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Development of Synchronized Logistics Scenarios

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Abstract

Internal Logistics is the industrial department responsible, within an organization, for overseeing the information flow and for controlling the physical movements of materials in the warehouse, factory and between workstations. Currently the improvement of Internal Logistics processes is a key factor for delivering products to customers on time and at a competitive price. There is an increasing need for eliminating non-value added tasks and reducing operating costs. In this context, the synchronization of supply routes is very important in order to create standards and improve the use of resources. The purpose of this study is to describe the way Logistics Scenarios were developed in an industrial environment and also to show the importance of Internal Logistics.

Keywords: *Internal Logistics, Logistics Scenarios, Milk Runs, Supply Routes*

1. INTRODUCTION

The work presented in this paper was developed in a multinational industrial company, and its main objective was the creation and implementation of Synchronized Logistics Scenarios, in order to guarantee the proper flow of information and materials using logistics trains (also known as Milk Runs - MRs).

MRs are currently used in order to supply all the required materials for production, preferably at the required time thus reducing the existence of unnecessary stocks within the factory area and also in the warehouse. MRs have a great importance in the production chain of the company, since they are responsible for delivering materials from the warehouse and manufacturing sections to the final cells, at the right time and in the correct amount.

MRs usually have a standard route, with a sequence of predefined tasks for the supply of the production cell and should always respect a specific Cycle Time (time that the cell takes for each production cycle, coinciding with a supply cycle of the MR). Routes can establish connections between several places of the manufacturing area (warehouse, intermediate sections and final cells), and are performed by various MRs. The way different routes are assigned to specific MRs define a Logistical Scenario. This scenario can be determined considering that the supply for each cell is done separately or it may be built in a synchronized manner. The use of isolated routes usually leads to an underutilization of the available MRs which results in a loss in resources efficiency.

This project focused on restructuring the MRs team of an organizational area (that includes three production cells, Cell 1, Cell 2 and Cell 3) that worked without Synchronized Logistics Scenarios. The idea was to define those scenarios and, if possible, reduce the number of required MRs for the supply of material to the cells, by revising the supply routes.

The beginning of the project took place in September 2011, with the analysis of the production and respective production scenarios, and with the creation and development of a solution for synchronizing the Logistics Scenarios. It ended March 2012 with the implementation and monitoring of the results.

The paper is organized into five sections. After a brief introduction to the problem, the theoretical background is presented in Section 2. Afterwards, in Section 3, the case study is presented, first by a short characterization of the company and then by reporting, in more detail, all project stages. Then, in Section 4, some of the results are presented, including the analysis of some indicators. Finally, conclusions and an outlook on future work are presented in Section 5.

2. THEORETICAL BACKGROUND

In this section a brief explanation of the main concepts required to implement the project is presented.

2.1 **Internal Logistics and Lean**

Internal Logistics is the subarea of Logistics responsible for controlling the flows of materials and information and for all the associated support operations within the company [1]. The reception of materials (raw materials, packaging, etc.), the storage, the picking and the supply of production cells are some examples of logistical operations performed in a warehouse or factory. In fact Internal Logistics is an important area within a company since the improvements implemented in this area have an impact in other sectors, such as in Production or Quality.

Nowadays, more and more companies seek to improve and optimize the processes of Internal Logistics in order to eliminate all the tasks that do not add value to the product. For this reason, many of the principles applied in improving Internal Logistics, arise from Lean philosophy.

Courtois *et al*. [2] refer that Lean is a management philosophy focused on the reduction of the seven main reasons of waste, such as: waiting time; overproduction; excessive transportation; excessive movement; among others. In order to successfully reduce, or even eliminate, these different types of waste, Lean uses several tools, some to identify the root/causes of problems, others to solve them, and others to control processes. As shown by Holweg [3] some of the more used tools/philosophies are: Kaizen; Just In Time (JIT); Pull System; Poka Yoke; Value Stream Management; Kanban; 5S's; Total Productive Maintenance.

