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System Quality Requirement and Evaluation

Importance of application of the ISO/IEC25000 series

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Abstract-ISO/IEC25000 (SQuaRE) series set of standards are very useful for the purpose of quality requirement and evaluation of system in the development and acquisition project. ISO/IEC25030 was published in 2007, which supports specifying a quality requirement for system and software products. ISO/IEC25040 was published in 2011, which supports quality evaluation for systems. Currently ISO/IEC JTC1/SC7 has published ISO/IEC250241:2012. Quality requirement and evaluation of system can be performed from the view point of system and software product quality model defined in ISO/IEC25010, 25012, 25020 and quality measurement of system can be executed by using the measurement method defined in ISO/IEC2502n. This paper proposes the importance of quality requirement and evaluation approach by using ISO/IEC25000 series of international standards.

Keywords- *Systems and Software Quality; Quality Requirement; Quality Evaluation; Quality Model; Quality in Use; Quality Characteristic; Quality Attribute; Quality Measure; Internal Measure; External Measure; Evaluation Process; Developers; Acquirers; Independent Evaluators; Development; Acquisition; Static Product; Dynamic Product*

I. INTRODUCTION

As the use of information technology grows, the information technology brought remarkable innovation to human society. Especially critical information systems, such as security critical, human life critical, economically critical and safety critical, are now indispensable and vital foundation to our society and companies.

If we wish to realise the sustainable and felicitous society in such a life environment, we have to realize the high-quality information systems.

For the purpose of development or acquiring information system successfully, it is very important to specify the quality requirement and realize the most suitable system product correspond to real customer needs in to the target system product during possible early stage of development.

In order to set out adequacy of the developing information system projects and to secure the quality of the system, quality requirements and evaluation of system and software is extremely important.

If we take the wrong approach of quality requirement in accord with the real needs of the customer, it may cause a big loss for a purpose of investment. Result of requirements analysis reveals problems such as miss-predictions/miss-estimation of purpose conformance and/or importance and/or a failure in completeness in the established target of the developing information system, system users could not obtain the effectiveness equivalent of investment's worth which they truly expect, even if the project is completed without relevant issues.

However, the quality requirements analysis is a very difficult work because it is non-formulaic and demands much of project planners' technical perceptiveness, sense in balance and experiences. Traditionally, analysis of quality requirements of a product has been conducted through questionnaires or interviews with customers.

Generally, survey items on questionnaires were selected either from previous questionnaires of similar system or based on survey investigator's personal experience with and preference of product requirements. This kind of lack of structure and incompleteness in the traditional approach introduced missing or biased product requirements and errors in prioritizing requirements to implement in the requirement analysis of a product, resulting in failing to assure the completeness of the quality requirement definition of a product.

What is worse, if the set target itself lacks validity, despite being set aiming at increasing the company value, the project then naturally gets stuck in the middle and, not only is unable to achieve the target, but also has risks to end up collapsing at the end.

On the other hand, we have been working on developing the techniques (SQuaRE) for quality requirements and evaluation for system and software product for a long time in ISO/IEC JTC1 (Joint Technical Committee 1 of the International Organization for Standardization and the International Electro technical Commission) SC7WG 6 (software and systems engineering under ISO technical committee, working group six).

As part of this project, we have also worked on the developments of ISO/IEC9126[3] and 14598[14][18] series, which are the standards to provide supporting technology for above-mentioned works.

Currently, the method of quantitative quality evaluation based on ISO/IEC9126-n software quality model and quality

measurements are widely recognized and used in worldwide for the purpose of the quality evaluation of software product.

ISO/IEC9126-1:2001 [3] defines the six quality characteristics of the software product. These six quality characteristics are described based on the model of Boehm [11] or McCall [12], or from the view point of a stakeholder's wide experience, which are considered as necessary and independent from user's point of view. This model introduced in ISO/IEC9126-1:2001 was formulated with almost perfect quality target-establishment and evaluation perspective of the quality of system, which covers both structure and completeness based on the hypothesis of a company, even with specific target, being "a kind of system".

