Lean Manufacturing - VSM2 - Solution support

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Exercise 1

* 20 – 10 cells working in parallel

Overall Demand

50 tractors:
- 25 tractors F1
- 25 tractors F2

Work content

- 160min/F1
- 140min/F2

C/O

- F1 to F1 = 10 min
- F1 to F2 (or F2 to F1) = 60 min
- F2 to F2 = 15 min

Exercise 1

Q1: In the current situation, can the company be sure of reaching the requested daily production without overtime?

Q2: During the last production meeting, plant director reported that there is tension and dissatisfaction within production plant. Indeed, assemblers are complaining that different stations are not well-balanced in their work content. Moreover, logistic operators are having difficulties in handling and in properly feeding (there are issues of mission components) materials to different station. Therefore, the management set the goal to improve efficiency. How will you reconfigure the production?

Exercise 1

Q1: In the current situation, can the company be sure of reaching the requested daily production without overtime?

For each cell: **Tp + Ts ≤ Ta**

Ta =7,5 h * 60 min./h * 2 operators = **900 min/day**

Demand for each cell = Overall demand/#cells = 50/10 = 5tractors per day
Tp = worst case = 3F1 + 2F2 = **760 min**
Ts = 2F1 + F1F2 + 2F2 = 2*10min + 60min + 2*15min = **110 min**

870 min/day ≤ 900 min/day
Company does not need overtime

Exercise 1

Q1: In the current situation, can the company be sure of reaching the requested daily production without overtime?

An alternative method consists in using the Work Pace
For each operator: **Tp + Ts ≤ Ta**

C/T if workload is perfectly balanced between operators:

C/T = WKC / #operators

C/O if workload is perfectly balanced between operators:

C/O = Ts/#operators

380 min/day + 55min/day ≤450 min/day
Company doesn't need overtime

Exercise 1

Q2: During the last production meeting, plant director reported that there is tension and dissatisfaction within production plant. Indeed, assemblers are complaining that different stations are not well-balanced in their work content. Moreover, logistic operators are having difficulties in handling and in properly feeding (there are issues of mission components) materials to different station. Therefore, the management set the goal to improve efficiency. How will you reconfigure the production?

Exercise 1

We have to improve the performances of each stages → it's as we are focusing on step 3 of future state creation

I can create/dedicate lines for the two product families.

Pros:

1. I decrease the C/O because I no longer have to change from one family to the other.
2. I can exploit specialization: increased efficiency and reduced costs.

Cons

1. The change in mix becomes very critical because it could create unbalance. You must also take into account demand variability.

In this case we can separate the two lines because the demand is constant.

Exercise 1

Takt time

TT (F1) = 450 minutes / 25 units = 18 min/u
TT (F2) = 450 minutes / 25 units = 18 min/u

Produce for supermarkets or for shipping?

First step: Verify the characteristics of the product and the market

- Cumbersome product
- Product of infinite range
- Product to order
- Constant volume of demand

HERE WE WANT TO PRODUCE FOR **SHIPPING** (MTO)
Therefore: 25F1 per day + 25F2 per day → each line has a target of 25 setups per day

Exercise 1

Creation of a continous flow

- How to create the continous flow?
- How **many resources** are needed and how to allocate them to the various product families?
- What actions are needed? To what extent will these **interventions** be?

Exercise 1

Family 1– Flow creation

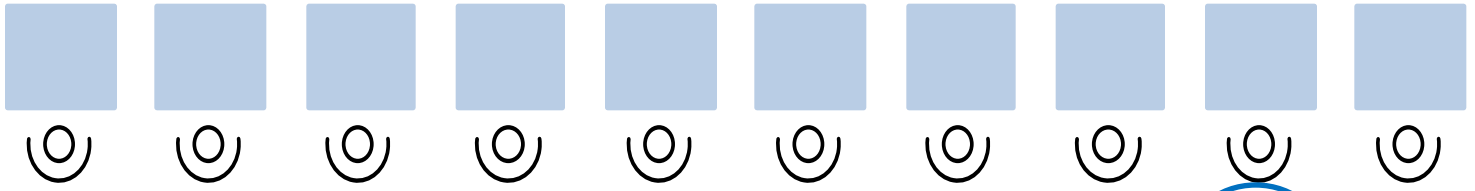
TT (F1)= 18 min/u

WKC= 160 minutes (to be divided between the different stations)
CO= 10 minutes workload for each production change (to be divided between the different stations)

