

POLITECNICO
MILANO 1863

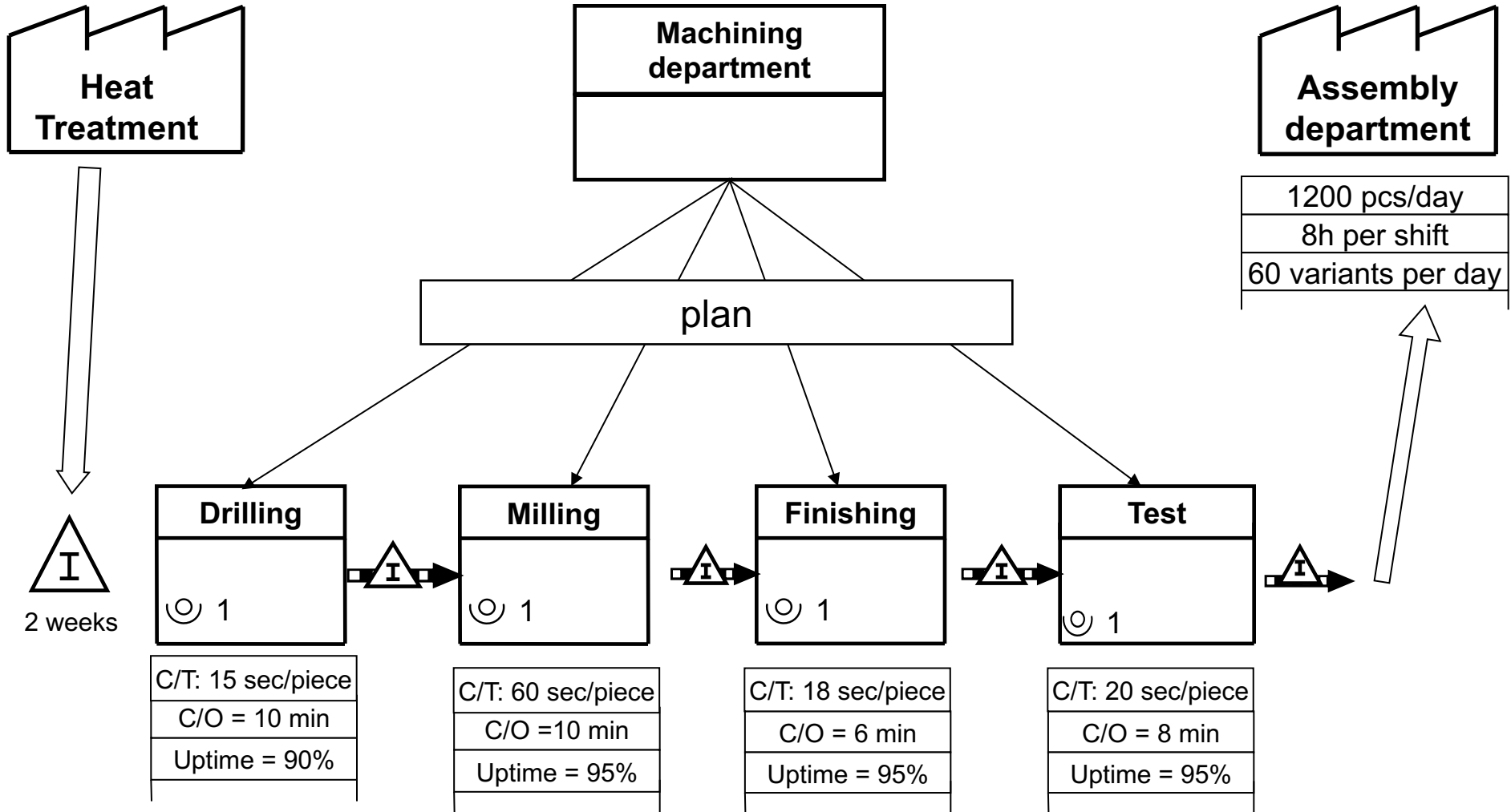
Lean Manufacturing – VSM4 – Solution support

