

Master Scheduling and Rough-cut Capacity Planning



SUPPLEMENT

D

Before studying this supplement you should know or, if necessary, review

1. Capacity management concepts, Chapter 9, pp. 316–322.
2. Work standards, Chapter 11, pp. 402–409.
3. Relevant inventory costs, Chapter 12, pp. 438–440.
4. Order quantity models, Chapter 12, pp. 446–459.
5. Aggregate Planning, Chapter 13, pp. 485–487.

LEARNING OBJECTIVES

After completing this supplement you should be able to

- 1 Explain the role of the master production schedule and describe the objectives of master production scheduling.
- 2 Develop a master production schedule and project the capacity needed using rough-cut capacity planning.
- 3 Calculate available-to-promise quantities.
- 4 Describe time fence policies.

SUPPLEMENT OUTLINE

Master Production Scheduling D2
MPS as a Basis of Communication D3
Objectives of Master Scheduling D4
Developing an MPS D4
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Evaluating and Accepting the MPS D9

Using the MPS D10
Using the ATP Records D11
Stabilizing the MPS D14
Master Production Scheduling and Rough-Cut
Capacity Planning within OM: How It All Fits
Together D15

WHAT'S IN OM FOR ME?



When planning your social and work-related activities for the upcoming semester, you use the same logic that is used in developing a master schedule and doing rough-cut capacity planning. You have a schedule of activities to do (the master production schedule), and you check to see whether you actually have the resources to do those activities (rough-cut capacity planning). Social activities could include sporting events, concerts, the movies, clubbing, dinners out, club meetings, shopping, family commitments, and/or just hanging out. You have work-related activities as well, such as classes, homework, an outside job, and/or group projects. Each of these activities requires some of your resources. At the very least, you must reserve time to do the activity. In some cases, you must also set aside some cash. Unfortunately, almost everyone has limited resources. The same is true for companies. You develop a list of the activities that you plan to do, estimate the resources required, and then determine whether your proposed list is feasible. Companies do the same thing: they develop a master production schedule, and then rough-cut capacity planning determines whether the schedule is feasible.

MASTER PRODUCTION SCHEDULING

Your company's aggregate plan specifies the resources authorized for use by the company's operations group. These resources include the size of the workforce, level of inventory held, number of planned shortages, authorized level of overtime and undertime, aggregate number of units or services to be produced in-house, and number of units or services to be subcontracted.

The **master production schedule (MPS)** is often stated in product or service specifications rather than dollars. It shows how many products or services are planned for each time period, based on the resources authorized in the aggregate plan. In manufacturing, the **master scheduler** develops the schedule based on the available capacity. In service companies, the office manager, department manager, or assistant manager might develop the schedule.

The MPS is the anticipated build schedule for manufacturing specific end products or providing specific services. The key distinction here is that the MPS is a statement of production or services and is not a statement of demand—a plan to satisfy customer demand while considering operational effectiveness and cost. Because of this, individual products can be finished ahead of time and held in inventory rather than finished as needed. The master scheduler or office manager balances customer service and capacity usage.

The aggregate plan shows how many products or services are planned for each time period. The MPS identifies the specific products or services planned for a given time period. Let's look at an example of how an aggregate plan is linked to the MPS.

Although this example involves manufacturing, think about how an MPS might look in a service operation such as a law firm. The firm knows how many hours of staff time are available (resources) and its current case load (demands). It must now decide how best to use the attorneys and law clerks each period to satisfy the corporate objectives.

► Master production schedule (MPS)

The anticipated build schedule.

► Master scheduler

The person responsible for managing, developing, reviewing, and maintaining the master schedule.

Developing the MPS at Amber's Backpack Company

Amber's Backpack Company (ABC) produces three models of backpacks: the basic backpack, the urban backpack, and the evening backpack. Each model needs the same amount of production time. ABC's aggregate production rate is 400 backpacks per week. A possible MPS for ABC is shown here.

Week	1	2	3	4	5	6	7	8
Basic backpack	400		400	400		400	400	
Urban backpack		250			250			250
Evening backpack		150			150			150
Total	400	400	400	400	400	400	400	400

The aggregate plan states that ABC should produce 400 units each week. The MPS shows the models and quantities that constitute the 400 units to be produced each week of the schedule.

EXAMPLE D.1



Ross Whitaker/The Image Bank/Getty

MPS AS A BASIS OF COMMUNICATION

The MPS is a basis for communication between operations and other functional areas. It is stated in product or service specifications rather than dollars. Your company uses an effective MPS in making customer delivery promises, using company capacity wisely, achieving the company's objectives, and making trade-off decisions between marketing and operations. Figure D-1 shows the connections between the master scheduling role and other parts of the planning process. Let's examine these connections, beginning with demand management.

Demand management includes a company's forecasting, order-entry, order-promising, and physical distribution activities. Demand management captures all activities that use capacity. These demands can be customer orders for products or services, a forecast of demand for products and services, interplant requirements, service parts requirements, and/or distribution requirements. If a demand is excluded, it will not be scheduled for completion. Communications between the master scheduler and demand management are ongoing.



► **Demand management**
The function of recognizing all demands for goods and services to support the marketplace.

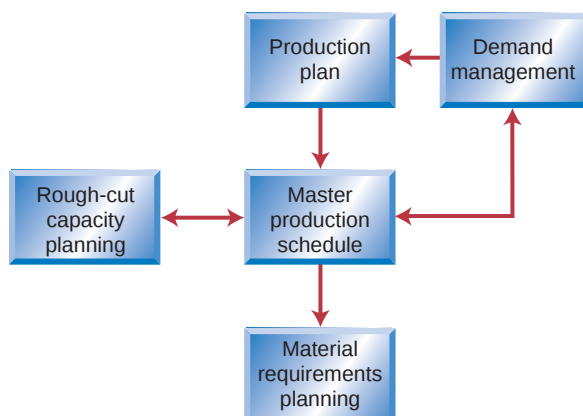


FIGURE D-1

Master production schedule linkages

The top row of the record shows the time periods (weeks, in our example); the forecast row shows the forecasted demand for the product. The projected available quantity row keeps track of how many units are available at the *end of each time period*. The MPS row shows when replenishment shipments need to arrive. MPS shipments arrive at the *beginning of the time period*. To calculate the projected available quantity, we use the following formula:

$$\text{Projected available} = \text{beginning inventory} + \text{MPS shipment} - \text{forecasted demand}$$

Period 1 To calculate the projected available quantity at the end of period 1, we take the beginning inventory (110 units), add any MPS shipments arriving that period (0 units), and subtract the forecasted demand for the period (50 units). This leaves the projected available quantity at the end of period 1, or $(110 + 0) - 50 = 60$ units projected available quantity.

Period 2 The beginning inventory in period 2 is 60 units, no MPS shipment is scheduled, and the forecast is 50 units. Therefore, the projected available quantity at the end of period 2 is 10 units.

Period 3 In period 3, we have 10 units beginning inventory, no MPS quantity, a forecast of 50 units, and a projected available quantity of -40 units; that is, we do not have enough of this product available to satisfy the forecasted demand in period 3. Thus we need to plan an MPS shipment to arrive at the beginning of period 3. We calculate the size of the replenishment order by the order quantity rule—in our case, a fixed-order quantity of 125 units. Table D-2 shows the revised MPS record with an MPS quantity of 125 units scheduled to arrive in period 3.

