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Automatic Parameter Configuration for Inventory Management in SAP ERP/APO

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Abstract

Companies today generally hold several thousands SKUs (stock-keeping units) in stock. With an ever increasing trend towards highly customized products, the number of SKUs held by companies is likely to increase even more in the future. For each of the SKUs held in stock, a decision has to be made on how to configure each module of the SKU's inventory system. Doing this for each SKU individually seems to be an unfeasible task, given the large numbers of SKUs held in stock by most companies. Therefore, these companies configure inventory systems not on a SKU-basis but on a group basis, where the groups are usually determined using an ABC/XYZ analysis. The configuration using such a rough group basis for several thousand SKUs does not allow for individually customized inventory systems and therefore might not exploit the implemented inventory methods in a software package in an optimal way. In this research project, decision systems allowing an automated inventory system configuration in SAP ERP and SAP APO at the SKU-level are developed. The SAP ERP corporate software package is the market leader for Enterprise Resource Planning systems, offering a wide range of inventory methods for the relevant inventory system modules. The advanced planning and scheduling system of SAP, Advanced Planning and Optimization (APO), provides additional inventory methods that can be chosen for the configuration in the inventory system modules.

Keywords: material resource planning, SAP ERP/APO, inventory management, parameter configuration

1 Introduction

Efficient material planning and control forms one of the most important competitive factors in many industries. High amounts of tied up working capital may account for a substantial cost factor of a product, which may severely affect the profit margin. Today, due to an ever increasing rate of customized products, companies often carry ten or hundred of thousands SKUs (stock-keeping units) in stock, making inventory control a burdensome task. Since the beginning of the last century, planning and control of materials represents one of the main areas in operations research. Numerous methods for efficient inventory control have been developed. Several of these methods have found their way into practice, mostly through corporate ERP software. SAP Germany, the world-market leader for corporate software, implemented over 200 methods for inventory control in their backbone transaction system SAP ERP and the advanced planning and scheduling system SAP APO (SAP SCM) . The implemented methods are drawn from operations research as well as from the best practices in several industries. The large amount of SKUs held in stock and the complexity of configuring an inventory planning and control system for a single SKU, given the numerous methods provided, seem to make inventory planning at the SKU level impossible. Thousands of inventory control systems would have to be defined and maintained manually. Therefore, common practice is to configure inventory control systems for inventory groups, which are formed mainly based on an ABC/XYZ classification. Furthermore, not all provided methods are considered by the inventory planner, as it is very difficult to keep overview of the 200 available methods and to know how and when to apply them. Thus, current practice in companies often does not result in efficient material planning and control as group-wise planning does not account for individual requirements of a SKU regarding the configuration of the inventory control system and further, the provided methods in a company's material planning software are not exploited adequately.

The goal of this research is to show how an automated decision system can help individually configure adequate inventory control systems for each SKU in stock, considering all the provided methods in SAP ERP and SAP APO. The general academic inventory control process will be outlined and compared to the inventory control process implemented in SAP. Five important parameters, which have to be configured for the SAP inventory control system, are identified and presented. These include 'MRP strategy' , 'MRP procedure', 'Forecasting', 'Safety stock planning' and 'Lot-sizing', whereas 'Forecasting' will not be discussed in this work, as a decision system for this parameter is already in place in SAP. For the remaining four parameters in SAP, implemented methods for their configuration are discussed, and decision systems are developed.

The criteria used for the decision systems of each parameter are mainly based on information stored in the SAP Material Master Data; however, some criteria draw on additional information, which then has to also be maintained in the Master Data. The use of the criteria, the interdependence of the decision systems developed for each parameter and potential implementation are discussed in the subsequent chapter. Finally, a conclusion is drawn, and potential future research projects are outlined.

2 Material Planning Process

The process of material planning and control involves several planning steps. In the following, these steps are outlined from a general operations research perspective and then compared to the inventory planning and control process, which forms the basis for inventory planning and control in SAP-ERP/APO. The complexity and interaction between the planning steps will be pointed out.

2.1 Material Planning Process in Operations Research

The architecture of a material-planning and control process depends on the type of material that is to be planned. In particular, whether the material planning is conducted in the context of a single-echelon or a multi-echelon environment. To define a generalized planning process, a multi-echelon material planning process will be outlined. The multi-echelon material planning process usually follows a general MRP (Material Requirements Plannning) process, which was developed by IBM in the early 1960s (Hopp and Spearman (2001)). Before the MRP paradigm was first introduced, each echelon in an inventory or production setting was planned and controlled as a single-echelon, so called consumption-based inventory control, and therefore planned disregarding the direct connection of the materials described by the BOM (Bill of Material). The MRP method makes use of the direct connections of lower-level items to the final product, and so distinguishes between independent (market) demand/requirements for the final products and dependent (internal) material requirements. However, a single-echelon, consumption-based inventory control might be preferable to an MRP approach when demand for a SKU is good to forecast, no forecast is conducted, and the control costs shall be kept at a minimum (e.g. KANBAN). Therefore, both approaches, MRP and consumption-based inventory planning are valid concepts for inventory planning and can also be combined within the BOM. In the following both approaches, the general MRP process and the consumption-based inventory planning, will be outlined.

MRP process

The MRP process starts with generating the system's input data, which are the independent demands for all final products as well as all low-level materials with direct market demand (e.g. spare parts). The independent demands are generated in the Master Production Schedule (MPS) ; further discussion about master production scheduling in advanced planning and scheduling systems can be found in Stadtler and Kilger (2007). To determine the independent demands, either only customer orders are collected or customer orders and additional forecast values are added. The prerequisite for a Make-To-Order policy for final products, where only customer orders are collected and no forecast has to be conducted, is that the accepted delivery time by the customer is greater or equal to the actual lead time of the product. In many situations, however, the lead time is greater than the accepted delivery time, thus a mixed Make-To-Order/Make-To-Stock policy has to be applied by splitting the BOM in two or more parts and conducting MRP runs for each BOM part separately, including the gross requirements determination. This is usually done by a forecast which has to be conducted to plan prior to the actual customer orders as discussed in Silver et al. (1998). Forecasts can be conducted either on qualitative or quantitative (historical demand data) information. Finally, the forecasted and, if available, the already received customer orders are added to the Master Production Schedule. The following figure shows a production situation where the maximum accepted lead time by the customer (seven days) is greater than the lead time of the whole BOM (14 days). Thus, the BOM has to be split at the lowest possible level to allow for the lowest possible inventory holding cost; this level represents the interface between MTO and MTS (push/pull interface).

For the top level SKUs of each BOM part, the independent demands and customer orders are determined and fixed in the Master Production Schedule for the planning period. Once the independent demands are planned in the MPS, the MRP procedure is launched. For each material, starting from top in the BOM, the following steps are conducted (Hopp and Spearman (2001)):

1. **Net requirements calculation:** Determine the net requirement by subtracting on-hand inventory and outstanding orders from the gross requirement. The gross requirement equals the determined requirement from the MPS for the top level BOM materials and through BOM explosion for the lower level materials.

2. **Lot-sizing:** Divide the net requirements in appropriate lot sizes for production or procurement.

