Basic production algorithms and its main concepts

Ing.J.Skorkovský,CSc.

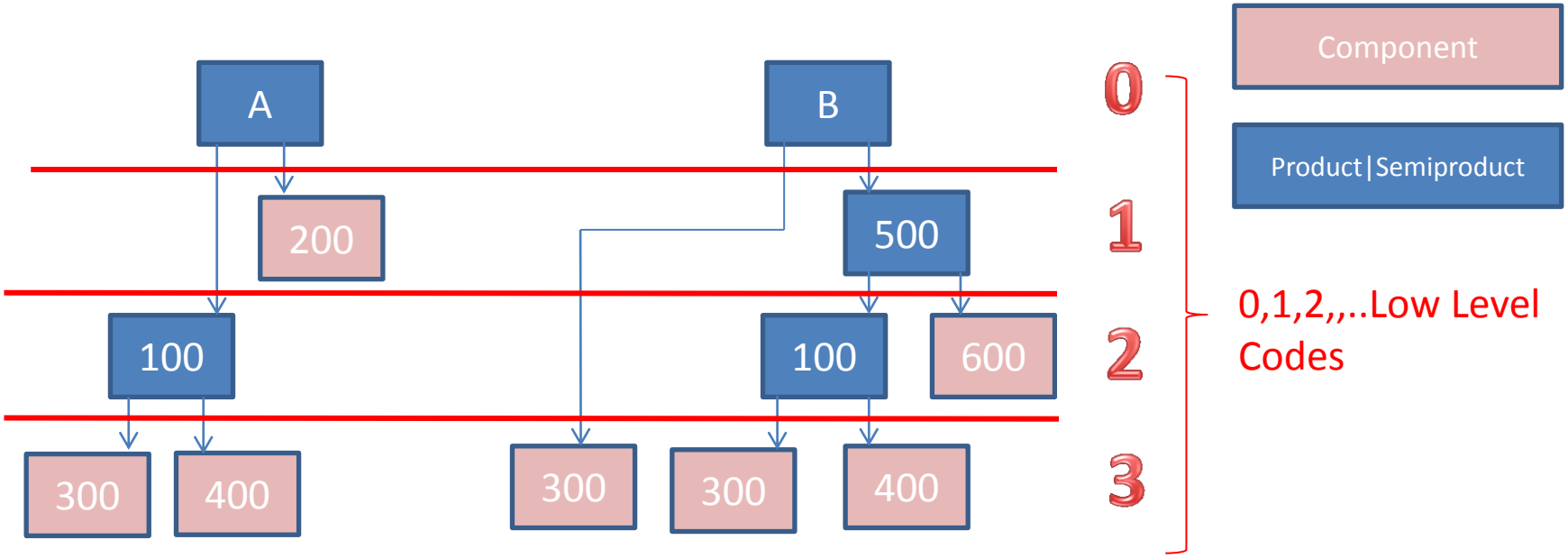
and various listed resources

Department of Corporate Economy

Main concepts

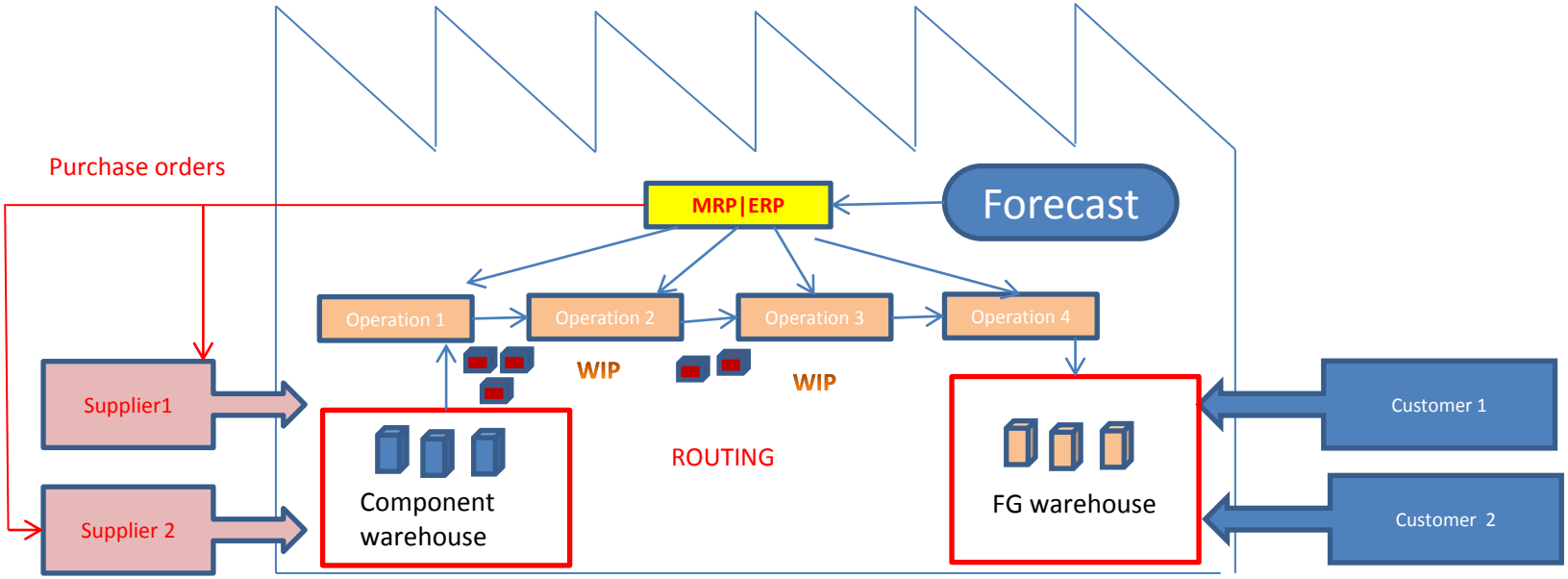
- MRP=Material Requirements Planning (push)
- MRP_II=Manufacturin Resource Planning (push)
- APS = Advanced Planning and Scheduling
- JIT = Just In Time (pull)
- TOC (Drum Buffer Rope) (push-pull->combined) – *will be prezeneted in another session of this course*

