ISO/IEC9126–3 internal quality measures: are they still useful?

Witold Suryn
Department of Software and IT Engineering
École de technologie supérieure,
1100 Notre Dame St. West, Montréal, Québec
H3C 1K3 Canada
Witold.suryn@etsmtl.ca

Blanca Gil
Department of Software and IT Engineering
École de technologie supérieure,
1100 Notre Dame St. West, Montréal, Québec
H3C 1K3 Canada
blgc1@yahoo.com

Abstract

This paper analyzes the applicability and relevance of internal quality measures presented and published in ISO/IEC 9126-3:2003 standard for software quality measurement and evaluation. As a result, the recommendations for modifications to the current set of ISO/IEC 9126-3 set of measures as well as to the existing quality model have been proposed.
Key words: Internal quality measures, quality model, Internal quality evaluation, Pure internal measures, measurement tracking.

Introduction

The objective of this paper is to present the results of a revision of the ISO/IEC 9126 Part 3: Software Engineering - Product Quality - Internal Metrics and related documents, making emphasis on those subjects that remain in relation with the definition, identification, choice, documentation, evaluation, traceability, predictive capacity and practical uses of internal quality measures. In order to achieve this goal, a dedicated analysis methodology has been developed as the evaluation tool.

Also, due to the vastness of the subject the following limitations were applied when conducting the research:

- Only the ISO/IEC 9126–3 measures were studied using the officially published version of the standard,
- The analysis was applied from a software lifecycle and a stakeholder perspectives only,
- The verification of measures through practical measurements of artefacts was not a part of this research,
- The embedded software development technology, due to its specific nature, was not taken into account in this research.

The following results make the outcome of this research:

- The list of 42 research axiom definitions derived from ISO/IEC 9126-1, ISO/IEC 9126-3, and ISO/IEC 14598-1 [ISO01, ISO03,ISO04],
- The extended set of artefacts applicable as "input to measurements" for internal quality measures,
- A proposition of enhancements to the existing ISO/IEC 9126 quality model,
- The proposition of 32 new, 20 modified and 3 deleted internal quality measures,
- The enhanced prediction capacity tables reflecting the results of this research.

1. Methodology

To accomplish the objectives of this research a dedicated four-phase analysis methodology has been developed. The methodology is based on an in-depth analysis of the ISO/IEC 9126-3: Internal Quality Metrics standard [ISO03]. The below structure presents its components:

Phase I. Identification and definition of the axioms (derived from ISO/IEC 9126 part 1 and 3 and from ISO/IEC 14598 part 1),

Phase II. Construction of the set of basic hypotheses. The candidate hypotheses were identified through:

- Study of chosen software lifecycle process models,
- Study of chosen artefacts to be measured,
- Study of the current quality model and associated measures,
- Study of the current measurable properties of chosen types of software products,
- Study of ISO 9126-3 prediction capacity (from internal quality to external quality),

Phase III. Construction of the analysis engine. The following elements were taken into consideration:

- The measurement: when, what and for whom,
- The applicable axioms,
- The quality model structure,
- Inconsistencies in the prediction capacity of internal quality measures,

Phase IV. Analysis and recommendation for improvement of measures in categories of:

- Characteristic of a measure,
- Predictive capacity,
- Functional correctness, precision and adequacy of the definition,
- Understandability of the description.

2. Analysis

2.1 Definition of axioms

2.1.1 Methodology

ISO/IEC 9126-1 - Quality model and ISO/IEC 14598-1 - General overview describe across their text fundamental features shared by all quality measures. In this paper those features - called further the *axioms* - are used as fundamental analysis criteria. To facilitate the reference to each one, the following axiom structure was used:

- The axiom's identification,
- The exact text taken from the Standard
- The location: the Standard and the page where the axiom is located inside the Standard (with P1 indicating ISO/IEC 9126-1, P3 - ISO/IEC 9126-3 and P5 - ISO/IEC 14598-1).

For the purpose of the methodology of analysis all the axioms were grouped in three categories:

Category I: Scope, lifecycle and tracking (estimation and prediction),
Category II: Applicability and relevance,
Category III: Measurement – quality and nature of measurement.

