26 Event-Based Planning for Standard Polymer Products

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In a highly dynamic market environment, the required planning quality for the entire supply chain can increase to such an extent that it can be reached with fixed planning cycles only at the very high cost of frequent planning. If demand or the raw materials market develops differently from what is anticipated, a readjustment of the entire supply chain becomes necessary to re-attain maximum planning quality and hence profitability. In a highly dynamic environment, an event-controlled synchronization of the production and sales planning in place of the timetable-controlled synchronization can ensure the necessary increase of planning quality and limit planning expenses to the necessary minimum. This study describes the planning scenario of a chemical industry company which has fully integrated the demand planning, master planning as well as production planning and detailed scheduling; its results are used as quotas in the availability check of customer requirements (see chapter 9). This integrated planning system is carried out, in whole or in part, event-controlled as a function of market trends.

The case study breaks down in four parts. Problem description, planning environment, and current market conditions; Introduction of a solution concept; Detailed description of planning levels already realized using SAP APO, as part of mySAP SCM and an optimized solution on the basis of ILOG; Summary of results and major findings gained during project realization.

26.1 Current Situation and Definition of Problem

The chemical manufacturer described herein produces several standard polymer products which are manufactured in various versions. The product is made from crude oil in several refinement stages. It is used in numerous applications for the production of packaging, films, casings of electrical appliances, components for entertainment electronics or household goods. The polymer is manufactured as a granulate and then injection-molded or extruded by the customer in the final application. The company produces for the European market at several locations. The various sites preferentially supply selected European countries. In addition, depending on the supply situation, allocation of countries to production sites is also handled dynamically.

The limitation to a few product versions is a response to the development of the market in the direction of a commodity market with standardized

products that are produced at high volumes. The individualization of the products, e.g. by dyeing with pigments is increasingly carried out by the final consumer. The flexibility of being able to produce different products has therefore increasingly shifted to the final consumer.

The company is in a highly competitive environment. While it retains a major position in the overall market, its market share is comparable with that of other competitors. From the viewpoint of the customer, polymer manufacturers are easily replaced. The product price is highly dependent on the price trends of crude oil, and other raw materials. The demand is likewise highly sensitive to price revisions. Hence, pricing is an essential marketing instrument of the company. Differentiating features with regard to quality and delivery reliability do not exist as they are taken for granted by the market.

As a rule, price changes of crude oil impact on subsequent raw material costs at a very short notice. These cost changes can, however, be passed on to the customer only with a certain time lag. This can cause the obtainable profit margin to shrink very quickly and in extreme cases even become negative. A possible reaction to this situation is the deliberate reduction of quantities put onto the market. With this measure, quantities which need to be marketed at a negative margin are kept under control without giving up major market shares at the same time.

The falling sales prices result in subjecting raw materials and finished product stocks to a very high valuation risk. Stocks which were produced with raw materials at high costs can in such a situation be sold only at relatively low selling prices which clearly reduce the available profit margin.

To achieve high profitability, it becomes necessary to pay consistent attention to low production costs and to combine this with efficient responsiveness to market prices. To do this, it is necessary on the one hand to plan resources efficiently, and on the other to forecast market changes as well as possible, and incorporate them into planning with little delay. The entire supply chain should be coordinated with the highest possible degree of integration. Not only individual components such as allocating production quantities to different production sites must be carried out but also be combined with other planning steps such as defining production sequences and planned output as well as the distribution of production quantities to the different markets. The planning must be very closely linked to the various business functions, such as procurement, sales and production planning which must be coordinated with each other with little time lag.

These requirements can be met by a system which demonstrates both a high degree of integration and a rapid response to changes in the planning conditions.

