Available online at www.sciencedirect.com
ScienceDirect
Procedia Manufacturing 13 (2017) 1261–1268
Procedia MANUFACTURING
www.elsevier.com/locate/procedia

Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain

Improving visibility using RFID – the case of a company in the automotive sector

F. Costa[b,*], M. do Sameiro Carvalho[a,b], J.M. Fernandes[a,c], A.C. Alves[a,b], P. Silva[d]

[a]*ALGORITMI Research Center, School of Engineering, University of Minho, Portugal*
[b]*Department of Production and Systems, University of Minho, Guimarães, Portugal*
[c]*Department of Informatics, University of Minho, Braga, Portugal*
[d]*Bosch Car Multimedia Portugal S.A., Braga, Portugal*

Abstract

The purpose of this paper is to present some results of an ongoing project that intends to improve internal logistics visibility using RFID at an electronics company of the automotive sector. The first step of this project was to identify the traceability problems of raw materials at the company and to design an RFID–based solution to solve such problems. Additionally, the main challenges related to the implementation of that solution were identified and discussed. Through interviews, documental analysis, and observation, the current internal logistic processes are described and the main traceability problems identified. This paper is, mainly, concerned with presenting the problems and the difficulties found by the project team. Additionally, the RFID based solution is proposed (prototype description) as also the key challenges, expected results and advantages (e.g. more increased control of raw materials and automatization of handling and storing processes).

Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.

Keywords: RFID; Traceability; Logistics; Monitoring of materials; Supply Chain Management

* Corresponding author. Tel.: +351 910350506.
E-mail address: francismmcosta@gmail.com

Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.
10.1016/j.promfg.2017.09.048

1. Introduction

This paper results from an ongoing project designated Smart Internal Supply Chain (SISC), which is part of a research & development partnership between Bosch Car Multimedia Portugal (Bosch Portugal) and University of Minho (UMinho), developed by a multidisciplinary engineering team, and composed of researchers from UMinho and Bosch Portugal. This project is integrated in a large research program, which aims to improve all the company processes by eliminating wastes to reduce costs and increase productivity and to reinforce the leanness of this company. Bosch Portugal produces electronics components such as multimedia and navigation systems for the automotive industry. The company faces a problem concerning the lack of traceability of its raw materials (RM), which has numerous consequences, inter alia, a longer response to its clients regarding the ability to satisfy an order and higher scrap costs resulting from the termination of the shelf life of the raw materials. Hence, the company started this project that is focused on using Radio Frequency Identification (RFID) technology with the aim of increasing the visibility of the supply chain, in particular, the internal movements of the raw materials.

The main objective of this paper is to present the results of the problems identification and key challenges related to the implementation of an industrial traceability system based on RFID technology. This technology is within the topic of Industry 4.0, characterized by a strong focus on automation and data exchange in manufacturing technologies.

Firstly, the authors have studied the current internal logistics operations with regard to the raw materials and their forms of traceability, in order to identify the main problems. In parallel, a literature review about the topic of traceability, more concretely, about the use RFID technology for traceability and its main key challenges was conducted. Then, the authors proposed a prototype using RFID technology to track and trace the raw materials at Bosch Portugal. Finally, the results of this implementation with respect to the problems identified are discussed.

2. Literature review

Firstly, this section aims to present a literature review on supply chain traceability issues: its relevance and impact. The second and third parts of the literature review focuses on the use of RFID technology: operation of the system and key challenges. Finally, case studies reported in the literature are used to illustrate some of the practical issues of using this approach in real world companies.

2.1. Supply Chain Management

Supply chain management (SCM) can be defined as "the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole" [1]. Fig. 1 intends to illustrate the flow of materials and information through the Supply Chain (SC).

