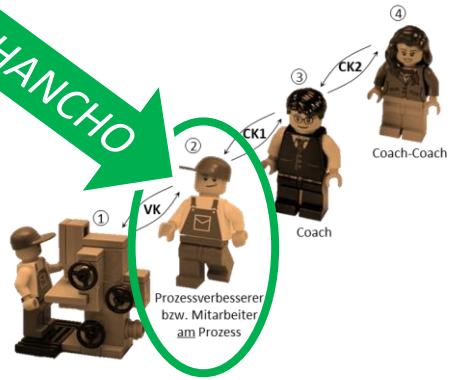
Process Analysis

to define the Current- and Target-Condition

with a practical example from a U-shaped assembly cell

The Hancho or „Process Improver“ constantly monitors the process, looks for deviations and tries to eliminate them

② Mentee, Hancho
or process improver



① Operator in the process

FESTOOL

The situation:

In order to increase the number of process improvers in our company without hiring new employees, we decided to develop people out of assembly processes into the process improver role.

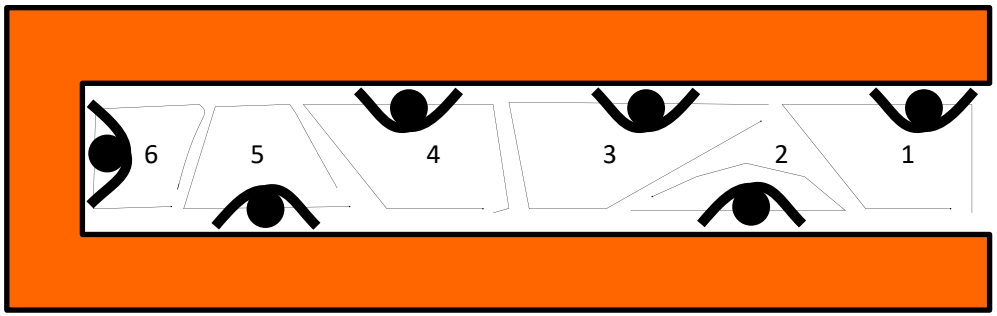
Target:

Reduce 1 assembly worker out of 6 in order to allow him to become a process improver.

Current assembly layout and working method:

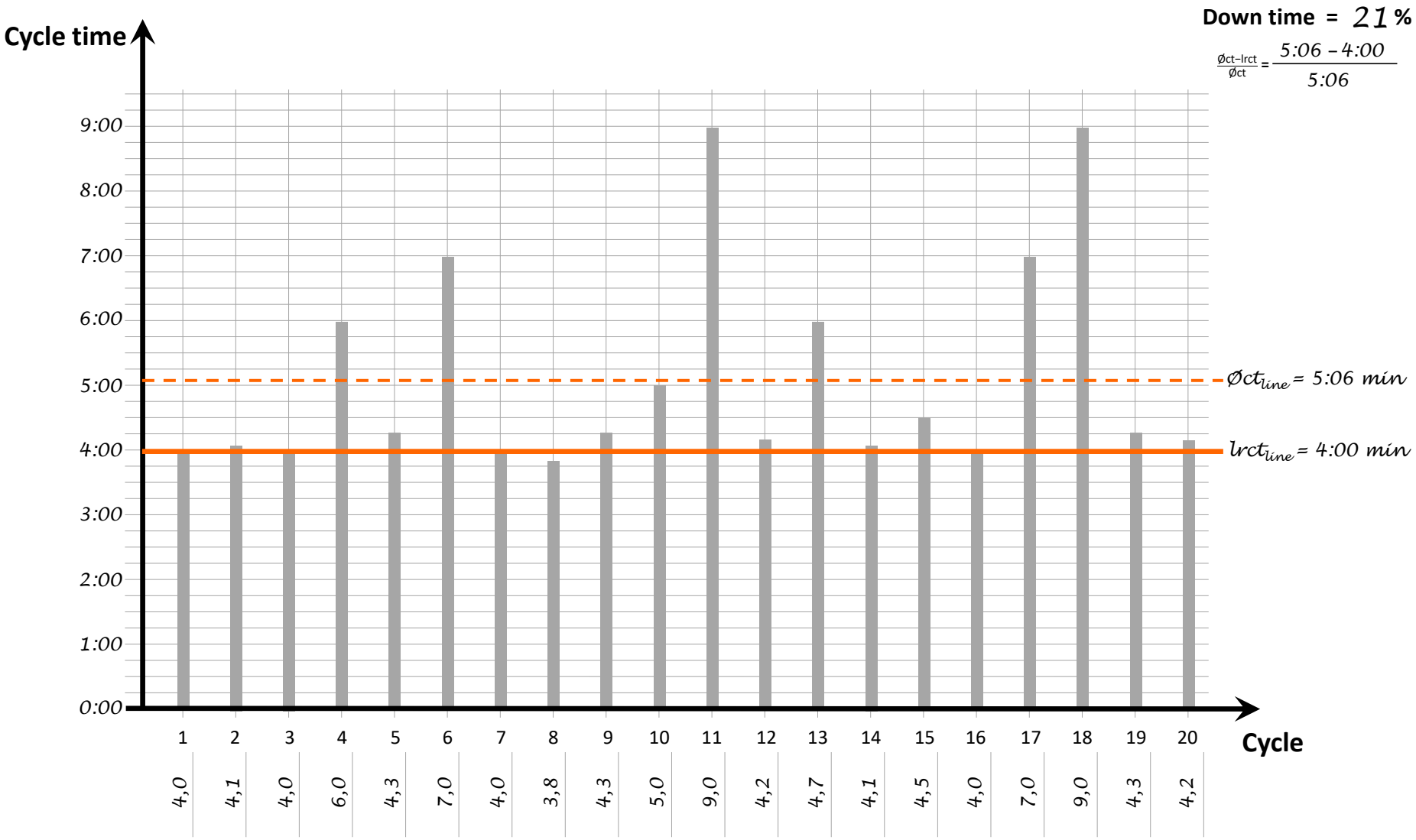
In this U shaped assembly cell 6 workers produce 88 Machines in a one-piece-flow. The work is balanced out so that each one of the 6 workers receives exactly 1/6 of the total assembly time.