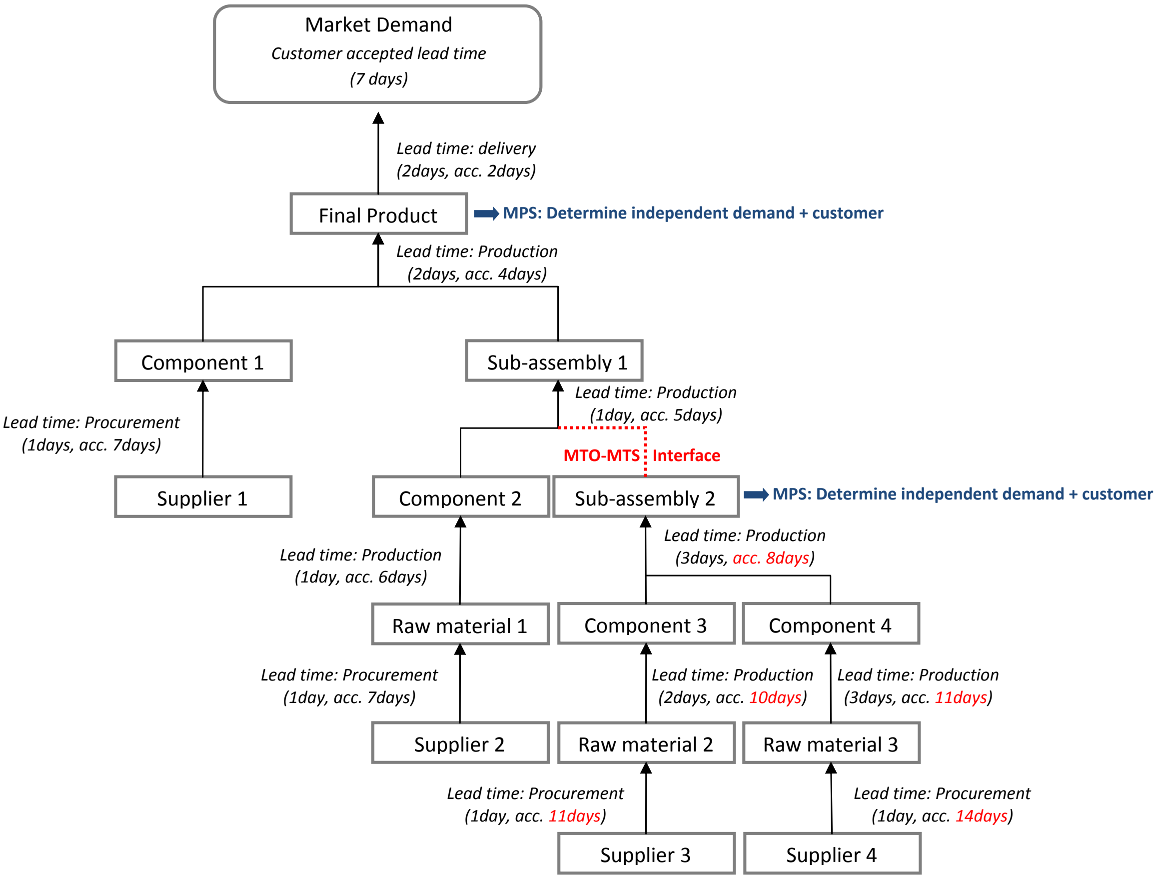

Figure 1: Example of a BOM splitting when production lead time is greater than the customer accepted lead time

3. **Time phasing:** Determine start dates for production and order dates for procurement given the due dates of the net requirements and the lead times.

4. **BOM explosion:** Use the start dates, lot sizes and the BOM to generate gross requirements of any required components at the next lower level.

5. **Iteration:** Repeat these steps until all levels are processed.

For an appropriate design of an MRP system, decisions have to be made in several areas (Figure 2):

1. **MRP strategy:** Given basic information such as the BOM structure, lead times, accepted lead time by the customer, production requirements, capacity restrictions etc., BOMs might have to be split and then an appropriate MRP strategy (MTS, MTO or a combination) has to be chosen.

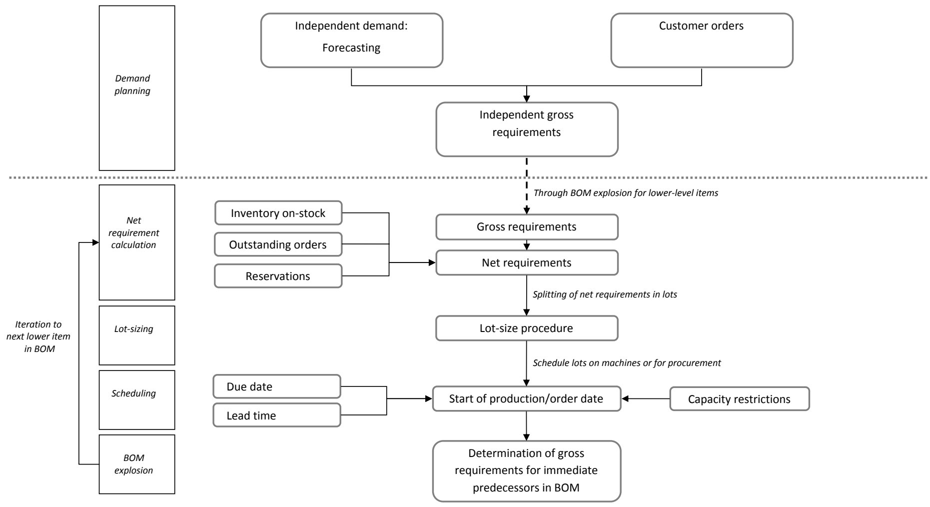

Figure 2: The MRP process

2. **Forecasting:** If a forecast has to be conducted, an appropriate forecasting method has to be chosen, including qualitative or quantitative methods.

3. **Safety stock:** Additionally to the forecast, a safety stock usually has to be planned to assure a set target service level. For products that experience independent demand, this safety stock has to cover demand variability, lead time variability as well as additional uncertainties that might arise. For lower level items, no safety stock is planned; however, if there is considerable lead time variability or other variability, a safety stock is planned to account for these uncertainties. The choice of the safety stock method can have substantial impact on the inventory performance of the whole MRP system.

4. **Inventory policy:** How the net requirement is determined and when to set an order (type of stock review policy) is determined by the chosen inventory policy.

5. **Lot-sizing:** The net requirements are split into lot sizes to assure feasible lot sizes (consider minimum, maximum and fix lot size restrictions) as well as to balance order versus inventory holding costs to reduce overall inventory cost.

6. **Job scheduling and capacity management:** In a production context the orders have to be planned in a feasible and cost-optimal sequence for each machine to allow for low overall production and inventory costs.

Consumption-based material planning process

The consumption-based inventory planning process is simpler than the MRP process, as interrelations between SKUs based on the BOM are ignored. Each SKU is treated independently from the others. Thus, a forecast has to be conducted for each SKU with a lead time greater than the accepted market lead time. If the lead time is shorter than the accepted lead time by the market, then no inventory is held except for safety stocks to cover lead time variability. Production or procurement only takes place when internal or external orders arrive. This approach is usually chosen when the inventory planning and control costs will be kept at a minimum.

The following figure shows a simple consumption based inventory planning process:

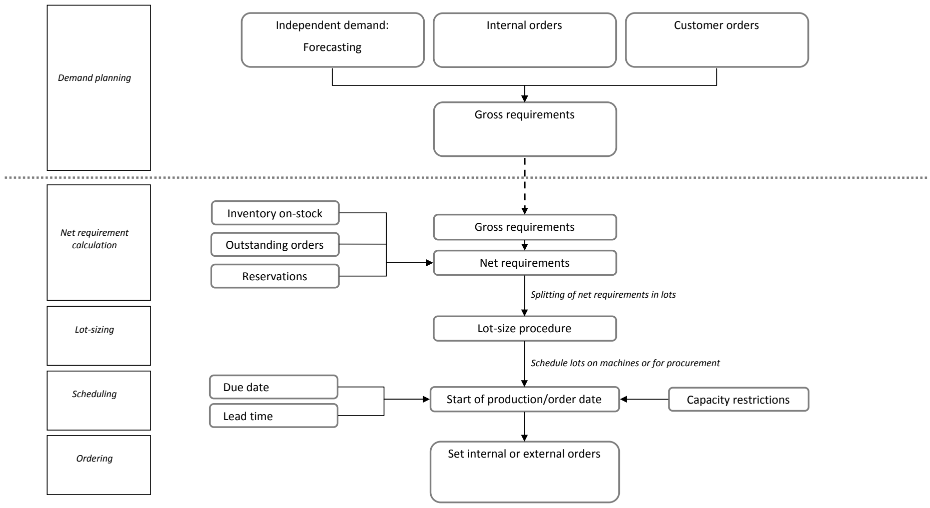

Figure 3: The consumption-based process

Depending on the lead time compared to the market accepted lead time, a forecast has to be conducted and/or internal orders and customer orders are considered. Then the net requirement calculation follows, then lot-sizing, scheduling and the placing of internal and external orders. The connection between BOM-related SKUs is only accounted for by orders; there is no central planning.

The following section discusses how the inventory planning and control process is implemented in SAP ERP and SAP APO.

2.2 Material Planning Process in SAP

Inventory planning and control in SAP can be conducted using the transaction based ERP software of SAP, SAP ERP or for more functions, the planning system SAP APO (now SAP SCM). When both systems are available, combinations of the modules in both systems can be used for the inventory planning as well. The following figure shows the inventory planning and control modules in SAP ERP and SAP APO; the systems can communicate with each other (data transfer) via the CIF (Core Interface) system.