We continue to calculate the projected available quantity until we find the next period in which the projected available quantity is negative, which is period 5. Therefore, we need to schedule another MPS replenishment for delivery at the start of period 5. At that point, we add another MPS shipment and continue forward. Table D-3 presents the completed MPS record, which shows replenishment orders needed in periods 3, 5, 7, 8, and 11. Each MPS quantity is determined using the given order quantity rule (125 units).

Week	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Projected available	60	10	85	35	-40							
MPS	0	0	125	0	0	0	0	0	0	0	0	0

TABLE D-2

First Revised MPS Record

Week	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Projected available	60	10	85	35	85	10	60	110	60	10	85	35
MPS	0	0	125	0	125	0	125	125	0	0	125	0

TABLE D-3

Completed MPS Record

ROUGH-CUT CAPACITY PLANNING

► Rough-cut capacity planning (RCCP)

The process of converting the master production schedule into requirements for key resources such as direct labor and machine time.

► Demonstrated capacity

Proven capacity calculated from actual performance data.

► Capacity planning using overall planning factors (CPOPF)

A rough-cut capacity planning technique. MPS items are multiplied by historically determined planning factors for key resources.

Rough-cut capacity planning (RCCP) calculates a rough estimate of the workload placed on critical resources by the proposed MPS. This workload is compared against **demonstrated capacity** for each critical resource. This comparison enables the master scheduler to develop a feasible MPS. Among the several approaches to rough-cut capacity planning is capacity planning using overall planning factors (CPOPF).

Capacity planning using overall planning factors (CPOPF) is a simple, rough-cut capacity planning technique. CPOPF develops a planning factor for each critical resource based on historical data. A planning factor shows how much of a resource is needed for one completed unit. Table D-4 shows the procedure for using CPOPF. Next, we will work through an example using the procedure.

TABLE D-4

Procedure for CPOPF

- 1. Determine the appropriate planning factors using historical data.
- 2. Multiply the MPS quantities by the appropriate planning factor.
- 3. Sum capacity requirements for each resource by time period.
- 4. Allocate capacity requirements to individual work centers based on historical percentages.
- 5. Evaluate the workload at each resource to validate MPS feasibility.

EXAMPLE D.2

CPOPF at Heavenly Ballroom Shoes

Jeremy Walker/The Image Bank/Getty Images, Inc.



Heavenly Ballroom Shoes, Inc. (HBS) produces two models of ballroom dance shoes. One model is for men (Model M) and the other is for women (Model W). Charles, the master scheduler, has accumulated the following historical data. During the past three years, HBS has produced 72,000 pairs of Model M, using 21,600 hours of direct labor and 5760 machine hours. During that same period, HBS produced 108,000 pairs of Model W, using 43,200 hours of direct labor and 12,960 hours of machine time.

- **Before You Begin:** To implement capacity planning using overall planning factors (CPOPF), planning factors are needed. In this case, we have two products, Model M and Model W. Each product requires both direct labor and machine time. We have historical data to determine, on average, how much of each resource has been used in the past to build these products. After developing the planning factors, determine how much capacity is needed to satisfy a specific proposed master production schedule. That is, if you know how many Model M's you plan to produce and you know how much direct labor each Model M takes on average, you can calculate the total amount of direct labor needed to build the Model M's for a particular period. You do the same thing for Model W's. Then do this for all periods in your plan. Summing these requirements will give you the total amount of direct labor and machine hours you need to build the units in the proposed master production schedule. These data can be further broken down by individual work centers based on historical data.

Step 1 Determine the planning factors. Charles uses two resources, direct labor and machine time, for each of the products. He needs four planning factors: direct labor for Model M, machine time for Model M, direct labor for Model W, and machine time for Model W. Using the historical data, Charles computes the planning factors as follows:

$$\text{Planning factor for direct labor} = \frac{\text{total direct labor spent building model}}{\text{number of units of model built}}$$

For Model M, this translates to

$$\text{Planning factor for direct labor} = \frac{21,600 \text{ hours of direct labor}}{72,000 \text{ pairs}}$$

The planning factor for direct labor for Model M is 0.30 hours. That means he allows for 0.30 hours of direct labor for each pair of Model M shoes. To calculate the planning factor for machine time for Model M, Charles substitutes total machine hours spent building Model M into the numerator as shown.

$$\text{Planning factor for machine time} = \frac{\text{total machine hours spent building model}}{\text{number of units of model built}}$$

The planning factor for the Model M machine time is 0.08 hours (5760 hours of machine time divided by 72,000 pairs of Model M). Charles continues the process to calculate the planning factors for Model W. The direct labor planning factor for Model W is 0.40 hours and the machine time planning factor is 0.12 hours. Table D-5 shows the four planning factors.

Given a proposed MPS, how would Charles calculate the workload for the proposed MPS? Table D-6 shows the proposed quarterly MPS for HBS.

Step 2 Calculate the workload generated by this schedule. Charles multiplies the MPS quantity times the appropriate planning factor. For example, Charles begins in Quarter 1 and calculates how much labor is needed to build 6000 pairs of Model M and 10,000 pairs of Model W. He multiplies 6000 pairs of Model M by its labor planning factor of 0.30 hours to arrive at 1800 hours of direct labor needed. He continues for Model W, multiplying 10,000 pairs by its labor planning factor of 0.40 hours to arrive at 4000 hours of direct labor needed. The total number of direct hours needed in Quarter 1 is 5800 hours (1800 for Model M and 4000 for Model W). Charles continues to do this for each time period. Table D-7 shows all the labor needs.

To calculate the machine needs, Charles continues the process. He multiplies the Quarter 1 needs for Model M by its machine time planning factor (6000 Model M's $\times$ 0.08 hours machine time = 480 hours needed). For Model W, 1680 hours of machine time are needed (10,000 Model W's $\times$ 0.12 hours machine time = 1200 hours needed). Table D-8 shows the machine needs for each product in each quarter.

TABLE D-5

Planning Factors

	A	B	C
3	Planning Factors (hours per pair)		
4		Direct	Machine
5		Labor	Time
6	Model M	0.30	0.08
7	Model W	0.40	0.12

TABLE D-6

Proposed MPS

	A	B	C	D	E	F
9	Quarterly Master Production Schedule (MPS) (pairs)					
10		Q1	Q2	Q3	Q4	Totals
11	Model M	6000	5500	9500	6500	27500
12	Model W	10000	12000	7500	10100	39600

Step 3 Calculate the total capacity needs for each resource for each time period. Charles does this by summing up the individual capacity needs for each of the products. Table D-7 shows the total labor hours needed for each quarter. Table D-8 shows the same information for machine hours needed.

Step 4 Calculate individual work center capacity needs based on historical percentage allocation. Charles calculates that 60 percent of HBS’s direct labor is used in work center 101 and 40 percent is used in work center 102. The same is true for its machine time. How would Charles calculate by quarters how much direct labor and machine time is needed at work centers 101 and 102? Table D-9 shows direct labor needs by work center. To calculate the labor hours needed in work center 101 in Quarter 1, Charles multiplies the total Quarter 1 labor needs by 60 percent (5800 hours of total labor needed by 60 percent equals 3480 hours of labor needed in work center 101 in Quarter 1). The labor in work center 102 in Quarter 1 is 2320 hours (5800 hours × 40 percent). Charles now has an estimate of the direct labor needs by quarter for each of the work centers. He can compare the direct labor hours needed with the available direct labor hours and make adjustments either to the available capacity or to the MPS.

