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Support methodology for product quality assurance: a case study in a company of the automotive industry

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Abstract

A visual management system aims to convert relevant information from the organization, the clients and the performance, for robust communication between all organization human resources through a set of suitable visual tools. Visual management makes part of the Lean Manufacturing methodology since it helps to highlight problems or wastes and assists in performing tasks. Among the visual management tools, the dashboard is defined as an interactive tool that presents a set of relevant information for the purpose of achieving organizational goals and strategies. The dashboard allows the monitoring and spread of relevant information to support tasks performing and decision-making. This paper presents a case study performed in an automotive company whose main objective was to simplify and standardize the collection and analysis of information concerning the product audit process, as well as improve the communication system between employees and departments involved, through the development and implementation of a dashboard. In order to achieve the intended objective, the case study involved: the definition of the information to be available in the dashboard for the audits; the development of a template to present the information briefly and clearly; identification of the necessary resources and connections for the correct operation of the dashboard (with real-time updates); definition of the process of information collecting and analysis, and the consequent connection with the problem solving process. The implementation of the dashboard allowed an increase in the reliability of the results and a significant reduction in the steps to analyze the data and, consequently, in their duration. In this way, the dashboard simplified and improved decision-making process and created a conducive environment for the departments involved in the quality audit process to perform the associated tasks.

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1. Introduction

For a component to be automotive qualified, manufacturers have to meet specific industry standards throughout the manufacturing and testing process. The IATF 16949 (International Automotive Task Force) standard is the global automotive industry standard for quality management systems. It combines the requirements of management systems with international automotive requirements of the following standards: VDA 6.1 (German automotive industry); QS-9000 (American automotive industry); EAQF (French automotive industry); and AVSQ (Italian automotive industry).

The clause 9.2.2.4. of this normative reference establishes requirements for the process of product audits. This clause indicates that an organization should audit the products using specific approaches. These approaches are required by the customer at appropriate stages of production and delivery to verify compliance with specified requirements. When they are not defined by the customer, i.e., if there are no Customer Specific Requirements (CSR), the organization must define and document the approach to be used. To monitor and support the product audit process, visual tools, such as the dashboard, can be used.

The dashboard is an interactive visual management tool that presents a set of relevant information for the purpose of achieving organizational goals and strategies [1]. This tool allows the involvement of all in the improvement of the process, through the communication of problems that require intervention [2]. According to Pauwels et al. [3], a dashboard has four purposes: (i) to convey consistency in the terminology used in performance indicators across the various organizational levels; (ii) monitoring the indicators, allowing corrective actions to be taken when necessary; (iii) planning objectives and strategies for the future; and (iv) reporting performance and key information to all stakeholders.

This article presents a work carried out in a company of the automobile industry whose objective was the simplification and standardization of the procedure of obtaining and analyzing information for conducting product audits. To improve the communication between the collaborators and the departments involved, a dashboard was developed and implemented. Its development was carried out following the steps defined by Vilarinho et al. [1] in the development of a dashboard to support the improvement of process and equipment performance in SMEs.

The paper was organized as follows. Section 2 presents a literature review on the topic. Section 3 details the process of product audit. Section 4 presents a set of requirements identified to build a dashboard for the product audit process. Section 5 exposes the outlines of the dashboards. Section 6 presents the results obtained with the implementation of the dashboard. In the Last section, the main conclusions are drawn.

2. Literature Review

The lack of information causes problems in people, processes and organization, not adding any kind of value to the customer [4]. However, even if the information is available, organizations have the ongoing challenge of analyzing and communicating effectively. The information must be visible, clear and simple [5].

According to Liff and Posey [6], visual management is an organizational improvement system that focuses on what is really important and on improving performance in every way. This strategy adds a new dimension to the processes, systems, and structures of the organization, applying graphic visualization techniques, in order to reinforce the focus on a sustainable competitive advantage. The visual management system converts relevant information from the organization, the customers and the performance, through a set of suitable visual tools, in a robust communication between all workers [7]. With this system, the relevant information is put in the right moment, in the right place, to help implement improvements where things happen – in the factory floor [8][9]. Visual management uses various tools and visual approaches. A visual tool consists of a mechanism capable of limiting, controlling, and directly and indirectly influencing decisions through the provision of relevant information [10]. Among the various tools, the dashboard stands out as being a powerful element in visual management. The dashboard is described by Yigitbasioglu and Velcu [2] as a visual and interactive performance management tool where the most relevant information is displayed on a monitor in order to achieve one or more organizational goals, allowing the user to identify, explore and communicate problem areas that need corrective actions.

