

CONWIP

(A pull alternative to kanban principle)

Main resources : Mark Spearman, David Woodruff and Wallace Hopp
Northwestern University,
Evanston, Illinois, USA

Diagrams, modifications, structures and editing (J.Skorkovský,KPH)
CONWIP diagrams: EuroLean+

Methodologies used for effective production control

- Based on **PULL** principle

- JIT

- Kanban (tool to support JIT)

- Zero inventory

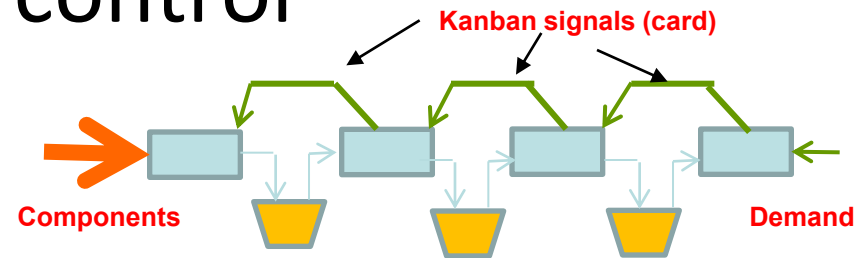
- Kanban is used mostly for repetitive manufacturing)

- Based on **PUSH** principle

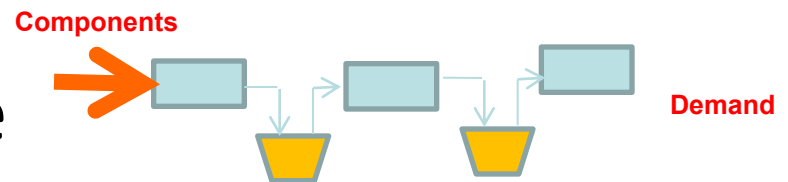
- MRP (MRP-II)


- Based on both principles (**push** and **pull**)


- CONWIP (Constant Work-In-Process)



greatly reduced inventory levels and production lead times

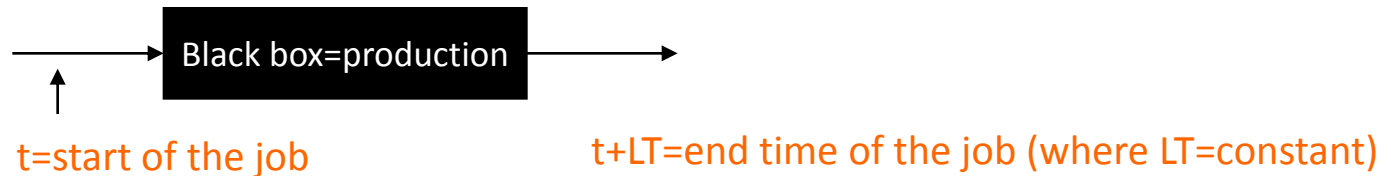


 =buffer

 =machine centre

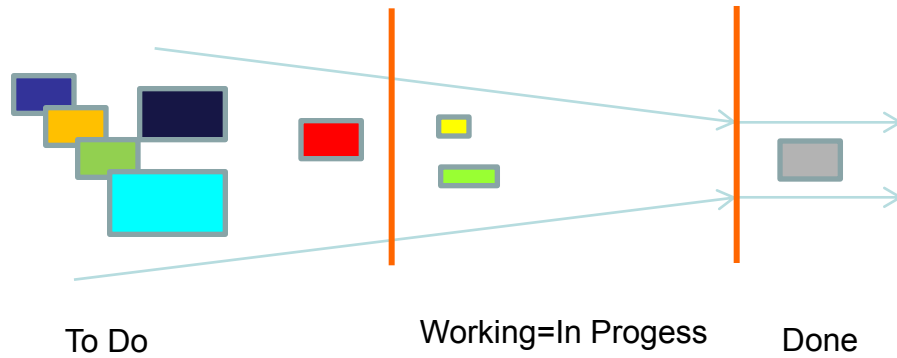
PUSH and PULL

- **PUSH** : production jobs (production orders) are scheduled (MRP and MRP-II)
 - often **not feasible plans** are generated and problems are often detected too late
 - used fixed lead times= LT (see next slide) does not depend on capacity utilization
 - Mind you, that **production is a random process** and estimation of LT is very pessimistic

