Digital Transformation Applied to Bauxite and Alumina Business System – BABS 4.0

Juliana Soares de Sousa[1], Israel Oliveira Rocha[2] and Rodrigo Martins de Castro[3]
1. Quality Analyst
2. Quality Specialist
3. Management System Manager
Mineração Paragominas SA, Paragominas, Brasil
juliana.sousa@hydro.com

Abstract

The Bauxite and Alumina Business System (BABS) is implemented in Norsk Hydro mining and refinery units in Brazil. The system has five principles: Standardized Work Processes, Defined Customer and Suppliers Relations, Optimized Flow, Dedicated Times, and Visible Leadership. In view of the various benefits derived from Digital Transformation, an opportunity was identified to incorporate new technologies into quality management processes, maximizing productivity, improving working conditions and product quality. Through the A3 thinking methodology, an analysis of the initial condition was carried out and a complete restructuring of management system governance was proposed, adopting Industry 4.0 tools in routine management. The work implementation was divided in four stages: proof-of-concept development, pilot project, capacity-building and site-wide implementation. All solutions were developed with Office 365® features, eliminating paper usage and ensuring up-to-date information in real-time for all system users.

Keywords: digital transformation, quality 4.0, BABS.

1. Introduction

There is an intense digital transformation taking place in industry, marked as the threshold of a new revolution: the fourth industrial revolution, or industry 4.0 [1]. This new revolution was preceded by three previous ones: the first industrial revolution, which introduced the use of coal as a source of energy, thus boosting steam engines and transforming manual work into automation, at the end of the eighteenth century; the second industrial revolution, which used electricity to deploy large-scale production lines in the early twentieth century; and the third industrial revolution, which sophisticated the products and the means of production at a low cost with the insertion of electronic systems and the programmable logic controller, CLP, in the early 1970s [2], [3].

The three industrial revolutions cited above were leveraged by technological milestones (the steam engine, the division of labor in the production lines and the CLP). Industry 4.0, on the other hand, is being fostered by the Internet, since it enables the connection between machines and humans through cyber-physical systems (CPS) [2].

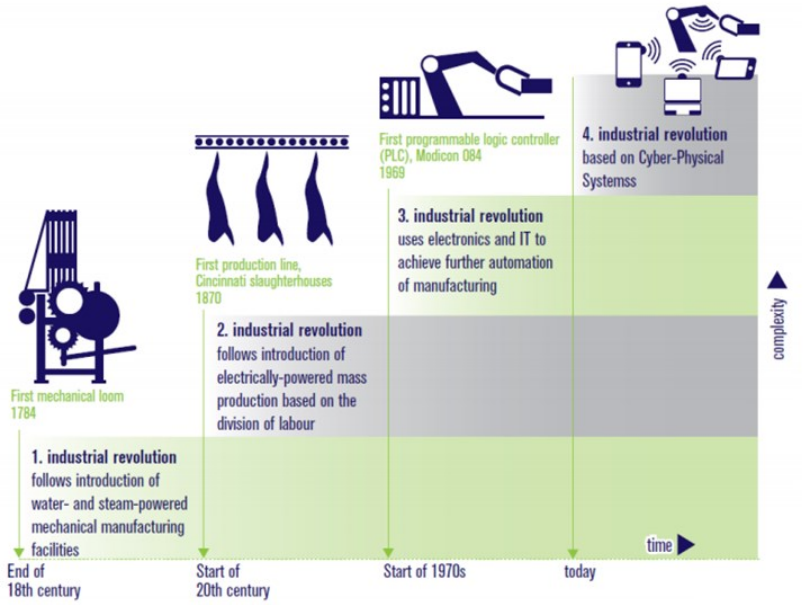

Figure 1. The four stages of the Industrial Revolution.

Industry 4.0 includes several technologies, such as: Internet of Things (IoT), Machine Learning, analytics, machine-to-machine (M2M) and cloud computing (Cloud), in addition to the aforementioned CLP.

Despite the constant technological advance incorporated into production processes and the complexity of the fourth industrial revolution in progress, it is still common to correlate the word "industry" to factories or high chimneys expelling smoke. Changing this mental model is one of the great challenges for companies, which need to pay attention to the digital transformation trends driving industry 4.0 and all it has to offer, under the risk of being marginalized in the market [3].

But at what cost should this technological escalation take place? Which guiding base for something complex and still unknown by professionals should be adopted, aiming to firm the positioning of the company in this scenario of profound technological innovation?

The World Economic Forum recommends the following three steps, that compose the driving force behind digital transformation (Figure 2) [4].

Figure 2. Essential digital transformation guidelines [4].

1. **Engaged employees:** finding, including and retaining talents with appropriate skills, and increasing the flexibility and adaptability of work tasks.
2. **Digitalize processes:** adopting digitalization to promote the rigorous use of digital data and models, as well as the adoption of other advanced technologies on a large scale;
3. **Capture new opportunities**: Seeking new opportunities through integration and collaboration of 4.0 industry resources across the value chain, as well as constantly reviewing and updating product portfolios and business opportunities.

Still, according to the World Economic Forum (WEF), 2018, these three steps should not only be implemented, but must be the fundamental basis of the company's strategy for the future.

Foidl and Felderer [1] stated that the industry 4.0 concept discussed earlier also applies to the field of quality management, by increasing the quality of products, services and processes. It is well known that the industrial market operates under intense competition, where the one that best satisfies the customer with a product / service of high added value, lower cost and shorter delivery time will outstand and conquer the market. In this scenario, quality management is established as a key strategy to guarantee the consumer market share, and as a consequence, the success of the company

The alignment of Quality management with industry 4.0, also called "Quality 4.0," is achieved through digitalization and usage of industry 4.0 technologies, such as advancement in data acquisition, scalability, analytics, and connectivity. The impact of this digitalization is reflected in the processes and people of the company, promoting changes in the quality culture. The reason of this change relies on the connection and sharing of information, opening doors for collaboration and transparency of processes and results [3].

