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Arkadiusz Wierzbic
Wroclaw University of Economics and Business
e-mail: arkadiusz.wierzbic@ue.wroc.pl
ORCID: 0000-0003-0118-4123

Karol Szewczyk
Robert Bosch Hungary – Mirków plant
e-mail: karolszewczyk2015@gmail.com
ORCID: 0000-0002-9086-1896

DIGITALIZATION OF AUDIT ACTIONS IN THE INDUSTRY 4.0 ERA

CYFRYZACJA DZIAŁAŃ AUDITOWYCH W DOBIE PRZEMYSŁU 4.0

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Summary: This digitalisation in the broad sense is not only about the processes that create added value, but also about the supporting processes. The activities of the quality management process are interesting in this regard. The purpose of the article is to examine the changes taking place in enterprises during the fourth industrial revolution in the area of the Layered Process Audit, i.e. a tool used to verify the functioning of processes against accepted standards. The article presents a brief description of this tool, as well as an example of a solution from the automotive industry functioning at the Robert Bosch Mirków plant. In addition, the results of surveys conducted in the group of process managers and auditors indicating the advantages of such an approach and areas for improvement were cited.

Keywords: Layered Process Audit, digitalization, Industry 4.0.

Streszczenie: Szeroko pojęta cyfryzacja nie dotyczy tylko procesów kreujących wartość dodaną, ale też procesów wspomagających. W tym zakresie interesujące są działania procesu zarządzania jakością. Celem artykułu jest zbadanie zmian zachodzących w przedsiębiorstwach w czasie czwartej rewolucji przemysłowej w obszarze procesu auditu warstwowego (*layered process audit*), czyli narzędzia stosowanego do weryfikacji funkcjonowania procesów względem przyjętych standardów. W artykule przedstawiona została krótka charakterystyka tego narzędzia, jak również przykładowe rozwiązanie z branży motoryzacyjnej funkcjonujące w zakładzie Robert Bosch Mirków. Przytoczono ponadto wyniki ankiet przeprowadzonych w grupie osób zarządzających procesem oraz osób wykonujących audyty, wskazujące zalety takiego podejścia, oraz wskazano obszary do doskonalenia.

Słowa kluczowe: audit warstwowy LPA, cyfryzacja, przemysł 4.0.

1. Introduction

The intention of the article is to present a new, digital approach to the conditional audit of the process used in a manufacturing company from the automotive industry. The first part of the article presents basic information about the fourth industrial revolution and the opportunities associated with it. Then, a brief description of audits in quality management is included. The following sections of the article present the characteristics of the layered process audit. The main part of the article is a case study which describes the LPA system, its functioning and the use of a digital tool for conducting the layer audit. The survey provided answers to questions about the usability of the solution (from the point of view of the user and the person responsible for the process) as well as allowed to determine the potential for improvement.

2. Fourth industrial revolution – Industry 4.0

The subject of the 'Industry 4.0' concept is a fairly new topic in management science. This concept was first used at the Hanover Trade Fair in 2011 by the Government of the Federal Republic of Germany. To date, no single definition has been developed, however the most popular one describes a common term for technology and value chain organization concepts. As part of modularly built intelligent factories, cyber--physical systems monitor physical processes, create a virtual copy of the physical world, and make decentralized decisions. Through the Internet of Things, cyber-physical systems communicate and cooperate with each other in real time [Hermann 2015].

In literature, cyber-physical systems, the Internet of Services (IoS) and the idea of smart factories have been classified as the four main components of Economy 4.0 [Wilkesmann, Wilkesmann 2018]. Economy 4.0 refers to a vision based on networking, self-regulation, self-configuration, knowledge orientation, automation, robotization, sensors, algorithms, advanced analytics, the integration of digital-physical systems (CPS), and the Internet of Things (Internet of Things – IoT) [Wilkesmann, Wilkesmann 2018]. The main benefit that underlines the importance of the digital economy is the opportunity to improve organizational performance at the supply chain level [Czyż-Gwiazda 2018]. E. Mączyńska presents a similar broad approach. The contemporary global economy is characterized by growing dynamism and the breakthrough nature of changes created primarily by the digital revolution and the Internet. The world is experiencing the so-called fourth industrial revolution (referred to as Industry 4.0). Thanks to the Internet, the sharing economy is developing, as are social networks and the Internet of Things [Mączyńska 2018].