BOM=Bill Of Material *(structure of the product)*



- **Independent** demand for products and semi-products and **dependent** for components
- Planning backwards from production schedule (**independent**) to **dependent-** demand components -without statistically calculated Reorder Point (ROP)– see next lesson and next slide as well
- IF ROP **is not** taken into consideration – MRP is **PUSH** system -> it computes schedule of what should be started (pushed) into system, that authorize production as inventory is consumed (ROP will be explained later in this session)

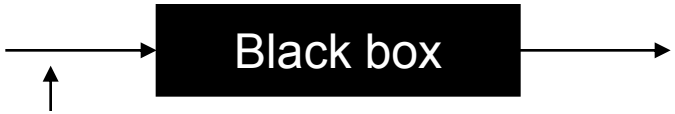
Push system


Purchase orders
MRP|ERP
Forecast
Operation 1
Operation 2
Operation 3
Operation 4
WIP
WIP
Supplier1
Supplier 2
Component warehouse
ROUTING
FG warehouse
Customer 1
Customer 2


Take it !
WIP

PUSH and PULL

- **PUSH :** production jobs (production orders) are scheduled: MRP and MRP_II= Manufacturing Resource Planning
  - often not feasible plans are generated and problems are often detected too late (rejects, lack of components,..)
  - used fixed lead times=LT (see next slide) do not depend on capacity utilization
  - Having in mind , that production is random process, Lead Time is very pessimistic constant



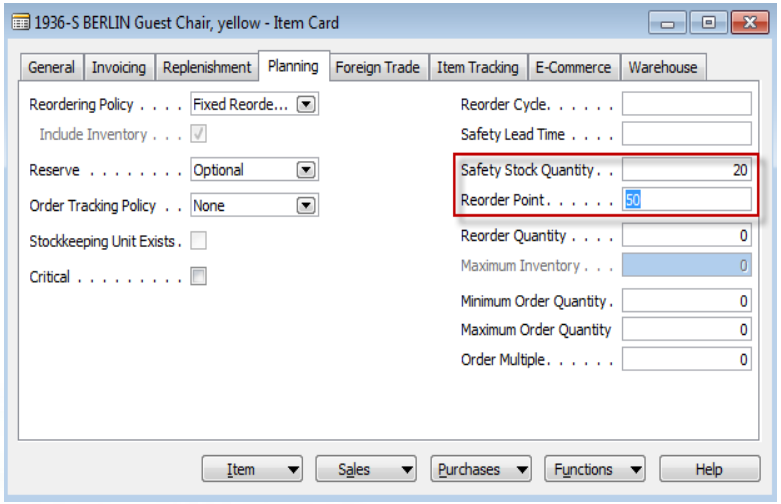
t=start of the job

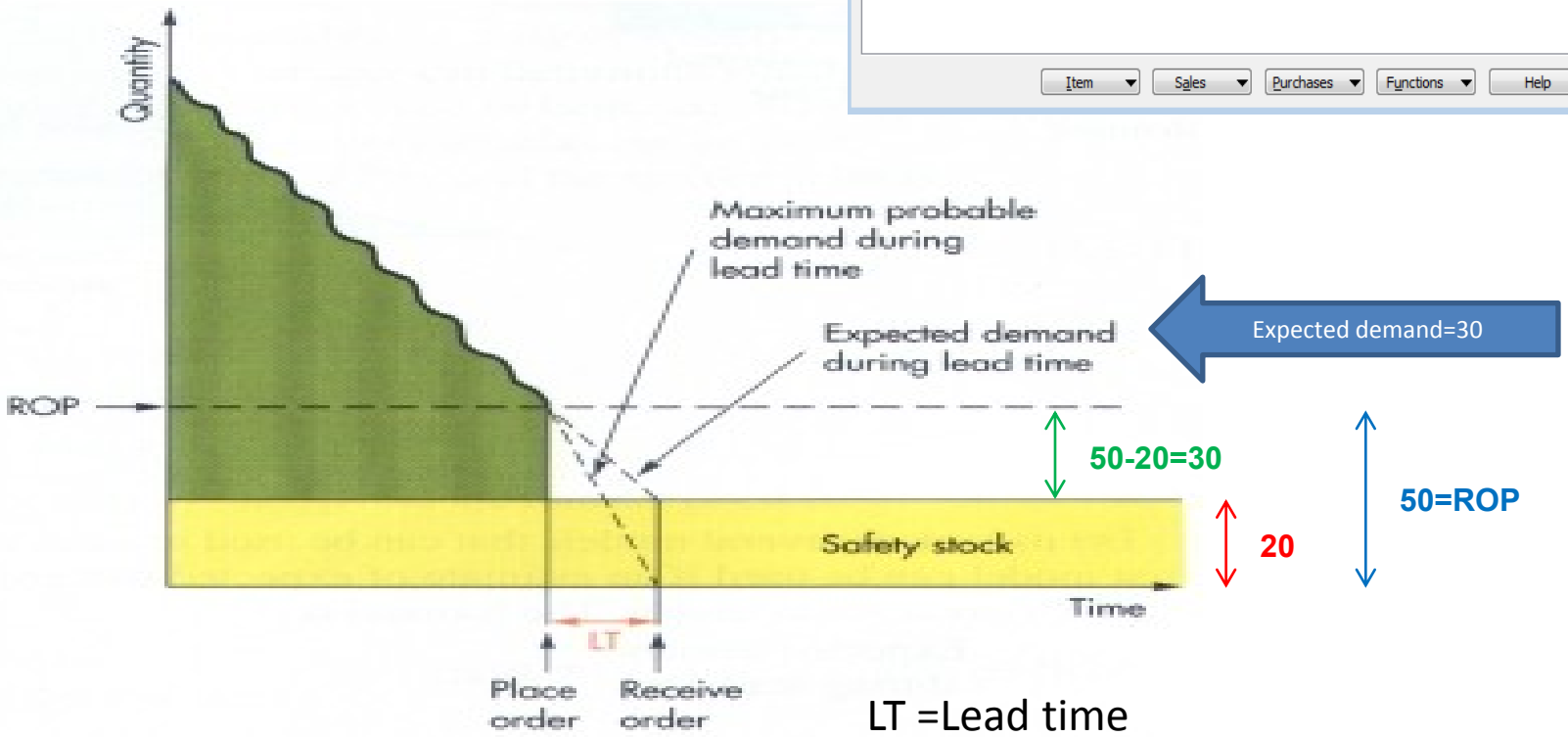
t+LT=end time of the job (where LT=constant)

