Co-funded by the Erasmus+ Programme of the European Union

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Material Requirement Planning

MRP

v1. Spring 2021

Material Requirement Planning - MRP

It is a **computerised** and **deterministic** technique that allows determining

- **requirements**
- **purchase (and production) orders releases**

of **demand dependent** materials needed to satisfy the **MPS**

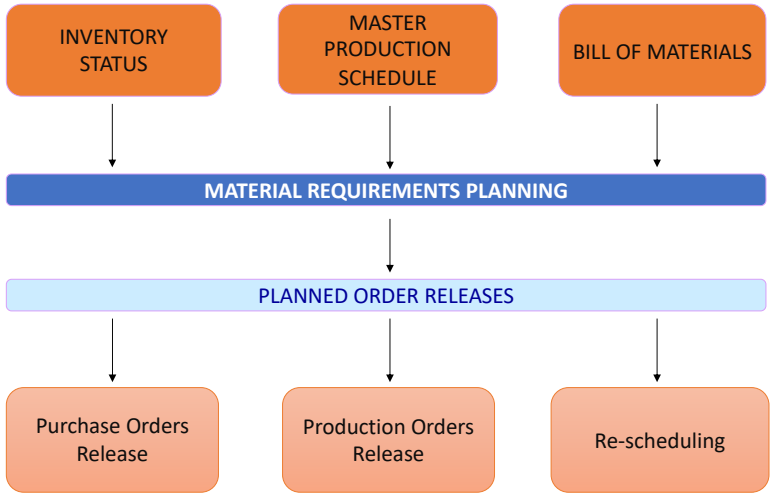
Explosion of material requirements

MRP translates master schedule requirements for end items ("independent demand items") into time-phased requirements for subassemblies, components, and raw materials ("dependent demand items")

MRP - Input Data

- Master Production Schedule (MPS)
- Bill of Materials (BOMs)
- Inventory Records file (Inventory Status)

MRP



Where MRP can be used

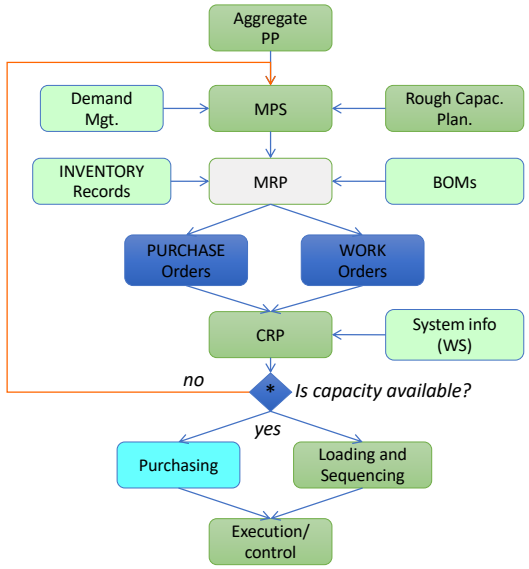
- Multi-stage production system
- Job-order production with a small fraction of independent demand
- Accurate forecasting
- Reduced variability of lead times
- Quality level fixable in advance
- Prevalence of assembly activities over manufacturing activities
- High production volume
- JIT – MRP synchro

MRP limits

- Works at **infinite capacity**
- Considers **constant lead time**

→ This is why the **Manufacturing Resources Planning – MRP II** uses:
  - Capacity Resource Planning (CRP)
  - Scheduling

MRP and Planning Tools relationship



Closed-loop MRP

Data

- Supply Lead Time (*L*)
- Safety stock (*SS*)
- Lot size (*Q*) / lot-sizing policy
- Supply Quality Rate
- Process Quality Rate
- Manufacturing and assembly process times
- Supplier price discounts
- …

Lot Sizing in MRP Systems

Lot-for-Lot

- The order or run size for each period is set equal to demand for that period (pure MRP); *lot-for-lot ordering minimizes investment in inventory*

