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INTEGRATED DEVELOPMENT OF QUALITY AND INFORMATION MANAGEMENT SYSTEMS IN ORGANIZED VEHICLE FLEET – POSSIBILITIES AND OPPORTUNITIES

Miloš Vasić[1,*], Miodrag Brzaković[2], Nada Stanojević[3]

[1]Institute for research and design in industry, Vatroslava Lisinskog 12a, Belgrade, Serbia
[2]University Business Academy Novi Sad, Faculty of Applied Management, Economics and Finance, Jevrejska 24, Belgrade, Serbia
[3]University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia
**mvasic@iipp.rs*

The subject of this paper is a complementary area consisting of management systems (QMS) and information systems (IS), i.e., the theoretical and practical need for their parallel design, development, implementation and operation. Companies are increasingly concerned with managing the quality of their products and services in accordance with international standards. Designing a quality management system requires the intensive participation of managers and employees who perform analysis and reengineering of business processes and accompanying procedures. Very similar requisites and tasks characterize the design of a company's information system, but these two endeavors are most often implemented as separate projects, handled by different teams, equipped with unrelated methodologies. Within the scope of this paper, the author's ambition was to establish a model of synergistic connection of the information system and the quality management system through the establishment of a Quality management system suitability function and check to what extent the definition of common databases, integrated data model and information model confirms or refutes the hypothesis that the integration of QMS and IS contributes to better overall business results and individually improves each of the connected systems.

Keywords: Quality management system, Information system, Synergy, Vehicle fleet

1 INTRODUCTION

Systemic quality management is a key dimension of every process, that is, every product. It is considered a significant competitive advantage in the global market. The concept and model of applying quality in business processes has gone through several evolutionary steps during modern history — from simple inspection to planned process control (Quality control), designed quality assurance of products or services (Quality Assurance; Quality Engineering), quality management (Quality Management System, Total Quality Management) and quality design (Quality by Design). These models of development and application of quality follow the evolution of business processes and revolutions in the industry. [1] The fourth industrial revolution is an opportunity for the quality management process to become the leading strength of companies through adaptation to technological innovation, modern data analytics and the ecosystem of entrepreneurship that characterizes the era of the fourth industrial revolution.

The possibility of the so-called inter-networking of objects (IoT) has created an opportunity to combine intelligent solutions embodied in various application software (SW) with the effective processing of a large amount of data (Big data) provided by cloud technologies (Cloud) and opened the way to considering the idea of creating a model of integrated development of the information and management system in the organized fleet.

The determination towards such directed research is also supported by the general impression that in the last few years the quality management discipline has stagnated, i.e. that innovative models of development and application of quality in business processes are scarce [2].

Today, management and planning, as well as control and monitoring of various activities in the transport sectors are considered extremely important at the global level and can lead to further development in both the economic and social fields.

Fleet management is a function that allows transport companies to see opportunities and remove or minimize risks associated with day-to-day business operations, but also with investing in equipment and vehicles, improving efficiency, improving productivity and reducing overall operating costs while at the same time complete (100%) compliance with international and national legislation and established business policy of the company itself.

Discovering potential opportunities to improve the operation of large vehicle fleets requires a comprehensive and timely assessment of business processes, not only in accordance with increasingly high environmental and safety standards, but also in accordance with established quality criteria and user satisfaction according to the changing parameters of the work environment and throughout the entire life cycle both a single vehicle and the entire system, i.e., fleet.

The quality management of transport services includes the implementation of a large number of synchronized and often simultaneous functions and is an extremely complex system based on the principles of logistics management, management of relations with interested parties, coordination with the established quality system, etc. [3]

Digital and connected solutions can make such business processes more efficient, flexible and productive with a high and sustainable quality of service or product, and in accordance with such a belief, the key elements of this work are given below.

2 DEFINING QMS AND IS AND THEIR RELATIONSHIPS

In this chapter, the most important elements for understanding quality, quality management systems and information systems will be presented, as well as interconnections essential for establishing a model of integrated development of information and management systems in an organized fleet.