Digital content related to text and images, thanks to technical means and software, can be quickly shared and it is possible to duplicate them and interactively collaborate on them, thus they become available for devices constituting a repository of specific data, information and codified knowledge. Activities on the digital content form not

only dynamize access to knowledge and create new knowledge, but also have a specific cost effect (cost close to zero), new conditions are created for innovation; digitization and digital transformation are becoming one of the factors of innovation. Digitization, based on hardware and software, in the process of civilizational progress is a series of interdependent technological solutions which are manifested in new technical and organizational solutions. At the same time, digital technologies are the basis for supporting the intellect of Man deciding on creativity and innovation, while providing a specific organizational, legal and competence environment [Kowalczyk 2018]. The concept of Industry 4.0 is present not only in Germany and the rest of Europe, there are also other global initiatives: "Smart Manufacturing Leadership Coalition", "Industrial Internet" in the United States, "Made in China 2025" in China and the Industrial Value Chain Initiative in Japan [Heilmann 2016]. K. Schwab in his study "The Fourth Industrial Revolution" does not limit himself to indicating technological changes. He devotes his attention above all to such crucial issues as changes in the ways of thinking, educating, working, caring for health, as well as doing business, organization, society or even the functioning of states [Schwab 2018].

3. The definition of audit and types of audits

The definition of an audit and the brief description of the types of audits are presented below. For the purposes of this study, an audit in terms of quality management in the enterprise is considered, while internal financial aspects are omitted. The concept of an audit is derived from Latin, in which the term 'audire' stands for to hear, to listen to [Gmińska, Voss 2018]. According to ISO 19011, an audit is a systematic, independent, documented process for obtaining evidence and an objective assessment to determine the extent to which agreed criteria have been met [ISO 19011: 2018].

Auditing is related to the formalization of management systems, which is possible through the implementation of standards, and the implementation of provisions of non-normative legal acts, as well as the development of proprietary solutions of formalization criteria. In Poland, in the field of quality management, many companies choose the direction of building a standardized system [Wawak 2013]. The concepts of formal and standardized system are described in the definition by T. Borys. A formalized management system is a coherent set of system solutions designed to ensure an environment that an organization in a selected area consciously plans, implements, controls and improves its activities. The system requirements are unified, i.e. they have been developed and presented in the available documentation. Maintaining the system requires collecting and possessing evidence of compliance. Meeting the requirements for a given management system can be objectively confirmed by the appropriate and independent institution. A standardized system should mean a formalized system whose structure and operating principles have been described in industry, national or international standards [Borys, Rogala 2011].

There are two criteria for the division of audits. The first is: who conducts them and for what purpose, and under the second criterion: what they relate to, one can mention: process, product, system, procedure and organization audit [Siarkiewicz 2018].

The first party audit, also called an internal audit, is carried out in the organization at the request of the organization's management by its own qualified auditor (an employee of the organization) or with the help of a hired specialist to examine and evaluate the management system or process. The purpose of internal audits is to check and assess whether it is possible to achieve the objectives set in the functioning of the existing management system. The audit report is a source of information for management about weaknesses that need improvement, as well as problems in the functioning of the system/process/product.

The audit of the second party (customer) is most often carried out in relation to the management system of the supplier or potential supplier in order to determine his/her ability to meet the requirements. As a result of such audits, the commissioner gains more confidence in his/her suppliers.

A third party (certification body) audit involves the analysis of a management system carried out by an independent, authorized body to obtain a certificate by the audited organization – a universally recognized certificate of compliance of the implemented system with the relevant standard.