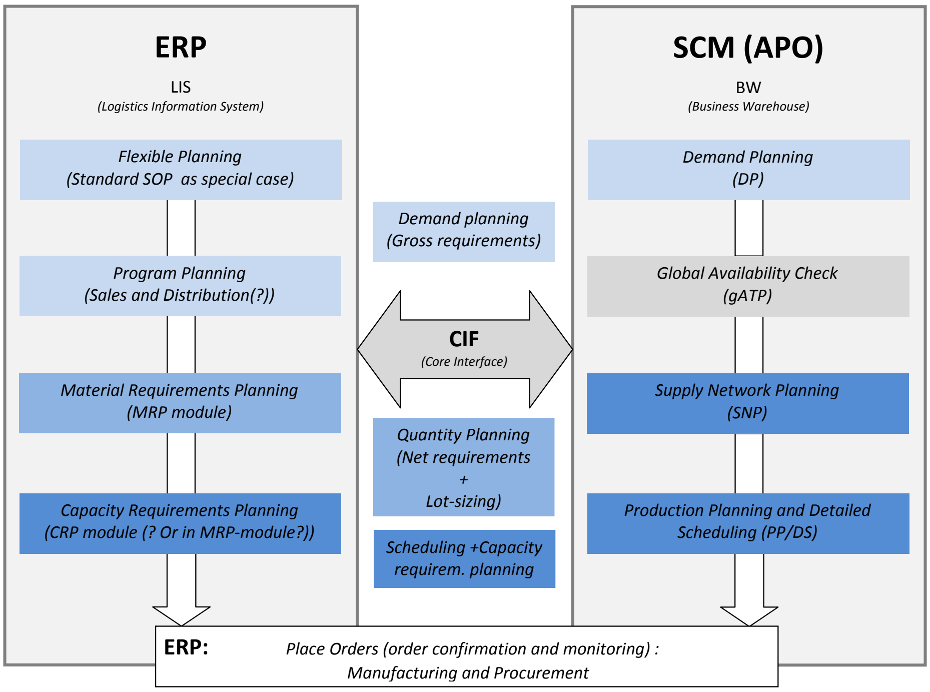

Figure 4: The Material Planning Process in SAP ERP and APO

The material planning process in SAP is very similar to the general MRP process as outlined in the previous section. The first step is the determination of the gross requirements for all BOM top level SKUs (program planning or Master Production Schedule). As already mentioned, if consumption-based inventory planning is chosen, then the gross requirements must be determined in the first step as well, disregarding their position in the BOM. In SAP, the gross requirements are determined by using forecasts and/or customer orders. The forecasts can be conducted in the SAP ERP module 'Flexible Planning' with 'Standard SOP' (Sales and Operations Planning) being a special method of 'Flexible Planning'; the forecasts are based on historic demand data, which is retrieved from the Logistics Information System (LIS) . In SAP APO the forecasts are conducted in the Demand Planning (DP) module , which draws the input data from the internal Business Warehouse (BW) . This module offers a much wider range of methods and functionalities than SAP ERP does. The dependent demands, i.e. the customer orders, are recorded in the Sales and Distribution area of SAP ERP (as orders are transactions). Once the gross requirements are determined, a global Available-To-Promise (gATP) can be conducted in SAP APO on the sales order. The ATP function implemented in SAP ERP can do a single-level check, however SAP APO offers more functionalities such as multi-level ATP checks, ATP checks across the whole Supply Chain Network and rule-based checks; further information about the ATP functionalities can be found in Gulyassy et al. (2009). Another intermediate step between demand planning and the MRP run is to use the SNP (Supply Network Planing) module in SAP APO to assign and plan the independent demand requirements and already received sales orders to production plants and procurement and to take stock transfers into account Dickersbach (2009). Thus, the primary demand is allocated to a production plant or procurement (i.e. supplier). Now, for quantity planning, the MRP run can be conducted in the ERP MRP module for each plant. Through BOM explosion the gross requirements are determined for all BOM levels; additionally lot-sizing and scheduling disregarding capacity restrictions can be conducted. The quantity planning can also be performed in SAP APO with additional functions. Scheduling and capacity requirements planning can be executed either in SAP ERP or SAP APO. If a finite production plan is to be determined, then the capacity requirements planning in SAP APO offers considerably more functions including the capacity planning table, detailed scheduling heuristics and an optimizer system using CPLEX, which is presented by Kallrath and Maindl (2006) in detail. Finally, order conversion and monitoring (processing of external procurement and manufacturing orders) is conducted, whereas orders for external procurements are executed in the SAP ERP module Materials Management (MM) which is in the Procurement area of SAP ERP, and orders for internal production are scheduled and monitored in the SAP ERP module Production Planning (PP) which is in the Production area of SAP ERP.

In the presented modules that make up the material planning process in SAP, several parameters have to be set for each material or material groups to allow for an adequate planning and cost-efficient material planning process. Important parameters in SAP will be presented in the next section.

2.3 Important Parameters in SAP ERP and APO to conduct the Material Planning Process

In the previous sections, the structure of the material planning process has been outlined, and the SAP modules in SAP ERP and SAP APO, with their basic function for the material planning process, have been presented. In the concerned SAP material planning modules several parameters have to be set for each material or material group to design the material planning process. For each parameter setting there is a choice of numerous methods implemented in SAP ERP and SAP APO. The choice of the parameter setting determines the customer service level (CSL) and the inventory cost. Therefore, choosing the right setting when running SAP as material planning and control system is the most important part of material planning. It has already been stressed that due to the high number of materials to be planned in a company, the high number of parameters to be set and the numerous methods that can be chosen for each parameter make the parameter setting a very difficult task. In companies usually two problems arise. First, due to the high number of materials to be planned one parameter setting is usually applied for material groups consisting of several hundreds or thousands SKUs. The special features of a SKU are therefore not always accounted for, as an individualized material planning process for each SKU is not generated. The second problem that often arises is that the material planner does not exploit the whole potential of the methods implemented in SAP as some of the functionalities and application of several methods might not be familiar to the planner. Thus many methods, which might lead to better results in terms of CSL and inventory costs, are often ignored when setting the parameters for material planning. In the following, five important parameters for the material planning process are presented and four of them will be considered for the development of an automated decision systems for the parameter setting in Section 3.

1. Parameter: MRP strategy

In SAP the MRP strategy parameter for a single material, material group or a whole or part of a BOM represents the basic structure about how the material planning process is conducted. This is a long-term parameter setting, as the name 'MRP strategy' suggests, and the basis for the subsequent parameter settings. Therefore, it is very important to set this parameter in an economically sensible way. As Hoppe (2006) states, the main decision when setting this parameter is to decide about whether to use a customer-independent make-to-stock (MTS) planning strategy, meaning that production and procurement for all materials takes place before demand occurs. Choosing an MTS strategy affects the choice of the forecasting parameter as a forecast is needed for the market demand or possibly a make-to-order (MTO) planning strategy is selected with a sales-order-related production and procurement as orders are only submitted once market demand is observed, i.e. customer orders are received. Using an MTO strategy implies that no forecast is needed as material planning is only based on received customer orders (only dependent demand is considered, no independent demand is planned).

In practice, mixed strategies, combinations of MTS and MTO strategies, are often applied. The materials on the higher levels of the BOM are planned based on customer orders to allow for customization and low inventory costs; however, lower BOM level materials are planned before customer orders arise (MTS) to shorten the total lead time of the final product. Thus, when setting the MRP strategy parameter to a mixed strategy, it must be decided on which BOM level to place the MTO-MTS interface (customer order decoupling point). This concept of BOM splitting has already been discussed in Section 2.1. Several more decisions have to be made when setting the MRP strategy parameter; these will be discussed in detail in Section 3.

2. **Parameter: MRP procedure**
   For the material planning process, it has to be decided which basic procedure in SAP shall be used. As mentioned before, the MRP procedure (deterministic, plan-driven procedure) or the consumption-based procedure can be used. A special form of the MRP procedure is used by the Master Production Scheduling (MPS) procedure, where the first master schedule items are planned with special care in a first planning run to determine the MPS. This generates the dependent requirements for the BOM levels directly under the MPS planning level. Material planning below these levels are not conducted in this planning run; once the MPS run is conducted, an MRP planning run is conducted for the planning of the remaining lower-level items. As can be seen, the right setting of the parameter MRP procedure highly depends on the setting of the MRP strategy parameter. There is a strong relationship between the production type (MTO, MTS and mixed strategies) and the applicability of an MRP procedure (MRP, MPS and consumption-based planning). Additional decisions have to made when choosing the parameter setting for MRP procedures; these will be outlined in detail in Section 3.