2.1.2 The list of axioms

The thorough analysis of ISO/IEC 9126 part 1, part 3 and ISO/IEC 14598 part 1 has allowed for the identification of the following axioms:

Category I: Scope, lifecycle and tracking (estimation and prediction)

Axiom 1: The metrics listed in this International Technical Report are not intended to be an exhaustive set (P1.vi).
Axiom 2: The views of internal quality, external quality and quality in use change during the software lifecycle (P1.3).
Axiom 3: The fundamental nature of the software product quality represented by internal quality remains unchanged unless redesigned (P1.5).
Axiom 4: The current state of the art does not provide all the support necessary for the purposes of prediction (P1.5).
Axiom 5: [Internal metrics] can be used to predict values of the external metrics (P1.6).
Axiom 6: The correlation between internal attributes and external measures is never perfect and the effect […] will be determined by experience and will depend on the particular context […] (P1.14).

Axiom 7: It is often difficult to design a rigorous theoretical model that provides a strong relationship between internal metrics and external metrics (P3.3) – Axiom also in ISO/IEC 9126-1 (P1.15).
Axiom 8: Internal metrics should also have predictive validity, which means that they should correlate with some desired external measures (P1.17)
Axiom 9: The internal metrics standard shows the relationship between external and internal metrics (P5.8).
Axiom 10: Internal metrics are of most interest during the development process (P5.12).
Axiom 11: Internal metrics are of little value unless there is evidence that they are related to external quality (P5.13).

Category II: Applicability and relevance

Axiom 21: This report is applicable to any kind of software product, although each of the metrics is not always applicable to every kind of software product (P3.vi).
Axiom 22: Quality requirements cannot be completely defined before the beginning of design (P1.4).
Axiom 23: The hierarchy [characteristics and sub-characteristics] is not perfect, as some attributes may contribute to more than one sub-characteristic (P1.14).
Axiom 24: The internal metrics may be applied to a non-executable software product during its development stages (such as request for proposal, requirements, definition, design specification or source code) (3) – Axiom also in ISO/IEC 9126-1 (P3.15).
Axiom 25: […] internal metrics […] measure intrinsic properties including those, which can be derived form simulated behaviour (P1.15).
Axiom 26: The measurements of internal metrics use number or frequencies of software composition elements which appear for example on source code statements, the control graph, data flow and state transition representations (P1.15).
Axiom 27: Documentation can also be evaluated using internal metrics (P1.15).
Axiom 28: The metrics listen in this [metric table] are not intended to be an exhaustive set and may not have been validated (P3.4).
Axiom 29: Additional specific metrics for particular purposes are provided in other related documents, such as functional size measurements or precise time efficiency measurement (P3.4).
Axiom 30: Lines of code, complexity, the number of faults found in a walk through and the Fog Index are all internal measures made on the product itself (P5.4).
Axiom 31: Modularity and traceability are examples of internal attributes, which can be measured (P5.12).
Axiom 32: ISO/IEC 12207 SLCP Reference: identifies software lifecycle process(es) where the metric is applicable (P3.4).
Axiom 33: Target audience: Identifies the user(s) of the measurement results (P3.4).

Category III: Measurement

Axiom 40: Measurements should be objective, empirical using a valid scale, and reproducible (P1.16).
Axiom 41: Internal measure […] is not derived form measures of the behaviour of the system of which it is a part (P3.4).
Axiom 42: Lines of code, complexity, the number of faults found in a walk through and the Fog Index are all internal measures made on the product itself (P3.4).

2.2 Identification of basic hypotheses

Internal quality measures, types of software product recognized by the standard as "measurable", the required measurement input (artefacts) and prediction capacity of the measures is the core components of the applicability of the standard. The study of these components rendered the following results as basic research hypotheses:

Hypothesis 1: Reducing the applicability of measures to software lifecycle supporting processes severely minimizes the possibilities of developing a quality software product,
Hypothesis 2: The selection of artefacts to be measured could affect the applicability of measures,
Hypothesis 3: Current classification (relationship to quality model) of measures could affect their applicability,
Hypothesis 4: Properties of artefacts to be measured could affect the applicability of measures,
Hypothesis 5: Current inconsistencies in prediction capacity could affect the applicability of measures, and

Hypothesis 6: The actual set of internal quality measures may require modifications in order to improve the applicability of the standard.