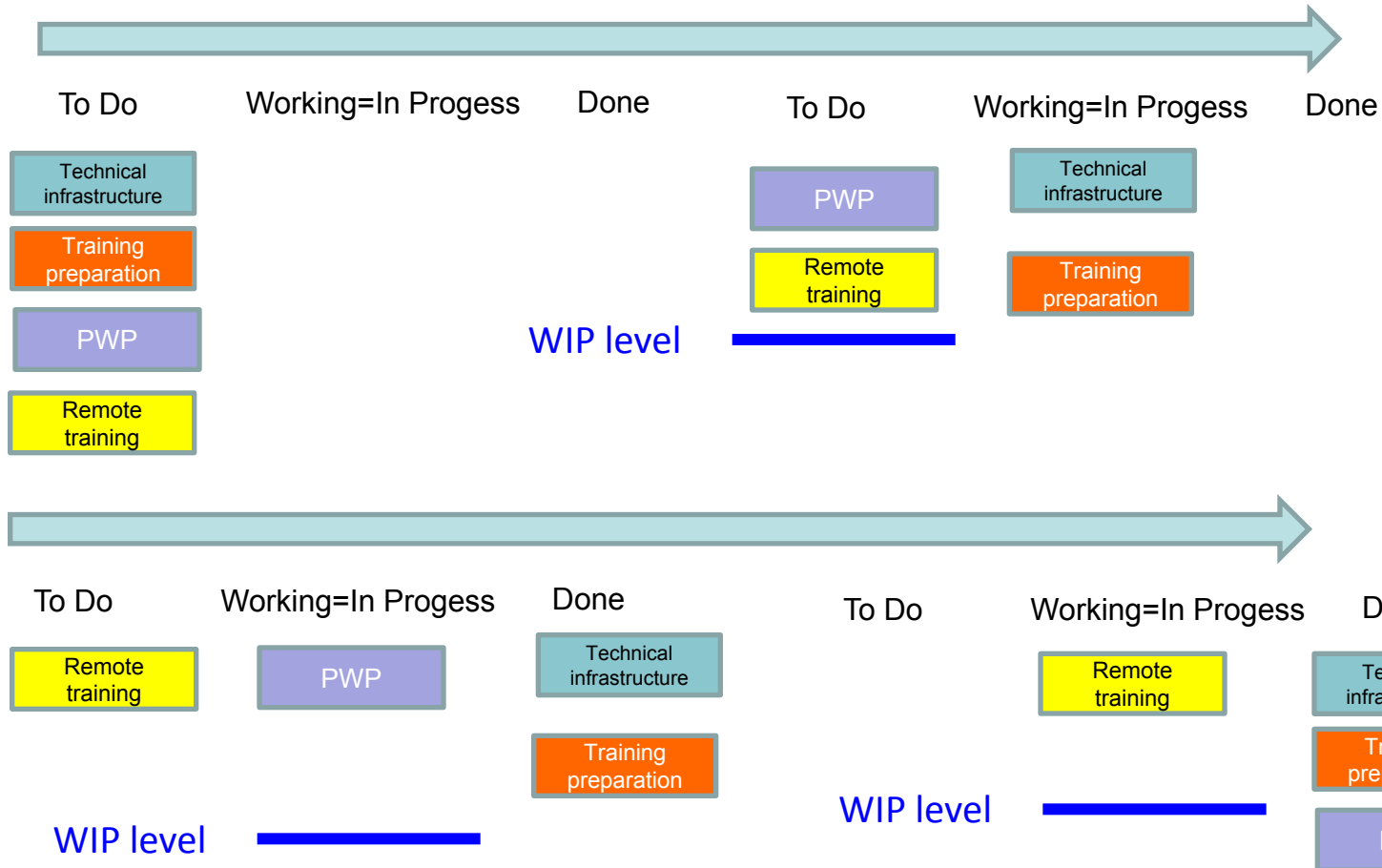


- **PULL** : production jobs (production orders) starts are triggered by the completion of another job.
- **In other words : It authorizes releases of the jobs)**

Kanban rules



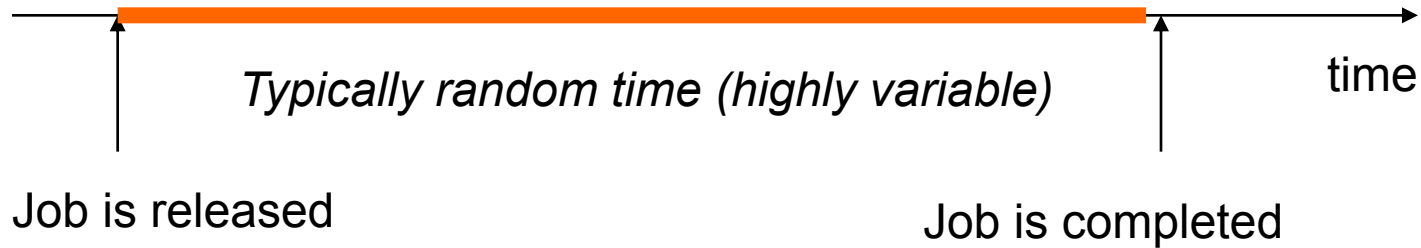
Kanban rules (signal card)



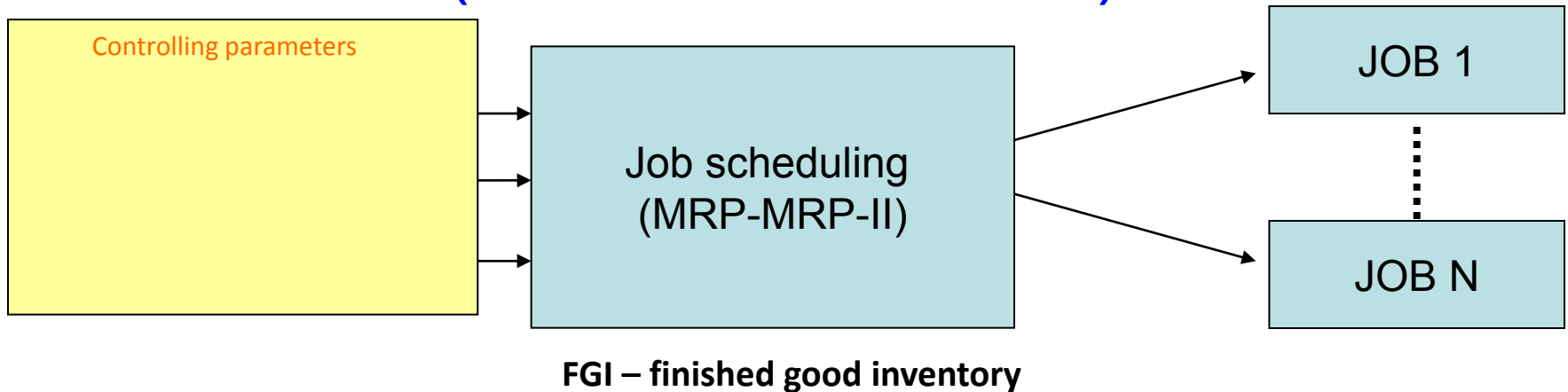
Too high a WIP setting leads to poor multitasking and increasing the value of the lead time (reduction of Throughput)

Flow time and Lead time

- **Flow time** (known also as a „**Cycle time**“)



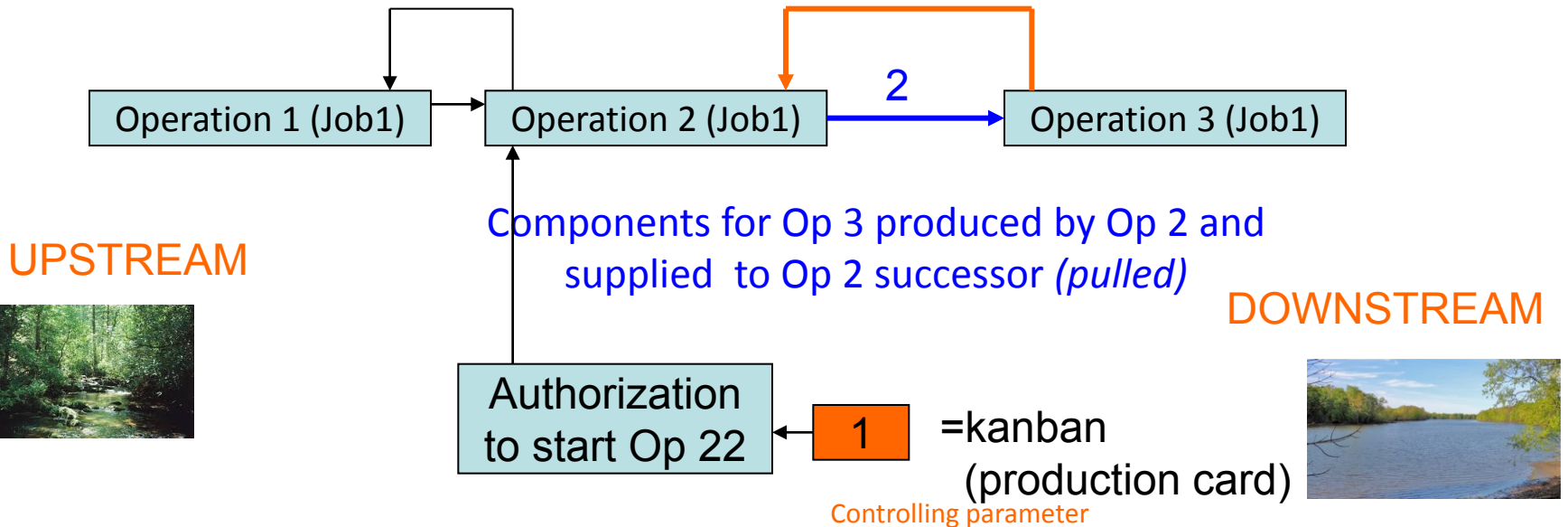
- **Lead time** (constant used for planning)



