Lean Manufacturing – VSM-1 – Solution support

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Exercise 1

Q1: Draw the company Current State Map of the Company

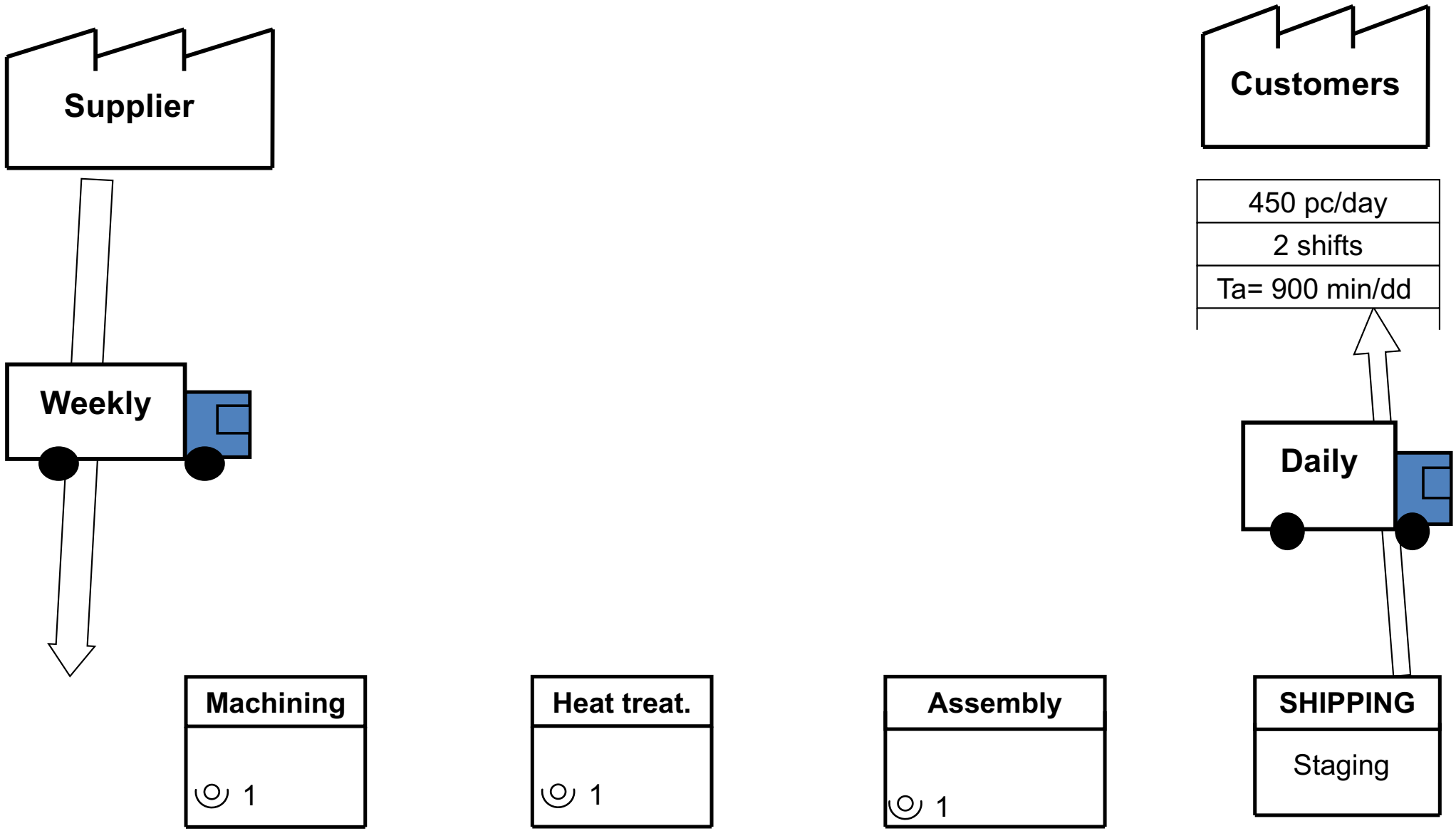
Q2: The general manager defines as internal target that each stage of the company must be flexible enough to produce all the variants each day. Which improvement should the company implement?

Exercise 1

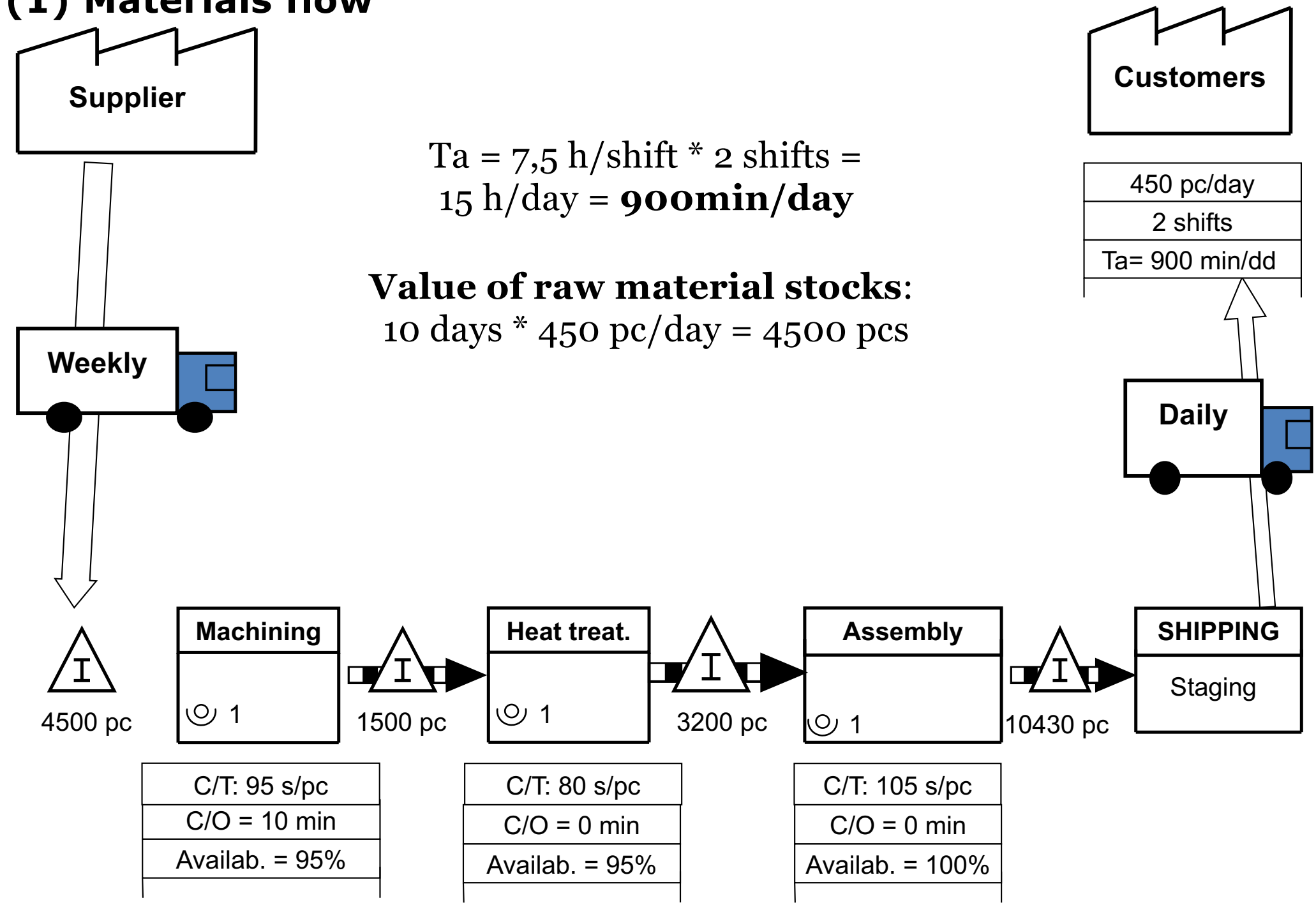
Q1: Draw the company Current State Map of the Company