PhD, Ing. Federica Costa– Prof. Alberto Portioli-Staudacher
Dipartimento Ing. Gestionale
Politecnico di Milano
Dep. Management, Economics and Industrial Engineering
Federica.costa@polimi.it

Exercise 1

	Drilling	Milling	Surface Finishing	Testing
Cycle time (sec/piece)	15	60	18	20
Setup time (min/setup)	10	10 (shape) 10 (material) 10 (size)	6	8
Availability	90%	95%	95%	95%
Available time (min)	480	1440	480	480

Current state



Exercise 1

Q1: Calculate the minimum EPE for each stage in the current situation.

Q2: Propose a future state solution for the company, identifying minimal intervention so that the company may be able to deliver batch of 20 units to the warehouse before the assembly department.

Exercise 1

Q1: Calculate the minimum EPE for each stage in the current situation.

EPE (every part ever) = time required to sort the whole product range

$$\mathbf{EPE * T_p + T_s \leq EPE * T_a}$$

$$\mathbf{EPE \geq \frac{T_s}{T_a - T_p}}$$

Exercise 1

Stage Drilling:

- EPE

$$(15/0,9*1200*X) + (10*10*60) \leq 480*60 * X$$

$$X \geq 0,682 \text{ days}$$

Stage Milling:

- EPE

$$(60/0.95*1200*X) + (60*10*60) \leq 1440*60 * X$$

$$X \geq 3,4 \text{ days}$$

Stage Surface Finishing:

- EPE

$$[18/0.95*1200*X] + [3*6*60] \leq 480*60 * X$$

$$X \geq 0,18 \text{ days}$$

Stage Testing:

- EPE

$$[15/0.95*1200*X] + [2*8*60] \leq 480*60 * X$$

$$X \geq 0,27 \text{ days}$$

Exercise 1

Q2: Propose a future state solution for the company, identifying minimal intervention so that the company may be able to deliver batch of 20 units to the warehouse before the assembly department.

**FROM PRESENT
STATE TO FUTURE
STATE
THE 8 QUESTIONS**

Exercise 1

1. What is the takt time of the production family?

$$TT \text{ (Stage 1-3-4)} = 480 \text{ min} / 1200 \text{ units} = 24 \text{ sec/u}$$

$$TT \text{ (Stage 2)} = 1440 \text{ minutes} / 1200 \text{ units} = 72 \text{ sec/u}$$

2. Produce for supermarkets or for shipping?

From the text: the goal is to produce for a finished good warehouse with a batch of 20 units

Exercise 1

3. Where to put the flow?

General methodology

- Start from the **final stage and go upstream** thinking stage by stage where to put CONTINUOUS FLOW and where to decouple (with SUPERMARKET or FIFO).
- Verify **DECAF Conditions**.
- Fix intermediate targets (not necessarily all at once in a continuous flow, but also FIFO and supermarket).

Start from department 4 then move upstream

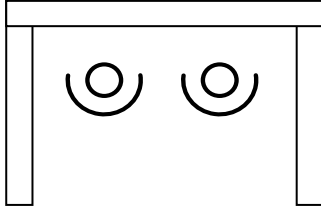
Milling works on 3 shifts, while all other stages works on 1 shifts.

It is therefore not possible to introduce a complete continuous flow.

We can propose to couple stages Finishing and Testing.

Exercise 1

Stage Finishing + Testing

Finishing + Testing

$C/T =$ $\text{Max}(18; 20) = 20 \text{ sec/piece}$
$C/O = 6-8 \text{ min}$
$A = 95\% * 95\% = 90,25\%$
2 Operators