Charles calculates machine hour needs in each department for each quarter in the same way as he calculates labor needs. Table D-10 shows the machine hours needed by each of the work centers for each quarter. Given this information, Charles can decide whether HBS needs additional equipment or whether it has adequate machine capacity in each of the work centers. Remember that a

TABLE D-7

Direct Labor
Hours Required

	A	B	C	D	E	F
13						
14	Direct Labor Hours Required			B16: =B11*\$B6 (copied to B16:E17)		
15		Q1	Q2	Q3	Q4	Totals
16	Model M	1800	1650	2850	1950	8250
17	Model W	4000	4800	3000	4040	15840
18	Totals	5800	6450	5850	5990	24090
19	B18: =SUM(B16:B17)			F16: =SUM(B16:E16)		
20						

TABLE D-8

Machine Time
(Hours) Required

	A	B	C	D	E	F
21						
22	Machine Time (Hours) Required			B24: =B11*\$C6 (copied to B24:E25)		
23		Q1	Q2	Q3	Q4	Totals
24	Model M	480	440	760	520	2200
25	Model W	1200	1440	900	1212	4752
26	Totals	1680	1880	1660	1732	6952
27	B26: =SUM(B24:B25)			F24: =SUM(B24:E24)		
28						

TABLE D-9

Direct Labor Needs by Work Center

	A	B	C	D	E	F	G
30	Direct Labor Hours Required by Work Center						
31		Historical Allocation	Q1	Q2	Q3	Q4	Totals
32	Center 101	60%	3480	3870	3510	3594	14454
33	Center 102	40%	2320	2580	2340	2396	9636
34	Totals		5800	6450	5850	5990	24090
35	C34: =SUM(C32:C33)			G32: =SUM(C32:F32)			
36							

TABLE D-10

Machine Hour Needs by Work Center

	A	B	C	D	E	F	G
38	Machine Time Hours Required by Work Center						
39		Historical Allocation	Q1	Q2	Q3	Q4	Totals
40	Center 101	60%	1008	1128	996	1039.2	4171.2
41	Center 102	40%	672	752	664	692.8	2780.8
42	Totals		1680	1880	1660	1732	6952
43		C42: =SUM(C40:C41)					
44						G40: =SUM(C40:F40)	

company can increase its capacity with overtime, temporary workers, subcontracting, or by using alternative manufacturing processes. When Charles is certain that the proposed MPS is feasible, he evaluates the MPS in terms of customer service, effectiveness of resource usage, and cost.

EVALUATING AND ACCEPTING THE MPS

To evaluate the MPS in terms of customer service, the master scheduler checks that promised customer delivery dates are met. He or she also makes sure that the MPS provides enough flexibility to respond to new customer orders.



To evaluate the MPS for effective use of resources, the master scheduler checks that enough capacity is available to meet the schedule in each time period. This capacity includes short-term changes such as overtime, subcontracting, and temporary employees.

To evaluate the MPS in terms of cost, the master scheduler compares the MPS to the aggregate plan, which specifies available resources. If the MPS needs additional resources, the company may not achieve the objectives of the marketing plan and, consequently, the business plan.

When the master scheduler has evaluated and accepted the MPS, this authorized MPS is input into the MRP system, which is discussed further in Chapter 14.

Before You Go On

Be sure that you understand the sequential process of master scheduling:

1. The master scheduler uses a rough-cut capacity planning technique to calculate whether the company has the capacity to meet the proposed MPS.
2. If the proposed MPS is feasible, it is evaluated in terms of customer service, effective use of resources, and inventory investment.
3. If the proposed MPS is accepted, it becomes the authorized MPS. If capacity is insufficient, either the MPS is modified or capacity is expanded.

USING THE MPS

► **Order promising**
The process of making order-delivery commitments.

► **Available-to-promise (ATP)**
The uncommitted portion of a company’s inventory and planned production, maintained in the MPS to support order promising.

One use of the authorized MPS is order promising. When a customer places an order for a product but does not expect immediate delivery, the delivery date is negotiated. The customer typically requests delivery at a future date and the company decides whether it can promise delivery on that date. This is called **order promising**. For example, your parents order a new car custom-built for you at the factory for delivery on graduation day. The company is order promising when it decides whether it can produce the car and deliver it on that date. By extending the MPS records we began using in Table D-1, we can do order promising. Let’s look at an extended MPS record in Table D-11.

The table now has two additional rows, one for customer orders and the other for available-to-promise quantity. The customer orders row has orders promised to customers for delivery in that time period. For example, the company has promised 35 units to be delivered in period 1, 25 units for delivery in period 2, and so forth.

The **available-to-promise (ATP)** row shows how many uncommitted units the company has available for delivery at a given time. Next, we look at an example of how to calculate the ATP quantity and the projected available balances.

TABLE D-11
Extended MPS Record

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	35	25	25	20	0	15	0	0	10	0	0	10
Projected available												
ATP												
MPS	0	0	125	0	125	0	125	125	0	0	125	0

EXAMPLE D.3
Filling in the MPS Record

► **Action bucket**
The current period.

Using the data shown in Table D-11, let’s look at how we get the numbers. In this case, both the forecast numbers and the customer orders are already filled in. The first calculations we need to do are in the projected available row: we take the beginning inventory, add to it any MPS shipment, and subtract the greater of the forecast quantity or the customer orders. For example, in period 1, the beginning inventory is 110 units, there is no MPS shipment, and since the forecast of 50 is greater than the customer orders (35), we have 110 units + 0 units – 50 units = 60 units projected available at the end of period 1.

We calculate the projected available quantity as
$$\text{Projected available} = \text{beginning inventory} + \text{MPS shipment} - \text{the greater of the period's forecast or the actual customer orders promised for delivery that period}$$

Table D-12 shows the appropriate projected available quantities. We calculate the ATP quantity for the current period or, as it is called, the **action bucket**, and each time an MPS replenishment order is scheduled. In our example, that means we compute the ATP quantity in periods 1, 3, 5, 7, 8, and 11.

TABLE D-12

Completed ATP MPS Record

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	35	25	25	20	0	15	0	0	10	0	0	10
Projected available <u>110</u>	60	10	85	35	85	10	60	110	60	10	85	35
Available-to-promise	50		80		110		125	115			115	
MPS			125		125		125	125			125	

We calculate the ATP quantity in the current period differently from how we calculate it in the future replenishment periods. In the current period (the action bucket), the ATP quantity equals the beginning inventory, plus any MPS quantity. These two represent the available inventory we have to work with. In period 1, this is 110 units plus 0, or 110 total units available. From this amount, we subtract the customer orders promised for delivery between now and the next replenishment order (period 3 in our case). The number of units already promised is 60 (35 units for delivery in period 1 and 25 units for delivery in period 2). After subtracting the 60 units promised from the 110 units available, we still have 50 ATP units for delivery either in period 1, period 2, or at some future date. We calculate ATP in the action bucket as

$$\text{ATP}_{\text{Action Bucket}} = \text{beginning inventory} + \text{MPS shipment} - \text{customer orders before next replenishment}$$

As we said, we calculate the ATP differently at future replenishment periods. In these cases, the ATP equals the MPS replenishment quantity less any customer orders promised for delivery between the date of the replenishment received and the next replenishment scheduled. For example, a replenishment order of 125 units is arriving in period 3. The customer orders already promised for delivery before the next replenishment order (period 5) total 45 units (25 units in period 3 and 20 units in period 4). Of those 125 units arriving, we have already committed 45, leaving 80 units still available to promise. We calculate the ATP at periods other than the action bucket as

$$\text{ATP} = \text{MPS shipment} - \text{customer orders between current MPS shipment and next scheduled replenishment}$$

In periods other than the action bucket, we do not include the beginning inventory since it is not clear what the available amount will be. Remember that we subtracted the greater of the forecast or customer orders promised for delivery each period. Thus, if the forecast is greater than the customer orders, we end up with more units in inventory than are reflected on the MPS record. Table D-12 shows the completed ATP quantities.

