REVIEW OF SOFTWARE QUALITY RELATED ISO STANDARDS

A SZOFTVERMINŐSÉGGEL KAPCSOLATOS ISO SZABVÁNYOK ÁTTEKINTÉSE

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Abstract

The present study aims to provide an overview of the current state of standardization efforts regarding software quality. Starting with the general characteristics of ISO standards, taking into account both their good and less good properties, briefly covering standardization organizations other than ISO. Starting from a brief, historical recall of the relevant basic concepts of quality and software quality, it outlines the key elements of the ISO / IEC 25000 family of standards, emphasizing the beneficial effects on IT security of using the family of standards, with a brief description of related additional standards. It illustrates the effective applicability of this family of standards with real-life examples from different parts of the world, taking into account Hungary's involvement and position on the subject.

Keywords

software quality, quality management, standards theory, information security, software development

Absztrakt

Jelen tanulmány egy áttekintő képet kíván szolgáltatni a szoftverminőséget érintő szabványosítási törekvések jelenlegi állásáról. Kezdve az ISO szabványok általános jellemzőitől, egyaránt számba véve azok jó és kevésbé jó tulajdonságait, röviden kitérve az ISO-tól különböző szabványosító szervezetekre is. A minőség és a szoftverminőség releváns alapfogalmainak rövid, történeti jellegű felidézésétől elindulva nagy vonalakban ismerteti az ISO/IEC 25000 szabványcsalád leglényegesebb elemeit, hangsúlyozva a szabványcsalád alkalmazásának kedvező hatását az informatikai biztonságra, a kapcsolódó további szabványok rövid ismertetésével. Való életből, a világ különböző részeiről származó példákkal illusztrálja az említett szabványcsalád hatékony alkalmazhatóságát, figyelembe véve Magyarország érintettségét és helyzetét a témában.

Kulcsszavak

szoftverminőség, minőségmenedzsment, szabványelmélet, információbiztonság, szoftverfejlesztés

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INTRODUCTION

Software is everywhere, it's in our computers, our cars, our watches, our washing machines, even in today's lawn mowers. Faulty software can cause many harms, in some cases, people's lives can depend on software quality, so it must be taken seriously. The quality of software in industrial applications or even in everyday life is vital for both developers and customers. Several standardization efforts aim to provide frameworks for evaluating software from the perspective of quality, but unfortunately, I they are not widespread enough. Software quality deficiencies can cause many issues, including security related problems. For example, I believe that usability problems can easily encourage users to deviate from the intended use of software systems. The topic has a strong relation with risk assessment, I plan to address this aspect in another article.

This study aims to do multiple things. I would like to give a review about software quality related de jure standards and also popularize them (knowing the disadvantages as well). I think that software quality standards should be used more widely in the industry.

ISO STANDARDS IN GENERAL

Let's start with a delicate topic, standards in general. The goals of standardization are well known, giving a unified approach on performing various activities, to put it simple, standards are showing the best way of doing things. [1] This is a goal with which one can easily identify, however not all features of standards are clearly positive, in the following I would like to highlight some difficulties as well. There are many standardization bodies around the world like ISO, ECMA, NIST etc., but mainly I shall focus on ISO in this article.

First of all, ISO standards cost money. It is only natural though, considering the lot of experience and work needed for creating a well-defined, usable standard. Secondly, ISO standards are famous for limited accessibility. David Travis also states that ISO standards are hard to access and expensive. [2] I can only confirm this from my personal experience. As an individual researcher, I have very few options to access ISO standards. First thing to check: university libraries, based on their catalogues, they do to not tend to hold copies of standards.

However, the Hungarian Standards Institution (Magyar Szabványügyi Testület, MSzT) has a reading room which provides international standards for reading purposes, but only those that have been published in Hungary. The service has a fee, but it is free for students. (On a side note: it is closed due to the current pandemic situation.) The institution has an online reading room as well, it is available as a yearly subscription, but there is no option for universities to have institutional access whatsoever. Furthermore, the students discount is valid only for the real reading room. [3]