- **PULL :** production jobs (production orders) starts are triggered by completion of another job (**JIT**-see later in this session)

Determination of the Reorder Point (**ROP**)

- **ROP**=expected demand during lead time + safety stock





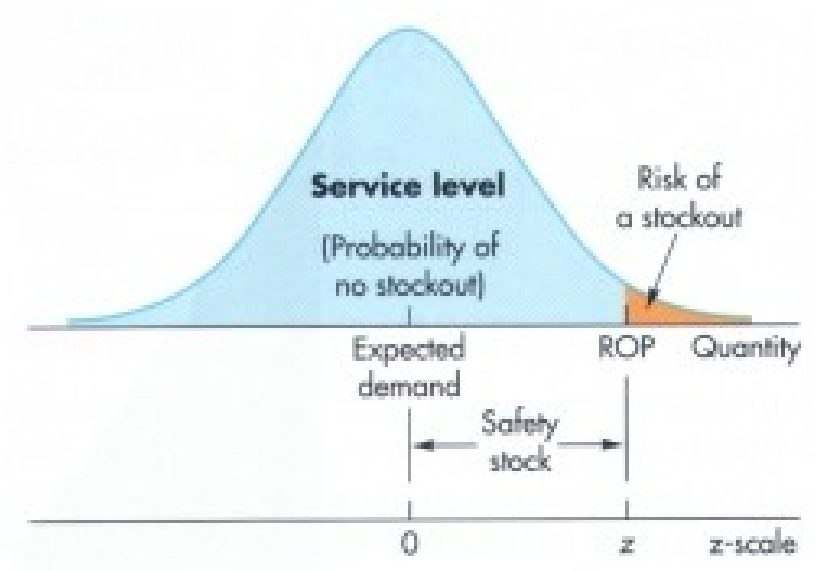
Determination of the Reorder Point (ROP)

(home study)

- **ROP =** expected demand during lead time + $z^* \sigma_{dLT}$

where **z** = number of standard deviations and

σ_{dLT} = the standard deviation of lead time demand and $z^* \sigma_{dLT}$ = **Safety Stock**



Example

(home study- also Pareto analysis and ABC model simplified- PWP will be shown later)

- The manager of a construction supply house determined knows that demand for sand during lead time averages is **50** tons.
- The manager knows, that demand during lead time could be described by a normal distribution that has a mean of 50 tons and a Standard Deviation of 5 tons (σ_{dLT})
- The manager is willing to accept a stock out risk of no more than 3 percent

Example-data

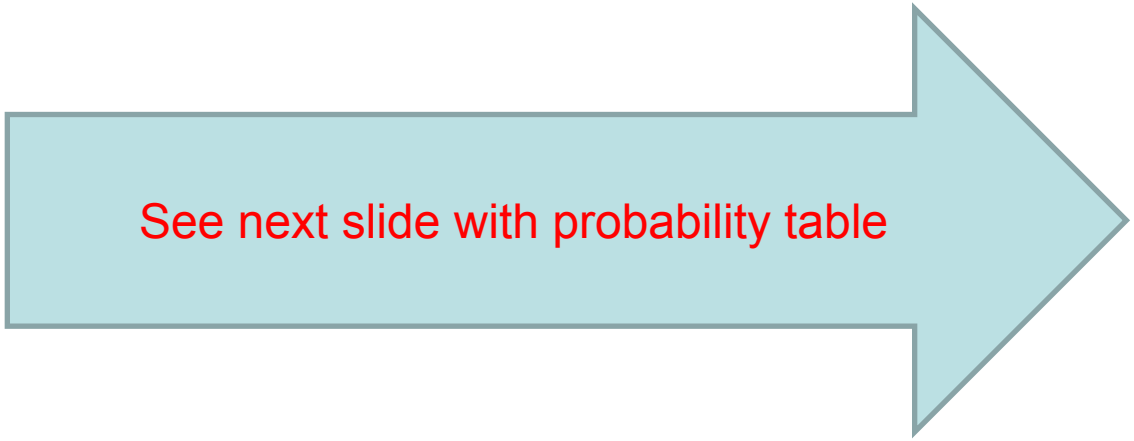
(home study)

- **Expected lead time averages** = 50 tons.
- σ_{dLT} = 5 tons
- **Risk** = 3 % max
- **Questions :**
  - What value of **z** (number of standard deviations) is appropriate?
  - How much safety stock should be held?
  - What reorder point should be used?

