**Universidade de Aveiro** Departamento de Economia, Gestão, Engenharia Industrial e Turismo
**2018**

**MARIA BEATRIZ MATOS**

# INVENTÁRIO GERIDO PELO FORNECEDOR PARA UMA CADEIA DE ABASTECIMENTO MAIS ÁGIL: UMA APLICAÇÃO PRÁTICA NA INDÚSTRIA

# VENDOR-MANAGED INVENTORY FOR A MORE AGILE SUPPLY CHAIN: AN APPLICATION IN THE INDUSTRIAL SECTOR

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Relatório de Projeto apresentado à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizado sob a orientação científica da Professora Doutora Ana Raquel Reis Couto Xambre, Professora Auxiliar do Departamento de Economia, Gestão, Engenharia Industrial e Turismo da Universidade de Aveiro.

*Keep curious. Keep Smart.*

**o júri**

presidente

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**palavras-chave**

Inventário gerido pelo fornecedor, cadeia de abastecimento ágil, gestão de materiais

**resumo**

Ao longo dos últimos anos, as empresas procuram soluções para inovar os seus produtos e serviços para responder à elevada exigência do mercado. No mundo VUCA, caracterizado pela volatilidade, incerteza, complexidade e ambiguidade da procura, ter uma cadeia de abastecimento ágil e colaborativa é essencial para maximizar a satisfação do cliente e reduzir os custos. Neste contexto, as empresas devem criar parcerias fortes e sincronizar os seus processos através da partilha de informação em tempo real.

Este projeto resulta da necessidade de melhorar a ferramenta de inventário gerido pelo fornecedor (VMI), uma plataforma *online* de troca de informação para gestão de inventário, na Bosch Termotecnologia em Aveiro. Embora a Bosch Aveiro tenha implementado a ferramenta de VMI há 3 anos, não existe nenhum guia para a parametrização da ferramenta. Assim, a ferramenta é reflexo do conhecimento técnico e prático dos seus utilizadores: planeadores e fornecedores. É de frisar que tanto os planeadores como os fornecedores estão conscientes do risco de excesso ou rutura de stock dos componentes neste tipo de planeamento.

Em conjunto com os utilizadores da ferramenta de VMI, foi feita uma atividade de resolução de problemas com recurso ao Diagrama de Ishikawa onde foram identificadas as principais causas de rutura e excesso de stock. Em seguida, estas foram priorizadas e foi decidido analisar em detalhe os parâmetros de VMI (o *lead-time*, o período e os limites mínimo e máximo) uma vez que foi considerada a principal causa de falha. Depois de várias experiências e estudos para melhorar a ferramenta de VMI, uma nova abordagem foi desenvolvida. O modelo proposto para a definição dos parâmetros de VMI considera, não só o consumo e o tempo de reabastecimento (à semelhança do modelo atual), mas também a flutuação da procura desses componentes.

No modelo proposto, os componentes foram divididos em quatro categorias (*runners*, *repeaters, low cost items* e *exotics*) de acordo com o seu comportamento e, para cada grupo, foram calculados os limites de cobertura ótimos. O projeto clarificou a importância de cada componente para a empresa o que permitirá uma tomada de decisão mais rápida e assertiva.

Para a Bosch Aveiro, este projeto resultou num *standard* para a parametrização das peças em VMI e cinco *best pratices*. Espera-se que a implementação do modelo proposto reduza o risco de rutura de stock, assim como o tempo de análise das peças em VMI, e também ajude a controlar o excesso de stock. Para além disso, este estudo evidenciou a importância da definição de *clusters* na gestão do inventário; portanto o próximo passo será analisar os componentes geridos nos outros dois tipos de planeamento (*push* e *pull*) de acordo com as quatro categorias definidas (*runners*, *repeaters, low cost items* e *exotics*).

**keywords**

Vendor-Managed Inventory, agile supply chain, materials management

**abstract**

Over the last years, industrial companies are looking for solutions to innovate their products and processes because of the high market demand. In the VUCA world, characterized by volatility, uncertainty, complexity, and ambiguity of the market demand, having an agile and collaborative supply chain is crucial to maximize customer satisfaction and achieve cost efficiency. In this context, companies must build strong partnerships and synchronize their processes by sharing information in real time.

This project resulted from the need of improving the Vendor-Managed Inventory (VMI) system, an online platform of electronic data interchange for inventory management, at Bosch Thermotechnology in Aveiro. Although Bosch Aveiro has been working with the VMI tool for 3 years, no guide is available about the operation of the tool, which means that the VMI tool is parameterized according to the know-how of the VMI users: material planners and suppliers. Furthermore, VMI users are aware of the possibility of excess or stock out of components in this type of planning.

Working closer to VMI users, a problem-solving activity was done through an Ishikawa Diagram where the root causes of failure were identified. Then, those causes were prioritized and it was decided to analyse in detail VMI parameters (lead-time, period, minimum and maximum limits) since they were considered the main cause of failure. After several experiences and studies to improve the inventory management in the VMI tool, a new approach was developed. The proposed model for defining VMI parameters considers not only the annual value of consumption and the replenishment time (as done in the current model), but also the fluctuation in demand of those components.

As a result of this work, the components were divided into four categories (runners, repeaters, low-cost items, and exotics) according to their behaviour (annual consumption value versus fluctuation) and, for each group, the coverage limits of stock were calculated. This study provided transparency about the importance of each component for the organization which enables quicker decisions.

For Bosch Aveiro, this project results in a standard to parameterize the VMI tool and five best practices. In addition, it is expected that the implementation of the proposed model will reduce the risk of stock out and the time spend on managing components in the VMI tool as well as control the components with an excess of stock. In addition, this study highlighted the importance of clustering the components in inventory management, so the next step will be the analysis of components managed by the other two material planning systems (push and pull) according to the four categories (runners, repeaters, low-cost items, and exotics).

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# 1. Introduction

The first chapter summarizes the contents of this project through a brief explanation of the current situation lived in the company and in the market. Within the logistics department, the main challenge of this work was to improve the Vendor-Managed Inventory (VMI) tool, so a specific methodology was defined.

## 1.1 Aim and Motivation

Due to the increase in market demand and customer requirements, the 21st Century has been challenging for companies. Offering quality products at the best price is not enough, being the company of the year is not enough, having innovative solutions is not enough. We are living in the VUCA World characterized by volatility, uncertainty, complexity, and ambiguity of market demand. Therefore, for a company to be competitive, it must focus on flexible processes that will help it in offering a high level of customer service at the lowest cost. In this way, having an agile and collaborative supply chain can have a big impact on response time to market and contribute to an efficient resources management (Packowski, 2013).

This project was developed in the logistics department of Bosch Aveiro, an essential link of key elements in the supply chain: customer, production, and supplier. In Bosch Aveiro, several projects have been developed in order to improve the use of the available resources and the agility of the supply chain, such as the implementation of Vendor-Managed Inventory (VMI) and Advance Shipping Notification (ASN) systems. Both concepts are based on sharing data in real time between Bosch Aveiro and its suppliers. The VMI tool allows sharing information about production needs and ASN is a digital delivery note.

The focus of the project is the VMI system that, currently, manages 29% of items, which represent 16% of annual consumption value in Bosch Aveiro. Since 2016, it was implemented in 14 national suppliers, of which 6 suppliers were implemented last year and the turned over was a 12-hour gain per week. Although the configuration of the VMI tool is crucial for achieving a high performance of the supply chain efficiency, in two years the standard had not been updated even though VMI users' experience shows that there is potential for improvement. In this context, an opportunity to improve the current model of VMI tool arose through the design of a new standard with VMI users' support that reflects the current situation.

The improvement of the VMI standard at Bosch can contribute to a wider range of companies. In the industrial sector, the concern with having a competitive advantage in the market is evident and the model developed can be implemented in companies with a high variety of components and materials within a seasonal business. Improving VMI tool becomes crucial to react faster to market fluctuations and thereby be agile in a VUCA World.

## 1.2 Methodology

Using the double loop design proposed by Pijl *et al*. (2016), the purpose of this project is to validate a new stock management approach for a VMI system that can be replicated under similar conditions.

> *"Design is a disciplined approach to searching, identifying and capturing value."*
>
> (Pijl, Lokitz, & Solomon, 2016)

According to Pijl *et al*. (2016), the double loop design is ideally used to deal with ambiguous environments and it is characterized by being a continuous and interactive tool. Over years, leaders, entrepreneurs, and innovators all around the world have been testing the double loop design process in different environments characterized by uncertainty. They agree that every project, product, company, change, or idea starts with a point of view. Therefore, it should be the basis for exploring new approaches to the current business model and promote change (Pijl, Lokitz, & Solomon, 2016).

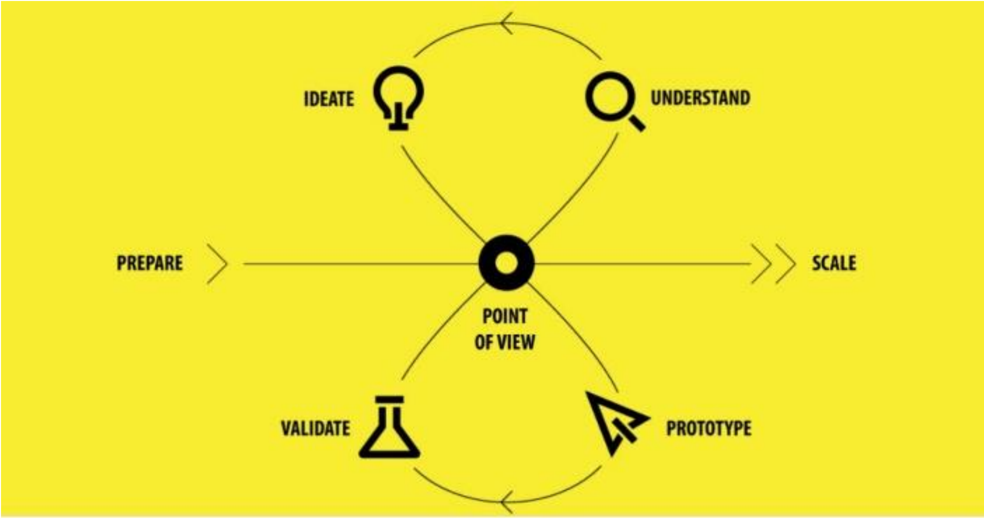



**Figure 1 - The Double Loop Design (Pijl, Lokitz, & Solomon, 2016)**

This tool has seven basic elements, as it is shown in figure 1, that helps designers to evaluate the potential of their ideas in a VUCA World; therefore, in this work, it will support the case study. Step by step, the idea of taking into account the fluctuation of components in materials management was developed, from the understanding of the current paradigm of Bosch Thermotechnology in Aveiro until the validation of the proposed framework.

In order to achieve more specific results, this project was done in two phases as it is shown in the chronogram (figure 2). The first part was focused on research and company integration and the second on the analysis and understanding of the impact of the proposed framework.

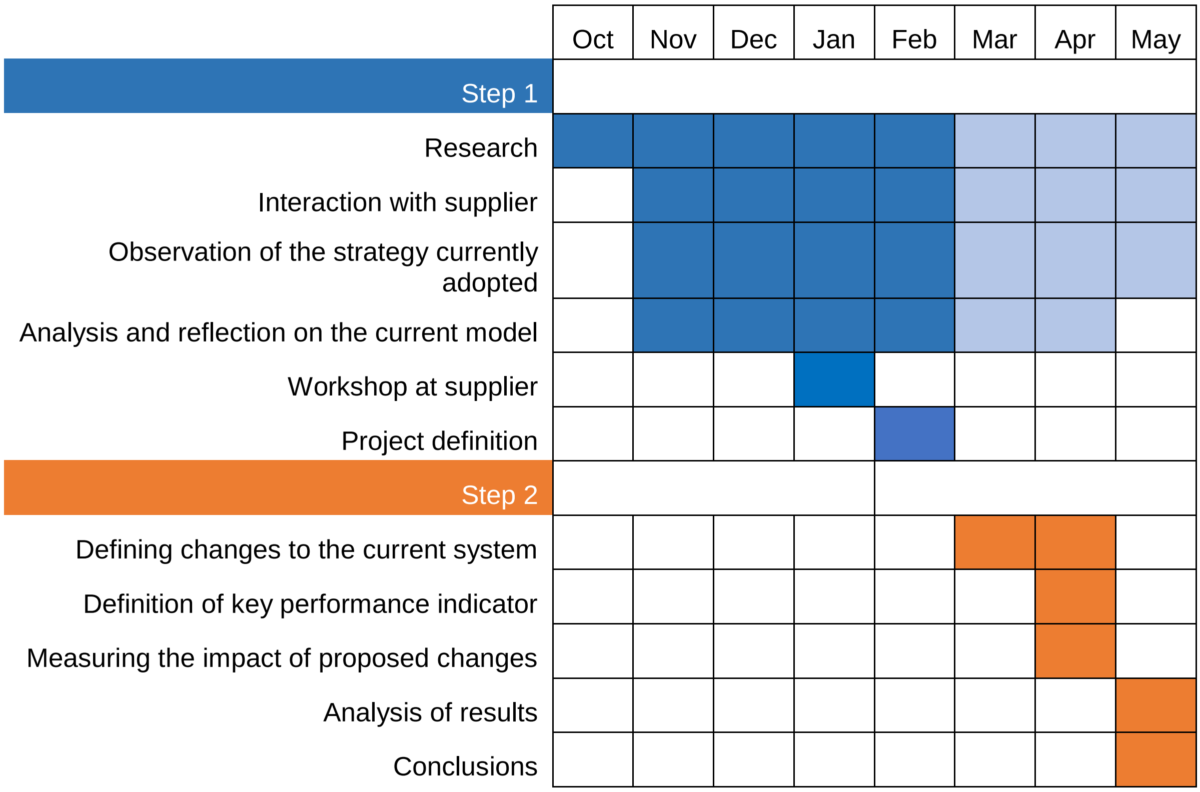



**Figure 2 - Project's Chronogram**

### 1.3 Structure of the report

In this chapter, the first section gives a brief overview of the current market situation and its main challenges, as well as the motivation for this case study; then, the methodology is presented; and, in the last section, the structure of this report is described.

Chapter 2 examines the basis for understanding the topic discussed so the main concepts are explored and analysed, always supported by literature review.

Chapter 3 links the theoretical concepts to the actual situation by presenting the case study developed in Bosch Thermotechnology in Aveiro.