3. **Parameter: Demand planning and forecasting**
   As mentioned before, in an MRP process, demand planning only takes place for the top-level materials of each BOM (whereas BOMs can be split). Additionally, demand planning is conducted for all consumption-based materials; however, consumption-based demand planning usually follows a simple reorder policy. There are three combinations of demands that can be planned: (customer-order) independent requirements, customer order requirements, or both, as discussed by Hoppe (2006). Once the parameters for MRP strategy and MRP procedure are set, it can be determined from these parameters which type of the three demand planning methods has to be conducted for each material. Demand planning for lower BOM-level materials is not conducted explicitly when using the MRP or MPS/MRP procedure, as these dependent demands are determined through the BOM explosion in the MRP process.

   When only dependent demands are planned (usually implying a strict MTO strategy is in place), no forecast has to be conducted. Only customer orders are considered for production and procurement, which are retrieved from SAP-ERP as already explained. However, if only independent demands are planned (implying a strict MTS strategy) or independent and dependent demands have to be considered for the gross demand planning, then a forecast has to be conducted to estimate future demand (independent demand). SAP-ERP and SAP-APO offer numerous quantitative and qualitative forecast methods. The main concern of the Demand Planning and Forecasting parameter is therefore the choice of an adequate forecast method. As Gulyassy et al. (2009) point out, in SAP APO a decision system is already in place to support the material planner in choosing a good forecasting method. Therefore, a new decision system is not developed for this parameter in Section 3.

4. Parameter: Safety stock

Safety stock planning is an important part of material planning when variability in terms of demand variability and/or lead time variability occurs. So, whether a safety stock has to be planned or not depends on whether a material experiences uncertain demand and/or uncertain lead times. Safety stock for uncertain demand has to be carried only when a forecast is conducted for a material, that is, when it is (partly) planned based on independent demand requirements. Materials for which no forecast is conducted, no safety stock has to be planned explicitly to cover demand uncertainties. Through BOM explosion, required safety stocks are already implemented in the upper-level materials, which experience uncertain market demand. However, lead time variability states another source of uncertainty, which all materials can be subject to. Thus, a (usually relatively small) safety stock or safety time to cover lead-time variability of a material might have to be planned.

Safety stock planning is a very important tool to achieve a set target customer service level (CSL), and so the choice of the safety stock planning method, which is the setting of the safety stock parameter in SAP, has a big impact on the service that is delivered to the customer. Additionally, the cost aspect of holding safety stock also is a critical aspect when setting the safety stock parameter as safety stock holding cost can become a substantial part of the total inventory holding cost. It is therefore important to balance holding cost and the service level in an economically sensible way.

In SAP-ERP and SAP-APO, dynamic (time dependent) and static (time independent) safety stock procedures can be chosen. Further, the methods can be divided into time-range of coverage methods and order cycle period methods and combinations of these. As will be discussed in Section 3, there is a strong interdependence between the safety stock and the lot-sizing parameter as both parameters have critical impacts on the inventory costs.

5. Parameter: Lot-sizing:

Once the net requirements, including the safety stock, are determined for a material, the net requirement will be split or merged into lots. There are two reasons for the splitting or merging into lots: in the academic inventory research the balancing of the order or setup cost and inventory holding cost is the focus of lot-sizing; additionally capacity restrictions and material flow as well as additional lot size constraints often given by the supplier (minimum, maximum or fixed lot size) or due to technical reasons (delivery in pallets) have to be considered for the planning and scheduling.

In SAP, numerous methods for lot-sizing are available. These can be divided into static lot-sizing methods, periodic lot-sizing methods and cost optimizing lot-sizing methods. Further, functionalities such as additional long-term (periodic) lot size planning, final lot size for the last order of discontinued materials and lot size splitting and overlapping are available and will be discussed in detail in the following section.

The presented parameters include the most important decision areas in the context of material planning, such as MTS versus MTO, consumption-based vs demand-driven and the standard modules of a (single-echelon) inventory system forecasting, safety stock and lot-sizing. The setting of these parameters to derive an adequate material planning system can be a complex task as the parameters are interrelated and numerous settings are available for each parameter. In the following section a decision system for each parameter will be presented to support the material planner in designing an adequate material planning system and/or allow for an automated setting for each material (when using SAP-ERP and SAP-APO). As a decision support system for the forecasting parameter setting is already in place in SAP-APO, the forecasting parameter is not considered in the following.

3 Decision Systems for the Material Planning Parameters

In the following decision systems are presented that allow an automated configuration/selection of methods for each parameter.

3.1 MRP Strategy

In the following, the decision system for the MRP strategies available in SAP ERP and SAP APO is presented. Four main decision levels have been identified:

1. **Production type:** The principal decision of the MRP strategy is the choice of the production type; in SAP it can be chosen from the five types MTO (Make-To-Order), MTS (Make-To-Stock), ATO (Assemble-To-Order), ETO (Engineer-To-Order) and STO (Service-To-Order). This strategic (long-term) decision about how to plan the material is usually derived from the nature of the industry, customer expectations and production settings. The production type is therefore seen as a criterion itself.

2. **Product type:** The type of product gives important insights about the position in the BOM of the material; the decision system differentiates several product types including customer specific products, configurable materials, general final products, assemblies and phantom assemblies, components, projects, parts of projects, serial products and services.

3. **Planning of configurable materials:** There are three basic types of planning for configurable materials offered in SAP: material variant, characteristics pre-planning and configurable material.

4. **Planning level in BOM:** The choice of the planning level in the BOM that will be used to determine the requirements of a material is an important decision. It determines the interface of MTS and MTO (customer order decoupling point) in the BOM and therefore the stock-levels as well as the forecast accuracy, which is the main driver of the safety stock level. The planning level is chosen based mainly on the comparison of the lead time with the accepted lead time by the market to allow a stocking level on the lowest possible level in the BOM (implying a low stock value and therefore low holding costs).

The decision system covers 28 MRP strategies of SAP ERP and SAP APO that are frequently used. The four decision levels give a first overview about the types and differences of the MRP strategies. The principle criterion for the choice of MRP strategy is the ‘production type’ that is used. Further, the ‘product type’ as a criterion gives important insights for the strategic material planning decisions. The MRP strategy sets the strategic (long-term) outline in which a material is planned. This involves several important implications about the further material planning process, including whether stocks have to be held at all and at which stage in the BOM, the determination of the pull/push interface in the BOM as well as which level is used for demand planning.

The choice of an adequate MRP strategy is crucial for an efficient material planning process. The numerous possible configurations of the 'MRP strategy' parameter (choice of MRP strategy), however, make it difficult to keep overview when deciding on the setting. The following figure shows the decision system.

