WHITE PAPER:

END-TO-END PLANNING –

IN THE INDUSTRIAL SECTOR

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Abstract

This paper examines End-to-End Planning (E2E Planning) and its influences and effects on company processes. E2E Planning integrates the value chain from the supplier to the customer. A strong focus is placed on the order-to-cash process, which is embedded in the E2E context. The paper shows the advantages of a holistic view of planning processes, including supply chain integration, synchronization, and digitalization. It also presents E2E planning as a possible solution for CO_2 reduction and bottleneck resolution.

Overall, the white paper illustrates how E2E Planning increases business efficiency, improves process quality, makes the entire company more agile in dynamic business environments and thus sustainably increases the resilience of companies.

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1 Classification and Motivation

In today's dynamic and constantly evolving business environment, efficient and frictionless planning is crucial to a company's success. Companies are faced with challenges ranging from customers' changing requirements and complex value chains to limited resources and capacities. In this complex business environment, the concept of "end-to-end planning" is becoming increasingly important.

End-to-end planning (E2E planning) is not a specific method or technique. Instead, it is a term used in various business contexts to describe the planning and controlling of business processes that extend across the entire value chain and all planning levels - from strategic through tactical to operational.

The use of end-to-end planning techniques and concepts has evolved and refined over time. It is difficult to pinpoint an exact start date for E2E planning as it has been introduced at different paces and times in different industries and companies.

Over the past few decades, increasing globalization, the development of information technologies and the growing complexity of supply chains have contributed to companies increasingly integrating E2E planning methods and techniques into their business practices. As a result, E2E planning has become an important approach in supply chain management and business planning to ensure efficient and effective business processes.

This paper takes an in-depth look at the different planning levels which form the core of E2E Planning. The strategic, tactical and operational planning levels are presented in order to gain a deep understanding of how this approach works and what its benefits are.
In addition, the impact of E2E Planning on various aspects of company processes is examined.
The focus lies on aspects such as the integration of the supply chain, the synchronization of supply chain components, the digitalization of processes and the consideration of all planning influences.

Additionally the role of end-to-end planning as a solution to many business problems will be discussed and the solution approaches of "green planning" and "bottleneck planning" will be addressed in this context.

From the sourcing of materials to production planning, distribution, and capacity

management - end-to-end planning not only promises optimized coordination of the various planning steps and improved responsiveness to changes in the corporate environment, but also provides the basis for proactively shaping these changes.

2 End-to-end planning - what is it?

The end-to-end process (E2E) integrates all of a company's activities along the value chain. The suppliers, the company itself and the customers. Together they form the actors in the extended supply chain, which is mapped in the end-to-end process.

Figure 1: End-to-End value chain

2.1 Order-to-Cash embedded in the E2E Process

The order-to-cash process is an integral part of the end-to-end process. It covers the part of the company's value chain that deals with the principle of profit maximization or the appropriate profit generation approach - starting with the customer order and ending with the receipt of payment.

Order-to-cash as part of E2E:

A company can be mapped at an abstract level on the following core processes: (In Figure 2, these are identified by numbers).

1. The customer places an order, which is recorded by the sales team.
2. The order is checked for feasibility by Sales.
3. The manufacturability of the order is checked and adjustments are made if there are any conflicts.
4. The revised order details are communicated to the customer.
5. At the same time, the production order is planned in the production schedule.
6. Production takes place on the basis of the optimal planning.
7. The finished products are delivered via the logistics department, the invoice is issued and payment from the customer is expected.

