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OPERATION AND SUPPLY CHAIN OPTIMISATION FOR SMALL COMPANIES

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Abstract: These days small companies follow a pre-defined path on the market: they start their activity, they prosper and, in the end, most of them lose their competitiveness and leave the market. Small companies cannot compare themselves with the large companies, as large ones can upgrade their technologies and processes at lower prices, without time consuming and with available financials to change the direction when the actions taken deviate from what was planned. That is why small companies suffer from disadvantages on the market. To overcome these situations and start competing, especially these days, small companies must incorporate creativeness in their way of thinking and acting. It is mandatory for small companies to design the daily activities performed based on new technology, historical data, up-to-date know-how etc., mostly because technology is more and more present, products have less life days and global trends are heading towards globalization and integration. In this paper a small electronics manufacturing company will be analysed. There will be applied simulation techniques and the result will provide a good view over the things needed for a small company to have efficient operations. Nevertheless, as any other good analysis, the paper will include some take away notes and proposals for future analysis.
Keywords: small companies, market, optimisation

1. INTRODUCTION

In an ever-changing environment, small businesses are frequently seen to start, activate and finally lose their competitiveness. In case of small companies these steps seem to be shorter as they are affected by the larger companies. This is why small companies need to be more creative in order to be competitive on the market. It is a must for them to start integrating technology in their operations, as it becomes increasingly available. This paper discusses a small business, an electronic manufacturing company located in Hungary operating in three shifts five days per week. Currently, it servesthirty-five customers with 600 products, including high product versions as well.

This complexity poses a challenge to the small company as compared to Amazon in terms of the customer service. Small and big companies have different resources and capital to improve their processes. Large companies show a tendency toward industry segmentation, like Amazon as they want to ship your product before you even think about it. Finding a way to maximize the customer service level while minimizing both inventory and resources might help to keep this small business running long into the future.

2. LITERATURE REVIEW

In today's business climate, it is imperative for companies to remain competitive to stay viable and show a reasonable profit. The current trend for any business to maintain successful operations is for it to utilize current technologies. In June 1994, the Boeing 777 was built with computer-aided design tools that were linked among 2,200 computers. They were able to design and even simulate the assembly of the plane, which was something that was never seen before. Supply chain, inventory, and demand simulation software are three different business processes that actually influence one another [1]. The supply chain can be defined as having items flowing from one stage of supply to the next, both within the business and outside. The supply chain is more of a high-level optimization. It has a varied focus, including decisions such as warehouse location, truck usage, and choice of supplier. Inventory optimization is more focused on just how much inventory a company should maintain to make the most profit. Both supply chain and inventory software need an accurate forecast of demand to be implemented properly and that is why we begin with demand planning software. Seasonal demand, which is dynamic, is a difficult thing to predict but it is worth the effort because it directly affects inventory costs and labour costs. An important part of managing a business supply chain is identifying whether or not seasonal demand is an actual force that affects the company or if the seasonal demand is a result of business practices. This false sense of seasonal demand could be caused by businesses over-compensating for what they believe is a pattern in demand for their products. For example, a business can „maintain minimum level of capacity .... and operate the plant at maximum production level" in order to satisfy current demand and obtain a level of inventory that would satisfy the supposed demand. In other words, businesses should produce what is currently needed while inventory levels are obtained for what will be required later. Supply chain management and optimization are very complex and intricate issues that continue to grow both in importance and acceptance, and are unique to each company that adopts these ideals. New technologies are critical to obtaining an optimal supply chain for businesses. There are, however, obstacles that complicate matters. Inventory levels and seasonal or stochastic demand heavily influence decision making for supply chain management and optimization. Any seasonal business has the challenge of determining how the issue of inventory optimization should be utilized. The inventory needs to be optimized not only for the weekly demands, but also the seasonal demand as a whole year. This business needs to optimize the necessary amount of supplies, passive, active, mechanics, and other supplied products, taking into consideration the fluctuations of customers throughout the week and throughout the high and low seasons. The business must also consider that once the high season comes to an end, remaining supplies are minimized. Several years of recorded data were available for review and analysis to build a model as well as forecast sales. To optimize inventory investment, a business needs to account for all of the variability in the supply chain. There are many different factors in a seasonal business that can determine a demand for a given time period.