2.1 Quality

Quality - a common term that is often used in everyday speech is a word of Latin origin (qualitas) which is translated as property, characteristic, virtue, value, good quality [4]. Quality is an association with something good, so the general approach to quality includes a way of thinking and acting aimed at improving the existing.

Deming says that good quality means a predictable degree of uniformity and reliability with a standard of quality that suits the customer. There are many definitions of quality, but the basic philosophy of all definitions is the same – consistency of compliance and performance, and keeping the customer in mind [5].

Since the middle of the last century, quality has been approached both from the point of view of the producer and from the point of view of the consumer. The producer viewed quality as compliance with the requirements and rules of the procedures that define production, and for the user, quality represents all the characteristics of the product that satisfy stated or implied needs.

Taking into account numerous authors and the development of theories, the International Organization for Standards (International Standard Organization - ISO) in 1986 sets quality standards, according to which quality is defined as: "a set of all product properties related to their ability to satisfy established or expressed needs". Over time, the definition has survived several changes so that, according to the latest valid edition of ISO 9000:2015 (Quality management systems — Fundamentals and vocabulary), quality is defined as the level to which a set of inherent characteristics meets the requirements.

Today we know that quality can be accessed from 4 basic points of view:

- consumer viewpoint - is approached as the level of use value of the product to which the satisfaction of a particular need is achieved;
- manufacturer's point of view - quality is treated as the degree to which the previously determined production requirements have been met;
- market view - quality is considered in the context of comparison with competitors (manufacturers of the same products and services);
- the point of view of society - is treated in the context of socio-economic justification, i.e. realization of purchase contracts and profit making;

The goal is the long-term satisfaction of the user's requirements, i.e., building trust and their long-term attachment to the organization through its products, which creates a good market position and business result.

2.2 Quality Management System

2.2.1 Quality System

The quality system is a process that, together with information technology, characterizes the end of the twentieth century, as a time of global communications, permeation and integration of states, economies and cultures. This process brings a new attitude towards the environment, customers and above all towards work.

The quality system is a transformational process and many companies and countries see in it a chance to join the world integration processes. The quality system appears as a dominant management system and a logical continuation of two trends:

- the trend of management concept development, from the classical school of systemic approach, strategic management, efficiency theory and competitive management,
- the trend of development of approaches and methods as well as the Japanese path towards world industry and market dominance.

The quality management system was developed on the basis of the technical development of quality in order to move from the technical aspect to the systemic aspect with such development. [6]

2.2.2 Quality management

This phase recognized as quality management includes quality assurance QA (Quality Assurance), which relies on and continues on the QC (Quality control) stage, where quality becomes the subject and method of assurance in all processes.

The change in the approach to quality occurs through the application of a concept that is characterized by failure prevention, rather than its control. Quality assurance appears as a result of a new quality philosophy, and its practical application comes to full expression with the introduction of the quality system, which later resulted in the ISO 9000 standard.

In contrast to earlier controls, quality control extends to the entire business process of the company and not only to direct production, so that management also becomes responsible for quality.

Quality management QM (Quality Management) relies on and continues the QA stage, where quality becomes the subject and method of management. Here, the management system is checked and evaluated according to the requirements of the ISO 9000:2000 standard [7].

2.2.3 International standards

The International Organization for Standardization represents a global network of world-leading standardization experts, accepted worldwide. All international standards (ISO) are approved with at least 75% positive votes of national bodies, of which there are currently 167 [8].

Therefore, the international standards adopted in this way represent strategic tools and provide guidelines to help companies in the most demanding challenges of modern business. They need to ensure that operations are as efficient as possible while securing access to new markets. The most widely applied international management systems are presented below.

2.3 Information system

Information system (IS) as a concept appeared in the middle of the last century, but even today it cannot be completely defined precisely. There is a very large number of different definitions of the information system and their diversity is most often reflected in three aspects - business, structural and functional aspects.

From a business point of view, we consider the contribution that IS creates for the business environment in the wider business context, so one of the definitions of an information system could be: An information system is a system developed to support processes, management and decision-making in an organization.

