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# PROVIDING QUALITY OF INFORMATION PROJECTS

**Specialty 121.03 - Computer Programming**

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It is possible to become acquainted with the thesis and abstract in the Scientific Library of the Moldova State University, on the MSU web page (http://usm.md) and ANACEC (www.cnaa.md).

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# ASIGURAREA CALITĂȚII PROIECTELOR INFORMAȚIONALE

**Specialitatea 121.03 – Programarea calculatoarelor**

**Autoreferatul tezei de doctor în informatică**

**CHIȘINĂU, 2020**

## I. CONCEPTUAL HIGHLIGHTS OF THE THESIS

**The actuality and significance of the providing quality of information projects (IPs).** At the present moment, on the one hand, we have the high demand for success IPs for Knowledge-based Information Society (KBS), e-business, e-economy, etc., and, on the other hand, we have the high share of IPs failure. The quality of IPs can not only be verified/controlled at the end of the project; it should be built and monitored throughout the lifecycle from conception to use.

Information and Communication Technology (I&CT) Development Index (IDI) for Moldova in 2017 reached 6.45, ranked 59th out of 170 countries, and Israel - 7.88, 23rd. For comparison, Iceland ranks first with the index value of 8.98 *[1]*. IDI is a composite index combining 11 indicators, categorized into three sets, which reflects the *Level of I&CT access, I&CT use* and *I&CT capability and skills*, required to use I&CT effectively in society.

Share of I&CT sector in Gross Domestic Product (GDP) from Moldova in 2017 and 2018 was 9% *[2]*. To compare with 2017, share of I&CT in GDP of Russia was 3%; in South Korea – 12%, in Poland's – 6.06%, in Germany 8.15%, in Czech Republic 8.43%, in France 7.33%. In January 2019, it became known that private technology companies in Israel, which are the main driver of the country's economy, achieved a record of $ 6.47 billion in investment in 2018. This is 17% more than a year earlier *[3]*. The evolution of information technology continues to affect significantly the business environment and demonstrate *the need to provide quality in information projects*. *I&CT changes business practices, reduces costs and alters the ways in which systems should be controlled. In addition*, according to ISACA (https://www.isaca.org/), technology plays a key role in these actions, as it is becoming pervasive in all aspects of business and personal life. At the same time, I&CT requires a high level of knowledge and skills required to control and audit information systems, and it increases the need for well-educated professionals in the fields of information systems (IS) governance, quality/security assurance and control *[4]*.

I&CT and software has become an important component of many spheres of life as it is used in all fields of activities like education, industry, services, management, etc. Often, I&CT and software systems have a major influence not only on the efficiency of management and production. I&CT also influences people's lives a lot. For example, I&CT are actively used in medicine, including the massive implantation of chips in humans' beings.

**Relevance, importance of the subject of the thesis and problem statement.** Neglecting the great importance and impact of I&CT, **today still persists poor information projects performance:** *only 32% of the software projects are* successful *[5], other 68% are challenged or failed*. The PMI report *„Pulse of the Profession* 2017*"* showed a slight improvement, but broadly speaking, the statistics tells a shocking story. Failed projects are still over 30%. The average budget

loss on projects for under performing companies was 46%. Over a third (34%) of projects aren't base lined at the planning stage *[6]*. This led to the fact that Quality Management in software developments is now recognized by *ISO, ISACA, IEEE, PMI* etc. as an important discipline, along with software engineering.

**The main purpose of the research** is to provide quality of information projects, considering the high-quality requirements at low costs, the standardization tendencies and the modern trends of Agile software development methodologies.

But the contexts of different organizations and quality characteristics for different types of information projects/systems are very different. For example, a database could differ vastly from an Internet site and their quality characteristics should be different, accordingly. *Building an integrated metamodel of IPs quality and the quality of resulting products requires* a great number of studies, analysis of I&CT and management standards, development methodologies for IPs etc. The role of resultant tailored quality models is *to support the main activities of quality assessment.*

**The objectives** of the thesis are the following:

- Study, analyze and identify the quality approach framework based on the best practices (actual international management standards), the specific context of the organization and the most appropriate IS/software development methodologies to provide quality.
- Identify the quality characteristics from the literature review regarding IPs, analyze the best quality models and practices for different IPs and develop a generic metamodel of quality, which will integrate quality characteristics, suitable for widely used types of IS.
- Perform on-site research to verify the relevance of the selected quality characteristics through the survey of experts in the field of information projects.
- Specify the requirement and develop a software tool to support for new approach *(as part of Project Management Office, PMO).*
- Implementing the developed approach in an organization.

**Applied methods of research.** Various methods of study and comparative analysis of sources of information with synthesis are used in the thesis. To evaluate the success/failure of the project, qualitative analysis methods are used for the triple constraints – *Schedule, Cost, Scope*- and recently added a few more things to manage such *Quality, Risk, and Customer Satisfaction.* Solving the problem requires a profound study and a general interrelated analysis of best practices/quality frameworks, summing up a relatively simple and transparent metamodel to help the manager choose the right strategy, tailored model and policy quality of the organization.

**The scientific novelty and originality** are reflected in a new approach for continuous assessment and improvement of IPs quality along software development lifecycle (SDLC) based on combination between modern Agile development methodology and tailored quality models, obtained from generic quality knowledge metamodel, which is extensible, flexible and adaptable and which is supported by software application with primary data extraction directly from the PMO tools.

**The theoretical significance** is supported by analyze, synthesis, specifying and defining the theoretical principles, generic metamodel and tailored models for personification of the quality, continuous assessment process of the quality of IPs through the project lifecycle, based on connection between several well-known basic models, tailored models, Deming quality wheel, Plan-Do-Check-Act cycle, Agile development methodology and PMO tools for quality assessment.

**Important scientific problem solved in the research.** A new approach opens up the possibility to define the quality of IPs at the conceptual level, creating the basis for the subsequent formal and informal assessment of the degree of compliance of the developed IPs with the quality requirements. A new approach permits continuous assessment of the quality of IPs along the lifecycle that can be systematically measured, calculated, managed and improved, based on primary data directly extracted from the PMO applications such as Jira, VersionOne, TFS, etc.

**The research is based on the following assumptions:**

- The quality of development IPs processes throughout SDLC and the resulting product quality (IS, information), even if they mean different things, need to be treated together.
- In order to improve the quality of information projects, it is required to build an information project quality assessment model that can be iteratively measured and improved, during the period of the project lifecycle.
- Among the possible solutions to the mentioned issues is adapting IS/software quality models so that characteristics and subcharacteristics are more meaningful to their users.
- IPs quality management along SDLC can be streamlined by automating routine work and using input data directly from modern Agile software development processes, assisted by digitized PMO.

**The approval of results and publications**. The obtained results were published in 10 scientific papers, among which 8 by a single author, with a total volume over 4 sheets of author, including 2 in magazines recognized abroad, 2 in journals *category B,* were reported in 4

international conferences and 2 in national (home) conferences *(see author's publications on thesis subject).*

The new assessment approach and the realized software tool are implemented in „WGS", Israel and in the study process of the Moldova State University. These results also can be directly used by any other organizations concerned with IPs development and/or by researchers and students of other educational institutions at software engineering disciplines.

**Structure and volume of the thesis.** The thesis consists of Introduction, four chapters, General conclusions and recommendations, Bibliography, and nine Appendices.

***Introduction*** describes the topicality and importance of the raised problems, the goals and objectives of doctoral thesis, scientific novelty, of the obtained results, theoretical importance and practical value of the work, results approval and summary of the doctoral thesis sections.

***Chapter I "State-of-the-art in the domain of IPs quality"*** deals with the theoretical framework of the topic and includes literature review of information project, project success/failure, project quality management, diagnose the problems and assumptions to solve of them.

***Chapter II "Methodological approaches of project quality management"*** describes the general framework of quality, some of quality concepts and principles defined by Shewhart and modified by Deming, Plan-Do-Check-Act cycle, used in all of the management standards. Chapter II attempts to bring more understanding to the use of standards appropriate to the company's needs.

***Chapter III "Software quality models and tools"*** offers an overview and a critical analysis of the system/software quality models, establishes the premises and formulates the basic tasks for the realization of the metamodel and the particular quality models of IPs.

***Chapter IV "Field research on information systems quality"*** describes the general metamodel of quality, the tailored models of quality for some classes of IS, the numerical methods for multicriterial calculus of quality and realized application for support of them.

The ***„General conclusions and recommendations"*** summarize the contribution of the research from different aspects: mention the important scientific and applicative solved problem, describes three main obtained results the significance and potential of the proposed metamodel and application for software development organizations and suggestions for perspective research in the domain of IPs and software quality improvement.

In addition, there is a ***Bibliography***, ***Publications*** *and* ***Appendices***, with supplementary information of doctoral thesis, including questionnaire, description of the developed software application, acts confirming the implementation of the obtained results, etc.

**Keywords:** Information Project (IP), Information System (IS), Software, Quality of IPs, Quality characteristics, Quality standards, Basic Model of Quality, Tailored/particularized Model of Quality, Quality Management System (QMS).

## II. CONTENTS OF THE THESIS

Building globally Knowledge-based Information Society, integrating new information technology into all areas of human activity, developing digital information products and services, including *e-banking, e-payments, e-government, e-education, e-health,* etc., are the strategic objectives of the governments of most countries of the world, including the Republic of Moldova and Israel, which have adopted Digital Development Strategies. *KBS-building plans at national level involve the realization of many informational projects aimed at meeting the social and personal needs in information products and services,* including a*ccess to information resources for anyone* who is empowered, *wherever* and *whenever* necessary, *in safety conditions*.

