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DEMAND DRIVEN MATERIALS REQUIREMENT PLANNING (DDMRP)

A new method for production and planning management

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ABSTRACT

This master thesina aspires to address the impact that planning activities have on an organization, considering the most recent planning methodology called Demand Driven Materials Requirement Planning. The introduction of the topic shall take a general route to explain the current scenarios of planning activities today, the trends reported over the past few years to highlight the need for a change in the planning methodology.

Today the economy is global, competitive and grants the customers the ultimate take on how they want the products they own. Talking in terms of business, organizations face the need to be much more flexible and supply chains the need to be agile. Quality and consistence are mere order qualifiers in today's competitive and complex business environments. The above factors considered, raised the set of problems that required deep understanding to analyse the need for this new planning methodology, its impact and influence in the organizational context and the effects of change to handle these issues.

The preliminary literature review is performed considering the fact of inventory distributions reported widely by organizations that implement current planning activities (MRP tools). This led to the idea of pursuing in detail through a systematic literature review on the topic of Demand Driven Materials Requirement Planning (DDMRP), one of the macro topics included in the new Demand Driven Planning model. Within the state of the art, the Demand Driven Materials Requirement Planning was considered and explained along with its main characteristics, principles and framework.

The research takes the route through a case study in a manufacturing company, allowing a deeper insight of the real-life implication of the new planning methodology. The case study helps understand the changes required in terms of production, distribution and planning activities to become a Demand Driven company. It addresses the impacts of such changes on the overall organizational context, the benefits or criticalities of the methodology. It helps to gather insights on how the changes allow organizations to tackle the increasing supply chain complexity and variability simultaneously enabling the optimal performance requirements of today's dynamic markets.

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1. INTRODUCTION

In this section of the report a background study of the research field is presented. This leads to the problem formulation and research questions that identifies the purpose of this thesina. This section aims at providing the readers with an idea of the issues that lead to the research questions and the need for this study.

1.1 The Scenario

Today, the manufacturing world is no longer made up of single enterprises. The markets are competitive and obvious advantages are achieved through building a network of enterprises that are collectively referred to as the ‘Supply Chain’. Since this network comprises of different enterprises there exists an exchange of information and commodities between the network actors. The efficiency and effectiveness of the supply chain depends on the methodologies involved in this exchange between the actors. Supply chain planning is therefore a very relevant aspect of how companies function today. Thus, the process of planning in the modern world would be the ideal starting point for this thesina.

1.2 The MRP Revolution

MRP is the most widely used acronym in the modern planning world and stands for Materials Requirement Planning. So, what is Materials Requirement Planning? According to the APICS dictionary “MRP is a set of techniques that uses bill of materials data, inventory data, and the master production schedule to calculate requirements for materials. It makes recommendations to release replenishment orders for materials. It is time-phased and makes recommendations to reschedule open orders when due dates are not in phase. Time-phased MRP begins with the items listed in the master production schedule and determines the quantities of all the components and materials required to fabricate those items as well as the dates on which each component and material is required. It is achieved by exploding the bill of materials, adjusting for inventory quantities on hand or on order, and offsetting the net requirements by the appropriate lead times.”

MRP is the most widely used planning methodology in the modern world. Most manufacturing companies and plants are completely committed to the use of MRP systems for their planning activities. It has become the only way forward for production and inventory management, replacing statistical methods of the past. Studies have shown that most modern Enterprise Resource Planning (ERP) software includes MRP. Furthermore, most ERP buyers implement MRP. So, what is the problem with this widely used planning technique? The problem is that MRP was conceived in the 1950's, codified in the 1960's and commercialized in the 1970's. Since then nothing major has changed in how the traditional core of the MRP systems function. But the markets have changed, business dynamics have changed. The table below will give you a small comparison between the extreme differences in which today's companies operate.

PARAMETER	IN THE PAST	TODAY
Supply Chain Complexity	Low	High
Product Life Cycles	Long	Short
Customer Tolerance Times	Long	Short
Product complexity	Low	High
Product customization	Low	High
Product Variety	Low	High
Forecast Accuracy	Reliable	Unreliable
Leaner Inventories	Low	High

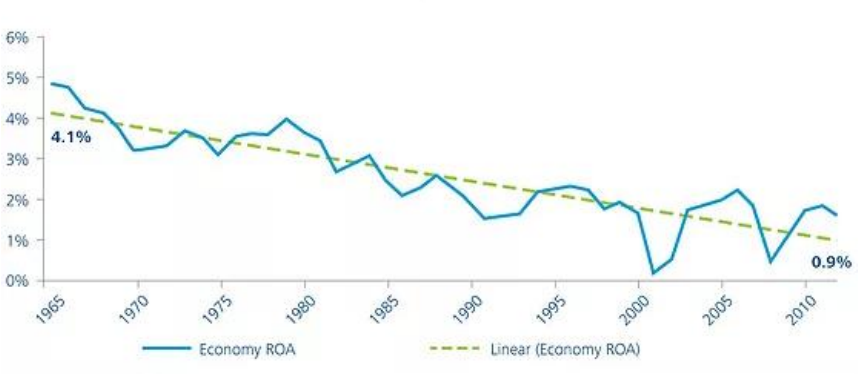
The above table clearly depicts that the business scenario today is nothing like that of the past. The world has become a much quicker place, customers more informed and demanding due to the high availability of options that the modern-day supply chain has to offer the markets. There is increased global sourcing and demand, unique value propositions to the end customer that have led to shortened product life-cycles and increased demand for customization, variety and complexity of the products. This situation has pushed businesses to adopt leaner inventory models without losing market share to avoid risk of obsolescence and huge losses. The responsibility falls on the shoulders of the planning personnel who must ensure reliable forecasts are provided to optimise production to serve the entire market without huge inventories. Thus, the planning methodology adopted plays a key role in the survival of any business across any industry. This comparison serves as the first revelation as to why it might be time to review this current planning methodology. The question of, are there more reasons to facilitate a proposal of a new planning methodology arose and further studies carried out by leading companies revealed further problems exist with the current planning technique.

1.3 Evidence of a Problem

There were three major preliminary pieces of evidence that a greater problem exists. The first is a continuous return on assets degradation, the second is companies performing work-around proliferation to make up for certain shortfalls of MRP systems and the last problem being the inventory bi-modal distribution.

The first problem related to the return on assets degradation has been established based on the paper in the Harvard Business Review by authors Martin Reeves, Simon Levin and Daichi Ueda. According to them, "We investigated the longevity of more than 30,000 public firms in the United States over a 50-year span. The results are stark: Businesses are disappearing faster than ever before. Public companies have a one in three chance of being delisted in the next five years, whether because of bankruptcy, liquidation, M&A, or other causes. That's six times the delisting rate of companies 40 years ago. Although we may perceive corporations as enduring institutions, they now die, on average, at a younger age than their employees. And the rise in mortality applies regardless of size, age, or sector. Neither scale nor experience guards against an early demise. We believe that companies are dying younger because they are failing to adapt to the growing complexity of their environment. Many misread the environment, select the wrong approach to strategy, or fail to support a viable approach with the right behaviours and capabilities.

The United States led the adoption of manufacturing information systems starting with MRP in the 1960s. These systems are expensive to purchase, to implement and to maintain. The value of these formal planning systems has always been based on the ability to better leverage the assets of a business. Did the widespread adoption of MRP and subsequent information systems enable the US economy to better manage assets?



The figure shows the return on assets for the US economy (1965-2012) and is sourced from Deloitte University Press, Computat Deloitte Analysis.

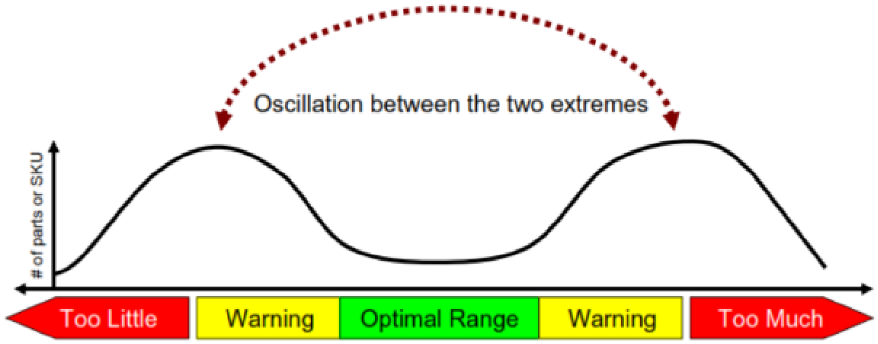
There is a steady decrease on return on assets for the US economy from 1965 to 2012. Furthermore, during this time period the same report shows that labour productivity (as measured by Tornqvist aggregation) more than doubled.

Obviously, there are many factors at play with this return on asset decrease but this report 'The Biology of Corporate Survival' of the Harvard Business Review from January/February 2016 certainly leads one to realize that the impact of widespread adoption of MRP, MRP II and ERP systems (at least in the US) has not significantly helped companies manage themselves to better return on asset performance. Indeed, when this decline is taken in combination with the increase in labour productivity, it suggests that companies are accelerating their mistakes."

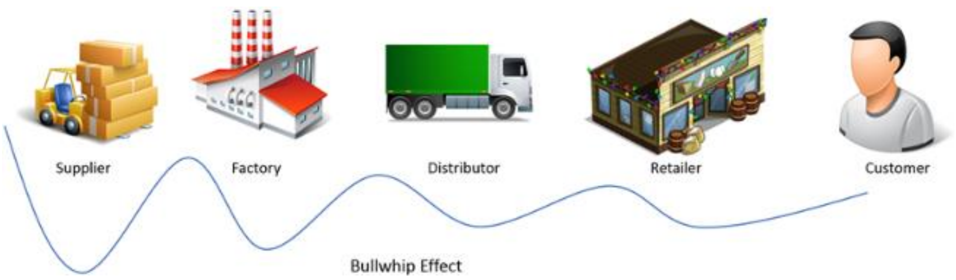
The second evidence of a problem stems from this possibility of companies accelerating their mistakes. In today's competitive business scenario, we mostly deal with customers that prefer the shortest lead times possible. Most supply chains are complex and volatile, shorter product life cycles, product complexity, customization and variety are high, many long lead time parts and pressure for lean manufacturing methods are the new normal. The above-mentioned factors contribute heavily for the need to forecast rather than the ideal situation of working on actual customer orders. Coupling the issue of a complex and elongated supply chain lead time and the shorter customer tolerance time ushers in the concept of safety stock at strategic points to service the market or even grow sales. This also means a longer frozen planning horizon and more detailed forecasting which is done using MRP systems in most companies today.

The present scenario depicts an even bigger problem surrounding the forecasting techniques used. Several studies conducted revealed that around seventy percent of the companies lack trust in MRP systems and often integrate ad-hoc tools in the form of spreadsheets to manage demand. These tools are used despite them lacking capability, scalability and transferability. They are also error prone with stats showing around ninety percent of the spreadsheets contain errors. The problem of inaccurate forecasts stems from the problem mentioned earlier. The effects on the operation of the company are drastic and can be explained by analysing the impacts it has on inventories which is the third and final evidence of a problem. Increased variability makes matters worse for the forecasting personnel.

Inventory and inventory optimization are one of the key activities that must be carried out by the planning department at any enterprise. It is basically the heart of the planning and the key to the survival for any enterprise today. There are two universal points of inventory, the first being 'too little' and the other 'too much'. Both these points are not ideal for a company. When there is too little inventory, we face component shortages, expedites and possible missed sales. When there is too much inventory, we face excess costs, hold excess materials running the risk of obsolescence and need excess storage space. We know that these two points exist, so somewhere between these points there exists an optimal range of inventory that protects flow without being excess and enables efficient and cost-effective operations.



However, most companies exhibit a bi-modal distribution, most of the inventory is either in the too little or the too much zones with very little in the optimal range. Every MRP run typically results in the oscillation of the inventory between the two extremes. This bi-modal distribution has devastating effects on the company because it creates unacceptable inventory performance like having too much of the wrong things. It also leads to unacceptable service level performances and potential loss of market share. Excess cash and expedite related wastes like overtime and additional freight charges.



Flow breaks down at both these points of inventory. These problems are only at the single company level. Considering the entire supply chain, the collective problem exhibits the 'bullwhip effect'. So, the variability is transferred and amplified in both directions along the supply chain. The more parts to the supply chain, the more complex they are. This scenario is no stranger to most companies implementing MRP planning techniques. There is an increasing need to tackle this variability and an urgent need to create a new innovative solution to today's planning dilemma. Both companies and planning personnel are in dire need of a new planning methodology that adapts to today's volatile market trends.

1.4 Purpose of this Thesina

The search for an answer to the problems mentioned in the earlier section of this report leads us to the purpose of this thesina. There exists a solution called Demand Driven Materials Requirement Planning (DDMRP) which claims to revolutionize the way modern day planning is carried out. It promises to solve planners' nightmares about inventory optimisation enabling the most efficient and effective supply chain operation in the midst of today's volatile market trends. The solution provides significant innovations compared to the MRP methodology and claims to always maintain inventory levels in the optimal range which was described earlier. It claims to make the impossible looking planning job much easier and provides more reliable forecasts off which to work for other activities like procurement of required materials and labour and production scheduling. Through the literature review and state of the art we will understand the various principles and frameworks of this new planning methodology. A few empirical research case studies will be reviewed before entering the most important case study to study the feasibility of changing to this new planning methodology. This therefore leads us to our fundamental research questions for this thesina.

1.5 Research Questions

The research questions were formulated following the preliminary literature review in the second phase of this study. The approach to this research is explained clearly with the flowchart of the various phases under the methodology section of this report. Through this preliminary literature review, we can understand that all is not well in today's planning methodology. It leads us to our first research question.

RQ1) Is there a need to change the most widely used current MRP planning methodology with this new planning methodology called 'DDMRP'?

From the preliminary research it seems like this could be a possibility. An in-depth research in the form of a systematic literature review and state of art could provide answers about DDMRP planning methodology being the right way forward for planners and organizations to tackle the globalization and uncertainty of today's business environment. From understanding the need for a change stems the next research question.

RQ2) What are the key differences between the MRP and DDMRP planning methodologies?

The systematic literature review and state of the art sections of this report are mainly used to understand the theoretical framework of the Demand Driven Materials Requirement Planning methodology. An in-depth focus on understanding this methodology will help answer the second research question. It will give readers an idea about the as-is MRP planning methodology versus the to-be DDMRP planning methodology.

The empirical research carried out also sheds lights on the difference in results of real-world implication case studies between the two planning methodologies answering a part of the second research question.

RQ3) How to implement DDMRP within a company, what are its impacts on other activities within the organization along with its benefits and criticalities?

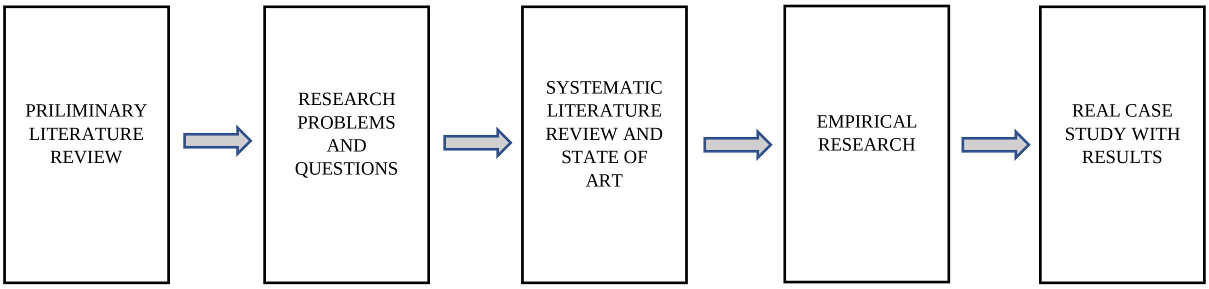
The answer to the third and final research question will be aided by performing a real case study using real data that at a manufacturing firm using currently the MRP planning methodology wishing to transition to this new Demand Driven Materials Requirement Planning methodology for their production, procurement and planning activities. The use of relevant past company data from the real world will help answer the possible benefits and criticalities of implementing this new planning methodology.

2. METHODOLOGY

This chapter of the thesina aims at explaining the different methodology adopted at various stages to achieve the answers to the research questions mentioned above. It gives insight to the reader about where the various information used in this report had been sourced and how each information, material and data have been used to better understand concepts and frameworks.

2.1 Research Strategy

A research strategy or a general plan of how to best conduct a study to finally answer the research questions is the first step of the process in the quest for answers. Saunders et al.2000 mentions that "a multi-method approach is best suited and advantageous to find the best possible solutions. It also mentions that data collection methods are very important to ensure that there is a high level of reliability." Since the planning technique that we wish to study is relatively new, the research strategy combines a literature study, empirical research and a real case study of implementation carried out at a manufacturing firm. The research approach flowchart figure is presented below to understand the progression of the thesis work.