In order for the hancho to be able to see bad balancing and disruptions as easy as possible, all workers are asked to start their cycles at the same time: not before all workers have finished their cycle and all problems were eliminated, are they allow to start again, all at once, their next cycle. If then the hancho observes that one out of 6 workers finishes his cycle later than the other five, he can assume that he must have had a problem and go and see immediately what the cause was and how he can assist the worker in getting his job done according to standard.



The following 20 cycles were timed at the assembly line

Important: the stopwatch runs through continuously during these 20 cycles, when one cycle ends, the next starts immediately.



ATTENTION while recording times, errors of up to 40% possible!

After a colon ":" come sixtieths of a minute (1/60)

After a comma "," come hundredths of a minute (1/100)

5:37 is not the same as 5,37!

5:37 min = 37/60 + 5 = 5,62 min

What can we learn from the 20 cycles we just stopped?

The average cycle time (Øct) is 5,1 min, the lowest repeatable cycle time (lrct) is 4,0 min. The average cycle time (Øct) includes all disruptions ocurred during the recorded 20 cycles, the lowest repeatable cycle time (lrct) only appears when there has been no disruption in that cycle.

Knowing these two numbers you can calculate the downtime rate (5,1 min – 4,0 min)/5,1 min = 21% and the necessary assembly time you would have in case of no disruption which would be: 6 workers x 4 min = 24 min assembly time. To produce 88 pcs. our work time will necessarily be 88 Stk x 5,1 min = 448,8 min + 40 min pause. Too long!

How is it that we do NOT want to achieve our target?

There are always many ways to achieve a target like „5 assembly workers instead of 6“ which would be counterproductive. Therefore we try to sort out from the outset these counterproductive measures:

- reduce the output per shift? No, therefore current condition = target condition = 88 Machines per shift
- we could work longer every day? No, therefore current working time = target working time = 6:00– 14:00
- do more overtime? No, therefore our target overtime = 0 min
- use pauses as working time? No , therefore target pause lenght remains = 2 x 15 min + 2 x 5 min = 40 min
- keep the 6 assembly workers? No, therefore our target remains = 5 workers per shift

How is it then, that we DO want to achieve our target?

In order to achieve the 88 Machines per shift with 5 workers, only two parameters remain to be worked on:

- Down time
- Assembly time

What could you practice next?

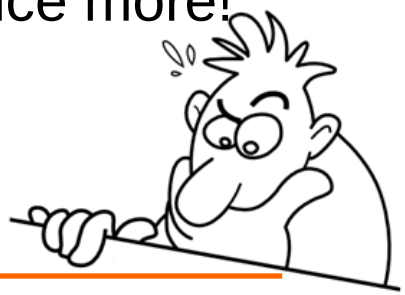
Print the empty forms in the next pages and try to make the calculations by yourself. For example you could assume a downtime reduction from 21% to 10%. Would this be enough to reach your target condition of 88 pcs. with 5 workers and no overtime?

Exercise: describe the current and target condition of this assembly

Results of the process analysis of the assembly line

Current condition	Target condition
Assembly workers = 6	Assembly workers = 5
Regular working hours: 6:00 – 14:00 Breaks: 2 x 15 min + 2 x 5 min Production volume = 88 pcs per day LRCT= 4 min Net working time = Customer takt = Assembly time = Downtime = Runtime = Overtime =	Regular working hours : Breaks: Production volume = Planned CT = Net working time = Customer takt = Assembly time = Downtime = Runtime = Overtime =

Trying to achieve the goal with a downtime of 10% results in 24.6 min over-time: too much! We need to calculate once more!



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LRCT= 4 min Net working time = (14-6)*60-30-10 = 440 min Customer takt = 440/88 = 5 min Assembly time = 6 x 4 min = 24 min Downtime = (5,1-4)/5,1 = 21 % Runtime = 5,1 min x 88 Stk = 448,8 min Overtime = 8,8 min	Planned CT = 24 min /5 MA = 4,8 min Net working time = (14-6)*60-30-10 = 440 min Customer takt = 440/88 = 5 min Assembly time = 5 x 4,8 min = 24 min **Downtime = 10%** ✓ Runtime = 4,8 x 1,1 x 88 min = 464,6 min **Overtime = 24,6 min** ✗

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What is the purpose of the target condition?

Without a target condition many solution paths would be possible, also unwanted ones, to achieve the target of reducing the number of assembly workers from 6 to 5. The unwanted solutions are excluded by the target condition. Only the two desired levers are now the focus of improvement activities:

- Reduction of downtime from 21% to 10%
- Reduction of assembly time from 24 min to 22,5 min

The target condition does not include any solutions, it only defines a challenging learning task that can only be solved using the improvement kata step by step.

How do we continue from here?

At this point, the coaching of the mentees would start with the third coaching kata question:

- Which obstacles are currently preventing you from achieving the target condition?

in order to help the mentee to accomplish his target step by step doing experiments according to the PDCA cycle.

What coud you do next?

Try to find a process with a short cycle time as shown above (about 30 sec to 120 sec), plot the 20 cycle times and fill out all recorded KPIs in a T-form. Then define a challenging target condition according to your experience, making sure to write down all numbers you want to keep equal and the parameters you want to improve.

Would you like to try the process analysis yourself? You only need to find a process suited for practice, print out the blank templates and get the tools listed in the next pages…

Helpful tools for your process analysis

What tools do we need on site?

- Stopwatch or smartphone, ideally with a lap time function
- Blank forms PA1, PA2 (see Templates)
- Pencil
- Eraser and sharpener
- Clipboard or stable pad

Take all pages 26 to 31 with you!

What do we want to record on site?

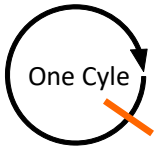
- A sketch of the line (use PA1 form) including.:
  - Workers and their paths
  - Stations with name
  - Inventories
  - Larger containers and bins, esp. input and output
  - Material flow

- Process stability chart (PA2)
  - of the line (measured at the exit)
  - of every single worker

Write down problems and their causes if you see some, include them in the chart.

What is a cycle time?

- A cycle time is, as in the case of a cars race,  closed. That means that the end of a cycle = the beginning of the next cycle or lap. Therefore, it does not matter which move or action you choose as cycle start <u>and</u> end, it is only important that it is always the same.



Always start the next lap time at the same point of the cycle!

- <u>Attention:</u>
  If the process has a major disruption or the worker even leaves the process, please keep the stopwatch running!

Please always observe courtesy rules when recording people!