Today many organizations invest millions in hope to get some value in return (ROI) from informational projects. But **many of IPs still fails**. This because the quality of IPs is a complex and multivalent concept, it means different things to different people, and, as rule, it is subjective; each project is unique, with its own quality requirements and specific constraints, highly dependent on the concrete internal context, e.g. *organization, team, culture, traditions* and external context, e.g. *stakeholders, competitors.* User requirements, the set of quality criteria, the weighting of the quality criteria for each of IPs can be very different.

There are many **other challenges of IPs quality,** among which can be mentioned:

- *Software can't be physically observed;*
- *The lack of knowledge of client needs at the start (often this is impossible);*
- *The rapid rate of change on hardware, software and of client needs* – are inevitable and generate a lot of extra work for improvement of quality, etc.

Two main needs arise from background analyze of IPs development in KBS:

- *To provide project managers a better understanding and fits methodologies for assuring information projects quality.*
- *To increase the quality of information projects along SDLC, focusing on information systems and application software*.

The quality of IPs as minimum include three aspects: *Quality of project management (processes), Quality of resulting product (IS, software applications)* and *Quality of information*, resulting by data processing. When we talk about IPs quality, we discover that human originality and creativity are closely related to it. But, *these aspects of quality are hard to measure, especially*

*as programmers see their work as a work of art rather than as a commercial product.* So, today *the quality assessment of informational projects is a critical task for many companies, especially concerned with the development of IPs;* is an important discipline and a field of study with interesting perspectives for researchers, since the rate of failed IPs is still quite high.

Meanwhile, researchers propose software metrics *(e.g. code length, comments, etc.)* as tools to measure programs source code, architecture, and performances. However, the software's physical characteristics very little reflect its actual quality; the relation between software quality models, metrics and type of projects is not yet clear and consensual. Moreover, the process of software quality assessment remains an open issue with many basic and particularized models, poorly applicable in practice.

The main idea to be drawn from context analysis is that *the quality of the project and the resulting product can be effectively managed considering both the software development methodology and tools that are suited to the project requirements and team abilities, as well as good management practices focused on specific standards families and quality models*.

**The research was focused on providing quality of information projects,** because within the framework of contemporary organizations about 50% of the activity takes place in the form of project activities and all 100% in the specialized organization for development and implementation of information system, web applications, software application etc.

**But the quality of IPs is a complex concept,** it means different things to different people, and it is highly context dependent. An appropriate model is *built on recognizing steps toward a standard solution* – it helps when the work of one team can be continued by another team at the point where the first stopped. Work is thus forwarded from team to team and time zone to time zone until it has been completed. *Since the quality of IPs can not only be verified/controlled at the end of the project –it should be built and monitored throughout the lifecycle from conception to use.* This is one of the reasons to examine in this thesis the possibility of improving the quality of IPs ***using a good methodology for project development and quality management***.

This is the main subject of the thesis, ***referred to as evaluating and improving IPs quality*** in accordance with a better standardized practice and using tailored quality models. Today *the quality assessment of informational projects is an important discipline and a field of study with interesting perspectives for researchers,* since the rate of failed informational projects is still quite high. *The existing general models are too abstract and poorly applicable in practice, and the author models are too detailed with a very narrow area of practical applicability*. The high level of abstraction practically eliminates the direct practical use, and the high degree of detail implies a very narrow applicability.

„. The paper tries to guide developers to Agile software development methods, which is in line with the general principles and PDCA *(Plan-Do-Check-Act)* approach of quality management (ISO 9001) to continuous improvement of quality and the integrated metamodel of quality, which encompasses the basics quality models, proposed in ISO 9126, ISO 25010, ISO 25012 etc.

The **thesis assumption** is to create a metamodel, which will permit realize a tailored/particular model for each typical group of IS, range of values which are acceptable for similar people and realize an original digital support for these. Using a good methodology and pattern *(such as design patterns, standardized processes, PDCA cycle, etc.),* we could increase the software quality.

**The new approach for IPs quality assessment** is composed by the following elements:

1. Generic metamodel of quality, which include the wide knowledge about quality factors, extracted from bibliographical sources, known basic models and quality standards;
2. Tailored quality models built from metamodel, based on field research, which permit providing quality of some type of IPs;
3. An original tool, with the extraction of some initial data directly from the Agile PMO.

The new suggested approach and application use collaboration tools and modern Agile methodology to develop IPs and standardized best practices for managing and continuously improving of quality. As Agile software development processes systematically collect multiple information *(sprints delivery plan, sprint retrospective, etc.),* it can be directly used to assess the quality of the project for formulating improvement tasks and increase project's successfulness for the customer.

The new approach was implemented in a software application, based on the research results dealing with analysis of the most actual researches and tracking the 25 most important quality characteristics. This software application enables to manage quality of IPs by performing quality assessments, in accordance with the quality characteristics for seven types of information systems. The presented approach is new, even if we were using the classical models of software engineering and standardized best practices. The modification we respect is *integration of existing quality models and best practices at conceptual level, which result in user-oriented quality conception trough tailored models,* in accordance with users' needs, users' requirements, using the new more suitable quality assessments models – mix of traditional evaluation methods and modern development methodology, such Agile.

This approach permits to build the adaptable/tailored quality models, more suitable to the concrete organization and project context; fits the quality characteristics, metrics with users' needs; realizes a combination of quality models with modern development methodology Agile and

original quality assessment tool; allows iterative measurement and continuous improvement of IPs quality throughout the life cycle.

**Traditional project management** *(PM, [7], [8])* along SDLC is iterative and describes *(Figure 1)*:

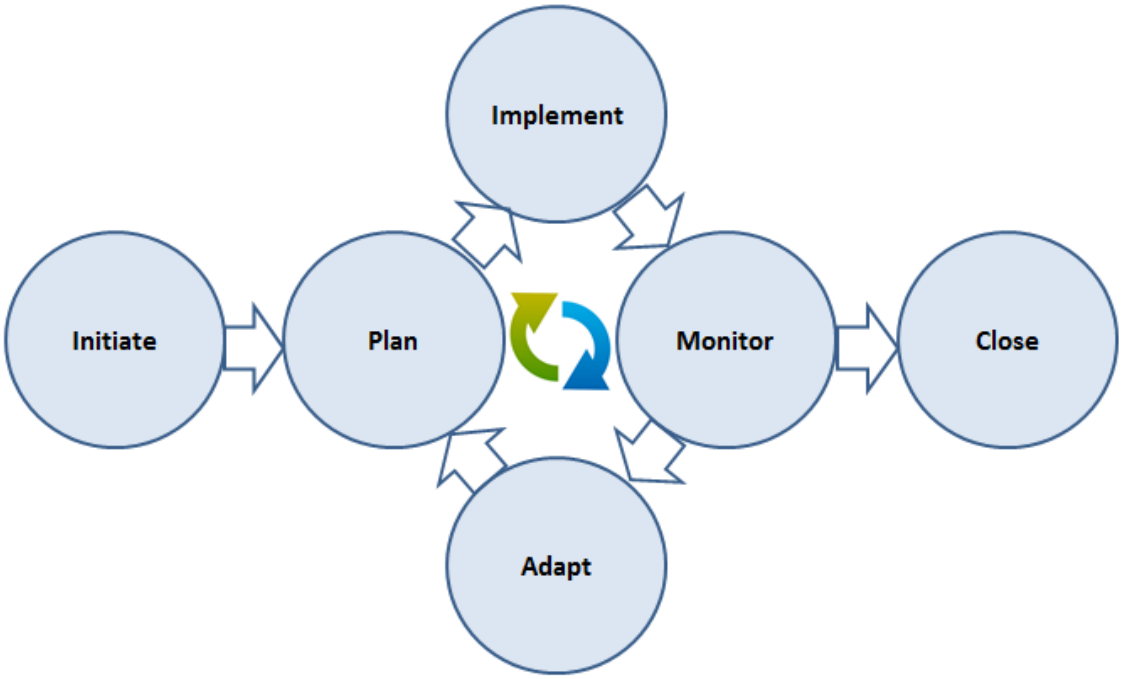


***Figure 1. Project Management Cycle***

***Source:*** *Adapted by the author based on [7], [8] (emphasize the PM cycle)*

- Six process groups of PMs: *Initiating, Planning, Executing, Monitoring and Control, Adapt, Closing.*
- The project management processes grouped into ten separate knowledge areas: *Project integration management, Scope, Schedule, Cost, Quality, Resource, Communications, Risk, Procurement, Stakeholder and* recently added *Customer satisfaction.*

**Project quality management** *aims to identify the required project quality, assess and control it, and finally attain the optimum results through specific processes and activities.* In order to obtain the desired result, a project manager must take care of the following three key concepts of quality management:

1. Customer satisfaction,
2. Prevention over inspection,
3. Continuous improvement.

**These three targets can best be achieved in Agile;** they help in accurately estimating what exactly a customer wants and what he actually needs. Once we have a clear understanding of these, we can without too much problems manage the project quality.

**Quality of IPs is dependent on type and complexity of information system.** IS are computer-based infrastructures, organizations, personnel, and components that collect, process, store, transmit, display, disseminate, and act on information. So, quality of Information systems is a function of *Infrastructure Quality, Software Quality, Data Quality, Information Quality, Process Quality, Quality of organization, Quality of services.* Quality management will be successful if all quality domains are under control. Obviously, treating all of them within a thesis is impossible, from which the thesis is based preponderant on IPs product quality.

**IS complexity** is considered one of the major risk factors involved in project failure. Level of complexity and time duration of project are positively associated to failure. One way to reduce the level of project risk and failure is to reduce the level of complexity. Thus, it is obvious that in order to improve IS success rate and rate of return on investment, organizations must address the problem of complexity in IS and reduce it at acceptable limits.