USING THE ATP RECORDS

The ATP records show how much inventory is available to satisfy customer demand, so your company bases its delivery promises to customers on these records. Using the completed ATP record in Table D-12, let's look at whether or not your company can promise delivery of a new order.

Suppose that marketing has a customer willing to purchase 200 units if your company can deliver the units in period 5. Using the ATP record, we need to see whether that delivery is possible. One way to do this is to adjust the ATP record as if the order had already been accepted. Table D-13 shows a revised ATP record including the new order.



TABLE D-13

Revised ATP
MPS Record

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	35	25	25	20	200	15	0	0	10	0	0	10
Projected available 110	60	10	85	35	-40	-115	-65	-15	-65	-115	-40	-90
Available-to-promise	50		80		-90		125	115			115	
MPS			125		125		125	125			125	



"Would you like that delivered soon,
pretty soon, or sometime-or-other?"

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In the customer orders row, 200 units are now scheduled for customer delivery in period 5. This changes the projected available quantities from period 5 onward and changes the ATP quantity in period 5. The two rules to remember here are the following.

1. A negative number in the projected available row is **sometimes** a problem. We calculate the projected available quantity by subtracting the greater of the forecast or the customer orders promised for delivery each period. If the forecast is subtracted because it is larger as in period 1 (50 units forecast compared to 35 units of customer orders), the company may not sell any more units for delivery in period 1. In that case, the ending inventory for period 1 would be 75 units (110 units to start with, less 35 units delivered).
2. A negative number in the available-to-promise row is **always** a problem. This means your company does not have enough inventory to cover the delivery. In our example, the company needs an additional 90 units to cover the new order scheduled for delivery in period 5.

One way to handle this problem is to look at earlier ATP quantities to see whether any inventory is available from earlier shipments. Period 1 has 50 uncommitted units and period 3 has an additional 80 available units. If we set 90 of these units aside for the period 5 order, we can agree to the new customer order. Look at the revised ATP record in Table D-14.

TABLE D-14

Second
Revised ATP
Record

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	45 ¹	25	105 ¹	20	110 ¹	15	0	0	10	0	0	10
Projected available 110	60	10	30	-20	-5	-80	-30	20	-30	-80	-5	-55
Available-to-promise	40		0		0		125	115			115	
MPS			125		125		125	125			125	

¹These quantities have changed in order to account for the additional 90 units needed to satisfy the order of 200 units for delivery in period 5. We commit 80 units from the period 3 replenishment order and 10 units from the ATP quantity in period 1.

Think of it this way: We set 10 units aside in period 1 and put the customer's name on the boxes for delivery in period 5. In period 3, we put names on an additional 80 boxes of units. Then in period 5, we use the 90 boxes of units already set aside plus 110 of the new units to total the 200 units needed. In this way, we can promise delivery of 200 units in period 5.

After we agree to the order for 200 units for delivery in period 5, the next order arrives requesting an additional 50 units for period 4 delivery. We put this order into the record and see the results in Table D-15.

The ATP quantity in period 3 is now -50 . Since a negative number in the ATP row is always a problem, we must check to see whether there is a way we can change that quantity to zero and accept the order. The only available inventory before delivery is requested is the 40 units available in period 1. Everything else has been promised. Therefore, we cannot accept this order for delivery in period 4. The earliest we can promise delivery is in period 7. Unless the customer is willing to agree with this delivery date, we cannot accept the order. We delete the 50 units from the period 4 customer orders and recalculate the other quantities. The ATP record reverts back to the numbers previously shown in Table D-14.

Let's look at a couple of additional orders and calculate whether they can be accepted for delivery at the requested time. The first new order is for an additional 50 units to be delivered in period 8; the second order is for 30 additional units in period 12. When we put these orders into the customer order row, the ATP record is updated, as shown in Table D-16. Since there are no negative values in the ATP row, we can promise both of these orders for delivery.

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	45 ¹	25	105 ¹	70	110 ¹	15	0	0	10	0	0	10
Projected available 110	60	10	30	-40	-25	-100	-50	0	-50	-100	-25	-75
Available-to-promise	40		-50		0		125	115			115	
MPS			125		125		125	125			125	

TABLE D-15

Third Revised
ATP Record

¹These quantities have changed to account for the additional 90 units needed to satisfy the order of 200 units for delivery in period 5. We commit 80 units from the period 3 replenishment order and 10 units from the ATP quantity in period 1.

Period	1	2	3	4	5	6	7	8	9	10	11	12
Forecast	50	50	50	50	75	75	75	75	50	50	50	50
Customer orders	45 ¹	25	105 ¹	20	110 ¹	15	0	50	10	0	0	40
Projected available 110	60	10	30	-20	-5	-80	-30	20	-30	-80	-5	-55
Available-to-promise	40		0		0		125	65			85	
MPS			125		125		125	125			125	

TABLE D-16

Final Revised
ATP Record

¹These quantities have changed to account for the additional 90 units needed to satisfy the order of 200 units for delivery in period 5. We commit 80 units from the period 3 replenishment order and 10 units from the ATP quantity in period 1.

The key requirement for using ATP is that manufacturing delivers the MPS replenishment on the scheduled date. For your company to meet these critical dates, operations must have the capacity specified in the MPS, and therefore the MPS itself must be feasible.

STABILIZING THE MPS

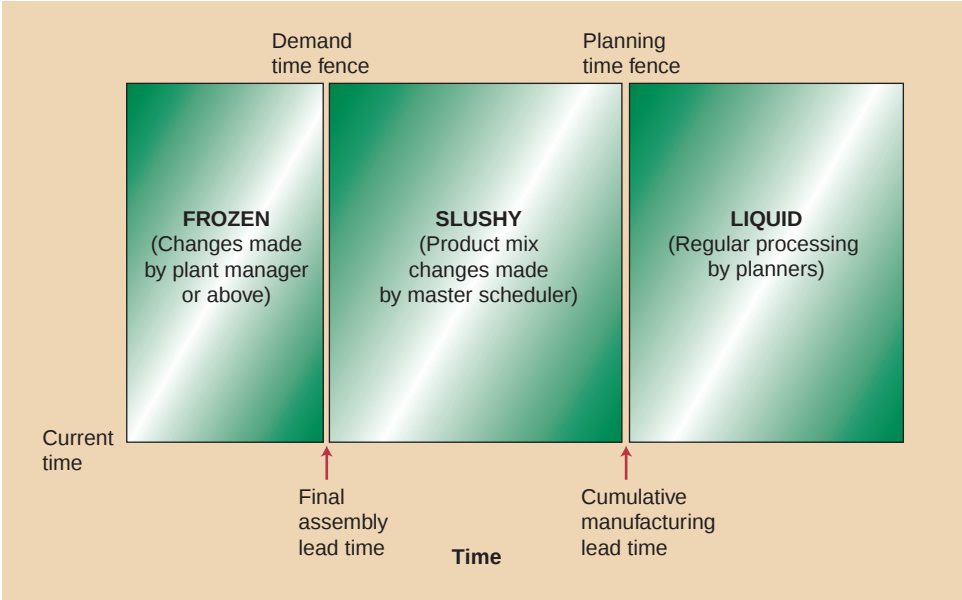
- **Time fence policies**
Partition the MPS into areas requiring different operating procedures.
- **Demand time fence**
Establishes that point of time in the future inside of which changes to the MPS must be approved by a higher authority.
- **Planning time fence**
Establishes a point of time in the future inside of which changes must be made by the master scheduler and changes outside of which can be changed by system planning logic.