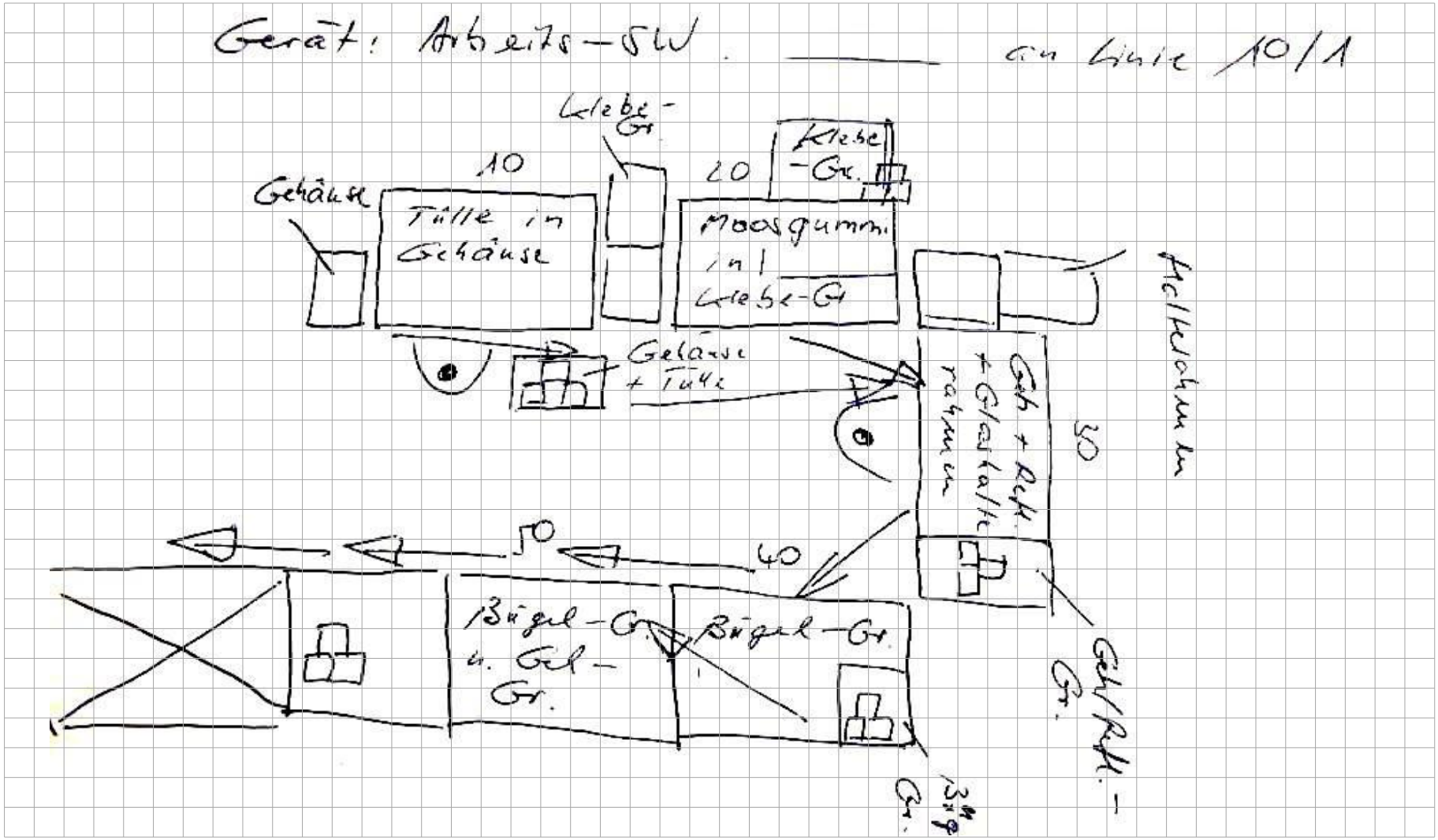
- **Greet every employee personally**
  Present yourself if the workers do not know you already

- **Explain the purpose of the exercise:**
  "We are here to do an exercise. We want to observe your process in order to better understand it and to learn how to detect instabilities and disruptions. Is it OK with you if we just looked while you do your job? Could we ask you some questions if something was unclear to us?“

- **Openly show at all time your sketches to each worker**
  Take the opportunity to get in a dialogue: "Is your process right the way I sketched it here?". Always assume that the employees does not know what you are doing and might even get nervous by being observed. Still, he will be glad if he gets involved and can help with information.

- **Openly show that you are using a stopwatch:**
  „We want to measure the stability of the line, we want to understand the process and do not want to stop you. Is it OK if we recorded some cycles? Please keep working as normal, as if we were not here. There is nothing at all that you could do wrong!“