Chapter 4 is dedicated to the conclusion, academic contributions, and further research. The limitations of this case study are also presented.

# 2. Theoretical Framework

This chapter exposes the essential theoretical concepts for understanding the purpose of this work. First, the importance of having a flexible supply chain to gain market share through the improvement of materials management process is highlighted. Then, selective inventory control, consumption fluctuation and material planning methods are explained in detail because the models behind these concepts are used in the case study.

## 2.1 Materials Management

Nowadays, companies are facing a demand from their clients that is characterized by high levels of service and quality. Due to this fact, to keep operating in the current marketplace, companies should redesign their standards in order to react faster to market needs. The ability to respond to market needs with the right product, in the right quantities, at the right time, at a reasonable cost, is known as agility and it is the main ingredient to a successful supply chain (Carvalho, et al., 2012) (figure 3).

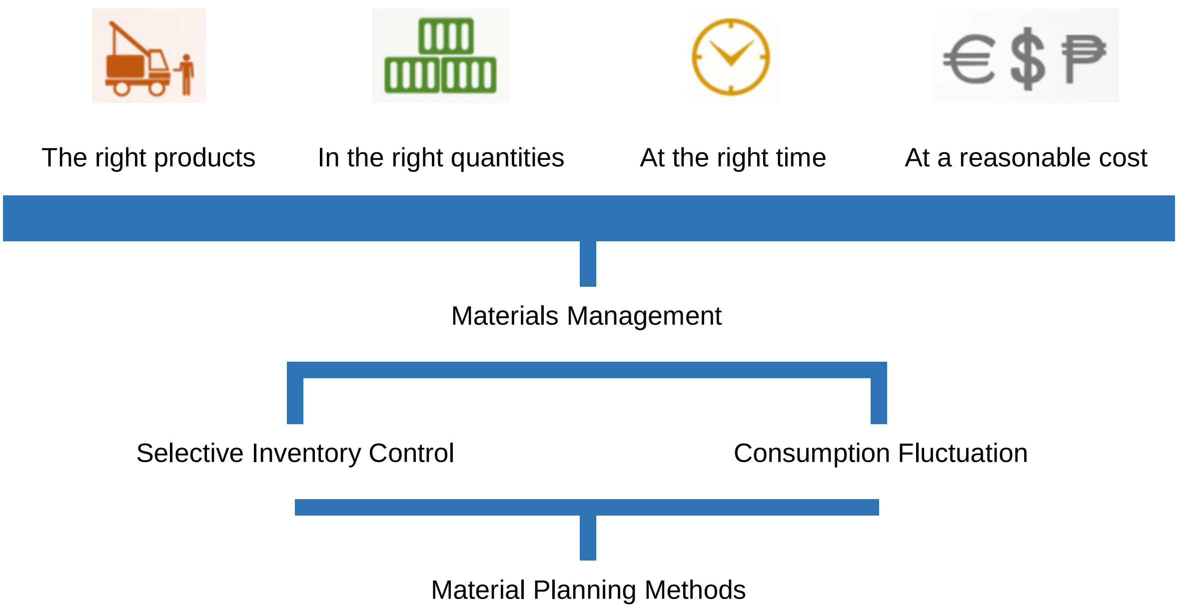



**Figure 3 - How to achieve an agile supply chain**

According to Arnold (2000), materials management is the business function responsible for the flow of materials, from supplier to consumer, for which maximizing the right utilization of the company's resources and providing a high level of customer service are the main goals.

Materials management can also be defined as an integrated process of managing the entire need, materials' flow, costs, and information that includes planning and controlling (Materials Management, 2017).

This activity would be simple and easy to do if we were operating with highly non-customized products. For example, at the beginning of the 20th Century, Ford Motor Company launched a new concept of production – mass production – by producing one single model in their factory. This allowed them to focus on value-added activities and have a single team dedicated to a product and customer segment exclusively. All cars manufactured were similar in most aspects, including colour – black. This would be the perfect world for assessing the inventory (Alizona, Shooter, & Simpson, 2009). However, throughout time, customer demand has been changing and personalized products are needed. Nowadays, one single factory is pressured to offer a range of different products with high quality, targeted at different customer segments, at the lowest cost (Decubber, 2016).

Working in a complex market, materials planners have to guarantee the availability of components for production at a reasonable cost. They should be able to order the right quantities at the right time. When placing an order is required, the material planner needs information about (Carvalho, et al., 2012):

- Quantity needed for production;
- Stock level;
- Open orders;
- Replenishment time.

Several stock management models have been developed and tested to reduce inventory cost. Each material has a certain importance for the organization so each material should be planned according to a specific model. By identifying the relevant materials for production, the organization can improve its performance (Carvalho, et al., 2012). To help in materials planning methods, there are some tools that can be used such as:

- ABC Analysis;
- XYZ Analysis.

### 2.1.1 Selective Inventory Control: ABC Analysis

According to Carvalho *et al*. (2012), ABC Classification is a ranking system for organizing items by volume or value of consumption. It helps the company to achieve business goals and should be aligned with company strategy.

ABC analysis is a method based on Pareto Principle, also known as the 80/20 rule, in which inventory is divided into three categories (Carvalho, et al., 2012):

- A items: 20% of the items that account for 80% of annual consumption volume or value;
- B items: 30% of the items that account for 15% of annual consumption volume or value;
- C items: 50% of the items that account for 5% of annual consumption volume or value.

The chart below (figure 4) shows ABC classification.

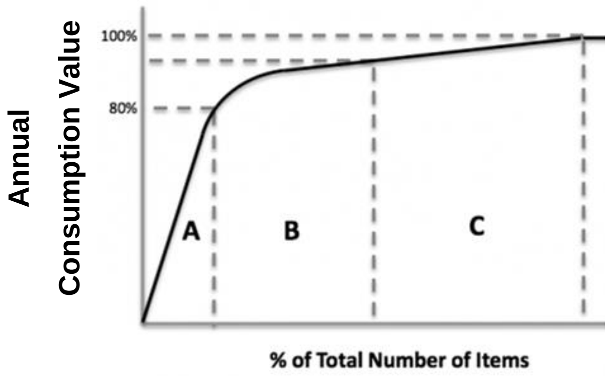



**Figure 4 - ABC Chart. Adapted from Fritsch (2014)**

According to Carvalho *et al*. (2012), A items are materials with high consumption value; therefore, frequent analysis is required. The material planner should be focus on this type of items since they have a higher financial impact on the organization. In parallel, B and C items represent a large number of items with lower consumption value so its control is less restricted. In this context, ABC classification helps the material planner to identify which items should be analysed in detail and to define the right coverage stock for each component.

### 2.1.2 Consumption Fluctuation: XYZ Analysis

ABC analysis is often combined with XYZ analysis because it adds a new dimension to inventory management. The analysis of consumption fluctuation of the items allows a deeper understanding of each item since it also takes into account the variability of its demand. In XYZ analysis, materials are classified into three categories (Scholz-Reiter, Heger, Meinecke, & Bergmann, 2011):

- X items: low fluctuation of consumption;
- Y items: high fluctuation of consumption;
- Z items: very high fluctuation of consumption.

The charts below (figure 5) illustrate the behaviour of the different categories explained:


**Figure 5 - XYZ Analysis (Cost Transformation Model, 2016)**

Based on the Coefficient of Variation (CV), Scholz-Reiter *et al*. (2012) determine XYZ Classification of each item (table 1). This statistics measure is defined as the ratio between the standard deviation ($\sigma$) and the mean ($\mu$) of the consumption of each item, and it is shown below (1):

$$CV = \frac{\sigma}{\mu} \qquad (1)$$

**Table 1 - XYZ Classification (Scholz-Reiter, Heger, Meinecke, & Bergmann, 2011)**

| ***Classification*** | **CV Value** | **Type** |
|---|---|---|
| *X* | CV < 0,5 | Low consumption fluctuation |
| *Y* | 0,5 ≤ CV ≤ 1 | High consumption fluctuation |
| *Z* | CV > 1 | Very high consumption fluctuation |

### 2.1.3 Materials Management

A combination of ABC and XYZ approaches can be used to define the best stock management strategy for each group because it takes into account both consumption value and demand volatility (table 2) (Pandya & Thakkar, 2016).

**Table 2 - ABC XYZ Classification (Cost Transformation Model, 2016)**

| | X | Y | Z |
|---|---|---|---|
| **A** | **AX Class**<br>· High consumption value<br>· Stable demand<br>· Reliable forecasts | **AY Class**<br>· High consumption value<br>· Predictably and variable demand<br>· Less reliable forecasts | **AZ Class**<br>· High consumption value<br>· Sporadic and variable demand<br>· Forecasting unreliable or impossible |
| **B** | **BX Class**<br>· Medium consumption value<br>· Stable demand<br>· Reliable forecasts | **BY Class**<br>· Medium consumption value<br>· Predictably and variable demand<br>· Less reliable forecasts | **BZ Class**<br>· Medium consumption value<br>· Sporadic and variable demand<br>· Forecasting unreliable or impossible |
| **C** | **CX Class**<br>· Low consumption value<br>· Stable demand<br>· Reliable forecasts | **CY Class**<br>· Low consumption value<br>· Predictably and variable demand<br>· Less reliable forecasts | **CZ Class**<br>· Low consumption value<br>· Sporadic and variable demand<br>· Forecasting unreliable or impossible |

The more accurate the forecast is, the easier it is to manage the stock. It means that if the forecast is reliable and the demand is stable, stocks can be low. In the industrial business, each component has its behaviour of consumption, so material planners should be able to handle in diverse ways those different types (Pandya & Thakkar, 2016).

On one hand, companies could avoid stock out by maintaining high inventory level. The main benefits of this policy are (Cost Transformation Model, 2016):

- Elimination of emergency replenishment;
- More flexible production;
- Less dependency on suppliers;
- Higher customer satisfaction.

On the other hand, the costs involved should be weighted as well (Cost Transformation Model, 2016):

- More storage space, human resources, and equipment are needed;
- Higher insurance costs due to the higher value at risk of loss;
- More fixed costs.

The costs, risks, and benefits of stock holding should be discussed by the departments directly involved such as production management, procurement, and customer service in order to set an inventory management strategy across the organization (table 3). Inventory management policy may include (Cost Transformation Model, 2016):

- The degree of automation of replenishment processes;
- Buffer stocks size;
- Inventory control frequency.

**Table 3 - Inventory Management Policy (Cost Transformation Model, 2016)**

| | X | Y | Z |
|---|---|---|---|
| **A** | **AX Class**<br>· Automated replenishment<br>· Low buffer – Just in time or consignments transfers the responsibility for security supply<br>· Perpetual inventory | **AY Class**<br>· Automated with manual intervention<br>· Low buffer – accept stock out risk<br>· Perpetual inventory | **AZ Class**<br>· Buy to order<br>· No buffer – customer understands lead time<br>· Not stocked |
| **B** | **BX Class**<br>· Automated replenishment<br>· Low buffer – accept stock out risk<br>· Periodic count; medium security | **BY Class**<br>· Automated with manual intervention<br>· Manually adjust buffer for seasonality<br>· Periodic count; medium security | **BZ Class**<br>· Buy to order<br>· No buffer – customer understands lead time<br>· Not stocked |
| **C** | **CX Class**<br>· Automated replenishment<br>· High buffer – safety first<br>· Free stock or periodic estimation by inspection or weighing; low security | **CY Class**<br>· Automated replenishment<br>· High buffer – safety first<br>· Free stock or periodic estimation by inspection or weighing; low security | **CZ Class**<br>· Buy to order<br>· No buffer – customer understands lead time<br>· Free stock or periodic estimation by inspection or weighing; low security |

In the procurement department, material planners define the most appropriate system for ordering parts depending on the components consumption value and fluctuation (Cost Transformation Model, 2016).

## 2.2 Material Planning Methods

According to the standard of material planning methods at Bosch Aveiro, items with very high fluctuation (Z items) are managed using a push system. This is a more traditional system based on forecasts. It is commonly used to manage items with unpredictable behaviour and its orders are placed manually. Pull and Vendor-Managed Inventory (VMI) systems are based on demand, therefore they are recommended for items with more stable consumption (X and Y items). The main difference between pull and VMI is how orders are processed. In a pull system, orders are placed automatically but, in VMI system, the supplier decides the quantity to be delivered (table 4).

**Table 4 - Materials Planning Methods at Bosch Aveiro**

| | **X** | **Y** | **Z** |
|---|---|---|---|
| **A** | Pull/VMI | Pull/VMI | Push |
| **B** | Pull/VMI | Pull/VMI | Push |
| **C** | Pull/VMI | Pull/VMI | Push |

Adapted from Monteiro (2012), the three systems of materials planning methods were summarised in table 5. In that work, push and pull systems were discussed in detail in terms of objective, production model, production orders, supply chain flow and stock quantities. Within this design, VMI system characteristics were now added to the original table.

**Table 5 - Characteristics of Materials Planning Methods. Adapted from (Monteiro, 2012)**

| | Push system | Pull system | VMI system |
|---|---|---|---|
| *Type* | More traditional | Lean thinking | Supplier's thrust (partnership) |
| *Aim* | Production maximization | Production optimization | Supply chain optimization |
| *Production Model* | Production to stock | Production of customers' needs | Production of customers' needs |
| *Production Orders* | Based on forecasts | Based on demand | Based on demand on time |
| *Supply Chain Flow* | Isolated processes | Synchronised processes internally | Synchronised processes internally and externally |
| *Stock Quantities* | Very high | Low | Low |

The overview above allows a better understanding of the three material planning methods used by companies nowadays and its impact.

## 2.3 VMI Applications

Although VMI system has been implementing in several companies and industries, the case studies analysed only show the general impact. Nonetheless, two examples (Papyrus Sweden and Schneider Electric) were chosen in order to sum up the benefits of VMI system.

Bellina *et. al* (2013) analysed the advantages and the impact of implementation of VMI system in Papyrus Sweden, a distributor of paper and printing solutions, with more than 500,000 customers in 19 countries (Papyrus, 2018). The results were summarized in table 6.