3. EVOLUTION OF MANUFACTURING PARADIGMS

Historically, manufacturing paradigms, driven by the change of the environment in which they operate, change in character and evolve in patterns over time (Figure 1). The various patterns witnessed up to now can be roughly correlated to movements between three stages:

(i) craft shops that employ skilled artisans,

(ii) long-linked industrial systems using rigid automation and

(iii) post-industrial enterprises characterised by flexible resources and information intensive intellectual work.

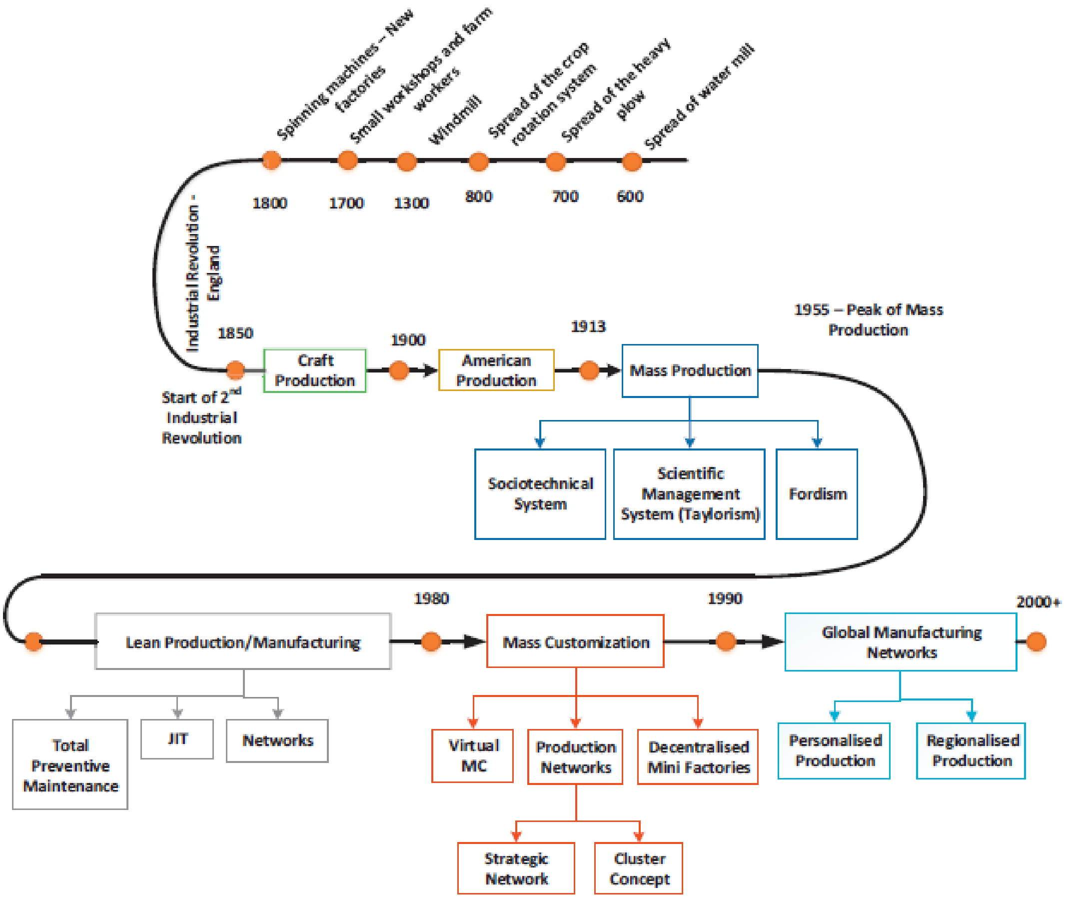

Figure 1. The evolution of Manufacturing Paradigms (Adapted from [2])

The most prevailing manufacturing paradigms are in chronological order of appearance: Craft Production, American Production, Mass Production, Lean Production, Mass Customisation and Global Manufacturing. Apart from American Production, all other paradigms are still "operational" today in different industrial sectors. Research nowadays focuses on strategies and methods for managing product, process and production systems development capable of supporting lean production, mass customization and systems for product personalization. Lean production is an integrated socio-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability.

