TU-E2020
ADVANCED OPERATIONS MANAGEMENT
Master Production Scheduling – Material Requirements Planning
Schedule for classes

26.10  Introduction to the Course / TS
27.10  Different models of Planning for Production and Supply Chain Management / TS

2.11   Product Life Cycle and Fleet Management in Operations / Tero Hurskainen
3.11   Demand management, Sales and operations planning and Master production scheduling / TS
3.11   Simul8 tool, and the 1st exercise given 14:15 – 15:00

9.11   Advanced Demand Planning and Capacity Management / JL
10.11  Sales and Operations Planning / Nina Tuomikangas
10.11  1st exercise and 2nd exercise given 14:15 – 15:00
10.11  1st Game Group (5 credits) 15:00 – 19:00
## Schedule for classes

<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.11</td>
<td>Materials requirements planning and distribution requirements planning / TS</td>
<td>12:00 – 16:00</td>
</tr>
<tr>
<td>16.11</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Game Group (5 credits)</td>
<td>12:00 – 16:00</td>
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<tr>
<td>17.11</td>
<td>Advanced Production Planning and Control with ICT tools and systems / Heikki Aalto</td>
<td>14:15 – 15:00</td>
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<tr>
<td>17.11</td>
<td>2nd exercise and 3rd exercise given</td>
<td>14:15 – 15:00</td>
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<tr>
<td>17.11</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Game Group (5 credits)</td>
<td>15:00 – 19:00</td>
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<tr>
<td>23.11</td>
<td>Capacity planning and management, and Production activity control / TS</td>
<td>14:15 – 15:00</td>
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<tr>
<td>24.11</td>
<td>Digital Manufacturing in Operations Management / Jan Holmström</td>
<td>14:15 – 15:00</td>
</tr>
<tr>
<td>30.11</td>
<td>Advanced Forecasting and Supply Chain Solutions / Olli Torkkeli</td>
<td>12:00 – 16:00</td>
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<tr>
<td>30.11</td>
<td>CANCELLED / 4th Game Group (5 credits)</td>
<td>12:00 – 16:00</td>
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<tr>
<td>1.12</td>
<td>4th exercise</td>
<td>14:15 – 15:00?</td>
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</table>
Production Planning & Control System Framework

- **Resource planning**
- **Sales & Oper planning**
- **Demand management**

- **Master production scheduling**
- **Front end The planning task**

- **Detailed capacity planning**
- **Detailed material planning**
- **Engine The scheduling task**

- **Material and capacity plans**
- **Backend The execution task**

- **Shop-floor systems**
- **Supplier systems**

**Enterprise resource planning (ERP)**
Master Production Scheduling – Material Requirements Planning

• The demand for end items is scheduled over a number of time periods and recorded on a master production schedule (MPS).

• The master production schedule expresses how much of each item is wanted and when it is wanted.

• The MPS is developed from forecasts and firm customer orders for end items, safety stock requirements, and internal orders.

• MRP takes the master schedule for end items and translates it into individual time-phased or rate-based component requirements.
Different capacity planning options

Capacity to match maximum demand
Capacity to match average demand
Capacity is adjusted to demand
Outsourcing of peaks OR Outsourcing the base load
Complimentary products

22.9.2011
Jari A.T. Laine
TU-E2020
Advanced Operations Management

Lecture 8 – Master Production Scheduling – Materials Requirement Planning
Master Production Schedule (MPS)

Master Production Schedule answers, for an individual end item, e.g. on a weekly level, to the following questions:

– What product will be produced?
– How many should be completed?
– When these products are completed?
Master Production Schedule

• MPS is a planned production schedule
• MPS is stated in items (end item, sub-items and options) in order to figure out the materials and capacity needs
• Used as a vehicle for communication with sales – sales can make accurate order promising against MPS
• MPS is updated as time goes on, this is called “rolling through time”
Attributes of the MPS

• The MPS is a statement of production, not of demand
• The MPS considers sales and operations plan, capacity constraints and other resource limitations, and the costs of production
• The MPS is stated in terms of product specifications—usually part numbers which have specific bills of materials (BOM)
• In assemble-to-order environments, the MPS may be stated in terms of an “average” final product
# Master Scheduling Approach