Data acquisition has been at the heart of quality for decades, since decisions need to be made based on facts revealed through data. The ISO 9000 standard, for example, reinforces the importance of evidence-based decision making. In the context of quality 4.0, a high volume of data is usually captured in companies, either by transaction reports or by connected equipment, thus requiring the use of data warehouses or data lakes. These data, which can be structured or unstructured, are collected at high speed, with accuracy and transparency [3].

Scalability translates into the ability to store a high volume of efficiently generated data. The cloud is a major contributor to scalability as it provides infrastructure for storage capacity, connectivity, and accessibility to captured data [1].

Once data is captured, the treatment process begins, which will result in insights about the event being analyzed. The treated data needs to be arranged in a simplified, easy-to-understand and accessible view to enable human interpretation with effectiveness.

Connectivity refers to the connection of processes, which include people, products, and devices. People leverage the development of Internet-connected devices; products provide performance feedback throughout their life cycle through sensors; and devices promote the previous processing of data, along with making decisions, (e.g which data to send), in addition to connecting the equipment to the network [3].

The system used for quality management in Mineração Paragominas is the Bauxite & Alumina Management System (BABS). It is used as part of the company's strategy toward its ambition to be better, bigger and greener, deploying the concepts and tools of lean management, sharing best practices and having Hydro Way as its fundamental base.

The BABS approach consists in implementing the principles and fundamental tools in an integrated mode. In this way, waste is eliminated and results are maximized, such as reduction in incident rate, increase in process stability, improve of product quality and increase in productivity.
The five principles underlying operation activities are: Standardized Work Processes, Defined Relationships between Customers and Suppliers, Optimized Flow, Dedicated Teams, Visible Leadership.

The BABS structure is shown schematically in Figure 3.

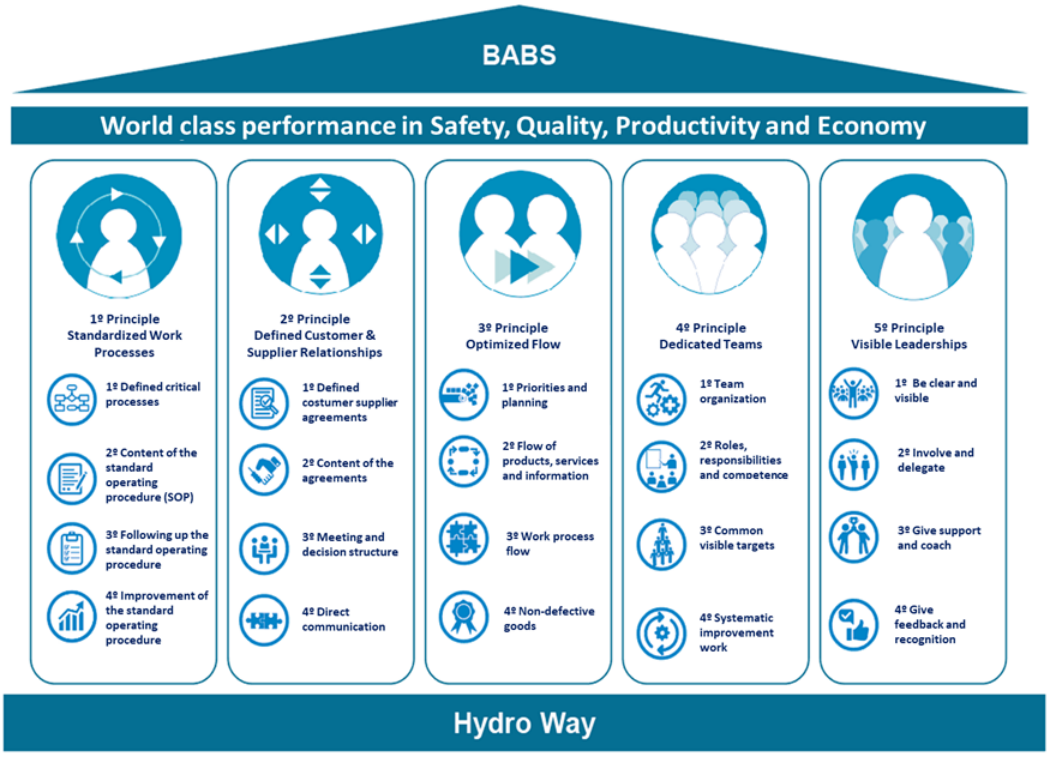

Figure 3. Schematic representation of BABS structure.

The BABS Principles are the basis of the Bauxite and Alumina Business System. During its implementation, several traditional quality tools such as Gemba Walk, 5S, standard operating procedures and their verification of effectiveness are used. These tools count on the support of physical checklists, which are forwarded to a complex flow of communication, both for registration in excel worksheets and follow-up action plans.

As internal standardization, the Gemba Walk was called WOC (walk, observe and communicate), Standard Operational Procedures were denominated SOP and its verification of fulfillment in practice were called SOP WOC.

In view of the diverse benefits of digital transformation, it was identified an opportunity to begin the process of digital transformation with focus to facilitate the employees' connectivity with routine governance systems and, thus, identify opportunities for improvement in the shortest time lapse.

The objective of this study is to show the implementation of industry 4.0 concepts, such as data acquisition, cloud and data processing in real time, over key tools for routine management, such as 5S, WOC and SOP WOC.