In the traditional *(waterfall, cascade)* approach each IS project will grow in complexity once initiated; the scope is fixed, but as rule, the time and costs are increasing. To meet this challenge, it is necessary to apply the Agile Philosophy of iterative and incremental development (*Figure 2*)

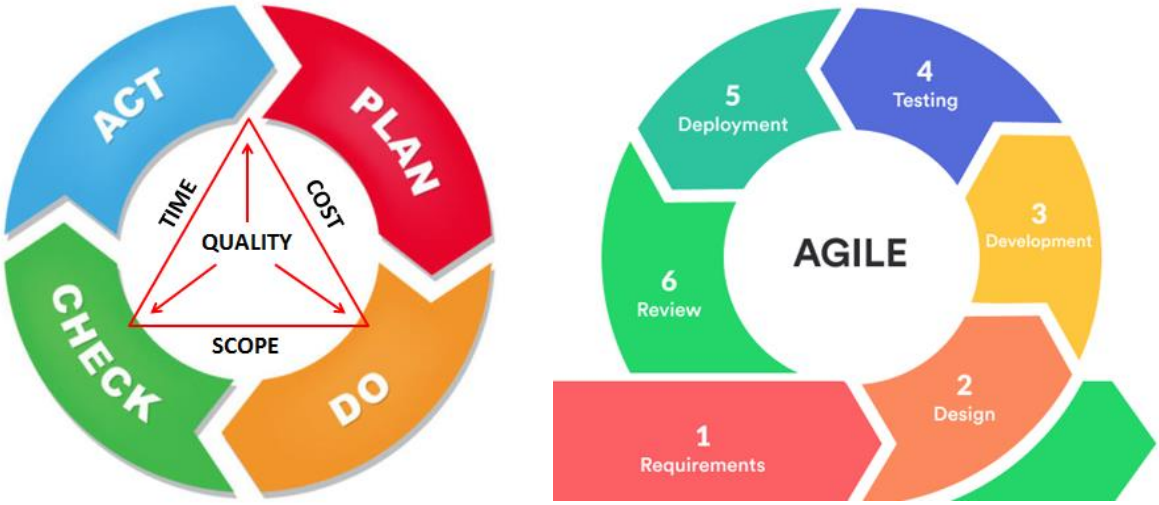


***Figure 2. Project quality management as continuous PDCA process***

***Source:*** *Adapted (combined) by the author based on [8], [9], [10]*

Also, adaptation and modification of underlying organizational processes in such a way that they become conducive for automation is an issue deeply intertwined with project definition and has to be tackled in the very beginning. Once the processes have been reengineered, the scope of

automation project can be fully visualized by all the stakeholders. This is the net benefit of the IS approach by Agile methods.

*Figure 2* illustrates combined approach model of the quality management system in projects: *Quality Planning (PLAN), Quality Assurance (DO), Quality Control (CHECK) a*nd *Quality Improvement (ACT).* In this way, the focus is on the customer, and the variation and continuous improvement are the central issues of the quality of IPs managed with Agile.

*Project quality management (PQM)* focuses on improving stakeholder's satisfaction through continuous and incremental improvements to processes, including removing unnecessary activities; it achieves that by the continuous improvement of the quality of material and services provided to the beneficiaries. It is not about finding and fixing errors after the fact, quality management is the continuous monitoring and application of quality processes in all aspects of the project *[11]*. Agile development best meets these all the needs. A general model of QMS for a modern software development company, in accordance with ISO 9001 standard, consisting of three parts, as it is shown in *Figure 3.* According to ISO 9001, QMS must be „born", „grow" and „mature" inside the company.

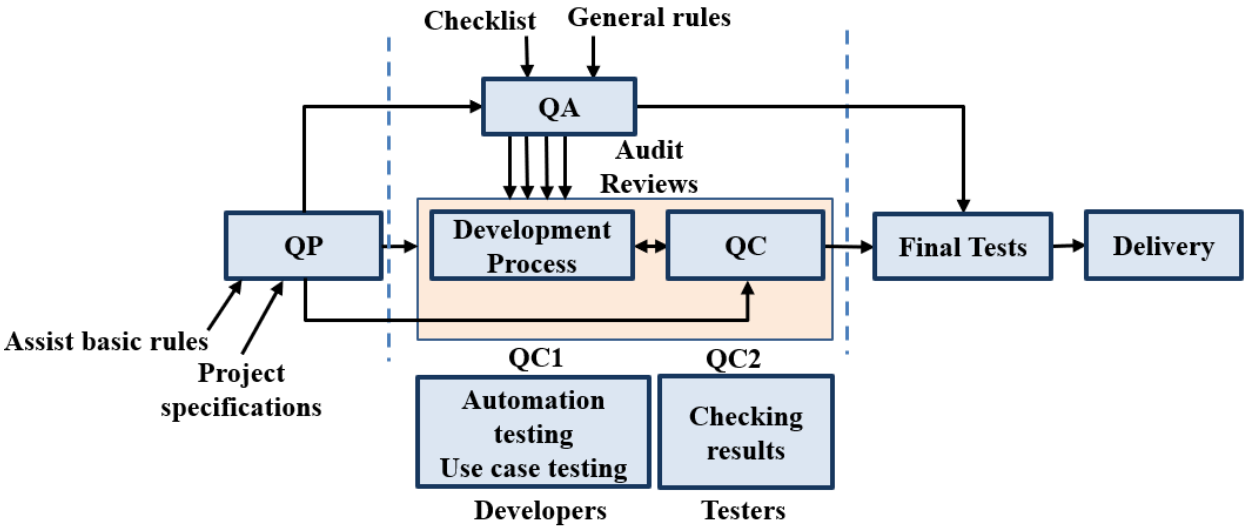


**Figure 3. QMS model for a modern software development company**

***Source:*** *Taken from [10]*

*Legend: QA = Quality Assurance, QP = Quality Plan, QC= Quality Control*

QMS for a software development organization covers: (a) the actual engineering activities *(analysis, design, design, coding),* (b) revisions applied to each step of the project, (c) testing strategies, including automated methods and tools, (d) control of the software documentation and its maintenance, (e) compatibility with standards, if these are applicable, (f) measurement and reporting mechanisms (e.g. internal quality). For example, quality management is oriented to

defining and standardizing processes, procedures, templates. Quality assessment in this approach uses capability maturity models, such CMM *[12]*, CMMI®02, and/or cycle PDCA, such *Agile [9]*.

Perception of quality acknowledge not only the existence of risks along a project's lifecycle but also that these risks must be prioritized differently along the project's lifecycle according to the exposure of the project's aspects to these risks (e.g. the potential damage that quality prevails, *[13]*). This can lead to a multi-processes approach as well as a multi-system approach *(Figure 4).*

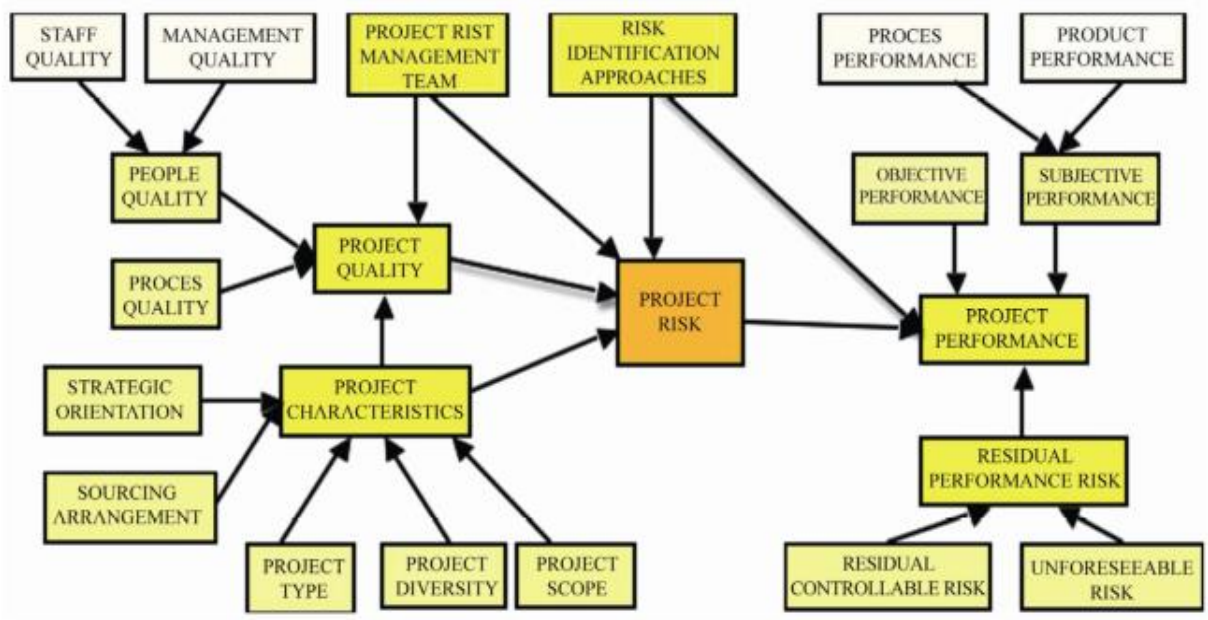


**Figure 4. Common conceptual framework for PM and QM**

***Source:*** *Taken from [14]*

This approach combines quality aspects associated with the project itself and the given reality as it is reflected by management perception as well as the project's objective characteristics such as the quality of human resources and management quality.

Development Agile cycle is fully in line (in according) with ISO management standards, TQM and allows for continuous improvement of product *(Figure 5)*.

Being Agile it is about the people and teams, about customer and delivering software, about continuous improvement, and constantly applies PDCA cycle:

- By the process (Retrospective analysis, Scrum, Kanban etc.);
- By the user feedback (Sprint review, demo Scrum);

By the team itself (peer review, pair programming etc.).