2.2.1 Hypothesis 1: Reducing the applicability of measures to software lifecycle supporting processes severely minimizes the possibilities of developing a quality software product

According to axiom 32 (clause 3.1.2.2), ISO/IEC 9126-3 uses the ISO/IEC 12207 generic model as a referenced model of software lifecycle (Fig.1). The findings of this research have proven that the only references to software lifecycle processes present in internal quality measures tables are those made to supporting lifecycle processes from ISO/IEC 12207 (mostly Verification and Validation). No primary (technical) processes are mentioned or referenced what suggests that the "recommended" actual applicability of internal quality measures does not cover the development phase (design, testing or coding) and its respective artefacts, thus limiting speed, range and efficiency of quality evaluation and its results (e.g. found deficiencies or recommended improvements of the evaluated software product).

Supporting lifecycle processes
6.1. Documentation process 6.2. Configuration management process 6.4. Verification process 6.5. Validation process 6.6. Joint review process
Development Processes
5.3.4. Software requirements analysis 5.3.5. Software architectural design 5.3.6. Software detailed design 5.3.7. Software coding and testing

Figure 1. ISO/IEC 12207 generic lifecycle process model

Such a situation, if retained, remains in an open conflict with the applicability objectives of the standard stated in ISO/IEC 9126-1 Annex A.1.2 page 15:
Internal metrics can be applied to a non-executable software product (such as a specification or source code) during designing and coding. When developing a software product the intermediate products should be evaluated using internal metrics which measure intrinsic properties, including those which can be derived from simulated behaviour.
At the same time ISO/IEC 12207 explicitly indicates the requirement of creating appropriate documentation within each of the software lifecycle processes, both primary and supporting, making it a perfect candidate for "input to measurement".
From the perspective of the user of the standard as well as from the perspective of better applicability of internal quality measures it is then reasonable to combine all appropriate ISO/IEC 12207 processes and their respective artefacts with corresponding internal quality measures. We need to build a clear link between the measure, the input to measurement and the point of its collection, i.e. the process and its phase with focus rather on primary (technical) processes than the supporting ones. Such a link will also help better identify "targeted audience", or participants, as different processes require different type of expertise.

The details of the above recommendation undergo a separate research and will be published at their full extent at a later date.

2.2.2 Hypothesis 2: Selection of artefacts to be measured could affect the applicability of measures

According to the data found in ISO 9126-3 column "Inputs to measurement" Review Report, Requirements Specification, Design and Source Code are the most important set of data inputs for measurement process. However, even if existing, this information is in most cases imprecise. The following lacking elements were found:

- Unclear definition of content and scope of Review Report. In software engineering domain any artefact created during a development process can be the subject of a review. Moreover, the artefacts created in different phases of the process seriously differ, what makes the recommendation of using Review Report meaningless, unless a precise indication of what product should be reviewed is given. This observation remains in close correlation with findings illustrating the hypothesis 1.

- The usability ISO 9126-3 Pure Internal Metrics strongly depends on the precise indication of required artefacts, being in most cases of the technical nature (for example, “Conditional statement” or “Program size” require a specific software artefact – source code). A quick look at the existing Pure Internal Metrics table reveals that not only indication of artefacts is missing but also a reference to software lifecycle processes or even targeted audience have not been considered worth of recommending.

As the above hypothesis has proven valid the extended set of artefacts addressing this problem has been identified. The new list of possible artefacts is presented below together with their applicable conditions:

a. If nothing else is indicated, the generic input to measurement could be chosen from:
    - Joint Review Report,
    - Validated Requirement Specification Documents,
    - Standards and Regulations,
    - Verification report.
b. If nothing else is indicated or none specific product is pointed, the products to be measured could be chosen from:
    - Functional Model,
    - Data Model,
    - Event Model,
    - Hardware Model,
    - Source code,
    - User documentation,
    - Technical documentation,
    - Use Case Diagram,
    - Activity Diagram,
    - State Diagram,
    - Sequence Diagram,
    - Class/object Diagram,
    - Component Diagram,
    - Deployment Diagram.