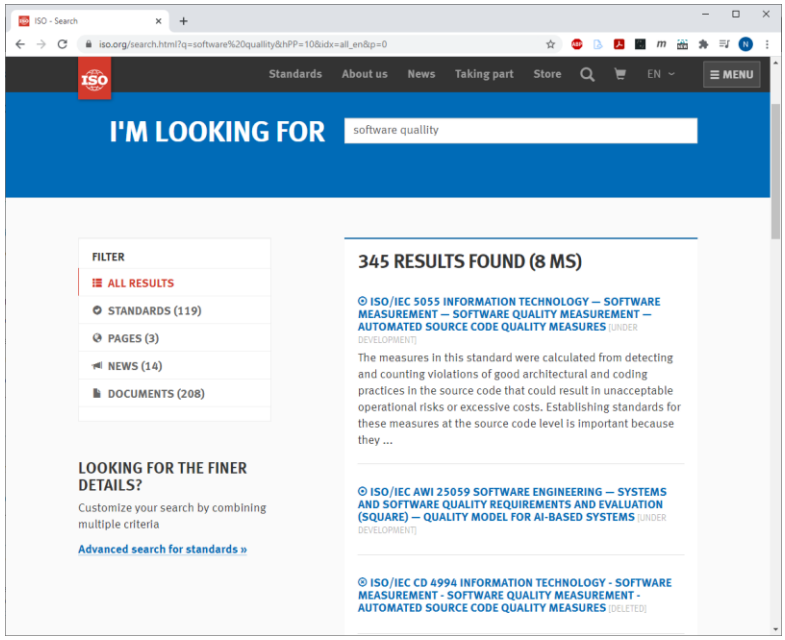
The price of standards only makes the situation worse; consider the ISO 9241 standard, a multipart standard covering ergonomics of human-computer interaction. It consists of more than twenty parts, buying all of them would cost at least a thousand euros. I have stopped counting at the fifth part of the standard. [2] [4] Obviously not all users need all parts of a standard, so the expenses can be fine-tuned.

I think that each and every standard, and family of standards should have a freely accessible, ISO-published, detailed guide that is available free of charge. It would make a lot easier for those interested in standards to find the most appropriate ones for their needs.

In connection with the price of standards emerges the problem of withdrawn standards. Let's consider ISO/IEC 9241-151 "Ergonomics of human-system interaction — Part 151: Guidance on World Wide Web user interfaces". It was first published in May 2008, and approximately 10 years later withdrawn, with no successor standard designated on the official site. After few internet searches I have found ISO/IEC/IEEE 23026:2015 "Systems and software engineering — Engineering and management of websites for systems, software, and services information", which based on its abstract covers more or less the ISO/IEC 9241-151, but I cannot state it with full conviction, because I do not own the new standard. I think that owners of soon to be withdrawn standards should be notified about the upcoming withdrawal, and should be offered alternatives to buy on a discount price.

Another "bad example" is the following standard: ISO/IEC/IEEE 12207-2:2020 Systems and software engineering — Software life cycle processes — Part 2: Relation and mapping between ISO/IEC/IEEE 12207:2017 and ISO/IEC 12207:2008. It costs approximately 180 EUR. [5] If a business wants to maintain compliance to ISO/IEC 12207, it has to pay for mapping tables between the withdrawn and newly published standards. I think that this kind of information should be a part of the aforementioned free-of-charge guide.

There are however some initiatives for making ISO standards more accessible in the form of review books, informational portals and such. These documents can really help businesses and individuals navigate in the world of standards. Again, the ISO 9241; without guidance it can be hard to determine, which part of the standard is relevant to a business. Although the table of contents is accessible for most of the standards on the official ISO website as a preview, it provides far too little information to make a well-informed decision.



1. Figure ISO search

One more note on the accessibility of standards, the official ISO website is less straightforward to a new inquirer. The search gives an overwhelming amount of information

if one does not know exactly, what he/she is looking for. I typed in 'software quality' in the ISO web shop search bar, the result is 345 elements of standards, news, web pages and documents mixed up in one list. On the first page there were 10 results, half of them was irrelevant because it was either deleted or under development. And there were 20 more pages to review.

The other method is to browse the catalogue by ICS, or TC. ICS stands for 'International Classification for Standards' and TC means 'Technical Committee'. Searching for 'ICS' on the ISO website leads the inquirer to the download screen of latest version of the ICS documentation and similarly a search for 'TC' gives information about the standard developing technical committees of ISO.

