TPPE74
Design and Development of Manufacturing Operations

Industrial Engineering and Management of European Higher Education

Seminar 2

System Design

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2021

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

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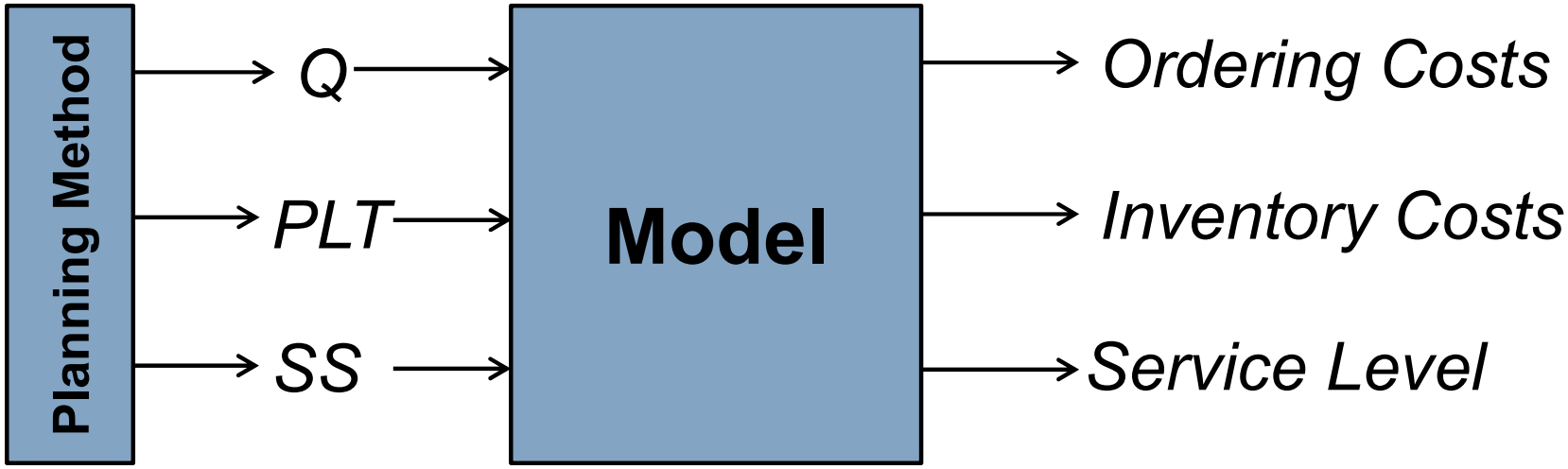
Content

- The Project Tasks
- The Manufacturing System
- Task B
- System Design
  - ROP
  - MRP
  - CP/CPB
  - Lean
- Lead Time and Cycle Time

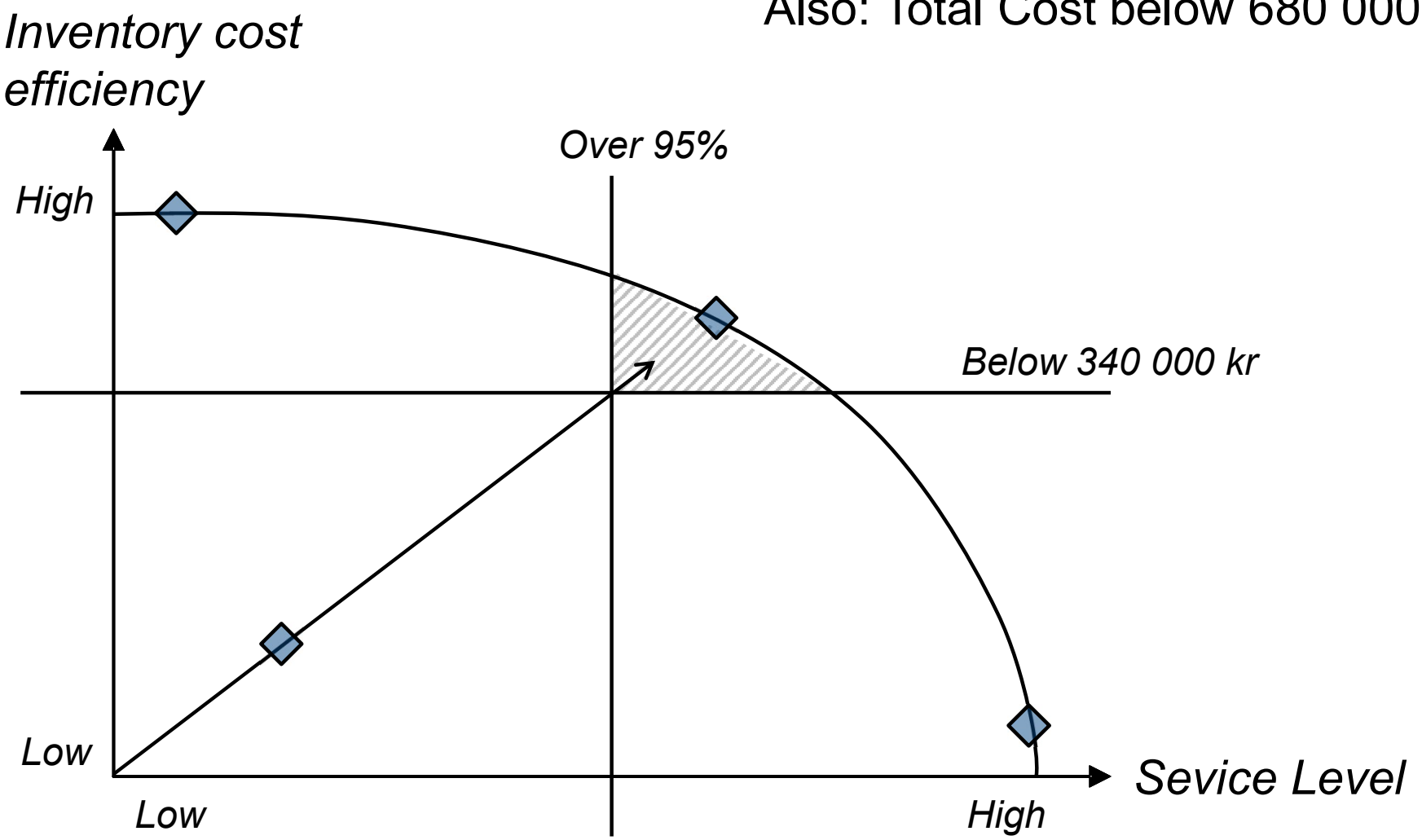
PicSim

- Production and Inventory Control Simulator (PicSim)
- Simulation model
  - 3 years of production
  - 1 year ”Warm-up”
  - 2 years data collection
  - …takes apr. 0.1 second…