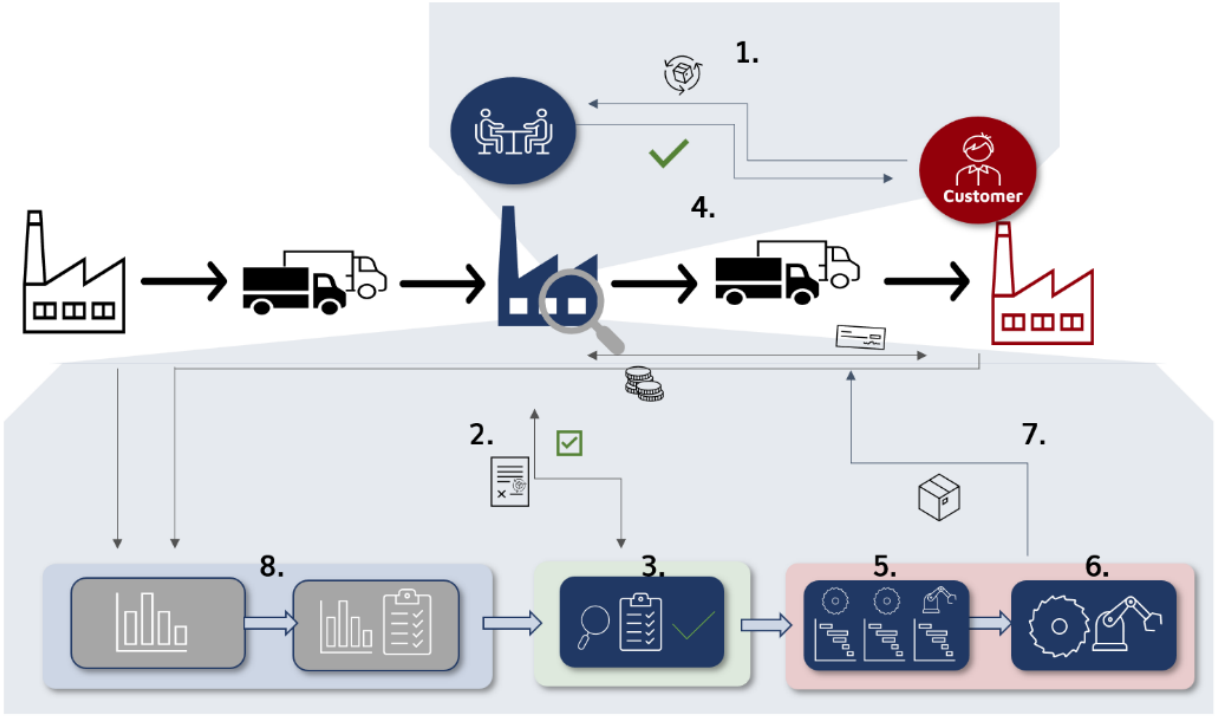

Figure 1: End-to-End with focus on Order-to-Cash

Tactical and operational planning for day-to-day business and the key processes as described are the relevant basis for successful business for every manufacturing company.

Furthermore, the corporate strategy influences every process and determines the path the company takes. Strategy adjustments provide a great lever for planning activities so that strategy implementation is successful.
The strategic activities complete the end-to-end planning (see bottom left in Figure 2).

8. Demand forecasts, such as "future demands", are planned strategically and must be checked against the capacities and materials available in the future to ensure that the sales budgets are then available for the precise planning of short-term weekly and daily business (see above).

Tactical and operational planning processes are coordinated with the strategy so that day-to-day business can be handled optimally, i.e. with high efficiency and maximum results.

2.2 Integration and Transparency

An integrated approach is important here: the individual process steps are not analysed separately, but in conjunction with linked operations. This integration of all process phases enables the organization, planning and implementation of value creation activities. (Busch, Dangelmaier, 2013)

The end-to-end process has the great advantage of transparency. By considering each production stage along the entire value chain with all material stages as a holistic process, each sub-step is disclosed, which creates holistic transparency across the business processes!

Only through transparency it is possible to visualize business processes and discover potential needs, problems, and optimizations. Digitalization allows the end-to-end process to be mapped and to create system-oriented "digital supply chain twins". In the company, this transparency can then make opportunities for action visible and the associated potential can be realized.

It is then possible to realize an integrated, central and digital bundling of all information (in the end-to-end process) through transparency across the entire operations. This information transparency supports and facilitates corporate decision-making as a whole, as well as every integrated planning decision itself.

If the holistic view of business processes exists as an end-to-end perspective, it is also possible to adopt a holistic, cross-process planning approach. This holistic planning makes it possible to set realistic goals, plan capacities and prioritize the overall optimum (global optimum) of the company's value creation instead of achieving several local optima that solve a local problem but cannot improve the entire E2E process.