2. Methodology

The methodology adopted for the implementation of this study was based on A3 Thinking. This method allows to obtain a structured solution for the problem situation, since all the learning built by the group is synthesized in a sheet (originally of format A3), which contemplates the initial condition, desired condition, analysis, action plan and verification of effectiveness. According to Durward [5] the A3 report is a powerful, simple and very practical tool that provides a concrete framework for implementing the PDCA cycle. This tool helped the authors to gain a deeper understanding of the problem, and to transform it into an opportunity to develop a competitive advantage.

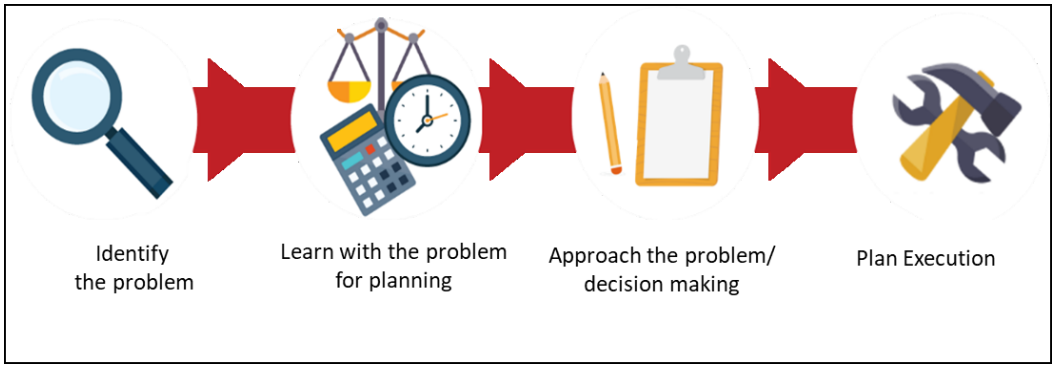

Figure 4. A3 Thinking Steps [6].

Mineração Paragominas makes use of applications present in Office 365 as a support in routine management. Therefore, solutions were sought within the Office 365 package to ensure compatibility within the tools to be created. The solutions used were Forms, Flow, SharePoint, Outlook and Power BI, described below.

- **Forms**: Online tool, where it's possible to create searches, tests and polls, besides easily view the results in real time. The platform lets you invite others to respond to created forms using any web browser, even on mobile devices. In this project, Forms was used to elaborate the digital interface of data collection.

- **Flow**: A cloud-based service that allows the user to automate process and task flows across multiple applications and platforms such as Office 365, OneDrive, Dropbox, Twitter, Facebook, Salesforce, and many others, including Google (a competitor to Microsoft in this niche). Flow was used to automate on-the-job evaluation routines, transferring data captured from digital forms to the cloud database, and also generating automatic response emails, as the submission of the answers occurred.

- **SharePoint**: Online content manager and application designer that makes it possible websites and intranets creation. It is also a secure way to store and share corporate or even public content. The data is stored in the cloud and can be accessed from any browser device. It is a tool for collaboration between groups that promotes efficiency and data management. SharePoint took on the role of big data in this study, storing the data in the cloud for further treatment, as well as being used as a platform for dissemination and user interface through the management website.

- **Power BI:** A business intelligence solution that allows one to connect to data from different sources, create models and unlock insights arranged in highly visual reports. One can also share the generated reports, or incorporate them into an application or website. Power BI was used as a connection tool with client areas, through the creation of dynamic interfaces that show in real time the behavior of the data captured on the previously presented platforms.

- **Outlook**: Application used to manage emails, schedules, tasks and file sharing in the cloud. It is a solution that promotes user connectivity by being compatible with mobile devices such as desktops, laptops, tablets and mobile phones, and accessible anywhere with internet connection. In this study, Outlook was used as an automatic means of communication with the final user.

This work execution was divided in four stages: proof of concept development, through the implementation of the aforementioned applications; pilot project, executing the model created in a department to evaluate opportunities for improvement; training users, in the correct managing of the developed digital resources and reviewing the concepts of Gemba quality tools; and, at last, the implementation throughout the company.

3. Results and Discussion

An evaluation of the initial condition was carried out, following the A3 Thinking guideline. In the initial condition, physical forms and checklists were used to capture data. Then, it had to be manually transferred to an offline database, usually in excel datasheet, to receive analytical treatment, be translated into visual reports and finally shared.

This process generated unproductiveness throughout its flow. Obtaining data was a time-consuming process, in view of the time from completing forms to posting the data on a database. The manual work required to transfer data to a database competed with routine tasks, leading to accumulation of activities and delay in data treatment.

Data processing also needed to be performed manually, and it generated static reports. The time needed to perform analytics resulted in reports that did not reflect the current state of the process, making it difficult to maintain visual management charts updated, too keep transparency and the ability to respond immediately in view of the identified opportunities. As an example, it's worth mention the identification of employees who would not have completed the form within the stipulated deadline.

The initial condition is represented in Figure 5.