In order to improve the way Internal Logistics' processes are performed it is important to use several of those Lean philosophies which will help to promote on time delivery of products to costumers, at the best possible price.

Following, three Lean tools/philosophies are explained in more detail: JIT, Pull System and Kanban, since they have a strong impact on Internal Logistics.

2.1.1 *Just In Time*

One of the bases of Lean Thinking is the JIT system. According to Kumar *et al.* [4] JIT is a philosophy that includes several thematic, such as materials management, quality management, layout management, product engineering, work organization and human resource management. JIT's essence consists in working with very low levels of stock and simultaneously with high levels of quality and productivity. Therefore, JIT emphasizes the concept of 'zero': zero defects, zero queues, zero stock, zero downtime and others.

According to the JIT philosophy, a worker can only produce what is requested by the worker that follows him in the production chain, at the right moment and quantity, with the clear goal of eliminating stocks [5]. If this concept is applied to the entire supply chain, then the stocks will become zero, saving warehouse space and associated costs. In this way, the supply chain also gains in productivity, increased quality and responsiveness to external environments.

To Carvalho [6], JIT has a number of characteristics that should be clearly understood so that they can help to improve the operation of the production company:

- In the case of companies with a high variety of products, the implementation of JIT is difficult (elimination of stocks), because it would also require a great flexibility of the production system. In this case is inevitable the existence of small supermarkets strategically located in the production chain. Even so JIT allows the proper management of these supermarkets;
- The use of productive cells for families of similar products, in order to reduce movements and setup times, is recommended;
- The quality of the products (zero defects) is of utmost importance so that these flow smoothly between stations;
- There is a great emphasis on quality control at the source and reducing process times in order to gain greater flexibility.

In conclusion, JIT, despite all the associated advantages, also implies some responsibilities. For example, the concept of 'zero defects' (do it right first time) is very important, considering that repairing a defective product is almost as expensive as producing a new one. Nonetheless, JIT is quite important for businesses since it helps them to be more competitive, by providing a better service to their customers at a lower cost.

2.1.2 *Pull System*

Pull System is one of the ways to achieve a JIT production. This system considers that production should be pulled by the client and not the opposite, i.e., production orders should only be created when there is a costumer request. By opposition, in a Push system, the materials are pushed along the production chain in accordance to a production plan based on demand forecasts.

As Ahlstrom [7] explains, "the starting point of a pull production system is the client request, that is redirected to the final assembly, which in turn requests to the previous process the materials that needs, and so on successively, i.e., the client request is replicated progressively reverse of the production process".

According to Smalley [8], the Pull System arose as a response to the limitations of traditional planning systems, such as:

- Differences between what is planned and the real daily needs of the final clients;
- Excess of work in process;
- Low efficiency on the communication of the real needs to the upstream processes in the production chain.

Smalley [8] believes that the use of a Pull System has, as main objectives, the following:

- Focusing and serving the final client;

- Protecting the internal activities from demand variability;
- Planning the operation of only the final production cells;
- Allowing each process to pull from the previous one the materials they really need.

The method usually used to implement a Pull System is the Kanban card.

2.1.3 *Kanban*

Kanban is a Japanese system, developed in the 1940s, as a way to control the flow of materials, people and information, facilitating the use of a Pull System.
According to Courtois *et al.* [2], the philosophy followed by the Kanban system advocates that a certain workstation should only produce what is requested by the following workstation and so on until the final station in the supply chain, which should only produce the essential to meet customer demand.
Both Ohno [9] and Gross *et al.* [10] agree that the Kanban system is based on a simple and effective methodology to control the product flow and is used for various purposes such as inventory, production and final cells supply control. When a client, final or intermediate, uses a product, Kanban is responsible for warning the supplier that the product has to be produced in order to replenish the stock. In this manner, workstations produce only what is really needed in the correct amounts and times.
For Development Team [11], Kanban acts as an information system that integrates the entire chain, links all processes and harmoniously connects the entire flow of material with client demand. They also observe that it may be applied not only to the internal processes of an organization, but can also integrate the external suppliers and customers.
As stated by Gross *et al.* [10], using a Kanban system has several advantages:

- Improves the production flow;
- Integrates all processes connecting them to the customer;
- Eliminates the missing components problems;
- Improves the response to changes in demand;
- Smoothes the production stock fluctuations by preventing overproduction, reducing stock and minimizing the risk of obsolete inventory.

