Module 4

Production and Supply Chain Management Information Systems

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Chapter Objectives

- Describe the steps in the production planning process of a high-volume manufacturer such as Fitter Snacker.
- Describe Fitter Snacker's production and materials management problems.
- Describe how a structured process for supply chain management planning enhances efficiency and decision making.
- Describe how production-planning data in an ERP system can be shared with suppliers to increase supply chain efficiency.

Introduction

- Enterprise Resource Planning (ERP) has its roots in Materials Requirements Planning (MRP)
  - MRP is still a large part of ERP systems
- Supply Chain Management looks at the entire supply system from raw materials to finished goods on the retail shelf

MRP vs ERP

- MRP- Solo software. Its systems are standalone and only work by themselves.
- ERP- Integrated software. Connect to other software systems and modules.

Production Overview

- To meet customer demand efficiently, Fitter Snacker must:
  - Develop a forecast of customer demand
  - Develop a production schedule to meet the estimated demand
- ERP system is a good tool for developing and executing production plans
- Goal of production planning is to schedule production economically

Production Overview

- A production plan answers two questions:
  1. How many of each type of snack bar should we produce, and when?
  2. What quantities of raw materials should we order so we can meet that level of production, and when should they be ordered?
- A successful company must be able to:
  - Develop a good production plan
  - Execute the plan
  - Make adjustments when customer demand differs from the forecast

Production Overview

- Three general production approaches:
  - *Make-to-stock(MTS):* products are made for inventory in expectation of sales orders
    - Most consumer products are make-to-stock
  - *Make-to-order(MTO):* products are made to fill specific customer orders
    - Expensive products or products made to customer specifications
  - *Assemble-to-order(ATO):* combination of make-to-stock and make-to-order
    - Final product assembled for a specific customer order from stock components

Fitter Snacker's Manufacturing Process

- Snack bar line produces:
  - 200 bars/minute
  - 3,000 lb/hr
- Production line operates for one 8-hour shift per day
- Raw materials are mixed in one of four mixers
  - Mixers can produce 4,000 lb of dough per hour
    - Excess capacity protects snack bar line from shutting down if a mixer breaks

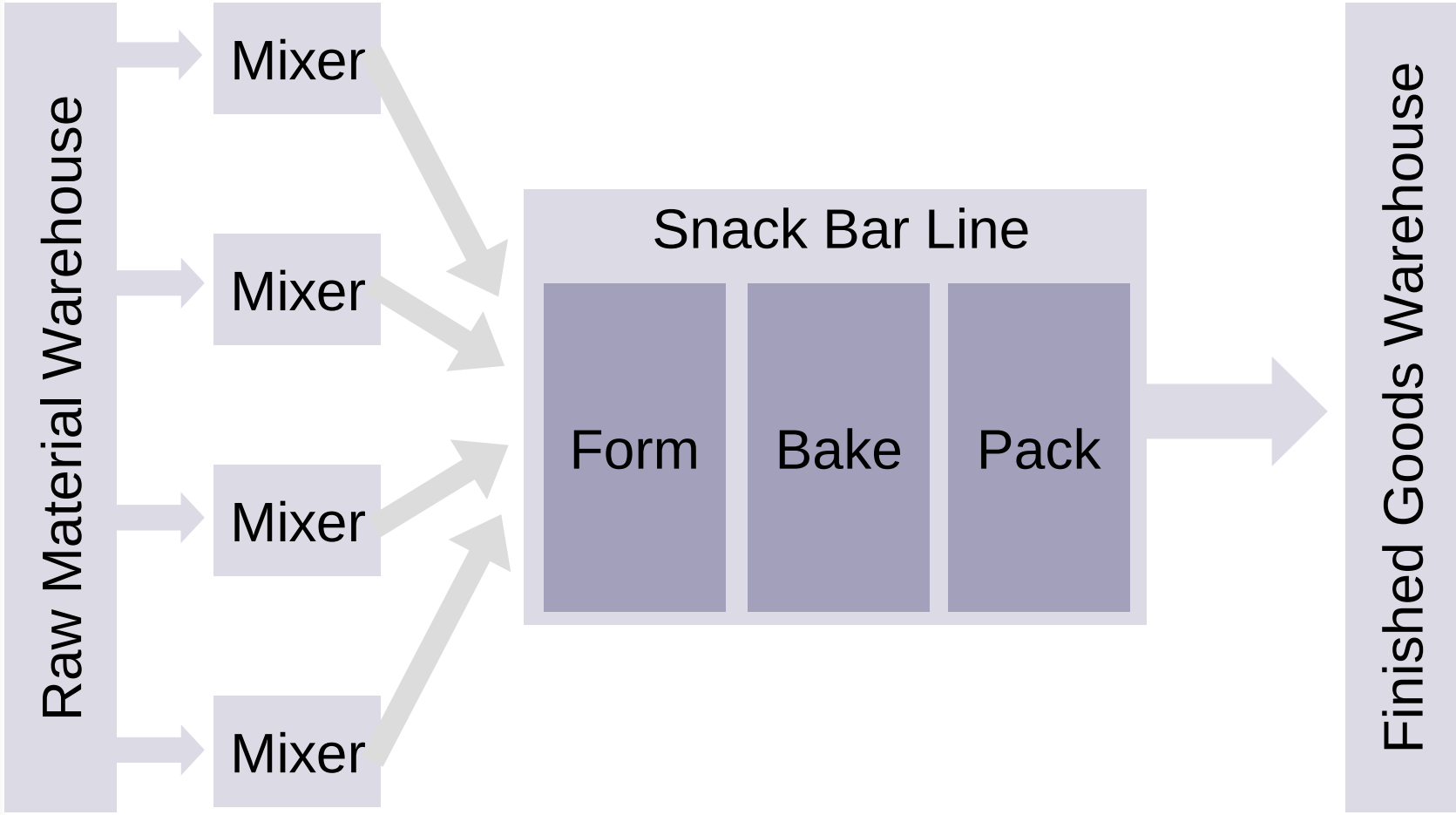


Figure 4.1 Fitter Snacker's manufacturing process

Fitter Snacker's Production Problems

- Fitter Snacker's production problem is deciding *how many* snack bars to make and *when* to make them
- Fitter Snacker's main production problems are in the areas of:
  - Communication problems
  - Inventory problems
  - Accounting and purchasing problems
- All of which are worsened by Fitter Snacker's un-integrated information system

Communication Problems

- Communication problems exist in most companies
  - Magnified in a company without an integrated information system
- At Fitter Snacker, Marketing and Production do not communicate or coordinate planning
  - Production is not always informed of sales promotions or unexpected planned orders
    - Can result in useless inventory, overtime production, expedited shipments and material shortages
  - Production may not inform Marketing about planned maintenance, which will reduce production

Inventory Problems

- Production manager schedules production based on experience, rather than formal planning techniques
  - Primarily compares current warehouse inventory levels with “normal” values
    - May include informal communications with marketing personnel
  - Inventory information is not available in real-time, and does not recognize inventory that has been sold but not shipped
    - Inventory available to commit to future orders is not known

Inventory Problems

- Inventory shortages may mean unplanned production changeovers, resulting in:
  - Lost production capacity
  - Potential shortages of other products
- Actual sales data is not available on a timely basis, because:
  - It is hard to gather
  - Lack of organizational trust
- With access to sales forecasts and plans and real-time sales order data, production could make better decisions and manage inventory better

Accounting Problems

- Most companies use **standard costs** to account for manufacturing costs
  - Standard costs are based on historical costs for materials, labor and factory overhead
  - Manufacturing costs are estimated by multiplying production quantities by standard costs
  - Actual production costs invariably deviate from estimates using standard costs, and adjustments must be made regularly

Production Planning Process

- Production planning involves:
  - Developing an aggregate production plan for groups of products
  - Breaking down the aggregate plan into more specific plans for individual products using smaller time increments
  - Use the production plan to determine raw material requirements

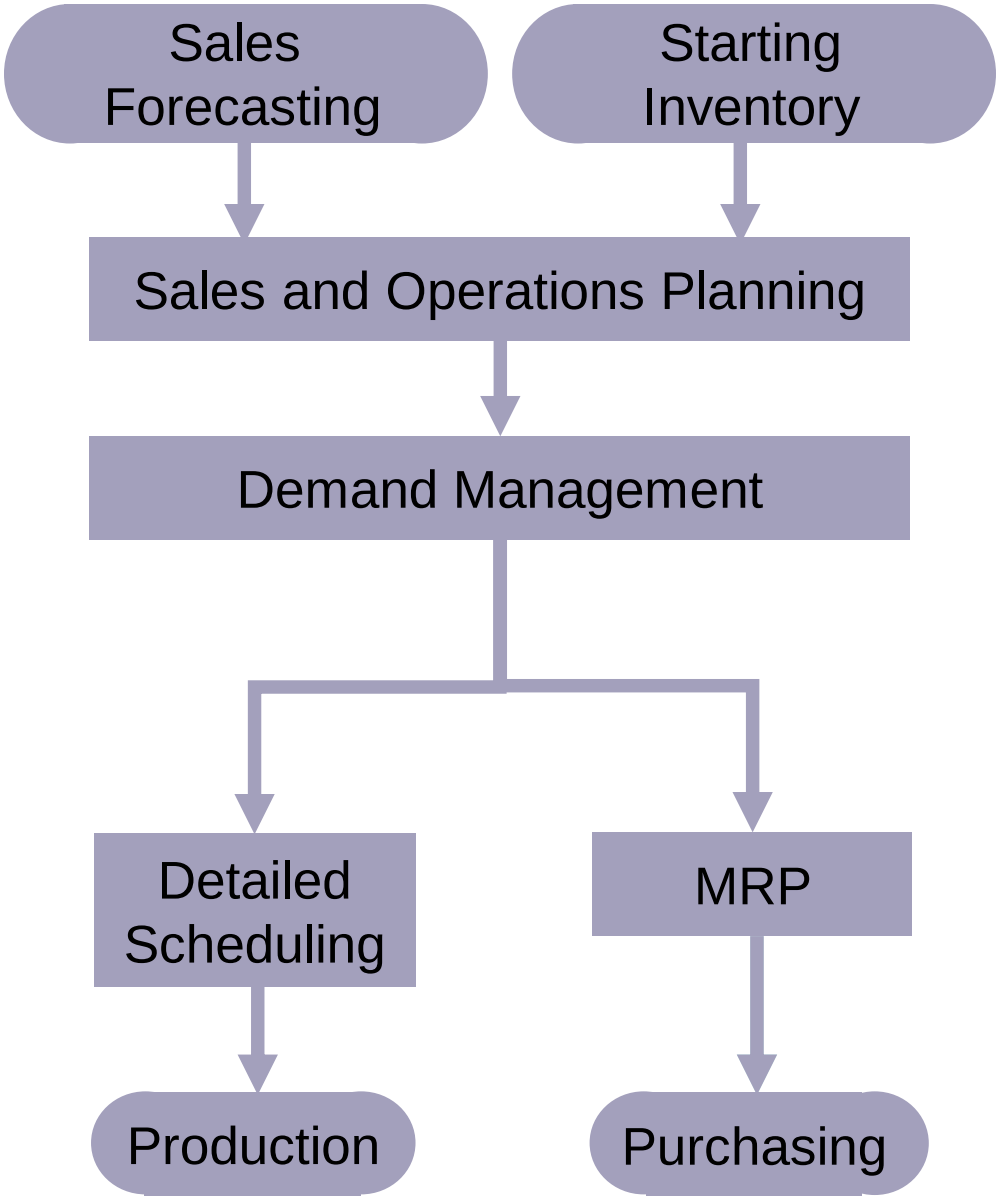


Figure 4.2 The production planning process

Production Planning Steps

- **Sales Forecasting**:
  - The process of developing a prediction of future demand for a company's products
- **Sales and Operations**:
  - Process of determining what the company should produce
  - Requires starting inventory levels and sales forecast
  - Capacity must be considered
  - Inventory may be built to meet demand for seasonal products

Production Planning Steps

- **Demand Management**:
  - Process of breaking production plan down into smaller time increments
- **Detailed Scheduling**:
  - Development of a detailed production schedule based on production plan from demand management
  - Scheduling method depends on production environment
- **Production**:
  - Uses the detailed schedule to determine what products to produce and what staffing is required

Production Planning Steps

- **Material Requirements Planning:**
  - Determines amount and timing of raw material orders
- **Purchasing:**
  - Takes quantity and timing information from MRP and creates purchase orders, which It transmits to qualified suppliers

Sales Forecasting

- In SAP R/3, sales (consumption values) are automatically recorded when sales are made in the SD module
  - Additional detail (sales by region or sales office) can be recorded by the Logistics Information System (LIS)
  - Business Warehouse (BW) can be used for even more detailed sales analysis
- With an integrated information system, accurate sales data are easily available for forecasting

Simple Sales Forecast

- Sales based on **simple adjustment to previous years** sales values

Sales Forecasting		Jan.	Feb.	March	April	May	June
Previous Year (cases)		5734	5823	5884	6134	6587	6735
Promotion Sales (cases)						300	300
Previous Year base (cases)		5734	5823	5884	6134	6287	6435
Growth:	3.0%	172	175	177	184	189	193
Base Projection (cases)		5906	5998	6061	6318	6476	6628
Promotion (cases)							500
Sales Forecast (cases)		5906	5998	6061	6318	6476	7128

Figure 4.3 Fitter Snacker's sales forecast for January through June

Sales Volume	July	Aug.	Sept.	Oct.	Nov.	Dec.
Previous Year	6702	6327	6215	6007	5954	5813

Figure 4.4 Fitter Snacker's sales for the previous period, July through December

Sales and Operations Planning(SOP)

- Input to SOP is sales forecast and beginning inventory
- Output is a production plan that balances market demand with production capacity
- Developing SOP answers the question:

  "How can manufacturing efficiently produce enough goods to meet projected sales?"