Depending on the subject of the audit, one can distinguish:

- a system audit, which aims to systematically evaluate the entire management system in the organization. The whole structure and course of processes is examined in terms of the possibility of achieving their goals;
- a process audit – the goal is to assess the scope of work, activities and course of activities, and to determine the means to achieve the intended goal;
- a product audit – the goal is to check whether specific product features have been achieved. It has the character of an additional examination understood as looking at the product through the eyes of the customer or user.

Due to the reason for conducting the audit, the following are distinguished:

- planned audits, also known as routines, with a preventative character,
- unscheduled audits, called deliberate or corrective [TUV Nord 2016].

Internal audits in some companies are treated as mandatory measures to maintain the certificate. However, many managers note that these methods increase the involvement of employees, allow problems to be solved closer to the source of their creation, and provide important information that cannot be obtained by looking at aggregated indicators [Wawak 2013].

To sum up, audit objectives are defined as confirmation of compliance or the identification of non-compliance of elements of the implemented system with the specified requirements of the reference standard on the basis of which the management system was built. The results of audits also allow to determine the effectiveness of the implemented system in achieving quality objectives, enable the detection of

threats in the organization, and, as a consequence, determine the directions for improving the process or the entire system. Another reason for conducting audits is to meet the requirements of applicable legal regulations, industry standards, customer requirements, etc., and to assess the degree of system preparation for certification [Fedus 2017].

4. Layered Process Audit

Layered Process Audit – LPA is a tool that is used to verify that work is carried out in accordance with established standards. It emphasizes the importance of these standards and identifies opportunities for continuous improvement. An LPA can be used to verify defined processes in the organization. The process is a set of activities related to product manufacture and control activities. Some aspects of the process are machines, materials, methods and employees. Incompatibilities, warranty repairs, and a decrease in customer or employee satisfaction are often the result of poor process control or misconduct which do not comply with process instructions. Employees often perform process steps routinely. When process changes are necessary, employees must be trained and adapt to new guidelines rather than following old habits. The LPA verifies in a structured manner whether the work is being done according to the original intentions. The LPA supports mutual communication between management and process users. In turn, these interactions strengthen trust and demonstrate mutual responsibility for work that has been well done. The LPA verifies whether controls are carried out and whether standard process elements are being observed or carried out correctly. It can be stated that an LPA is not an audit, but a verification of whether the audit was carried out in accordance with the audit plan [Bosch 2014].

It should be highlighted that there is a difference between the internal auditor of the management system and the LPA auditor. In the case of a layered process audit, the auditor can be ‘anyone’. This applies to the operator who personally checks the quality and compliance of the process without worrying about a ‘formal audit’. They are also shift managers who check key processes and their elements. Feedback on the compliance of the process is immediate, as are the necessary corrective actions. People at the next level of management perform the same controls, ending with top management; in this way, everyone is an LPA auditor. The auditor does not have to have training in the field of Quality Management System, as these are not system audits. When implementing an LPA, it is best to explain the principles of the layered audit to staff using the “is/is not” tool in accordance with Table 1.

The audits frequency and layer levels depend on the size of the organization. For example, one of the leading PSA car manufacturers recommends performing daily audits on all shifts by shift managers. Weekly projects should be led by the manager of a given production area and support departments (quality, maintenance, engineering). The purpose of the audit is, among others, to verify the performance

Table 1. How to explain the LPA rules to staff

Layered process audit "is"	Layered process audit "is not"
• verification that the process and procedures are checked,	• quality audit verifying product characteristics,
• activity within the scope of duties that belongs to the operational group where the audit is performed (e.g. production),	• activity in the scope of responsibilities that belongs to the support group (e.g. quality),
• carried out by many layers of management at the plant,	• carried out only by a laboratory inspector or technician,
• a tool that consists of quick questions, usually yes / no,	• a tool that requires measurements of parts or other product characteristics,
• a short list of key risky process steps and procedures,	• a long list of questions that contains items not related to customer satisfaction,
• performed regularly, with a predetermined frequency,	• performed when the auditor has time,
• performed by a specific person in accordance with the layer in the organization,	• performed by a worker delegated by a responsible person,
• carried out on the spot where the activity takes place,	• performed in the auditor's office,
• verification method, checking the durability of corrective actions,	• method of determining corrective actions,
• a method used to verify quality documentation (instructions, control plans) whether it is used,	• a control method that can be added to the process control plan,
• an activity in which the audit results are regularly reviewed by management,	• an activity whose results are entered but not reviewed by management,
• an action in which non-conformities are addressed immediately,	• an action in which non-conformities are recorded and addressed at a later date,
• planned activity for human processes and procedures,	• the action used to validate the operation/ machine,
• a method that improves communication between the operator and management,	• the method of identifying the worst employees,
• a method that emphasizes the importance of compliance with processes and procedures,	• method showing management supervision to the employee,
• audit of the selected process and procedure/ process step.	• replacement of the internal audit of the Quality Management System (e.g. IATF 16949) .