## Linking Market Requirements and Manufacturing Strategy to Design of the MPS Approach

<table>
<thead>
<tr>
<th>Strategic Variables</th>
<th>Master Scheduling Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MTO</td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>Variety</td>
</tr>
<tr>
<td><strong>Market requirements</strong></td>
<td>Individual product volume per period</td>
</tr>
<tr>
<td><strong>Delivery</strong></td>
<td>Speed</td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
</tr>
<tr>
<td><strong>Manufacturing</strong></td>
<td>Process choice</td>
</tr>
<tr>
<td></td>
<td>Managing fluctuations in sales volume</td>
</tr>
</tbody>
</table>
MPS in MTO

- Used when the product is custom-built to individual specifications
- Customer order is the unit of control in MPS
- Order backlog is the critical measurement
- Planning bills of material are used extensively
- Major source of uncertainty is customer time requirements
MPS in ATO

• Used when manufacturing lead time exceeds customer expectations, variety and cost of end products precludes holding finished items in inventory, and/or modules or options can be combined to satisfy unique customer requirements

• Key control point is final assembly schedule (FAS)

• Planning bills of material are used to represent “average” product

• Main source of uncertainty is product mix
MPS in MTS

• MPS is stated in end items, which are produced to forecast demand
• Customer orders are filled directly from stock
• Procedures for monitoring accuracy of demand forecasts are required
• Main source of uncertainty is forecast errors
## Features of MPS approaches compared

<table>
<thead>
<tr>
<th>Basis for planning and control</th>
<th>MTO</th>
<th>ATO</th>
<th>MTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control point</td>
<td>Order backlog</td>
<td>Final assembly</td>
<td>Forecast</td>
</tr>
<tr>
<td>MPS unit</td>
<td>Customer orders</td>
<td>Product</td>
<td>End items</td>
</tr>
<tr>
<td>Product level</td>
<td>End product</td>
<td>variants/options</td>
<td>End product</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPS features</td>
<td>High requirement</td>
<td>Low</td>
<td>Low requirement</td>
</tr>
<tr>
<td>Customer order promising</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Importance of forecast accuracy</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Use of planning bills</td>
<td>Time requirements</td>
<td>Product mix</td>
<td>Forecast accuracy</td>
</tr>
<tr>
<td>Nature of uncertainty</td>
<td>Customer order</td>
<td>Customer order</td>
<td>Replenishment to stock or customer call-off</td>
</tr>
<tr>
<td>Basis of delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MTO**
- High requirement
- Low
- Yes
- Time requirements
- Customer order

**ATO**
- Low requirement
- High
- Yes
- Product mix
- Customer order

**MTS**
- No
- Forecast accuracy
- Replenishment to stock or customer call-off
Available-to-Promise

- When immediate delivery is not expected (or is not possible due to stockouts), a promised delivery date must be established
- The order promising task is to determine when the shipment can be made
- Available-to-promise (ATP) procedures coordinate order promising with production schedules
Available-to-Promise Logic with Planning BOM

- Are the common parts on the BOM available?
- Is the requested gear option available?
- Is the requested Taylor option available?

Flowchart:
1. Are the common parts on the BOM available?
   - Yes
   - No
2. Common Parts Available?
   - Yes
   - No
3. Gear Available?
   - Yes
   - No
4. Taylor Available?
   - Yes
   - No
5. No
   - Try 1 period later
   - Yes
   - Book order
TU-E2020
Advanced Operations Management

Lecture 8 – Master Production Scheduling – Materials Requirement Planning
Master Production Scheduling – Material Requirements Planning

• The demand for end items is scheduled over a number of time periods and recorded on a master production schedule (MPS).

• The master production schedule expresses how much of each item is wanted and when it is wanted.

• The MPS is developed from forecasts and firm customer orders for end items, safety stock requirements, and internal orders.

• MRP takes the master schedule for end items and translates it into individual time-phased or rate-based component requirements.
Material Requirements Planning (MRP) is a computer-based production planning and inventory control system.

- MRP is concerned with both production scheduling and inventory control.
- MRP is a material control system that attempts to keep adequate inventory levels to assure that required products and materials are available when needed.
- MRP is applicable in situations of multiple items with complex bills of materials.
- MRP is not useful for job shops or for continuous processes that are tightly linked.
Material Requirements Planning (MRP) is a computer-based production planning and inventory control system.