3 steps:
(1) Material flow
(2) Information flow
(3) Timeline

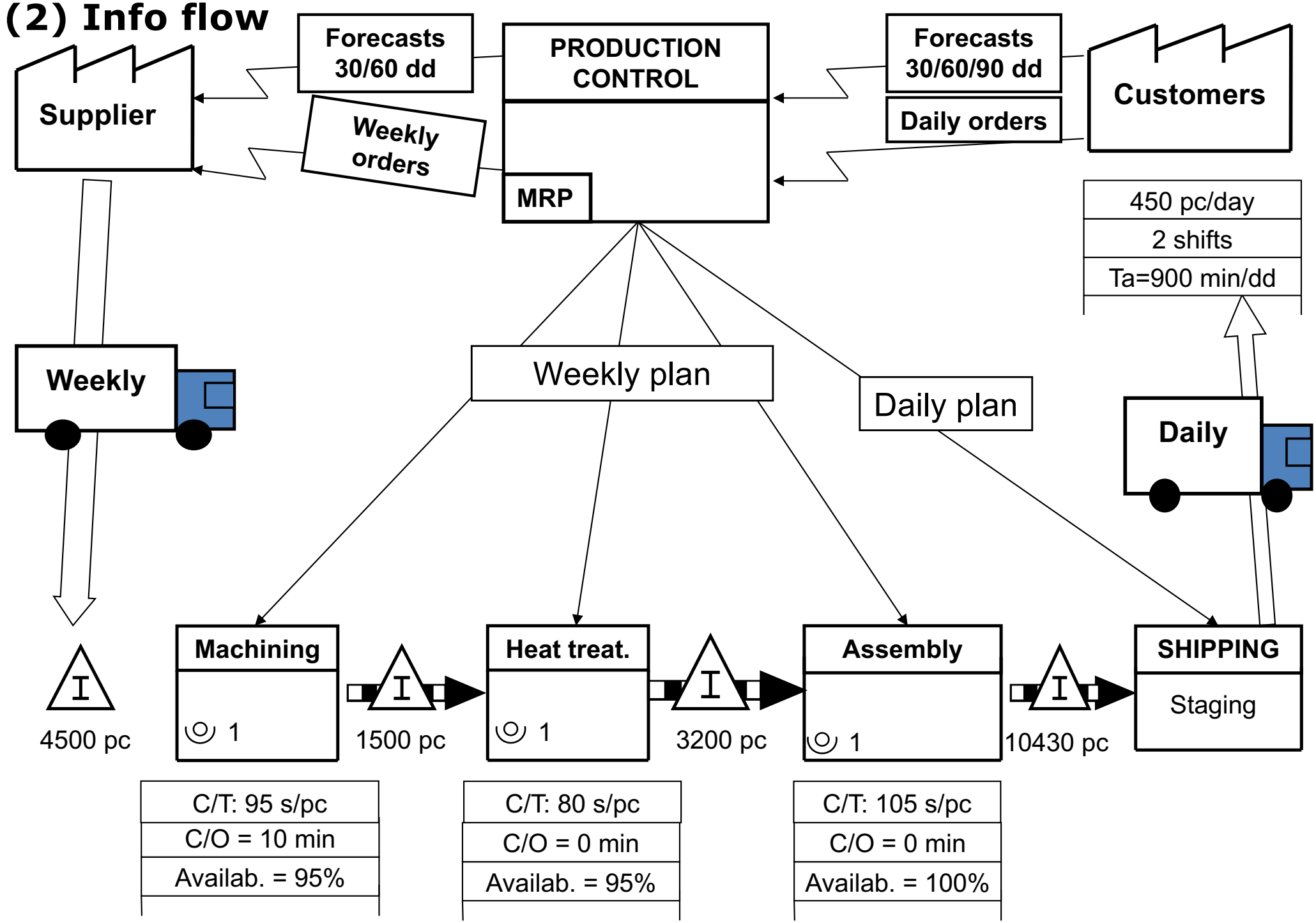
(1) Materials flow



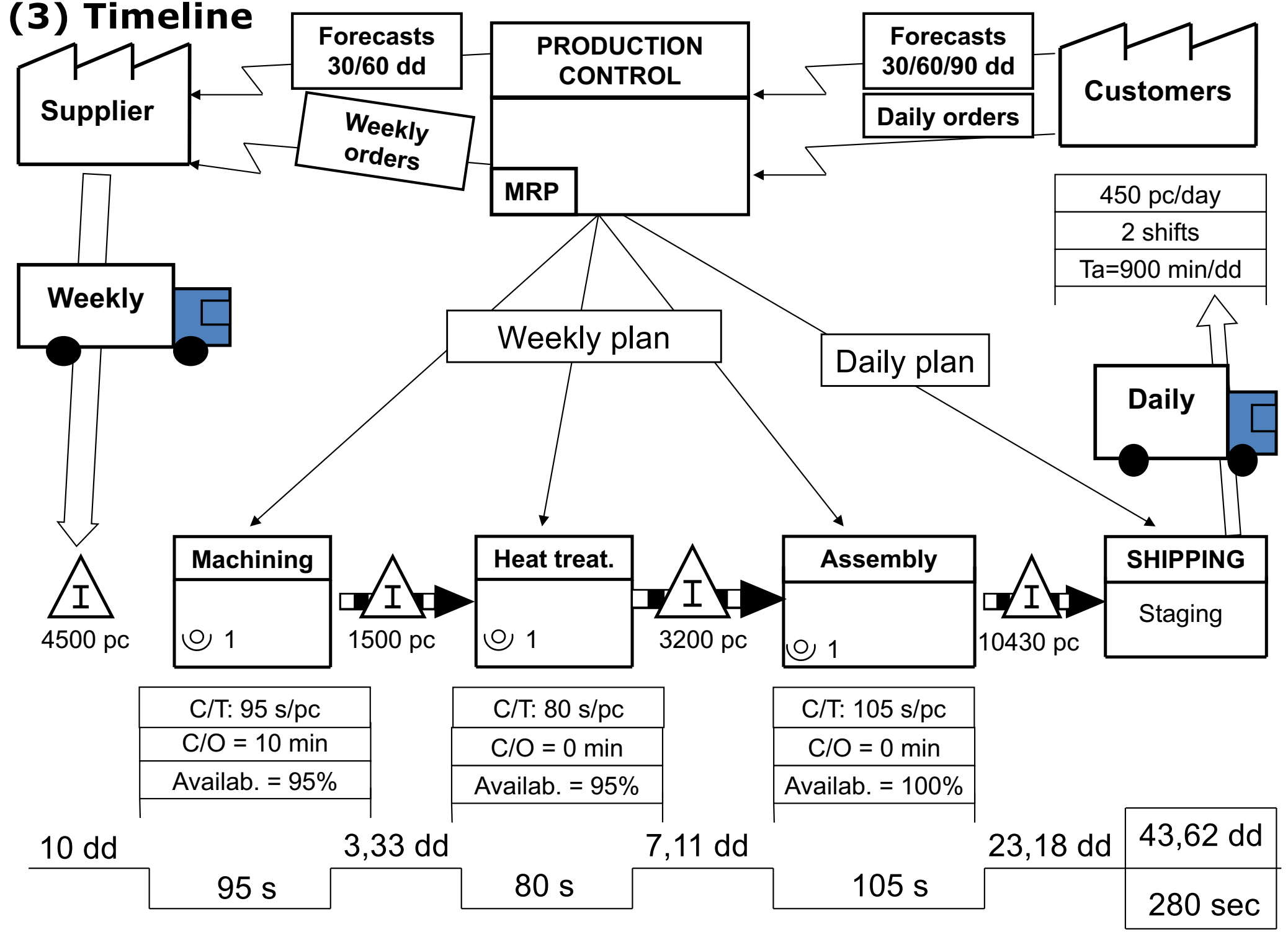
(1) Materials flow



(2) Info flow


Supplier
Forecasts 30/60 dd
Weekly orders
PRODUCTION CONTROL
MRP
Forecasts 30/60/90 dd
Daily orders
Customers
450 pc/day
2 shifts
Ta=900 min/dd
Weekly
Weekly plan
Daily plan
Daily
I
4500 pc
Machining
1
C/T: 95 s/pc
C/O = 10 min
Availab. = 95%
1500 pc
Heat treat.
1
C/T: 80 s/pc
C/O = 0 min
Availab. = 95%
3200 pc
Assembly
1
C/T: 105 s/pc
C/O = 0 min
Availab. = 100%
10430 pc
SHIPPING
Staging

(3) Timeline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4500 pc
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10430 pc
1
1
1
C/T: 95 s/pc
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Availab. = 95%
C/T: 80 s/pc
C/O = 0 min
Availab. = 95%
C/T: 105 s/pc
C/O = 0 min
Availab. = 100%
10 dd
3,33 dd
7,11 dd
23,18 dd
43,62 dd
95 s
80 s
105 s
280 sec

Exercise 1

Q2: The general manager defines as internal target that each stage of the company must be flexible enough to produce all the variants each day. Which improvement should the company implement?

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

$$\mathbf{EPE*Tp + Ts \leq EPE*Ta}$$

Being able to daily supply customers with the whole range -> EPE = 1

The stage that creates rigidity to the system is the **machining**
All other stages have null setup times.