Specific industry types may benefit from a combined implementation of agile and lean practices in their organisation. However, a point in the production procedure should be defined, where these concepts can be easily decoupled according to the incoming demand. This can lead to improved overall performance and profitability of the factory.

Mass customization emerged as a new production paradigm in the late 1980s in order to respond to consumer demands for product variety and appears as an alternative to differentiate companies in a highly competitive and segmented market. This paradigm aims at producing goods and services catering to individual customer's selections with near mass production volume and cost efficiency. The tools of mass customisation can substantially enable product personalisation.

Personalised production aims at the procurement of truly unique products, through the tight integration of the customer in the design process. However, to make personalized production a cost effective reality, several enabling technologies and features must be developed, such as: methods and tools for understanding and capturing consumers' needs and preferences, design by non-designers techniques, cyber-physical systems for collaboration, on demand manufacturing and assembly systems, process, product, volume and production flexibility among other.

Large contract manufacturing companies with plants located in different regions are able to manage higher customer demands. To achieve cost efficiency in production, an appropriate amount of customer orders are required for large capacities. If customers have a low demand in the region, contract manufacturing companies with large capacities might not be able to fulfil such demands. Low volume customer orders do not foster profitability as high fixed costs exceed planned profit levels. In case of orders with large volumes, productivity may be increased while unity price of purchased components may be decreased at the same time. Stable component prices and efficient capacity utilization becomes possible in an environment where there are long term forecasts and their variations do not cause disturbance in the MRP. There are no simulation systems for planning variations, the robust planning module of the MRP system meets the expectations of the demand and supply chain in addition to high profitability.

Contract manufacturing companies with smaller capacities are able to ensure stable operations with a mix of low volume and high complexity. Flexible organizational structures and resources better suit customer expectations as they are more tailor made. It is essential to build good customer relationship and effective cooperation already in the product design phase. Using operations experience might prove to be cost effective in this phase. Even without long term and reliable forecasts, with this strategy flexibility and proper cost levels could be achieved in the supply chain.

In case of low volume orders, machine utilization might be much lower and production costs may be higher as compared to large manufacturers. Companies with low volumes need to find innovative solutions in production planning and scheduling. The E2E process and other process simulations need to be planned and designed in detail. Learning simulation techniques improves planning skills and enhances precision when it comes to planning purchasing and production processes. These are all required for ensuring on time delivery to the customer.

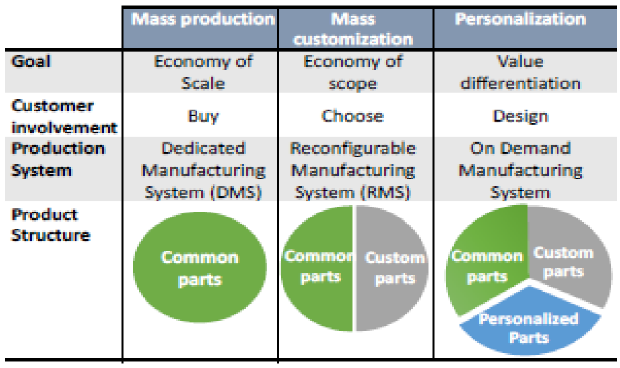

Figure 2. Different between production paradigms (Adapted from [3])

4. ROLE OF SIMULATION IN MANUFACTURING

A supply chain is the value-adding chain of processes from the initial raw materials to the ultimate consumption of the finished product spanning across multiple supplier-customer links. Robust and flexible system mechanisms are required to realize such inter-enterprise collaboration environments often enabled by the use of simulation technology. Digital Enterprise Technologies (DET) in general, represents an established new synthesis of technologies and systems for product and process development and life-cycle management on an efficient basis. A method to model, simulate and optimize supply chain operations by taking into consideration their end-of-life operations is used to evaluate the capability of OEMs to achieve quantitative performance targets defined by environmental impacts and costs of lifecycle. A method of examining multi objective re-configurability of an Original Equipment Manufacturer supply chain is presented in order to adapt with flexibility dynamically changing environmental restrictions and market situations. A discrete-event simulation model of a capacitated supply chain is developed and a procedure to dynamically adjust the replenishment parameters based on re-optimisation during different parts of the seasonal demand cycle is explained. A model is implemented in the form of Internet enabled software framework, offering a set of characteristics, including virtual organisation, scheduling and monitoring, in order to support cooperation and flexible planning and monitoring across extended manufacturing enterprise.