- Fitter Snacker Production Capacity:

$$\left(200\frac{\text{bars}}{\cancel{\text{min.}}}\right)\left(60\frac{\cancel{\text{min.}}}{\cancel{\text{hr}}}\right)\left(8\frac{\cancel{\text{hr.}}}{\text{day}}\right)=96{,}000\ \text{bars/day}$$

$$96{,}000\ \cancel{\text{bars}}/\text{day}\left(\frac{1}{24}\frac{\cancel{\text{box}}}{\cancel{\text{bars}}}\right)\left(\frac{1}{12}\frac{\text{case}}{\cancel{\text{box}}}\right)=333.3\ \text{cases/day}$$

Demand Strategies

- When demand is forecasted to exceed capacity, a company might:
  - Choose not to meet all demand or reduce promotional expenditures
  - Use overtime to increase capacity
    - Will increase costs
  - Inventory can be built up in earlier periods
    - Will increase costs and inventory may be lost
  - Try a hybrid approach

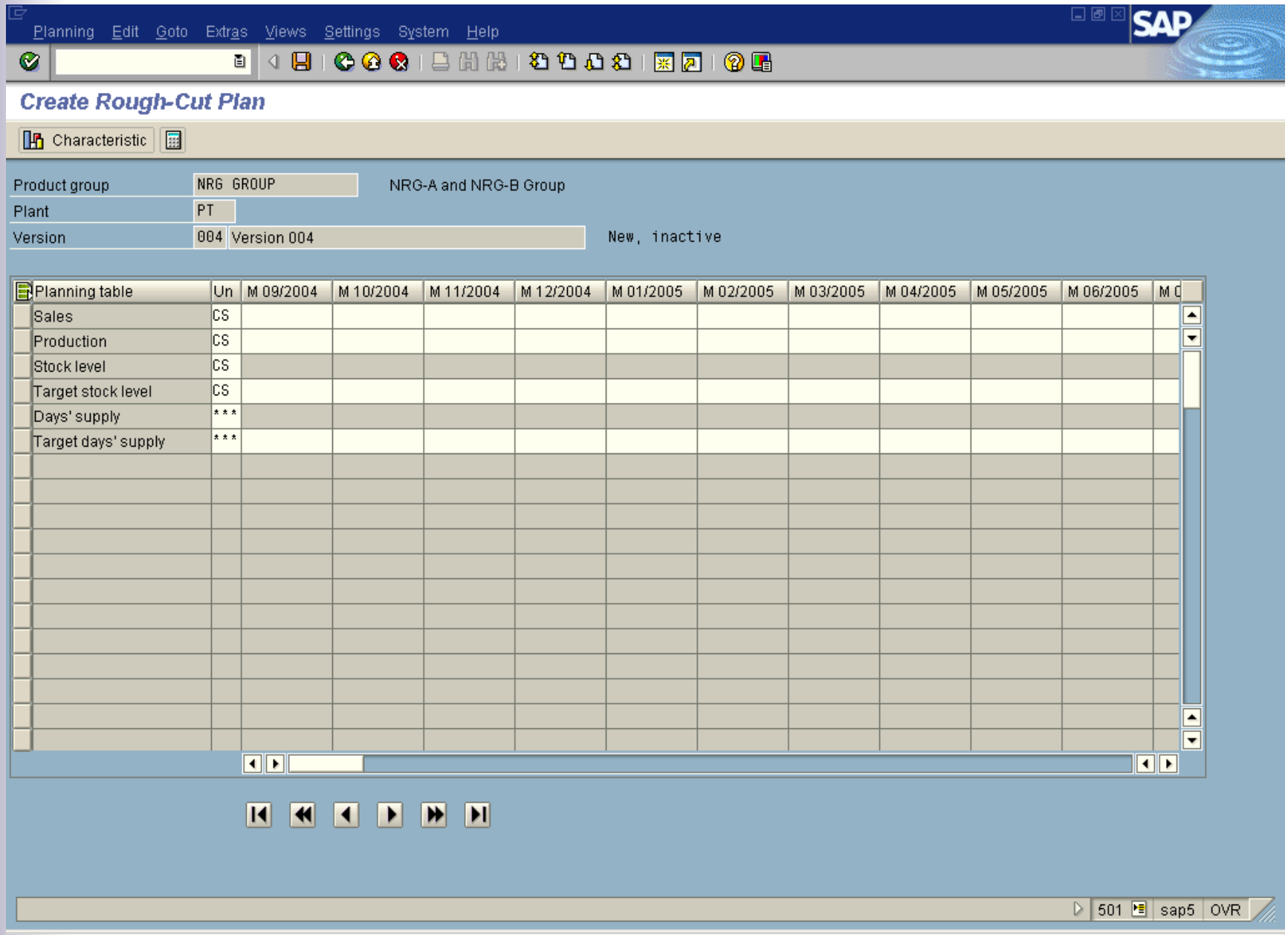


Figure 4.6 Sales and Operations Planning Screen in the SAP R/3 system

Forecasting in SAP R/3

- Because the SAP R/3 system is integrated, accurate historical sales values are readily available for forecasting
- In forecasting, "correcting" historical sales data is valid if:
  - Production was not able to meet demand, so that the historical sales data does not represent actual demand
  - Unusual conditions like weather affected demand
  - The effect of sales promotions needs to be "backed out" of the data
- In the SAP R/3 system, a number of forecasting models are available