Economic Order Quantity

- This is sometimes the case for lower-level items that are common to different parents and for raw materials*; adopted if usage is fairly uniform*

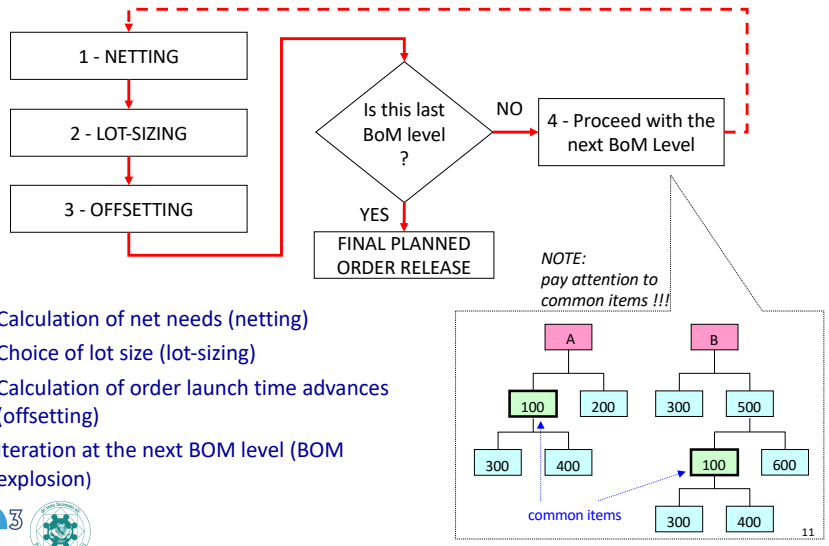
Fixed-Period

- Provides coverage for some predetermined number of periods (e.g., two or three; a simple rule is: *Order to cover a two-period interval*)

MRP - Definitions

Gross Requirements G(t)	Total expected demand for an item or raw material in a time period *t*
Scheduled Receipts S(t)	Open orders scheduled to arrive from vendors or elsewhere in the pipeline at time *t*
Projected on Hand H(t)	Expected amount of inventory that will be on hand at the beginning of each time period *t*
H(0)	inventory at the beginning of the first time period (not including SS)
Net Requirements N(t)	The actual amount needed in time period *t*
Planned Order Receipts P(t)	Quantity expected to be received by the beginning of the period *t*
Planned Order Releases R(t-L)	Planned amount to order in each time period; planned order receipts offset by lead time. *This amount generates gross requirements at the next level in the production chain*

MRP Logic (4 steps)



a. Calculation of net needs (netting)

b. Choice of lot size (lot-sizing)

c. Calculation of order launch time advances (offsetting)

d. Iteration at the next BOM level (BOM explosion)

MRP Logic (for each level of BOM)

Given: *H*(0), Lot sizing Policy, *Q, L*

1. N(t) = G(t) – S(t) – H(t-1)

   If N(t) < 0, then N(t) = 0

2.1. If N(t) = 0, then P(t) = 0

2.2. If 0 <N(t)< Q, then P(t) = Q

2.3. If N(t) >= Q, then

   a. *Fixed-lot* policy *Q*: P(t) = SUPINT[N(t)/Q)]*Q

   b. *Lot-for-lot* policy: P(t) = N(t)

3. H(t) = H(t-1) + P(t) + S(t) - G(t)

   Repeat 1. to 3. for each t

4. R(t-L) = P(t)

MRP and Quality

The level of quality assured and the procedures of quality control affect the effectiveness of the MRP:

- Quality of raw/semi-finished materials entering the production process
- Quality of the production processes

We assume a rejection coefficient!