- ***„Thank you very much for allowing us to watch you during work!“***

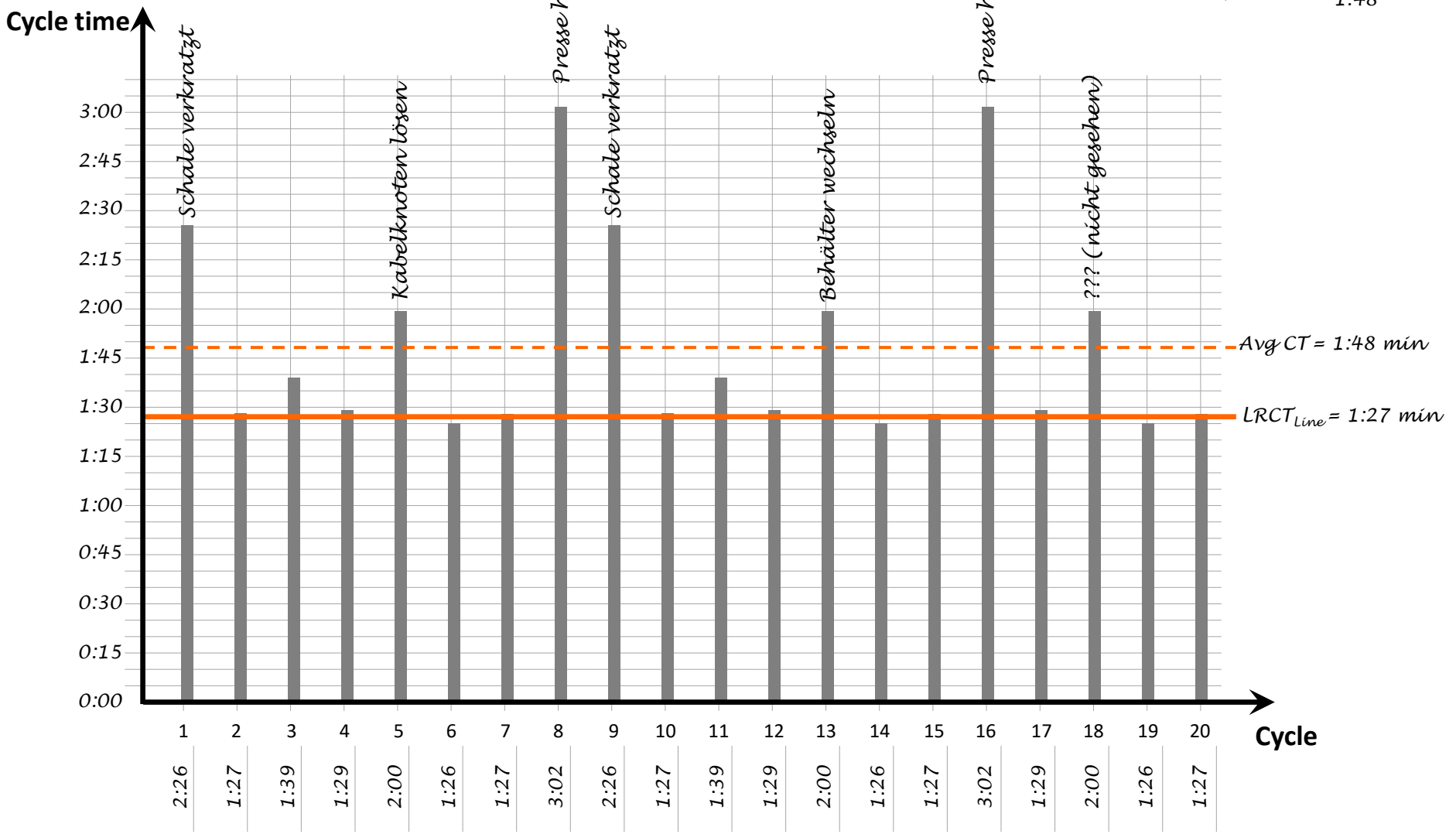


Worker: 3 | Station incl. name: PRESS | Inventories: I | Big containers incl. Input and output: | Material flow: | System boundary:

PA2-Process stability chart | **Process :** Montage 7 | ☒ **Line exit cycle** ☒ **Worker nr.** 4 | **Process improver:** Peter Müller

Downtime = 19 %

$$\frac{\text{ØCT–LRCT}}{\text{ØCT}} = \frac{1:48 - 1:27}{1:48}$$



Process:

Process improver:

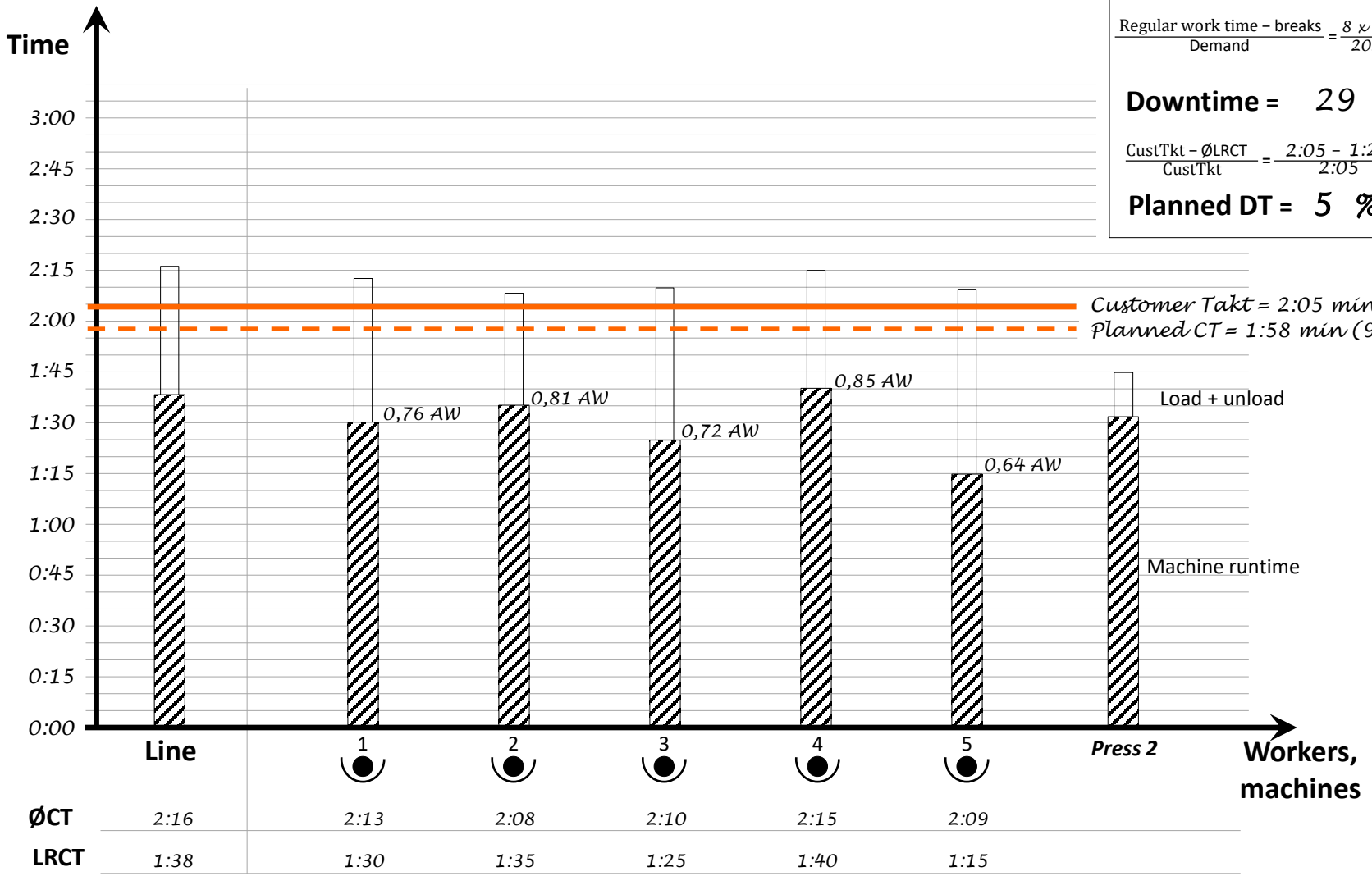
Customer Takt = 2:05 Min

$$\frac{\text{Regular work time – breaks}}{\text{Demand}} = \frac{8 \times 60 - 60}{202\ pcs/shift}$$

