Production planning follows the same basic principles in both SAP ECC and SAP APO. This chapter provides an overview of planning with the two systems. This is followed by a discussion of the advanced options available to you with APO.

2 An Overview of Production Planning with ECC and APO-PP/DS

Production planning in APO-PP/DS uses the same processes that are familiar from the SAP ECC system. It is based on master data records, specifically plants, material masters, bills of material (BOM), and routings (PP) or master recipes (PP-PI). Planning results in planned orders, which are converted into manufacturing orders for executing production. These may be either production orders (PP) or process orders (PP-PI).

Repetitive Manufacturing (REM) is also possible, whereby production is executed on the basis of planned orders.

2.1 Production Planning Functions

PP/DS is short for Production Planning and Detailed Scheduling. Of course, the objectives of this kind of planning did not originate with APO. Production planning in ECC pursues the same objective, that is, consistent, capacity-based planning. In ECC, these functions are found under Material Requirements Planning (MRP) and Capacity Requirements Planning (CRP).

The basic principles of planning in APO and ECC are outlined below, followed by a discussion of the advanced options in APO.
2.1.1 Material Requirements Planning

The goal of Material Requirements Planning (MRP) is to ensure material availability in good time and in sufficient quantities. Two different procedures can be used:

- **Material Requirements Planning**
  In this case, procurement planning is controlled by material requirements. The requirements consist of sales orders, planned independent requirements, dependent requirements, and so on. Planning is based on backward scheduling from the requirements date to ensure on-time availability.

- **Consumption-Based (Reorder Point) Planning**
  In this case, materials planning is based on consumption. Reorder point planning simply checks whether the available stock has fallen below a defined threshold value or reorder point. Whenever this happens, procurement is planned with forward scheduling.

As you can see, the two procedures are essentially different. Consumption-based planning is usually used for only low-value, non-critical materials (consumable material, for example), while MRP is used for precise planning. Consumption-based planning therefore only plays a secondary role in the context of advanced planning in APO-PP/DS.

**MRP type**
In ECC, you define the MRP procedure in the **MRP type** field in the material master. Typical entries in this field are **PD** for MRP or **VB** for reorder point planning. However, both these entries are irrelevant for planning materials in APO. If a material is planned in APO, it cannot be planned again in ECC. Therefore, you should select the entry **X0** as the MRP type to exclude it from planning in ECC.

There is no MRP type in the APO product master. Planning in APO is essentially "requirement-driven" (i.e., it is based on the MRP procedure described above) unless a different procedure is explicitly chosen by applying a corresponding heuristic.

The starting point for MRP is a requirement for a material in a plant. As a rule, this requirement is in the future. We proceed from the following assumption:

*Material A is required in quantity B on date/at time C in plant D.*
Think of how this applies to a sales order, for example. However, dependent requirements resulting from in-house production can also be formulated in this way.

With backward scheduling for material A in plant D, a suitable procurement element is generated in such a way that the availability date of this element corresponds to the requirements date. The start date of procurement therefore precedes the availability date, and the procurement lead time represents the time interval between these two dates (backward scheduling).

Scheduling of a procurement element depends on the procurement type:

- **In-House Production**
  A routing and a BOM or master recipe is required to produce a material in-house. The in-house production time is the sum total of the durations of the individual operations, plus any additional floats/time buffers.

- **External Procurement**
  If you want to procure a material from an external vendor or to transfer your stock from another location, you must schedule a delivery time.

In the system, these two procurement types correspond to the entries E for in-house production and F for external procurement on the MRP 2 view of the material master (see Figure 2.1). If you enter X here, both procurement types are permitted, but planning initially assumes in-house production.

![Figure 2.1 ECC Transaction "Change Material Master" (Transaction Code MM02, Material Master View "MRP 2" with Field Selection for Procurement Type)](image-url)
You can define the procurement type more precisely by specifying the special procurement type (Special procurement field). For example, you can configure external procurement as a stock transfer from another production location. With external procurement, you can define a vendor-specific delivery time and factor this in your planning.

With in-house production, various dates and times can be defined. The ECC manufacturing order contains both production dates and basic order start and finish dates. Floats separate these dates: the float before production separates the order start date and the production start date, while the float after production comes between the production finish date and the order finish date (see Figure 2.2).