After a brief explanation of Internal Logistics and how it relates to Lean, in the next section it will be explained some more specific aspects of Supply Systems.

2.2 **Supply Systems**

It is important to discuss briefly some of the aspects of Supply Systems namely, the involved actors (the workers that operate the Milk Runs that, from this point on, are referred to as MRs), the supply locations (like supply shelves and supermarkets) and the supply routes.

2.3.1 *Milk Run*

The use of MRs is becoming more common in industries as a result of the need to move goods, information and materials between locations inside a factory. MRs are operators that perform supply routes, usually with a specific vehicle for this purpose, and are, therefore, responsible for the movement of those goods or materials [12]. These vehicles can be moved manually, where the operator pushes the cars, or by cars pegged to a motor vehicle, thereby facilitating materials circulation. The use of this new concept has led to the implementation of systems that have proved to be more efficient and economical compared to other existing methods (for example, the use of traditional stackers).
MRs have defined routes for the transport of raw materials, assembly parts/components and finished goods, moving through the production area, collecting and supplying materials. The materials are provided not only by the warehouse but also by manufacturing sections, being transported to the work areas in the final production cells. All logistics trains must have a standard route, based on a sequence of predefined tasks to supply a final production cell, respecting its Cycle Time [13].

Figure 1. Example of a logistics train

This mean of transport is usually composed by two parts. The front is a motorized vehicle, which is driven by the logistics operator, and the back is a set of logistics cars. In Figure 1 an example of a logistics train used by the MRs, is presented.
As reported by Domingo *et al.* [14], the use of these systems presents several advantages over traditional means of transport:

- Economic: savings in equipment, human resources, time and stocks.
- Production: frequency of a greater number of supplies made in smaller batches originates the reduction of stocks and production time of the material, providing a higher final output.
- Congestion: MR eliminates traffic jams because it replaces stackers in order to transfer material.

- Flexibility: this method enables an easier adaptation to changes in production.
- Quality: combined with productivity, quality is also benefited, since the logistics trains only supply reliable materials.

Supplies made by MRs can be deposited in two places, directly on the supply shelves or in the supermarkets. These two locations have different features and functions and will be discussed in the next subchapter.

2.2.2 *Supply Shelves and Supermarkets*

The supply shelf is a space to put materials, which is located in the workstation near the workers. Usually this space is prepared so that the use of material requires minimal movements by the worker. The supply shelves should have enough material to satisfy the production, while the empty boxes, collected by the MR in its last trip, are replaced by boxes with material [15]. Therefore, it becomes important to understand and establish the proper number of boxes to be used on each supply shelf. The preparation of all the parts supplied by the MR, in the right box and in the right quantity, is made in the warehouse and/or in the production sections.
Supermarkets are a way of locating materials near their point of use, namely the supply shelves [16]. They are areas similar to a supply shelf, but, are not located in the workstation itself. In the supermarkets several materials are clustered which, for various reasons (physical characteristics, difficulty repacking and other) cannot be supplied directly to a supply shelf.
Usually, the supplies made to the supermarkets include boxes with high number of parts, without a standardized number and type of box. In these cases, the MRs only delivers the boxes with materials to the supermarkets, leaving the tasks of counting and repacking to a specialized operator - POUP (Point Of Use Provider), also responsible for moving the materials from the supermarkets to the supply shelves.