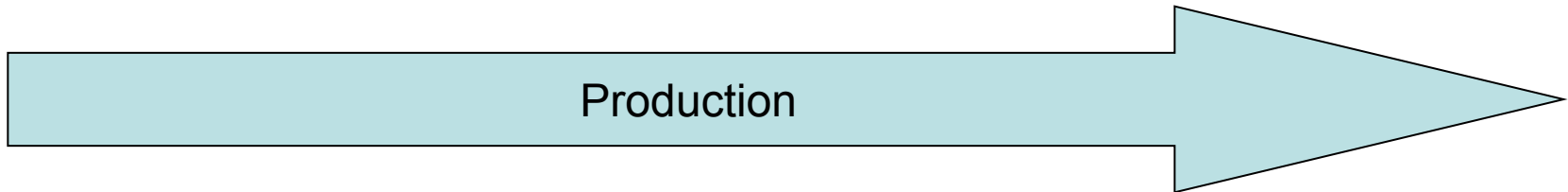
KANBAN

Components for Job 3 needed...

1 (kanban = card)

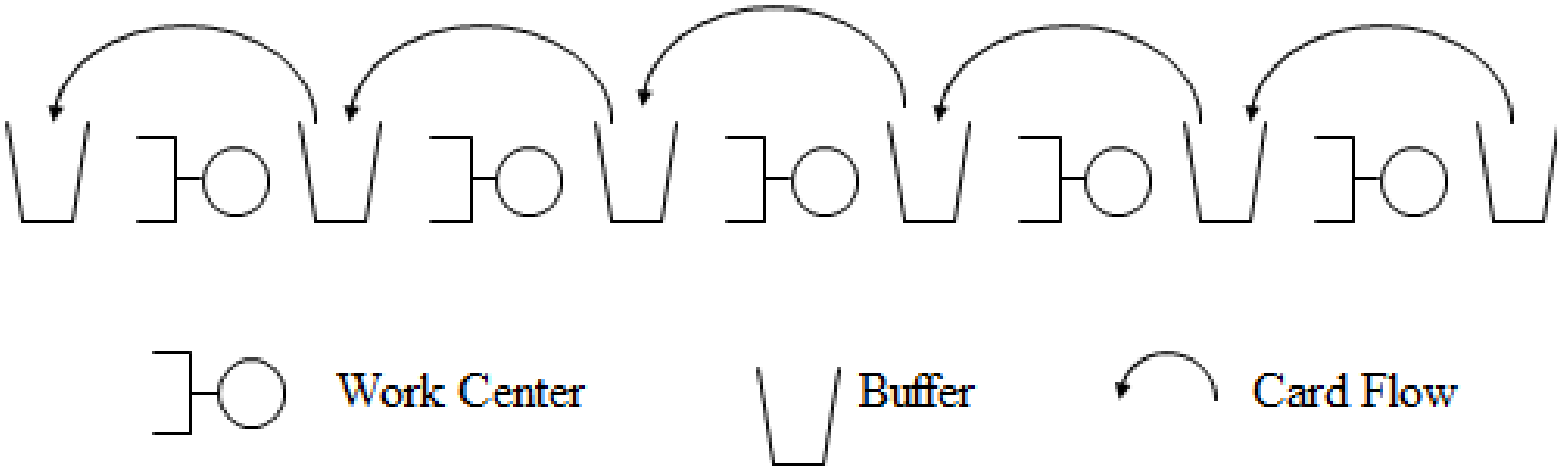


Job=Work order=Production order



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

KANBAN



Trade-offs

- Too many Kanban cards-> Too much WIP and long Cycle times
- Too few Kanban cards->lower throughput and vulnerability to demand

Little's law – not for AOMA

- Little's law : $\text{Cycle Time} = \text{WIP} / \text{Throughput}$
 - see basic explanation further ahead
 - more detailed explanation : [Factory Physics](#) (W.J.Hopp and M.L.Spearman)

JIT

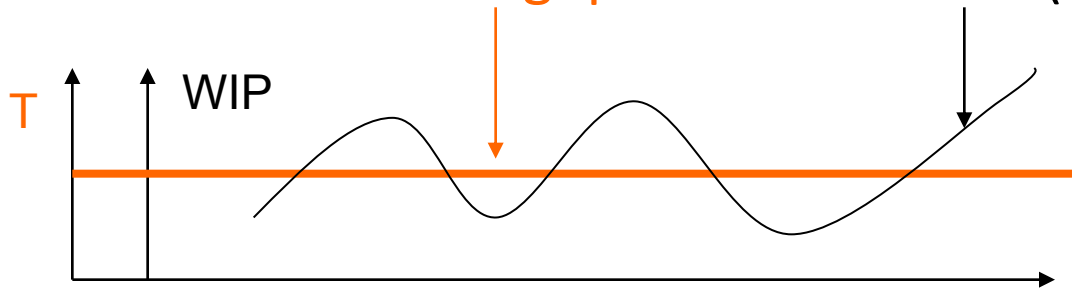
- Kanban is not JIT (JIT is a manufacturing philosophy)
- JIT encompasses :
 - Kanban (card system transferring signals)
 - total quality control (TQM) – e.g. scrap loss not tolerated....
 - setup time reduction
 - worker participation !!!!
 - lean production (low level of waste)
- Advantages of JIT philosophy :
 - reduced WIP (Work In Process)
 - shorter flow times (cycle times)
 - **lower production costs**
 - greater customer responsiveness
 - reduces setup times

PUSH and **PULL** are not mutually exclusive approaches and other statements...

