Software Technology and Engineering Practice (STEP) 2002
Montreal, Canada, October 6-8 2003

Software Product Quality Practices
Quality Measurement and Evaluation using TL9000 and ISO/IEC 9126

Witold Suryn[1], Alain Abran[2], Pierre Bourque[3], Claude Laporte[4]
Department of Electrical Engineering, École de Technologie Supérieure (ÉTS)
Montréal, Québec, Canada, H3C 1K3
(aabran@ele.etsmtl.ca, wsuryn@ele.etsmtl.ca, pbourque@ele.etsmtl.ca,
claporte@ele.etsmtl.ca)
Fax: +1 (514) 396 8684

[1] Witold Suryn is the executive co-editor and co-editor of ISO/IEC 9126, ISO/IEC 14598 and ISO/IEC SQuaRE series of standards
[2] Alain Abran is the Secretary of ISO/IEC JTC 1/SC7 and Co-Executive Editor, SWEBOK Project
[3] Pierre Bourque is the coeditor of the Guide to the Software Engineering Body of Knowledge (SWEBOK) project
[4] Claude Laporte is the ISO editor for the SWEBOK Technical Report

Abstract. Both ISO and industry led forums, such as QuEST, have tackled the measurement of software product quality and proposed corresponding quality views. This paper presents how both quality views bring distinct contribution to software product quality and how they can be implemented jointly to verify that the quality requirements have indeed been built in and quality target achieved in the product use. More specifically it presents how the QuEST TL9000 Handbook and ISO/IEC 9126 can be jointly used for defining, measuring, evaluating and finally achieving appropriate quality of user-centered software product.

Keywords: software product quality, operational quality, quality measures, quality evaluation, standards, TL9000, ISO 9126, ISO 14598.

1. Identification of quality requirements

For the users, a software product more and more often corresponds to a black box that must effectively support their business processes. As a consequence of this evolution, the business needs represent the driving force in the development of software product of high quality. This in turn requires that operational quality of the software, as well as the user satisfaction of using a software product, set the framework for the software development effort, from the beginning of the development process in eliciting business-related software product quality requirements, up to the end to allow a rigorous evaluation. This *business view of quality* is illustrated in Fig.1, where the business required operational quality and satisfaction drives the product definition, the product development, and where the

business quality obtained is derived from the evaluation of the product in use.

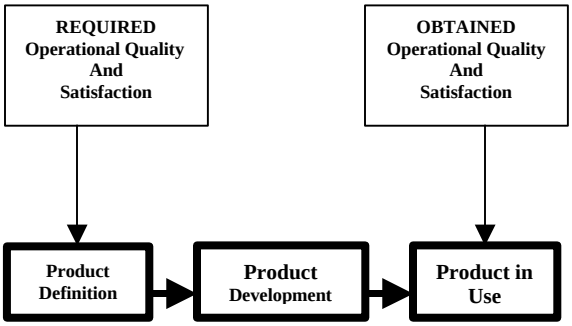

Fig. 1 Business View of software product quality

Identifying quality requirements that can be elicited, formalized and further evaluated in each phase of full software product lifecycle thus becomes a crucial task in the process of building a high quality software product.

The QUEST Forum's TL 9000 Handbooks were designed specifically for the telecommunications industry to document the industry's quality system requirements and measures. The TL 9000 Quality System Requirements Handbook [1] establishes a common set of quality system requirements for suppliers of telecommunication products: hardware, software or services. The requirements are built upon existing industry standards, including ISO 9001. The TL 9000 Quality System Measures Handbook [2] defines a minimum set of performance measures, cost and quality indicators to measure progress and evaluate results of quality system implementation.

TL 9000, applicability in software product lifecycle is illustrated in Fig.2. While it maps well with the business view of product quality (Fig. 1), it does not address directly the development process itself.