PicSim

Also: Total Cost below 680 000 kr



Simulation Result for the Case Company

Simulation Results			Simulation Results						
Group No.	1								
Run No.	0								
Input data									
Product/Item	A1	A2	A3	A4	A5	A6	A7	A8	A9
Lead time	3	4	3	4	4	3	3	3	3
Order quantity	495	632	692	1611	2619	2000	226	1732	1342
Safety stock	200	100	300	400	600	1400	100	1200	900
Costs									
Ordering cost	158400		Total Ordering Cost			158400			
Inventory of raw materials	94587		Total Inventory Cost			498498			
Work in process	347459								
Semi-finished and finished goods inventory	56452								
Total	656898								
Service levels (%)									
Product 1	28.3								
Product 2	72.8								
Product 3	20.8								
Overall	28.5								
Statistics									
Stockouts of finished products	3583.00	680.50	5940.00						
Average inventory level A1-A9	-434.00	186.00	-1149.00	721.50	975.00	2040.00	177.50	3103.00	4858.50
Average actual lead time A1-A5 (weeks)	7.09	8.69	7.36	11.20	15.25				
Average queueing time P1-P5 (hours)	51.34	37.77	44.98	88.66	53.36				
Average load P1-P5 (%)	82.46	67.13	66.21	78.77	73.03				
Inventory turnover rates									
Raw material inventory	8.54								
Work in process	5.89								
Semi-finished and finished goods inventory	36.23								
Total	5.72								

Max 680 000

Max 340 000

Min 95%

Four Tasks in the Project

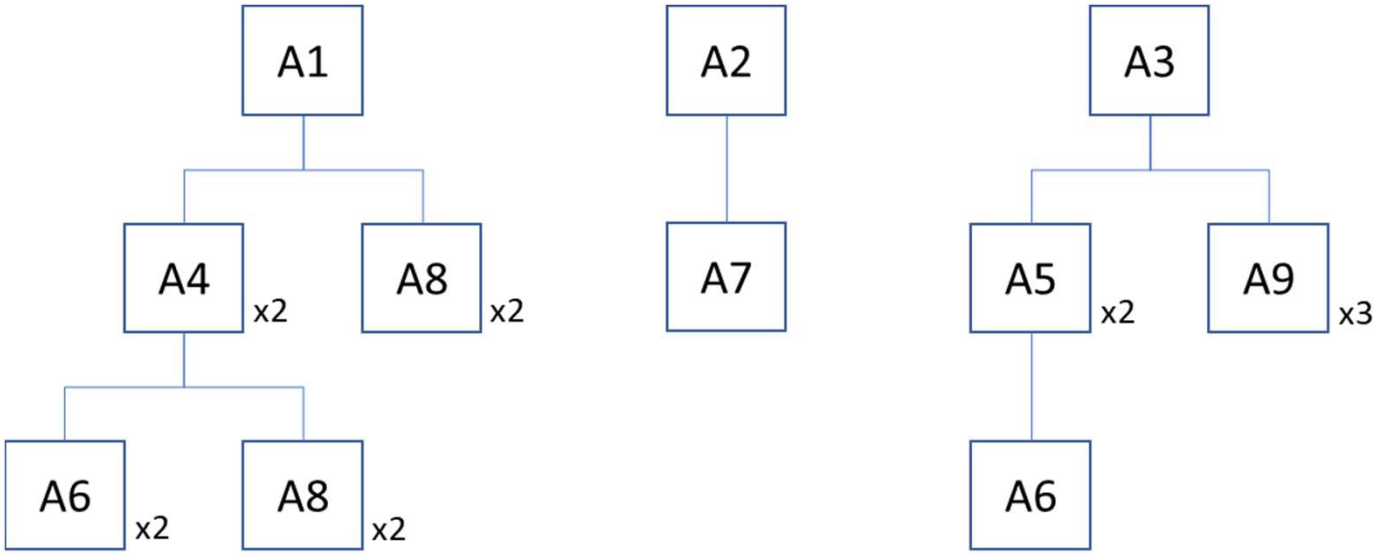
- Task A
  - Create graphs over nine different relationships.
  - Lisam Quiz to test conceptual shape.
- Task B
  - Run 10 simulations (we run the model) with the target to reach:
    Inventory cost: 340 000 kr
    Service level: 95 %
    Total Cost: 680 000 kr
  - Test all different planning methods
  - Lisam Quiz before simulations (at least one in each group needs to pass)
- Task C
  - Carry out a setup time reduction and study the effects.
  - Run 3 simulations (we run the model) to study the effects.
- Task D
  - Formulate system specific guidelines and rules that apply to the design parameters.
  - Run 3 simulations (we run the model) to “optimize” the system.
  - Competition!