Source: [AIAG CQI-8 2005].

of the activities of the layer below, i.e. shift managers. Monthly or quarterly LPAs should be performed by plant management including the plant director, who during the audit should focus on reviewing the results from the layer below taking into account corrective actions [PSA 2013].

The organization, Automotive Industry Action Group AIAG, in its development "CQI 8 Layer Process Audit Guidelines – LPA" presents the methodology of this activity in a production company. As the advantages of LPA, one can mention that an

effective layer audit is used by management to verify and confirm process compliance, identify areas of potential deviations, and present opportunities for continuous improvement. The results have a direct impact on the quality of the product that is sent to the client. Changes in the organization have a positive impact on the business results of the organization. A correctly implemented layer audit system provides the following benefits:

- checks the compliance of the process with the documentation,
- improves communication,
- instills discipline,
- reduces the risk of hazardous situations,
- reduces waste,
- improves product quality and customer satisfaction,
- improves cash flow,
- reduces the possibility of quality incidents,
- enhances interaction between management and employees,
- allows feedback directly available from operators,
- supports the standardization of production processes,
- strengthens key stages of the process, taking into account safety requirements,
- demonstrates the importance of key stages of the process by reviewing them with management and employees [AIAG CQI-8 2005].

5. Digitization of audit activities – case study

The next part of the article presents information on the implementation of an LPA in the selected manufacturing company. The AIAG handbook contains numerous recommendations regarding the questionnaire and the frequency of audits. For the purposes of the article, attention has been focused on the implementation system, in which layer audits with the developed form can be carried out in paper or digital form. This article discusses the example used at an automotive parts manufacturing plant in Wroclaw, which implemented a digital approach to layered audits. The plant employs about a thousand people and is involved in the production of safety products – parts of braking systems. Production processes include machining, semi-assembly and final assembly operations.

In the first stage of implementation, the focus was on training auditors and employees on the LPA principles based on the company procedure, for the purpose of which a paper form was developed, characterized by its simplicity and a large document functionality. The top of the columns contained audit questions, and the rows the layers of audit. Comments were to be written in boxes as well as confirmation of observations "OK/NOK". Then the discrepancies were manually entered into the list of open points during morning meetings in the production area. Corrective actions were developed for identified non-compliance, designating responsible persons and deadlines for carrying out the activities. During this time, open points

were reviewed and actions already completed were closed. It quickly turned out that the implemented form and system was not effective. The reason for this was the relatively long time needed for administrative activities, rewriting data, setting up new lists of open points, and reviewing the consistency of documents. The readability of the data and the transparency of the documents were low. With the implementation of Industry 4.0 solutions in the production plant, it is time to optimize.

A. Scheduling of an audit

The audit schedule developed is reflected in the system called "Super list of open points". It manages reminders about the performance of audits for the layers of engineers, managers and directors. Information about the need to conduct an audit comes via email in the week in which the audit is to be carried out (Team Leader, TL – the shift manager performs an audit on a daily basis). If the audit is not performed on time, it will escalate with information to the auditor and the supervisor that the action was not carried out. The audit is carried out in the area according to the schedule in a separate application prepared for this action. In order to better visualize this, sample screens illustrating the stages of the audit were made – see Figure 1.