In this context, we must point out the following basic difference between ECC and APO: APO-PP/DS ignores the float before production and the float after production, and APO orders don’t contain basic order start and finish dates. Therefore, you should always enter a scheduling margin key (for example, AP1) with a float before production and float after production both equal to zero for materials that are planned in APO (see Figure 2.3).
2.1.2 Multilevel Planning

With in-house production, you generally use multilevel planning, where the material is produced from other materials that must be available in time for the production process. You can refer to the BOM for information about the required materials. Since a BOM item may be the header of another BOM, planning may encompass several BOM levels. The objective of multilevel planning is therefore to create procurement elements at the right time across all relevant BOM levels (see Figure 2.4). The procurement dates for the assemblies and components are calculated from the BOM structure using backward scheduling from the requirements date of the finished product.

This enables operation-specific material staging.

Multilevel planning uses backward scheduling from the requirements date for the finished product. This means that the start dates for procurement of the required assemblies and components are calculated to ensure that production of the finished product can start on
time. The sum total of these times is referred to as the total replenishment lead time. This is distinct from the in-house production time, which refers only to the time taken to produce individual materials.

Problems may occur with your procurement plan if the requirements date is less than the end of the total replenishment lead time in the future. With backward scheduling, this corresponds to a situation in which the start date for assemblies or components (or even for the finished product itself) would have to be in the past.

Since the system does not create orders in the past, forward scheduling is generally used in this situation. With forward scheduling, the start date of the relevant order is the current date, while the end date is scheduled in the future as the start date plus the lead time of the order. This kind of order is therefore delayed because the requirements date that triggered the order (think of a secondary requirement, for example) cannot be covered in time.

In ECC requirements planning, exception messages normally alert you to this kind of problem. These messages indicate that procurement of a material will be delayed. These delays typically occur in lower-level assemblies, while procurement of the finished product still appears to be on schedule. The exception message is not normally propagated to the relevant finished product. It is the MRP con-
troller's responsibility to identify problematic supply chains using these exception messages and to solve the problem, for example, by changing procurement elements manually or by finding alternatives in the procurement process.

2.1.3 Material Planning and Capacity Planning

In material planning, procurement elements are created with dates that correspond to the requirements situation. This type of planning is based on the individual in-house production times or delivery times of the materials in question.

With externally procured materials, you therefore have to assume that the planned vendor will be able to deliver within the planned delivery time. If in doubt, confirm this with the vendor. You may find that you will need to switch to another vendor with a different delivery time.

The situation is more complex for materials produced in-house. In this case, material planning uses the MRP II concept. This means that material planning is initially based on infinite production capacities, with capacity planning following in a second, separate step. When an order is created, there is therefore no check to determine whether the required work centers or resources are available for the relevant period or are already fully occupied by another production process.

Capacity planning comprises the following steps: First, the available capacity at the work centers (or resources (PP-PI)) is established. For example, it is established that work center A is available for 40 hours each week.

The orders (planned orders or manufacturing orders), on the other hand, have certain capacity requirements, resulting from the routing (or master recipe (PP-PI)). The routing can be broken down into operations. Each operation is assigned a work center, where it can be executed. For example, operation 10 requires work center A for 10 minutes for each piece of the finished product. This means that work center A is required for 50 minutes if you have an order with an order quantity of five pieces. An order therefore contains not only the planned production start and end dates, but also the operations dates, including details of the required production resources, and, in addition, it formulates the corresponding capacity requirement.
The goal of capacity planning is to ensure that orders can be executed, in other words, that work centers are available when required. Capacity planning therefore compares the capacity requirement with the available capacity. Since a work center may naturally be required by different orders for completely different finished products, this comparison is normally carried out as work center-specific.

**Scheduling**

To ensure that a certain order can be executed at a certain time at a specific work center, the order is scheduled. A production resource can only be reserved by an order using scheduling. Scheduling can be performed interactively in a capacity planning table (or detailed scheduling planning board in APO) for individual orders, or it can be executed automatically as a background job. Problems associated with capacity planning can be extremely complex. For example, orders may involve several operations that require different resources. Successful scheduling of one operation at a resource may conflict with the dates of the other operations, and so on.

**Bottleneck resources**

What this means is that capacity planning is restricted to the planning of the bottleneck resources. You therefore must assume that no more than one resource from the routing actually needs to be checked for scheduling conflicts, and have to trust that the remaining operations in the order will work. This focus on bottleneck resources is an important principle in capacity planning and is also integral to ensuring an executable production planning process in the context of APO-PP/DS.