Observing IS from a structural angle defines the internal and external structures of the system, their behavior, as well as the behavior of the system as a whole. Given that IS is viewed as a product that must satisfy given conditions, a possible definition of IS could be: An information system is a system made up of people, data, processes and interfaces.

Viewing information systems from a functional point of view is suitable for conceptual modeling and focuses on the functions that IS fulfills, so a possible definition could be: An information system is a system that collects, stores, processes and delivers information.

In short, the business aspect tells us what the goal of information systems is and why they are created, the structural aspect tells us what the information system consists of and how the information system is implemented, and the functional aspect tells us what tasks information systems (as well as all its parts) perform. they have to perform. It is important to note that for the development of an information system it is necessary to consider all aspects.

2.3.1 Management information systems

A management information system is a network based on computers, which provides appropriate data to the management of the company for the purpose of decision-making, and also contains the necessary mechanisms for introducing changes that the management of the company makes when making decisions [9]. Accordingly, management information systems are used for collecting, processing, storing and disseminating information, which should enable managers and analysts to have a quick, comprehensible and consistent insight into information relevant to making business decisions, predictions and forecasts.

2.4 Interconnection of management systems and information systems

Companies are increasingly concerned with managing the quality of their products and services. Having a quality certificate becomes a mandatory condition for presence in selected markets, and designing a quality management system requires the intensive participation of staff and managers who perform analysis and reengineering of business processes and accompanying procedures. It is interesting that very similar requisites and tasks characterize the design of a company's information system. However, these two endeavors are most often carried out as separate projects, handled by different teams, equipped with unrelated methodologies.

ISO 9001 is a quality management standard adopted by nearly one million [10] companies worldwide. It requires the internal development of management procedures, work instructions, improvement plans, with a precisely defined

measurement system. External information flows are also important, so the quality management system becomes a tool for managing relations between the organization and its environment.

On the other hand, IS development also considers the impact of the business environment and internal characteristics of the company, such as its policies and procedures. However, IT teams and quality systems teams usually do not use the synergistic potential of these two systems. Based on narrow areas of expertise, quality professionals see IS as mere support, while IT professionals view QMS as mere compliance.

However, if it is taken into account that during the development, implementation and application of the wider enterprise architecture, the corresponding business processes can immediately become ready for quality audit by the certification body, i.e. that the organization, after being officially certified according to ISO 9001 or another management system, can more easily to perform the architecture of the company and the basis for the future information system, the need to create a common organizational view on the development of the management system and the information system, as well as the synergy of the expert system created in this way, is recognized.

2.4.1 Synergy potentials of management systems and information systems

Bearing in mind that a large part of the attention that IT has received in operational literature is a consequence of the spread of the principles of total quality management (TQM) [11] and that quality management is also one of the most important business management philosophies aimed at improving quality performance, the focus is given the relationship between IT and quality performance.

If IS is viewed only as a support for QMS, there is a risk of missing a holistic consideration of the organization's IS operations, primarily through missing consideration of the need to add other IS processes and links arising from IS management practices, related business processes and socio-technical IS aspects.

For this reason, it is proposed to study QMS not only as a source of IS requirements, but also as a source of principles and values, with the potential for a dynamic contribution to IS design and management.

In this sense, it is necessary to keep in mind that the design and implementation and application of implemented solutions have different challenges and that these are the sources of potential synergy. These processes depend on each other: the operation is the result of design and implementation, but also the basis for new iterations of established connections, as recommended by the PDCA cycle. The scheme of possible synergistic action of these two subject systems that will be considered is presented in Figure 1.