Historical Sales Data

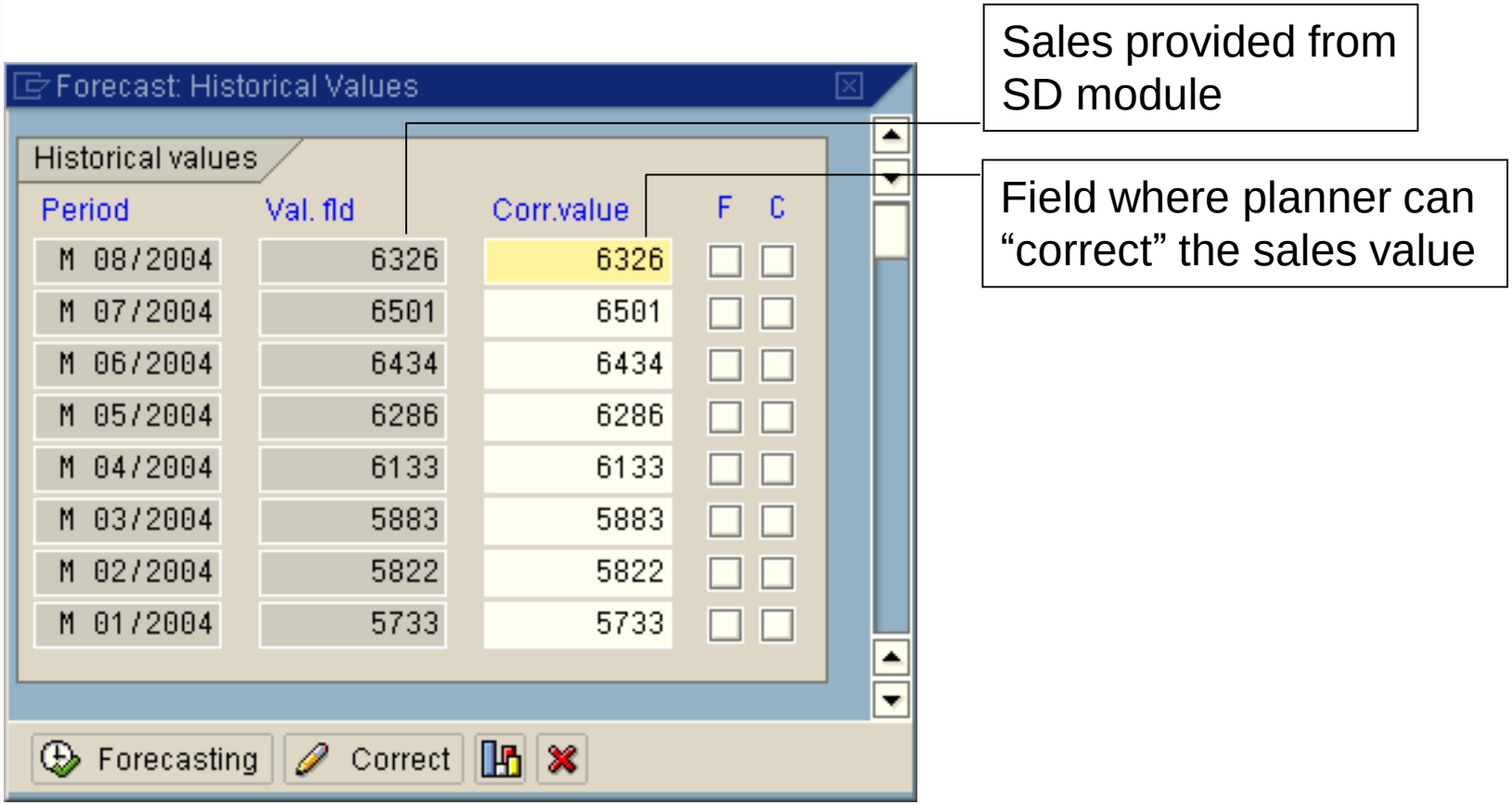


Figure 4.7 Historical sales levels for Fitter Snacker

Forecasting Models in SAP R/3

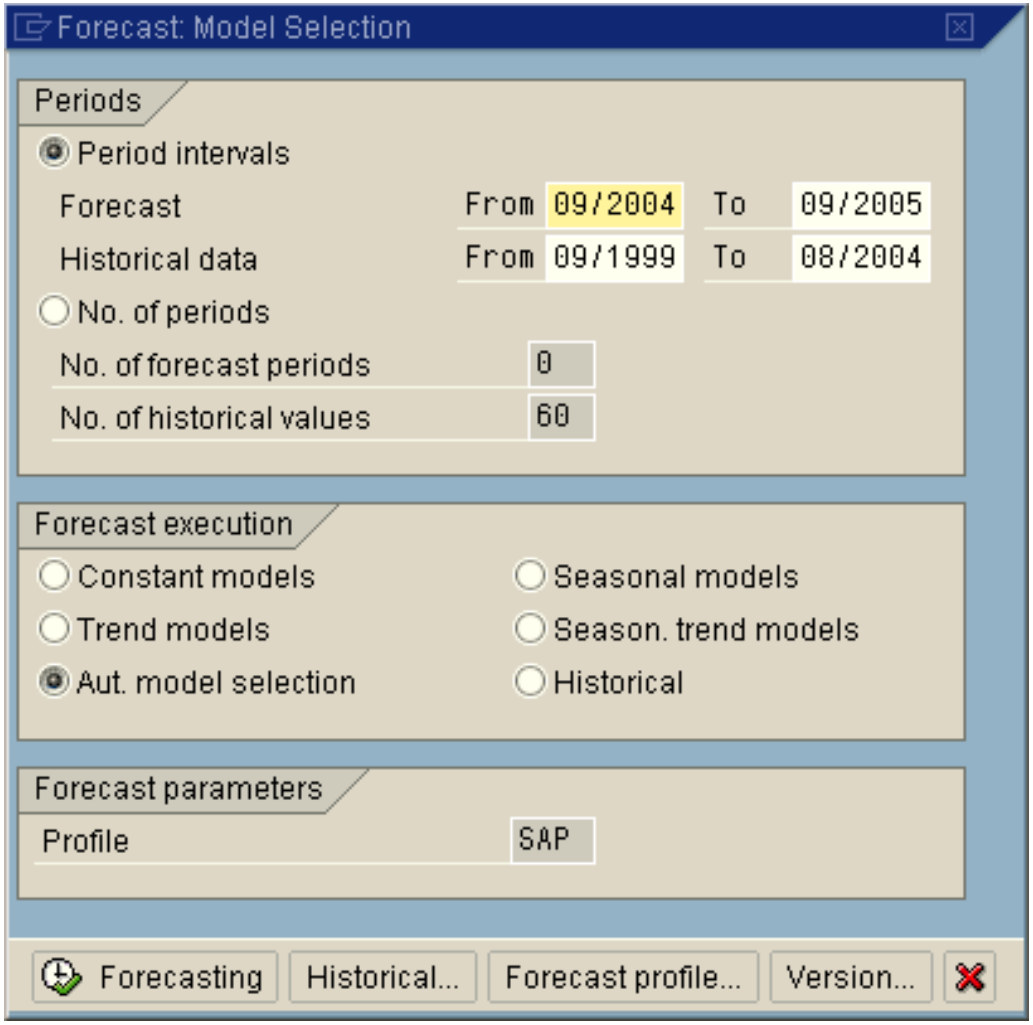


Figure 4.8 Forecasting model options in the SAP R/3 system

Evaluating Forecasts

- Using graphs to evaluate forecasts is frequently the best method

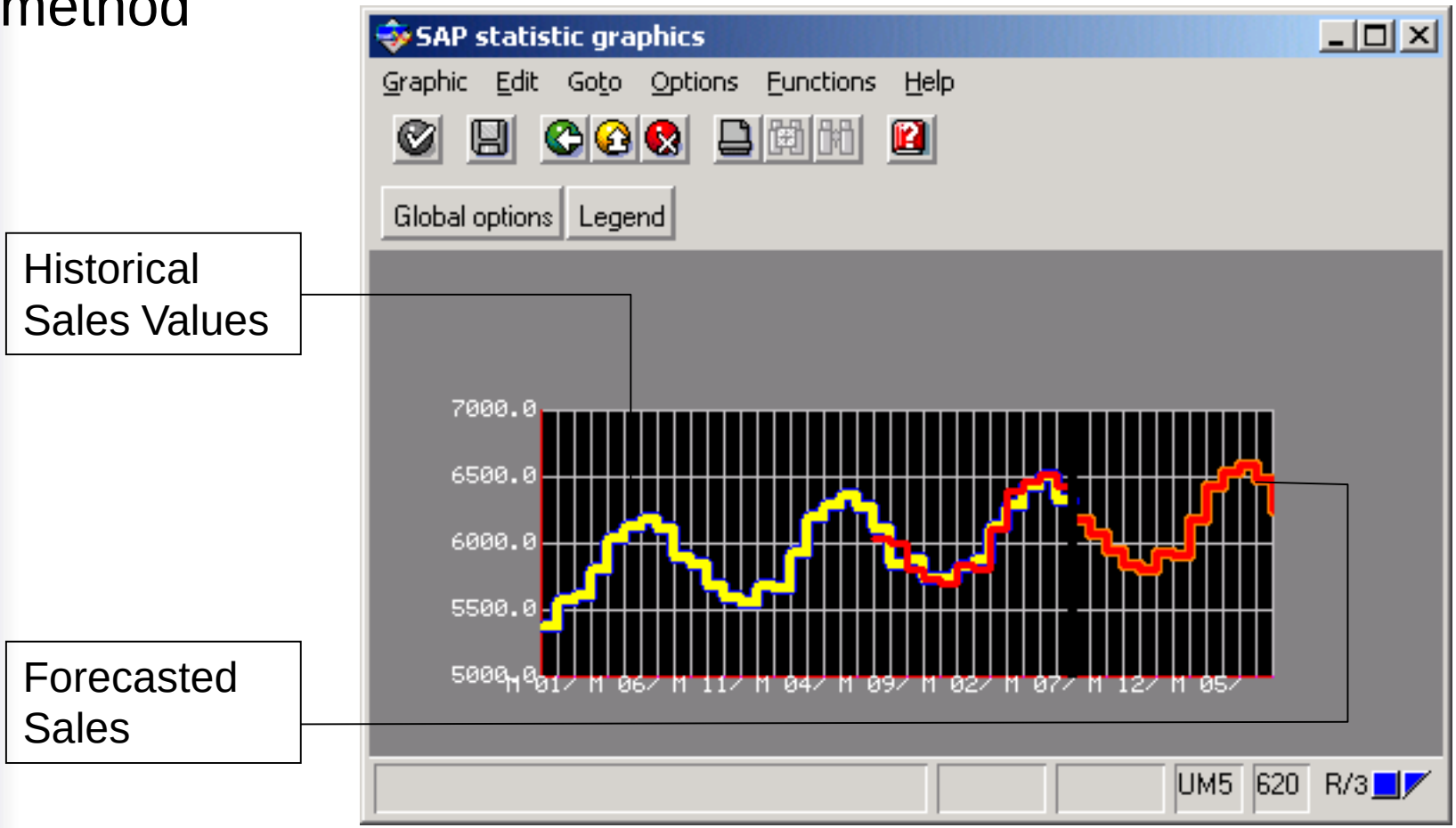


Figure 4.9 Forecasting results presented graphically in the SAP R/3 system

Rough-Cut Capacity Planning

- In SOP, rough-cut capacity planning can be used to evaluate plan feasibility
- For simple products/processes like Fitter Snacker, the capacity estimations are pretty accurate
- For complicated assemblies/manufacturing processes, accurate rough cut capacity estimates are hard to achieve

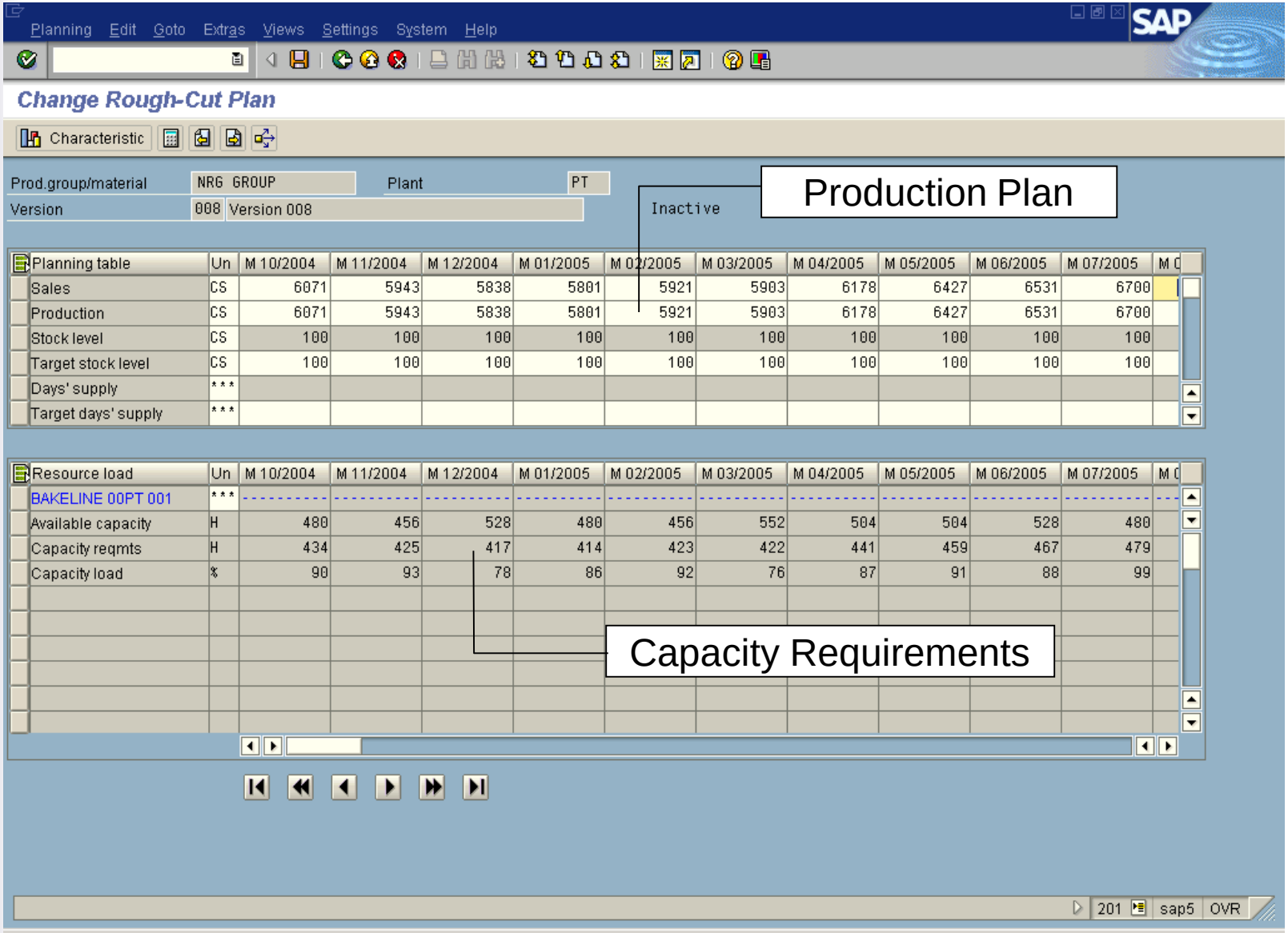


Figure 4.10 SOP with rough-cut capacity calculation in the SAP R/3 system

SOP Effectiveness

- ERP systems provide sophisticated SOP tools, but require commitment from both parties to be successful
  - Without cooperation and agreement on forecasts, sales promotions and production plans, a company will have:
    - Excess quantities of some products
    - Shortages of others
    - Higher costs due to overtime and expedited shipping
  - Successful SOP needs a culture of cooperation, which requires top management support to develop

Another Look: Sales and Operations Planning

- Kellogg achieved significant savings from coordinated SOP process
- Key was changing focus of key players
  - Focus was influenced by way players were evaluated
    - Marketing and sales: tons of cereal sold
    - Manufacturing: tons of cereal produced
  - Neither party was evaluated on how much profit Kellogg was making
- Kellogg's new SOP process, Integrated Business Planning (IBP), is focused on making profit for the company
- Kellogg has reduced capacity, inventory and capital needs while selling more cereal than ever before

Disaggregating SOP

- Planning is done on aggregate product groups to make the process easier to manage and evaluate
- Aggregate plans must be disaggregated to that more detailed plans can be made for individual products
- In SAP R/3, the product group hierarchy, which is defined with fixed percentages for each member, is used to determine production quantities for each product
- With Fitter Snacker, the product group consists of two products
  - NRG-A typically accounts for 70% of sales
  - NRG-B typically accounts for 30% of sales

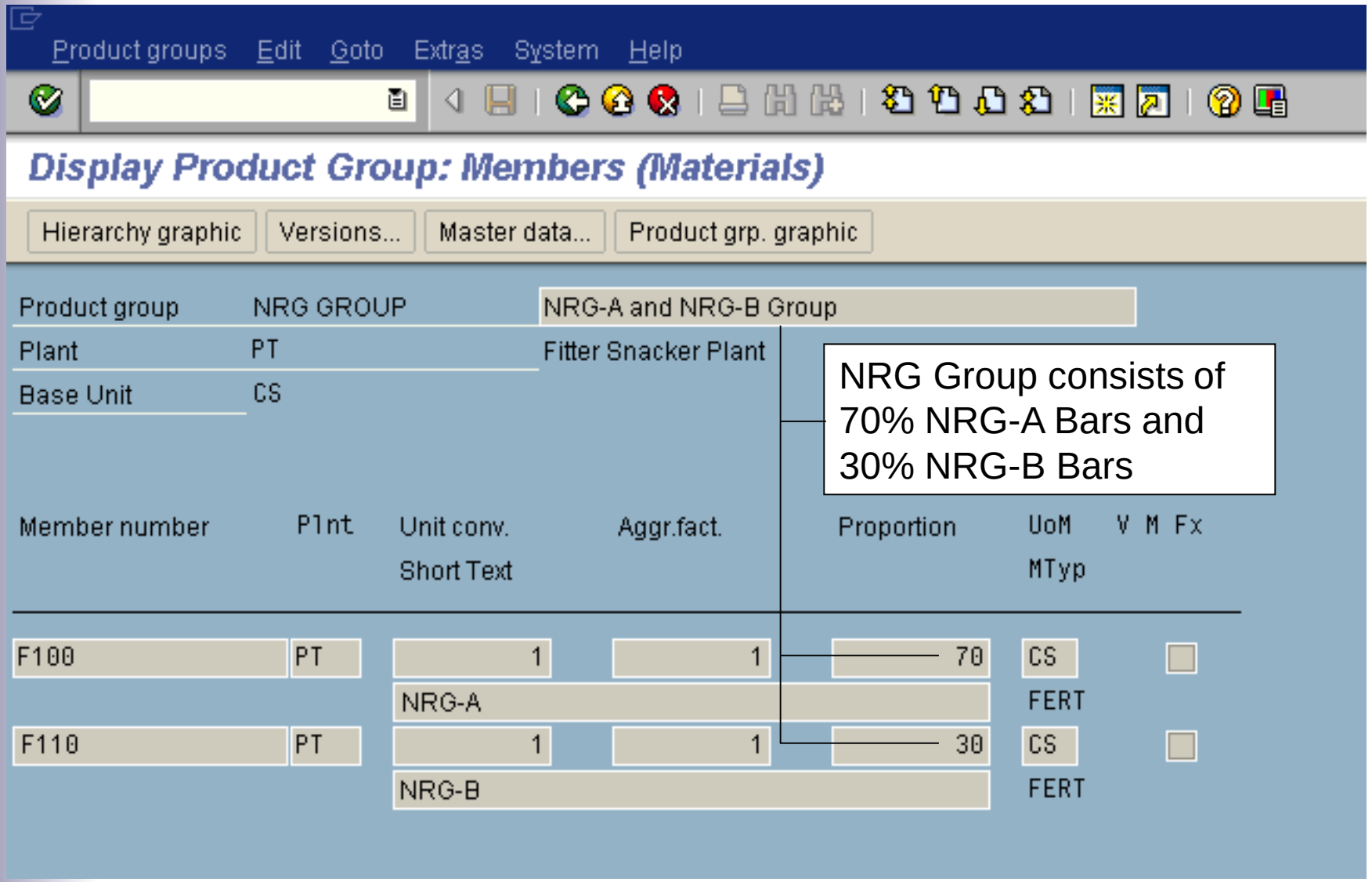


Figure 4.11 Product Group Structure in SAP R/3 System

Stock/Requirements List

- The Stock/Requirements List shows:
  - Current stock
  - Required materials
  - Material receipts planned
  - Material availability