Since the costs of visual equipment (such as smartphones or even televisions) have declined, and digital production monitoring and control is replacing excel sheets and static frames, the use and implementation of more sophisticated systems, such as dashboards, is made easier [11].

The information on a dashboard is displayed visually through text, graphics, and maps, with an emphasis centered on the graphical elements. With these graphical elements, it is possible to communicate with greater efficiency compared to the textual part. The goal is thus to make information accessible and transparent so that the correct message is transmitted to people [12]. A visual tool such as the dashboard presents a wide range of purposes that can positively influence the industry. These purposes are categorized by Pauwels et al. [3] into consistency, monitoring, planning and communication:

The value of a dashboard is strictly related to the characteristics it presents and to the way it is used in organizations. However, there is no consensus on how a dashboard should be presented and what information it should contain. In a holistic perspective, a dashboard gathers, summarizes and presents information from a varied set of sources, so that the user can see, at one time, several indicators and graphs able to assist in decision making [2].

Few [12] classifies a dashboard according to the type of activity that must be supported, whether strategic, analytical or operational. These dashboards, according to the author, are easily distinguishable from each other as they have clear visual differences. When designing a dashboard, in addition to choosing the scope, being strategic, analytical and operational, it is necessary to understand what really adds value. The value of a dashboard focuses on the replacement of obsolete methods of direct query data for an interactive view, transforming large sets of data into relevant information for users. A strategic dashboard assists top management by providing an overview of performance indicators and trend or forecasts graphs. This category does not need data in real time, but rather, benefit from static moments. An analytic dashboard, however, requires a specific context and intends to analyze, compare and monitor, allowing the analysis of causes, i.e., this category allows the analyst to do a detailed investigation, using possible means to analyze the data. An operational dashboard, unlike strategic and analytical dashboards, presents the data in real time, so that operations are monitored and controlled. This category presents details of tasks and activities, such as: what to do; what to order; who are responsible, among others.

According to Skorka [13], it is possible to add value to dashboards considering five aspects: (i) the correct choice of performance indicators; (ii) data and information must be understandable; (iii) a call-to-action approach must be pursued; (iv) a dashboard should be developed with the purpose of obtaining knowledge; (v) a dashboard should motivate users to take actions.

An approach for the purpose of developing a dashboard aimed at improving the performance of productive processes and equipment was defined by Vilarinho et al. [1]. After identifying this gap in the scientific literature, the authors felt the need to create a procedure for the development of the dashboard. The steps defined by the authors are as follows: (a) diagnosis of the production area; (b) requirements for the dashboard; (c) definition of the template; (d) ensure the availability of necessary resources; (e) implementation; f) evaluation and improvement of the dashboard.

3. Product Audit process

In the company where this work was carried out, the product audit process is the responsibility of the quality department which has the following functions: quality control, continuous improvement of processes, analysis of products returned from the customer and direct communication with the customer.

The Product audits include:

- Flying Product Audits that encompass the complete production portfolio, evaluating the mechanical and cosmetic characteristics of finished products according to the specific VDA (Verband der Automobilindustrie) 6.5 - Product Audit. This approach can be called Dock Audits, according to VDA 6.5 and IATF 16949;
- GP12, which is applied mainly to the start-up of production of the product and to the execution of pre-series, in which 100% of production is verified;

- Containment, which consists of checking a specific aspect of the product which presents, or has presented, a non-conformity.

The three audits types include a manual procedure for obtaining and analyzing information, and presenting the results to all stakeholders in the process, especially to the Quality department. Each employee records in paper format the product model, the quantities audited and the defects identified. After completion, these records are given to the audit product responsible that transcribes all the data into a data analysis file (in Microsoft Excel). The responsible then processes and analyzes the data to transmit the results to those involved in this process. In addition, the transmitted results include the quality index known as FTQ (First Time Quality), calculated by dividing the number of defective units by the quantity of product audited, and is expressed in parts per million (ppm).