**Finite and infinite scheduling**

If a check is performed to determine the existing production resource load, that is, to determine whether capacity is available or has already been reserved by another order, this is referred to as finite scheduling. The availability checked in this instance is finite. If this check is not performed, this is referred to as infinite scheduling, whereby the available capacity is assumed to be infinite.

**Interaction with requirements planning**

Finite capacity planning generally results in date shifts because time gaps must be found when the bottleneck resources can be scheduled. If a date is brought forward, the availability date of the order is delayed as a result. The deadline of the requirements date of the finished product is missed. If, on the other hand, the order is moved backward in time, the secondary requirements dates for the materials required for production are also delayed, with the result that the
receipt elements cannot cover these requirements in time. In short, capacity planning generally impacts the requirements plan (see Figure 2.5). Operation 0020 shown in Figure 2.5 is executed using the bottleneck resource. The total order is based on the bottleneck resource, which means that the availability date and secondary requirements have to be shifted.

You will need to react to these shifts with a new requirements plan, with which any new orders are generated with the scheduled requirement, and so on.

Material requirements planning and capacity planning are thus closely interwoven. The goal of production planning is to take into account these interdependencies and to create a consistent procurement plan.

To facilitate the planning process, the production plan is often firmed in the short term after capacity planning is completed. Individual orders or all orders can be firmed in a defined planning time fence. Firming means that the dates and quantities of the orders cannot be changed automatically; however, they can still be changed manually. The component requirements used for an order can also be firmed. This is useful if the required components are manually changed for an order in a way that deviates from the BOM explosion, with the result that a new BOM explosion is no longer possible.
2.2 Advanced Production Planning with APO-PP/DS

The previous section discussed the basic principles of production planning with SAP, which apply equally to ECC-MRP and APO-PP/DS. Even if you use APO-PP/DS, you still need to make the basic settings for the production planning process in ECC, so that you can then systematically enhance planning with the functions in APO. This section illustrates the advanced planning options that are available in APO-PP/DS.

APO-PP/DS offers an extremely wide range of additional processes and options. In practice, any one of the points discussed below would be enough to justify using PP/DS—you don’t have to use all of the functions simultaneously. Indeed, a gradual and selective enhancement of the core processes is often much more useful.

Note that the following description of the advanced options is not exhaustive. Rather, it focuses on just some of the main features, by way of an introduction to the more detailed descriptions of the individual functions in the following chapters.

2.2.1 Requirements Planning with Exact Times

Requirements planning in ECC is generally accurate to the day. Even if you can enter an availability date with an exact time, as would be done in sales orders, requirements planning still takes into account only the date. Similarly, requirements planning takes into account only the dates of dependent requirements, which are derived from the exact start time of an operation. This means that it is impossible to distinguish between two different requirements that relate to the morning and afternoon of the same date. Orders created to cover requirements in ECC only contain an availability date.

In APO-PP/DS, requirements planning is based on exact times (accurate to the second). Sales orders, dependent requirements, and all other requirements are assigned an exact time. Orders to cover the requirements are scheduled for precisely this time.

If, for example, you need a precise requirement coverage for a just-in-time processing, this can be planned with APO-PP/DS.
2.2.2 Descriptive Characteristics

If you use the Planning with final assembly planning strategy, the planned independent requirements are consumed by sales orders, which are generally received at a later stage. In ECC, this consumption is both plant-specific and material-specific.

In APO, you can control consumption more precisely across plants and materials. For example, consumption can be specific to individual customers. For this purpose, planned independent requirements are created with reference to individual customers, that is, they are assigned additional descriptive characteristics. Sales orders that are received then only consume the forecasts for these customers.

2.2.3 Simultaneous Quantity and Capacity Planning

In ECC, quantities and capacities are planned separately. This applies to requirements planning, but the possibility of taking into account capacities is similarly limited when you manually create or move an order. Instead, this must be done in a second step.

In APO-PP/DS, you can plan quantities and capacities simultaneously. For example, the capacity situation can also be considered when an additional order is created in a short-term horizon in which capacity planning has already been completed and the production plan is already defined. The order can be created only if periods of available capacity are found for the operations in the order, and it is then automatically scheduled for this period.

2.2.4 Production Planning Runs with Several Steps

In APO-PP/DS, it is easy to construct the automatic production planning process from several steps. The individual steps are simply specified in the production planning run. An example of how individual steps can be placed in a logical sequence is shown below:

1. Requirements planning based on MRP logic
2. Scheduling of capacities for bottleneck resources
3. Requirements planning for the materials for which capacity planning has resulted in shifts in requirements

These steps can be easily defined using procedures referred to as heuristics, and can be limited to specific materials or resources (see Fig-
ure 2.6). The result of this kind of planning run (which, in practice, often comprises up to 10 steps) is a procurement plan, which allows for as many conditions of planning as possible (capacity bottlenecks, deadlines).