Speaking of Technical Committees, according to ISO official website ISO member bodies, like the aforementioned Hungarian Standards Institution (Magyar Szabványügyi Testület, MSzT) can choose if they want to participate to a particular TC and the level of involvement. The membership in a TC can be of two types: observing (O) or participating (P). O-members can observe the standards that are being developed, offering comments and advice. While P-members actively participate by voting on the standard at various stages of its development. [5]

In the 2004 study, Who Develops ISO Standards? A Survey of Participation in ISO's International Standards Development Processes stated that historically speaking, ISO standards have been dominated by industrialized nations, especially Western European countries. And there was no significant improvement in participations of less-developed regions despite ISO acknowledging the problem of under-representation of less-developed regions. The study also stated that the contribution of less developed countries matters less even if they are P-members of a TC, furthermore developed nations tend to send far more delegates to meetings and to hold more leadership positions within TCs. [6]

I haven't found a similar, more up-to-date study, but I have checked the official ISO website regarding the Hungarian participation in developing standards. MSzT is a participating member of 104 TC's and observing member of 419 TC's furthermore, it's a P-member of ISO/CASCO (Committee on conformity assessment) PDC and O-member of two other PDC's. PDC stands for Policy Development Committee. [5] In my humble opinion, I consider it very important that Hungary participates in so many TCs, thus providing an opportunity to influence the development of international standards.

The two following membership is relevant to this study: MSzT is P-member of the ISO/TC 176 Quality management and quality assurance TC and O-member of the ISO/IEC JTC 1 Information technology TC. [5]

On a side note: I do not know if the official ISO website is certified based on any ISO standards, but personally I would find it appealing if it were. ISO could easily set a good example by certifying its own website based on the relevant ISO/IEC standards, such as ISO/IEC/IEEE 23026:2015 and/or ISO/IEC 250xx standards.

Furthermore, the application of standards is optional in many cases. On one hand, this can be considered as an advantage, because small businesses do not have pay for the standards and the certification process, because no organization enforces the use of standards in any way (they are not like laws). On the other hand, not using a standard may deprive businesses of applying good practices, in some cases reduces their chances of winning tenders.

There are however standardization bodies other than ISO, like W3C (World Wide Web Consortium), ECMA (European association for standardising information and communication systems) etc. I would like to stress out that many of important standards, or in other words recommendations with great impact on the world are freely available like the W3C XML recommendation (Extensible Markup Language (XML) 1.0 (Fifth Edition)), or the ECMA-262 ECMAScript® 2020 language specification which is the basis of the very popular JavaScript programming language.

The software industry has taken significant steps towards open-source software in the recent years, with several large companies opening the source code for their very important products, e.g., the Microsoft .NET programming platform. I believe that a similar approach to standards would greatly contribute to the widespread use of standards.

SOFTWARE QUALITY

Next, I shall give a brief overview of the concepts of quality and software quality in particular. According to the Cambridge English Dictionary the word quality has three main meanings: 'how good or bad something is', 'a high standard', 'a characteristic or feature of someone or something'. [7]

In his 1984 paper Garvin synthetized the various interpretations of quality into 5 definitions. The *transcendent definition* mainly represents a philosophical position, which on its own proved to be less pragmatic in the past years. [8] [9]

The *product-based definition* views quality as an exactly measurable variable, so quality is an objective characteristic stemming from the features of the product. [8] [9]

The *manufacturing-based (or process-based) definition* simply states that quality is nothing more than compliance with requirements. [8] [9]

The *user-based definition* is subjective, because it views quality in terms of suitability for use, practically speaking, the best product is the one that is best suited to accomplish the goal. [8] [9]

Finally, the *value-based definition* states that a good quality product fulfils requirements in a cost-effective way, to put it simple, it is suitable for the task and in the same time preferably inexpensive. [8] [9]

Basically, two approaches, the process based and product based, have taken root in the industry, complemented by certain aspects of the other perspectives. [9]

ISO 9001:2015 standard uses a process-based approach helping its users creating, and maintaining processes that ensure the quality of the product or service in question. It defines quality as the following: 'degree to which a set of inherent characteristics of an object fulfils requirements '. [10] So, basically, as Crosby also stated in 1979, quality means meeting the specification. [11]

This definition however needs further clarification based on the aforementioned standard. An "object" can be anything perceivable or conceivable, given that software is object in this terminology.