**Measurement is a key to process improvement**. The needs for improvements can be decided after performing measurements. In many cases this is impossible until the final delivery of the product. In Agile software processes development, it is possible along life cycle.

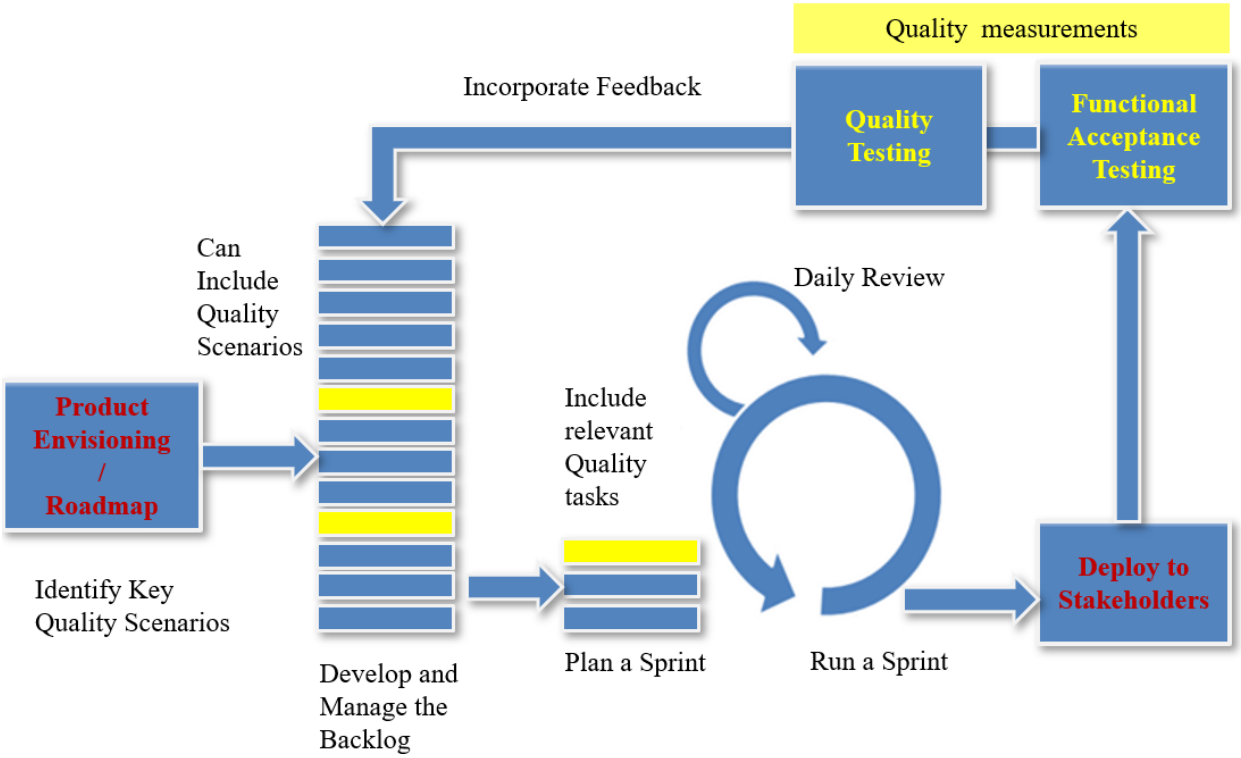


**Figure 5. Quality Cycle in Agile/SCRUM**

***Source:*** *Taken from [15]*

**System/software quality model**

To predict and develop high quality software at lower costs, quality models are required. The models to evaluate the quality of software have been constructed defining the fundamental factors (also called characteristics), and within each of them the subfactors (or subcharacteristics). Metrics are assigned to each subfactor for the real evaluation. Quality model is a set of selected quality characteristics with the assigned measures and the relationships between them relevant to a context that provides the basis for specifying quality requirements and evaluating quality of an entity.

The software quality models are designed to *allow developers a clearer understanding of the relationships between internal and external quality, ways to reduce the number of defects in software development, increase efficiency*, etc. A quality model specifies *which properties are important for a product* (e.g. usability, traceability, etc.) *and how these properties are to be determined*. For each attribute, one or more quantitative or qualitative metrics can be defined in order to assess its value. In addition, the quality model describes additional functional properties, such as *„how the software was created"* and *„how it works"*. The quality required for a software product must be defined in the software requirements definition document. Also, the definitions of quality attributes, measurement methods, and attribute acceptance criteria must be specified.

*Figure 6* shows the general evolution of quality models from the McCall model in 1977 until 2011, with ISO 25010:2011 models.

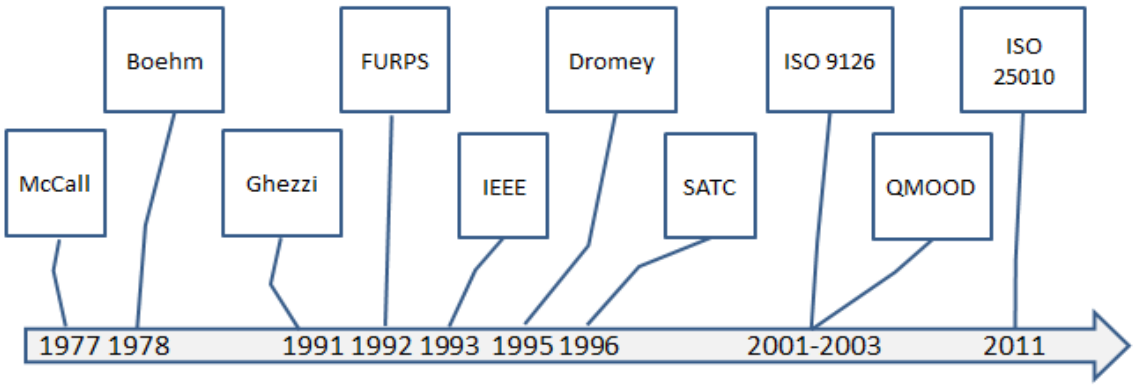


**Figure 6. The most famous quality models**

***Source:*** *Developed by the author based on literature analysis*

Consequently, the models are classified in **basic models**, and those based on components called **tailored** or **private** or **authors quality models**, enriched with other characteristics, specific to certain areas, e.g. *onboard software, navigation systems*. Simultaneously with the development of the Internet and Web as open systems, in 2003 a new subclass of tailored models - **open source quality models** started, e.g. Cap Gemini, Open BPR etc.

**The basic models** are used for global evaluations of software products. The basic models *are hierarchical;* they *can be adjusted to any type of software product* and are oriented to the evaluation and improvement. The most important hierarchical models are: McCall, Boehm, FURPS, FURPS+, Dromey, family ISO 9126 and ISO 25010. The main problem is that *these models are too abstract and too general for specific areas* or concrete type of IS, and the main challenge is to find the required quality characteristics for each one of the information project type.

*Figure 7* shows the stages of Iterative Improvement of quality along the project lifecycle according to the latest ISO 25010 model.

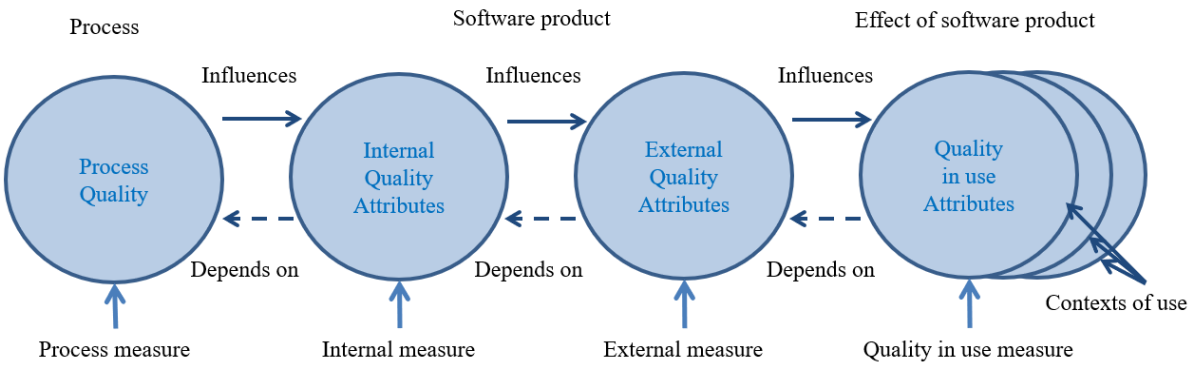


**Figure 7. Quality in the life-cycle of software development**

***Source:*** *Taken from ISO 25010 [16]*

**Tailored quality models** began to appear since 2001. The main characteristic is that they are specific to a particular domain of application and the importance of characteristics may be variable in relation to a general model. *Identifying* and *quantifying* the quality of software products is a first task in determining the quality of applications and ensuring the desired quality level. Secondly, *estimation of IS quality will be correct if it is based on the „lifecycle - criterion quality metric of quality" relationship*. Due to this approach, it is appropriate to judge not only the quality criteria nomenclature, but also the dominant role and the content of each criterion in relation to the development stage of the IS.