A. Schedule, information about the need for an audit,

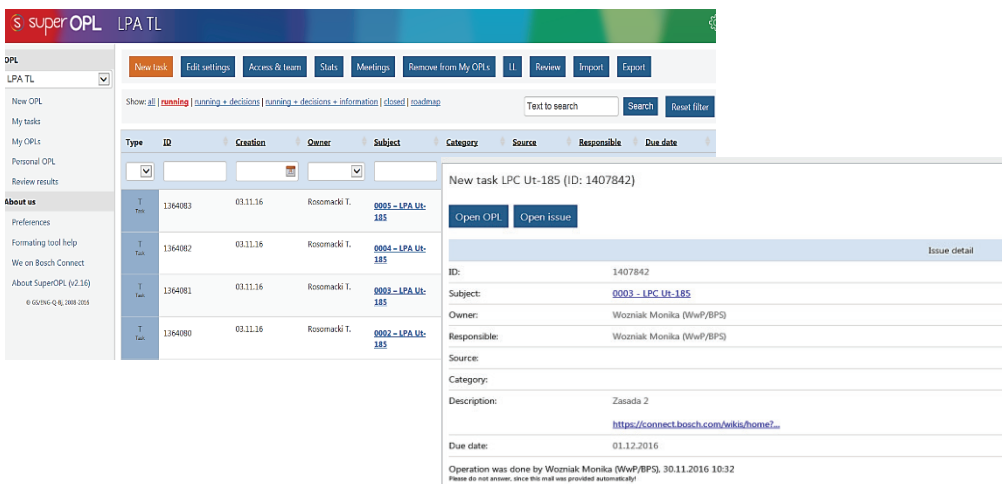

Fig. 1. The system of the super list of open points containing the schedule of LPA audits with an example email to the person responsible

Source: company internal materials.

B. Execution of an audit

Performing an audit using a tablet is in accordance with instruction 285/2017. For this purpose, a survey is used (Figure 2) as in the image below, and selected fields are marked, i.e. the area of the audit, production line, and position. The

questions are answered with ‘yes’, ‘yes but’ and ‘no’. In the case of the answer ‘yes, but’ or “no” it is necessary to determine the non-compliance, describe the facts on the basis of observation, which will be the basis for determining corrective actions. After completing the questions, the form is sent for further processing.

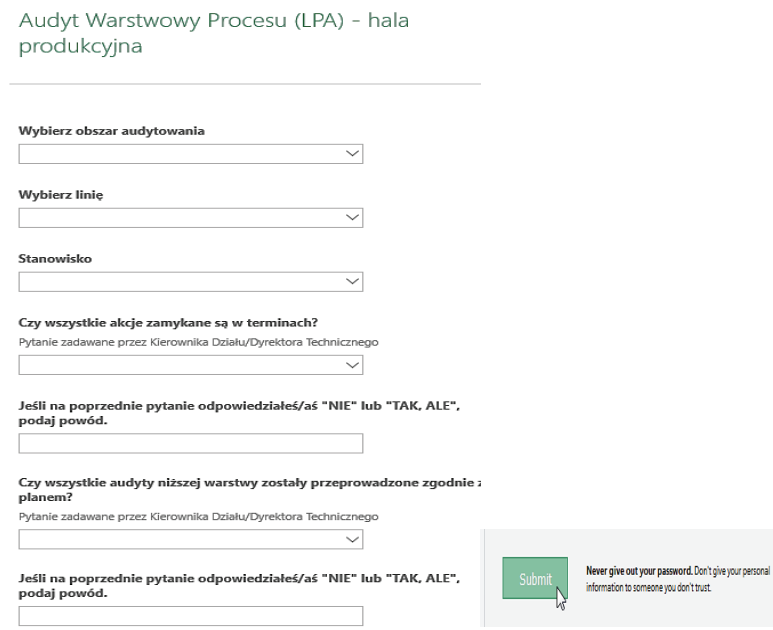

Fig. 2. Digital LPA form

Source: company internal materials.