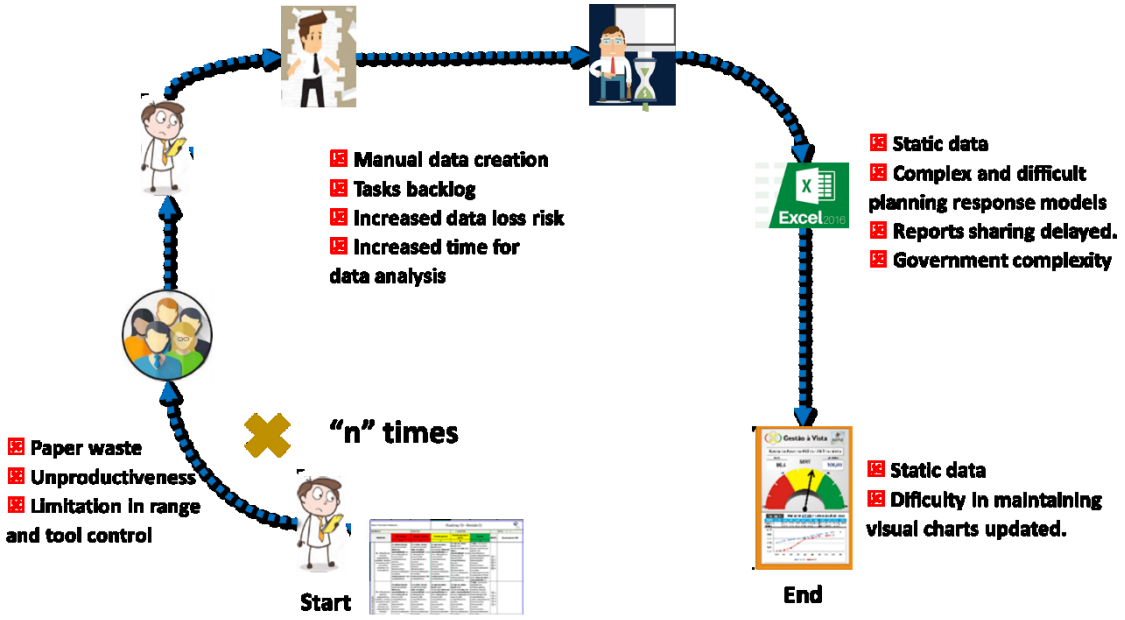

Figure 5. Initial condition of Gemba evaluation process.

After consolidating the automation of this process, using Office 365 applications, incorporating improvements from the pilot project study and empowering those involved in the use of digital tools, the new optimized flow was obtained, as shown in Figure 6.

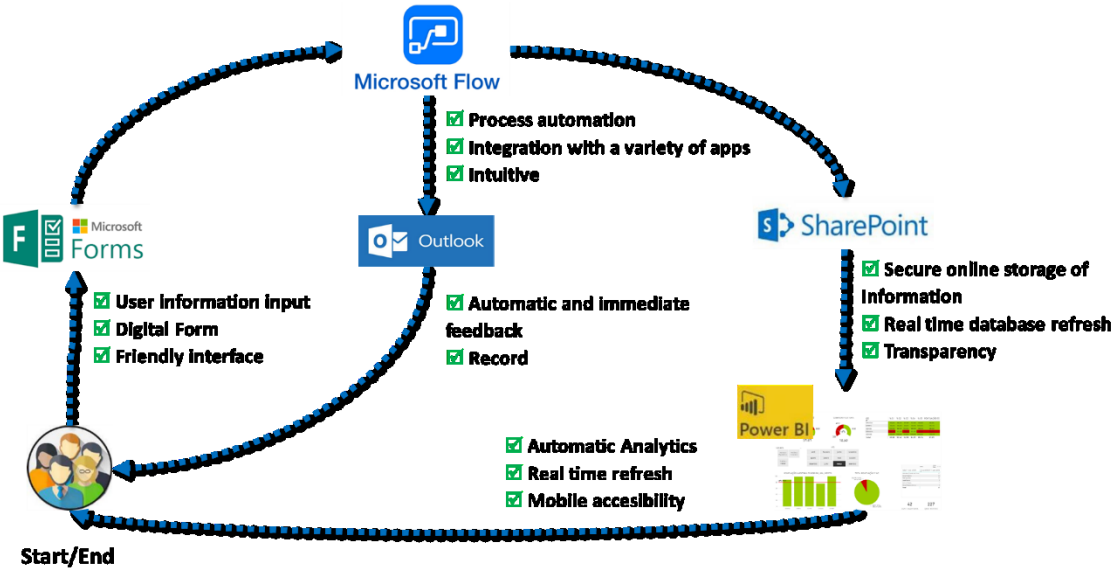

Figure 6. Current condition of Gemba evaluation process and government, after improvements.

The new flow starts with the insertion of the data from Gemba evaluations in a digital form, accessed via web or mobile (a). The response submission triggers a Flow (b), which transfers the input data to the online data repository located in the SharePoint cloud (c), and sends an automated Outlook e-mail to the user, which includes a confirmation message and a summary report with the answers submitted (d). Then the model created in Power BI for data processing and visual reporting is run, thus keeping the information updated in real time (e). Finally, the

website dedicated to BABS in SharePoint acts as a channel of communication with users, in which one can find databases, reports of Power BI, among other pertinent information (f).