2.2.5 Pegging and Control of the Material Flow

In ECC, dynamic references are created between requirement and procurement elements in order to evaluate requirements planning. These references can be seen in the MRP list or in the current stock/requirements list as part of the Pegged Requirements and Order Report functions, and they can be used to edit the planning result manually. Because these references are generated dynamically and are not stored in the database, they are not available for other transactions or functions.

Pegging

In APO-PP/DS, dynamic references are similarly created between requirements and procurement elements following requirements planning or the generation of orders. In APO, these references are...
called *pegging relationships*. These relationships are created in multi-level production across all BOM levels. This network of relationships is referred to as a *pegging network*. In contrast to ECC, pegging relationships are stored in the APO database and are therefore available to all applications in APO. The pegging network can be used in capacity planning, for example, to shift the corresponding orders for components whenever an order is shifted.

Dynamic pegging can be influenced by a range of settings, and can be adjusted to suit the specified planning situation (see Figure 2.7). You can also fix pegging relationships so that the relevant orders and requirements remained fixed in a relationship with one another, even if the planning situation changes and new dynamic pegging relationships are created as a result. You can create (and delete) these fixed relationships manually or automatically with the relevant functions or heuristics.

![Dynamic and fixed pegging](image)

Figure 2.7  APO Transaction "Product," Transaction Code /SAPAPO/MAT1, Product Master and Pegging Settings
2.2.6 Determining the Source of Supply and Cost-Based Planning

The procedure for selecting a source of supply in ECC is described below.

Source of supply for external procurement in ECC

You may have several different vendors for externally procured materials. If you want one of several vendors to be automatically selected in materials planning, all planning-relevant vendors must first be defined in the purchasing info record, scheduling agreement, or contract in the source list. If several MRP-relevant vendors exist, the selection of a single vendor must be defined using a quota arrangement. In this case, scheduling of the replenishment lead time may be vendor-specific.

Source of supply for in-house production in ECC

Several sources of supply may also exist as alternative production versions for materials produced in-house. Production versions are defined in the material master, and they, in turn, define which manufacturing process is to be used, usually by specifying a routing and a BOM (or master recipe in PP-PI). Production versions can be limited in terms of their validity periods and lot-size range (see Figure 2.8). If several valid production versions exist simultaneously, ECC simply selects the first valid version, or a quota arrangement is used to distribute production among several production versions.

Sources of supply in APO

The ECC sources of supply described above are the same in APO after they are transferred. However, the process for selecting a source of supply is different in APO, in that costs may play a crucial role.

First, a check is performed to determine whether a specific source of supply can deliver by the required delivery date. If this is not possible because the replenishment lead time is too long, APO searches for an alternative source of supply with a shorter replenishment lead time. For example, the vendor with the shortest delivery time can be automatically selected if scheduling problems arise.

Cost-based planning

Costs can also be considered in relation to supply. You can ensure that, among several possible vendors, the one with the lowest costs is always automatically selected (provided that there are no scheduling problems). Various price scales can be taken into account in this

---

1 At this point, we’ll focus on using production versions, because only they are relevant to APO.
case, which means that different vendors may be used, depending on the lot size.

2.2.7 Advanced Alert Handling

Exception messages (alerts) indicate problems with planning. In ECC, exception messages are displayed in the MRP list (or in the current MRP data structures).
stock/requirements list). Collective evaluation is possible if you call up the collective display of all MRP lists. In the material overview, you can display all exception messages that appear in the individual materials, sorted by exception group (see Figure 2.9). To examine a problem, you must then access the individual list.

**Alerts**

In APO-PP/DS, the options for alert handling are much more advanced than they are in ECC. First, you can display alerts in the evaluation lists (for example, in the order views) in many different ways. In addition, alerts that are issued in relation to the supply of an important component are also propagated to and displayed in the finished product (network alerts). Alerts are propagated based on the relevant pegging relationships. The pegging network can also be used to evaluate the entire order structure for orders (see Figure 2.10).