The above list does not claim to be complete or exhaustive; however its content tries to reflect the actual reality of software engineering where object-oriented development seems to gain the dominant position.

2.2.3 Hypothesis 3 and 4: Current measures classification and properties of artefacts to be measured could affect the applicability of measures

During the analysis of the standard several inconsistencies in the classification of measures were found. The important example is the ISO/IEC 9126-3 table of “Pure internal metrics”. These metrics are very technical, with obvious relationship to software quality, in particular to higher level Internal quality measures, but are mentioned as “informative” in Annex E with no appearance in ISO/IEC 9126 quality model. Due to their unquestionable importance it seemed profitable to incorporate them into the model through a modification of its existing structure, thus indicating their presence and applicability.
The enhanced model with added new characteristic named “Internal technical measures” is presented in Fig. 2.

The proposed “Internal technical measures” characteristic consists of:

- “Development standard measures” sub-characteristic assessing the adherence to writing guidelines for product components. This sub-characteristic would contain:
    - Self-descriptiveness measures: measures of the product attributes that describe the product by itself,
    - Self-containedness measures: measures of the product elements that allow understanding of the product nature by itself,

- Pure reusability measures: measures of the extent to which a product can be used in different contexts from which it was originally designed,
- Pure maintainability measures: measures of the extent to which the software can be modified at the lowest possible cost,

- "Size" sub-characteristic providing measures of a size of a product (for example lines of code or functional points),
- "Complexity" sub-characteristic with measures assessing complexity of a product.

This extended quality model offers some important benefits to the users of the standard however the potential application of proposed changes requires careful consideration of possible impact on the existing use of the standard. The possible solutions are discussed in clause 3.

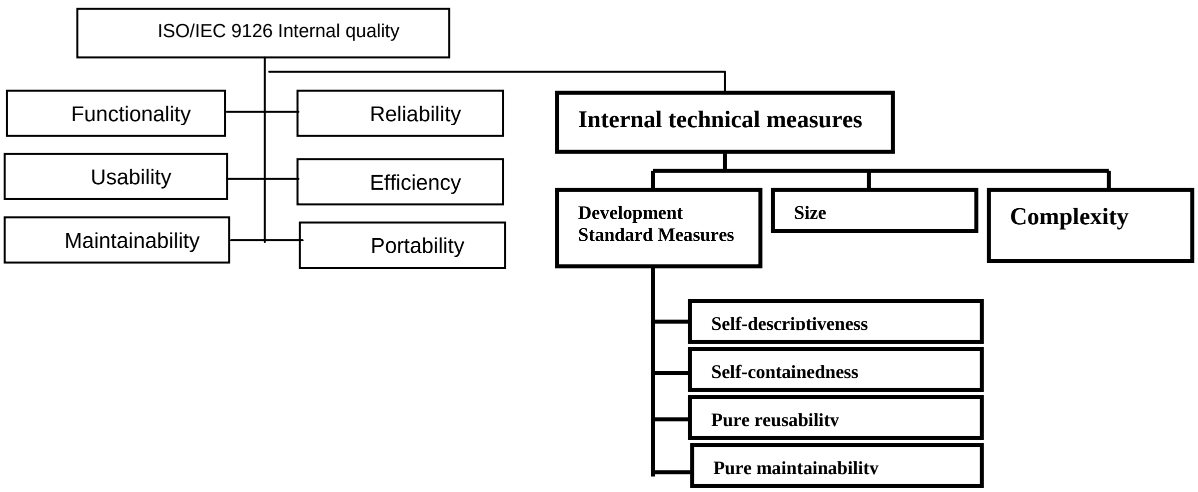

Figure 2. Enhanced ISO/IEC 9126 Internal quality model

2.2.4 Hypothesis 5: Current inconsistencies in prediction capacity could affect the applicability of measures

According to ISO 9126 axioms 8, 9 and 11 ("Internal metrics are of little value unless there is evidence that they are related to external quality", clause 3.2.1.1), the prediction capacity of internal measurements is a fundamental applicability feature. In course of this research the prediction relationship between internal and external quality measures has been analyzed using the following qualification rules:

a) Sharing the same name and purpose. If measures shared both name and purpose the analysis concluded that a direct prediction relationship exists,
b) Sharing the same measurement purpose only. If measures shared only the purpose it was concluded that the internal measure could predict the results of one or more external measurements and that there is an indirect prediction relationship,
c) No sharing. If measures shared neither the name nor the purpose in any sense, it was concluded that there was no visible prediction relationship.