DeCAF condition

Dedicated

Capable

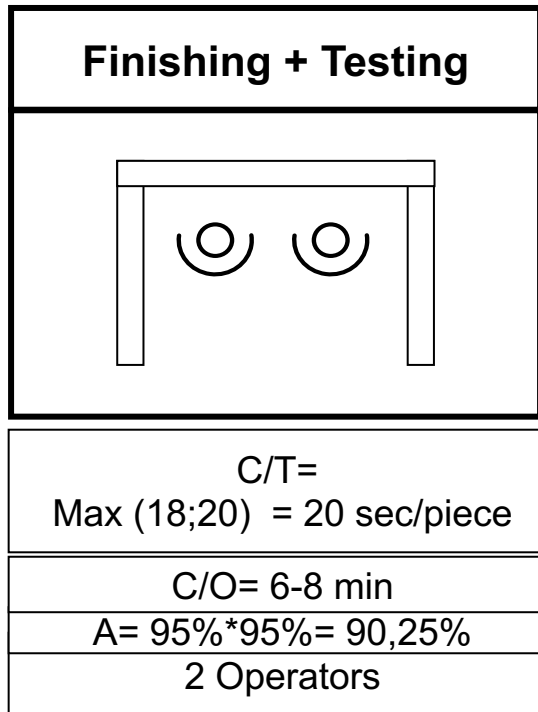
Available

Flexible

- **Dedicated:** yes
- **Capable:** $CT < TT$
 $20 \text{ sec/u} < 24 \text{ sec/u}$
yes
- **Available:** $CT/A < TT$
 $20 \text{ sec/u} / 0,9025 < 24 \text{ sec/u}$
yes

Exercise 1

Stage Finishing + Testing



- **Flexible**

In order to reach the target of 20 units per batch, 60 setups per day are required.

Target to deliver 20 units/batch

#Setups = 60 setups per day

$$T_p + T_s \leq T_a$$

$$T_s \leq (T_a - T_p) = 480 - 1200 * 20 / (60 * 0,9025) = \mathbf{36,79 \text{ min/day}}$$

This is the time available to do setups.

We need to set an improvement target (reduce C/O)

$$C/O = T_s / \#setups = 36,79 / 60 = \mathbf{0,61 \text{ min/setup}}$$

If the setup time is reduced to 0,61 min/setup it is possible to couple the departments in a continuous flow.

Exercise 1

4. Where to put the pull-supermarket?

There will be a finished good supermarket.

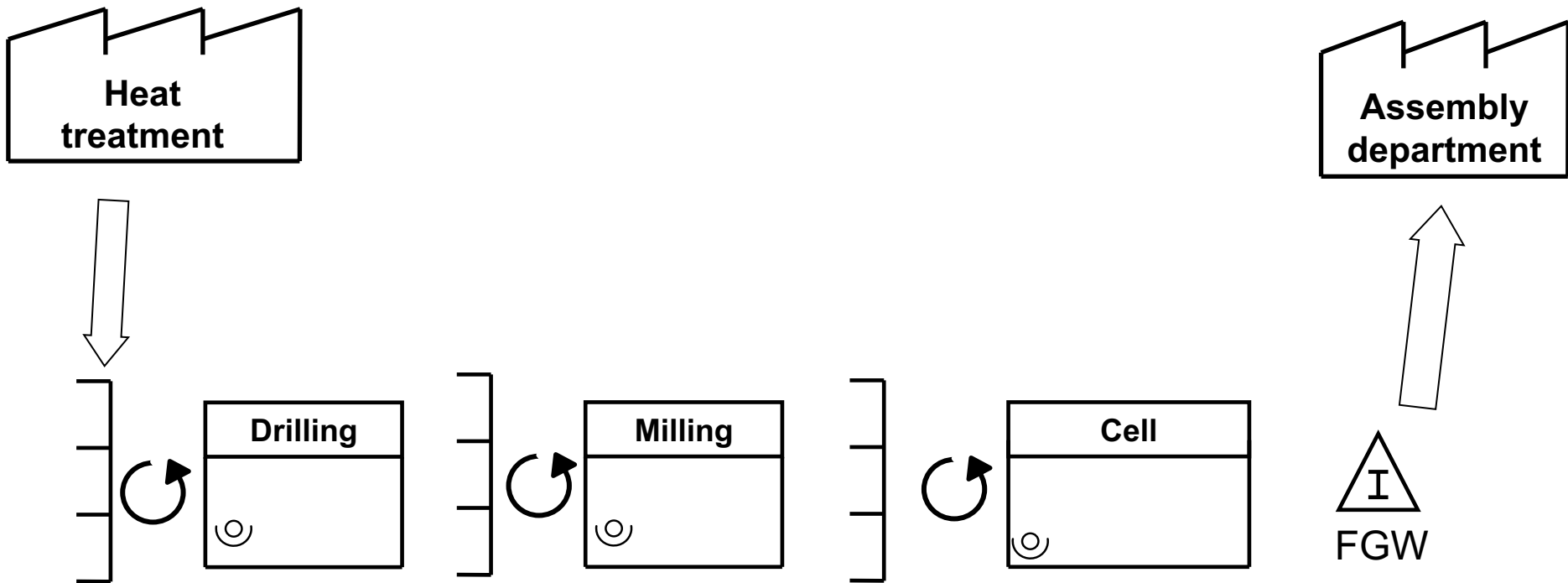
All the upstream stages are decoupled by supermarkets.