**Alert Monitor**

Finally, the Alert Monitor provides a comprehensive tool for the centralized evaluation of alerts. The Alert Monitor provides an overview of all relevant alerts. Alerts can be evaluated across all materials, resources, plants, and so on (see Figure 2.11).
### Figure 2.10 APO Transaction "Product View," Transaction Code /SAPAPO/RRP3,
Accessing the Context for an Order in Multilevel Production from the Product View

### Figure 2.11 APO Transaction "Alert Monitor," Transaction Code /SAPAPO/AMON1,
Alert Monitor with PP/DS Alerts
If you incorporate the Alert Monitor into the product planning table as a chart, this enables alert-based planning in the sense that you can make manual changes in one chart (for example, you shift orders in the capacity planning table) and simultaneously monitor the alerts that are triggered or resolved as a result in the Alert Monitor chart.

### 2.2.8 Advanced Options in Capacity Planning

In ECC, capacity planning can be performed manually (in the capacity planning table), or executed automatically as a background job. All orders that require the same work center can be scheduled in chronological sequence.

One general benefit of using capacity planning in APO is the improved performance. Due to the liveCache architecture, the detailed scheduling planning board in APO can be used for many orders, without affecting runtime (in ECC, the time it takes to import a large number of orders from the database can lead to situations in which the planning table can almost no longer be used). The considerably enhanced performance in APO also enables the inclusion of new features, such as an **Undo** function, which allows you to manually undo individual steps.

A whole range of advanced options and selection criteria are provided for manual and, in particular, automatic scheduling and rescheduling of orders. These options are merely listed at this stage. You can use the strategy profile (see Figure 2.12) to define, among other things:

- Finite or infinite scheduling, using a finiteness level if required
- Scheduling sequence
- Whether alternative resources (modes) are to be taken into account
- Compact scheduling
- Whether pegging relationships are to be considered
- Whether order-internal relationships are to be taken into account

Various functions and heuristics are available for capacity planning; (fixed) pegging can be used in various ways; resource overload alerts can be used for troubleshooting; and so on.
APO is ultimately a production planning system, which contains a powerful optimization tool, the PP/DS Optimizer. Optimization is the final step in the production planning process, which can therefore be logically broken down into the following three steps:

1. Requirements planning (quantity planning)
2. Capacity planning
3. Optimization

Steps 2 and 3 can also be merged and executed by the Optimizer (see Figure 2.13). The Optimizer thus represents the only option for con-
sistently taking into account all constraints in a multilevel production plan.

2.2.9 Simple Options for Enhancement with Custom Functions and Heuristics

In ECC (as in APO), the exact steps involved in planning can be determined by a range of customizing settings. However, if you want to take things a step further and, for example, create special new planning algorithms, a modification of the ECC system is required.
In APO-PP/DS, it is very easy to incorporate new algorithms and processes into the planning process by adding them to the system as additional functions or heuristics. They are then available alongside the standard algorithms (see Figure 2.14) and can simply be used as alternatives in the applications. A system modification is not required.

![Figure 2.14](image)

**Figure 2.14** APO Customizing Setting “Change Heuristics,” Transaction Code /SAPAPO/CDPSC11, List Showing Some of the Delivered Heuristics
2.3 Planning in APO and Execution in ECC

To fully benefit from using APO-PP/DS, an understanding of the main options for advanced planning is essential. This includes a clear understanding of how an APO function affects the final production plan that is to be executed.

Planned orders and purchase requisitions represent the direct result of production planning in APO-PP/DS. These orders are created based on APO master data, which was transferred from ECC. When they are converted into manufacturing orders or purchase orders, the orders must be transferred to the executing ECC system. The corresponding ECC master data is again essential for this purpose. The ECC master data design is therefore very important in APO planning. Master data should be maintained in a way that both supports the relevant APO process and enables a smooth transfer of the planning result from APO back to ECC.

The planning steps executed in APO only make sense if the results can have a rippling effect in the manufacturing order or purchase order in ECC. Note also that certain process steps in the ECC manufacturing order must be transferred back to APO (production backflushes result in the reduction of the corresponding capacity requirement in APO, for example). But, it is not useful to exploit all of the options that are theoretically possible in the ECC manufacturing order. For example, you could manually reschedule an operation from the production order by changing the default values. However, the result could not be taken into account in APO because the APO order is based on the APO master data. Therefore, this step is not permitted. The reasoning behind this constraint in this example is that rescheduling is a function of production planning and thus of APO, and therefore should be executed in APO.

It follows that you should therefore verify the integrity of all process steps with APO. These include creating master data, transferring master data to APO and enhancing it there as required, using transaction data, planning in APO, converting orders and transferring them to ECC, and backflushing manufacturing orders.
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