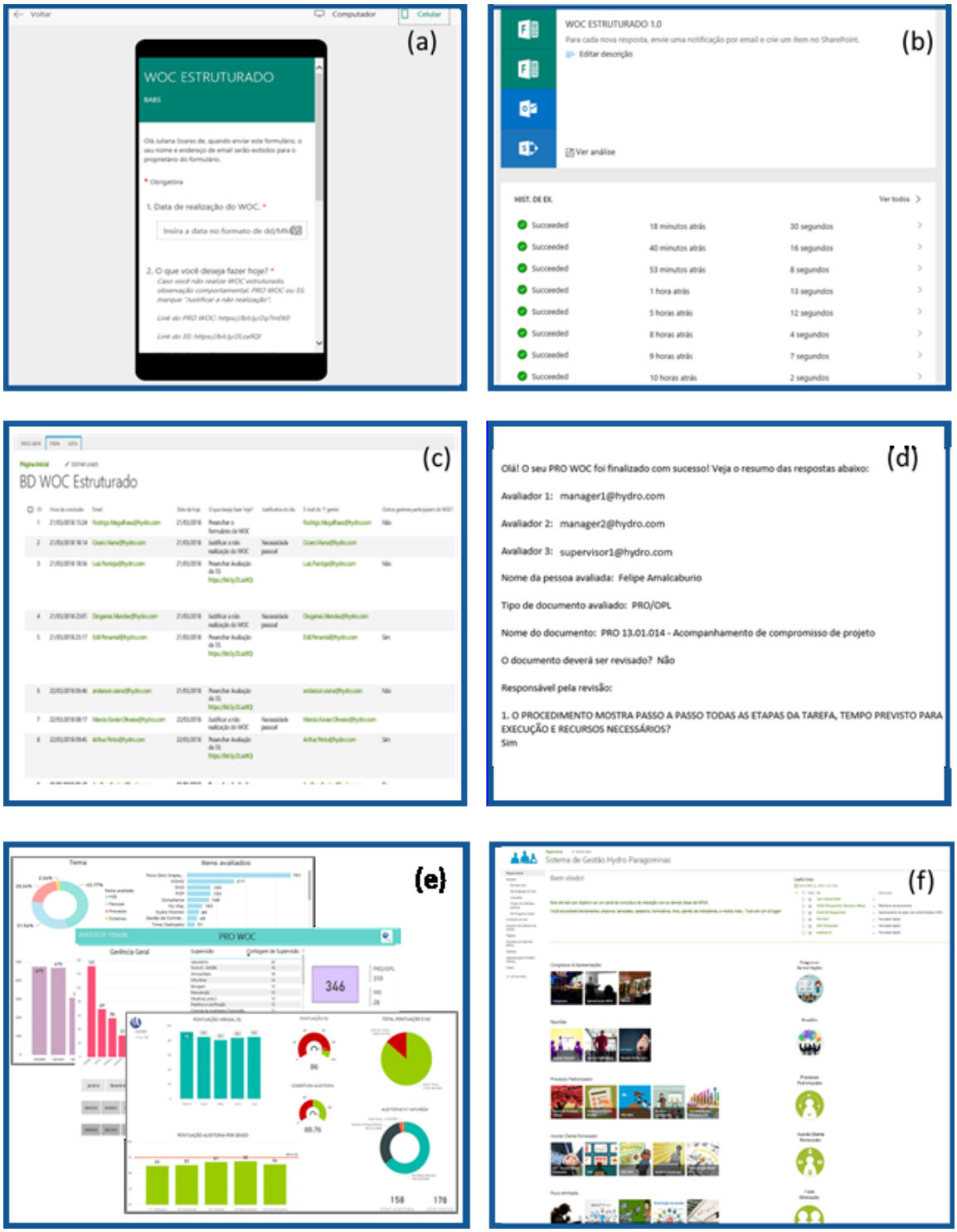

Figure 7. Results of the process of digitalization and automation of the flow. (a) Digital form (b) Flow used for connection between applications and process automation (c) Database saved in SharePoint cloud (d) Email automatically sent to users (e) Power BI dynamic reports (f) BABS SharePoint website.

The restructuring of 5S, WOC and SOP WOC format, from their execution on the job to their governance, is in line with the concept of quality 4.0 addressed in the "Quality 4.0 Impact and Strategy Handbook" [3]. Data acquisition is performed digitally through Forms. Scalability is provided by storing the data in the SharePoint cloud. Analytics is powered by Power BI, which is also used to structuring data in simplified and visual mode, easing accessibility to information and interpretation of results. Finally, connectivity occurs through the interaction between people, mobile devices and systems in real time, which benefits transparency and decision making in a short time.

Figures 8 – 10 exhibit examples of reports interfaces resulting from the new flow.

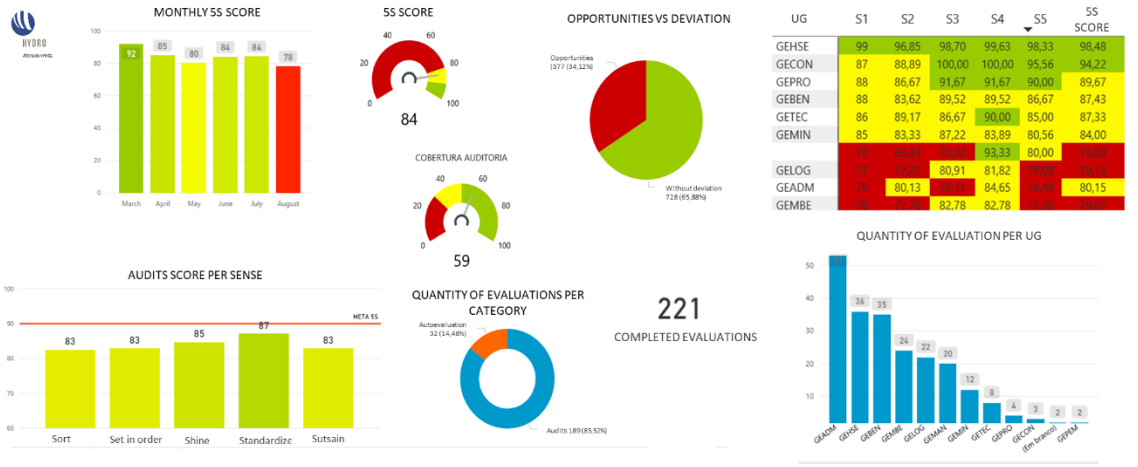

Figure 8. Real-time information interface of 5S evaluations.