Supermarket size (if internal): $1,5 * EPE_{upstream} * D_{dd}$

Supermarket size (if external): $2 * EPE_{upstream} * D_{dd}$ [for the exam only]

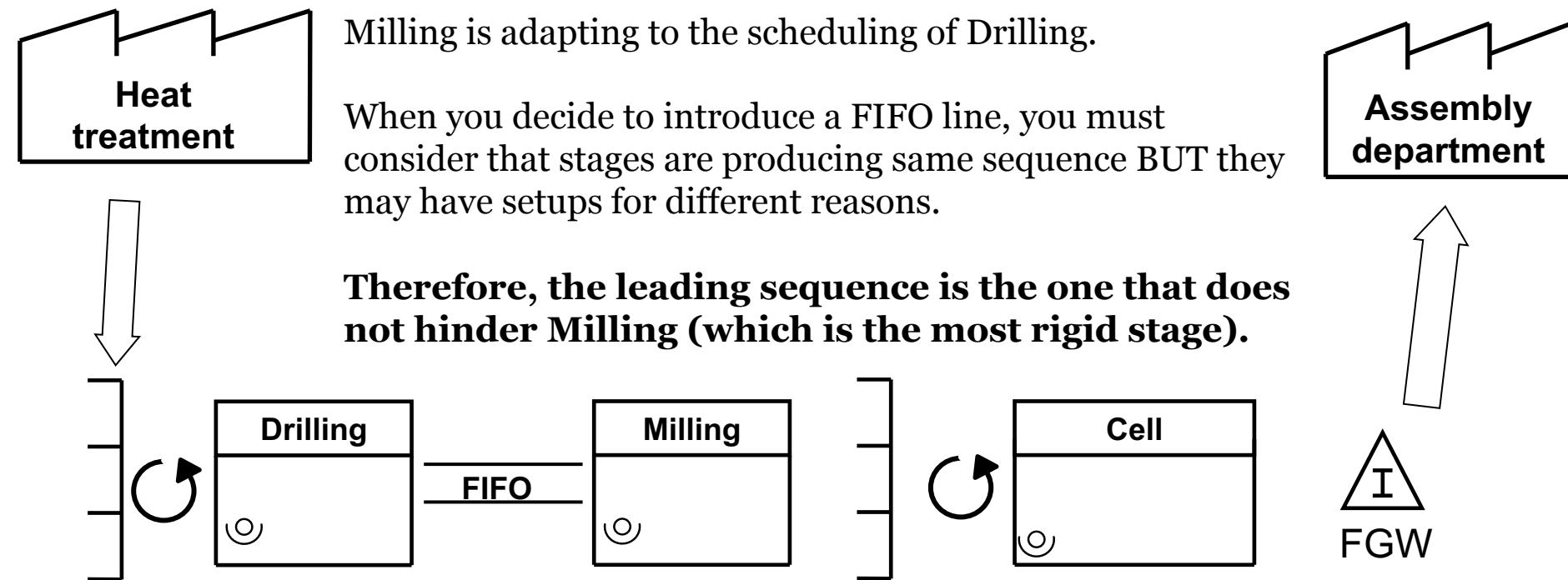
For the raw-materials supermarket, you must consider the interarrival times between two supplier deliveries.