C. List of open points after layered audits

After completing the audit, the reported nonconformities are automatically entered to the list of open points of LPA audits. Daily, during the morning meetings, new nonconformities are reviewed and corrective actions are defined, a responsible person is chosen and the deadline of the action is determined. The next step is to review the timeliness of actions which were already planned. This system guarantees that the reported nonconformities will not be ignored, as it could have been in the paper version of the layered audit.

D. Process indicators

Layer audits are checked at weekly quality department meetings with plant management. During these meetings, the results showing the number of audits performed in relation to the plan are reported and a decision is made if escalation is necessary. Figure 3 presents an analysis of the number of audits carried out with relation to planned audits by shift managers (Team Leader – TL) in the period from

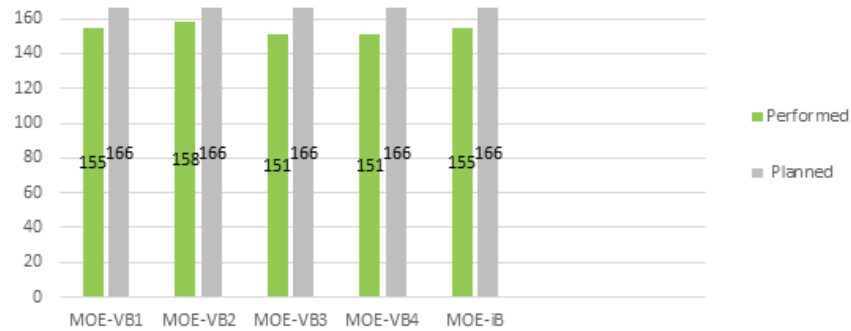

Fig. 3. Number of audits carried out compared to quantity of planned audits (TL level) in the period of January to August 2019

Source: own study based on internal materials from the assessed company.

January to August 2019. On the X-axis one can see five production areas, from MOE –VB1 to MOE-IB, while the Y-axis denotes the quantity of audits.

In addition, Figure 4 shows the number of audits planned/carried out from the level of section managers (SM) in the period January-August 2019.

The Y-axis represents the quantity of audits, while the X-axis shows five production areas, from MOE –VB1 to MOE-IB.

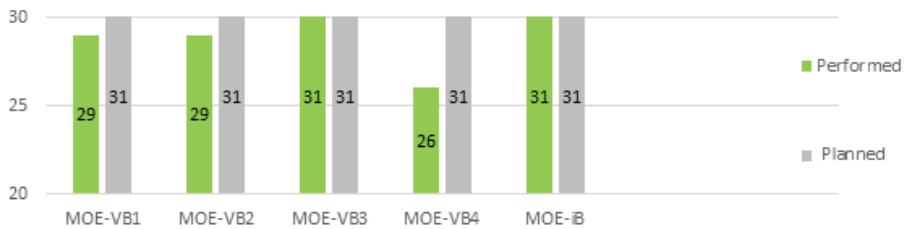

Fig. 4. Summary overview with the number of audits carried out in relation to the quantity of planned audits by section managers MS in the period January-August 2019

Source: own study based on internal materials from the assessed company.

Observations and nonconformities are analyzed in the morning production meetings. The data allows to analyze nonconformities in time on a specific production line. For example, on production line number 17 there were 162 nonconformities from 22 November 2017 to 30 September 2019. It should be emphasized that in the above-mentioned period of time there was a clear reduction in the number of non-compliance with audits, which is associated with the implementation of corrective actions.

6. Results of the research

In order to improve the layered process audit using digitization, it was decided to obtain feedback from users of the LPA on tablets, digital form and recipients of management information about the potential for improvement and usability of the implemented tools. This study used two surveys which were conducted in September 2019 using the prepared research questionnaires.

The first study aimed at obtaining feedback from the management of production areas about the difference between the traditional form of layered audit and the digital form. The survey consisted of 13 questions and was sent to two value stream directors, direct recipients of post-audit information and to the management system coordinator. The respondent was asked to provide a subjective rating on the Likert five-point scale, where 1 is 'definitely disagree', 2 – 'do not agree', 3 – 'have no opinion', 4 – 'agree' and 5 – 'definitely agree'. The questionnaire was properly completed by three respondents. The results are presented in Table 2.