The master scheduler tries to minimize the number of changes made to an authorized MPS because each proposed change can affect the feasibility of the MPS. To deal with MPS changes, companies sometimes use **time fence policies**. Figure D-2 illustrates the MPS and time fences. The figure shows the **demand time fence** and the **planning time fence**, which split the MPS into three parts. The portion of the master schedule from the current time up to the demand time fence is frozen and any changes are kept to a minimum.

Companies typically require these changes to be authorized by a person other than the master scheduler because they may need additional resources. This portion of the MPS normally uses all available capacity to produce customer orders. Adding any orders without adding resources results in a delay of the currently scheduled jobs.

The third portion of the MPS starts at the planning time fence and extends into the future. This portion of the MPS is considered liquid because all orders requested during this portion are accepted as long as the resources authorized by the aggregate plan are adequate. The planning time fence is typically placed far enough into the future so that there is enough time to order any necessary materials and complete the normal manufacturing process. Production planners, discussed in Chapter 14, generally place these orders.

FIGURE D-2
Time fences



EXAMPLE D.4**Time Fences
at HBS**

Heavenly Ballroom Shoes (HBS) has frozen the first month of its MPS. Quarter 1 is shown in monthly time periods. The HBS marketing director, Marilee, has gotten an endorsement from this year's national ballroom champions for HBS shoes. Because of this endorsement, marketing needs two new, more upscale shoe models (Model WC and Model MC) for use in major competitions. The new models must be available by the end of January or HBS will lose market share. Marilee has asked Charles, the master scheduler, to schedule production of 500 pairs of each of these new models in January. The endorsement represents a major business opportunity for HBS, but HBS does not have the capacity to accept the order for the new shoes. HBS can accept the order only by authorizing more resources for manufacturing or by delaying the shoes that are currently scheduled.

Model	January (pairs)	February (pairs)	March (pairs)	Total Q-1 (pairs)
Model M		666	5,334	6,000
Model W	5,333	4,667		10,000
Total	5,333	5,333	5,334	16,000
Planned capacity available (pairs)	5,335	5,335	5,335	16,005

HBS has set up its MPS so that a decision to change the frozen portion has to be authorized by a manager who is also authorized to provide resources. In this way, HBS protects against jeopardizing existing orders to satisfy new ones.

The second portion of the MPS is the time between the demand time fence and the planning time fence. This is called the slushy portion of the MPS, during which it is the master scheduler's responsibility to negotiate changes in the MPS. For example, if Marilee in HBS marketing needs a product other than what is scheduled, Charles, the HBS master scheduler, first calculates whether the materials are available to make the other product. Then Charles asks Marilee which items marketing would be willing to do without. This is necessary to free up capacity so that the other product can be made.

In this portion of the MPS, changes in the product mix are possible, but changes needing additional resources are not. Thus, HBS will produce 5333 pairs of shoes during a month, but the mix of the shoe models may vary. A revised MPS for February might look like the following. The product mix has changed but the total number of pairs produced remains constant.

Model	Quantity
Model M	166
Model MC	500
Model W	3667
Model WC	1000
Total pairs	5333



MASTER PRODUCTION SCHEDULING AND ROUGH-CUT CAPACITY PLANNING WITHIN OM: HOW IT ALL FITS TOGETHER

In most companies, the operations manager develops the aggregate plan, which determines the resources available to operations to execute the master production schedule. The plan will clearly indicate the size of the workforce and the aggregate production rate. The master production scheduler then develops the master production schedule. The only feasible plan that can be developed is one by the scheduler working with marketing, operations, demand management, and the customers. The master scheduler's job is to develop an MPS that achieves the company's desired customer service level, uses capacity effectively, and minimizes the inventory investment. To make sure that the master production schedule is feasible, rough-cut capacity planning is done.

Supplement Highlights

- 1 The MPS shows how the resources authorized by the aggregate plan will be used to satisfy the objectives of the organization. The MPS specifies the products and quantities to be built in each time period. The MPS is a common organizational document used to facilitate communication between different functional areas. The master scheduler develops a proposed MPS based on input received from the aggregate plan and demand management. This MPS is checked for feasibility using a rough-cut capacity planning technique.
- 2 The objectives of master scheduling are to satisfy customer service objectives, use resources effectively, and minimize costs. An MPS is developed by looking at individual MPS records and calculating when replenishment quantities are needed. The individual MPS records are summed together to show the total proposed workload.
- 3 Available-to-promise logic is used when promising order delivery dates to customers. ATP logic allows the company to make viable delivery promises.
- 4 Time fence policies stabilize the MPS. The demand time fence and the planning time fence divide the MPS into three portions: frozen, slushy, and liquid. Changes in the frozen portion are infrequent and must be authorized by a manager with authority to release additional resources to operations. Changes to the slushy portion are negotiated between the master scheduler and marketing. Changes in the product mix can occur but not changes in total volume. Changes in the liquid portion are made by planners since adequate lead time is available.

Key Terms

master production schedule (MPS) D2	demonstrated capacity D6	time fence policies D14
master scheduler D2	capacity planning using overall	demand time fence D14
demand management D3	planning factors (CPOPF) D6	planning time fence D14
material requirements planning	order promising D10	
(MRP) D4	available-to-promise (ATP) D10	
rough-cut capacity planning	action bucket D10	
(RCCP) D6		

Formula Review

1. Calculating the projected available quantity:

$$\text{Projected available} = \text{beginning inventory} + \text{MPS shipment} - \text{forecasted demand}$$
2. Calculating a planning factor for direct labor:

$$\text{Planning factor for direct labor} = \frac{\text{total direct labor spent building model}}{\text{number of units of model built}}$$
3. Calculating a planning factor for machine time:

$$\text{Planning factor for machine time} = \frac{\text{total machine time spent building model}}{\text{number of units of model built}}$$
4. Calculating projected available quantity when using ATP MPS records:

$$\text{Projected available} = \text{beginning inventory} + \text{MPS shipment} - \text{the greater of the period's forecast or the actual customer orders promised for delivery that period}$$
5. Calculating ATP quantity in the action bucket:

$$\text{ATP}_{\text{Action Bucket}} = \text{beginning inventory} + \text{MPS shipment} - \text{customer orders before next replenishment}$$
6. Calculating ATP quantity at future replenishment periods:

$$\text{ATP} = \text{MPS shipment} - \text{customer orders between current MPS shipment and next scheduled replenishment}$$

Solved Problems



(See student companion site for Excel template.)