A "requirement" is 'need or expectation that is stated, generally implied or obligatory'. Requirements can be of many types e.g., customer, statutory, regulatory. Requirements can be fulfilled or neglected, these two states were named by the authors of the standard "conformity" and "nonconformity". [10]

The traditional definition of quality cannot be interpreted directly for software though for many reasons. Firstly, software quality has different meanings for different participants in the software development process. A good software for developers has a readable, maintainable source code etc. A good software for operators is easy to install, has a straightforward configuration, secure enough, etc. A good software for end-users is suitable for the task, fast, has a straightforward UI etc. Secondly, the other aspect arises from the former, for a software to be called good, functional compliance is not enough by far.

This is why the definition of requirement needs further refinement in terms of software. Ian Sommerville basically distinguishes between two types of requirements: *functional* and *nonfunctional*. Sommerville also mentions a third category called *domain requirements.* [12]

Functional requirements describe in detail how the software system should work. Non-functional requirements are another dimension of software expectation because they do not directly relate to the functionality of the system, but rather describe the resulting properties of the system or impose constraints on them. [12]

In my opinion, non-functional requirements can also be interpreted as requirements for meeting functional requirements, as they set expectations for functionalities in terms of speed, size, usability, robustness, and portability (e.g., an application is suitable for performing a certain task, but is it fast enough while doing it? is it secure enough while doing it? etc.). Conformance to regulations and standards is also a nonfunctional requirement. [12]

Domain requirements stem from the industry environment in which the software is used, and can be classified into the former two categories. [12]

Back to the standards, at first ISO 9000 has not supported software development processes specifically, so the ISO 9000-3 was published to fulfill the needs of the software industry. In 2004 the first version of ISO/IEC 90003 superseded the aforementioned standard, giving guidelines on applying the latest ISO 9000 in software development. [9] [13]

There are also other approaches to ensure the quality of software development processes like CMM (Capability Maturity Model), CMMI (Capability Maturity Model Integration), ISO/IEC 33001:2015, among others, but they are out of the scope of this study.

In contrary, the now obsolete yet noteworthy ISO/IEC 9126 and its successor, the ISO/IEC 25010:2011 keeps software as a product in focus. The quality model defined in the former serves as a solid base for the ISO/IEC 25010.

Although the two interpretations of quality (process-based and product-based) mentioned above are fundamentally different, they go hand in hand in many cases. The process-based ISO 90003 recommends that the ISO/IEC 25010 should be used to define the quality attributes of the software produced with the ISO 9000 conformant software development processes. [13]

The ISO/IEC 25000 family of standards, also known as SQuaRE (System and Software Quality Requirements and Evaluation), provides a framework for the evaluation of software product quality having five divisions: Quality Management (2500x), Quality Model (2501x), Quality Measurement (2502x), Quality Requirements (2503x) and Quality Evaluation (2504x). [14] [15]The standards included in the series are shown in the table below.

ISO number	Name

ISO/IEC 25000 family	Systems and software engineering - Systems and software quality requirements and evaluation (SQUARE)
Quality Management Division	
ISO/IEC 25000:2014	Guide to SQUARE
ISO/IEC 25001:2014	Planning and Management
Quality Model Division	
ISO/IEC 25010:2011	System and software quality models
ISO/IEC 25012:2008	Data Quality model
Quality Measurement Division	
ISO/IEC 25020:2015	Measurement reference model and guide
ISO/IEC 25021:2015	Quality measure elements
ISO/IEC 25022:2015	Measurement of quality in use
ISO/IEC 25023:2015	Measurement of system and software product quality
ISO/IEC 25024:2015	Measurement of data quality
Quality Requirements Division	
ISO/IEC 25030:2015	Quality requirements
Quality Evaluation Divison	
ISO/IEC 25040:2011	Evaluation reference model and guide
ISO/IEC 25041:2012	Evaluation guide for developers, acquirers and independent evaluators
ISO/IEC 25042:2015	Evaluation modules
ISO/IEC 25045:2015	Evaluation module for recoverability

1. Table ISO/IEC 25000 family

The two standards (Guide to SQuaRE and Planning and management) in the Quality Management division define all common models, terms and definitions referred by all other standards from the series. [15]

The ISO/IEC 25010 standard from the Quality Model division defines quality requirements for software development products in eight areas (functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, portability). [14] Note that seven main categories of eight are related to non-functional requirements, which also confirms that software quality depends on functional conformity only to a relatively small extent.