**Table 6 – Advantage and Impact of VMI System in Papyrus Sweden**

**(Bellina, Bodins, Krieger, & Olivier, 2013)**

| Advantages | Impact |
|---|---|
| Decrease stock | Decrease 60% of stock value |
| More efficiency in the supply chain | Suppliers saved 50% travel shifting |
| Decrease the coverage in days | Before VMI, the coverage was between 16 to 36 days and after the implementation was 10 to 11 days |
| More accurate lead time | Better supplier service level |
| Deliver optimization since the supplier decide when which items and which quantities should be delivered | More efficiency product mix<br>Optimization – full truckloads deliveries |

The second example of VMI application is Schneider Electric. Schneider offers integrated energy solution in more than 100 countries (Schneider, 2018) According to Lionel (2010), in 2005, the company did a pilot test but, due to the high investment in tools and resources, the company had decided to not implement on a larger scale. In 2007, Lionel designed a simplified solution to industrialize VMI system in Schneider and, then, he analysed the impact of the VMI system for Schneider and distributors. In the top of the list were a stock coverage reduction, automation of non-value added activities, close work with suppliers, decrease the waste in transportation and the number of carton box used to transport the goods.

## 3. Case Study

This chapter links the literature review to the current situation lived at the logistics department of Bosch Thermotechnology at Aveiro. The case study was supported by the double loop methodology. It started with *prepare* through the company and team integration; then, 3 cycles of *point of view*, *understanding*, and *ideate* were done due to the complexity of the topic; then, *prototyping* and *validation* of the proposed model; and, finally, the application of the model to other suppliers at Bosch Aveiro (figure 6).

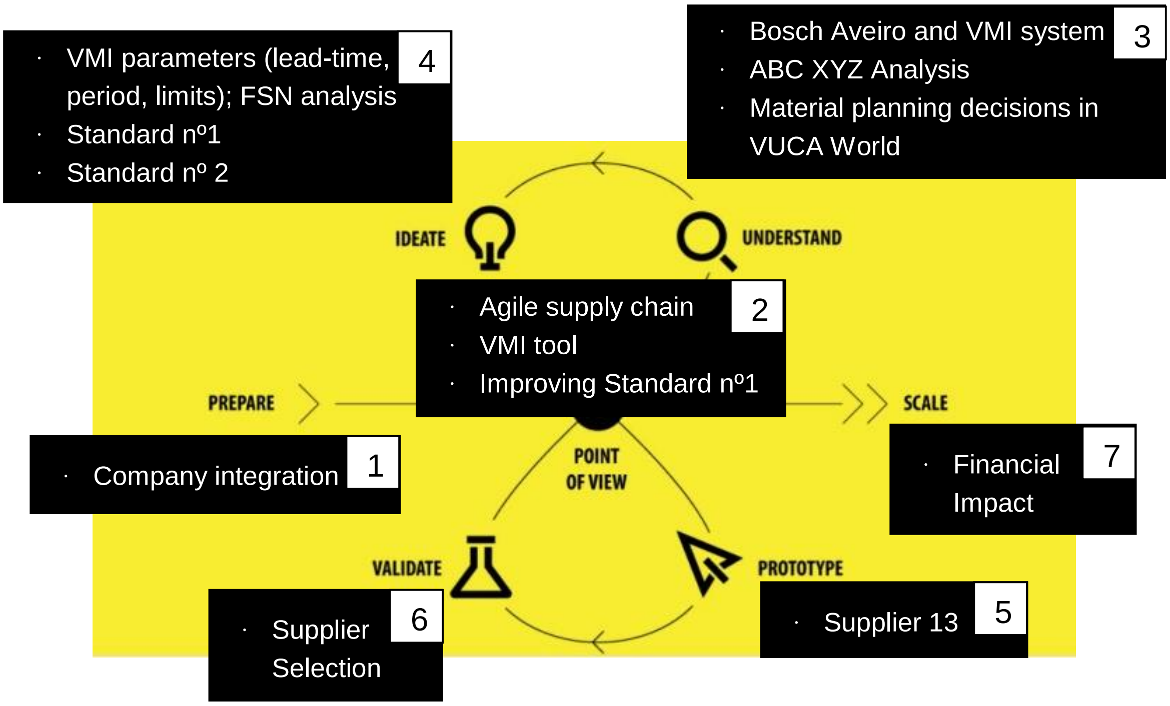



**Figure 6 - Double Loop Design application**

## 3.1 Prepare

The first step of the double loop design is *prepare*. Pijl *et al*. (2016) state that regardless of the project's aim, preparation is key. During this stage, the individual should integrate a team, prepare the working environment and look for tools that could help the team solve the problem.

> *"You must prepare to observe and understand your customers, business, and context. You must prepare to ideate, prototype, and validate."*
>
> (Pijl, Lokitz, & Solomon, 2016)

Related to this project, there was a one-month preparation before the work with suppliers started. During that month, it was possible to get to know each element of the team where the project took place, share experiences, observe meetings, integrate their processes and routines, learn how they work as a team and participate in the whiteboard every morning.

## 3.2 Point of View: agile supply chain

To have a competitive advantage in the market, Bosch Aveiro should eliminate non-value added activities and costs that are associated with it. In the logistics department, stock level is a key performance indicator that is controlled every day. In this context, finding innovative solutions for inventory management becomes imperative.

After researching the topic in detail, it was evident that the VMI system could contribute to a more agile supply chain. VMI strategy highlights the just in time system in which internal and external processes are synchronised, always focused on the improvement of the supply chain. In the VMI system, the supplier is responsible for delivering the material into the buyer’s warehouse at the right time; therefore, the material planner does not need to order the components. Instead, the material planner must control that the deliveries meet the production needs and they are within the limits defined previously with the supplier. Because of this policy, the time needed for managing the components is lower, as well as the quantity of material in stock.

At that time, the VMI system was already implemented in Bosch Aveiro with reliable daily suppliers but, even so, some components had stock out and others excess of stock. How could this situation be improved?

## 3.3 Understand: Bosch Aveiro and VMI System

From a point of view to an idea, it is important to understand the context and the business where the situation occurs.

### 3.3.1 Logistics @ Bosch

Bosch Group

Robert Bosch GmbH is a multinational company focused on offering engineering and electronics solutions to the customer. Throughout 130 years, it has invested in different business areas, and it has become a leading global supplier of technology and service (Bosch, Our History, 2017).

In 2016, the four business sectors (mobility solutions, industrial technology, consumer goods, and energy and building technology) represented 73.1 billion euros in sales revenue. From these, 7 billion euros were spent on research and development. Nowadays, Bosch employs more than 390 000 associates in over 450 subsidiaries located in 60 countries (Bosch, Our Figures, 2017).

Bosch Thermotechnology in Aveiro

The Bosch Thermotechnology division is leader in the development and production of heating and hot water equipment by offering highly innovative solutions (Bosch, History, 2017).


**Figure 7 - Bosch Thermotechnology in Aveiro (Vulcano, 2017)**

In Portugal, Vulcano was founded in Aveiro as a result of a licensing agreement with Robert Bosch in 1977. A few years later, in 1988, Vulcano was acquired by the Bosch Group and, nowadays, it is the world's competence centre for hot water solutions in the Thermotechnology sector of Bosch.

**Figure 8 - Water Heater Sensor Connect (Esquentador Sensor Connect, 2017)**

With roughly 1 100 employees working in the production of boilers, heat pumps and water heaters, Bosch will have invested 25 million Euros by 2020 in the second building exclusively dedicated to research and innovation (figure 7) (A Bosch em Aveiro, 2017).

In 2016, Bosch Aveiro launched the first water heater remote controlled through a tablet or a smartphone (figure 8). Sensor Connect won the Green Project Awards 2016 and the Innovation Awards in Construction 2017 in the "equipment" category (Vulcano, 2017).

Logistics Department

The success of the organization is the result of the effort of all the employees working in the various departments. The logistics department (LOG), specifically, guarantees an efficient material and information flows, always focused on customer satisfaction (figure 9).

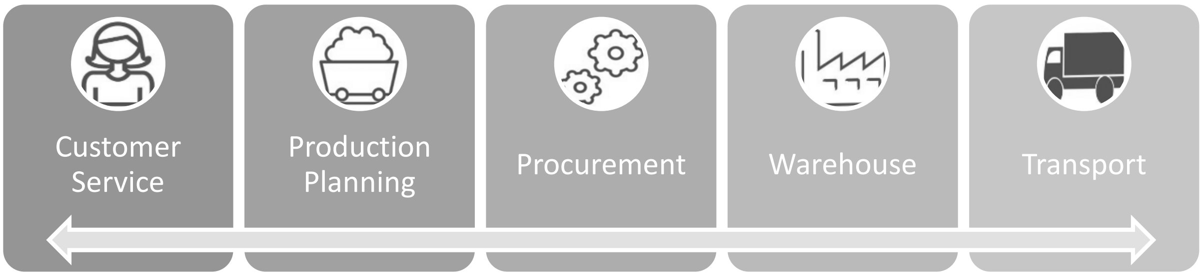



**Figure 9 - Logistics' Flow**

In Bosch Aveiro, this department is divided into five teams with different tasks as illustrated in figure 10. LOG1 receives the orders and manages the stock of finished goods. Then, LOG-PL plans the production aligned with the factory's productive capacity. After that, LOG2 orders the quantity needed for production from the suppliers and LOG3 arranges the transport. LOG3 also guarantees the transport of the products from the final warehouse to the customers. Concurrently, LOG9 is responsible for the continuous improvement of logistics' processes.

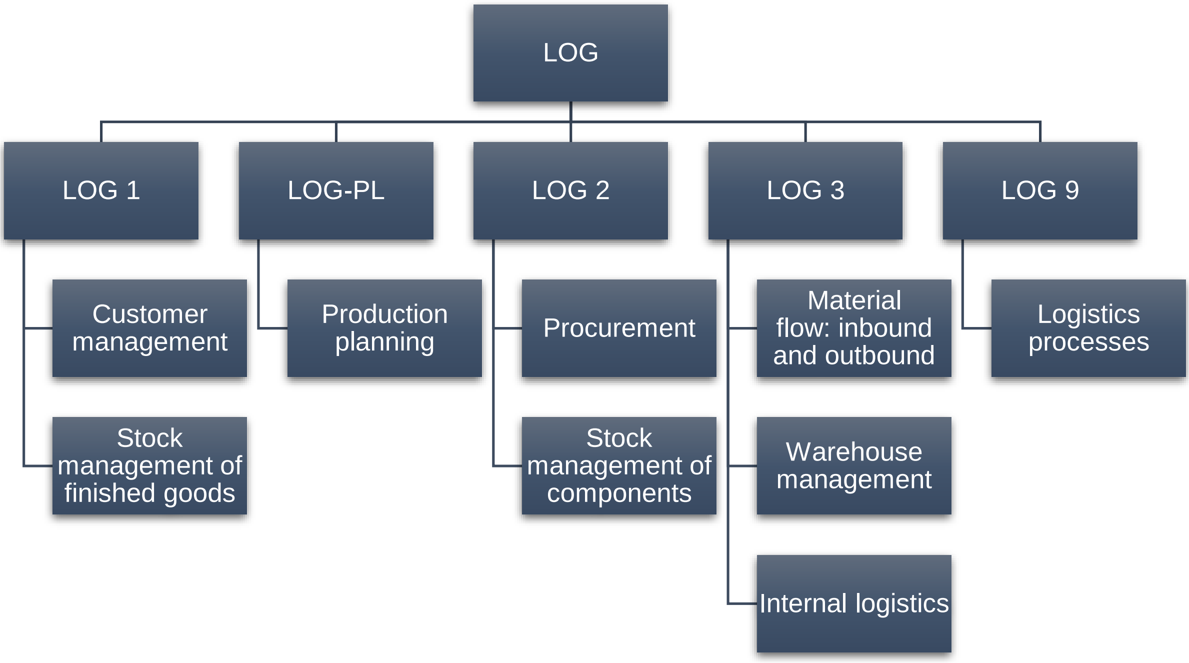



**Figure 10 - Logistics Department Organigram**

The work described in this report was supported by the LOG2 team. This team, responsible for procurement and stock management of raw material and purchased components, is composed of eight professionals that work daily to ensure that the material needed for production is available at the minimum cost. Each material planner is responsible for ordering goods from specific suppliers according to the production planning and supported by material planning methods: push, pull or VMI systems.

### 3.3.2 VMI @ Bosch Aveiro

In Bosch Aveiro, the VMI system is working through an online platform where suppliers can access real-time demand of Bosch production. Currently, the VMI system is only working for national suppliers with daily deliveries, but Bosch Aveiro wants to implement it for suppliers with weekly deliveries as well.

Nowadays, material planners are facing the problem of excess or out of stock of components in the VMI system. In order to improve the current situation, it is crucial to understand the VMI tool parameters, the initial state and the main causes of failure.

VMI Tool Parameters

The VMI tool offers a set of options to parametrize each component: lead-time, period, minimum and maximum, as it is shown in figure 11.

Within a seasonal business as the production at Bosch Aveiro[1], the moving average allows for a better performance of the VMI tool because defining minimum and maximum quantities become dynamic and follow the seasonality of the products (Hammer, 2014).

[1] Although, only production volume of 2017 was available (appendix A), expertises in the field guarantee that Bosch Aveiro works in a seasonal business.

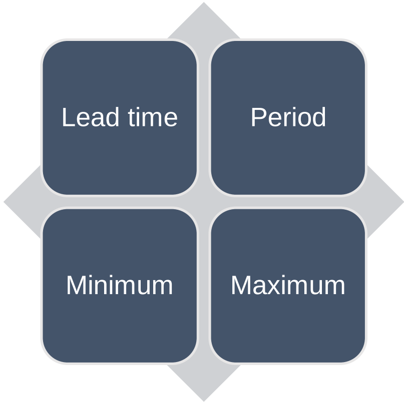



**Figure 11 - VMI Tool Parameters**

According to Packowski (2013), the lead-time is the total time since the order to the delivery. In the VMI tool, it is a frozen period agreed with the supplier.

The period is the forecast horizon used to calculate the moving average (2). Therefore, it depends on the forecast accuracy of internal production.

$$Moving\ average\ (qty) = \frac{\Sigma\ Needs\ (qty)}{Period\ (days)} \tag{2}$$

The minimum (3) and maximum (4) are the limits of stock agreed with the supplier for each component. To calculate the minimum and the maximum stock, the VMI tool multiples the average of needs (2) by the coverage limits using the minimum and maximum values of coverage days that are defined, respectively.

$$minimum\ (qty) = moving\ average\ (qty) x\ minimum\ (coverage\ days) \tag{3}$$

$$maximum\ (qty) = moving\ average\ (qty) x\ maximum\ (coverage\ days) \tag{4}$$

Initial State

Currently, Bosch Aveiro is working with more than 1300 references, of 14 daily suppliers, in the VMI system through an online platform that provides the needs for production, in real time, to VMI users: material planners and suppliers (figure 12).