**Metamodel of quality and particular/tailored quality models**

The main conclusion drawn from the basic and adapted quality models analysis is that both the quality factors of models can be managed in a similar manner, **providing a unique framework**, a **unified metamodel** *(Figure 8).*

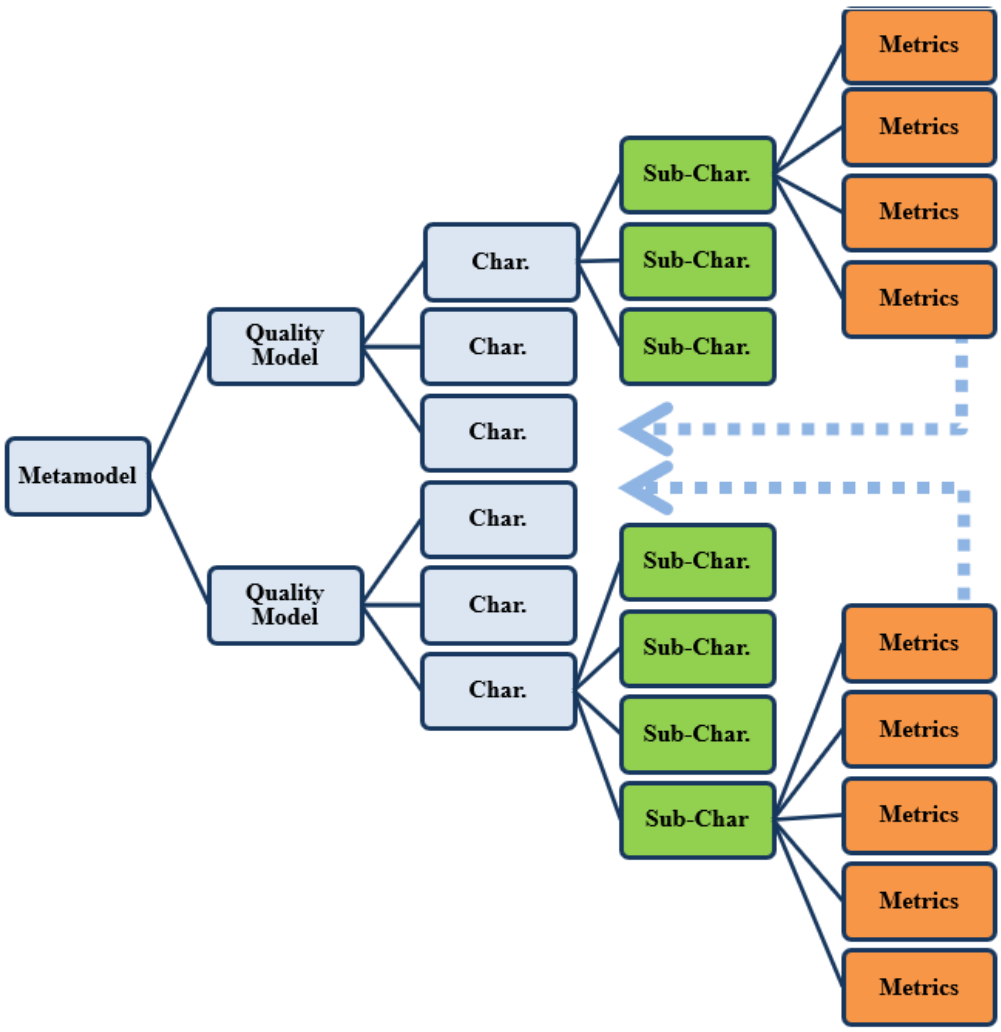


**Figure 8. A fragment of the general metamodel and Tailored quality models**

***Source:*** *Developed by the author*

Quality factors and concepts defined in the standards, enriched with the decisions outlined in the previous chapters, form together a rich base of knowledge for building a metamodel. But the development of quality model with a set of fit to IP metrics is far from being a simple task. Theoretically, metamodel can include also the Characteristics of Infrastructure quality, Quality of services, Process quality, Quality of organization etc.

**The core quality model (metamodel)**, is *compose* of a series of quality characteristics attributes of included basic models and user added characteristics. All the attributes are described in these respective models and standards. Terminology and definition of quality characteristics are in according with ISO 25010:2011. All of the definitions of characteristics, subcharacteristics, metrics, and measurement function are including in the repository file of the application. *Fragment of Quality Knowledge Database is shown in Annex 1 – Annex 2 of the thesis*.

***The quality characteristics and subcharacteristics are mapped to some type of IS***, e.g. „web application" and applied standards from company, like ISO 9126 or ISO 25010.

Measurement concepts are in turn mapped to one or more metrics, e.g. „code size", which is measured through source lines of code, and „control-flow complexity", measured through cyclomatic complexity.

The metrics are defined in ISO 25022:2016, ISO 25023:2016, ISO/IEC 25024:2015 and other. But the list of metamodel metrics can be extended /added to the user's need and desire.

Despite the number of Standards and Quality Models, little information exists how to measure, collects the values of characteristics and how evaluate a concrete type of IS. There is a need for research providing information about significance of each quality characteristic included in quality model and the weighting of the characteristics.

The purpose of the field research was **to building a metamodel** and find out which of the quality characteristics will be taken into the quality model for some type of IS, with respect to the research results from the literature review and the field study *[17], [18], [19]*.

**Metamodel is more general and allows more degrees of freedom**. This metamodel includes some basic models (e.g. ISO 9126, ISO 25010, ISO 25012 models) and some enriched models (e.g. Dromey) with the possibility to generate other particular quality models based on the adaptation of one of them. *The specific model is developed according to the metamodel and user requirements.* Adaptation consist in eliminate some characteristics and/or add other characteristics, including individual characteristics, defined by the developing organization and stakeholders for concrete use-case. The resulting specific particular model is built under the subset of the most common quality characteristics and organization needs. In resulting model all relations between

characteristics – subcharacteristics – metrics and the formula calculus are inherited from the metamodel, and have two variants of realization: simple media or multicriterial calculus.

*This two-tier approach offers the possibility to compare similar products based on a particular manufacturer's model as well as different products and different manufacturers based on the basic features included in globally accepted and recommended ISO standards*.

Proposed scenario for improving information project quality is presented in *Figure 9*.

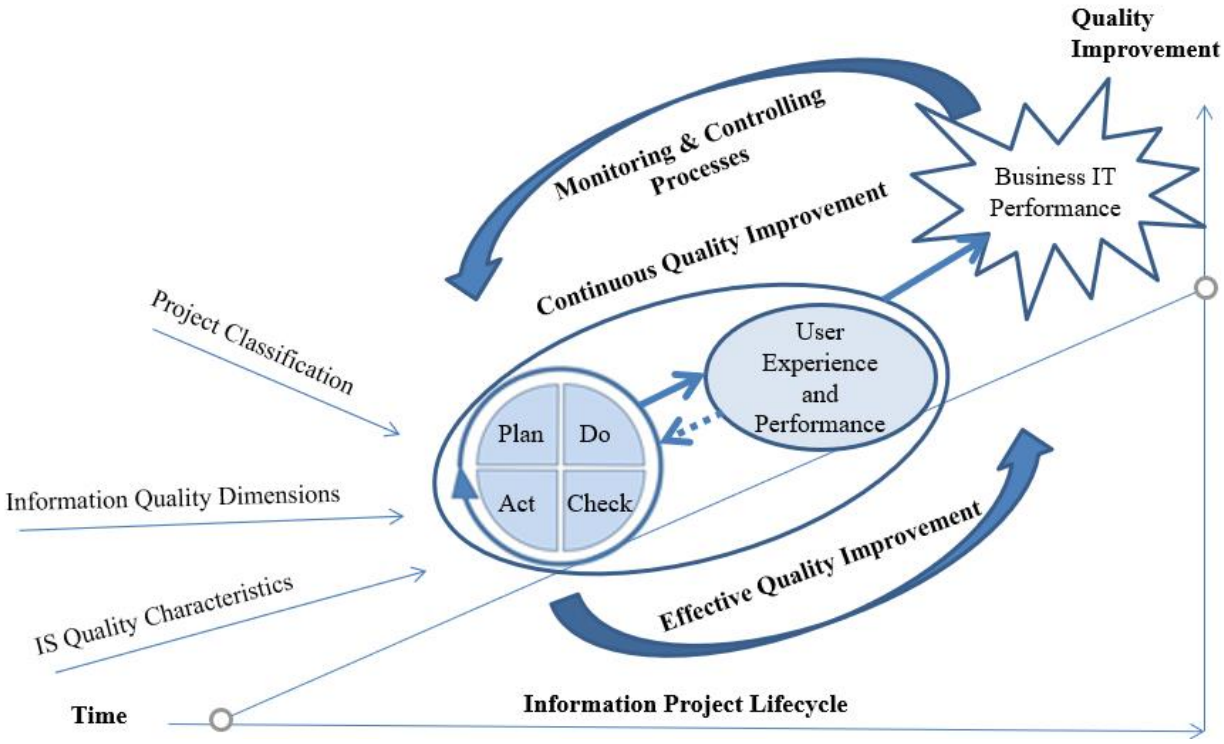


**Figure 9. Scenario for continuous improving information project quality**

***Source:*** *Developed by the author in [17]*

Quality improvement is an iterative process that requires planning, execution, checks and feedback from the information consumers (IS users) in the organization. In order to improve the quality of IPs, it is required the iterative measurement and evaluation along the project life cycle, stored in data base application**.**

**Quality assessment methods**

For quality assessment **objective and subjective assessment methods** have been used. Objective assessment measures the extent to which IPs conforms to quality specifications and references. Subjective assessment measures the extent to which IPs is fitness for use by end consumers.

The expert opinion survey was designed to verify the hypotheses in practice:

- Field assessment of the significance/weights of each characteristic for seven types of IS, that measure the degree of satisfaction;

- Identification of generally accepted characteristics from experts for different IS (with a score greater than 3.5 out of 5).