Furthermore, the evaluation of the performance of electronics manufacturing networks under highly diversified product demand is succeeded through discrete-event simulation models in with the use of multiple conflicting user-defined criteria such as lead time, final product cost, flexibility, annual production volume and environmental impact due to product transportation.
The historic evolution of simulation is depicted in Figure 3.

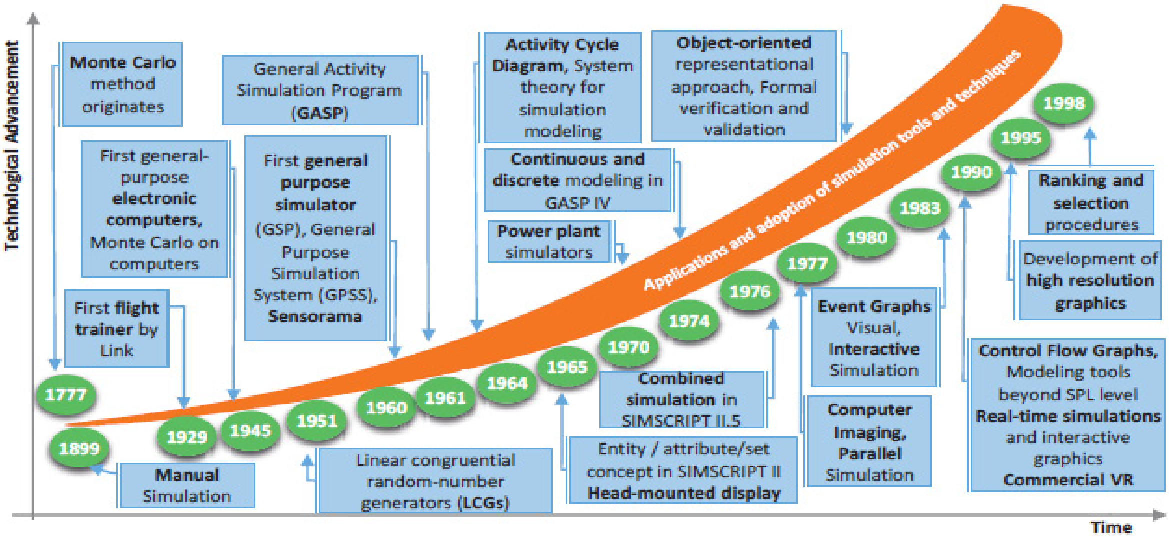

Figure 3.The evolution of simulation (Adapted from [4])

Although the term "Monte Carlo method" was coined in 1947, at the start of the computer era, stochastic sampling methods were used long before the evolution of computers [5]. It is widely acknowledged that the contemporary meaning of simulation originated with the work of Comte deBuffon in the 18th century, who developed a Monte Carlo-like method and used it to determine the outcome of an experiment consisting of repeatedly tossing a needle onto a ruled sheet of paper. The aim of the experiment was to calculate the probability of the needle crossing one of the lines [6]. About a century later, Gosset used a primitive form of manual simulation to verify an assumption about the exact form of the probability density function for Students t-distribution [7]. In the mid-1940s, simulation makes a significant leap with the contribution of the first general-purpose electronic computers. Ulam, von Neumann and Metropolis use Monte Carlo on computers to solve problems concerning neutron diffusion. Tochter and Owen develop the General Simulation Program in 1960, which is the first general purpose simulator to simulate an industrial plant that consists of a set of machines, each cycling through states as busy, idle, unavailable and tailed [8]. During the period 1960-1961, Gordon introduces the General Purpose Simulation System (GPSS) [7]. Simultaneously, Nygaard and Dahl initiate work on SIMULA and they finally release it in 1963 and Kiviat develops the General Activity Simulation Program (GASP). Although, a significant evolution of simulation is noticed, there are still problems concerning model construction and model analysis which are mentioned and addressed by [9]. Moreover, Bryant initiates parallel simulation [10]. In the beginning of the 1980s, major breakthroughs take place, military flight simulators, naval and submarine simulators are produced and NASA develops relatively low-cost VR equipment [11].