Supervision

- Supervision in Teams, lists for booking
  - Week 14 to week 20, one day a week, see Time Edit
  - 08:30 -10:00 Booking in Sign Up (Lisam)
  - 10:15 -11:30 Free supervision (Lisam)

Project Task

- Manufacturing System
  - 9 products, 3 end-products, 2 manufactured components and 4 purchased components
  - 5 planning groups (resources)
  - 5 planning methods, Reorder point, MRP, Cyclic planning, Cyclic planning with base period, and Lean Production



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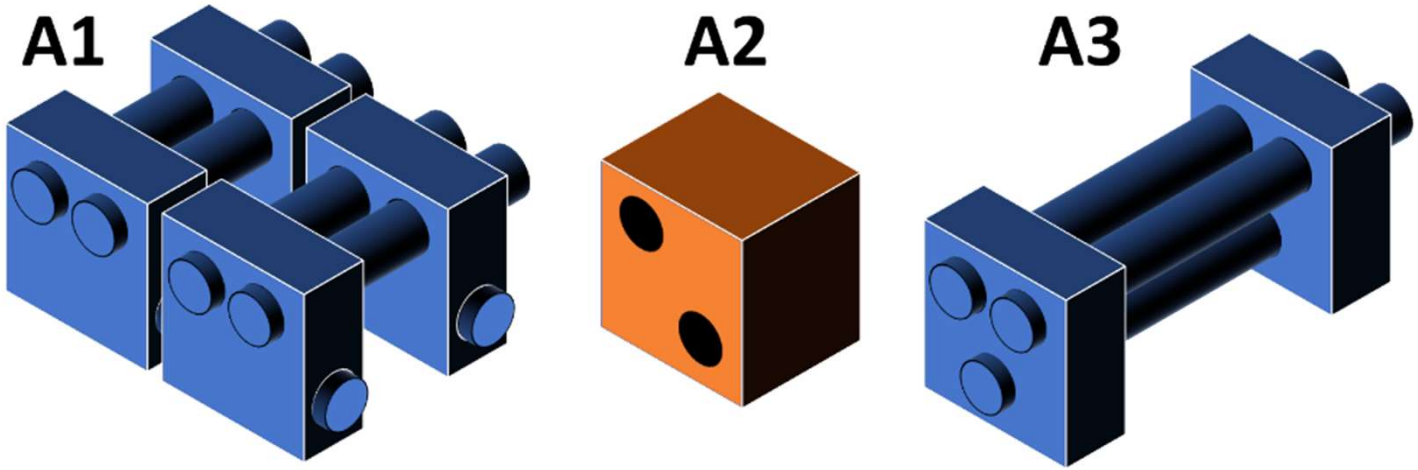
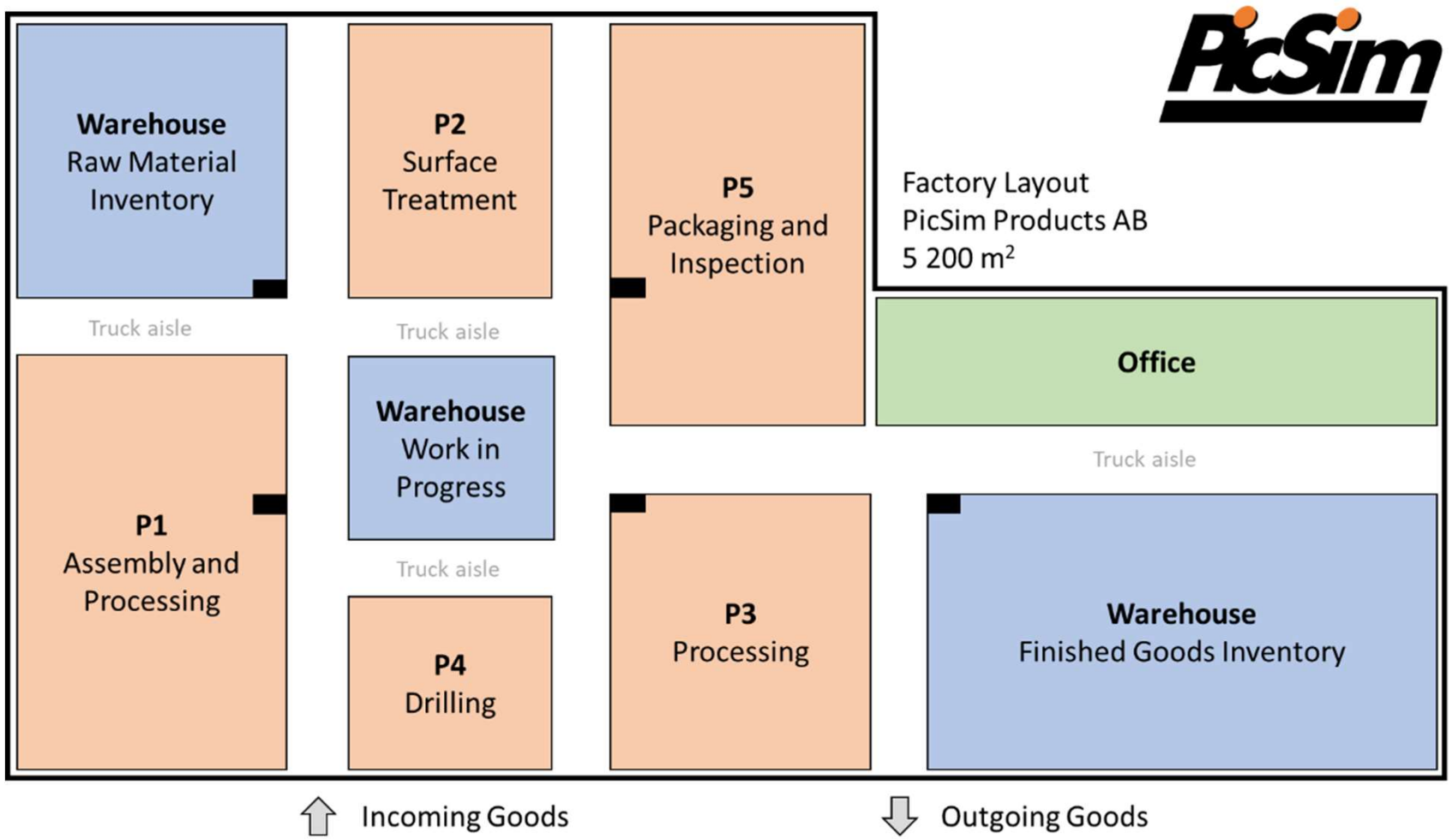


Project Task



Batched Production!