As a rule, quality evaluation according to the quality models McCall, Boehm, FURPS, Dromey, ISO 9126, ISO 25010 etc. uses a set of values/metrics and **linear expressions of calculation for each factor**, such as:

$$\boldsymbol{Fq} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \boldsymbol{Ai} * \boldsymbol{Mi} \quad (1)$$

Where:

$\boldsymbol{Fq}$ = is the quality factor,

$\boldsymbol{Ai}$, i=1,... n are the coefficients of regression,

$\boldsymbol{Mi}$, i=1,... n are the metrics corresponding to the quality factor,

Then the general quality is determined as the weighted sum of the factors values.

$$\boldsymbol{Q} = \sum_{\boldsymbol{q=1}}^{\boldsymbol{m}} \boldsymbol{Fq} * \boldsymbol{Pq} \quad (2)$$

Where:

$\boldsymbol{Fq}$, $q=1,... m$, are the calculated values of the factors,

$\boldsymbol{Pq}$, $q=1, \ldots m$, are the corresponding weights of the quality factors.

But quality indicators are often contradictory and optimization of parameters for each of them leads to inadequate solutions. A technique for establishing a compromise on quality characteristics that satisfies all participants in the development, marketing, and use of a software product is the negotiation technique based on the *win-win spiral model*. A risk in engineering software requirements is to increase the level of a quality characteristic, for example *performance*, to the detriment of another at least or as important, e.g. *portability*. Many software projects have been abandoned because they had a poor set of quality requirements, even though they had well-specified interface and functional requirements.

As mentioned in the thesis, linear patterns do not always adequately reflect the relationships between the quality characteristics. More than that, using the expert opinions for determines the importance of each quality factors may be subjected to subjective influences: two distinct groups of experts can reach different values of the coefficients and grades that are given. *In complex systems such IS with the use of several indicators/criteria there may be several criteria objectives/functions, often interdependent.* Thus, during the development and using of complex software systems, the assessment of the quality of the relevant processes becomes possible only with the use of several indicators (several target, criterion functions). This leads to the emergence of multi-criteria choice tasks *that can be used successfully to evaluate the quality of the processes/products.*

**The software application**

To estimate the values of quality indicators in developed application four methods can be used: *measurement, registration, calculation* and *expert*, as well as combinations of these methods.

*The measuring method* is based on the use of measuring and special software for obtaining information about software characteristics, for example, determining the volume, the number of lines of code, operators, the number of branches in the program, the number of entry/exit points, reactivity, etc. *The registration method* is used when calculating the time, number of failures, the beginning and end of the software operation in the course of its execution, etc. *The calculation method* is based on statistical data collected during testing, operation and maintenance of software. The calculation method is estimated indicators of reliability, accuracy, stability, reactivity, etc. *The expert method* is carried out by a group of experts *(users-specialists)* who are competent in solving this problem or the type of software.

Information Project Management System (IPMS) *[17], [18], [19],* which realizes proposed in thesis is scenario for improving information project quality, in detail is presented in *Annex 9 of the Thesis*, which includes: *Description of the application, Entity Relationship Diagram, User manual,* some *Excel templates for collecting of primary data and calculation of value of quality factors* and *Installation kit.*

IPMS is a Web and/or desktop application which enable organizations to manage quality of information projects, by performing quality assessments, in accordance with the tailored model for concrete type of information project, obtained from metamodel *(knowledge about quality models, quality characteristics, subcharacteristics and metrics)* and using a linear calculation of quality factors values. The application is independent of the tailored model applied; it is suitable for any type of organization and/or any type of project.

The main menu *(Figure 10)* shows some options for entering / editing the initial data, such *Organizations, Projects, Evaluations, Tables settings of the application* etc. The application settings allow to adapt/specify the quality model for each evaluated informational project. After updating the model, the input values of the quality characteristics can be introduced/imported, the weighted values of the quality factors can be calculated, the reports, graphs, statistics, etc. can be managed and displayed.

Each information project relates to quality characteristics of tailored model in accordance with the project type, in order to perform the relevant quality assessments. For each project, it is possible to create quality assessment, contains a specific quality characteristics list for that project type, and to display a list of related project quality assignments.

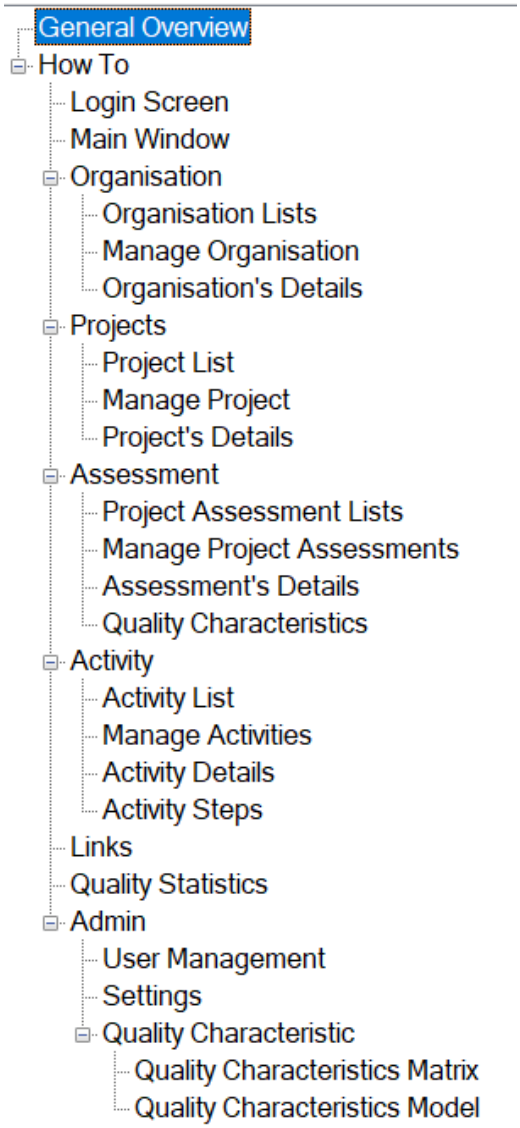


**Figure 10. Help Window and main menu of IPMS**

***Source:*** *Developed by the author*

Using the data input screens, it is possible to create a new organization, new project, new assessment and/or update any database objects, including metadata about quality models, quality characteristics, quality subcharacteristics, quality metrics etc. Metamodel can be extended/ adapted from organization needs: user can add some characteristics, subcharacteristics and metrics, can modify some measurement functions in the knowledge database and/or in the Excel templates for collecting of primary data and calculation of value of quality factors.

Each information project relates to quality characteristics in accordance with the project type, in order to perform the relevant quality assessments. And each project must be assigned to a specific organization in order to manage the quality of organization projects. In addition, it is possible to create or maintain quality assessments or quality activities.

The application has a built-in help with detailed description of operation *(Figure 10)*. Install kit and applications scenario, help text and others print-screens of the IPMS are shown in *Annex 9* and, along with the entry templates, are written on the CD. The application is installed on Microsoft Azure cloud server and can be verified from the Web, without installing it on the desktop. *Figure 11* show how to launch the remote application from the cloud server.

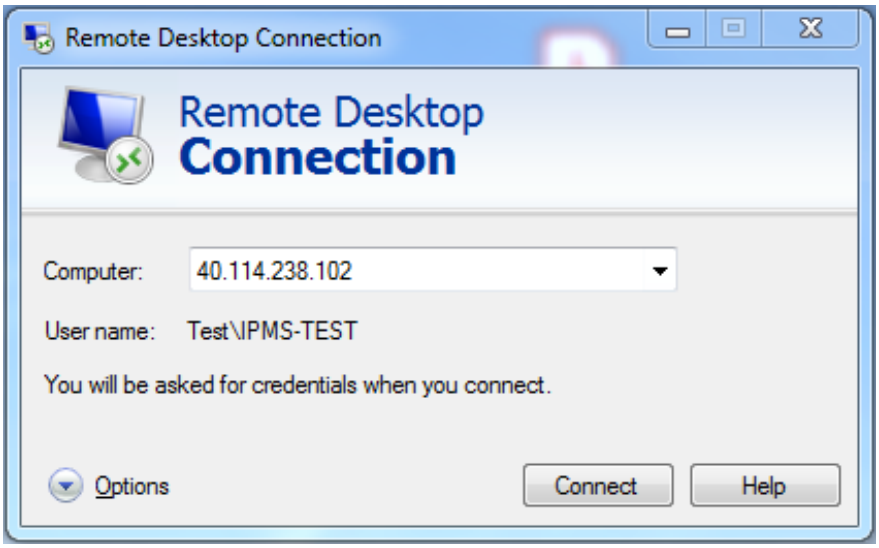


**Figure 11. Remote Desktop Connection to launch the IPMS application on the cloud**

***Source:*** *Developed by the author*

To access the application, send an e-mail to the author's address to receive information regarding the updated Login and Password.

When the user creates a new project, he enters the project classification data. The application identifies the appropriate quality model according to the type of project or standard which the user selects. The user creates new assessment and the application show the quality characteristics factors of the model. The user inputs the assessment characteristics values or import from external Excel file. The application calculates the assessment score. The application analyzes the project data with the assessments score and display the project quality graph.

For each assessment, it is required to enter the valuation of the quality characteristics (based on some templates). While saving the quality assessment characteristic values, the application calculates the weighted scores according to the quality factor of the characteristic in the settings table. The quality characteristic settings table holds the characteristics quality factors for each information project type, according to the survey results.

## III. GENERAL CONCLUSIONS AND RECOMMENDATIONS

**The important scientific solved problem in the research** is *a new approach for continuous assessment and improvement of the quality of information projects through the lifecycle*. This approach opens up the possibility *to define the quality of IPs at the conceptual level,* creating the basis for the subsequent formal assessment of the degree of compliance of the developed IPs with the quality requirements.

The new approach is composed by following obtained results:

(1) Generic metamodel of quality, which include the best practices and a vast knowledge base about quality factors, extracted from known basic models and quality standards;

(2) Tailored quality models built from metamodel, based on field research, which permit providing quality for seven type of IPs; and

(3) An original support application for quality assessment with the extraction of some initial data directly from the Agile PMO.