Since the setup time is not null, it is not possible to allocate a workload equal to the takt time

Exercise 1

Family 1– Flow creation



Allocated time	18	18	18	18	18	18	18	18	16	
Cumulated	18	36	54	72	90	108	126	144	160	

1 Resource is no longer required → increase in Productivity

The last station results to be less loaded. In case of further improvements, it may be possible to move the resource to other value-added activities. Unfortunately, until then we can only re-balance the load to save more time for setup.

Exercise 1

Family 1– Flow creation

Needed interventions:

- #operators= 9
- WKC: 160 min/u
- C/T= 160/9 = 17,78 minutes/u
- C/O= 10 minutes (setup work content) – to see if compatible with given objectives and constraints;
- Daily demand: 25 tractors F1
- 25 setups per day

Exercise 1

Family 1– Flow creation

DeCAF condition
- Dedicated
- Capable
- Available
- Flexible

- **Dedicated:** yes

- **Capable:** CT<TT
  17,78 min/u < 18 min/u
  yes

- **Available**: CT/A < TT
  17,78 min/u / 100% < 18 min/u
  yes

Exercise 1

Family 1– Flow creation

- **Flexible**

Target is to carry out **25 setups per day.**

(17,78min/u)*25 u/day+x*25 setups ≤450 min/day
Where x is the setup time
x ≤ 0,22 min/setups

Reducing the setup time by SMED.

It means that 0.22 min is the maximum time of C/O that a station may have.
If we bring the setup time to less than 0.22 minutes we can work in a flow with 9 resources on family 1 line. It means that if the setup load is perfectly balanced on operators (10min/9 op. = 1.1 min/op) from 1,1 min should reach 0.22 min.

Exercise 1

Family 2– Flow creation

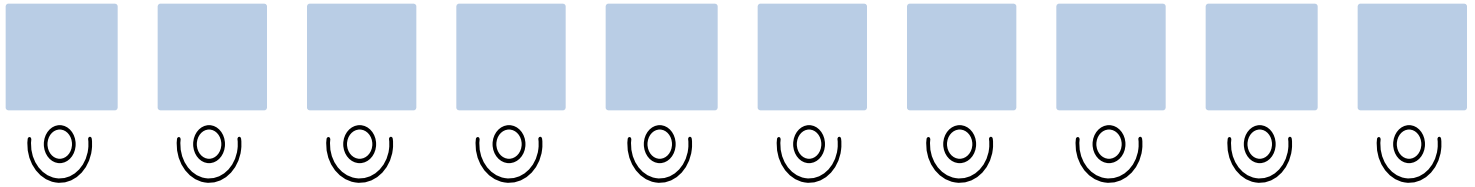
TT (F2)= 18 min/u

WKC= 140 minutes (to be divided between the different stations)
CO= 15 minutes workload for each production change (to be divided between the different stations)

Since the setup time is not null, it is not possible to allocate a workload equal to the takt time

Exercise 1

Family 2– Flow creation



Allocate time	18	18	18	18	18	18	18	14		
Cumulated	18	36	54	72	90	108	126	140		

2 Resources are no longer required → increase in Productivity

Exercise 1

Family 2– Flow creation

Needed interventions:

- #operators= 8
- WKC: 140 min/u
- C/T= 140/8 = 17,5 minutes/u
- C/O= 15 minutes (setup work content) – to see if compatible with given objectives and constraints;
- Daily demand: 25 tractors F2
- 25 setups per day

Exercise 1

Family 2– Flow creation

DeCAF condition
- Dedicated
- Capable
- Available
- Flexible

- **Dedicated:** yes

- **Capable:** CT<TT
  17,5 min/u < 18 min/u
  yes

- **Available**: CT/A < TT
  17,5 min/u / 100% < 18 min/u
  yes

Exercise 1

Family 2– Flow creation

- **Flexible**

Target is to carry out **25 setups per day.**

(17,5min/u)*25 u/day+x*25 setups ≤450 min/day
Where x is the setup time
x ≤ 0,5 min/setups

Reducing the setup time by SMED.