The Manufacturing System

Table 1. Means and standard deviations for weekly demand.

End product	Mean value	Standard Deviation
A1	100	12
A2	50	8
A3	150	15

Table 2. Product values in SEK per unit.

Products	Value
A1	1060
A2	500
A3	940
A4	370
A5	210
A6	70
A7	390
A8	80
A9	100

The Manufacturing System

Table 3. Processing times per unit (hours).

Planning Group \ Product		A1	A2	A3	A4	A5
P1	Assembly and Processing	0.03	0.05	0.07	0.02	0.04
P2	Surface treatment	0.06	0.08	-	0.02	0.04
P3	Processing	-	-	0.05	0.03	0.04
P4	Drilling	-	0.05	-	0.02	0.08
P5	Packing and Inspection	0.11	0.06	0.10	-	-

Table 4. Setup times and capacities for planning groups.

Planning Group \ Product		Setup time [hours]	Capacity [hours/week]
P1	Assembly and Processing	2	40
P2	Surface treatment	2	40
P3	Processing	3	40
P4	Drilling	3	40
P5	Packing and Inspection	1	40

The Tasks

- Task B
  - Improve the system in maximum 10 simulation runs
  - Chose your runs carefully.
  - Give a suggestion for “optimal” planning and control for the company.
  - The evaluation…
    - **Service level more than 95%**
    - **Total inventory holding costs less than 340 000 SEK**
    - **Total costs less than 680 000 kr**
  - Reorder point systems, MRP, cyclic planning (base period, common cycle), and Lean production.
    - Motivate recommended values.
    - Note that, in order to dismiss a planning system, strong empirical evidence is needed as motivation.
  - Only control parameters may be changed in this task.
    - Planned Lead time, PLT
    - Order quantity, Q
    - Safety stock, SS

Examination – Grading Criteria

- Grade Pass requires the following:
- Active participation in the project group.

- For Task B:
  - Maximum of 10 simulation runs with at least 1 result is better or as good as the requirements (target values) for the total cost, total inventory cost and overall service level.
  - Theoretical motivation for all planning methods that show why or why not ROP, MRP, Cyclic planning and Cyclic planning with base period solution, or Lean Production is an appropriate planning method in this project.
  - Simulation results for all planning methods that show why or why not ROP, MRP, Cyclic planning and Cyclic planning with base period solution, or Lean Production is an appropriate planning method in this project.
  - Calculation and motivation for choice of Order quantities, Planned Lead Time, and Safety Stock and/or Safety Lead Time. For all runs.

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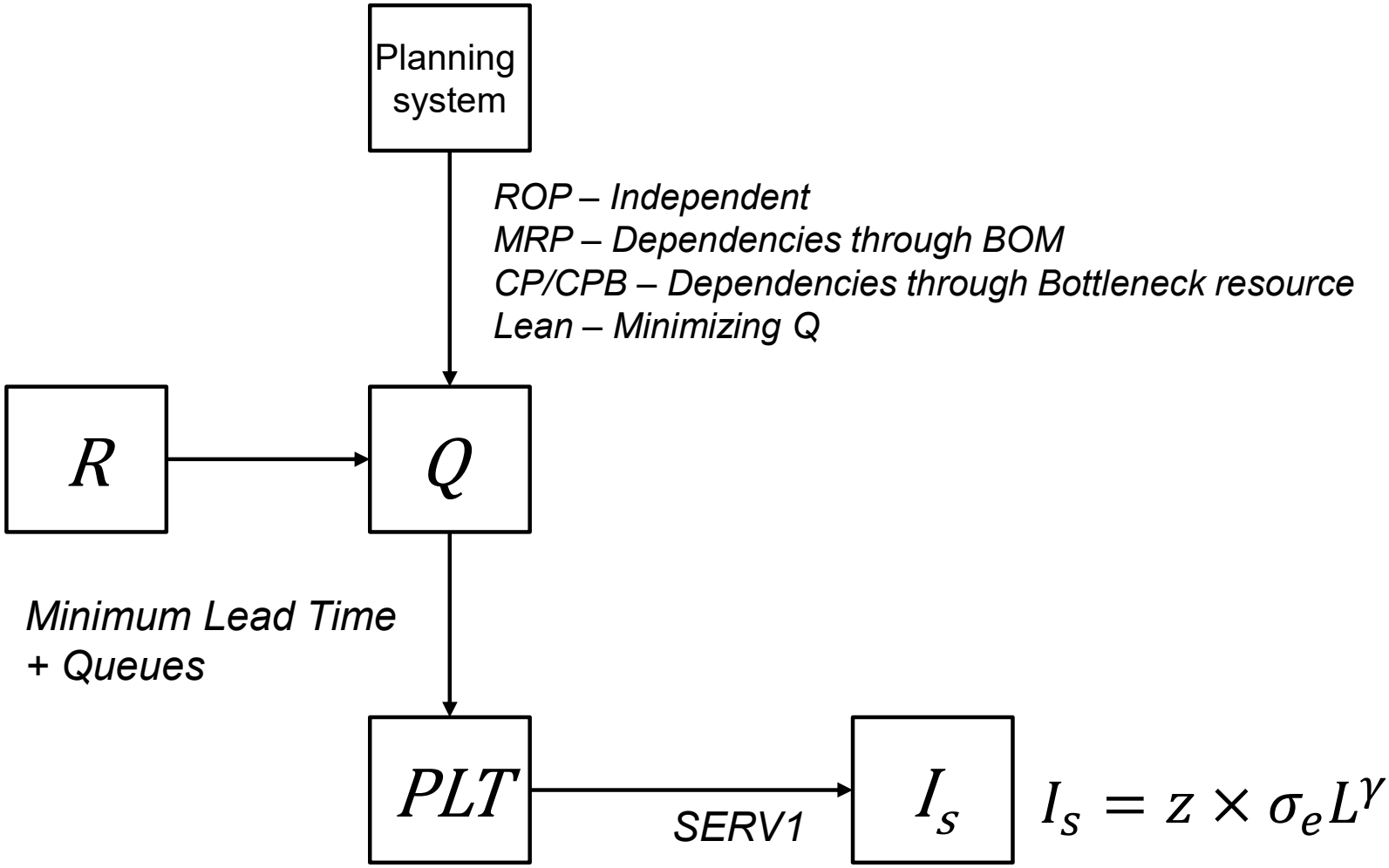
System Design