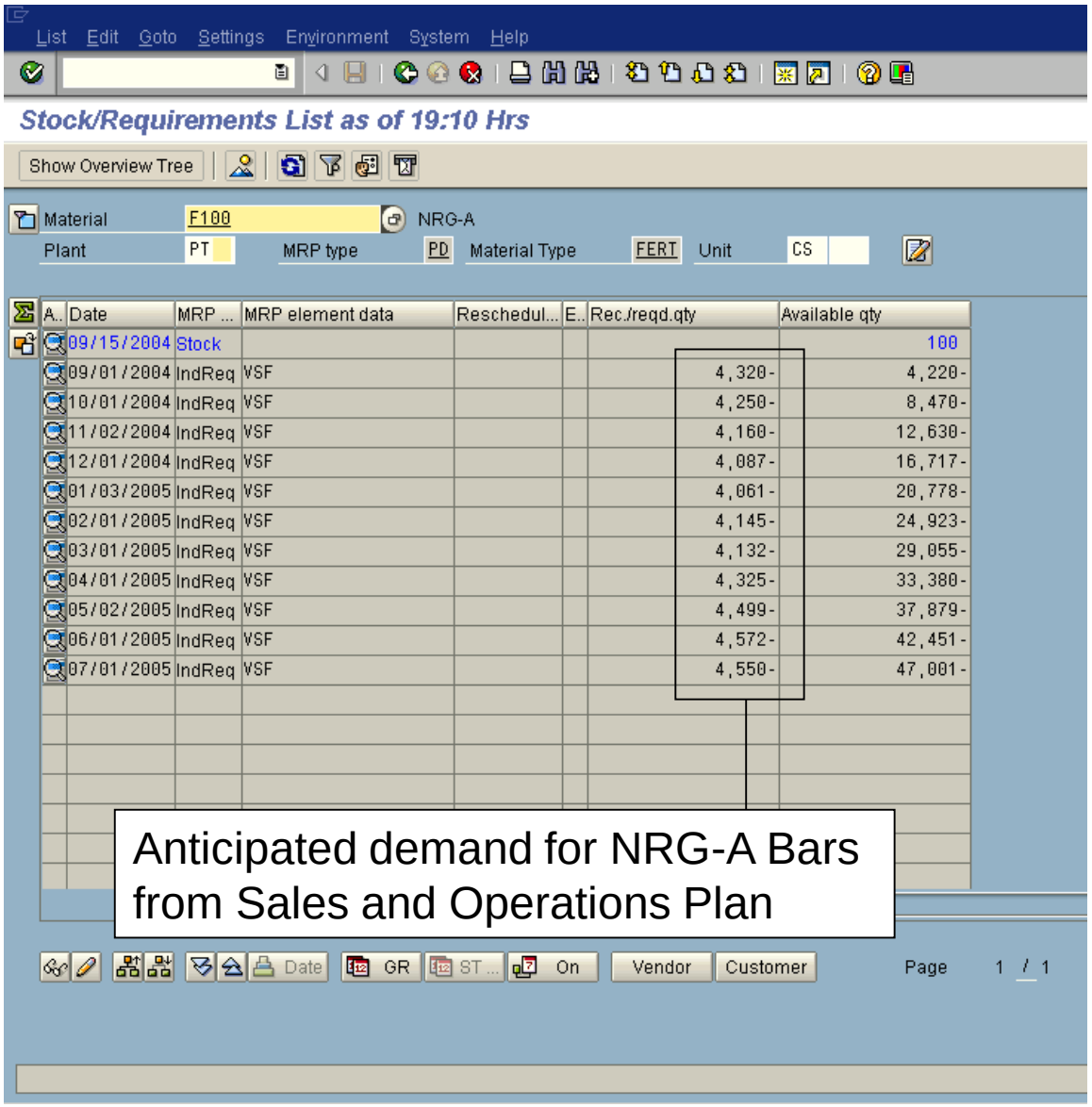


Figure 4.12 Stock/Requirements List for NRG-A bars after disaggregation

Demand Management

- Demand Management links SOP with Detailed Scheduling and MRP via the Master Production Schedule (MPS)
- Fitter Snacker's Demand Management process splits the Monthly SOP plan into weekly and daily increments
  - Demand Management process in SAP R/3 uses the factory calendar to determine the number of working days in a particular week or month

Weekly Disaggregation

		Week 1
Demand Management		**1/2 - 1/5**
Monthly Demand	**NRG-A**	4134
	NRG-B	1772
Working Days in Week		4
Working Days in Month		22
MPS	**NRG-A**	752
Weekly Demand	**NRG-B**	322

$$4134\left(\frac{4}{22}\right) = 752$$

$$1772\left(\frac{4}{22}\right) = 322$$

Daily Disaggregation

Demand Management		Jan 2
Monthly Demand	NRG-A	4134
	NRG-B	1772
Working Days in Month		22
MPS	NRG-A	188
Daily Demand	NRG-B	81

$$\left(\frac{4134}{22}\right) = 188$$

$$\left(\frac{1772}{22}\right) = 81$$

		Week 1	Week 2	Week 3	Week 4	Week 5	
Demand Management		**1/2 - 1/5**	**1/8 - 1/12**	**1/15 - 1/19**	**1/22 - 1/26**	**1/29 - 1/31**	**2/1 - 2/2**
Monthly Demand	**NRG-A**	4134	4134	4134	4134	4134	4198
	NRG-B	1772	1772	1772	1772	1772	1799
Working Days in Week		4	5	5	5	3	2
Working Days in Month		22	22	22	22	22	20
MPS	**NRG-A**	752	940	940	940	984	
Weekly Demand	**NRG-B**	322	403	403	403	422	

Demand Management		**Jan 2**	**Jan 3**	**Jan 4**	**Jan 5**	**Jan 6**
Monthly Demand	**NRG-A**	4134	4134	4134	4134	4134
	NRG-B	1772	1772	1772	1772	1772
Working Days in Month		22	22	22	22	22
MPS	**NRG-A**	188	188	188	188	188
Daily Demand	**NRG-B**	81	81	81	81	81

Figure 4.14 Fitter Snacker's production plan for January: The first five weeks of production are followed by a day-by-day disaggregation of week 1.

	Week 1	Week 2	Week 3	Week 4	Week 5	
Demand Management	**7/2 - 7/6**	**7/9 - 7/13**	**7/16 - 7/20**	**7/23 - 7/27**	**7/30 - 7/31**	**8/1 - 8/3**
Working Days in Week	**4**	**5**	**5**	**5**	**2**	**3**
Working Days in Month	**22**	**22**	**22**	**22**	**22**	**18**

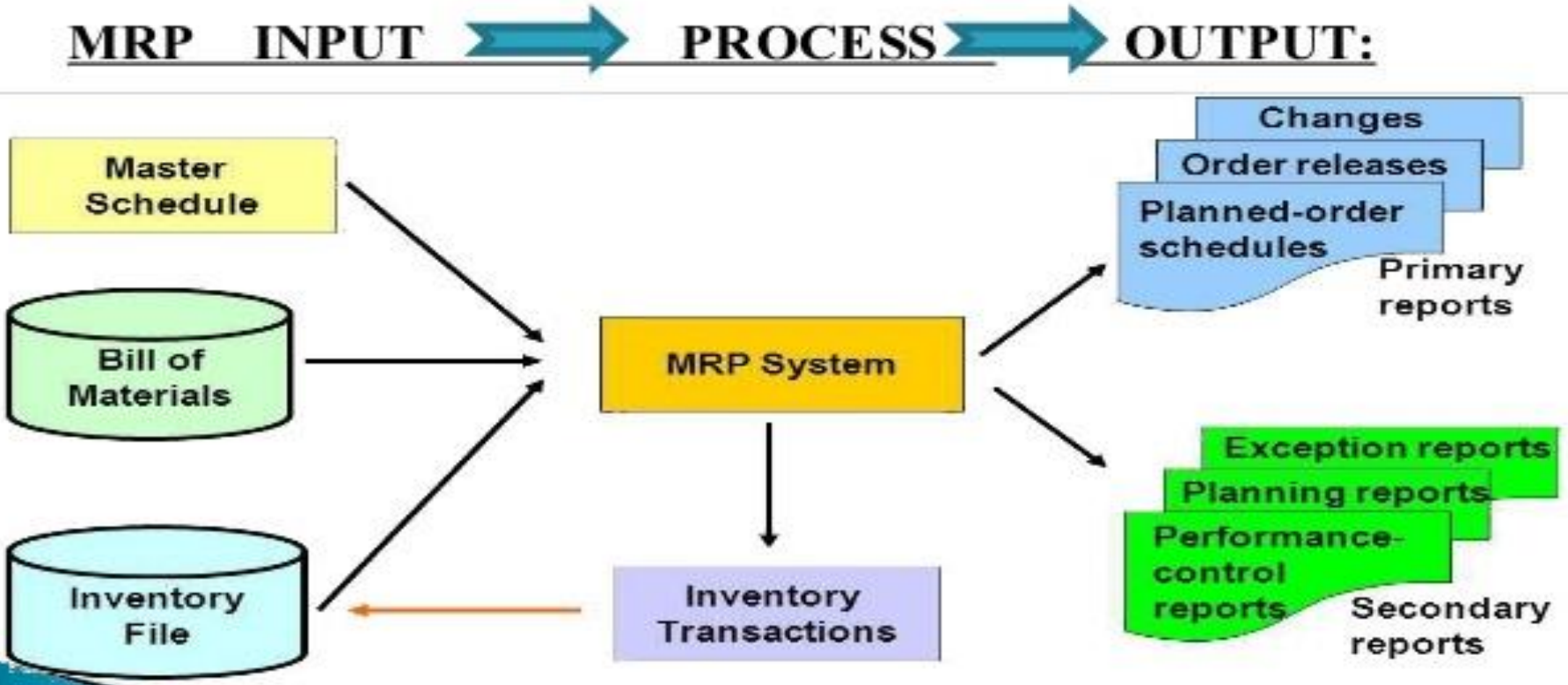
Demand Management	**July 2**	**July 3**	**July 4**	**July 5**	**July 6**
Working Days in Month	**22**	**22**	**22**	**22**	**22**

Figure 4.15 Fitter Snacker's factory calendar for July

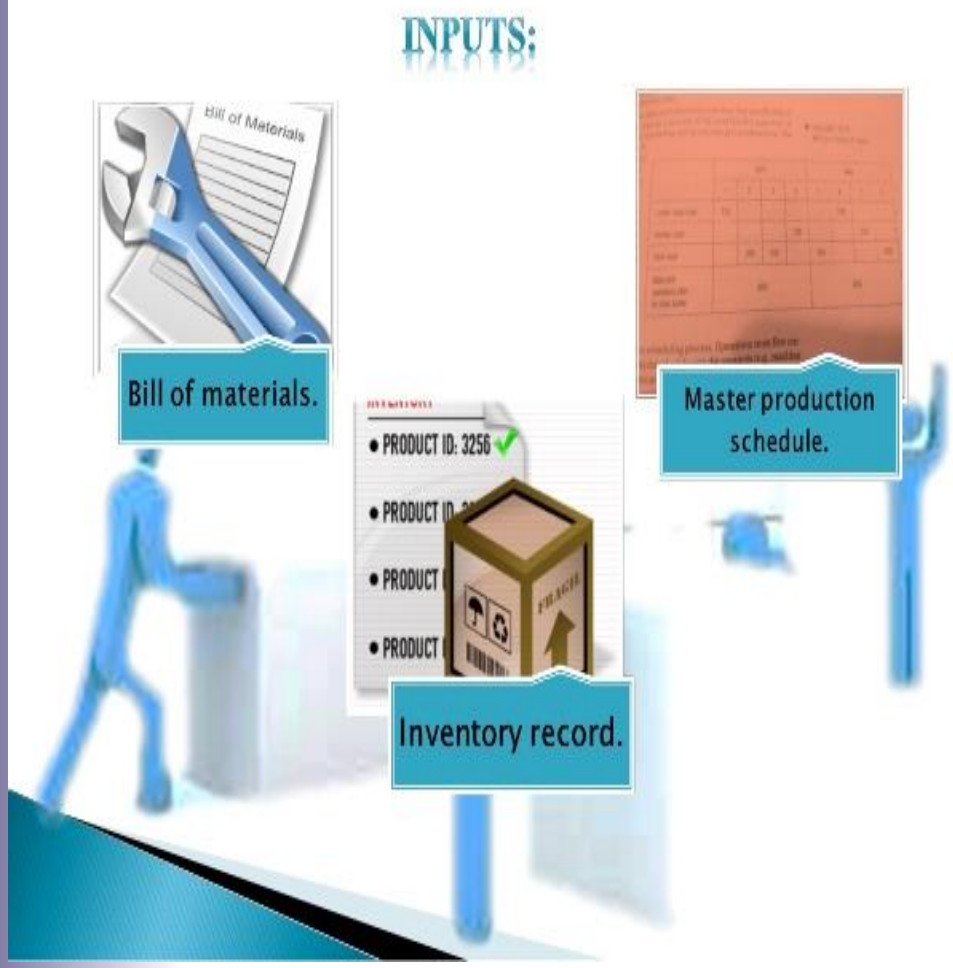
Material Requirements Planning

- Material Requirements Planning (MRP) is the process of determining the quantity and timing of production and/or purchase quantities needed to support the Master Production Schedule (MPS)
- MRP would allow Fitter Snacker to accurately plan its raw material purchases