Downtime = 29 %

$$\frac{\text{CustTkt} - \text{ØLRCT}}{\text{CustTkt}} = \frac{2:05 - 1:29}{2:05} \times 100$$

Planned DT = 5 %



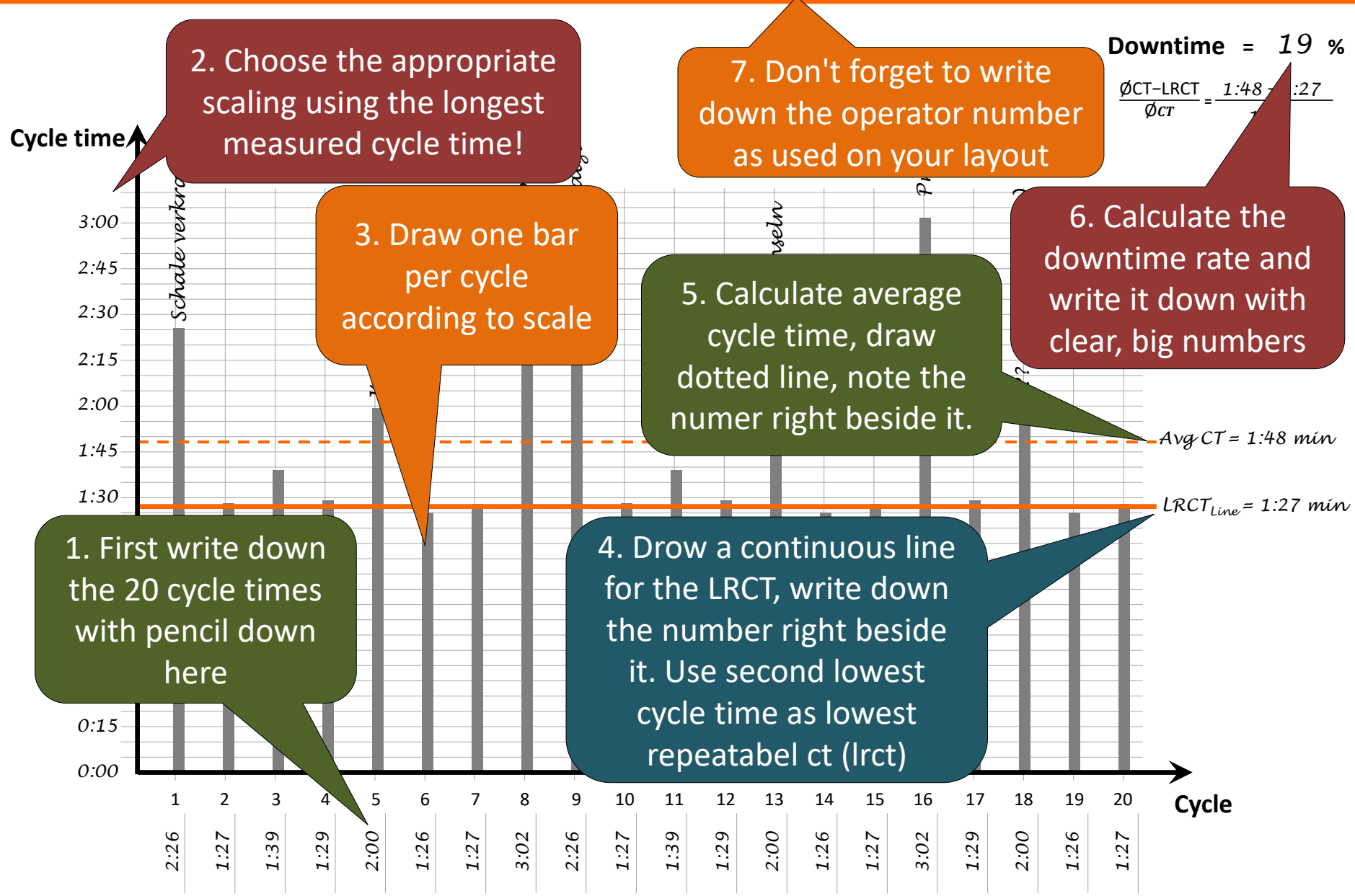
	Line	1	2	3	4	5	Press 2
ØCT	2:16	2:13	2:08	2:10	2:15	2:09	
LRCT	1:38	1:30	1:35	1:25	1:40	1:15	

Right number of workers = $\frac{\text{Sum of all LRCT of all AW}}{\text{CustTkt x (1 – Target downtime)}} = \frac{1:30 + 1:35 + 1:25 + 1:40 + 1:15}{2:05 \times 0,95}$ = 3,75 Assembly Workers

Process : Montage 7

☒ Line exit cycle
☒ Worker nr. 4

Process improver: Peter Müller



Version 5.0

Process:

Process improver:

1. Calculate customer takt. If possible use demand of last 2-3 months and break it down to daily demand!

2. Chose the appropriate scaling according to customer takt

3. Draw customer takt with a continuous line

4. Draw one column per operator incl. LRCT and ØCT *(Please ignore columns for line and press now!)*

5. Calculate downtime using this formula

6. Determine your Target downtime (for example 10%), calculate planned CT and draw dotted line accordingly

7. Calculate the "Right number of operators"

Customer Takt = 2:05 Min

$$\frac{\text{Regular work time – breaks}}{\text{Demand}} = \frac{8 \times 60 - 60}{202\ pcs/shift}$$

