each of the phases of the life-cycle described in ISO/IEC 15288.

The ISO/IEC 14598 generic model of an evaluation process, supported by the quality measurements from ISO/IEC 9126, is presented in Figure 6, and specifies four major sets of activities for an evaluation, together with the relevant detailed activities:

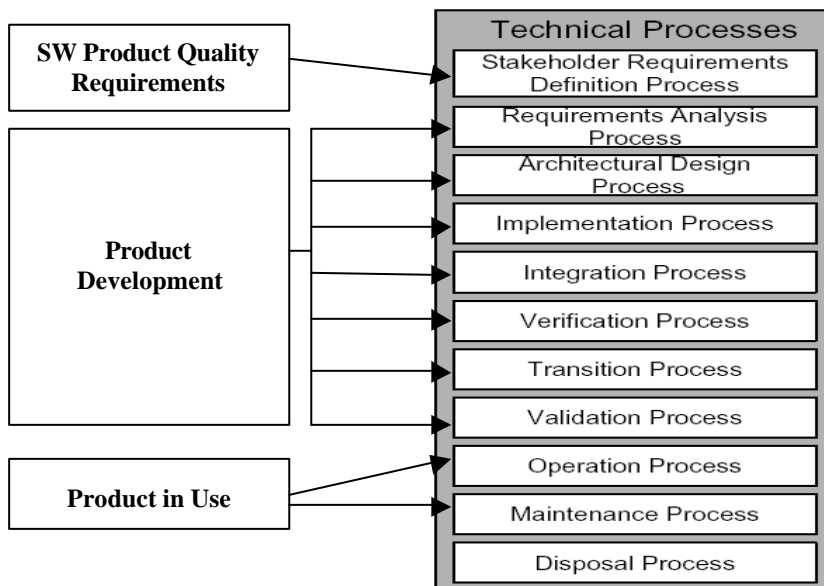
1. Establishment of the evaluation requirements
2. Specification of the evaluation
3. Design of the evaluation
4. Execution of the evaluation



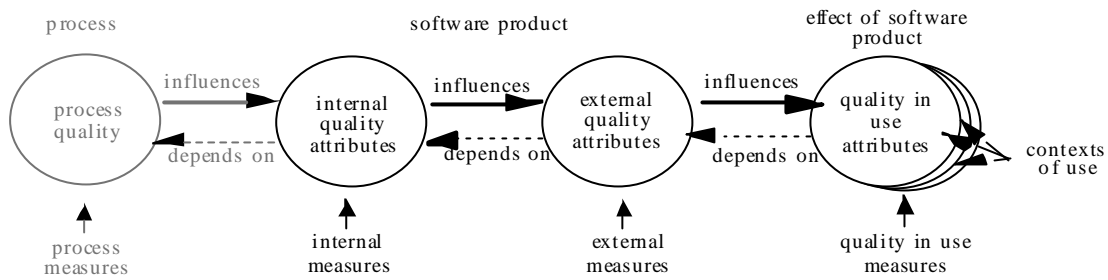
**Figure 1 :** High-level mapping of ISO/IEC SC7 software product quality standards and a software life cycle