The product audits process transmits information through static boards divided into two areas: internal and external area. This designation comes from the physical space where the audits are performed: the external area is located in the palletizing area that audits products shipped by the final assembly process, while the internal area is a space dedicated to conducting audits in a controlled environment. This process is strongly influenced by the reported information and therefore a set of fragilities were identified:

- Missing information. These boards do not have the capacity to house a large amount of distinct information that is relevant to the process.
- Lack of space for the whole product portfolio. Since the communicative boards present space limitations, an increase in the product portfolio increases the amount of information and makes the board confusing to the user.
- Lack of clear information on product rejection criteria.
- Movements to access information. Since static boards do not provide all the information to perform the product audits tasks, employees need to move between areas to clarify questions with the process leader, such as: rejection criteria and conditions to end the audit; the models to audit; the level of rejection obtained during the previous shift, among others.

With the development of the dashboard, it is intended to provide information and decisions at the right time, in the right place, to the right people, thus reducing the wastes that hinder the smooth operation of the product audit process. Thus, the static communicative boards will be replaced by digital boards that dynamically provide the current state of the product audit process and help employees to carry out their tasks. In order to verify the viability of the project, it was decided to analyze, firstly, the impact of the application of dashboards to the GP12 audits and Containments. Due to frequent changes in rejection criteria and models to be audited, access to information is a very significant factor in the performance of these audits.

4. Dashboard Requirements

The success of this project comes mainly from a robust identification of the requirements coming from the customers of the dashboard. In this way, it will be possible to make a comparative analysis of the information acquired and highlight the most relevant points for the success of the project [14]. To avoid ambiguous requirements, it is necessary that the transmission of information be transparent [15].

Table 1 presents the requirements identified by the observation of the current system and in meetings with the participation of those involved in the process, namely the person responsible for product audits, the company's quality manager and the person responsible for programming and graphic design of the future application. The meetings were conducted focusing on the wastes observed in the process using a Lean thinking approach and defining requirements to reduce theses wastes. The team also reflected on the information that will lead to a better process efficiency and effectiveness, and to quality improvement. These requirements were ordered by their relevance, starting with the most relevant ones.

One of the most relevant requirements is to develop dashboards adapted to each area: analytical and operational, in the external and internal area respectively. In the internal area, it is exclusively intended to assist the employees in their tasks and, in the external area, to inform the productive area about the quality of the product. However, some information will be also provided to assist employees in the audit process.

Table 1. Requirements for the development of the dashboard.

Requirement	Why?
Information regarding GP12 audits and contentions should be presented on different dashboards.	In order to avoid confusion in the reading of the information, the information regarding GP12 audits should be separated from the information related to containments.
To support the internal and external area, dashboards must be created in both areas. In the internal area, the dashboards (one for each type of audit) will be operational to assist the performing of audits and, in the external area, will be analytical to mainly contain information for the production lines on the quality of the product for its improvement.	In the internal area, information is needed exclusively to assist audits. In the external area, it is especially important to provide information on audit results. However, some information to assist audits should also be provided.
Dashboards must be automated, i.e., they will use digital screens interconnected with computers to present the information automatically. In addition, they must be connected to scanners that have dedicated software, to record defects in the information system.	The time for data processing and dissemination is time-consuming which does not allow immediate action. The process of data collection and processing is subject to human error and the information is unreliable.
Support the Quality department in the monitoring of the process, in the identification of improvement actions and in the management of associated persons.	Process monitoring requires frequent movements between the quality department and the product auditing area.
Dashboards should contain information regarding product rejection criteria to facilitate audits and reduce errors.	The information on the rejection criteria is not unequivocal.
Dashboards should quantify and describe the defects present in the models produced and disclose them in real time.	To know the current state of production processes, the main information to be disclosed in the analytical dashboards is the quantity and description of the identified defects.
Promote the participation of the product audit team in the problem solving process from the information provided in the dashboards.	To improve the values of the indicators in the area, the participation of employees in the audit process is desirable.
Assist meetings at the beginning of each turn providing information on events and audits of the previous shift.	Need to provide information on previous-shift audits.
The information in the dashboards must be interlinked with the information system, so that the information collected and processed by this system is made available in real time to the productive area.	Information on product quality is made available to those involved in the audit process after the time required for the processing and analysis of the data.
The dashboards must contain simple, direct and transparent information and must present a specific zone that transmits the most relevant information of each model to the user.	The information provided in the dashboards should be understood by all the team that carries out the activities and should be of quick consultation.
The dashboard should present the FTQ indicator for each model, in order to discriminate the most critical models.	The organization must know in real time the quality level of the produced products.
Inform the organization about the costs of audits (calculated based on the number of parts audited), audit opening time (time in days in which the audit is active), and the average time to audit a product.	These indicators allow monitoring the audit process and evidence the impact of defects in order to trigger actions by those involved.
The responsible for the product audit process should be free to choose which data to display on the dashboard.	During customer visits, certain sensitive data cannot be displayed.
Users should be able to access non-visible information.	High amount of information due to the high number of products.
They should contain appropriate text, colors, shapes, animations and graphics to discriminate customer, model and audit type.	High amount of information associated with products and types of audits.