26.2 Solution Concept

To coordinate in particular sales and master planning, companies use procedures that differ by their complexity. In the simplest case, the coordination only deals with information provided by sales planning which is input into the subsequent master planning but does not involve any direct coordination between the planning levels. The next stage of coordination can be achieved by processes in which both the systems and the organization of the various units are harmonized. This coordination takes place at fixed dates at which the practical steps up to the next scheduled coordination date are laid down. These fixed planning cycles can be dispensed with if a tighter supervision of total changes in the supply chain is made and a higher degree of integration between the planning levels is realized. The result is an event-based planning which in each case leads to a new planning result when this is required to ensure optimal supply chain performance. A further integration of the planning processes can be achieved by linking the quantity-oriented logistical planning with the value-oriented budget planning of the company. Emphasis is hereby put on the consistency of the planning process via quantity and value planning during which both areas exchange figures and confirmations. The following illustration gives an overview of the different degrees of integration of the planning levels.

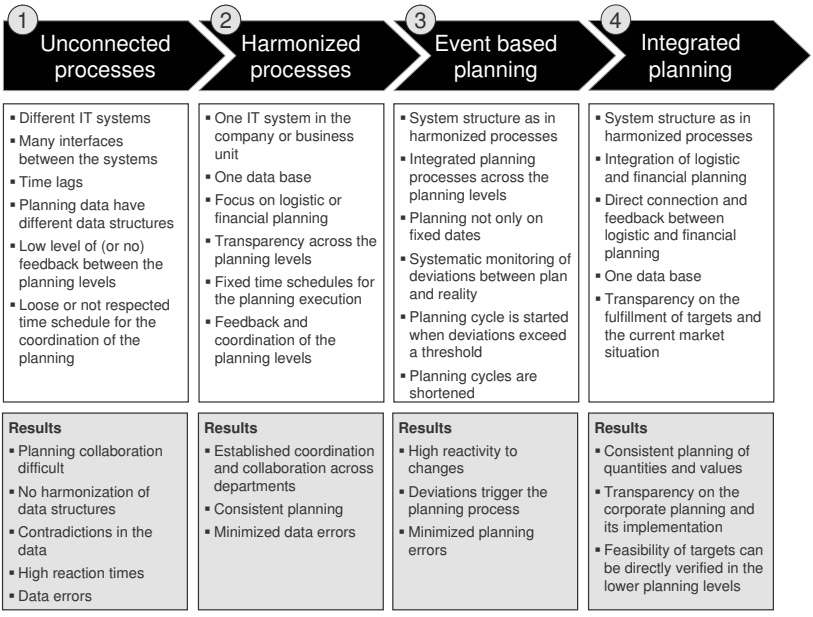

Fig. 26.1. Integration and coordination of different planning levels

With the above-described project, the company has begun the change from planning with harmonized processes to event-based planning. Subsequent integration with the budget processes is a possible part of a future project.

At project begin; the company used a solution concept which represented a unified system base for sales planning of all units in the manner of a harmonized process. This solution was based on the module Demand Planning (DP) of mySAP SCM and is being used for the sales planning of all markets and products of the business unit in question (see chapter 7). This allows achieving a high level of transparency on the requirements of all markets and keeps good track of any changes from sales forecasts. The forecasts and their manual reviews are undertaken at fixed dates. The planning cycle is completed once a month and provides the required input data for subsequent master planning (see chapter 8). A response to unusual market changes with subsequent adjusted master planning is made only effective to the next planning cycle. So far this planning platform has ensured consistent planning with only minor data errors. However, in view of the high degree of change in sales, the reactivity of the planning system was not high enough and resulted in lost sales and excessive inventories of finished goods, depending on the current demand situation.

This initial solution concept has now being expanded and is introduced in greater detail below. The fixed planning cycles have been discontinued so that now planning can be undertaken at any point of time, i.e. event-based. This imposes two conditions: on the one hand, there must be a continuous data supply and updating; on the other hand, deviations from the plan must be continuously monitored. Monitoring is essential since it determines the need to start the following planning cycle. By including the inventories days of supply and production capabilities, changes to both the sales market and to the supply side of the supply chain can be monitored.

As soon as predefined thresholds are exceeded, a separate demand or master planning or, in the case of major deviations, total replanning of sales and the production network is triggered. Typically, the planning frequency is higher than it is for planning in fixed planning cycles since sales planning can be carried out separately from master planning and no complete replanning is required in every case. At times of fewer changes or deviations, the planning frequency may be reduced.

