Material Requirements Planning

Outline

- MRP Overview
- MRP Terminology
- Time Phasing of Order Point
- MRP Example

MRP Overview

- Material Requirements Planning is a technique for determining when to order dependent demand items and how to reschedule orders to adjust to changing requirements

MRP Terminology

- Dependent demand
- Parent items
- Siblings
- Component items
- Lot size
- Time Phasing
- Time bucket (time period)
- Requirements
  - Gross
  - Net

MRP Terminology

- Requirement explosion
- Bill of materials
- Scheduled receipt
- Planned receipt
- Lead time offset
- Planned order release
- Level numbers (these are assigned on the basis of the maximum number of stages of assembly required to get the subassembly or the part into an end product)

Time Phasing of Order Point

- **Example**
- Given
  - Demand is 50, 20, 10, 30, 20, 60, 70, 10, 20 and 20 for weeks 1 to 10 respectively
  - Lead time is 2 weeks
  - Lot size is 40 units
  - Safety stock is 15 units
  - There a scheduled receipt of 40 units during week 1
  - Initial on-hand inventory is 20 units
- We need to develop the gross and net requirements report for the 10-week period

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40									
On Hand at end of Period	20										
Planned Order Release											

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40									
On Hand at end of Period	20	10									
Planned Order Release											

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40							
On Hand at end of Period	20	10									
Planned Order Release		40									

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40							
On Hand at end of Period	20	10	-10								
Planned Order Release		40									

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40						
On Hand at end of Period	20	10	-10								
Planned Order Release		40	40								

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40						
On Hand at end of Period	20	10	-10	20							
Planned Order Release		40	40								

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40						
On Hand at end of Period	20	10	-10	20	30						
Planned Order Release		40	40								

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40						
On Hand at end of Period	20	10	-10	20	30	10					
Planned Order Release		40	40								

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40					
On Hand at end of Period	20	10	-10	20	30	~~10~~ 50					
Planned Order Release		40	40	40							

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40					
On Hand at end of Period	20	10	-10	20	30	50	-10				
Planned Order Release		40	40	40							

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40				
On Hand at end of Period	20	10	-10	20	30	50	~~-10~~ 30				
Planned Order Release		40	40	40	40						

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40				
On Hand at end of Period	20	10	-10	20	30	50	30	-40			
Planned Order Release		40	40	40	40						

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40	80			
On Hand at end of Period	20	10	-10	20	30	50	30	~~40~~ 40			
Planned Order Release		40	40	40	40	80					

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40	80			
On Hand at end of Period	20	10	-10	20	30	50	30	40	30		
Planned Order Release		40	40	40	40	80					

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40	80			
On Hand at end of Period	20	10	-10	20	30	50	30	40	30	10	
Planned Order Release		40	40	40	40	80					

Time Phasing of Order Point

Example Item

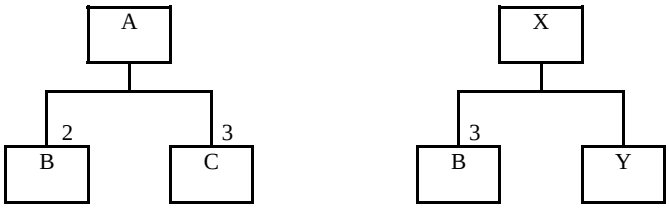
Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40	80		40	
On Hand at end of Period	20	10	-10	20	30	50	30	40	30	~~10~~ 50	
Planned Order Release		40	40	40	40	80		40			

Time Phasing of Order Point

Example Item

Lead Time = 2 Lot Size = 40 Safety Stock = 15		Period									
		1	2	3	4	5	6	7	8	9	10
Projected Requirement		50	20	10	30	20	60	70	10	20	20
Scheduled Receipts		40		40	40	40	40	80		40	
On Hand at end of Period	20	10	-10	20	30	50	30	40	30	50	30
Planned Order Release		40	40	40	40	80		40			

MRP Example



MRP Example

Level 0: End item master schedule: A

Lot size = 50 Lead time = 2		Period							
		1	2	3	4	5	6	7	8
Projected Requirement		40	10		30	15	20		80
Scheduled Receipts		45			50				100
On Hand at end of Period	20	25	15	15	35	20	0	0	20
Planned Order Release			50				100		

MRP Example

Level 0: End item master schedule: X

Lot size = 100 Lead time = 3 Safety Stock = 20		Period							
		1	2	3	4	5	6	7	8
Projected Requirement		50	30	80		60	50	10	20
Scheduled Receipts			100			100	100		
On Hand at end of Period	80	30	100	20	20	60	110	100	80
Planned Order Release			100	100					

MRP Example

Level 1: Component material plan: C

Lot size = 25 Lead time = 2		Period 1	2	3	4	5	6	7	8
Projected Requirement			150				300		
Scheduled Receipts							250		
On Hand at end of Period	200	200	50	50	50	50	0	0	0
Planned Order Release					250				

MRP Example

Level 1: Component material plan: Y

Lot size = 1 Lead time = 1		Period 1	2	3	4	5	6	7	8
Projected Requirement			100	100					
Scheduled Receipts			43	100					
On Hand at end of Period	57	57	0	0	0	0	0	0	0
Planned Order Release		43	100						