Downtime = 29 %

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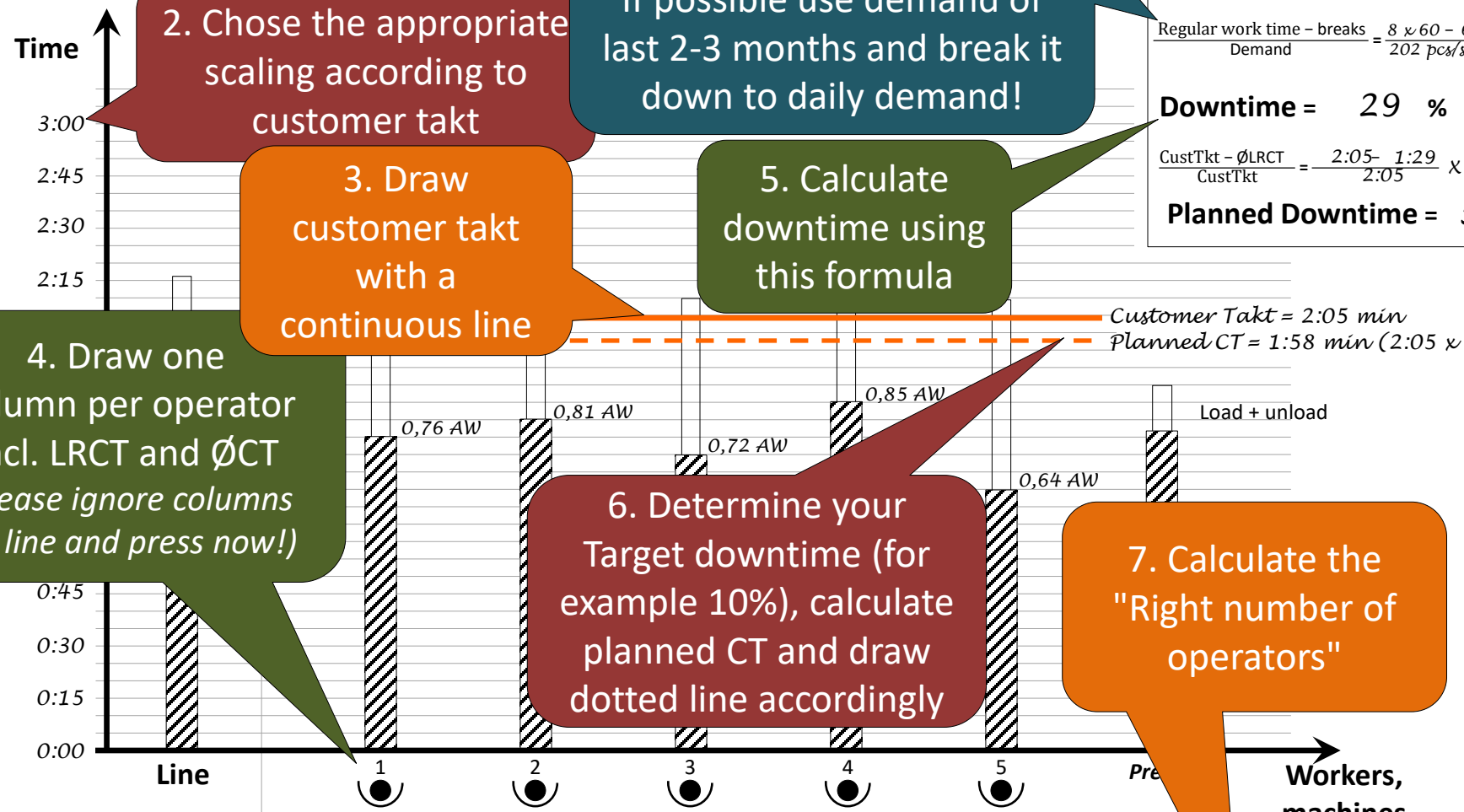
Planned Downtime = 5 %



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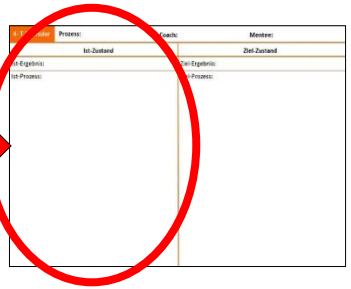
Calculating the target condition (incl. target assembly time und downtime) starting from the target number of workers

	Calculating method	*Example*
Output	**1- Define Target number of workers**	*3 Op*
	2- Demand	*220 pcs/Shift*
Process	**3- Regular working time**	*8 hrs x 60 min = 480 min*
	4- Breaks	*2 x 15 + 2 x 5 = 40 min*
	5- Net working time = reg. WT - breaks	*480 – 40 = 440 min*
	6- Customer takt (CusTkt) = Net WT / Demand	*440 min/220 pcs = 120 sek*
	7- Target downtime % (for example 10%)	*10 % downtime*
	8- Target downtime min = Net WT x Target downtime %	*440 min x 0,1 = 44 min*
	9- Planned cycle time (PCT) = CusTkt x (1 – Downtime)	*120 sek x (1-0,1) = 108 sek*
	10- Target assembly time = Number of workers x PCT	*3 AW x 108 Sek = 5:24 Min*

On the left side of the T-Form you can now write down the measured values on the corresponding row

Fill out left „Current condition“ side of T-Form only AFTER right side has been completed



Current number of operators as a whole number!

Use same downtime as in PA3-Form

Calculate Downtime per shift

Write down every single LRCT of every single operator

Current assy time = Summ of all LRCTs of every single operator

Underline worksites and circle the corresponding target numbers!

Current condition	*Target cond*
Number of operators = 4 operators	*3 Operators*
Demand = 220 pcs per shift	*220 pieces per shift*
Reg. working time = 8 x 60 = 480 min	*8 hs x 60 min = 480*
Breaks = 2 x 15 + 2 x 5 = 40 min	*2 x 15 + 2 x 5 = 40 m*
Net WT= 480 – 40 = 440 min	*480 – 40 = 440 min*
Cust.Tkt = 440 min/220 pcs = 120 sec	*440 min/220 pcs = 120 sek*
Downtime = 23 %	*Downtime = 10%*
Downtime = 440 min x 0,23 = 101 min	*Downtime = 44 min*
$LRCT_1$ = 123 sek, $LRCT_2$ = 97 sek,	*Planned CT = 120 x (1-0,1) = 108 sec*
$LRCT_3$ = 62 sek, $LRCT_4$ = 90 sek	
Assy time = ∑LRCTs = 6:12 min	*Assy time = 3 MA x 108 Sek = 5:24 Min*

