Harmonization Issues in the Updating of ISO Standards on Software Product Quality

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Abstract. *Within the context of the current ISO project to upgrade the set of technical reports on the measurement of the quality of software products (ISO 9126), the ISO working group concerned has come up with proposals for various documents (standards or technical reports) in the new ISO 25000 series to improve the interpretation and use of the quality measures. This paper investigates some of the harmonization issues arising with the addition of new documents like ISO 25021, in particular with respect to previously published measurement standards for software engineering, such as ISO 9126, ISO 15939, ISO 14143-1 and ISO 19761.*

Keywords: Software Product Quality, Software Measurement, ISO 25021, ISO 9126, ISO 15939.

1 Introduction

In 1991, the ISO published its first international consensus on the terminology for the quality characteristics for software product evaluation (ISO 9126:1991) [1]. During the period 2001 to 2004, the ISO published an expanded version, containing the ISO quality models and a consensus on inventories of proposed measures for these models. The current version of the ISO 9126 series of standards consists of four documents [2-5]:

- ISO 9126-1: Quality Models
- ISO TR 9126-2: External Metrics[1]
- ISO TR 9126-3: Internal Metrics
- ISO TR 9126-4: Quality in Use Metrics

The ISO has now recognized a need for further enhancements to ISO 9126, primarily as a result of advances in the field of information technologies and changes in environment [6]. Therefore, the ISO is now working on the next generation of software product quality standards, which will be referred to as Software Product

[1] The term 'metrics' used in ISO 9126 is replaced by 'measures' in the new series of standards, in accordance with ISO 15939.

Quality Requirements and Evaluation (ISO 25000). This series of standards will replace the current ISO 9126 and ISO 14598 series, and will consist of five divisions [7], each of which may contain one or more documents:

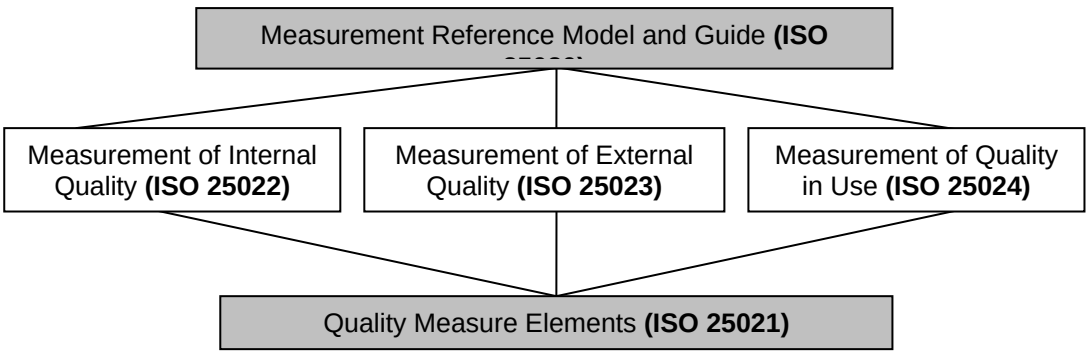
- ISO 2500n: Quality Management Division
- ISO 2501n: Quality Model Division
- ISO 2502n: Quality measurement Division
- ISO 2503n: Quality Requirements Division
- ISO 2504n: Quality Evaluation Division

This work is being carried out by Working Group 6 (WG6) of the software and system engineering subcommittee (SC7) of the ISO/IEC joint technical committee (JTC1) on Information Technology, that is, ISO/IEC JTC1/SC7.

One of the objectives of this new ISO 25000 series (and what makes it different from the current ISO 9126 series) is the harmonization of its contents with the software measurement terminology of ISO 15939 [8], itself based on the ISO metrology terminology [9]. Figure 1 shows the proposed structure of the quality measurement division (ISO 2502n) series that is to replace the current four-part ISO 9126 series of standards [10]. This proposed quality measurement division (ISO 2502n) will consist of five documents:

- ISO 25020: Measurement Reference Model and Guide
- ISO 25021: Quality Measure Elements
- ISO 25022: Measurement of Internal Quality
- ISO 25023: Measurement of External Quality
- ISO 25024: Measurement of Quality in Use

Figure 1: WG6 Proposed Structure of the Measurement Division (ISO 2502n series)



Included in this new set of technical reports is a proposed new structure with additional new concepts, such as: ‘quality measure elements’ (QME) and ‘software quality measures’ [10]. This paper also investigates these proposed concepts, their

use and interpretation, and their relationship to similar concepts in other ISO documents.