2.2.3 *Supply Routes*

To create supply systems, it is important to define the type of supply routes. From a traditional point of view, routes can be chosen to supply each individual cell. However, considering a Lean point of view, synchronized routes can be adopted.
In traditional routes each MR is responsible for the supply of a cell, or part of it. Each MR is then connected to just one cell; however, one cell may have several associated MRs. The use of this type of supply system allows for a complete independence among cells. For example, if one cell stops production it does not interfere with the supply of other cells, since the MRs are independent. On the other hand, this system has an import limitation because the use of dedicated MRs leads to, in most cases, a waste of resources because the MRs' capacity is not totally used.
It was the identification of this problem and the necessity to solve it that led to the development of supply systems with synchronized routes.
Synchronized routes mean that a MR can be responsible for supplying materials to different cells. Supply tasks are divided among MRs in order to improve their usage rate thus reducing unoccupied time of the involved human resources. Its main advantage is the increase of the MRs team productivity however, it is necessary to have a greater control of the cells in order to prevent problems, considering that they might be 'linked' by the same provider (MR).

3. CASE STUDY

Four main stages were considered in the development of this study: (i) historical data gathering and analysis regarding production scenarios, (ii) definition of the potential future production scenarios, (iii) development and analysis of Logistics Scenarios, and (iv) Synchronized Logistics Scenarios implementation.
In order to contextualize the problem, a brief description of the organization where this study was developed is presented.

3.1 **Company's brief description**

The case study is an international reference in the thermotechnology market and its main products are water heaters and boilers. Due to the great differences in the characteristics of the product families, the shop floor of the company is divided into three divisions: the High Output (HO) division, whose cells are dedicated to the production of boilers; the Confort division, whose cells are dedicated to the production of water heaters; and the Manufacture division, that is responsible for the intermediate production for the other two divisions. In Figure 2, it is possible to see the factory layout.
The shop floor has, therefore, two divisions dedicated to the assembly of finished goods: HO (in light orange) and Confort (in blue); and one dedicated to the intermediate production, Manufacture (in green), which is composed by the intermediate product sections, the final production cells for components; and by the kits area (responsible for the spare parts required by each product). The factory has other two important areas: the Warehouse for purchased goods and the Buffer where finished goods are held.

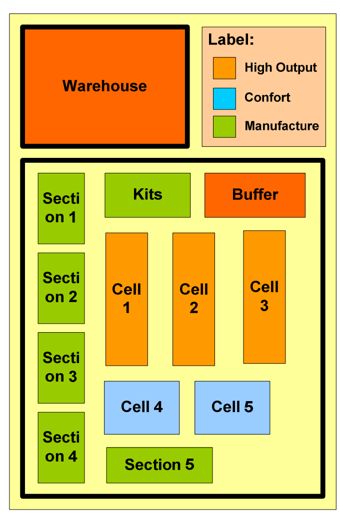

Figure 2. Factory's shop floor

The need to redefine the standards, for the supply routes to the final cells of the HO division, was identified, and so the project was developed in this division, for its three cells.

While all the cells produce the same product family, each one produces different product subtypes, based on the difficulty in execution and speed of assembly for each product. Therefore, Cell 1 (C1) produces the easiest products with a production lot of 16 units; Cell 2 (C2) produces products of moderate difficulty and has a production lot of 15 units; and products which are more difficult to produce are reserved to Cell 3 (C3), which has a production lot of only 10 units.

This is crucial information for the HO's MRs team, because they must supply each cell taking into account the respective Cycle Time, in order to avoid stopping production and also to respect the lead times promised to clients. Each cell has its own associated MRs, responsible for supplying all the necessary materials for production in that cell. These materials are brought from three distinct places: warehouse, sections and kits. The MRs are also responsible for delivering finished goods to the buffer. In this sense the MRs for each cell have three main routes:

- Warehouse route – responsible for collecting the necessary materials in the warehouse and for delivering them to the production cell;
- Sections route – responsible for gathering the required materials in the production sections and for delivering them to the production cell;
- Kits route – responsible for collecting the kits and for delivering them to the production cell.

The finished goods route is always included in one of these three routes, depending on which MR has more available time for that task.

The number of MRs needed for these routes depends on the production cells' technical capacities and, consequently, on its Cycle Time. In 2011, with a production variation between 88 and 256 units/shift, C1 needed one or two associated MRs; C2, with a production variation between 110 and 270 units/shift, needed two or three MRs; and C3, with a production variation between 20 and 60 units/shift, needed only one MR.