**The main research result is core/generic quality metamodel, adaptable, flexible and extensible,** which contain the quality characteristics of included basic models *(McCall, ISO 9126, ISO 25010 etc.)* and user defined characteristics. Metamodel absorbs the best of the moment practices, defined în ISO 9001 standards and the ISO 25000 family, which meet current trends in quality management of software. Obtained metamodel is based on an extended literature review, qualitative and quantitative analysis methods, detailed survey questionnaire for different kind of people and different type of IS.

**The second obtained result,** was established the tailored quality models for some of the most important types of IS and values of corresponding weights of these quality factors, which allows a more accurate quality assessment for these type of IS. The research area was mainly oriented for information systems, such ERP, CRM, BI, etc. Weights were determined based on experts' answers. The most important result of this experts' survey says that there is a variance in scaling the characteristics of quality, depending of the type of project, the fitting quality scale according to information needs of the customers both inside the organization and out of it. A well-established QMS quickly develops business and offers advantages such as: simplifying and optimizing processes, increasing customer satisfaction, motivating employees, lowering costs and increasing productivity, creating or adjusting specific quality tools, quality standards and others.

**The third obtained result is universal** application for continuous quality assessment. The quality assessment activities should be carried out in an iterative way of measurement and improvement. This fact requires a quality model that, on the one hand, gets the suitable parameters that fit an information project and, on the other hand, allows measuring, in a unified scale, the quality improvement results, along with the project lifecycle. The realized application is based from project classification, tailored quality models, and valuable information system quality characteristics as inputs directly from PMO applications. The generated tailored model is flexible,

adaptable and extensible: end user can adapt this model according to his requirements, define and add some new characteristics and/or measurement functions.

Universality of application was achieved by the separation of the initial input data from the application and from measurement, registration, calculation and expert methods. *All of these are programmed in the Excel templates, and permit to determine the values of the quality factors, defined in according of the users' needs.* The Excel files also serves as data-collectors, extracted from various PMO instruments, used along lifecycle of development of IPs.

**The applicative value of the research.** The new assessment approach, generic metamodel, tailored models, measurement functions – all of these have been realized in software universal application tool IPMS for support of managers. The research outcomes can be directly used for 12 type of IS, such ERP & CRM, GIS & Map Library, Enterprise Portal & Knowledge Management, Business Intelligence & Big Data, Internet Site & Web Application, Document Management System and Mobile Application. The new assessment approach and the realized software tool are implemented in „WGS", Israel and in the study process of the Moldova State University. But the results could be used by researchers and students in software engineering disciplines, could be easily implemented in any organizations that use IPs, in according to the specific criteria of that project. The applications can save the inputs and outputs of quality assessment results to the database, in order to compare between the quality activities over time.

**Recommendations and suggestions for future research.** The present research can be expandable. Building a framework for measuring, assessing and improving quality requires both methodological support and technology support with the right tools. Also, developing/implementing this tool as a software application designed to support quality management, *more theoretical and empirical research, including expert opinion surveys are required.*

In particular, research could be continued in several directions, but not only:

(1) Quality modeling along the lifecycle, investigation of characteristics and related metrics, measurement functions to determine correlation, significance, the degree of overlap, dependencies and degree of automation is the most important way to increase the quality, inclusively using a formal, mathematical modeling, such set theory, graph theory, etc.

(2) Refinement of many quality factors, metrics that, in aggregate, adequately reflect the quality of software along the lifecycle.

(3) Because quality indicators and expert opinions often can be contradictory, identification of these parameters and their importance for each of IPs require adequate solutions, which can be identified among multicriterial quality assessment methods.

(4) The most qualitative input data for quality evaluation are the objective data, collected directly from the outputs of the technological processors. Accordance of outputs of technological development processes with inputs of quality assurance can offer a good basis for improvement of quality.

## REFERENCES

All web references were verified on December 10, 2019


1. ICT Development Index 2017. ITU, 2017 (publ. 06.11.2019). https://www.itu.int/net4/ITU-D/idi/2017/index.html/
2. Gross Domestic Product in the Republic of Moldova in 2018 and in quarter IV 2018. (publ. 5.03.2019) https://statistica.gov.md/newsview.php?l=en&id=6300&idc=168/
3. ИТ-рынок Израиля (for 2018-2017, publ. 06.11.2019). http://www.tadviser.ru/index.php/Статья:ИТ-рынок_Израиля/
4. ISACA Model Curriculum for IS Audit and Control. ISACA, 2nd Edition, 2009. 57p
5. Sundararajan S., Bhasi M., Pramod K. An Empirical Study of industry practices in Software Development Risk Management. In: International Journal of Scientific and Research Publications. 2013; 3(6). pp. 1-11.
6. The State of Project Management Annual Survey 2016. Management WP, 2016. https://www.wellingtone.co.uk/wp-content/uploads/2016/01/The-State-of-Project-Management-Survey-2016.pdf/ . 23 p
7. The Project Management Cycle. PM4DEV, 2007. 15 p.
8. A Guide to the Project Management Body Of Knowledge (PMBOK). PMI, Sixth Edition U.S.A., 2017. 976 p.
9. Rob Cole and Edward Scotcher. Brilliant Agile project management. A practical guide to using Agile, Scrum and Kanban. U.S.A., 2015. 198 p.
10. Lungu I. Integrating Quality Management System into Software Development Processes: ASSIST; 2017. Available from: https://assist-software.net/blog/integrating-quality-management-system-software-development-processes/
11. Project Quality Management. PM4VED, 2008 (22 p)., 2016 (23 p.) https://www.pm4dev.com/ resources/docman/pm4dev-ebooks/5-project-quality-management/file.htm/
12. Paulk M. et al. Capability Maturity Model for Software. Software Engineering Institute Carnegie Mellon University; 1993. 87p. https://apps.dtic.mil/dtic/tr/fulltext/u2/a263403.pdf

13. Hoermann S., Schermann M., Krcmar H. When to manage risks in IS projects: An exploratory analysis of longitudinal risk reports. In: Proceeding of 10th International Conference on Wirtschaftsinformatik, 2011. pp. 871-880.
14. Sarigiannidis L., Chatzoglou P. Software Development Project Risk Management: A New Conceptual Framework. In: Journal of Software Engineering & Applications, 2011; 4(5), pp. 293-305.
15. Yoder J., Wirfs-Brock R. Aguiar A. QA to AQ. Patterns about transitioning from Quality Assurance to Agile Quality, 2014, 18p. http://www.wirfs-brock.com/PDFs/QA2AQ.pdf
16. ISO/IEC 25010:2011. Systems and software engineering. Systems and software quality requirements and evaluation (SQuaRE). System and software quality models: 34
17. Bergmann R. Information Projects Quality Model. In: EPH - International Journal of Science and Engineering, November 2016; 2(11). pp. 38-56.
18. Quantifying Information Quality. In: Studia Universitatis Moldaviae, 2015, nr.7 (87), Seria „Științe exacte și economice", pp. 86-97. https://studiamsu.eu/nr-7-87-2015/
19. Bergmann R., Bragaru T. Standards and Software Quality Models. In: Scientific and didactic journal ECONOMICA, nr.2 (108), Chişinău: ASEM, June 2019, pp. 118-132. https://ase.md/files/publicatii/economica/2019/ec_2019_2.pdf/

## AUTHOR'S PUBLICATIONS ON THESIS SUBJECT


1. BERGMANN, R. Information Projects Quality Model. In: EPH - International Journal of Science and Engineering, Volume 2, Issue 11, November-2016, pp.38-56. https://ephjournal.com/index. php/se/article/view/224, https://ejournal.undip.ac.id/index.php/ijse/. ISSN 2454-2016
2. BERGMANN, R. Models and Standards of Information Quality Assurance. In: Наука №4-3, февраль 2016 Костанай, научно-производственным журнал, pages 9-12. https://www.twirpx.com/file/1934885/. ISSN 1684-9310
3. BERGMANN, R. Quantifying Information Quality. In: Studia Universitatis Moldaviae, 2015, nr.7 (87), Seria „Științe exacte și economice", pp. 86-97. http://studiamsu.eu/nr-7-87-2015/. ISSN 1857-2073
4. BERGMANN, R. BRAGARU, T. Standards and Software Quality Models. In: Scientific and didactic journal ECONOMICA, nr.2 (108), Chişinău: ASEM, June 2019, pp. 118-132.https://ase.md/files/publicatii/economica/2019/ec_2019_2.pdf/. ISSN 1810-9136
5. BERGMANN, R. Providing Quality of Information Projects. Proceeding of International Conference Mathematics & Information Technologies (MITRE-2015). Chişinău: CEP USM, 2015, p.90. ISBN 978-9975-71-678-9
6. BERGMANN, R. Information Systems and their Business Value. In: Materials of International Conference „European Economic Integration". Chişinău: USEM, 2016, p.58-60. ISBN 978-9975-3147-2-5
7. BERGMANN, R. Information Projects Quality Model. Proceeding of International Conference Mathematics & Information Technologies (MITRE-2016). Chişinău: CEP USM, 2016, pp.74-75. ISBN 978-9975-71-794-6
8. BERGMANN, R. Information Projects Quality Assessment. Proceeding of International Conference Mathematics & Information Technologies (MITRE-2019). Chişinău: CEP USM, 2019, pp. 67-68. ISBN 978-9975-149-17-4
9. BERGMANN, R. Information Projects Quality Model. The 5th social psychology conference for PhD students, SODOCO, Haifa University, Israel, December 12, 2016, poster 17 p.
10. BERGMANN, R., SIROTA, J. Information Projects Quality Model and the Global Volume of Data. The 5th Kinneret Conference on Software Engineering Education, Kinneret Academic College, Israel, February 21, 2017, p. 18-19.