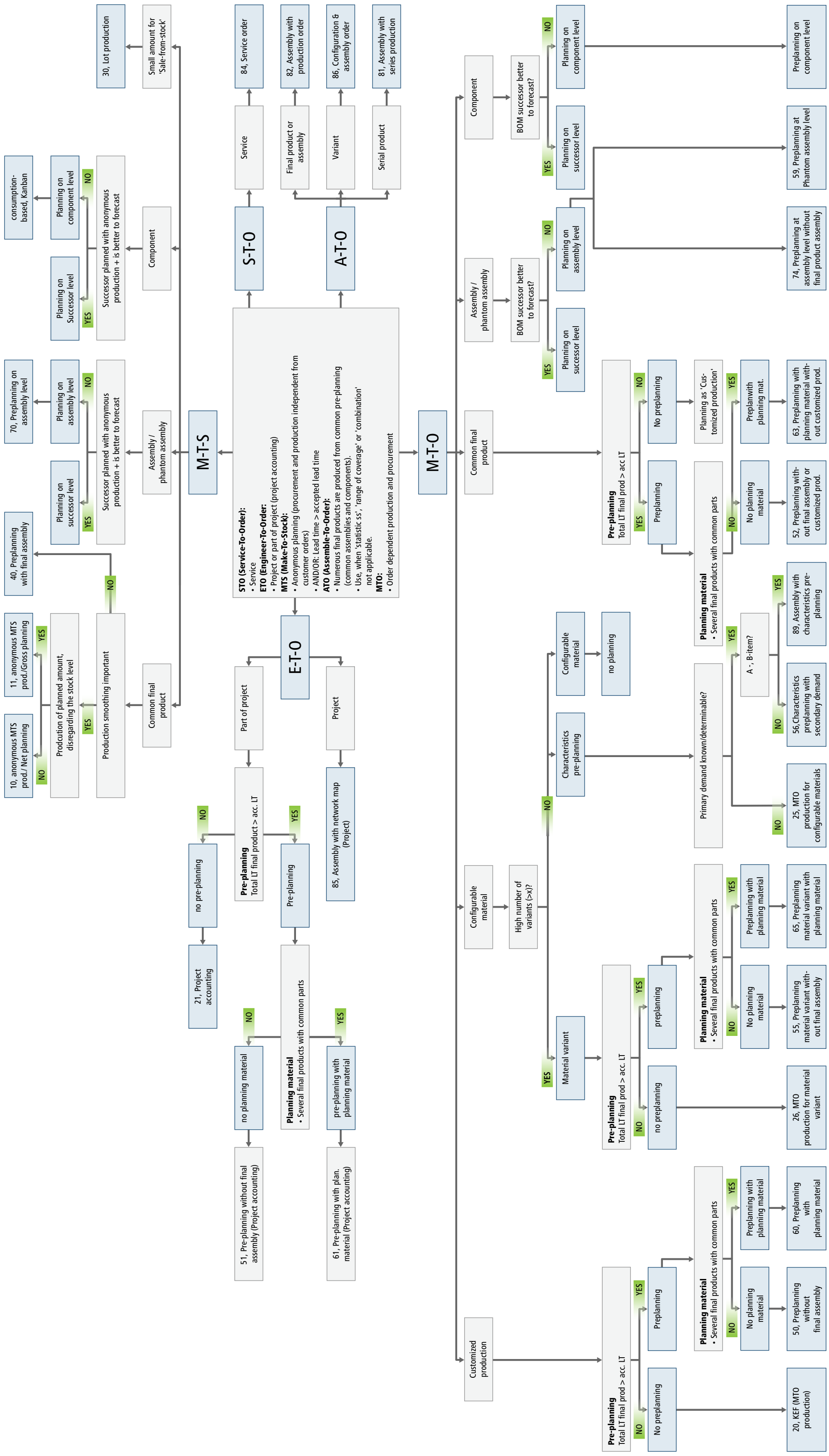

Figure 5: Configuration of the SAP MRP Strategy Parameter
For better viewability, this Figure is available as a separate download at:
`http://www.meiss.com/en/publications/inventory-parameter-configuration-sap.html`

3.2 MRP Procedure

The MRP procedure defines how orders are initiated. The decision system comprises 30 MRP procedures that are implemented in SAP ERP and SAP APO. The MRP procedure is highly interrelated with the MRP strategy and also strongly influences the structure of the material planning process. Important decision levels are:

1. **Demand-driven (MRP) versus consumption-based:** The principal decision when setting the MRP procedure is whether a demand-driven or a consumption-based procedure shall be applied. In general, demand-driven MRP procedures are preferable to consumption-based procedures as forecasts are only conducted for a few BOM levels and only a few BOM levels need to carry stock to account for forecast errors and lead time variability. However, when lead time restrictions are in place due to market expectations, consumption-based procedures might have to be applied for the lower-level BOM items. Further reasons for using a consumption-based procedure are the smoothing of the production to allow for a smoothed capacity utilization and the use of a simplified order system such as KANBAN when material planning and control costs shall be kept at a minimum.

2. **Periodic versus continuous review:** The choice of a periodic or continuous inventory review policy has to be made in the MRP procedure module as well. In general, a continuous policy is preferable to a periodic policy as it allows for more flexibility and immediate reaction on current requirements, as no or little time elapses between an under-stocking situation and a subsequent order. However, a realtime review of stock levels may arise higher control costs or might not be implementable due to organizational restrictions.

3. **MRP with Master Production Schedule:** In the context of demand-driven material planning, demand planning for critical or important materials can be conducted in a first step, the Master Production Scheduling. This first demand planning step allows the planning of the demand of the master schedule materials for a fixed planning horizon with the benefit of decreased planning nervousness in the MRP system.

4. **Supplier managed inventory:** If a customer's inventory shall be replenished by the supplier, SAP offers 'replenishment' MRP procedures allowing a consumption-based replenishment planning for the customer. For external customers, the SAP VMI (Vendor Managed Inventory) module can be used. For demand-driven material planning, the SMI (Supplier Managed Inventory) can be chosen.

The decision system for the choice of an adequate MRP procedure in SAP ERP and SAP APO is presented in Figure 6.

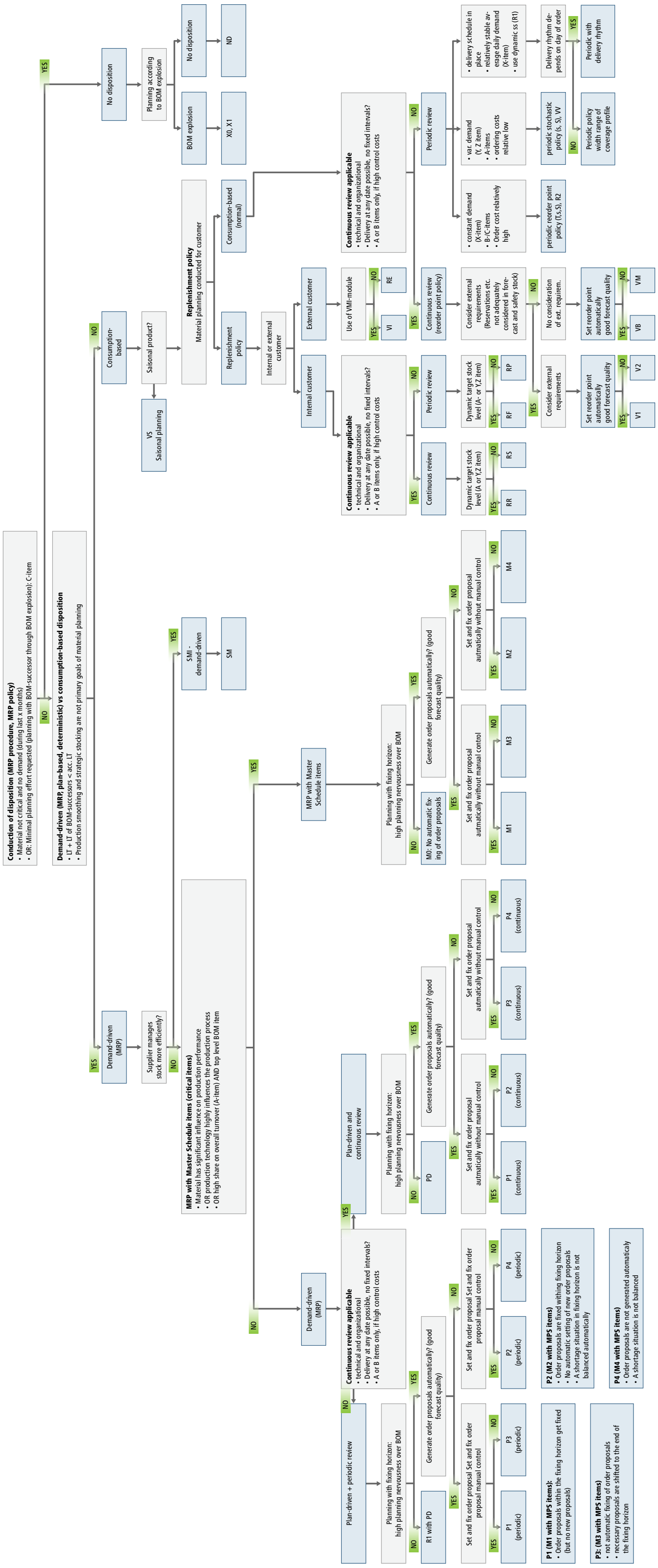

Figure 6: Configuration of the SAP MRP Procedure Parameter
For better viewability, this Figure is available as a separate download at:
`http://www.meiss.com/en/publications/inventory-parameter-configuration-sap.html`

3.3 Safety Stock

The setting of the safety stock parameter has a high influence on the resulting inventory cost. The MRP strategy and MRP procedure design the material planning process for each material. Given the structured planning process, a safety stock method needs to be chosen that leads to minimal costs. The influence on the design and flow of the material planning process of the safety stock parameter is low. The safety stock and lot sizing parameters should therefore be chosen with a strong focus on cost factors. Besides costs, the setting of an adequate safety stock method is also of high importance to achieve a specified service level. In the presented decision system, four important decision levels can be identified.

