SAVINGS IN INTERNAL LOGISTICS USING A RFID-BASED SOFTWARE SYSTEM IN A LEAN CONTEXT

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ABSTRACT

Raw material traceability in internal flows is essential for the logistics management, allowing a better material process planning and an improved real-time trace. In fact, logistics planners need to track and trace raw material throughout the internal replenishment process, including the reception and storing processes. In this research, it is proposed a software system that integrates RFID technologies and information for internal logistics in a lean context named "Smart Internal Supply Chain" (SISC). Misplacement of material, line stoppages, unattended material turning outdated and obsolete, are some examples of the problems that can be mitigated using the proposed solution. This paper also discusses the prospective impact of SISC implementation and the expected results in terms of productivity improvement. The benefit of using RFID in the internal supply chain is evidenced, increasing the efficiency and productivity of processes up to 50% and consequently, saving logistics costs.

Keywords: RFID, Traceability, Internal logistics, Logistic software system, Industry 4.0

1 INTRODUCTION

In the context of Industry 4.0 [1], companies must be involved in research and development (R&D) activities to continuously improve their processes to better attend their clients but also to reduce their footprint impact. In order to accomplish such activities types, companies make strategic partnerships with scientific communities. One such partnership was established between Bosch Car Multimedia Portugal (Bosch-Braga) and University of Minho (UMinho) uniting the business reality with the academic world. In the context of this partnership emerges the Innovative Car project which main goal is to augment the investment in R&D, for the development and production of future mobility concepts in the automotive sector. It is focused on the development and production cycle regarding advanced multimedia solutions for the automotive industry.

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This paper results from one of the Innovative Car - iFactory subprojects called “Smart Internal Supply Chain (SISC)”. The SISC team is a multidisciplinary engineering team, composed by researchers from UMinho and Bosch-Braga associates which has as main goal to improve internal logistics by providing a real time traceability of raw materials (RM), increase information accuracy as well as streamline unexpected or urgent amendments to the production planning process. This is an urgent need as some problems have been happened recurrently, e.g. the lack of raw material (RM) traceability, entailing in material losses, and scrap costs for shelf-life expiration, as well as longer response times to customers. These problems brought costs presented in this paper that the company wants to reduce.

Also, and due to the fact that Bosch-Braga adopted the lean methodology at more than a decade, to reduce wastes, it is possible to understand that the main goals in this lean journey is to optimize the different internal logistics processes, increasing productivity and improving customer responsiveness. Thus, this project introduces the concept of RFID technology in the internal logistics process responsible for managing the supply chain. Also, it aims to sustain improvement at the process level and material resource management. The system is based on a totally innovative concept aligned with the industry 4.0 concept, characterized by a focus on automation as well as data exchange in manufacturing technologies. The savings with this new solution is also presented.

2 SUPPLY CHAIN TRACEABILITY USING RFID TECHNOLOGY

An efficient supply chain management process guarantees a continuous material and information flow throughout the whole logistics process. In this context, the traceability and transparency along the supply chain is a key element to sustain a competitive advantage. The use of RFID technology may ease the supply chain traceability.

Nowadays, due to the complexity and the volume of goods transported along the supply chain, it becomes more complex to manage, control and plan the replenishment process [2], [3]. The supply chain management encompasses the planning of many different activities related to the materials procurement, production and purchase, as well as their transportation to the customer, so it is important to streamline the material and the information flow [4]. Since, in the supply chain, small savings in operational costs could lead a significant impact on logistics costs and profit margins, the lean production becomes an important method to improve the processes efficiency, eliminating wastes, non-value activities, lead times and consequently, decrease costs [5].

The lean concept emerges in the 90s to improve processes, applying systematic methods and policies which aims to eliminate wastes and non-value activities, implementing pull production [6]. This concept has been following the development of technology to offer the companies the competitive advantage that they need to give the customers a quick and reliable response [5], [7], [8]. Authors have been defending that the adoption of lean production combined with technology allows a more efficient supply chain management [8], [9].

Transparency and visibility are key factors to achieve a well-rounded supply management process. These factors provide enough insight and information to enable the logistics operation to improve and achieve better overall performance of the supply chain, by helping to create more accurate forecasts and timing tighter replenishments. It is also possible to better identify gaps and shortages with a more transparent supply process, as well as reduce planning efforts or even production costs [3], [7].

Since the information is more readily available, transparency and visibility can also impact the inquiry time. Thus, it is a possibility to turn the real-time supply management process into a reality.