Holistic E2E planning makes it an opportunity to save time and resources and to identify bottlenecks in advance or solve (anticipated) problems. Through structured, holistic planning, costs can be saved, existing resources used efficiently, customer satisfaction increased, higher process quality ensured and, ultimately, business results can be improved.

3 Level of planning

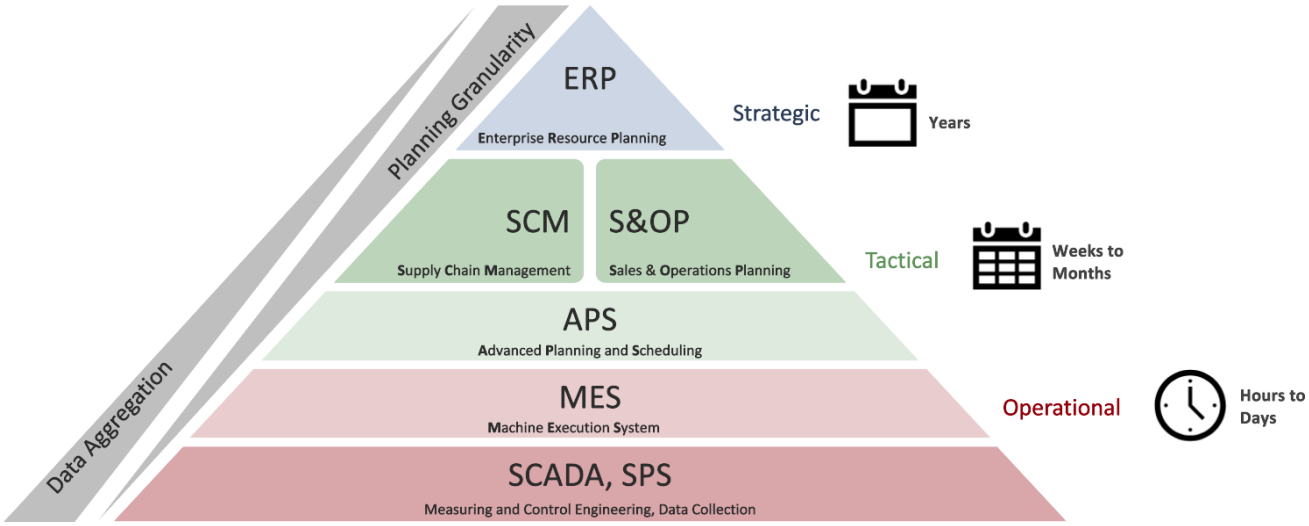

Figure 2: Planning pyramid

3.1 Strategical Level

Strategic planning in the holistic end-to-end process deals with long-term goals and customer needs, as well as the planning of the company's resources and processes required to achieve these goals. Strategic planning refers to a planning horizon of typically one to five years.
In planning, sales and demands are forecasted with a view to targets, customers and all associated process steps, such as long-term material planning and supplier contracts, which are taken into account.

Strategic planning in end-to-end planning can also include the following aspects:

1. Supplier management:
   The selection, evaluation and binding of suppliers to ensure that the quality and availability of raw materials and components are guaranteed.
2. Customer service management:
   Setting targets for customer service and sales budgets, processing orders quickly and responding promptly to problems.

3. Technology management:
   The evaluation and implementation of systems to improve the efficiency and effectiveness of the value chain with measuring and monitoring of KPIs.

4. Resource management:
   The long-term assessment of resource requirements per technology based on the demand forecast, taking into account global trends and thus possible shifts in product characteristics and requirements for available technologies and resources. Against this background, the strategic orientation can be supported in the best possible way from an investment planning (CAPEX) perspective.

Strategic planning helps companies to optimize their supply chains in order to achieve competitive advantages. The focus lies on synchronizing supply and demand (Göpfert, 2013). Companies can thus develop more efficient processes and better cooperation with suppliers and customers in order to increase customer satisfaction and profitability.

In addition, strategic planning provides the basis for medium and long-term investment planning (CAPEX), which focuses on the successful survival of the company, taking the aspects mentioned above into account.

