POLITECNICO DI TORINO

Master of Science in Engineering and Management

MASTER THESIS

Analysis of Advanced Planner Optimizer (APO) in supporting PP/DS (Production planning and detailed scheduling) within the supply chain management function.

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ABSTRACT OF THESIS

Companies want to save money and do everything in the shortest amount of time, with as few uses of resources as possible. One of the ways to get this point across is introducing any system to manage its resources in a better way and have the possibility to make decisions quicker to respond at the correct time to the wide demand change.

The majority of the big companies have the necessity to have a system in place to help them to run their business processes. To integrate those processes, ERP system was introduced, a system that supports and integrates business activities in a global way.

The following points will provide better understanding of PP/DS benefits for companies' performance. Initially at production level companies, are able to achieve complete integration between business areas allowing higher control and planning management, to improve their performance. Additionally, results of the empirical research provide justification of a framework that identifies the principal tools and process implemented during the PP/DS run, describing improvements during the production planning achieving competitive advantage.

Key words: Supply chain management, Production planning/Detail Scheduling (PP/DS), SAP, ERP.

CONTENT

ABSTRACT OF THESIS 2
OVERVIEW 7
Thesis Objectives and Scope 10
Thesis Structure 12
CHAPTER 1. RELEVANT BASIC 14
ERP SYSTEMS 14
Brief evolution 15
SAP 18
SAP SCM 20
Supply Chain Planning Process 21
Supply Chain Management 25
Advanced Planner and Optimizer (APO) 28
Components of SAP APO 30
a. Demand Planning 30
b. Strategic Network Planning (SNP) 31
c. Production Planning and Scheduling (PP/DS) 32
d. Distribution and Transportation Planning (TP/VS) 33
e. Global Available to Promise (Global ATP) 33
SAP 4HANA 34
CHAPTER 2. COMPANY CHARACTERIZATION 39
Brief overview 39
Products 40
Initial production plan 43
Project objective 46
Chapter 3. SYSTEM TO BE INTRODUCE 47
Planning process 48
Main elements involved in the PP/DS module. 50
Master data for production: 51
A. Product 52
B. BOM 54
C. Routing 56

D. Resources 57
E. PDS for PP/DS 58
Transactional data 59
A. Sales order 59
B. Production order 61
C. Purchase requisition 62
D. Stock transfer 62
Scheduling and Strategy Profile 63
Scheduling Planning Board 64
Work area 65
CHAPTER 4. METHODOLOGY CONFIGURATION. 68
Classification configuration 68
Advanced Planning Configuration 72
Alert Monitor 72
Production Planning 73
Variants creation 73
Detail Scheduling Strategy profile creation 75
Selection Options (resources, product, Profiles) 76
Pegging relations 78
Production Planning Horizons 79
CHAPTER 5. PRODUCTION PLANNING RESULTS WITHIN THE NEW METHODOLOGY 81
Alert Monitor Evaluation 83
Production Planning Heuristics 87
Detailed Scheduling 87
Drag and drop 89
Alternatives resources 90
Modification of capacity variants 92
Closing of the GAP 95
Fix plan 96
Plan Order conversion 97
CHAPTER 6. CONCLUSIONS 101
REFERENCES 108

LIST OF FIGURES

FIGURE 1. PROBLEM TREE 10
FIGURE 2. ERP MODULES EXAMPLES. 15
FIGURE 3. DEPLOYMENT TYPES 17
FIGURE 4. THE APPLICATIONS OF SAP BUSINESS SUITE. 19
FIGURE 5. PROCESSING OF CROSS-COMPANY PROCESSES AND THE COLLABORATIVE PLANNING AND PROCUREMENT PROCESSES. 21
FIGURE 6. SUPPLY CHAIN PLANNING PROCESS. 22
FIGURE 7. APO PLANNING AND ECC-INTEGRATION. 23
FIGURE 8. PRODUCTION PLANNING & DETAILED SCHEDULING – OVERVIEW 24
FIGURE 9. INTERNAL AND EXTERNAL SUPPLY CHAIN. 25
FIGURE 10. SUPPLY CHAIN MANAGEMENT. 27
FIGURE 11. THE SUPPLY CHAIN PLANNING MATRIX 28
FIGURE 12. SAP APPLICATIONS AND COMPONENTS COVERING THE SUPPLY CHAIN PLANNING 30
FIGURE 13. EXAMPLE PROCESS CHAIN FOR DEMAND PLANNING. 31
FIGURE 14. 5 YEARS EVOLUTION IN INTERNET USERS JANUARY 2019. DATAREPORTAL. 34
FIGURE 15. MOBILE'S SHARE OF TIME SPENT ON THE INTERNET JANUARY 2019. DATAREPORTAL. 35
FIGURE 16. WHY SAP S/4HANA ENTERPRISE MANAGEMENT? 36
FIGURE 17. KEY CAPABILITIES OF AN EXCEPTION-BASED USER INTERFACE DESIGN. 37
FIGURE 18. ELTEK PLANTS. 39
FIGURE 19. MEDICAL PARTS. 40
FIGURE 20. GROUP OF APPLIANCE PRODUCTS. 41
FIGURE 21. AUTOMOTIVE PRODUCTS. 42
FIGURE 22. ACTUAL CUSTOMER ORDER. 44
FIGURE 23. PLANNING PROCESS OVERVIEW. 48
FIGURE 24. ORDER CONVERSION TRIGGERED FROM APO. 49
FIGURE 25. PRODUCTION PLANNING & DETAILED SCHEDULING - MASTER DATA 51
FIGURE 26. GENERAL MATERIAL DATA. 52
FIGURE 27. MRP DATA. 53
FIGURE 28. ADVANCED PLANNING DATA. 54
FIGURE 29. GENERAL INFORMATION. 54
FIGURE 30. SEQUENCE OF OPERATION. GENERAL INFORMATION.. 55
FIGURE 31. COMPONENTS OF FINAL MATERIAL. 55
FIGURE 32. ROUTING MASTER DATA. 56
FIGURE 33. ROUTING OPERATIONS.. 56
FIGURE 34. RESOURCE MASTER DATA. 57
FIGURE 35. STRUCTURE THAT CONTAINS THE MASTER DATA FOR PLANNING IN SAP APO.. 59
FIGURE 36. SALES ORDER GENERAL INFORMATION.. 60
FIGURE 37. PRODUCTION ORDER DETAILS. 61
FIGURE 38. PURCHASE ORDER EXAMPLE. 62
FIGURE 39. FINITE AND INFINITE RESOURCES WITH CAPACITY OVERLOAD. 63
FIGURE 40. PLANNING BOARD.. 64
FIGURE 41. WORK AREA GENERAL BASIC DATA.. 66
FIGURE 42. CAPACITIES IN THE WORK AREA. 66

FIGURE 43. PROCESS CLASSIFICATION.. 68
FIGURE 44. CREATION OF THE ALTERNATIVE CHARACTERISTIC. 69
FIGURE 45. CLASS CREATION. 70
FIGURE 46. CHARACTERISTICS RELATED TO THE CLASS. 70
FIGURE 47. ROUTING WITH A GROUP OF ALTERNATIVE MACHINES.. 71
FIGURE 48. WORK CENTER WITH THE ALTERNATIVE MODE CLASS. 71
FIGURE 49. PRODUCTION PLANNING RUN WITH MULTIPLE STEPS.. 73
FIGURE 50. STRATEGY PROFILE CREATION.. 76
FIGURE 51. PLANNING BOARD. 77
FIGURE 52. PROFILE DETAIL. 78
FIGURE 53. PRODUCTION PLANNING HORIZONS. 79
FIGURE 54. NEW PLANNING PROCESS. 82
FIGURE 55. DELIVERY DATE IS NOT MET. 83
FIGURE 56. RESOURCE LOAD EXCEEDS 100% OF THE CAPACITY. 84
FIGURE 57. ALERT REPORT. 85
FIGURE 58. HEURISTICS RESULTS.. 86
FIGURE 59. NUMBER OF THE RESOURCES INVOLVED ON THE PLANNING TABLE. 89
FIGURE 60. ROUTING – WITH THE CLASSIFICATION FLAG ALLOW TO HAVE AN ALTERNATIVE MACHINE.. 90
FIGURE 61. ALTERNATIVE RESOURCE FOR ASSEMBLY OPERATION.. 91
FIGURE 62. AVAILABLE CAPACITY BY 15 SHIFTS. 92
FIGURE 63. SHIFT DISTRIBUTION (15 SHIFT). 93
FIGURE 64. SHIFT DISTRIBUTION (20). 94
FIGURE 65. AVAILABLE CAPACITY BY 20 SHIFTS. 94
FIGURE 66. CLOSING GAPS. 95
FIGURE 67. GAPS CLOSED.. 95
FIGURE 68. FIXING ORDER.. 96
FIGURE 69. LIST OF MODIFIED ORDERS. 97
FIGURE 70. ORDERS TO CONVERT 97
FIGURE 71. CAPACITY REPORT EXAMPLE. 99

OVERVIEW

Managed all the operations inside a company is not easy and is even more complicated when they are not integration between them. Additionally, when those tasks are done without any technological support, the cost, risk to make any mistake and time consuming are high.

As well, market globalization and technological development force the companies to find the way to survive in the widely environment. Today, even medium companies count with different plants, located far away from the central operational plant, and customer all around the world. From the above arises the question, how to manage all the activities in an effective way?

After the chaotic disintegrated business process, enterprises realized the importance to have a better managed control. So on, they "started to transform themselves from vertically integrated organizations focused on optimizing internal enterprise functions to more-agile base" (Genovese, Miklovic N, Wood, Zrimsek, & Rayner, 2000) , through the Enterprise Resource Planning (ERP) implementation.

Under the ERP system all departments could process their transactions using the same system "language", which is one of the factors that allows the integration inside the company. (Action, 2017). Also, is necessary to considerate that the ERP system must be extensible in terms of support for a range of external constituents in the Supply Chain Management to perform multidimensional analysis on large volume of data.

This new concept has the object to "coordinate material, information and financial flows in a company's value chain including business partners such as suppliers, contract manufacturers, distributors, and customers" (Kallrath & Maindl, 2006). An effective management allow costs reduction, competitive advantage, fast and flexible responses at customer needs. SAP Supply Chain Management is a complete solution that covers Supply Chain Networking (SCN), Supply Chain Planning (SCP), Supply Chain Coordination (SCC), and Supply Chain Execution (SCE). (SAP, 2018)

Going deeper in the SCM, is necessary to detail two important components for this project, those are related with present and future planning. The “earlier” Supply Chain Planning (SCP) is run in a determinate time of period to get a specific result.

The strategy of the Supply Chain design and the planning component involved under the Demand Planning and Supply Network Planning (PP/DS) are the two fundamental activities under the SCP concept. On the other hand, the “later” call Supply Chain Execution (SCE) which must be prepared to act at any event, so on must be always available with actual information. This one is composed by tree types of activities, Procure, manufacturing and delivery.

Those process must be executed through any enterprise resource planning software as SAP which enable the companies to run in an integrated way their processes. Depends on the nature of the company, they are going to decide under which module or which combination of modules are going to work.

“It’s suite of software products includes:

- Customer Relationship Management
- Enterprise Resource Planning
- Supply Chain Management and logistics Software
- Manufacturing, Warehouse and Industrial Software
- Marketing and Sales Software” (Gerard, 2015).

This project is going to be developed on the base SAP ECC and SAP SCM modules.SAP ECC integrates digital information that's created in one area of a business with data from other areas of the same business in real-time. Includes components such as SAP Customer Relationship Management and Supply Chain Management. On the other hand, the SCM module which includes collection of planning applications related to Advanced Planning, Optimization, Scheduling and Integration with other SAP execution applications. (SAP, 2018).

While the market is changing, the SAP software is constantly developing new products to help their customers respond to dynamic market conditions and help them maintain their competitive advantage and now SAP offers variety of products to address varied needs of an organization.

For example SAP HANA, means High Performance Analytic Appliance which “Harness the power of your data and accelerate trusted outcome-driven innovation by developing intelligent and live solutions for real-time decisions and actions on a single data copy” (SAP, SAP , n.d.)

Thesis Objectives and Scope

Companies are been forced to react as fast as possible at technical development if their wish is continuous in the market. That's the reason why they should identify the principal issues to determinate a way to survive.

Some of the problems identified were lack of mechanisms controls inside the company, existence of multiple wastes of time and inventory, also the absence of standardizing and integration between the processes of the areas make the bad business performance

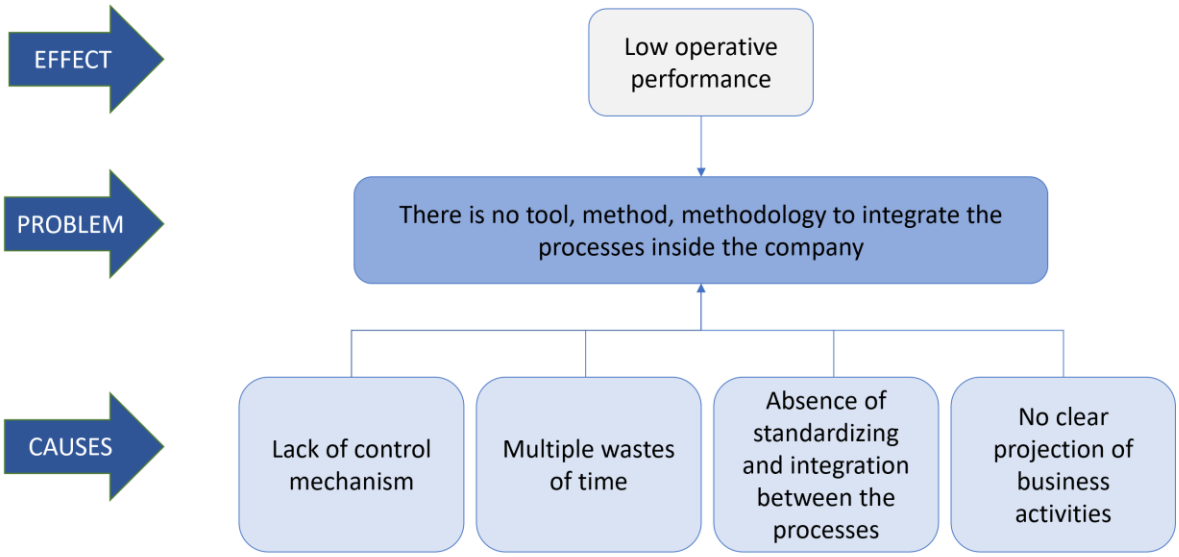


Figure 1. Problem tree. Own creation.

Through those symptoms, has been possible to identify that there is no tool, method, methodology to integrate the processes in the company. This lack, generates a low operative performance, evidenced by intermittent production and poor coordination between areas. Simultaneously all those details can trigger at a low level of service. Figure 1.

Based on the problem described, this project was aimed at addressing the research two questions: What set of approaches, methods and tools allow the business process integration? And what

tools are used for an adequate planning of the production and after its validation improve its operational performance?

The general objective of this project was to identify how PP/DS tool as a part of SAP, helps ELTEK company to improve their supply chain management through a new methodology which allow the company to have a better planning and scheduling performance.

In order to comply with the general objective, research activities were carried out that fulfilled the following specific objectives:

1. Characterize the ERP system through qualitative analysis, in order to identify key basis variables.

2. Characterize the current SAP SCM system through qualitative analysis, in order to show the changes in the production flow with the application of the APO PP / DS tool in the follow chapter.

3. Explain the new SAP proposal, through the PP/DS view which improve the system performance.

Thesis Structure

The fast change in technology and the increasing number of competitors, oblige companies to have a system with which they can react quickly to changes and make quick decisions that allows them to have a factor that differentiates their processes from others, and allows them to survive.

This document shows how the implementation of the PP/DS tool can improve production process inside the business. In general, through the new planning and scheduling parameters, could be reach a higher resources usability, better production control and visualization, allowing the improvement of the production results and reduce cost of maintenance because the number of orders on the status to be delivery are going to be less.

To understand how PP/DS is developed, it is presented a brief introduction related to what is an ERP system focusing on the business processes and the evolution on the past few years. After, the importance of the supply chain management inside a company and the key success factor are explained, to have a better understanding of how the business areas are related.

Subsequently, the lector should have the ability to understand the integration between SAPO APO with SAP ERP which supplies master and the transaction production, sales and material data in the real-time, allowing a constant flow of information.

To demonstrate how the introduction of the PP/DS improves processes inside the company, it is described under what principles the company made the production planning before the PP/DS. It is also presented the principals issues and how they affected the development of the activities and the relationship with customers decreasing their satisfaction.

The next chapter presents the planning methods and tools, which are introduced in the new business plan, in order to contribute to improving the operational performance of the ELTEK system. Following is explained how production planning is running after the introduction of the new system, how it changes the internal performance and what are the considerations that were taken into account for its implementation.

Finally, to concluded, the general business objective is to implement in their system a tool that allow them to have a better process control of their production planning (plan orders, re-scheduling, process capacities, resources overload), being integrated with the whole business network.

CHAPTER 1. RELEVANT BASIC

This chapter presents theoretical bases, the methodology and tools that have been considered as the axis of interpretative analysis and development of this project. All the following concepts are related to the production planning, and the related information systems.

First is descried the Enterprise resource planning which is the father of our central IT system SAP. After to understand the production process, is introduced the supply chain of management, and their components. In it, is describe how planning process is involved on the SCM and how affect company performance. The follow described concept is APO, a tool to support the supply chain process to managed business process. Finally, is explain the SAP next generation business suite, calling SAP 4/HANA. Managed platform is designed to process large amounts of data extremely fast, bases in the technology and society evolution (internet and the use of smartphones)

ERP SYSTEMS

“Enterprise Resource Planning systems or enterprise systems are software systems for business management, encompassing modules supporting functional areas such as planning, manufacturing, sales, marketing, distribution, and others” (Rashid, Hossain, & Patrick, 2002) .

The ERP allows a continuous flow of information between the different business areas. Is a modular tool, that’s means that the information inside the business is divided in different modules, depending on their nature (figure 2). Each business has different specifics necessities, so each one is going to have a different implementation and use of the system.

Some advantages are:

- Reliable information data, due the coherent and exact data that is provided from the process interaction.

- There is a central data base, where each module can get needed information. This data base is created to avoid redundancy between operations and data.
- Because is a system which has as an object the integration between areas in the business, has as an advantage the improve the quality of the decisions. Now the quality of the information is higher due the central data base, and the reductions on the delivery and cycle times.

(Rashid, Hossain, & Patrick, 2002)

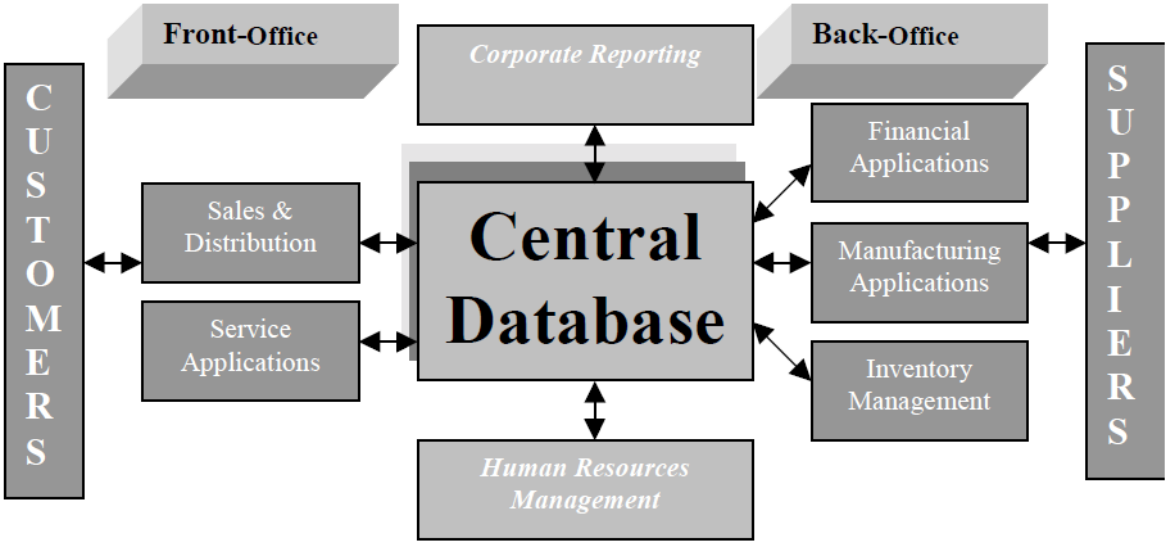


Figure 2. ERP modules examples. Rashid, Hossain, & Patrick, 2002

Brief evolution

Since the introduction of the computer, around 1980 were developed some approaches to what we know today as ERP. However, due to the "high level of organizational and technical complexity associated with their development and imple mentation, integrated enterprise-wide systems have been difficult to achieve" (Kuldeep & Hillegersberg, 2000).

Nevertheless, the complexity and barriers, in 1990 the first-generation ERP systems packages appeared in manufacturing industry establishing a new vision for the resource planning domain.

"That vision centered on resource planning and inventory accuracy, as well as visibility beyond the plant and throughout the manufacturing enterprise, regardless of the production type of each business" (Hofmann, 2008).

Kuldeep and Hillegersberg explains that the way to integrate information and processes in an organization, in order to implement the ERP concept, arises with an inside-out process. First, it is necessary to understand the based process as the Inventory Control packages (IC). Then, the material requirement planning, better known as MRP and manufacturing resource planning (MRPII). Finally, processes related with more external factors as sales, purchasing, and marketing could be included.

ERP is offered by vendors specialized in the software market. The most common vendors are SAP, Baan, J. D. Edwards, Oracle and PeopleSoft (Kuldeep & Hillegersberg, 2000). Their responsibility is to listen to the customers need and to provide the basic ERP aiming at the customer profile.

Arnesen defines three ERP software delivery methods (figure 3):

- On-premises software: In this case, each company buys the software license; this one is installed in their home hardware. Then, the internal staff handle the activities.
- Hosted Software: In the 2000s was called Application Service Provider (ASP). This method implies the license acquisition by the customer, but the hardware maintenance and upgrades are handled by a third-party company. Meaning that the solution is running by an external service and the access is acquired through the internet.
- Cloud or Software as a Service: This method is similar as the Hosted Software because the vendor is handling all the system. However, this is a multitenant scenario where the vendor must maintain the software reducing the company's-specific customization. (Arnesen, 2013)
- Hybrid: Customers run certain parts of the business software on their own servers and use the additional solutions of a cloud provider (company, 2016).

As the market has matured, vendors have addressed earlier security fears and added capabilities that have users whizzing in hours through tasks that formerly took days. Which is why the Cloud ERP software was introduced, a more robust software than in earlier incarnations (Ghahremani, 2018).

Figure 3. Deployment Types (company, 2016)

Each vendor has their own nature, and that affects directly the way that Cloud ERP is developed. One category fit on the On-premises method, where vendors have different levels of cloud technology. They are constantly modifying their software technology to fit in the cloud model (which is the direction Microsoft Dynamics is going) or building a separate cloud solution from the ground up (Arnesen, 2013).

The newer vendor heads the other category. In this case, all the customers are always on the latest ERP version, and since it refers to a recent release, they do not have to support older versions as the others do. This is considerate as an advantage because companies do not need any hardware or any significant technology infrastructure, which allows a lower internal cost.

However, under this method, companies are cloud vendor dependent, and there is a probability to lose all the information due to a natural disaster, an internet connection failure or in the worst case, vendor goes out of the business. Furthermore, because the software is less mature, companies may have to wait for key functional upgrades to become generally available (Arnesen, 2013).

SAP

Five former IBM employees start a company they call SAP (System Analysis and Program Development). The company establishes its headquarters in Weinheim in 1972, working principle at nights and weekends with the goal to achieve a "standard application software for real-time data processing" (SAP, SAP History | About SAP SE, n.d.)

The first introduction system was made on the pharmacy sector and tabaco companies with the financial mode. The company starts with 9 employees, generating DM 620.000 in revenues.

"An SAP trademark begins to emerge - the integration of all of the company's applications. Materials management data flows directly into financial accounting on a value basis, while invoice verification and posting can be completed in one step" (SAP, SAP History | About SAP SE, n.d.).

The company does not take any break time and in 1977 expand their market outside Germany for the first time. At this year SAP company have 25 employees generating DM 3.81 million in revenue (SAP, SAP History | About SAP SE, n.d.). SAP year by year introduce "technology innovations to drive sustainable growth, profitability, and value to their customers" (SAP S. , 2016).

Today, SAP is the market leader in centralized enterprise application software. Is well known as ERP and data management who services enables their customers to operate profitably, adapt continuously, and make a difference between competitors. (SAP, SAP, n.d.)

There are two options to process activities on the business world. The option to work under decentralized or centralized processes. Decentralized becomes with disparate information system,

duplication of data, customer dissatisfaction and material stock imply high cost. This is the reason why a big percentage of the business decided to work under centralized system. Data is in a central location and could be reach by different departments as is show in the figure 4.

Some companies, large and medium decided to use a group of applications call SAP Business Suite (figure 4), to run efficiently their operational process, integrated data, make a better use of resources, have low operation cost and try to do not lose any market opportunity. (Rouse, Techtarget, 2018) .

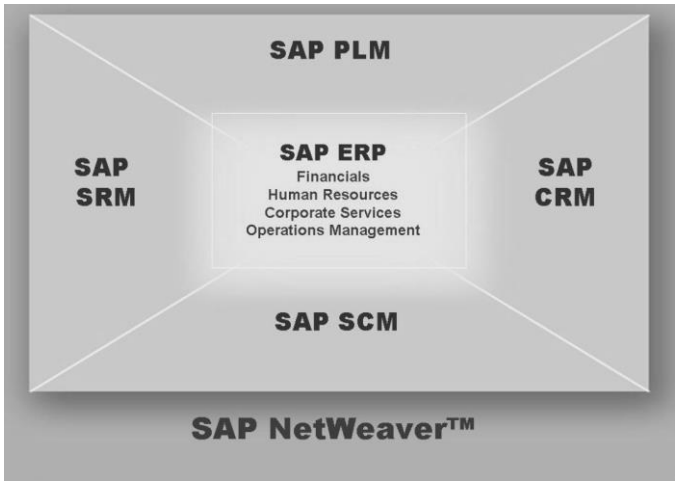


Figure 4. The applications of SAP Business Suite. SAP

The integration between the areas showed in the previous figure, is one of the possibilities to get a good enterprise managing if the way in which was set is the correct depends on the business characteristics. This allows to make a faster decision because all departments are sharing the same information. For example, the process has the capacity to run faster in front to possible unexpected changes on the demand. Those changes are reflected immediately into the production, which is forced to make necessary adjustments to cover the new requirement.

Gartner's market analysis demonstrates that the "digital business changes the way an organization deals with customers, suppliers, partners, internal processes and employee engagement". This change affects ERP development, since it forces them to deal with the market behavior to meet

new customer needs by new business options. That's why ERP system "enables companies to address current challenges and future opportunities with flexibility, speed and insight" (News, 2019).

For example, SAP drives digital transformation and delivers instant business value by the introduce of the SAP S/4HANA. Even if there is a new element in the system (Cloud), SAP still offering on-premise and hybrid, allowing companies to fit their necessities. "SAP new methodology provides unparalleled business agility, enabling companies to exceed customer expectations and navigate dynamic marketplace" (News, 2019).

The SAP new consideration raised its sales. "Cloud subscription and support revenues makes a grew by 18 percent to exceed 1 billion euros for the first time" (CNBC, 2018).

"Cloud growth accelerated outside the United States and grew faster than any of SAP's major rivals, including Oracle, Salesforce and Workday" (CNBC, 2018).

SAP SCM

SAP SCM is a flexible tool for mapping internal enterprise process. This application enables a company to "efficiently plan process, implement and monitor complex delivery, procurement and production relationship" (SAP SE, 2015).

The implementation depends on each enterprise souls. Each industry has special requirements and processes that must be considerate for run their process with SAP SCM help. Also is necessary to decide the planning period, which determinate which components (planning tool as APO, for inventory SNC and EM as Event Management) or areas that must be involved into the process.