But, these previous series of standards could not support requirement specification at early stage of development, and did not have standard corresponding to quality requirement analysis. If we could not be clearly defined quantitative quality requirements before development. We could not perform suitable implementation correspond to real needs of customers. Because, specified quantitative quality requirements may be the objective and criteria of evaluation for target system and software product.

Exactly, this lack of solution could not realize effective development activity and could not improve both system design and evaluation processes.

Recently, previous ISO/IEC9126 and 14598 series of standards have revised to the ISO/IEC25000 (SQuaRE) series of standard in order to add supporting standard for quality requirement of system and software.

The ISO/IEC published ISO/IEC25030 [7] [13] quality requirements standards, which is useful for specifying systems and software product quality requirements at early stage of development. This standard was enacted lately for the first time in the world as the standards that assist requirements specifications based on the system and software quality model described in ISO/IEC9126-1:2001.

ISO/IEC25040 [8] is useful for evaluating systems and software product quality based on the defined quantitative quality target by using ISO/IEC25030.

ISO/IEC25041, evaluation guide for developers, acquires and independent evaluators, which is currently published.

Also, ISO/IEC9126-1 has revised to ISO/IEC25010:2011 in order to defined additional two characteristics [4].

Currently, ISO/IEC JTC1/SC7/WG6 is developing international standards on quality measures as ISO/IEC2502n, which is the part of 25000 series - Quality measurement division.

Hence, in this paper, we propose here the general concept of quality requirement and evaluation based on the product quality model and framework of ISO/IEC25000 series and importance of this approach for applications.

II. CONCEPT OF 25000 SERIES

A. Organization of 25000

Figure 1 shows the organization of the ISO/IEC25000 (SQuaRE) series of standards defined in ISO/IEC25000 [1].

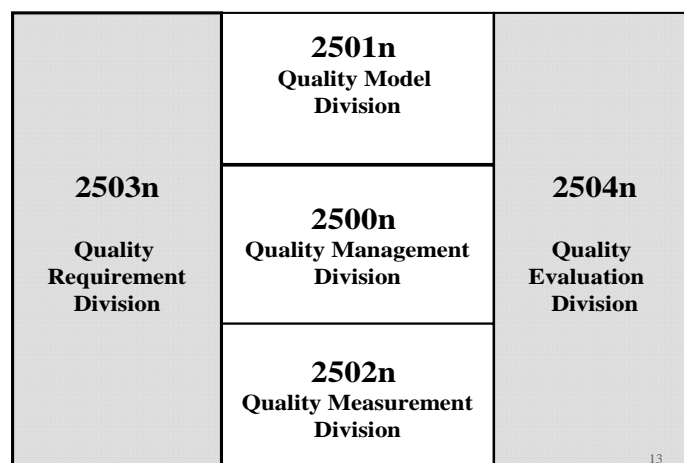


Fig. 1 Organisation of the 25000 series of international standards -ISO/IEC25000 [1]

Purpose of the ISO/IEC25000 series of standards is to assist developing and acquiring system and software products with the specification of quality requirements and evaluation. It includes five core divisions: quality management, quality, model quality measurement, quality requirements, and quality evaluation, as well as 25000 Extension divisions. The ISO/IEC25000 set of standards supports two main processes i.e. system and software product quality requirements specification and

evaluation. It also provides two main tools such as system and software product quality models and quantitative quality measures in order to support system product quality requirements and evaluation processes.

B. Concept of Quality Requirement and Evaluation

Figure 2 shows the concept of system and software product quality requirements and evaluations by using ISO/IEC25000 series of standard.