1. **Static versus dynamic safety stock:** The principal differentiation of safety stock methods is between static (time-independent) and dynamic (time-dependent) safety stocks. Generally, dynamic safety stocks lead to a better inventory performance in terms of costs and service level as the safety stock is determined based on current requirements. The planning effort, however, is usually higher for the material planner as dynamic safety stock methods need steady maintenance. An important exception is the statistical safety stock methods, which can be run in an automated way. Static safety stock methods may be used when the additional planning effort for dynamic methods can not be justified due to low holding costs or a poor service level when the material is of lower importance. Static safety stock methods are preferable for lower value materials and low demand and lead time variability, e.g. in a KANBAN system. Dynamic methods are preferable for higher value materials and for materials with higher demand and lead time variability.

2. **Range of coverage versus order cycle safety stock:** In SAP, alternatively to the common order cycle safety stock, a range of coverage safety stock can be selected. This method is preferable when safety stock is held mainly for the protection against lead time variability, as it is measured in safety time.

3. **Statistical safety stock methods:** As mentioned before, statistical safety stock methods are automated dynamic methods and therefore require limited planning maintenance. In SAP, the Normal distribution and the Poisson distribution (in the Spare Parts Planning module (SPP)) are implemented. Based on a target service level, the required safety stock is determined by the system. The alpha service level or the beta service level can be chosen as service level measures. As stated by Tempelmeier (2006), the alpha service level, as an event oriented measure, should be chosen when stock-out costs have mainly fix cost elements, whereas the beta service level, as an

amount oriented measure, should be used when the stock-out costs have mainly variable cost elements.

4. **Position in product life cycle:** The position of a material in its product life cycle is important for the safety stock level, as new, old and established products require different planning. Additionally, materials with seasonal demand require special treatment.

The decision system considers 14 safety stock methods implemented in SAP.

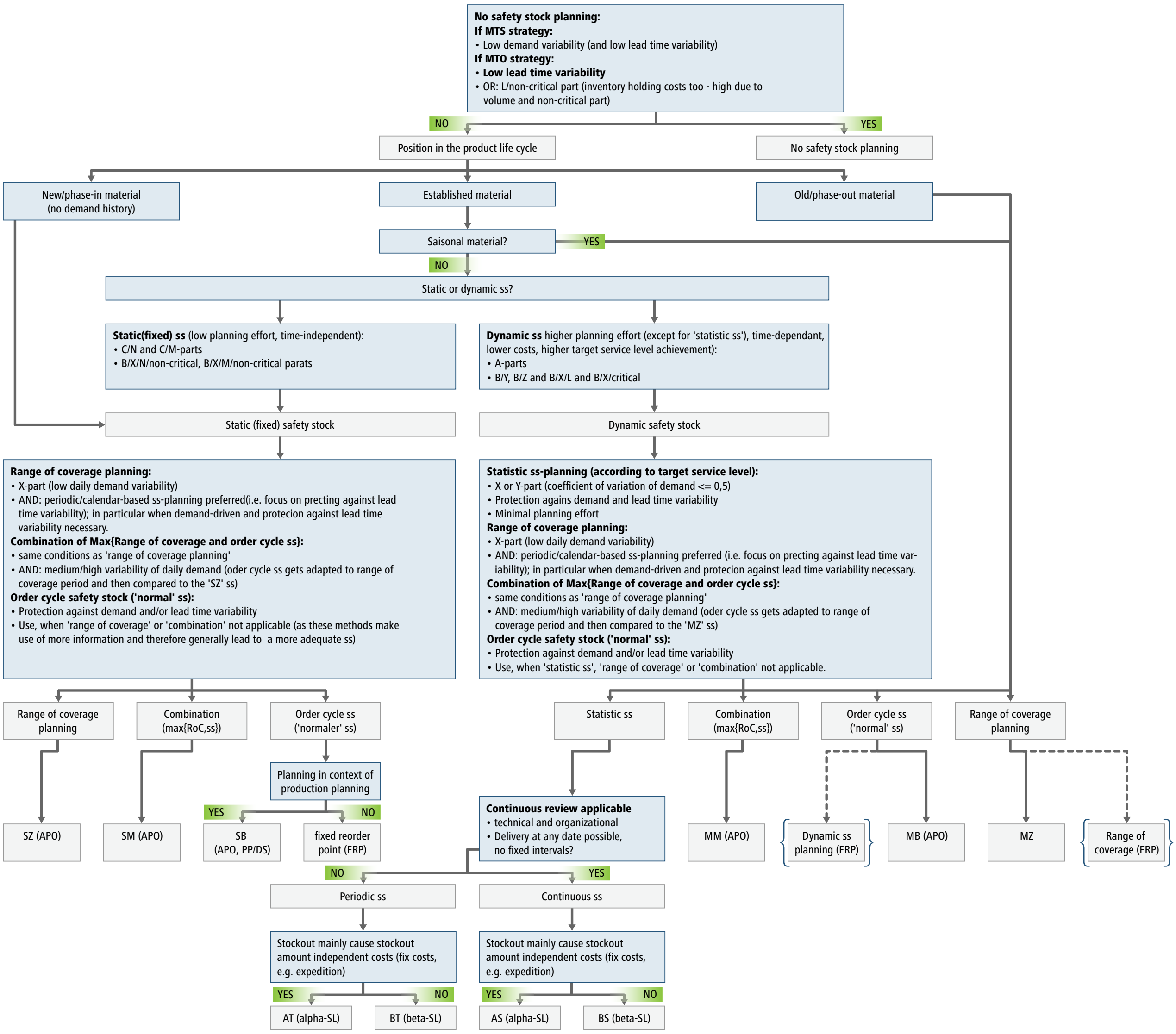

Figure 7: Configuration of the SAP Safety Stock Parameter
For better viewability, this Figure is available as a separate download at:
http://www.meiss.com/en/publications/inventory-parameter-configuration-sap.html

3.4 Lot-sizing

The lot size parameter determines, given the structured (or designed) material planning process, how net requirements shall be combined into orders. As the safety stock parameter, the lot sizing parameter has a strong cost focus. The principal idea of lot sizing is to balance ordering cost with inventory holding cost and therefore decrease overall inventory cost. The main decision levels of the lot size parameter are:

1. **Static, periodic or optimizing lot size:** The principal decision for the lot size parameter setting is to decide on whether to use a static, periodic or optimizing lot size method. The ‘optimizing lot size’ methods are generally preferable as they offer a scientific optimal method and are well established and tested in practice. However, when cost factors (i.e. holding cost and ordering cost) are not available or demand variability is too high, a periodic or static method has to be chosen. The periodic length for a lot size method can be chosen either in common time units, e.g. daily or weekly, or according to the accounting period or planning period. ’Replenishment up to maximum level’ is a special form of the static lot size, which is to be applied when storage space is limited, e.g. tanks or silos, and the inventory holding costs per material unit are negligible compared to the order cost. Further, this lot size method is applicable for low value materials with a relatively constant demand (also for KANBAN planning). All materials, for which the optimizing methods, periodic methods and ‘replenishment up to maximum level’ are not applicable, are planned according to the exact lot size method, where only the set lot restrictions are considered and no additional required consolidation is conducted (i.e. no additional balancing of ordering and holding costs). The remaining materials are usually mid and low items with highly variable demand. For the mid-value items, a frequent manual update of the lot size by the material planner is recommended.

2. **Position in product life cycle:** As presented in the safety stock decision system, new, old, and seasonal materials need special treatment.

3. **Planning with lot splitting and overlapping:** SAP offers the ‘splitting and overlapping’ function for all lot size methods, which is recommended when lots are large relative to the available capacity; production planning of split lot sizes increases flexibility, throughput and WIP (work-in-process) as batch sizes are decreased.

4. **Long-term periodic lot size planning:** In some cases production planning or the supplier require the quotation of long-term lot sizes in order to conduct capacity planning, material pre-planning and reservations. For this case, SAP offers the additional use of a long-term lot size planning method. For the long-term lot size planning, all

periodic lot size methods are available. The period length is chosen based on the requirements of the production, supplier, controlling or any other addressees.