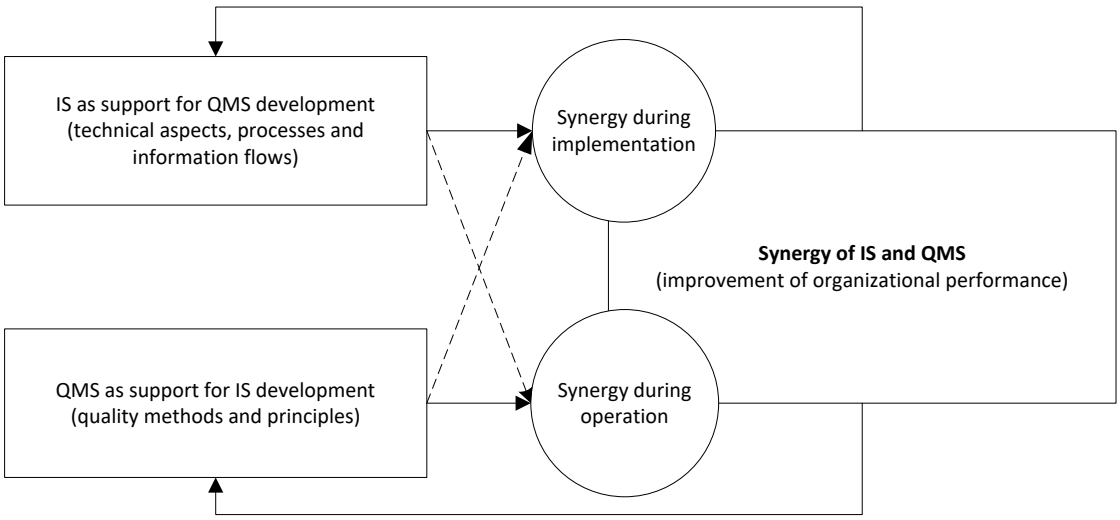

Figure 3.7: Scheme of the possible synergistic action of the information system and the quality management system

In such interweaving of the two subject systems, the expected advantages of synergy ensure always available accurate, valid and reliable information in real time, with facilitated information sharing, data download, consolidation, analytics and reporting, all according to the built-in rules of established processes.

3 DEFINING AND DISPLAYING THE NEW FUNCTION - SUITABILITY OF QMS

The implementation of the management system aims to improve the organization's operations while continuously meeting the requirements of interested parties [12]. The basis for the good functioning of the management system is its high degree of effectiveness. In theory and practice, several methods are used to assess the effectiveness of the management system: internal audit, second-party audit, third-party audit, risk analysis, stakeholder responses, etc.

[13]. On the other hand, this paper presents a new method that analyzes response times, i.e. the speed of response of the business system, as a factor in evaluating the effectiveness of the management system.

3.1 Tools for checking established management systems

Independent certification audit is the most commonly used method for verifying the effectiveness of the applied management system. However, organizations also need more efficient methods to check the effectiveness of their systems, primarily because external certification audits very often require large financial allocations, and also due to the fact that certification/surveillance audits are generally conducted only once a year.

Some previous researches have already pointed to the problem of achieving a high degree of efficiency and effectiveness of the management system and highlight this as one of the main problems faced by companies when implementing ISO standards [14]. However, in addition to known methods, which are described in detail through numerous literatures dealing with the subject area [15, 16, 17, 18] in research and practical applications, there is still a need to introduce a new method, i.e., a fundamentally new way of looking at the measurement problem and improving the effectiveness of the management system.

3.2 Effectiveness of the established quality management system

The effectiveness function reflects the overall properties of the observed management system and provides answers to the following questions:

- Can the system be put into operation (reliability)?
- How long can it work (availability)?
- How does it perform the task (suitability)?

How the established management system performs the task represents its functional suitability, i.e. the degree of satisfaction of functional requirements with adaptation to the environment. The reliability and availability of that system are random functions, while the functional suitability is a quantity determined by the design or construction of the system itself.

Therefore, the suitability of the established system affects the overall safety of functioning, and it focuses on the features of the management system in terms of the possibility of implementing the necessary measures, that is, the adaptability of the system to perform corrective procedures within the stipulated deadlines.

In order to understand the suitability function of the quality management system, the modeling was carried out within a transport company that has more than 300 vehicles for public transport of passengers and in its business relies on both the quality management system and the business information systems. The result is presented on the example of a corrective measure and explained in more detail in Figure 2.