The statistical data of internal/external quality measures predictability relationship are presented in Table 1. The detailed data of the analysis, as being too voluminous are not part of this article, being however available upon request.

When analysing the statistics of prediction capacity of internal quality measures the following observations were drawn:

- The nature of prediction is non-orthogonal, i.e. there are internal quality measures that are related to more than one external quality measure. For example, in Reliability characteristic the measure of fault detection is found being indirectly related to five external quality measures,

- The number of internal quality measures that remain non-related (or, in other words, do not serve the predictability purpose) is relatively small (7 out of 70, or 10%),
- The number of external quality measures that have no visible relation to internal quality measures is much greater (28 out of 112, or 25%)

Table 1. Statistics of prediction relationship between Internal and External quality measures

Characteristic (Internal and External Quality)	Number of all Internal quality measures	Number of all External quality measures	Internal quality measures with direct prediction relationship	Internal quality measures with indirect prediction relationship	Internal quality measures with no prediction relationship	External quality measures with no prediction relationship
Functionality	14	14	12	3	2	0
Reliability	8	18	6	7	0	1
Usability	18	28	7	10	0	7
Efficiency	9	24	5	3	2	15
Maintainability	9	16	2	6	1	4
Portability	12	12	10	1	2	1

All the three above observations indicate that the prediction mechanism between internal and external quality is not complete, leaving too many external and internal quality measures/attributes unrelated to each other.
Further analysis of the relationship between internal and external quality measures revealed possibilities of addressing this problem, however mostly through the addition of new measures discussed in section 2.2.5 below. The detailed results, as being too voluminous are not part of this article, being however available upon request.

2.2.5 Hypothesis 6: The actual set of internal quality measures may require modifications in order to improve the applicability of the standard

As the ISO/IEC 9126 standard has undergone continuous development since 1991 it is understandable that the actual measures, especially in internal quality area, where the technological evolution is the fastest may prove partially incomplete, obsolete or even unnecessary. This part of the research had as the objective to verify how the existing set (and nature) of internal quality measures serve their users in their direct application during development of a software product.
The following criteria were applied when analysing the existing measures:

- Characteristic of an attribute. This criterion verifies whether the measure of a given attribute fits into its actual sub-characteristic in the quality model.
- Predictive capacity. Predictive capacity criterion verifies an existence and the type of prediction relationship of the analyzed internal quality measure to its possible counterparts in external quality.
- Definition and description of the measure. This criterion verifies functional correctness, precision, adequacy and understandability of definitions and descriptions of measures in order to find eventual applicability problems resulting from wrong usage of measures.

The obtained results presented in Tables 2, 3 and 4 seem to be self-explanatory, but the below comments may prove helpful:

- Most of additions were proposed to the Maintainability and the Usability sub-characteristics (12 and 10 respectively), what may suggest that different aspects of usability might require some evolutionary corrections. One of possible reasons for such a state could be a de-synchronization between speed of developing the standard and dynamics of technological evolution in the domain,
- Most of modifications were recommended for Functionality and the Efficiency sub-characteristics (number of affected measures: 10 and 5 respectively; number of singular modifications: 31 and 20 respectively). The nature of possible modifications indicates rather missing precision than serious lacks of information,
- Only 3 measures were proposed to be deleted (Efficiency - 2 and Reliability - 1) which may be interpreted as a positive indicator of the generic validity of the core of quality model and related internal quality measures.