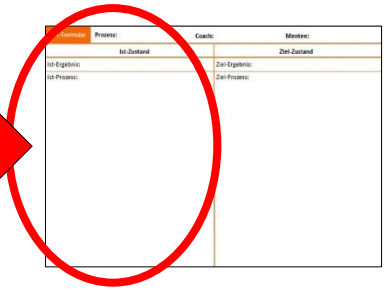
Calculating the target condition (incl. target assembly time und downtime) starting from the target number of workers

	Calculating method	*Example*
Output	1- Define Target number of operators	*1 Op*
	2- Demand	*132 pcs/shift*
	3- Define Target workload	*15%*
Process	4- Regular working time	*8 hrs x 60 min = 480 min*
	5- Breaks	*2 x 15 + 2 x 5 = 40 min*
	6- Net working time $_{Total}$ = Regular WT - Breaks	*480 – 40 = 440 min*
	7- Net working time $_{Task\ X}$ = Net WT $_{Total}$ x Op. Workload	*440 min x 0,15 = 66 min*
	8- Net working time $_{Rest}$ = Net WT $_{Total}$ – Net WT $_{Task\ X}$	*440 min – 66 min = 374 min*
	9- Customer Takt (CusTkt) = Net WT $_{Task\ X}$ / Demand	*66 min/132 pcs = 30 sec*
	10- Planned % Down Time (for example 10%)	*10 % down time*
	11- Down time/Shift = % Down Time x Net WT $_{Task\ X}$	*0,1 x 66 min = 6,6 min/shift*
	12- Planned Cycle Time (PCT) = CusTkt x (1 – % Down Time)	*30 sec x (1-0,1) = 27 sec*
	13- Planned Assy Time $_{Task\ X}$ = # Op x Planned Cycle Time	*1 Op x 27 sec = 0:27 min*

Calculating the target condition (incl. target assembly time und downtime) starting from the target number of workers

Calculation 7- needs values 5- and 6-, so calculate those first, please!

Fill out the LEFT side of the T-Form SECOND!

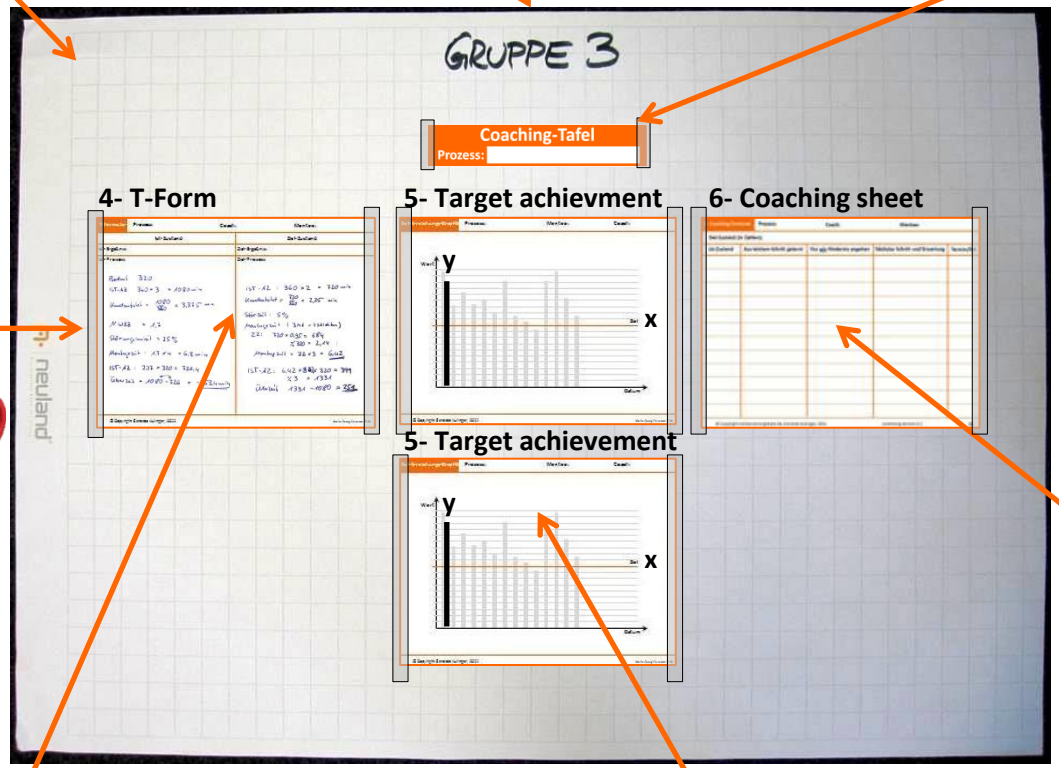


	Calculating method	*Example*
	1- Define Current number of operators	*1 Op*
	2- Demand	*132 pcs/shift*
Output	**7- Current Workload = Net WT $_{Task\ x}$ / Net WT $_{Total}$ x 100**	*121 min / 440 min x 100 = 27,5%*
	3- Regular working time	*8 hrs x 60 min = 480 min*
	4- Breaks	*2 x 15 + 2 x 5 = 40 min*
	5- Net Working Time $_{Total}$ = Regular WT – Breaks	*480 – 40 = 440 min*
Process	**6- Net Working Time$_{Task\ X}$ = Demand x Avg CT (from PA2)**	*132 x 55 sec = 121 min*
	8- Net Working Time$_{Rest}$ = Net WT$_{Total}$ – Net WT$_{Task\ X}$	*440 min – 121 min = 319 min*
	9- Customer Takt (CusTkt) = Net WT$_{Task\ X}$ / Demand	*121 min/132 pcs = 55 sec*
	10- Current % Down Time $_{Task\ X}$ (for example 28% from PA2)	*23 % down time*
	11- Down time/Shift = % Down Time x Net WT$_{Task\ X}$	*0,23 x 121 min = 27,8 min/shift*
	12- Lowest repeatable Cycle Time, LRCT (from PA2)	*42,35 sec*
	13- Assembly time $_{Task\ X}$ = LRCT x Current # Operator(s)	*42,35 sec*

Calculate TC for *Value Stream Loop* including assy time, downtime, C/O, SWIP, starting from *Right Number of Operators* and *Lead Time*