MRP and Enterprise Resource Planning (ERP)

- MRP programs are integrated into **ERP systems**
- ERP represents a comprehensive software approach to support decisions concurrent with **planning and controlling** the business
- ERP (i.e. Oracle, SAP) **integrate application programs** in finance, manufacturing, logistics, sales and marketing, human resources, and other functions in a firm
- This integration is accomplished through a **database shared** by all the functions and data-processing applications

Example 1

Lot Size	25
Lead Time	2
On Hand	10
Safety Stock	0
Allocated	0
Low Level Code	1

	PD	Period 1	2	3	4	5	6	7	8
Gross Requirements		**10**	**15**	**25**	**25**	**30**	**45**	**20**	**30**
Scheduled Receipts		**10**	**25**						
Projected on Hand	**10**	*10*	*20*	*20*	*20*	*15*	*0*	*5*	*0*
Net Requirements				*5*	*5*	*10*	*30*	*20*	*25*
Planned Order Receipts				*25*	*25*	*25*	*30*	*25*	*25*
Planned Order Releases		*25*	*25*	*25*	*30*	*25*	*25*		

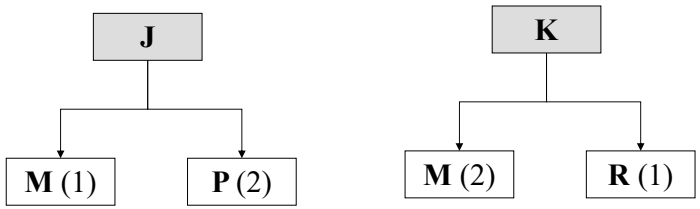
Hp: "Lot for lot" policy with minimum order quantity Q

Example 2

Lot Size	**1**
Lead Time	2
On Hand	20
Safety Stock	0
Allocated	0
Low Level Code	1

	PD	Period 1	2	3	4	5	6	7	8
Gross Requirements		**5**	**10**	**18**	**0**	**10**	**6**	**0**	**14**
Scheduled Receipts			**20**						
Projected on Hand	**20**	*15*	*25*	*7*	*7*	*0*	*0*	*0*	*0*
Net Requirements						*3*	*6*		*14*
Planned Order Receipts						*3*	*6*		*14*
Planned Order Releases				*3*	*6*		*14*		

Example 3



	J	K	M
Lot size	1	1	30
Lead time	1	2	1
On Hand	15	50	225
Safety Stock	0	0	0
Allocated	0	0	0
Low level code	0	0	1

Net requirements at each level determine gross requirements at the next!

Lo

J	PD	Period 1	2	3	4	5	6	7	8
Gross Requirements		**0**	**50**	**80**	**10**	**0**	**60**	**10**	**25**
Scheduled Receipts									
Projected on Hand	**15**	*15*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Net Requirements			*35*	*80*	*10*		*60*	*10*	*25*
Planned Order Receipts			*35*	*80*	*10*		*60*	*10*	*25*
Planned Order Releases		*35*	*80*	*10*		*60*	*10*	*25*	

Lo

x1

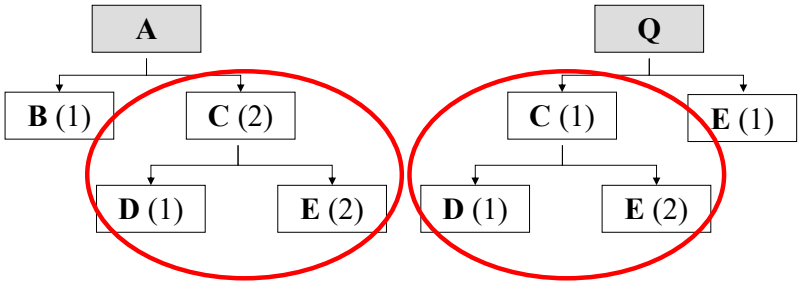
K	PD	1	2	3	4	5	6	7	8
Gross Requirements		**25**	**15**	**120**	**0**	**60**	**0**	**15**	**0**
Scheduled Receipts									
Projected on Hand	**50**	*25*	*10*	*0*	*0*	*0*	*0*	*0*	*0*
Net Requirements				*110*		*60*		*15*	
Planned Order Receipts				*110*		*60*		*15*	
Planned Order Releases		*110*		*60*		*15*			