Exercise 1



Exercise 1

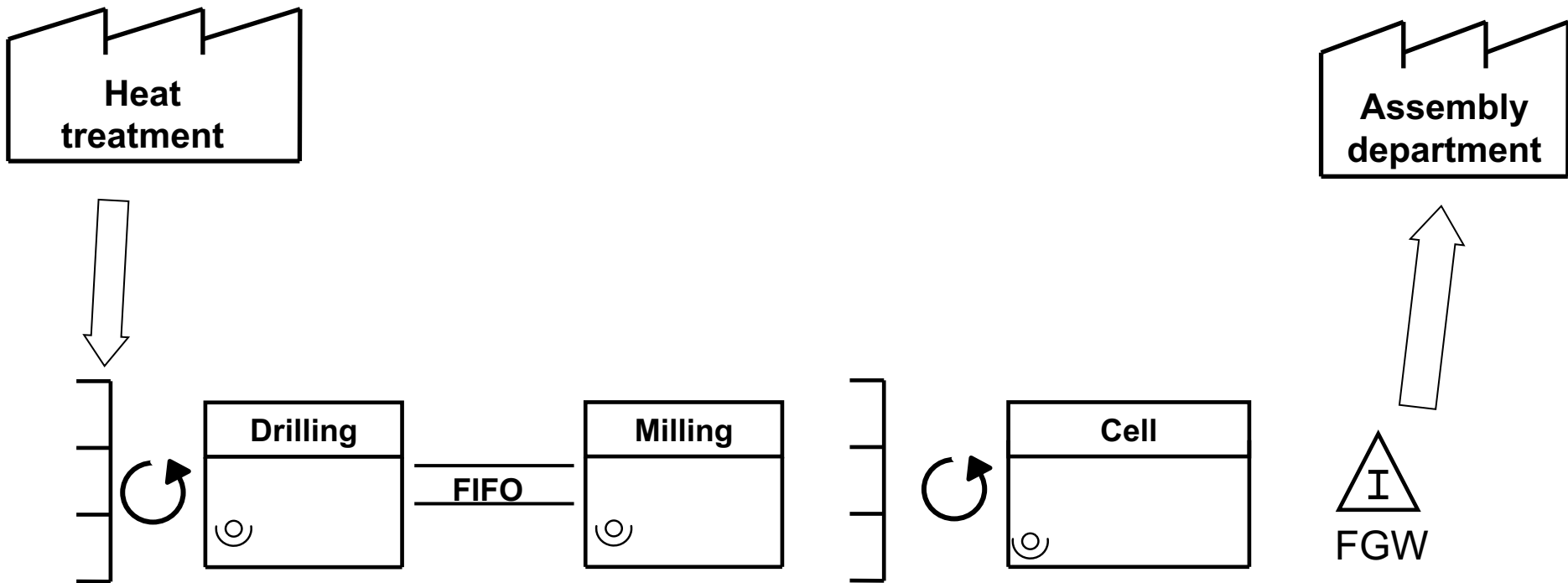
For this situation there is the opportunity to insert a **FIFO line** between Drilling and Milling. Indeed, Drilling is decoupled from Milling only because of different shifts. Drilling is very flexible (EPE=0,682 days) resulting in a very little supermarket (around 1 day).