In early 1990s, real-time simulations and interactive graphics become possible due to the increased computer power and commercial VR applications become feasible [12]. In addition, the development of high-resolution graphics focuses on gaming industry surpassing in that way the military industry.

5. CASE STUDY

In the case study, a small electronics manufacturing company is analysed. The company has thirty-five customers and 600 products in its portfolio. Total performance of the E2E process is very poor with significant amount of backlogs and low value of customer on time delivery. Delay was accepted in the organization and improvements were not a priority. This resulted in a low employee motivation due to bad business results. On time delivery of the suppliers shows also very disappointing value and raw material shortage disturb continue operation every day. Rescheduling of production and resource reallocation daily practice. All resource (employee and asset) utilization stay on low level even the big effort of engineering and operators does not change. Company management decided to investigate planning system and found the following result.

OEM customers send EDI message to manufacturer to MRP system. EDI received and stored in SAP system without pre check. Total EDI messages are analysed on weekly level.

Consolidated EDI date transferred to excel environment for further data structure change. This was required to get in order and necessary format of the date for further transformation.

Modified data transferred manually to the PCP (Production Capacity Planning) excel environment, where most of the BOM and master data were stored from SAP. In the PCP system customer order deliveries were traced for further planning purpose.

PCP database also got two input from other excel files where the empty returnable packaging was managed. Returnable packaging came from customer as standard packaging type to deliver them to their manufacturing facility. Expendable packaging was also follow in excel environment which was an alternative packaging material of customer returnable packaging. If the customer could not manage well the returnable packaging deliveries, supplier needed to implement one way (expendable) packaging availability for shipment requirements.

Production planning had two phases, one of them planed the final assembly production process. In this database was the strongest correlation with final assembly result and customer order requirements. This planning was done by manually and managed by one person for whole customer portfolio. Second part of the planning was related with machining (SMD) production planning based on internal Kanban system signal or weekly qty requirements.

Any case of supplier delivery problem or internal quality challenges where the planned qty could not be manufactured excel rescheduled plan information was not uploaded to SAP system. Any modification of the final assy plan had no correlation to machining plan and SAP. That caused inaccuracy in case of raw material planning.

This level of data fragmentation and low efficiency caused customer dissatisfaction and high level of internal inventory value. Both outcome of the process does not support company grow and enough cash to manage business.

Material management team had available SAP data only for purchasing of raw material where lead time was 4-16 weeks and moving planning data just was recognized on weekly level. Customer service team had daily contact with customer and received EDI for further orders. Two teams of supply chain had not too much influence of the changes that result lot of production stop and raw material shortage or inventory excess. Fire-fighting was the type of the way of working and information exchange happened verbally between the teams to inform each other about the changed of any data in planning or purchasing data flow. Data flow showed in Figure4.