As mentioned above in the above figure, the research will go through a series of steps, starting with the preliminary literature review, to identify the research problem and to formulate the research questions. The research questions are formulated to answer the research questions, using the research methodology following the preliminary literature review. The next step in the research methodology is to do a systematic review which will structure the research, and make way to create the outline to build the contents for the state of art. The following step will be the state of art, which will explain the literature concerning the topic of research in-depth. The comprehension from this step will be utilized in the next step, which will be the empirical research for real-life implications of the topic. The empirical research will be sourced from the various testimonials shared with the Demand Driven Institute on their website of real-world implementation of this methodology and provides empirical results expected within an organization that wishes to change to the latest planning methodology being researched in this thesina. The purpose of the Research methodology is to generate the route to research problems, questions and the directions to answer them.

2.2 Literature Review

A literature review consists of endless information flow of previous and current research within the specific field of interest, to read and comprehend. Ejvegard's 1996 paper states that, "a literature review is very important as it shines light on the path the research will follow, therefore, the effectiveness and planning are key parameters. Key words should be applied when searching for information, ensuring effectiveness with relevant information. Planning ensures that appropriate time is spent within each area of study before the next phase of research is initiated." Saunders et al. 2000 mentions that, "a carefully planned literature study will ensure relevant and up-to-date literature, while establishing what has been previously done." The whole research was split into two parts, starting with preliminary literature overview, to find the research problem. The preliminary literature review was based on the current MRP planning methodologies as mentioned above. The preliminary literature review brought light to the topic of DDMRP mentioned above and had scope for further research. DDMRP is a fairly new topic (one of the earliest books mentioning DDMRP with modern implication was only in 2011 by Joe Orlicky). The preliminary research gave directions to DDMRP and the need for its implementation in today's complex business environment. Deeper research on the topic showed that a change is required and hence lead to the main topic of research which required a systematic literature review and state of art. According to Saunders et al. 2000 paper, during the systematic literature review this phase must be performed with attention because it could be really hard for researchers to find gaps from the previous studies of the actual research field.

The Systematic Literature Review is a methodical review of the literature papers identified during the preliminary literature review. It gives the structure to the research and allows to identify the route to deeply understand the topic of research. This leads to identifying topics of the state of art, which is used to answer the research questions. Because the research topic is relatively new, and materials related to the research topic are comparatively fewer in comparison to other common research topics. This serves as both an advantage and disadvantage for the research. The advantage being that the time required to carry out a literature review is much lesser than the usual and there does not exist the problem of having to find the most relevant articles and papers for the study. The disadvantage however is that the scope for comparison amongst various authors interpretation of the new planning methodology is difficult.

2.3 Empirical Research

The empirical research section is quite important both to the researcher and the research study. It is based on previous observations and helps in gathering insight on the research topic from actual experiences elsewhere. This phase was carried out using the material available on the demand driven institute website. There were many testimonial videos of actual companies responding to the implementation of DDMRP. Strangely all that was reported was positive, however it led to answering a part of the second research question. It shown light on the results that most companies faced after implementing this new planning methodology. All companies reported an immediate reduction in stock numbers and claimed to have an optimized inventory level. Other aspects like Lead Time, forecast reliability also showed improvements under this DDMRP methodology for production and planning activities. This provided another reason for the purpose of this thesina, to research for possible criticalities with this new planning methodology. The case studies used in this phase of the research will be presented in detail after an overall explanation of the theoretical framework of this new planning methodology in the systematic literature review and state of art of this report.

2.4 Data Collection

Data is the most key aspect to the quality of any research. Data collection methods are very important to ensure that the research follows the initial intended path in quest for the answers. The two main approaches commonly used in scientific research are quantitative and qualitative methods. A quantitative method consists of statistical facts or hard data – numbers, graphs and other numerical information that can be given or obtained during the research (Dahmström 2011), while a qualitative method includes interviews or observations – soft data (Saunders et al. 2000). Depending on the type and source of data, the categorization of data can be carried out. The two main categories of data are Primary and Secondary Data.

Primary data are new data, collected and gathered with a single purpose of answering specific questions within a specific research or field. There are therefore many advantages with primary data, the major one being the accuracy and truthfulness found in the information, since the data is recently collected and fresh. Limitations and questions within primary data are also advantageous, since these can be adjusted according to the situation given (Dahmström 2011) Therefore, primary data like questionnaires, interviews and observations are therefore used by the authors.

Secondary data is typically statistical data or quantitative data. These are usually numbers and figures collected and concluded by the company. Other sources of secondary data might be statistical foundations and different sources from the Internet (Dahmström 2011). Usage of secondary data is also of great importance, since this information is interpreted and concluded by someone else in a similar situation, while being cheaper at the same time (Dahmström 2011).

The preliminary literature review which was conducted to formulate the research questions was carried out using qualitative data. This phase consisted of data mostly sourced from the internet and enabled to guide the study in the direction of the requirement for a change in current planning methods. The search for a new planning methodology brought into light the topic of Demand Driven Materials Requirement Planning for this research. The empirical research which deals with real world implementations and testimonies from companies that switched to the DDMRP planning methodology also consist of secondary qualitative data.

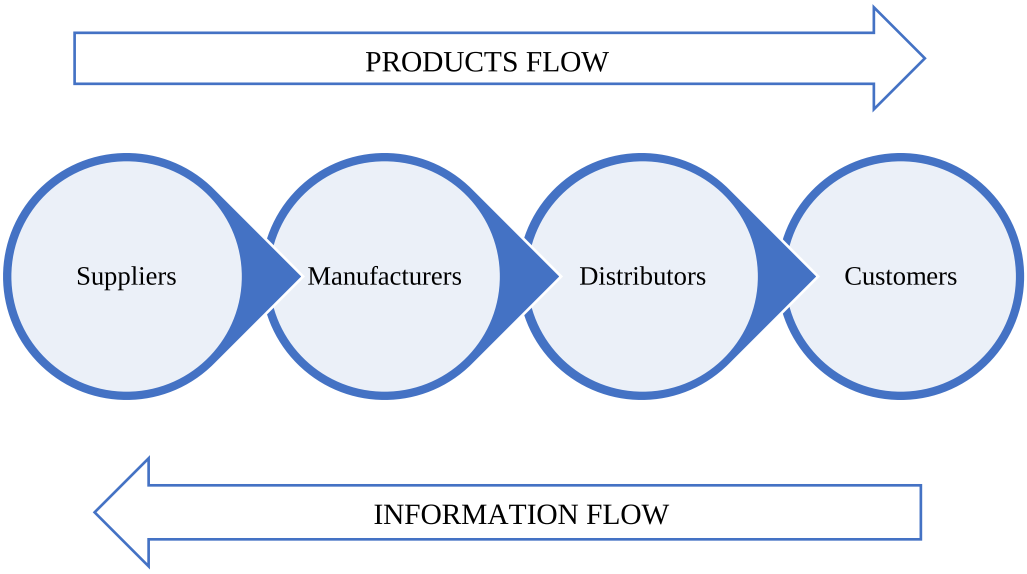
The theoretical framework and concepts within the DDMRP planning technique were sourced from the Demand Driven Institute. The section of the systematic literature review and state of art consists primarily of secondary data mostly qualitative. The real case study of the implementation at a manufacturing firm which is the contribution of this research consists of primary data from the previous year gathered during the four months of internship at the firm. The quantitative data used for calculations and other research purposes have been altered a little before being handed over to ensure protection of company data. All discussions and doubts regarding data were answered by the firms planning manager during the internship. The above-mentioned research methodology and data collection, comprehension and processing activities ensured suitable answers to the research topic in discussion.

3. THEORITICAL FRAMEWORK

This chapter comprises of all the theories and concepts, used as the foundation to understand the research topic. This phase of understanding the concepts behind this new methodology will help in the next step of the research, the application of the methodology as a real case study at a manufacturing firm. It will be the pillar to the answers that this research topic yields as a response to the research questions formulated as a result of the preliminary literature review.

3.1 The Importance of Flow

The most primary theoretical concept that is required for the successful completion of this research is to understand the concept of flow and its importance to the world of planning and operations. The first law of manufacturing was established by George W. Plossl and hence commonly known as Plossl's law. He states that "all benefits will be directly related to the speed of **flow** of materials and information".

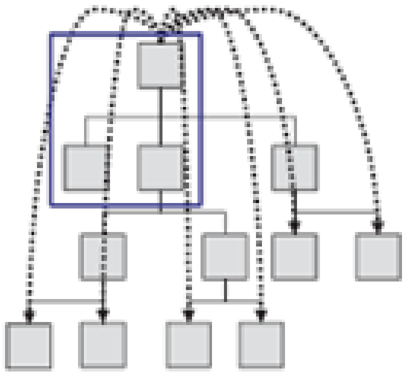


The above figure depicts a very basic supply chain configuration and highlights the different flows across the supply chain. This system works based on information and product flows that stem from the customer demand. The system is said to benefit proportional to the speed at which this flow takes place as mentioned in the law. Flow brings coherence between various functions (finance, R&D, operations, sales and marketing) of a company and enables to meet the primary objectives of each function thereby ensuring overall efficiency in the company's performance.

When a system flow is optimal, the service rendered is consistent and reliable, revenues are maximised and protected, and inventories are minimised. Typically, this enables planners to achieve the synchronization between supply and demand. With this synchronization there will be direct benefits for the purchasing function, optimizing company spending only on materials that are required. Scheduling and shop-floor activities can also be optimised to perform at the most efficient and effective levels.

Today the most widely used improvement methodologies are Lean, Six Sigma and Theory of Constraints. Lean manufacturing stresses on the concept of reducing waste, Six Sigma about reducing variability and Theory of Constraints about improving the throughput. Research shows that the concept of flow can be defined as the common link between these most popular improvement methodologies. However, there is an important caveat to this law of flow defined by Plossl. It is important to mention that both the materials and information that flows inside the system is relevant. This basically means that one must completely understand the needs of the market and synchronize operations towards fulfilling those needs. So, having the right information is the sole criteria to ensure that you produce the right materials.

The first law of supply chain management is therefore a modified version of Plossl's law and states, "all benefits will be directly related to the speed of **flow of relevant** information and materials". The primary objective of operations management is to protect and promote this flow of relevant information and materials. However, today's operations reality exhibits the bullwhip effect mentioned in the earlier section of the report. This effect is mainly due to the nature of communication along the supply chain being serial in nature. A small change in demand downstream can cause extreme changes upstream of the supply chain due to distortions to relevant information leading to distortions in the delivered materials. The reason behind this phenomenon is that the current MRP planning methodology treats everything as dependent.



The figure depicts a typical MRP explosion, in this system everything is coupled. The raw materials sourcing, processing, manufacturing, outsoucing, assembly, painting, configuration and distribution are considered during the MRP run. This leads to a **coupled lead time calculation** starting from the sourcing of raw materials required to serving the customers needs. The MRP makes forecasts and suggestions taking into consideration the customer toloerence times and the lead time factors for the markets. The safety stock is also accounted for during the MRP explosion. Current business scenarios indicate that customer tolerance lead times are much shorter than the cumulative manufacturing and procurement lead times. Since the MRP systems are loaded with forecasts based on such information, there arises the need to change these forecasts when the actual demand is known. Such problems have led companies to perform the work around proliferation mentioned earlier using spreadsheets based on their market dynamics. MRP plans built using all these dependencies mention the timing and quantity requirements, the case of any supply variability leads to delay accumulation across the dependent networks, causing an unsynchronized operations process and stagnation of flow. All these factors lead to distortions in the information passed along the supply chain, leading to materials not available at the required time, meaning distortions to the materials. These distortions are the reason for the presence of the bullwhip effect amongst today's supply networks, and organizations not operating in the most efficient manner. Therefore, the importance of flow and its relevance has been established to help the research in search of answers to tackle the current problems.

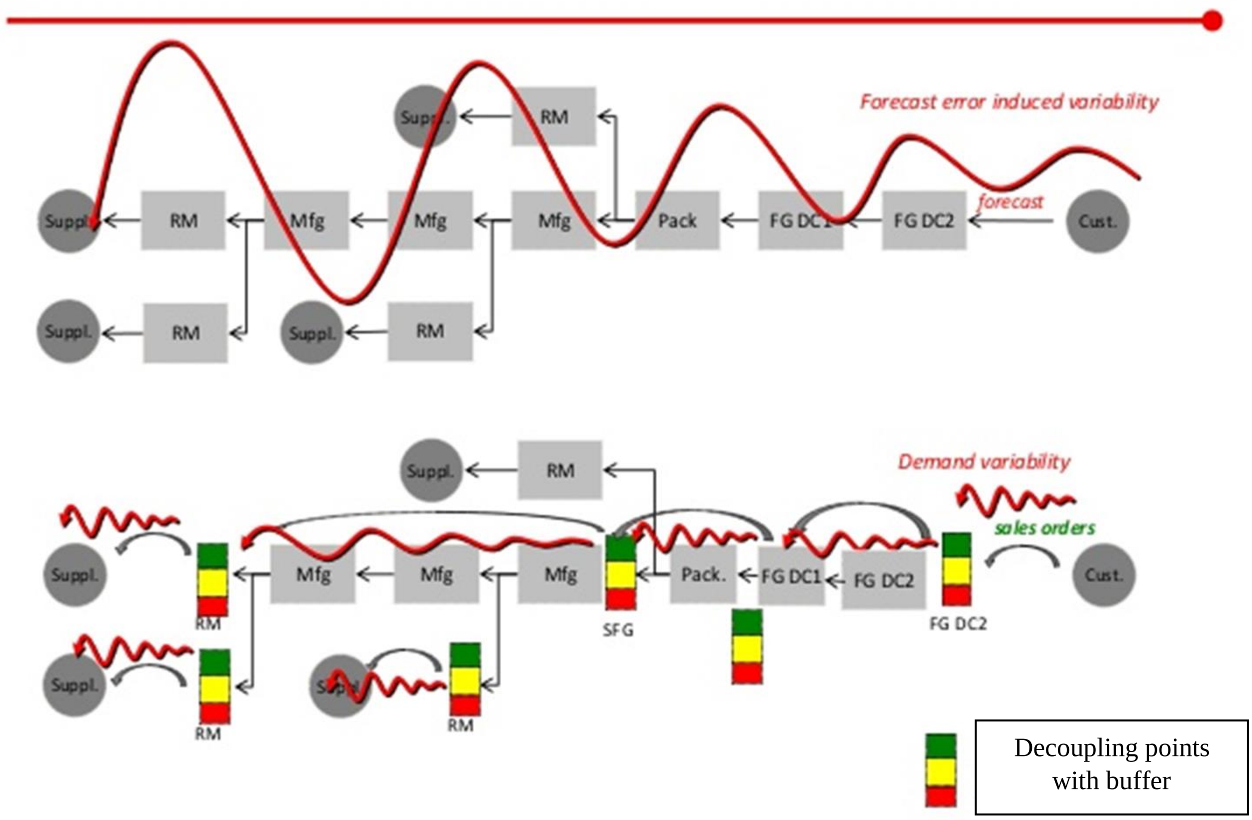
3.2 Decoupling – A possible solution

There exists the need to try and mitigate this variability caused by the bullwhip effect as mentioned earlier. Decoupling and then adding a buffer to the decoupling point is a solution that could stop the distortions from being transferred both upstream and downstream of the supply chain.

What is decoupling? According to the APICS dictionary 14th edition, " Decoupling is creating independence between supply and use of material." This is widely achieved by planning inventory between operations such that there exists no constraint due to fluctuations in supply rate or any other source of variability. This inventory typically mitigates distortions from being transferred within the system.

What is a decoupling point? According to the APICS dictionary 14th edition, " A decoupling point is a location in the product structure or distribution network where inventory is placed to create independence between processes or entities." There could be multiple decoupling points within a single system. The selection of these points are typically taken at the higher level of an organization as it involves investment and decides possible customer lead times.

How does decoupling help mitigate variability and tackle the bullwhip effect?



The above figure demonstrates how decoupling helps in mitigating the distortions caused by the bullwhip effect. It is possible to create buffer for raw materials, work-in-progress and also finished products. If there involves a process that is outsourced, a buffer can be created decoupling that process and avoiding distortions caused by any supply variability. Decoupling creates independent planning horizons between two consecutive decoupling points. This helps for a much more appropriate demand signal. Through this we can also ensure that the first law of manufacturing is adhered to because it ensures that mostly relevent data is passed within the system. Decoupling also helps to immediately reduce the lead time to serve the customers because the time from just the last decoupling point of the system needs to be calculated for the potential market lead time.