The following lot size decision system considers 16 methods implemented in SAP ERP and SAP APO.

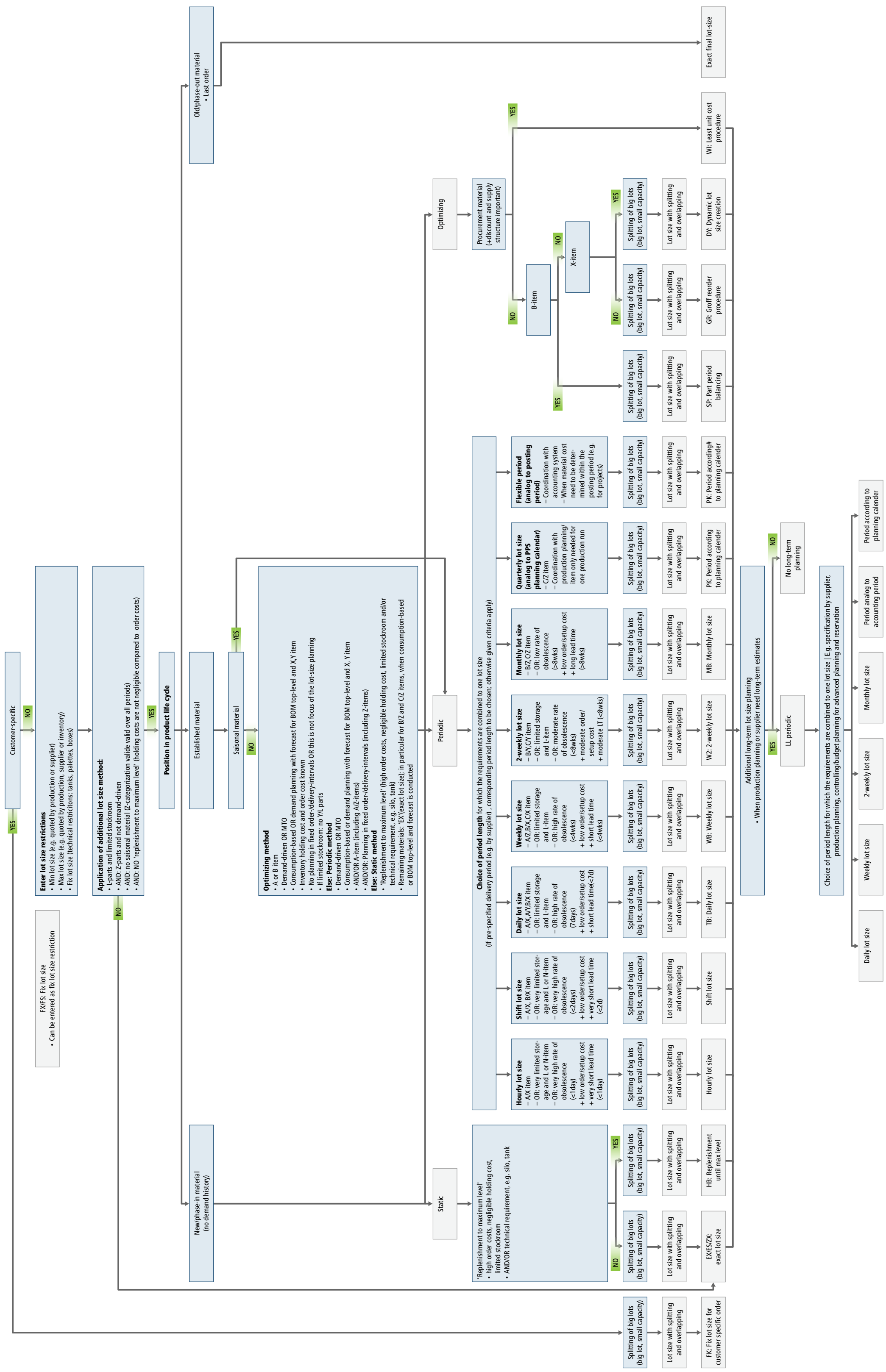

Figure 8: Configuration of the SAP Lot Sizing Parameter
For better viewability, this Figure is available as a separate download at:
`http://www.meiss.com/en/publications/inventory-parameter-configuration-sap.html`

The four presented decision systems give a structured overview of the available inventory methods in SAP for each parameter. As these parameters are complex and linked to one another, decisions taken in one parameter might affect decisions in following parameters. Further, same or similar criteria are used in the different decision systems, which might give rise to a simplification or merging of the decision systems to one system. Interrelations and further insights will be discussed and outlined in the following chapter.

4 Analysis of the Decision Systems

The complexity of the decision systems, their interrelations and applied criteria will be discussed in the following.

4.1 Interrelations of the Decision Systems and Overview of Decision Criteria

In the decision systems for the four material planning parameters, 51 criteria are used. The following table shows which criteria are used for which parameter. Some of the criteria are used in combination with each other for a decision in the system, which leads to this relatively high number of applied criteria. As indicated in the table, twelve criteria were identified as being of major importance, including the common ABC, XYZ and LMN (large, medium and small volume item) analysis as well as inventory cost factors such as holding cost and order cost. Further, the criterion 'criticality' implies that the material plays a critical role in the production process or for the final product or that the material has a critical supply chain. Critical materials might require special treatment when determining the safety stock; further the criticality can be accounted for already in the material planning layout of the MRP process, the MRP strategy. Further materials which require special treatment are 'old' and 'new' materials, which are identified by the criterion 'position in product life cycle', as well as materials with seasonal demand.

	Criteria	Classification fuction	MRP strategy	MRP procedure	Safety Stock	Lot Sizing
Important/frequent criteria	**ABC classification**			x	x	x
	XYZ classification			x	x	x
	LMN classification				x	x
	Lead time variability				x	
	Criticality (of material)		x		x	
	Position in product life cycle				x	x
	Saisonal material			x	x	x
	Forecast quality			x		
	Required planning effort (low)			x	x	
	Continuous vs periodic review			x	x	
	Order cost			x		x
	Holding cost					x
MRP strategy criteria	Production type	STO, ETO, MTS, ATO, MTO	x			
	Product type	Customized product, configurabel material, common final product, (phantom) assembly, component, (part of) project, service	x			
	BOM successor better to forecast	BOM planning level	x			
	Total LT of final product > acc. LT	Conduct preplanning	x			
	Several final products with common parts	Using planning material	x			
	Configurabel materials					
	High number of variants (>x)?	Material variant vs characteristics planning	x			
	Primary demand known/ determinable	MTO for configurable materials vs characteristics preplanning with secondary demand	x			
MRP procedure criteria	Material not critical	Conduct disposition		x		
	No demand during last x months			x		
	LT + LT of BOM successors > acc. LT	Demand-driven vs consumption based disposition		x		
	Production smoothing and strategic stocking are not primary goals			x		
	Demand-driven MRP					
	Supplier manages stock more efficiently	Supplier managed inventory		x		
	Material has significant influence on production performance	MRP with Master Schedule items		x		
	A-item (High share on overall turnover)			x		
	Production technology highly influences the production process			x		
	Continuous review feasable (technical and organizational)	Continuous vs periodic review		x	x	
	A and B items only (if high control costs)			x	x	
	Delivery at any date possible, no fixed intervals?			x	x	
	High planning nervousness	Planning with fixed horizon		x		
	Automatic order proposals are of good quality	Use automatic order proposals		x		
	Fix order proposals automatically without manual control	Fix order proposals automatically without manual control		x		
	Consumption-based					
	Material planning conducted for customer	Replenishment policy (Vendor managed inventory)		x		
	Internal or external customer	External: use VMI module		x		
	Reservations etc not adequately considered in forecast and ss	Consider external requirements		x		
	Delivery rythm important (planning in fixed order/delivery intervals)	Disposition with range of coverage or delivery rythm / range of coverage lot size		x		x
Safety stock	Planning in context of production planning	use APO PP/DS module			x	
	Stockouts mainly cause stockout amount independent costs (fix costs, e.g. Expedition)	Alpha vs beta service level			x	
Lot size criteria	Customized material	Customer specific lot size				x
	Lot size restrictions	min, max, fix lot size restrictions				x
	Restricted stockroom focus of planning	LMN analysis considered				x
	technical lot size requirement	silo, tank - replenishment to maximum level				x
	Procurement material	WI: Least unit cost procedure				x
	Relatively small capacity compared to lot size	Splitting of big lots				x
	Production/supplier requires long-term lot size planning	Additional long-term lot size planning				x

Figure 9: Criteria Overview

The MRP strategy sets up the material planning structure in which the planning process will take place. This parameter mainly draws on given conditions, involving minor managerial decisions and therefore makes use of only eight criteria, seven of which are used for this parameter exclusively. This implies a rather low dependance on other parameters; however, the following parameter decisions heavily depend on the decisions undertaken in the MRP strategy. For example, the BOM level chosen as the planning level will have an impact on the forecast quality, as materials in the BOM might experience different demand variability.