This paper discusses the issues concerning terminology harmonization in section 2, and the issues concerning the harmonization of quality model coverage between ISO DTR 25021 and ISO 9126 in section 3. A discussion, conclusions and recommendations are presented in section 4.

2 Terminology harmonization

2.1 Metrology terminology

The ISO 9126 working group (WG6) has proposed the introduction of four new expressions in ISO DTR 25021 [10], namely: 'Quality Measure Elements', 'General Quality Measure Elements', 'Specific Quality Measure Elements' and 'Quality Measures'. The introduction of these new terms raises the following concern: either the proper mapping to the set of classic metrology terms has not yet been completed or there are concepts and related terms missing in the metrology vocabulary. The latter would be surprising, since metrology is a rather mature domain of knowledge based on centuries of expertise in the field of measurement and related international standardization. In this paper, we revisit the WG6 proposal in order to recommend a proper mapping of concepts to the related metrology [9] terms and to ISO 15939 [8].
The following two expressions come from the ISO standard on software measurement process, ISO/IEC 15939 [8], which is itself based on the definitions in the ISO International Vocabulary of Basic and General Terms in Metrology (VIM 1993) [9]:

Base measure: a measure defined in terms of an attribute and the method for quantifying it. A base measure is functionally independent of other measures.

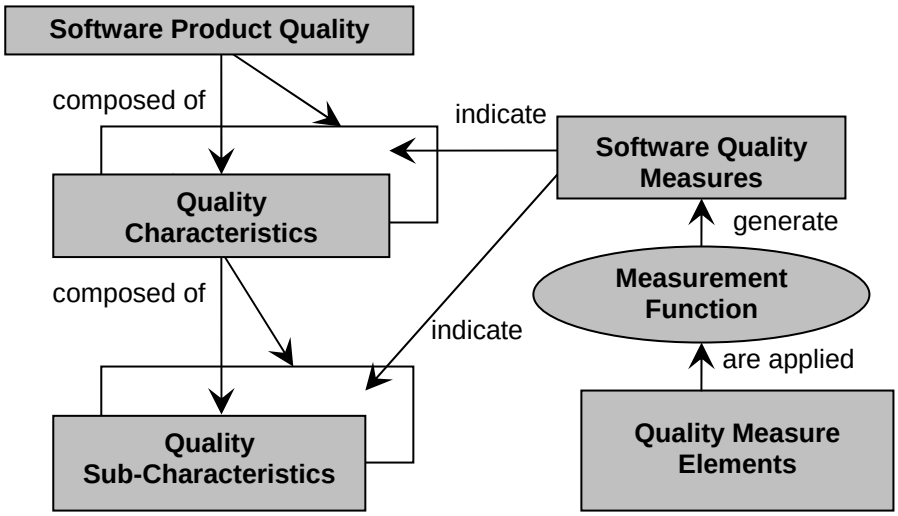
Derived measure: a measure defined as a function of two or more values of base measures. A transformation of a base measure using a mathematical function can also be considered as a derived measure.

In [10], it is claimed that a quality measure element is either a base measure or a derived measure, but then the consensual metrology terms are ignored in favor of locally defined WG6 measures, thus bypassing the ISO and SC7 harmonization requirements on measurement terminology.

The 'quality measure elements' are described as an input for the measurement of the 'software quality measures' of external quality, internal quality and quality in use [10]. Figure 2 shows the proposed relationship between the 'Quality Measure Elements' and the 'Software Quality Measures', and between the 'Software Quality Measures' and the quality characteristics and subcharacteristics. In metrology, these would correspond to base measures and derived measures respectively. It can be observed as well that these measures, in particular the derived measures, are defined specifically to measure the subcharacteristics of internal and external quality or the

characteristics of quality in use. None of these is directly related to the top level of ‘software quality’ (which is itself decomposed into three models, then into 16 characteristics and further into a large number of subcharacteristics). Therefore, the expression selected, in [10], ‘software quality measures’,, is at a level of abstraction that does not represent the proper mapping of the measures to the concept being measured.