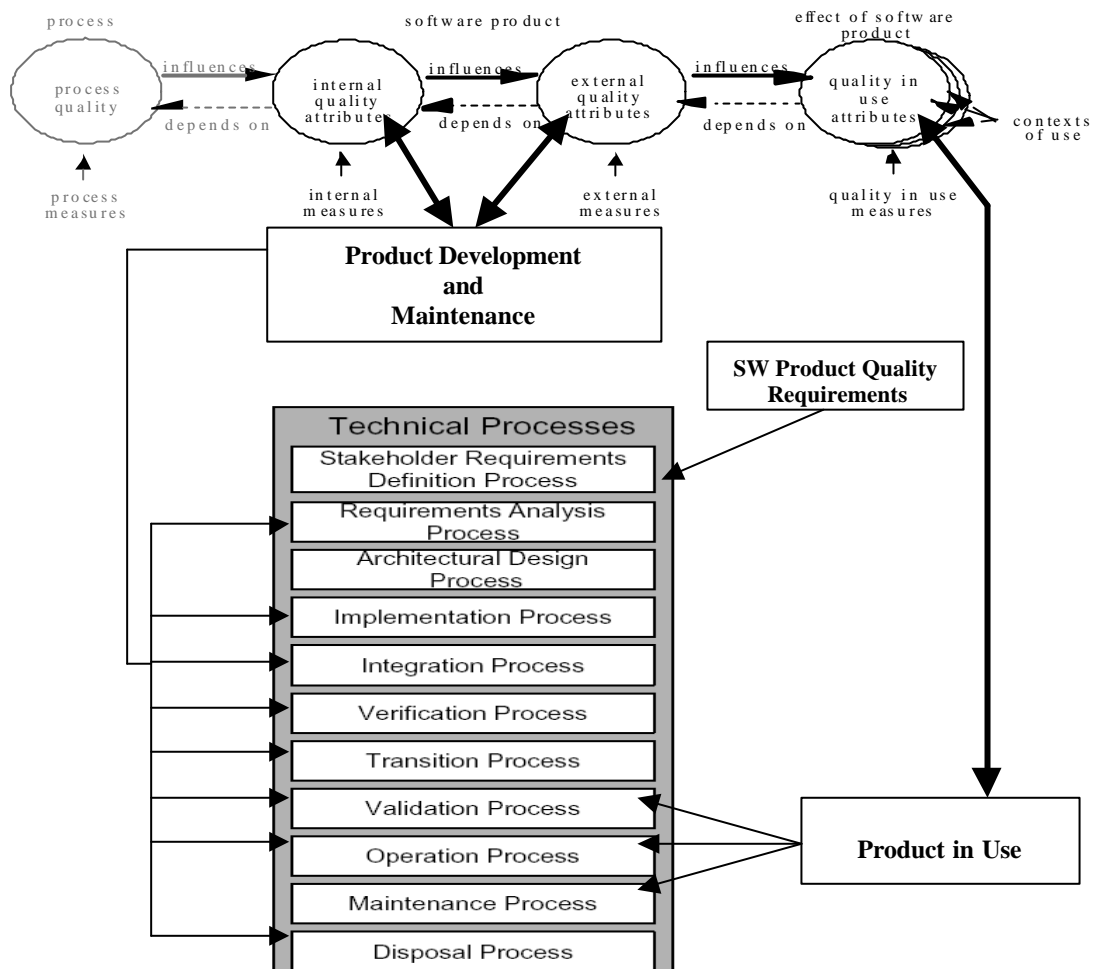
**Figure 2 :** ISO/IEC 15288 software product life cycle phases and related technical processes



**Figure 3 :** Product life cycle mapping to technical process life cycle



**Figure 4 :** ISO/IEC 9126 -- Model of quality in the product life cycle



**Figure 5 :** Current mapping of ISO/IEC 9126 to the ISO/IEC 15288 software product life cycle phases

We also indicate in Figure 6 which inputs are required from ISO/IEC 9126, that is, its quality model and corresponding measures.

The standardization work on ISO/IEC 14598 was completed prior to the publication of the 2002 version of ISO/IEC 9126, and, while it provides generic linkages between the high-level concepts of the ISO 9126 quality

instruments (i.e. characteristics, subcharacteristics and measures), it is not yet specified in the format of specific prescriptive quality engineering practices. In particular, the current versions of these ISO/IEC standards do not provide a clear mapping between the quality engineering instruments already developed and the various phases of the product development life cycle. This is illustrated in Figure 7.