The decision system for the MRP procedure parameter represents the most complex system, involving 22 criteria, 12 of which are used exclusively for that parameter. This is due to the function of this parameter, which is filling the planning framework given by the MRP strategy with detailed planning and control procedures, e.g. decisions about applying SMI or VMI, using a Master Production Schedule, a continuous or periodic review policy or fixed planning horizons. This multitude of decisions to design a detailed material planning process leads to a high number of criteria used. The MRP procedure parameter is influenced by decisions taken in the MRP strategy module. Further, it has seven criteria in common with the safety stock module, which suggests that similar decisions have to be made in both modules. As the MRP strategy and MRP procedure parameters together form the (detailed) process design of the material planning run, both strongly influence the safety stock and lot-sizing parameters.

The safety stock and lot sizing parameter have, unlike the planning process designing MRP strategy and MRP procedure parameters, a stronger immediate cost focus. While assuring a high service level, the goal in these two parameters is to minimize inventory costs. The ABC- and LMN-analysis are therefore important criteria in both decision systems. The lot-sizing decision system directly draws on the order and holding costs, which is a sign of the very strong cost focus of the lot size parameter. The safety stock parameter needs to assure a determined service level, and therefore, criteria representing the level of demand and lead-time variability are important. Both parameters have to be configured given the detailed material planning process designed by the two preceding parameters, showing their high dependency on these two parameters. The safety stock and lot-sizing parameters follow similar goals and hence, are similar in structure and criteria used; the dependencies between these two parameters, however, are limited.

4.2 Implementation of the Decision System in SAP ERP/APO

Before planning an implementation of the decision systems in SAP, these systems should be tested in the context of various industries and supply chain designs to assure that the systems configure adequate material planning systems for a wide range of different materials. Next, the additional information cost incurred by providing the necessary input data for the decision systems needs to be evaluated and compared to the potential cost savings of having the material planning systems configured automatically by the system. As discussed in the previous section, 51 criteria need to be applied for the conduction of all four decision systems. That implies that a lot of information has to be stored and maintained in the Material Master for the decision systems to work. The following table gives insights about which information needs to be maintained for which criteria.

Data	Criteria	Drawing from other criteria
Compulsory data entries		
cost/value per unit	ABC classification	C-item: low planning effort required
historical demand data	XYZ classification	X-item: good forecast quality (or use MAPE)
		primary demand known (MTO) / determinable (good forecast quality = X-item (or use MAPE))
		automatic order proposals are of good quality (good forecast quality (X-item or MAPE))
		fix order proposals automatically without manual control (automatic order proposals are of good quality (good forecast quality (X-item or MAPE)))
	no demand during last x months	
	seasonal material (seasonal demand pattern)	
	position in product life cycle (demand increase, stagnation, fall)	
historical lead times	lead time variability AND total LT of final product > acc. LT	
(market) accepted lead time		
BOM	BOM successor better to forecast (in combination with forecast quality criterion)	
	several final products with common parts	
	production or procurement	
production type	production type	
product type	product type	
Evaluation: continuous review feasable (or: electronic inventory control in place)	continuous review feasable (technical and organizational)	
	A and B items only (if high control costs (e.g. manual control necessary/no electronic system in place))	
Data entries only if relevant/available		
lot size restrictions (if in place) + technical lot size (max replenishment level)	lot size restrictions	
	technical lot size requirement	
(average) order cost	order cost	
inventory holding cost (rate)	holding cost	
storage space requirement (if restricted stockroom of importance)	LMN classification	
	restricted stockroom focus of planning ('yes', when storage space requirement data entered)	
Evaluation: criticality of material (material has significant influence on production performance, production technology highly influences the production process etc.)	critical material	
delivery schedule (if available)	fixed delivery schedule	
number of variants	high number of variants (> x, e.g. 50 or what is not managable manually)?	
production smoothing important (technical requirements), e.g. high production starting cost	production smoothing and strategic stocking are primary goals	
Evaluation: supplier manages stock more efficiently	supplier manages stock more efficiently	
Evaluation: high planning nervousness over BOM levels	high planning nervousness	
Evaluation: material planning conducted for customer (internal or external)	material planning conducted for customer	
	internal or external customer	
Evaluation: reservations not adequately considered in forecast and safety stock (regular, expected demand or rather irregular, unexpected demand (e.g. new customer))	reservations etc not adequately considered in forecast and ss	
Evaluation: stockouts cause mainly amount independent (fixed) costs (if known)	stockouts mainly cause stockout amount independent costs (fix costs, e.g. expedition)	
capacity [per time unit]	relatively small capacity compared to lot size (lot size/capacity[per time unit] > x)	
long-term lot size requirement in place and period length	production/supplier requires long-term lot size planning	
planning with fixed planning horizon: manual control of order setting necessary and possible? (automatic order setting inadequate, enough staff and A or C item)	fix order proposals automatically without manual control (automatic order proposals are of good quality (good forecast quality (X-item or MAPE)))	

Figure 10: Data Overview

Only eight data entries are compulsory to maintain in the Material Master file for each SKU. Additional 16 data entries can be maintained to allow for a wider range of methods to chose from in the decision systems. Out of the 16 data entries, only relevant information in the specific context of a company's inventory and supply chain has to be stored; the decision about how much information to maintain can be made on a SKU basis. Thus, the information requirement can be controlled and kept to a reasonable level for each SKU or SKU group. Further, some decisions can be excluded from the decision systems and be set manually to avoid an overwhelming data maintenance effort, e.g. the decision about splitting or not splitting a lot size when the lot size is relatively large compared to the available capacity might be a decision to be done along the operations run.

Some of the 8 compulsory data entries are usually already maintained in SAP, such as 'value per unit', 'historical demand', 'historical lead times' or at least an estimate of the average lead time, and the BOM. Further, some of the optional data entries are usually maintained in SAP as well, such as 'lot size restrictions', 'order cost', 'inventory holding cost' and 'delivery schedule'. Thus, the additional data requirements needed for applying the decision systems might cause limited effort.

The implementation of the decision systems in SAP ERP or SAP APO as an add-on (monitor) tool might be a promising solution to apply the results of this work effectively in SAP for the everyday business. In order to reduce the required effort of an implementation, the decision systems can also be implemented individually. This will incur less work and cost and allow the use of the decision system for the parameters in which the most support is needed by the material planners. As mentioned before, such a decision system for the configuration of the forecast parameter is already in place in SAP. Further, it is possible to exclude some detailed decisions from the decision systems to allow for a rough configuration of the parameter only, leaving some details for manual (group-wise) configuration. This also reduces the data maintenance effort as mentioned earlier.

5 Conclusion and Further Research

The developed decision systems for the configuration of the MRP strategy, MRP procedure, safety stock and lot size parameters in SAP ERP and SAP APO offer high potentials of saving cost and the time of the material planner. Further, the systems are the first to categorize the available methods implemented in SAP ERP/APO for each parameter; the decision systems give valuable insights about which inventory methods are implemented and what their functionalities are. The implementation of the systems can be flexible as they can be applied independently from each other, and several decision steps within each system could be excluded and left for manual configuration to reduce implementation and data maintenance efforts. In the literature, no similar decision systems can be found, making the presented ones the first approach for an automated configuration of the parameters in SAP.

Next steps of this research project could be to implement the decision systems in a software tool and run tests on empirical data. Considering inventories and whole supply chains from various industries can show if the configuration systems deliver adequate configurations of the parameters. Further, the implemented inventory methods in SAP ERP/APO can be examined to identify missing methods or areas with potential improvement. For example, only the Normal distribution can be applied for the parametric safety stock planning; however, current literature in inventory management suggests that the distinguished application of a wide range of statistical distributions for safety stock planning might lead to substantial cost savings and increase of the service level.

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