Closely connected with planning is the implementation of plan-based decisions. A system-supported implementation of current planning results is necessary in particular with frequent and non-synchronized changes. This is done by integrating the availability check at the time of order entry (see chapter 9) with the results of detailed production planning. For this purpose, planned production quantities are returned to sales planning, and considering actual sales forecasts, a quota allocation of available stocks and planned receipt quantities of final products for the various markets is undertaken.

When orders are entered, final products availability is confirmed only if the quota for the market to which the customer is assigned is not yet exhausted. Consumed quotas are employed to monitor market conduct and may result in triggering a new planning round whenever a quota is used up. The decision is taken in due consideration of the current supply strategy so that a deliberately generated scarcity of the supply and the resulting early exhaustion of available quotas does not trigger new planning.

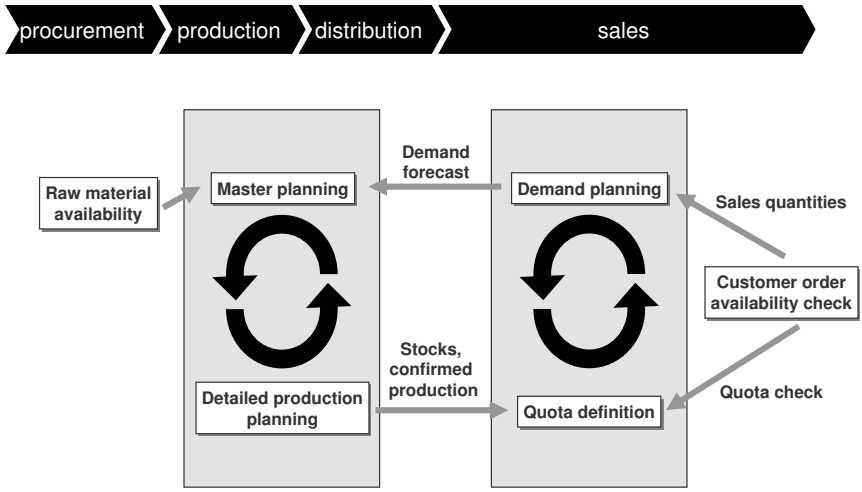

Fig. 26.2. Integration between demand planning and master planning

Figure 26.2 shows the two planning areas of demand planning and master planning. A new planning is triggered when the data to which the units are linked display clear deviations from expected values. Thus, in the area of sales planning there is monitoring of sales versus forecast quantities, as well as monitoring of quota consumption over time. In the area of production planning, planned stocks versus actual stocks and scheduled and actual production quantities as well as raw material availability are monitored. In the event of major deviations between these indicators, the system issues alerts for the responsible. Depending on the degree of discrepancy, replanning is initiated only within the area or a new coordination of both areas is launched.

Hence, when raw material quantities become scarce or consumption of the final product rises, new production planning is triggered. If after a new planning cycle all demands can again be met, no further planning activities are triggered. If customer orders remain unconfirmed, a signal is sent to sales planning to redefine the quotas. In the event of major deviations in demand from the original demand forecasts, the complete planning cycle including sales planning would then again be started anew.

In this way, equilibrium between sales and production planning is again created. The next planning cycle is then started only when new deviations are detected. The planning cycle can be performed both for all units together or only for one unit as the case may be. For this purpose, product dependent threshold values have been defined which when exceeded set off the corresponding planning steps.

Planning Levels

The proposed solution introduced above was implemented with SAP mySAP SCM components and with optimization components from ILOG company:

- Demand planning using mySAP DP (Demand Planning)
- Master planning using mySAP SNP (Supply Network Planning)
- Detailed production planning with the help of the optimization tool on the basis of ILOG components whereby the results are further processed via mySAP PP/DS (Production Planning and Detailed Scheduling)
- Availability check using mySAP gATP (global Available to Promise)
- Customer order handling, handling of production orders and the procurement of raw materials are processed using SAP R/3

The next sections describe the planning components in greater detail. SAP R/3 functions are not shown since they are not used more for planning functions.

Illustration 26.3 shows the planning levels in detail. The various elements are looked at more closely in the following sections.