Figure 2: Quality Measure Elements Concept in the "Software Product Quality Measurement Reference Model" [10]



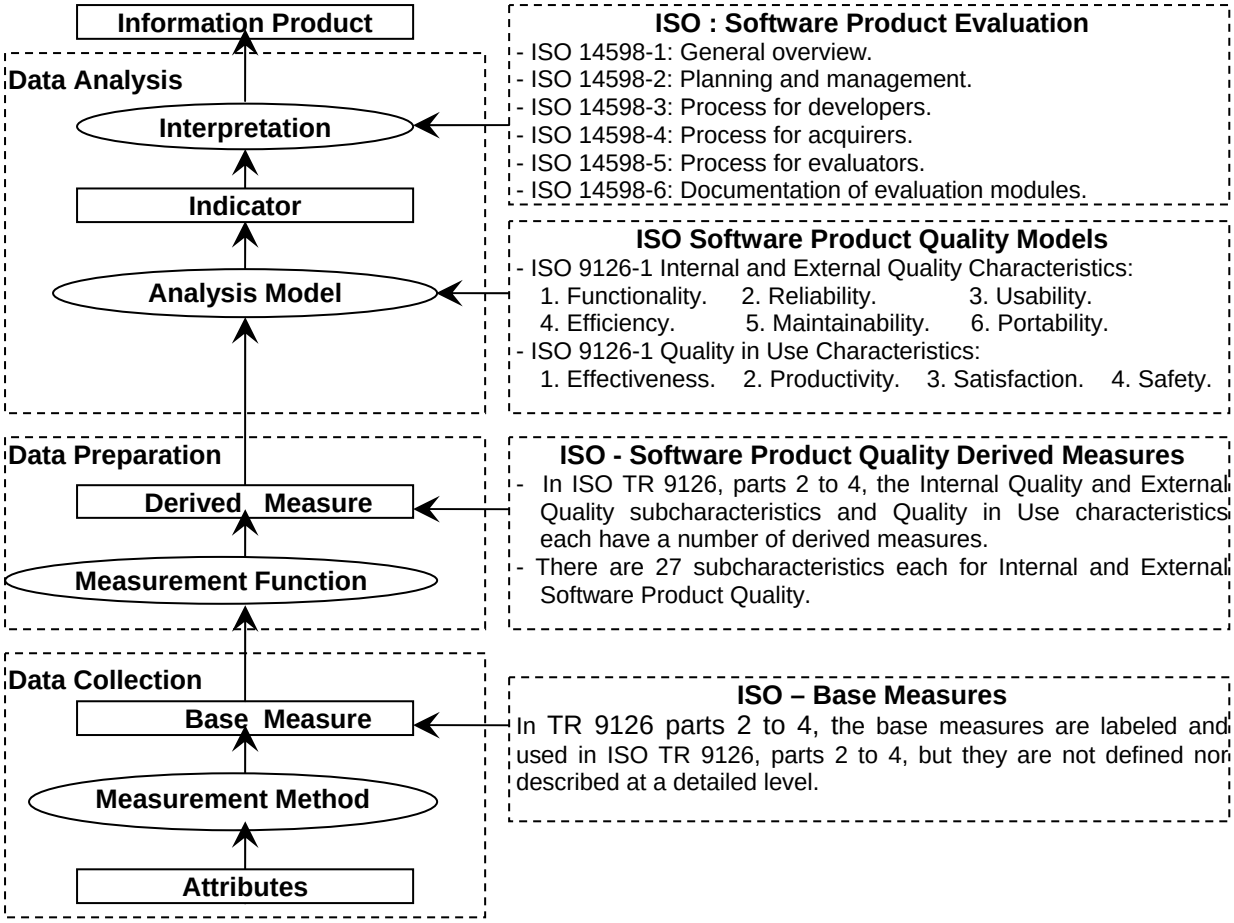
2.2 Harmonization with the ISO 15939 Information Model

The ISO 15939 information model has been divided into three different sections: data collection, data preparation and data analysis [11]. Figure 3 shows a mapping between this information model (left-had side of Fig. 3) and the software product quality measurement and evaluation of ISO series 9126 and 14598 (right-hand side of Fig. 3).