HOW MRP WORKS



MRP



MRP Outputs

Manufacturing Orders
Purchasing Orders
Various Reports

COMPONENTS REQUIRED FOR YOYO

Strings

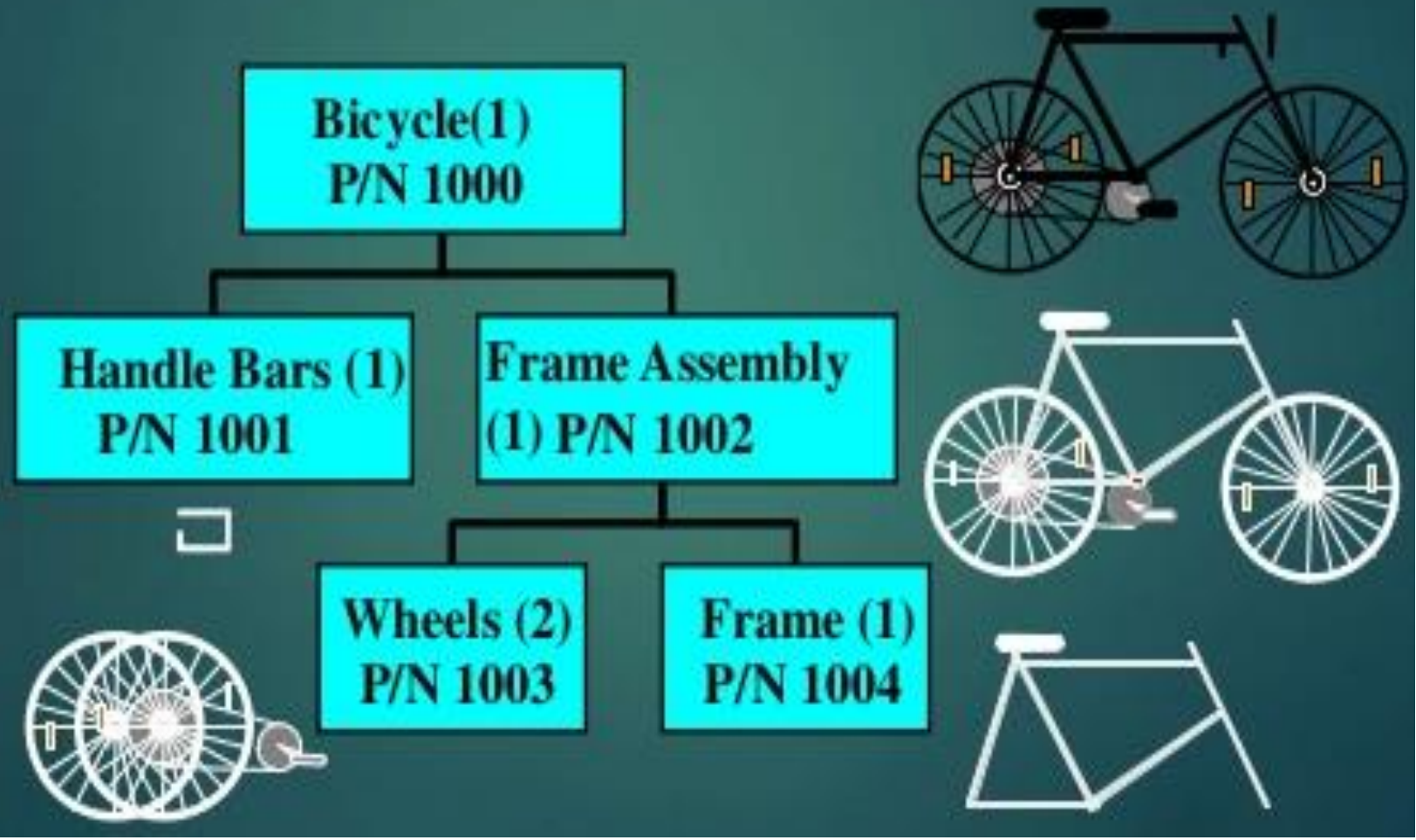
Wooden sides

Wooden peg

Cardboard boxes

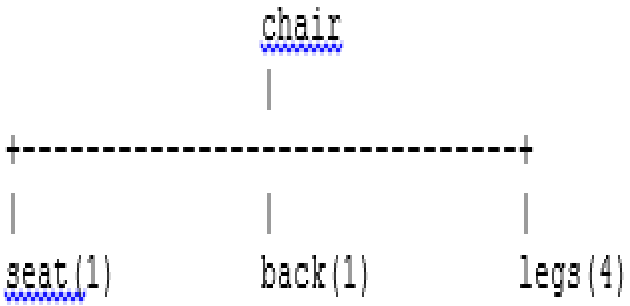
Output

Bill-of-Material Product Structure Tree



Bill of materials Example

- In order to show the make-up (in terms of the parts needed for production) we have a *Bill of Materials (BOM)* for the end-product (namely the chair). Below we show the BOM for the chair.



This BOM means that to produce one chair we need:

- one seat
- one back
- four legs

Bill of Material

- The Bill of Material (BOM) is a list of materials and quantities needed to make a product
- For Fitter Snacker, the BOM is the “recipe” for a 500 lb. batch of snack bar dough

The bill of material (BOM) for Fitter Snacker's NRG bars

	Quantity	
Ingredient	**NRG-A**	**NRG-B**
Oats (lb)	300	250
Wheat germ (lb)	50	50
Cinnamon (lb)	5	5
Nutmeg (lb)	2	2
Cloves (lb)	1	1
Honey (gal)	10	10
Canola Oil (gal)	7	7
Vit./Min. Powder (lb)	5	5
Carob Chips (lb)	50	
Raisins (lb)	50	
Protein Powder (lb)		50
Hazelnuts (lb)		30
Dates (lb)		70

Lead Times and Lot Sizing

- The BOM can be used to calculate how much of each material is required to produce a finished product
- Determining the timing and quantity of purchase orders requires information on lead-times and lot sizing
- For purchased products, the lead time includes:
  - Time for supplier to receive and process order
  - Time to take material out of stock, package it, load it on a truck and deliver it to the manufacturer
  - Time required at manufacturer to receive the material:
    - Unload the truck
    - Inspect the materials
    - Move to storage location or production line

Lead Times and Lot Sizing

- Lot sizing is the process of determining production or order quantities
- In many cases, lot sizes for purchased items are constrained by packaging and transportation
- For Fitter Snacker:
  - Oats need to be purchased in multiples of 44,000 lb. hopper truck quantities
  - Wheat Germ needs to be purchased in multiples of 2,000 lb bulk containers
  - Protein powder needs to be purchased in multiples of 1,250 lb. pallet quantities

SAP R/3 MRP and MRP Records

- MRP list is similar to Stock/Requirements List
- Stock/Requirements shows results of MRP calculations, plus any changes that have occurred since the MRP calculations were performed:
  - Planned orders converted to production orders
  - Material receipts
- MRP calculations can require significant computer resources, so are usually performed daily or even less frequently

Figure 4.18 The MRP List in SAP R/3

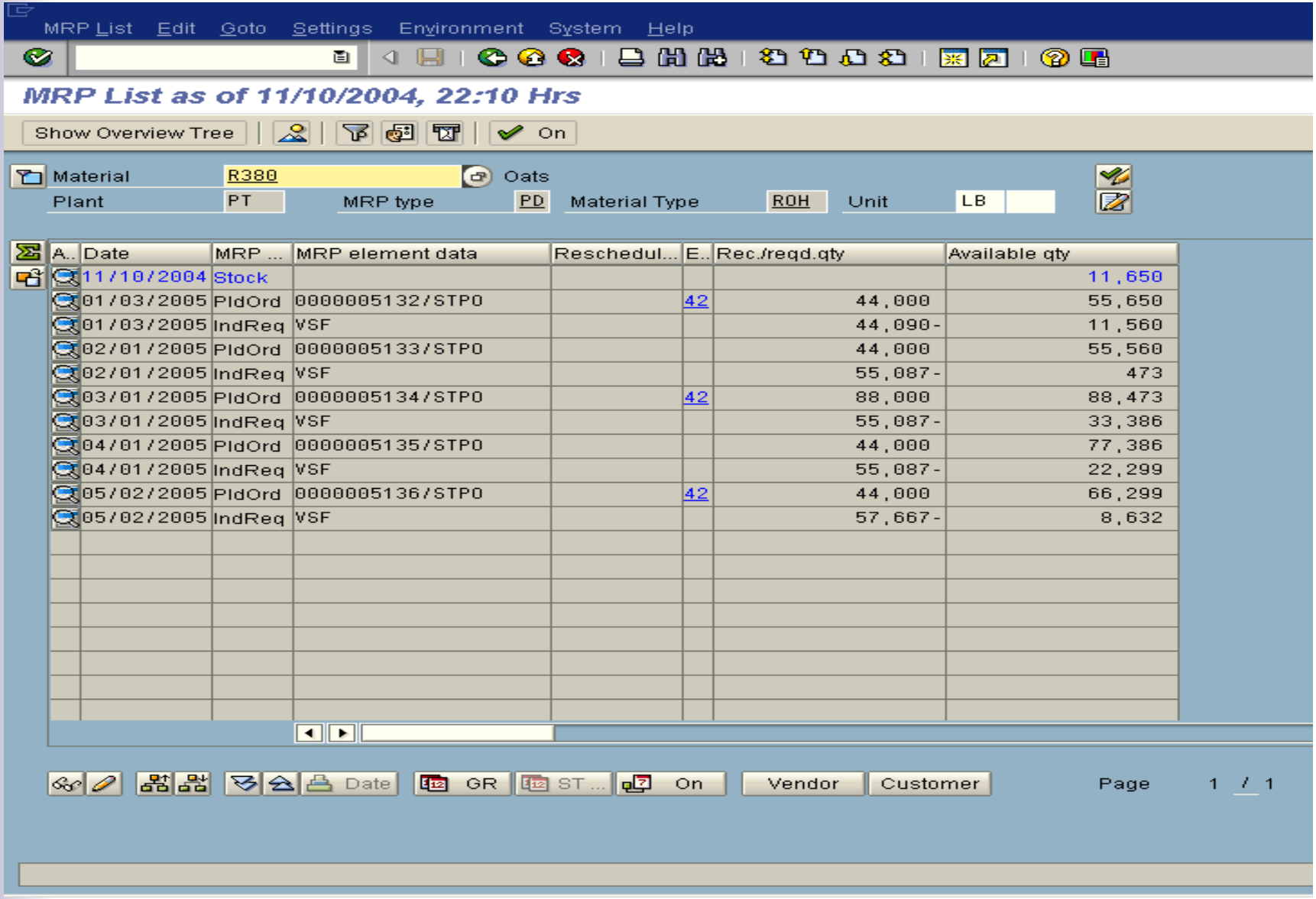
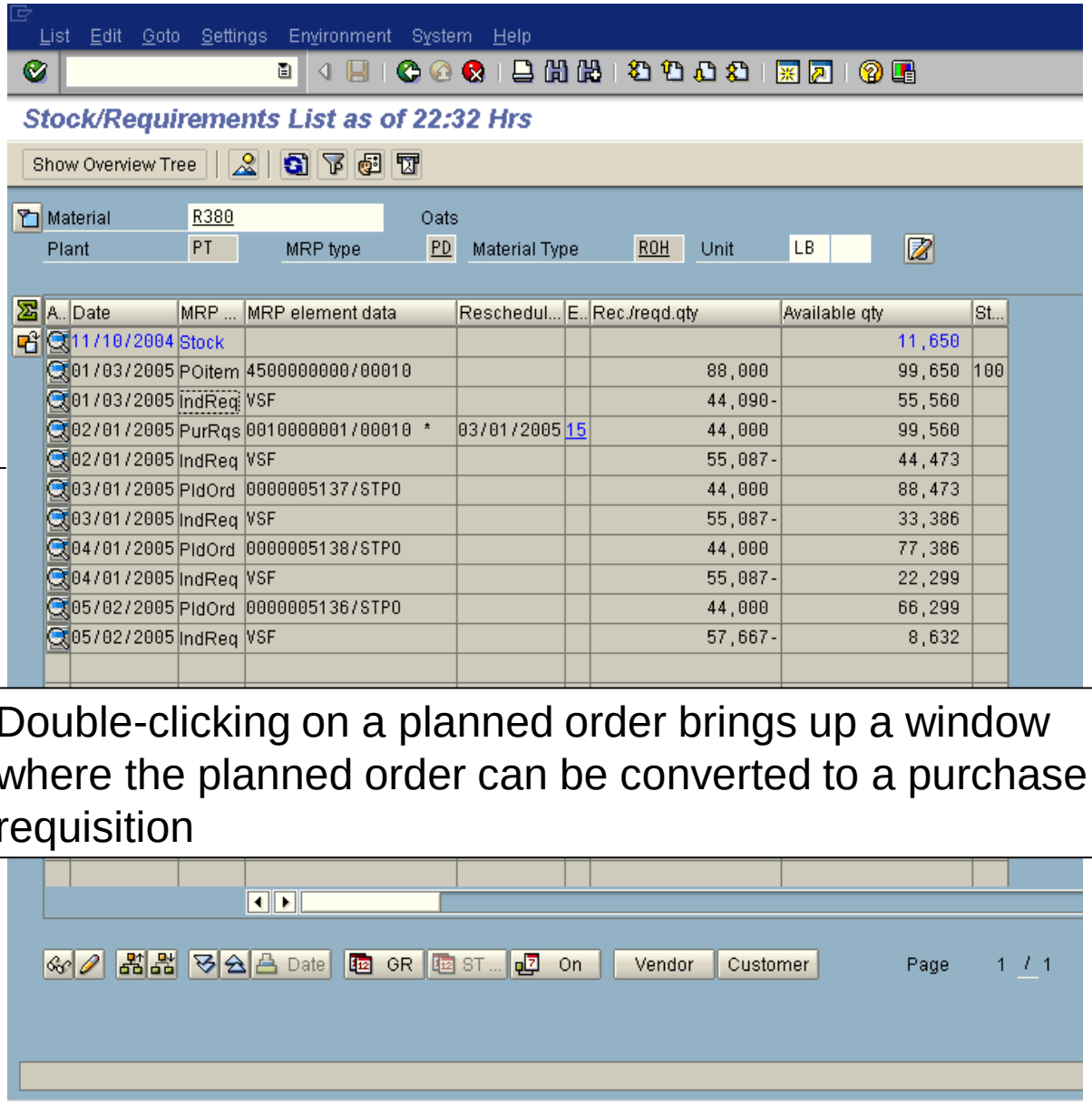