- **Push** and **Pull** can be combined
- MRP is considered to be more applicable than kanban
- MRP is in almost any discrete part production
- Kanban(JIT,**pull**) – superior results if applicable
- Kanban(JIT,**pull**) – is difficult to use if :
 - Jobs with short production runs
 - Significant setup times (numerically controlled machines)
 - Remarkable Scrap losses
 - Unpredictable fluctuation in demand

PUSH and PULL and the types of the queueing networks

- **Push** : open queueing network
- **Pull** : closed queueing network
- **Push** : schedule **Throughput** and measure (observe) WIP



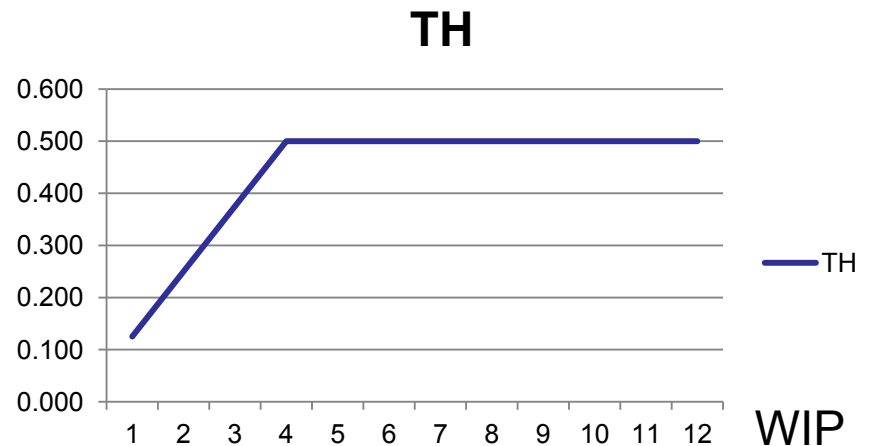
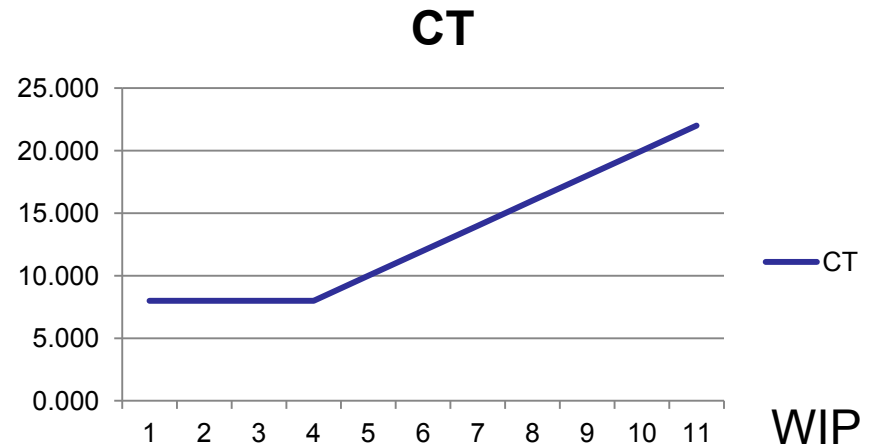
- **PULL** : setup WIP and measure (observe) Throughput

Advantage of **PULL** over **PUSH** (home study not for MPH-AOMA)

- **PUSH** : WIP and Throughput fluctuations – result in violation of the assumption, that CycleTimes (**CT**) and therefore Lead Times (**LT**) are constant !
- WIP is easier to optimize than Throughput (**T**)
- **Little's law** :
Average CT = Average WIP / Average T – meaning that **CT** cannot be constant but vary with **WIP** and **T**.
- **Pull is easy to manage** : why ? -> **WIP** is easier to control than **capacities** needed to appropriately release work in **push** system . The problem is estimation of these capacities as exact as possible,

Little's Law (home study- not for MPH_AOMA)

WIP	CT	TH
1	8	0,125
2	8	0,250
3	8	0,375
4	8	0,500
5	10	0,500
6	12	0,500
7	14	0,500
8	16	0,500
9	18	0,500
10	20	0,500
11	22	0,500
12	24	0,500



CONstant Work In Process = CONWIP

- System having benefits of a PULL and can be used in variety of manufacturing environment
- CONWIP : generalized form of Kanban
- CONWIP relies on signals (electronic, paper cards...)

CONstant Work In Process = CONWIP

- **Kanban:** card is used to signal production of a specific part
- **CONWIP :** card is assigned to production line and are not part number specific