The MRs supply system was determined on a cell by cell basis, without the synchronization of Logistics Scenarios. That supply system meant that each MR was dedicated to just one cell.

For example, in HO, for the more usual level of production in 2011 (256 units in C1, 110 in C2 and 40 in C3), six MRs were needed to make the routes shown in Figure 3.

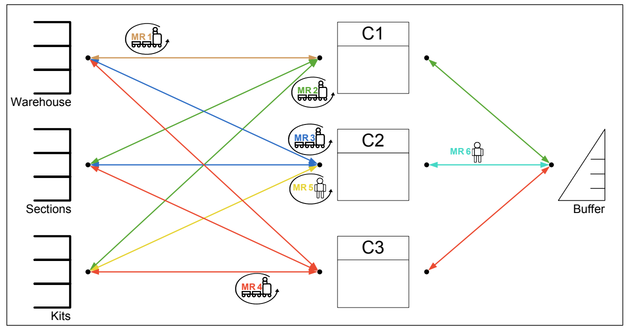

Figure 3. Supply routes of the HO MRs for the most usual scenario in 2011

By observing Figure 3 it is evident that each MR did not execute routes to different cells. For example, MR5 performed only the kits route of C2, not performing any other route, even though there was available time for that MR.

In addition to this limitation of this supply system, it was also possible to identify other differences between MRs. For example, there were MRs who used logistics trains, such as MR1, MR2, MR3 and MR4, but some of them performed the routes on foot, as was the case of MR5 and MR6. Another negative aspect is related to the absence of standard routes (shown, in Figure 3, with a circular arrow) for all MRs, such as MR6, who did not have standard tasks, which led to constant support requests to other MRs.

After the analysis of the situation it was clear that the absence of Synchronized Logistics Scenarios contributed to a series of inefficiencies in the supply system. It was, at that time, decided to proceed with the project to develop Synchronized Logistics Scenarios for the three HO cells, in order to standardize all MRs routes, but also to improve the usage rate of the available resources.

The following section describes the first phase of the project.

3.2 Historical data gathering and analysis regarding production scenarios

In order to understand the scenarios used by the HO production, historical data was collected and used to determine which production scenarios were more frequent in 2011. Based on the resulting information it was possible to determine which production scenarios had a higher probability of being used in 2012.

Information of every week of the year 2011 was collected and analyzed in two different ways. In a first instance, data regarding the scenarios used in 2011 for each cell, separating the information for each production shift, was analyzed.

For the second analysis, the data concerning the scenarios used in 2011 in each cell was also used, but only the days with two production shifts were considered. In this way it was possible to compare both analysis and verify if there was any substantial difference in the results.

This process was applied to all the HO cells (three cells of different dimensions) but, in order to exemplify the results, only one cell is used: Cell 1, and the results obtained for that cell are presented in Table 1.

Table 1. Scenarios used in 2011 in Cell 1 (shifts analyzed separately)

Cell 1 – Year 2011			
Scenarios	Number of days		
	Shift 1	Shift 2	
248	133	45	178
208	10	17	27
168	13	64	77
128	23	22	45
88	0	18	18
Total:	179	166	345

Table 1 shows that Cell 1 worked in two shifts, totaling 345 shifts, using 5 different scenarios. The scenario of 248 units/shift was the most used (52% of the time), followed by the scenarios 168 and 128 units/shift.

Table 2 presents the results of the second analysis made to Cell 1.

Table 2. Scenarios used in 2011 in Cell 1 (in the days both shifts were used)

Cell 1 – Year 2011							
Scenarios		Shift 2					Total Shift 1
		248	208	168	128	88	
Shift 1	248	29	12	53	13	9	116
	208		5	5			10
	168			4		9	13
	128				9		9
	88						
Total Shift 2		29	17	62	22	18	

Again, it can be concluded that the most common scenario was 248 units/shift.