3.2 Tactical Level

Tactical planning in E2E planning refers to medium-term planning and decisions that contribute to achieving the long-term goals of strategic planning. These decisions typically relate to a planning horizon of several months to a year.

Tactical planning decisions relate to specific issues such as production and capacity planning, inventory and warehousing strategies, procurement and supply chain strategies and decisions on optimizing transport and logistics networks. Through tactical planning, the feasibility of orders can be granted.

The following management perspectives are part of tactical planning:

1. Supply Chain management:
   Coordination of the supply and production chain at all stages of production.

2. Sales and Operations Planning: combines inventory management, capacity and production planning:

   Inventory management: The determination of inventory levels and strategies to ensure the availability of material/goods while keeping (storage) costs low.

   Capacity planning (tactical): Planning capacities in terms of production, storage and transportation to ensure that the supply chain works (for the next months) effectively, and bottlenecks are avoided.

   Production planning: The planning of production capacities, times and systems to ensure seamless production.

3. Workforce planning:
   Employee planning based on possible requirements such as skills, shift model, number of employees, etc..

Tactical planning helps companies to optimize resources and capacities and minimize bottlenecks in the value adding process in order to achieve greater efficiency and effectiveness.

3.3 Operational Level

Operational planning in E2E planning refers to the short-term planning of plants, resources and the workforce. The focus is on the operational implementation of strategic and tactical planning as well as the management of immediate/non-plannable challenges that may occur in day-to-day work.

Usually, operational planning takes place in a time frame of days to weeks and is focused on the short-term horizon. Operational planning includes activities such as optimizing the sequence in the various production lines, planning deliveries, monitoring inventories, managing transports and reacting to short-term bottlenecks or changes in customer orders.

Operational planning includes the following elements:

1. Capacity planning (operational):
   Detailed planning of the availability of the required production capacity in order to fulfil customer orders efficiently and on time. The usable production plants, available resources and personnel must be considered here.

2. Material requirements planning:
   Planning of the material required to carry out production. In doing so, ranges, delivery times and stocks of raw materials and components must be taken into account.

3. Production controlling:
   Short-term production planning involves controlling production processes and monitoring machines and systems in order to avoid bottlenecks, downtimes and long set-up times.

The most important goal of operational planning is the continuous optimization of the value chain with the aim of ensuring the best possible sequence in the production sector to be planned. This is achieved continuously and in parallel with overcoming any problems that may occur in order to ensure a high level of customer satisfaction and gain competitive advantages.

4 Effect of E2E Planning on processes

The application of a holistic planning approach makes it possible to prioritize the global optimum in the end-to-end process, i.e. across the entire value chain, instead of prioritizing local optima.

The key influences of this prioritization on the end-to-end process are highlighted below in comparison to partial planning (local optima).

4.1 Supply Chain Integration

E2E Planning integrates the supply chain across all processes, systems and resources!

Supply chain integration connects all participants in the supply chain in order to achieve a holistic goal. No separate goal of one process step is prioritized, which may pose problems for other operations, but a unified, holistic goal is strived for and achieved together through integrated processes. The overall optimum of the process can thus be reached.

For example, it is important for sales to move away from the traditional, dominating view of "sell more". Without E2E planning, the sales department plans to sell a lot in order to achieve certain sales targets. However, if there is no capacity for production to produce these production orders, then partial planning reaches its limits.

In E2E planning, the supply chain is integrated in such a way that "sell right" is the new motivation for sales. It is a new approach that involves holistic planning of which primary materials are in stock,

what capacities are available in personnel and systems and therefore how much can be sold. This means that sales and production are synchronized, planned in an integrated manner and there are no inconsistencies, as is the case with partial and separate planning of the departments/process steps.
(Mollenkopf, Frankel & Russo, 2016)

4.2 Supply Chain Synchronization

The synchronization of the supply chain and the entire E2E process is made possible by holistic planning. By planning the entire process, demand and supply are synchronized (Göpfert, 2013). At a strategic level, demand is planned using forecasts, so that materials and capacities can be planned in line with this. At the tactical and operational level, synchronization takes place in the medium/short term so that production and orders are parallelized. (Hahn, Duplaga & Hartley, 2000)