Exercise 1

$$\text{FIFO size} = \Delta\text{shifts} * D * 1,5 = 1200 \text{ pcs}$$

Please note that 400 pc is the demand for the single shift of the slowest stage



Exercise 1

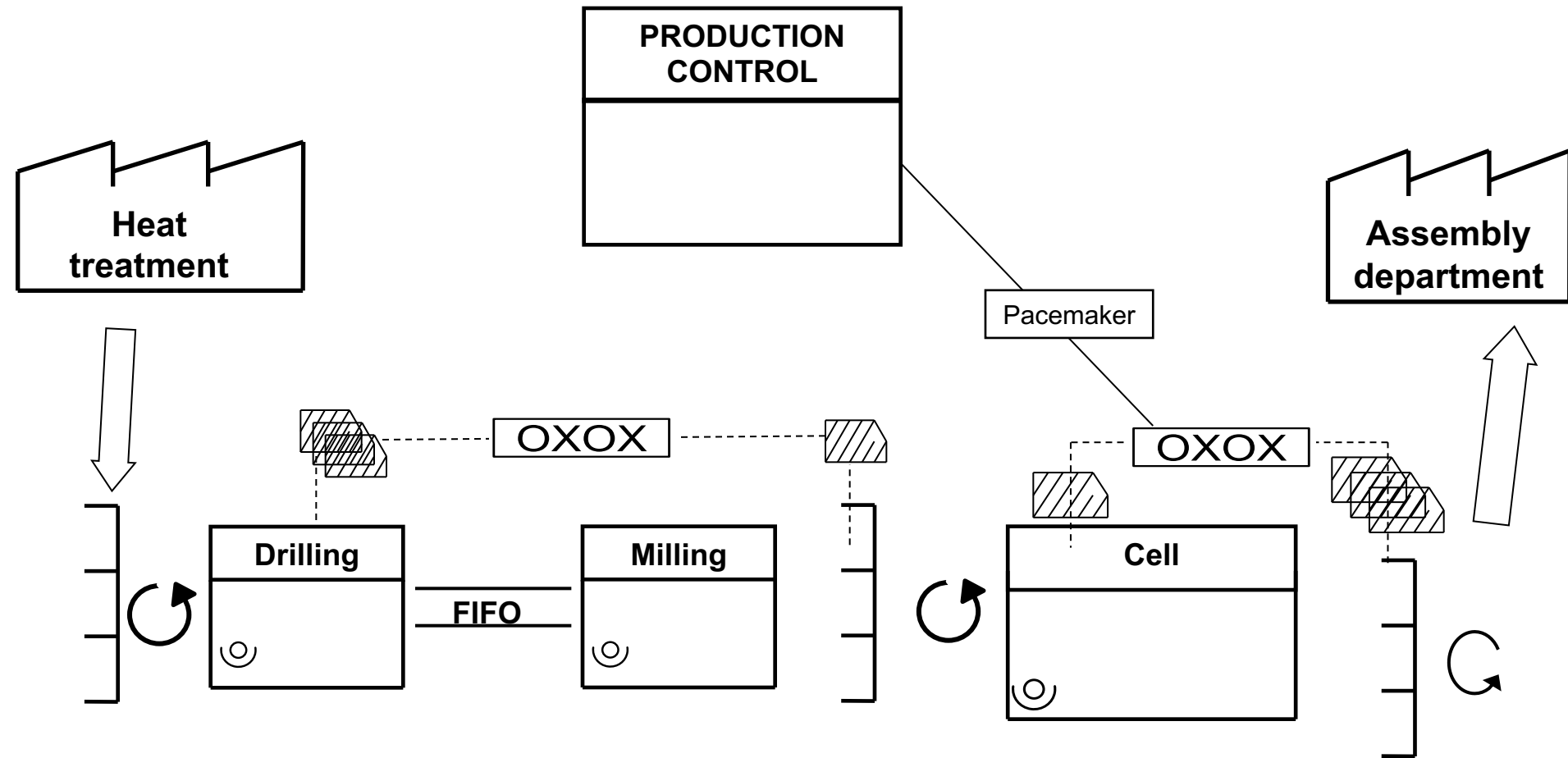
5. Where is the company single scheduling point?

6. How should the company level the product mix to pacemaker process?

5. The company schedules the production only for the **cell**.

6. Hejunka box and Batching level the mix for the cell and drilling - system.

Exercise 1





POLITECNICO
MILANO 1863