2.3 Description Harmonization

The WG6 proposal in [10] recommends next a set of 15 ‘General Quality Measure Elements’ – Table 1 – to be used as ‘Specific Quality Measure Elements’ within the software product life cycle; [10] includes a description of its selection of 61 such ‘Specific Quality Measure Elements’. However, it is noted that there are no specific quality measure elements related to the general quality measure elements ‘Number of User Operations’ or ‘Number of System Operations’.

Figure 3: Mapping between ISO 15939 Information Model and ISO 9126 and ISO 14598



For the description of each of these quality measure elements, different ‘aspects’ are proposed in [10]:

1. Scale type: the aspect related to the scale type used for measurement.
2. Focus: the aspect related to the scope and objective of the measurement (e.g. the software product itself, the software product in a system, the software product in a system used by a specified user in a specified scenario).
3. Method type: the aspect related to the measurement method type relating to the quality measure element used for measurement.

For aspect 3, it is stated in the same document that the scope and objective are related to the different parts of ISO 9126 (internal quality, external quality and quality in use). It must be noted that the use of expressions such as ‘scope’ in [10] for a measurement method is not harmonized with the corresponding ‘scope’ terminology used in other ISO software measurement-related standards, such as ISO 14143-1 [12] and ISO 19761 [13].

Table 1: 'General Quality Measure Elements' [10]

1. Number of Functions	2. Number of Failures
3. Number of Faults	4. Product Size
5. Time Duration	6. Number of Test Cases
7. Number of Restarts	8. Number of I/O
9. Number of Trials	10. Number of Data Items
11. Data Size	12. Number of Requirements
13. Number of Tasks	14. Number of User Operations
15. Number of System Operations	

It can also be observed that, in Table 1, a number of the quantities have a label starting with 'number of'. However, these do not use a reference scale typical of measures in the sciences or in engineering, but are rather counts on entities. For any of these proposed counts, such as the 'number of functions', no specific method is proposed for an identification of the number of functions in a consistent manner across measurers and organizations; for instance, the definition of the word 'function' could differ from one individual to another within the same organization, and more so across organizations. Therefore, to say in [10] that such numbers are obtained by an 'objective' method is an overstatement, since they must be obtained mostly on the basis of the judgment of the person carrying out the count.

Of the 15 proposed general quality measure elements, only 'time' comes from a classic base measure using, for instance, the international standard unit of the second (or a multiple or submultiple of it) as its reference scale. There are also measuring instruments to ensure that time measurements are indeed obtained in an objective manner.

It can also be observed that, of the 15 measures proposed in Table 1, at most four are directly related to the quality of software: number of faults, number of failures, number of restarts and number of trials. None of the other 12 measures is directly or indirectly related to the quality of software. In fact, they are strictly independent of it per se,, as they are often used for normalization purposes, for instance.

Finally, in [14], the issue of documenting a base measure using the full set of metrology concepts about quantities and units has been investigated and recommendations provided that would lead to a more comprehensive design of the software measure.

2.4 Lack of reference to corresponding ISO measurement standards

For the 'product size' general quality measure element, [10] lists many ways to measure product size: lines of code, function points, modules, classes and visual structures. There are also various methods for counting lines of code and for measuring function points. Therefore, this general quality measure element could be further split into different base measures. Moreover, the ISO has specified mandatory requirements for function point measurement methods [12], and has recognized four different functional size measurement methods as ISO standards meeting these requirements, such as COSMIC-FFP [13]. None of these existing ISO software

engineering standards, which are referenced in ISO 90003 [15], has been mentioned or referenced in [10]. Also, the various methods available to obtain those numbers have their strengths and weaknesses, from a measurement perspective, in terms of repeatability, reproducibility, software domains of applicability and accuracy.

3 Coverage Harmonization

3.1 Limited coverage of the ISO quality models and corresponding measures

ISO TR 9126, parts 2 to 4, presents the ISO inventory of measures for the full coverage of the ISO software product quality models (internal quality, external quality and quality in use) for measuring any of their quality characteristics and subcharacteristics. The full sets of base measures in these three parts of ISO 9126 are presented in Appendix A and include 82 base measures.