After collecting and analyzing the historical data it was possible to continue to the second stage of the study, the definition of potential future production scenarios, presented in the following section.

3.3 Definition of the potential future production scenarios

This is a crucial step in the study because it is essential to determine realistic production scenarios so that they are consistent with the real production needs. Also, because the time horizon considered is long, the scenarios must be carefully determined.

Therefore, for the creation of potential future production scenarios, two important types of information were taken into account: on one hand, the history of the scenarios used in 2011, and on the other, the production forecast of the cells for the year 2012. This was used to determine the maximum production capacity of the cells. In Table 3 the information regarding the history of the scenarios used in 2011, is presented.

Table 3. Scenarios more frequently used in 2011 in Cell 1, Cell 2 and Cell 3

Cells	Scenarios
1	248
	168
	128
2	160
	210
	270
3	40
	20
	50

In Table 4 it is possible to see the maximum production planned for 2012.

Table 4. Maximum production of the HO cells for 2012

Cells	Maximum Production
1	256
2	129
3	30

There were also some restrictions regarding the planned production: the second shift output should be approximately half the first shift output, and the production of Cell 3 should be entirely finished in the first shift.

Considering all the information, it was decided to use two potential scenarios for Cell 1 and Cell 2 and three for Cell 3, as shown in Table 5.

Table 5. Production forecast of the HO cells for 2012

Cells	Scenarios
1	256
	98
2	129
	65
3	30
	15
	0

To complete the analysis, considering not only the historical data but also the forecasts, two final production scenarios for 2012 were determined, as seen in Table 6.

Table 6. Main potential production scenarios

Scenarios	Cells		
	1	2	3
A	256	129	30
B	98	65	0

These two scenarios were selected because it was considered that with them it would be possible to satisfy the production needs. The idea is to use, in most days, scenario A on the first shift and scenario B on the second shift. The next stage of the study was the development of the new Logistics Scenarios.

3.4 Development and analysis of Logistics Scenarios

For the study of the Logistics Scenarios it was essential to understand what were the requirements in terms of supplies. This was crucial information in order to determine the best way of assigning tasks to the MRs.

With this in mind, the information was gathered considering various Cycle Times and different times for each supply route of the three cells. It was then developed a MRs tasks chart, for the several production scenarios. Consequently, it was then possible to determine the minimum number of MRs needed for the supplies, using Synchronized Logistics Scenarios, as shown in Figure 4, for scenario A.

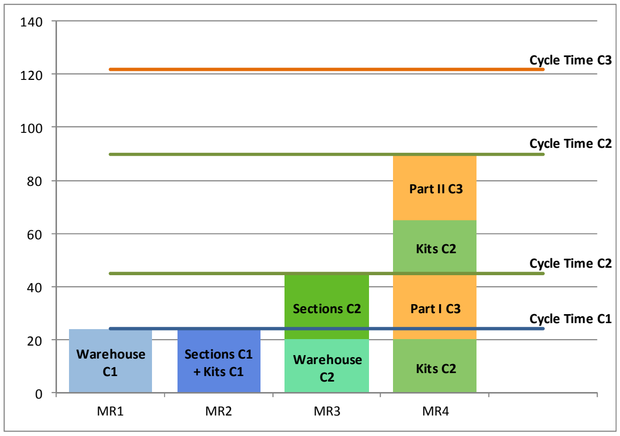

Figure 4. MRs tasks chart for scenario A

With the analysis of the chart in Figure 4, it is noticeable that all MRs comply with the Cycle Times of the cells. It is also evident that, in order to supply the HO cells at their maximum capacity, it takes four MRs.

It was however possible to develop Synchronized Logistics Scenarios, by synchronizing Cell 2 with Cell 3, as is shown in Figure 5.

After the development and analysis of all the new Logistics Scenarios, these were, then, simulated using the software Rockwell - Arena©, as a way to validate the results obtained so far. The simulation models also served as a way to evaluate the behavior of the production system by considering the variability in the supply times.