Demand Planning The determination of future sales quantities starts out from the historical sales figures which are used as a basis for a statistical forecast (see chapter 28). The customer orders are initially stored in a central SAP Business Information Warehouse (BW) and the sales figures consolidated there are then transferred to the BW which is integrated into Demand Planning (DP). Sales figures are updated daily in the DP and the statistical forecast is also carried out daily.

A monthly rolling sales quantity plan (business forecast) for the business unit is defined with respect to the sales goals for the current year. A consolidation is carried out between logistics, production management considering production capabilities, product marketing, and regional sales management.

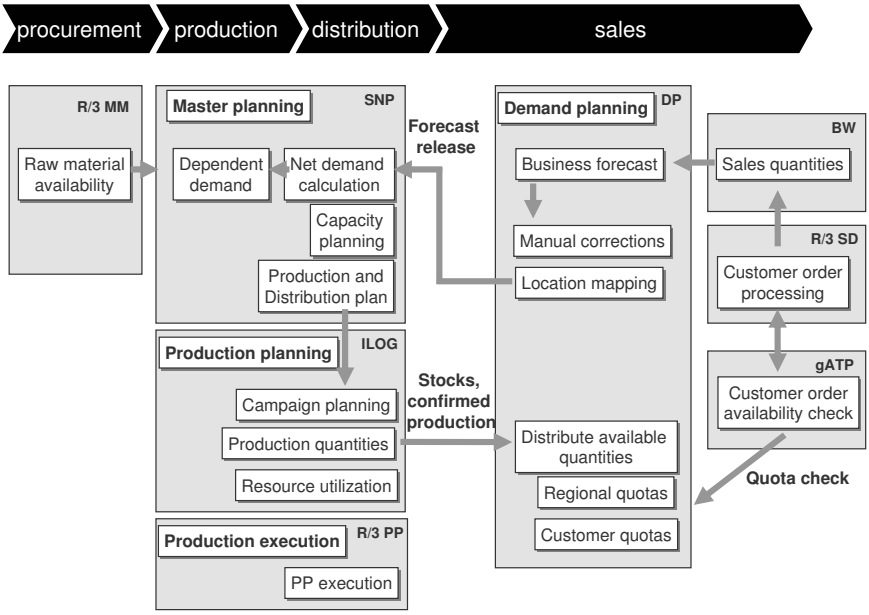

Fig. 26.3. Detailed flowchart of sales and production network planning

The business forecast is the framework for production capabilities and the achievable sales quantities in the different markets. The sales quantity plan is created in a detailed way for the next 3 months with an extension for the months 4 through 6. This plan is created at the product group and sales region level. The sales quantities may be refined manually to correct the figures of individual products or countries.

The regions are preferentially supplied by certain production sites. Thus, the next step is location mapping which assigns by region which production site is to supply a given demand. It is still possible to deviate from this allocation during master planning; however, the additional shipping costs are weighed against the overall goals pursued by planning.

As a last planning step, the external sales quantities are reviewed a last time and are released by sales planning to master planning.

The sales quantities are monitored in the quota allocation. The actual sales quantities are compared against the defined quotas. In case of significant deviations, quotas may be updated or in case of major deviations a trigger for the update of the sales quantity plan may be given.

Master Planning Master planning is carried out with the help of mySAP SCM module Supply Network Planning (SNP). The goal of this planning step

is to prove the feasibility of the required production quantities. The plan is detailed in the next planning step of detailed production planning.

For this purpose, various planning tables for manual revisions as well as the SAP (standard) optimizer for automatic planning runs are used. Planning is done for the next 6 months using a detailed monthly breakdown. Accordingly, monthly buckets are used to define the monthly quantities to be produced, procured and redistributed.

First, all demand types, receipts and stocks are consolidated in the net demand calculation. For this purpose, an SNP planning table is used in which total demand, both unfilled customer orders and the consolidated gross forecasts carried over from demand planning, are shown. In addition, currently available raw material quantities as well as redistributions within the production network and redistributions to other company departments are shown. Already at this level, the planner can enter requirements for the automatic master planning run, e.g. by correcting available raw material quantities. As a rule, this step is repeated several times when the first results of the automatic planning run are available.