SAP runs under SAP ECC which develops the "classic" planning functions, while Supply Chain Planning takes place in SAP ECC and SAP SCM (APO). These could be running thanks to the integration between the systems through the CIF interface plays a key role.

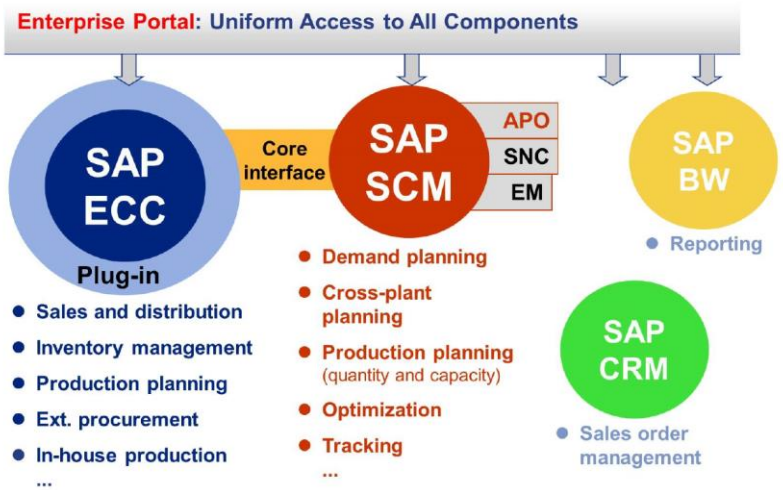


Figure 5. Processing of cross-company processes and the collaborative planning and procurement processes. (SAP, SAP, n.d.)

The SAP SCM is divided into Supply Chain Planning, Execution, Visibility and Collaboration. In particular, the area of Supply Chain Planning includes demand planning, distribution and procurement planning, and detailed production planning. These functions can be executed in SAP ERP Central Component (SAP ECC) and/or in SAP SCM in the components SCM DP, SCM SNP and SCM PP/DS. On the other hand, the Supply Chain Execution contains planning execution as part of manufacturing and Materials Management. (AG., 2010).

Supply Chain Planning Process

Seeing the figure 6, it could determinate the SCP process. Some activities are executed by ECC and other by SCM components. However, those two systems could be integrated through the Core Interface (CIF) and use both when planning.

To build a production plan the company at first collects data from sales order, inventory or purchase orders, so on, demand Planning (DP) determinates future demand program. This task is executed by SAP ECC as a part of Flexible planning using Standard and Operations Planning (SOP), or SAP SCM through the Demand Planning.

Then, independent requirements (planned independent requirement or sales orders) are generated by SAP ECC Demand Management. In this step, SCM must refer on the ECC data through CIF and consumed in a similar way the requirements strategies in SAP ECC.

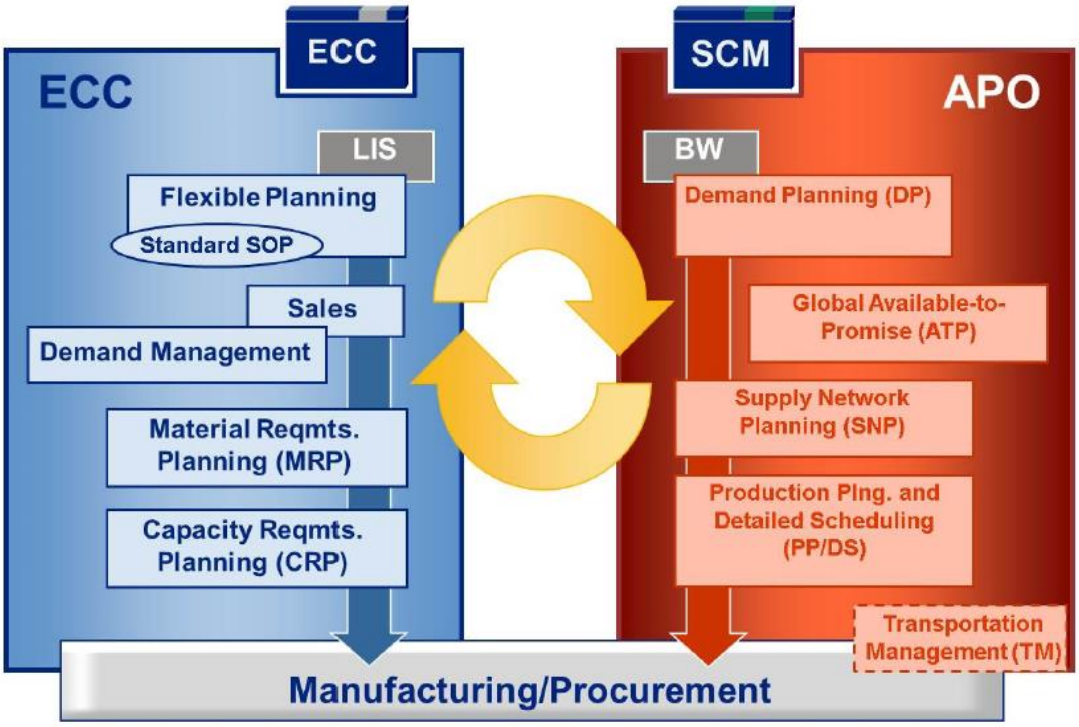


Figure 6. Supply Chain Planning Process. SAP SE

Business process starts when the ECC system creates sales order and through the ATP is determined if the orders can take place in the SAP SCM depending on the material or production resources. The Supply Network Planning (SNP) determines the plan product flow along the supply chain, and integrates "purchasing, manufacturing, distribution, and transportation so that comprehensive tactical planning" (SE, 2016).

To plan material requirements with the production plant is necessary to run MRP in the ECC system to ensure material availability or if any material gaps that need to be purchased from external vendor, transfer it from another warehouse or produced in-house. Additionally, ECC

system, must executed separately Capacity Requirement Planning (CRP) to check the availability of resources.

As is described previously, APO is a planning tool that relies stock and sale data from the ECC system. It must make a constant information exchanged between ECC system (figure 7).

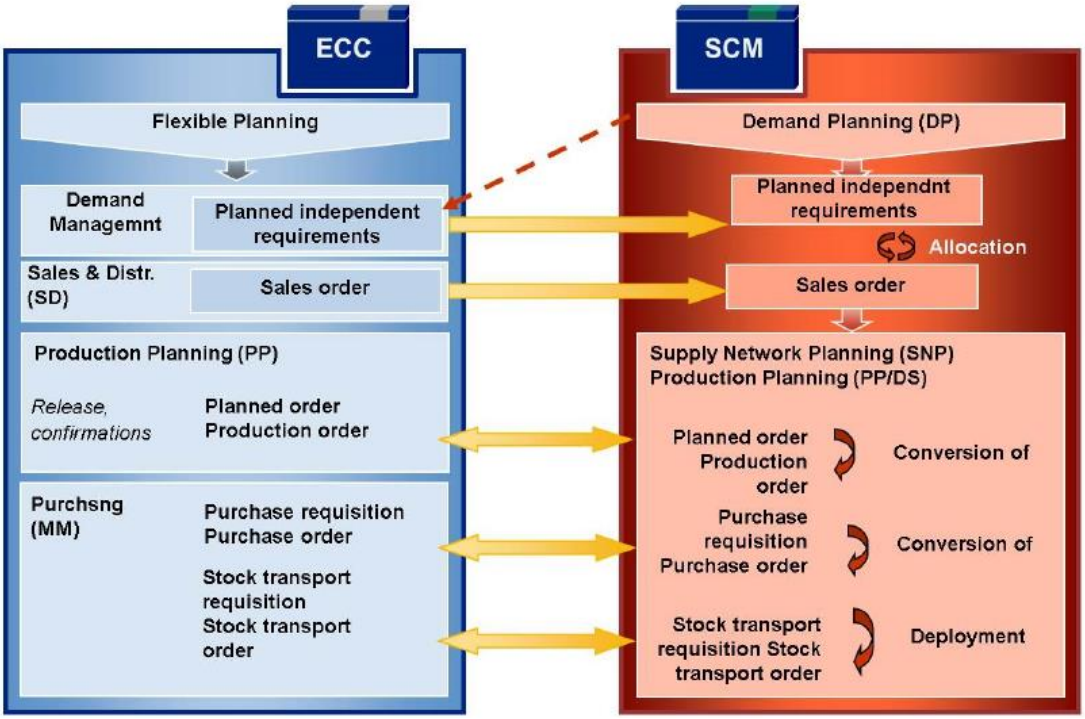


Figure 7. APO Planning and ECC-Integration. (company, 2016)

Through the Production Planning and Detailed Scheduling (PP/DS) which "is used to plan critical products, such as products with long replenishment lead times or products that are produced on bottleneck resources" (AG, 2014) and have the possibility to plan material and capacity simultaneously identifying critical product being integrated with Advanced Planning and Optimization (APO).

To aboard transportation task is necessary SAP SCM TP/VS component. As result is obtained transportation plan that attends any process constraint, which is transfer to ECC system when is complete. Finally, is executed the production and procurement where the process and production

orders, confirmations, generated deliveries and good movements are handled by SAP ECC. However, these last steps are not going to be developed by the project soul.

SAP emerge PP/DS as part of APO in 4/HANA. PP/DS is executed to determinate the plan that the products have to follow during the production. Inside the new system. master data[1] change, so it has to be created in the SCM and be transfer through the CIF. (figure 8).

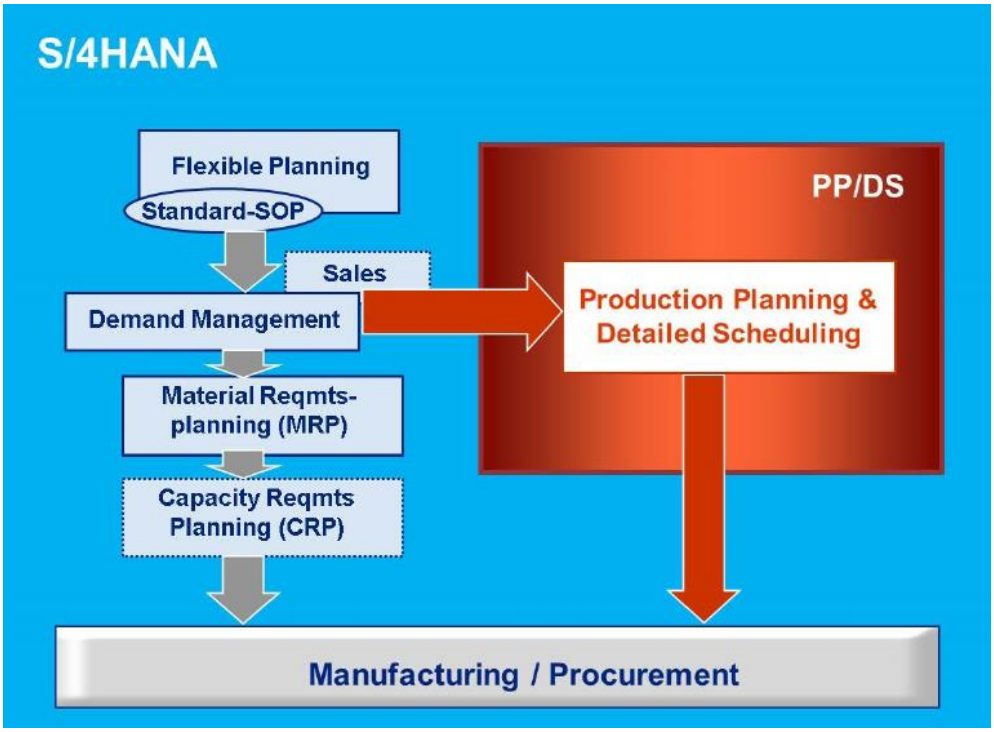


Figure 8. Production Planning & Detailed Scheduling – Overview (company, 2016)

When PP/DS is including in SAP 4/HANA the company can contemplate two options to make the planning process. It could do the phases described before, or it can take the new path through the PP/DS where the MRP and CRP does not have to be process.

This new phase counts with innovation aspects as the introduction of the heuristics, alert monitor, planning table, and so on.

[1] See chapter 3

Supply Chain Management

Today, companies are always in a competitive world, so they need specifics tools to improve their organizational performance and survive in the wide market. One key to stay alive with a good performance is the way which is managed the information. Therefore, is important to understand the SCM concept.

Inside the company, the SCM consists of customer, distributions centers, plants and suppliers. Depends on the Distributions centers is determinate the production level. Most common process on the SCM are Demand Planning (DP), Order fulfillment (sales and transportation planning), Distribution, Production and External procurement (Dickersbach, 2006). SCM goal is to "integrate both information and materials flows seamlessly across the supply chain as an effective competitive weapon" (Bratić, 2011).

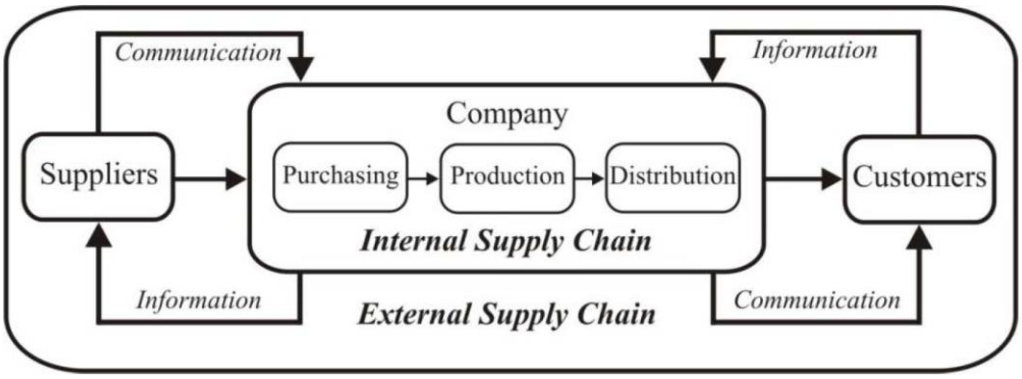


Figure 9. Internal and External Supply Chain. Bratić

The SCM principle is to integrate the company business process as internal as external level. Looking at the figure 9, the immediate internal subjects are suppliers and customer that are involve along the whole supply chain. Also, the coordination and the information flow between internal process as manufacturing, logistic and material management are essential aspects. All those relations are necessary to know how resources must be consume in the best way, determinate technology and which are the capacities to enhance competitive advantage.

Logistics must have integration, agility, measurement, and positioning in order to increase competence among industry members (Aishah, Pyeman, & Tajuddin, 2013). The integration between external and internal components on the supply chain allow a shorter response time, and a better decision. This factor is seen as a technique to operate under the best possible scenario.

Any company can be divided in two parts, internal involving closer components and factor as the purchasing, production and the distribution. Being considerate as the most important factor in the supply chain, because it "contributes to the effectiveness and efficiency of supply chain performance" (Aishah, Pyeman, & Tajuddin, 2013) if is compared with other business part, related to the exterior.

On the other hand, are presented the externals components which are related to the activities make it outside the company, as the transportations and relation with the suppliers and customers. The relation between both parts, shows the management and how is been coordinate the information in the supply chain.

Even if the product processed inside the company have to be delivery by and external factor, the fact that the product was all product inside the company. and even if the product could be not produced if there is not any supplier which brings the raw material, the final product was doing inside the company and there is decided when the product is ready. All those decisions, process, are made it inside the company, s that makes the internal supply chain more important than the external SC.

The internal SC is affected by some external factor, but they could be managed in a good way if the process is integrated and counts with the necessaries tools to responded at those change. Some examples are, the fluctuating customer demand. Which implies that the company has to be prepared for any unexpected change on the demand, it could be the case where the demand is higher, so they need to find the way to increase the capacity, or on the contrary, if there is a period of low demand, the business knows how to respond and could survived at the situation.

Other threat is the fast change on the technology, where is introduced a new software programs which are helping to the supply management. Improving planning process, making faster decisions which are factor that improved their performance making them more competitiveness. However,

the good performance of the tools, is depending on the business situation. Between behind it, the customization has to be the principal aspect to meet the correct company necessity and works with the same goal of the company (RADFORD, 2017).

Going deeper in the SCM, is necessary to distinguish between present and future planning. The "earlier" Supply Chain Planning (SCP) is run in a determinate time of period to get a specific result. Some examples are "strategic and tactical planning such as network design, network or master planning, production planning, transportation planning and routing and demand forecasting" (Kallrath & Maindl, 2006). On the other hand, the "later" call Supply Chain Execution (SCE) or Supply Chain Operations, which must be prepared to act at any event, so on must be always available with actual information. This one is composed by tree types of activities, Procure, manufacturing and delivery (see figure 10).

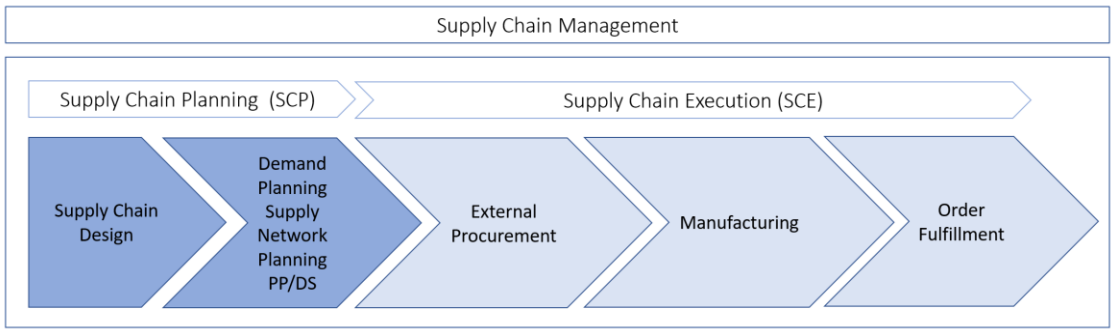


Figure 10. Supply Chain Management. Own construction.

To make a more specific SCP definition is necessary to introduce Rohde who defines the *supply chain planning matrix classifying SCP tasks by planning horizon and supply chain process* (Figure 10). The Y axis give an idea of how frequently those activities are planning. On the other axis is found the process as Source, Make and Deliver.

SCM process starts forecasting future sales, the quantity demanded to be distributed in the company network (Strategic Network Planning). When this quantity is determinate, could be obtain the production plan form scheduling (performed in a period some production order) and production planning (considerate the demand on the factory as sales orders and determinate how

much have to be produced for each code) to be finished in a determinate period. This process is running inside each factory and the objective is determinate the optimal production size to reduce the change time between product and decrease stock level (Gerard, 2015).

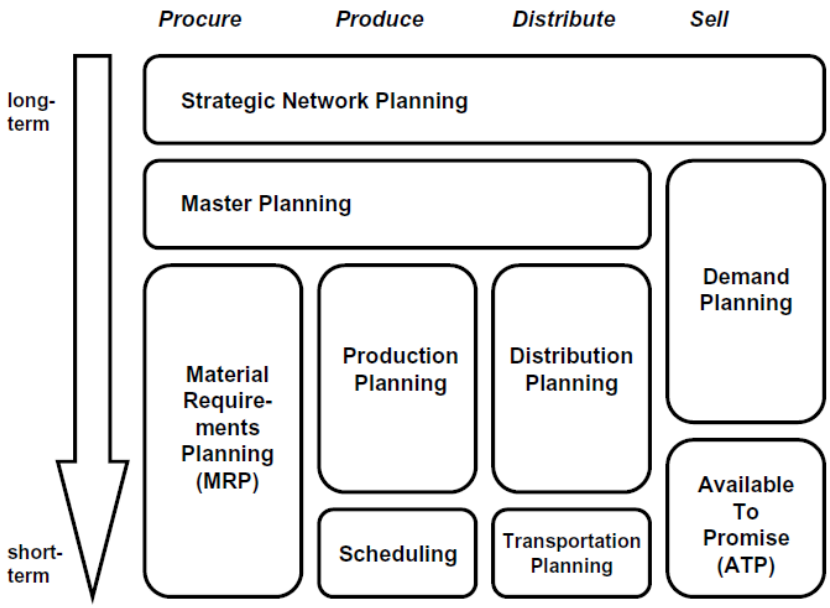


Figure 11. The Supply Chain Planning matrix (Kallrath & Maindl, 2006).

Thea successful supply chain area is a biggest potential for most companies, so the management project requires more than the implementation of a planning tool, is necessary to pass from the SCP matrix to implement a process optimization (Dickersbach, 2006). Optimization techniques are applicable in the areas of Strategic Network Planning, Master Planning, Production Planning and Scheduling, and Distribution and Transportation Planning (Kallrath & Maindl, 2006).

Advanced Planner and Optimizer (APO)

"SAP APO is not a standalone product but integrates with SAP ERP which supplies master and the transaction production, sales and material data in the real-time to the APO application" (Murray, 2019). This ensures real-time integration of the transaction system SAP ERP and the APO. For

example, production orders that are created in SAP APO are immediately transferred to ERP and can be used by a subsequent MRP process to plan non-bottleneck components there.

APO is able to support SCM processes by visualizing and processing data with a set of algorithms (Dickersbach, 2006). This tool provides the functionality to planning and execute supply chain process through a group of tightly integrated components (Figure 11).

APO also supports, business collaboration on the three planning levels; Strategic planning running the DP such as sales forecasting, Tactical planning involve DP and SNP; Operational Planning cover by DP such as customer order, PP/DS, TP/VS and Global ATP. Additionally, by the cross- functional process, allow the constant co-operation between partner along the supply chain process, this creates a better partner relationship. Finally, APO supports the "Constant optimization and evaluation of the supply chain network's efficiency" (SAP, 2018)

Optimization techniques are applicable depending on the level of planning detail, time horizons and processes as is show in the figure 12.

APO have five modules or components:

a. Demand Planning (DP)
b. Strategic Network Planning (SNP): Location and production distribution.
c. Production Planning and Scheduling (PP/DS): Short-term single location.
d. Distribution and Transportation Planning (TP/VS): Routing and load consolidation
e. Available to Promise (ATP)

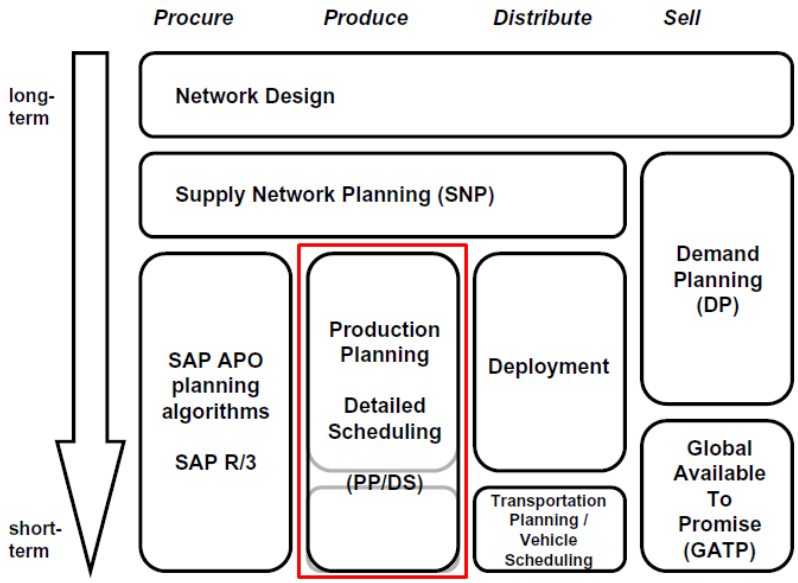


Figure 12. SAP applications and components covering the supply chain planning (Kallrath & Maindl, 2006).

Depending on the project horizon, and the complexity, PP/DS, and GATP might vary strongly. The other components remain in the same project line, for example DP horizon is month or week or SNP months, weeks or days. (Dickersbach, 2006)

Components of SAP APO

a. Demand Planning

Demand Planning is a powerful and flexible tool that supports the demand planning process inside the company. This tool supports the forecasting of the market demand to get as a result the demand plan (SAP, 2018) . SAP APO allows companies though Alert Monitor "track exceptional, unexpected or critical situations in the demand planning process" (Dickersbach, 2006).

Before any planning implementation, two considerations must be pointed. First, is related to product type and the second, is to control the period to perform the activity. Those aspects make the process different inside each planning types.

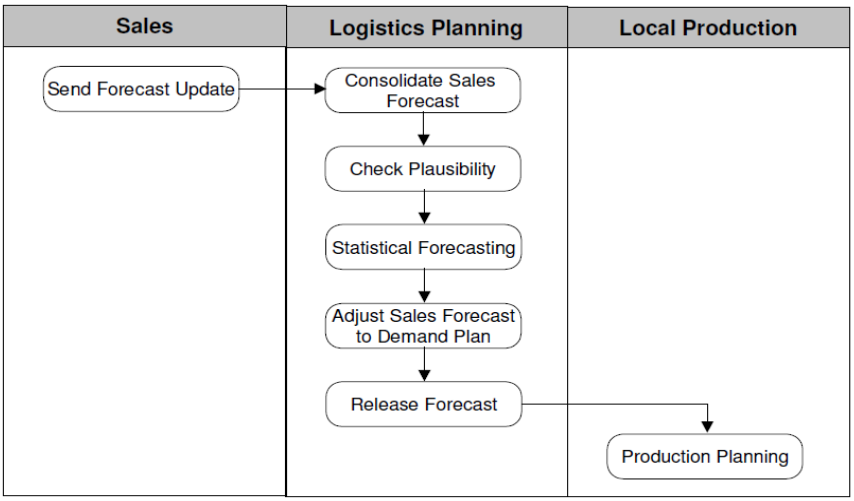


Figure 13. Example Process Chain for Demand Planning (Dickersbach, 2006).

DP could be integrated in tree types of planning: strategic, tactical and operational, because the DP can be performance as a long-term data on sales forecasts, or customer orders in a shorter period.

One of the advantages of the data is that could be aggregate and disaggregated along the planning levels. This distribution allows to have always a consistent plan with a detail level. Forecast consumption allows defining requirement strategies that determine how to process customer orders and forecast values in the same time bucket (Dickersbach, 2006).

b. Strategic Network Planning (SNP)

SNP helps to aggregate the whole SC, is run for long or middle period to synchronize activities and plan the flow of material. In addition to the creation of purchasing, production, distribution and

transport plans, is also responsible to match supply and demand, considering demand uncertainties.

Running SNP in APO implies to have a specific data to achieve satisfactory results. " SNP master data includes information about locations, products, resources, production process models (PPMs) or production data structures (PDS), and transportation lanes" (SAP H. P., 2018).

After that all prerequisites are been decided, SNP runs using the heuristic, the optimizer, supply and demand propagation. Subsequently, SNP determinates the estimates sales volumes, covering material to be transfer between installations and the quantities to be produced and procured. All this data is gotten under a global model which is use advanced optimization techniques considering constrains and penalties.

After production planning is complete and the "system knows what will actually be produced (this information is saved automatically in live Cache), the deployment run generates deployment stock transfers" (SAP H. P., 2018).

c. Production Planning and Scheduling (PP/DS)

The central topic of this project is the SAP APO PP/DS component. In this case APO supports various processes across industries (make-to-order production or make-to-stock production) and production types (shop floor production, repetitive manufacturing, or process manufacturing) (SAP, SAP Supply Chain Management (SAP SCM), 2016).

In PP/DS, you convert SNP orders into PP/DS orders to make them available for Production Planning and Detailed Scheduling. Thanks to this tool, is possible to determinate critical products, which are going to impact in the flow of the process line.

PP/DS works in an integrated way with other components as Supply Chain Engineer SCE, to assign location, product and resources. Through the PDS object is possible to group the routing, BOM and classification, and PPM which "describe operations and their capacity and component

requirements for in-house production" (Dickersbach, 2006). Also is possible to check sales order or any changes on the planning plan and announce it by the Global Available to Promise (Global ATP).

d. Distribution and Transportation Planning (TP/VS)

Transportation component helps to close the planning process delivering client orders. This process collects a lot of possible shipment scenarios all with the object to minimize the shipment effort. The planning challenge is affected by the customer availability to receive the product (window time), due date, vehicle availability, customer locations and others.

e. Global Available to Promise (Global ATP)

Next to those standard components, APO aggregated cross-functional components: Supply Chain Collaboration which supports the communication between business partners, and the functional component, which is developed at the production level, call Supply Chain Monitoring. By the SCM, is possible to monitor the planned quantity, also included the alerting feature to make a notification for an exception scenario. There are also several industry-specific scenarios and functionality available, including a standard interface for connecting external optimizers to PP/DS for trim loss problems (Kallrath & Maindl, 2006).