• Problem 1

Complete the following MPS records. The beginning inventory is 20 units and the order quantity is an FOQ = 50 units in part (a) and a POQ = two periods in part (b).

• Before You Begin:

This problem compares two different replenishment policies, an FOQ = 50 units with a POQ = two periods. Calculate the projected available quantity to determine when a replenishment order is needed. When the projected available quantity is negative, a replenishment order is needed in that period. Note that different policies can have orders due in different periods. The number of orders and the inventory levels can vary based on replenishment policy.

Period	1	2	3	4	5	6	7
Forecast	20	20	20	20	10	10	10
Projected available							
MPS							

Period	8	9	10	11	12	13
Forecast	10	10	10	20	20	20
Projected available						
MPS						

Period	1	2	3	4	5	6	7
Forecast	20	20	20	20	10	10	10
Projected available	0	30	10				
MPS		50					

Period	8	9	10	11	12	13
Forecast	10	10	10	20	20	20
Projected available						
MPS						

• Solution a

Begin by calculating the projected available quantities. At the end of period 1, the projected available should be 0 (20 units of beginning inventory less 20 units forecasted demand). If no order is received, the projected available row is negative at the end of period 2. When this row turns negative, we need a replenishment order for that period. The replenishment order in this case is 50 units. The updated MPS record is shown in Table D-17.

When spreadsheeting this problem, you can include a conditional statement to check whether the projected available quantity is negative. When the projected available is negative, an MPS quantity is then entered into the appropriate cell. The program then recalculates the projected available quantity and continues on to the next negative result.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2	Master Production Scheduling													
3														
4	Beginning Inventory	20												
5	Order Quantity	50												
6														
7	Week	1	2	3	4	5	6	7	8	9	10	11	12	13
8	Forecast	20	20	20	20	10	10	10	10	10	10	20	20	20
9	Projected Available	0	30	10	40	30	20	10	0	40	30	10	40	20
10	MPS	0	50	0	50	0	0	0	0	50	0	0	50	0
11														
12		B9: =B4+B10-B8												
13		B10: =IF(\$B\$4-B8<0,\$B\$5,0)												
14														
15														
16														

TABLE D-17

Solution to Solved Problem 1a

When you are solving the problem manually, continue calculating the projected available quantities until the next negative. At that point, we need another replenishment order. The completed MPS is shown here.

Period	1	2	3	4	5	6	7
Forecast	20	20	20	20	10	10	10
Projected available	0	30	10	40	30	20	10
MPS		50		50			

Period	8	9	10	11	12	13
Forecast	10	10	10	20	20	20
Projected available	0	40	30	10	40	20
MPS		50			50	

• **Solution b**

Period	1	2	3	4	5	6	7
Forecast	20	20	20	20	10	10	10
Projected available	0	20					
MPS		40					

Period	8	9	10	11	12	13
Forecast	10	10	10	20	20	20
Projected available						
MPS						

• **Problem 2**

Tim’s Wire Shop builds two different, complicated wiring assemblies. Production of the WA-1001 model has averaged 50,000 units annually. Historically, Tim’s Wire Shop has used 12,000 direct labor hours and 5000 hours of machine time annually to build the WA-1001 wiring harness. The other wiring assembly, WA-5005, has an average annual production of 40,000 units. Annual direct labor used on the WA-5005 is 26,000 hours and 2000 hours of machine time.

Develop the following four planning factors:

- Planning factor for direct labor for WA-1001
- Planning factor for direct labor for WA-5005
- Planning factor for machine time for WA-1001
- Planning factor for machine time for WA-5005

• **Before You Begin:**

In this problem, you need to calculate planning factors. Use the historical data to determine on average how much direct labor

Once again, we need an MPS replenishment in period 2. To calculate the quantity, we sum the forecasted demand for the next two periods and subtract any beginning inventory. We need 20 units in both periods 2 and 3 for a total of 40 units; we have no beginning inventory, so we order 40 units. Look at the final MPS record that follows.

Period	1	2	3	4	5	6	7
Forecast	20	20	20	20	10	10	10
Projected available	0	20	0	10	0	10	0
MPS		40		30		20	

Period	8	9	10	11	12	13
Forecast	10	10	10	20	20	20
Projected available	10	0	20	0	20	0
MPS	20		30		40	

We need the next replenishment order in period 4, which should be for 30 units (20 demanded in period 4 and 10 units for period 5). The completed MPS record is shown above.

Note that replenishment orders are now scheduled for periods 2, 4, 6, 8, 10, and 12.

was used to make a model WA-1001 and a model WA-5005. Do the same for machine time.

• **Solution**

To calculate the planning factor for direct labor for WA-1001, divide the annual direct labor hours by the annual number of units produced.

Planning factor for direct labor for WA-1001 = 12,000
direct labor hours/50,000 units, or 0.24 hour per unit

Planning factor for direct labor for WA-5005 = 26,000
direct labor hours/40,000 units, or 0.65 hour per unit

Planning factor for machine time for WA-1001 = 5000
hours of machine time/50,000 units, or 0.10 hour per unit

Planning factor for machine time for WA-5005 = 2000
hours of machine time/40,000 units, or 0.05 hour per unit

• Problem 3

Given the proposed MPS shown here and the planning factors from Solved Problem 2, calculate the needed capacity for each period for direct labor and machine time.

• Before You Begin:

Use the planning factors developed in Solved Problem 2. Calculate the amount of capacity needed to satisfy the master production schedule shown. Determine the quarterly requirements for both direct labor and machine time.

Item	Quarter 1	Quarter 2	Quarter 3	Quarter 4
WA-1001	10,000	15,000	15,000	13,000
WA-5005	15,000	10,000	9,000	8,000
Total	25,000	25,000	24,000	21,000

Model	Direct Labor Factor	Q-1 MPS Qty	Q-1 Hours Req'd	Q-2 MPS Qty	Q-2 Hours Req'd	Q-3 MPS Qty	Q-3 Hours Req'd	Q-4 MPS Qty	Q-4 Hours Req'd	Total MPS Qty	Total Hours Req'd
WA-1001	0.24	10,000	2,400	15,000	3,600	15,000	3,600	13,000	3,120	53,000	12,720
WA-5005	0.65	15,000	9,750	10,000	6,500	9,000	5,850	8,000	5,200	42,000	27,300
Total		25,000	12,150	25,000	10,100	24,000	9,450	21,000	8,320	95,000	40,020

Use the same approach to calculate machine time needs.

Model	Machine Time Factor	Q-1 MPS Qty	Q-1 Hours Req'd	Q-2 MPS Qty	Q-2 Hours Req'd	Q-3 MPS Qty	Q-3 Hours Req'd	Q-4 MPS Qty	Q-4 Hours Req'd	Total MPS Qty	Total Hours Req'd
WA-1001	0.10	10,000	1,000	15,000	1,500	15,000	1,500	13,000	1,300	53,000	5,300
WA-5005	0.05	15,000	750	10,000	500	9,000	450	8,000	400	42,000	2,100
Total		25,000	1,750	25,000	2,000	24,000	1,950	21,000	1,700	95,000	7,400

• Solution

To find the direct labor hours needed, multiply the MPS quantity for each item by its planning factor. Do this for each period.

• Problem 4

Tim's Wire Shop uses three different departments to produce these wire assemblies. Each of these departments uses direct labor and machine time. Historically, Department 101 uses 25 percent of the direct labor time and machine time for these products, Department 102 uses 35 percent and Department 103 uses 40 percent. Calculate the direct labor and machine time needs for each department for each quarter.