L1

x2

M	PD	1	2	3	4	5	6	7	8
Gross Requirements		**255**	**80**	**130**	**0**	**90**	**10**	**25**	**0**
Scheduled Receipts		**30**							
Projected on Hand	**225**	*0*	*0*	*0*	*0*	*0*	*20*	*25*	*25*
Net Requirements			*80*	*130*		*90*	*10*	*5*	
Planned Order Receipts			*80*	*130*		*90*	*30*	*30*	
Planned Order Releases		*80*	*130*		*90*	*30*	*30*		

Example 4



	A	Q	B	C	D	E
Lot size	1	1	1	1	200	500
Lead time	4	2	3	2	1	1
On Hand	18	6	10	20	0	30
Safety Stock	5	6	0	0	0	0
Allocated	10	0	0	0	0	0
Low level code	0	0	1	1	2	2

Lo

A	PD	Period 1	2	3	4	5	6	7	8
Gross Requirements									**103**
Scheduled Receipts									
Projected on Hand	**3**	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*0*
Net Requirements									*100*
Planned Order Receipts									*100*
Planned Order Releases					*100*				

L1

B	PD	1	2	3	4	5	6	7	8
Gross Requirements					**100**				
Scheduled Receipts									
Projected on Hand	**10**	*10*	*10*	*10*	*0*				
Net Requirements					*90*				
Planned Order Receipts					*90*				
Planned Order Releases		*90*							

L0

A	PD	1	2	3	4	5	6	7	8
		Period							
Gross Requirements									**103**
Scheduled Receipts									
Projected on Hand	**3**	3	3	3	3	3	3	3	0
Net Requirements									100
Planned Order Receipts									100
Planned Order Releases					100				

L0

Q	PD	1	2	3	4	5	6	7	8
Gross Requirements								**200**	
Scheduled Receipts									
Projected on Hand	**0**	0	0	0	0	0	0	0	
Net Requirements								200	
Planned Order Receipts									
Planned Order Releases						200			

L1

C	PD	1	2	3	4	5	6	7	8
Gross Requirements					**200**	**200**			
Scheduled Receipts									
Projected on Hand	**20**	20	20	20	0	0			
Net Requirements					180	200			
Planned Order Receipts					180	200			
Planned Order Releases			180	200					

L0

Q	PD	1	2	3	4	5	6	7	8
Gross Requirements								**200**	
Scheduled Receipts									
Projected on Hand	**0**	0	0	0	0	0	0	0	
Net Requirements								200	
Planned Order Receipts									
Planned Order Releases						200			

L1

C	PD	1	2	3	4	5	6	7	8
Gross Requirements					**200**	**200**			
Scheduled Receipts									
Projected on Hand	**20**	20	20	20	0	0			
Net Requirements					180	200			
Planned Order Receipts					180	200			
Planned Order Releases			180	200					

L2

E	PD	1	2	3	4	5	6	7	8
Gross Requirements			**360**	**400**		**200**			
Scheduled Receipts									
Projected on Hand	**30**	30	170	270	270	70			
Net Requirements			330	230					
Planned Order Receipts			500	500					
Planned Order Releases		500	500						

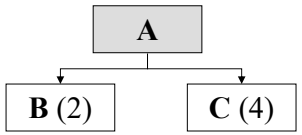
L1

C	PD	1	2	3	4	5	6	7	8
Gross Requirements					**200**	**200**			
Scheduled Receipts									
Projected on Hand	**20**	20	20	20	0	0			
Net Requirements					180	200			
Planned Order Receipts					180	200			
Planned Order Releases			180	200					