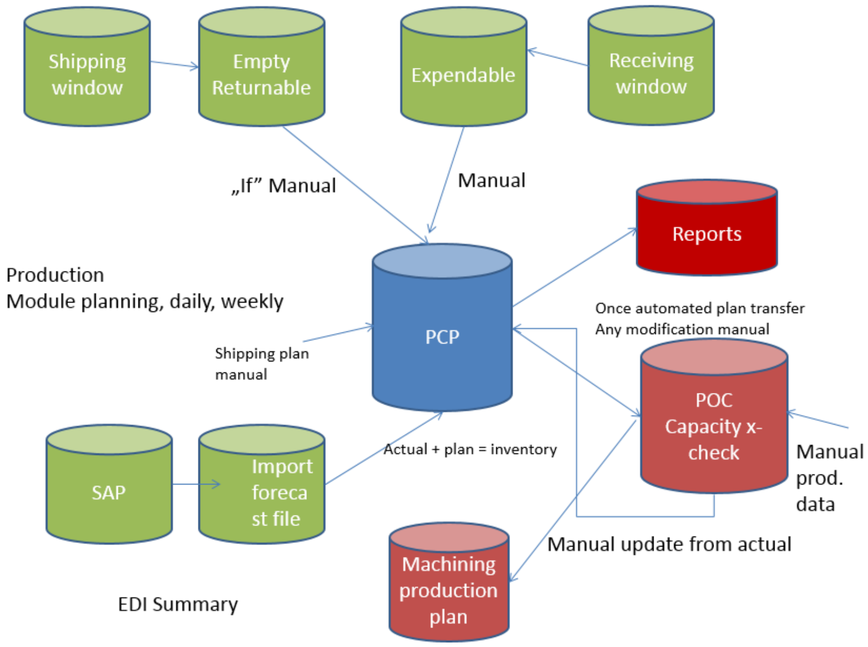

Figure 4. Supply chain data flow of the investigated company

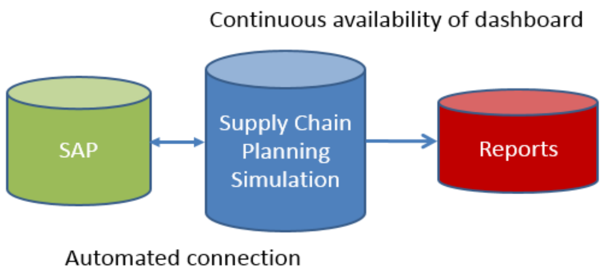

Figure 5. Simple model

Management decided to change the process and make sure the complexity and volume increase does not influence efficiency of the planning and purchasing process. Simple model showed in Figure 5.

Management concluded that the system optimization shall take place so that business results could increase and that the customers could receive their products.

Based on the production paradigm, the small company had a low volume – high mix production. This was a market segment where it could earn business and profit. Tendering in case of high volume production seemed to be unfeasible as a global production footprint was often times a prerequisite. Being a small company with a small footprint in Europe, large volume production with several regional units is just impossible. Therefore, in such a case, there was no need for technology development mainly due to a lack of financial resources. As opposed to large companies, one of the major advantaged of such small companies is a fast and precise customer service with low volume – high mix production. For that end, accurate supply chain and planning procedures and flexible processes are required. Figure 5 shows such a system where SAP stores only master data and manages core tasks. Supply chain tasks and other operational tasks are managed by a planning simulation tool in addition to the ERP system. This tool guarantees that data are integrated and based on the input data and having the necessary capacity it re-calculates parameters of all related processes using the available algorithms. The simulation has several advantages: it does not occupy the MRP system and it is also faster.

In case of input data changes e.g. new capacity allocation, the system develops a planning option. After reviewing it, the user is able to make further analyses and develop a new action plan so that customer delivery dates are met. These decisions might include a change in the delivery method of materials, a new allocation of production capacities or requesting overtime. Figure 6 shows the summary of planning data.

The Supply Chain Cockpit enables the planner to grasp the planning situation at a glance and analyze it down to the smallest detail - over several aggregation levels. Individually parameterizable alert functions keep the focus on what is most essential. In addition to the logistical parameters, value and cost aspects of the planning are also evaluated.