The respondents answered questions about the usefulness of an IT tool in the context of using the results by the recipient with high marks (4 to 5 points). The difference between the answers characterizing the ease of paper and digital audits is clearly visible. The respondents definitely rate the digital form better. Similar results were obtained by analyzing the answers to subsequent survey questions regarding good access to information before the audit for employees, timely performance of audits, completeness of data, effective review of post-audit activities and easy access to data, statistics and analysis. From the answers received, one can draw conclusions about the decided superiority of the digital form of conducting LPA audits.The second survey concerned the electronic tool itself for conducting an LPA audit using a tablet. The research questionnaire consisted of nine closed questions, And 24 people filled it in correctly. The respondent was asked to provide a subjective rating on a five-point scale, where 1 is 'very bad' and 5 'very good'. The results of the study are presented in Figures 7 to10 on the following pages.

Table 2. The results of the survey

Question	Results of answers		
1. Conducting an LPA audit on a paper form is easy for employees.	2	4	2
2. Conducting an LPA audit on an electronic form is easy for employees	5	5	5
3. The utility of the IT tool in the context of using the results by the recipient is high.	5	5	4
4. Good access to information before the audit (in paper form) for employees.	2	2	1
5. Good access to information before the audit (in electronic form) for employees	5	5	5
6. Timely carrying out audits in paper form.	1	2	1
7. Timely carrying out audits in electronic form.	4	5	5
8. Complete audit data (paper version).	2	2	2
9.Complete audit data (electronic version)	5	5	4
10. Effective review of post-audit activities (paper form).	2	4	2
11. Effective review of post-audit activities (electronic form).	5	5	4
12. Easy access to data - analysis, creation of statistics in paper LPA.	1	1	1
13. Easy access to data - analysis, creation of statistics in electronic form.	5	5	5

Source: own study.

The first question concerned the ease of conducting the audit.

The analysis of data from Figure 5 indicates that the digital audit system is easy for the respondents; 13 respondents rated this question at 4 points, and 6 people at 5 points. The next question concerned the functionality of the tablets used to conduct layer audits. The answers to this question are presented in Figure 6.

The results of the analysis indicate that the respondents are not accustomed to using the tablet as a tool for direct data entry. Therefore, additional training of tablet users is planned as an immediate action. The next step should be the analysis and the possibility of updating the eLPA application (performing audits using cell phones or personal computers). Figure 7 presents the answers to the question on the detail of LPA questions and their adaptation to a given area.

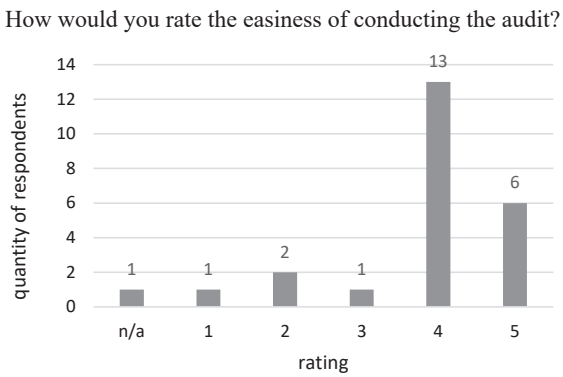

Fig. 5. Evaluation of the ease of conducting the audit

Source: own work.

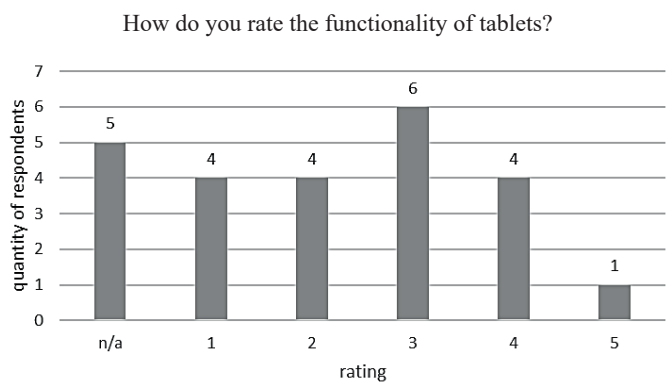

Fig. 6. Tablet functionality evaluation

Source: own work.