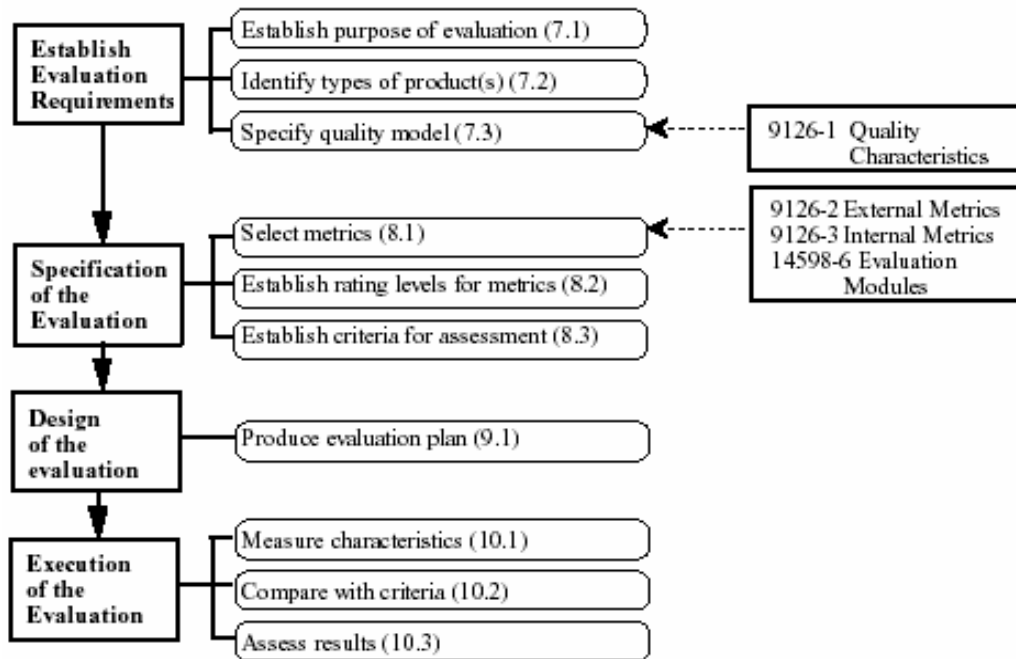


Figure 6: ISO/IEC 14598 -- Evaluation process

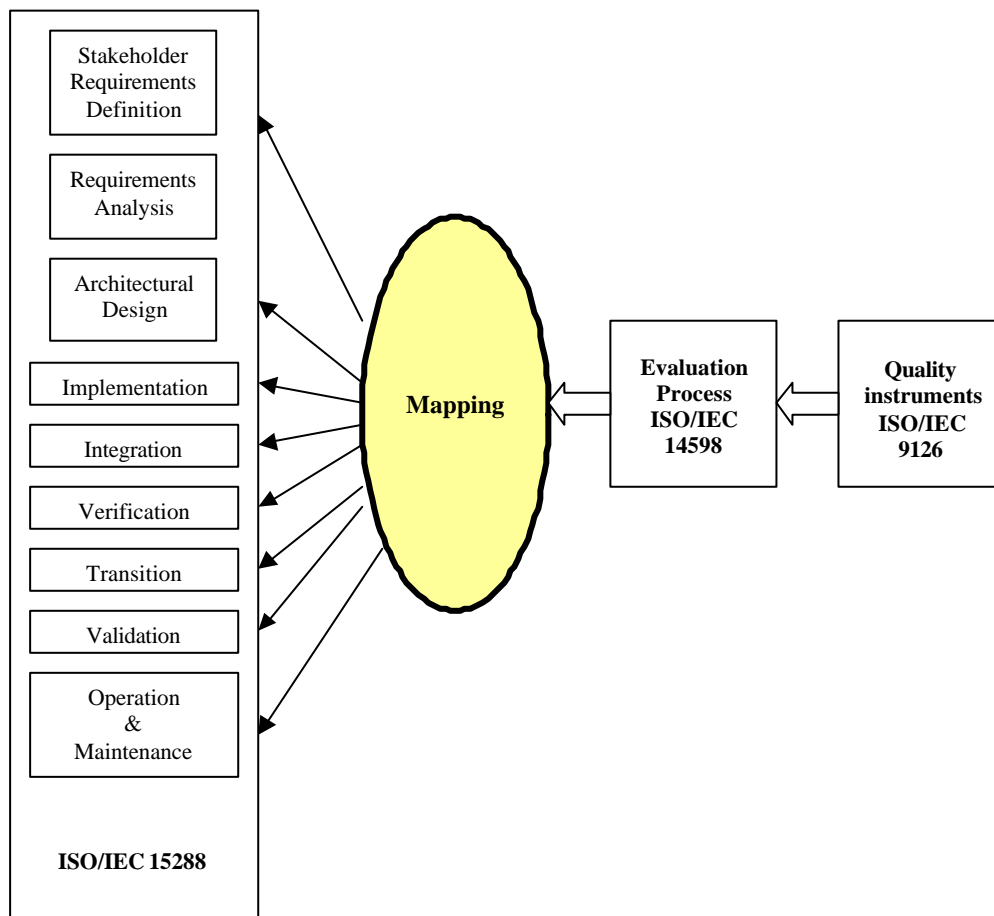


Figure 7 : Missing mapping between ISO/IEC 15288 life cycle phases and ISO/IEC 9126 and 14598

Currently, it is therefore left to each individual practitioner to identify the links between the life cycle phase-related quality requirements and their measurement counterparts. This, of course, requires literacy on the part of the practitioner in ISO quality models and related measures, in addition to relevant training and experience in their application in organizational contexts.