Global ATP is one of the central methods of SAP Advanced Planning and Optimization (SAP APO) that utilizes SAP liveCache. The data is stored in the SAP liveCache in the form of ATP time series. One of the functionalities is referring at the Scheduling. This check represents an online search that should ensure that your company can provide the requested product at the requested time in the quantity requested by the customer (Documentation, Global Available-to-Promise (Global ATP), 2018).

SAP 4HANA

Inside of a small company data management is relatively easy to manage. There are just few activities to run. To communicate data between the different areas is not as relevant as in big companies. The flow information between areas is not that complicate, at the fact that they do not have distributions centers around the world, and a big work network.

However, the goal of all companies is expanding their operations. this fact obligates the company to have a different managed process. Now they could not have the same coordinate system. At the beginning of the ERP system the introduction of a supporting data bases to work under an integrating system made sense. Some years after, were realized that the communication between areas generate a big data footprint generating some cross- information problems.

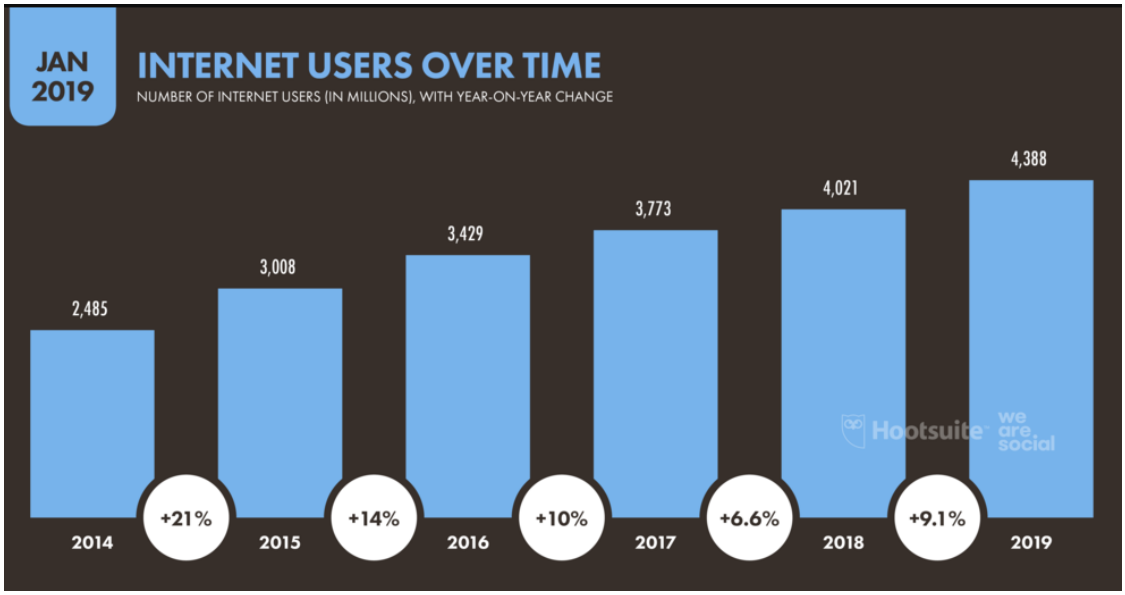


Figure 14. 5 Years Evolution in Internet Users January 2019. DataReportal. (KEMP, 2019).

Is common to ask how information flow is going to be managed on big companies?

Is inevitable to do not be affect by the technologies and internet evolution. Reports that "the number of internet users around the world has grown by more than 1.9 billion since our 2014

reports, an increase of more than 75% in just five years. This year's total of 4.39 billion global users is also more than double that was reported in 2014" Figure 14. (KEMP, 2019).

Also, the cellphone use affects the way to developed normal activities and business process. According to Kemp, the number of people around the world who use a mobile phone increased by 100 million in 2018, with the global total reaching more than 5.1 billion users by January 2019, concluding that mobile phones now account for almost half the time that people spend on the internet.

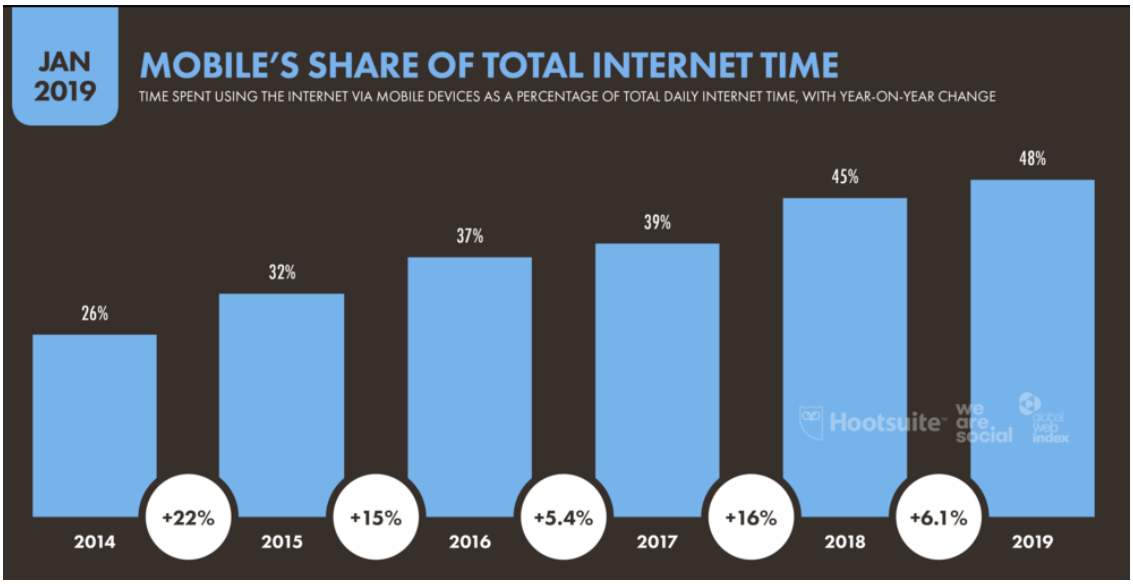


Figure 15.Mobile's Share of Time Spent on the Internet January 2019. DataReportal (KEMP, 2019).

As a result of the technology growth, ERP new generation is implementing new tools to find the way to solve problems in an easy way to the complex environment.

Looking for a new way to management process and information, the next generation business suite, SAP 4-HANA was introduced. This new data managed platform is designed to process large amounts of data extremely fast. Because it can manage transactional and analytical data under the same base, there is no need to create different bases for each business area (Technology, cSAP S/4HANA, The Digital Core, 2016).

All data live in a single database connecting operation across business units (ERP, CRM, SRM, SCM, and PLM, reintegrated in one system). That provides managers all the information that they need in real time and in an easy way. Although, flexibility and speed of the new system is a fundamental factor to have a better information analysis and make better decisions (Technology, SAP HANA -- Transforming Business Systems, 2012).

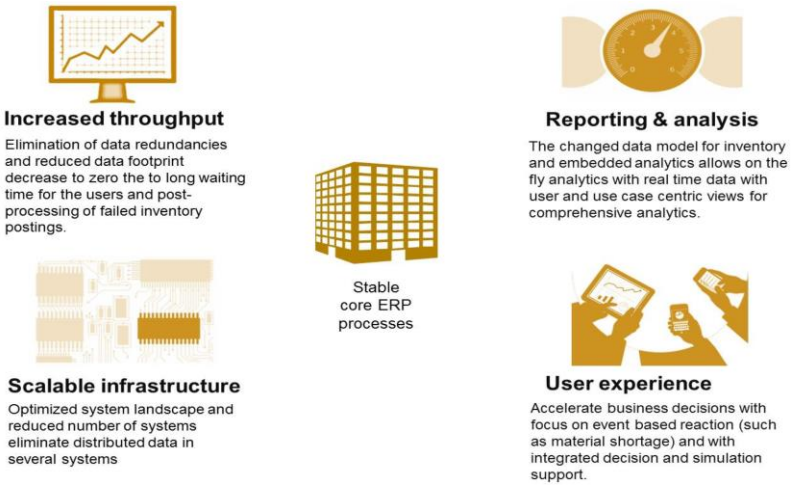


Figure 16.Why SAP S/4HANA Enterprise Management? (company, 2016)

S4H is based in four pillars (figure 16). First, the increased system throughput by eliminating data redundancies and reduced data footprint in ten times. This is possible by the new way to group history information in tables. The reduction on the data footprint provides the option to use the application in a mobile device. It is also reduced the response time and allows to have a greater amount of information on a screen.

Rethinking data base does not just impact the reduction of it. This also relapse in the simplicity of the model that helps with the reporting. This second pillar is "SAP S/4HANA will provide one solution for one business problem, with a multi-year roadmap" (company, 2016). This allow a faster analysis of the adequate data to report creation.

Other pillar is the scalable infrastructure which provides superior flexibility at the organization because can be deploy either on-premise, cloud or hybrid to best suit business and IT priorities depending on which deployment model is best for each area of the business.

The use of electronic devices is no longer reserved for a group of experts, is now spread within society. This technology shift could be seen by the last pillar, SAP Fiore design. It brings the possibility to access to the information through any smartphone, tablets and even smart watches with their easy-to-use and flexible user interfaces. It counts with an intuitive graphics for faster insights and pre-evaluated solution proposals (company, 2016).

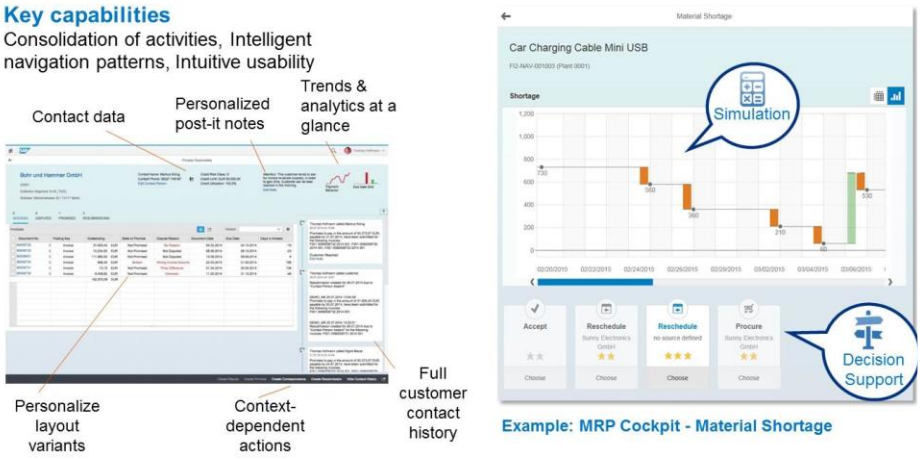


Figure 17. Key Capabilities of an Exception-Based User Interface Design. (company, 2016).

With the exponential growth of computing processing and internet development, the challenges for the ERP vendor has increased up to the limit to redesign ERP products, breaking the barrier of proprietorship and customization.

The previous characteristics themselves, makes a simplified new data model which allow the business process handled problems with a bigger support.

From vendors to customers of the ERP it is been understood the necessity for packages to pursuit an open architecture, providing the exchange of modules and allowing an easy customization and user interfacing.

However, it is not stated that implementing an ERP system in an organization will improve it's functionalities in no time. this performance on cost savings and service improvement depends on how good the ERP selected fits to the organizational functionalities (company, 2016).

CHAPTER 2. COMPANY CHARACTERIZATION

Brief overview

Eltek S.p.A. has been founded in 1979 by Luigi Sassone, formerly manager of major international corporate groups.

The Eltek Group specializes in research, design, development and production of mechatronic components (GROUP, 2018). The company is organized by three products types, appliance, automotive nd medical. Under the first category (Appliance) are creating dispensers for detergent and rinse aid, water valves, thermal actuators and others. The second product area is dedicating to the automotive, in which are develop heaters, mechatronic components and sensors. The last unit refers at the Medical/biotechnology industry. Under this unit are developed molding plastic parts and are assembling medical devices.

The group counts with strong international presence having different plants strategically located around the world. The principal production plant situated in Casale Monferrato and five more (Hone, Mendrisio, Jundaì, Bielsko Biala, Yantai) and two commercial offices (New Jersey and Germany).

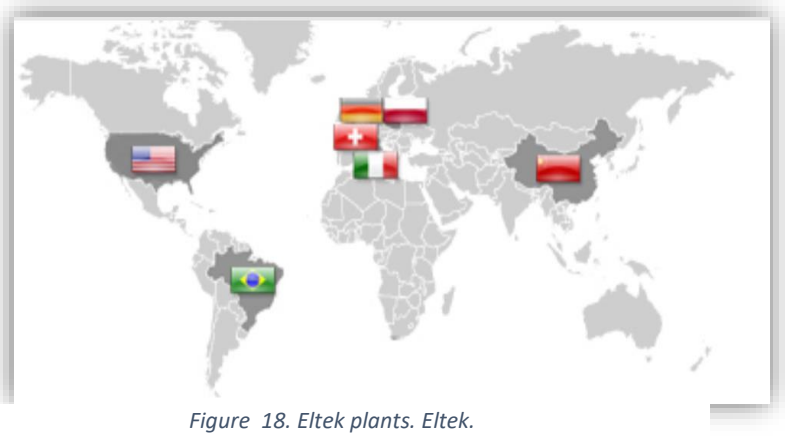


Figure 18. Eltek plants. Eltek.

Eltek is a proactive business trying to respond since the beginning at the market change. They start with the vertical integration on the process production, acquiring the majority shares of a company manufacturing moulds and injecting plastic moulding in Aosta Valley (Italy). After, by market demands, was introduced in the Eltek group the Brazil project.

Thanks to the continuous business growing, was opening in Poland the new establishment, following by Yantai (China) plant siting to produce automotive and appliance components. Looking for expand their markets in electronic components, was introduced the Swiss plant, who produce the high-performance pressure sensors. Later, to better serve the American market, has been established Eltek USA, and the second commercial office in Germany.

Products

Production organization is divided in three categories, medical, appliance and automotive.

A. **Medical** (figure 19)

1. **Pressure sensor:** element to determine the actual pressure applied to the sensor (HBM, s.d.)
2. **Plastic components:** divided in dental products (retractors) and packaging and pharma

1. 2.

Figure 19. Medical parts. Eltek

(GROUP, 2018)

B. Appliance (figure 20) :

1. Thermoactuators: small electric linear motor based on a temperature sensitive element.
2. Water Measurement and flow regulator systems: devices which can be assembled on hydraulic systems. They provide an electric signal at a specific flow rate.
3. Pressure Transducer: devices for the measurement of pressure of air or water and are designed and tested to be used in heating and industrial circuits.
4. Safety and filtering systems: The component is a mechanical filter useful to protect water inlet of appliances or water-heater
5. Dispensers: device which releases the detergent and rinse aid in the dishwasher.
6. Water solenoid valve: typically used on household appliances connected to the hydraulic network

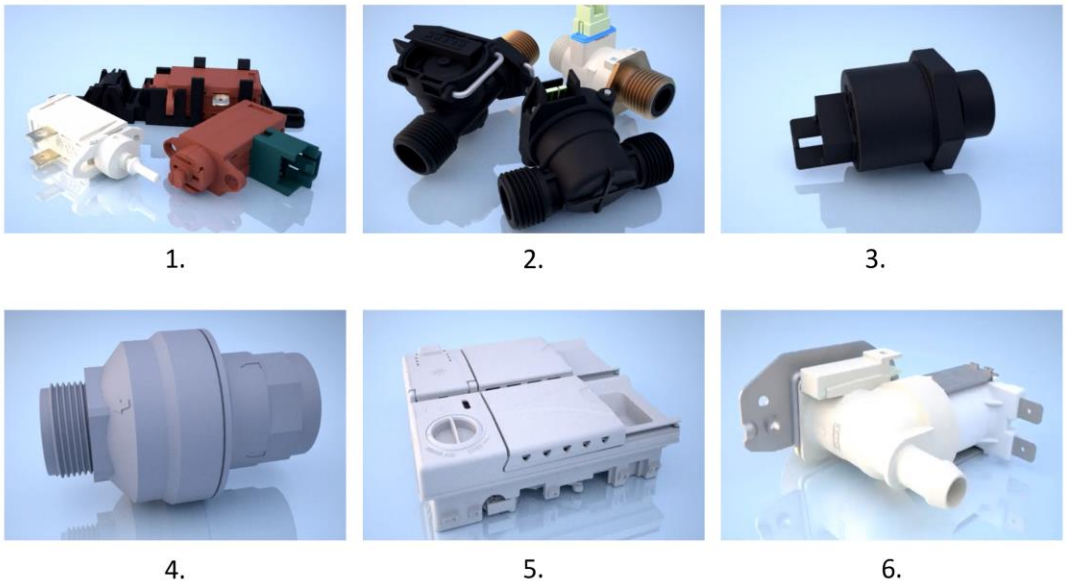


Figure 20. Group of appliance products. Eltek

(GROUP, 2018)

C. Automotive (figure 21)

1. Diesel Heater: are designed to keep engines ready for instant cold weather operation.
2. Sensors: measure the temperature of Ad-Blue in the SCR, this is used to limit the exhaust emissions of nitrogen oxides
3. Coils and solenoids: It is a basic electromagnetic actuator that converts the electrical signals into mechanical force, which triggers the valves to control the pressure or size and directions of flow (Electromagnetic, 2018).
4. Moulded parts: are dived in cages and housings, plastic components with metal inserts, and mechatronic housings.

Figure 21. Automotive products. Eltek

(GROUP, 2018)

As was mentioned before, the company have the ability to cover three industrial types. Also have the flexibility to run small or bigger process batches, under semi-automatic or fully automatic production lines depending on the demand volume.

The company works under the production strategy make to order. That is means, that the plan production is made it according to customer requirements (sales order / Independent requirements). To deal with the planning production is necessarily have a tool to process management and achieve an optimal performance.

Looking for improving their performance, Eltek Group decided to implement a new system who has the possibility to cover all their business process, having a better global control.

Initial production plan

Companies can work under the strategy of make to stock or make to order to match the plan production with customer demand. Under the first strategy, the company produce depends on forecasting and analyzing the possible demand behavior to determinate how many products must be created to cover the future request. In summary, in this strategy merchandise in anticipate.

By the other hand, the make to order strategy, depends directly of the customer requirement. That means that the production process is drive by the customer's orders. Inside Eltek group is necessary to use both strategies. The production plan for the finished goods is made in based on the orders and not future estimations, for the semi-finished goods and raw material the strategy is a pure make to stock.

The complexity on the make to order strategy, falls on the way in which the production plan is completed. As a consequence, the production planner in base on the among of the orders has to organized in the best possible way their machines, depending on resources, capabilities and other aspects, to meet the customer requirements on time.

When there are a few production orders to be schedule in the production line, the number of customer and requirements are not so big, a basic software works. But, a big business as Eltek, which counts with different production types and have a considerable number of clients, needs a

system to integrate all data and terminate the way in which doing the planning process should be "easy", fast and realistic.

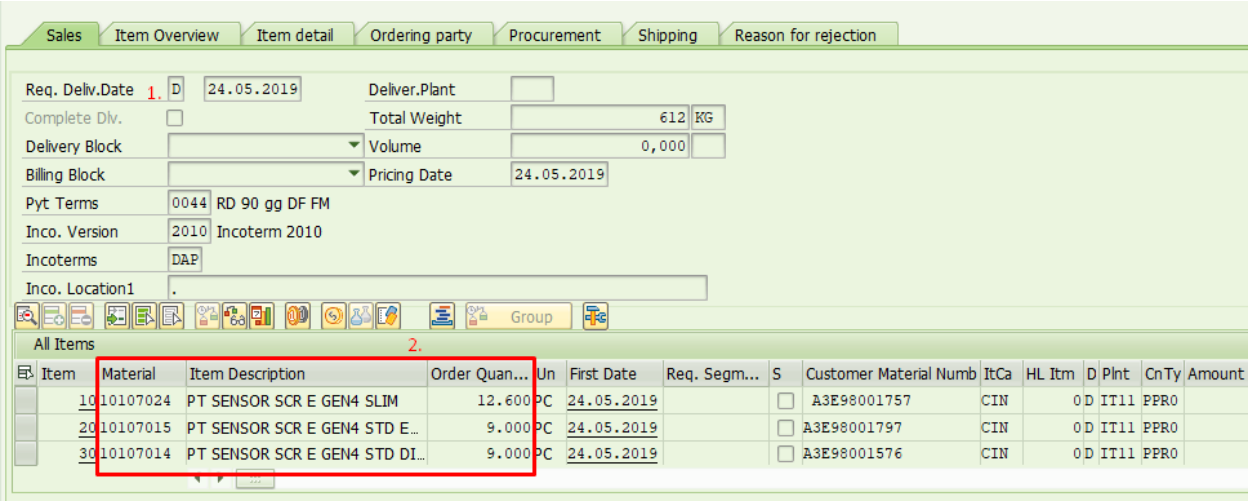


Figure 22. Actual customer order. Own creation. [2]

The planning process starts with a list of customer requirements (sales sales). Inside it is describe the *proposed date* by which the customer should receive the goods (figure 22 #1). Item code, description, and total order quantity for each item (figure 22 #2) are also important part of the sale order. When the responsible has already this information, can continue with the planning process.

One night before of the production date, is considerate the production flow for the next production day. The responsible has to evaluate aspects as delivery date, quantity to be process and if it has the necessary resources to handle the work.

The responsible has the challenge to ensure that customers receive their goods on time. This activity is very time consuming and difficult some daily task like the determination of the available capacities and considerate any possible problem during the production.

[2] it is an example of the current system. However, it shows the components of a production order generated with the previous system

The day after, the planning is ready to be executed. Production line is working, and the resources that are been assigned to execute the orders are making their job. However, production area is not an isolate area. On the contrary, this is directly related with sales department. Customer requirements born in this area, and there are cases where the order has a high priority that it need to be handled immediately, or they need to know the first possible delivery date almost immediately.

Sometimes production manager decides to stop actual production to start the new order and cover the client demand. However, there is also the opposite situation where production planning could not cover client demand due to the lack of capacities, so in this case, they have to propose a possible delivery date.

Taking the decision to interrupt production, brings with it some consequences. At first, the set-up of the machines that are already working is going to be lose, because they have to restart the production line with a different configuration. On the other hand, the time dedicated at the currently production plan, is almost lost, because was introduced a new order which change the schedule making the day before.

In the case that the production responsible, does not accept to process immediately the new order, because the capacity of the resources is not enough to process more, or the other orders must be process, it has to be proposed the possible delivery date. Which is a difficult decision to estimate, given that they have a very short planning horizon.

The first way to planning production is based on a basic software that do not responds adequately to the necessities. Because Eltek is a company which needs a specific way to determinate a path to process customer orders, given by their size, is introduce the new methodology, described in the next chapter.

Production responsible wonder be able in first place to expand the planning horizon, to identify issues in an easier and faster methodology, to have a real time visibility of supply chain and to

find better solutions to material shortage issues. Sales area wants to reduce losing sales and customers due to inability to meet customer dates creating low customer satisfaction.

After an analysis of the current situation were decided that the company needs an integrator tool between sales and production areas, to have real time visibility of the changes in demand, to be able to result shortages and make decision with actual information and use the best planning solution to cover costumers' orders.

Project objective

The business production project is based on plastic products, the proposed production plan is based on: Implementing the new SAP tool 4HANA on their business processes to improve their performance by a better internal management. Have the support tool to respond quickly at market changes, making a fast rescheduling in their production lines considering resources capacities. Additionally, have a general view of the planned /productions orders over a certain period.
To concluded, the general business objective is to implement at first in Italy plants, a software that allow them to have a better process control of their production planning (plan orders, re-scheduling, process capacities, resources overload), being integrated with the whole business network. And depending on the running in the Italy plants, in the future implement the software in the other plants, adapting the model to the particularities of each plant.

Chapter 3. SYSTEM TO BE INTRODUCE

In this chapter are presented the planning methods and tools used by SAP S/4HANA, that make possible the production planning development.

With the objective to reduce processing time and stock, have better resource utilization and get a higher process control, is introduce the SAP APO module, called Production Planning and Detail Scheduling (PP/DS). Through it can be generate procurement proposals to cover uncovered internal or external product requirements using an exact planning time.

Materials that are considered critical for the production planning since they are classified as bottleneck, are planning under the PP/DS functions. While less critical materials that are usually consumption-based purchasing materials are planned with MRP.

The S/4hana system takes the advantages of PP/DS module and the planning procedures of the ERP system that gives the input to PP/DS. For production and provisioning to finite capacity, optimizing resources and material capacity.

The advanced planning functions available in PP/DS make a change in their data names. For example, "materials become products, factories and business partners become locations, workplaces become resources, and parts lists and work plans become product data structures (PDS)" (Neubronner, 2019).

Some advantages of the implementation, are the possibility to perform planning activities improving their performance, reduce time and make the activities lighter. Also, they are going to have a general visualization of the machine's capacity utilization and the material availability in the different departments and warehouses inside the ELTEK group at any time.

In order to understand how PP/DS is involved in ELTEK process, is necessary to explain the general planning process flow (figure 23) and define the main elements involved in the PP/DS module.

Planning process

To guarantee the right behavior of the implemented system, it has to be mapped the planning process flow figure 23, to understand where each component is needed.

The product production can be plan under different planning strategies. The main process in PP/DS are Make to stock, Make to order and External procurement. As previously mentioned, ELTEK planning works under the make to order strategy. Under this production type, each sales order has to be planned in a separate segment. production that means the planning process must starts with the demand planning, which is very much about figuring out what the actual demand and the required components (Rouse, Demand Planning, 2010).

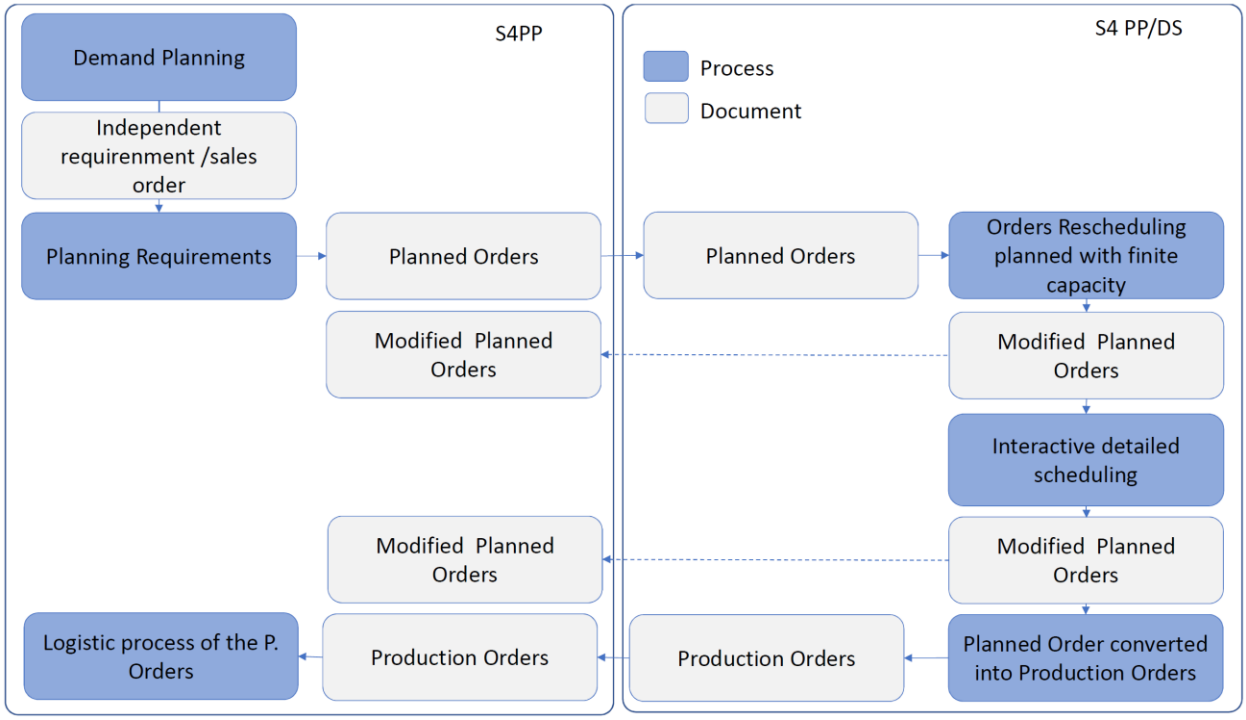


Figure 23.Planning Process Overview. Own creation

To create an order, it must be determinate the necessary quantities of the components to form the final product. It has to be also as a requirement to determinate the duration of each operation,

to make the scheduling of the group of orders. All this data is going to be in the master data, which is explain in the figure 25, the routing figure 32 and the resources figure 34.