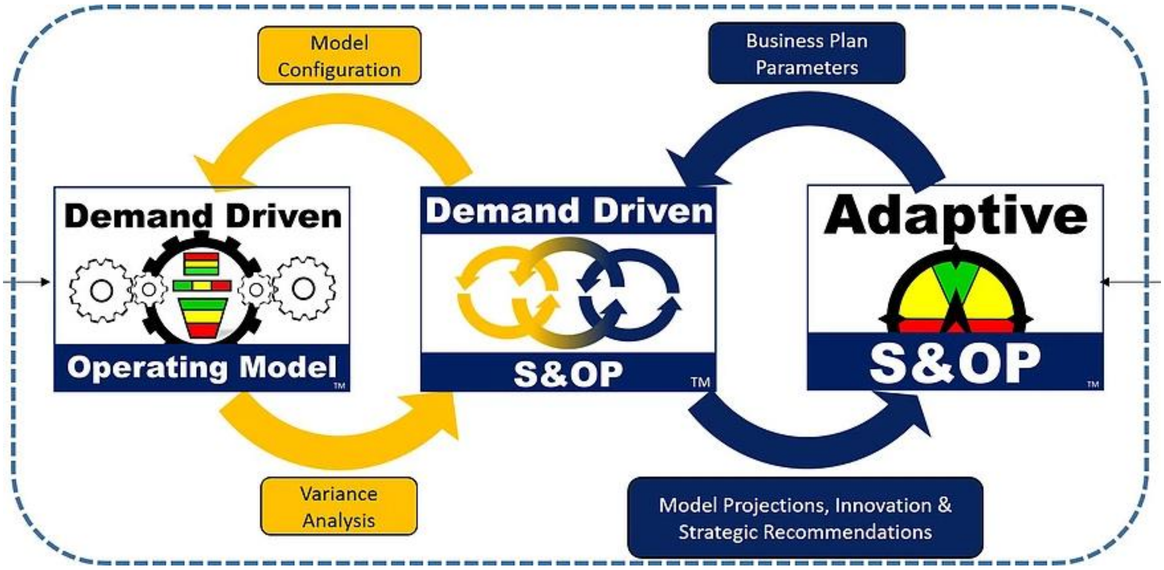
Decoupling is one of the primary concepts used in the new Demand Driven Materials Requirement Planning methodology. Decoupling points unlock the solution for a better planning methodology, but they cannot be placed everywhere as it involves investments. Strategic decisions about location and quantities are important for success.

3.3 Demand Driven Basics

The previous sections have introduced the readers to two primary concepts that help understand further basics of becoming demand driven. Strategically decoupling and buffering optimally is the critical phase towards a transition to become a demand driven organization. This part of the report addresses the real meaning of being ‘Demand Driven’. As seen earlier, this cannot be achieved with just MRP methodologies because in the MRP explosion everything is dependent when compared to a technique that stresses the need to strategically decouple and create independent planning horizons. MRP methodologies basically lead companies to operate in a push-based mechanism. However, Demand driven is about creating a pull environment around the organization. This concept of pull is a strong part of the Lean manufacturing theory, where the systems function on the concept of takt-time, pulling either from Kanban loops or supermarkets as and when required by the system. MRP methodologies drastically contradict this pull strategy by making everything dependent, proving to a hindrance to the flow. Lean manufacturing stresses about having clear signals for every resource and makes everything independent enabling a pull strategy with smother operations and minimal wastes. MRP’s deficiencies are a major hindrance to flow. Lean manufacturing emphasises the importance of flow but focuses on reduction of waste, therefore does not have the appropriate framework to completely allow a change towards being a demand driven enterprise.

The reason for companies to shift towards a demand driven planning methodology has already been established. The business environments are complex and volatile and the issues with the current MRP methodology have been explained in earlier sections of the report. So, what does it mean to be ‘Demand Driven’? To become demand driven means that there needs to be a fundamental change in the way an organization operates. There needs to be a change from traditional cost-based methodology which are more widely known as push techniques towards a core concept of working with actual demand and flow-based methodologies. The mantra that demand driven refers to is the 3P’s **‘Position, Protect and Pull’**. Demand driven does not mean that you change from a Make to Stock approach to a Make to Order everything approach and doesn’t specify to add inventory wherever possible. It relies on creating flow and pacing the work around actual demand with the aim of synchronizing the complex and dynamic environment. It is important to understand that it is not just a superior forecasting approach. So, being demand driven as quoted by the Demand Driven Institute means, “Sensing changing customer demand, then adapting planning and production while pulling from suppliers – all in real time". So, for an enterprise to be demand driven, we must put in place methodologies to protect and promote the flow of relevant materials and information along the supply chain. While abiding to the first law of manufacturing, the methodology must be able to simultaneously synchronize the complex and dynamic market, providing clear signals to pace the operations based on actual demand. The starting point towards achieving this for any organization lies with the understanding and implementation of Demand Driven Materials Requirement Planning, a new method for production and planning activities for an enterprise.

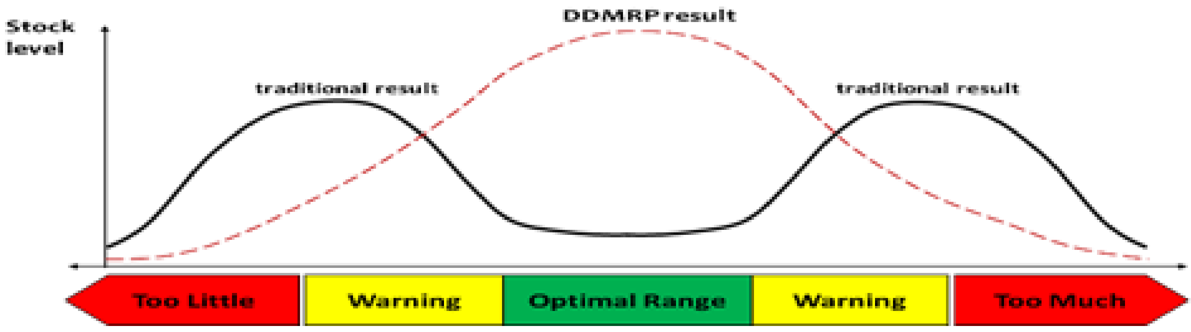
Today researchers at the Demand Driven Institute are developing the Demand Driven Adaptive Enterprise (DDAE) Model. They say, "the model spans the operational, tactical and strategic ranges of an organization allowing it to continuously and successfully adapt to the complex and volatile supply chains we see today. It combines the fundamental principles of flow management with the emerging new science of complex adaptive systems (CAS). It is the way that successful businesses will work in the 21st Century." The Demand Driven Adaptive Enterprise comprises of three model components as shown in the figure below.



This figure demonstrates the journey that an enterprise undergoes during the transition towards being a demand driven enterprise. The Demand Driven Operating Model (DDOM) is the starting point for any organization that decides to transform itself into a demand driven enterprise. After successful implementation of the DDOM model, we move to the other two components of the DDAE model to achieve the goal of becoming demand driven. The scope of this research is limited to within the DDOM model more related to DDMRP.

3.4 Demand Driven Materials Requirement Planning

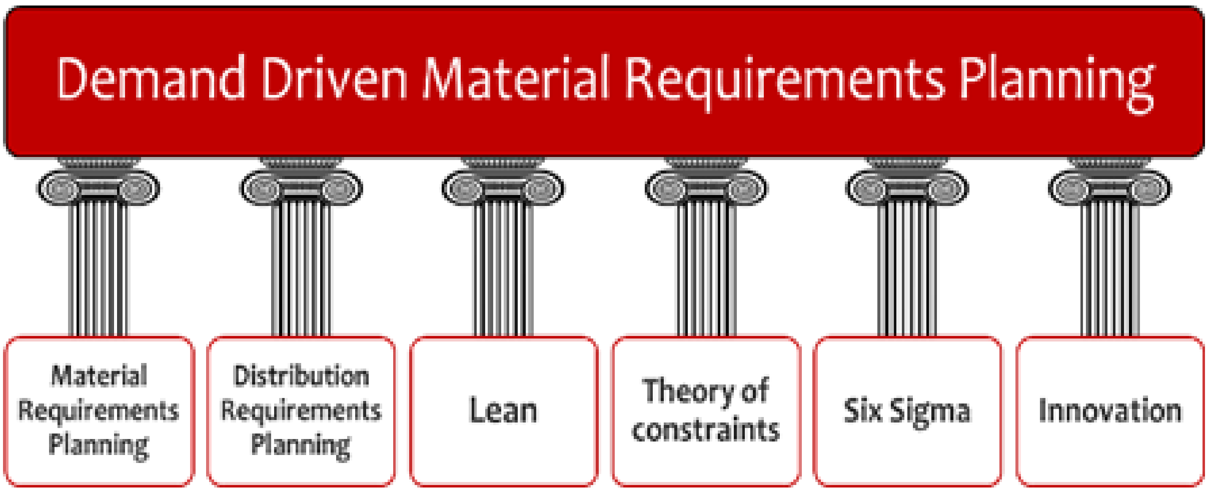
DDMRP unlocks the solution to most of the problems experienced by organizations amidst the very dynamic and volatile markets of today. Strategic decoupling and creating flow as discussed in the earlier sections are primary parts that unlock the solution leading to this new method of production and planning based on actual demand for organizations hoping to transition towards becoming a demand driven enterprise. The benefits of decoupling and how strategically decoupled buffer helps mitigating the transference of variation along the supply chain network have already been explained. This helps in tackling the bullwhip effect and creates many shorter planning horizons between two consecutive buffer points. These shorter planning buckets help organizations to work on actual demand and gain better signals. Another major problem that most manufacturing companies are facing was related to that of the bi-modal distribution of inventory. DDMRP focuses on optimizing these inventory levels in the modern complex business environment. The figure below shows us the expected results from implementation of the DDMRP planning methodology.



The figure clearly explains that the use of today's widely used traditional MRP planning methodology results in companies stock levels oscillating between the two extremes of either having 'too little' or 'too much'. Both these are very dangerous and if such extremes exist, then somewhere in the middle exists an optimal range of stock levels. DDMRP results focuses on keeping inventory in this optimal range and creating flow through various innovations of this latest planning methodology that will be explained in one of the following sections in this report. The name DDMRP comes from the fact that it uses still relevant aspects of MRP and the 'Demand Driven' is from the fact that the methodology creates a pull-based system that works based on the actual demand. The key areas to apply DDMRP at any organization are within the procurement, distribution and operations fields.

3.4.1 Definition for DDMRP?

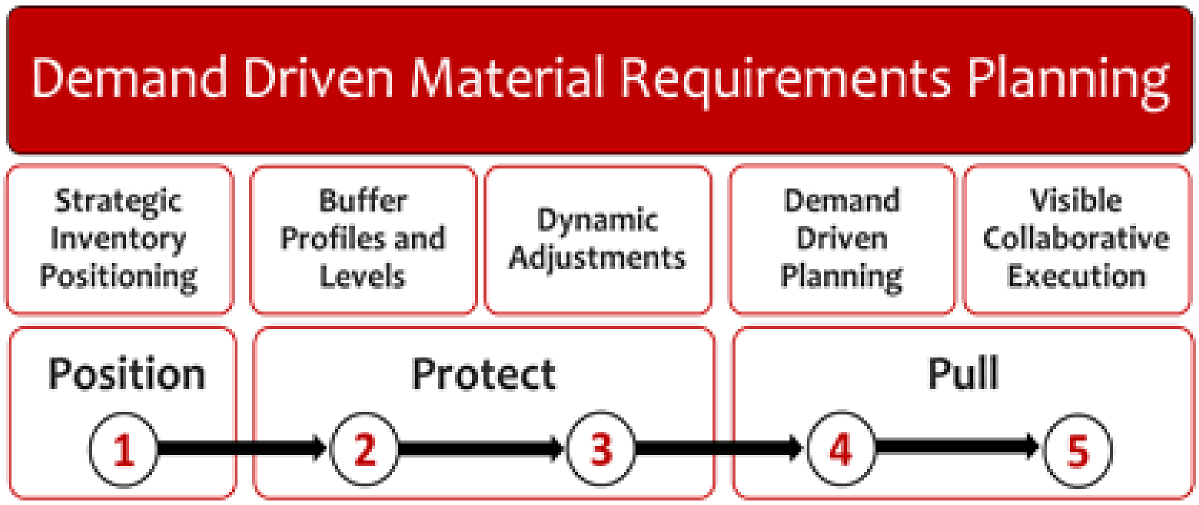
According to the demand driven institute, Demand Driven Materials Requirement Planning can be defined as a “formal multi-echelon planning and execution method to protect and promote the flow of relevant information through the establishment and management of strategically placed decoupling point stock buffers. DDMRP combines some of the still relevant aspects of Material Requirements Planning (MRP) and Distribution Requirements Planning (DRP) with the pull and visibility emphases found in Lean and the Theory of Constraints and the variability reduction emphasis of Six Sigma. These elements are successfully blended through key points of innovation in the DDMRP method. DDMRP is the supply order generation and management engine of a Demand Driven Operating Model (DDOM). DDMRP can best be summarized as...**Position, Protect and Pull”.** It is important to highlight that the laws related to flow in the earlier sections of this report are also key principles that are observed within this new methodology. The methodology identifies six key pillars exhibited in the figure below as the foundation for this new principle of production and planning.



The six pillars ensure that DDMRP is built to contribute towards helping organizations to sense actual demand and serve markets adapting to the quickly changing market scenarios of today. It aims to help solve a common issue faced by most markets today, the customer lead times being considerably shorter than the cumulative lead times to serve the market. The above pillars are very efficient flow-based principles that with innovation can clearly bring about drastic changes to current performance of enterprises.

3.4.2 Components of DDMRP

Demand Driven Materials Requirement Planning consists of five sequential components as shown in the figure. It is possible to implement only sequentially as further components cannot be realized without the previous component. The mantra of this methodology mentioned earlier can be related to the five components as shown in the figure below. 'Position' relates to the first component and 'Protect' relates to the next two components of the sequence. The first three components highly emphasize the primary and evolving configuration of the demand driven materials requirement planning model. 'Pull' relates to the last two components of DDMRP and captures the essential daily activities that would be required to operate with this new technique of planning. The successful implementation of these components initiates the journey to transform an organization into a Demand Driven Adaptive Enterprise.



Strategic Inventory Positioning phase will determine where the decoupling points are placed. Buffer profiles and levels will determine the amount of protection at those decoupling points. Dynamic adjustments define how that level of protection flexes up or down based on operating parameters, market changes and planned or known future events. Demand driven planning phase is the process in which supply orders are generated. The final phase of visible and collaborative execution is the process by which DDMRP system manages open supply orders. This part of the systematic literature review is sourced from the demand driven institute website which is a global organization founded by Carol Ptak and Chad Smith. They focus on providing education and certifications towards the research area of becoming Demand Driven. The idea and previous research all stem from books written by the founders of this institute.

3.4.3 Innovations of DDMRP

The biggest debate that exists in the operations world now is, what is so unique and different about DDMRP? In fact, there are no radical innovations or new theories that are introduced in this new planning model. It focuses on blending different information and theories that are already common today, stressing that each theory alone is not enough to create a proper demand driven enterprise. This section introduces the innovations that make DDMRP unique and helps to answer part of the second research question.

The pioneers in this Demand Driven field, Ptak and Smith believe that there are four key innovations that make DDMRP special. They are:

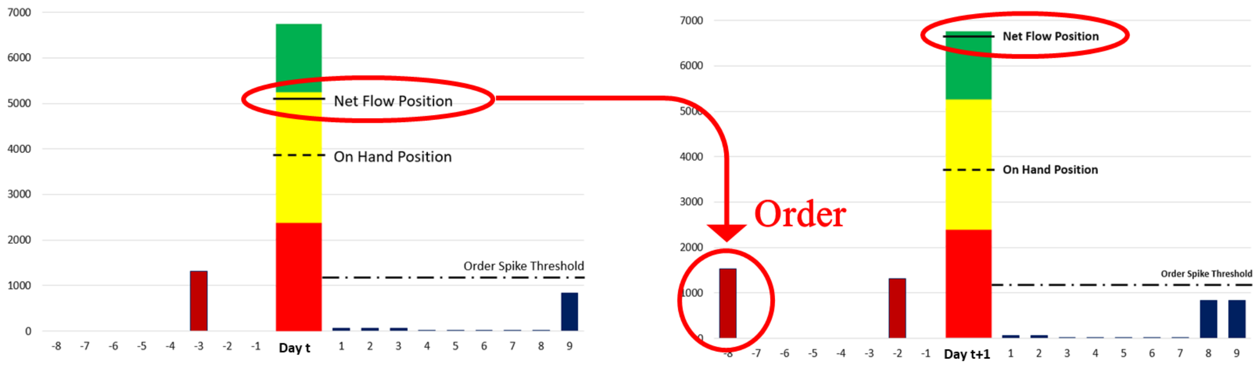
1. **Decoupled Lead Time**
2. **Net Flow Equation**
3. **Decoupled explosion**
4. **Relative Priority**

Decoupled Lead Time is defined as the longest cumulative coupled lead time chain of a manufactured items product structure. We are familiar with two types of lead times used in the MRP methodology, the manufactured lead time and the cumulative lead time. The manufactured lead time is the sum of all the lead times of only the manufacturing activities involved in the realization of the final product. The cumulative lead time is the sum of all lead times involved in the realization of the final products which includes lead times of purchase of raw materials or outsourced parts. The cumulative lead time is always larger than the manufacturing lead time. In the MRP explosion, we consider the cumulative lead time for the calculations to generate suggestions for supply order generation, coupling everything which leads to plans that are generated based on forecasts for long periods. Decoupling points and inventories planned at these strategic points help us create a set of lead time buckets within a specific product structure. It considers only the lead times between two consecutive decoupled points along a products structure. The sum of all these lead times between two consecutive decoupling points coupled together gives us the decoupled lead time used in DDMRP. This helps creating shorter lead times to the market as only the time from the last decoupling point is considered to serve the market, different from MRP calculations. It also enables the entire system to function based on pull strategies from sensing actual demand for shorter periods.