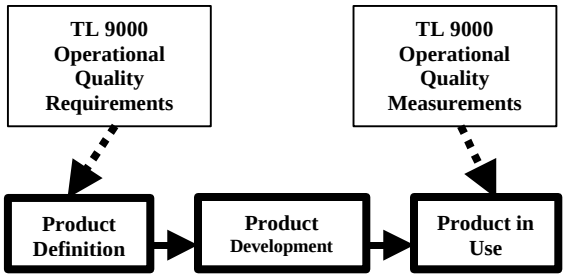

Fig.2 Applicability of TL9000 standards in software product lifecycle

In parallel the ISO/IEC Joint Technical Committee (JTC1), Subcommittee 7 (SC7) on system and software engineering has developed a set of quality standards for the full development process (ISO/IEC 9126). These standards take the initial quality requirements into account during each of the development phases, allowing the quality planning, its design, monitoring and control.

Software product quality can then be evaluated by measuring the internal attributes (typically static measures of intermediate products), or by measuring external attributes (typically by measuring the behaviour of the code when executed), or by measuring the quality in use attributes. The objective is for the product to have the required effect in a particular context of use. To produce these effects measurement and evaluation of the quality of software product has to be performed during all its lifecycle (Fig. 3).

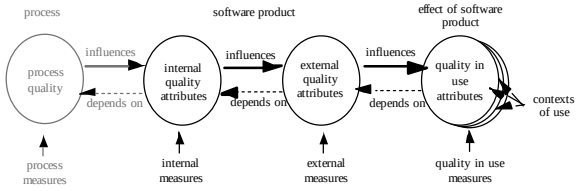

Fig.3 ISO/IEC 9126 Quality in lifecycle

Moreover, the proper quality measurement and evaluation

methodologies have to be present *and* applied. This ISO/IEC 9126 series of standards [3, 4, 5, 6] offers both ISO recognized quality models and corresponding measurements together with scales and measurement methods. ISO/IEC 14598 series of standards [7, 8, 9, 10, 11, 12] is a complementary set offering the support for software quality evaluation processes.

Figure 4 presents a high level view of how these ISO/IEC standards complement and implement the TL9000 quality requirements in the development process.
The practical use of these two combined sets of standards requires however a much more detailed view for defining, planning and implementing the quality. The precise identification of applicable standards and their particular documents is presented in the next section for each phase of the software development process.

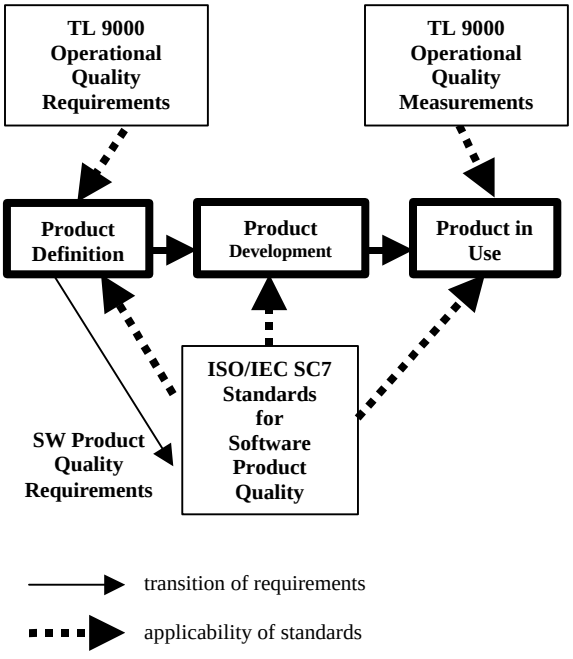

Fig.4. Integration between TL9000 and ISO/IEC SC7 standards

The ISO/IEC standards being further considered are:

- ISO/IEC 9126 series - Software and System Engineering – Software Product Quality Metrics. 1999-2002 [3, 4, 5, 6]
- ISO/IEC 14598 series – Software and System Engineering – Software Product Evaluation. 1996-2002 [7, 8, 9, 10, 11, 12]

2. Quality measurement and evaluation practices

For the simplicity of the following discussion the practical steps to follow correspond to software life cycle phases proposed in ISO/IEC 15288 [13].