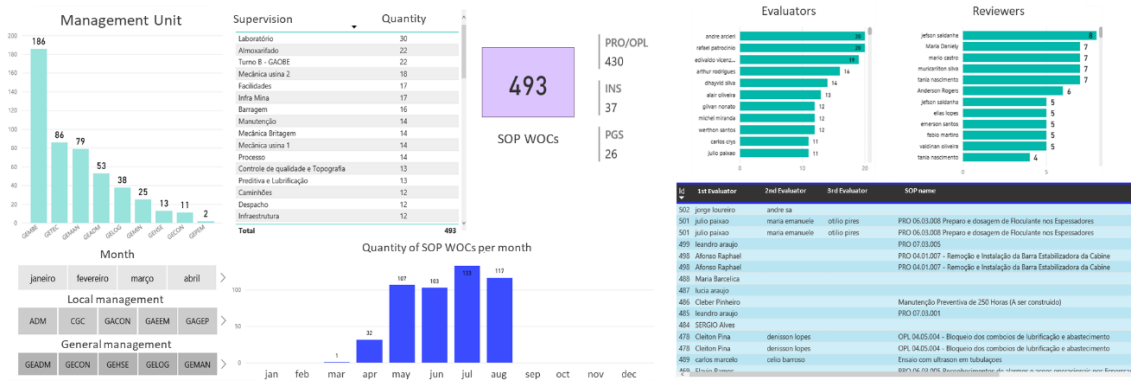

Figure 9. Real-time interface of SOP WOC information.

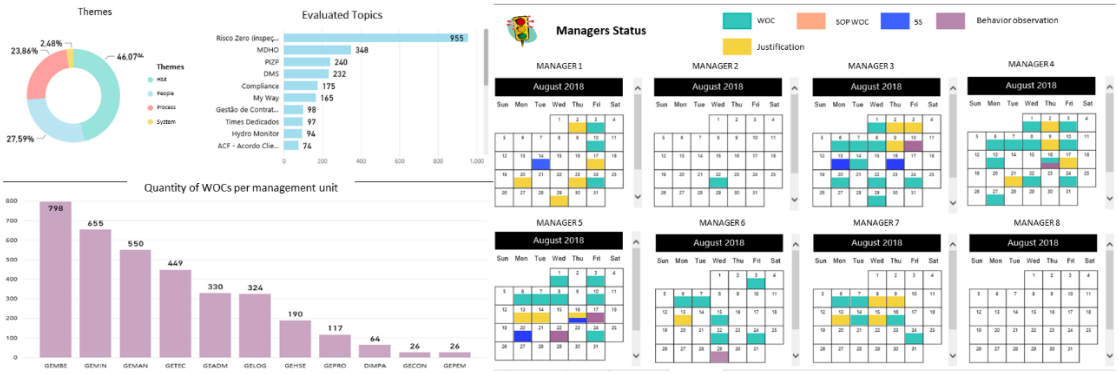

Figure 10. Real-time WOC information interface.

In addition to productivity gains from process automation, the methodology implemented leveraged the adherence of leadership and staffs to the traditional Gemba tools WOC, SOP WOC and 5S. It occurred because a conceptual recycling of these tools was carried out, along with training in the use of digital resources. For adhesion control purposes, numerical targets have been defined, which can be monitored through the created reports. In addition, the generation of reliable data in real time provided actions to recognize the people with the best performance in management and local forums.

The implementation of BABS 4.0 began in March, with WOC and 5S, succeeded by SOP WOC in April.

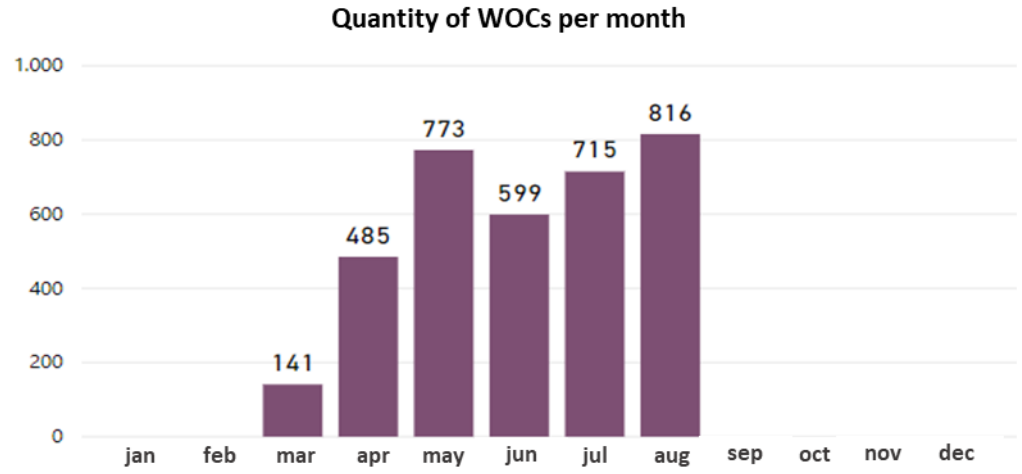

Figure 11. Quantity of WOCs per month.

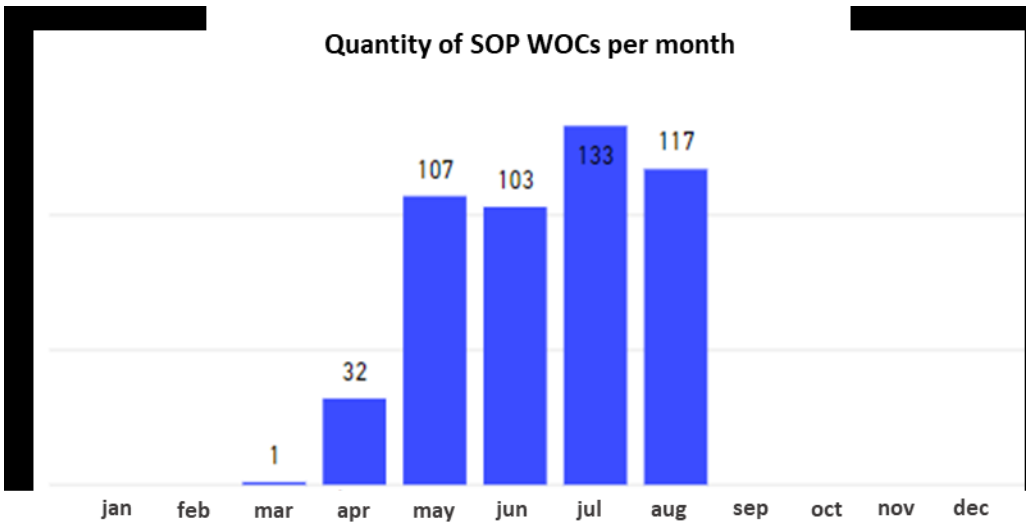

Figure 12. Quantity of SOP WOCs per month.