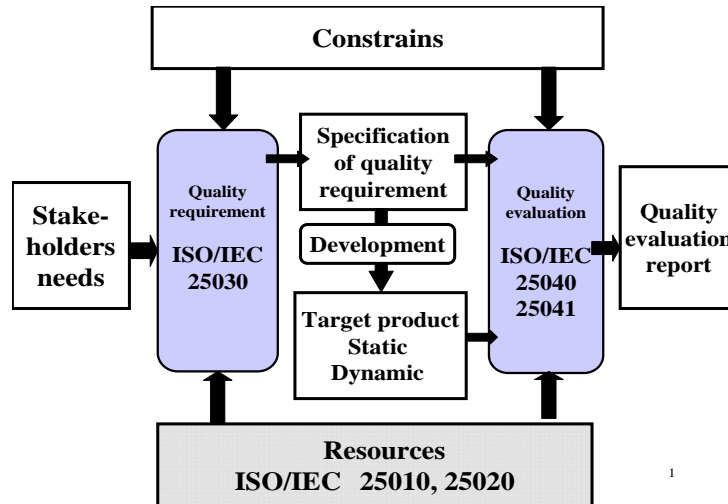


Fig. 2 Concept of quality requirement and evaluation

Stakeholders have needs for quality requirement for systems and software product development and acquisition.

In order to perform system development, at first, designer should specify a product quality requirements based on a functional requirements from the view point of customer's needs.

After implementation, developer should evaluate the target system product based on the quality requirement specification in order to assure the quality of developed product.

From Figure 2, ISO/IEC25030 provides the requirements and recommendations for defining quantitative quality requirements specification from selected and described customer's needs.

Product quality requirements can be specified during the process defined in ISO/IEC25030 for each product quality characteristics and sub-characteristics described in ISO/IEC25010 [4], 25012 [5] and ISO/IEC25020 [6] by using ISO/IEC2502n: Quality measures.

The specified quantitative quality requirements should be used as the criteria of system and software product quality evaluation.

From Figure 2, system quality evaluation can be performed by using ISO/IEC25040 [8] and 25041 [9] based on the specified quantitative quality requirements, which are specified by using ISO/IEC25030 during system design phase.

ISO/IEC25040 provides the standardized common evaluation process for each stakeholder such as developers, acquirers and independent evaluators, for systems and software products quality evaluation based on the quality requirements, which are defined by using ISO/IEC25030.

ISO/IEC25041 provides the quality evaluation guides for developers, acquirers and independent evaluators from the view point of each stakeholder's role and responsibility by applying common evaluation process described in ISO/IEC25040.

III. QUALITY MODELS

A. Target Entities of the Quality Models

Figure 3 shows the target entities of the quality models and the related entities. The ISO/IEC25000 series provides quality in use model and Systems and software Products quality model described in ISO/IEC25010, as well as data quality model described in ISO/IEC25012.

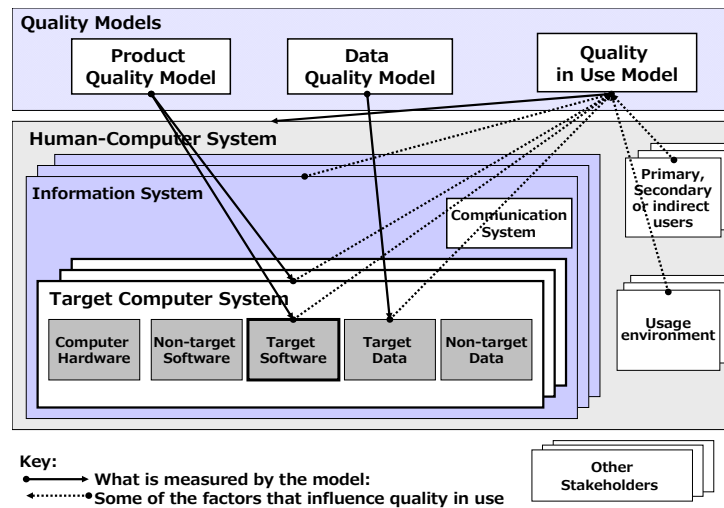


Fig. 3 Target of quality models -ISO/IEC25010:2011 [4]

From Figure 3, any system, in general, composes hierarchical structure.

ISO/IEC25010:2011 defines human-computer system as the highest level. It includes the information systems, which can include users and other technical and physical environments, such as machines and buildings.

The information system includes the target computer system and can also include one or more other computer systems and communication systems.

The target computer system also includes computer hardware, non-target system products, non-target data, and target data.

The system and software product quality in use model focuses on the human-computer system that includes the information system.

The system and software product quality model focuses on the target computer system that includes the target software product. The data quality model focuses on the target computer system that includes the target data.