The automatic planning run performs several steps simultaneously. Thus, the computation of secondary demand, the capacity planning as well as the drafting of a production and distribution plan in a single planning run is made without visibility to the planner.

The planning run uses a cost-oriented mathematical optimization method (SAP Standard) which aims at minimizing all decision-relevant costs. The planning run is controlled by modifying the cost parameters and by weighting partial goals. E.g., for every product the storage costs at the various stages of the distribution network are quoted. Warehousing can be controlled through the different cost rates at the various locations so that e.g. at a high warehousing cost at the production site and at a low cost at the distribution site, stocks are redirected to the distribution warehouse. By weighting partial goals it becomes possible to set priorities so that e.g. warehousing costs can be put into a relationship to the costs for late delivery. By building up stocks, it is possible to compensate peak demand when necessary which is done by having the plan assume high cost rates for late delivery while at the opposite ratio stocks are minimized by reducing the high delivery service rate.

The optimization run of the automatic master planning takes into account the following costs whereby the overall goal is to minimize total costs:

- Production costs
- Storage costs
- Transportation costs
- Costs for violation of the safety stock level
- Non-delivery costs
- Late delivery costs

The costs are set as a function of the site (e.g. site-specific transportation costs) and of product (e.g. non-delivery costs) and/or as a function of both the product and the site (e.g. production costs, location specific storage costs).

Next to these goals, the optimization run is also controlled by further input values. These take into account on the one hand the constraints to be respected, such a discontinuations, and capacity profiles but also planning decisions already made such a fixed production quantities or minimum resource utilizations. In detail, the following data are used as input for SNP planning:

- Scheduled discontinuations of production resources
- Minimum batch sizes and minimum stocks
- Planning recipies with allocated resources and validities
- Resource capacity
- Manual correction of stocks
- Manual definition of production and procurement quantities
- Additional purchases, setting the maximum purchasing quantities
- Maximum delay

The automatic planning run makes the planner a proposal which she can revise in the SNP planning table. Thus, she can e.g. increase the production quantity of one product at the expense of another, if the priorization of products by production costs has been insufficient. The monthly production and distribution quantities then become the requirements from master planning which must be incorporated into the subsequent detailed production planning. In each case, only the current month and the next two months are supplied since this is the limit of detailed production planning.

Detailed Production Planning The detailed production planning is performed using an independent optimization solution using ILOG technology integrated into the SAP system. The PP/DS module installed in the SAP standard cannot be used for these tasks since there are special requirements not covered by the standard:

- In many areas, the resource capacity is variable and is a planning result.
- The outputs of several production stages must be coordinated with each other in such a way that no intermediate stocks are generated.
- During product changes, set-up times apply while production continues so that the resulting product is, however, outside the specifications; plus there are further specific requirements.

The master data in mySAP SCM provide that a resource is working at a fixed output rate but different output rates can be defined. Planning does not allow, however, that the output rate is one planning result. Accordingly, no handling is envisaged in which the planner can easily and efficiently set the individual resource output rate for each order.

In the production process, several stages are directly linked to each other so that no storage of intermediate product is possible. An aggravating factor for planning is that the resource output rate on the different production stages can change and that these changes need to be reflected into the output rates of adjacent stages. In the module PP/DS of SAP, this is supported by the automatic planning procedure only in part.

In detail, the production process must meet various requirements which can be modeled in the SAP standard in part. Thus, e.g. a resource can only be used for production or it is performing a change over activity, both cannot be modeled in the SAP standard at the same time. The raw material consumption arising during a change over is, however, not negligible and must also be considered; one reason being the requirement that no stocks may be generated on intermediate stages.

To be able to overcome the above-mentioned limitations of the standard, a specific optimization solution which includes a separate user interface was created to allow easy modifications of output rates.

Detailed production planning and scheduling determines the daily production quantity for products on the resources of the sites based on the monthly requirements. Planning is performed for the current month as well as the next two months.

The goals of detailed production planning are:

- The monthly input quantities computed by SNP must be met as accurately as possible
- The target inventory days of supply of the products is to be met as accurately as possible
- Change over times are to be minimized
- And other goals.