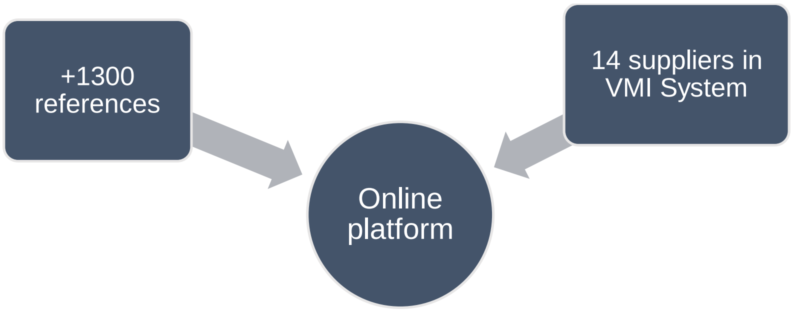



**Figure 12 - VMI features in Bosch Aveiro**

In the beginning, VMI parameters were set according to the annual value of consumption (ABC classification) as the standard shown in table 7.

**Table 7 - Basic parameter setting on VMI tool @ Bosch Aveiro**

<table>
<tr><th>Type</th><th>Minimum (coverage days)</th><th>Maximum (coverage days)</th><th>Period (days)</th><th>Lead time (hours)</th></tr>
<tr><td>A/B</td><td>3</td><td>4</td><td>7</td><td rowspan="2">Variable</td></tr>
<tr><td>C</td><td>7</td><td>10</td><td>7</td></tr>
</table>

Through time, parameters have been adjusted according to VMI users' knowledge and experience but no standard was created to update the information (table 8).

**Table 8 - Current VMI Parameters per supplier[2]**

| | | | Type A/B | | | | Type C | | | | Low cost items | | | | Without Class | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Supplier | LT | Nr | Nr | Min | Max | P | Nr | Min | Max | P | Nr | Min | Max | P | Nr | Min | Max | P |
| 1 | 1h/24h | 54 | 10 | 4 | 7 | 7 | 41 | 4-7 | 7-10 | 7 | 0 | - | - | - | 3 | 4 | 7 | 7 |
| 2 | 24h | 69 | 0 | - | - | - | 0 | - | - | - | 68 | 3-7 | 6-10 | 5 a 7 | 1 | 3 | 4 | 7 |
| 3 | 24h | 210 | 0 | - | - | - | 0 | - | - | - | 190 | 4-7 | 7-10 | 4-7 | 20 | 4-7 | 7-10 | 7 |
| 4 | 24h | 69 | 1 | 3 | 4 | 7 | 1 | 4 | 7 | 7 | 67 | 4-7 | 7-10 | 7 | 0 | - | - | - |
| 5 | 24h | 130 | 10 | 2 | 3 | 7 | 49 | 3-7 | 6-10 | 7 | 50 | 3-7 | 6-10 | 7 | 21 | 3-7 | 4-10 | 7 |
| 6 | 1h/24h | 214 | 4 | 2-3 | 3-4 | 7 | 27 | 4-7 | 7-10 | 4-7 | 167 | 3-7 | 4-10 | 4-7 | 16 | 4-7 | 5-10 | 5-7 |
| 7 | 24h | 32 | 13 | 3 | 4 | 7 | 12 | 3-5 | 6-10 | 7 | 3 | 3-4 | 6-7 | 7 | 4 | 3-7 | 4-10 | 7 |
| 8 | 24h | 58 | 0 | - | - | - | 0 | - | - | - | 50 | 3-15 | 6-20 | 7 | 8 | 4-7 | 7-10 | 7 |
| 9 | 24h | 97 | 45 | 3-10 | 4-12 | 7 | 52 | 7-10 | 10-12 | 7 | 0 | - | - | - | 0 | - | - | - |
| 10 | 24h | 4 | 0 | - | - | - | 4 | 5 | 10 | 7 | 0 | - | - | - | 0 | - | - | - |
| 11 | 24h | 23 | 10 | 1-2 | 2-3 | 5 | 13 | 1-3 | 2-4 | 4- 5 | 0 | - | - | - | 0 | - | - | - |
| 12 | 24h | 105 | 23 | 2-3 | 3-4 | 4-5 | 12 | 4-7 | 7-10 | 5-28 | 64 | 3-7 | 6-10 | 4-28 | 6 | 3-7 | 4-10 | 5-7 |
| 13 | 1h | 211 | 90 | 3-10 | 7-15 | 7 | 120 | 5 | 7-10 | 28 | 0 | - | - | - | 1 | 3 | 7 | 7 |
| 14 | 24h | 28 | 1 | 2 | 3 | 7 | 2 | 5 | 10 | 7 | 24 | 4-7 | 7-10 | 7 | 1 | 4 | 7 | 7 |
| Total | | 1304 | 207 | | | | 333 | | | | 683 | | | | 81 | | | |

## Cause-Effect Diagram

In order to identify root causes of the excess or out of stock of components in the VMI system, a Cause-Effect Diagram, also known as Ishikawa Diagram, was developed. Ishikawa Diagram is a simple analysis tool that can support brainstorming sessions and help to organise the information regarding the causes of a particular problem (Ilie & Ciocoiu, 2010).

First, the Ishikawa Diagram was done for out of stock due to its importance for the production. For example, if a stock out situation occurs, the production would stop and Bosch Aveiro loses sales. After that, the causes for the excess of stock were identified and most of them were similar; therefore, only one Ishikawa Diagram was designed. The diagram below (figure 13) outlines the three main causes: VMI tool, supplier, and internal processes at Bosch Aveiro.

[2] Legend: LT – lead-time; Nr – number of references; Min – lower limit; Max – upper limit; P - period

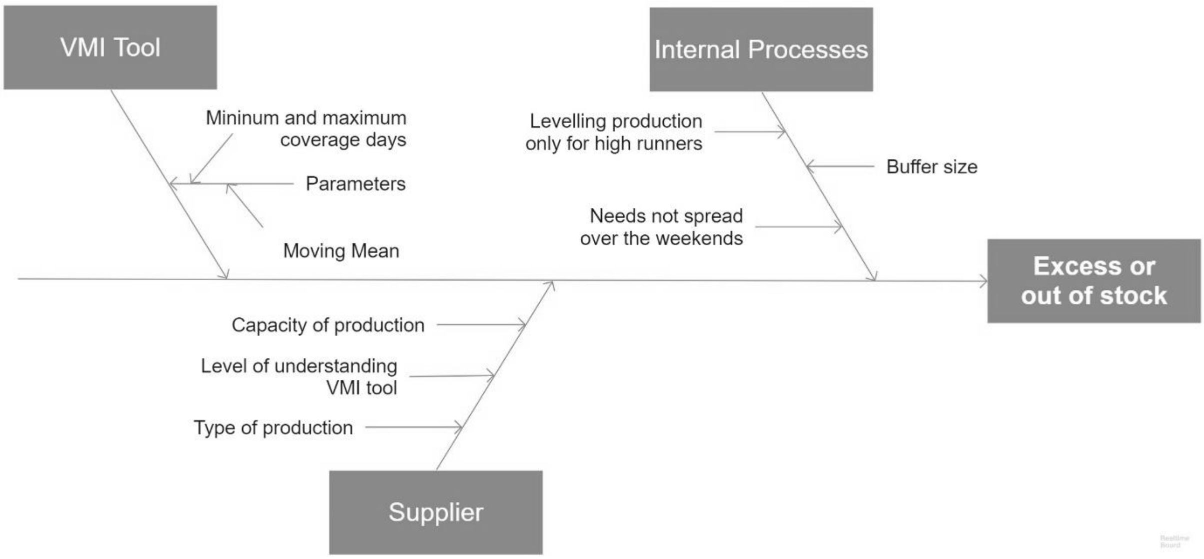



**Figure 13 - Ishikawa Diagram for VMI Problem**

The VMI tool is an online platform parametrized by VMI users. This platform is highly customized and, for each component, the material planner has to indicate the lead-time, period and the limits (minimum and maximum) in coverage days. Combining this information with the forecasts, the VMI tool suggests the quantity that should be delivered by the supplier. Therefore, if the tool is not parameterized correctly, it can lead to an excess or out of stock of raw materials in this system.

From the supplier side, the lack of capacity to respond quickly to variations in demand or the misunderstanding of the information given by the VMI tool can lead to an excess or out of stock situation. Another factor that can have an impact on the quantity delivered is the type of production in the supplier. If the supplier has a just in time system implemented or produces material with a high level of rejection in the quality department, the possibility of failing the deliver within the VMI system is higher than with the push system.

Regarding internal processes at Bosch Aveiro, there are several causes identified. First, the leveling of production in Bosch Aveiro is only available for runners (products with a high volume of consumption, high order frequency and low fluctuation of consumption) but the VMI tool is applied to all components. Second, the size of the buffer should be defined according to components' need. Big size buffers mean a lower possibility of stock out but it also means more inventory costs for the organization. Third, the production needs of Fridays, Saturdays, and Sundays are only divided on Thursday. Therefore, on the days before, the supplier delivers more quantity than the actual needs because the quantity needed is higher in the system than in reality. For example, on Thursday, a supplier exported data from the VMI tool as it is shown in table 9. For a specific component, the production needs scheduled on Thursday to Friday were 2200 units but, in fact, the demand for Friday was only 1200 units and the remaining quantity was needed for the weekend production: 600 units on Saturday and 400 units on Sunday. Currently, the supplier only got this information on Friday, which means that on Friday, stock of components can be above the maximum but it is known and acceptable for both parts.

**Table 9 - Communication of needs to supplier**

| | | **Date of need** | | | |
|---|---|---|---|---|---|
| | | Thursday (day x) | Friday (day x+1) | Saturday (day x+2) | Sunday (day x+3) |
| **Communication date** | Friday (day x+1) | - | 1200 units | 600 units | 400 units |
| | Thursday (day x) | 1500 units | 2200 units | 0 units | 0 units |

From all the causes identified, this project focused on the parametrization of the VMI tool because of its potential contribution to achieving an agile and flexible supply chain at Bosch Aveiro.

### 3.4 Ideate: VMI tool

In order to improve the VMI tool, VMI users were involved:

- A brainstorming session was done with the material planners;
- A workshop at the supplier's facilities was done;
- Two suppliers were inquired about VMI operation.

From the ideate session, a proposed model has risen to improve the VMI tool. Currently, the VMI tool is parameterized according to the annual consumption value (ABC classification), the replenishment time and VMI users' knowledge. In the proposed model, the fluctuation of components (XYZ analysis) was added to the main feature in order to reflect the VMI users' knowledge in the VMI tool. Moreover, material planners highlighted the importance of identifying components as runners, repeaters or exotics to manage the inventory (figure 14). This classification will be explained in detail later on (section 3.9.2. ABC XYZ analysis: runners, repeaters, exotics) but, basically:

- runners are components with high consumption and low fluctuation;
- repeaters are components with medium consumption and medium fluctuation;
- exotics are components with low consumption and high fluctuation.

Material planners were already familiar with this concept because, nowadays, the classification runners, repeaters and exotics is applied to characterize finish goods at Bosch Aveiro.

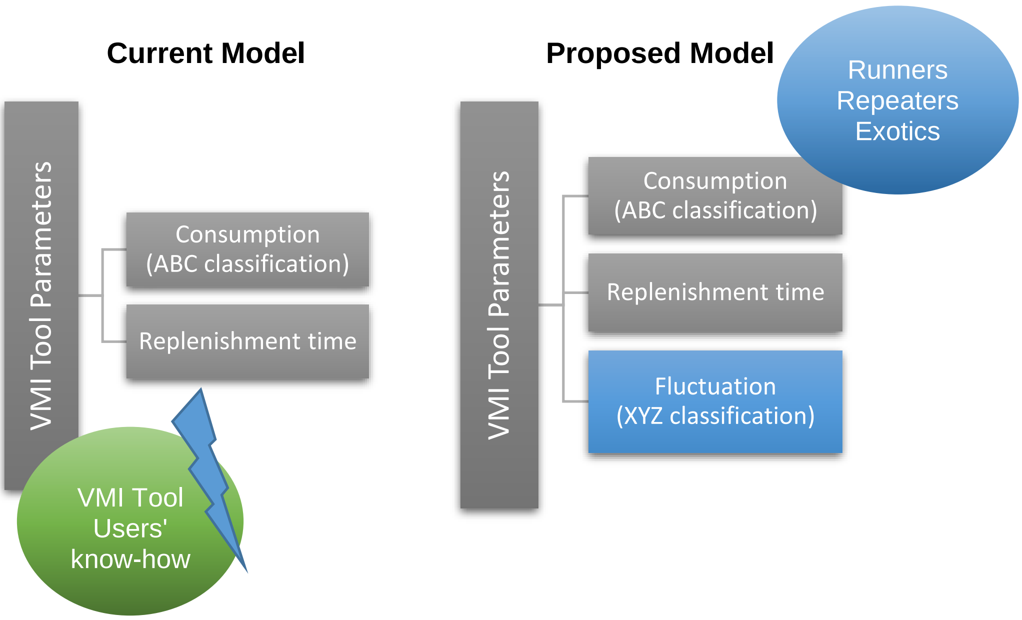



**Figure 14 - Current versus Proposed Models**

To design a new model, VMI tool parameters were analysed in detail.

### 3.4.1 VMI tool parameters

<u>Lead-time</u>

The lead-time (in hours) is the average required time for order processing, manufacturing, quality control, transportation and inbound handling (Packowski, 2013) (figure 15).

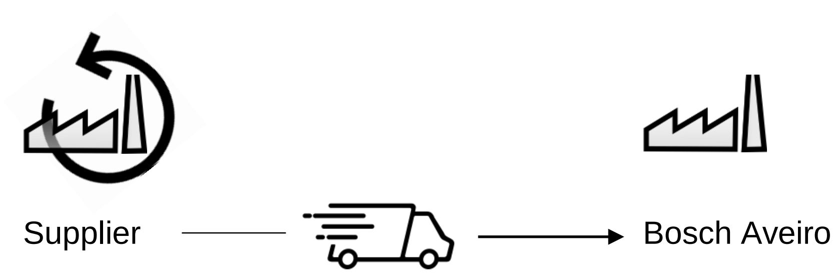



**Figure 15 - Lead-Time feature**

Therefore, the lead-time can be different depending on the component. According to VMI users, components that integrate exotic products can have a higher lead-time than standard components and the organization is aware of the risk of a higher lead-time for exotic products although, currently, lead-time is defined per supplier and not per component.