The net flow equation is calculated to understand and plan the process of creating supply orders. In the DDMRP planning methodology the various decoupling points are buffered with inventory split into three sections based on their levels. The green zone is the optimal range of inventory, the yellow is the warning range which triggers a supply order and the red zone is basically a safety stock to meet spikes due to upstream or downstream variation. The net flow equation is calculated using a simple formula:

- **Net Flow(t)**=On Hand(t)+On Order (t)-Sales Order(t)

On Hand refers to the actual physical inventory available, On Order refers to the already ordered yet to receive stock and sales order represents the sum of inventory that has already been committed to past sales orders or due today and in the near future.

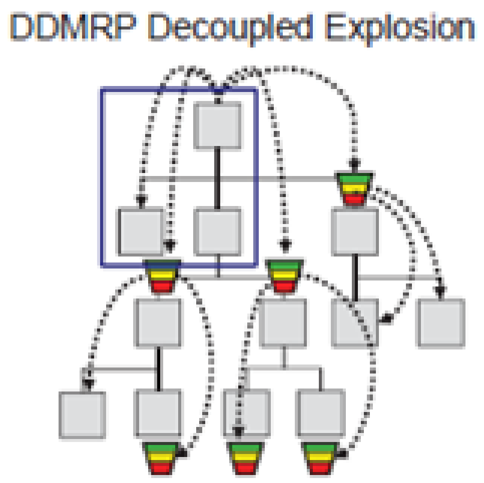


The figure illustrates how the net flow position is always calculated to the maximum inventory level decided which is indicated by the top of the green zone. The order is generated when the inventory drops below the green zone as illustrated in the above figure. The order quantity is given by the formula:

- **Order amount (t+1)**=Top of Green (t+1)-Net Flow Position (t)

The top of green and the different zones are determined in the second step of implementation of DDMRP which is 'Buffer profiles and levels.' The net flow equation is computed daily and helps planners understand clearly what inventory levels are available, what is the amount of inventory that are yet to be received and what amount of my inventory is already committed towards fulfilling customer orders.

Decoupled explosion is the termination of the dependent requirements explosion at each decoupling point. The figure helps demonstrate a typical decoupled explosion. If a supply order



is generated at the top level of this bill of materials shown in the figure, the requirements explosion stops at the next decoupling point. The stock levels at that buffer allow for such independent explosions without disrupting operational flow. This is because unlike in MRP, the buffer points calculation is never netted to zero, instead to the top of the green zone of the buffer. Each decoupling point functions autonomously based on different net flow calculations to determine the need for generating a supply order. Between the decoupling points, dependent demand requirements explode in the same manner as an MRP explosion. However, in an MRP explosion the demand for an entire planning horizon is considered all the way to the purchasing of raw materials. There exists a possibility within the MRP to decouple explosion with the help of a stop explosion flag. But this feature comes with various criticalities which have already been discussed in this research, emphasizing the need for the more innovative DDMRP decoupled explosion.

Relative priority helps focus attention to ensure the flow of operations is never disrupted. There exists a hierarchy of priorities based on the availability which could be classified in a simple manner as urgent, important and not important in that order. Traditional MRP methods do not classify priorities, instead provide binary signals to either generate a supply order or not. The DDMRP approach focuses on providing more informative alerts regarding priorities using a colour reference scheme along with a relative percentage to signal priorities. It is a key differentiator from MRP methods and functions differently in the planning and execution phases. In the planning phase, the net flow equation is used to determine the relative planning priority as compared to the execution phase where the average on-hand position is used to determine the relative priority. MRP methods use only due dates to signal priorities, it sequences priorities based on due dates whereas DDMRP sequences priorities based on more accurate buffer status. The priority is first driven by the colour of the buffer status with red representing the most urgent, yellow the important and green the not important. Within the colour ranges, the percentage is used to prioritize, lower percentage means higher priority. The percentage is computed by dividing the net flow percentage to the top of green zone value.

3.5 EMPIRICAL RESEACH

After the phase of understanding the need for a change towards the DDMRP methodology and a systematic literature review to understand the concepts and theories of becoming demand driven, the components, innovations and models to implement DDMRP, an empirical research was carried out. This section aims at studying and analysing without verification the empirical results expected from a successful implementation of the Demand Driven Materials Requirement Planning model.

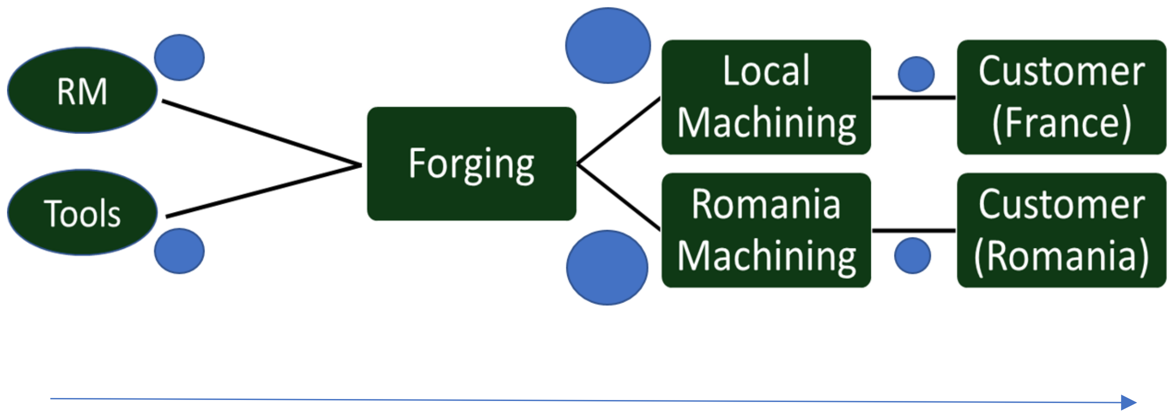
The empirical research revealed that the DDMRP is a proven method spanning across different industries like aerospace, pharmaceuticals, consumer products, steel, machining and forging etc. In fact, the method was spontaneously adopted by many leading establishments globally, most noticeably by Michelin. The empirical research suggests that demand driven materials requirement planning will completely revolutionize the way organizations operate and manage their supply chains.

All the case studies referred during the empirical research suggested that company performances improved drastically when they shifted to this new DDMRP planning methodology. The most commonly reported improvements were:

- **Service levels** – Improved customer service with a high 97% on time performance achieved consistently.
- **Lead time** – Immediate lead time shrinkages with certain industries even reporting a reduction up to 80% from earlier lead times.
- **Inventory levels** – Most companies recorded 30-45% stock reductions by placing them in strategically decoupled buffers while simultaneously improving service levels.
- **Supply Chain Cost Structure** – The lowest possible supply chain cost structures were reported with the elimination of previously common costs such as expediting, need for faster distribution modes for urgent orders. A much more accurate forecast ensured no excess inventory costs.
- **Operational efficiency** – The method is easy and intuitive with the use of colours to convey signals and helps employees see priorities rather than conflicting signals given out by the conventional planning methodologies.

A case study about the implementation of the Demand Driven Materials Requirement planning model at the Satureca Group which operates in the steel, machining and forging industry serves as the reference point for identifying key differences in performances before and after implementation of the DDMRP model.

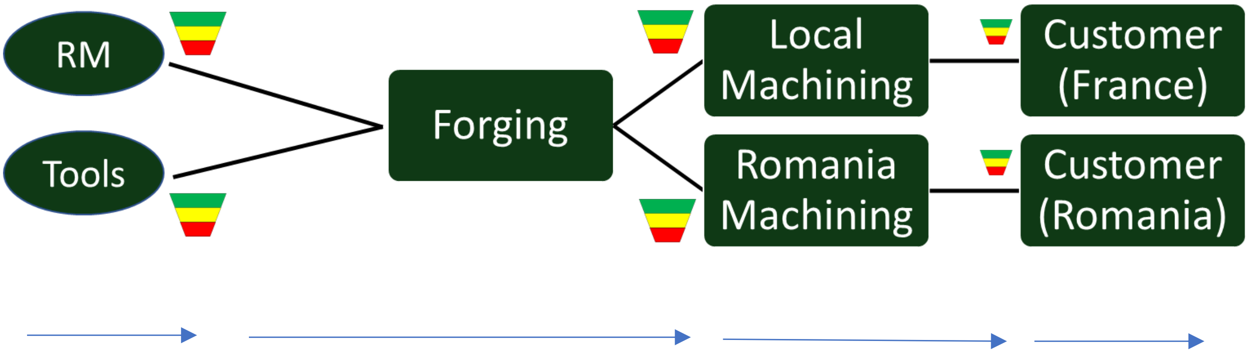
Before DDMRP



COUPLED LEAD TIME

The above figure demonstrates the basic supply chain configuration before the implementation of DDMRP using the coupled lead time. The forecast for the next three weeks were considered as the input for the forging department that operated under a manufacturing lead time of 2 weeks delivering to the machining process. At the end of these 2 weeks, a new forecast would determine if the forged parts were actually required by the machining department to serve the customers. The market scenario was very volatile meaning the customer forecasts and orders were varying even on the delivery due date, the supply markets were also not reliable with delays in the delivery of raw materials. Bad forecasts meant that stock was out of control and sometimes what was available would not be needed by the machining department creating excess stock before the machining process. It also meant creating urgencies in both factories and daily consumption from consignment stocks. Planning was therfore a critical process for this organization and the current planning methodologies created huge problems across the supply chain. There was an urgent need for a planning methodology that could manage stock levels optimally while serving the volatile market. Supply order generation and management needed to be optimized and prioritized daily, hence the implementation of DDMRP.

After DDMRP



DECOUPLED LEAD TIME

The five sequential steps for the implementation are carried out and the supply chain configuration is split into different buckets by the strategically decoupled buffer clearly indicated in the above image. The buffer profiles and levels are calculated using standard DDMRP formulas. The results of implementing the DDMRP methodology were:

- Stock levels controlled in every strategic position
- Immediate lead time reduction of 50% due to the decoupled lead time innovation
- Reduction of stock at buffer positions by 35% in three months
- No more urgencies, distortions caused at the machining process due to bad forecasts has been eliminated
- Machine capacity has increased due to availability created by producing actual demand requirements

The empirical research tends to suggest that everything about the implementation of DDMRP will result in drastically improved performances on many fronts. This seems too good to be true and thus leads us to the next part of the research, which is the implementation of this methodology in a real case study at a manufacturing firm, analysing the possible benefits and criticalities faced in the journey of transformation for any organization. The next section will also provide answers to the third and final research question of this thesina.

4. ISEO GROUP CASE STUDY

4.1 Introduction

After the literature review and empirical research, the main contribution of this thesina in the form of understanding current planning activities and implementing the new Demand Driven Materials Requirement Planning at a manufacturing firm was carried out. This section of the report explains in detail about the process of implementation and expected results at the Iseo Group, starting its journey towards becoming a demand driven enterprise. This case study was carried out during the internship program at the company as a demand planning intern. The various numbers, images and process descriptions were carried out with the help of the planning manager of the Iseo group. The data used in the spreadsheets are real company data from previous years which have been modified for the sake of confidentiality before handing over for the purpose of this research. First, after the presentation of the company, a planning and procurement activities overview has been performed – the latter through the spend analysis and the spend classification. Thereafter, we moved toward the core of the project: DDMRP technique and an analysis based on a real case carried out by following the 5 steps of this new planning technique. To wrap up, we made a critical analysis highlighting the benefits – inventory optimization, lead time compression, higher customer service – as well as the costs – software, training – and the possible impacts on both the procurement and planning activities.

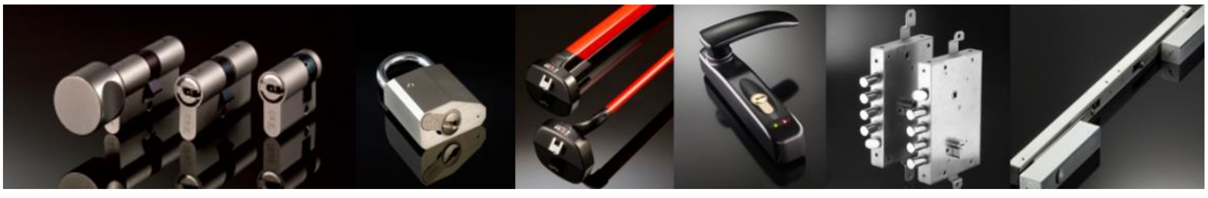
4.2 Company Presentation

ISEO group is a leading Italian family-run business. The company was founded in 1969 from Giuseppe Facchinetti's extraordinary entrepreneurial spirit. It began manufacturing locks, cylinders and padlocks in Pisogne, a village on Lake Iseo in northern Italy from which the company got its name. Security is the group's core business, and a value that has guided them over the years. Respect is another value that is part of their history. Respect for their clients, partners and those who work their best each day. Respect for the world, for all cultures and for the environment. Respect even in the face of competition to ensure a genuine entrepreneurial ethic. However, the most important value instilled within the organization is to remain deeply rooted to its origins, ISEO has remained faithful to its own territory and to the manufacturing vocation of the family that founded it and brought it up to its current size.

In 1998, the founder's son Evaristo Facchinetti began a new phase of development and founded the "ISEO Group". His growth strategy focussed on two key elements, size, because it makes a difference in a competitive market and the human factor, because entrepreneurial spirit is the centrepiece of the group. In line with this strategy, ISEO started taking over complementary companies which brought additional quality, specialization and production vocation. In 2002, ISEO signed an important agreement with DORMA, worldwide leader of door closers, automatic doors and access control systems which enabled a strong know-how integration and built up new synergies from culture, technology and products. Today, ISEO group is strongly oriented towards the global market and widely spread internationally due to the creation and acquisition of local subsidiaries. One of the major success factors with this strategy was the 'A team rather than a group' approach. This allowed a composition of a team of synergetic companies that maintain their own management staff, specialization, entrepreneurship and manufacturing sites enabling ISEO to offer the customers a deep product range and higher service quality.

ISEO has always been focusing on staff know-how, loyalty and reliability. Research is a major factor that has made growth possible. There is no innovation without research and without innovation the group believes it would not have made it to where they are today. So, ISEO invests and prioritizes research and innovation because they believe it makes a difference. The ISEO Technology Division is equipped with modern prototyping and testing equipment and has over 40 engineers working everyday with seriousness and passion to develop and spread knowledge throughout the group. The group has six manufacturing sites with the main production facility located in Pisogne, Italy. The other production sites are in Germany, France, Spain, South Africa and Romania.

The product portfolio of ISEO consists of cylinders, locks, padlocks, panic and emergency exit devices, door closers and Iseo Zero1 electronic solutions. The cylinder is the heart of security, it is the structural element whose design and manufacturing characteristics ensure effective closing performance. ISEO produces around 12 million cylinders a year and have been doing so for 40 years. In a word, ISEO produces world class access management systems.



The goal at ISEO is that quality is simple yet ambitious, offer compliance with the highest standards of international certification in all markets. They are in the homes of millions of families, guaranteeing them serenity. They have been chosen by important institutions for major projects with the projects at Rho Exhibition centre in Milan and the Vatican University ranking among the most prestigious ones. Other major projects involve institutions like banks and hotels. These results are down to the fact that the quality and reliability gathered by years of work it has been doing in designing, manufacturing and selling smart access management systems for people's safety and anti-intrusion security.

4.3 Procurement Overview

This section aims at analysing the as-is situation of procurement activities at ISEO Serrature by performing the spend analysis and spend classification based on course material from the supplier relationship management lab.

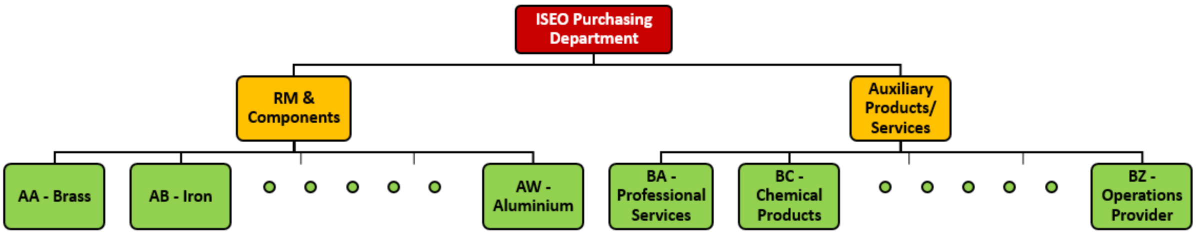
4.3.1 Procurement Organization

The procurement function has a **hybrid organization**: each plant has its own purchasing department, but there is one group CPO that coordinates every subsidiary, hence the policies – tasks and responsibilities – are homogenous. The common guidelines involve suppliers' scouting, contracting, negotiation and evaluation. The Group, in searching and assigning a new source of supply, is necessarily bound to the execution of a tender – formal or informal – for the choice of the supplier; the number of suppliers to be evaluated depends on the nature and/or the amounts of the goods to be supplied. In order to maximize possible synergies, it's a common requirement for all the companies in the Group to allow a comparison between the various suppliers even from different countries.