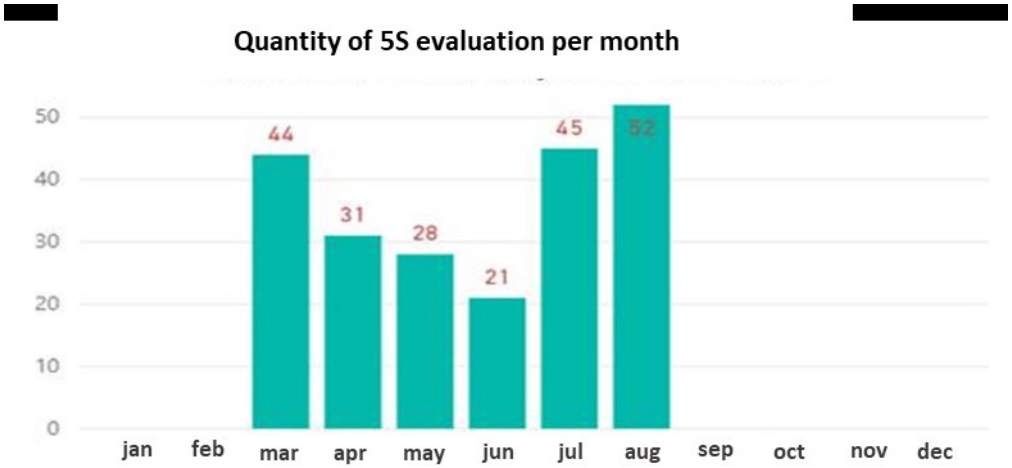

Figure 13. Quantity of 5S evaluations per month.

The WOC digital tool was launched with an initial focus on HSE. Since then, it has been observed that 46.2 % of the WOCs performed had HSE as the main theme approached, in which 92 % were centralized in inspections to detect possible risk conditions in the field (Figure 14). In addition, a major focus was given to people, since employee behavior and risk perception are directly related to accident rates.

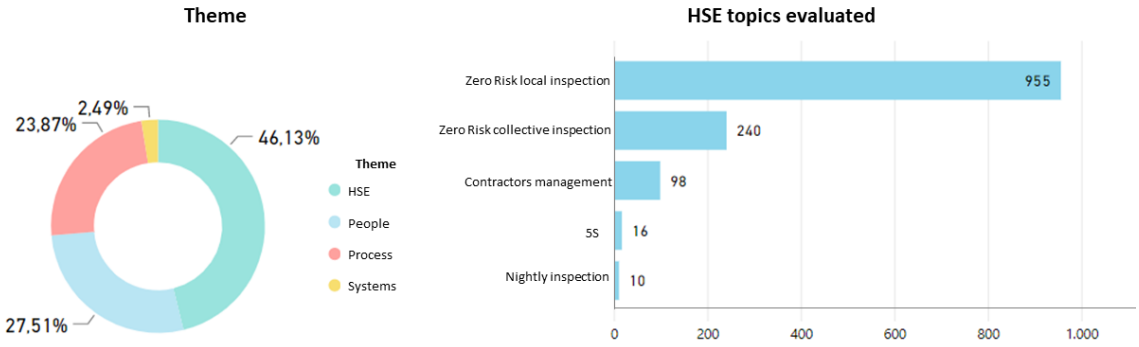

Figure 14. Number of WOCs performed since the implementation of the digital tool, according to category and items evaluated.

The current model of BABS 4.0 applies the concept of continuous improvement (PDCA), being subjected to critical reviews in safety committees and leadership meetings on a monthly regularity. The Gemba tools by themselves also drive improvements over the opportunities identified in the field, following the PDCA methodology. Figure 15 shows the number of improvements submitted monthly by the management units and the percentage per category. To date, 52.8 % of the improvements submitted were focused on HSE, 41 % on performance and 6.2 % on innovation.

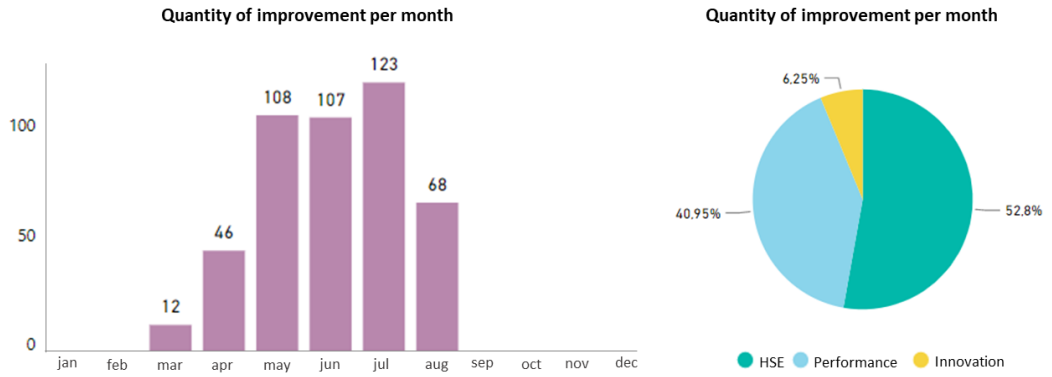

Figure 15. Quantity of improvements submitted and percentage per category.