L2

D	PD	1	2	3	4	5	6	7	8
Gross Requirements			**180**	**200**					
Scheduled Receipts									
Projected on Hand	**0**	0	20	20					
Net Requirements			180	180					
Planned Order Receipts			200	200					
Planned Order Releases		200	200						

Example 5



	A	B	C
Lot size	1	1	50
Lead time	1	1	2
On Hand	3	20	80
Safety stock	0	10	40
Allocated	0	0	0
Low level code	0	1	1

External needs

	1	2	3	4	5	6
A	1	2	2	3	3	1
B	0	0	4	0	8	0
C	0	0	0	6	6	0

Lo

A	PD	1	2	3	4	5	6
		Period					
Gross Requirements		**1**	**2**	**2**	**3**	**3**	**1**
Scheduled Receipts							
Projected on Hand	**3**	*2*	*0*	*0*	*0*	*0*	*0*
Net Requirements				*2*	*3*	*3*	*1*
Planned Order Receipts				*2*	*3*	*3*	*1*
Planned Order Releases			*2*	*3*	*3*	*1*	

L1

B	PD	1	2	3	4	5	6
Gross Requirements			**4**	**10**	**6**	**10**	
Scheduled Receipts							
Projected on Hand	**10**	*10*	*6*	*0*	*0*	*0*	*0*
Net Requirements				*4*	*6*	*10*	
Planned Order Receipts				*4*	*6*	*10*	
Planned Order Releases			*4*	*6*	*10*		

L1

C	PD	1	2	3	4	5	6
Gross Requirements			**8**	**12**	**18**	**10**	
Scheduled Receipts							
Projected on Hand	**40**	*40*	*32*	*20*	*2*	*42*	*42*
Net Requirements					*8*		
Planned Order Receipts					*50*		
Planned Order Releases			*50*				

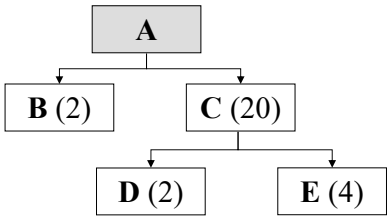
Scraps calculation in MRP

Scraps (s): *coefficient* (quality rate)

Gross Requirements (G)
Scheduled Receipts (S)
Projected on Hand (H)
Net Requirements (N)
Planned Order Receipts (P)
Planned Order Releases (R)

$$N(i) = [G(i) - S(i)(1-s) - H(i-1)]/(1-s)$$
$$H(i) = H(i-1) + [S(i) + P(i)](1-s) - G(i)\ ,\ i = 1,2,\ldots$$

Example 6



	A	B
Lot size	250	400
Lead time	2	1
On Hand	350	400
Safety stock	50	100
Allocated	100	0
Scraps	0,05	0,1
Low level code	0	1

Lo

A	PD	1	2	3	4	5	6	7	8
		Period							
Gross Requirements				**100**	**200**	**200**	**200**	**100**	**50**
Scheduled Receipts									
Projected on Hand	*200*	*200*	*200*	*100*	*138*	*176*	*214*	*114*	*64*
Net Requirements					*106*	*66*	*26*		
Planned Order Receipts					*250*	*250*	*250*		
Planned Order Releases			*250*	*250*	*250*				

L1

B	PD	1	2	3	4	5	6	7	8
		Period							
Gross Requirements			**500**	**500**	**500**				
Scheduled Receipts									
Projected on Hand	*300*	*300*	*160*	*20*	*240*	*240*	*240*	*240*	*240*
Net Requirements			*223*	*378*	*534*				
Planned Order Receipts			*400*	*400*	*800*				
Planned Order Releases		*400*	*400*	*800*					

Summary

- Describe the inputs, outputs, and nature of MRP processing
- Understand the MRP logic
- Analyze MRP problems
- Evaluate the impact of Quality and lot-sizing over MRP

- References:
  Ch. 21 Jacobs, Chase