It means that 0.5 min is the maximum time of C/O that a station may have

If we take the setup time to less than 0.5 min, we can work in a flow with 8 resources in family 2 assembly line.

Exercise 1

In case we were able to bring the change-over times of the two lines below the defined maximum time:

- Material handling simplifies (shift to one point for each line) … Maybe one handler can also be enough.
- The space required in the factory would be reduced (less space for buffers).
- The planning and control of production and coordination activities will drastically simplify, as well as the work of operators (free time to resources, increase labor productivity).
- Productivity improves.

Exercise 1

5. Where is the company single scheduling point?

The company schedules only one station per line (first stage of transformation).

Exercise 2

Q1: In the initial situation described in the text, calculate the EPE for standard parts for each stage and the minimum batching for standard units so that the company can produce every day 15 special units in unitary batches on stages 2, 3 and 4.

Q2: The company is willing to implement Lean techniques in order to improve the production process, keeping the same approach of make to stock for standard products and make to order to special ones.

Support the company in drawing its future state, highlighting information and material flows. In sizing the improvements, you must ensure the company the ability to both deliver 15 special parts every day in unitary batch and have an EPE for standard products at maximum to 4 days in each stage.

Q3: How long does special order take to be delivered to the customer?

Exercise 2

Initial configuration

	Stage 1	Stage 2	Stage 3	Stage 4
Standard parts cycle time (min)	5	7	7	12
Special parts cycle time (min)	7	8	11	10
Setup time (min)	25	5	10	5
Availability	90%	85%	95%	90%
Dedicated	75%	100%	100%	100%
Number of shifts	2	2	2	3

Ta= 8 hours net per shift

<u>Standard products</u>
D= 85u/day
Variants= 4

<u>Special products</u>
D= 15 u/day
Variants=each one is different

Production stages decoupled by stocks

Exercise 2

Q1: In the initial situation described in the text, calculate the EPE for standard parts for each stage and the minimum batching for standard units so that the company can produce every day 15 special units in unitary batches on stages 2, 3 and 4.

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

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

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

Exercise 2

Stage 1

On the first stage also the 5 standard components, necessary for the production of special products, can be produced in batches (the 5 variants are produced based on forecast).

Stage 1 EPE needs to take into account:

- Time required to produce **85 standard units** per day in **4** variants
- Time required to produce **15 special products** units per day in **5** variants
- **Setup times** for standard and special products

Ta= 8 h * 2 shifts * 60 min/shift * 75% = **720 minutes**

$$EPE \geq \frac{Ts}{Ta - Tp} = \frac{25\frac{min}{setup} * (4+5)}{720\ min - \frac{(7*15+5*85)}{90\%}} = \mathbf{1{,}716}$$

Exercise 2

Stage 2, 3, 4

- Whenever you change a special product version, a setup is needed.
- Every day for each department must be produced on average 15 special products.
- Special products are produced in unitary batches.
- The time available for the production of standard units is equal to the available time for the stage decreased by the time necessary for the production of special units

  Ta (STD) = Ta – Tp (SPE) - Tsu (SPE)

$$EPE_{STD} \geq \frac{Tsu_{STD}}{(T_a - Tp_{SPE} - Tsu_{SPE}) - Tp_{STD}}$$

Exercise 2

Stage 2, 3, 4

	Stage 2	Stage 3	Stage 4
Available time (shift time*n of shift*%dedicated)	960	960	1440
Special processing time [(C/T spec / A)*D. spec]	141.18	173.68	166.67
Setup time (15 special)	75	150	75
Available time standard products	744	636	1198
EPE (STD) - days	0.45	4	0.31