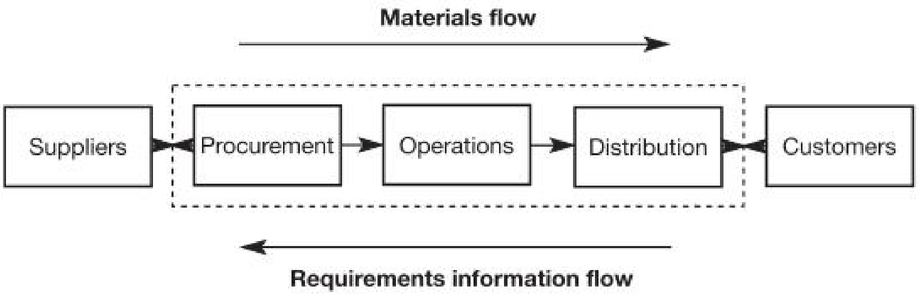


Fig. 1. Supply Chain Flow [1].

SC management involves the coordination and collaboration of activities between its various stakeholders. This encompasses the planning and management of all activities related to the provision and purchase of materials, processing, and logistics management activities such as demand forecasts, order processing and fulfilment, transports service, billing and payment processing [2].

2.2. Traceability in the Supply Chain

Industrial traceability can be defined as the ability to identify a product or component along the supply chain, i.e. the ability to check and identify the history and location of an item through a paper or electronic documentation [3].

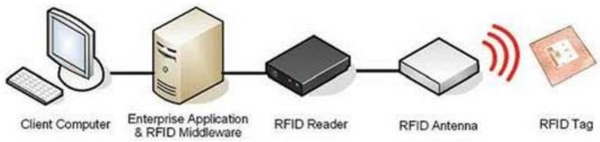
According to Töyrylä [4], the use of traceability data:

- Allows the creation of customized products and services according to the customer's need;
- Predicts or reduces the number of unwanted events, i.e. reduces the errors in the manufacturing and distribution processes as well as the number of losses due to theft and deterioration;
- Reduces the negative impact of undesirable events like a product recall, quality problems, customer complaints, theft and counterfeiting;
- Reduces and prevents future problems.

One of the main features that affects the cost and practicality of industrial traceability systems is the level of granularity. Generally, the levels of granularity are: pallet, carton and item. The main advantage of having an item-level traceability is the high accuracy of the information. However, a thinner traceability results in higher costs with the systems as well as in more information to be processed [5].

2.3. RFID technology

RFID technology could be described as a wireless identification method that contributes to the improvement of communication skills and electronic information associated with physical items [6]. This is an automatic identification technology, widely used to identify, track and detect multiple objects and/or people simultaneously through electromagnetic waves [7]. An RFID system (Fig. 2) is generally made up of three components: (1) a tag placed on the object to be identified; (2) a reader and its antenna(s) that communicate with the tag without having to be in direct line with this, and (3) a host server equipped with a middleware responsible to manage the system and interact with the organization's information systems, i.e. client computer in the Fig. 2 [8]. There are three types of frequency in which the RFID systems operate: low frequency (LF), high frequency (HF), and ultra-high frequency (UHF). The frequencies are in the range 125-134 kHz for LH, 13.56 MHz for HF, and in the range 866-966 MHz for UHF [9].



(3) (2) (1)

Fig. 2. RFID system [10].

2.4. Key challenges affecting RFID technology

Mcfarlane and Sheffi [11] identified some challenges and barriers that have prevented a large-scale adoption of RFID technology. The authors divided these challenges in technological and organizational. Regarding the technology, they had identified the following challenges and barriers: i) Data storage and access – track every item-level object generates a huge amount of data that must be stored and consulted quickly; ii) Accuracy – while the operations and their underlying information systems grow increasingly in getting real-time information, automatic identification data of products and the specifications placed on the identification systems will tend to the absolute accuracy; iii) Interference – with the expansion of wireless devices (phones, Personal Digital Assistants (PDA), radio, etc.) there is the potential for electromagnetic interference with large-scale Auto-ID systems.

The organizational ones are the following: i) Information Sharing – since the data is shared through the Supply Chain there is a question of ownership of the data; ii) Security – once writing into the tag is possible, incorrect information can be accidentally or intentionally written; iii) Costs – this is a continuous challenge once the tag prices can prevent a widespread adoption of this technology.