To assess the **purchasing maturity** at ISEO, the Reck and Long (1988) model was implemented using a questionnaire (Exhibit 1) highlighting important characteristics related to supplier relationships management: first, the suppliers are seen as a company resource tending to nurture and grow relationships since they are evaluated based on concepts such as TCO and alignment to the company competitive strategy rather than simple price or least total cost. From an internal perspective, the department has been evaluated looking at the cost reduction but has a high visibility and it's involved in long-term planning decisions providing a strategic driver. Overall, the purchasing department is classified at the **supportive** stage.

4.3.2 Spend Analysis

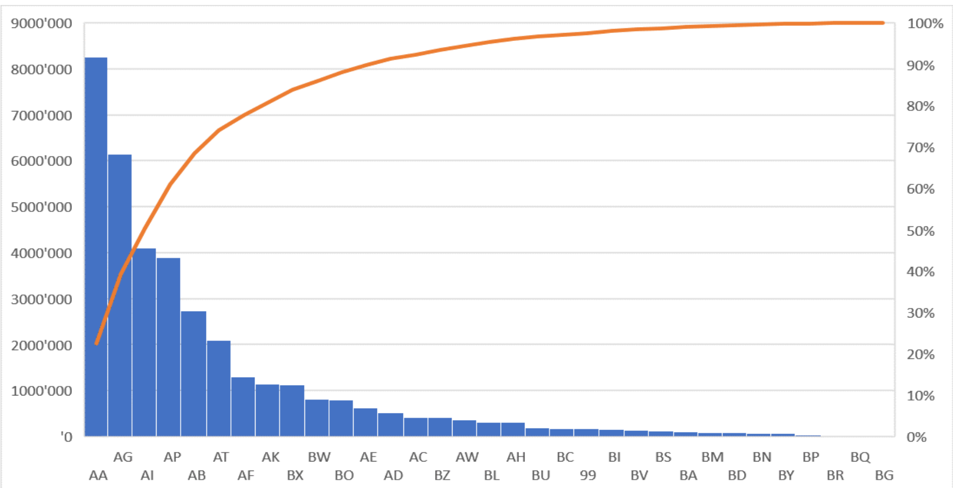
A classification of the purchasing categories at ISEO has been performed through the **category tree**. This comprises two levels based on the **commodity** or **merchandise classification** in use at the company.



Category Tree

The first level is made by two macro-categories – RM & Components, and Auxiliary Products/services - while the second level comprises 13 elements under the manufacturing category, and 20 under the service category. The classification is characterized by a double positioned letteral code where the first character provides information about the corresponding category (i.e. A: RM, B: Service) – full classification in Exhibit 2.

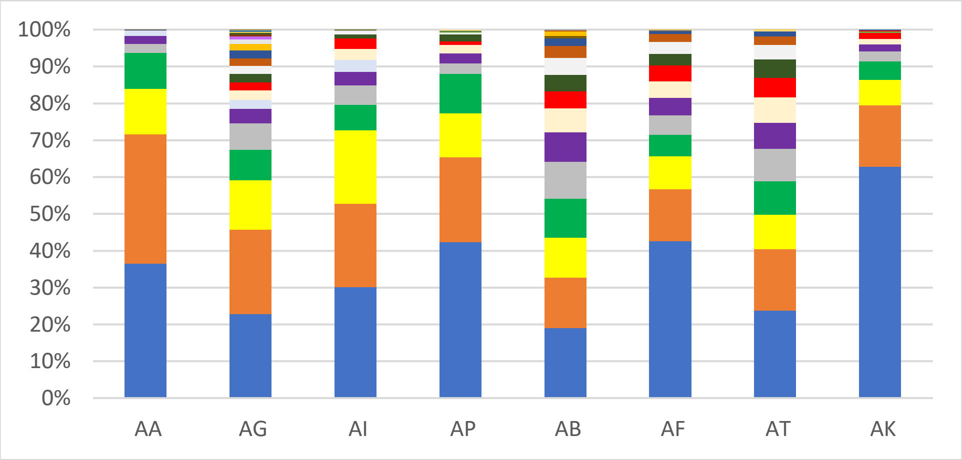
Second, **ABC analysis** with the marginal approach has been carried out because of the higher accuracy; both differences in measurement units (e.g. brass in kilos, springs in number, maintenance in hours) and unavailability of data related to the number of orders lines led us to perform the analysis only on value, while volume was analysed in a qualitative way – according to the suggestion of the ISEO Purchasing Manager.



Class	Items per Class	% of Value
A	9	83.83%
B	9	12.35%
C	15	3.81%

In the A class, 8 categories out of 9 are RM & Components (the 9th A category is labelled as "various"), while the C class includes only services: this shows that ISEO purchases much more direct material that goes into the final products; from this point, our analysis includes only the left side of the category tree given the higher importance of products for the company and the availability of the data. This consideration led us to restrict our focus to only A class items plus springs, classified as B because of the high purchased volume.

To go into more detail of the company's purchases, the **fragmentation analysis** (refer figure) has been used to study the high priority classes, identified through the ABC and to show how the spending is split among suppliers.



Fragmentation Analysis

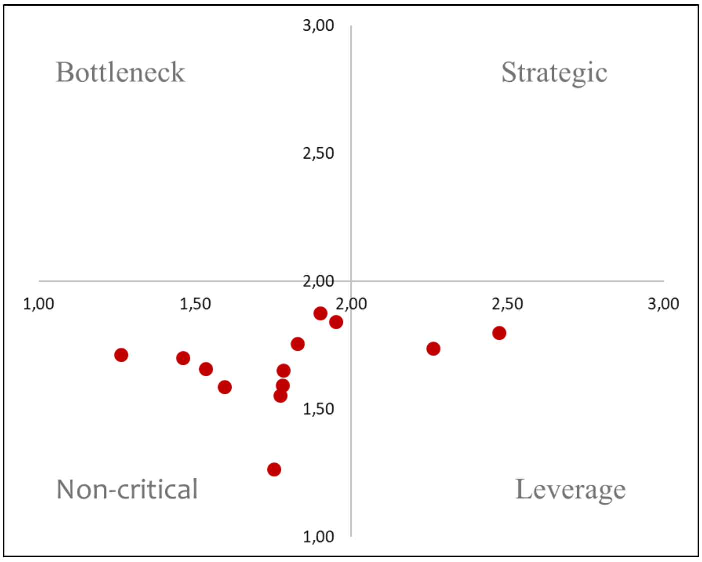
As shown above, ISEO relies on a multi-sourcing strategy for each item category with these two peculiarities:

- Each supplier provides only one item category; hence they are specialized.
- AP (*Subcontracting*) and AG (*sintered and diecasting*) are internally heterogeneous in nature: for these reasons, what looks like a multi-sourcing strategy is a single or parallel sourcing for the specific item (e.g. Sintered has only 2 suppliers).

4.3.3 Spend Classification

To assess if ISEO follows a proper category strategy, the **Kraljic matrix** was performed; the two dimensions were computed as follow:

- For the Strategic Importance, the parameters used are the *profit impact* – based on ABC value – and the *strategic class* – the strategic importance that the quality of the material has for the production process (this ranking is made by ISEO's Purchasing Department);
- For the Supply Risk, the parameters used are the *concentration of the market* – based on the number of suppliers in the market – and the *bargaining power* – based on both suppliers' and buyers' power.



The output (refer figure) shows that all the categories but two are **non-critical**, while Aluminium and Brass are classified as **leverage**; these results shows that there is coherence with the sourcing strategies followed by the company (multi-sourcing), but there are two misalignments: Aluminium (AW) and Springs (AC) have few suppliers. For AW, this is because for each profile an *extrusion die* is required, meaning higher investment costs; for AC, the revenues generated by the volumes don't allow ISEO to lose contractual power, hence the number of suppliers is enough.

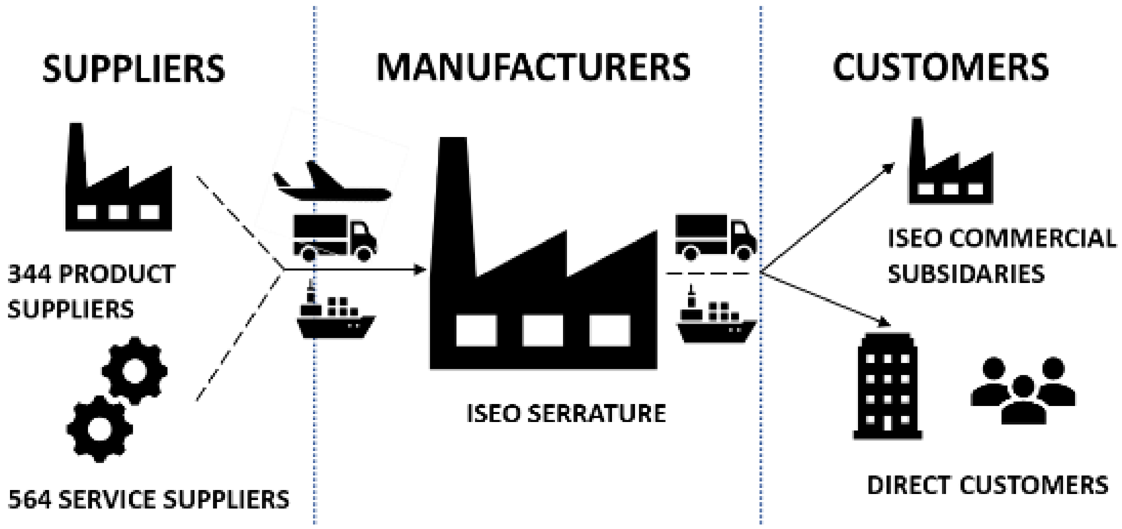
The absence of strategic product has two main reasons: first, most of the product lines can be defined as a commodity, hence the value is added by the production processes, and secondly some critical items (e.g. due to different technologies) provided by a supplier may be hidden by the product range provided by the suppliers of the same category.

The **supplier matrix** was performed in a qualitative way because the usage rate cannot be computed since the data about suppliers' turnover were not available; however, according to the information received from an interaction with the Purchasing Manager, almost all ISEO's suppliers exploit their full capacity for them, hence their dependence rates are high, leaving Iseo in a position of power over most of their suppliers.

4.4 Planning Overview

4.4.1 ISEO Supply Chain Structure

ISEO's market involves two distinct types of customers – external customers (e.g. OEM, Locksmiths, DIY, private) and intercompany subsidiaries (e.g. ISEO Middle East, ISEO South Africa). The products offering comprises mechanical, electronical and mechatronic products: the market of the first category represents the major portion of the production and, depending on the specific product lines, is currently positioned between the growing and the mature phase of the product lifecycle; for the last two categories, the market is fast-growing but represents a relatively lower percentage of the overall production at ISEO Group. ISEO's supply chain can be represented as in the visual below (refer figure).



Supply Chain Map

Another key classification needing to be addressed from a planning perspective is the type of demand. The first type includes customer orders for standard products (MTS), which account for 90% of the company sales and the industry demand. The second type of demand is for a special kind of orders referred internally as “Commessa’ (customized product) which accounts for only 10% of the sales, which the company satisfies using a kind of MTO/ATO manufacturing strategy. ISEO Germany works solely on ‘Commessa’ products and procurement and planning activities are different from that of standard products because they work only after receiving the customer orders. The customer orders are processed, and the required materials are procured, and production and delivery activities are planned separately and fed directly into the MRP activity for procurement. Following procurement, the algorithm provides work orders for the work related to ‘Commessa’ products and on approval created the short-term production plan to feed the lines. ISEO Serrature is one of the main production units within the organization and serves clients worldwide unlike most of the subsidiaries that mostly serve their local markets. The production process can be broadly classified into the manufacture of the keys, the body and the rotor. The various components are produced in distinct stages initially before they are fed into the profiling phase of the production. In this phase of the production the keys and cylinders are matched based on the different profiles and enter the final phase of assembly and testing which is done manually by the operator. The final phase of the production is the packaging phase, which follows a line production where the products are stacked in boxes of 25 pieces ready for shipping.

4.4.2 Planning Process

Presently the planning is done with a frozen horizon of 4 weeks and every fifth week is used to address the need for any alterations required due to the possible variations. The key activities of the planning department include the manufacturing planning and control as well as the material procurement and the supplier scheduling activities. Starting point and key element of the planning system is the yearly Production Plan. It is computed every year, during the Budget phase, based on the sales forecasts for the next year, using a level strategy. The Production Plan is then exploded to compute the yearly requirements in terms of labor and machine hours as well as purchase materials. After approval, the Production Plan is loaded in the system and it serves as input and constraint to the subsequent planning phases (forecast and MPS generation, MRP). It is managed and controlled at the product family level and monthly quantity volume and it will not be modified for the entire year unless required from an official revision.

The weekly planning process (refer Exhibit 3 made using the Signavio software) starts from the forecast calculation, a customized algorithm that computes a weighted average quantity per product family based on the following three inputs: monthly average actual consumption, monthly Production Plan quantity and actual sales orders. The above calculated forecast is fed into the pre-MRP run

.

The pre-MRP run is the next major weekly activity in the production planning cycle and constitutes the bridge between the sales and the production. This calculation is used to automatically create the MPS (for finished products and components sold) taking in input the requirements coming from actual sales orders, forecast and finish product safety stock. The safety stock, managed at the level of product families and eventually SKU, is established by senior management and is a key factor to allow and maintaining the customer service level required. It is normally expressed in terms of days of consumption and used as an extra-requirement to buffer supply and demand at the MPS level. Each last day of the week, the MPS for the finished (standard) products is levelled to adjust the weekly load to the existing capacity of the production lines, as per the constraints established by the Production Plan, before being published and released into the system.

Starting from the MPS, the weekly MRP run generates the detailed production schedules for internal departments and external outwork suppliers as well as the suggestions of the materials to be ordered. For some external suppliers the purchase orders are replaced by a release sent automatically through emails. The internal schedules are input to the CRP process that identifies short-term imbalances in the plan. Together with other reports, the CRP output is analyzed during the weekly production meeting in order to decide on eventual actions such as overtime, extra shift, etc. At the components and raw material levels, the company tries to minimize the use of safety stock. When needed it is generally managed in days of coverage in a number that covers half of the LT, to consider demand and supply variability.

The Logistics department is responsible for the delivery planning process, that comprises the following three main activities: finished goods receipts control and storage, delivery preparation and shipping to the end customers or ISEO plants.

1. **Control**: the material received is divided into four categories – internal and external workings, products marketed and customers' returns – by the warehouse attendant.

During the reception, a unique code (i.e. UDC) is created and identified by a barcode that allows to keep track of it throughout the warehouse.

2. **Storage**: the warehouse manager is directly responsible for the storage of finished, semi-finished and marketed products, and they are stored in appropriate locations indicated by RF terminals; once the items are placed, the system will be automatically updated.

3. **Delivery**: the issue of the material from the warehouse can be made against customer orders, internal withdrawals or returns to the customers/suppliers. This activity is carried out through special shipment picking lists designed to manage all necessary phases (picking, packaging and delivery) related to shipping of products.

4.4.3 IT Support

IT support for the SC planning process is wholly provided by SIGIP ERP tool: this software allows the company to manage every single step in the planning process including sales forecasting computation, sales order management and delivery date calculation (discrete ATP), production and inventory planning and control, warehouse management, product costing and shop floor control and performance analyses through the use of an integrated software (TeM). SIGIP has a high flexibility thanks to a high degree of parametrization, indeed it can be customized according to the need of the company (e.g. ISEO Germany works according to an MTO strategy, hence SIGIP is specifically designed for it). Another support is given by "Tempi e Metodi", a software used in the company for controlling the shop floor activities and related performance through real time connection with machines and the ERP.