Table 2. Internal quality measures – identified candidates for inclusion

	FUNCTIONALITY
1	Computational completeness
2	Precision accuracy
3	Data exchangeability completeness (data format based)
	USABILITY
5	Demonstration consistency
6	User Interface consistency
7	User Documentation consistency
8	Output Messages consistency
9	Help consistency
10	Help understandability
11	Completeness of training material
12	Default value availability
13	Operation procedure reduction
14	Consistency with others known systems
	EFFICIENCY
27	Estimated Software platform response time
28	Estimated Data management response time
29	Estimated Transmission response time
30	Estimated I/O Utilization size

	RELIABILITY
4	Fault density
	MAINTAINABILITY
15	Activity recording legibility
16	Modification complexity
17	Parameterized availability
18	Reuse utilization
19	Programming Style consistency
20	Frameworks utilization
21	Patterns utilization
22	Programs libraries utilization
23	Data stores / procedures utilization
24	Technical Documentation consistency
25	Technical Documentation understandability
26	Completeness of Technical Documentation
	PORTABILITY
31	Internationalization
32	Ease of installation

Table 3. Internal quality measures – identified candidates for deletion

	RELIABILITY
1	Incorrect operation avoidance

	EFFICIENCY
2	Turnaround time
3	Transmission Utilization

Table 4. Internal quality measures with identified needs for modifications

	FUNCTIONALITY		**EFFICIENCY**
1	Functional adequacy	12	Response time
2	Functional implementation completeness	13	Throughput time
3	Functional implementation coverage	14	I/O utilisation
4	Computational accuracy	15	I/O utilisation message density
5	Access auditability	16	Memory utilisation message density
6	Data corruption prevention		**RELIABILITY**
7	Intersystem standard compliance	17	Fault detection
8	Precision	18	Test adequacy
9	Data exchangeability	19	Failure avoidance
10	Interface consistency	20	Restoration effectiveness
	USABILITY		
11	Demonstration capability		

The aggregated results obtained by this analysis are presented in the below tables (Table 5 and 6).

Table 5. Statistics of interventions in individual measures area

Characteristics	Additions	Major Modifications	Minor Modifications	Deletions
Functionality	3	20	11	0
Reliability	1	5	3	1
Usability	10	1	0	0
Efficiency	4	16	4	2
Maintainability	12	0	0	0
Portability	2	0	0	0
T O T A L = 95	**32**	**42**	**18**	**3**

Table 6. Classification of interventions in individual measures area

Characteristic	CRITERIA											
	Attribute Characteristic				Description and Definition				Predictive Capacity			
	Mi	My	A	D	Mi	My	A	D	Mi	My	A	D
Functionality			3		11	20			1	6	2	
Reliability	1	1	1	1	1	2					1	
Usability			10			1				1	10	
Efficiency	2	14	4	2	3				2	7	3	1
Maintainability			11								4	
Portability			2								1	
T O T A L	**3**	**15**	**29**	**3**	**15**	**23**	**0**	**0**	**3**	**14**	**21**	**1**

The full analysis and resulting detailed data (55 analysis modules with corresponding tables) are now in preparation for publication and will available at a later date as a white paper.

3. Improvement options

All the hypotheses and related research discussed in previous clauses have rendered results that could prove useful for software engineering community, with a special emphasis on the software quality engineering part. The possible recommendations of changes go into two basic categories:

- Changes to ISO/IEC 9126 quality model, and
- Interventions to internal quality measures taking form of modifications or deletions of existing measures and additions of new measures.

Recommendations of changes to the quality model seem to be at the first glance particularly inconvenient or even dangerous. The ISO/IEC 9126 model for internal and external quality is present in the industry and research for over 13 years gaining during this time the unquestionable international recognition. From this perspective almost any change to the model could meet mixed reactions from the international community of users; however, a quick analysis of the model proposed in this paper will reveal that the central part of the model being the core ISO/IEC 9126 quality model remains intact while the modifications appear as side enhancements. This particular form of possible changes has been proposed with two objectives in mind:

- Keeping the commonality feature of the model intact (e.g. the core of the model is still common for internal and external quality),
- Keeping the original core of the model intact so the actual users may still reference it as before if they do not wish to use the enhanced part of the overall model.

Such an approach allows then for a full implementation of changes to the model recommended in this paper if the editors and experts from ISO (Subcommittee SC7 – Systems and software engineering, Working Group WG6) agree upon it.