<u>Period</u>

The period (in days) would determine the risk associated with the forecast accuracy and how scattered are the peaks of needs in relation to the average. Since the peaks of needs would be analysed in the XYZ classification by categorising items according to their fluctuation and assigning them specific coverage limits, the period will then focus only on the forecast accuracy.

In Bosch Aveiro, the production is frozen every Tuesday until Sunday of the following week. Therefore, on Tuesday 1, the material planners have 12 days of accurate forecast but on Wednesday of week 1 only 11 days would have an accurate forecast. If 12 days were considered for the period on the VMI tool, the data would not be reliable because the 12 days of period would include production that would not be frozen, since the period would be based on the moving average (as explained in section 3.3.2). In this context, in the best case, it would be considered 12 days for the period and, in the worst case, 5 days of accurate forecast; therefore, it is suggested the use of 5 days to parametrize the period in the VMI tool (figure 16).

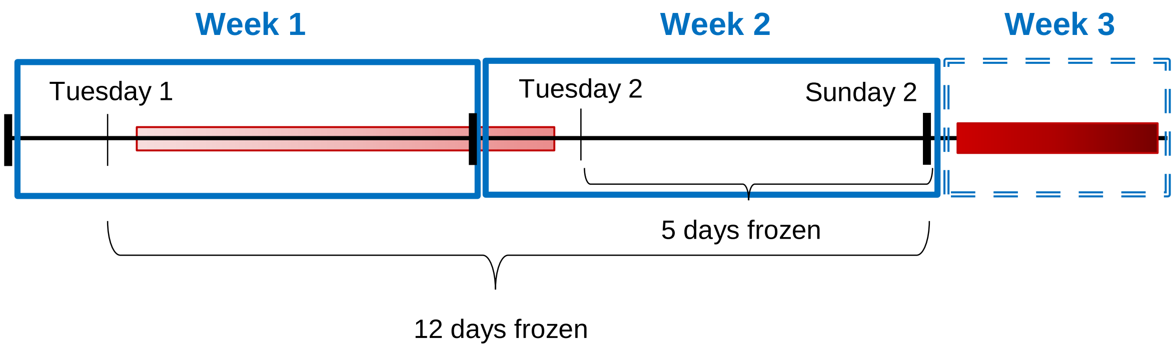



**Figure 16 - Frozen Period**

The main disadvantage of the 5-day period is the higher impact of a new consumption value on the limits' target. It could be solved by improving forecasts accuracy and, consequently, increase the number of days considered for the period.

<u>Limits</u>

Currently, limits (minimum and maximum) are defined considering the annual consumption value, the replenishment time and VMI users' know-how.

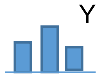
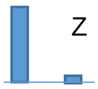
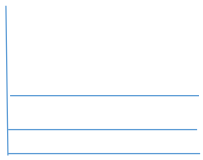
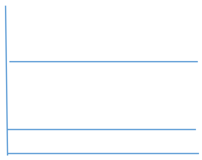
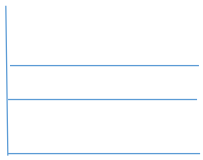
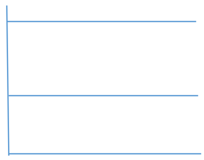
After the brainstorming session, it was agreed that the coverage limits would be defined according to the category of the component (runner, repeater or exotic) because VMI users shared that fluctuation of components is reflected on the current VMI tool parameters (table 8), although there is no empirical study about the adequate limits.

Ideally, high-value components (€) have low coverage because of the cost they represent to the organisation. In contrast, low-value items (€) should not be analysed as often as high-value items so companies accept a higher quantity in stock to improve the efficiency across the supply chain such as the time to place materials in the warehouse, critical part analysis and firefighting with the supplier. In this context, ABC classification can support the definition of coverage days. Minimum of components classified as A or B (high-value items) should be as low as possible and risk of stock out is acceptable. Contrary, minimum of C components (low-value items) can be a week or a month depending on the frequency of delivery and costs of stock (table 10).

Consequently, XYZ classification is needed to support the material planner to identify items with low and high variation in demand and define the range between minimum and maximum. Therefore, items with low fluctuation have a lower spread than items with more fluctuation (table 10).

Replenishment time of supplier should be considered when defining the limits because it impacts the time needed to ship the goods from the moment an order is released (Hsu & Lee, 2009). It includes time to move the lot size from the warehouse to the production, maximum waiting time at the production cell, time for transportation by the milk run, changeover time, the time required to produce the entire lot size and time to bring the lot size to the expedition warehouse (Vishwanath & Vasanth Kumar, 2016).

**Table 10 - Minimum and maximum draft**

<table>
<tr><td></td><td></td><td colspan="3">Defining the spread (Min-Max)</td></tr>
<tr><td></td><td></td><td> X</td><td> Y</td><td> Z</td></tr>
<tr><td rowspan="3">Defining the minimum</td><td>A</td><td rowspan="2">Max<br>min<br></td><td colspan="2" rowspan="2">Max<br>min<br></td></tr>
<tr><td>B</td></tr>
<tr><td>C</td><td>Max<br>min<br></td><td colspan="2">Max<br>min<br></td></tr>
</table>

For each component, a minimum and a maximum value are set in the VMI tool depending on the behaviour of that particular component (table 10).

When the total stock (5) level reaches the minimum, the reorder quantity is triggered to target the maximum value defined (6) (figure 17) (Hammer, 2014).

$$Total\ Stock\ (qty) = stock\ on\ hand(qty) + stock\ on\ order\ (qty) \qquad (5)$$

$$Q\ (qty) = Max(qty) - \min(qty) \qquad (6)$$

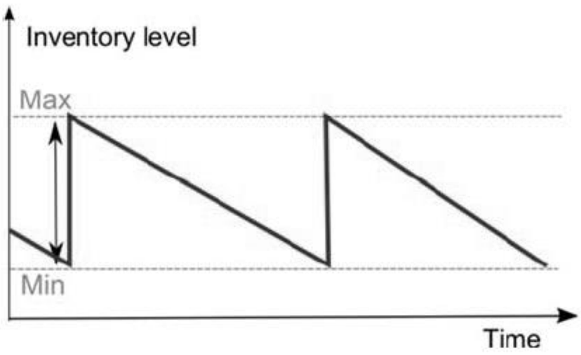



**Figure 17 - Reorder Point (Hammer, 2014)**

Based on stock management models described in the literature (Bellina, Bodins, Krieger, & Olivier, 2013) (Carvalho, et al., 2012) (Tavares, Oliveira, Themido, & Correia, 1996) and material planners' experience, the minimum and the maximum in coverage days were drawn. The minimum quantity should cover the maximum of needs, considering replenishment time (7); however, once the minimum is calculated as the product of the minimum quantity to the moving mean (2), for components with fluctuation, there is a risk of stock out. In order to solve this issue, Bellina *et al*. (2013) suggest adding a safety stock to the minimum quantity. Aligned with the company's strategy of reducing the inventory costs, the company decided to assume the potential risk of stock out and do not add a safety stock for components with demand variation. The maximum quantity should soak up the variation of needs; therefore, the peak amplitude, which means the quantity between the maximum consumption during a year and the average, is calculated and added to the minimum (8).

$$minimum\ (days) = \frac{Maximum\ consumption\ (qty)}{Average\ (qty)} + Replenishment\ Time \tag{7}$$

$$maximum\ (days) = \frac{Maximum\ consumption\ (qty) - Average\ (qty)}{Average\ (qty)} + minimum\ (days) \tag{8}$$

### 3.4.2 FSN Analysis

During the brainstorming session, material planners emphasized that from time to time, they analyse the top five references with higher coverage as well as slow moving and non- moving items in order to control components that become obsolete.

In order to classify items according to their consumption pattern, Devarajana & Jayamohan (2016) explained the FSN analysis (table 11) and defined the Stock Turnover (ST) as the ratio between the annual consumption of a material divided by its average inventory as it is shown below (9):

$$ST = \frac{annual\ consumption}{average\ inventory} \tag{9}$$

**Table 11 - FSN Classification (Devarajana & Jayamohan, 2016)**

| *Type* | ST Value | Characteristics |
|---|---|---|
| *F* | ST > 3 | Fast moving |
| *S* | $1 \leq ST \leq 3$ | Slow moving |
| *N* | ST < 1 | Non-moving |

According to Brindha (2014), items classified as S or N should be identified and treated asunder because their consumption is low and very irregular. FSN analysis allows the organization to take appropriate actions to manage the dead stock.

At Bosch Aveiro, slow movers and non-movers are identified according to:

- Slow moving: components without consumption in the last 6 months;
- Non-moving: components without consumption in the last year.

In this project, K items include slow moving and non-moving components according to Bosch Aveiro classification.

## 3.5 Point of View: VMI tool

After understanding the context and exploring new approaches to improve the VMI tool, an exhaustive study of consumption value and fluctuation was done. First, the classification was done for all references of raw material in Bosch Aveiro in order to have an overview of the inventory characteristics and then a relevant supplier was chosen to design the model.

## 3.6 Understand: ABC XYZ Analysis

To support the analysis of raw material in terms of consumption value and fluctuation, ABC and XYZ classifications were used.

### 3.6.1 Raw material @ Bosch Aveiro

Based on data from the whole last year (2017), components were analysed according to consumption value (ABC classification) and fluctuation (XYZ classification). From approximately 10 000 references managed in Bosch Aveiro, raw material represents only a half; therefore, the study was conducted with almost 5 000 references because the role of material planners is to guarantee the availability of these components. Moreover, the study was conducted without slow moving and non-moving components because the consumption of this items is very low and irregular during the year. The result is presented in tables 12 and 13.

**Table 12 - Relative Consumption Value (2017)**

| | X | Y | Z | TOTAL |
|---|---|---|---|---|
| A | 64% | 13% | 3% | 80% |
| B | 6% | 6% | 3% | 15% |
| C | 1% | 2% | 2% | 5% |
| TOTAL | 71% | 21% | 8% | 100% |

**Table 13 - Relative Number of Items (2017)**

| | X | Y | Z | TOTAL |
|---|---|---|---|---|
| A | 4% | 2% | 1% | 7% |
| B | 7% | 7% | 4% | 18% |
| C | 9% | 21% | 45% | 75% |
| TOTAL | 20% | 30% | 50% | 100% |

## ABC Analysis

- Items A: 7% of the items represent 80% of the annual consumption value (€).
- Items B: 18% of the items represent 15% of the annual consumption value (€).
- Items C: 75% of the items represent 5% of the annual consumption value (€).

## XYZ Analysis

- 20% of the items have low fluctuation (X) and represent 71% of the annual consumption value (€).
- 30% of the items have high fluctuation (Y) and represent 21% of the annual consumption value (€).
- 50% of the items have very high fluctuation (Z) and represent 8% of the annual consumption value (€).

### 3.6.2 Raw material managed by Supplier 13

From the 14 suppliers currently using the VMI tool in partnership with Bosch Aveiro, Supplier 13 was chosen to deploy this study because, according to the material planners, it is the most experienced supplier using the VMI tool and it handles a wide and diverse set of components. This supplier represents 10% of the raw material managed in the whole factory and 16% of the components managed through the VMI tool.

Based on data from last year, components managed by Supplier 13 were analysed according to the consumption value (ABC classification) and fluctuation (XYZ classification) as it is shown in tables 14 and 15.

**Table 14 - Relative Consumption Value (2017)**

| | X | Y | Z | TOTAL |
|---|---|---|---|---|
| A | 44% | 6% | 0% | 50% |
| B | 12% | 21% | 5% | 38% |
| C | 1% | 5% | 6% | 12% |
| TOTAL | 57% | 32% | 11% | 100% |

**Table 15 - Relative Number of Items (2017)**

| | X | Y | Z | TOTAL |
|---|---|---|---|---|
| A | 3% | 1% | 0% | 4% |
| B | 5% | 9% | 2% | 16% |
| C | 4% | 14% | 62% | 80% |
| TOTAL | 12% | 24% | 64% | 100% |

ABC Analysis

- Items A: 4% of the items represent 50% of the annual consumption value (€).
- Items B: 16% of the items represent 38% of the annual consumption value (€).
- Items C: 80% of the items represent 12% of the annual consumption value (€).

XYZ Analysis

- 12% of the items have low fluctuation (X) and represent 57% of the annual consumption value (€).
- 24% of the items have high fluctuation (Y) and represent 32% of the annual consumption value (€).
- 64% of the items have very high fluctuation (Z) and represent 11% of the annual consumption value (€).

### 3.7 Ideate: Standard nº1

For each component, the limits (minimum and maximum) were calculated using the equations (3) to (8). In order to create the Standard nº1, A and B items were grouped (as done in the current standard) and Z items (components with very high fluctuation) were excluded because according to Bosch Aveiro standard about material planning decisions, they should be managed using the push system (table 16). Then, minimum and maximum were defined for each group by doing the average of each parameter.

**Table 16 - Standard nº1**

| | X items | Y items | Z items |
|---|---|---|---|
| A items<br>B items | min. 4 days<br>Max. 6 days<br>Period 5 days | min. 8 days<br>Max. 16 days<br>Period 5 days | Push system |
| C items | min. 4 days<br>Max. 6 days<br>Period 5 days | min. 11 days<br>Max. 21 days<br>Period 5 days | |

Lead-time agreed with the supplier

By analysing table 16, components with low fluctuation (items X) have 4 days as the minimum limit and 6 days as the maximum limit (+2 days) independently of the value of consumption. For components with medium fluctuation (items Y), if the component is classified as:

- A/B, the minimum is 8 days which means that it is higher than in components with low fluctuation. The difference between the maximum and the minimum is also higher than in AX/BX items.
- C, the minimum is 11 days which means that it is higher than in items classified as A or B. The difference between the maximum and the minimum is also higher than in CX items.

Current VMI tool parameters (table 8) do not fit Standard nº1 (table 16). In the current parametrization, only Supplier 1 has 4 days as the minimum limit defined for A/B items. There are 2 suppliers which the minimum limit defined for A/B items is higher than 4 days (Supplier 9 and Supplier 13) and, for the remaining components, the minimum is lower than 4 days. The maximum limit defined for A/B items vary between 2 days and 15 days. Standard nº1 suggests 6 days as the maximum limit defined for AX/BX items and 16 days for AY/BY items. Since in the current VMI tool parameters the components are not classified according to their fluctuation (XYZ analysis), the result is hardly comparable. For C items, currently the minimum limit is between 1 and 10 days and the maximum is between 2 and 10 days. In Standard nº1, the minimum limit can be 4 days or 11 days and the maximum limit 6 days or 21 days, depending on the fluctuation. Currently, the period is between 4 days and 28 days and in Standard nº1 is 5 days. The lead-time is agreed with the supplier and it is parametrized as follows:

- 1 hour if the delivery is on the same day as the data communication;
- 24 hours if the delivery is for the next day as the data communication, which means one day frozen agreed with the supplier.