The duration of each operation is determinate using the PDS which is define by the strategy profile (figure 50). "These parameters contain settings regarding the scheduling mode (e.g. find slot, insert operation or infinite), the planning direction (backward, forward, with reverse), and whether the validity of the operation and the dependent objects are taken into account" (Dickersbach, 2006).

First, it has to be considering the production plan under infinity capacity and the alert notification shows the results. After, the orders have to be rescheduling under the real plant capacity, to ensures the right sequence by the planning board which is the central tool where operations, orders and the resource load are displayed (Dickersbach, 2006).

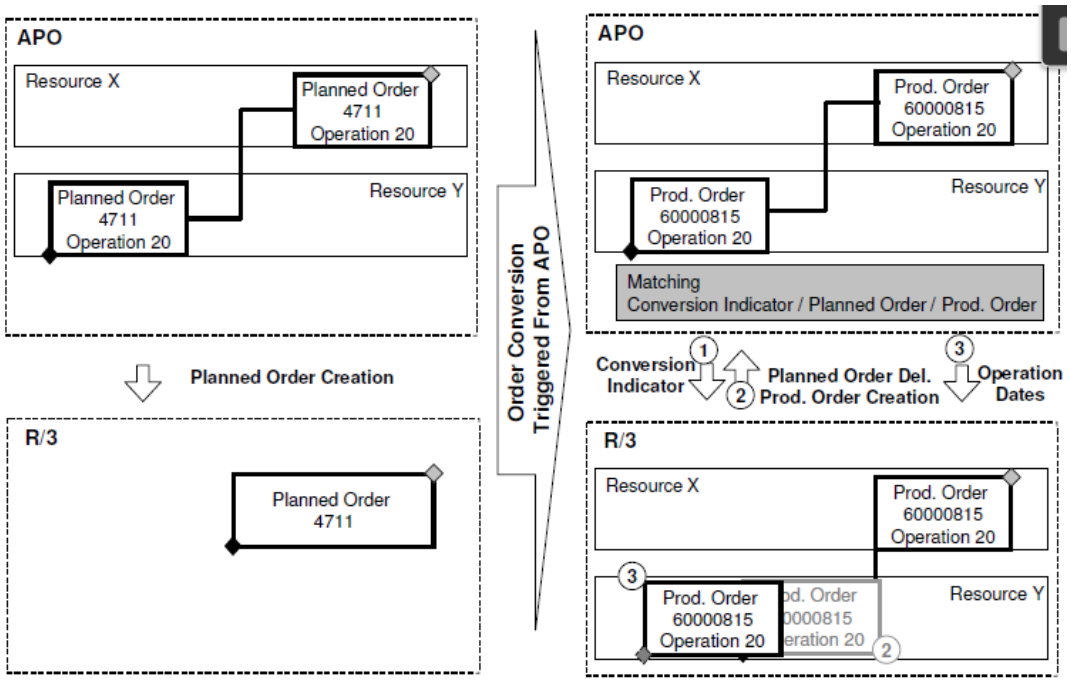


Figure 24. Order Conversion Triggered from APO. (Dickersbach, 2006)

There is the possibility that the result of the last production planning does not meets expectations. However, using the optimization tool, the production planner can make any change, according to their criteria. For example, it could be modified an order depending on the delivery order time. They can take an order which is far way for the delivery time and can be assigned to a closer period.

Using the new planning tool, planned orders are modified in terms of quantity or dates on the planning table, looking for the best process scenario using the rescheduling functionalities. Then the planned orders are fixed to do avoid any change at the next MRP run.

The next step is the conversion of planned orders into production orders is either triggered in APO or in R/3 (Dickersbach, 2006). To make the conversion in APO there is the automatically option by SAP transaction where all the selected order are going to be change or manually, where the conversion is done one by one.

According to Dickersbach the advantage to convert the orders in APO and not in the R/3 is the connection between deleted planned order and the new production order is considered, so that the production order is matched with the planned order and the operation dates are kept.

At this point the planning process ends and starts the physical production on the shop floor.

Main elements involved in the PP/DS module.

PP/DS models represents a supply chain from the suppliers to the customers. This model is managed by locations, products, resources and PDS.

For each module, it has to be assigned two kinds of data, master data and transactional data, to represent the company supply chain. One of the advantages of this tool is the flexibility to make different simulations with different model versions.

Two kinds of data:

- Master Data: is the data that remains unchanged over a long period, is shared across modules, for example quality management, production and sales to obviating the need for

defining it in various application areas (ERPDB, 2019). The relevant master data for production planning are mainly: Product, BOM (Bill of Material), Routing, Resource and PDS[3].

- **Transactional data:** Are the result of the planning activities, for example the production orders, purchase requisitions, stock transfer orders, sales orders, forecast, and stock.

Master data for production:

Production master data is divided in different factor as is show in the figure below.

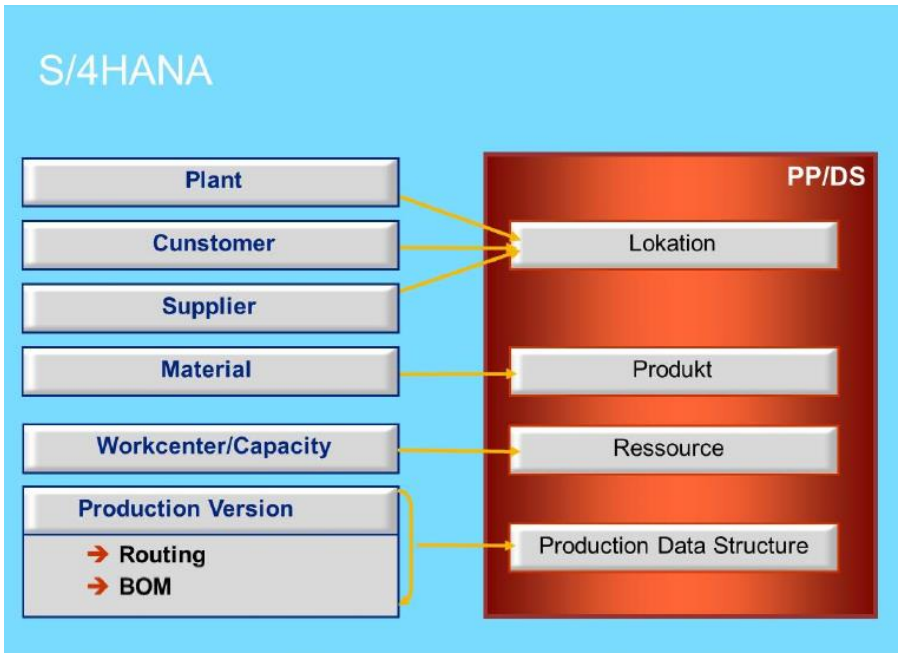


Figure 25. Production Planning & Detailed Scheduling - Master Data (company, 2016)

[3] Describes the operations and their capacity and component requirements for in-house production.

A. Product

Product master is the central storehouse that contains descriptions of all materials that an enterprise procures, produces, and keeps in stock. This material compilation reduces redundancy data problem.

Some master data information related to production are:

Figure 26. General material data. Own creation

1. Unit of measure: Unit of measure in which stocks of the material are managed. The system converts all the quantities you enter in other units of measure (alternative units of measure) to the base unit of measure.
2. Division: The product is assigned just at one division. This allows the people in a division who process orders and service customers to specialize within a manageable area of expertise.
3. Material group: Key that you use to group together several materials or services with the same attributes, and to assign them to a specific material group.

It must be declared the Material Requirement Planning (MRP) to ensure material availability in good time and in enough quantities.

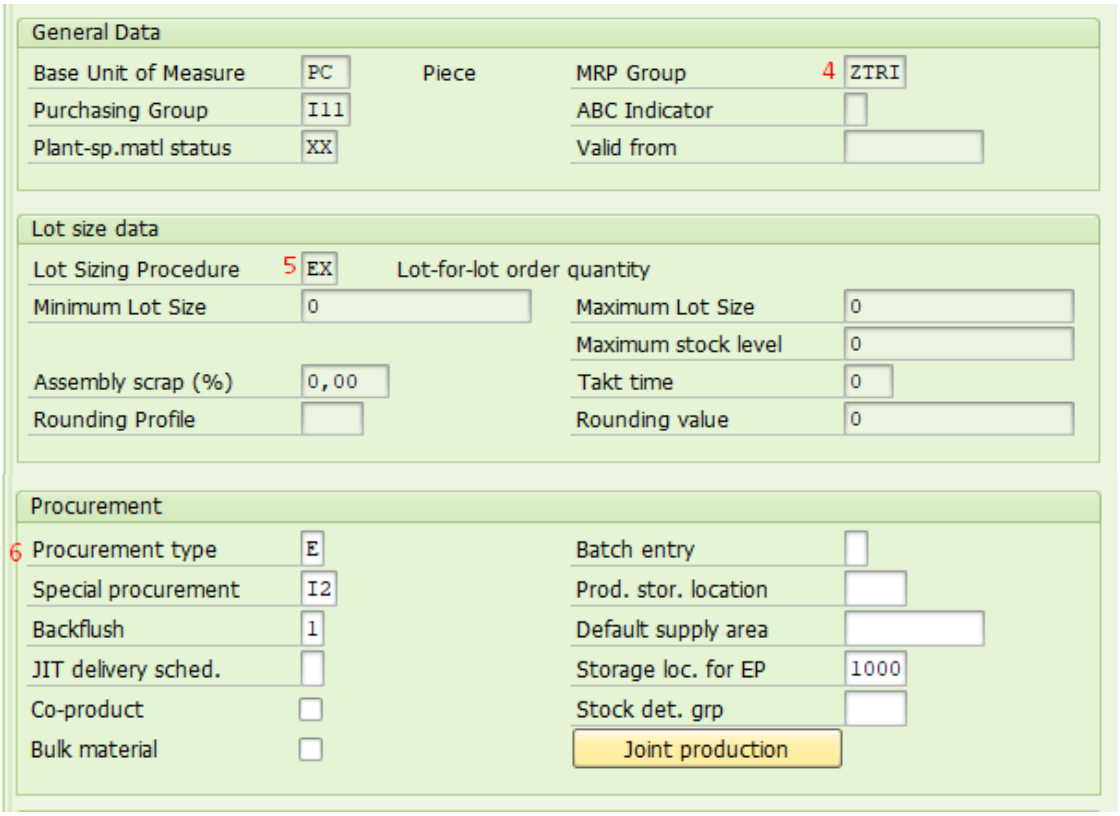


Figure 27. MRP data. Own creation.

4. MRP Group contains all the materials from the point of view of MRP for assigning special control parameters for the total planning run. These control parameters include, for example, the strategy group, the consumption mode, and the planning horizon.
5. Lot size data: determines which lot-sizing procedure the system uses within materials planning to calculate the quantity to be procured or produced
6. Procurement type: Indicator that defines how the material is procured.

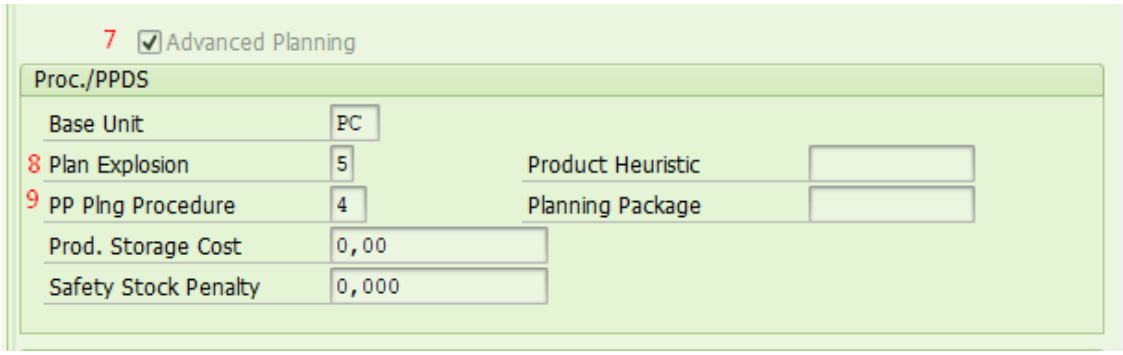


Figure 28. Advanced Planning data. Own creation.

7. **Advanced Planning:** In order to integrate Material to Products and Work center to Resources to plan under PP/DS system, it must be selected the Advanced Planning task, in both Materials as Work center master data.
8. **Plan Explosion:** specify which task list type (BOM and routing) the system uses to create receipts in *Production Planning and Detailed Scheduling* (PP/DS).
9. **PP Planning Procedure:** it has to be assigned a planning procedure to each location product that you want to plan in PP/DS, to specify which planning action the system should executes for each product.

   Declaring number 4 in the planning procedure, is creating a planning file when a change is made that is relevant for planning or it could be created for components when a new requirement occurs.

B. BOM

The BOM contains the assemblies or components that are involved in the production of a material, that must be assigned on the routing parameter.

Is used for the MRP, production, procurement and product costing

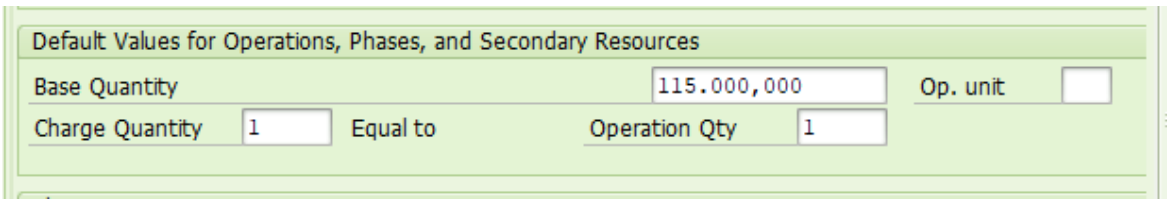


Figure 29. General information. Own creation.

1. **Base quantity**: Quantity of the material to be produced to which the standard values of the operation refer.
2. **Operations window:** Determines in which order the operations of a sequence are carried out
3. **Materials:** list of materials to make a product, as is show in the figure 30 and 31

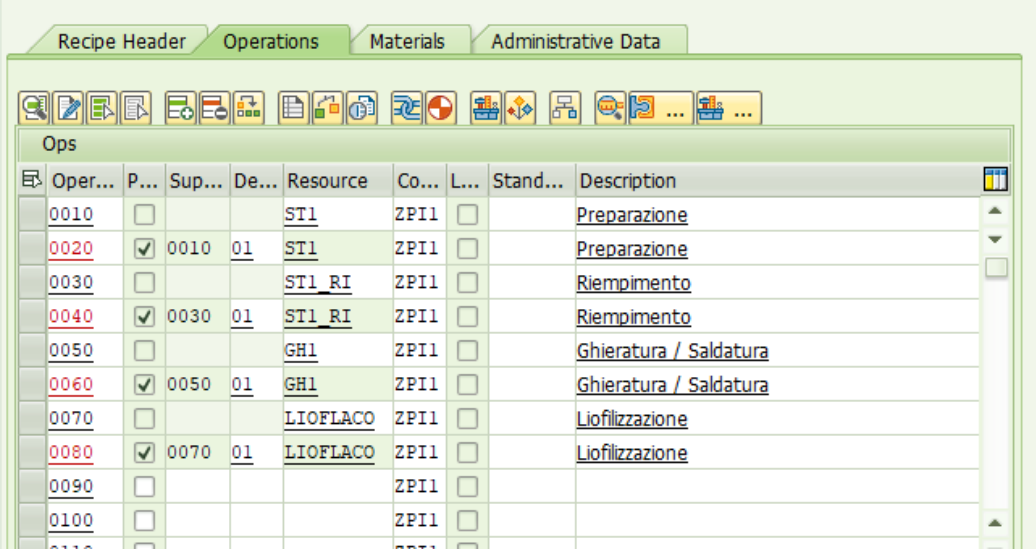


Figure 30. Sequence of operation. General information. Own creation.

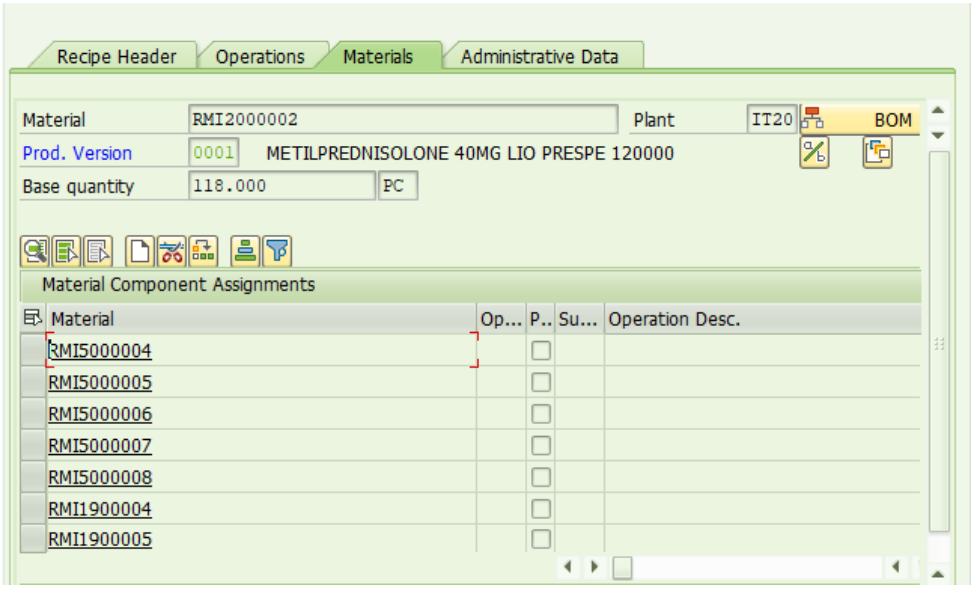


Figure 31. Components of final material. Own creation.

C. Routing

The routing represents how the process work on the production floor (Documentation, SAP manufacturing execution , n.d.). It makes reference to the material whose material required is describes on the BOM and also contains parallel or alternative sequences in addition to the standard sequence. It could be also assigned production resources or tools such as a measuring instrument or a support.

Information that can be found in the routing necessary to the production planning:

1. **Group:** To identify two routings that have different production steps for one material.
2. **Group Counter:** In Production Planning and Control, for example, it serves to identify alternative production processes and is used to make a distinction between similar routings.
3. **Plant:** where the routing is valid.
4. **Usage:** Specifying the areas in which the rout can be used.

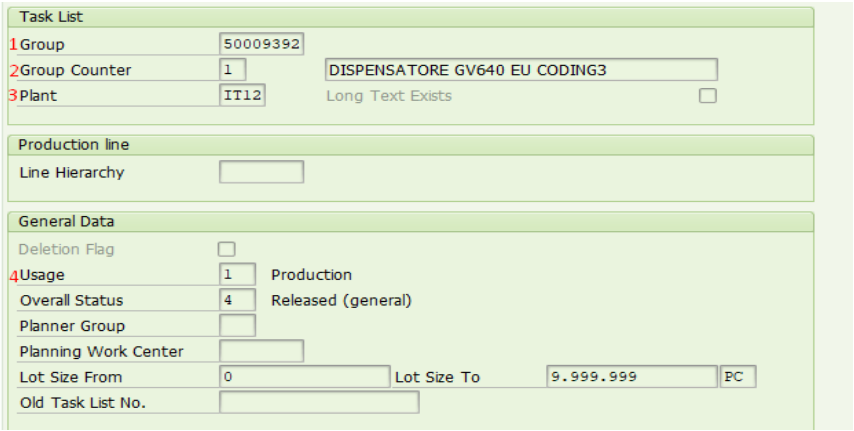


Figure 32. Routing master data. Own creation.

Operations executed are:

Operation Overview

Op...	SOp	Work c...	Plant	Co...	Standar...	Description	Base Quantity	Machine	Activi...	Labor
0903		40200	IT12	YBP1		ciclo	1.000	12.996	HMAC	14.616
9999		W12-W17	IT12	ZP98		VERSAMENTO	1.000			

Figure 33. Routing operations. Own creation.

D. Resources

The master data of each resources is used to specify the working and non-working time, and rate of capacity utilization. There are two types of production resources. Single, as a machine where it could be executed just one operation at a time or multi-resources where multiple activities can be performed allowing more than one activity to be scheduling at the same time.

The basic features of the PP/DS resources are:

- Resources capacity: is determinate by shift sequence that represent the time in which the resource is available.
- Finite Resources: is determinate by the planning mode in the strategy profile and the control flag which allow overload alert.
- Calendar Resources: are handling resources without determinate capacity. where only the calendar properties are required for the scheduling of the goods receipt in PP/DS.
- Resources Integration: transfer resources as a multi resource is concluded after setting the work center capacity, number of individual capacities or if flag option is available for several operation.

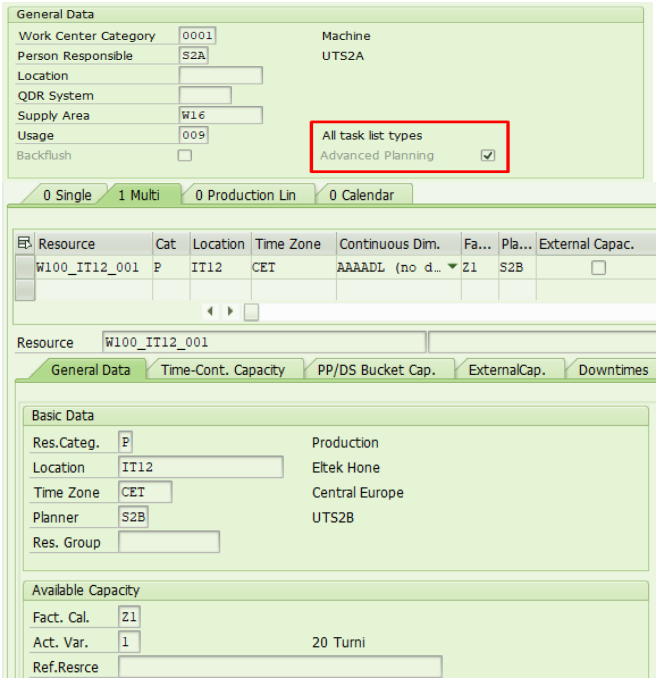


Figure 34. Resource master data. Own creation

E. PDS for PP/DS

Consists of the logical sequence of operations needed to produce the finished or semi-finished goods, specifying not only the physical place in which the production activity is made (Work center/resource), but also the different type of time (setup, production, breakdown). It also contains the components resource consumption. It specifies time relationship between the activities of different operations using them as a grouping entity. Activity type (production or set up), activity duration, operation scrap, mode requirement and assignment are relevant data for planning maintained an activity level.

On component level the information is maintained whether the product is input or output, the quantity and if is consumed at the start, end or is continuously consumed. BOM ratio could be variable related to the output quantity or fix independent of the order quantity.

"The mode determines the duration of the activity and on which resource the activity is scheduled. Entries on this level are the mode priority, the resource and the location, the variable and the fix duration (related to the base quantity) and scheduling constraints (e.g. break not allowed, production within a shift)" (Dickersbach, 2006).

1. Product: material to be produce.
2. Operation: Indicates a specific operation, which is an independent part of a recipe executed on a processing unit.
3. Activities: Indicate under which activity process.
4. Mode: Modes are used to assign alternative primary resources to activities. You can use the resource selection that is subordinate to the mode to also assign secondary resources to an activity.
5. Resource: Indicate which is the resource to use in the material production, related to the duration of the activity, which is dependent on the lot size of the material to be produced.

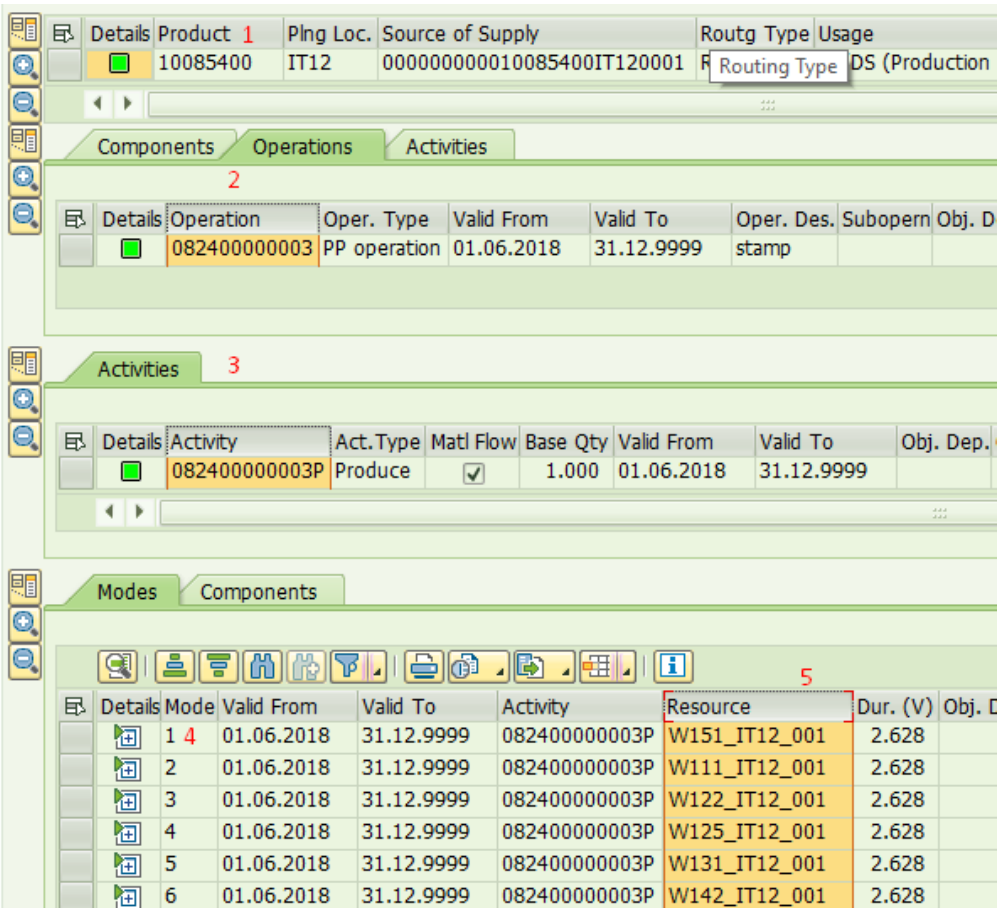


Figure 35. Structure that contains the master data for planning in SAP APO. Own creation.

Transactional data

A. Sales order

The sales order is a contractual agreement between a sales organization and a sold-to party about delivering products or providing a service for defined prices, quantities and times (Portal, 2017).

General elements inside the Sale order related to the production:

1. **Standard Order:** The number that uniquely identifies the sales document.
2. **Requirement delivery date:** The proposed date by which the customer should receive delivery of the goods or it may be the current date, automatically proposed by the system.

3. **Item overview:** shows the list of the customer requirement.