In 2001-2002, ISO/IEC SC7 WG6 conducted a Web-based survey [11] to collect feedback from practitioners and the academic community in order to prepare the next generation of ISO quality engineering instruments. From this Web survey, WG6 experts identified the following areas for improvement:

- Completeness:
  - A need for a new standard to tackle the software quality requirements specifications;
  - A need for verification of the quality measures<sup>1</sup>, with required enhancements as necessary;
- Consistency with other ISO standards published in parallel:
  - Modification of vocabulary to comply with ISO/IEC SC7 directives;
  - Compliance of new versions of measurement-related models to comply with the new ISO/IEC 15939 measurement model;
- Scope of applicability:
  - Enhancements to better address quality needs in system life cycle phases;
  - User guidance as part of the series of standards;
  - Addition of execution workflow recommendations, i.e. explicit methodology for adequately applying the quality engineering instruments within the standards.

### 3. Design of the second generation of software product quality standards

ISO/IEC SC7 WG6 has decided to respond to this feedback by designing the second generation of quality standards, referred to as SQuaRE or Software Product Quality Requirements and Evaluation. The following strategy was adopted to develop this second generation of quality standards:

- merger of the two current separate series into one, harmonized structure,
- introduction of a new organization of the standards,
- introduction of a new general reference model,
- introduction of detailed guides,
- introduction of a standards on Measurement Primitives,
- introduction of a standard on Quality Requirements,

- introduction of guidance on the practical use of the series with examples,
- coordination and harmonization of the software measurement model with ISO/IEC 15939.

The general objective for this next series is to respond to the evolving needs of users through an improved and unified set of normative documents covering three complementary quality processes: requirements specification, measurement and evaluation. The motivation for this effort is to supply those responsible for developing and acquiring software products with quality engineering instruments supporting both the specification and evaluation of quality requirements. SQuaRE will also include criteria for the specification of quality requirements and their evaluation, and recommended measures of software product quality attributes which can be used by developers, acquirers and evaluators. SQuaRE will consist of 14 documents grouped under five thematic headings:

- Quality Management,
- Quality Model,
- Quality Measures,
- Quality Requirements, and
- Quality Evaluation.

The *Quality Management* theme will contain the unit standards defining all common models, terms and definitions referred to by all other standards in the SQuaRE series. Readers are reminded that the Quality Management theme will deal with software products, in contrast to the distinct processes of Quality Management as defined in the ISO 9000 family of standards. This theme will include two unit standards:

- *Guide to SQuaRE* – to provide the SQuaRE structure, terminology, document overview, intended users and associated parts of the series, as well as reference models;
- *Planning and management* – to provide the requirements and guidance for planning and management support functions for software product evaluation.

The *Quality Model* theme will contain the detailed quality model and its specific characteristics and subcharacteristics for internal quality, external quality and quality in use. This theme will include:

- *Quality model and guide* – to describe the model for software product internal and external quality, and quality in use. The document will present the characteristics and subcharacteristics for internal and external quality and characteristics for quality in use.