A study conducted by Azevedo and Carvalho [12] identified other barriers in the implementation of this technology such as: compatibility with existing information systems; lack of know-how and invasion of privacy.

2.5. Some case studies

According to a study presented by Eurostat only 3% of companies in European Union were using RFID technology by 2010 [13]. Most of them use this technology to personal identification and access control (56%), supply chain and inventory tracking (29%), motorway tolls (25%), theft control (24%), production control (21%) and asset management (15%) [13]. Next, a summary of some studies is presented: Throttleman [12, 14], Metro Group [15], Walmart [15, 16], Brazilian Air Force [17, 18] and Panalpina Group [17]. Main results are depicted in Table 1.

Table 1. Case studies of RFID technology implementation.

Company	Sector	Results
Throttleman	Apparel	• Tags reading at a rate of rate of 15000 pieces per hour with an accuracy of 99.9%; • Reduction from 5 days to only 24 hours in the time spent by clothes at the distribution center; • 60% decrease of the warehouse space; • Total cost of the implementation under 6 digits; • Costs with tags four times higher than with barcodes.
Metro Group	Retail	• Greater automation in reception and materials handling compared to the traditional barcode reducing errors resulting from manual operations; • Reduction of losses and thefts by 11% and 18% as well as reduction of 10% to 20% of out of stocks; • Reduction of 8.5 million euros per year in Germany resulting from the combination between RFID system and EDI (Electronic Data Interchange); • Reduction up to 2.84 € per dispatch note.
Walmart	Retail	• Reduction of 16% in out of stocks; • Replenishment three times faster; • Reduction of almost 90% of time with pallet building; • Reduction of 10% to 15% in manual orders; • Reduction of several manual processes as well as errors with data record. • Interference with other devices (e.g. walkie-talkies, forklifts, electric motors, computing equipment). • High cost of implementation for some suppliers.
Brazilian Air Force	Defense	• Reduction of processing time in the shipment of goods in Washington from 3 or 4 days to 3hours; • 600% increase in the productivity of materials handling; • Reduction in the preparation time of the shipping documents from 3 hours to 1 minute; • Reduction in the receiving time of a container from 8 hours to 45 minutes; • Reduction in the number of errors related to the register of materials from 2% to 0.005%.
Panalpina Group	Logistics	• Ability to monitor the environmental conditions of the materials during transportation, enabling customers to a higher level of service which results into higher customer satisfaction; • Minimize the risks along the supply chain.

According to the revised case studies, the main advantages for the adoption of this technology are: automation of the registration processes and movement of materials; stocks reduction and its increasing visibility; reading and writing capabilities with a short distance between the reader and the tag, among others. However, researchers point out several critical aspects in the implementation of this technology such as: lack of standardization, management difficulties due to the enormous amount of data generated, information sharing between the various elements of the chain and business partners and the implementation costs of the system. On the other hand, the adoption of this technology is relatively recent, so the bibliography on case studies is scarce.

3. Traceability at Bosch Portugal

This section firstly describes the flow of raw materials and its traceability processes at Bosch Portugal and secondly points out some of its problems. For a better understanding of raw materials flow, it is important to identify the main locations at Bosch Portugal and its corresponding code (storage type) in the ERP system (SAP):

- MOE1 – Production by automatic insertion, supplied by SMD (Surface Mounted Device) supermarket with electric equipment such as inductors, capacitors, and PCB's (Printed Circuit Boards) – Storage type: MO1;
- MOE2 – Final Assembly, supplied by several supermarkets near the production lines which in turn are supplied by the main warehouse of raw materials – Storage type: MO2;
- Reception – RM reception and registration – Storage type: 902;
- Warehouse 102 – Main warehouse of raw materials – Storage type: 102;
- PQA (Plant Quality Automotive) – where the MP is subject to quality tests – Storage type: 817;
- Repackaging – where the RM are repackaged in boxes (with electrostatic discharge protection) before going to production lines – Storage type: MO2;
- Bulky Zone – intermediate location between the Repackaging and supermarkets, where raw materials of larger dimensions and higher consumption rate are placed – Storage type: MO2;
- SMD – an advanced warehouse where part of the components consumed at MOE1 are stored.