When a traceability system is implemented, real-time information processing and big data analyzing are necessary tools for these types of processes [10]. The access to real-time information allows not only to retrieve the main information of the materials along the supply chain but also their location at the different points and stages of the flow, as well as their history, increasing the quality information. The traceability allied to the information accuracy, in turn, enable (1) to reduce and prevent unexpected errors, (2) to create customized products according to the customer needs and expectations, and consequently, guarantee the product quality and customer responsiveness [11], [12], [13].

The RFID technology can be described as a wireless identification method that contributes to the improvement of the communication capacities and electronic information associated with physical items [14]. This is an automatic identification technology, widely used to identify, simultaneously track and detect multiple objects and/or people through electromagnetic waves [15]. This technology enables simultaneous reading of multiple objects that do not need to be very close and in direct line with the readers. In addition, it enables a greater interaction with the tag, replacement of the traditional barcode, allowing data reading and writing. These characteristics have allowed revolutionizing the management of the supply chain as well as improving the warehouse management and inventory control [16]. Therefore, the RFID technology can be a great combination with lean concept, since it will help to increase transparency along the material flow, reduce errors in information systems and transfer data and information in real-time [8].

Apart from the visibility increase, the information accuracy, related to the precise location of the materials and their full history along with the entire supply chain, there are other clearly potential advantages of the RFID technology implementation. For instance, (1) automation of the material registration and handling processes; (2) reduction of the inventory levels and delivery times by the information related with the replenishment times; (3) reduction of inventory losses; (4) increase process efficiency; (5) real-time information [5], [17], [18], [19], [20].

3 PROBLEM STATEMENT

Bosch-Braga works with many different logistic service providers that are responsible for the dispatch of RM from the suppliers up to Bosch's facilities. This raises many challenges in what logistics processes are concerned, i.e., planning, management, reception and replenishment of RM to the production lines. Customers usually require a high level of flexibility and agility to the organization, which results in high levels of variability in demand and supply of RM. However, it is important to have permanent access to up-to-date RM traceability, maintaining the inventory levels as low as possible to ensure the organization’s competitiveness standards.

One of the most critical problems in Bosch-Braga is the lack of RM visibility in numerous plant locations. Currently, throughout the replenishment flow, there are relevant steps in which the supply management process has low or any visibility. Thus, the current state of RM visibility makes it difficult to plan customers’ needs and may even, in extreme cases, cause delays in production due to the lack of material. The ERP system (SAP) has some constraints regarding internal supply chain visibility. From the RM warehouse until its consumption point at the production line there is no information concerning RMs status. In order to better understand the problem described, the internal material flow, as well as, the SAP visibility is represented in Figure 1.

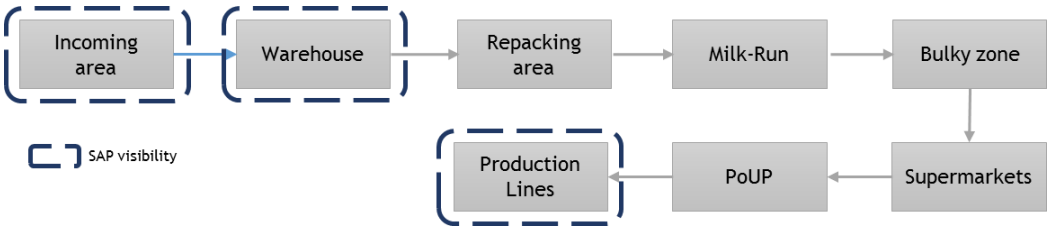

Figure 1: Internal material flow

As it is shown in Figure 1, the first step of the internal supply chain is the reception area, where the material is received and booked on SAP. Afterwards, the material is chaotically allocated to a storage position in the warehouse, followed by the physical put away. Once the material is requested for production, the picking from the warehouse and put away on the repacking area is performed. The picking process represents the removal of RM from the warehouse. All raw materials packed in one-way boxes are repacked into returnable packages (RPs) in the repacking area. The milk-run (a cyclic method to supply materials within the production performed by a tugger vehicle) goes through the repacking area and the bulky zone (place where bulky material or material with a high replenishment rate is stored) carrying the material to the supermarkets (RM buffers close to the production lines). Then, the Point of Use Provider (PoUP) supplies the production line from the supermarket stock.