Detailed production planning must solve the following essential tasks and respect several constraints:

- A resource can be used only to manufacture one product at the same time, within one day there may be at most one change over, i.e. at most two products can be manufactured per day.
- The preferred production sites should be respected when products are manufactured by multi-sourcing.
- For each resource, an optimal output rate is specified which should be reached if possible; the output may vary between a minimum and a maximum.
- Only a previously defined limited number of product changes and output rate changes are allowed per day, production site and group of resources. Sometimes, such changes are allowed only on certain days.
- During a product change over, a very specific change over time applies per resource, product outside the specifications is produced, and raw materials are, however, consumed.

- Continuous production on all production stages, no resource standstill (except in the case of discontinuations).
- No stocks between production stages, only at the level of raw materials and finished products
- After a discontinuation, a resource must be started up at a predefined pattern, only certain products are permitted for the first order
- Raw materials are available only in a limited quantity
- Production campaigns have a predefined minimum length
- The products are produced preferably on certain resources, however, changes to another resource are allowed
- Fixed orders must be taken into account and cannot be modified.
- A certain portion of waste and products outside specifications can be returned to production as a raw material

The solution of the optimization task is made using a multistage mixed-integer optimization method. The optimization task is decomposed into separate parts and solved in consecutive steps:

- Allocation of orders to resources and determination of the sequence of orders on the resources.
- The definition of order sizes as well as output rates to resources, definition of change overs.

A checker is available to ensure that manually corrected plans observe all the constraints of the planning task. This is an especially adjusted optimization model which loads a predetermined planning situation and records all violations of constraints in a log file. From this log file, the planner can see both the detailed figures of partial goals and the degree of non-compliance by soft constraints and possible violations of hard constraints. The following illustration shows the architecture of the detailed production planning solution in detail.

Detailed production planning is started by the planner in the APO after master planning has been completed. After execution of the transaction, the optimization user interface is loaded in the workstation of the planner. From this interface, similar to the graphical planning table, he can control the entire planning process. He can look at the existing order situation, modify the constraints for optimization, trigger an optimization and manually correct optimization results.

After the start of the optimization, all relevant data are loaded from the APO. This includes the input data from the SNP for the monthly production quantities as well as the master data, e.g. the recipes and routings. In addition, settings not available in the SAP standard such as minimum and maximum output rates of resources are transferred. The data are then processed by the optimization user interface and transferred to the data model of the optimization engine. The interface then controls the optimization process, calls up the various subsequent optimizations and transfers the (intermediate) results.

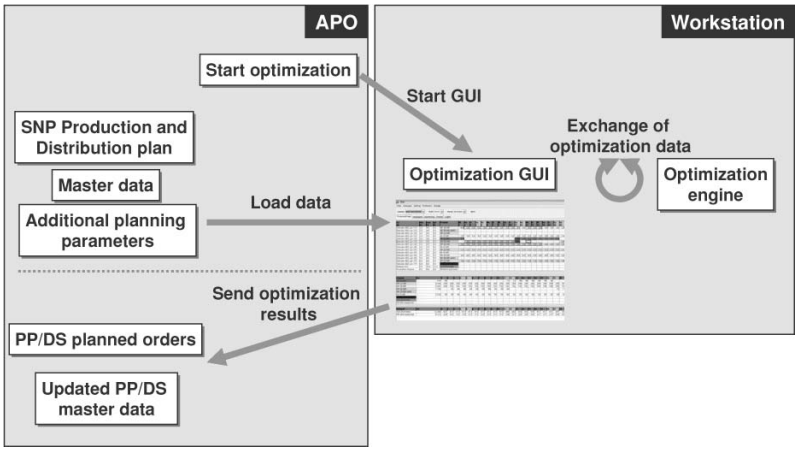

Fig. 26.4. Architecture of detailed production planning solution

After optimization is completed, the planner can verify the results on the interface and if necessary, adjust them manually. Possible changes are adjusting the output rate of resources, the production length of a campaign to change the total of produced quantities or defining on which resource a product is to be produced. When the planner is satisfied with the result, he stores the result and starts the return transfer to the APO. In the APO, the necessary changes to the master data are automatically carried out to permit new output rates on a resource. Thereafter the PP/DS plan orders are generated in the APO.