Example-solution

(home study)

- **Service level =**1,00-0,03 (risk) =0,97 and from probability tables you will get z= +1,88



Probability table

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

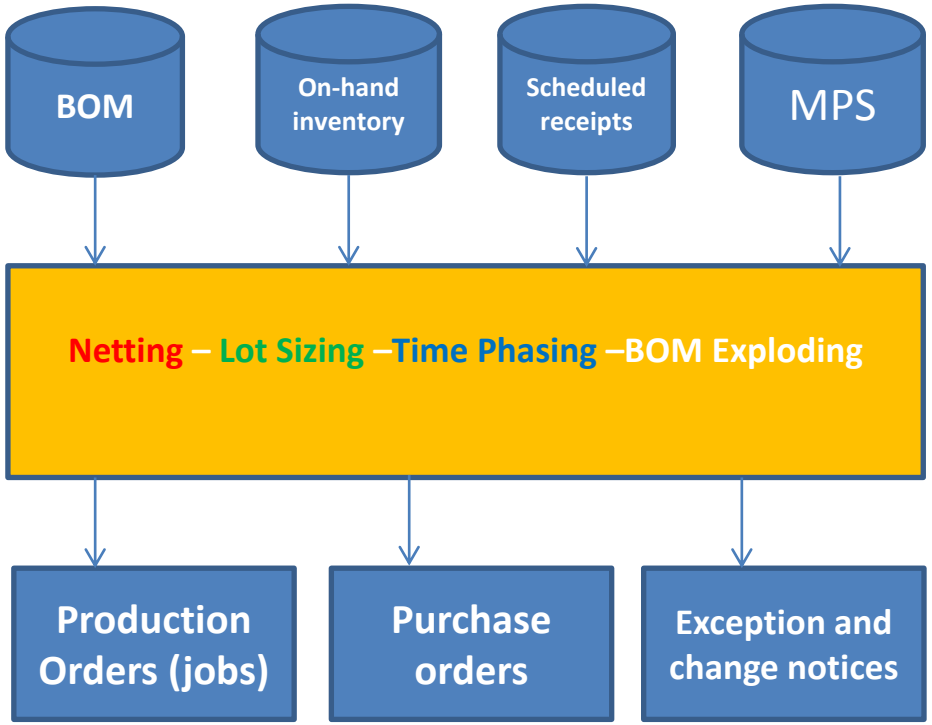
Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670

Example-solution

(home study)

- **Service level =**1,00-0,03 =0,97 and from probability tables we have got : z= +1,88
- **Safety stock = z * σ_{dLT}** = 1,88 * 5 =9,40 tons
- **ROP** = expected lead time demand + safety stock = 50 + 9.40 = **59.40 tons**
- ***For z=1 service level =84,13 %***
- ***For z=2 service level= 97,72 %***
- ***For z=3 service level = 99,87% (see six sigma)***

Schematic of MRP



MPS=Master Production Schedule

Net requirement =Gross requirement – Stock in hand – Purchases + Sales + Safety Stock

Lot sizing= divide netted demand into appropriate lot sizes to form jobs (see LLC) and **EOQ PWP show (later)**

Time Phasing = offset the due dates of the jobs with lead times to determine start times
(Due Date-Lead time = Start of the job)

MRP matrix calculation (see related xls file in study material)

- **Parameters**
  - **Gross requirements**
    - Derivied from Master Production Scheduled or Planned order releases of the parent BON (finished good)
  - **Scheduled receipts**
    - On order (issued) and scheduled to be received
  - **Projected on hand**
    - Anticipated quantity on hand at the end of the period
  - **Net requirement**
    - **Net requirement** =Gross requirement – Stock in hand – Purchases + Sales + Safety Stock
  - **Planned order receipts**
    - When order need to be received (documents are not issued)
  - **Planned order releases**
    - When order need to be placed to be received on time

MRP matrix example 1

(home study)

MRP basic calculations		Lot-for lot - ordering exact quntity needed					
		Lead Time =1 - time to get item from the moment the purchase order is issued or to make it					
Master Production Schedule							
Part A	Projected on hand	1	2	3	4	5	period
Gross Requirements		85	95	120	100	100	
MRP							
Part A		1	2	3	4	5	period
Gross Requirements		85	95	120	100	100	
Scheduled Receipts	Is already issued	175					
Projected on hand (POH)	25	115	20	0	0	0	
Net requirements		0	0	100	100	100	
Planned order receipts				100	100	100	
Planned order releases			100	100	100		
		Period	Action				
		1	25+175-85=115=POH				
		2	POH=115-95=20				
		3	Cannot cover GR, so we have to release one PO for 100 one period earlier in order to get it in period 3				
		3	Net req=120-20 =100, POH in period 3=120-20-100=0				
		4	Net req =100-0=100-POH=100, so we heave to release one PO one period earlier in order to cover demand in period 4				
		5	Similar to period 4				

MRP matrix example 2

(home study)

MRP														
Part A		1	2	3	4	5	6	7	8					
Gross Requirements		20	30	50	50	60	90	40	60					
Scheduled Receipts	Is already issued		50											
Projected on hand (POH)	40	20	40	40	40	30	0	10	0					
Net requirements				10	10	20	60	40	50					
Planned order receipts				50	50	50	60	50	50					
Planned order releases		50	50	50	60	50	50							
		Period	Action											
		1	Can be covered from POH and new POH=40-20=POH-GR=20											
		2	In period 2 GR can be covered by POH and SR, but next period where GR=50 will be not covered, so POR must be released in per 1 (LT=2)											
		3	We have got 50, POH=40, so altogether we have 90 nad after demand is covered only 90-50=40=POH											
		3	Net req=50-40=10 in order to cover demand in period 4, but we can released only 50 or more, so in period 2 another 50 is released											
		4	Demand is covered by receipt 50 and POH =10 but for the next period net req=60-40=20											
		5	Net req= 60-40=20, so demand in period 5 can be covered by POH=40+ quantity X, which have to be ordered 2 period earlier											
		5	Quantity X can 50 or more. So take it 50 as sufficient quantity, and POH =30=40+50-60											
		6	To cover demand in period 6 we need at least 90 and we have only 30 in POH, so 90-POH=90-30=60 have to ordered 2 period earlier											
		6	POH-90-60-30=0; Ner req=90-30=GR-POH=60 , which is reason why we have ordered 60 two period earlier											
		7	Net req= 40 because 40-0=GR-POH=40. To cover it we have to order two period earlier 50											
		8	and so on											