B. View Point of System Product Quality Model

In order to define the quality requirements of system and software product, designer should clearly identified customer quality requirements based on the product quality model and should set the quality objectives during design phase of development.

It becomes possible to assure the integrity and completeness in describing customer quality requirements of a product and to avoid incorrectly prioritizing or missing quality objectives of a product resulting in improvement in accuracy of describing customer quality requirements.

Recently, the ISO/IEC9126-1:2001 software product quality model, which defined six quality characteristics, has replaced by ISO/IEC25010:2011 system and software product quality model.

Figure 4 shows the structure of the system and software product quality model defined in ISO/IEC25010:2011, which provides the eight quality characteristics such as functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability and sub-characteristics included in each characteristics.

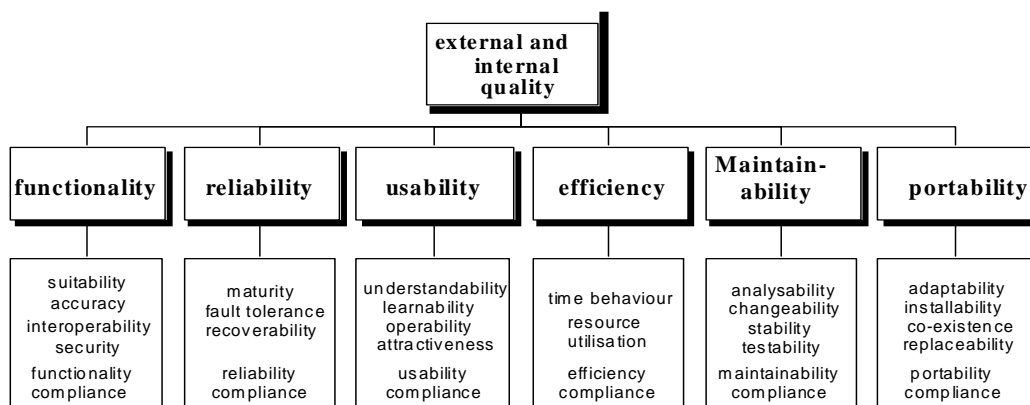


Fig. 4 Product quality model-ISO/IEC25010 [4]

Each quality characteristic is composed of a set of related sub-characteristics.

System and software product quality provides a view of the dynamic properties related to the execution of the system on computer hardware and applying an operating system or static properties that typically are available during the development.

ISO/IEC25010 defines additional two quality characteristics such as compatibility and security as the system level. Also, ISO/IEC25010 defines quality in use model, which focuses on the total human-computer system that includes the target computer system and target system product from the users' viewpoints.

The quality in use model defines five quality characteristics such as effectiveness, efficiency, satisfaction, freedom from risk, and context coverage. The system quality in use view is related to a specific application of the system in its operational environment, for carrying out specific tasks by specific users.

ISO/IEC25012 defines the data quality model indicated in Figure 3.

It can be used for developers, acquirers, and independent evaluators, as well as users of the information system.

IV. QUALITY REQUIREMENT

A. Categorization of System Requirements

Figure 5 shows an example of categorization of system requirements based on the consideration of Figure 3.

System requirements	Software requirements	Software product requirements	Inherent property requirements	Functional requirements	
				Software quality requirements	Quality in use requirements
					External quality requirements
					Internal quality requirements
		Software development requirements	Assigned property requirements	Managerial requirements including for Example Requirements for price, delivery date, Product future, and product supplier	
	Development process requirements				
	Other system requirements	Development organisation requirements			
		Include for example requirements for computer hardware, data, mechanical parts, and human business processes			

Fig. 5 Example of system requirements categorisation-ISO/IEC25030 [7]

Usually, stakeholders' needs for systems and software should be selected and transformed into both functional requirements and non-functional requirements.

Non-functional requirements could include quality requirements and other requirements such as hardware, data, and business requirements so on.

ISO/IEC25030 mainly focuses on system product quality and applies to organizations in their role as both acquirers and developers. However, it does not cover specification of other requirements.

As shown in Figure 5, system requirements include software requirement and other system requirements.

Software requirements include software product requirement and software development requirements.

Software product requirements include inherent property requirement of software and assigned property requirements of software.