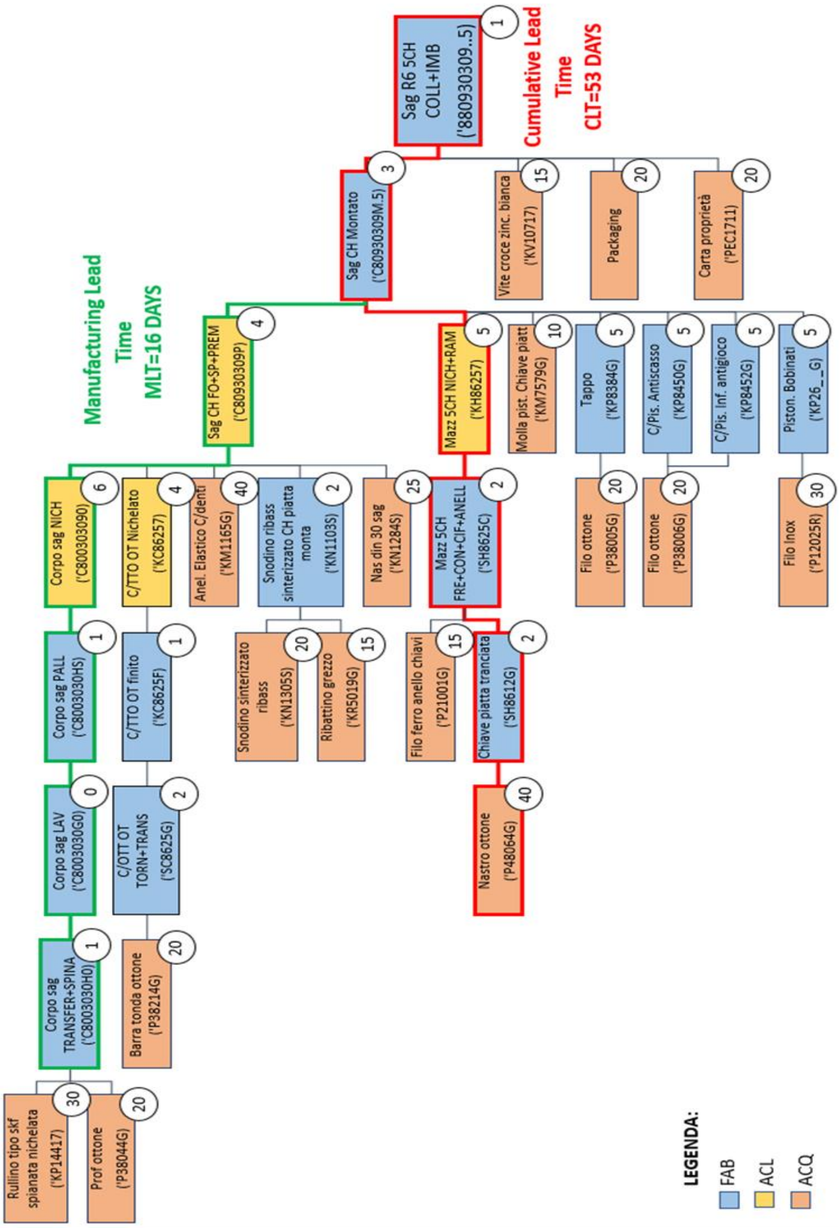
Overview Conclusion

After completion of the research related to the As-Is situations of procurement and planning activities, the data related to forecast versus sold for the previous year was verified to calculate the forecasting accuracy of the current planning methodology. This served as the starting point, establishing facts related to MRP methods stated earlier and the need for a change to the DDMRP planning methodology to tackle the increasing variability.

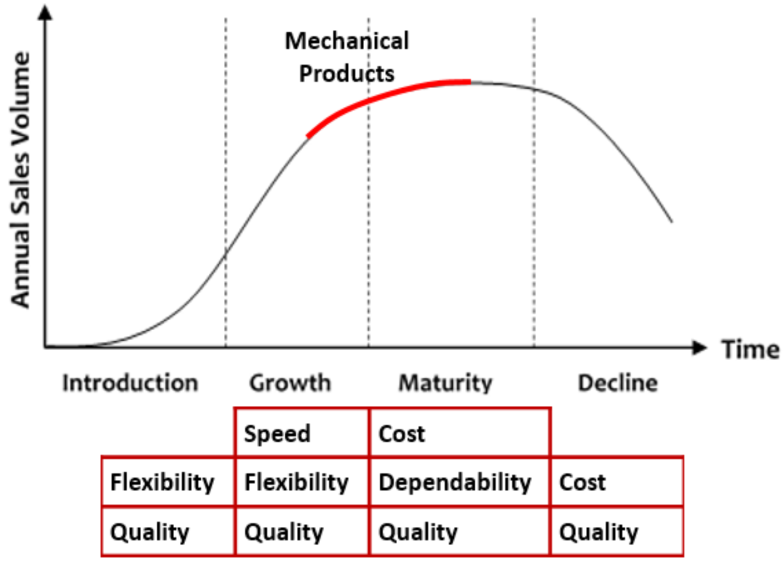
4.5 Analysis of the Core Problem

Starting Point

As a starting point the five keys R6 cylinder, which is one of the most sold products of the product line 23 amongst Iseo's product portfolio was chosen as the candidate for the DDMRP application study. The production process, outlined in the as-is BOM (refer figure), comprises components manufacturing (mechanical transformation), external surface treatment, external pre-assembly product assembly, controlling and packaging; the key manufactured components are the body, the rotor and the keys.



The mechanical products, a market in the maturity phase and the main source of revenues for ISEO, must compete on all the operations performance objectives such as quality, reliability, cost, speed and flexibility. Particularly today, speed and flexibility are becoming **order winners**, while cost, quality and dependability are **order qualifiers**. The goal is to find the best answer to the trade-off between flexibility and cost.



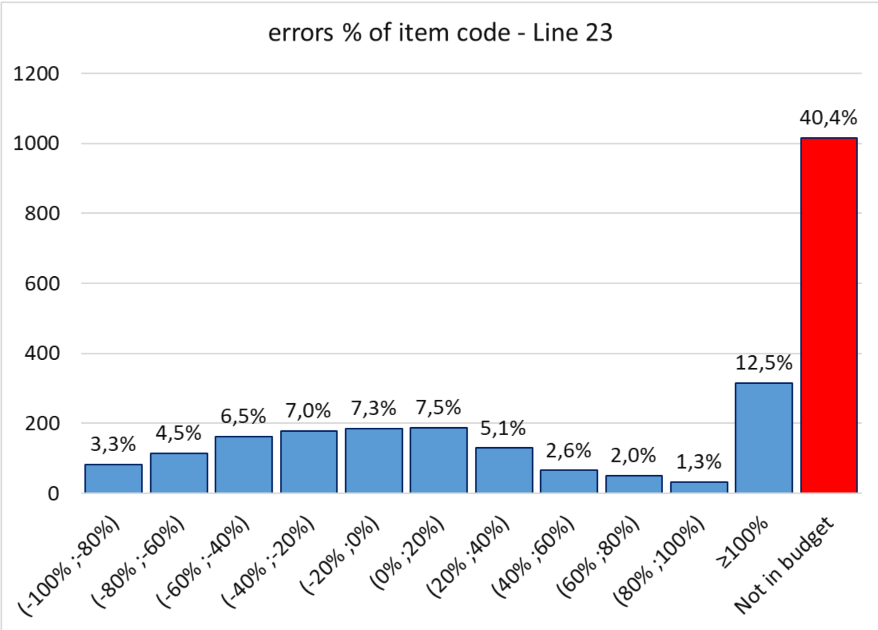
PRODUCT LIFECYCLE MODEL

The ISEO situation has been assessed using the "Sand Cone" model (Ferdow and Demeyer, 1990):

- Quality is high
- Dependability is high: service level between 95% and 98%
- **Speed must be increased**: the as-is situation shows that the actual Manufacturing LT (MLT, 4-5 weeks) is higher than the Delivery LT expected by the customer (2 weeks);
- **Flexibility must be increased** to respond to always more demanding customer requirements (changes in mix and volumes).
- Cost is competitive with the biggest players in the market.

To reach higher performance in terms of speed and flexibility, ISEO aims at shortening the MLT to a value at least equal to the expected Delivery LT, hence reducing the actual demand time fence (frozen horizon) from 4 to 3 weeks without compromising the service level.

The difficulties in forecasting the demand make more difficult to reach the desired improvements with traditional methodologies. The analysis of the differences between the forecast and the actual sales of line 23 (reversible key cylinders) gives a significant and consistent picture of the situation:

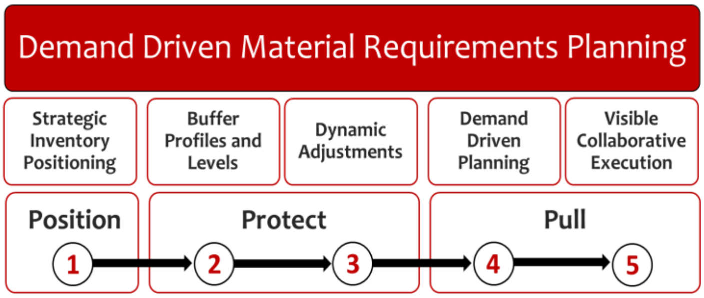


Actual vs Budgeted Sales

Less than 27% of the item (i.e. products with different code) has an error between -40% and 40%. The red bar shows the “not in sales budget” items, those that are not included in the initial yearly sales forecast: they are 40.4% in terms of item codes, but they correspond to 7.3% in terms of volume, hence again high variety and low volumes. Drilling down to the product families, the situation seems to be even worse. To reach its goal, the company is searching for new solutions able to cope with demand variability by making the system more reactive and responsive to the increasing demanding customer requirements.

This situation clearly suggests that current planning activities are seriously affected by inaccurate forecasts. Traditional planning methodologies are constantly sending companied into battle with contradicting information due to complex environments. A new planning methodology which is capable of adapting to the market variability is required, leading Iseo Group to contemplate adopting the DDMRP planning methodology and begin transition into a demand driven enterprise.

4.6 DDMRP Implementation



DDMRP has five sequential components that follows “position, protect and pull”. The first three steps essentially define the initial and evolving configuration of a DDMRP model – hence we studied the impact on the planning, while the last two define the day-to-day operation of the method – hence we ran simulations to understand completely how it works. DDMRP is the ideal starting point for an organization that aims at transforming itself into a Demand Driven Adaptive Enterprise.

4.6.1 Step 1: Strategic Inventory Positioning

THEORY

The first step aims at positioning the buffers starting from the Bill of Material (BOM) drawing. There are six placement considerations that must be analysed:

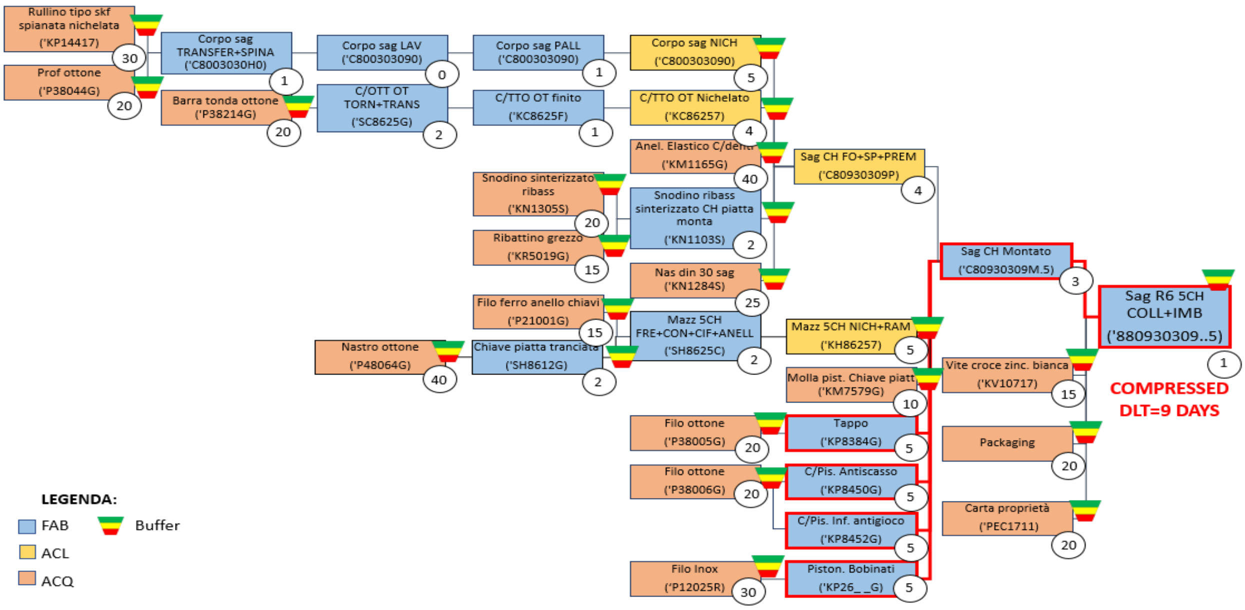
1. **Customer tolerance time**: the time the typical customer is willing to wait before seeking an alternative source
2. **Market Potential LT**: this LT will allow an increase of price or the capture of additional business either through existing or new customer channels;
3. **Sales Order visibility horizon**: the frame in which the company typically becomes aware of sales orders or actual dependent demand;
4. **External variability**: both on demand and supply side
5. **Inventory leverage and flexibility**: the places in the integrated BOM structure or the distribution network that enable a company with the most available options as well as the best LT compression;
6. **Critical Operation Protection**: these types of operations include areas that have limited capacity or where quality can be compromised by disruptions or where variability tends to be accumulated.

It’s important to evaluate for each component of the BOM, the **Decoupled LT**, which is a qualified cumulative LT defined as the longest unprotected/unbuffered downstream sequence.

The use of DLT paves the way to better see the inventory leverage and flexibility consideration for decoupling point positioning.

APPLICATION

The starting point is the BOM representation (refer the as-is BOM figure above) of the R6, highlighting the nature of each component (FAB: manufactured internally, ACL: manufactured externally, ACQ: purchased) and the LT that characterizes each stage. The as-is situation shows an MLT of 16 days, that depends mainly on the time-consuming manufacturing processes of the body, and a Cumulative LT (CLT) of 53 days, that depends mainly on the purchasing activity of the brass (“Nastro Ottone”, LT= 40 days) for the manufacturing of the keys. The delivery LT is not considered because ISEO agrees with customers the date on which the goods are ready to be shipped. The result of the first step is shown in the below figure.



Decoupled BOM

The information needed were provided by both the CPO and the Planning Manager. The latter worked with us in the position of the buffers keeping in mind the six abovementioned conditions:

- Customer Tolerance and Market Potential LT are considered together and are evaluated as 1-2 weeks (1 week = 5 days). Looking at the BOM from the right (finished product) the buffers are places in all the second level in order to have a CLT lower than 5-10 days. The exception is the already mounted item (“Montato”): to protect the flow, buffers can be placed in all the following boxes at the third level.

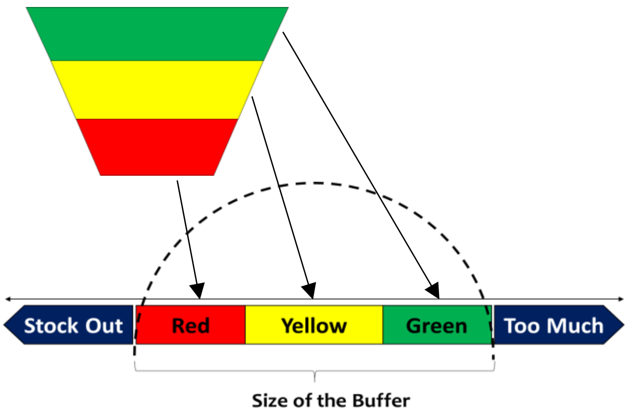
- The Sales Order visibility horizon is equal to 15 days, so the already positioned decoupling points mean that highly accurate demand signals are available within the system response time.
- The external variability on the customer side is high (as shown in the forecast analysis), hence a buffer is needed at the finished product position, while the supply side is stable (medium to low variability)
- The Inventory Leverage and Flexibility consideration led us to put buffers for each raw material. The last two passages opened the possibility to eliminate some previously positioned buffers: the purpose it to avoid too much fragmentation and overall inventory in the flow, hence buffers on “tappo”, “antiscasso”, “antigioco” and “pistoni bobinati” are delated.

  On the other hand, for the company is better to decouple the flow before the pre-mounted (“CH FO+SP+PREM”) because the previous items are used for many other products. As a result, buffers are positioned at “corpo sag NICH” and “OT Nichelato” level.
- The machine that performs milling, coining, encrypting and ringing the keys (“Mazz 5ch FRE+CON+CIF+ANEL”) represents a technological constraint, hence a critical operation: this situation led us to introduce a buffer at this level.

4.6.2 Step 2: Buffer Profiles and Levels

THEORY

The placed stocks are defined as **replenished strategic** and **dynamic buffers**. The second step aims at sizing the proper level of the buffers with the goal of absorbing shocks and compressing the lead time. The dimension of the buffer is the sum of three zones:



DDMRP Buffer

1. **Green**: the heart of the order generation aspect of the buffer determining the frequency of order generation and the minimum size of each other.
2. **Yellow**: the heart of the demand coverage in the buffer.
3. **Red**: the safety embedded in the buffer position.