Ta= 900 min/day
Product range= 68 products
Demand= 450 pc/day

Exercise 1

EPE*Tp + Ts ≤ EPE*Ta

1*Tp + Ts ≤ 1*Ta

We need to verify for Machining stage if the equation is valid

i.e. whether Machining stage is able to fully satisfy customers requests in terms of volume and mix.

$$1 * \frac{95 sec/pc}{60 * 95\%} * 450 \frac{\text{pc}}{\text{day}} + 10 \frac{\text{min}}{\text{setups}} * 68 \text{ setups} \leq 900 \frac{min}{day}$$

$$1430 \frac{min}{day} \leq 900 \frac{min}{day}$$ ✗

Hence, according to the current situation the company is not able to fully satisfy customers demand daily.

Exercise 1

We need therefore to improve the system i.e. redefining setup time for Machining so then it is possible to achieve EPE = 1 day

1*Tp + Ts ≤ 1*Ta

$$1 * \frac{95 sec/pc}{60 * 95\%} * 450 \frac{\text{pc}}{\text{day}} + \boldsymbol{x} * 68 \text{ setups} \leq 900 \frac{min}{day}$$

Where $\boldsymbol{x}$ is the setup time

$\boldsymbol{x}$ ≤ 9000/ 4080 = 2,2 minutes

Reducing the setup time by SMED.

Exercise 2

Q1: Draw the company Current State Map of the Company

Q2: In the current situation, which is the EPE of the company to fulfill the requirements of demand (volume and mix)?

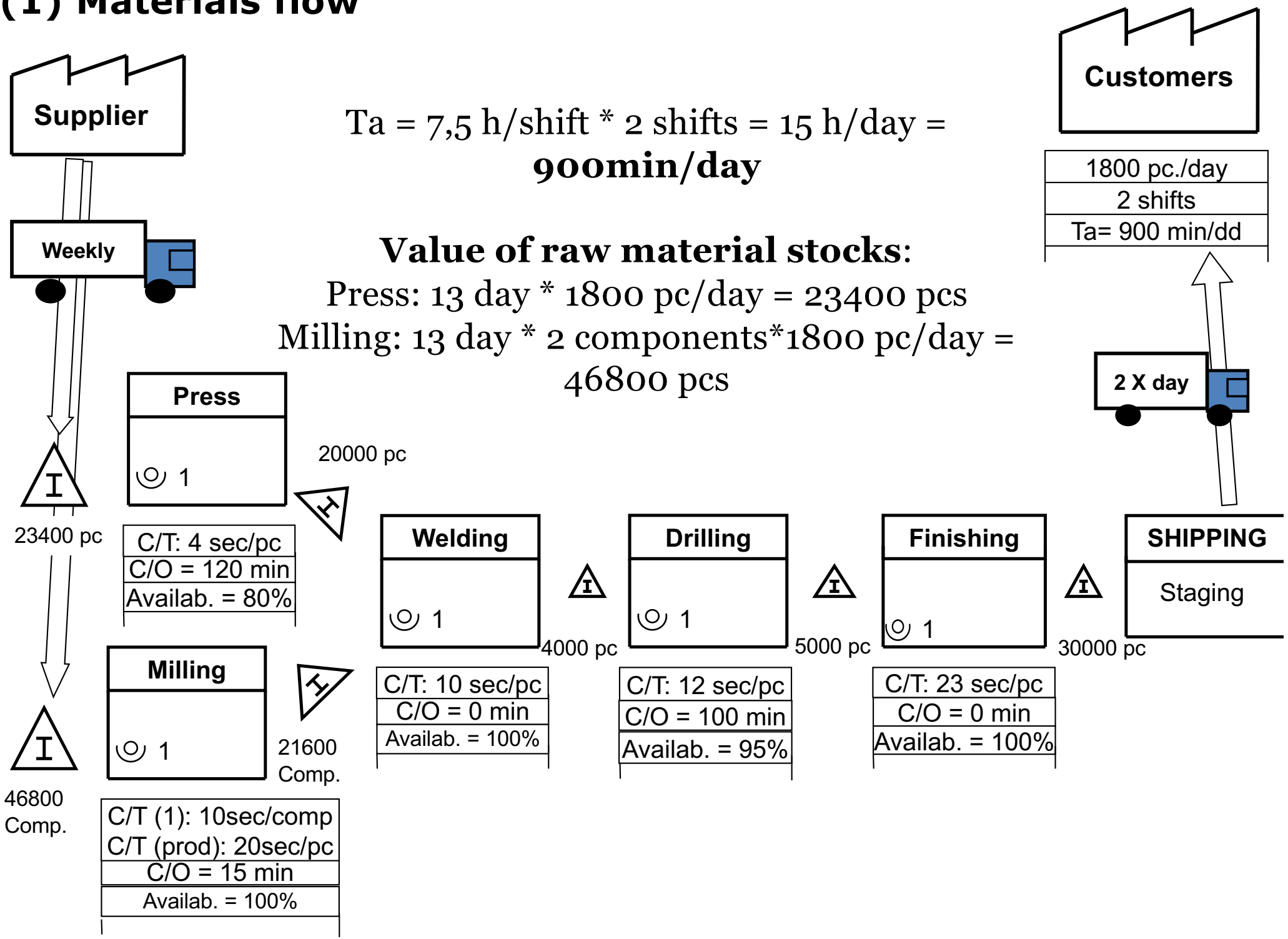
Q3: The new plant manager decided to decrease warehouse costs. After analysing the customer demand she decided to set a maximum stock level of 3600 finished products, and all other buffers/stocks sized with the same EPE. Highlighting all suggested improvements in order to ensure the target achievement.