CONWIP Configuration

Basic CONWIP



Multi-Loop CONWIP



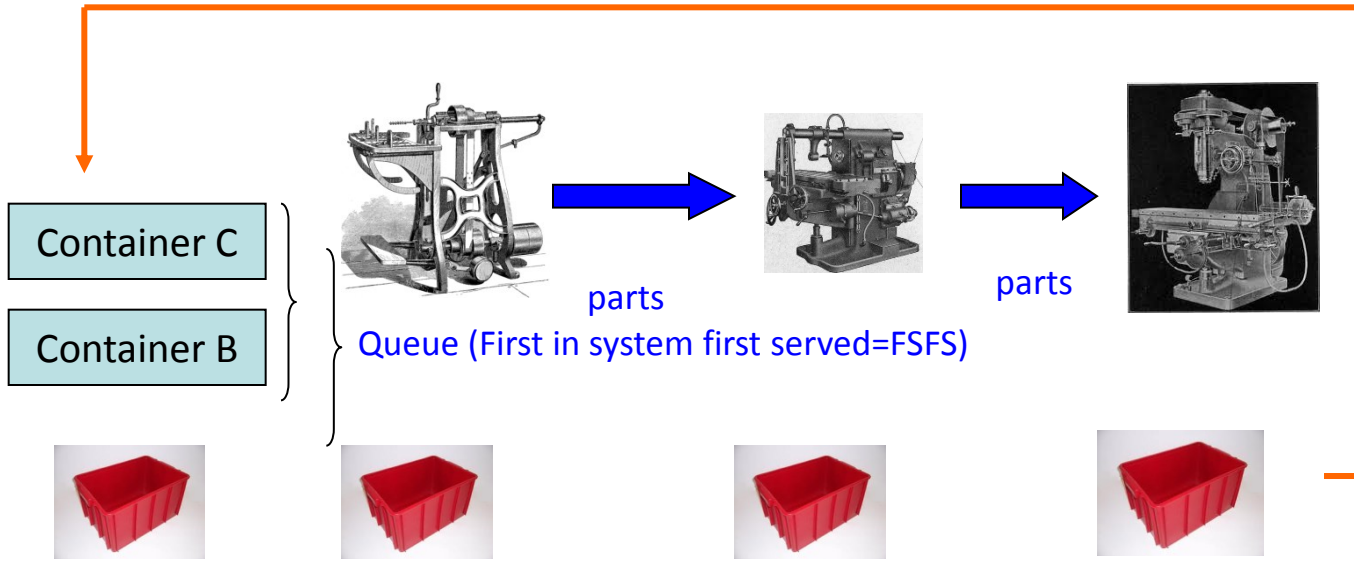
Kanban



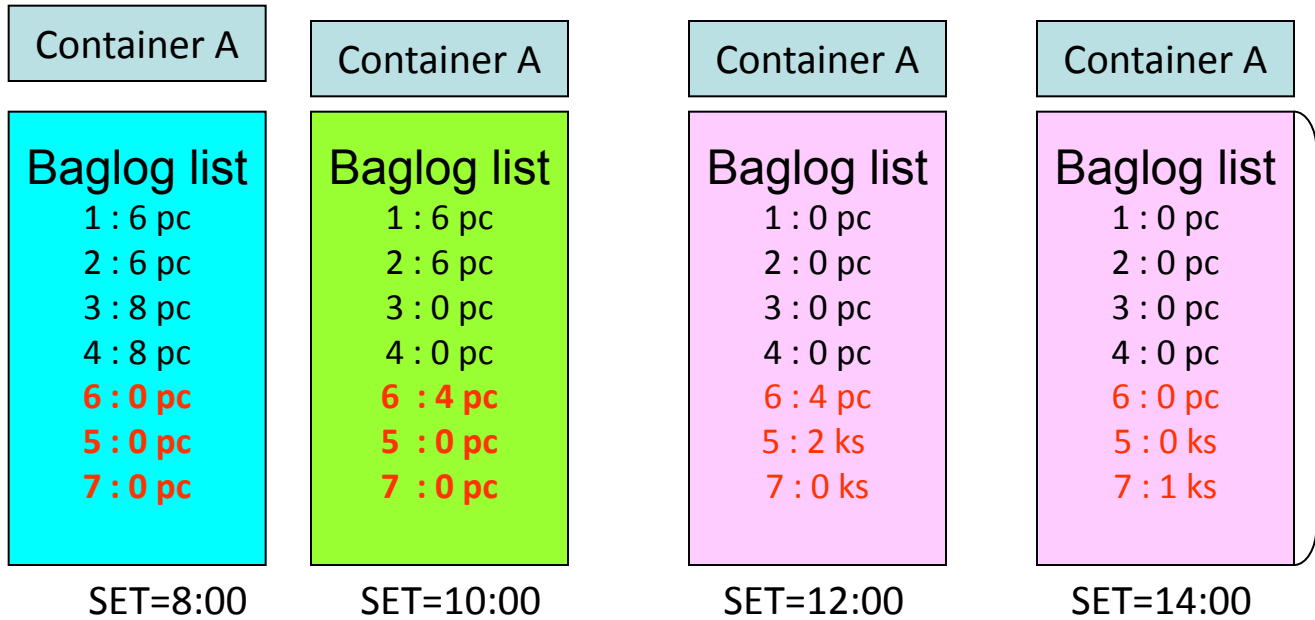
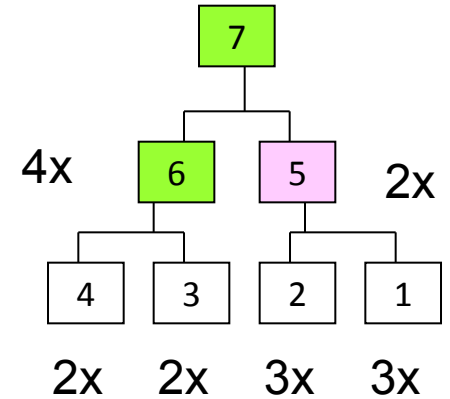
For this course only **red framed** scenario will be considered.
It is a system controlled by one loop (feedback)

CONWIP

cards



BOM of the final product (7)

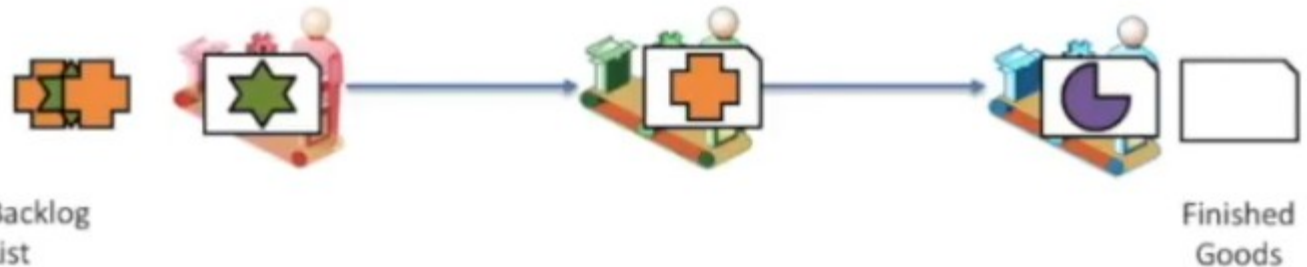
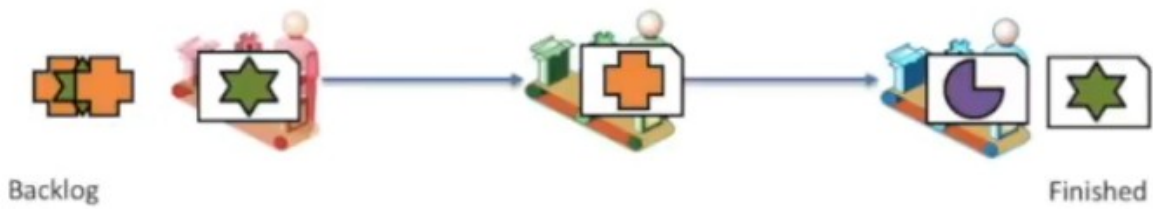