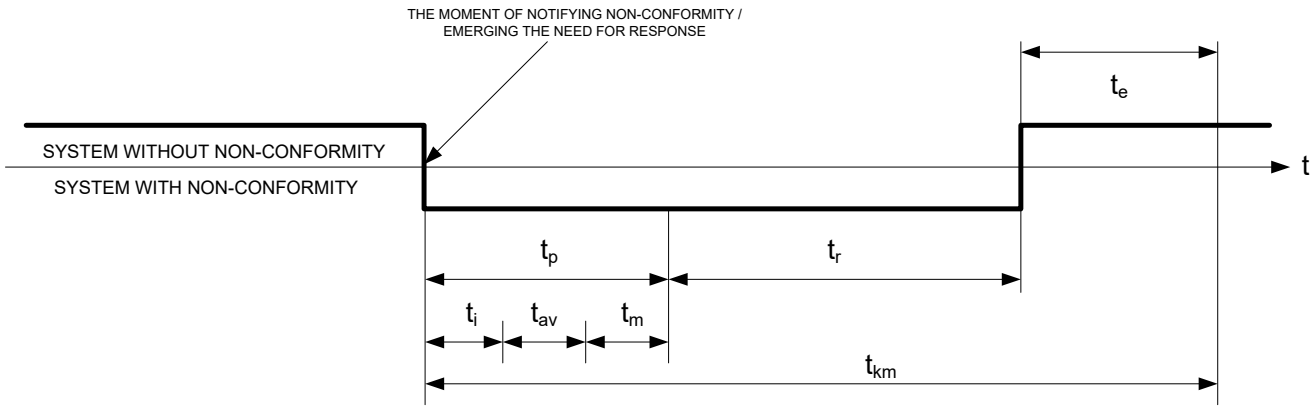

Figure 2: Schematic representation of the time from observation to closure of corrective action

Where:

t_{km} – total time required to close CM (corrective measures)

tr – time required for realization of CM

t_p – time required for CM planning, and consists of:

- t_i – time required for application to RCM (request for corrective measure)
- t_{av} – time required to determine the cause of CM
- t_m – time required for accepting CM

t_e - the time required for evaluating the effectiveness of CM

From the diagram, it can be seen that situations are considered when the system is in operation (without non-conformities) and when the system is in failure (with non-conformities), where for the sake of a more efficient transition from the state of failure to the state of operation, paper considers the time required for planning corrective measures, for the implementation corrective measures, as well as the time needed to evaluate the effectiveness of the implemented measure.

The time for evaluating the effectiveness of the corrective measure t_e is important from the aspect of confirming/determining the positive outcomes of the implemented corrective measure. Only with a positive assessment of the results that the corrective measure gave, the established system considers that the corrective measure is closed. Otherwise, it is necessary to repeat the activities to eliminate it.

When it comes to the **time for the implementation of the corrective measure t_r**, it is a function of a number of parameters (occurrences) and can be described as:

$$T_r = f(RR, \mathrm{TN}, ZP, FO)$$

Where occurrences mean:

- RR – availability of resources needed for the implementation of RCM (request for corrective measure)
- TN – type of non-conformity
- ZP – significance of the process affected by the non-conformity
- FO – other factors that affect non-compliance and/or realization of CM

The availability of resources is recognized as an important parameter that in many cases is conditioned by external factors (even when the organization has funds, it is possible that the lack of equipment, experts or materials on the market delays the execution of the defined corrective measure).

The type of non-conformity is also recognized as an important parameter that indicates the ease of elimination of the observed non-conformity (some non-conformities can be eliminated only by internal activities, some affect a smaller number of processes and a smaller number of people, some require the involvement of top management, some require external assistance...)

The importance of the process affected by the non-conformity is also recognized as an important parameter, because in every organization the processes vital for the continuous and successful operation of the organization differ from the processes that make up the support or logistics of the work.

These three parameters are recognized as the parameters that have the greatest influence on the estimation of the time required for the implementation of the corrective measure.

In addition to them, there are a number of other influential parameters that are not excluded from observation, but due to periodicity (rarely to occasionally), they are collectively included as other factors that influence non-compliance and/or realization of CM.