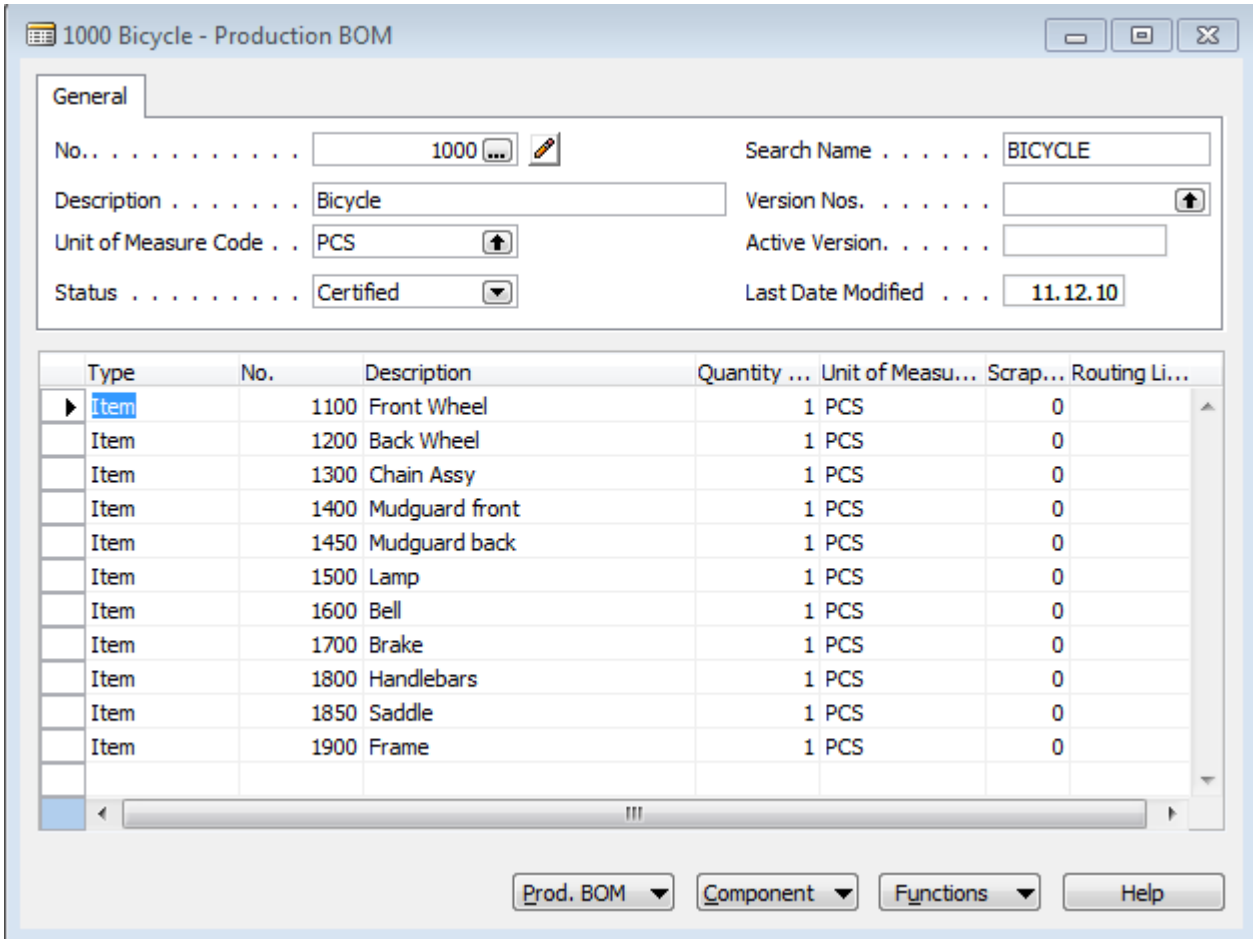
Benefits of MRP

- Low levels of in process inventories
- The Ability to keep track of material requirements
- A means of allocating production time
- The ability to easily determine inventory usage by backflushing (see explanantion below)