Inherent property requirement of software include functional requirements and software quality requirements.

Functional requirements include the application domain specific requirements as well as functional requirements that support quality requirements.

Software quality requirements include requirements for quality in use, external and internal quality. Assigned property requirements of software may include price and delivery date of software.

Software development requirements may include requirements for artifacts, development processes, project, development organization, and developers.

B. System and Software Quality Requirements Process

Figure 6 shows the system and software product quality requirement definition process and analysis process described in ISO/IEC25030.

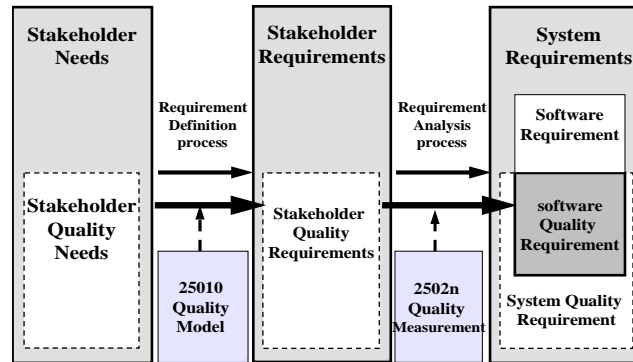


Fig. 6 Software quality requirement definition analysis -ISO/IEC25030 [7]

Figure 6 shows how system and software quality requirements are derived as part of the requirements processes defined in ISO/IEC15288 [10].

The definition process focuses on stakeholder requirements to the system. The stakeholder quality requirement can be defined based on the system and software product quality model described in ISO/IE25010:2011 and 25020:2007.

The analysis process assumes some architectural decisions, which makes it possible to identify quantitative quality requirements relevant for the software included in the system. The software quality requirement can be defined based on the system and software product quality measures described in ISO/IEC2502n.

V. QUALITY EVALUATION

A. Quality Measurement and Evaluation

Currently, ISO/IEC JTC1/SC7/WG6 is developing inter-national standards on quality measures as ISO/IEC2502n, which is the part of 25000 series - Quality measurement division.

ISO/IEC2502n provides the quality measure element and the quality measures, which intended to provide quality measures for system product quality, quality in use and data quality.

The quality measures described in ISO/IEC2502n are useful not only for quantitative product quality evaluation but also for quantifying the product quality requirement specifications by using ISO/IEC25030 for each quality characteristics, sub-characteristics defined in ISO/IEC25010 and 25020.

ISO/IEC25021 provides the quality measure element, which replaces TR25021 and is used for constructing system quality measures.

ISO/IEC25022, 25023 and 25024 provides the quality measures, which intended to provide quality measures for product quality, quality in use and data quality.

Figure 7 shows the general process of system and software product quality evaluation, which described in measurement, evaluation and total assessment.

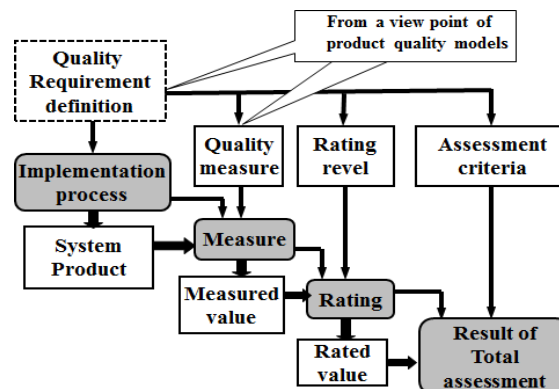


Fig. 7 General Process of product quality evaluation

After implementation of system, evaluator should measure and evaluate the system and software product based on the quantitative quality requirement of target product by using ISO/IEC25040 and 25041 in order to assure the developed or acquired product.

After that, evaluator should decide the compression of testing or choose the most suitable product from candidate products during acquisition base on the result of total quality assessment of product.

From Figure 7, for the purpose of evaluation, at first, evaluator should confirm the quantitative quality aims for each quality characteristics of the target system, which are defined from the view point of system and software product for quality model described in ISO/IEC25010, 25012, 25020 by using ISO/IEC2502n product quality measures at design.