The time for planning the corrective measure t_p is recognized as the time in which the synergy of the information system and the quality management system can be best observed. Within this time, it was additionally recognized and introduced as a new term - "**system response time**".

The response time of the system (response = reaction speed) is the time from the moment of detection of non-compliance (which is specified in the request for initiation of corrective measures) to the moment of initiation of the measure. This time is not measured from the moment of submission (application) of the request for a corrective measure, but from the time specified in the request for a corrective measure as the time of non-compliance.

The method - "system response time" is based on the fact that the effectiveness of the management system directly depends on the model and level of system implementation and its readiness to take effect, that is, to achieve the expected results in the minimum time and in the given environment [19].

System response time is a measure that indicates the synergy between IS and QMS. With a better connection of these two systems, the response time is less. A lower system response time indicates a better suitability of the quality management system.

3.3 The suitability of the quality management system

When defining the Quality management system suitability function and, analogously, the term Quality management system suitability, it is possible to distinguish between two TIMES OF THE SYSTEM WITH NON-CONFORMITY (Figure 3): the first, which represents the time from the occurrence of non-conformity, i.e. the emergence of the need to react to of the beginning of the execution of the corrective measure implementation procedures, and the second, which includes the time of execution of the immediate implementation procedures of the defined corrective measure.

The synergy of information and quality management systems is especially manifested in the first defined time, that is, reducing this part of time to a minimum (CM planning), is possible only in cases of high suitability of the quality management system.

Quality management system suitability function was determined empirically, within the framework of an organized fleet with more than 300 vehicles. Time intervals and the number of observed non-conformities were observed, in order to calculate the suitability of the quality management system by calculating the probability density of the duration of corrective measures.

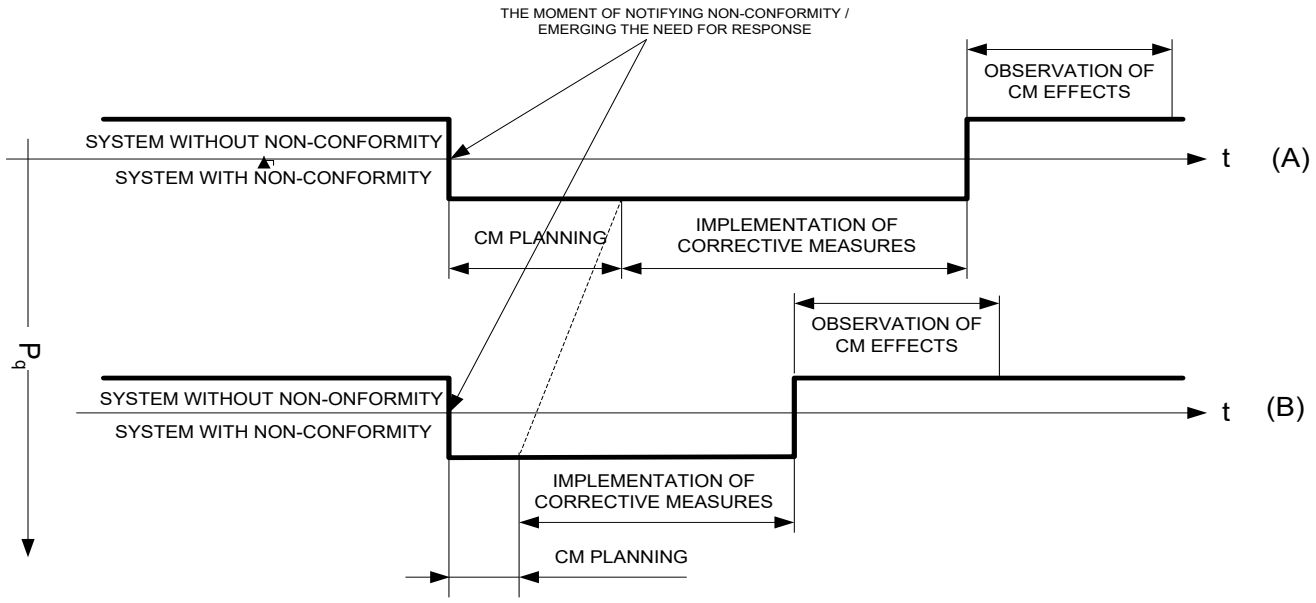

Figure 3: Synergy planning reduces the execution time of action planning and thereby directly increases the convenience of the quality management system