System Design 1: ROP

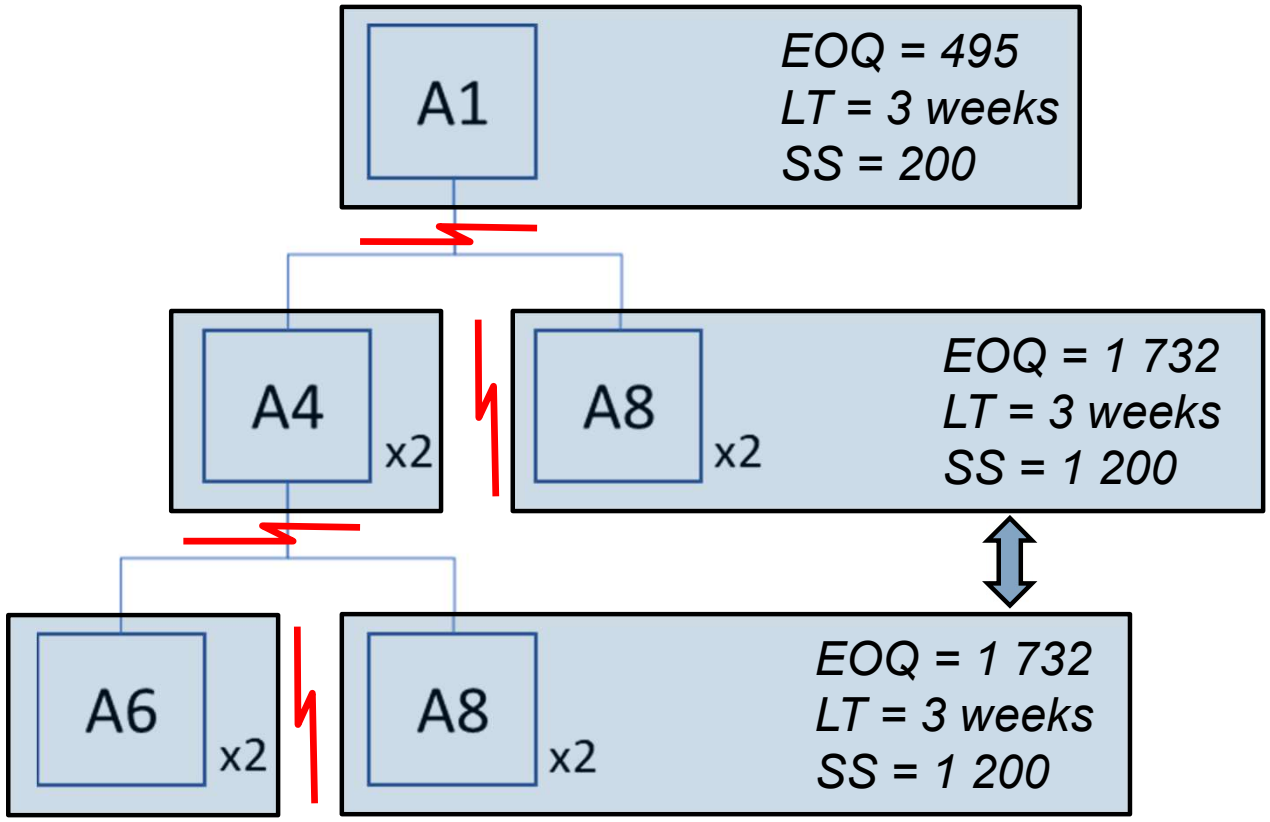
Table 6: Design parameters ROP system

Design parameters	Reorder Point System Specific
Order quantities (Q)	EOQ, independent
Planned lead times (PLT)	PLT, Planned Lead time
Safety mechanisms (SM)	SS, Safety Stock

- All end products and components are totally independent
- ROP trigger production orders in the system
- ROP = R * PLT + SS

System Design 1: ROP – Synchronizing the planning design

- ROP
  - Totally independent



System Design 2: MRP

Table 7: Design parameters MRP system

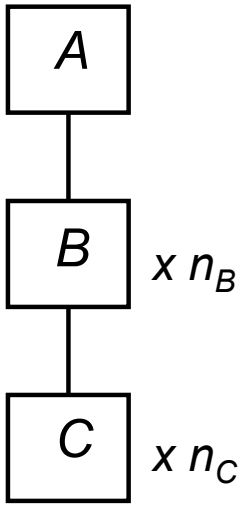
Design parameters	MRP System Specific
Order quantities (Q)	EOQ, for end product level. Components have Q according to BOM
Planned lead times (PLT)	PLT, Planned Lead time
Safety mechanisms (SM)	SS, Safety Stock or SLT, Safety Lead Time

- All end products are independent, but components are dependent through the BOM
- Forecasts are Weekly Demand
- Production orders are triggered based on ROP-like MRP calculations

QUIZ B1

System Design 2: MRP – Order quantities

- Use EOQ on end product level
- Integer multiples
  - Relative to the quantity of the end product
- Modification for items that are used in multiple positions
  - In the same product
  - In different products