5. Dashboard Design

The dashboards were divided into four distinct areas: the header, which shows the type of audit (area 1); Global Aspects (area 2), which consists of general data or information on the various models to be audited; Specific features and information (area 3) to characterize each model and each client for a given audit; and a news bar (area 4). It was established that the GP12 audit would be represented by the green color and Containments by the red color.

Despite the willingness of the Quality department to include other information, it was necessary to select the most relevant information for the process, since too much information would compromise the readability of the dashboard Fig. 1 presents the outline of the internal dashboard for containments.

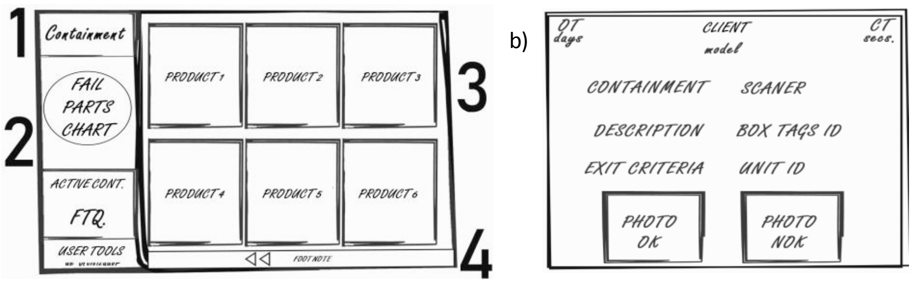

Fig. 1. (a) Dashboard outline of the internal area for containments; (b) specific information for area 3.

Area 2 in Fig. 1 presents a set of information: (i) circle chart of the main nonconformities identified in the process; (iii) active containments; (iv) and the FTQ indicator for each model. Area 3 (Data) presents detailed information for each model (Fig 1. b): (i) The opening time (OT) - the time (in days) that the audit is active; (ii) the cycle time (CT) - the time required to perform the audit (in seconds); (iii) the customer; (iv) the model; (v), the active containments for the product (Containment); (vi) Containment description; (vii) exit criterion, that consists of the time or necessary conditions for ending the containment; (viii) additional information to identify the product; (ix) a space dedicated to subjective rejection criteria to present for instance a set of two photographs, one showing a correct situation and another showing an incorrect one. The information contained in area 4 (News Bar / Footer) will be the same in the four dashboards and will expose the key issues that have occurred throughout the entire product audit process. Regarding to the internal dashboard for G12 audit, the structure is similar, except area 3 where the main failure modes found, the quantity inspected and rejected are shown for each model.

Fig. 2 shows the outline of the external dashboard for containments. Areas 1, 2, and 4 contain the same information as the internal dashboards. Area 3 (Data) is directed to external customers (production) who are not direct actors in the process, presenting indicators of the process: (i) The total cost, which is calculated considering the time elapsed since the beginning of the containment; (ii) Record of corrective actions (CAR) to eliminate problems in the process; (iii) the rejection level (FTQ indicator), in a bar chart, for the current day and for the last 7 days; (iv) to evidence trends for one week, each day will be represented by a circle of green color if the daily FTQ shows better results than the previous day, or a circle of red color, otherwise. The external dashboard for GP12 audits only shows differences in area 3, presenting the indicators values for the GP12 audits.

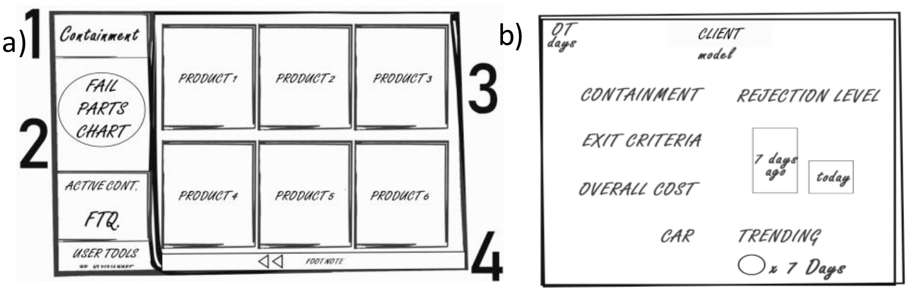

Fig. 2. (a) Dashboard outline of the external area for containments; (b) specific information for area 3.