The quality models in ISO/IEC 25010:2011 can be used in the following product development activities: identifying software requirements; validating requirements; identifying software design objectives; identifying software testing objectives; as part of quality assurance in establishing quality management criteria; identifying user acceptance criteria for a software product; in developing quality characteristics. According to its recommendation, ISO/IEC 25010: 2011 should be used either in conjunction with other members of the SQuaRE family of standards or in addition to ISO/IEC/IEEE 12207:2017 and/or ISO/IEC/IEEE 15288. [16] [17] The assessment of the requirements can also be used in the implementation phase to test the products delivered by the system vendor. [18] In my understanding the quality profile of software product should be determined in cooperation by the developers and users in the earliest phase as possible, in order to ensure that quality means the same for every stakeholder in the development process.

Also from Quality Model division, the ISO/IEC 25012 - Data Quality model: defines a general data quality model for structured data retained within computer systems. It focuses on the quality of the data as part of a computer system and defines quality characteristics. [14]

ISO/IEC 12207:2017 System and software engineering – Software lifecycle processes also provides processes that can be employed for defining, controlling, and improving software life cycle processes within an organization or a project. ISO/IEC/IEEE 15288:2015 System and software engineering – System life cycle processes, according to the official ISO website, establishes a common framework of process descriptions for describing the life cycle of systems created by humans from an engineering viewpoint. The previous two standards share a common terminology. Thus, the choice of whether to apply the former standard for the software life cycle processes, or the latter depends on the system-of-interest. Processes in both documents differ in activities and tasks to perform software engineering or systems engineering, respectively. [5]

The standards in the Quality Measurement division provide a software a reference model for measuring software product quality, mathematical definitions of quality measures, and guidance for their application. [14]

The Quality Requirements division this division helps specifying quality requirements. These quality requirements can be used in the process of quality requirements, elicitation for a software product to be developed or as inputs for an evaluation process. The requirements definition process is mapped to technical processes defined in the aforementioned ISO/IEC 15288. [15] [14]

The Quality Evaluation standards form the ISO/IEC 25000 family requirements, recommendations and guidelines for software product evaluation. [14]

ISO/IEC 14598-6:2001 is also a relevant standard to the Quality Evaluation division, reviewed and confirmed in 2008. According to the official ISO website, this standard defines the structure and content of the documentation to be used to describe an Evaluation Model. Evaluation modules are intended to be used within the context of the ISO/IEC 9126 and the ISO/IEC 14598 multipart standards. [5]

I have found this standard somewhat outdated, since the ISO/IEC 9126 is withdrawn and replaced by ISO/IEC 25010, and the ISO/IEC 14598 no more published parts other than this one. [5] However, I assume, that the concepts in this standard can be mapped to ISO/IEC 25010, since it is the official successor of ISO/IEC 9126. However, ISO/IEC 25040 states, that SQuaRE replaces the ISO/IEC 9126 series and the ISO/IEC 14598 series. [15]

REAL WORLD APPLICATIONS OF ISO/IEC 25000

One of the drawbacks of ISO standards, as I mentioned in the previous chapter, is the voluntary application. The use of software quality related standards can be motivated from the customer side though. The Spanish public administration includes among the requirements the conformance to ISO/IEC 25000 in the software related requests for proposals (RFP). In the 2020 digital hospital model specification of San Carlos Clinical Hospital the Servicio Madrileño de Salud (Madrid Health Service) included the ISO 25000 certification among its criteria, having the ISO/IEC 25000 certification provide 7 points out of the 40 points assigned to the technical conditions. [19] [20] This example can be set in parallel with Nigel Bevan's opinion in his article on Usability Standards. Bevan states that standards have the greatest impact incorporated into regulations and contracts. [4]

More examples can be found in Spain: CGM CompuGroup Medical obtained an ISO/IEC 25000 certificate for Functional Suitability for their decision support software. The

AENOR (Spanish Association for Standardisation and Certification) and AQC Lab evaluates and certifies software products in Spain in the Functional Suitability and Maintainability area of SQUARE. [14]

Based on the Spanish example public administrations of other countries should consider incorporating the requirement of ISO 25000 conformance and certification in request for proposals which includes software development activity.