Exercise 2

Minimum batch size for standard products

$$MBS = \frac{D * EPE}{\#variants}$$

	Stage 1	Stage 2	Stage 3	Stage 4
EPE	1.72	0.45	4	0.31
Average batch size of a standard products	**36.55**	**9.6**	**85**	**6.6**
Average batch size of a special products	5.16	1	1	1

Exercise 2

Q2: The company is willing to implement Lean techniques in order to improve the production process, keeping the same approach of make to stock for standard products and make to order to special ones. Support the company in drawing its future state, highlighting information and material flows. In sizing the improvements, you must ensure the company the ability to both deliver 15 special parts every day in unitary batch and have an EPE for standard products at maximum to 4 days in each stage.

FROM PRESENT STATE

TO FUTURE STATE

THE 8 QUESTIONS

Exercise 2

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

TT (Stage 2-3) = 960 min/ 100 units = 9,60 min/u
TT (Stage 4) = 1440 minutes / 100 units = 14,40 min/u
TT (Stage 1) = 960 min *Dedication/100 = 7,2 min/u

2. Produce for supermarkets or for shipping?

First step: Verify the characteristics of the product and the market

Standard units: few variants (4), very short delivery times, size is not critical, costs, perishability, ecc. They are produced for supermarket.

Special units: many variations, greater time allowed. The aim is to produce for shipping (in the text it says they are already produced for shipping)

Exercise 2

3. Where to put the flow?

General methodology

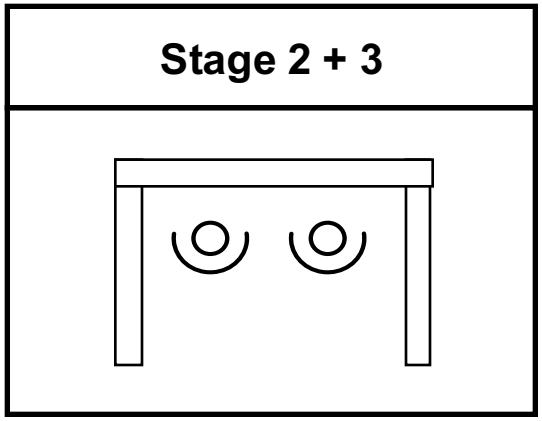
- Start from the **final stage and go upstream** thinking stage by stage where to put CONTINUOUS FLOW and where to decouple (with SUPERMARKET or FIFO).
- Verify **DECAF Conditions**.
- Fix intermediate targets (not necessarily all at once in a continuous flow, but also FIFO and supermarket).

Start from department 4 then move upstream

The department 4 works on 3 shifts, while dep. 3 works on 2 shifts, so it's not possible to introduce the continuous flow. It should be decided between FIFO and SUPERMARKET.

Exercise 2

Stage 2 + 3

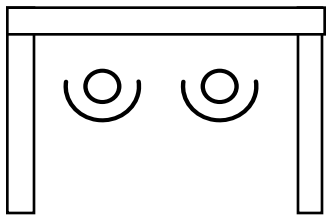


DeCAF condition
Dedicated
Capable
Available
Flexible

- **Dedicated:** yes
- **Capable:** CT<TT
  7,6 min/u < 9,6 min/u
  yes
- **Available**: CT/A < TT
  7,6 min/0,808 < 9,6 min/u
  yes

Exercise 2

Stage 2 + 3

Stage 2 + 3

C/T= (7*85 + 11*15)/100 =7,6 minutes
C/O= 10 min
A= 85%*95%= 80,8%
2 Operators

- **Flexible**

It's requested that the company can deliver 15 special pieces every day in a batch of one and have an EPE for standard products of maximum 4 days

Which is the cell EPE?