• Before You Begin:

In this problem, allocate the capacity requirements calculated in Problem 3 among three different departments. Use the given

historical averages to allocate the direct labor and machine hours needed each period by each department.

• Solution

To calculate the direct labor hours needed for each department, take the total direct labor needed for the quarter and multiply it by the appropriate percentage for each work center. For example, in Quarter 1, the total direct labor needed is 12,150 hours. Multiply that by 25 percent to allocate the appropriate amount of labor to Department 101. The same approach is used for allocating machine time among departments. The completed allocations are shown here.

Labor Allocations						
Department	Historical Percentage Allocation	Labor Hours Required Q-1	Labor Hours Required Q-2	Labor Hours Required Q-3	Labor Hours Required Q-4	Total Labor Required
Department 101	25%	3,037.5	2,525	2,362.5	2,080	10,005
Department 102	35%	4,252.5	3,535	3,307.5	2,912	14,007
Department 103	40%	4,860	4,040	3,780	3,328	16,008
Total		12,150	10,100	9,450	8,320	40,020

Machine Allocations						
Department	Historical Percentage Allocation	Machine Hours Required Q-1	Machine Hours Required Q-2	Machine Hours Required Q-3	Machine Hours Required Q-4	Total Machine Labor Required
Department 101	25%	437.5	500	487.5	425	1,850
Department 102	35%	612.5	700	682.5	595	2,590
Department 103	40%	700	800	780	680	2,960
Total		1,750	2,000	1,950	1,700	7,400

• **Problem 5**

Jeannette’s Cashmere Sweaters has authorized the following MPS for her exclusive line of cashmere sweaters. She wants to use the MPS record for promising future orders. Current order promises are included. The MPS order quantity is 60 units. Beginning inventory is 0. Complete the following MPS record.

Period	1	2	3	4	5	6
Forecast	15	15	15	15	20	20
Customer orders	12	10	8	5	0	0
Projected available						
Available-to-promise						
MPS	60				60	

Period	7	8	9	10	11	12
Forecast	20	20	25	25	25	25
Customer orders	15	0	30	0	0	0
Projected available						
Available-to-promise						
MPS		60		60		60

• **Before You Begin:**

Complete the MPS record. Calculate the projected available quantity by subtracting the greater of the forecast or the actual customer orders from the sum of the previous period’s projected available quantity plus any MPS order being received this period. Remember that a negative value in this row does not necessarily mean that you have a shortage. Calculate the available-to-promise quantity in the action bucket (period 1) and each period when an MPS shipment is due to arrive. Remember

that only in the action bucket calculation is the beginning inventory included. In other periods, do not consider the beginning inventory since it is not clear what that quantity will be. A negative number in this row is always a problem.

• **Solution**

Projected available quantity is calculated as

Projected available = beginning inventory + MPS shipment
– the greater of the period’s forecast or the customer orders promised for delivery

Therefore, the projected available quantity at the end of period 1 is 45 units (the beginning inventory of 0 plus the MPS shipment of 60, less the forecast of 15). The correct projected available quantities are shown here.

Period	1	2	3	4	5	6
Forecast	15	15	15	15	20	20
Customer orders	12	10	8	5	0	0
Projected available	45	30	15	0	40	20
Available-to-promise	25				45	
MPS	60				60	

Period	7	8	9	10	11	12
Forecast	20	20	25	25	25	25
Customer orders	15	0	30	0	0	0
Projected available	0	40	10	45	20	55
Available-to-promise		30		60		60
MPS		60		60		60

The ATP quantity in the action bucket is 25 units: a beginning inventory of 0 plus an MPS shipment of 60 units, less the customer orders of 35 units before the next replenishment (12 in period 1, 10 in period 2, 8 in period 3, and 5 in period 4). Use the formula for ATP at MPS replenishments to calculate the other ATP quantities.

$$\text{ATP} = \text{MPS shipment} - \text{customer orders between current MPS shipment and next scheduled replenishment}$$

Compare your answers with those shown.

• Problem 6

Jeannette has received several additional orders to consider. Using the ATP record calculated in Problem 5, calculate which of the new orders Jeannette should accept. The new orders are (1) 20 units for delivery in period 4, (2) 50 units for delivery in period 8, (3) 40 units for delivery in period 12.

• Before You Begin:

In this problem, determine which orders can be promised for delivery. The key is to understand which units are not yet committed and might be used to satisfy a future delivery. Place the new orders into your MPS record and see what problems occur. Then try to determine how to solve these problems.

• Solution

The first step is to put the new orders into the MPS record and consider the implications. The updated MPS record is shown here.

Period	1	2	3	4	5	6
Forecast	15	15	15	15	20	20
Customer orders	12	10	8	25	20	0
Projected available	45	30	15	-10	30	10
Available-to-promise	5				25	
MPS	60				60	

Period	7	8	9	10	11	12
Forecast	20	20	25	25	25	25
Customer orders	15	50	30	0	0	40
Projected available	-10	0	-30	5	-20	0
Available-to-promise		-20		60		20
MPS		60		60		60

Note that Jeannette can accept order 1 for delivery of 20 additional sweaters in period 4. She can also accept order 3 for 40 units delivered in period 12. However, Jeannette has a problem accepting order 2. The ATP quantity in period 8 is -20, which means Jeannette must ensure that enough sweaters are available to satisfy that order. Since the ATP quantity in period 5 is 25 sweaters, Jeannette can set aside 20 of these sweaters so that she has enough to satisfy order 2. Therefore, she can accept all three orders.

On the revised MPS record, we see that the customer order in period 8 is reduced 20 units, which are transferred to period 5. The 20 units transferred to period 5 are the 20 units that were not available in period 8. Look at the changes in the updated MPS record.

Period	1	2	3	4	5	6
Forecast	15	15	15	15	20	20
Customer orders	12	10	8	25	40	0
Projected available	45	30	15	-10	10	-10
Available-to-promise	4				4	
MPS	60				60	

Period	7	8	9	10	11	12
Forecast	20	20	25	25	25	25
Customer orders	15	30	30	0	0	40
Projected available	-30	0	-30	5	-20	0
Available-to-promise		0		60		20
MPS		60		60		60

Discussion Questions

- 1. Visit a local business and learn how it calculates its resources.
- 2. Describe the inputs needed to do master production scheduling.
- 3. Describe the different sources of demand.
- 4. Discuss the objectives of the master scheduler and how they influence master scheduling decisions.
- 5. Explain the process of developing an authorized MPS.
- 6. Explain the importance of rough-cut capacity planning in the MPS process.
- 7. Describe the role of time fence policies.
- 8. Explain the changes you can make in the frozen portion of the MPS and who must authorize such changes.
- 9. Explain the changes you can make in the slushy portion of the MPS and who authorizes such changes.
- 10. Discuss how the MPS might be used in a service organization.

Problems

1. David’s Delightful Kites Company (DDKC) manufactures kites. The most popular is David’s Daredevil model. Demand management has prepared forecast estimates for the next six weeks. Beginning inventory is 15 David’s Daredevils. As the master scheduler for DDKC, you must prepare an MPS. Your MPS order quantity is 72 kites.