System Entry Time=SET

maintaining of BLL is responsibility of inventory control staff

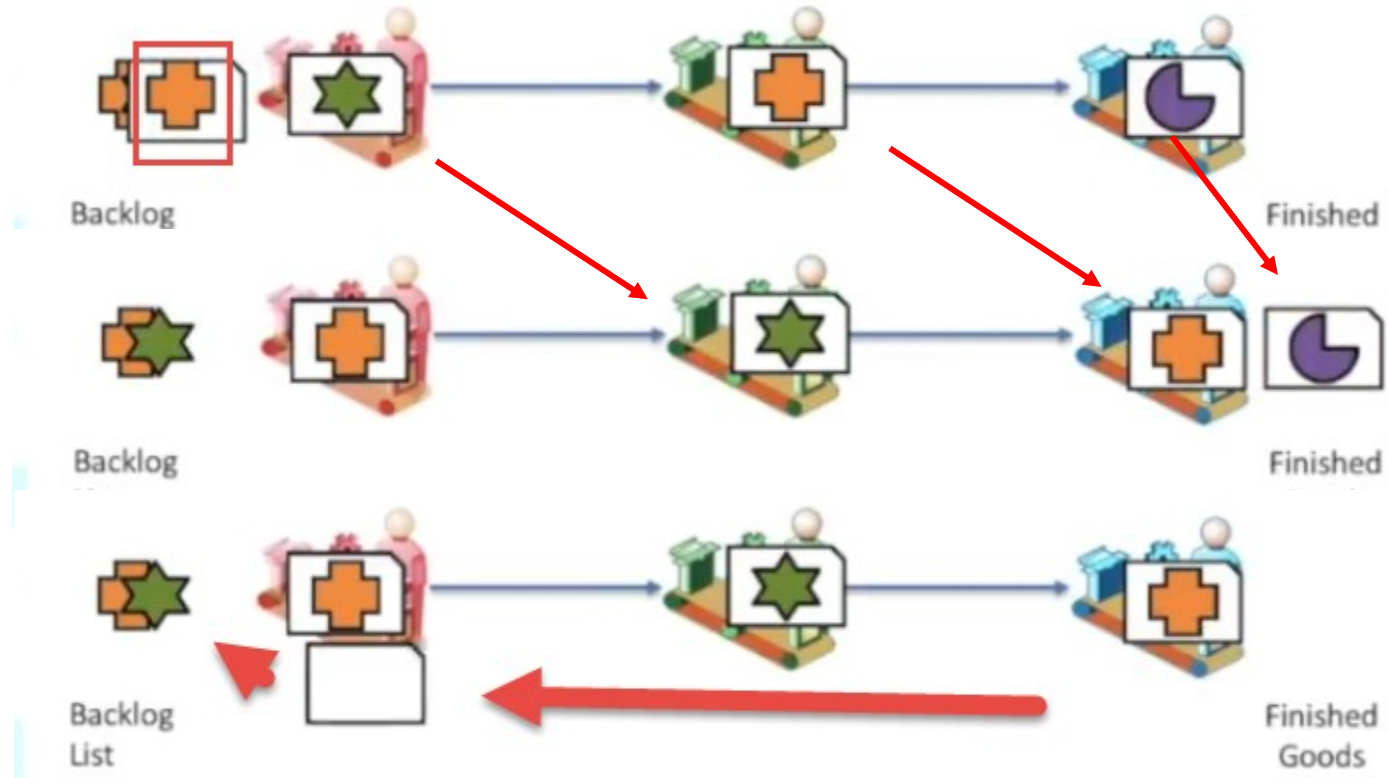
One loop (card based-pull based) I.

The objective of CONWIP is to maintain the WIP (Work in Process) in a production system at a constant level.