## 3.8 Point of View: improving Standard nº1

In order to improve the proposed model, the double loop design was applied again. First, the material planners were interviewed to understand the differences between the current parameters and the Standard nº1. Second, potential causes of deviation were summed up and analysed in detail. In parallel, a study about how to manage inventory in the VUCA world was done. Then, Standard nº 1 (table 16) was upgraded and a new model arose.

## 3.9 Understanding: material planning decisions in VUCA world

The new model was developed with VMI users and its experience was used to improve Standard nº1.

### 3.9.1 VMI users' know-how

After several meetings discussing the current VMI tool parameters, six factors were identified to improve the current standard (table 16). These factors (figure 18) are the result of VMI uses' knowledge and experience.

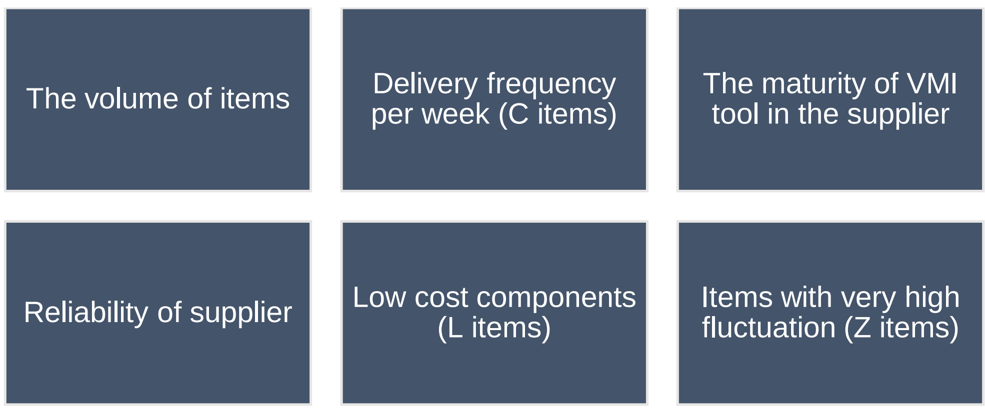



**Figure 18 - Factors to be added to Standard nº1**

In detail:

1) The volume of items

Currently, the lowest value for the minimum (in coverage days) set in the VMI tool is one day for high volume components because of its physical volume. This criterion should be considered in the standard in order to adequately use the space available in the warehouse.

2) Items with very high fluctuation (Z items)

Z items can be considered in the VMI system when the supplier has experience and responds quickly to demand fluctuations because, for Bosch, to hold stock of Z items represents a high cost. These components should be identified for a special follow-up from the supplier. For these components, replenishment time can be longer because the supplier could need more time for producing and delivering the components once they are out of standard production (Errasti, Chackelson, & Poler, 2010).

3) The maturity of VMI tool in the supplier

The longer the VMI tool is implemented in the supplier, the lower the coverage (in days) needs to be. With training and experience, suppliers can analyse the VMI tool better and faster so coverage can be reduced (Bellina, Bodins, Krieger, & Olivier, 2013).

4) Reliability of supplier

Reliability of supplier is a result of service level through years of partnership. A high service level is a basic requirement to implement the VMI tool because, in this type of system, the supplier is responsible for managing deliveries and stocks (Bellina, Bodins, Krieger, & Olivier, 2013).

5) Delivery frequency per week (C items)

According to (Brindha, 2014), the strategy for C items is to avoid non-value added activities across the supply chain. In this context, even if 2 or 3 days of coverage would be enough for guaranteeing the availability of the components, the minimum should be set in 7 days. By increasing the coverage of C components, it is expected to decrease the time spent with:

- Critical part analysis;
- Placing the goods in the warehouse;
- Controlling the quantity in the borderlines;
- The changeover of production (in the supplier);
- Packaging (in the supplier).

6) Low-cost components (L items)

Components with high consumption value (classified as A or B items) but a low unit cost (classified as L items) should not be analysed as often as expensive components. In this context, a higher coverage is acceptable for low-cost items (Brindha, 2014).

### 3.9.2 ABC XYZ analysis: runners, repeaters, and exotics

According to Bohnen, Buhl, & Deuse (2012), by combining ABC and XYZ classifications, components can be divided into runners, repeaters, and exotics as it is shown in table 17.

- Runners are fast-moving components with a high volume of production, high order frequency and low fluctuation of consumption;
- Repeaters are a medium-demand volume with medium variability;
- Exotics are characterized by low demand volume, low order frequency and high variation in demand.

**Table 17 - ABC XYZ classification. Adapted from (Bohnen, Buhl, & Deuse, 2012)**

| | X | Y | Z |
|---|---|---|---|
| A | Runner | Runner | Repeaters |
| B | Runner | Repeaters | Exotics |
| C | Repeaters | Exotics | Exotics |

Packowski (2013) states that, for each group, a stock management strategy can be defined (figure 19), such as:

- the inventory spread (min-max) is wider for repeater than for runners;
- more inventory is held of exotics than of runners although more quantity (total annual consumption value) is higher for runners;
- due to its high consumption value (€), runners should have low coverage in stock;
- the risk of stock out is higher in exotics than in runners due to its unreliable forecast;
- due to its low consumption value (€) and the importance of reducing cost across the supply chain, repeaters and low-cost components can have a higher coverage in stock than runners.

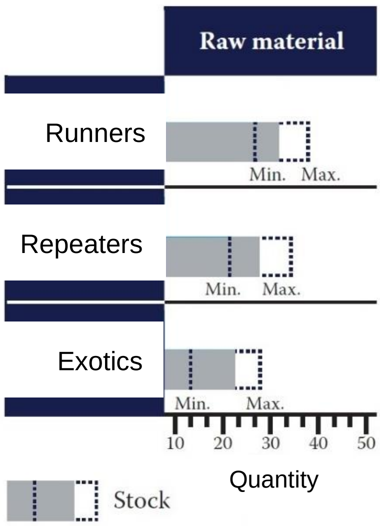



**Figure 19 - Inventory Level (Packowski, 2013)**

ABC XYZ Analysis – Supplier 13

Based on data from last year, components from Supplier 13 were classified as runners, repeaters, and exotics depending on its annual consumption value and fluctuation. Moreover, a new cluster was created to highlight components with a low unit price.

To define the criteria of low-cost items, the raw material managed in Bosch Aveiro was organized by unit cost from the lowest to the highest. Then, the impact of increasing the coverage was measured and, with the approval of the Logistics Director, the low-cost items were set on 0,30€ per unit.

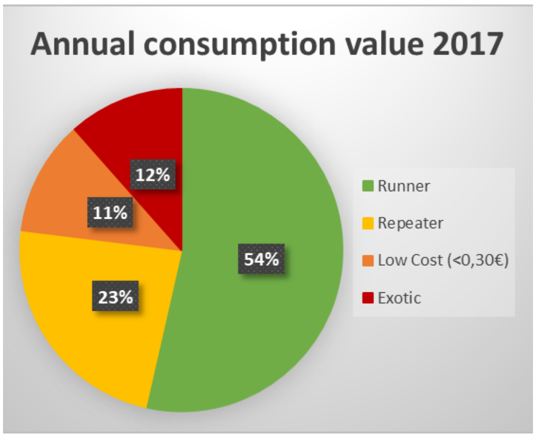



**Figure 20 - Annual consumption value (2017)**

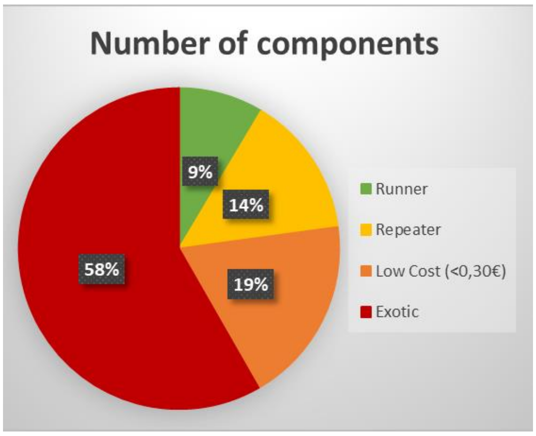



**Figure 21 - Number of component (2017)**

ABC XYZ Analysis (figures 20 and 21)

- Runners: 9% of the components represent 54% of the annual consumption value;
- Repeaters: 14% of the components represent 23% of the annual consumption value;
- Low-cost components: 19% of the components represent 11% of the annual consumption value;
- Exotics: 58% of the components represent 12% of the annual consumption value.

### 3.10 Ideate: Standard nº2

By adding the factors described previously to Standard nº1 (table 16), and considering the ABCL XYZ analysis (runner, repeater, exotic or low-cost items), a new model was developed.

First, for each component of Supplier 13, the limits (minimum and maximum) were calculated using the equations (3) to (8) and then, they were grouped in table 18.

**Table 18 - Limits calculated for Supplier 13**

| | | X | | Y | | Z | | K |
|---|---|---|---|---|---|---|---|---|
| A | min | [3,0-3,7] | min | [2,7-2,7] | min | - | min | - |
| | Max | [3,6-4,8] | Max | [4,3-4,3] | Max | - | Max | - |
| B | min | [3,1-3,6] | min | [3,5-4,3] | min | [6,9-7,5] | min | - |
| | Max | [3,6-4,8] | Max | [4,6-8,2] | Max | [11,2-12,6] | Max | - |
| C | min | [3,2-3,6] | min | [3,5-6,1] | min | [4,8-44,8] | min | - |
| | Max | [3,9-4,6] | Max | [4,5-9,8] | Max | [7,1-87,0] | Max | - |
| L | min | [2,9-4,0] | min | [4,0-5,1] | min | [37,1-37.1] | min | [15,1-52,0] |
| | Max | [4,2-5,5] | Max | [5,6-7,6] | Max | [71,7-71,7] | Max | [29,2-103,0] |

In order to create Standard nº 2, the numbers above (table 18) were rounded to the unit and three samples were excluded because their values were out of scope. While for the remaining categories, Supplier 13 had more than one component; for categories CZ, LZ and LK, there was only one component, so its coverage was not an average but the coverage of that component itself. By analysing table 18 and clustering according to the classification runners, repeaters, exotics and low-cost components, it was evident that the coverage of that three samples was very high and the decision was to ignore the value of them.

For each category, it was defined a gap for each limit (minimum and maximum), the period, the lead-time and the phase of implementation as it is shown in table 19.

**Table 19 - Standard nº2 – VMI tool parameters for local suppliers**

| | Min.* | Max.* | Period | Lead-time | Phase of implementation |
|---|---|---|---|---|---|
| Low-cost items | [4-6] | [6-8] | 5 days | low | 1 |
| Runner | [3-4] | [4-5] | 5 days | low | 2 |
| Repeater | [4-6] | [6-8] | 5 days | medium | 3 |
| Exotic | [7-10] | [10-13] | 5 days | higher | 4 |

* Limits in coverage days
Exception: for high volume components Min. [1-2] Max. [2-3] Lead-time low[3]

In Standard nº2 (table 19), the implementation of the VMI tool in suppliers is divided into 4 phases. In phase 1, low-cost items are implemented and tested in the system. It is recommended to use the upper limits in phase 1, which means 6 days for the minimum and 8 days for the maximum. In phase 2, runners are tested, in other words, fast-moving components with a high volume of production, high-frequency order frequency, and low fluctuation. It is recommended to use the upper limits as well which means that, for AX, BX and AY items, the minimum is 4 days and the maximum is 5 days. In phase 3, repeaters (medium-demand volume with medium variability) are added to the VMI tool using upper limits too. In the last phase, when the level of maturity of the VMI tool in the supplier increase, as well as the level of reliability, exotics can be included in the system (Bellina, Bodins, Krieger, & Olivier, 2013). These components are characterized by low demand volume, low order frequency and high variation in demand; therefore, the risk of failure is higher and the supplier should be aware of it[4].

For each group of components, the range of minimum and maximum was defined. In the beginning, the VMI tool should be parameterized based on the upper limits. For example, runners should have 4 days of coverage minimum and 5 days maximum; and, exotics should have 10 days of coverage minimum and 13 days

[3] Factor nº1: the volume of items

[4] Factor nº2: items with very high fluctuation

maximum. Over time, if the supplier is reliable and responds quickly to the demand, the coverage limits may decrease slightly[5].

Minimum for repeaters and low-cost items is 4 to 6 days[6] because of their low consumption value or their low unit cost. These items should be seen as an opportunity to maximize the efficiency across the supply chain. By increasing its coverage, the time spent with non-value added activities decreases.

Slow moving and non-moving components should not be in the VMI tool because of variability in the demand (Bellina, Bodins, Krieger, & Olivier, 2013).

### 3.11 Prototype

According to Pijl *et al*. (2016), prototypes are a genial and simple way of finding the potential of ideas. Moreover, prototyping an idea will help the team understand the main risks and challenges that they will face when the idea is implemented.

In order to validate Standard nº2 in Bosch Aveiro (table 19), Supplier 13 was chosen. Since it is not possible to compare the current classification (ABC analysis) to the proposed classification (runners, repeaters, low-cost items, and exotics) to understand the main differences, a narrow analysis was done by comparing the current situation and the proposed ABC classification. Table 20 shows that:

- 58% of the components remain in the same category according to the annual consumption value;
- 17% of the components are currently classified as C but their unit cost is lower than 0,30€ (L items);
- 19% of the components are currently classified as B when, in fact, their behaviour during the last year is that of a C item. This means that material planners are spending more time analysing these components that it was

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[5] Factors nº3 and nº4: the maturity of VMI tool in the supplier and its reliability

[6] Factors nº5 and nº6: delivery frequency per week

supposed to. Moreover, depending on the fluctuation of these components, the priority (and coverage) is different.

**Table 20 - Current versus Proposal ABC Classification**

| | | VMI tool classification | | | |
|---|---|---|---|---|---|
| | | A | B | C | TOTAL |
| Proposal classification | A | 1% | 2% | 0% | 3% |
| | B | 1% | 16% | 1% | 17% |
| | C | 1% | 19% | 41% | 61% |
| | L | 0% | 2% | 17% | 19% |
| | TOTAL | 3% | 39% | 58% | 100% |

This analysis hides the fluctuation of the components and its impact; therefore, a financial study about the impact of the implementation of the proposed model was also done.