3.1. Raw materials flow

The RM are unloaded at Bosch Portugal either in pallets or cases. There are two different types of boxes for RM: one way (carton) or returnable (RAKO). At the reception, RMs are registered and sent to their destiny which is mainly: PQA, Warehouse 102 or SMD. Mechanic RMs are stored in Warehouse 102, while electrical ones may also be transported directly to SMD. From the SMD they are transported to MOE1 and from here to MOE2. The others are delivered at the Repackaging where they are removed from their carton boxes and placed inside RAKO ones. Besides, it is automatically printed a Kanban, designated e-kanban, which is placed on the RAKO box. Once repackaged, those boxes go to the stands in front of the Repackaging desks or to the Bulky Zone (for some specific RM of big dimensions and/or high consumption). Whether from the stands or the Bulky Zone they are transported by milkruns to Supermarkets next to the production lines. Then, operators designated as Point-of-Use-Providers (POUP) supply production lines. They are also responsible to put empty boxes in carriers which are close to the supermarkets and emptying e-kanbans. The latter is carried out with a PDA and will generate an order to the main Warehouse when the default batch is reached. Finished goods are transported to the shipping area and delivered to the customers by a Logistic Service Provider. The following flow chart briefly illustrates the whole flow of RM at BrgP (Fig. 3).

3.2. Main problems identified

Following the flow described above, it was identified some problems concerning traceability and its processes. Firstly, there is a lack of standardization in RM labels once some different types are used. Secondly, there is an important lack of traceability from the Warehouse to MOE2. RMs are allocated in the SAP system to MOE2 at the picking process resulting in no-visibility at the Repackaging, Bulky Zone, Milkruns and Supermarkets. On the other hand, there is no automatization in different logistics operations such as goods receipt, put away, picking and ordering of RM. Finally, there is any traceability of RAKO boxes. Table 2 summarizes those issues along with its degree of criticality.

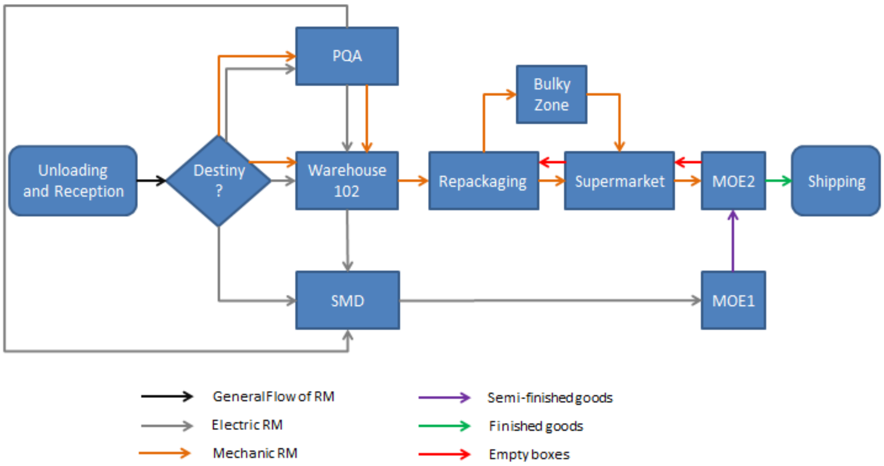


Fig. 3. Flow of RM at BrgP.

Table 2. Main problems of RM flow at BrgP.