Exercise 2

Q1: Draw the company Current State Map of the Company

3 steps:
(1) Material flow
(2) Information flow
(3) Timeline

(1) Materials flow



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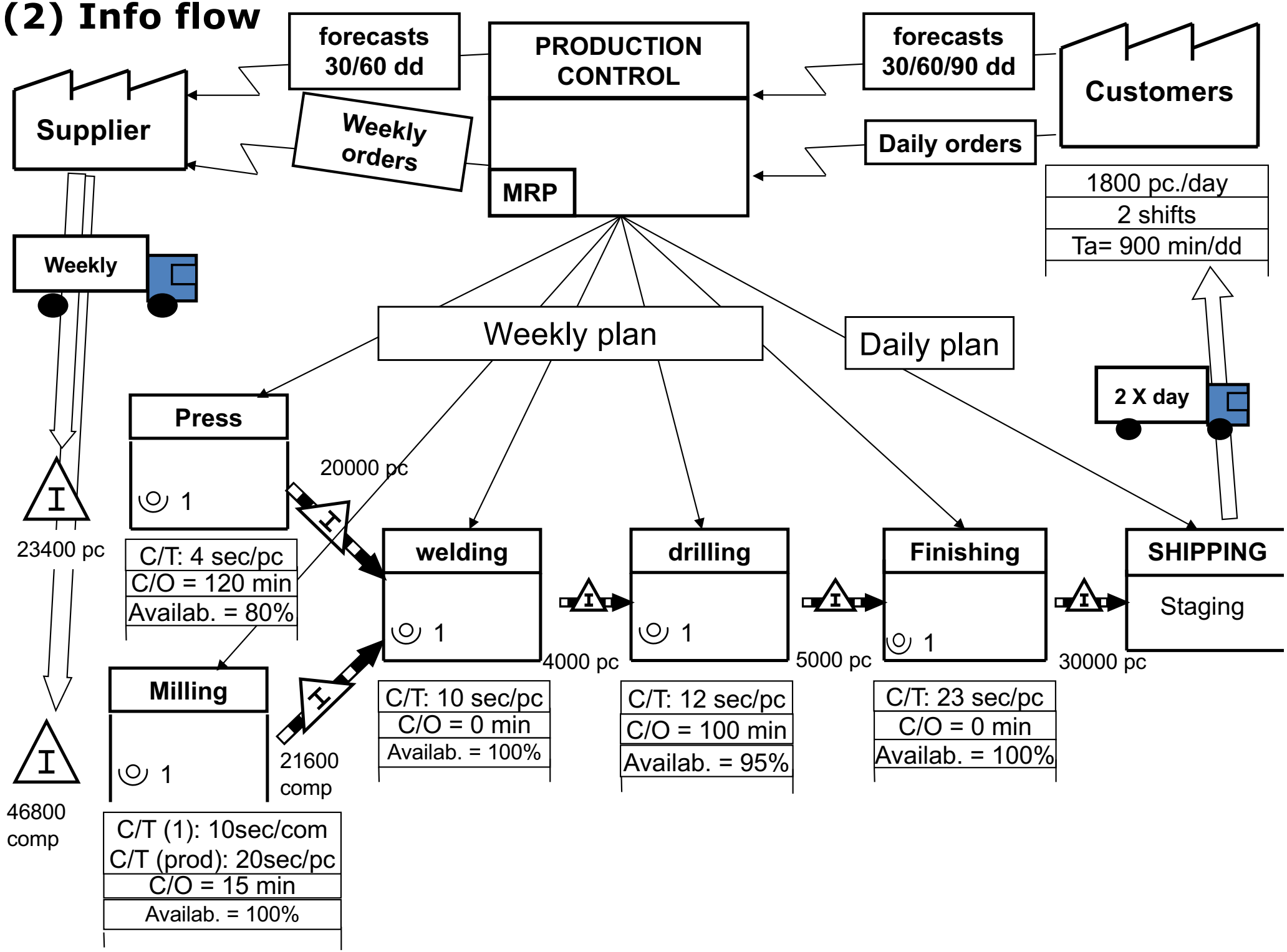
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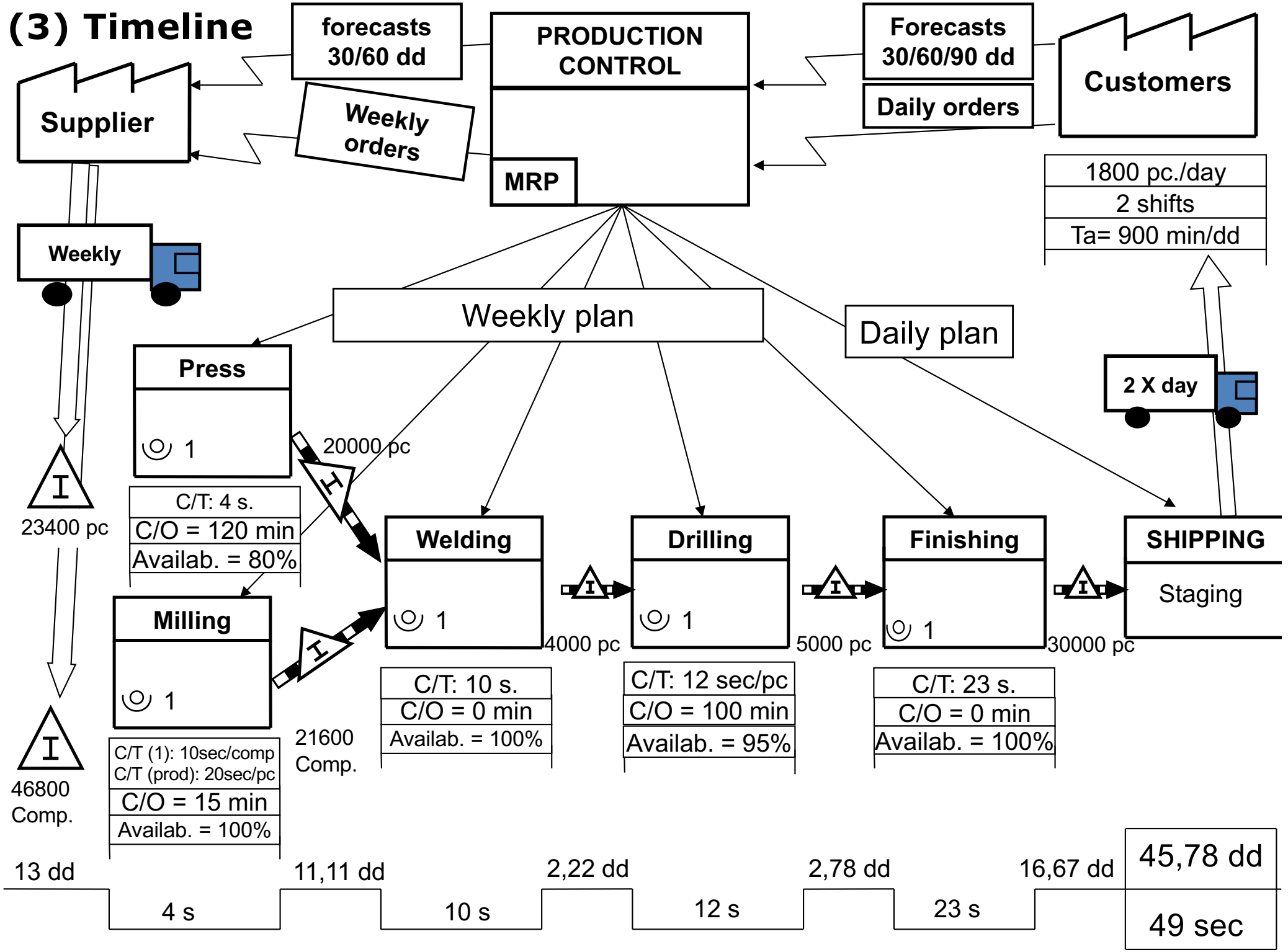
Customers
Supplier
Weekly orders
Daily orders
MRP
1800 pc./day
2 shifts
Ta= 900 min/dd
Weekly
Weekly plan
Daily plan
2 X day
Press
1
20000 pc
23400 pc
C/T: 4 sec/pc
C/O = 120 min
Availab. = 80%
welding
1
drilling
1
Finishing
1
SHIPPING
Staging
4000 pc
5000 pc
30000 pc
C/T: 10 sec/pc
C/O = 0 min
Availab. = 100%
C/T: 12 sec/pc
C/O = 100 min
Availab. = 95%
C/T: 23 sec/pc
C/O = 0 min
Availab. = 100%
Milling
1
21600 comp
46800 comp
C/T (1): 10sec/com
C/T (prod): 20sec/pc
C/O = 15 min
Availab. = 100%

(3) Timeline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4000 pc
Drilling
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5000 pc
Finishing
1
30000 pc
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Milling
1
21600 Comp.
C/T: 10 s.
C/O = 0 min
Availab. = 100%
C/T: 12 sec/pc
C/O = 100 min
Availab. = 95%
C/T: 23 s.
C/O = 0 min
Availab. = 100%
46800 Comp.
C/T (1): 10sec/comp
C/T (prod): 20sec/pc
C/O = 15 min
Availab. = 100%
13 dd
4 s
11,11 dd
10 s
2,22 dd
12 s
2,78 dd
23 s
16,67 dd
45,78 dd
49 sec

Exercise 2

Q2: In the current situation, which is the EPE of the company to fulfill the requirements of demand (volume and mix)?

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

$$\mathbf{EPE*Tp + Ts \leq EPE*Ta}$$

$$EPE \geq \frac{Ts}{Ta - Tp}$$

What is the EPE for the company?

It's necessary to calculate the time, in days, necessary to restore the product range, under the constraint of available times and the demand required by the customer.

Exercise 2

Press

$4/0{,}8*1800*X + 6*120*60 \leq 900*0{,}6*60*X$

$X \geq 43200/23400 =$ **1,85 dd**

Milling

$(10)*2*1800*X + 6*15*60 \leq 900*0{,}7*60*X$

$X \geq$ **3 days**

Drilling

$12/0.95*1800*X + 6*100*60 \leq 900*60*X$

$X \geq$ **1.15 days**

Welding and Finishing have C/O null.

COMPANY'S EPE = 3 DAYS

Exercise 2

Q3: The new plant manager decided to decrease warehouse costs. Therefore, the maximum size allowed for any stocks or buffer is 2700pc. Draw the Future State of the company, highlighting all suggested improvements in order to ensure the target achievement.

Buffer size = 1,5 * EPE^{Target} * D = 2700pc

$\boldsymbol{EPE^{Target}}$ **= 2700pc / (1,5*D) = 1 day**

Exercise 2

The Future State Map is built by answering 8 key questions:

1. What is the **takt time** of the production family?
2. The company needs to build the product for a finished products **supermarket** or **directly for shipment** to the customer?
3. Where to **put the flow**?
4. Where to enable a **pull supermarket**?
5. What only point in the production chain (the **pacemaker** process) does the company have to plan?
6. How should the company **level the production** mix at pacemaker process?
7. What should be the **increase of work** to be released to the pacemaker process?
8. What **improvements** to the process will be required to get the Value Stream flow described by the Future State?

Exercise 2

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

Time Available for production (Ta)= Time plant opening– Scheduled stops
Customer request = customer demand (d)

$$\text{Takt time (TT)} = \frac{\text{Ta}}{\text{d}}$$

Ta = 900min/day
D = 1800 pc/day

TT= 900 min/day/1800 pc/day = 30 sec/pc

Exercise 2

2. Produce for supermarkets or for shipping?

How to organise the production?

Some drivers:

- Delivery time to the customer
- Product features (good value, obsolescence level, standardization level of the product)
- Demand predictability
- Demand stability
- .....