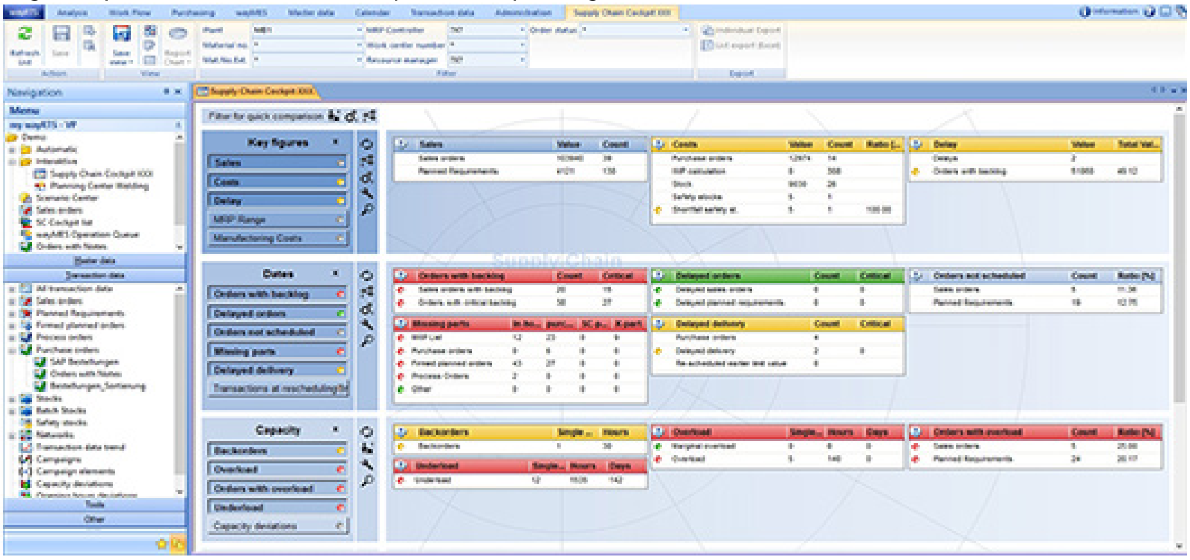

Figure 6. The planning situation at a glance with the Supply Chain Cockpit

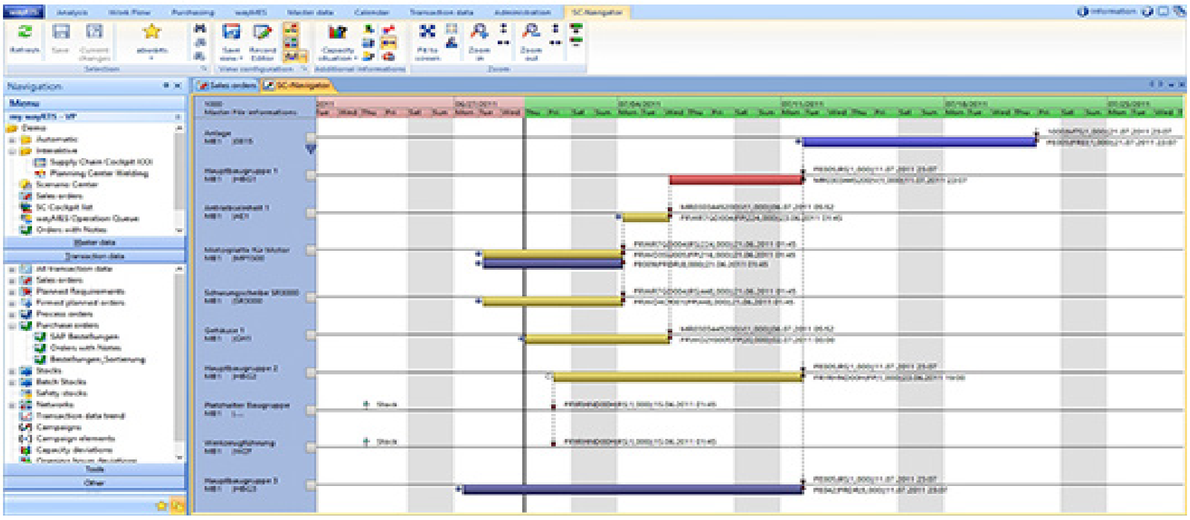

Figure 7. Analysis and planning of the order network in the Supply Chain Navigator

Thanks to modern visualization and filter possibilities, supply chain simulation offers full transparency across the entire order network starting from the responsive performance of services. The reference to the customer order is retained at all times. Due to excellent graphical preparation and context-sensitive scaling, the planner always has all essential information compact in view. This includes flexible and individually configurable views and dynamic filter functions (e.g. on the critical path). See Figure 7.

The visualization functions create the basis for interactive planning which can be used to modify the capacities, orders and throughput times using drag & drop. Since Supply Chain simulation is real-time enabled, the effect of the interventions is made directly visible across all production steps and can be easily tracked. Also very important moment all fixed plan parameters are going to uploaded to MRP system. See Figure 8.