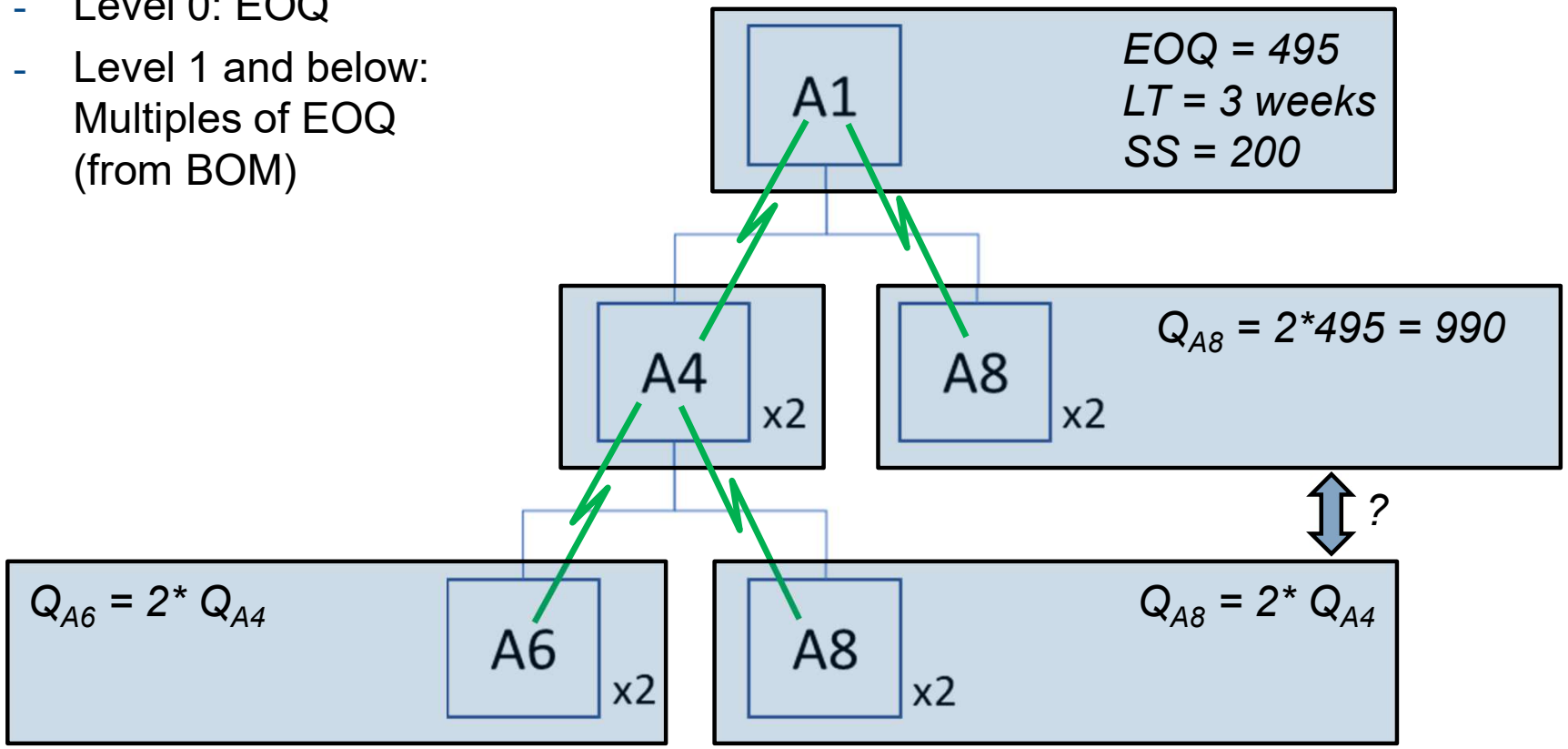


$$Q_B = n_B \cdot EOQ_A$$

$$Q_C = n_C \cdot Q_B$$

System Design 2: MRP – Synchronizing the planning design

- MRP
  - Introducing dependency through the BOM
  - Level 0: EOQ
  - Level 1 and below: Multiples of EOQ (from BOM)