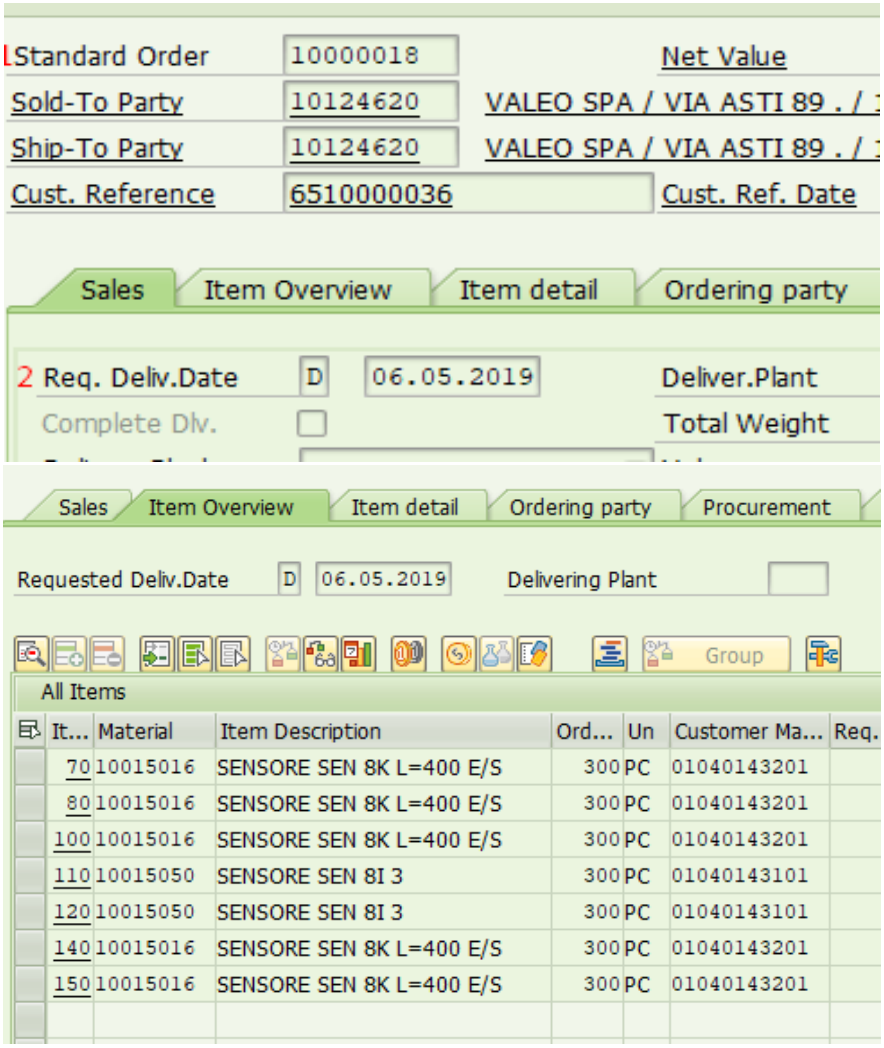


Figure 36. Sales order general information. Own creation.

B. Production order

A production order specifies details related at the material to be produce. For example, in which plant, which operations, and on which date production is to take place (SAP, SAP Library - Production Orders (PP-SFC), 2017).

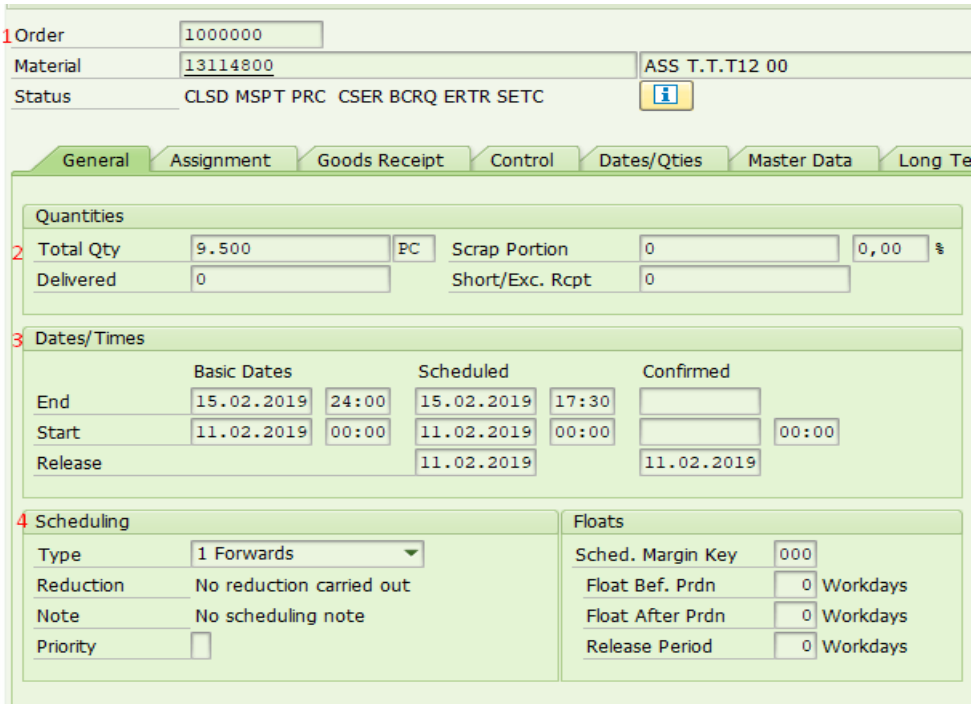


Figure 37. Production order details. Own creation.

Order example:

1. **Order:** Number which identifies an order within a client.
2. **Total quantity:** Total quantity (including scrap) to be produced in this order
3. **Dates/Times:** shows the earliest date for the execution of the production order (Start) and the date on which the required quantity of the material is available (End)
4. **Scheduling:** Via the scheduling type you can control, how the production order should be scheduled (for example forward, backward).

C. Purchase requisition

Companies does not process all the materials, that's the reason why they have to purchase the raw materials from other entities.

As is seen in the figure 38, the order has a list of materials with the required quantity, the delivery date and who created the requirement.

D. Stock transfer

Stock transfer requirements are requirements from other locations inside the same such as distribution centers (SE, SCM100 Business Processes in Planning (SAP ERP), 2015)

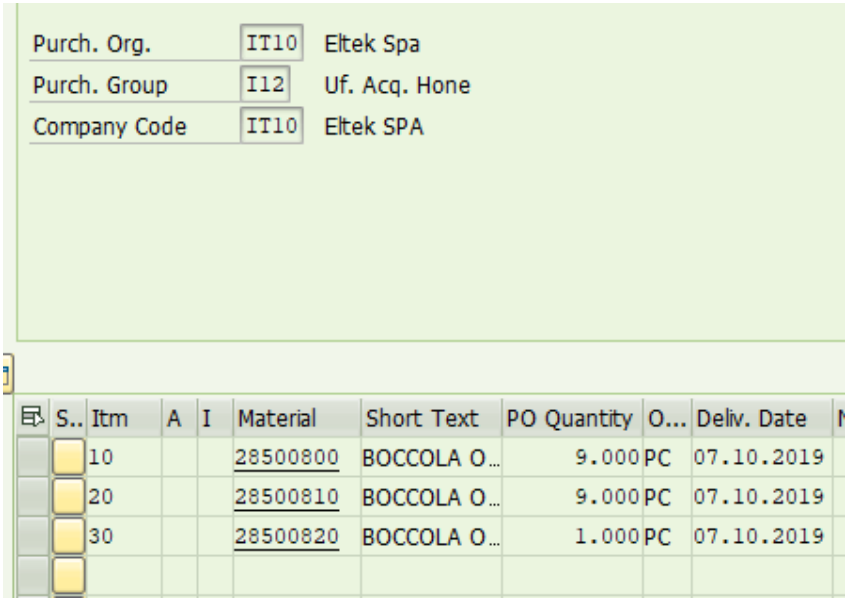


Figure 38. Purchase order example. Own creation.

Scheduling and Strategy Profile

The main configuration in the PP/DS module, is the planning strategy, element that contains the logic in which the production orders will be scheduled. This strategy could be configurated in different ways, the main features are **scheduling mode,** divided in infinite sequence scheduling or finite (figure 39). Under the infinitive options the production planner is free to schedule, one other next to the other one, without leaving any gap between activities. This mode could be run for single or multiactivity resource. On the other hand, is the finite scheduling where the capacity is declared as a constraint, making more restrictive the scheduling activity.

- Planning with infinite scheduling:
  Alerts output when overload on finite resource
- Planning with finite scheduling:
  Existing load taken into account when scheduling finite resources

	Finite strategy	Infinite strategy
Finite resource	Rescheduling Alert output	No rescheduling Alert output
Infinite resource	No rescheduling No alert output	No rescheduling No alert output

Finite and Infinite Resources with Capacity Overload

Figure 39. Finite and Infinite Resources with Capacity Overload. (company, 2016)

Under the strategy profile, it is also taking into account, the **planning direction.** If the system "searches for a scheduling date in the set planning direction for the last activity" (company, 2016), is considerate Forward mode. Instead of forward, is backward, where the objective is to search the first possible scheduling date.

Furthermore, are defined the scheduled parameters as scheduling strategies divided on find slot, insert operation, where the operations should be scheduled as closed as possible to de delivery

date. In those cases, if the “system cannot find a gap big enough, gor any constraint, all operations remain where they are, and the operation could be not rescheduling” (company, 2016).

Other scheduling strategy “squeezing in operation” consists on, insert operation at a specified time, follow by the reschedule predecessors and successors, and finally control the current time constraints. If the order is still in delay, it must be made a shift into the future.

Scheduling Planning Board

Detail scheduling planning board is used for capacity load leveling and the sequence planning. Through it we can see orders in a detailed level setting the layout according to the requirements or any change made it by the reasons mentioned before.

One example is the figure above which organized planning and process information.

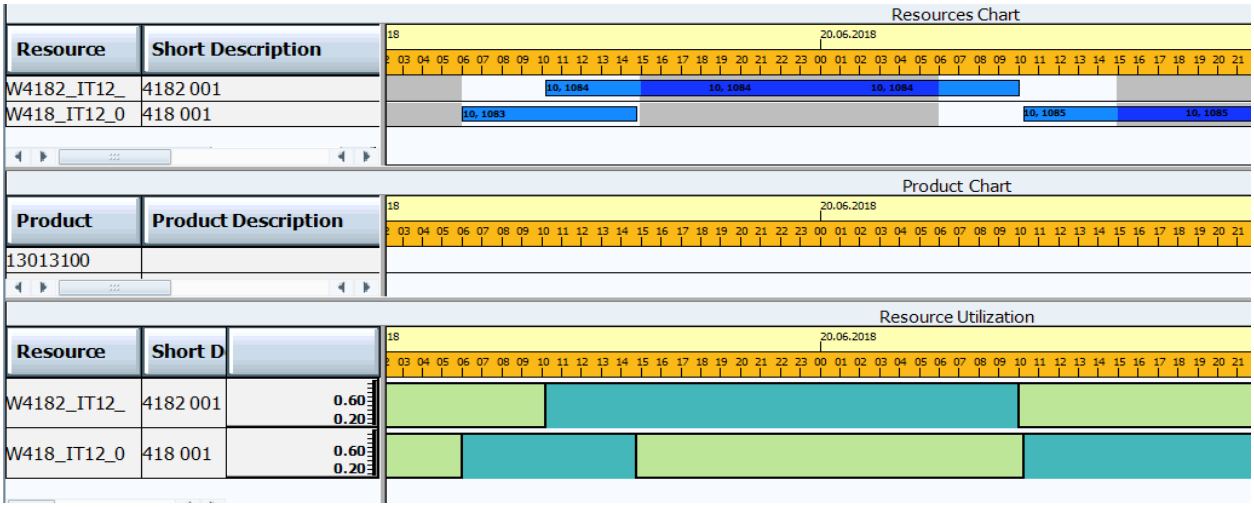


Figure 40. Planning Board. Own creation.

The most common information at Planning Board are resources, operations and order chart. And can be determinate as dynamic chart, to which is possible to make a series of change when there is a new demand or a new resource requirement. Also is a visual tool because has different graphic

elements, each of them has their own color and structure to be differentiated from the other properties.

Operations can be scheduled by “drag and drop” on grey areas, that means in non- working times. This fact is control by the strategy profile. “ The system only permits scheduling of the operation on this date when all other prerequisites have been fulfilled” (company, 2016), and there is not any violated constraint.

Is necessary to declare a Profile to define the layout and group the Work area, time profile and version to determinate the content. Second, the scheduling possibilities and alert profile calling from the optimizer profile. Also contains the strategy profile, the propagation range, the heuristic profile and the optimizer profile, which define the scheduling possibilities.

Work area

Depending on the order specification it generates a unique combination between a set of resources or products.

Then the most important fields of a work center that are related to production will be shown:

1. Person responsible: The person or group of people who are responsible for the maintenance of the work center master files.
2. Supply area: Serves as a place for interim storage on the shop floor and is used to make material directly available for production purposes.
3. Advanced planning: It supports advanced planning and scheduling.
4. Standard Value Maintenance: Is used to calculate execution time, capacity requirements and costs.

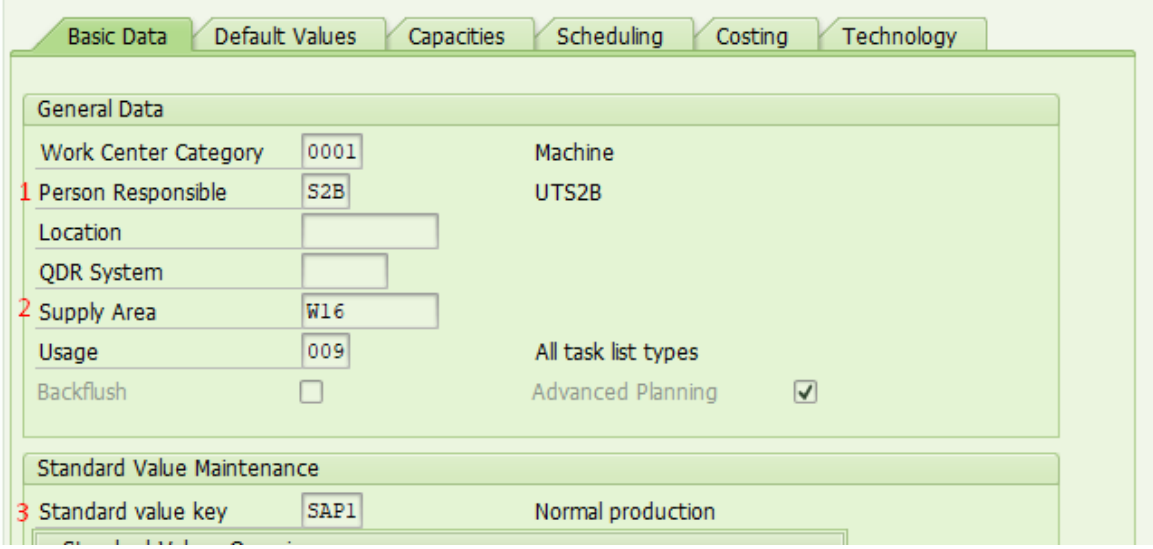


Figure 41. Work area general basic data. Own creation.

At each work area is assign two types of capacities, being necessary both necessary for the operation of the workplace. Those are the machine capacity and the person capacity. Both entities have different processing formulas since they have would have different capacity requirements for processing. (figure 42)

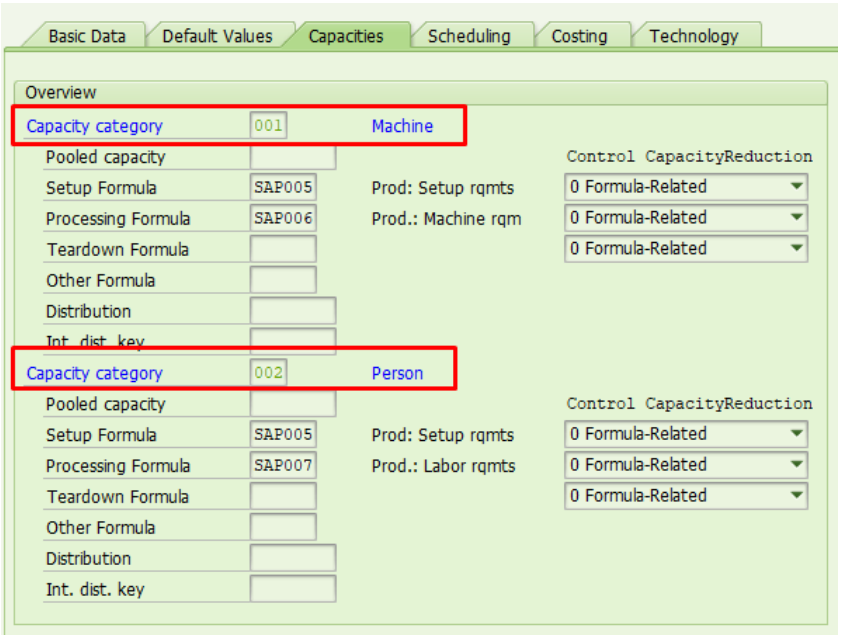


Figure 42. Capacities in the work area. Own creation.

To closed this chapter is important to remember that doing the planning considering critical products (such products with long replenishment lead times or products that are produced on bottleneck resources) and having better coordination between system entities (resources, production and procurements) is possible to reduce lead times, increase on-time delivery performance and reduce stick cost. (SE, Simplification List for Production Planning and Detailed Scheduling , 2018).

"In APO there are more possibilities to model the technical constraints of the production process than in R/3, because each technical constraint increases the complexity of the planning problem " (Dickersbach, 2006) provoking errors and decreasing performance. On the other hand, the main difficulties are relating at the lot size determination and manifold master data settings.

Determinate lot size makes an impact on the production planning results and scheduling challenges. When the lot size is small, generates a greater number of orders increasing the effort on planning and task execution. For big lot size, the lead time is increased. And master data is related with location, products, resources and PDS resp PPM (Dickersbach, 2006).

CHAPTER 4. METHODOLOGY CONFIGURATION.

Before the implementation of the tools that are proposing to improve ELTEK performance. A configuration on the system have to be made according to the ELTEK necessities, as will be describe below.

Classification configuration

For the new methodology, it has to be created a new classification type to relate characteristic, class, work centers and routings, allowing the company responds better at any variability on the demand.

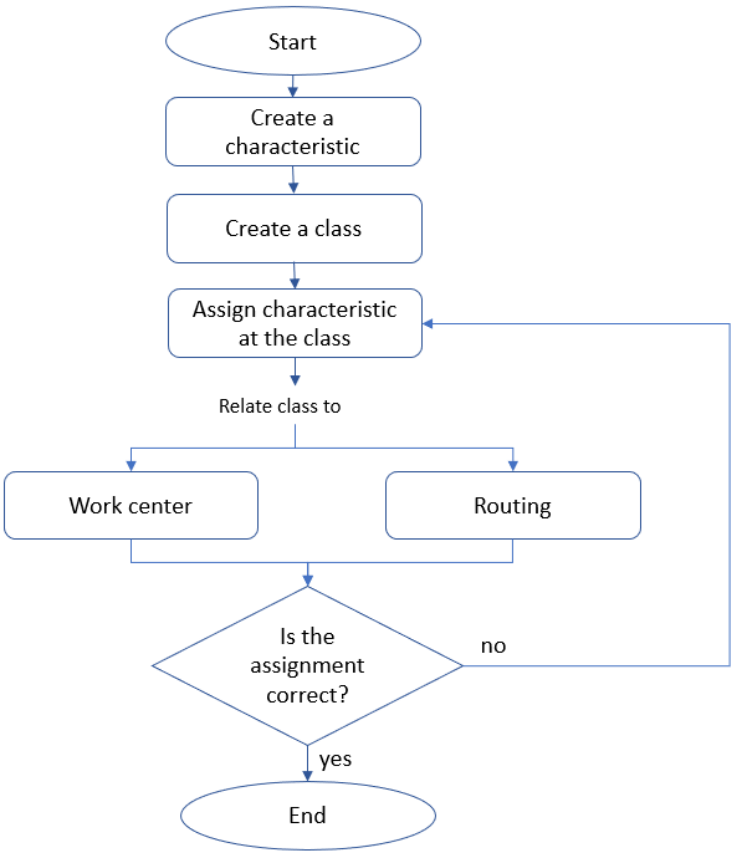


Figure 43. Process classification. Own creation.

This configuration allows the production planner to make a change. This allow to re-assign some orders that had been initially assigned at a main machine, on an alternative machine. This modification makes an increasing on the productive system capacity. To make this possible, it must be followed a series of step described in the figure 43.

First, is necessary to create characteristics where the planning levels are defined. The "characteristic values are the objects for which you aggregate, disaggregate, and evaluate business data. Time characteristics define the periods over which you display, plan, and store data" (SE, SCM100 Business Processes in Planning (SAP ERP), 2015).

In this case, was created the characteristic related to the alternative machine (figure 44)

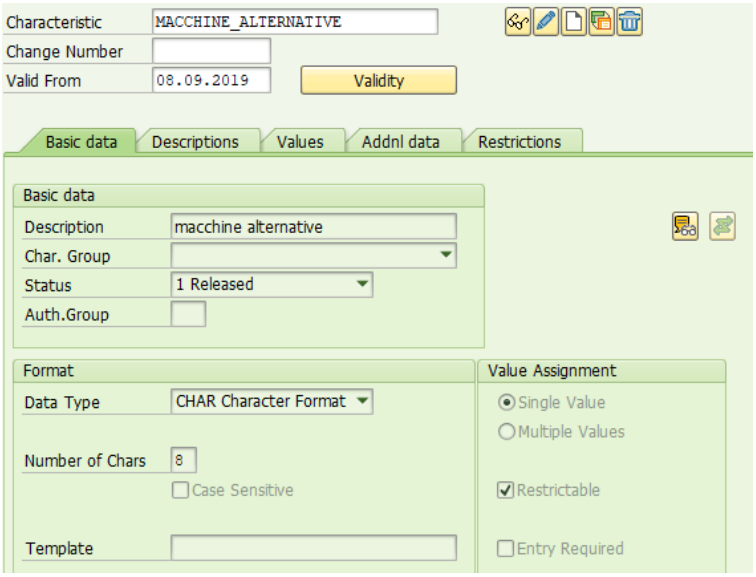


Figure 44. Creation of the alternative characteristic. Own creation.

Characteristics are maintained and grouped together in classes inside this system. When alternative modes are use during the PP/DS concept, one step to make it possible is to confirm the PDS configuration. It need to be "stored more than one mode with alternative resources for each activity operation" (company, 2016), and it has to be also assigned the priority mode, to execute

the activity under the new alternative option and allow them to join between order to be process and alternative resource.

Therefore, the class alternative mode was created. This class could be created under different types. In this case, the class is setting to the work center mode (Figure 45).

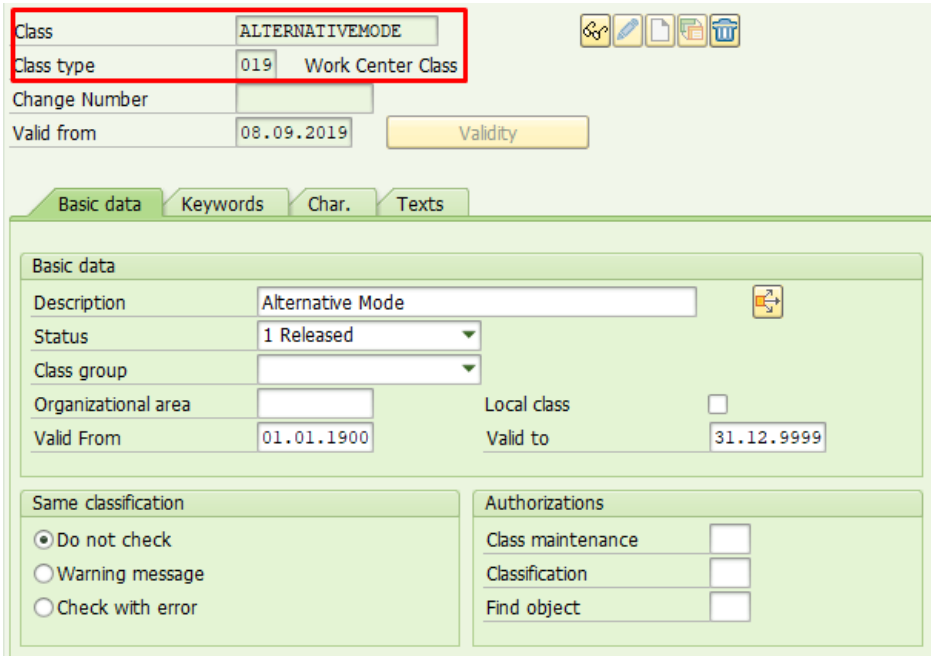


Figure 45. Class creation. Own creation.

For the properly system development, the class has to have the relation with the alternative characteristic described in the first step (figure 46).

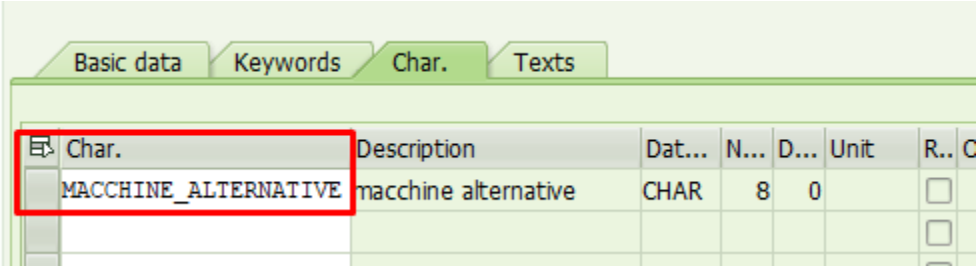


Figure 46.Characteristics related to the class.

After it is determined the path route, it must be assigned to the work center and the routing the option to work with the alternative machine.

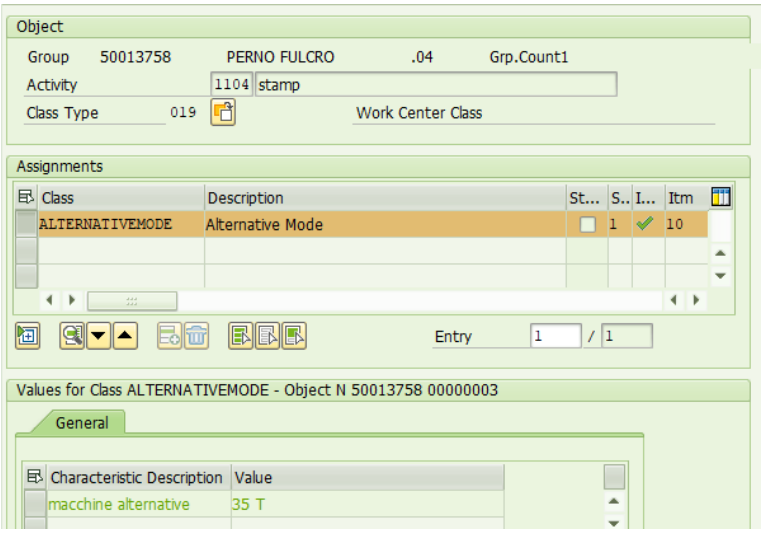


Figure 47. Routing with a group of alternative machines. Own creation.

In the figure 47, could be seen that in the activity 1104, which determines in which order the operations of a sequence are carried out, is assign the alternative machine located in the group value of 35T. That means, that all the routings that have the activity 1104, are going to have the option to be process by any machine grouped under the value of 35T.

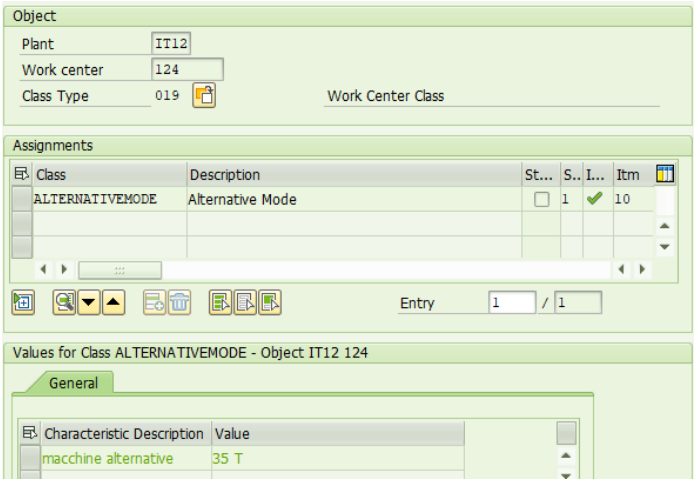


Figure 48. Work center with the alternative mode class. Own creation.