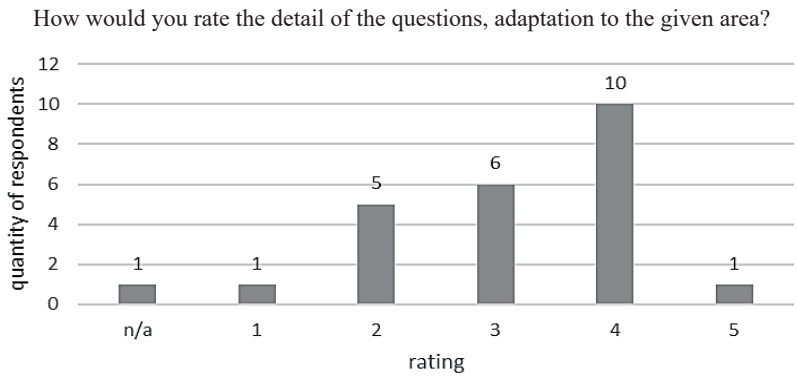

Fig. 7. Assessment of audit questions

Source: own work.

Additional comments of the respondents indicated that in the case of departments supporting, e.g. logistics, specific questions should be developed. The answers of respondents from production areas were in the range of 4 to 5 points, so it can be concluded that the questions are mainly adapted to this area of activity. The answers to the next question: "How do you assess the supervision of post-audit activities?" are presented in Figure 8.

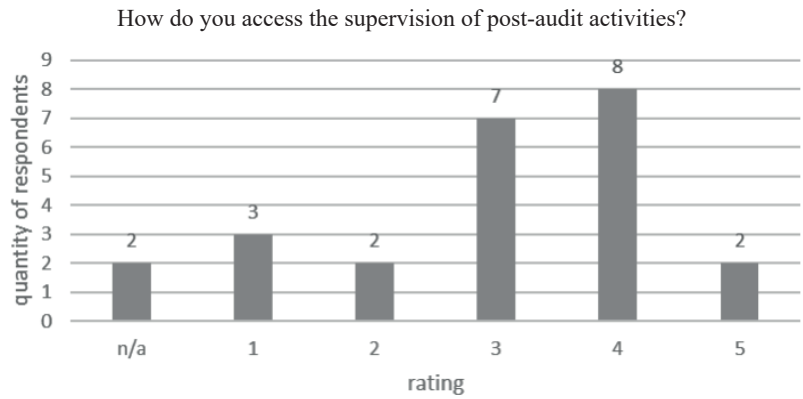

Fig. 8. Assessment of supervision of post-audit activities

Source: own work.

The answers of ten respondents are in the range of 4 to 5 points, seven people did not have an opinion, two people answered "not applicable", and five people gave negative information, 1 to 2 points. It is worth noting that this aspect of the operation of the LPA digital system was positively assessed by management (see Table 2). This assessment is influenced by the fact that by using the active cockpit it is possible to automatically enter data into the list of open points and obtain greater data transparency.

7. Conclusion

The article presents the results of two surveys that were aimed at obtaining feedback from management and direct users of the digital layered process audit application eLPA. Employees participating in the survey very positively assessed the idea of such a survey and appreciated the opportunity to comment. Analysis of the responses indicates the superiority of the current digital solution, which eliminates the disadvantages of the paper form, but also has the potential for improvement. Based on the survey, the management of the plant decided to update the software in 2020. As part of these activities, it will be possible to use devices other than tablets (e.g. mobile phones). Another convenience will be the creation of an automatic summary of audit results from the layer below and a report with a list of open points available in the same application. The next step at the Wrocław plant will be the continuation of research in the area of "5S" audits. The study is limited in scope to one plant, which is why it does not allow general reasoning about the advantages of the digital form of conducting a layered process audit. The research results, however, show that the digital form that has worked well in the plant being tested has the potential to create value in other organizations as well.

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