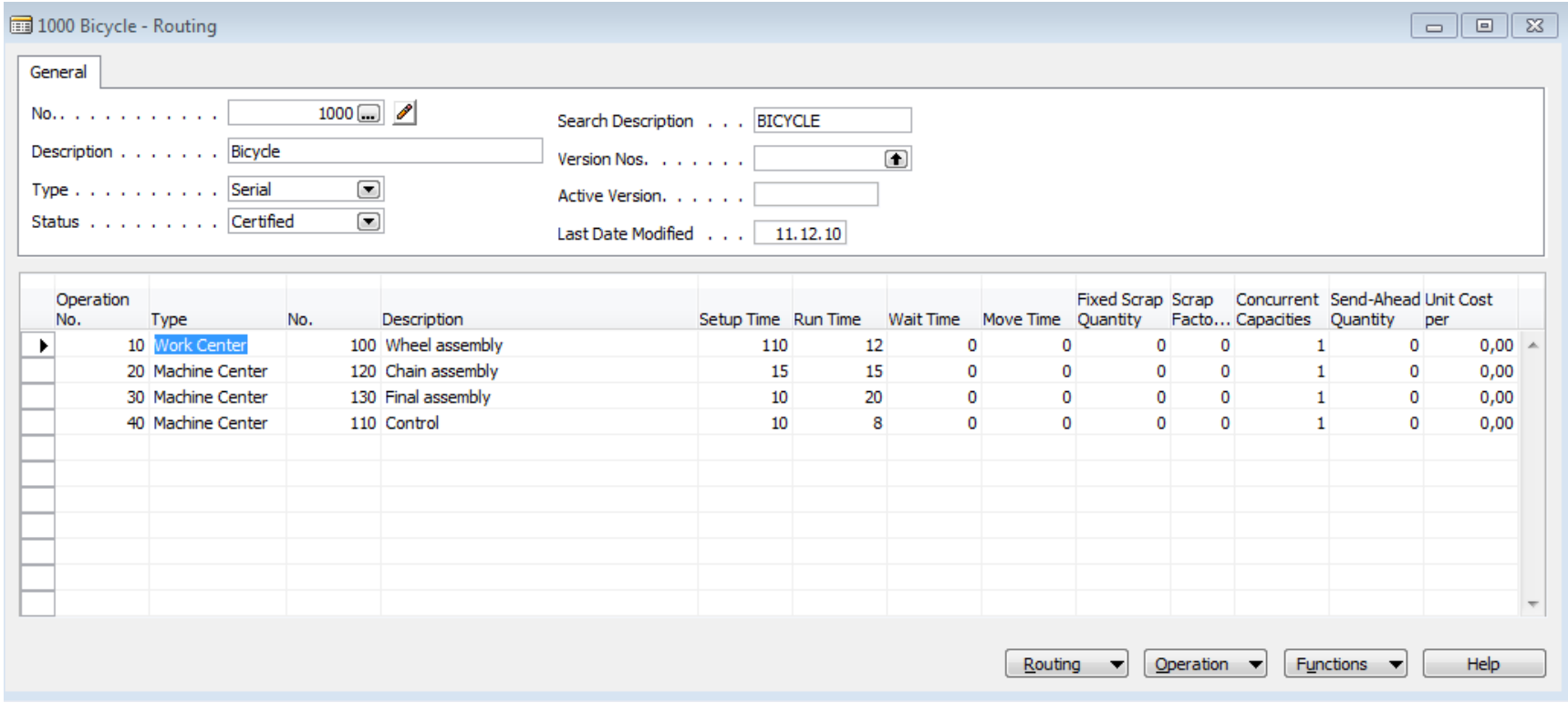
  Process of determining the number of parts that must be subtracted from inventory records. This number is computed by referring to the number of parts withdrawn from the inventory (and delivered to the shop-floor) and the number of parts assumed (according to the BOM) to have been consumed in a manufacturing line at one or more deduct points.