Week	1	2	3	4	5	6
Forecast	20	35	50	50	45	40
Proj. Available 15						
MPS						

- (a) Prepare the MPS using an order quantity of 72 kites.
- (b) Calculate the ending inventory for each period.
- (c) What is the maximum number of units held in inventory?
- (d) How many MPS orders are needed?
- 2. In an effort to reduce setup frequency, DDKC has decided to use an MPS order quantity of 120 kites. (See Problem 1 for data.)
 - (a) Prepare the MPS using the new order quantity.
 - (b) Calculate the ending inventory for each period.
 - (c) Compare this MPS with the MPS developed in Problem 1.
- 3. DDKC has decided to change its replenishment policy. Instead of producing 72 or 120 kites each order, DDKC has reduced its MPS order quantity to 48 kites.
 - (a) Develop an MPS using 48 kites as the order quantity.
 - (b) Calculate the ending inventory for each period.
 - (c) Compare this MPS with the schedules developed in Problems 1 and 2.
- 4. Wine Accessories Inc. (WAI) produces two models of corkscrews, the standard model and a deluxe model. WAI follows a level aggregate plan, producing 20,000 corkscrews per month, or 5000 corkscrews per week. The MPS is developed in weekly time periods. The forecasts for each model and the projected available are shown in the next two tables. The replenishment order quantity is 2000 units for the standard model and 1000 units for the deluxe model. Note that you can place multiple orders if a single order is insufficient to cover the forecast (you can produce 4000 units of the standard model if necessary, or 2000 or 3000 units of the deluxe model). Remember that total weekly

production is limited to 5000 corkscrews. Develop an MPS for each of the products.

Standard Corkscrew	1	2	3	4
Forecast	3000	3500	5000	4000
Proj. Available 2000				
MPS				

Deluxe Corkscrew	1	2	3	4
Forecast	2000	1500	1000	3000
Proj. Available 2000				
MPS				

- 5. WAI uses two resources for each product that it builds: direct labor and machine time. From historical records, WAI calculates the following planning factors:
 - Direct labor for standard corkscrew is 0.20 hour.
 - Direct labor for deluxe corkscrew is 0.50 hour.
 - Machine time for standard corkscrew is 0.10 hour.
 - Machine time for deluxe corkscrew is 0.30 hour.Calculate the capacity needed for the MPS developed in Problem 4.
- 6. WAI is evaluating a new machine that reduces the machine time needed for the standard corkscrew to 0.08 hour, but increases the machine time for the deluxe corkscrew to 0.40 hour.
 - (a) Calculate the machine capacity needed for each period if WAI uses the new machine.
 - (b) Will the new machine prove beneficial to WAI?
- 7. WAI knows from historical records that approximately 40 percent of its labor is used in Department 101 and 60 percent is used in Department 102. The reverse is true of machine time; 60 percent is used in Department 101 and 40 percent is used in Department 102.
 - (a) Calculate the labor and machine hours needed in Department 101 for each period of the MPS developed in Problem 4.
 - (b) Calculate the labor and machine hours needed in Department 102 for each period of the MPS developed in Problem 4.
- 8. WAI has developed the following MPS. Calculate the projected available and the available-to-promise quantities for WAI.

	1	2	3	4	5	6	7	8
Forecast	30	30	30	40	40	40	45	45
Customer Orders	35	15	20	18	12	0	15	0
Proj. Available 50								
Available-to-promise								
MPS		100			100		100	

9. WAI, the company in Problem 8, has received the following additional customer orders shown here. You must determine which of the orders the company can accept. If the company must reject any orders, you must explain why.

Order Number	Order Quantity	Desired Week
1	10	3
2	25	1
3	40	5
4	20	6

10. Josh Randall, a sales representative for WAI, has convinced his customer (order #2 in Problem 9) to reschedule. Order #2 has agreed to accept delivery of 25 units in week 2 as long as WAI can also guarantee delivery of an additional 25 units in week 5. If WAI cannot meet both delivery requirements, the customer has threatened to withdraw its entire order. You have already promised orders 1, 3, and 4. Can you assure Josh that WAI will deliver on time? Show your calculations.

CASE: Newmarket International Manufacturing Company (C)

Newmarket International Manufacturing Company (NIMCO) was founded by Marcia Blakely only two years after leaving graduate school. Her knowledge of mass customization was the driving force behind starting NIMCO. The company produces three major custom products. Volume on the products is high even though each item is customized specifically for the customer. The products are processed through up to four different work centers. Even though each item is unique, the processing time at each work center is constant due to the sophisticated equipment used.

Today's Opportunity

Joe Barnes had just left the staffing meeting. The information you provided was quite helpful, and he believes he has ade-

quate resources to accomplish the required manufacturing for the second quarter. Effective capacity levels (including regular time and planned overtime) for each work center are shown here, as is the amount of time required for each product at each work center. The demand forecasts for each product are also shown.

Effective Weekly Capacity Levels

Work Center 1	Work Center 2	Work Center 3	Work Center 4
920 hours	740 hours	920 hours	725 hours

Product Standard Time by Work Center

Product	Standard Hours at Work Center 1	Standard Hours at Work Center 2	Standard Hours at Work Center 3	Standard Hours at Work Center 4	Total Standard Time (Hours)
A	0.06		0.14	0.04	0.24
B	0.15	0.13		0.10	0.38
C	0.03	0.08	0.12	0.06	0.29

Quarter 2 Demand Forecasts

Week	Demand for Product A	Demand for Product B	Demand for Product C	Week	Demand for Product A	Demand for Product B	Demand for Product C
14	3600	4000	2000	21	4300	3600	3000
15	4000	4000	2500	22	4000	3600	3000
16	4300	4000	2800	23	4000	3800	2800
17	4400	3800	3100	24	3600	3800	2800
18	4500	3800	3200	25	3200	3800	2600
19	4500	3800	3200	26	3000	4000	2600
20	4400	3600	3200				

1. Joe now needs a rough-cut capacity check to determine whether the capacity at each work center is adequate to support the expected demand. Using the forecasted demand as your proposed master schedule, calculate the load profile for each work center for each week of the second quarter. Highlight any weeks in which problems might occur.

2. Joe knows from past experience that he has some flexibility in his workforce. Therefore, as long as the total capacity

needed does not exceed the total available, the master schedule should be feasible. He also knows that he can increase his capacity total an additional 2.5 percent through extra overtime and still be within his budget. Given this new information, what recommendations do you have for Joe? What weeks are likely to be problems, and how should he use the capacity in those weeks? How important to NIMCO is it to have a flexible workforce?

On-line Resources



Companion Website www.wiley.com/college/reid:

- Take interactive *practice quizzes* to assess your knowledge and help you study in a dynamic way
- Review *PowerPoint slides* or print slides for notetaking
- Download *Excel Templates* to use for problem solving
- Find links to *Company Tours* for this chapter
Motorola, Inc.
Ferrara Fire Apparatus, Inc.
- Find links for *Additional Web Resources* for this chapter
H&R Block, www.hrblock.com
United Parcel Service of America, Inc., www.ups.com
APICS—Educational Society for Resource Management, www.apics.org

Additional Resources Available Only in WileyPLUS:

- Use the *e-Book* and launch directly to all interactive resources
- Take the interactive *Quick Test* to check your understanding of the chapter material and get immediate feedback on your responses
- Check your understanding of the key vocabulary in the chapter with *Interactive Flash Cards*
- Use the *Animated Demo Problems* to review key problem types
- Practice for your tests with *additional problem sets*
- *And more!*

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