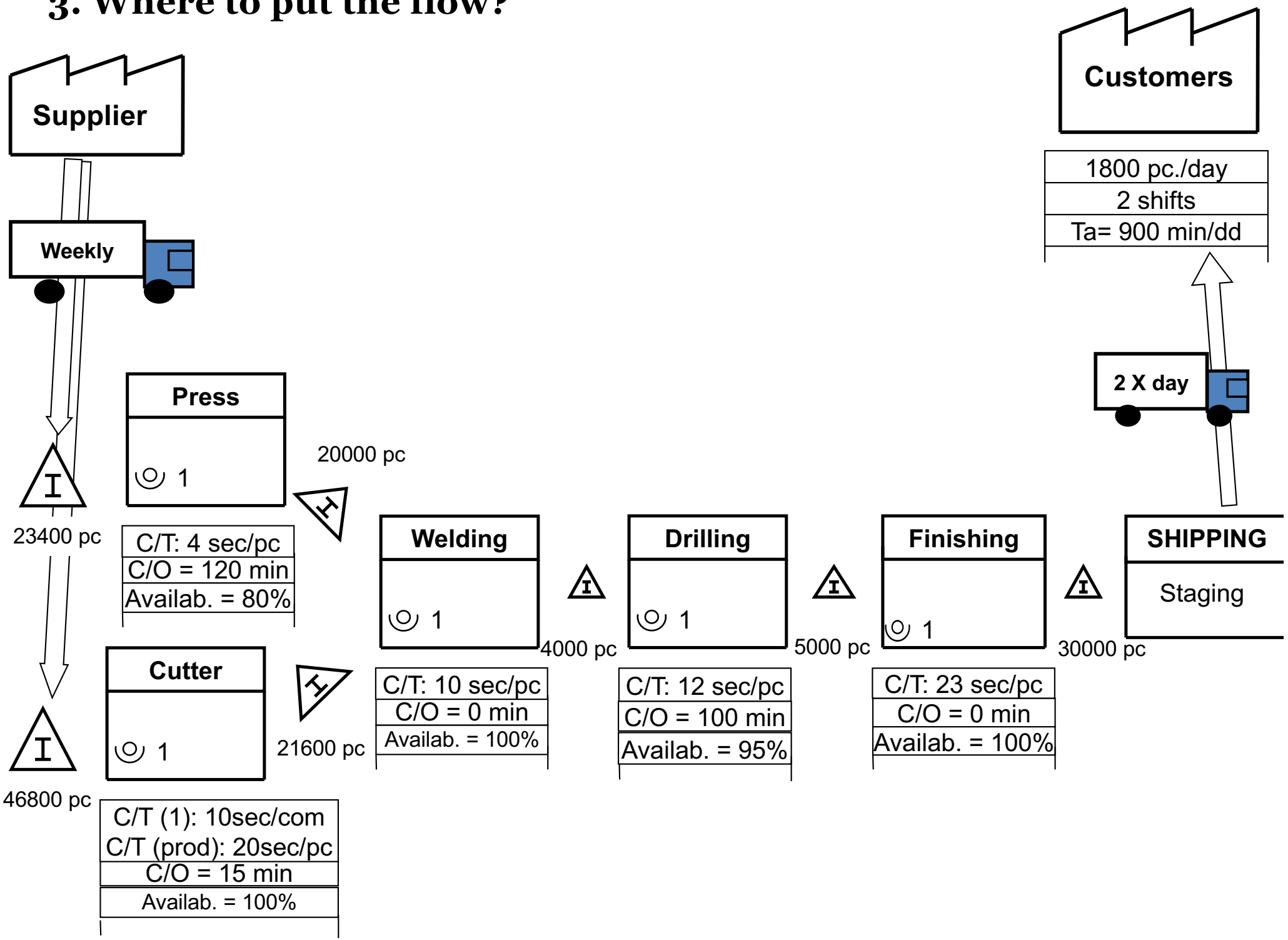
We can become faster enough to have next day delivery, but finished goods inventories are in this case mostly for absorbing customer demand

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**.
- Set intermediate targets (not necessarily all at once in a continuous flow, but also FIFO and supermarket).

3. Where to put the flow?

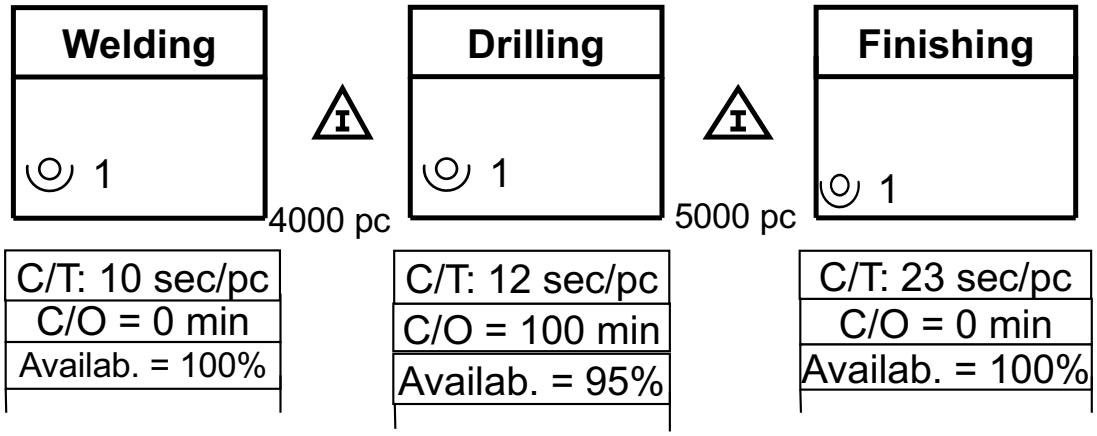


Exercise 2

3. Where to put the flow?

DeCAF condition

- Dedicated
- Capable
- Available
- Flexible



Exercise 2

3. Where to put the flow?

You can create a cell for welding, drilling, assembly.

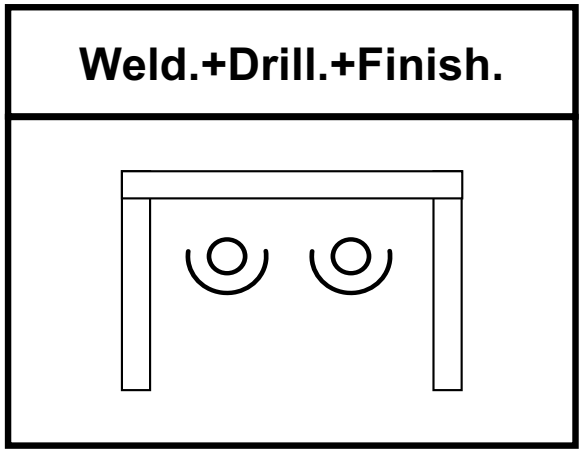
What actions are needed?

Create a cell means to bring machines closer and remove the decoupling stocks.

- How many **operators** are needed at the cell?
- What is the **cell cycle time**?
- What is the **cell Availability**?
- What is the **cell setup time**?

Exercise 2

3. Where to put the flow?



C/T= 23 sec/pc
C/O= 100 min
A = 95%
2 Operators

WCT=(10+12+23)sec = 45 sec

#operators=$\left\lceil \frac{WCT}{TT1} \right\rceil = \left\lceil \frac{45}{30} \right\rceil = \lceil 1{,}5 \rceil =$ **2 operators**

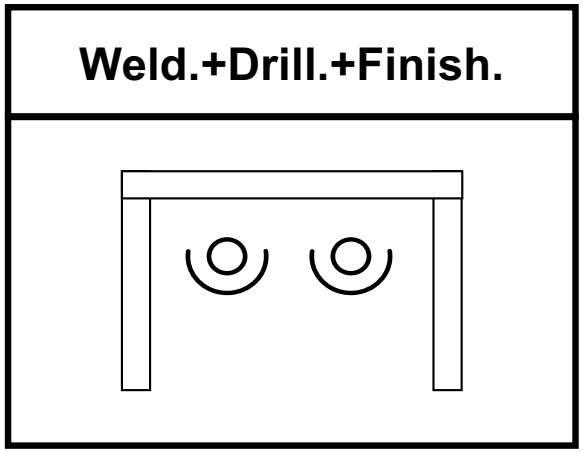
We can save one operator

Rebalance of work: first operators works on 2 machines for welding and drilling, the second on the finishing machine

(1) Workload of first operator: 22s
(2) Workload of second operator: 23 s.