4.3 Digitalization of holistic E2E processes

Digitizing the supply chain using a digital supply chain twin makes the process transparent. Data from the entire process can be recorded and processed in an integrated manner so that well-founded decisions can be made taking the entire E2E process into account. Decision-making can also be automated on the basis of rules, system-driven and tool-based, so that the entire process, capacities, resources, supply and demand can be planned and optimized. Due to the digital planning of the E2E process, information is centrally stored and accessible, making it possible for planning to cover all operations in the supply chain. The digitalization of the supply chain promises a transparent, integrated and responsive end-to-end process. (Burnette, Dittmann, 2018)

4.4 Consideration of all planning influences

E2E Planning incorporates all planning influences into the planning process. Material requirements planning is used to plan the entire value chain with all material stages and the storage of the material. In addition, production planning as the most important bottleneck of the E2E process, is planned in the long, medium and short

term at strategic, tactical and operational planning levels so that capacities can be checked and used in the best possible way. Furthermore, workforce planning can be carried out within the process so that the availability of human resources, which directly influence the process, is also considered.
This holistic planning enables integrated and synchronized planning of the supply chain so that the operations of the value chain can run without interruption.

5 E2E Planning in practice: Use Cases

E2E planning can be used to overcome challenges of any kind in the value chain. In the following, two completely different use cases are used to illustrate the use of holistic planning to solve problems. The case studies show a recently emerged challenge for companies (the necessity of CO_2 demand regulation in production processes) and an existing/classic challenge (dealing with bottlenecks). These two problem areas can be solved by E2E and are intended to show exemplarily that the entire impact area spanning these two extremes can be optimized by E2E planning.

5.1 Managing CO_2-requirement: Green Planning as solution

Due to legal requirements, companies are faced with the challenge of reducing their high CO_2 emissions. This challenge arises from economic pressure. CO_2 certificate prices are climbing, free certificates are being abolished step by step until 2034 and the obligation to participate in CO_2 certificate trading is being extended to many sectors of the manufacturing industry.

For companies, the problem of reducing CO_2 emissions is not only due to the macroeconomic conditions outlined above, but many companies also have the intrinsic motivation of wanting to reduce their carbon footprint in order to gain a competitive advantage.

The challenge of reducing CO_2 emissions is therefore proving to be an important area of tension that is driven by different areas of interest. This area of tension can be resolved through E2E planning.

The solution through the holistic approach, which addresses all three planning levels and tackles the sustainable reduction of emissions, is called "green planning". Green planning is in other words E2E planning with the aim of reducing CO_2 demand.