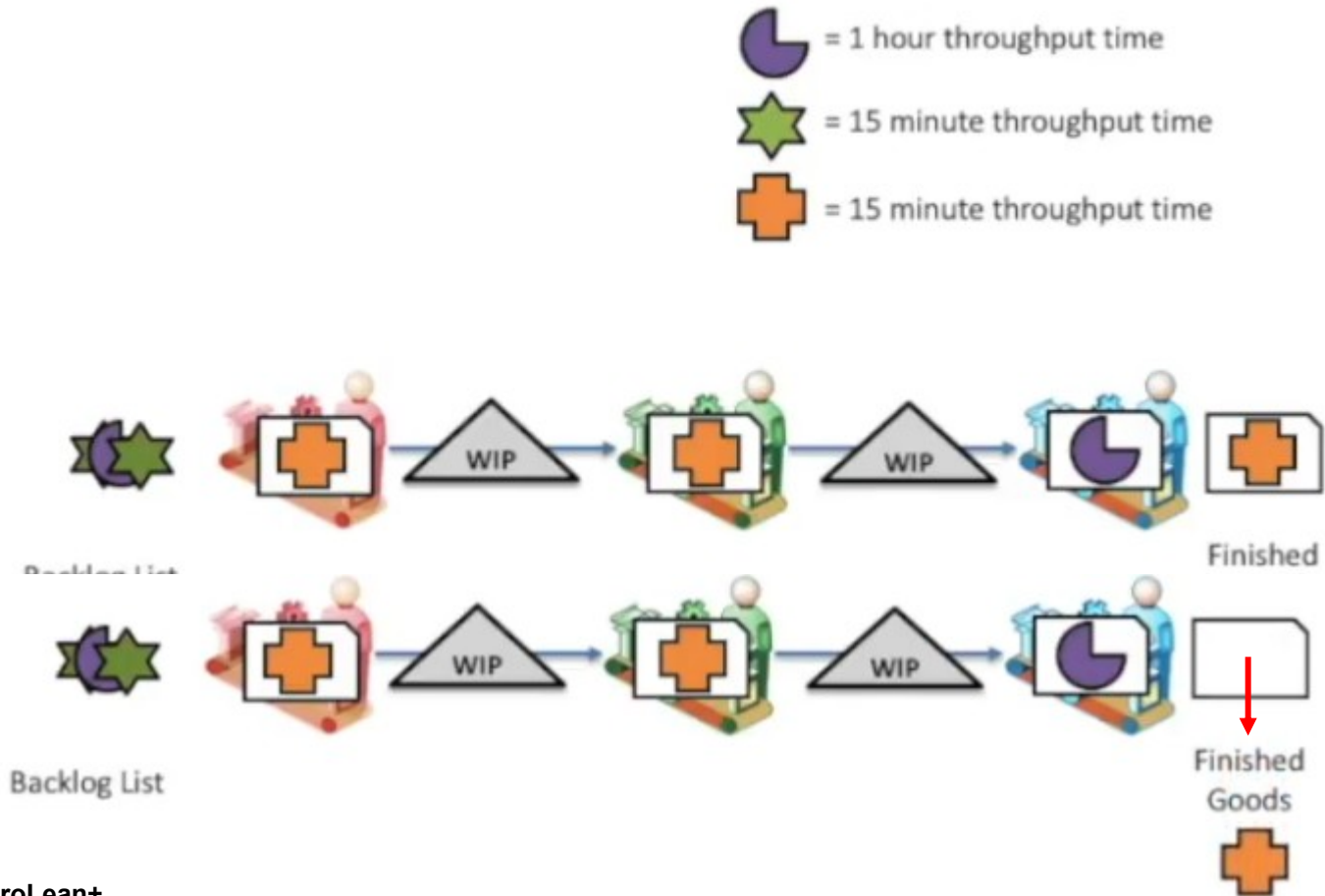


We have in our production line all in all 4 kanban cards
When FG is consumed one card is free

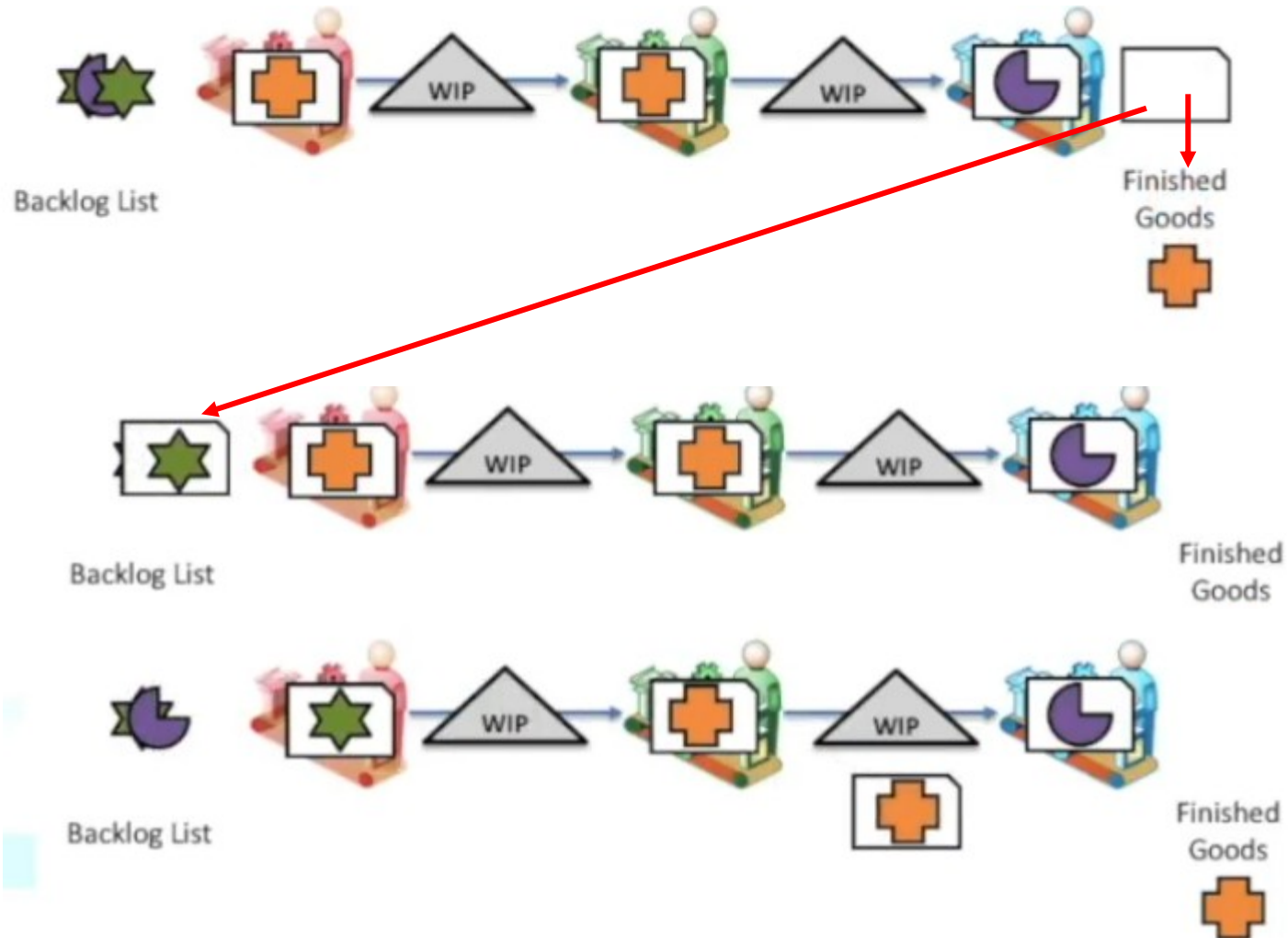
One loop (card based – pull based) II.