Figure 4.19 The Stock/Requirements List in SAP R/3



Double-clicking on a planned order brings up a window where the planned order can be converted to a purchase requisition

Planned Order to Purchase Requisition

- Planned orders are “recommendations” from the MRP calculation process on what materials should be ordered/produced to meet the Master Production Schedule (MPS)
- Planned orders must be converted to purchase requisitions before the purchasing department will begin the process to create a purchase order
- Planned orders can be converted to purchase orders manually, or the SAP R/3 system can convert a group of planned order to purchase orders
  - e.g. all planned orders that should be placed this week can be converted to purchase requisitions

Planned Order to Purchase Requisition

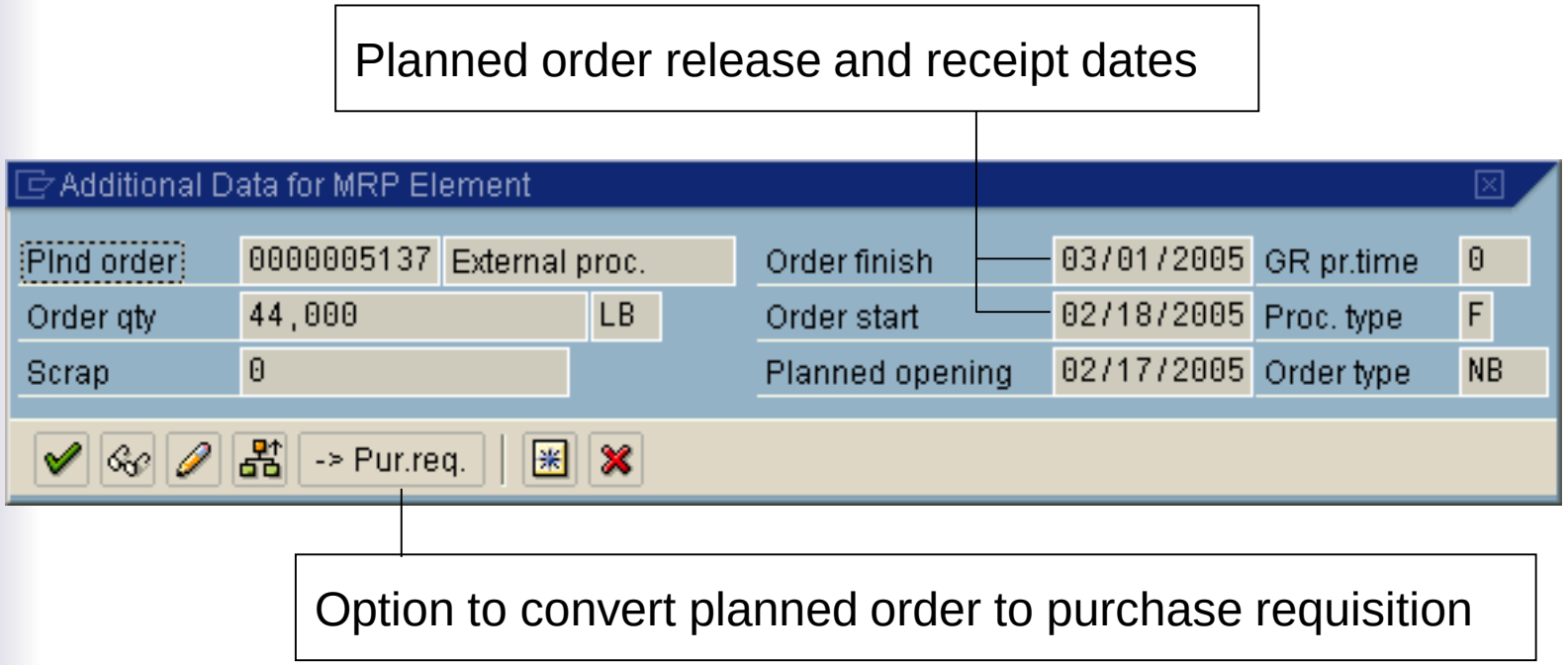


Figure 4.20 Conversion of Planned Order to Purchase Requisition

Purchase Requisition to Purchase Order

- The purchasing department converts purchase requisitions into purchase orders
- Purchasing specialists may group items from different purchase requisitions on one purchase order to save costs
- Purchasing specialists may produce more than one purchase order for the items on a requisition
- The SAP R/3 system provides tools to help the purchasing specialist select the best supplier (vendor) for a material
  - Once the purchase order is complete, it is transmitted to the supplier (vendor)
  - A number of methods (mail, fax, EDI, internet) are available for transmitting purchase orders

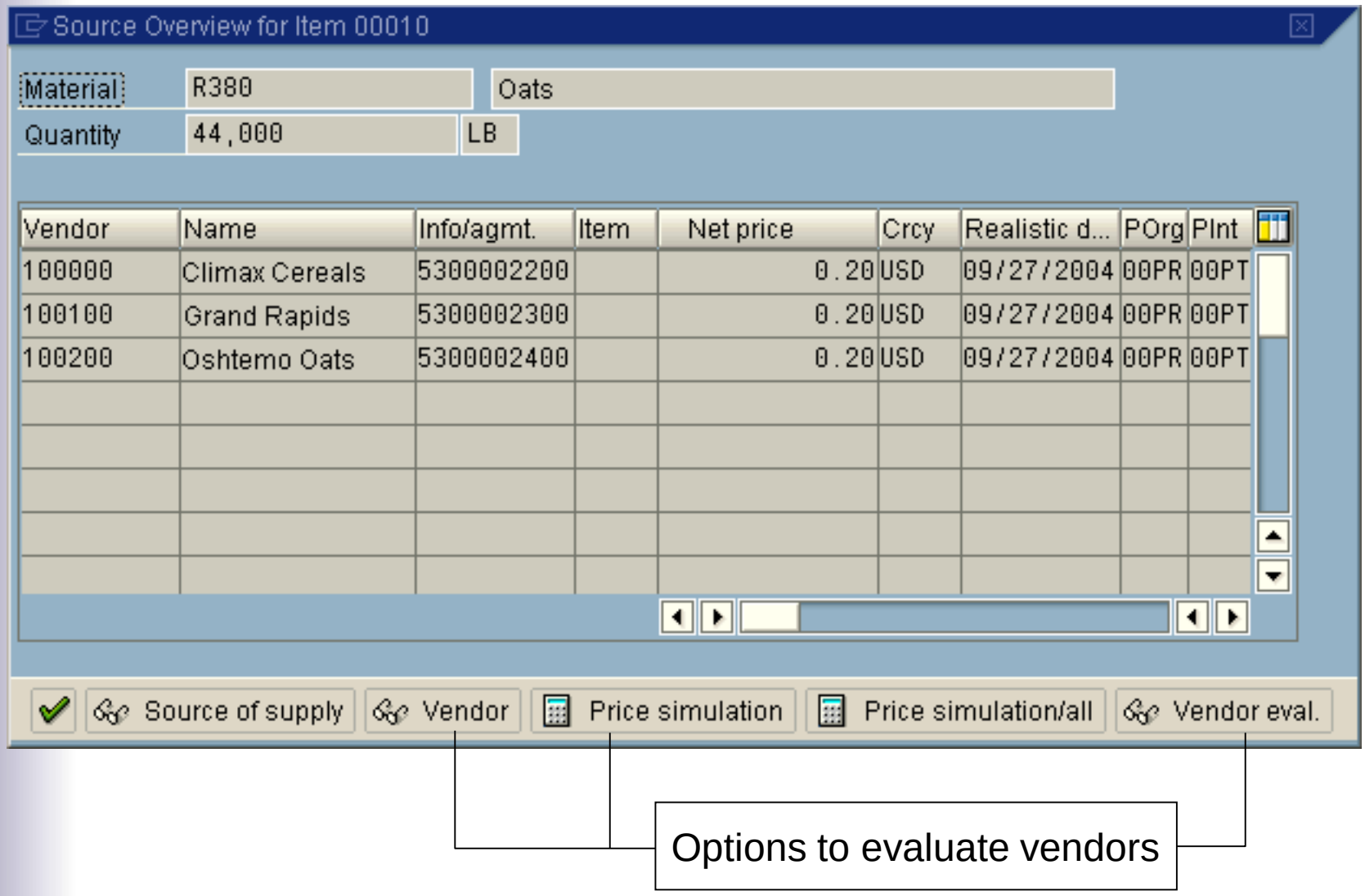


Figure 4.21 Source Overview screen for supplier selection

Detailed Scheduling

- Detailed scheduling is a complex process
- Scheduling frequently involves a balance between:
  - Long production runs, which reduces lost capacity due to equipment setups, and
  - Short production runs, which result in lower inventory levels
- Because the mixing capacity at Fitter Snacker is greater than the baking line capacity, scheduling at Fitter Snacker is focused on the baking line
- Repetitive manufacturing can be used to schedule production at Fitter Snacker
- Repetitive manufacturing schedules production run times instead of specific production quantities