System Design 3: CP Common Cycle Time

Table 8: Design parameters CP system

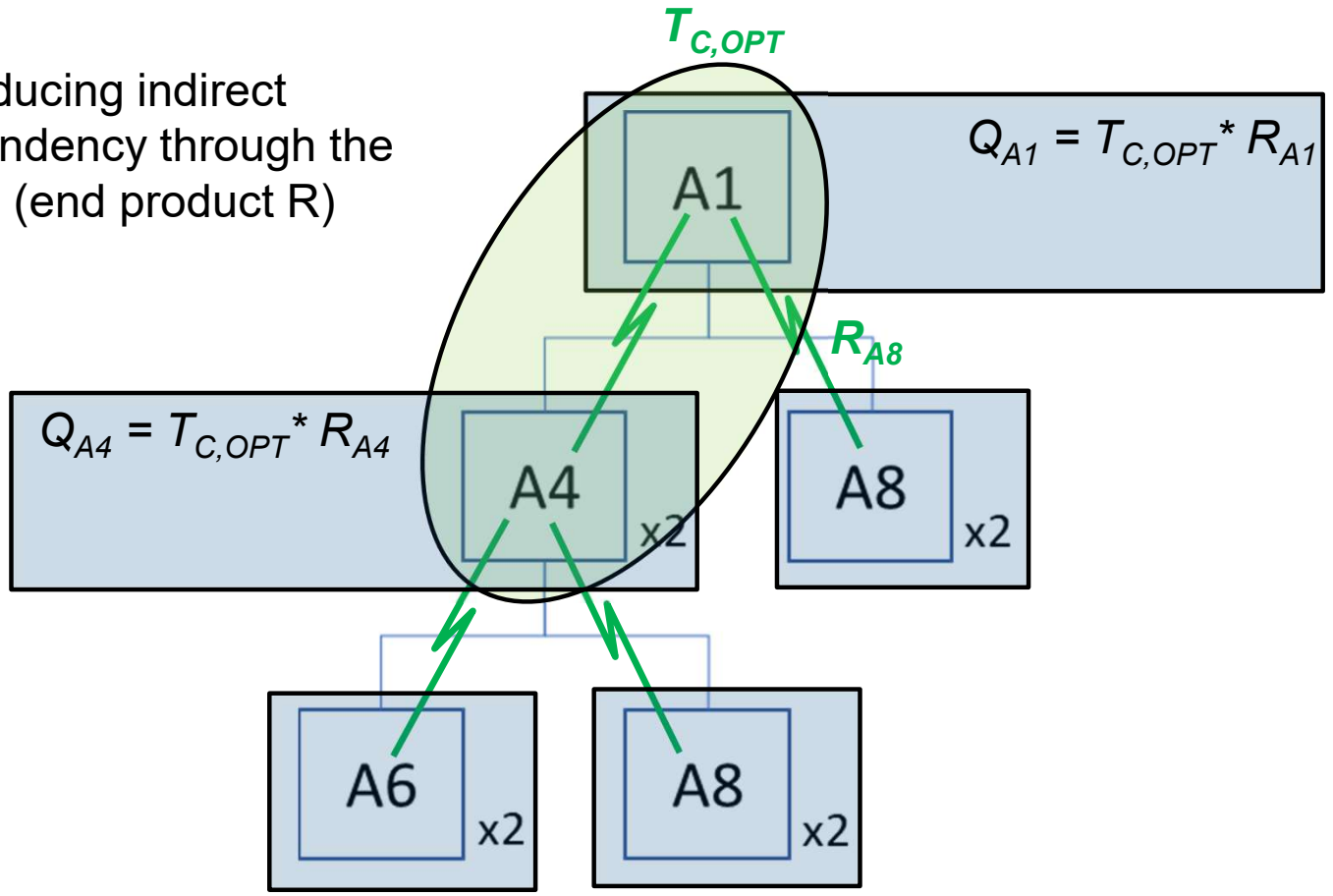
Design parameters	Cyclic Planning Specific
Order quantities (Q)	Calculated through T_{opt}
Planned lead times (PLT)	PLT, Planned Lead time
Safety mechanisms (SM)	SS, Safety Stock or SLT, Safety Lead Time

- All end products are independent, but components are dependent through the BOM
- Manufacturing is synchronized in a bottleneck resource, using a cyclic plan
- Bottleneck analysis

QUIZ B2

System Design 3: CP T – Synchronizing the planning design

- CP Common Cycle Time
  - Introducing dependency through the BN Resource (PG)
  - Introducing indirect dependency through the BOM (end product R)



System Design 4: CP Base Period

Table 8: Design parameters CP system

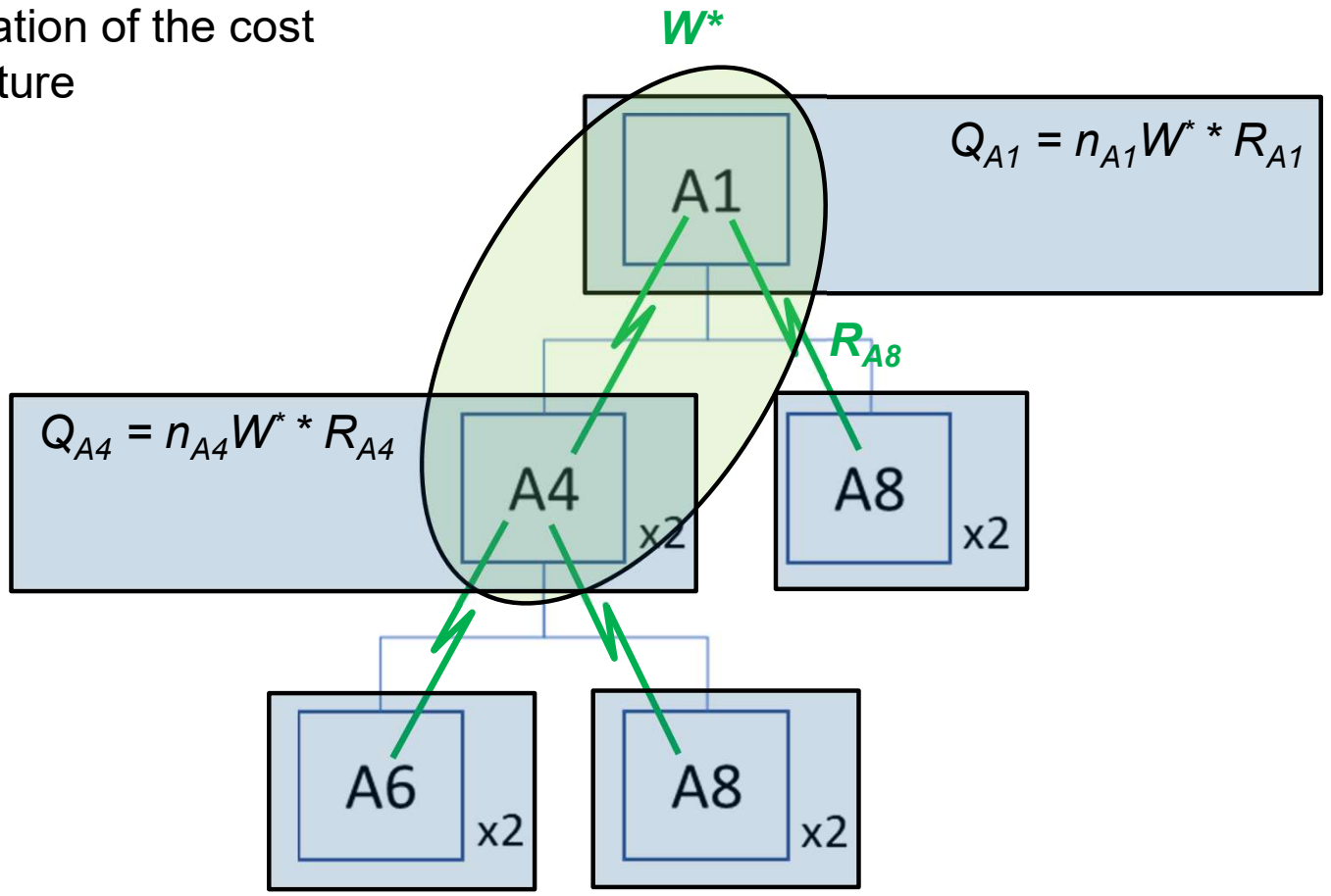
Design parameters	Cyclic Planning Specific
Order quantities (Q)	Calculated through T_{opt}
Planned lead times (PLT)	PLT, Planned Lead time
Safety mechanisms (SM)	SS, Safety Stock or SLT, Safety Lead Time