Second, evaluator should define the quality measures and the criteria for evaluation of target system based on the confirmed quantitative quality aims.

After that, evaluator should measure and rating the quantitative quality of target system by using defined quality measures in order to take the measured value of each attribute.

Total assessment of target system can be calculated by using the result of rating and measured value of each quality characteristics.

ISO/IEC25040 contains general requirements and recommendations for system and software product quality evaluation based on the specified quality requirements.

This International Standard provides a standardized common evaluation process description, inputs, constraints, resources for, and outcomes of each evaluation process for evaluating system and software product quality and states the requirements for the application of this process.

ISO/IEC25040 defines the common evaluation process based on the specific evaluation process for developers, acquirers and independent evaluators in ISO/IEC14598-1 [14], -3 [16], -4 [17], and -5 [18] and replaced them.

This standardized process can be used for, both evaluation of the quality of commercial-off-the shelf software product and custom made software product. It can be used during or after the development and acquisition process.

This International Standard establishes the relationship of the evaluation process to the ISO/IEC25000 series as well as shows how each ISO/IEC25000 document should be used throughout the activities of the evaluation process.

Following are the standardized system and software product quality evaluation process described in ISO/IEC25040:

- (1) Establish the evaluation requirements
- (2) Specify the evaluation
- (3) Design the evaluation
- (4) Execute the evaluation
- (5) Conclude the evaluation

This process can be applicable to each stakeholder such as developers, acquirers and independent evaluators, but not limited to them.

B. Quality Evaluation Guide for Each Role

Recently, ISO/IEC25041 have published at 2012.

This International Standard provides the quality evaluation guides, which intended to focus on specific issues related to the developers, acquirers and independent evaluators.

This International Standard provides requirements, recommendations and guidelines for system and software product quality evaluation for the application of ISO/IEC25040 common quality evaluation process.

It is a short version of ISO/IEC14598-3, -4, and -5 and replaces them. This proposed standard is not limited to any specific application area, and can be used for quality evaluation of any type of systems and software products.

This International Standard defines the roles and responsibilities of each stakeholder such as developers, acquirers and independent evaluators. Also, this Standard defines the relationships among the target entity and evaluation activities.

VI. CONCLUSION

In this paper, we have proposed the quantitative product quality requirement and evaluation approach described in ISO/IEC25000 (SQuaRE) series of standards. Based on the observation of this paper, we can achieve development or acquiring information system successfully.

It is strongly recommended to use the ISO/IEC25000 series of standards for supporting system product quality requirement and evaluation activities.

For the purpose of defining the most suitable quality requirement for target system successfully, at first, we must measure the current status of business situation, which can be included in the previous information system by using quantitative quality measures described in ISO/IEC2502n from the view point from quality characteristics, 25012 and sub-characteristics defined in ISO/IEC25020.

Analysis of quality requirements for the new system has been conducted through questionnaires or interviews with customers from the view point of system and software product quality characteristics and sub-characteristics described in ISO/IEC25010, 25020 and quality in use characteristics described in ISO/IEC25010.

After that, we could define the target quality for the new system based on the differences between actual measured value of previous system and expected value of new system.

After implementation, we have to measure the target system based on the defined quantitative criteria and quality measures during testing phase in order to assure the quality of new system.

After installation of system in the operational user's environment, we could evaluate the effectiveness or profitability of new system based on the defined quality in use requirement during system planning and design phase.

Above quality requirement process, we recommend to use the ISO/IEC25030, which support quality requirement process based on the quality characteristics, sub-characteristics described in ISO/IEC25010, 25012 and ISO/IEC25020.

For the quality evaluation process, we recommend to use the ISO/IEC25040 and 25041, which support quality evaluation process based on the quality characteristics, sub-characteristics described in ISO/IEC25010, 25020 and quality measures described in ISO/IEC2502n for each stakeholder.

Currently, we are developing ISO/IEC2502n: quality measures series for quality in use, system and software quality, and data quality as the part of quality measurement division of ISO/IEC25000 series.

In the father work, after completion of ISO/IEC25000 series of standards, we would like to promote the application of recommended solution in order to realize the high quality system and improve the quality of critical system of society continuity.

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