It is clear that the Suitability of the quality management system shows the quality of the process from the moment when the need to react (elimination of non-conformity) arose until the beginning of the active part of the duration of the implementation of the corrective measure, i.e. the execution of the immediate procedures provided for by the corrective measure. This time expresses the cumulative effect of a large number of factors of a random nature, so it (time) is also a random variable that is subject to certain laws of distribution. This distribution very well characterizes the entire quality management system, all influencing factors and their effects. Therefore, it can be assumed that this distribution represents a basic measure of the quality of the established management system and is expressed as a cumulative probability function in the form:

$$P_Q(t) = \int_0^t f(t_{km} - t_r) dt_Q$$

In this way, the ability of the quality management system in the organized fleet to (under combined phenomena) perform the required function under established conditions at a given time or for the observed period was seen.

4 CONCLUSION

Bearing in mind the accelerated digitization of business, the paper considered whether it is possible to better connect data generated by the application of QMS and IS (which are usually independently implemented and applied), to create information based on the synergy of these two systems that will contribute to more effective decision-making. related to more effective management of business processes.

IS, as a socio-technical construction that usually includes information technology (IT) to support business processes, represents the basis of the organization of modern business and is increasingly applied, especially with the development that Industry 4.0 brings with it. On the other hand, we have QMS, which has a long tradition of application and represents one of the most widespread management systems in everyday business application.

The author's long-term consulting practice has shown that in a large number of organizations established QMS very often remain on the formal contribution to business results - through a minimum of activities essential for securing a certificate, instead of actively, that is, effectively contributing to informed business decision-making.

The subject of this research was the complementary field of management systems (QMS) and information systems (IS), that is, the theoretical and practical need for their parallel design, development, implementation and exploitation.

The created model of assessment of the convenience of the quality management system is aimed at organized vehicle fleets such as vehicle fleets of transport companies. Conducted research and created relationships indicated:

- that parallel work on the formation of models and the establishment of databases for QMS and IS, enables the reduction of parallel processes and the avoidance of shared information, by defining common documents and their flows,
- that when there are already implemented QMS and IS in large fleets, then it is very important to connect the systems by defining key indicators of business as "measuring devices" of the effectiveness and efficiency of the connection of QMS and IS, because this is important information that contributes to understanding the need and creating opportunities for improvement effective and efficient business management. In this paper, this was achieved by introducing time indicators into the quality management system, i.e. by introducing the term "management system response time" as an indicator of the level of synergistic action of QMS and IS,
- that the introduction of a new function - Suitability of quality management systems enables better monitoring of the performance of the implemented system. It represents an important parameter of the assessment of the established system, because the quality of the provided service has a positive effect on user satisfaction, and at the same time it acts as an intervening variable that strengthens the influence between the established quality system and user satisfaction.

The conducted research showed that organizations do not realize the full potential of the simultaneous functioning of both systems. This is caused not only by operational problems (lack of computer literacy or inaccessibility of promulgated procedures/documents), but also by the limitation of the existing body of knowledge. There are no guidelines issued by an international standardization organization for proper QMS and IT integration, so ISO consultants and ISO auditors may not have the appropriate knowledge and experience to support QMS and IS integration.

In addition, the effectiveness of the synergy model largely depends on the effectiveness of the basic IS solutions into which it is integrated. This means that if there are problems with IT support (eg lost access, lost data, programs temporarily unavailable, user interface not adapted, low performance of software and hardware), it can affect the performance of the QMS, i.e. the synergies in question. The extent of the impact depends on the way and depth of integration of both systems.

Work on integration and establishment of connections within the framework of these two systems contributes to the individual improvement of each of these systems, but above all contributes to the improvement of the basic business process.

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