And the work center is going to have also the same classification of the alternative group (figure 48). Is recommended to confirm all the relations just made it, just to be sure that the data is going to work properly in the forward steps.

Advanced Planning Configuration

Each business has their own way to planning. This is why, for ELTEK was develop a customizing for their Production Planning and Detailed Scheduling processes.

Production planning use the production planning run to cover uncovered product requirements (SAP H. , n.d.). Is "use the production planning run to execute heuristics, detailed scheduling functions, or optimization for a large number of objects online or as a background job" (company, 2016) which are supported by tools as the "Detail Scheduling Planning Board" and "Production Planning Table".

Alert Monitor

Due the methodology runs in based on exceptions, must to be done an evaluation to point the problem situation. In the ECC system the alert view was just reach it by the material overview, individually. In the new methodology is more advanced and it can be display in an aggregate list.

The role of the alert monitor is to inform the production planner, any situation that has to be adjusted in the planning. How alerts are display depends on the context, version, model and period, which are defined in the overall profile.

"Alerts in SAP Advanced Planning and Optimization (SAP APO) help to identify any exception or unwanted situation that requires the attention of planners so that they can take corrective actions" (Jaiswal, 2016). Is used to select the objects for which alerts are to be displayed in the Alert Monitor. "Therefore, filters the display of alerts. This enables the production planner to maintain a user- specific selection of alerts for the production task area" (company, 2016) .

"Alert Monitor provides a central tool for planners to analyze the problems and take required actions to correct them" (Jaiswal, 2016). Under this tool, it could be assigned different priority

levels and issued as information, warning, or error, and defined a tolerance value, activating an alert when the any values exceed the threshold.

Production Planning

Variants creation

In the production planning run, there are two types to process steps. The functions for Detail Scheduling and heuristics for Production planning.

Production planning is determinate by a list of steps, which can be define using procedures referred to *heuristics* to define which objects are to be processed. (figure 49). the system already has some predefine scenarios. However, any heuristics can be defined in customizing depending on the necessity.

For each processing step it has to be define under which parameters the software is run, that means it has to be assigned a heuristics or function, profile and the objects to be process during the heuristic execution.

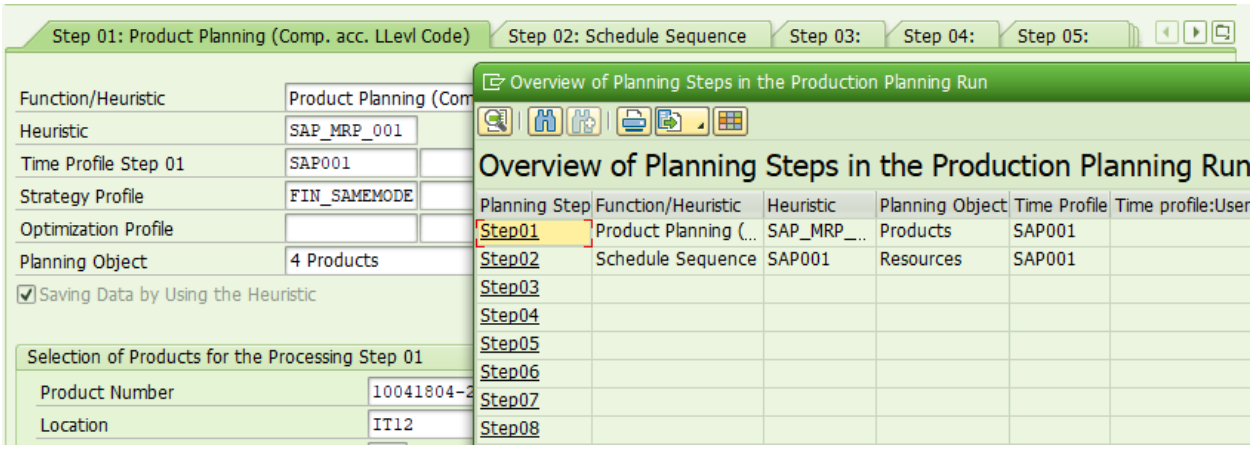


Figure 49. Production Planning Run with Multiple Steps. Own creation.

For this project, are being introduced some heuristics as:

- "Multi Resources" type, which runs MRP with rescheduling on the alternative resources. For this type, the capacity is considerate as finite because if it was considered with finite capacity, the system blocks the drag and drop operation.
- Other new option allows the possibility to MRP with rescheduling on the alternative resources.
- The MRP runs with rescheduling on the main resource, planning with just one alternative machine, creating a sequence of orders, one behind the other.
- Sometimes the master data is change. Therefore, it takes the new variant to reexplote the orders.
- There is also the option to scheduling using different production versions

The production planning can be executed to one product as a single- item, or as a total planning of group of products This has two possibilities to be executed, could be "online" when the quantities are low, and the response time is short, or to planning a mass data, there is the background processing, where is used variants that contain specific massive settings. "This function allows them to start the job immediately or determine that it is to be started at a later time" (company, 2016).

"Interactive planning can be carried out from the product view, product planning table, and the detailed scheduling planning board" (company, 2016) . To make this possible, they have to make refence on Product Heuristic, which use just the product master or planning procedure to determinate the plan. Or Variable Heuristic where the planning result, could be influence by specification created by the user, without having to change product master. In this option, *n* heuristics can be created to guide the plan process.

Some examples of Product heuristics are:

- *Fixing Horizon* to freeze a period of the plan, this option allows to do not make any disturb on the shop floor. An increase of the fixing horizon for the top-level product can be used as well as an additional security to prevent the loss of pegging in cases where many demands are in the past.
- *Bottom up strategy* works with an infinite scheduling strategy as the Top Down. "Reschedules dependent on the demands to the earliest receipt date" (Dickersbach, 2006). That means that the planned order of the final product, cannot start until all components are ready to be consumed.
- Top- Down Heuristic adjusts the planned and the production orders to the demand date. This strategy and Bottom up must be included into the MRP heuristic with the setting to sort the BOM levels in descending order following forward scheduling (Dickersbach, 2006).

Detail Scheduling Strategy profile creation

It could be created any strategies depending of the production constraints. On the strategy profile is declared the strategy to be used to run the production plan and the sequences in which the system can use the strategy.

For the current mode, it has to be declared if the system has to retain the current mode when rescheduling a selected operation or if it may reschedule the operation on an alternative resource (automatic mode selection). See figure 50

Also is determinate if the planning direction is forward the system searches in the future for a scheduling date or backward is when the system begins its search at the desired finish date

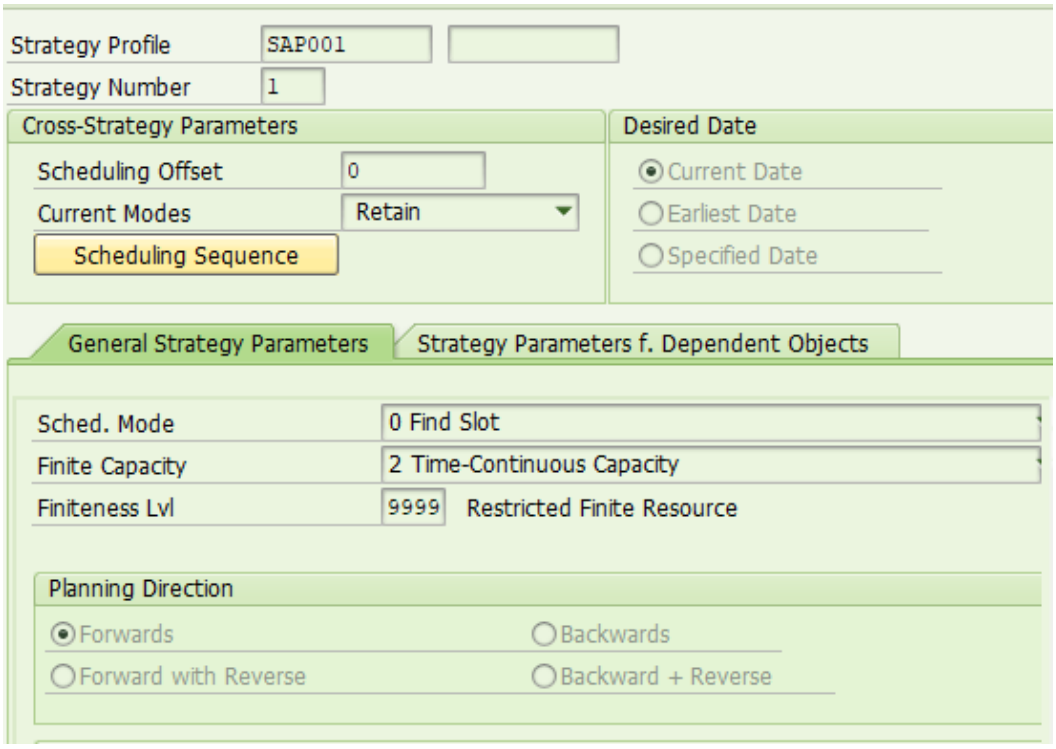


Figure 50. Strategy profile creation. Own creation.

- Selection Options (resources, product, Profiles)

1. Profiles (Figure 51 and figure 52)
    a. Planning board profile: Defines the structure of the detailed scheduling planning board and the selection and display of the objects to be displayed
    b. DS strategy profile: Defines the scheduling strategies for *Production Planning and Detailed Scheduling* and time in which the system can use the strategy.
    c. Heuristic Profile: Defines which heuristics are available in interactive planning

1. Time profile: Since the planning board is made up of several elements, it must be assigned the process times of each one (resource, production run).
2. Work area: Determines which resources, products and orders can be displayed in the *planning board*

3. ***Set:*** A set groups selection criteria within a view (orders, products, resources). To improve the performance, the number of selections it should be small as more as possible.

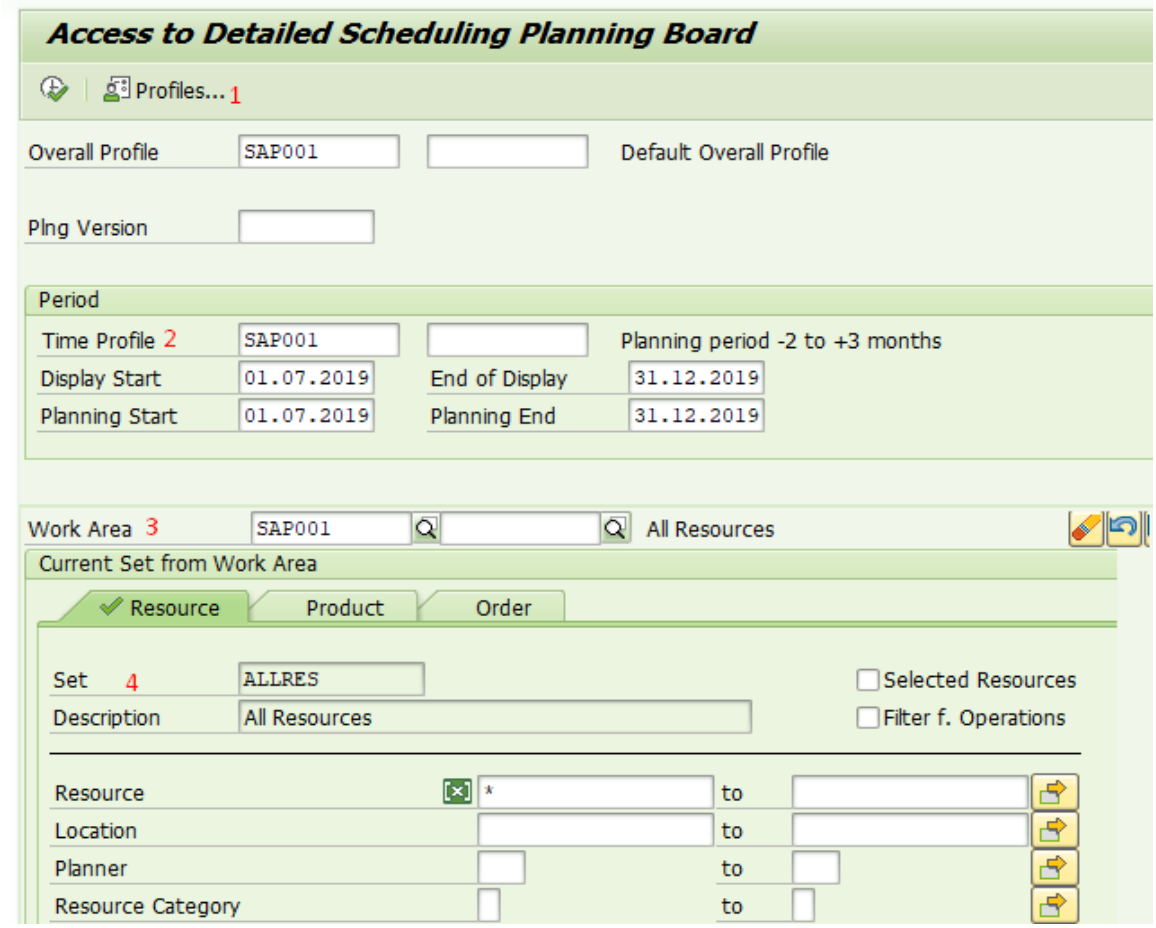


Figure 51. Planning Board. Own creation

Figure 52.Profile detail. Own creation.

- Pegging relations

PP/DS system uses pegging strategies to assign receipts to relevant requirements. By determining which materials are involved on those order could be avoided any incoherent on the production chain. Pegging relationship could be fixed or dynamic.

Fixed pegging inhibits the change of the relationship during planning. It could be related to a quantity and the specific requirement. “For pegging relationships to be created, the product, location, account assignment (make-to-stock and make-to-order production) and planning version (active or inactive version) must be the same” (company, 2016).

- Production Planning Horizons

“Within the PP/DS horizon, the key focus of PP is lot size-orientated planning in the sense of quantity-orientated requirements planning” (Company, 2016). After the capacities are settled by the DS, it could be deciding the viability of the planning. Normally tends to be above the planning time fence.

This chapter, allowed to identify that one of the advantages of using PP / DS is the ease with which production alternatives can be created, also it increases the flexibility and the adaptative behavior at the time to make any planning scenario and the fact that programming methodologies take these alternatives into account is one of the reasons why PPDS was chosen.

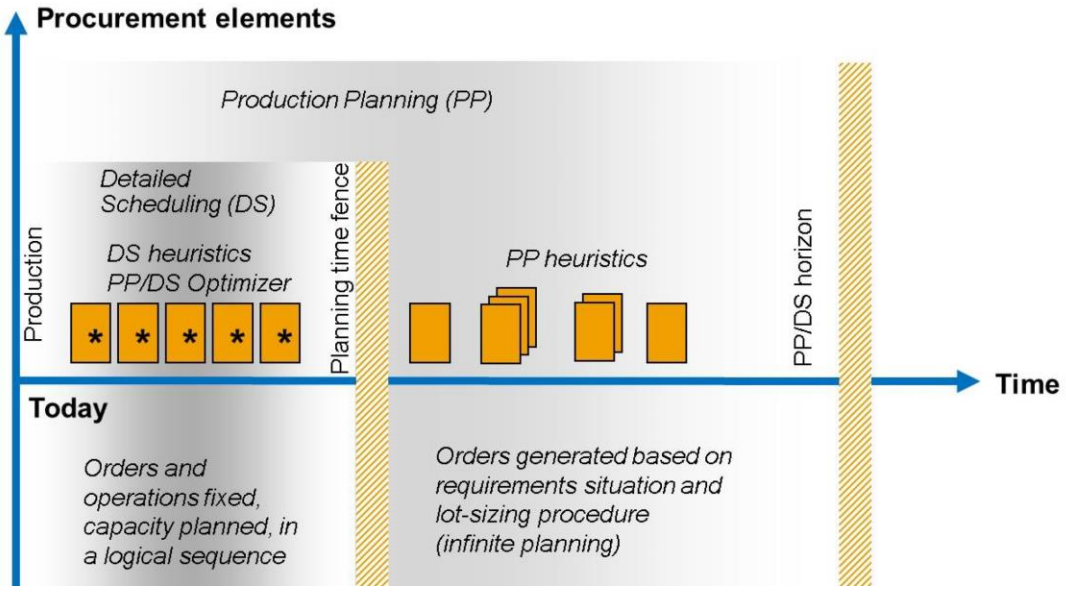


Figure 53. Production Planning Horizons. Company, 2016

Business process has the risk to be affected by events as changes in sales order, or creation of dependent demand. That is why through the strategies mentioned and the planning procedure could be decided to “cover the requirement immediately, cover the dependent demand with existing receipts, or call the production planning heuristic immediately, create a planning file entry or do not carry out any action” (Dickersbach, 2006). By using variable heuristics scenarios as the planning task, it could be influence planning results. In the case where there is a last-minute order and by any path it could be program immediately, the system should propose the closer production date.

The introduction of the new planning table has several advantages being compare with the classic ERP graphical planning table. Since it has a complicated customizing, poor performance and locking problems. Some advantages of the new planning table are:

- Support the basic features, such as changing operation start times or resources by drag and drop.
- The influence on business processes should be minimal
- Is more flexible and be easier to use
- Advanced functionality for resource and order planning as pegging, will be available.
- It could be specifying alternatives resources, and rescheduling operation under the new specification.

Having both the product and the resource chart at a glance gives you the opportunity to plan multiple products on multiple resources, as in repetitive manufacturing (company, 2016).

CHAPTER 5. PRODUCTION PLANNING RESULTS WITHIN THE NEW METHODOLOGY

Chapter 5 describes how the proposed methodology is implemented in ELTEK process, after the integration between the analysis of ELTEK issues (chapter 2) with SAP tools (chapter 3) and its own configuration. While the proposed methodology is described, is explain how through the PP/DS tool as a part of SAP, is improve ELTEK scheduling and planning process. Allowing the company to have a better supply chain performance.

As was mentioned in chapter 2, the planning process was based on an excel file. The planning horizon was just of one day, since the planning was done the previous day. The ideal situation for the production planner is to has the possibility to run his production without any extra modification. However, the production planning is related to a demand, which means that production planning has to be modified if a sales order arrives later.

Any time that sales area receives an important order, must be contact the production planner to determine a delivery date. At this point, it must be established the best possible solution, rescheduling orders to try to cover the order and give the most real delivery date, within a short response time. This task it itself is hard to perform and more when there is any support tool which can show the actual capacity scenario, to determine which option causes a minor impact on production.

The new methodology makes a change in the planning way, including some features that are not available in older systems. For example, the use of the heuristics which make the process more flexible and extended, or the pegging concept, where “receipt elements are assigned to the requirements and the use of alternative used to increase process capacity” (SAP A. , 2006). The new production planning follows the flow described in the figure 54.

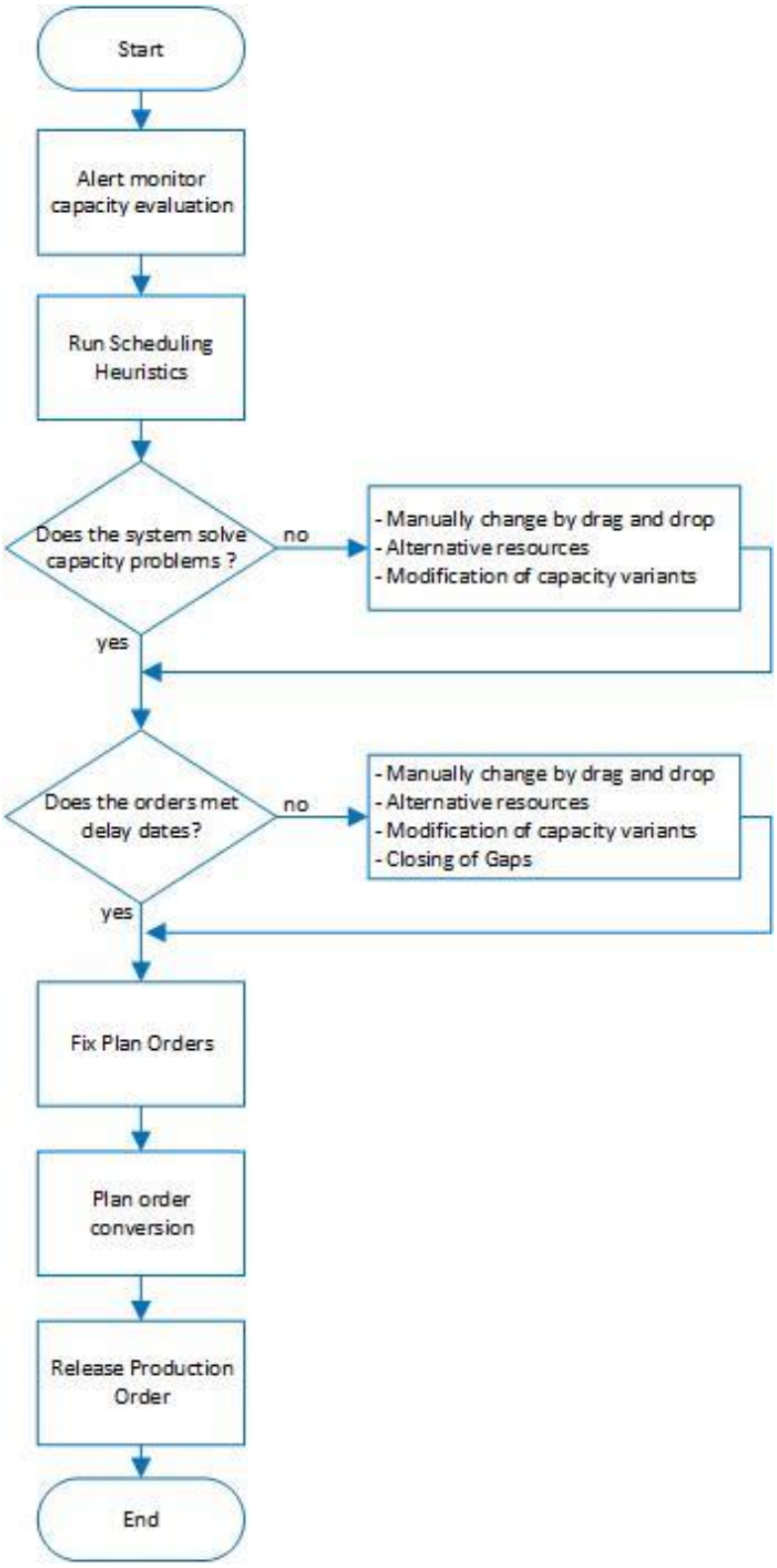


Figure 54. New planning process. Own creation

The methodology implemented works under the concept to work under exception. That means that the production planner has to start the planning process looking for those situations that apparently can cause any problem and are pointed as critical situation. This could be reach through the Alert Monitor Evaluation.

Alert Monitor Evaluation

Within the alert monitor is defined "for which products and resources and which situations are display alerts" (company, 2016).

Production planning process starts making a list of alerts depending on the two alert types:

1. **Requirement / Receipt Alerts:** alert generation when the requirement date is not met.

   It is possible to define three thresholds to identify the type of alert generated (information, warning or error) Figure 55.

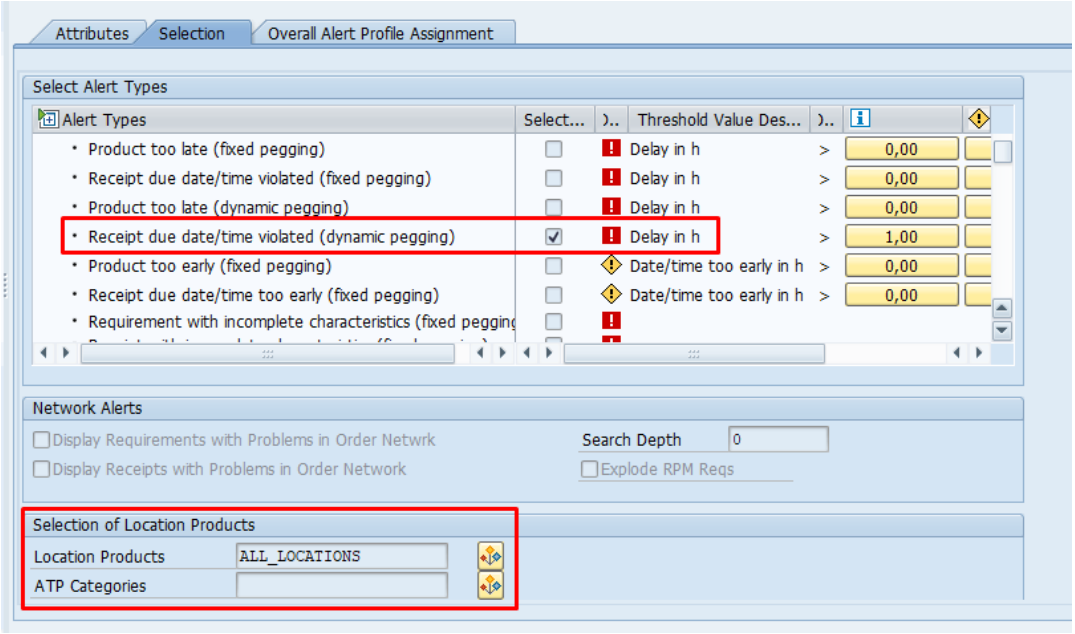


Figure 55. Delivery date is not met. Own creation.

2. **Alert to Overload resource:** alert generation when the resource load exceeds 100% of the capacity. This is notified by the red icon shows in the figure above. This only happens if the production planner defines the resources as finite.

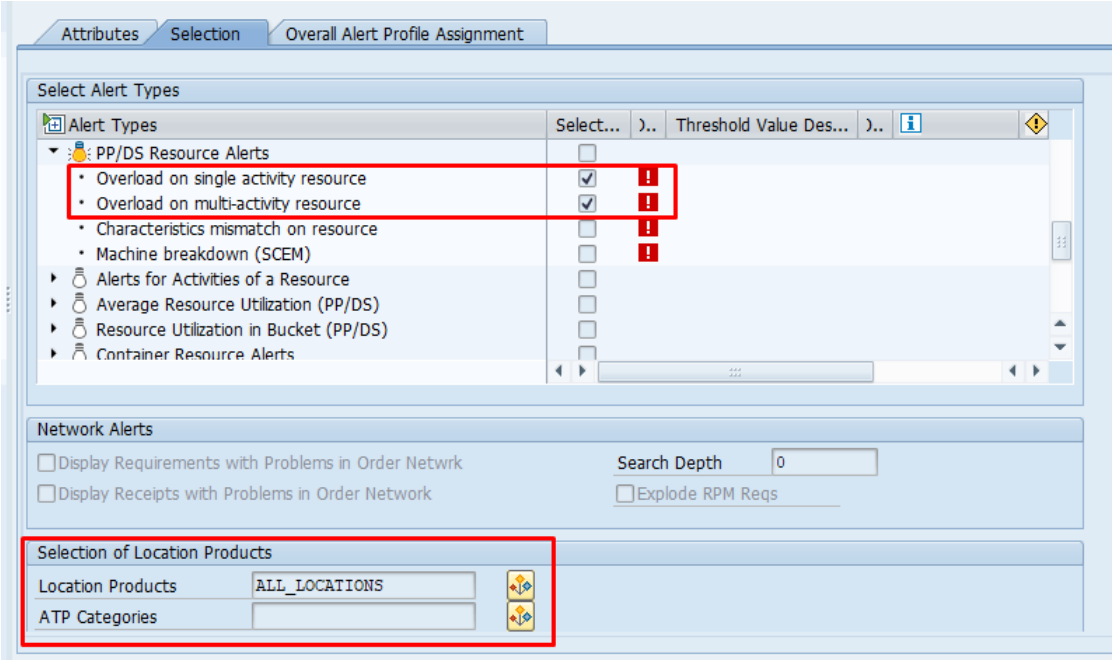


Figure 56.Resource load exceeds 100% of the capacity. Own creation.