Of these 82 base measures, only 15 are included in [10]; this means that the coverage in [10] is very limited, and the reasons for this are not obvious. The proposed content coverage of this subset of base measures is claimed in [10] to be the 'most important'; however, no specific criteria to determine its 'importance' are provided. Some generic information is provided in [10] to suggest that these measures were derived from a questionnaire-based survey; however, it does not provide the reader with information about the criteria for selection, the size and representativeness of the sample in the countries where the data were collected, or the representativeness of this sample outside these countries. Another claim, that "*they represent a default kernel of quality measures, which are proven to be beneficial and common practice*" [10], is not supported by documented evidence, nor is there a discussion of its generalizability outside its data collection context.

Appendix B presents a detailed analysis of the coverage of the quality measures in [10], together with the corresponding availability in ISO TR 9126, parts 2 to 4. Appendix B specifically illustrates that 15 measures for the 'internal quality' of software product are selected in [10] out of an inventory of 70 in the corresponding ISO TR 9126-3, while 55 measures are excluded, again without a documented rationale.

Furthermore, the 15 measures of internal quality selected in [10] cover only 4 of the 6 quality characteristics of the ISO model of internal quality, and only 9 of 27 subcharacteristics; again, the rationale for excluding any characteristic or subcharacteristic is not documented.

Similarly, for the 'Quality in Use' quality measures, [10]:

- Includes only 2 quality measures of the 15 already available in ISO TR 9126-4
- Excludes 2 QIU characteristics, that is, 'safety' and 'satisfaction'
- Does not include any Specific Quality Measure Elements related to the 'Number of User Operations' and 'Number of System Operations'

3.2 Overlapping issues

Some additional information included in [10] has already been covered in ISO TR 9126 documents, and will be included in the ISO 25000 series; for instance, information about the ‘scale types’ is covered through rephrasing information contained in other documents, once again increasing synchronization and harmonization right away and over the long term. Similarly for the narratives about the measures of internal software quality, external software quality and software quality in use, as well as for the narratives about the software measurement methods.

This is contrary to the ISO practice of avoiding duplication or the rephrasing of information across ISO documents, and increases the possibility of inconsistencies across documents; it could later lead to significant effort over the long term in maintaining synchronization of documents covering similar subsets of information.

These examples point to configuration management issues over the long term which will represent additional cost to the purchasers of these ISO documents, since they will be required to pay twice for the same information which is a subset of the full inventory. This could lead to some confusion for standards users as to which of these documents is most valuable to a standard purchaser, and under what circumstances.

4 Discussion

4.1 Summary of harmonization issues in ISO DTR 25021

The ISO is now working on the next generation of software product quality standard, which will be referred to as Software Product Quality Requirements and Evaluation (ISO 25000). One of the objectives of this new ISO 25000 series (and what differentiates it from the current ISO 9126 series) is the harmonization of its contents with the software measurement terminology of ISO 15939 [8], itself based on the ISO metrology terminology [9]. In this paper, terminology harmonization issues have been identified, as well as the coverage of harmonization issues in ISO DTR 25021 and ISO 9126 in terms of the coverage of ISO quality models.

Below is a summary of the harmonization issues identified:

A) Terminology in [10]:

- what is referred to as a ‘quality measure element’ corresponds to the classic concept of ‘base measure’ in ISO 15939;
- what is referred to as ‘software quality measure’:
    - corresponds to the classic concept of ‘derived measure’ in ISO 15939;
    - is not at the proper level of abstraction for the concept being measured when mapped to the hierarchy of concepts for software product quality adopted by the ISO.

B) Harmonization with the Information Model of ISO 15939:

- unless the terminology is harmonized with ISO International Vocabulary of Basic and General Terms in Metroogy, then it is challenging to align the older versions of the ISO 9126 and ISO 14598, and it will be even more challenging with the upcoming updates in ISO 25000.
- should the harmonization of terminology be accepted, it becomes then easier to map each of these ISO 9126 and 14598 series into the Information Model of ISO 15939.

C) Description harmonization:

- A large number of the base measures proposed are counts of entities rather than measures per se with required metrological characteristics, such as: unit, scale, dimension, measurement method, measurement procedures, etc.
- In [10], in some instances, like ‘product size’ for example, there is no reference to other existing ISO standards for software size, such as ISO 19761, etc.
- There are a number of claims that the proposed base measures are ‘objective’, while they are obviously derived from a manual process without precisely documented measurement procedures, thereby leaving much to the measurer’s judgment.