- All end products are independent, but components are dependent through the BOM
- Manufacturing is synchronized in a bottleneck resource, using a cyclic plan
- Bottleneck analysis

QUIZ B3

System Design 4: CP B – Synchronizing the planning design

- CP Base Period
  - Same as CP Common Cycle Time, but with better utilization of the cost structure



System Design 5: Lean Production

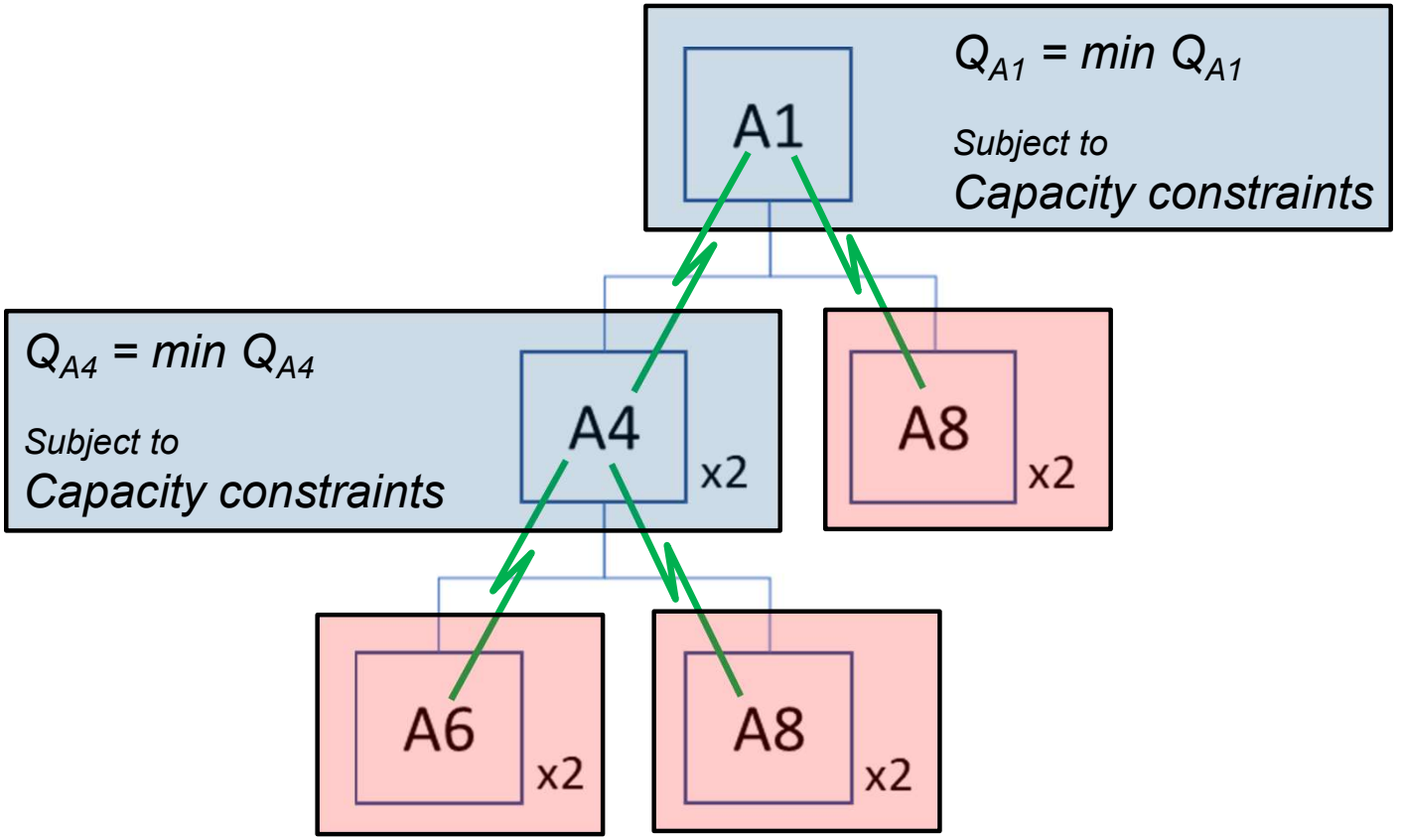
Table 9: Design parameters Lean Production system

Design parameters	Lean Production Specific
Order quantities (Q)	As small as possible to follow single piece flow
Planned lead times (PLT)	PLT, Planned Lead time
Safety mechanisms (SM)	SS, Safety Stock or SLT, Safety Lead Time

- All end products are independent, and components ***can be*** dependent through the BOM
- Minimize the order quatities to be as small as possible
- Close to full capacity utilisation

System Design 5: Lean – Synchronizing the planning design

- Lean Production
  - Dependency through the BOM
  - Minimizing Q



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Difference between Cycle Time and Lead Time