Regarding the process shown in Figure 1, there is a huge lack of traceability from the warehouse to production lines, resulting in non-visibility at certain internal logistic locations: repacking, milk-runs, bulky zone, supermarkets and PoUP. Thus, when the RM is on these plant locations, it is not possible to accurately determine the material location, since in SAP all these different locations represent a single location. This situation entails in different problems such as, material deviations and losses, production stoppages, overstock, shelf-life expiration, planning errors.

Furthermore, there is a lack of standards in RM labelling, as there are different types of RM and different associated flows, allowing the adoption of different working procedures. On the other hand, there is no automation in different logistics operations such as goods receipt, put away, picking and RM ordering. All these factors, result in inefficient processes along the internal material flow, as well as, a high dependency on human intervention. Table 1 summarizes the main internal logistics constraints in different plant locations or process stages.

Table 1: Main constraints of the internal logistics processes

Material reception	
Lack of automation	• RM manual booking (barcode reading); • Manual material movement confirmation; • Manual material request; • Paper dependent workflow; • No early warnings.
Lack of standards	• Different suppliers use different labels; • Different material replenishment processes (Kanban and electronic Kanban);
Lack of accuracy in the material movements confirmation	• No matching between physical and virtual flow.

4 PROPOSED SOLUTION

The solution adopted to solve the problems identified above is the introduction of RFID technology combined with a visualization and control system – namely SISC. The RFID technology is responsible for the registration of RM in operational areas while the system is responsible for its monitoring. Moreover, this system provides several performance indicators based on statistics provided.

The R&D team is responsible for the following major tasks: (1) developing the SISC system with software technologies; (2) clearly understand how the RFID technology works in order to maximize its potential and (3) to adapt it to the specific characteristics of Bosch-Braga by analysing the different processes, evaluating the requirements and the impact of its changes and to monitor performance indicators. Since SISC aims to eliminate blind spots in the internal supply chain where currently it is not possible to gather and understand, in detail, the RM location in the logistics flows, new control points were defined. Figure 2 represents the internal material flow with SISC and RFID implementation.

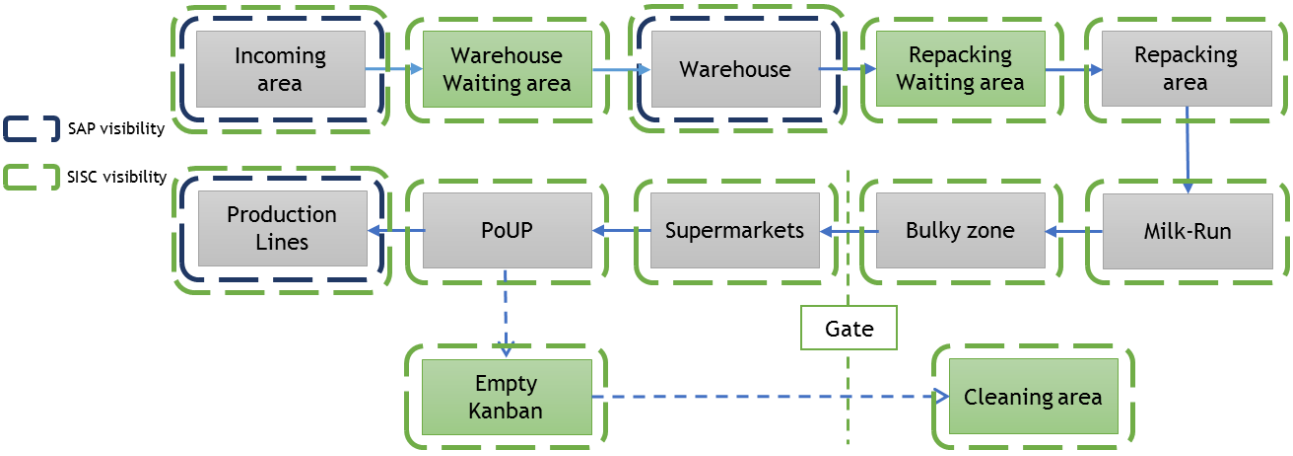

Figure 2: SISC Internal material flow

As it can be seen in the Figure 2, all steps of the RM in the Bosch-Braga plant are covered with SISC, and there are no blind spots, guaranteeing the RM traceability along the internal supply chain. Thus, all the information collected in these new control points will be kept in SISC system and sent to the SAP, when applicable.

The RFID process is based on RFID tag readings, creating events which are processed in the system. These reading events are going to be monitored by portable and fixed readers, located in strategic control points. The RFID information system is going to be able to show with precision where the material is, since the tags are read automatically every time they move from a place to another.