Exercise 2

3. Where to put the flow?



C/T= 23 sec/pc
C/O= 100 min
A = 95%
2 Operators

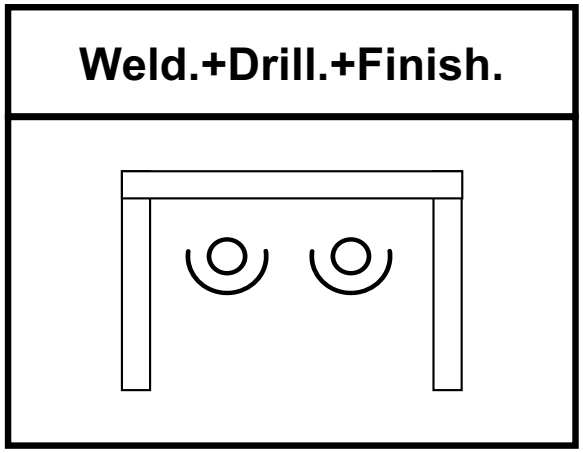
- **Dedicated:** yes
- **Capable:** CT<TT
  23 sec < 30 sec
  yes
- **Available**: CT/A < TT
  23 sec/0,95 < 30 sec
  yes
- **Flexible**

Which is the cell EPE?

$$\boldsymbol{EPE} \geq \frac{\boldsymbol{Ts}}{\boldsymbol{Ta} - \boldsymbol{Tp}} = \frac{6 * 100 * 60}{900min * 60 - \frac{23}{0{,}95} * 1800} = \mathbf{3{,}45\ days}$$

Exercise 2

3. Where to put the flow?



C/T= 23 sec/pc
C/O= 28.94 min
A = 95%
2 Operators

Improvement: EPE^{Target} **= 1 day**

EPE*Tp + Ts ≤ EPE*Ta

1*Tp + Ts ≤ 1*Ta

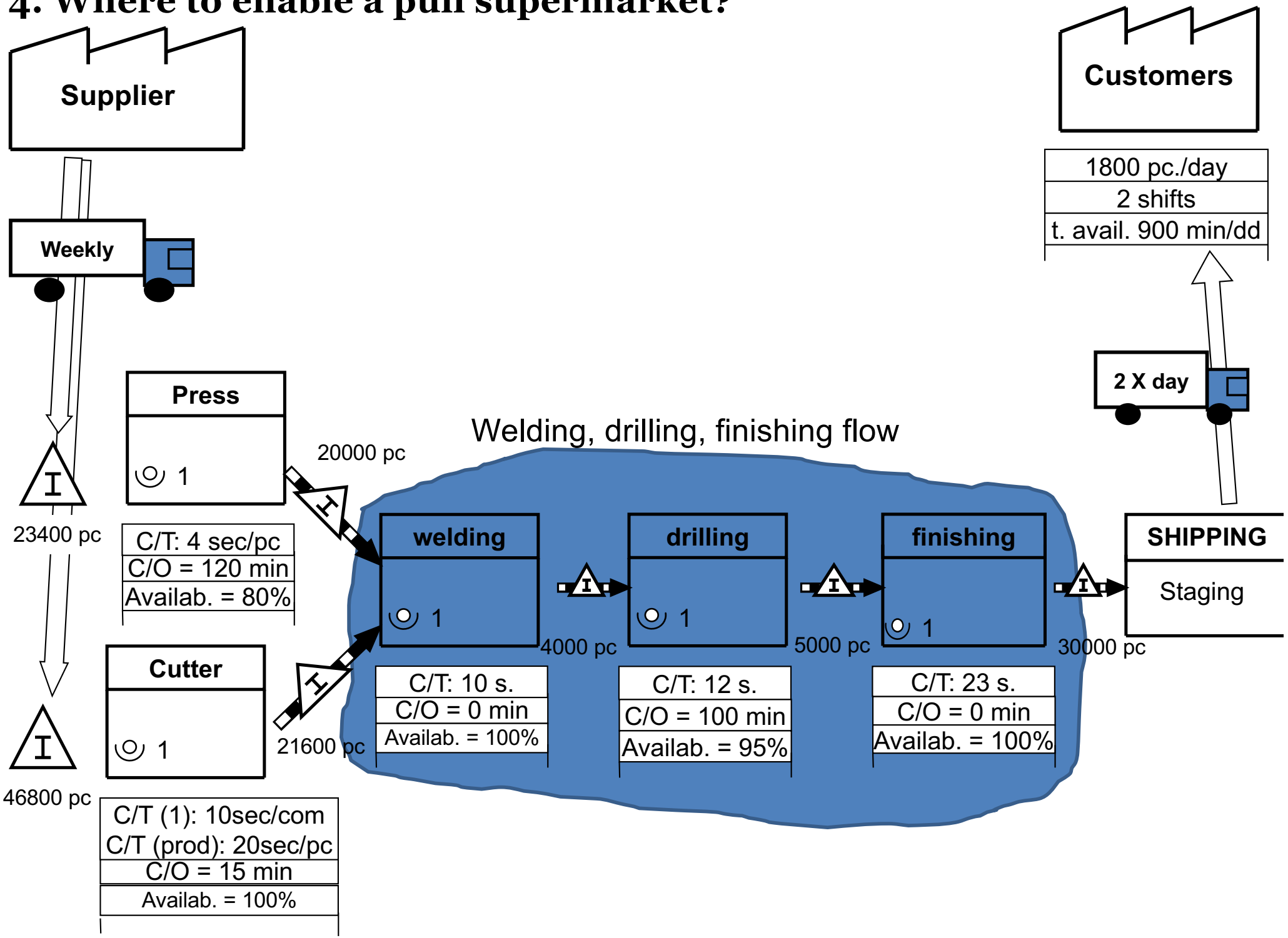
$1*\ (23sec/pc)/95\%*1800$ pc/day+$\boldsymbol{x}*6$ setups*60 ≤900 min/day*60

Where $\boldsymbol{x}$ is the setup time

$\boldsymbol{x}$ **≤ 28,94 min/setups**

Reducing the setup time using SMED.

4. Where to enable a pull supermarket?



Exercise 2

4. Where to enable a pull supermarket?

- High production batches
- Low machinary reliability
- Shared resource.....

Press stage

Cutter stage

Starting from the initial situation of stage rigidity, identify a first initial goal of improvement (EPE reduction)

Then proceed to subsequent improvements

Exercise 2

4. Where to enable a pull supermarket?

Press stage (initial minimum EPE = 1.85 days)

First improvement goal: $\boldsymbol{EPE^{Target} = 1\ day}$
Calculate the first reduction target of the setup time

EPE*Tp + Ts ≤ EPE*Ta

1*Tp + Ts ≤ 1*Ta

$$1 * \frac{4sec/pc}{80\%} * 1800\frac{\text{pc}}{\text{day}} + \boldsymbol{x} * 6\ \text{setups} \leq 900\frac{min}{day} * 60 * \mathbf{60}\%$$

Where $\boldsymbol{x}$ is the setup time

$\boldsymbol{x \leq 65\ min/setup}$

Exercise 2

4. Where to enable a pull supermarket?

Cutter stage (initial minimum EPE = 3 days)

First improvement goal: $\boldsymbol{EPE^{Target} = 1\ day}$
Calculate the first reduction target of the setup time

EPE*Tp + Ts ≤ EPE*Ta

1*Tp + Ts ≤ 1*Ta

$$1 * \frac{10 sec/pc}{100\%} * 1800 \frac{\text{pc}}{\text{day}} * 2\ \frac{comp}{pc} + \boldsymbol{x} * 6\ \text{setups} \leq 900 \frac{min}{day} * 60 * \mathbf{70}\%$$

Where $\boldsymbol{x}$ is the setup time

$\boldsymbol{x \leq 5\ min/setup}$

Exercise 2

4. Where to enable a pull supermarket?

Size of internal supermarkets downstream Press= 2700 pc
Size of internal supermarket downstream Cutter = 2700pc * 2= 5400 pc