The sizing of the buffer must be made as follows:

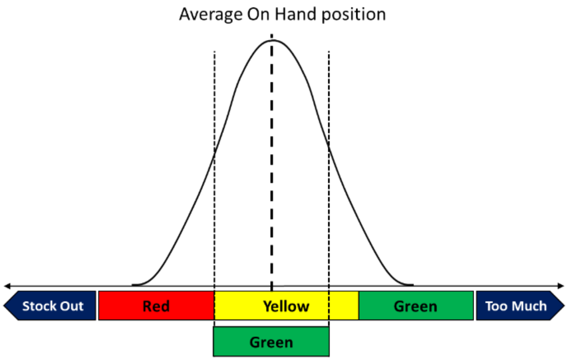
- The dimension of the green zone is defined by the maximum between
    1. Minimum Order Quantity (MOQ)
    2. $Desired\ Order\ Cycle\ (DOC) * Average\ Daily\ Usage\ (ADU)$
- For the yellow zone, the dimension is given by

$$ADU * DLT$$

- The Red Zone dimension is given by the sum of
    1. Red Zone Base: $Lead\ Time\ Factor\ (LTF) * ADU * DLT$
    2. Red Zone Safety: $Red\ Zone\ Base * Variability\ Factor\ (VF)$

In this phase is also useful to define and study the actual value of the **average On Hand** (OH) **position**, evaluated as the average value of inventory in the stock. It corresponds to the centre of the optimal normal distribution of the stock (refer figure) and it can be calculated as

$$Average\ OH = Red\ Zone + \frac{Green\ Zone}{2}$$



Average OH Position

APPLICATION

The different values needed to evaluate the optimal buffer levels are obtained in different ways, based on the following parameters:

- MOQ [pcs]: can be imposed or calculated, based on the percentage of actual machine time on the total machine time (set-up time included).
- DOC [days]: not contemplated by the company strategy because it’s a continuous production.

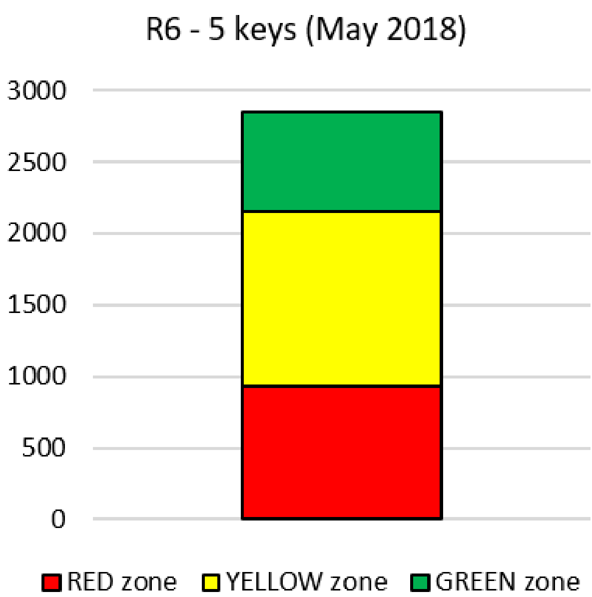
- ADU $\left[\frac{pcs}{day} or \frac{kg}{day}\right]$: evaluated using the *forward-looking calculation*, a weighted formula that contains (in our case) consumptions data of 12 past and 6 future months; august is not considered in this evaluation since it's made by 5 working days. The methodology suggests evaluating the ADU consumption on a weekly basis, but the available data were evaluated on a monthly basis.
- DLT [days]: calculated for each buffer position starting from the Decoupled BOM (figure).
- LTF: it's evaluated according to the DLT of each buffer, considering the threshold fixed with the Planning Manager (table). For each DLT, an LTF value is evaluated according to a linear distribution in the corresponding range.

LT Category	Days	LTF Range
Long	15 to 55	.2 to .4
Medium	5 to 14	.41 to.6
Short	0 to 4	.6 to 1

LTF Range

- VF: evaluated as the coefficient of variability (C_V) of ADU.

Since SIGIP provides data about overall consumption of an item, and lot of components are used in different finished products, it was necessary to define different coefficients aiming at evaluating only the ADU related to the R6 family; it's important to highlight that this assumption affects also the MOQ, otherwise the Green zone would be always sized by this parameter. In the figure below an example of the results is shown:



ADU	289
MOQ	0
DLT	9
LTF	0,52
VF	0,59
Red base	1364
Red safety	801
RED zone	2164
YELLOW zone	2603
GREEN zone	1364
Average OH	2846

4.6.3 Step 3: Dynamic Adjustment

<u>THEORY</u>

The results of the previous step are related to a specific moment; in order to have the trend of the value of a single stock level over time it is necessary to apply the third step, that consists in a **dynamic adjustment**. There are two types of adjustments:

1. **Recalculated Adjustment**: an automated recalculation of a buffer position involving any critical buffer equation input (ADU, MOQ, LTF).
2. **Planned Adjustment**: based on strategic, historical and business intelligence factors, these adjustments are manipulations of the buffer equation that affect inventory positions by raising or lowering buffer levels and their corresponding zones.

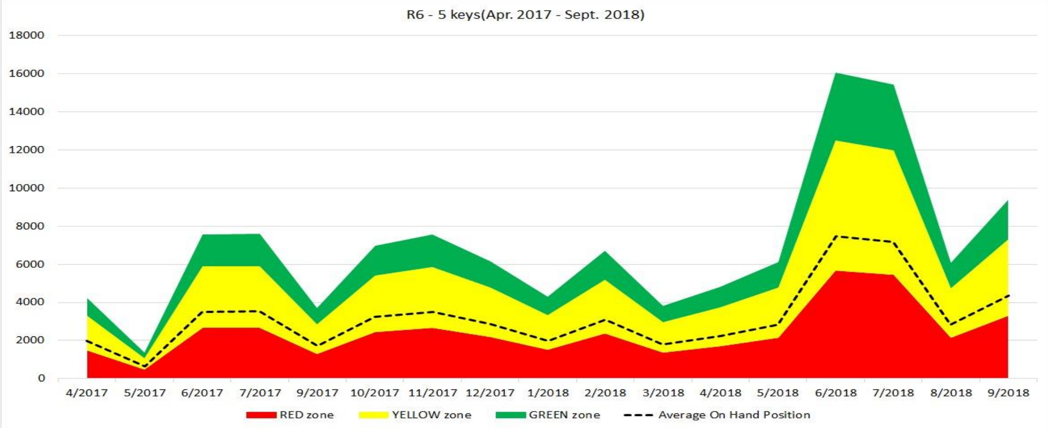
<u>APPLICATION</u>

A dynamic excel sheet for evaluating the buffer profiles was built starting from this data and considerations:

1. The recalculated adjustment is applied accordingly to the change of ADU over time. The different values are taken from SIGIP and the buffer profiles of both past and future situations are evaluated. The data about MOQ and LTF are fixed for the period in examination, but the system is even ready for value changes of these voices.
2. No planned adjustment factors because the forward-looking ADU calculation negates the need of these factors. Since the ADU is evaluated on a monthly basis, the system could be less reactive than the expectations.

An extract of the results is shown in the figure: the analysis has been made looking at 12 past and 5 future months (august is not included) for each buffered item, and a dynamic graph shows the evolution of the buffer profiles over time. The figure shows the adjustments made based on the changing ADU over time, ensuring the system changing according to the market variability.

880930309..5	ADU	MOQ	DOC	DLT	LTF	VF	Red base	Red safety	RED zone	YELLOW zone	GREEN zone	Average On Hand Position
1/2018	203	0	0	9	0,52	0,59	956	561	1517	1824	956	1995
2/2018	316	0	0	9	0,52	0,59	1490	875	2365	2844	1490	3110
3/2018	181	0	0	9	0,52	0,59	853	500	1353	1627	853	1779
4/2018	228	0	0	9	0,52	0,59	1073	630	1703	2048	1073	2239
5/2018	289	0	0	9	0,52	0,59	1364	801	2164	2603	1364	2846
6/2018	759	0	0	9	0,52	0,59	3577	2100	5677	6827	3577	7466



Dynamic Adjustments

4.6.4 Step 4: Demand Driven Planning

<u>THEORY</u>

The goal of this step, which is where the **pull logic** (i.e. lean pillar) emerges, is to generate the order for the buffer supplies, starting from the Net Flow Equation:

$$Net\ Flow(t) = On\ Hand(t) + On\ Order\ (t) - Sales\ Order(t)$$

Where:

- **On Hand**: inventory physically in stock.
- **On Order**: the quantity of the stock that has been ordered but not received
- **Qualified Sales Order Demand**: sales orders due today, in the past and qualified future spikes.

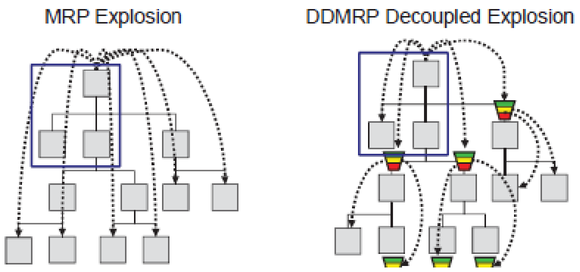
The **Order Spike Threshold** can be calculated as the 50% of the total Red Zone and it's used to recognize peaks of demand inside the **Order Spike Horizon**, equal to the DLT of the buffer, aiming at covering the overall needs created by planned orders; the DLT defines the period in which the data of both supply and demand side have to be considered.

The Net Flow equation is performed every day on all buffered item; not all the items has to be ordered every day, but only those for which the Net Flow Position is in the yellow or red zone of the buffer. Each day the qualified sales orders demand is uploaded in the system and, if needed, the supply order for the next period is generated as

$$Order\ amount\ (t+1) = Top\ of\ Green\ (t+1) - Net\ Flow\ Position\ (t)$$

The need and the urgency of the reorder can be visualized through the **planning priority**, expressed as a percentage of the OH over Top of Green: the reorder will be generated if this % is lower than $\frac{Top\ of\ Yellow}{Top\ of\ Green}$.

In DDMRP the process of requirements explosion is called **decoupled explosion**: it is the process of calculating demand for components of a parent item requirements by the component usage quantity specified in the BOM. It starts when a part's Net Flow Position (NFP) enters the rebuild zone, and the explosion stops at each stock position. DDMRP explodes same as MRP between the decoupling points.



Decoupled Explosion

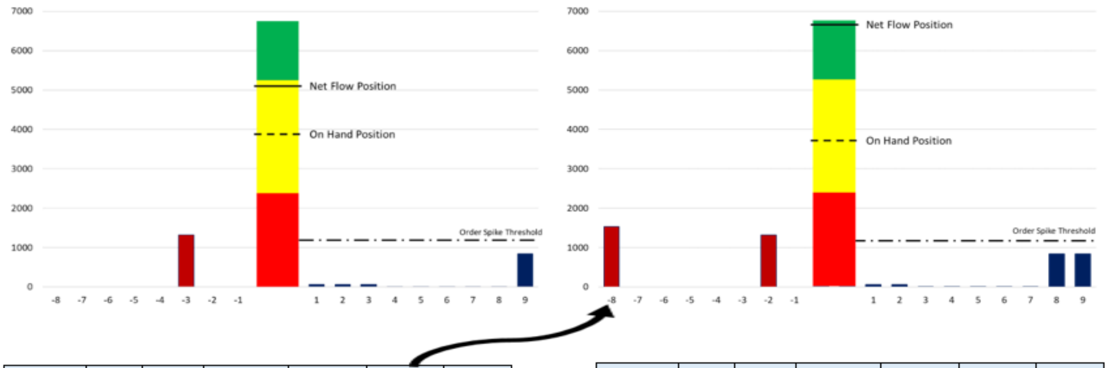
APPLICATION

For this step, as well as for the final step, the application corresponds to a simulation with few data with the purpose of understanding the execution phase of the methodology: the last phases are related to changes in operations processes rather than configuring the system. In particular, the focus for this step is showing the order generation process using as an example the buffer on the finished product (880930309.5).

The input for this analysis is:

- Buffer levels (previously calculated, step 2 and 3);
- Initial On-Hand inventory (data coming from SIGIP);

- Demand for next 20 days evaluated on a weekly basis: DDMRP methodology is a daily-basis operational methodology, hence weekly data were divided by 5 to have the daily demand (assuming a linear distribution of the demand along the week);
- First two weeks volume supplied to the buffer.



Planning Priority	On Hand	On Order	Qualified Demand	Net Flow Position	Order Amount	Ending On Hand
77%	3912	1321	64	5169	1530	3848

Planning Priority	On Hand	On Order	Qualified Demand	Net Flow Position	Order Amount	Ending On Hand
99%	3848	2851	64	6635	0	3784

Order generation Day 8-9

The order generation is not done daily: the order is made once the planning priority is yellow, meaning that the NFP is in the yellow zone. Consequently, looking at a single product family, the production seems to be occasional. It's necessary to perform this analysis on the entire product portfolio in order to understand how the continuous production can be maintained.

4.6.5 Step 5: Visible and Collaborative Execution

THEORY

The last step aims at building a system of execution alerts, that can be classified as

- **Buffer Status Alerts** (independent point): the focus is on the current or projected On Hand level of each buffer, aiming at prioritizing their management in order to protect the availability. In the execution phase, the colours representing the zones changes: yellow zone is treated as green, red zone is split between yellow and red: the yellow and red barrier is called **On Hand Alert Level**, and the deeper the OH penetration, the more severe the situation is.

$$OH\ Buffer\ Status = \frac{On\ Hand}{Top\ of\ Red}$$

- **Synchronization Alerts**: they involve dependent points in the system and rise from difficulties related to materials or LT. *Materials Alerts* can be triggered by late supply, early start commitment or insufficient supply, leading to a negative OH situation effect that is propagated along the unbuffered stages. A *LT Alert* is an execution alert for strategic non-buffered items that rises due to problematic suppliers or handling/transportation difficulties. According to the present and future alerts, a system of notifications towards the supplier of the buffer can be put in place to fight the stock-out possibility.

APPLICATION

A simulation was run on the same data used in the previous step in order to evaluate the Buffer Status Alerts. The percentage was calculated using the formula mentioned in the theory section. The buffer alerts are given primarily based on the colour scheme with red being the most important priority and green the least priority. If they are in the same colour, a second signal in terms of the percentage of penetration into the stock levels is used to prioritize. The higher the percentage the lower the priority. The below table is imported from an excel spreadsheet used to calculate the OH buffer status of the same product used in step 4.

	OH Buffer status		OH Buffer status		OH Buffer status		OH Buffer status
Day 1	203%	Day 8	165%	Day 15	212%	Day 22	94%
Day 2	186%	Day 9	163%	Day 16	212%	Day 23	90%
Day 3	168%	Day 10	160%	Day 17	241%	Day 24	86%
Day 4	151%	Day 11	213%	Day 18	205%	Day 25	81%
Day 5	133%	Day 12	213%	Day 19	170%	Day 26	155%
Day 6	171%	Day 13	213%	Day 20	134%	Day 27	139%
Day 7	168%	Day 14	212%	Day 21	98%	Day 28	193%

Buffer Status Alerts - Simulation

The above figure is the graphical representation of the simulation of the calculation of the net flow equation and how the supply order is generated, showing clearly the difference between the net flow position which is always calculated to the top of the green zone and the on-hand position which refers to the physical stock present at the buffer points.

This simulation compared with the graphical representation clarifies two important concepts of this step:

- Day 8 has low priority (165% on hand buffer status and still in green zone) even if it is related to a reorder in supply as shown in the graphical representation (as on day 8 the net flow position falls into the yellow zone): this highlights that the planning decision has nothing to do with the execution alerts, hence they don't imply operative decisions.

- From day 21 to day 25 the priority of the buffer alerts increases but still in the yellow zone. However, according to the results of the step four shown in the graphical representation figure, the OH position decreases progressively until the top of the red zone. It must be noted that the OH buffer status never becomes red since the OH inventory doesn't reach the half of the red zone as in step 5 as explained earlier the meaning of the colours are changed. So, the risk of a stockout are very minimal.

This concludes the five sequential steps involved in the DDMRP implementation process. The final part of the third research question is about the critical analysis after implementation.

4.7 Critical Analysis of the DDMRP Implementation

Our analysis starts from the primary objectives that the company wants to reach by implementing the DDMRP planning methodology. The first problem is that the **MLT** is higher than the expected Delivery LT. This is **reduced** from 4 weeks to 2 weeks due to the first step by a strategically decoupled buffer position which creates a decoupled lead time of 8-9 days to serve the customer. This enables a reduction of the frozen horizon from the current 4 weeks, allowing the Planning Manager to act on the 3rd week rather than the 4th week of the planning horizon. This lead time compression goes hand in hand with a higher **customer service level** and **satisfaction**, given that users achieve on-time fill rate of 97-100% as mentioned by the Demand Driven Institute. This may even lead ISEO to quote a premium price since the company would be able to cope with orders in a shorter time.

The second problem is the high **variability** on the customer side already mentioned earlier in the report, causing a huge bullwhip effect. This can be **highly mitigated** by the decoupling inventories, hence for the company it will be very effective if applied on those product families with high variability and low sales volume. The second step of buffer profiles and levels will ensure proper inventory optimisation and prevent the distortions caused by the bullwhip from amplifying along the supply chain.