Discovery Phase. In this phase three sets of requirements have to be identified and defined:

- Functional and non-functional requirements of the product (out of the scope of this paper)
- Operational quality requirements, and
- Quality in Use requirements

It is important to note that according to the model of quality in software life cycle defined in ISO/IEC 9126-1 [3] the requirements of Quality in Use contribute to specifying External Quality requirements, which in turn contribute to specifying Internal Quality requirements (Fig. 3). This indicates that the attributes of Quality in Use must drive the technical and technological decisions that (will) have to be taken when the development process starts. This requires that Quality in Use characteristics be analyzed, that applicable measures be identified and

that target values for each of them be assigned. The ISO standard to be applied to complete this task in the Discovery phase is ISO/IEC 9126 – Part 4: Quality in Use Metrics [6]. The ISO Quality in Use characteristics to be analyzed are:

- effectiveness
- productivity
- safety, and
- satisfaction

Quality in Use requirements help define success criteria of the new software product; however, alone they will not assure the product's long term success in the market. Such a success is achieved when Quality in Use comes together with, among others, fulfilled operational quality requirements.
Again, this requires that operational quality requirements be analyzed, applicable measures identified and target values for each of them assigned.

TL 9000 – Quality Management System Measurement Handbook [2] identifies four (4) categories of requirements and/or measurements applicable to software products:

- common measurements – referring to number of problems reported, response time, overdue problem responsiveness and on-time delivery.
- hardware and software measurements – referring to system outage.
- software measurements – referring to software installation and maintenance.
- service measurement – referring to service quality.

The final set of quality requirements and their targeted values, comprising of both operational quality and Quality in Use requirements will then become the major milestone and contributor in the definition of functional and non-functional requirements of the future software product with the *user perception of the software product quality* already "built-in" into the overall quality definition.

Requirements Analysis Phase. In this phase, the applicable quality requirements define the external and internal quality attributes of software product to be developed.
The ISO standards to be applied in this phase are:

- ISO/IEC 9126 – Part 2: External Quality Metrics [4], and
- ISO/IEC 9126 – Part 3: Internal Quality Metrics [5]

We stress here, that the attributes of both external and internal quality being defined in this phase must be traceable to the quality requirements previously set up in the Discovery phase.

Implementation Phase. This phase creates *a product* that can be measured and evaluated. The product is often created in an iterative fashion with intermediate product versions which may change many times before becoming a ready-to-use solution. It is therefore critical to measure and evaluate its quality at each iteration for identifying the required improvements for the subsequent iteration. The ISO standards to be applied in this phase for the measurement, documentation and evaluation of Internal Quality (and, if needed, External Quality) attributes defined in Requirements Analysis phase are:

- Measurements of Internal and External Quality attributes.

Documents to be used: ISO/IEC 9126 – Part 2 and 3 [4, 5].

- Documentation of measurements. Document to be used: ISO/IEC 14598 – Part 6 [12].
- Evaluation of the quality of the intermediate products. Documents to be used, depending on the position of the evaluating entity: ISO/IEC 14598 – Part 3: Process for Developers [9], Part 4: Process for Acquirers [10] or Part 5: Process for Evaluators.

The results of measurements of Internal and External Quality attributes are compared with target values assigned to them in previous phases and the conclusions are sent back to development teams for corrective measures.

Verification Phase. In this phase, the various components of a product are integrated and it must be verified that the stakeholder's functional, non-functional and External Quality requirements have been satisfied. The process of the evaluation of External Quality requires a procedure similar to the Internal Quality evaluation. It is being similarly well supported by standardization instruments.

The results of measurements of External Quality attributes must be compared with target values assigned to them in previous phases. The resulting conclusions may be used as corrective measures. This feedback may be directed to different phases of the process depending on the nature and the level of the severity of the identified discrepancies between the required and obtained External Quality.