MRP_II =MRP + resource capacity planning

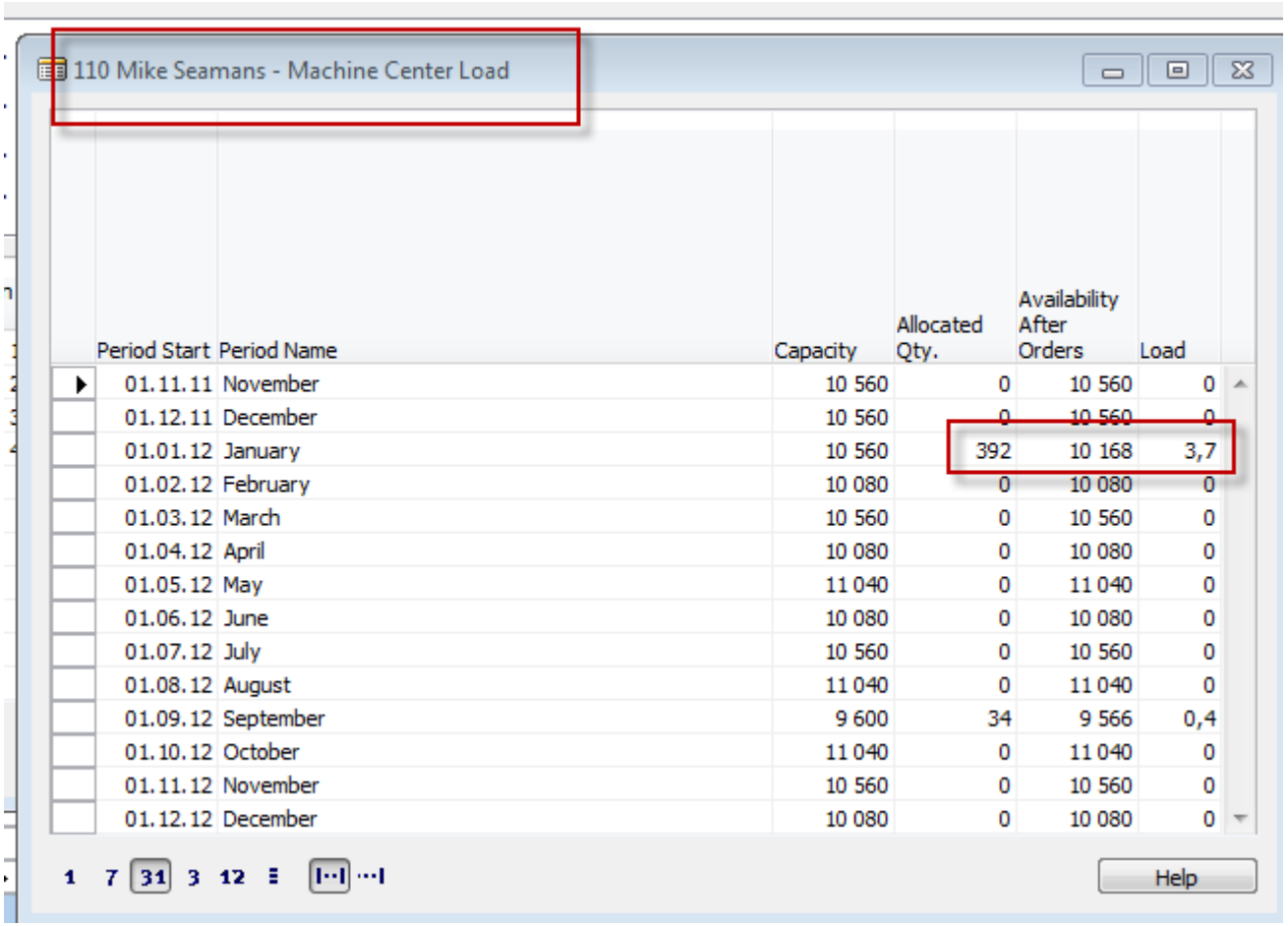
BOM in MS Dynamics NAV



Routings in MS Dynamics NAV



Capacity of resources in MS Dynamics NAV



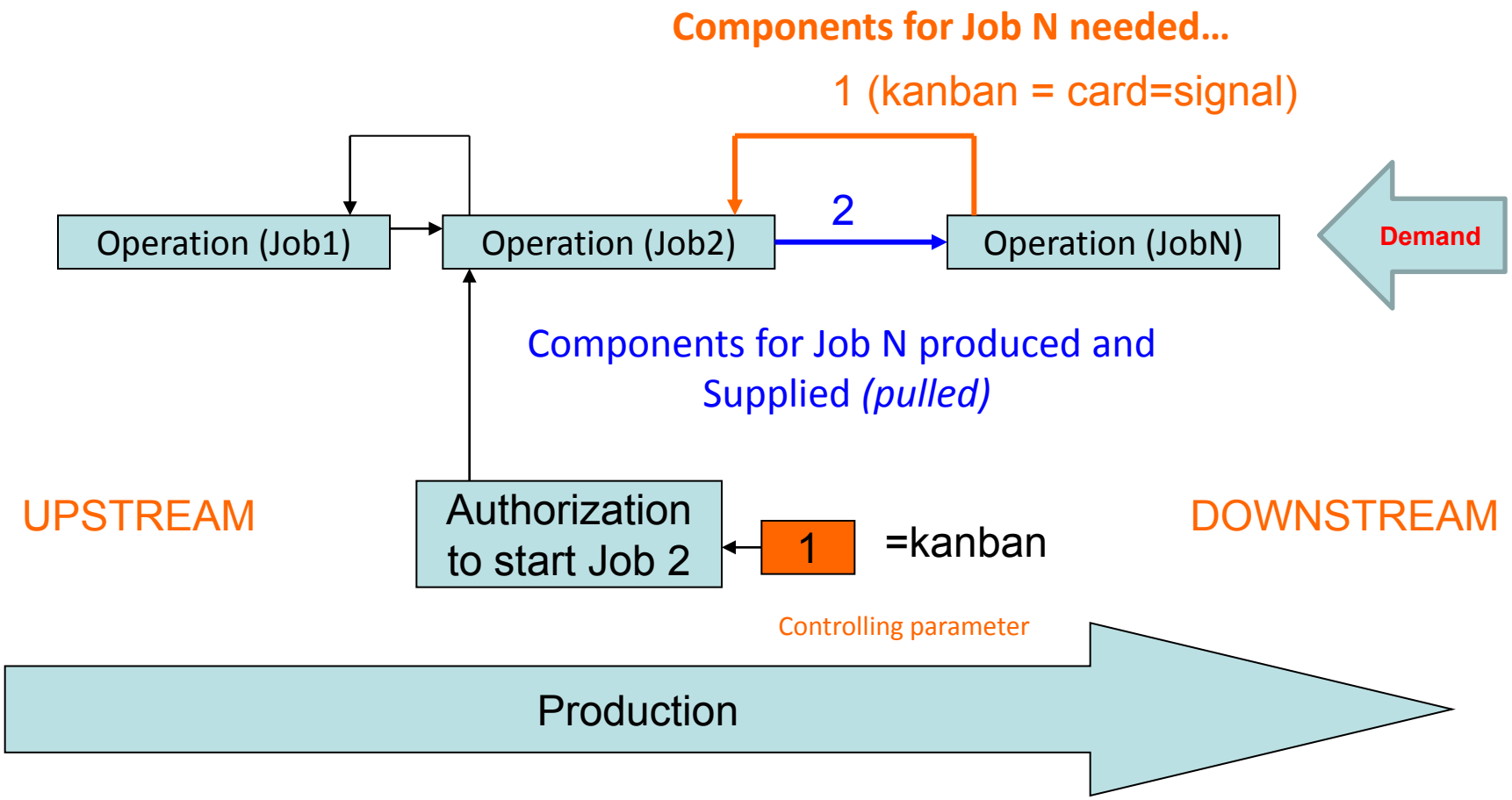
Period Start	Period Name	Capacity	Allocated Qty.	Availability After Orders	Load
01.11.11	November	10 560	0	10 560	0
01.12.11	December	10 560	0	10 560	0
01.01.12	January	10 560	392	10 168	3,7
01.02.12	February	10 080	0	10 080	0
01.03.12	March	10 560	0	10 560	0
01.04.12	April	10 080	0	10 080	0
01.05.12	May	11 040	0	11 040	0
01.06.12	June	10 080	0	10 080	0
01.07.12	July	10 560	0	10 560	0
01.08.12	August	11 040	0	11 040	0
01.09.12	September	9 600	34	9 566	0,4
01.10.12	October	11 040	0	11 040	0
01.11.12	November	10 560	0	10 560	0
01.12.12	December	10 080	0	10 080	0

JIT=Just In Time

- Toyota Motors and Taiichi Ohno

- Production based only on demand
- Lower inventory costs
- The concept behind it is that a company can save money on parts and components---by not have having to store them--- if they are delivered to the assembly line **just in time** to be installed on the car as it is being built.