According to the official website of the EU project SmartOpenData, it aims to make environmental and geospatial data concerning rural and protected areas more readily available and re-usable, better linked with data without direct geospatial reference so different distributed data sources could be easily combined together. The projects evaluation plan heavily uses SQUARE. [21]

In the 2019 article Examples of practical use of ISO/IEC 25000 it is stated that in Italy the ISO/IEC 25000 family was primarily applied by companies where the attending experts had participated in the TC developing the standard. Other companies with very large databases also applied the standard in order to guarantee consistency between multiple systems. Finally similarly to the example of the Spanish public administration, the application of ISO/IEC 25000 series is required or recommended in the public procurement of IT products. [22]

In the paper Measuring Public Value UX based on ISO/IEC 25010 Quality Attributes the authors measured the user experience of a job-seeking website called JobsMalaysia managed by Malaysian government. The authors performed the testing in an accredited Software Testing facility in Malaysia. The facility was MS ISO/IEC 17025: 2005 certified in software testing including usability and user experience. The usability characteristics were measured against ISO/IEC 25010:2011. The authors state that measuring usability based on the quality characteristics defined in the former standard seemed to be the most optimal method. [23]

In Hungary the National Accreditation Authority (Nemzeti Akkreditáló Hatóság, NAH) is entitled to conduct accreditation procedures. Having checked nah.gov.hu, I found that there is no organization in Hungary accredited for certifying software products based on the ISO/IEC 25010 standard. There are however many laboratories which are certified to operate based on MSZ EN ISO/IEC 17025:2018. Most of them are eligible to conduct certification processes in terms of software and IT systems, based on ISO/IEC 18045:2008, which is practically speaking an evaluation guide to ISO/IEC 15408 (Common Criteria). [24] Such a prevalence of Common Criteria is not surprising considering that the Hungarian Administrative IT Committee (Közigazgatási Informatikai Bizottság, KIB) published recommendations related to IT security based on Common Criteria. [25]

HOW CAN SOFTWARE QUALITY SERVE INFORMATION SECURITY?

In the following, I would like to emphasize that efforts spent on enhancing software quality can contribute to improvement of information security. No wonder that the ISO/IEC 27000 family of standards is very popular nowadays, in the Information Age. Basically, the standard provides guidelines to implement an ISMS (Information Security Management System). The level of security in a system depends on many things though e.g., education and safety awareness of users, IT governance policies, applied security solutions in the system etc. Such system would probably contain various software implementations. I believe

that the quality of the applied software in Electronic Information Systems can highly contribute to increasing the overall security of any system.

Software quality has eight high-level characteristics according to the ISO/IEC 25010 standard, each of them is composed of a set of related subcharacteristics as it can be seen on the diagram below. [9] Obviously Funcitional Suitability is vital for a software, but I think tha deficiencies of other kind can cause even security problems. Usability deficiencies can easily encourage users to deviate from the intended use of the software system, bypassing even the security solutions of it.

I think that in software-intensive systems the ISO/IEC 25000 family should be heavily used, possibly in the early stages of software development in order to define the proper characteristics that guarantee the adequate level of security in the system. In this aspect security, reliability, usability and usability characteristics are key to achieve the expected level of security.

2. Figure Characteristics of software quality based on ISO/IEC 25010

SUMMARY

I shall summarize my findings as follows. First of all, making ISO standards more easily accessible would greatly contribute to the wider application of standards. ISO should provide detailed guides to their standards free of charge. It would also be highly advisable to provide institutional read-only access for universities to standards for academic purposes. Even making specific standards open-source should be considered.

There are many relevant ISO standards in the topic, it takes a bit of an effort to get familiar with all of them. There also should be ISO-published documents about the relationships between standard families.

Using standards in contracts help spreading of ISO standards. Either governmental or commercial customers should incorporate conformance to ISO/IEC 25000 into their software related contracts (either COTS, or personalized development).

Unfortunately, there is no organization right now in Hungary, which can evaluate and certify software based on ISO/IEC 25010. Furthermore, as far as I know the ISO/IEC 25000 family have not been published in Hungarian. MSzT being an O-member of the ISO/IEC JTC 1 Information technology TC, which is in charge of developing the standard family is great news though, but it would be even better if it could achieve P-member status.

Last but not least, applying the security, reliability and usability characteristics of ISO/IEC 25010 on software in complex IT systems can improve the overall security.

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