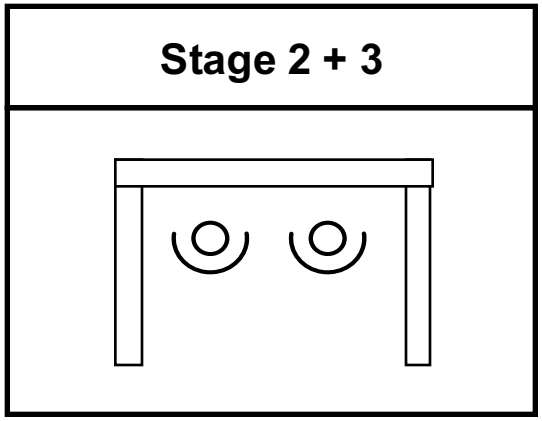
$$\boldsymbol{EPE\ STD} \geq \frac{\boldsymbol{Ts}}{\boldsymbol{Ta\ STD} - \boldsymbol{Tp\ STD}}$$

$$= \frac{10\ min/setup * 4}{\left(960min - 10 * 15 - \frac{11 * 15}{0{,}808}\right) - \frac{7 * 85}{0{,}808}}$$

This way you can not even meet customer demand.

Exercise 2

Stage 2 + 3



C/T= (7*85 + 11*15)/100 =7,6 minutes
C/O= 1,18 min
A= 85%*95%= 80,8%
2 Operators

- **Flexible**

EPE^{Target} **= 4 days**

EPE*Tp + Ts ≤ EPE*Ta

4* (7/80,8%)*85 +x*4 ≤(960 -x*15-(11/80,8%*15))*4

Where x is the average setup time for standard and special

x ≤ 1,18 min/setups

If you can bring the setup time to 1.18 min. then you can couple the two stages (2 + 3) in a continuous flow.

Stage 1 is not dedicated to the product family, so it can not be put into a one piece flow.

Exercise 2

4. Where to put the pull-supermarket?

STD products

For STD products there's a finished good supermarket. Moreover, between dep. 4 and 3, being a supermarket downstream of 4, it is necessary put a supermarket. Finally, there is a supermarket upstream of department 2. The pull supermarket will be inserted upstream of Department 2.

Supermarket sizing = **1,5 *EPE* D_{dd}**

Main rule: EPE to consider when sizing the supermarket is the one of the stage upstream of the same supermarket

SPE products

Stage 2 → Stage 3 OPF (continuous flow in the cell)
Stage 3 → Stage 4 FIFO

Exercise 2

5. Where is the company single scheduling point?

STD products

The only scheduling point is Stage 4, upstream the finished goods supermarket.

SPE production

The only scheduling point is the cell that includes stages 2-3.

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

STD products

According to shipments that are made, the finished goods warehouse sends upstream the kanban, and these are smoothed (with Heijunka) based on volume and mix.

SPE products

You take leveled (volume and mix) from the Pre Shop Pool.

Exercise 2

Q3: How long does special order take to be delivered to the customer?

Delivery time = PSP Time +
+ Processing time (cell) + FIFO Time + Processing Time (stage 4)

PSP Time → How to size it?

Total Processing Time = 8+ 11 + 10 min = 29 min

How to size FIFO
FIFO Size = Δshifts*D*1,5 = 1*15*1,5 = 22,5 pc → more conservative
You could also consider the demand in one shift → 15/3=5 pc
FIFO Time = 22,5 pc/15pc/d =1,5 days

Exercise 2

How to dimension PSP

Assuming a significant variability in the volume of SPE demand (+/- 60% d/d)

Variability is absorbed with PSP (pre-shop-pool) → **3σ**

PSP size = Average demand + (3*% Variability * Demand) = 15+ 3*60%*15 =**42pc**
PSP Average Time = 15pc/15pc/d = **1 day**
PSP Maximum Time = 42pc/15pc/d = **2,8 days**

Considering this average level, it is good to give the customer a time indication that considers **3 days as throughput time of the PSP** (1 on average, with an oscillation between 0 and 3 days)

[for the exam only → PSP throughput time for the customer= PSP Maximum Time]

Exercise 2

Average Delivery time = PSP Average Time + Total Processing time + FIFO Time =
= about 1 day + 29 minutes (negligible) + 1,5 days= **c.a. 2,5 days**

Maximum Estimated Delivery time = PSP Maximum Time + Total Processing time + FIFO Time =
= about 2,8 day + 29 minutes (negligible) + 1,5 days = **c.a. 4,3 days**

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