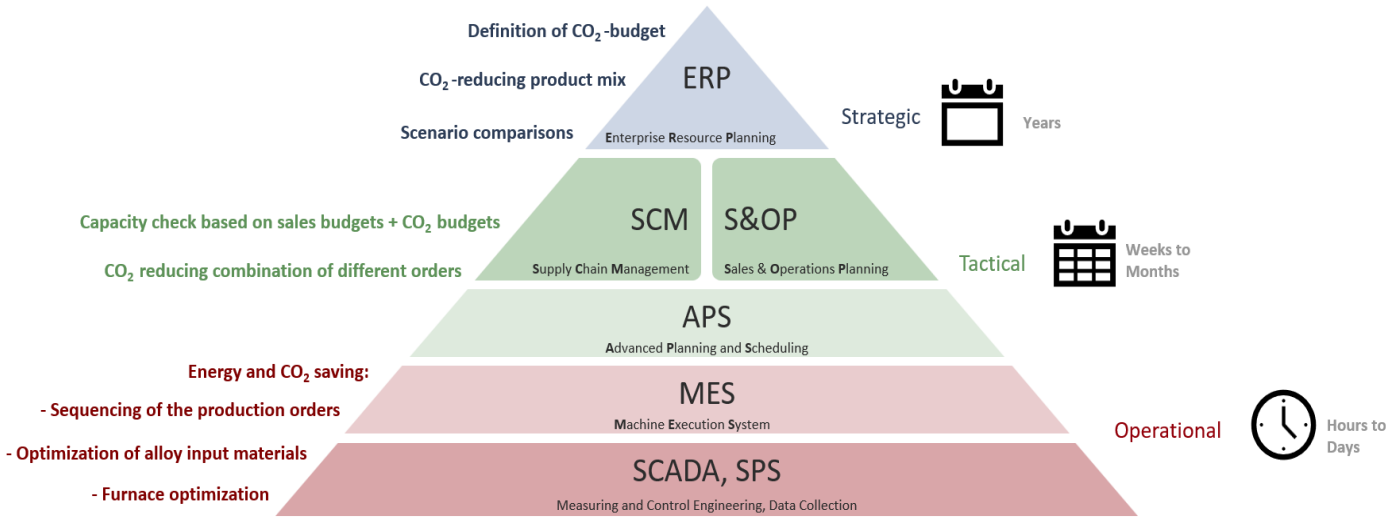

Figure 3: Aspects of Green Planning shown on the Planning pyramid

Emissions reduction can already be tackled at the strategic level by planning sales based on a CO_2 -friendly product mix. In this way, orders with lower energy consumption can be prioritized in sales planning and CO_2 budgets can be set additionally to sales budgets. At a strategic level, the question "How much CO_2 will we produce in the coming months/years?" is already answered at this stage.

In addition, digital scenario comparisons can be used where different scenarios are compared to optimize individual parameters. In this way, duration, costs and CO_2 emissions can be individually optimized and the impact of one parameter on the others can be tracked.

In doing so, it is possible to find out which change in the parameters leads to the lowest CO_2 production and how the duration and costs are affected. This means that the effects of the parameters can be considered when planning and making decisions.

At a tactical level, the medium-term rough planning can create a CO_2 reduction through planning of orders in sales budgets and CO_2 budgets simultaneously. For energy-intensive industries, it is important that orders are checked and assigned to other orders with similar characteristics. (For example, oven temperature, so that the heating processes for different products is matched. Heating the ovens consumes an extreme amount of energy and causes high CO_2 emissions.)

CO_2 can therefore be reduced through the tactical planning of orders and, in addition, the feedback to the customer is made more precise through checking the orders feasibility. This not only optimizes planning in a CO_2-friendly way, but also customer communication.

There are also opportunities to implement energy efficiency and CO_2 reduction at an operational level by optimizing the production sequence, material characteristics and capacity planning.

Green planning is therefore an innovative approach to unite efficiency in companies and climate protection goals. By planning processes holistically, CO_2 requirements can be reduced and monetary losses - caused by CO_2 costs - can be minimized, while at the same time a positive contribution to sustainability is made.

5.2 Coping with bottlenecks: Bottleneck-planning as solution

The area of impact of the second use case deals with a different, classic area - handling bottlenecks. This is an existing challenge that occurs in most companies.

Bottlenecks, for example due to plant breakdowns, employee absences or delays in material deliveries, affect the entire value chain and should be urgently compensated to prevent major sales losses due to capacity bottlenecks.

E2E planning can also overcome this challenge:

Bottleneck planning involves planning how to deal with bottlenecks in the best possible way so that negative consequences of bottlenecks, e.g. disruption to the value chain, delayed production, failure to meet delivery deadlines, customer dissatisfaction or revenue losses, are buffered.

Bottlenecks usually occur in day-to-day business, at the operational planning level (for example due to plant or employee shortages).

Tool-supported rescheduling can then be carried out at the operational planning level at short notice, so that no major delays have to be encountered.

If it becomes apparent that the downtime will be of medium duration, planning can be carried out at a tactical level. Orders that require systems or employees that are affected by the unavailability can be planned in such a way that the unavailability is taken into account when checking feasibility.