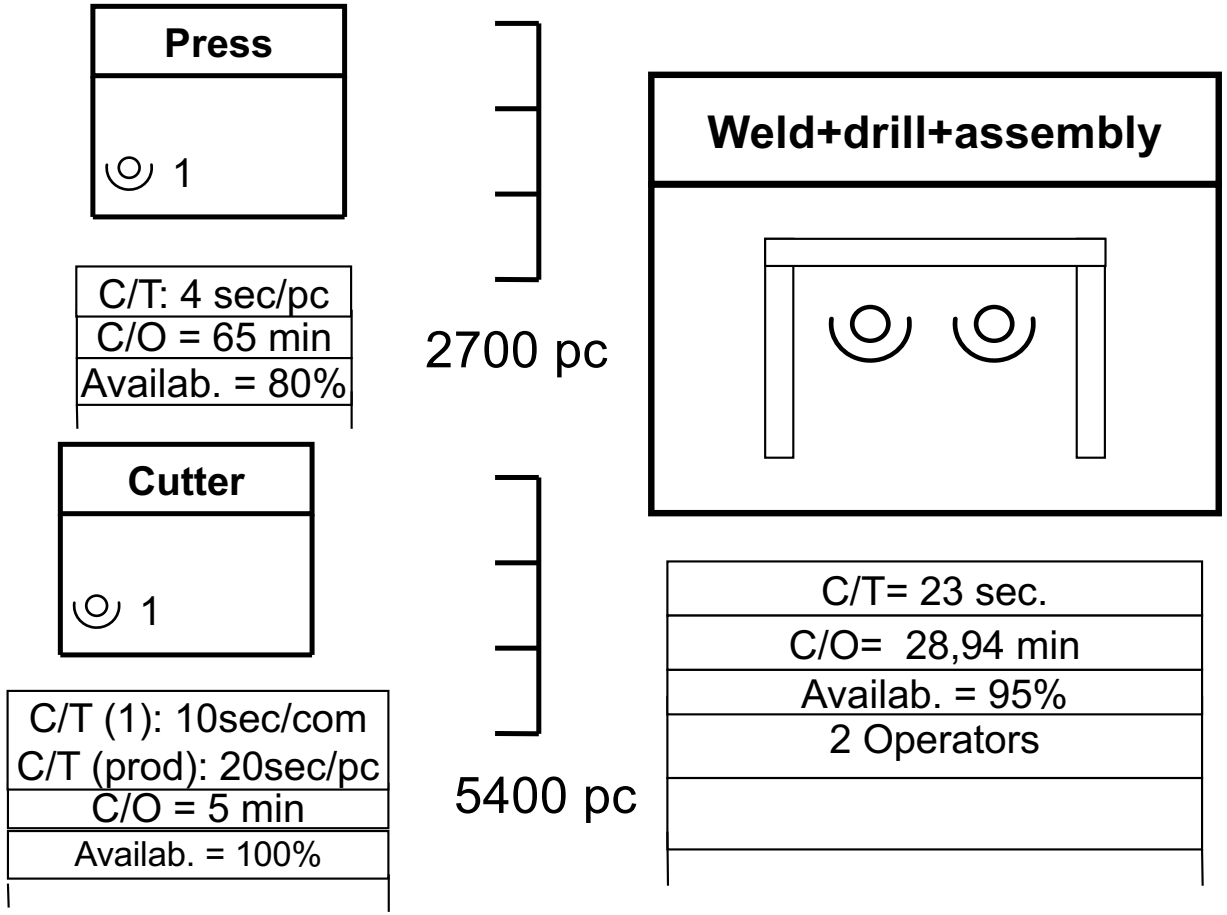
Size of <u>external</u> supermarket = 2* EPE^{Target}*D = 3600 pc

Size of raw material supermarket = 2* D * $EPE^{Supplier}$

Size of raw material (Press) = 2*1800***5** = 18000 pc
Size of raw material (Cutter) = 2*1800***5** *2= 36000 pc

Exercise 2

4. Where to enable a pull supermarket?



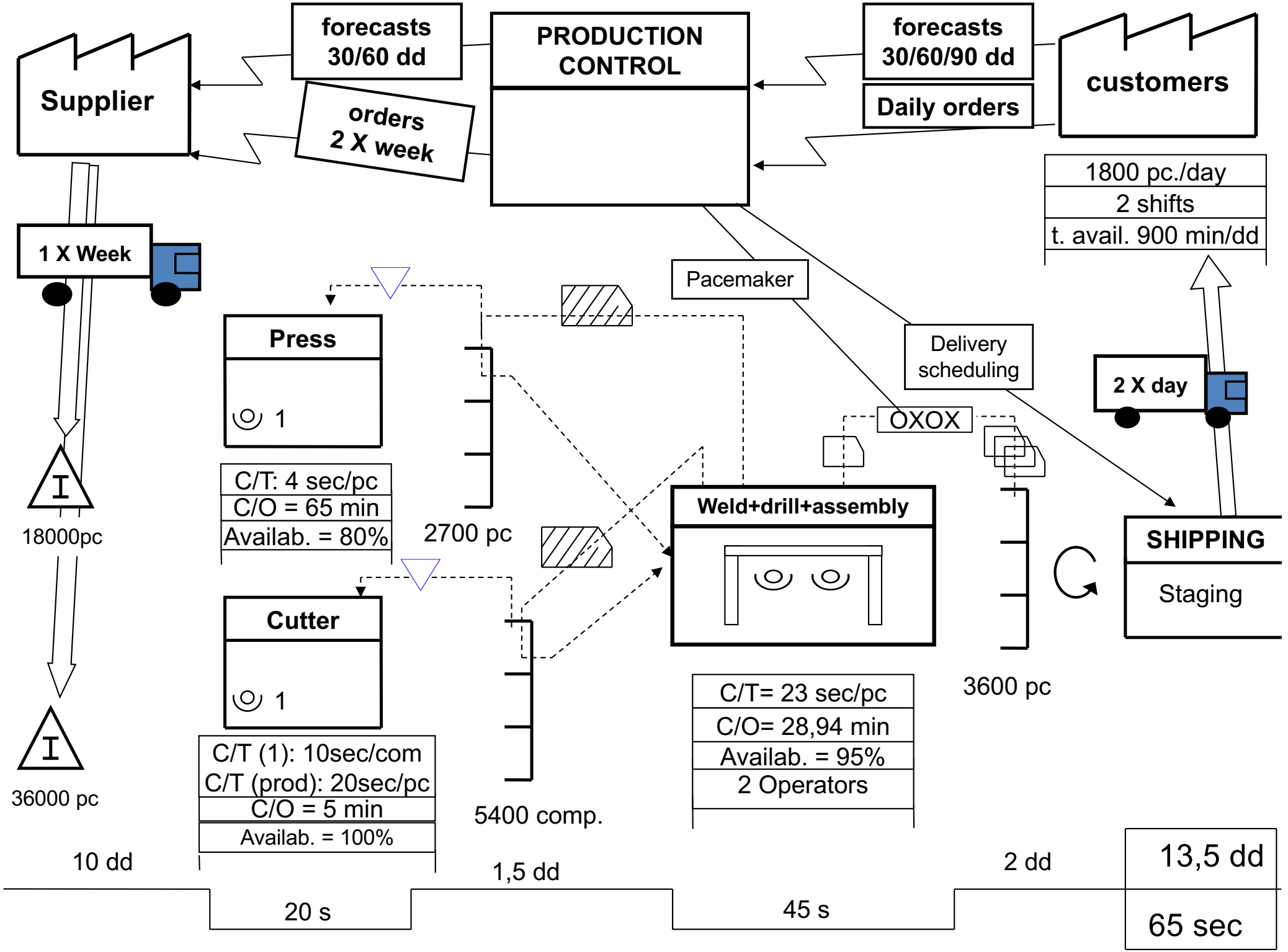
Exercise 2

5. Where is the company single scheduling point?

Pacemaker is the cell

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

Kanban System
According to shipments that are made, the finished goods warehouse sends upstream the Kanban to a levelling box, where volume and mix are levelled and Kanban are sent to the cell in a paced way.


Supplier
forecasts 30/60 dd
orders 2 X week
PRODUCTION CONTROL
forecasts 30/60/90 dd
Daily orders
customers
1800 pc./day
2 shifts
t. avail. 900 min/dd
1 X Week
Pacemaker
Delivery scheduling
2 X day
Press
1
C/T: 4 sec/pc
C/O = 65 min
Availab. = 80%
2700 pc
OXOX
Weld+drill+assembly
SHIPPING
Staging
18000pc
Cutter
1
C/T (1): 10sec/com
C/T (prod): 20sec/pc
C/O = 5 min
Availab. = 100%
5400 comp.
C/T= 23 sec/pc
C/O= 28,94 min
Availab. = 95%
2 Operators
3600 pc
36000 pc
10 dd
1,5 dd
2 dd
13,5 dd
20 s
45 s
65 sec