With RFID implementation, there are processes along the internal flow that will be improved, since the flow is streamlined and more transparent. All RPs are identified with a RFID tag whose information is being recorded in several locations, allowing their tracking and tracing along the entire flow. These RFID tags relate to the information regarding the RM part number, storage location and quantity, recording the time and date of all stock transfers. For security reasons, the information must be stored in the system's database that communicates with the tag, instead of being directly in the tag.

Furthermore, the human intervention will be reduced by the real-time information and automation of some tasks. These factors will have a major impact in these three processes: (1) warehouse (picking and put away), (2) repacking area and, (3) milk-run. Since the barcode readings will be replaced by automatic RFID readings, it is possible to save time and improve the basic transport

activities. The real-time information will also allow to balance and optimize the workflow and their respective workstations.

5 EVALUATION OF EFFICIENCY IMPROVEMENT AND SAVINGS

SISC and RFID implementation improvements must be evaluated to know the savings obtained with these, as well as the main processes and activities influenced by them.

Since the material movement confirmations will be automated, the barcode readings will be replaced for automated RFID readings and the number of material movement confirmations can be duplicated. This way, it is possible to have the control of the flow from the picking and put away processes without creating extra effort for the physical operation. It will be possible to reduce operation time and increase granularity in the put away and picking warehouse activities. The operator will have a list with information related to all pending put away and pickings and based on this, the operators' physical position and machine capacity can be re-organized. SISC can provide a heuristic capable of improving the distance travelled of even based on the effort for each WH task. Thus, it will be possible to improve (1) process balancing, (2) operator's work sequence and (3) turret-truck utilisation.

The repacking process will also suffer improvements, yet again, the label reading time will be reduced once this task will be automated as well as the association to the supermarket position and subsequent label (containing supermarket position) printing. Therefore, it is not only expected to increase productivity in the repacking area but also to balance the workstations' workload. Since the label reading and label printing activities will be replaced by automatic RFID tag reading, it will be possible to reduce the total operation time.

Due to the access to relevant information, namely, the material available to pick up in the repacking workstations, it is also possible to improve the Milk-run activities. SISC will provide a route suggestion, allowing to the Milk-run operator to know in advance in which points he/she must stop, i.e., he/she only stops where there is material to pick up or supply and not in all predefined points. The Milk-run operator will have in advance (1) a list with information related to the next supply points in the supermarkets and (2) associated RM that must be supplied. The organised information provided to the Milk-run operator will allow to reduce the occurrence of human errors, as well as to improve the travel and handling time.

All these activities were properly analysed to evaluate their impact in the process efficiency. Table 2 presents the increased productivity regarding the process affected by SISC.

Table 2: Benefits of RFID implementation

Saving	Currently	RFID	
Picking and put away process productivity	**23** picking and put away events processed by one man in one shift	**35** picking and put away events processed by one man in one shift	**52% increase**
Productivity on the repacking area	**215** repacked packages by one man in one shift	**253** repacked packages by one man in one shift	**18% increase**
Productivity on the MR process	**23** MR cycles by one man in one shift	**30** MR cycles by one man in one shift	**30% increase**
RP label printing	**1,536,000** label printed per year	**0** label printed per year	**100% decrease**

As it can be seen in the table above, there are significant and relevant productivity improvements in the analysed processes. The information provided by SISC, allied with the RFID implementation

and real-time track and trace provides a faster, more efficient, accurate and flexible processes. Efficient processes bring many advantages and benefits such as (1) reduction of needless activities (e.g., inventory, transportation, movements), (2) reduction the errors occurrence and, (3) reduction of wait periods. With all these improvements, it is possible to increase processes efficiency up to 52%, as well as, eliminate printing and labelling needs. Furthermore, with the improvements in the analysed processes, it is possible to save some logistic costs (~200 thousand Euros, in an early stage). At the same time, it is also possible to release the resources capacity, thus allowing to response the Bosch-Braga growth.

6 CONCLUSION

The prospective impact of the SISC software system has already been evaluated and it is possible to assess the increased levels of raw material visibility and handling operations automation. A significant decrease in errors, time and waste is also foreseen and can reach up to 30% for some operations. Productivity increase is expected to have a large impact in the overall performance of the company.