It can be observed in Figures 16 and 17 that there was a continuous reduction in the frequency rate and in the accumulated operational cost in the first semester. One of the contributing factors is the leverage of WOC, SOP WOC and 5S, since their methodology involves the consolidation of a culture based on safety, performance and improvement. The maintenance of the work environment in order and the discipline coming from the five senses contribute favoring the identification of opportunities in the field. WOC adds up ensuring the daily presence of leadership with their teams, developing employees, and identifying local problems before they become major ones. Finally, standard procedure audits (SOP WOC) include in its scope the validation of risks and dangers raised through task execution, the validation of preventive actions, as well as the guarantee of good critical tasks execution to the results of the area.

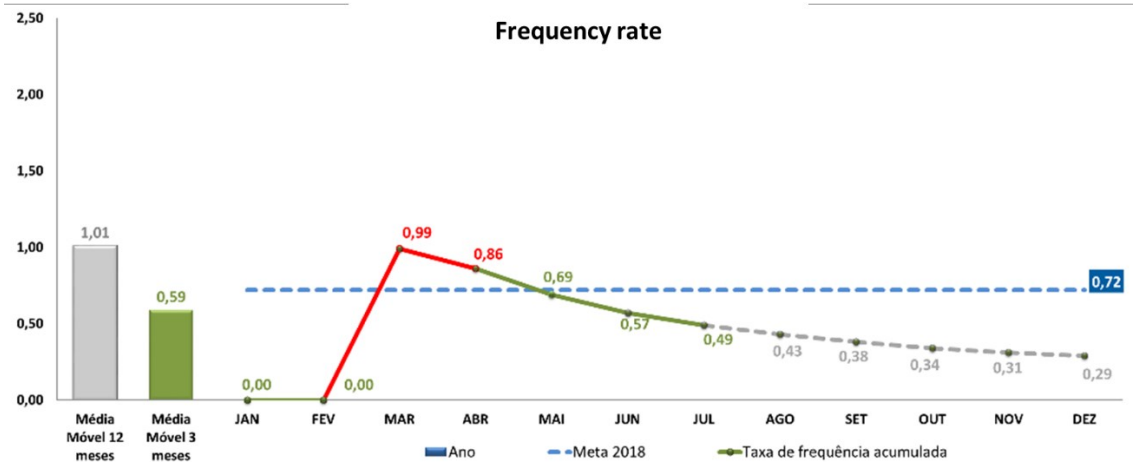

Figure 16. Frequency rate.

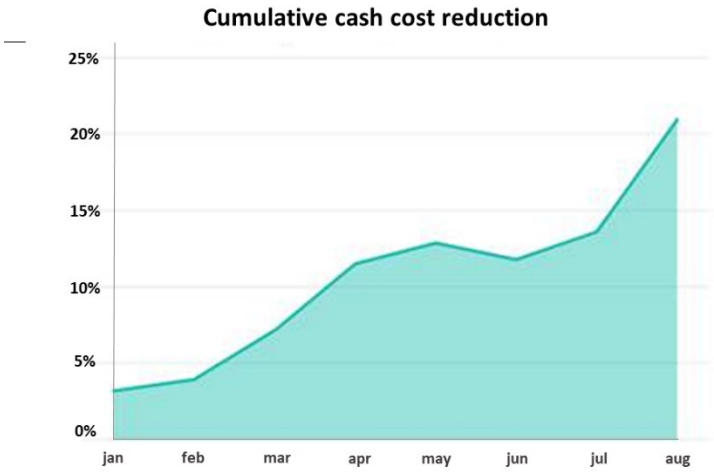

Figure 17. Cumulative cash cost reduction.

4. Conclusion

We are experiencing an intense movement in terms of digital transformation in the means of production, promoting the technological integration between production levels and planning, through digitalization, automation and connectivity. Quality management acts as a key and determinant success factor for companies, considering the scenario of extreme competitiveness in the market. It aims customer satisfaction, optimizing production processes, eliminating waste and generating value.

In order to enable quality management to fulfill its role efficiently, its tools must accompany the technological evolution taking place in industry, changing the use of static paper and worksheets by digital, dynamic and connected models.

In this study we applied the 4.0 Quality concepts of digitalization, data acquisition, scalability, analytics and connectivity to elevate traditional management system tools to the industry 4.0 standard. In this way, process flows that involved physical checklists, manual work, static reports and outdated information, were exchanged to digital interfaces, online data storage, automatic flows and dynamic real-time updated reports.

The digitalization and automation of 5S, WOC and SOP WOC processes from data capture in the field to governance on computers or mobile screens has resulted in a simple, integrated flow with user-friendly interfaces and secure databases with remarkable gains in HSE, productivity, transparency and credibility of information. The time once necessary to store data, treat it and consolidate it into reports can now be employed in other tasks, such as continuous improvement activities. The reliability and transparency of the data generated favors periodic cycles of results critical analysis, in order to continuously improve the process.

It should be emphasized that the management system must optimize the processes through the application of tools, concepts and, most important, through people involvement. Therefore, the awareness and training of the leadership and employees involved in the process was paramount for success. In addition, the ease of access to data and reports, which can be monitored in real time, together with actions of public recognition, also boosted the employees' adherence to the principles of BABS.

As an opportunity for improvement in this process of digital transformation it can be mentioned the insertion of tools and software that improve the user experience, aiming at the customization of digital forms, through the convergence to a mobile platform (apps development), using specific developed tools for this purpose.

Communication between teams for information security can be tailored through the use of applications such as MS Teams and HUB, specifically targeted at corporate teams management. It would rule out the need to use android / OS applications out of the company's IT control reach.
Finally, it should be noted that the application of industry 4.0, within the scope of the management system, is already a reality, in which Hydro seeks pioneering.

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