Other benefit that can be reached is the **inventory optimization**: it could happen that in the buffered stages the amount of stock is higher than the As-Is situation (refer Feb 2018 in the table), as the goal is not to reduce inventory but simply optimise it, but the overall amount of stocks could also be reduced because some previous stock locations are now removed as in the case of Iseo. In monetary terms the savings were calculated using the formula:

$$\Delta cost = \Delta Stock * Industrial\ Cost$$

	gen-18	feb-18	mar-18	apr-18
Savings due to lower stock level	- 19'127 €	2'952 €	- 9'197 €	- 5'476 €
Savings due to removed buffers	- 13'259 €	- 9'700 €	- 7'508 €	- 12'141 €
TOTAL	**- 32'385 €**	**- 6'748 €**	**- 16'705 €**	**- 17'617 €**

Inventory Optimization – Savings

It's important to clarify that these values come from the analysis of the R6 product, so the amount of savings can vary a lot if applied also to other products.

Last benefit, already mentioned in the step 4, is regarding the **planning personnel**. Since there is an interface that shows clearly the different planning priorities using colour and percentages, this system is **easier and more intuitive** than the MRP. To determine if we should implement this planning methodology, a study on the costs and criticalities of implementation should be performed and if the benefits outweigh the costs and criticalities, we can implement DDMRP.

Regarding costs, two are the main areas: first, for the implementation a DDMRP compliant **add-on application** is required in order to have synergies with SIGIP (the current ERP application used at Iseo), whose cost is around 20-25 k€ as estimated in the Demand Driven Institute website. Then, **training** is fundamental: since this methodology is completely new to the ISEO Group, special courses are needed to educate the employees, both under a theoretical perspective and a practical one. The overall expense, calculated based on intuition of the managers at ISEO, will be around 40-50 k€. According to these values, under an economic perspective, implementing the methodology could be convenient, but a more detailed analysis, comprehensive of all the products must be carried out dealing with more accurate data. More importantly changes regarding the operations perspective, related to machine capacity and set up times must be considered and levelled to ensure the new planning methodology is more efficient. If critical operations are neglected while implementing DDMRP, the results will be drastic on the organization and could lead to huge losses.

The implementation of the methodology will impact on the following activities of the organization:

- **Planning:** these activities are easily manageable by changing the settings of SIGIP
    - The ADU must be evaluated on a weekly basis compared to the monthly evaluation carried out now, aiming at increasing the reactivity of the system.
    - The stock level, buffer size is now dynamic and doesn't depend only on LT anymore as earlier. The parameters used in the sizing must be continuously updated to dynamically adjust and optimise stock levels.
    - Linked to the previous point, the Net Flow Position must be computed every day and not on a weekly cycle.
    - The order between each buffer generation will be made automatically and, under a single item perspective, discontinuously by the system.

- **Procurement:** buffer alerts highlight the priority of the categories to be purchased, while through synchronization alerts the company can define a reminder and notification plan with attention to the critical suppliers. Moreover, if a new supplier is involved, the information (e.g. new MOQ) must be promptly updated because of the dynamic nature of the buffer size. This means a discontinuous procurement practice based on priorities which could lead to more challenging situations with suppliers.

However, this methodology presents some criticalities:

- **DDMRP cannot be applied to all the identified buffers**. In the case of Iseo, regarding the purchase of raw materials, referring to the metals (e.g. brass)

    - The LT are too high, hence there is no actual demand for such a long period;
    - The suppliers are managed by contract, where the quantity is defined and not the price. This is due to the high price volatility; hence the quantity is adjusted according to it (if the price is low the company will buy more than the actual need because the cost of keeping it in the warehouse is lower than the higher price that the company will pay in the next period of purchase)

- As said in the step 4, it’s necessary to **apply** the DDMRP methodology on the **entire product portfolio** aiming at understanding how the continuous production can cohabit with the irregular reorder of the buffers. The result could be that this technique may be applicable only on a part of the product portfolio.

- The most challenging, the implementation of the DDMRP will affect the **embedded culture** and consolidated working habits of the company: the transition from an MRP push-based system to a lean pull-based production environment will affect the entire organization. But, in the long term, such a transition will probably become essential and possibly provide a sustainable competitive advantage.

This concludes the critical analysis of benefits, costs and criticalities of the implementation of the DDMRP planning methodology. For the successful implementation of this methodology, it is essential that the benefits outweigh the costs and criticalities identified during research.

5. CONCLUSION

This research covers the area related to supply chain planning for the modern world. The purpose of the study was to understand the new planning methodology called Demand Driven Materials Requirement Planning and how to implement it within an organization wishing to transition towards a Demand Driven Enterprise. The whole noise created by this new methodology that claims to revolutionize the way supply chain planning functions, amidst the complex modern-day business environment, led to the formulation of the first research question, regarding the need for a change in the current planning methodologies used by companies. This led the research in the direction of how planning is carried out within organizations presently. The most widely used methodology presently was identified as the MRP planning methodology. This initiated the process of identifying gaps with current techniques and the need analysis for a change to the DDMRP methodology.

The preliminary research shed light on many problems related to the current planning methodology and highlighted very evidently the need for a change. Most companies revealed that the issues identified with current MRP methodologies were coherent with typical real-world problems faced by planners worldwide. Most worrying was the fact that almost all companies agreed that they use work around proliferation, often in the form of spreadsheets that are error prone to tackle these problems. These gaps helped formulate the second and third research questions, second one more related to the major differences between the two methodologies and the last related to implementation and analysis of the DDMRP.

The literature review and empirical research helped in providing answers to the major differences between the two methodologies. The results of the empirical research from real world implementation testimonies by various companies emphasized only positive results. The literature review and the empirical research helped answer the second research question. However, the empirical results needed to be verified, which enabled the final stage of this research, the case study of implementation of the Demand Driven Materials Requirement Planning methodology at the Iseo Group. This case study was carried out using past company data that had been modified for confidentiality. But with this real-world case study, the process of implementation and changes expected can be studied, along with the benefits, costs and criticalities answering the final research question. Brief conclusions to the research questions can be found in the following paragraphs of this report.

RQ1) Is there a need to change the most widely used current MRP planning methodology with this new planning methodology called 'DDMRP'?

Preliminary research about the topic of supply chain planning revealed major problems with the way most companies operate. It was quickly established that the present business environments are complex and variable and supply chains are becoming global and need to be adaptive to tackle increasing variability. Today the customers are more demanding and competition more aggressive and supply chain need to be more reactive and agile. MRP planning methodologies were designed and revolutionized in the 1960's when markets were more stable and demand less variable. It was designed to couple everything and optimise the supply chain operation. However, most companies report receiving conflicting messages from MRP systems. Studies have shown that the return on assets have been steadily decreasing and companies often exhibit a bi-modal distribution of inventory levels of either having too much or too little. It is easily understandable that most companies lack trust in MRP systems and often waste resources on verifying MRP outputs or creating work around proliferation to ensure smooth operations. This lack of trust answers the question and emphasizes the need for a change in planning methodology to enable organizations to tackle the globalization and uncertainty of today's business environment. The DDMRP methodology looked the most promising solution to address the requirement for a change.

RQ2) What are the key differences between the MRP and DDMRP planning methodologies?

The literature review and empirical research sections helps the readers understand the various theoretical concepts related to the new planning methodology. This enables the comparison between the as-is situation with the to-be situation. The aim of both methodologies is similar, trying to create flow and optimize the supply chain operation. But MRP methodologies were created a long time ago and provide conflicting messages because everything is **coupled in the bill of materials** and order generation after an explosion is considered from the lead time for acquiring raw materials all the way to the finished products. This requires plans to be made for long periods and forecasts to be highly accurate. The DDMRP method focuses on creating independent planning horizons by strategically **decoupling the bill of materials.** The strategically placed buffers across the bill of materials enables shorter planning buckets and more accurate forecasts based on actual demand. This decoupling leads to the biggest innovation of the DDMRP methodology which is, the **decoupled lead time.** The decoupled lead time is calculated as the sum of all the lead time between two consecutive decoupling points along the product structure of the bill of materials. This enables a lead time compression as the time to market is calculated as the lead time from the last decoupling point. MRP methods use a **cumulative lead time and manufacturing lead time** concept. The order generation is therefore for a longer period as mentioned earlier and priorities are managed using **due dates.** The DDMRP methodology is more intuitive and calculates priorities using formulas that indicate the penetration into the buffer profiles. The priorities are managed based on the **colour code and percentage value,** proving to be more accurate than using due dates. MRP methodologies use **forecasts** to generate orders. An inaccurate forecast would create many problems, forecasts for long periods also mean the systems are less reactive to any demand variations. The order generation in the DDMRP method is based on the **buffer profiles and levels.** An order is generated every time the net flow position falls into the yellow zone of the buffer. The buffer levels are predetermined, and the order is always made to equate the net flow equation to the top of the green zone. The buffer profiles and levels are continuously evaluated, and dynamic adjustments are made based on the average daily consumption or other trends of each decoupling point. The **net flow position** is another major innovation of the DDMRP methodology, it is used to ensure that the strategic decoupled points always maintain the optimal level of inventory and is evaluated daily. This enables the system to react to actual demand and protects flow of operations.

RQ3) How to implement DDMRP within a company, what are its impacts on other activities within the organization along with its benefits and criticalities?

The literature review helped in understanding the 5-step sequential framework used to implement the DDMRP planning methodology. It highlights that the implementation of DDMRP is the first step in the journey of an organization seeking to transition into a Demand Driven Enterprise. The first step of placing the strategically decoupled buffers is the most important and was carried out by various considerations. The product R6 of the line 23 from the product portfolio was selected for the case study of the implementation of DDMRP. The bill of materials of the entire product structure was identified and the 5 steps were sequentially implemented. The Iseo Group case study section clearly explains the theory and application of each step in a detailed manner with various graphical representations and simulations. After the implementation study, it was possible to perform the critical analysis using the above data to understand the possible benefits and compare to the results of the empirical research. In addition to this, the calculations for costs related to the implementation and possible criticalities not mentioned in the empirical research were identified and presented.

The critical analysis carried out after working with real data on a part of the product portfolio at the Iseo Group for the implementation of the Demand Driven Materials Requirement Planning methodology provides the major contributions to this research. From the economic point of view, it was identified that the implementation of this DDMRP methodology would bring savings, particularly from removing of various existing inventory. The benefits related to lead time compression and intuitive alert signals enable a much more efficient way of planning activities within the organization. However, the results are from the study of implementation on a part of the product portfolio, application on the entire portfolio might provide different results and needs to be verified before implementation. It has been established that the implementation will affect functions like planning, procurement and production activities within the organization as mentioned in detail earlier. An important criticality identified is about the fact that DDMRP cannot be always applied in the case of Iseo. The example of purchasing of metals (eg brass) is carried out based on contracts which specify quantities and not price. Activities like forward buying are common due to the high price volatility of the supply market. The most important criticality is probably that implementation affects the culture of the organization. It is important that the top management trust the process and suitable training is imparted throughout the organization to get everyone on board and believe that this transition is the way forward.

The **biggest limitation to the research** is that it was performed only on a part of the product portfolio. The DDMRP theory suggests that application on the whole product portfolio. Since we worked on past data and only on a part of the product portfolio, we applied various correction coefficients to the SIGIP data which was related to the whole line 23 and not just the R6 cylinder. These coefficients were introduced based on the intuition of the planning manager at Iseo. It was also understood that DDMRP is only the first step forward in the long journey towards adopting the Demand Driven Adaptive Enterprise model which enables organizations to function as a demand driven enterprise adapting to the complex and volatile modern business environment. These limitations also provide **scope for future work** and new research topics in the field of supply chain planning in the modern world.

6. EXHIBITS

EXHIBIT 1 – QUESTIONNAIRE

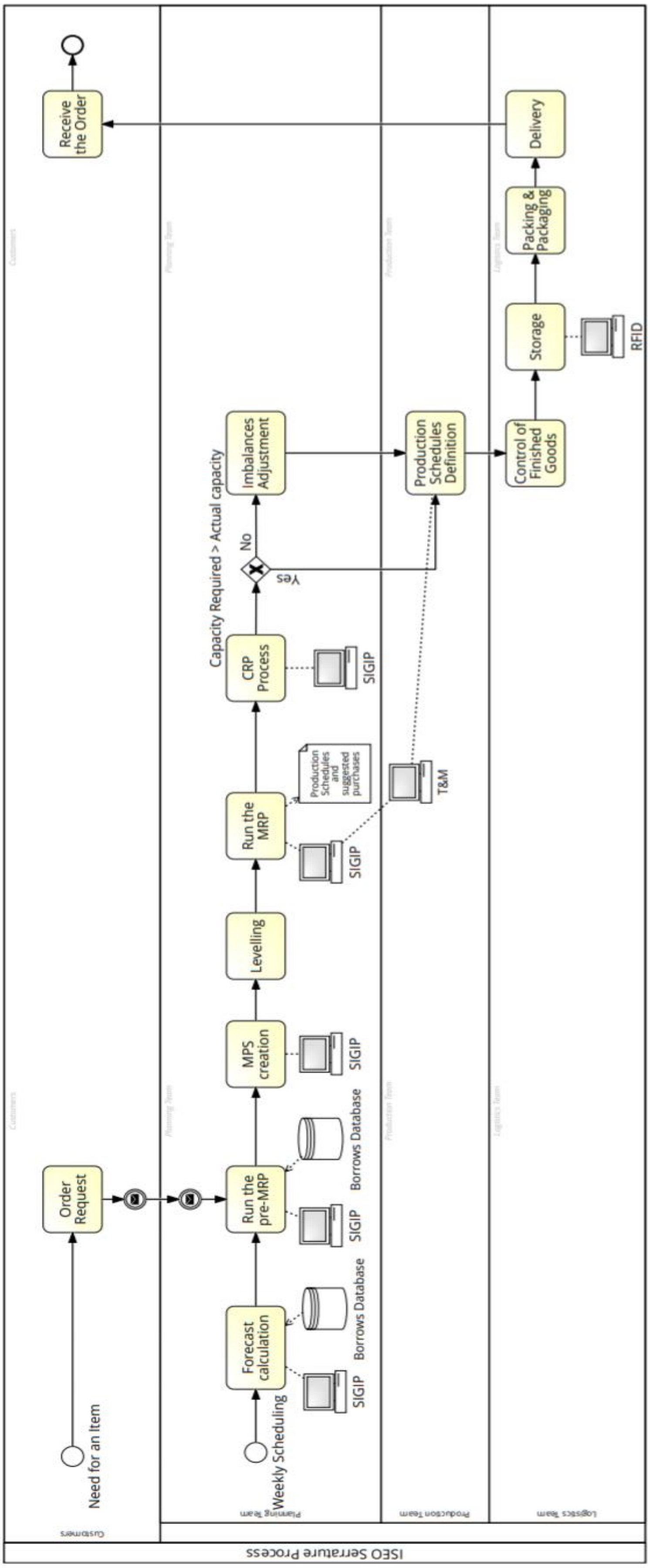
	Passive	Independent	Supportive	Integrative
Nature or Long-term planning	None	Commodity or procedural	Supportive or strategy	Integral strategy
Impetus for change	Management demands	Competitive parity	Competitive strategy	Integration with management
Career advancement	Limited	Possible	Probable	Unlimited
Evaluation based on…	Complaint	Cost reduction or supplier performance	Competitive objective	Strategic contribution
Organizational visibility	Low	Limited	Variable	High
Computer system focus	Repetitive Tasks	Techniques and efficiency	Specific decision request	Needs or decision
Sources of new ideas	Trial and Error	Current Purchasing practices	Competitive strategy	Fundamental information exchange
Basis of resource availability	Limited	Arbitrary	Objective	Strategic Requirement
Basis of supplier evaluation	Price and availability	Least total cost	Competitive objectives	Strategic contribution
Attitude towards supplier	Adversarial	Variable	Company resource	Mutual interdependency
Professional development focus	Deemed unnecessary	Current new practices	Elements of strategy	Cross-functional understanding
Overall characterization	Clerical function	Functional efficiency	Strategic facilitator	Strategic contribution

EXHIBIT 2 – ISEO PURCHASING CATEGORIES

Code - RM	Item
AA	Brass
AB	Steel
AC	Springs
AD	Screws, Dies
AE	Pins, Washers, knobs
AF	Packaging
AG	Sintered and diecasting
AH	Various produced materials
AI	Commercialized
AK	Electrical component
AP	Subcontracting
AT	Painting and treatment
AW	Aluminium

Code - Services	Item
BA	Professional services
BC	Chemical Products
BD	D.P.I.
BG	Fuel
BI	Pallets
BL	Commercial tooling
BM	Spare Parts
BN	Consumables
BO	Equipment and machine
BP	Maintenance
BQ	Measuring instrument
BR	Gadget
BS	Catalogues
BU	Drawing tools
BV	Powder Paint
BW	Service provider
BX	Various
BY	Electric material
BZ	Lender

EXHIBIT 3 – PLANNING PROCESS



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https://www.demanddriveninstitute.com/compliant-software

DDMRP principles
https://www.demanddriveninstitute.com/ddmrp

Information about the company
https://www.iseo.eu/iseo_holding/ing/index.htm

Article about DDMRP
https://www.linkedin.com/pulse/truth-ddmrp-implementation-patrick-rigoni/