Once the Alert Monitor profile is defined, the alert program is run and appears the number of generated alerts and a detail list as is how in the figure 57, where we can identify critical situations.

Before continuing, it has to notice that one of the Alert Monitor advantages is the possibility to changes profile parameters in an easy way, allowing the user to have different scenarios in a short time, to make an evaluation an determinate under which base is better to make the production run.

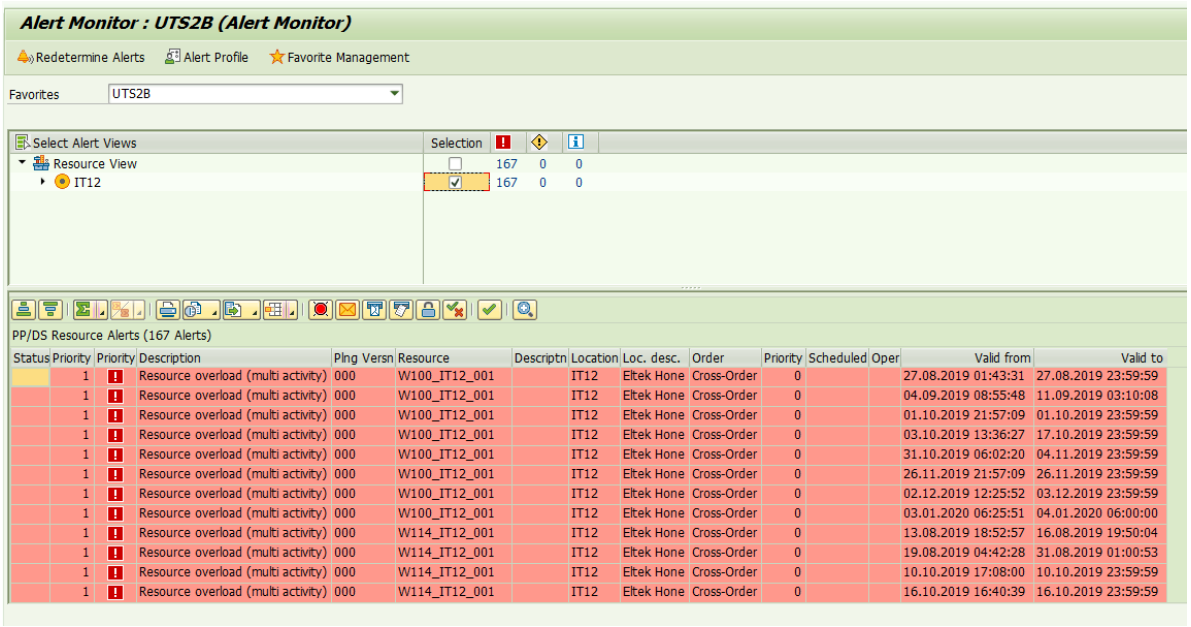


Figure 57. Alert report. Own creation.

To plan a product, is being use an interactive planning with is composed by two functions, Product heuristics and Variable Heuristics. Under the Production heuristics the production plan is made it through the planning procedure which is specify the actions that the system should executed if a relevant event occurs during production process. On the other hand, the Variable Heuristics, where the result could be change by "planning specific planning problems using heuristics different at the previous ones.

During the production run, is defined a list of planning heuristics to be execute, the strategy profile to be used and the objects. It could be also some restrictions for specific objects. After the production planning run perform, could be save the results on a simulation version. And after decided if the previous simulation could be running, modify otherwise, just cancellate.

The result of the planning table (figure 57) shows the master data information, which are the resources and products involved in the planning period. And the other relevant aspect created is the division of the planning table into orders production dates, the product chart and the capacity of the resources indicated by the last part of the table.

After the planning run, two scenarios can be presented. First, can be occur that there is still something to change in the planning result. In this case, the producer planning must make the required adjustments to have an ideal production plan. Or, the previous critical situations were organized automatically by the planning table.

> "If a planned order is connected to a requirement, such as a sales order, with a fixed pegging relationship, then this relationship will be retained when you convert the planned order to a manufacturing order. In this way, you can be sure that fixed pegging relationships between receipt elements and requirement elements are retained in Production Planning and during the execution of production, even after various document switches" (company, 2016).

This scenario does not show any alert notification, and its seems like everything on the planning table is under control. So on, we can continue with the next control point given by the general planning production flow of the figure 58.

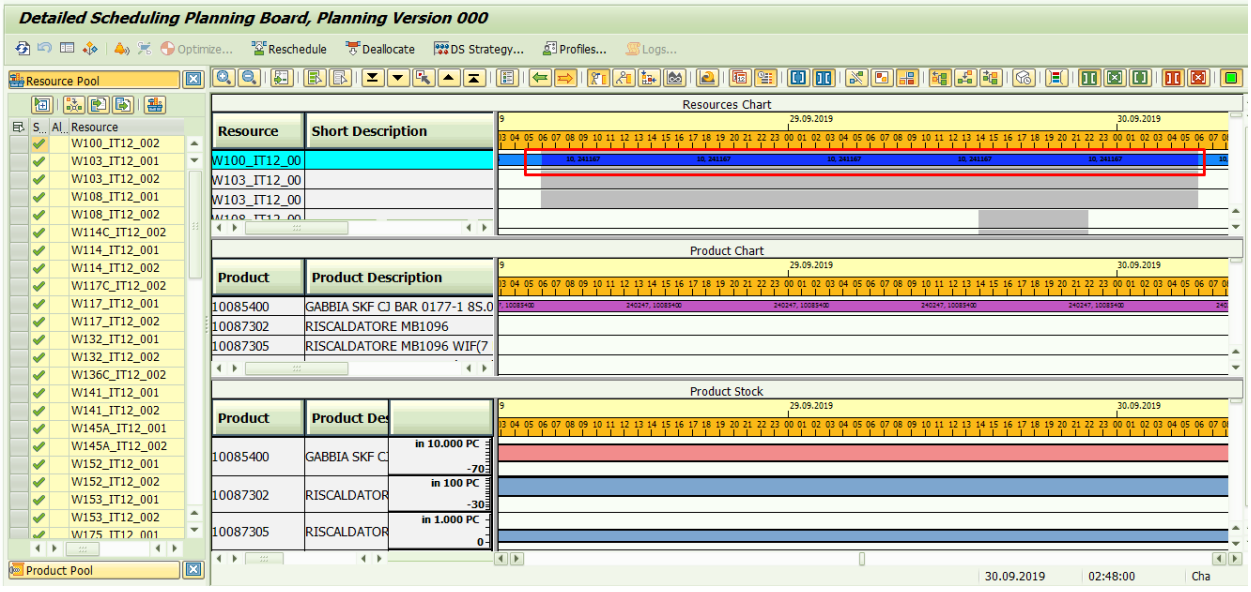


Figure 58. Heuristics results. Own creation.

Production Planning Heuristics

The process follows with PP heuristics have a planning focus on the products. The heuristic list is performed to get a net requirements calculation this is why " is run as infinite and does not take into account any overloads on resources that may be occur" (company, 2016).

However, as a follow step is related with detail scheduling, where the focus is inly made it for resources and operations. During the process is use this heuristic "to schedule selected scheduled operations in a particular sequence in the production planning run and the DS planning board" (company, 2016).

When procurement type (in house/ external) was defined, the production data structure "PDS" is exploded in the planning run for each planned order, and the capacity level of each resource was evaluated. Is possible that the production planning run calculates planned orders details.

Planned order is usually planned using detailed scheduling, and according to the SAP entity, the system selects the source of supply according to the resources, PDS, and strategies, giving way to solve common questions as:

- When will it finished?
- Which components are required?
- For which day are required?
- Which steps are executed in production?
- Which resources are used?

Detailed Scheduling

During detailed scheduling activity, are some constrains to consider. There are, resources capacity, rate of capacity utilization, activity duration given by the PDS, and as a last point of reference DS strategy where is determinate how the system executes scheduling or rescheduling.

DS strategy is determinate under an infinite scheduling, where the resources capacity is do not considerate as a constraint, or under a finite scheduling, where the resources characteristics are

important for the planned order creation. Each DS strategy is created under different parameters as, the planning directions, which could be forward or backward.

When all the DS strategy knows already under which rules have to run, making reference on the PDS, Strategy profile, and Resources, it starts to search for the first or last available date to schedule each activity of an operation. When the first activity is scheduled, the follow activity is also scheduled, until all activities of the planed order are scheduled.

The DS board was divided into several panels that allow displayed different objects (planned orders, production orders, purchase requests ...), and transactional data such as stock and resource loading.

The execution of the planning table, allows the user:

- Check the available capacity of a particular resource department (work centers).
- View planned and / or production orders over a certain period of time.
- Monitor stock performance for a set of materials.
- Perform different types of heuristics to solve overload situations.
- Manually move planned and production orders with unreleased states.

Based on these principles, the user runs scheduling heuristics to determinate if the resources can meet the demand with a determinate capacity or if it has to find an external capacity support.

At first is necessary to define:

1. Overall Profile: To specifies the settings for scheduling with the detailed scheduling planning board.
2. Planning Version: contains master data and additionally transaction data. It is possible to create different planning versions of each supply chain model for simulation purposes. However, at any point in time, only one model and one of its versions is active

3. Work area: Determines which resources, products and orders can be displayed in the *detailed scheduling planning board*

After defining the selection parameters, the system will propose a possible planning mode with a specific number of resources, schedule sales orders, products and delivery dates. "*If a product is not available, a planned order for the required quantity is created for in- house production as a part of the CTP scenario. If a resource planned using finite scheduling is already used up on the desired date, the system searches for another date when the planned order can be created*" (company, 2016). As is show in the figure 58 and the final result, organize on the table given on the figure 59.

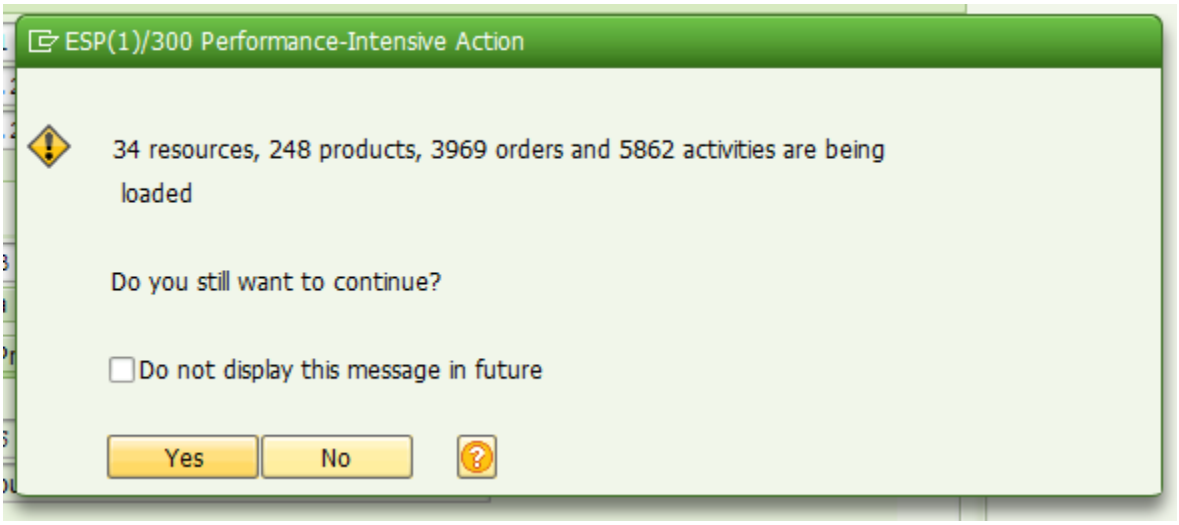


Figure 59.Number of the resources involved on the planning table.Own creation.

Drag and drop

When planning table results does not met production planner expectations or sales order requirement. For example, if there is an order which is far away to the delivery date or there is not enough capacity to fulfill with the customer requirements it must be make a manually change.

At this point, we assume as a second case that is one operation that they need to schedule in a previous produce data. There is an option offers by planning board, which allows to the planning producer to schedule operations in the non- working times of a resource. The operations that have been assigned in a non-workspace, must by obligation be fixed and cannot be changed again.

Any possibility change can be related to make any adjustment at the main resources, expanding capacity with alternative's areas, or the last option is the creation of capacity variants, increasing capacity through new shifts or creating sequences.

Alternatives resources

Because there are different products that could be process by different machines, there is the possibility to expand the resource capacity to process plan order, by assigned a specific material to an alternative resource. Thanks, at this "flexible" option, the load on the principal machines seeing on the first scheduling planning board, could be reduced.

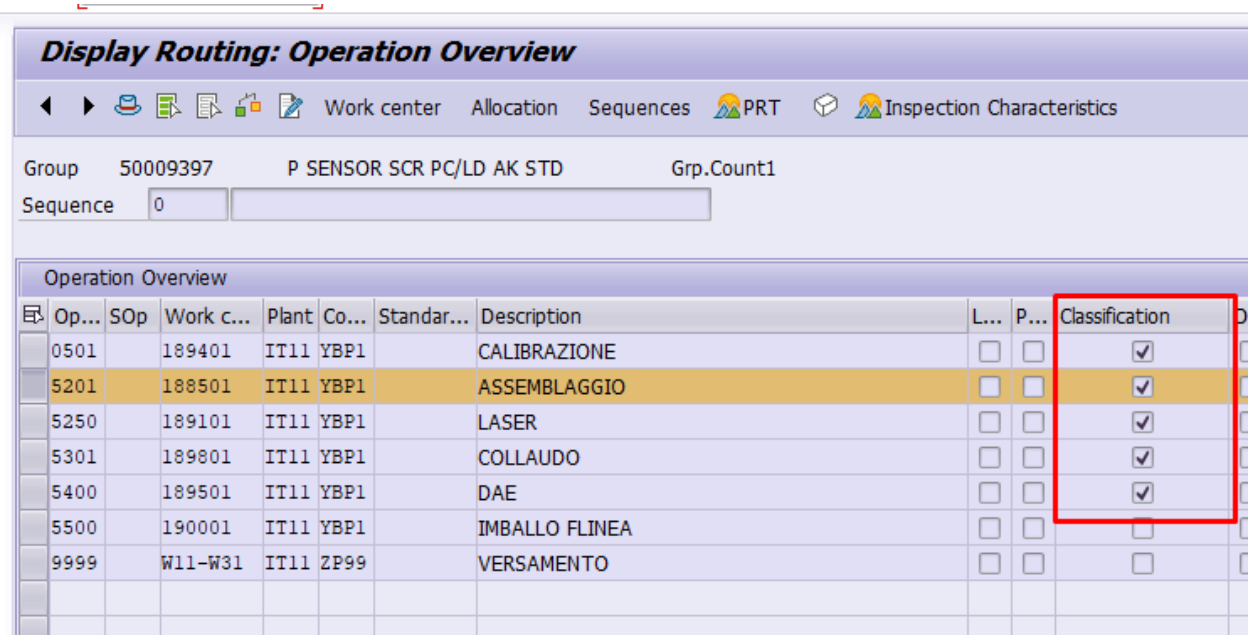


Figure 60. Routing – with the classification flag allow to have an alternative machine. Own creation.

According to this project, the productive machines, or also calls resources, are divided in principals and alternative. The "alternative" concept is introduced because the company works with a specific planning strategy and is planned at finite capacity. This concept allows to reduce the overload on main machines of the production line.

The principal idea is to run the heuristic assigning different priorities to the modes. In PDS is being specify several alternatives modes, and during the order creation, the system selects the mode according to the priority. Thanks to the creation of an alternative resources, the system can move orders from the principal machines to alternatives machines, searching to reduce the workload on the main machines and have the possibility to process plan orders before the first scheduled date.

One product can be process by the alternative resources just if in the routing the flag is active as is show in the figure 60 for the operations of "*calibrazione", "assemblaggio", "laser", "collaudo"* and "*DAE"*.

After this check, is possible to control the alternatives options (figure 61). In this figure, it seen a list of resources like apparently are completely different but is not true at all because they can realize the same operations.

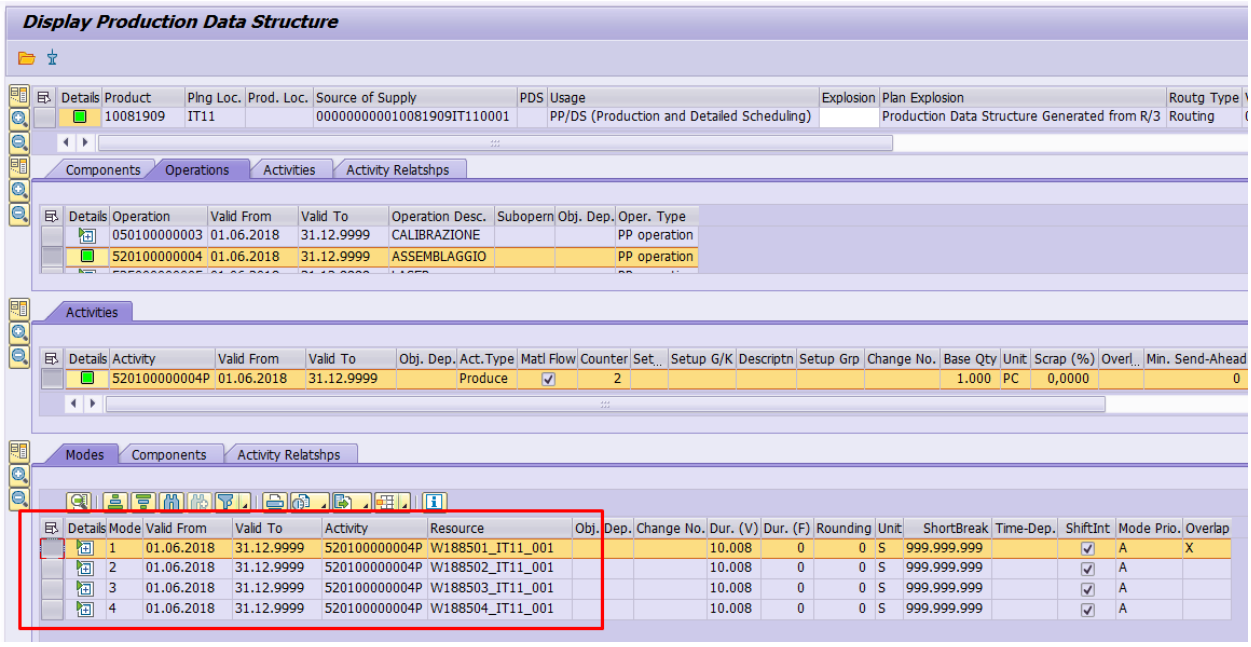


Figure 61. Alternative resource for assembly operation. Own creation.

Modification of capacity variants

This section shows how a way to change process capacity by the number of shifts with a specific sequence or a creation of an alternative resource to increase process capacity.

Increasing the capacity of a work center can be made it by the assignation of more shift number generating a longer labor journey.

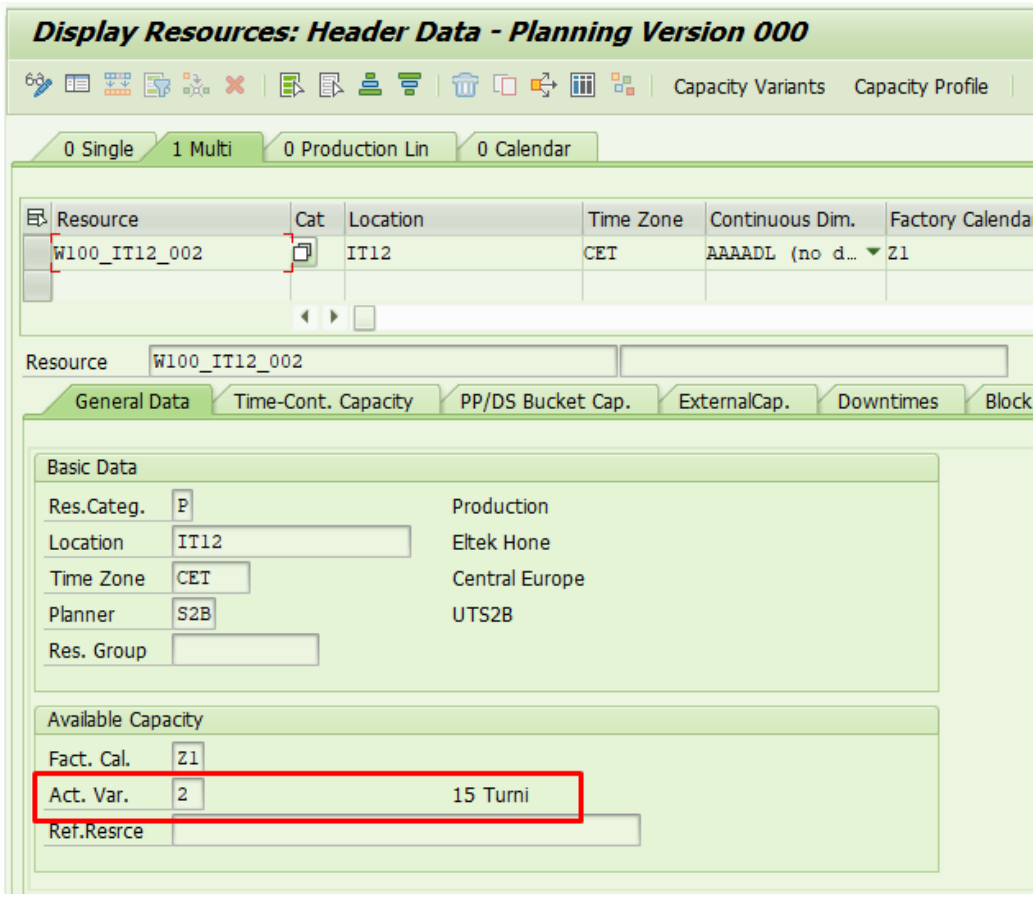
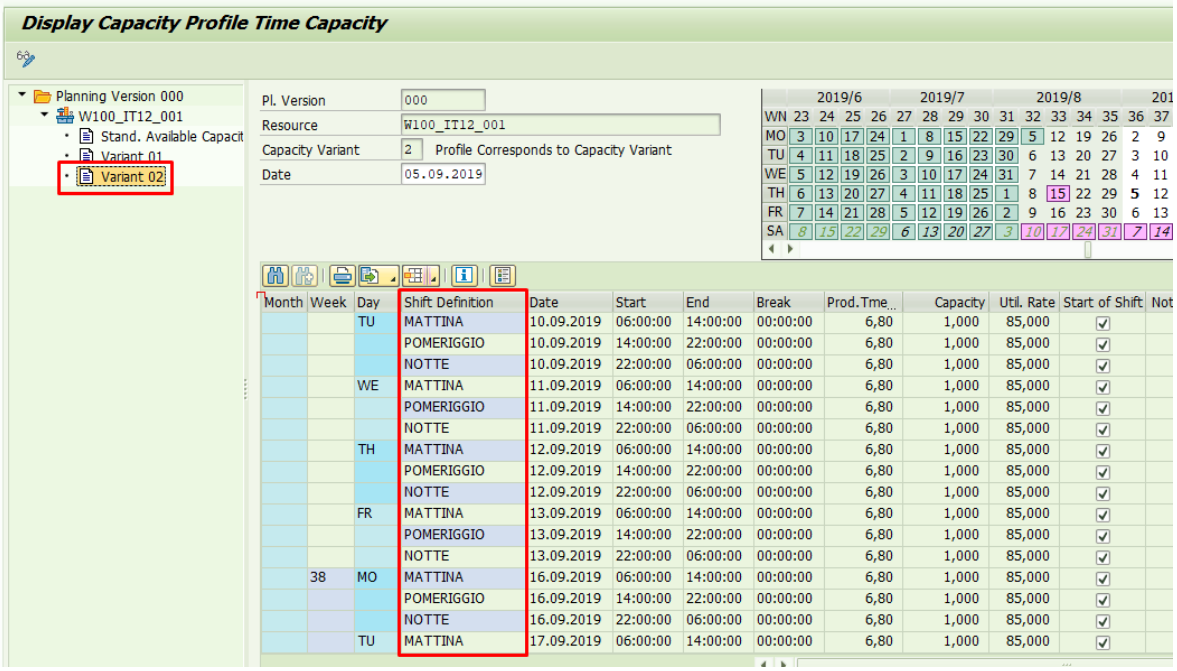


Figure 62. Available capacity by 15 shifts. Own creation.

In the previous figure can be observed the camp to defines the active variant of capacity for the resource with the number 2, which means 15 shifts. Eltek has two options, one is to have 15 shifts or 20 shifts.

The result of the figure 63 was considering by the 15 shifts. For this variant, the time capacity is lower than the one we would obtain with a shift of 20. As is observed on the figure 65, on the line of SHIFT DEFINITION there are tree shift during the day, but the most important aspect is that days as Saturdays and Sundays are not involved.



Month	Week	Day	Shift Definition	Date	Start	End	Break	Prod.Tme..	Capacity	Util. Rate	Start of Shift	Not
		TU	MATTINA	10.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	
			POMERIGGIO	10.09.2019	14:00:00	22:00:00	00:00:00	6,80	1,000	85,000	☑	
			NOTTE	10.09.2019	22:00:00	06:00:00	00:00:00	6,80	1,000	85,000	☑	
		WE	MATTINA	11.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	
			POMERIGGIO	11.09.2019	14:00:00	22:00:00	00:00:00	6,80	1,000	85,000	☑	
			NOTTE	11.09.2019	22:00:00	06:00:00	00:00:00	6,80	1,000	85,000	☑	
		TH	MATTINA	12.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	
			POMERIGGIO	12.09.2019	14:00:00	22:00:00	00:00:00	6,80	1,000	85,000	☑	
			NOTTE	12.09.2019	22:00:00	06:00:00	00:00:00	6,80	1,000	85,000	☑	
		FR	MATTINA	13.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	
			POMERIGGIO	13.09.2019	14:00:00	22:00:00	00:00:00	6,80	1,000	85,000	☑	
			NOTTE	13.09.2019	22:00:00	06:00:00	00:00:00	6,80	1,000	85,000	☑	
	38	MO	MATTINA	16.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	
			POMERIGGIO	16.09.2019	14:00:00	22:00:00	00:00:00	6,80	1,000	85,000	☑	
			NOTTE	16.09.2019	22:00:00	06:00:00	00:00:00	6,80	1,000	85,000	☑	
		TU	MATTINA	17.09.2019	06:00:00	14:00:00	00:00:00	6,80	1,000	85,000	☑	

Figure 63. Shift distribution (15 shift). Own creation.

After making “Drag and drop” we can change this number to the second variant equal to 20 shifts. In this case the capacity of the resources should be increase because now on Sundays and Saturdays are delegate tree shifts.

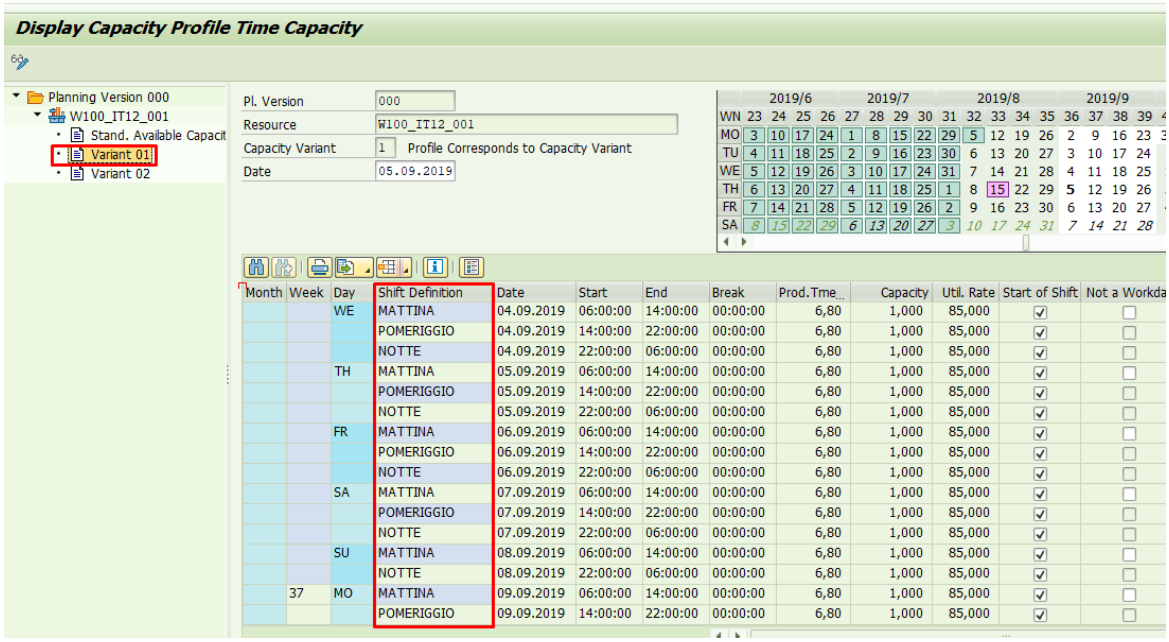


Figure 64. Shift distribution (20). Own creation.