D) Coverage harmonization in [10]:

- The set of base measures documented represents only a limited subset of the base measures within ISO 9126, parts 2 to 4; the rationale for inclusion or exclusion is not documented.
- The set of base measures does not allow coverage of the full spectrum of quality characteristics and subcharacteristics in ISO 9126, parts 2 to 4; again, the rationale for inclusion or exclusion is not documented.

4.2 Recommendations

From the above analysis, the following recommendations are put forward:

- Ensure that the terminology on software product quality measurement is fully aligned with the classic measurement terminology in the sciences and in engineering;
- Provide full coverage of the base measures for all three ISO models of software quality;
- Provide improved documentation of the base measure using the criteria from metrology;
- Provide clear mapping and traceability of the new ISO 25000 documents to the ISO 15939 Information Model.

Acknowledgments

The opinions expressed in this paper are solely those of the authors.

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The following apendices were not included in the journal due to space constraints.

Appendix A

List of ISO 9126 Base Measures

External Quality - Base Measures	
1	Number of Functions
2	Operation Time
3	Number of Inaccurate Computations Encountered by Users
4	Total Number of Data Formats
5	Number of Illegal Operations
6	Number of Items Requiring Compliance
7	Number of Interfaces Requiring Compliance
8	Number of Faults
9	Number of Failures
10	Product Size
11	Number of Test Cases
12	Number of Breakdowns
13	Time to Repair
14	Down Time
15	Number of Restarts
16	Number of Restoration Required
17	Number of Tutorials
18	Number of I/O Data Items
19	Ease of Function Learning
20	Number of Tasks
21	Help Frequency
22	Error Correction
23	Number of Screens or Forms
24	Number of User Errors or Changes
25	Number of Attempts to Customize
26	Total Number of Usability Compliance Items Specified
27	Response Time
28	Number of Evaluations
29	Turnaround Time
30	Task Time
31	Number of I/O Related Errors
32	User Waiting Time of I/O Device Utilization
33	Number of Memory Related Errors
34	Number of Transmission Related Errors
35	Transmission Capacity
36	Number of Revised Versions
37	Number of Resolved Failures
38	Porting User Friendliness
Internal Quality - Base Measures	
1	Number of Functions
2	Number of Data Items
3	Number of Data Formats
4	Number of Interface Protocols

5	Number of Access Types
6	Number of Access Controllability Requirements
7	Number of Instances of Data Corruption
8	Number of Compliance Items
9	Number of Interface Requiring Compliance
10	Number of Faults
11	Number of Test Cases
12	Number of Restoration
13	Number of Input Items Which Could Check for Valid Data
14	Number of Operations
15	Number of Messages Implemented
16	Number of Interface Elements
17	Response Time
18	Turnaround Time
19	I/O Utilization (Number of Buffers)
20	Memory Utilization
21	Number of Lines of Code Directly Related to System Calls
22	Number of I/O Related Errors
23	Number of Memory Related Errors
24	Number of Items Required to be Logged
25	Number of Modifications Made
26	Number of Variables
27	Number of Diagnostic Functions Required
28	Number of Entities
29	Number of Built-in Test Function Required
30	Number of Test Dependencies on Other System
31	Number of Diagnostic Checkpoints
32	Number of Data Structures
33	Total Number of Setup Operations
34	Number of Installation Steps
	Quality in use - Base Measures
1	Task Effectiveness
2	Total Number of Tasks
3	Task Time
4	Cost of the Task
5	Help Time
6	Error Time
7	Search Time
8	Number of Users
9	Total Number of People Potentially Affected by the System
10	Total Number of Usage Situations