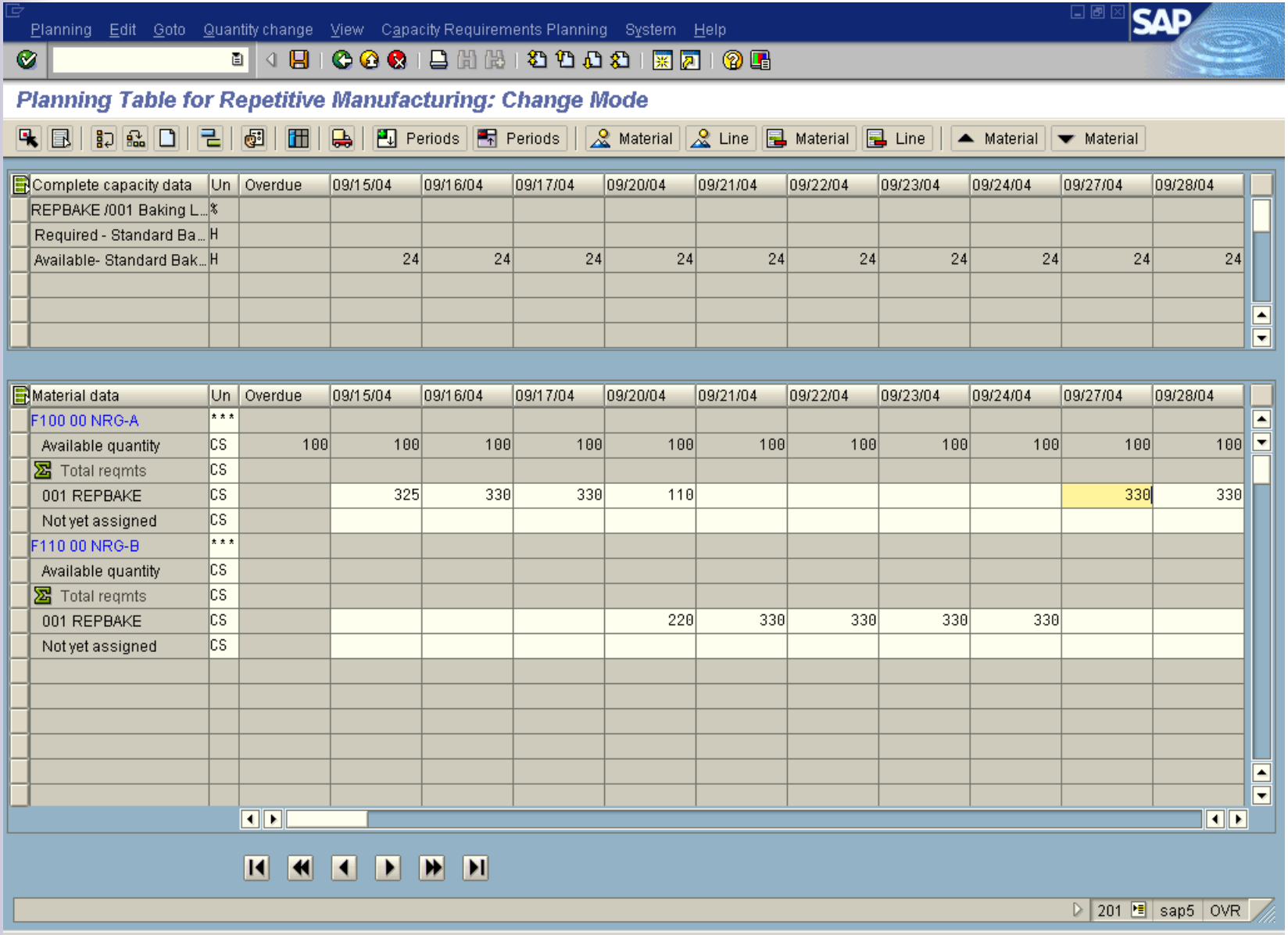


Figure 4.22 Repetitive Manufacturing Planning Table in the SAP R/3 system

Linking Production and Accounting

- Data can be entered into the SAP R/3 system through a PC, bar code scan, wireless PDA or RFID technology
- Because SAP R/3 is integrated, information entered for a material movement will be used to automatically update accounting records
  - One data entry activity provides data for two functions (materials management and accounting) simultaneously, providing data consistency
- For example, the Goods Receipt screen simplifies the connection between the material received from the supplier and the purchase order that created it
- Accurate data requires company personnel to consistently and accurately enter information into the system

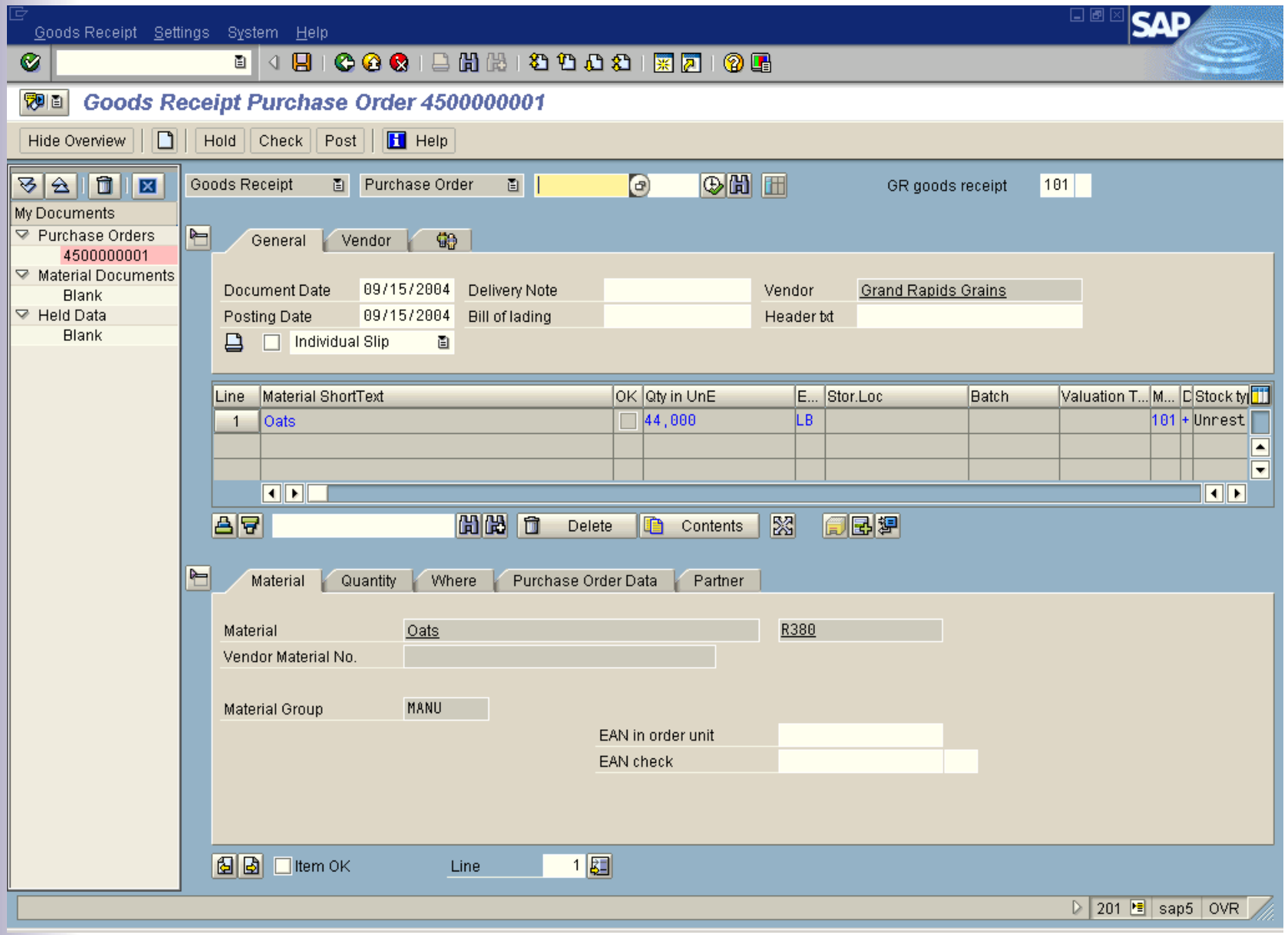
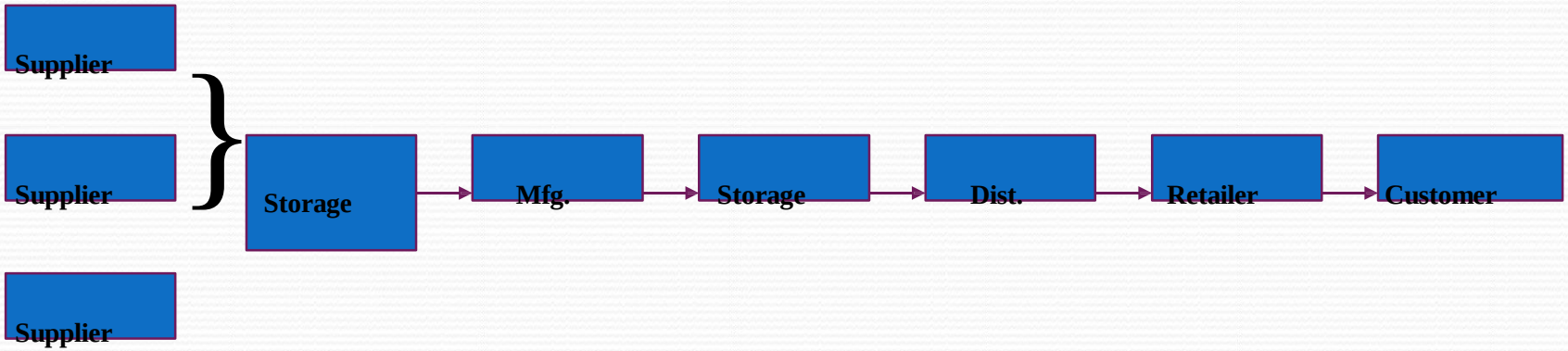


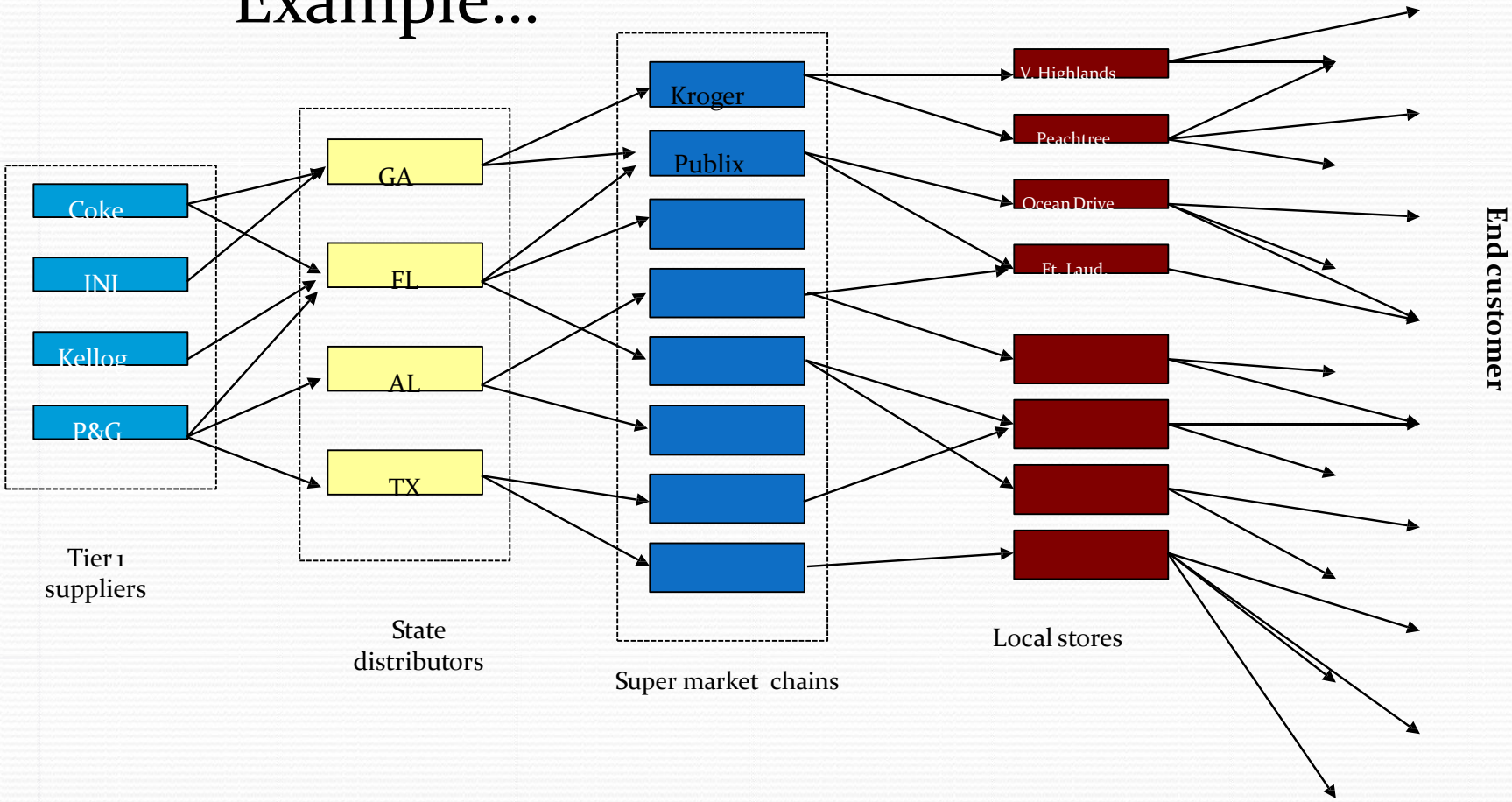
Figure 4.23 Goods receipt screen in SAP R/3

What is Supply Chain?