The change on the shift makes a variation on the result of the planning table. When work hours are increased, the gray area that represents the hours of rest decreases, as it can see in the figure 65.

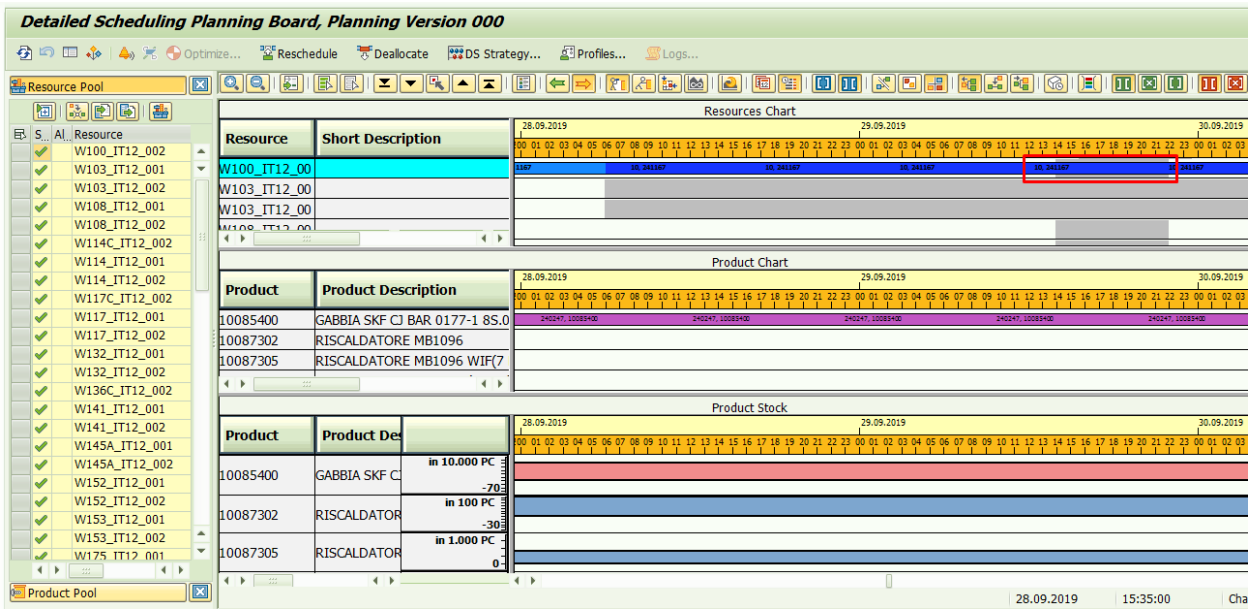


Figure 65. Available capacity by 20 shifts. Own creation

Closing of the GAP

After moving orders to alternative resources, or forward in time, it is possible to find GAPs (spaces where the CDL are available) figure 66. Eliminating gaps (figure 67) between orders allow the continuous flow operation of the orders, permitting to have higher usability and complete orders before the expiry date.

It has to be declared in the planning table, that is necessary to cut all gaps. This activity is not automatically because we are working in a system which is not an optimizer. But it has the possibility to make this change.

> Eliminated spaces (gaps) between orders allow the continuous operation of the machine, allowing the maximus usability and complete some orders before the expiry date. Pegging Relation could be born the question relation to the cost of maintaining, however, depending of the order and client type, it could be delivery before the first delivery data. This fact, increase customer satisfaction, does not affect cost of maintained and reduce the set-up cost.

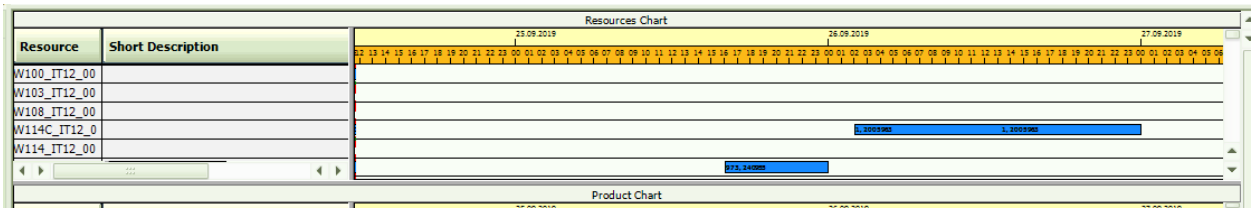


Figure 66. Closing gaps. Own creation.

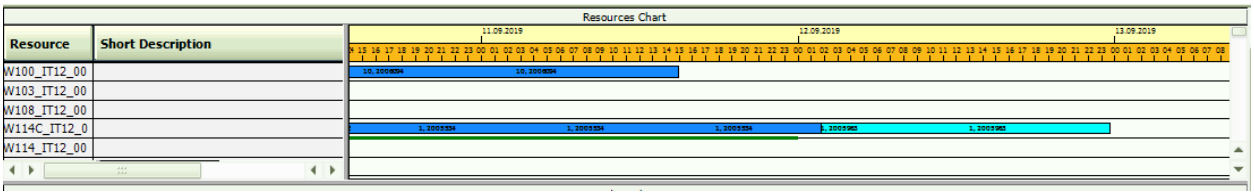


Figure 67. Gaps closed. Own creation.

Supposing that everything is under control, and there is not more alert to be correct. The follow step is to fix the plan order, to do not have the possibility to lose all the configuration that was created before. The next step is to convert the plan order to production order, that means that is already to be release on the production area.

Fix plan

Once the orders have been scheduled (using alternative CDL or moving forward / backward), these must be fixed to prevent the next round of MRP from overwriting the changes made.

This could be done on the same planning table screen or in a massive way by different transaction on the system.

After, it has to be understood punctually the orders that have been modified by a specific run. A log is displayed that indicates if the fixation was performed correctly and highlights the modified orders as is show in the figure 69.

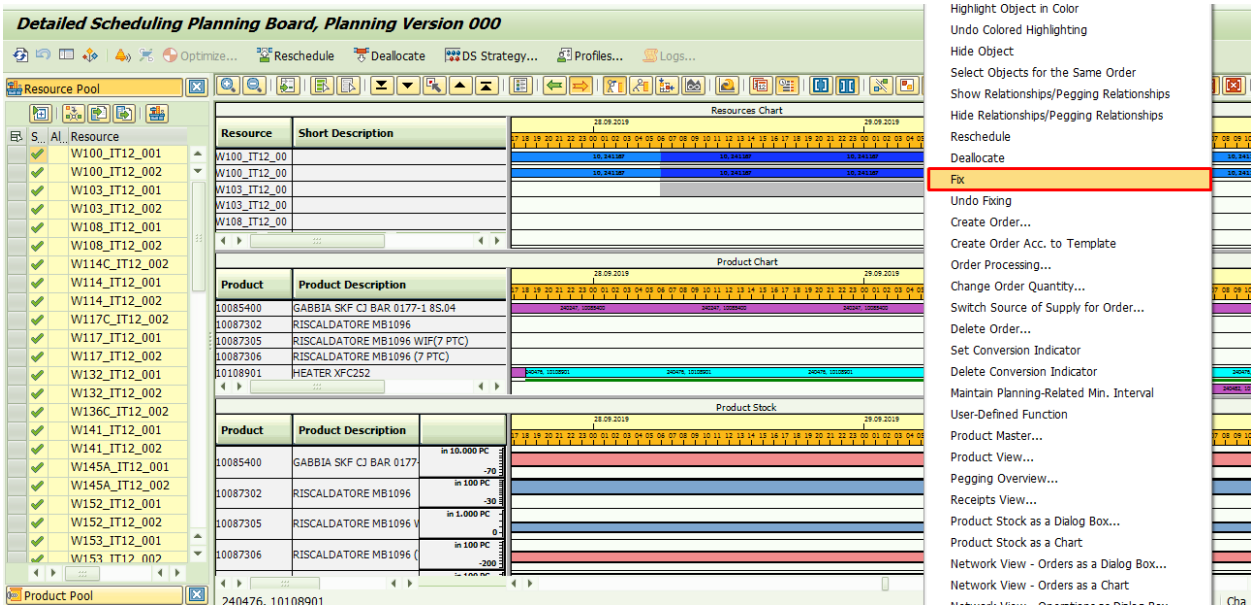
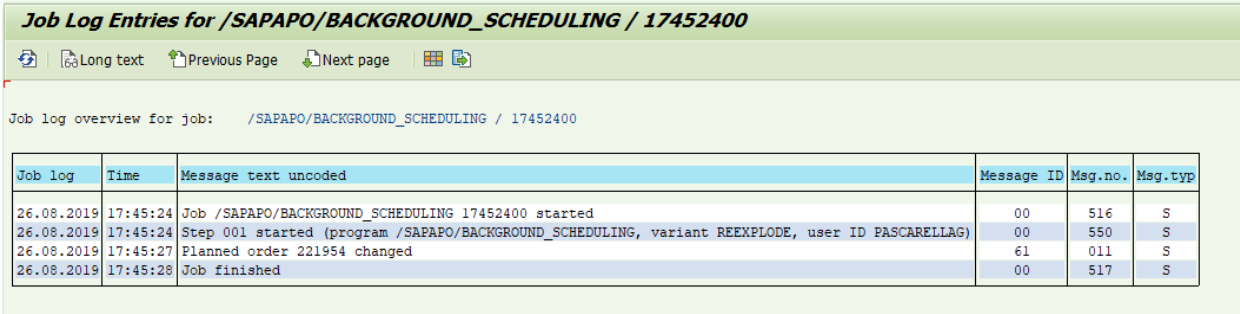


Figure 68. Fixing order. Own creation.



Job log	Time	Message text uncoded	Message ID	Msg.no.	Msg.typ
26.08.2019	17:45:24	Job /SAPAPO/BACKGROUND_SCHEDULING 17452400 started	00	516	S
26.08.2019	17:45:24	Step 001 started (program /SAPAPO/BACKGROUND_SCHEDULING, variant REEXPLODE, user ID PASCARELLAG)	00	550	S
26.08.2019	17:45:27	Planned order 221954 changed	61	011	S
26.08.2019	17:45:28	Job finished	00	517	S

Figure 69. List of modified orders. Own creation.

Plan Order conversion

Once a time horizon has been defined for converting planned orders into production orders, the user can select orders to proceed with the conversion. There are several options to perform this activity, it could be massive or specific.

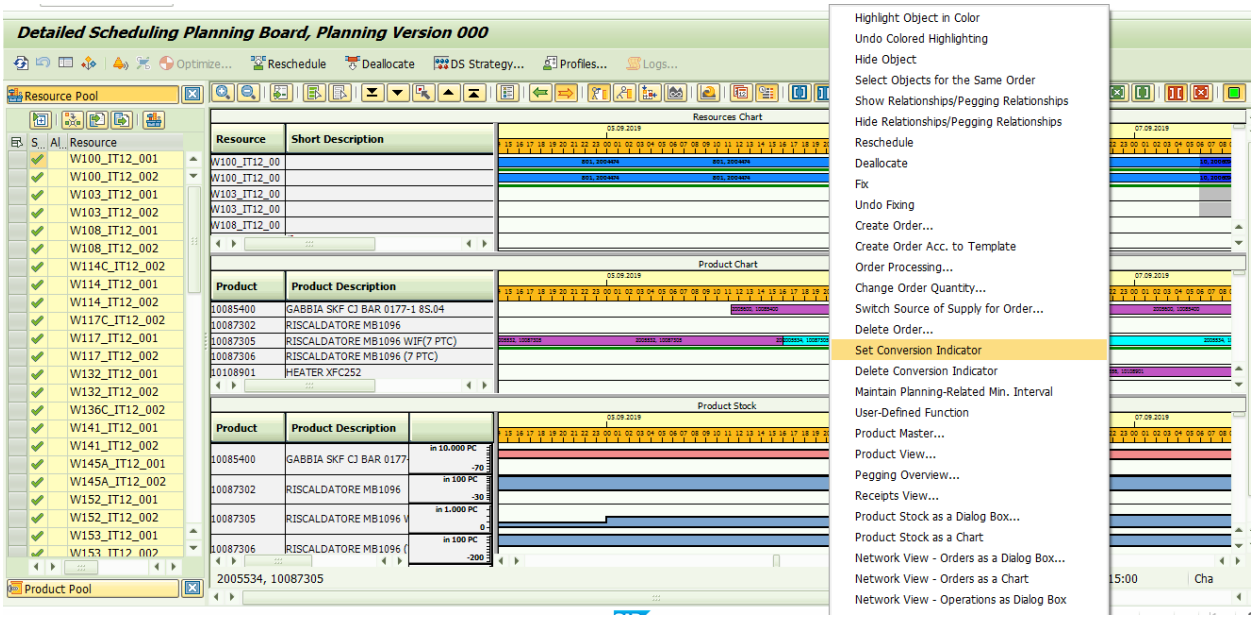


Figure 70. Orders to convert. Own creation.

Order conversion could be realized from different places. One massive option is from the figure70, or any final result of the planning table, which allow us to convert directly the plan orders to production orders.

Other massive option allows to define a time interval in order to extract all the orders that have a start date thin the chosen interval. It is also possible to choose orders for a certain group of CDLs or for an entire plant. Other option could be the single conversion done for orders placed on a single product.

The final step is realest the production list at the shop floor figure 70

Thanks to the new methodology, the planning person has a bigger and flexible horizon to plan, it could be considerate a plan for 2 weeks, 3 weeks or even infinite period. It also has a better handling of the work centers capacity and a faster and a more accurate answer to the demand changes.

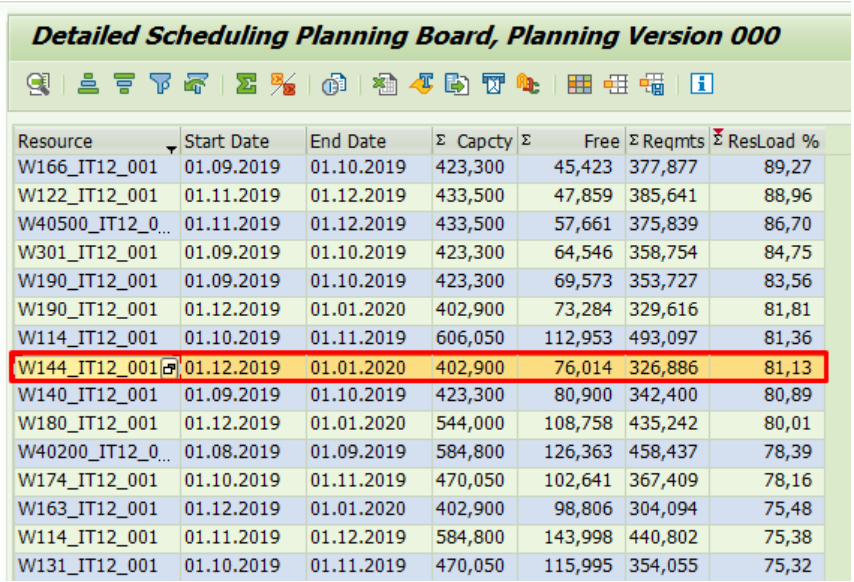
Support reports

If in the system is created a new order by the sales area, the production planner has to make a capacity evaluation, to determinate if the production plan can be adjusted to cover the new requirement. Considering the original production process (without S4HANA) production planner had to evaluate the excel file made just one day before, and in base on it and the experience, determinate (without any certain information) If the resources capacity is enough in the period of time to process the new order.

Before the S4HANA implementation, by the lack of control towards the production process, the supply chain performance was affected. Having knowledge of what is happening with all elements involving in the production process is considering an essential point to improve internal process and increase the customer satisfaction.

With the S4HANA introduction, the production planner has the possibility to get a total overview of the current planning situation in a quick way. For instance, at the arrival of a new customer

requirement, the production planner has the possibility to make a report related at the capacity that are been consume by the resources, operations, and even it could determinate the orders in process.



Detailed Scheduling Planning Board, Planning Version 000

Resource	Start Date	End Date	Σ Capcty	Σ Free	Σ Reqmts	Σ ResLoad %
W166_IT12_001	01.09.2019	01.10.2019	423,300	45,423	377,877	89,27
W122_IT12_001	01.11.2019	01.12.2019	433,500	47,859	385,641	88,96
W40500_IT12_0...	01.11.2019	01.12.2019	433,500	57,661	375,839	86,70
W301_IT12_001	01.09.2019	01.10.2019	423,300	64,546	358,754	84,75
W190_IT12_001	01.09.2019	01.10.2019	423,300	69,573	353,727	83,56
W190_IT12_001	01.12.2019	01.01.2020	402,900	73,284	329,616	81,81
W114_IT12_001	01.10.2019	01.11.2019	606,050	112,953	493,097	81,36
W144_IT12_001	01.12.2019	01.01.2020	402,900	76,014	326,886	81,13
W140_IT12_001	01.09.2019	01.10.2019	423,300	80,900	342,400	80,89
W180_IT12_001	01.12.2019	01.01.2020	544,000	108,758	435,242	80,01
W40200_IT12_0...	01.08.2019	01.09.2019	584,800	126,363	458,437	78,39
W174_IT12_001	01.10.2019	01.11.2019	470,050	102,641	367,409	78,16
W163_IT12_001	01.12.2019	01.01.2020	402,900	98,806	304,094	75,48
W114_IT12_001	01.11.2019	01.12.2019	584,800	143,998	440,802	75,38
W131_IT12_001	01.10.2019	01.11.2019	470,050	115,995	354,055	75,32

Figure 71. Capacity report example. Own creation

For example, order report allows to make an extraction of all the orders and to identify resource, order number, product, quantity, start / end date, start / end time. And capacity report displays the capacity utilization for a group of resources over a certain time horizon.

It can be observed in the figure 71, a general report of the capacity use. Is given the total capacity, the necessity capacity to handle the order and how much rest as free capacity. The last one is going to be one of the alternatives solutions to cover sudden orders.

With the new methodology this demand change, does not generate the same fatigue as before. At this time, production planner can have a detailed analysis of the orders that are being created and the capacity that is using thanks to the evaluation made it in the DS planning board.

In this way, if there is a new client requirement to be delivery in a short period, the planner has the necessaries tools to make a quick decision, either adding the new order to the planning of the day or proposing a date by which it can be delivered.

CHAPTER 6. CONCLUSIONS

Having an ERP system, the company can have a continuous information flow between the different business areas. Permitting the exchanged of reliable information between different modules inside the supply chain. However, to see any positive result on the process performance causing by this change, the ERP system has to be adapted to the company soul.

SAP is one of the most used ERP systems, “enables companies to address current challenges and future opportunities with flexibility, speed and insight” (News, 2019). SAP drives digital transformation and delivers instant business value by the introduce of the SAP S/4HANA. “SAP new methodology provides unparalleled business agility, enabling companies to exceed customer expectations and navigate dynamic marketplace” (News, 2019).

The functionality of the new mode collects under one operation a list of steps that were previously done separately. For the classic implementation, the read/write activities were performed separately, that means that for each material selection, the system has to create a cycle (Loop), going through the plan order, depends requirements, follow by the purchase requisition, after it has to read the stock to be transfer. This process continues going through more elements, depending on the activity complexity. This repetitive cycle was carried out, and is still do it, in business that still have the classic system and they do not have a tool as the S4HANA.

Now, with the optimized SAP 4HANA system, the way in which S4HANA is reading the activities to be done is been “optimized by taking advantage of the parallelization” (company, 2016). This is possible using support tables which contain stock, demand and supply information which is read it in parallel. One example is the process during the production planning run, where several heuristics or functions can be executed one after the other with a short runtime.

The closer relation between business areas, makes the information flow between them, be done in real time. knowing in real time what is happening, is considerate other advantages of the new system. For example, production area is affected by the customer demand, which is reflected in a sales order, which is created on the sales department.

Before the S4HANA implementation, could be not passed immediately affecting both areas. In one hand is the sales area, because the customer requirement, is not knowing yet but the production planner, that means that the order is not being processing yet. On the other hand, on the production area, the producer planner is trying to do a plan based on the orders that in that moment are arrived. First, the activity itself is hard to do it because it does not have any tool to support any decision to make, and as second point, is an activity that probably it has to be modified when the new customer order arrives.

With the S4HANA implementation, this kind of issues have been mitigated with planning tools as the PP planning procedure. Where for any new order that could create a change on the scheduled program, the production area has directly the information from the sales area to program the respective changes in the shortest possible time.

Through this new link between areas the production planner can take quick decisions related to the production if it has to be modified some order schedule. It allows also the possibility to determinate the delivery order date, which is a precious information for sale area because it has to be communicated to the client. These types of information based in a complete material group improvement increase customer satisfaction.

The new SAP methodology gives the possibility to solve problems before that happened, this is given by the possibility to modify scenarios to see the process possible behaviors supported by alerts and specifics heuristics. Making the previous configurations is possible to get reports shortages in real time. In an ordinary system you would need to wait for an overnight batch process and put yourself at risk of being too late but know the new MRP COCKPIT automatically analyzes the situation and quickly gives you several solutions to avoid disruption.

To make the production in SAP, is necessary to send information between ERP and APO. APO should process the planning process. After when the information is completed it has to go back to the ERP system. The change of information is not the optimized solution because the transactional times are higher, and the quality of the information can decrease.

One of the advantages of the new implementation is based on the time responds, reducing transactional time. Other advantage is the lower error probability, due the new way to read / write in parallel, and the change in which the information does not have to be process by an external system anymore.

Through the SAP PP/DS introduction, order sequences of lead times can be reduced; more-precise planning enables you to reduce stocks, and simultaneously achieve improved delivery reliability. The heuristics implementation allows a more flexible planning process.

The use of the PP/DS methodology allows companies to evolved planning constrain in one single system, that means less complexity, thanks to the new information, which allow the system to read in just one place. Also, no latency and real time visibility are considered advantages of the PP/DS introduction in the companies. These aspects help to increase productivity, decrease safety stock and drive more profitability.

After the analysis of ELTEK methodology and the tools that SAP can propose, were considerate the possible types of planning and scheduling production. The above, with the intention of determinate how PP/DS tool as a part of SAP, helps the companies to improve scheduling and planning process. Allowing the company to have a better supply chain performance.

It was also identified waste of time on activities done by the production planner that have to be reprocessed due the generation of a new urgent order. Also, poor coordination between areas, limitation to determinate a delivery time, and lack to make a production plan in a wider horizon. This kind of issues affects the production perform, creating an intermittent production process, and directly affecting the relationship with the customers.

Before the software implementation, decisions related to the planning were based only in the experience and planner perception. Now in the new implementation, was structured the production flow to determinate what to do in case of an emergency or unexpected change. First, the alert monitor shows the critical situations depending on the planner requirement. After with the Production planning, works with the necessary components to produce the order and all the

activities related. There is also the pegging activity to determinate which component is going to be consume in a determinate order.

The follow step is more specific, the Detailed scheduling allows the customer to access to more specific details and make some changes. It could be the overload level on the main resources, or the order production day. The next phase allows the user to fix changed orders, with the reason to block any possible change made it automatically for the system in next planning run. To finish the planning process, the order have to be converted in production order and make the release to start the production process.

Each step of the process flow mentioned before, comes with a unique characteristic to improve a specific activity into the planning production process. We already know that the software starts to work under the exceptions concept, introducing the opportunity to work under the alert monitor tool.

Alert Monitor is a central tool for planners to analyze the problems and take required actions to correct them (Jaiswal, 2016). This tool give to the customer the possibility to work just in the identified issue, being more efficient and improving their performance, for example " exception condition would be receipts being available later than the requirements, thereby not allowing the products to be delivered on time" (Jaiswal, 2016).

Through the PP planning procedure could be specify what to do when the system is executing a product. This tool is related to the planning strategies in PP/DS that allow the producer planner to planning different scenarios, in a quick and easy way.

Under the PP section, are tools as the Production Planning Run, where the producer planner defines a sequence of processing steps "for which the system executes various heuristics for the defined objects" (company, 2016), and it could be also run detailed scheduling functions.

The mainly use is to control the quantity planning, is decided if the components for a determinate order is available to go to the next planning step. The overload on resources is not an important aspect under this step seeing that is just asking for the available material to cover sales order.

The production planning run is used to execute the created heuristics, one after the other. This flexible design allows the user to run different scenarios, in a quick way, and could be save some planning to completed after the planning process.

SAP APO uses pegging, activity within the system is created the relationship between the receipt and issue elements of the BOM. PP phase lets the production planner to have “multi-level view of material availability”.

This phase allows the user to have more detail access to the planning process. This step is different to PP process because “when creating an order, the system selects the mode automatically according to priority and available date”, but under the Detailed Scheduling Planning Board, the production planner must select manually the planning mode. According to the SAP guide, this optimization is used to reduce the number of delays resulting from the original schedule, also the it helps to minimize setup times and costs.

By the planning board, the master data and order quantities could be change or just displayed. Also, the orders and operations could be rescheduled by the “drag and drop” option which allows to make any movement, anywhere, making a change for the delivery change, or making a rescheduling to alternative resources. It could be done even in non-working periods. The system “only permits scheduling of the operation on those spaces when all other prerequisites have been fulfilled” (company, 2016). After the change, the system tends to fix the operations on the desired place, to block any possible modification, that could be made by the next planning run.

Other issue identified during the analysis phase was the lack of mechanisms controls inside the production area. That did not allow the possibility to identify the current resource capacity. With the PP/DS implementation, through the DS phase, could be managed the overload issue. With the creation of alternative resources, the overload on the main work centers, could be distributed over the alternative resources.

It could be simulating shift changes, to evaluate how the resources load could be change. This is one of the features that has generated the greatest pleasure; first for the comfort which it can be used, and second for the result obtained.

The introduction of the PP table and DS planning board allow the production planner to have a better understand of the problems that are happening during the production. In this new methodology orders and work center are assigned in a way which allow the company to respond better at any variability on the demand.

With the S4HANA implementation, the horizon plan is bigger and more flexible, it could be decided to work under a program of 2 weeks, 3 weeks or even months, this defers depending on the planner necessities. There is a better handling of the work centers capacity and a faster and a more accurate answer to the demand changes.

The lack of visualization of the components that are been used in the production process, affects the SC performance when there is any unexpected change. This was an issue that was cover with the "support reports, which show an overview of the current planning situation" (company, 2016). It could be getting any insight on any data from anywhere.

With the S4HANA introduction, the production planner has the possibility to get a total overview of the current planning situation in a quick way. Having knowledge of what is happening with all elements involving in the production process is considering an essential point to improve internal process and increase the customer satisfaction.

After implementation the company improves their performance, cutting some internal SC issues that are presenting by the absence of communication. The system now counts with a complete business integration presenting a bigger cover of their activities. commended to solve a problem.

During the software implementation, the customer acceptance is also an important aspect to be considerate. The way in which the customer accepts the change between "the having any tool to plan the production" to have a complete production system and the customer experience are key points to meet the final objective.

With the new methodology S4HANA, was noticed that the customer has a fast interface understanding and acceptance. The intuitive graphic interface lets the customer simulates any

process with not big trouble. There is also the option to personalize each screen to see just the planning tools that each producer planning is going to use, contributing with the response time.

The integration between the operational functions and the service given by the S4HANA software, was done successfully, and after 8 months of using the software in the Italy plant, ELTEK decides to extend its use into the Switzerland production plant.

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