The major objectives of an MRP system are to simultaneously:

1. Ensure the availability of materials, components, and products for planned production and for customer delivery.
2. Maintain the lowest possible level of inventory,
3. Plan manufacturing activities, delivery schedules, and purchasing activities.
Material Requirements Planning (MRP) and Bill of Materials, Inventory Control, Production Scheduling

- The product structure records, also known as bill of material records (BOM), contain information on every item or assembly required to produce end items. Information on each item, such as part number, description, quantity per assembly, next higher assembly, lead times, and quantity per end item, must be available.

- The inventory status records contain the status of all items in inventory, including on hand inventory and scheduled receipts. These records must be kept up to date, with each receipt, disbursement, or withdrawal documented to maintain record integrity.

- MRP will determine from the master production schedule and the product structure records the gross component requirements; the gross component requirements will be reduced by the available inventory as indicated in the inventory status records.
Product Definition

### Production Process

- **Product**: A
  - **Bulk**: 40,60
  - **Stabilizing**: 20 C – 25 C
  - **Time**: 2h

- **Product**: X

### Ingredients
- **NaOH**
- **BODE**
- **HA**

### Equipment
- Production Line
  - Blender
  - Mixer
  - Kärl 60L

### Production Line

### Mechanical BOM
- **Part**: Syringe
- **Part**: Needle
- **Part**: Cylinder

### Formula BOM

### Operation
- **Operation**: BULK
- **Operation**: Xxx
- **Process Step**: Stabilize
- **Process Step**: Yyy

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<table>
<thead>
<tr>
<th>Product</th>
<th>Bulk</th>
<th>Stabilizing</th>
<th>xxx</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40,60</td>
<td>20 C – 25 C</td>
<td>2h</td>
</tr>
<tr>
<td>X</td>
<td></td>
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</tbody>
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Aalto University
School of Science
Detailed material planning options

• Time-phased material planning
  ➢ Typically using MRP approaches
  ➢ Production process usually based on batch production

• Rate-based material planning
  ➢ Repetitive manufacturing, assembly lines, JIT, TOC
  ➢ Establishing rates of production for each part in the factory

• Choice depends on the production environment, product structure and process design characteristics
Market requirements and the shop-floor system options

<table>
<thead>
<tr>
<th>Market requirements</th>
<th>Strategic Variables</th>
<th>Shop-Floor System Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MRP Based</td>
</tr>
<tr>
<td>Product</td>
<td>Design</td>
<td>Custom</td>
</tr>
<tr>
<td></td>
<td>Variety</td>
<td>Wide</td>
</tr>
<tr>
<td>Individual product</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>volume per period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodating demand changes</td>
<td>Total volume</td>
<td>Easy/incremental</td>
</tr>
<tr>
<td></td>
<td>Product mix</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Speed</td>
<td>Achieved by schedule change</td>
</tr>
<tr>
<td></td>
<td>Schedule changes</td>
<td>More difficult</td>
</tr>
</tbody>
</table>

| Manufacturing       | Process choice      | Low-volume batch | High-volume batch/line |
|                     | Changeover cost     | High             | Low                    |
|                     | Organizational control | Centralized | Decentralized (shop-floor based) |
|                     | Work in process     | High             | Low                    |
|                     | Source of cost reduction | Overheads | High                    |
|                     | Inventory           | Low               | High                   |
Shop-floor system options

• MRP based systems
  ➢ Activities triggered by processes authorizing production quantities, routings, due dates—continually recalculated through MRP planning
  ➢ Tracking of shop orders is done throughout the production

• JIT-based systems
  ➢ Produce in response to downstream use of the item, be it work center to work center or for the overall demand of the end item
  ➢ Tracking of individual orders is not necessary in the process
  ➢ Relatively constant demands are required for the JIT-based approach
Lean as a management philosophy: several elements go beyond PPC
Integrating MRP and JIT for Lean

• The need to integrate
  – Generally MRP firms trying to implement JIT aspects
  – JIT practices may seem to be in conflict with MRP practices
  – Factory floor changes may require PPC system adjustments

• Supporting integration through physical changes
  – JIT support requires reducing the volume of inventory transactions
  – Making changes in the flow of materials and production process (e.g. cellular manufacturing)

• Integration techniques
  – A combination of MRP and JIT requires a mechanism to allow moving back and forth between the two
Summarizing principles

- Understanding the manufacturing task is critical in developing the production process design, the PPC system design, and the other elements of the manufacturing infrastructure.

- The manufacturing process’ particular features need to be considered in choosing among the options in PPC system design.

- Different material planning approaches are increasingly integrated in designing PPC systems.