No.	Problem	Degree
1	Lack of standardization in RM labels	Low
2	Lack of visibility in important points of the flow: Repackaging, Bulky Zone, Milkrun, Supermarket and Production Lines	High
3	Lack of Automatization	Medium
4	Lack of visibility of RAKO's boxes	Medium

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 – designated SISC (Smart Internal Supply Chain). The RFID technology is responsible for the registration of RM in operational areas while the system for its monitoring. Moreover, this system provides several performance indicators based on statistics provided. The multidisciplinary project 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 to adapt it to the specific characteristics of BrgP and the last ones by analyzing the different processes evaluating the requirements and the impact of its changes and to monitor performance indicators.

4.1. Expected results

The lack of standardization in RM labels was the first problem identified regarding traceability. RMs come from many different suppliers with different types of labels. Ideally, only one type should be used to facilitate the goods receipt, but, unfortunately, that was not the current scenario. The standardization of the labels should be done continuously in close partnership with suppliers.

The most important consequence that results from the use of RFID technology in the facilities of Bosch Portugal is the increase of RM traceability. The SAP system provides visibility of RM in three locations: Reception, Warehouse 102 and MOE2. Besides, the confirmation of RM as part of MOE2 stock is carried out immediately after the picking at the WH102 instead of when it physically arrives in MOE2. As shown below (Fig. 4), this system will provide visibility of RM in other important points of the flow (green) complementing to the ones existing now.

Another important benefit of this implementation is the possibility to increase automatization of processes regarding the registration and monitoring of RM. At the reception, there will be hardware capable to do the goods receipt without human intervention. At the main warehouse, RM registration process for both put away and picking will be carried out automatically as well as the RM ordering in the production lines.

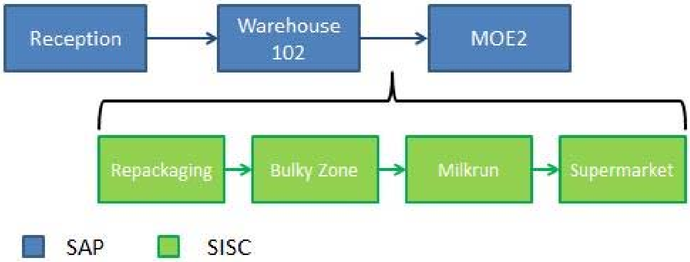


Fig. 4. RM visibility in both traceability systems.

Finally, it will be possible to track RAKO boxes. All of them are equipped with a tag (unique ID) which is recorded in several locations allowing its tracking. It will be possible to know, in real time, where the box is and if it is full or empty. On the other hand, it will be possible to consult all the data about them, such as its location in a specific day and hour, number of times it was used, which and how many RM were transported, etc.

4.2. Key challenges and difficulties

Regarding the critical aspects found in the implementation of the technology, the main one concerns to the complexity of the logistics operation in Bosch Portugal, since the RM could:

- Enter the facilities whether in boxes or pallets;
- Come in RAKO boxes or cartons;
- Be identified with different types of labels;
- Be stored in a different way – pallet or box bin;
- Be transported to many different destinations after the Goods Receipt.

At Bosch Portugal, it was decided to have traceability at the box-level. Traceability in a pallet-level would not provide enough accurate information, while item-level is not possible and very expensive since some components are very small to have a tag attached to them. Tags must contain information regarding the RM part number, storage location and quantity recording the time and date of stock transfers. The information must be stored in a database that communicates with the tag, instead of being directly in the tag for security issues.

The ergonomic point of view is an important factor as well, since this technology will automate some processes carried out by the workers. This is particularly sensitive for them, since they may have to change some processes that they have been doing for years and it is important to have them motivated to use this technology.

Another challenge refers to the lack of compatibility and integration of the new technology with the SAP system of the company. This ERP system is central, i.e., it is managed by the headquarters and used for all the other plants of the Bosch Car Multimedia group, making it (almost) impossible to change its structure.

The lack of know-how regarding the RFID technology by team members and the fact that there are not so many cases of large implementation of this technology on the market to perform a benchmarking analysis were also a constraint.

Finally, the large investment in the technology is also an important challenge, but due to confidentially issues cannot be quantified. Although, it is expected to have long-term gains by reducing:

- Special transportations costs;
- Scraping costs;
- Inventory losses;

- Production breakdowns.