Appendix B

Table B1: External Quality – ISO TR 9126-2 and ISO DTR 25021

Quality Characteristics	Quality Subcharacteristics		Measure Names	ISO DTR 25021	ISO 9126-2
Functionality	Accuracy	1	Computational accuracy	√	√
		2	Precision	√	√
		3	Accuracy relative to expectations		√
	Interoperability	4	Data exchangeability (Data format-based)	√	√
		5	Data exchangeability (User's success, attempt-based)		√
	Security	6	Access controllability	√	√
		7	Access auditability		√
		8	Data corruption prevention		√
	Suitability	9	Funcional implementation completeness	√	√
		10	Functional adequacy	√	√
		11	Functional implementation coverage	√	√
		12	Functional specification stability (volatility)		√
	Functionality Compliance	13	Functional compliance		√
		14	Interface standard compliance		√
Reliability	Maturity	15	Failure density against test cases	√	√
		16	Failure resolution	√	√
		17	Fault removal	√	√
		18	Mean time between failures (MTBF)	√	√
		19	Test maturity	√	√
		20	Estimated latent fault density	√	√
		21	Fault density	√	√
		22	Test coverage (Specified operation scenario testing coverage)		√
	Recoverability	23	Restartability	√	√
		24	Availability		√
		25	Mean down time		√
		26	Mean recovery time		√
		27	Restorability		√
		28	Restore effectiveness		√
	Fault Tolerance	29	Breakdown avoidance		√
		30	Failure avoidance		√
		31	Incorrect operation avoidance		√
	Reliability Compliance	32	Reliability compliance		√
Usability	Learnability	33	Effectiveness of the user documentation and/or help system	√	√
		34	Help accessibility	√	√
		35	Ease of function learning		√
		36	Ease of learning to perform a task in use		√
		37	Effectiveness of user documentation and/or help system in use		√
		38	Help frequency		√
	Operability	39	Physical accessibility	√	√
		40	Operational consistency in use		√

Quality Characteristics	Quality Subcharacteristics		Measure Names	ISO DTR 25021	ISO 9126-2
		41	Error correction		√
		42	Error correction in use		√
		43	Default value availability in use		√
		44	Message understandability in use		√
		45	Self-explanatory error messages		√
		46	Operational error recoverability in use		√
		47	Time between human error operations in use		√
		48	Undoability (User error correction)		√
		49	Customizability		√
		50	Operation procedure reduction		√
	Understandability	51	Completeness of description	√	√
		52	Function understandability	√	√
		53	Understandable input and output	√	√
		54	Demonstration accessibility		√
		55	Demonstration accessibility in use		√
		56	Demonstration effectiveness		√
		57	Evident functions		√
	Attractiveness	58	Attractive interaction		√
		59	Interface appearance customizability		√
	Usability Compliance	60	Usability compliance		√
Efficiency	Resource Utilization	61	I/O loading limits	√	√
		62	Maximum memory utilization	√	√
		63	Maximum transmission utilization	√	√
		64	Mean occurrence of transmission error	√	√
		65	I/O device utilization		√
		66	I/O-related errors		√
		67	Mean I/O fulfillment ratio		√
		68	User waiting time of I/O device utilization		√
		69	Mean occurrence of memory errors		√
		70	Ratio of memory error/time		√
		71	Media device utilization balancing		√
		72	Mean transmission error per time		√
		73	Transmission capacity utilization		√
	Time Behavior	74	Response time (Mean time to respond)	√	√
		75	Throughput (Mean amount of throughput)	√	√
		76	Turnaround time (Mean time for turnaround)	√	√
		77	Response time		√
		78	Response time (Worst case response time ratio)		√
		79	Throughput		√
		80	Throughput (Worst case throughput time ratio)		√
		81	Turnaround time		√
		82	Turnaround time (Worst case turnaround time ratio)		√
		83	Waiting time		√

Quality Characteristics	Quality Subcharacteristics		Measure Names	ISO DTR 25021	ISO 9126-2
	Efficiency Compliance	84	Efficiency compliance		√
Maintainability	Analyzability	85	Audit trail capability	√	√
		86	Diagnostic function support		√
		87	Failure analysis capability		√
		88	Failure analysis efficiency		√
		89	Status monitoring capability		√
	Changeability	90	Software change control capability	√	√
		91	Change cycle efficiency		√
		92	Change implementation elapsed time		√
		93	Modification complexity		√
		94	Parameterized modifiability		√
	Stability	95	Change success ratio		√
		96	Modification impact localization (Emerging failure after change)		√
	Testability	97	Availability of built-in test function		√
		98	Retest efficiency		√
		99	Test restartability		√
	Maintainability Compliance	100	Maintainability compliance		√
Portability	Adaptability	101	Adaptability of data structures	√	√
		102	Hardware environmental adaptability (adaptability to hardware devices and network facilities)	√	√
		103	System software environmental adaptability (adaptability to OS, network software and cooperated application software)	√	√
		104	Organizational environment adaptability (Organization adaptability to infrastructure of organization)		√
		105	Porting user-friendliness		√
	Installability	106	Ease of installation	√	√
		107	Ease of setup retry		√
	Coexistance Replaceability	108	Availability coexistence		√
	Replaceability	109	Continued use of data		√
		110	Function inclusiveness		√
		111	User support functional consistency		√
	Portability Compliance	112	Portability Compliance		√