## Financial Impact Analysis

First, the current stock and the current VMI tool parameters were compared (figure 22). In short:

- The current stock is lower than the minimum limit currently parametrized in the VMI tool:
    - Runners (-29%);
    - Repeaters (-38%);
    - Low cost components (-3%).
- For exotics, the current stock is 31% higher than the maximum limit defined.

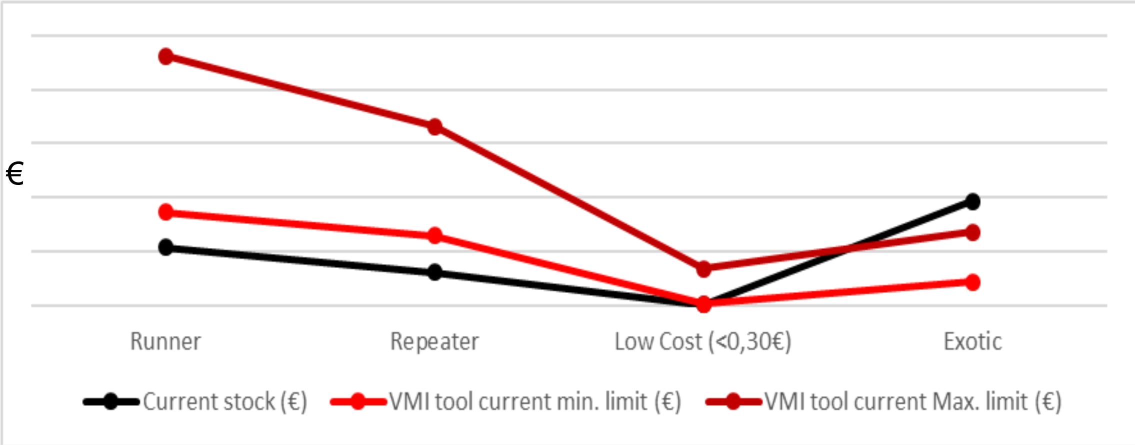


**Figure 22 - Current stock versus current VMI tool parameters in Euros (Supplier 13)**

Then, the analysis of implementing the proposed model was conducted with the lower limits for the minimum and the maximum. Standard nº2 shows the importance of each component for the organization by assessing different coverage to specific components; for example, a thinner stock and restricted control are required for runners. Figure 23 highlights the reduction of the spread (min-max) for runners, repeaters and low-cost components (blue versus red lines). Moreover, the minimum stock of runners remained almost the same (-2%) although it had increased for repeaters (21%), low-cost components (17%) and exotics (69%). Analysing the maximum limit current parametrized in the VMI tool, it reduced for runners (-43%), repeaters (-15%), low-cost components (-21%), while it increased for exotics (46%). Overall, in the proposed model, for Supplier 13, the minimum stock increased 20% and the maximum stock decreased by 18%.

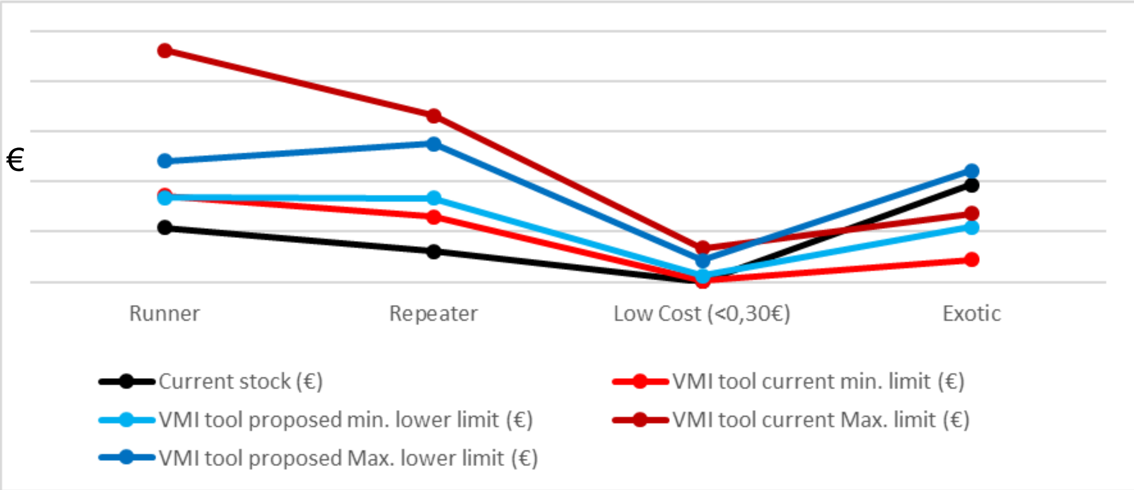


**Figure 23 - Financial impact of the proposed model (Supplier 13)**

Supplier's feedback referees bottle-neck for specific components and restriction of components for production; therefore, the analysis of financial impact of the upper limits was not done. Also, in this step, it was decided to not validate the proposed model with Supplier 13 due to its internal production issues.

## 3.12 Validate

In order to validate the model, Standard nº2 will be implemented in a set of references where:

- The lead-time will be adjusted depending on the category;
- The period will be adjusted to 5 days;
- The limits (minimum and maximum) will change according to the Standard nº2.

Then, the impact will be measured for 3 months by three key performance indicators:

1. Number of critical parts per day (in units);
2. Level of stock every week (in Euros);
3. Time spent in follow-up activities with suppliers such as emails and phone conferences by material planners (in minutes).

Due to the restrictions on delivering certain components and on the internal production of Supplier 13, VMI experts decided that the model would be validated with another supplier. At the moment, Supplier 4 and Supplier 7 seem to be the best ones to test the change on the lead-time and on the period (from 7 days to 5 days) because the limits of A/B items already fit Standard nº2. In order to measure the impact of the change in the limits, Supplier 9 could be tested because this supplier manages all the types of components (runners, repeaters, low-cost items, and exotics).

> *"(...) you will find that your initial assumptions were wrong. (...) This is actually great news. It means that you'll learn a ton about your idea early. And you'll learn how to make it better, before committing investments and taking big risks."* (Pijl, Lokitz, & Solomon, 2016)

### 3.13 Scale

After the validation and changes (if needed), the model should be implemented in the remaining suppliers using the VMI tool. The scale is important not only to make the impact bigger but also to discover new risks and potentialities (Pijl, Lokitz, & Solomon, 2016).

Even though there was no validation of Standard nº2 in the field, the financial impact was measured for the components parametrized in the VMI tool. First, the components were divided into the four categories (runners, repeaters, low-cost items, and exotics) according to their annual consumption value and fluctuation; and then, the impact of Standard nº2 implementation was measured.

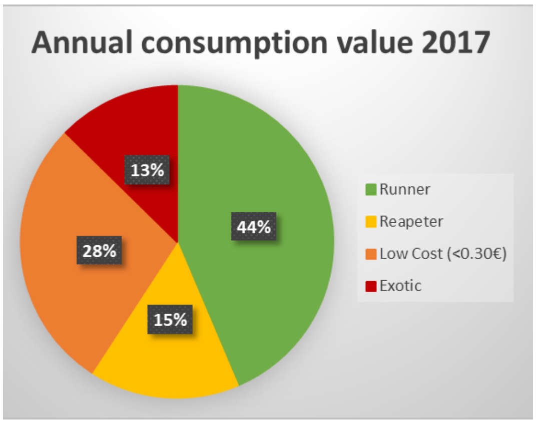


**Figure 24 - Annual consumption value (2017)**

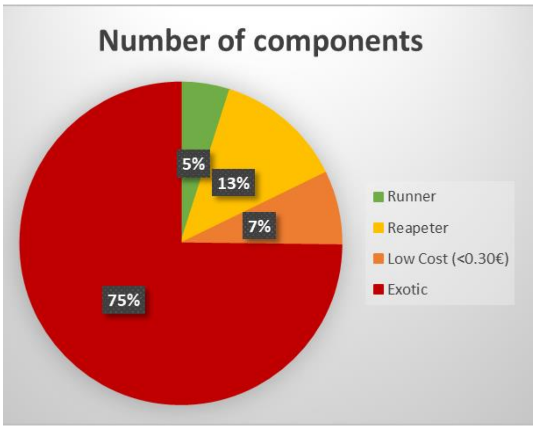


**Figure 25 - Number of components (2017)**

## ABC XYZ Analysis (figures 24 and 25)

- Runners: 5% of the components represent 44% of the annual consumption value;
- Repeaters: 13% of the components represent 15% of the annual consumption value;
- Low-cost components: 7% of the components represent 28% of the annual consumption value;
- Exotics: 75% of the components represent 13% of the annual consumption value.

## Financial Impact Analysis

Comparing the current stock to the current VMI tool parameters (figure 26):

- the current stock is lower than the minimum current parametrized in the VMI tool for:
  - runners (-40%);
  - repeaters (-13%);
  - low cost components (-16%).
- for exotics, the current stock is 16% higher than the maximum defined.

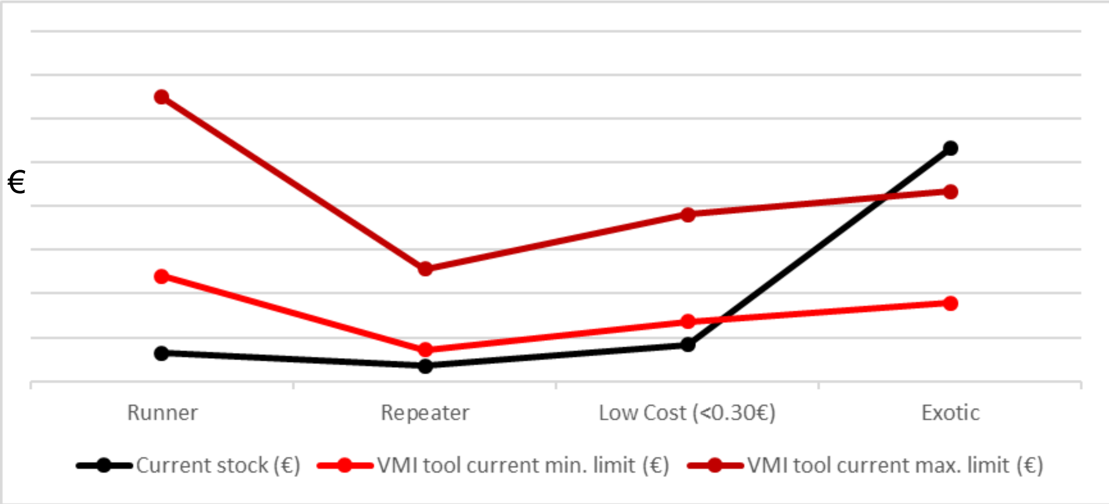


**Figure 26 - Current stock versus current VMI tool parameters**

Applying Standard nº2 to the set of references that are currently in the VMI tool, the financial impact in terms of stock was measured for two extremes:

1. Using the lower limit in all references (figure 27 – blue lines);
2. Using the upper limit in all references (figure 27 – green lines)

Therefore, it is expected that the total value in stock for components in VMI would be between the best case (figure 27 – blue lines) and the worst case (figure 27 – green lines). Figure 27 highlights the reduction of the spread (min-max) for runners, (blue and green versus red lines). Moreover, by using the proposal:

- lower limits, the minimum stock of runners remained almost the same (-4%) although it had increased for repeaters (10%), low-cost components (19%) and exotics (52%). Comparing to the maximum limit current parametrized in the VMI tool, there is almost no variation for repeaters (-2%) and low-cost components (3%) while it reduced for runners (-32%) and it increased for exotics (30%). Overall, the minimum stock increases by 19% and the maximum stock decreases by 3% (figure 27 – blue lines).
- upper limits, the minimum stock increase for all categories: runners (+22%), repeaters (+62%), low-cost components (+75%) and exotics (+94%). Comparing to the maximum limit current parametrized in the VMI

tool, there is a reduction of stock for runners (-19%) while it increases for repeaters (+29%), low-cost components (+36%) and exotics (+55%). Overall, the minimum stock increases by 61% and the maximum stock decreases by 21% (figure 27 – green lines).

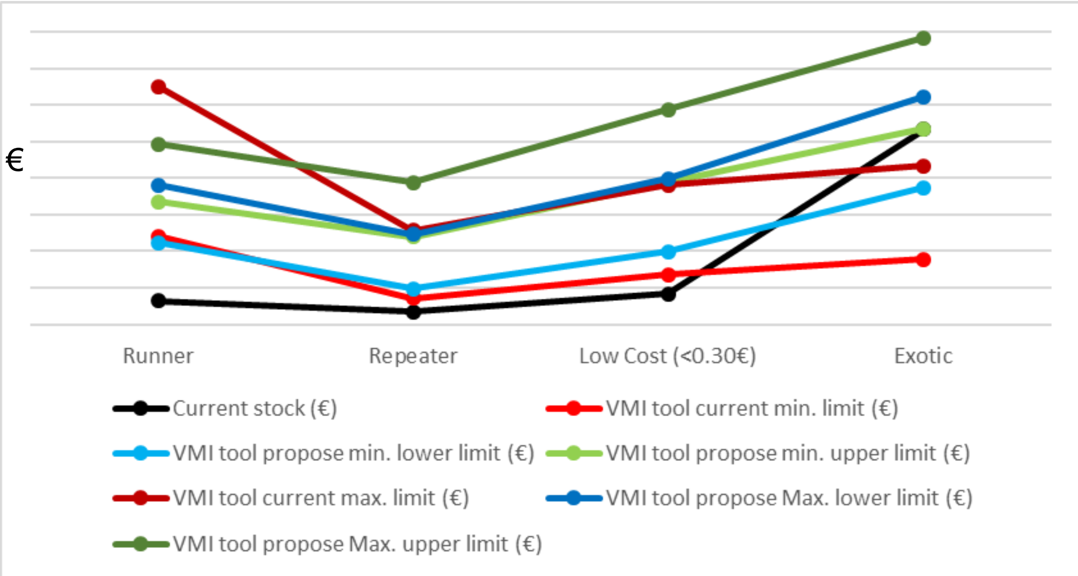


**Figure 27 - Financial impact of the proposed model in the VMI tool**

The financial analysis of the implementation of Standard nº2 gave an overview of the proposed changes as well as its impact on the organisation.