6. Dashboard Implementation and observed results

To implement the dashboards, physical and computer resources were required. Monitors, computers, intranet access conditions, and scanners for the purpose of registering the associated products and defects were placed in the previously specified locations. Although the registration was automatic with the help of scanners, it was necessary to ensure the feeding of the dashboard with additional information. To enable this registration process, a graphic interface was created. This interface allows recording information in three categories (Fig. 3): (i) general, with aspects that all audits must present (e.g., customer, product, type of audit); (ii) specific, with aspects which varies according to the audit (e.g., description, costs) and (iii) operational, with information that will feed the operational dashboards (cycle time, photographs explaining rejection criteria, work instructions).

Fig. 3. Product audit interface.

The architecture of the information system associated with the dashboard includes: (i) the database in SQL Server; (ii) the information system (FIS) of the company, which was updated to receive new data. (iii) dashboards in the internal and external areas; (iv) and the form (Fig. 3) that allows collecting data and information, necessary to feed dashboards with data; (v) The registration of product evaluation that is carried out using a scanner, connected directly to the database.

Fig 4. shows the implemented dashboards. There were opposing views in the team regarding the language to use on dashboards because the company wants to show the dashboard to its international customers. However, due to the ease of use of the tool by the employees, it was decided that the information would be presented in Portuguese. To begin the use of the dashboard, it was necessary to train the employees and to follow the first uses to overcome potential resistances to the change, to ensure its correct use and to detect possible improvements.

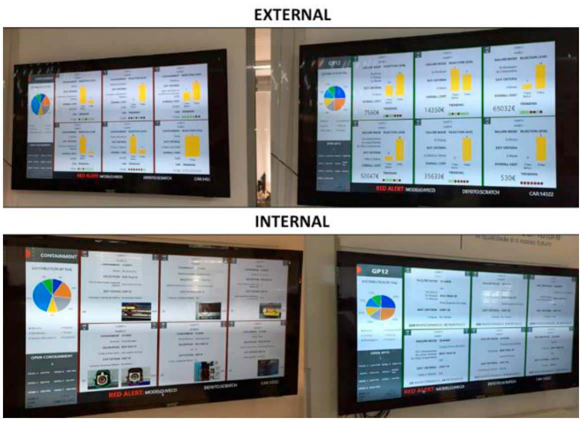

Fig. 4. Implemented dashboards in the external and internal area.

With the implementation of dashboards, the collection of information becomes automated. The scanner together with the data collection interface allows recording information and presenting it automatically in real time. This solution allows reducing the number of steps, and thus the cycle time, required to present the results of the product audits and the possibility of errors associated with data transfer, including the lack of identification of the audited products. The uncertainty of the rejection criteria was also reduced. Greater involvement of employees, including quality, engineering and production departments was verified. The weekly meetings within the Quality department thus became based on reliable data acquired by the information system. The dashboards began to assist the Quality department in monitoring and identifying improvement actions and in eliminating audits that do not add value analyzing the cost-benefit ratio of the audits.

7. Conclusion

Although the use of dashboards is quite common within organizations, there is no guarantee that they are being well developed and therefore well implemented. The approach created by Vilarinho et al. [1] proposes a set of steps for the development of a dashboard for the productive process and equipment. Although the methodology was proposed for the development of a dashboard to support the improvement of productive process performance, it was used in this work to develop a dashboard to support the product audits process of an automotive company.

The product audits process had a system for information transmission supported by static, non-standard frames, and those involved could not get the best out of this tool. The procedure for obtaining and analyzing the data followed a set of steps that were subject to errors, required a high effort and were time-consuming.

Therefore, a digital application was implemented, following the steps defined by Vilarinho et al. [1], to exhibit the most relevant data in the right moment, to the right people in order to guarantee product quality. The methodology of Vilarinho et al. [1] proved to be efficient and effective in obtaining a communication tool that satisfies those involved in the process, reduces the time of treatment and availability of the information and increases the reliability of the collected data. Although this implementation has been successful, it is possible to point out as a limitation the large amount of information to be made available in the dashboard due to the high quantity of product types in the automotive company.

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