Table B2: Internal Quality – ISO TR 9126-3 and ISO DTR 25021

Quality Characteristics	Quality Subcharacteristics		Measure Names	ISO DTR 25021	ISO 9126-3
Functionality	Accuracy	1	Computational accuracy	√	√
		2	Precision	√	√
	Interoperability	3	Data exchangeability (Data format-based)	√	√
		4	Interface consistency (protocol)		√
	Security	5	Access controllability	√	√
		6	Access auditability		√
		7	Data corruption prevention		√
		8	Data encryption		√
	Suitability	9	Funcional implementation completeness	√	√
		10	Functional adequacy	√	√
		11	Functional implementation coverage	√	√
		12	Functional specification stability (volatility)		√
	Functionality Compliance	13	Functional compliance		√
		14	Intersystem standard compliance		√
Reliability	Maturity	15	Fault removal	√	√
		16	Fault detection		√
		17	Test adequacy		√
	Recoverability	18	Restorability		√
		19	Restoration effictiveness		√
	Fault Tolerance	20	Failure avoidance		√
		21	Incorret operation avoidance		√
	Reliability Compliance	22	Reliability Compliance		√
Usability	Learnability	23	Completeness of user documentation and/or help facility	√	√
	Operability	24	Physical accessibility	√	√
		25	Input validity checking		√
		26	User operation cancellability		√
		27	User operation undoability		√
		28	Customizability		√
		29	Operation status monitoring capability		√
		30	Operational consistency		√
		31	Message clarity		√
		32	Interface element clarity		√
		33	Operational error recoverability		√
	Understandability	34	Completeness of description	√	√
		35	Function understandability	√	√
		36	Demonstration capability		√
		37	Evident functions		√
	Attractiveness	38	Attractive interaction		√
		39	User interface appearance customizability		√
	Usability Compliance	40	Usability Compliance		√
Efficiency	Resource Utilization	41	I/O utilization		√
		42	I/O utilization message density		√
		43	Memory utilization		√
		44	Memory utilization message density		√

Quality Characteristics	Quality Subcharacteristics		Measure Names	ISO DTR 25021	ISO 9126-3
		45	Transmission utilization		√
	Time Behavior	46	Response time		√
		47	Throughput time		√
		48	Turnaround time		√
	Efficiency Compliance	49	Efficiency compliance		√
Maintainability	Analyzability	50	Activity recording		√
		51	Readiness of diagnostic function		√
	Changeability	52	Change recordability		√
	Stability	53	Change impact		√
		54	Modification impact localization		√
	Testability	55	Completeness of built-in test function		√
		56	Autonomy of testability		√
		57	Test progress observability		√
	Maintainability Compliance	58	Maintainability compliance		√
Portability	Adaptability	59	Adaptability of data structures	√	√
		60	Hardware environmental adaptability (adaptability to hardware devices and network facilities)	√	√
		61	System software environmental adaptability (adaptability to OS, network software and cooperated application software)	√	√
		62	Organizational environment adaptability		√
		63	Porting user-friendliness		√
	Installability	64	Ease of setup retry		√
		65	Installation effort		√
		66	Installation flexibility		√
	Co-existence	67	Availability of coexistence		√
	Replaceability	68	Continued use of data		√
		69	Functional inclusiveness		√
	Portability Compliance	70	Portability compliance		√

Table B3: Quality in Use – ISO TR 9126-4 and ISO DTR 25021

Quality Characteristics		Measure Names	ISO DTR 25021	ISO 9126-4
Effectiveness	1	Task effectiveness		√
	2	Task completion	√	√
	3	Error frequency		√
Productivity	4	Task time	√	√
	5	Task efficiency		√
	6	Economic productivity		√
	7	Productive proportion		√
	8	Relative user efficiency		√
Safety	9	User health and safety		√
	10	Safety of people affected by use of the system		√
	11	Economic damage		√
	12	Software damage		√
Satisfaction	13	Satisfaction scale		√
	14	Satisfaction questionnaire		√
	15	Discretionary usage		√