# 4. Conclusion and Future Research

The last chapter is dedicated to the conclusion by summarizing the key features of the study. Moreover, the contribution of the proposed model is highlighted, the limitations of the case study are presented and possible directions for further research are outlined.

## 4.1 Conclusion

Living in the VUCA world, companies aim to be cost competitive and flexible in order to maximize customer satisfaction by offering personalized products at a reasonable price.

The findings of this project emphasize the importance of human resources' knowledge and experience across the supply chain, from the supplier to the customer needs, and highlight the possibility of improving the current paradigm at Bosch Aveiro by improving the VMI tool.

## 4.2 The contribution of the proposed model

For Bosch Aveiro, this project results in a standard to parameterize the VMI tool and five best practices. The standard is explained in detail in section 3.10 Ideate: Standard nº2 and the best practices are in appendix B. In Bosch, a best practice is a guideline that helps associates about a specific topic so it is written in the mother tongue. In this case, the best practices are:

1) Clusters for parametrization. This best practice is an overview of the which best practice may be consulted for clustering the components according to its material planning decisions. It is under construction once this project was the beginning of classifying the components according to consumption value and fluctuation.

2) ABCL Classification. It explains the concept of ABC classification and L components, how to classify the materials according to its consumption value and how to update the data in the SAP system[7].
3) XYZ Classification. It explains the concept of XYZ classification, the criteria and how to classify the materials according to its fluctuation.
4) ABCL-XYZ Classification. It explains in detail the characteristics of each group.
5) Coverage for raw material in VMI system. It shows the concept of VMI system, its scope, how to use the standard and some tips.

In addition, it is expected that the implementation of the proposed model will reduce the risk of stock out and the time spend on managing components in the VMI tool and on controlling the components with an excess of stock. In addition, this study highlighted the importance of clustering the components in inventory management. So, the next step will be the analysis of components managed by the other two material planning systems (push and pull) according to the four categories (runners, repeaters, low-cost items and exotics).

For the academic field, this work adds a real case study about material management in the VUCA World. The project was done in cooperation with a professional team that supported and helped the development of Standard nº2 by sharing their experience and knowledge. Therefore, the study links the theoretical concepts of literature review, mainly from the 21st Century, to the current industrial environment.

[7] SAP system is an Enterprise Resource Planning (ERP) software used to manage resources in the organizations (SAP, 2018).

### 4.3 Limitations of the case study and further research

A number of limitations might have influenced the results obtained. One situation was that phase-in and phase-out components were not analysed in detail during the project. Furthermore, the model was designed to be implemented in local and daily suppliers, which means that, to apply Standard nº2 to other suppliers, a deeper study of other components' behaviour is recommended. The study was conducted in a seasonal business working with a broad range of components so, to apply the proposed model to other businesses, a new research must be developed. In addition, suppliers that are currently working with the VMI system have a strong partnership with Bosch Aveiro and years of experience; therefore, the model proposed might not meet the needs of other companies.

In future researches, the limitations presented above can be studied in detail and new approaches should arise. It would be interesting to understand the possibility of extending the proposed model to other components, businesses, and suppliers. It would also be interesting to define the limits considering the size of the truck and, in this way, maximize the transportation.

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# Appendix A - Seasonality

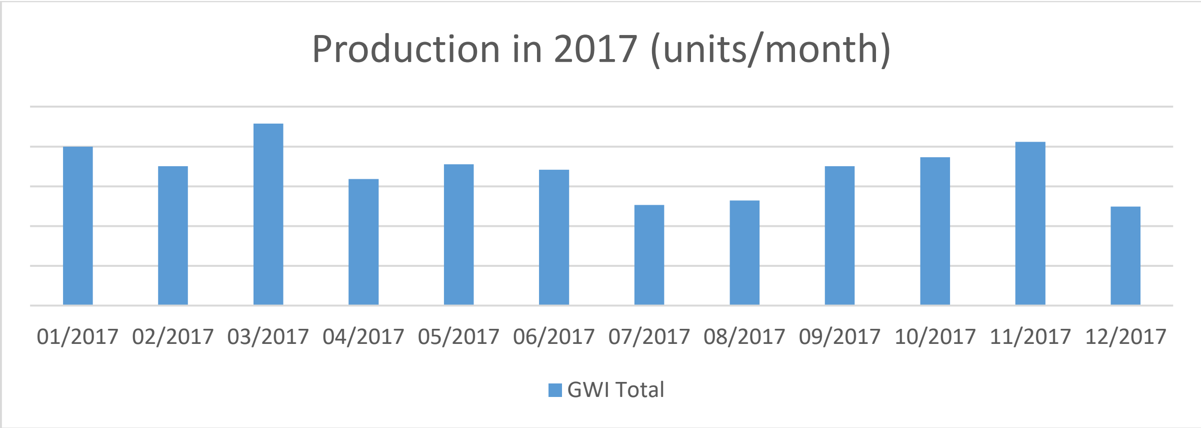
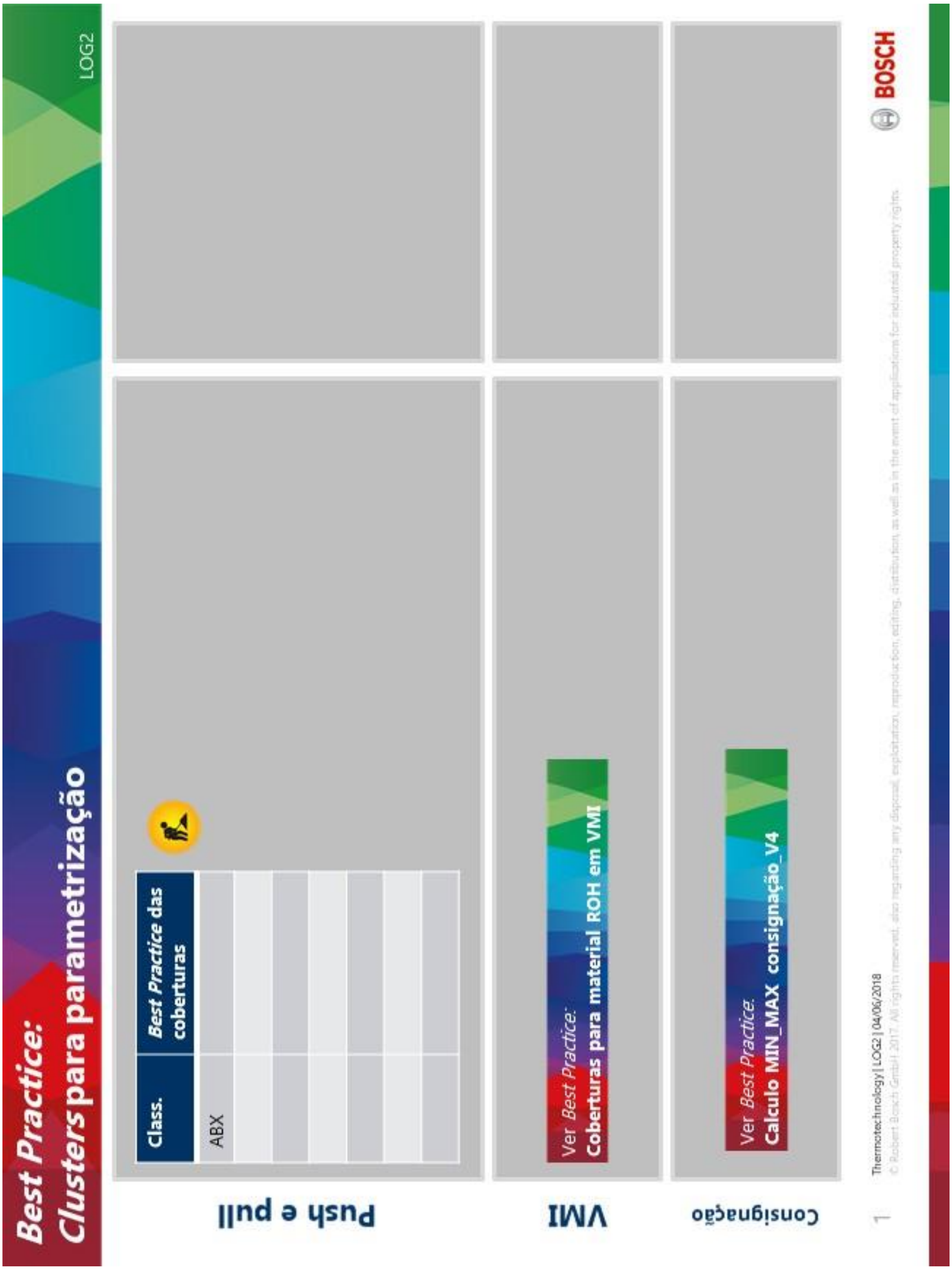



**Figure A1 - Production in Bosch Aveiro (2017)**

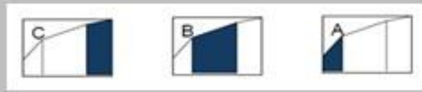
## Appendix B – Best Practices



# *Best Practice:* Classificação ABCL
# Como classificar materiais ROH?

LOG2

**Conceito**




**A:** Peças de valor de consumo elevado (representam 80% do valor total de consumo)
**B:** Peças de valor de consumo médio (representam 15% do valor total de consumo)
**C:** Peças de valor de consumo baixo (representam 5% do valor total de consumo)
**L:** Peças A ou B com valor unitário baixo (ver *Best Practice:* Classificação ABCL - XYZ)

**Processo**

**Classificação ABCL**

1. Exportar consumo no último ano do SAP:
   - Transação Z23CRUU_ABC_CLAS_ROH
   - Horizonte: 01.01.20xx a 31.12.20xx > Executar
   - Exportar > Panilha eletrónica > .xsxl
2. No excel, filtrar ROH:
   - Organizar referências por ordem decrescente do consumo total do ano anterior (€).
   - Calcular % (consumo cada peça/consumo total do ano).
   - Calcular % acumulada.
   - Classificar ABCL, de acordo com o critério.

**Atualização em massa no SAP**

1. Usar transação Z23MMUC_MATMAS_M.
2. Verificar campo que se pretende modificar.
3. Nome da tabela: MARC.
4. Selecionar 1º campo [referência sem traços]; 2ºCampo [Classificação].
5. Importar informação do excel para o SAP.


**Outros**

**Sistemática** A classificação ABCL deve ser revista uma vez por ano.

**Responsável** <escrever nome responsável>

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**Best Practice:** Classificação XYZ

## Como classificar materiais ROH?

LOG2

**Conceito**


**X:** Peças sem flutuação
**Y:** Peças com flutuação
**Z:** Peças com muita flutuação

**Critério**

**Coeficiente de Variação (CV)**
$CV = \frac{\sigma}{\mu}$, com
$\sigma$: *desvio padrão*
$\mu$: *média*

**X:** $CV < 0{,}5$
**Y:** $0{,}5 \le CV \le 1$
**Z:** $CV > 1$

**Processo**

**Classificação XYZ**

1. Exportar consumo no último ano do SAP:
   - Transação Z23CRUU_ABC_CLAS_ROH.
   - Horizonte: 01.01.20xx a 31.12.20xx > Executar.
   - Ver consumo > Semana > Executar.
   - Exportar > Panilha eletrónica > .xsxl.
2. No excel, filtrar ROH:
   - Calcular $CV$.
   - Classificar XYZ, de acordo com o critério.

**Outros**

**Sistemática** A classificação XYZ deve ser revista uma vez por ano.

**Responsável** <escrever nome responsável>




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## *Best Practice:* Classificação ABCL - XYZ

# Como classificar materiais ROH?

LOG2

**Conceito**

| | X | Y | Z |
|---|---|---|---|
| A | • Elevado volume de produção<br>• Elevada frequência de entrega<br>• Baixa flutuação no consumo | • Elevado volume de produção<br>• Elevada frequência de entrega<br>• Baixa flutuação no consumo | • Volume de produção médio<br>• Variabilidade da procura média |
| B | • Elevado volume de produção<br>• Elevada frequência de entrega<br>• Baixa flutuação no consumo | • Volume de produção médio<br>• Variabilidade da procura média | • Baixo volume de produção<br>• Baixa frequência de entrega<br>• Elevada variação no consumo |
| C | • Volume de produção médio<br>• Variabilidade da procura média | • Baixo volume de produção<br>• Baixa frequência de entrega<br>• Elevada variação no consumo | • Baixo volume de produção<br>• Baixa frequência de entrega<br>• Elevada variação no consumo |

**Critério**

| Classificação ABCL | |
|---|---|
| A | Peças de valor de consumo elevado |
| B | Peças de valor de consumo médio |
| C | Peças de valor de consumo baixo |
| L | Peças A ou B com valor unitário baixo (<0,30€) |

\+

| Classificação XYZ | |
|---|---|
| X | Peças sem flutuação |
| Y | Peças com flutuação |
| Z | Peças com muita flutuação |

Ver *Best Practice*: Classificação ABCL

Ver *Best Practice*: Classificação XYZ




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## *Best Practice:*
## Coberturas para material ROH em VMI

LOG2

**Conceito**

- Ferramenta de gestão de stocks em tempo real através do *Electronic Data Interchange* (EDI)
- Parceria entre fornecedor e Bosch

**Âmbito**

✓ Fornecedores nacionais
✓ Fornecedores fiáveis

**Standard para Coberturas**

| | Min. | Max. | Período |
|---|---|---|---|
| AX, BX, BY | [3-4] | [4-5] | 5 dias |
| AZ, BY, CX | [4-6] | [6-8] | 5 dias |
| BZ, CY, CZ | [7-10] | [10-13] | 5 dias |
| L | [4-6] | [6-8] | 5 dias |

Exceção: components com grande volume. Min [1-2] e Max. [2-3]
Os limites estão definidos em dias de cobertura

Para classificação dos materiais,
consultar *Best Practices*. Classificação ABCL e XYZ

**Limites**
Decidir entre os limites inferior e superior para o min. e para o máx. de cobertura depende de:
- Maturidade do fornecedor na utilização do VMI
- Riscos de rutura no passado
- Frequência de entrega

**Cobertura fora do standard**
Para a atualização de coberturas em massa, consultar o especialista da ferramenta de *Supply On* na equipa.

**Supply On**

**Sistemática** A cobertura das peças em VMI deve ser revista uma vez por ano.

**Cobertura fora do standard** Não é permitido definir critérios fora dos intervalos especificados sem validação prévia do *Group Leader*.




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