## SUMMARY

The thesis ***„Providing Quality of Information Projects”*** is written in English and submitted by Mr. *Ran BERGMANN* for fulfillment of the requirements for the PhD in informatics, specialty *121.03 – Computer programming*. The thesis was elaborated at the Moldova State University, Chisinau.

**The structure of the thesis**: The thesis consists of Introduction, 4 main chapters, Conclusions and Recommendations, Bibliography of 167 titles. The main text amounts up to 161 pages, includes 55 figures, 16 tables, 16 formulas, and 9 annexes. The obtained results of the thesis were published in 10 scientific papers, with a total volume over 4 sheets of author.

**Keywords**: Information Project (IP), Information System (IS), Software, Quality of IP, Quality characteristics, Quality standards, Generic Quality Metamodel, Tailored Model of Quality, Quality Management System (QMS).

**Research Goal and Objectives. The aim of this thesis** is to provide quality of IPs. **The objectives** of thesis are described as follows: developing the generic quality metamodel, which integrates the knowledge about known quality models, quality factors, and the best practices, presented on the actual international standards; identifying of the quality factors, and building the tailored/specific quality models, obtained from generic quality metamodel; assessing quality along lifecycle; specifying the requirement, developing a software application to support for metamodel administration, generation of tailored models and quality assessment, as part of the Project Management Office (PMO), with the implementation of results in an organization.

**The scientific novelty and originality** are reflected in a new approach for continuous assessment and improvement of IPs quality along lifecycle based on combination between modern Agile development methodology and tailored quality models, obtained from generic metamodel and in an original digital application/tool for support of new approach.

**The important scientific** problem solved in the research: A new approach opens up the possibility to define the quality of IPs at the conceptual level, creating the basis for the subsequent formal assessment of the degree of compliance of the developed IPs with the quality requirements.

**The theoretical significance** is confirmed by the analysis, generalization and determination of the theoretical principles of a new approach for the continuous process of assessing the quality of IP throughout the project life cycle, based on the combination and relationship between the Deming quality improvement model, adaptable quality models and the modern Agile development methodology.

**The applicative value.** The new assessment approach for quality factors, generic metamodel, tailored models, measurement functions – all of these have been realized in a software application tool IPMS - *Information Project Management System*, as extension for the PMO. The proposed approach and elaborated application have huge potential for software industry in reducing significantly the time and cost of quality assessment of IPs and improvement of quality.

**The implementation of the results.** The new assessment approach and the realized software tool are implemented in "WGS", Israel *(Annex 5)* and in the study process of the Moldova State University *(Annex 6).* However, these results also can be directly used by any other organizations concerned with IP development and/or by researchers and students of other educational institutions at software engineering disciplines.

## ADNOTARE

Teza ***„Asigurarea calității proiectelor informaționale”*** este scrisă în limba engleză și prezentată de domnul *Ran BERGMANN* pentru obținerea titlului de doctor în informatică, *specialitatea 121.03 – Programarea calculatoarelor*. Teza a fost elaborată la Universitatea de Stat din Moldova, Chișinău.

**Structura tezei**: Teza constă în Introducere, 4 capitole principale, Concluzii generale și recomandări, Bibliografie 167 de titluri. Textul principal cuprinde 161 de pagini, include figuri, 16 tabele, 16 formule și 9 anexe. Rezultatele obținute ale tezei au fost publicate în 10 lucrări științifice, cu un volum total de peste 4 coli de autor.

**Cuvinte cheie:** proiect de informații (IP), sistem informațional (IS), software, calitatea IP, caracteristici de calitate, standarde de calitate, metamodel generic de calitate, model particularizat de calitate, sistem de management al calității (QMS).

**Scopul și obiectivele cercetării.** Scopul tezei constă în furnizarea de calitate a IPs. **Obiectivele tezei** constau în dezvoltarea metamodelului generic de calitate, care integrează cunoștințele despre modelele de calitate cunoscute, factorii de calitate și cele mai bune practici, prezentate în standardele internaționale actuale; identificarea factorilor de calitate și construirea modelelor de calitate particularizate/specifice, obținute din metamodelul generic de calitate; evaluarea calității IP/IS de-a lungul ciclului de viață; specificarea cerințelor și dezvoltarea unei aplicații software-suport pentru administrarea metamodelului, generarea modelelor specifice, evaluarea calității, ca parte a *Project Management Office* (PMO) cu implementarea rezultatelor într-o organizație.

**Noutatea științifică și originalitatea** sunt reflectate într-o nouă abordare pentru evaluarea și îmbunătățirea continuă a calității IPs de-a lungul ciclului de viață, bazat pe combinația între metodologia modernă de dezvoltare Agile și modele de calitate particularizate, obținute din metamodelul generic și în aplicația originală/instrument software-suport a noii abordări.

**Problema științifică importantă rezolvată** în cercetare: noua abordare deschide posibilitatea de a defini calitatea IPs la nivel conceptual, creând baza pentru evaluarea formală ulterioară a gradului de conformitate a IPs dezvoltate cu cerințele de calitate.

**Semnificația teoretică** este confirmată de analiza, generalizarea și determinarea principiilor teoretice ale noii abordări a procesului de evaluare continuă a calității IP pe întregul ciclu de viață al proiectului, bazată pe combinația și relația dintre modelul de îmbunătățire a calității Deming, modele de calitate adaptabile și metodologia modernă de dezvoltare Agile.

**Valoarea aplicativă.** Noua abordare de evaluare a factorilor de calitate, metamodel generic, modele particularizate, funcțiile de măsurare - toate acestea au fost realizate într-un aplicație instrumentală software IPMS - *Information Project Management System,* ca extensie PMO. Abordarea propusă și aplicația elaborată au un potențial imens pentru industria software în reducerea semnificativă a timpului și costului evaluării calității IPs și îmbunătățirii calității.

**Implementarea rezultatelor**. Noua abordare de evaluare a calității și instrumentul software realizat sunt implementate în „WGS”, Israel *(Anexa 5)* și în procesul de studiu al Universității de Stat din Moldova *(Anexa 6).*Dar, aceste rezultate pot fi, de asemenea, utilizate direct de orice alte organizații implicate în dezvoltarea IPs și/sau de către cercetătorii și studenții altor instituții de învățământ a disciplinelor de inginerie software.

## АННОТАЦИЯ

Диссертация на тему ***«Обеспечение качества информационных проектов»*** написана на английском языке и представлена господином *Ран БЕРГМАНН* для получения степени кандидата наук по Информатике, специальность *121.03 – Компьютерное программирование.* Диссертация была разработана в Молдавском Государственном Университете.

**Структура диссертации:** Диссертация состоит из введения, 4-ех основных глав, заключения и рекомендаций, списка литературы из 167 наименований. Основной текст составляет 161 страницы, включает 55 рисунков, 16 таблиц, 16 формул и 9 приложений. Полученные результаты опубликованы в 10-ти научных работах, общим объемом свыше *4 авторских листов.*

**Ключевые слова:** *информационный проект (IP), информационная система (IS), программное обеспечение, качество IP, характеристики качества, стандарты качества, обобщенная метамодель качества, частная модель качества, система менеджмента качества (QMS).*

**Целью работы** является обеспечение качества IS. Подцели состоят в разработке обобщенной метамодели качества, которая объединяет знания об известных моделях качества, факторах качества и лучших практиках, представленных в актуальных международных стандартах; выявление факторов качества и построение частных/ специфических моделей качества, полученных из обобщённой метамодели качества; оценка качества на протяжение жизненного по цикла *IP*; спецификация требований и разработка программного приложения-инструмента для поддержки метамодели, создания специализированных моделей и оценки качества IS, как часть Офисного Управления проектами (PMO), с внедрением результатов в некоторой организации.

**Научная новизна и оригинальность** отражены в новом подходе к непрерывной оценке и улучшению качества IS на протяжении жизненного цикла на основе сочетания современной методологии разработки Agile и адаптируемых моделей качества, полученных из обобщенной метамодели и в оригинальном цифровом приложении/инструменте для поддержки нового подхода.

**Важной научной проблемой**, решаемой в исследовании, является новый подход, который открывает возможность определения качества IS на концептуальном уровне, создавая основу для последующей формальной оценки степени соответствия требованиям качества, разработанных IS.

**Теоретическая значимость работы** подтверждается анализом, обобщениями определением теоретических принципов нового подхода для непрерывного процесса оценки качества ИС на протяжении жизненного цикла проекта, основанного на объединение и связь между моделью повышения качества Деминга, адаптируемых моделей качества и современной методологии гибкой разработки Agile.

**Прикладная ценность работы**. Новый подход к оценке факторов качества, обобщенная метамодель, адаптируемые модели, функции измерения были реализованы в программном инструменте IPMS *Information Project Management System* как расширение для PMO. Предлагаемый подход и разработанное приложение имеют огромный потенциал для индустрии программного обеспечения в значительном сокращении времени и затрат на оценку качества ИС и их улучшение в программном инструменте (Information Project Management System) как расширение для PMO.

**Внедрение результатов**. Новый подход к оценке качества и реализованный программный инструмент внедрены в "WGS", Израиль (Приложение 5) и в учебном процессе Молдавского Госуниверситета (Приложение 6). Эти результаты также могут непосредственно использоваться любыми другими организациями, занимающимися разработкой ИС, и/или исследователями и учащимися других учебных заведений по дисциплинам, связанных с разработкой программного обеспечения.

**BERGMANN Ran**

**PROVIDING QUALITY OF INFORMATION PROJECTS**

**121.03 - Computer Programming**

**Abstract of the PhD Thesis in Informatics**

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