The standards in the *Quality Measures* area will be derived from ISO/IEC 9126 and ISO/IEC 14598. This theme will cover the mathematical definitions and

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<sup>1</sup> ISO/IEC 9126 uses the term “metric”

guidance for practical measurements of internal quality, external quality and quality in use. In addition, it will include the definitions for the measurement primitives for all other measures. This theme will also contain the Evaluation Module to support the documentation of measurements. This theme will include:

- *Measurement reference model and guide* – to present introductory explanations, the reference model and the definitions that are common to measurement primitives, internal measures, external measures and quality in use measures. The document will also provide guidance to users for selecting (or developing) and applying appropriate measures;

Example: the phase of construction creates intermediate, non-executable software products that can only be evaluated from static point of view. In this case, the user will be directed to Internal quality measures standard, where he can choose the measures that best serve his information needs;

- *Measurement primitives* – to define a set of base and derived measures, being the measurement constructs for the internal quality, external quality and quality in use measurements;
- *Measures for internal quality* – to define a set of internal measures for quantitatively measuring internal software quality in terms of quality characteristics and sub-characteristics;
- *Measures for external quality* – to define a set of external measures for quantitatively measuring external software quality in terms of quality characteristics and subcharacteristics;
- *Measures for quality in use* – to define a set of measures for measuring quality in use. The document will provide guidance on the use of the quality in use measures.

The *Quality Requirements* theme will contain the standard for supporting the specification of quality requirements, either during software product quality requirement elicitation or as an input for an evaluation process:

- *Quality requirements and guide* - to enable software product quality to be specified in terms of quality requirements;

The *Quality Evaluation* theme will contain the standards for providing requirements, recommendations and guidelines for software product evaluation, whether performed by evaluators, acquirers or developers:

- *Quality evaluation overview and guide* – to identify the general requirements for specification and evaluation of software quality and to clarify the generic concepts. It will provide a framework for evaluating the quality of a software product and for

stating the requirements for methods of software product measurement and evaluation;

- *Process for developers* – to provide requirements and recommendations for the practical implementation of software product evaluation when the evaluation is conducted in parallel with development;
- *Process for acquirers* – to contain requirements, recommendations and guidelines for the systematic measurement, assessment and evaluation of software product quality during acquisition of “commercial-off-the-shelf” (COTS) software products or custom software products, or for modifications to existing software products;
- *Process for evaluators* – to provide requirements and recommendations for the practical implementation of software product evaluation, when several parties need to understand, accept and trust evaluation results;
- *Documentation for the evaluation module* – to define the structure and content of the documentation to be used to describe an Evaluation Module.

To help users of the SQuaRE series, each theme will have its own guide. These guides will document:

- terms and definitions used in each theme,
- logical structures represented by the models (e.g. quality model),
- recommendations for the application of the theme standards, and
- relationships among documents.

Among all the SQuaRE guides, one in particular – *Guide to SQuaRE* – will provide a different type of help to the user. Apart from its basic role of introducing all terms and definitions common to the series, this guide will present the whole SQuaRE series as a collection of quality engineering instruments and will provide help to the user in navigating and choosing among the detailed standards as a function of his role, information needs and tasks. This type of guidance will use the *SQuaRE general reference model* to illustrate the decision and execution processes. Figure 8 presents a simplified version of this model.

At the General Guidance level, the user will be supported in learning the structure of the series, common vocabulary, common models, types of documents and navigation rules.

At the Particular Guidance level, the user will be supported in identifying the particularities of his tasks and in making appropriate choices of standard documents which are necessary to execute these tasks.

At the Quality Engineering level, the user will be helped to translate his choice of applied documents into a choice

of which corresponding quality engineering instruments will be used in execution at the Requirements-Planning-Measure-Evaluate level (e.g. the characteristics and measures required to evaluate quality in use in the Target of Process - User Task).

The Requirements-Planning-Measure-Evaluate level will represent the phases of a complete quality engineering process which may, but will not necessarily have to be executed in its entirety. Together with the next level, Target of Process (Software Product or User Task), this level will define the applicability area that corresponds to quality engineering instruments chosen at the Quality

Engineering level. This choice may be fine-tuned through iterations between the two levels.

The SQuaRE general reference model has been developed to offer assistance to all users, regardless of their experience, roles and information needs. This document will also explain the relationship between quality engineering instruments and phases of the life cycle of a software product.

To increase the *user friendliness* of this second generation of standards, a hyper-media edition is also being developed.