5. Conclusions

This paper addresses inbound logistics traceability issues in a company of the automotive sector in the context of a research & development partnership between an industrial company and the University of Minho (UMinho). The project aimed at identifying traceability issues in the inbound logistic area and designing an RFID-based solution. Besides a literature review of related work the project allowed to identify the main traceability challenges of internal flows to ensure the maximum visibility along the whole flow of RM in a company with a highly complex inbound logistics operation. The monitoring process of RM must evolve in terms of ergonomics, time and accuracy.

The critical aspects of the adoption and implementation of RFID technology were also identified. From the organizational point of view, the lack of know-how on RFID technology has proved to be one of the most important aspects. The project team is multidisciplinary, with expertise in all areas of the project, however, it is still inexperienced and had never worked with RFID technology. Another important issue refers to the security of the information in the tags. Therefore, it was established that the whole information must be stored in a database that communicates with the tags. The main advantages of this technology are the possibility to track the RM in seven different points of the flow unlike the previous scenario as well as the automatization of different processes. In the long term, it is expected to reduce wastes such as scraping costs, special transportation costs, inventory loss and human errors. This system will generate a large amount of new data, such as occupancy rates of milk-runs and replenishment times, which can lead to new optimization projects.

Acknowledgements

This work has been financially supported by the Portugal Incentive System for Research and Technological Development in scope of the projects in co-promotion nº 002814/2015 (iFACTORY 2015-2018).

References

[1] M. Christopher, Logistics & Supply Chain Management, 4th ed. Pearson, 2011.
[2] W. He, E. L. Tan, E. W. Lee, & T. Y. Li, A solution for Integrated Track and Trace in Supply Chain based on RFID & GPS, in Emerging Technologies & Factory Automation, 2009.
[3] C. Ene, Econ. Agric., 60 (2) (2013) 287–297
[4] I. Töyrylä, Realising the potential of traceability - A case study research on usage and impacts of product traceability, Ph.D. thesis in Technology, Helsinki University of Technology, 1999.
[5] G. Aiello, M. Enea, & C. Muriana, Eur. J. Oper. Res, 244 (1) (2015) 176–186
[6] V. Modrak, P. Knuth, and J. Novak-Marcinein, Medwell Journals, (2010) 28–34
[7] A. Mishra, Promet – Traffic&Transportation, 22 (5) (2010) 363–372
[8] J. Barjis and S. F. Wamba, Bus. Process Manag. J.,16 (3) (2010) 897–903
[9] Y. Z. Mehrjerdi, Assem. Autom. 31 (2011)251–262
[10] A. Varatharajah, “RFID System,” 2016. Available at: https://www.supinfo.com/articles/single/2317-rfid-system.
[11] D. Mcfarlane and Y. Sheffi, Int. J. Logist. Manag., 14 (1) (2003) 1–17
[12] S. G. Azevedo and H. Carvalho, Int. J. Retail Distrib. Manag., 40 (2) (2011) 128–156
[13] X. Zhu, S. K. Mukhopadhyay, and H. Kurata, J. Eng. Technol. Manag. - JET-M, 29 (1) (2012) 152–167
[14] Alien, European Retailer Throttleman Improves Supply Chain with RFID, Alien Technology, 2008.
[15] O. Ali, Improved supply chain performance through RFID technology: comparative case analysis of Metro Group and Wal-Mart, Master of Information Systems Technology, University of Wallongong, 2012.
[16] B. Srivastava, Int. J. Manuf. Technol. Manag., 21 (3-4) (2010) 289–307
[17] M. M. Ferreira and C. E. Cugnasca, Logística e RFID: Casos e aplicações, in A Gestão dos Processos de Produção e as Parcerias Globais para o Desenvolvimento Sustentável dos Sistemas Produtivos, 2013.
[18] E. Perin, Brazilian Air Force Boosts Efficiency of Its Air Logistics Center, RFID J., 1–2, 2012.