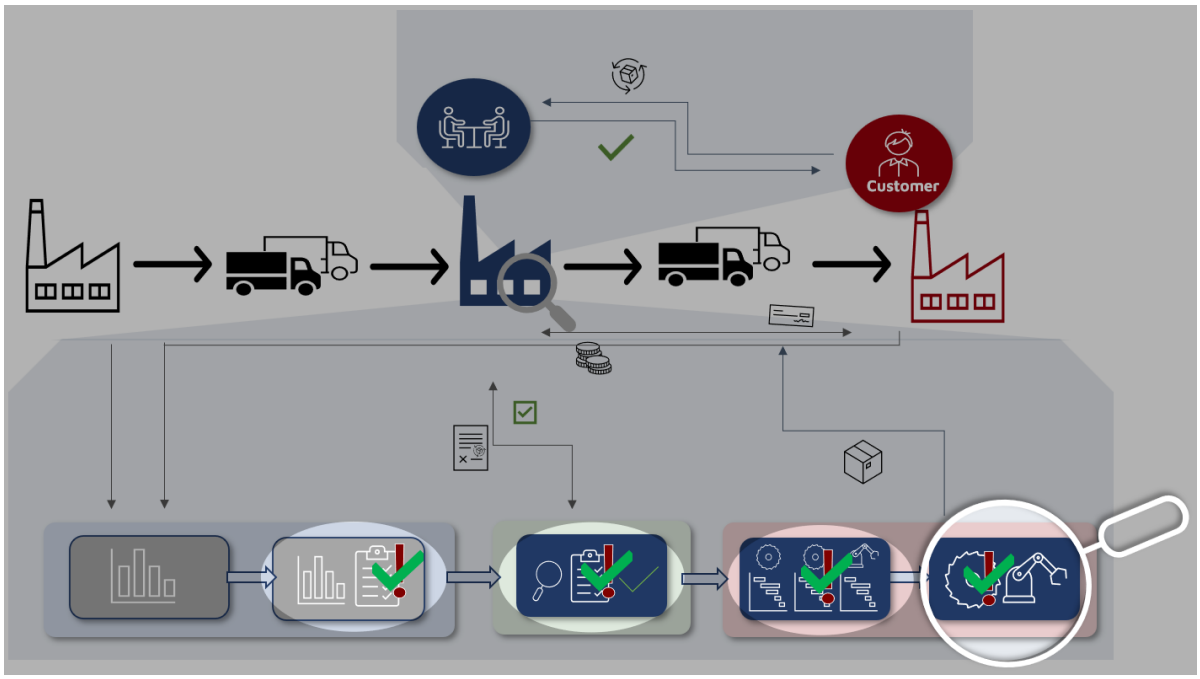

Figure 4: E2E Planning buffers bottlenecks

In addition, the order confirmation with an extension to the delivery time can then be sent directly back to the customer so that the customer is not dissatisfied.

However, if the downtime is longer-term, strategic planning is required to determine whether the forecast sales can be realized with the remaining plant capacity based on the demand forecasts. Strategic planning and a checking of plant capacity are urgently required here. In critical situations, holistic planning buffers the negative consequences of failure across all planning levels.

By seamlessly integrating planning across levels, this implementation enables optimal planning and continuation of production and the end-to-end process, even under difficult circumstances.

Through holistic planning, companies can operate efficiently and smoothly despite bottlenecks, ensuring long-term process quality, strengthening customer relationships and consolidating the success of the company. By minimizing the negative consequences of operational downtime, holistic planning is a valuable part of a robust business operation that meets the demands of the modern business world.

6 Conclusion

In summary, End-to-End Planning plays a decisive role in the optimization of business processes.

E2E planning increases business efficiency, improves process quality, makes the entire company more agile in dynamic business environments and thus increases the resilience of companies in the long term.

This holistic approach enables companies to establish a high level of transparency across the entire value creation process. Based on the transparent end-to-end process, planning can aim for the global optimum of the process and be aligned accordingly. With an additional view of the different planning levels, based on the planning horizons, E2E planning is the best way to map and optimize every value creation process. Holistic planning not only results in smooth, optimal processes along the value chain, but also in solutions for existing and new challenges. E2E planning covers the entire spectrum of possible business challenges - from overcoming bottlenecks to mandatory CO_2 emission control.

Holistic planning also has the advantages of supply chain integration, digitalization and synchronization, so that process steps can be integrated, coupled and mapped in a digitally transparent manner. This also enables tool-based support for holistic E2E planning.

In order to implement all these factors in the future and achieve the global optimum instead of independent local optima, it is very important for companies to take all planning influences on the process into account.

The future of successful industrial business management undoubtedly requires a view of the "big picture" - that is what end-to-end planning offers.

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