The interventions to measures on the other hand, appear rather as the maintenance or update effort which should be recognized as a natural process, particularly important in the domain so quickly evolving as software engineering. The recommendations presented in this paper together with details to be published in the previously signalled white paper could – if recognized by ISO - help speed up updating the standard in its new edition and once again prove the value of co-operation between standardizing organizations and academic community.

4. Conclusions

The research presented in this paper would find the evaluation of the state-of-the-art, relevancy and applicability exhibited by both quality model and associated internal quality measures of ISO/IEC 9126-3 as relatively positive.

The identified needs for modifications indicate rather necessity of maintenance than of a thorough re-engineering of the standard.

Following this conclusion, the enhancements of the quality model proposed by this research could make a valuable enrichment while keeping the basic structure of the model and its sustained value intact.

The proposed enhancements in the area of measurable artefacts and input to measurement could make the necessary intervention allowing for keeping the standard up to date with the evolving development technologies.

The rather massive intervention proposed in the area of detailed measures (95 interventions of different type) may create a negative impression while the real conclusion would be of the following nature: the fact that only 3 measures were proposed to be deleted (less than 3%) indicates that the core of measures stay valid even if requiring adaptive adjustments. Addition of new measures makes part of perfective maintenance required to stay abreast with the technology to which the standard is supposed to be effectively applied. Strengthening prediction capabilities towards external quality makes one of the other benefits of the above interventions.

The practical implementation of suggested changes in ISO software quality measurement and evaluation standards (if they meet ISO/IEC SC7 subcommittee interest) could become beneficial to both industrial and academic users on the international level.

5. References

[BOE76] Boehm, B.W., Brown, J.R.; Lipow, M., "Quantitative Evaluation of Software Quality", Proceedings of Second International Conference on Software Engineering, IEEE, Oct., 1976

[ESA03] “Software Quality Modeling and Metrication”; ESA Multimedia; 2003; esamultimedia.esa.int /docs/industry/SME/2003/software_engineering/B-Software_Quality_Modeling_and_Metrication.pdf

[ISO01] ISO/IEC 9126. Software Engineering - Product Quality – Part 1: Quality Model, ISO 2001

[ISO02] ISO/IEC 9126. Software Engineering - Product Quality – Part 2: External Metrics, ISO 2003

[ISO03] ISO/IEC 9126. Software Engineering - Product Quality – Part 3: Internal Metrics, ISO 2003

[ISO04] ISO/IEC 14598. Software Product Evaluation - Part 1: General Overview, ISO 1999

[ISO05] ISO/IEC 15288. Lifecycle Management. System Lifecycle Processes. 2000.

[ISO06] ISO/IEC 12207. Standard for Information Technology. Software lifecycle processes. Industry implementation of International Standard ISO/IEC 12207 : 1995.

[JAC99] Jacobson, I., Booch, G., Rumbaugh, J. (1999). The Unified software development process (1st edition). Addison-Wesley;

[LAU02] Lauesen, S. (2002). Software Requirements Styles and Techniques. Addison-Wesley.

[MEY98] Meyer, B., (1998) The role of object-oriented metrics. *A shorter variant of this article appeared in Computer (IEEE), as part of the Component and Object Technology department, in the November 1998 issue. http//:archiv.eiffel.com*

[PRE97] Pressman, R. S. (1997). Software Engineering a practitioner’s approach (4^{th} edition). McGraw-Hill;

[PRO01] Probert, R. L. (2001). Software Quality Engineering. Telecommunication Engineering Research Group, School of Information Technology and Engineering, Faculty of Engineering, University of Ottawa; From www.site.uottawa.ca/~bob/csi5111/notes/1.0SQ1209.ppt

[RUP00] IBM and RUP (Rational Unified Process) from: http://www.rational.com/.

[SMI97] Smith, D. (1997 Compilation). Risk Management & Metrics. Class CS 3302. From http://www.cc.gatech.edu/classes/cs3302_97_fall/

[TOP98] ISO 12207, ISO 15504, SW-CMM v1.1, SW-CMM v2 Draft C Mapping – Top-Level Standards Map. (1998). From www.sei.cmu.edu/pub/cmm/Misc/standards-map.pdf