Validation Phase moves the software product to the business level, where the user validates its usefulness for conducting his business, usually with no regard to technicalities. This means that Quality in Use requirements have to be satisfied "here and now". The process of the evaluation of Quality in Use requires the same procedure as External Quality evaluation and is being equally well supported by standardization instruments. A key difference is in using ISO/IEC 9126 – Part 4 [6] instead of ISO/IEC 9126 – Part 2.

The results of measurements of the Quality in Use attributes are compared with target values assigned to them in previous phases. The resulting conclusions may be sent back for corrective measures. This feedback may be directed to different phases of the process depending on the level of the severity of discrepancies between required and obtained Quality in Use.

Operation and Maintenance Phase is the phase where the software product is finally evaluated in terms of operational quality and Quality in Use.

Operational quality measurements require data, which to be representative have to be collected over relatively long period of time. The TL 9000 Quality Management System Measurements Handbook [2] can then be used to collect the appropriate measures and to perform the needed calculations to evaluate the obtained operational quality. Depending on the area of measurement and evaluation the results can be used immediately, for instance for improvements of the service quality, or in next round of product development, if the evaluation indicates weaknesses of the product being in the field.

Applying measurements and evaluation of Quality in Use in Operation and Maintenance phase is particularly useful with large and complex software products. The validation phase, where Quality in Use is being measured and evaluated for the first time, happens over a relatively short period with limited exploration opportunities (for instance, with a limited number of users) while Operation and Maintenance phase offers a real life context with unlimited time and exhaustive conditions of exploitation. The measurement and evaluation procedure for Quality in Use in Operation and Maintenance phase are the same as proposed for the Validation phase. The evaluation results can be useful both immediately (*evolutional* role of maintenance process) and over a longer perspective, when a new product or its next release is considered.

3. Applicability considerations

- The process discussed in section 2 omits the Architectural Design phase, the Integration phase and the Transition phase since the ISO/IEC standards do not directly address them.
- Both TL9000 and ISO/IEC standards offer the *process support* for identification, definition, measurement and evaluation of software product quality. However, with the TL9000 Quality Management System Requirements Handbook [1] the support processes are located at the business level. On the other hand, with the ISO/IEC standards the support processes are placed at the software development management level with ISO/IEC 14598 – Software Product Evaluation –Part 2: Planning and management [8].

Bibliography

[1] TL9000 Quality Management System Requirements Handbook, Release 3.0, QuEST Forum 2001
[2] TL9000 Quality Management System Measurements Handbook, Release 3.0, QuEST Forum 2001
[3] ISO/IEC 9126 – Software and System Engineering – Product quality – Part 1: Quality model. 1999-2002
[4] ISO/IEC 9126 – Software and System Engineering – Product quality – Part 2: External Quality Metrics. 1999-2002
[5] ISO/IEC 9126 – Software and System Engineering – Product quality – Part 3: Internal Quality Metrics. 1999-2002
[6] ISO/IEC 9126 – Software and System Engineering – Product quality – Part 4: Quality in Use Metrics. 1999-2002
[7] ISO/IEC 14598 – Software and System Engineering – Software Product Evaluation – Part 1: General overview. 1999-2002
[8] ISO/IEC 14598 – Software and System Engineering – Software Product Evaluation – Part 2: Planning and management. 1999-2002
[9] ISO/IEC 14598 – Software and System Engineering – Software Product Evaluation – Part 3: Process for developers. 1999-2002
[10] ISO/IEC 14598 – Software and System Engineering – Software Product Evaluation – Part 4: Process for acquirers. 1999-2002
[11] ISO/IEC 14598 – Software and System Engineering – Software Product

Evaluation – Part 5: Process for evaluators. 1999-2002
[12] ISO/IEC 14598 – Software and System Engineering – Software Product Evaluation – Part 6: Documentation of evaluation modules. 1999-2002
[13] ISO/IEC 15288 - Software and System Engineering – Life Cycle Management – System Life Cycle Processes. 2002