Nowadays, companies are aware of the environmental issues, making their processes compliant with industry sustainability standards. Bosch is compromised with the future of the planet, while developing new solutions based on environment friendly processes. The “Green Supply Chain” principle is the staple for showing the world that it is possible to do better for the industry, while preserving the planet. The elimination of label printing is a clear example that we can have savings for the company as well as for the planet. All along this project development, testing and implementation the team was always focused on trying to come up with a sustainable solution.

This paper focuses on the development of the SISC software system that, using RFID technology, improve internal logistics performance at Bosch-Braga aligned with Industry 4.0 principles that drives Bosch´s goals for the near future.

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8 REFERENCES

[1] H. Kagermann, W. Wahister, and J. Helbig, “Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the Future of German Manufacturing Industry,” 2013.

[2] J. Cooper and J. Griffiths, “Managing Variety in Automotive Logistics With the Rule of Three,” *Int. J. Logist. Manag.*, vol. 5, no. 2, pp. 29–40, 1994.

[3] M. Kärkkäinen, “Increasing efficiency in the supply chain for short shelf life goods using RFID tagging,” *Int. J. Retail Distrib. Manag.*, vol. 31, no. 10, pp. 529–536, 2003.

[4] W. He, E. L. Tan, and E. W. Lee, “A solution for integrated track and trace in supply chain based on RFID & GPS,” *Emerg. Technol. Fact. Autom.*, 2009.

[5] J. C. Chen, C. H. Cheng, P. B. Huang, K. J. Wang, C. J. Huang, and T. C. Ting, “Warehouse management with lean and RFID application: A case study,” *Int. J. Adv. Manuf. Technol.*, vol. 69, no. 1–4, 2013.

[6] D. Kolberg and D. Zuhlke, “Lean Automation enabled by Industry 4.0 Technologies,” *IFAC-*

PapersOnLine, vol. 28, no. 3, pp. 1870–1875, 2015.

[7] A. B. D. Ranasinghe and D. McFarlane, "RFID Opportunity Analysis for Leaner Manufacturing," *Int. J. Prod. Res.*, 2009.

[8] D. Powell and L. Skjelstad, "RFID for the extended lean enterprise," *Int. J. Lean Six Sigma*, vol. 3, no. 3, pp. 172–186, 2012.

[9] J. Riezebos, W. Klingenberg, and C. Hicks, "Lean Production and information technology: Connection or contradiction?," *Comput. Ind.*, vol. 60, no. 4, pp. 237–247, 2009.

[10] G. Aiello, M. Enea, and C. Muriana, "The expected value of the traceability information," *Eur. J. Oper. Res.*, vol. 244, no. 1, pp. 176–186, 2015.

[11] P. Helo and B. Szekely, "Logistics information systems," *Ind. Manag. Data Syst.*, vol. 105, no. 1, pp. 5–18, 2005.

[12] I. Töyrylä, "Realising the potential of traceability - A case study research on usage and impacts of product traceability," 1999.

[13] C. Ene, "The relevance of traceability in the food chain," *Econ. Agric.*, vol. 60, no. 2, pp. 287–297, 2013.

[14] V. Modrak, P. Knuth, and J. Novak-Marcinein, "Advantages and Risks of RFID in Business Applications," *Int. Bus. Manag.*, vol. 4, no. 1, pp. 28–34, 2010.

[15] A. Mishra and D. Mishra, "Application of RFID in Aviation Industry: an Exploratory Review," *Promet-Traffic Transp.*, vol. 22, no. 5, pp. 363–372, 2010.

[16] J. Barjis and S. F. Wamba, "Organizational and business impacts of RFID technology," *Bus. Process Manag. J.*, vol. 16, no. 6, pp. 897–903, 2010.

[17] D. Lee and J. Park, "RFID-based traceability in the supply chain," *Ind. Manag. Data Syst.*, vol. 108, no. 6, pp. 713–725, 2008.

[18] A. Sarac, N. Absi, and S. Dauzre-Prs, "A literature review on the impact of RFID technologies on supply chain management," *Int. J. Prod. Econ.*, vol. 128, no. 1, pp. 77–95, 2010.

[19] M. J. Imburgia, "The role of RFID within EDI: Building a competitive advantage in the supply chain," in *Service Operations and Logistics, and Informatics, 2006. SOLI '06. IEEE International Conference*, 2006, pp. 1047–1052.

[20] D. Owunwanne and R. Goel, "Radio Frequency Identification (RFID) Technology: Gaining A Competitive Value Through Cloud Computing," *Int. J. Manag. Inf. Syst.*, vol. 20, no. 2, pp. 37–45, 2016.