A supply chain is the system of organizations, people, *activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities transform raw materials and components into a finished product that is delivered to the end customer.*



A Supply Chain Example…



A Example Of A Supply Chain

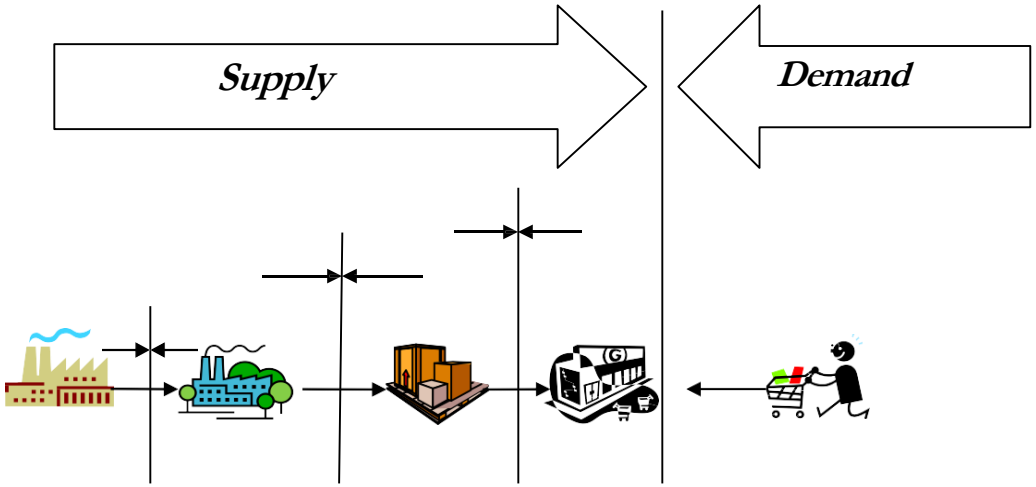
- *Say we get an order from a European retailer to produce 10,000 garments.*
- *For this customer we might decide to buy yarn from a Korean producer but have it woven and dyed in Taiwan. So we pick the yarn and ship it to Taiwan.*
- *The Japanese have the best zippers ... so we go to YKK, a big Japanese zipper manufacturer, and we order the right zippers from their Chinese plants.*
- *The best place to make the garments is Thailand. So, we ship everything there.*
- *The customer needs quick delivery, we may divide the order across five factories in Thailand. Effectively, we are customizing the value chain to best meet the customer's needs.(Interview of Victor Fung of Li & Fung in HBR, Sept-Oct 1998.)*

In the interview example, it can be seen that Li & Fung has created a supply chain for the purpose of meeting a customer's needs.

In general, this case is more the exception than the rule, but serves to illustrate some of the pieces of a supply chain.

Supply Chain Management

Supply chain management deals with linking the *organizations within the supply chain in order to meet demand across the chain as efficiently as possible.*



Mission impossible: Matching Supply and Demand

Why so difficult to Match Supply and Demand?

- *Uncertainty in demand and/or supply*
- *Changing customer requirements*
- *Decreasing product life cycles*
- *Conflicting objectives in the supply chain*

Conflicting objectives even within a single firm

- *Marketing/Sales wants: more inventory, fast delivery, many package types, special wishes/promotions*
- *Production wants: bigger batch size, latest ship date, decrease changeovers, stable production plan*
- *Distribution wants: full truckload, low depot costs, low distribution costs, stable distribution plan*

Why is Supply Chain Management so important?

- *To gain efficiencies from procurement, distribution and logistics*
- *To make outsourcing more efficient*
- *To reduce transportation costs of inventories*
- *To meet competitive pressures from shorter development times, more new products, and demand for more customization*
- *To meet the challenge of globalization and longer supply chains*
- *To manage the inventories needed across the supply chain*

Procurement is the process of sourcing and acquiring the goods and services a company needs to fulfill its business model

ERP and Suppliers

- Fitter Snacker is part of a supply chain that starts with farmers growing oats and wheat germ and ends with a customer buying an NRG bar from a retail store
- Historically, participants in the supply chain have used competitive bidding to achieve low prices
  - This frequently leads to adversarial relationships
- The supply chain is frequently more efficient if participants work collaboratively to:
  - Improve products
  - Reduce paperwork
  - Reduce inventories and costs
  - Increase responsiveness to the customer

The Traditional Supply Chain (cont'd.)

- EDI and ERP
  - Before ERP systems were available, companies could be linked with customers and suppliers through electronic data interchange (EDI) systems
  - Well-developed ERP system can facilitate SCM
    - Needed production planning and purchasing systems already in place
  - With ERP system, sharing production plans along the supply chain can occur in real time

Traditional Supply Chains

- In the traditional supply chain, information is passed through the supply chain reactively
- Information on changes to customer demand may not reach suppliers for days or week
- Information is filtered by purchase order process

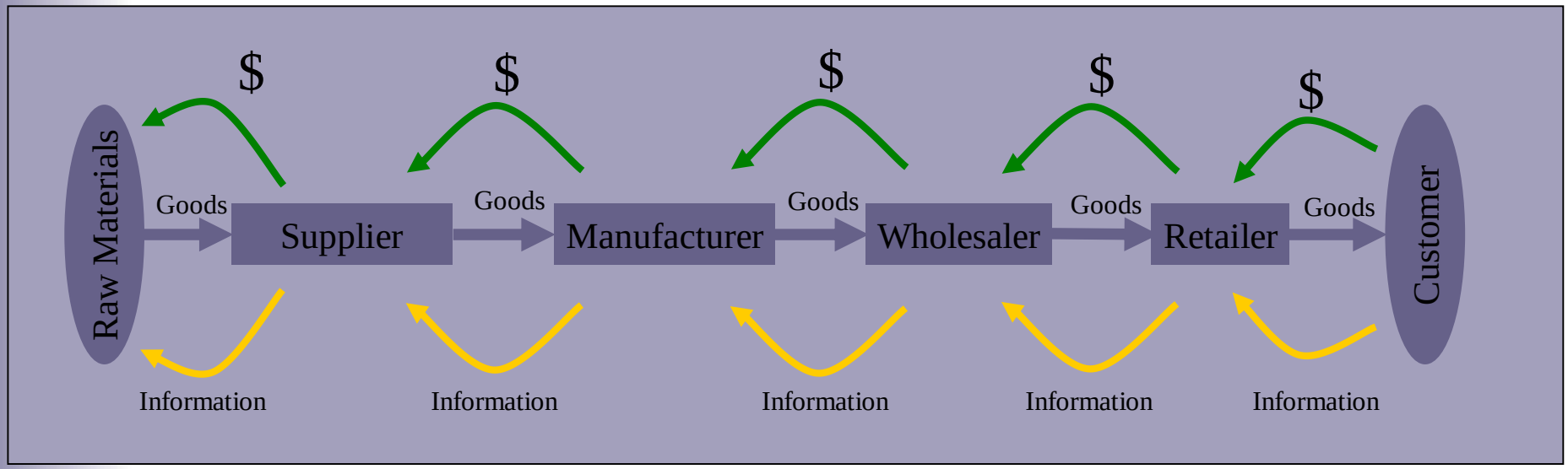


Figure 4.24 Supply-chain management (SCM) from raw materials to consumer

ERP and Supply Chains

- ERP systems can facilitate supply chain efficiency
  - Production plans can be shared along the supply chain in real time
  - Integration of accounting allows managers to evaluate impact of plans on total supply chain costs
- Measures of supply chain performance include:
  - Cash-to-cash cycle time
  - Total SCM costs
  - Initial fill rate
  - Initial order lead time
  - On-time performance

The Measures of Success

- Performance measurements (**Metrics)**
  - Show the effects of better supply chain management
  - **Cash-to-cash cycle time**
    - Time between paying for raw materials and collecting cash from customer
      - In one study, the cash-to-cash cycle time for companies with efficient supply chain management processes was a month, whereas the cycle averaged 100 days for those companies without effective supply chain management.
  - **Total supply chain management costs**
    - Include cost of buying and handling inventory, processing orders, and information systems support
      - In one study, companies with efficient SCM processes incurred costs equal to 5 percent of sales. By contrast, companies without SCM incurred costs of up to 12 percent of sales

The Measures of Success (cont'd.)

- Other metrics have been developed to measure what is happening between a company and its suppliers
- **Initial fill rate**
  - Percentage of the order that the supplier provided in the first shipment
- **Initial order lead time**
  - Time needed for the supplier to fill the order
- **On-time performance**
  - If supplier agreed to requested delivery dates, tracks how often supplier actually met those dates

Another Look—Supply Chain Management with Customer Collaboration

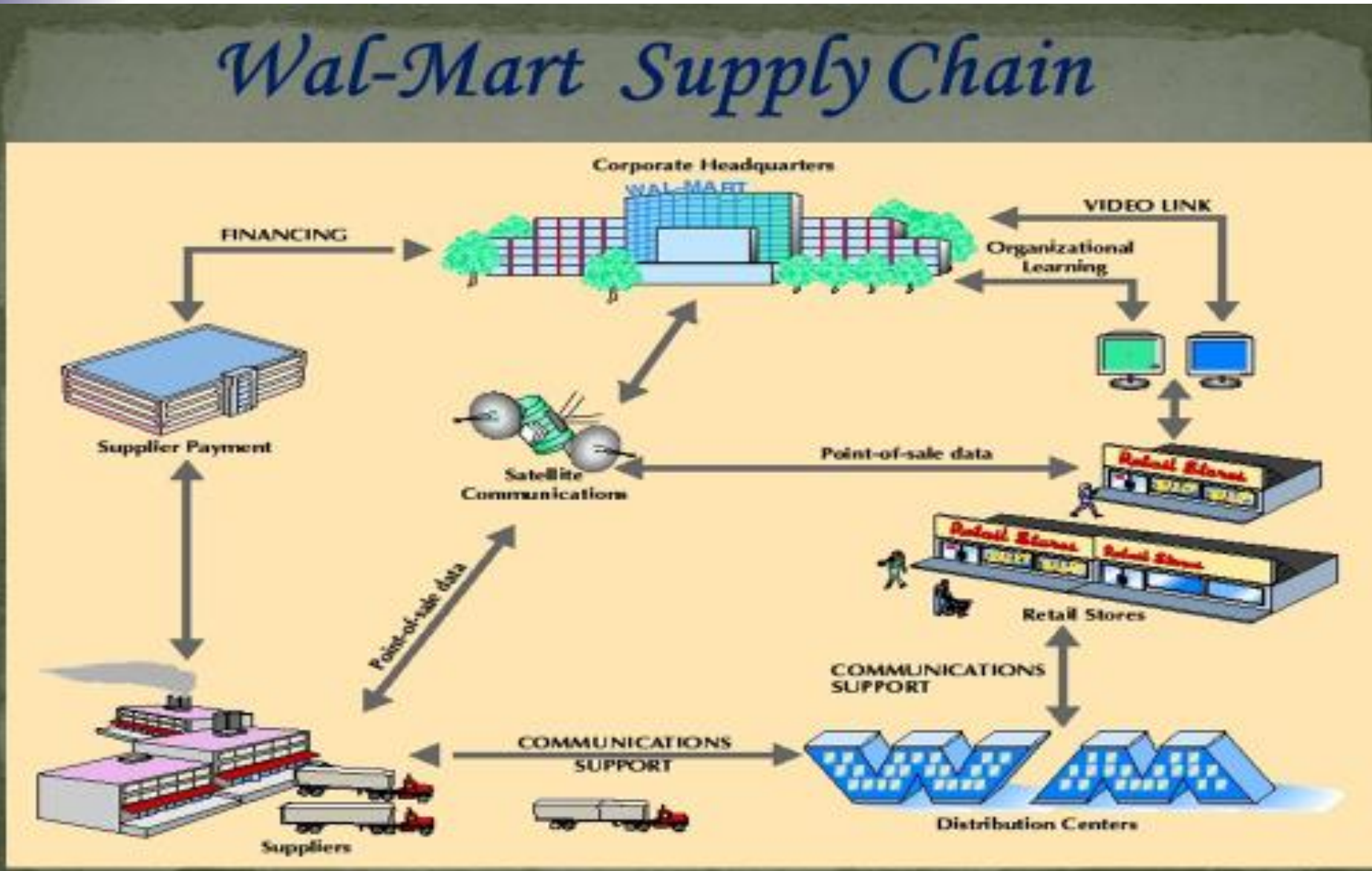
- Wal-Mart uses data to gain competitive advantage with its supply chain
  - Purchase data from bar code scanners is recorded in a massive data warehouse at Wal-Mart headquarters
  - Wal-Mart uses data mining techniques to predict what customers will buy at different times of the year
    - This data is shared with Wal-Mart suppliers to plan production
- Wal-Mart also allows its 5,000 suppliers to directly access its data warehouse through its Retail Link program
- Wal-Mart is leading the effort to include RFID technology(automatically identify and track **tags**)
- SAP's R/3 software has RFID capabilities

Supply Chain Success Story- Wal-Mart

In the late 1970s, with about 200 stores, Wal-Mart was a relatively small retailer. At that time, Sears and Kmart dominated the retail market. Since then, WalMart gained significant market share from these retailers and became the largest and most profitable retailer in the world.

Today, Wal-Mart is admired for its collaboration and technology driven supply chain practices and is leading the retailing industry with its innovative supply chain practices.

Wal-Mart Supply Chain



Summary

- An ERP system can improve the efficiency of production and purchasing processes
  - Begins with Marketing sharing sales forecast
  - Production plan is created based on forecast and shared with Purchasing so raw materials can be ordered properly.
- Production planning can be done without an ERP system, but an ERP system that contains MRP allows Production to be linked to Purchasing and Accounting
  - This data sharing increases a company’s overall efficiency.

Summary (cont'd.)

- Companies are building on their ERP systems and integrated systems philosophy to practice supply chain management (SCM)
  - SCM: company looks at itself as part of a larger process that includes customers and suppliers
  - Using information more efficiently along the entire chain can result in significant cost savings
  - Complexity of the global supply chain
    - Developing a planning system that effectively coordinates information technology and people is a considerable challenge