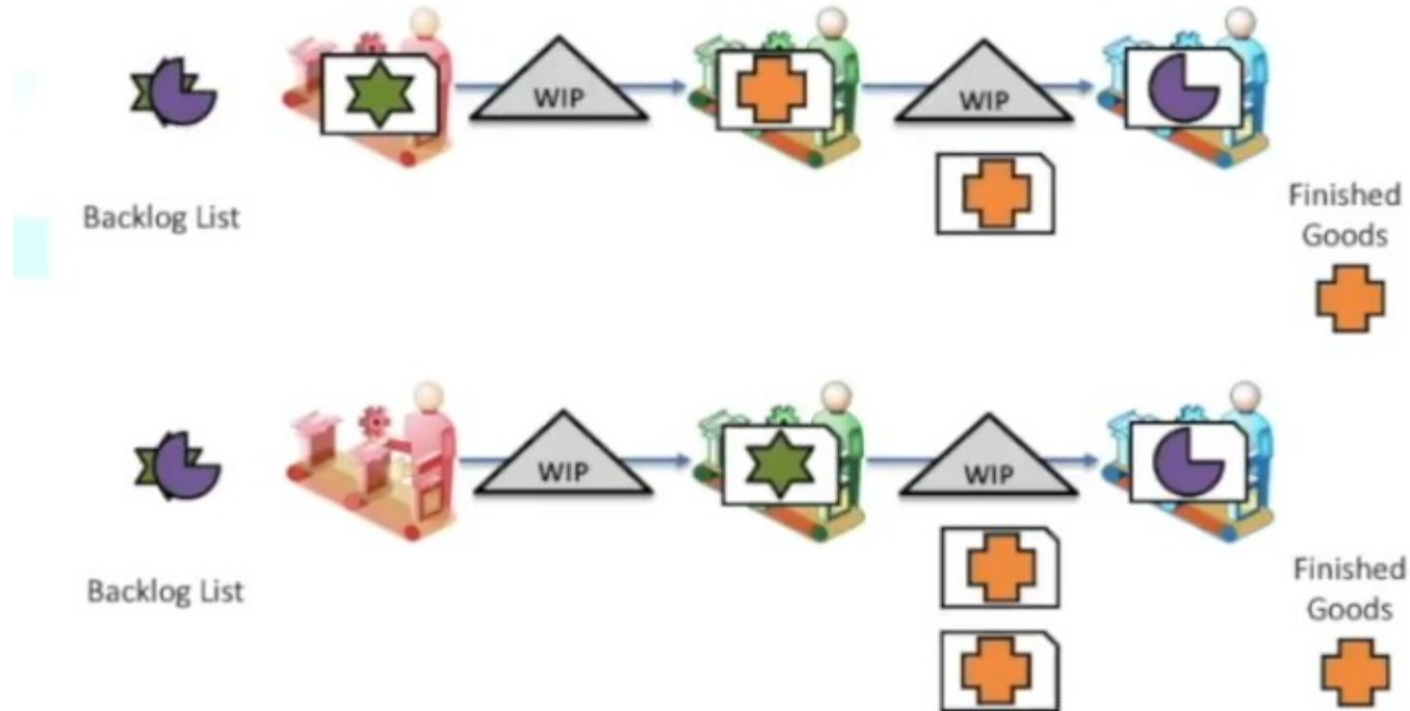
CONWIP –different throughput times I



CONWIP –different throughput times II.



CONWIP –different throughput times III.



CONWIP characteristics

- **Order release** is based on a **backlog list**
- The backlog list is not defined by the CONWIP system
 - **Relies on personnel to set priorities!**
- Queue discipline within the production system is **FSFS** (first in system first served)
- The number of cards can be calculated similar to Kanban, although it requires adjustment and fine-tuning

CONWIP-air traffic control



Originating airport



Destination airport
(air above airport)

If heavy air traffic, departing planes should be held on the ground at the originating airport rather than control flying aircrafts in the air above destination airport as a holding pattern

The results : greater safety and lower fuel consumption

CONWIP-Theory of Constraints

- Balance the flow and not the capacity
- Operation of the CONWIP line is regulated by the bottleneck resource
- If we have sufficient demand, the correct number of the cards will maintain just enough WIP to keep bottleneck busy

Thanks for your attention

(next few slides are not part of this course)

Utilization, Bottleneck rate and Raw process time (cycle time)

- **Arrival rate to the machine** (working centre) = AR
- **Effective Production Rate** (maximum average rate at which workstation can process parts, considering effects of failures, setups and other detractors that are relevant over the planning period) =EPR
- **Utilization = AR/EPR = U**
- r_b = *parts per time unit of the workstation with highest long-term utilization (U)*
- T_0 = raw process time of the line = $\sum_1^N PT_i$,where N= number of workstations
- **Critical WIP** = $W_0 = r_b \times T_0$,where T_0 =minimum cycle time and r_b = maximum throughput

Example

- Capacity of 4 machines is equal
- Thus every machine is bottleneck
- Line is balanced
- $r_b = 0,5$ product/hour
- Daily line produces 12 products = $0,5 \times 24$
- $T_0 = 8$ hours = 2 hours (product on one machine) \times 4 machines in the line
- **Critical WIP** $= W_0 = r_b \times T_0 = 0,5 \times 8 = 4$ product
- S

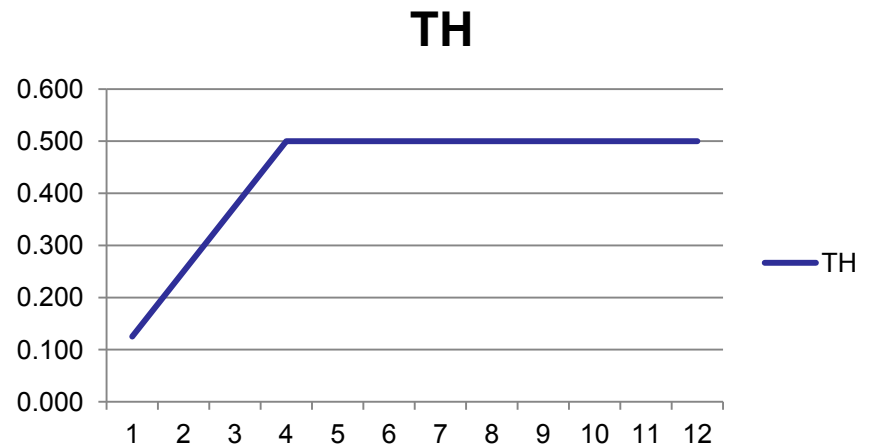
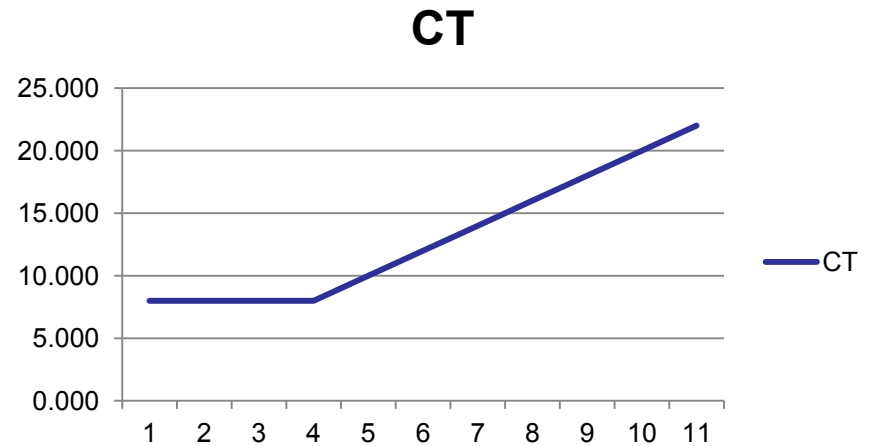


Little's Law

- $WIP = TH \times CT$, where TH=throughput and CT=cycle time

Little's Law

WIP	CT	TH
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Conwip