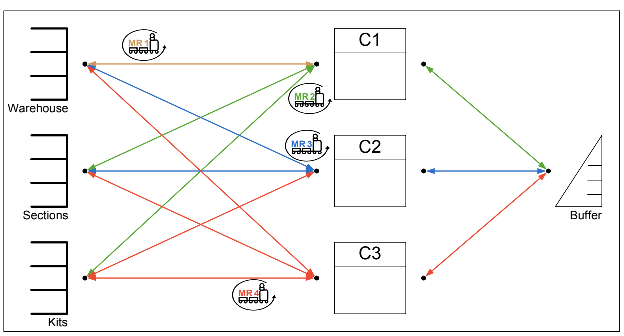

Figure 5. Supply routes of the HO MRs for scenario A

After this stage the new scenarios were implemented, as described in the following section.

3.5 Synchronized Logistics Scenarios implementation

From the analysis of the MRs tasks charts it was possible to establish the number of required MRs for each scenario and, at the beginning of 2012, the implementation of the different Synchronized Logistics Scenarios started.

After the implementation of the new scenarios a constant monitoring of the MRs routes was performed in order to understand if they could carry out the new routes at the required times. The daily average of route times, obtained for each MR, was then calculated and analyzed using bar charts.

By way of example, Figure 6 shows the results obtained by MR1 in scenario A.

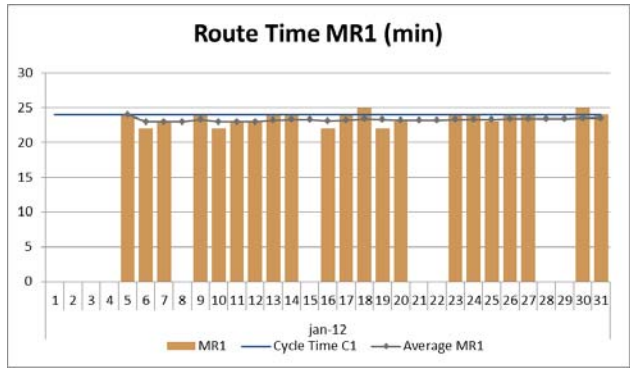

Figure 6. Average times for MR1 route for scenario A

With the analysis of the chart in Figure 6, it is evident that MR1 complies with the proposed route time 90% of the days and is below the cell Cycle Time in 43% of the occasions.

The monitoring of the MRs took place for about a month and the results obtained were very satisfactory, since all MRs were able to execute their routes within the stipulated times and the main results are presented in the next section.

4. RESULTS

The last stage of this study comprised a comparison between the new scenarios with identical scenarios existing previously, in order to quantify the obtained improvements.

In order to do this, two indicators were analyzed: the first one compares the ratio of equipments supplied by MR, obtained by dividing the total number of appliances supplied by the total number of MRs; and the second indicator calculates the average usage rate of MRs in the scenarios.

Scenario A was compared with an identical scenario used before the implementation of the project, called 'scenario X1' (production of 248 units in the Cell 1, 110 in the Cell 2 and 30 in the Cell 3). Table 7 shows the obtained result, regarding the first indicator, with the respective comparison.

Table 7. Scenario A versus scenario X1

Information	Scenario X1	Scenario A
Number of equipments	388	415
Number of MRs	6	4
Nr equipments / MRs	64.67	103.75

The results obtained in the two scenarios show that scenario A is much better since it supplies a greater number of equipment, with a smaller number of MRs.

The use of the new scenario represents a difference of 39.08 units supplied by MR, which corresponds to an increase of 60.43% in the ratio value.

As for the second indicator, the results from Arena© were used. Data gathered with the simulation of the new scenarios was used to compare the average usage rate of the MRs in scenario X1 and in scenario A. Table 8 shows the results for both scenarios.