MRP Example

Level 1: Component material plan: B

Lot size = 100 Lead time = 1 Safety Stock = 50		Period							
		1	2	3	4	5	6	7	8
Projected Requirement			400	300			200		
Scheduled Receipts			300	300			200		
On Hand at end of Period	225	225	125	125	125	125	125	125	125
Planned Order Release		300	300			200			

MRP Lot Sizing Procedures

- **Lot for Lot (LFL)**
- **Economic Order Quantity (EOQ)**
- **Period Order Quantity (POQ)**
- **Part Period Balancing (PPB)**
- Incremental (INC)
- Silver-Meal (SM)
- Wagner-Whitin (WW)
- Gupta-Brennan (G-B)
  - Gupta, S. M. and L. Brennan, "Heuristic and Optimal Approaches to Lot Sizing Incorporating Backorders: An Empirical Evaluation", ***International Journal of Production Research***, Vol. 30, No. 12, 2813-2824, 1992.

Lot Sizing Procedures

- **Example**
- Given
  - Demand is 124, 60, 316, 183, 0, 55, 43, 154, 0, 0, 114 and 171 for weeks 1 to 12 respectively
  - Set up cost is $100
  - Carrying cost is $0.21/unit-week
  - Assume lead time to be zero
- We need to find the total inventory cost for the 12-week period when LFL, EOQ, POQ and PPB procedures are used

Lot Sizing Procedures Example (LFL)

LFL

Lot Size = 1 Lead Time = 0		Week 1	2	3	4	5	6	7	8	9	10	11	12	
Projected Requirement		124	60	316	183		55	43	154			114	171	1220
Scheduled Receipts		124	60	316	183		55	43	154			114	171	1220
On Hand at end of Period	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planned Order Release		124	60	316	183		55	43	154			114	171	

- Total Cost = 9*100 + 0 *0.21 = $900

Lot Sizing Procedures Example (EOQ)

$$D_{av} = \frac{124 + 60 + \cdots + 171}{12} = 101.7$$

$$\text{EOQ} = \sqrt{\frac{2D_{av}P}{W}}$$

$$= \sqrt{\frac{2*101.7*100}{0.21}}$$

$$\approx 311$$

Lot Sizing Procedures Example (EOQ)

EOQ

Lot Size = 311 Lead Time = 0		Week 1	2	3	4	5	6	7	8	9	10	11	12	
Projected Requirement		124	60	316	183		55	43	154			114	171	1220
Scheduled Receipts		311		311	311				311					1244
On Hand at end of Period	0	187	127	122	250	250	195	152	309	309	309	195	24	2429
Planned Order Release		311		311	311				311					

- Total Cost = 4*100 + 2429 *0.21 = $910.09

Lot Sizing Procedures Example (POQ)

$$\text{EOQ} = 311; \quad D_{av} = 101.7$$

$$\text{POQ} = \frac{\text{EOQ}}{D_{av}}$$

$$= \frac{311}{101.7}$$

$$\approx 3 \text{ (rounded to closest integer)}$$

Lot Sizing Procedures Example (POQ)

POQ

Lot Size = POQ = 3 / Lead Time = 0		Week 1	2	3	4	5	6	7	8	9	10	11	12	
Projected Requirement		124	60	316	183		55	43	154			114	171	1220
Scheduled Receipts		500			238			197				285		1220
On Hand at end of Period	0	376	316	0	55	55	0	154	0	0	0	171	0	1127
Planned Order Release		500			238			197				285		

- Total Cost = 4*100 + 1127 *0.21 = $636.67

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No
	154	0	1	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No
	154	0	1	0	0	No
	154	0	2	0	0	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No
	154	0	1	0	0	No
	154	0	2	0	0	No
	268	114	3	71.82	**71.82**	No

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No
	154	0	1	0	0	No
	154	0	2	0	0	No
	268	114	3	71.82	**71.82**	No
	439	171	4	143.64	215.46	Yes

Lot Sizing Procedures Example (PPB)

Order Arrives in Period #	Tentative Lot Size	Extra Inventory	No. of Periods held	Extra Carrying Cost	Cumulative Extra Carrying Cost	Is This > Setup Cost ?
1	124	0	0	0	0	No
	184	60	1	12.60	12.60	No
	500	316	2	132.72	**145.32**	Yes
4	183	0	0	0	0	No
	183	0	1	0	0	No
	238	55	2	23.10	23.10	No
	281	43	3	27.09	**50.19**	No
	435	154	4	129.36	179.55	Yes
8	154	0	0	0	0	No
	154	0	1	0	0	No
	154	0	2	0	0	No
	268	114	3	71.82	**71.82**	No
	439	171	4	143.64	215.46	Yes
12	**171**	0	0	0	0	No

Lot Sizing Procedures Example (PPB)

PPB

Lot Size = PPB		Week												
Lead Time = 0		1	2	3	4	5	6	7	8	9	10	11	12	
Projected Requirement		124	60	316	183		55	43	154			114	171	1220
Scheduled Receipts		500			281				268				171	1220
On Hand at end of Period	0	376	316	0	98	98	43	0	114	114	114	0	0	1273
Planned Order Release		500			281				268				171	

- Total Cost = 4*100 + 1273 *0.21 = $667.33