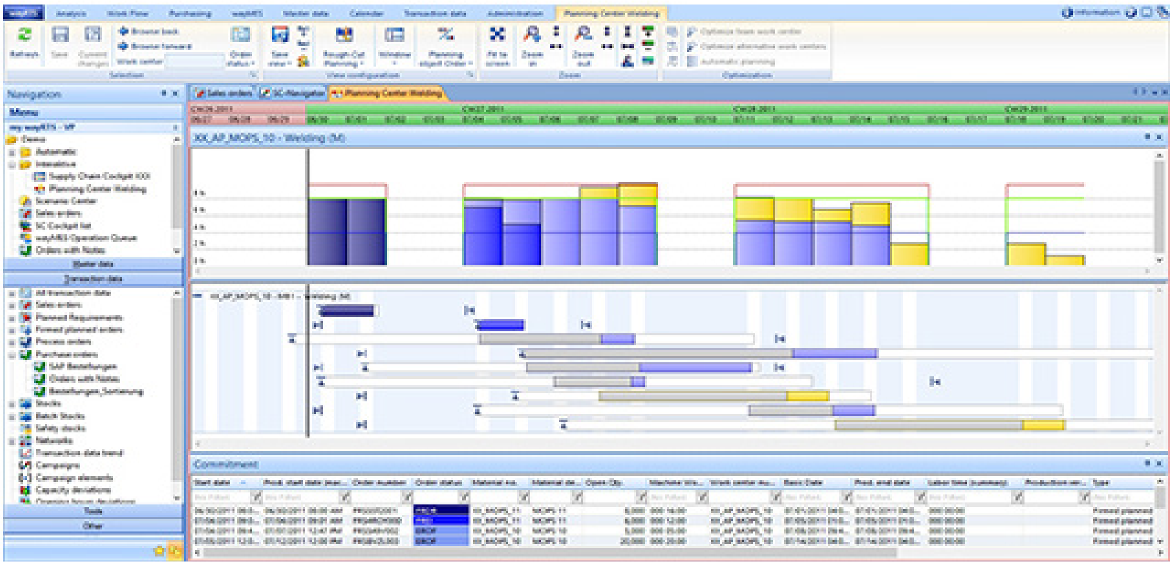

Figure 8. Visually interactive rough and detailed planning in the Planning Center

6. SUMMARY

It is essential for companies with smaller capacity and resources to understand their positions in the manufacturing services industry. It is not enough to implement different production models like Lean but it is important to understand flexibility on the market. High volume mass production is critical to all manufacturing companies where large product volumes use available resources and take advantage of price discounts. Small companies may only survive on a competitive market if they work in close cooperation in design issues with the customers and serve them on demand. This requires high flexibility both in terms of planning and production. To achieve such flexibility, small companies need to be creative in technologies and process operations. If flexibility is provided, supplier network operations still need to be effective which means that components are available on time at a low price. Small companies are required to manage an increase in the complexity of product mix. With the development of information technology and mathematics, planning simulation systems have rapidly improved and their implementation is accessible to all on the market and can apply them during planning processed. Both numeric programming and network research has significantly contributed to the implementation of simple but stable computer aided simulations systems. The electronics company described in the case study believed that the related competences available were enough to manage planning procedures. It was only enough until product complexity negatively impacted productivity. Data transfer from one system to another in an Excel environment was manually performed and effects of the changes were not monitored in the simultaneous systems. In sum, the MRP system was a data provider however, the impact of changes required during planning was not monitored. Running parallel planning systems caused a problem in the entire customer service system as production plan changes were not harmonized with the delivery of raw materials. This resulted in the low utilization of capacities and high stock values. In the long run, the company would use its cash and would make its operations impossible. The top management of the company in the case study recognized the need for change on time and found the simulation tool on the market which best suited it business processes. One of the advantages of the system is that it provided an automatic data connection with the ERP system. In case of any production plan changes, the planner is able to review the impact of changes and make the necessary action before finalizing the plan itself. Modifying the production plan on a daily basis does not jeopardise supplier network planning since being a simulation, these changes are not recorded in the ERP system.

Implementing such a complex supply chain planning system makes customer communication more effective as action plans are easier to define and monitor their execution. In all cases, when the customer is involved in the decision-making process, trust towards the company is enhanced and increased customer orders are provided for.

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