Table 8. MRs usage rate

Scenario X1		Scenario A	
Milk Run	Usage rate	Milk Run	Usage rate
MR1	89.30%	MR1	88.13%
MR2	70.70%	MR2	88.30%
MR3	74.42%	MR3	94.27%
MR4	31.40%	MR4 (Cell 2)	49.64%
MR5	37.21%	MR5 (Cell 3)	34.75%
MR6	9.30%		
Average	52.06%	Average	88.77%

The previous scenario X1 has a lower usage rate for each MR, and, naturally, a much lower average usage rate of MRs. With the new implemented scenario, an increase in usage of around 36% is expected.

The indicators were analyzed for all the new scenarios and they consistently performed better than the previous solutions.

Regarding the number of MRs required before and after the project, the results are summarized in the Table 9. It is noticeable that, in all cases, there was a reduction in the number of required MRs in order to obtain the same output level.

Table 9. Synchronized Logistics Scenarios

Logistics Scenarios			Number of Milk Runs			
C1	C2	C3	Before	After	Savings	% Savings
256	129	30	6	4	2	33%
256	129	15	6	4	2	33%
256	129	0	5	4	1	20%
256	65	30	5	4	1	20%
256	65	15	5	3	2	40%
256	65	0	4	3	1	25%
98	129	30	5	3	2	40%
98	129	15	5	3	2	40%
98	129	0	4	3	1	25%
98	65	30	4	3	1	25%
98	65	15	4	2	2	50%
98	65	0	3	2	1	33%

A comparative analysis, for each scenario, between what existed and what started to exist, reveals significant improvements in the evaluated indicators. For example, in the case of scenario A, by comparison with the previous similar scenario (scenario X1), the value of the first indicator improved 60.43% and the usage rate increased from 52% to 89%, with a reduction in the number of MRs by 33% (four to six).

5. CONCLUSIONS AND FUTURE WORK

The project carried out had, as main goal, the creation of Synchronized Logistics Scenarios in order to reduce the resources spent in supply tasks. With the implementation of the new solutions a significant improvement, regarding the number of MRs necessary to supply the three cells, was obtained. Before the implementation of the project, the team of MRs needed six elements to carry out the routes and, with its implementation, the team was reduced to four elements, corresponding to a 33% decrease in its dimension.

Additionally, these improvements and the reorganization of the work contributed to a more balanced occupation of the MRs as well as a higher usage rate of the elements that remained in the team.

With respect to other future process improvements, there are two projects that can be studied and eventually implemented, possibly bringing to the team considerable savings, in terms of the number of required MRs, and in terms of efficiency of the team. Firstly, since the times of the warehouse and sections routes of Cell 1 are identical, there is a possibility of doubling the supply cycle (32 units) in order to achieve further reductions in the number of MRs. Secondly, the possibility of grouping the supply to the cells according to the supplier could also be studied. This would mean that a MR would be responsible for all the supplies from the warehouse to all of the cells, another for the supplies from the sections and another to supply the kits. Naturally these changes would have to be thoroughly analyzed because, although they may lead to reducing the number of MRs, they could have some negative impacts that should be assessed (like, for example, increase in the size of the logistics trains).

It would also be of great interest to expand this type of study to other areas of the factory, since it was proven that the use of Synchronized Logistics Scenarios has a positive impact on the system's performance.

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Razvoj sinhronizovanih logističkih scenarija

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Rezime

Interna logistika je industrijski departman koji je odgovoran, unutar organizacije, za nadzor protoka informacija i za kontrolu fizičkog pomeranja materijala u skladištu, fabrici i među radnim stanicama. Trenutno, poboljšanje procesa interne logistike predstavlja ključni faktor isporuke proizvoda potrošačima na vreme i po konkurentskoj ceni. Postoji sve veća potreba za eliminisanje zadataka koji ne donose vrednost i smanjenje operativnih troškova. U ovom kontekstu, sinhronizacija maršuta nabavke je veoma važna kako bi se stvorili standardi i poboljšalo korišćenje resursa. Svrha ove studije je da se opiše način na koji se logistički scenariji razvijaju u industrijskom okruženju, kao i da se pokaže značaj interne logistike.

***Ključne reči**: interna logistika, logistički scenariji, protoci mleka, maršute nabavke*