Production planning and scheduling is completely modeled with SAP standard objects so that it can be processed further in the subsequent SAP standard process. The generation of process orders for production in R/3 PP is then again made entirely in the SAP standard.

Quota Allocation and Availability Check Production quantities defined in the detailed production planning are used to generate the quotas which must be available to satisfy customer needs per product and region. For this purpose, the production quantities are returned to demand planning. The demands of the regions and the available stocks and the production quantities are then shown by product. These are compared to the planned sales quantities. If the available quantities are adequate, the quotas can be

allocated as required by the demand. Otherwise, the quota planner reduces the amount of the quota to available quantities in regions which cannot be fully supplied.

Quotas are communicated to sales management, which may accept, increase or decrease them. The desired quotas as defined by the sales management are taken into account by the quota planner. He will then reallocate the quotas accordingly. As an option, sales management may define additional customer specific quotas within a region. When a customer order file is created, an availability check is always triggered in order to check whether the product for the customer order is available. This is done by checking existing stocks but also planned receipts. In addition, the order quantities are checked first against the quota of the region to which the customer is allocated, and .second against the customer specific quota if one has been defined.

With every confirmed customer order, the available quota is reduced by the order quantity. A customer order cannot be confirmed without a free quota; this implies that the total of all customer orders within a region may not exceed the quota quantity or available quantities.

The consumption of the quota is monitored by the quota planner constantly, and its consumption may lead to a redefinition of the regional quota. This update is communicated to the sales management and the described coordination takes place. In case of very important deviations, it may be necessary to update the sales quantities in the demand planning. The quotas will then be redefined based on these new sales quantities. If the available quota is exhausted; the customer order can no longer be confirmed. The customer order is then transferred to backlog processing. Where special priorities exist, the customer order can be confirmed if the quota is increased with respect to the high priorities. When there are no priorities, the customer order is declined.

Monitored Key Figures Trigger New Planning New planning of individual parts of the planning solution is triggered whenever there are major deviations between the expectations of future and actual development. For this purpose, various key figures are monitored. When monitoring sales processes, the following parameters are used:

- Consumption of quotas through customer orders
- Deviations of customer orders from the forecast
- Deviation of selling prices from plan prices

These parameters basically deal with the question whether the demand deviates from the plan. In the case of larger deviations, new planning is made initially within the sales process. Thus, e.g. the plan for a region can be overruled if the customer quota shows an excessively high degree of consumption. If the stocks of that product are still sufficiently high, matching the quota could be sufficient without having to trigger a new production planning.

The monitoring of the production and distribution processes involves the following parameters:

- Inventory of final products, days of supply
- Finished production quantities to planned production quantities

If the inventory days of supply key figure falls below the specified target value, it will be necessary to modify the production quantities or dates of the product. With smaller deviations, manual correction of a product may be sufficient, but with larger deviations new planning for all products or production plants will become necessary.

Threshold parameters between the sales and production and master planning units have been defined for which the possibly required measures have been deposited. The measures state whether separate planning of an individual unit is sufficient or whether the replanning of the entire supply chain planning is definitely required.

26.3 Results and Lessons Learned

With the above-described process, the company was able to substantially increase its responsiveness to changes in the market and in production. The key factors here are close integration and the coordination of partial processes, and the standardization of processes. The labor-intensive coordination and data transfers could be avoided and planning results obtained in a short time and at low efforts and new planning results implemented. Moreover, the high degree of coverage of functional requirements of the processes by the planning solution is of crucial significance. By recognizing the need for new planning, the necessary corrections can be directly triggered without having to accept a long delay up to the following scheduled planning round. Now, a completely new planning solution can be obtained within a couple of days, an isolated update of i.e. the network and the detailed production plan can be derived within less than one working day. The efforts to create a new planning solution are significantly lower. Lost sales in case of increased customer demand were reduced significantly. Excess stock of finished products is avoided completely as the production quantities are synchronized very closely to the market demand. The implementation of the planning solution helped the company to improve the organization of the planning department. The benefits were achieved through stable and coordinated processes of planning and execution.