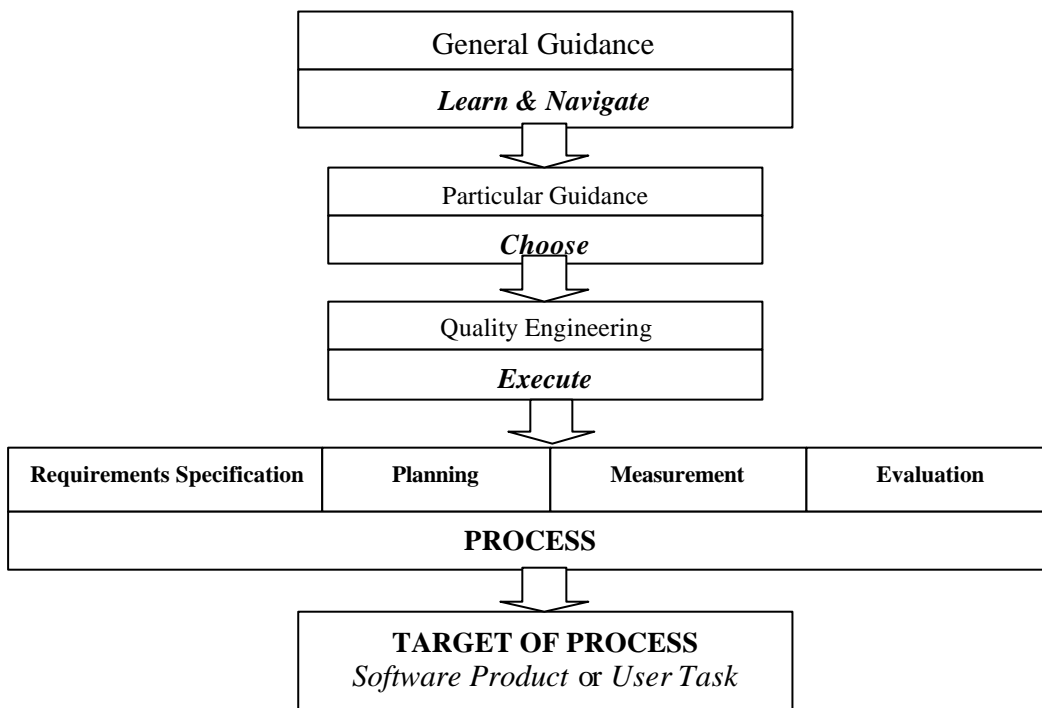


Figure 8: Simplified SQuaRE general reference model

#### 4. Summary and work in progress

ISO/IEC working group six (WG6) of the software engineering subcommittee (SC7) is in charge of the development of standards for software product quality and is in the process of completing the publication of two series of standards: ISO/IEC 9126 - *Software product quality* [1] and ISO/IEC 14598 - *Evaluation of software products* [2]. Two years ago, the international members of WG6 carried out an analysis of what was then a 'work in progress' to verify the applicability and relevance of the series of standards being developed. This study highlighted the need for further improvements, and led to two strategic decisions for the ISO subcommittee on software engineering:

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In May of 2000, the ISO/IEC SC7 WG6 experts started work on this second generation of standards, referred to as the new *SQuaRE* series. Each of the standards in this series must go through the regular ISO review processes:

- Working draft (WD);



- Committee draft (CD), and final committee draft (FCD);
- Draft international standard (DIS), and final draft international standard (FDIS).

Of course, depending on the number and technical nature of the national comments submitted at each voting ballot phase, there can be multiple iterations within each of the above review processes.

The current status of the SQuaRE project is as follows:

- One of four (4) new standard documents will be launched in 2003 for the second CD voting ballot;
- The three remaining new standard documents are in their first CD phase;
- All documents inherited from ISO/IEC 9126 and ISO/IEC 14598 are in their revision/synchronization phase, to be ready for IS publication at the same time as the additional new standard documents to be developed.

This iterative process of international scrutiny of the project and its documents will produce an international consensus for this next generation of software product quality standards.

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## Acknowledgments

The authors express sincere appreciation to all ISO/IEC JTC1/SC7 WG6 members, especially to the convener, editors and co-editors, and to the WG6 secretariat for their continuous efforts and contributions. They are: Motoei Azuma, Nigel Bevan, Jorgen Boegh, Gilbert Le Gall, Michael Gayle, Vipula Godamunne, John Harauz, Tom Ipoly, Antonia Jeanrenaud, Ota Novotony, Danilo Scalet, Renate Sitte, Yukio Tanitsu, Jiri Vanicek, Atsushi Yamada, and Toshihiro Komiyama.