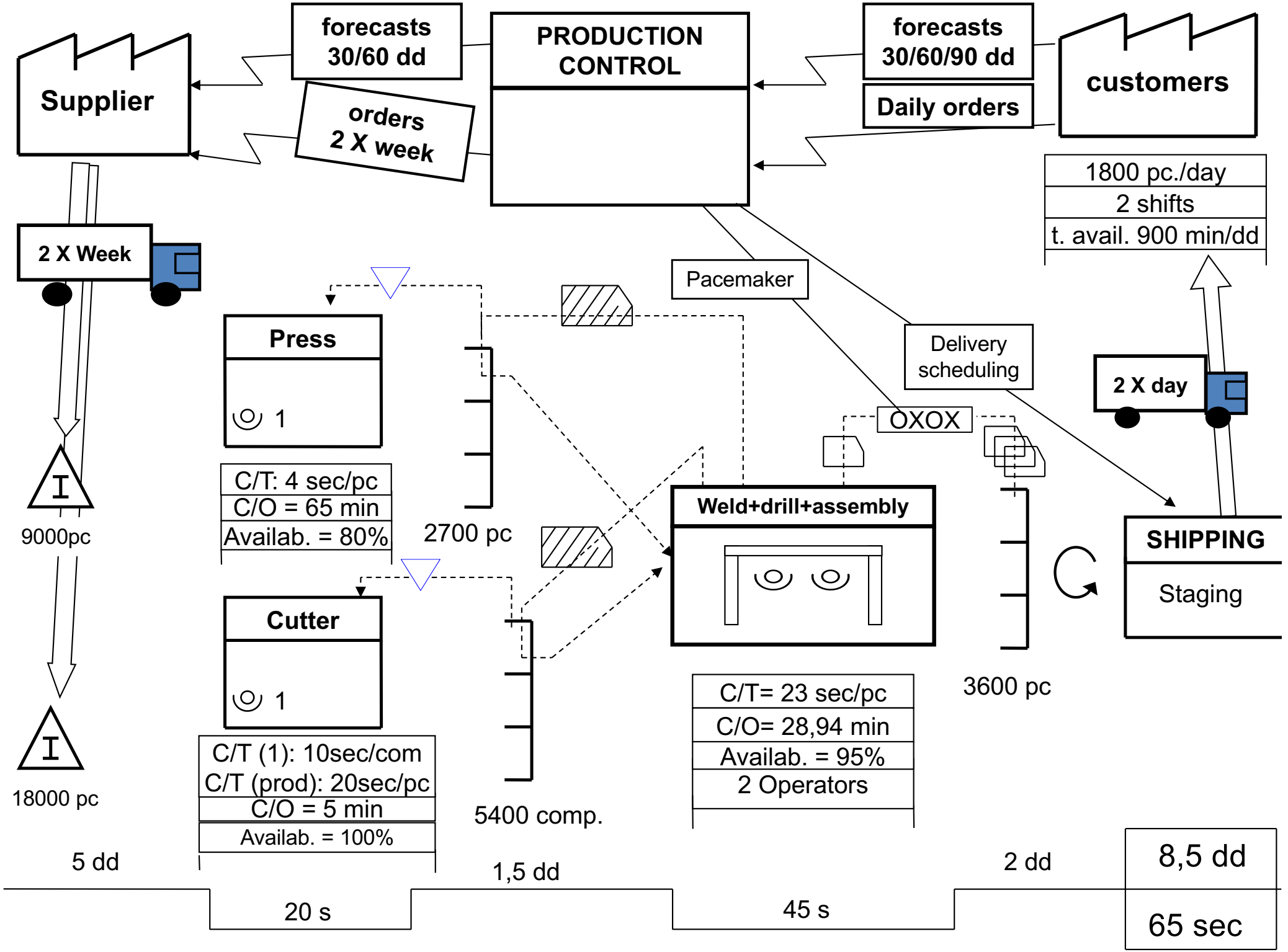
Exercise 2

External relationships

Further improvement can be achieved with more frequent delivery from the supplier. For example twice a week, exploiting the fact that he is delivering to our companies other days of the week for other families of products
If we achieve 2 deliveries/week

Size of raw material supermarket = 2* D * $EPE^{Supplier}$

Size of raw material (Press) = 2*1800***2,5** = 9000 pc
Size of raw material (Cutter) = 2*1800***2,5** *2= 18000 pc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2 X day
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C/O = 65 min
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Weld+drill+assembly
SHIPPING
Staging
9000pc
Cutter
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C/T (1): 10sec/com
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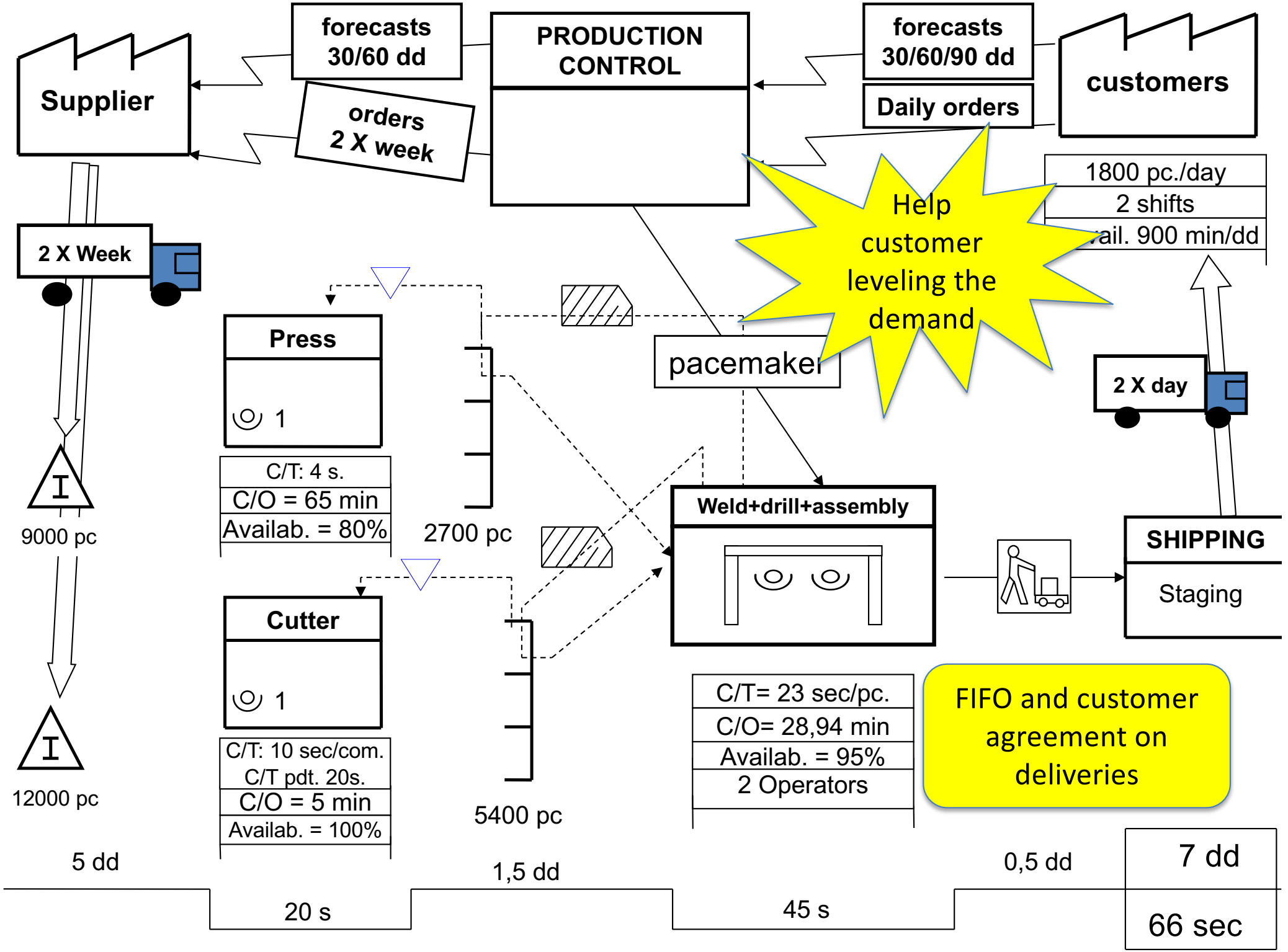
C/O = 5 min
Availab. = 100%
5400 comp.
C/T= 23 sec/pc
C/O= 28,94 min
Availab. = 95%
2 Operators
3600 pc
18000 pc
5 dd
1,5 dd
2 dd
8,5 dd
20 s
45 s
65 sec

Exercise 2

Results comparison

	Current State	Future State	Variation
NVA time	45,78 dd.	8,5 dd. (supermarket)	-77%
#operators	5	4	- 20%


Supplier
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orders 2 X week
PRODUCTION CONTROL
forecasts 30/60/90 dd
Daily orders
customers
1800 pc./day
2 shifts
Avail. 900 min/dd
Help customer leveling the demand
2 X Week
9000 pc
12000 pc
Press
1
C/T: 4 s.
C/O = 65 min
Availab. = 80%
2700 pc
pacemaker
2 X day
Weld+drill+assembly
SHIPPING
Staging
Cutter
1
C/T: 10 sec/com.
C/T pdt. 20s.
C/O = 5 min
Availab. = 100%
5400 pc
C/T= 23 sec/pc.
C/O= 28,94 min
Availab. = 95%
2 Operators
FIFO and customer agreement on deliveries
5 dd
20 s
1,5 dd
45 s
0,5 dd
7 dd
66 sec

POLITECNICO
MILANO 1863