JIT=Just In Time



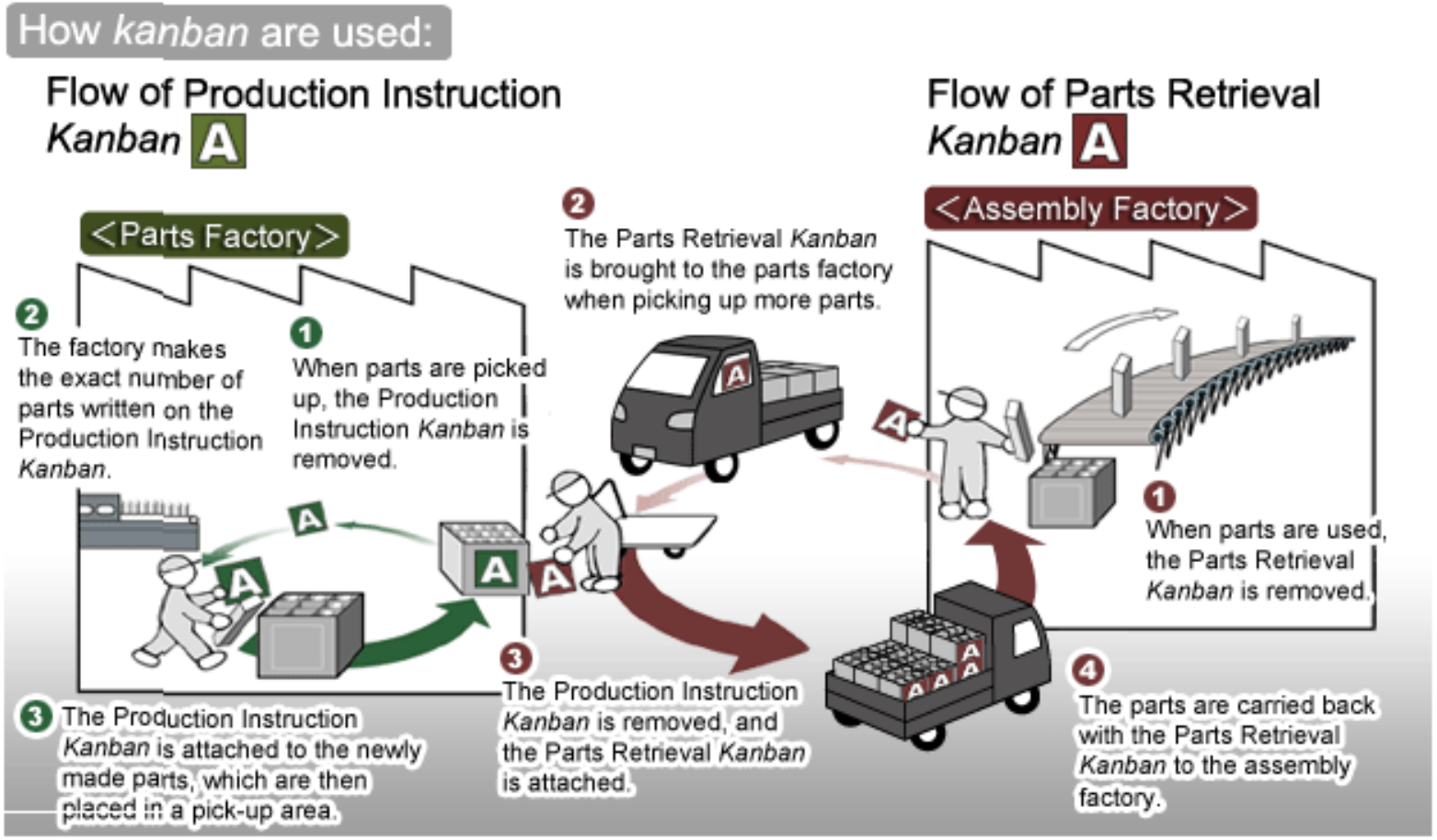
The number of kanban cards in the system determines the WIP levels in the plant

JIT (manufacturing philosophy)

- Kanban is not JIT !!!
- JIT encompasses：
  - kanban cards (kan=card, ban=signal)
  - total quality control (TQM) – e.g. scrap loss not tolerated….
  - setup reduction
  - worker participation
  - lean production (low level of waste)
- Advantages of JIT philosophy：
  - reduced WIP (Work in Progress)->higher Throughput (see Little´s law- will be presented later)
  - shorter production times
  - lower production costs
  - greater customer responsiveness

Kanban principle

(home study)



Resource :

Some units (not for BPH_PIS2)

- **Will be presented later in sections such as :**
  - Little´s law (LT=WIP*CT=WIP/Throughput)
  - Theory of Constraint…
- **Cycle Time (CT)–** time to complete task (time/unit)
- **Takt Time (TT) –** rhythm in which we have to produce in order to satisfy customer demand (demand is 240 toaster ovens and we can produce these in 480 minutes ->TT= 480/240=2
- **Lead Time (LT) –** Number of minutes, hours, or days that must be allowed for the completion of an operation or process, or must elapse before a desired action takes place –see next slide
- *Comment : CT<>LT !!*

Lead time (not for BPH_PIS2)

The lead time is the time and not the effort. You may have a lead time of 100 days and only have to work 1 hour to fix the bug. Sometime you start working on the bug. The *cycle time* is the time from the start of the work until the bugfix is live.