	Calculating method	*Example*
Output	1- Target number of operators	*1- 3 ops.*
	2- Customer demand per day	*2- 220 pcs/shift*
	3- Process lead time	*3- 30 min*
Process	4- Total working time per day	*4- 8 hs x 60 min = 480 min*
	5- Breaks per day	*5- 2 x 15 + 2 x 5 = 40 min*
	6- Net working time per day = total wt/d - breaks	*6- 480 – 40 = 440 min*
	7- Customer takt (CusT) = Net wt/d / demand per day	*7- 440 min/220 pcs = 120 sec/piece*
	8- Target downtime (e.G. 10%)	*8- 10 % downtime ratio*
	9- Downtime/day = Net wt/d x Target downtime	*9- 440 min x 10% = 44 min/day*
	10- Target Change Over ratio (e.G. 10%)	*10- 10 % C/O ratio*
	11- CO time per day = Net wt/d x target CO ratio	*11- 440 min x 10% = 44 min/day*
	12- Total number of product types	*12- 22 types*
	13- EPEI (Every Part Every Intervall, e.G. 1 day)	*13- 2 days*
	14- Change overs per day = Number of types/EPEI	*14- 22 types/2 days = 11 types/day*
	15- Target C/O time = CO time per day/COs per day	*15- C/O = 44 min / 11 types/d = 4 Min*
	16- Planned cycle time (PCT) = CusT x (1-DT-CO ratio)	*16- PCT = 120 sec x (1-0,1-0,1) = 96 sec*
	17- Target assembly time = Number of ops x PCT	*17- 96 sec x 3 ops = 4:48 min*
	18- SWIP (Standard Work in Process) = Process LT/CusT	*18- SWIP = 30 min/120 sec = 15 pcs*

How to fill out the initial Coaching board necessary for the group coaching exercises we will do at the process we just analysed



1- Place flipchart paper in horizontal position

2- Write down group and number

3- Place titel tag, write down the process name

4- Place forms 4, 5 and 6 beside of each other

use tape on both left and right side of each sheet to avoid the sheets to bend up!

5- place here the T-form you filled out before during your process analysis

6- use one target achievement sheet per target- and process-number you will work on, write down target number, draw bar with current value according to scale

7- write down the names of the designed mentee and coach for this process

Empty forms for your Process Analysis

Process:

Process improver:

Worker: 3

Station incl. name: PRESS

Inventories:

Big containers incl. Input and output:

Material flow:

System boundary:

Process:

Process improver:

Worker: 3

Station incl. name: PRESS

Inventories:

Big containers incl. Input and output:

Material flow:

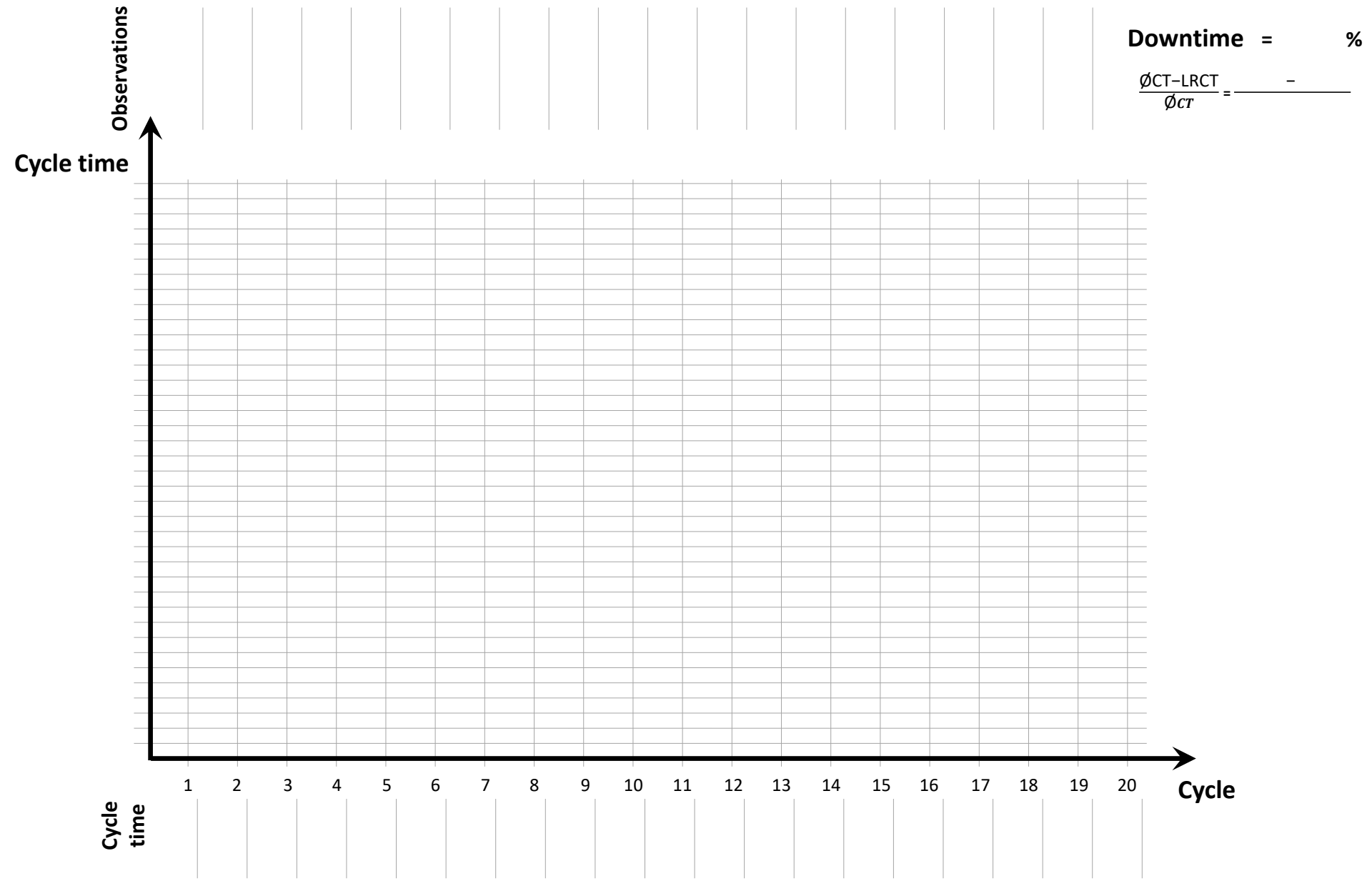
System boundary:

PA2-Process stability chart

Process :

☐ **Line exit cycle**
☐ **Worker nr. ____**

Process improver:



PA2-Process stability chart

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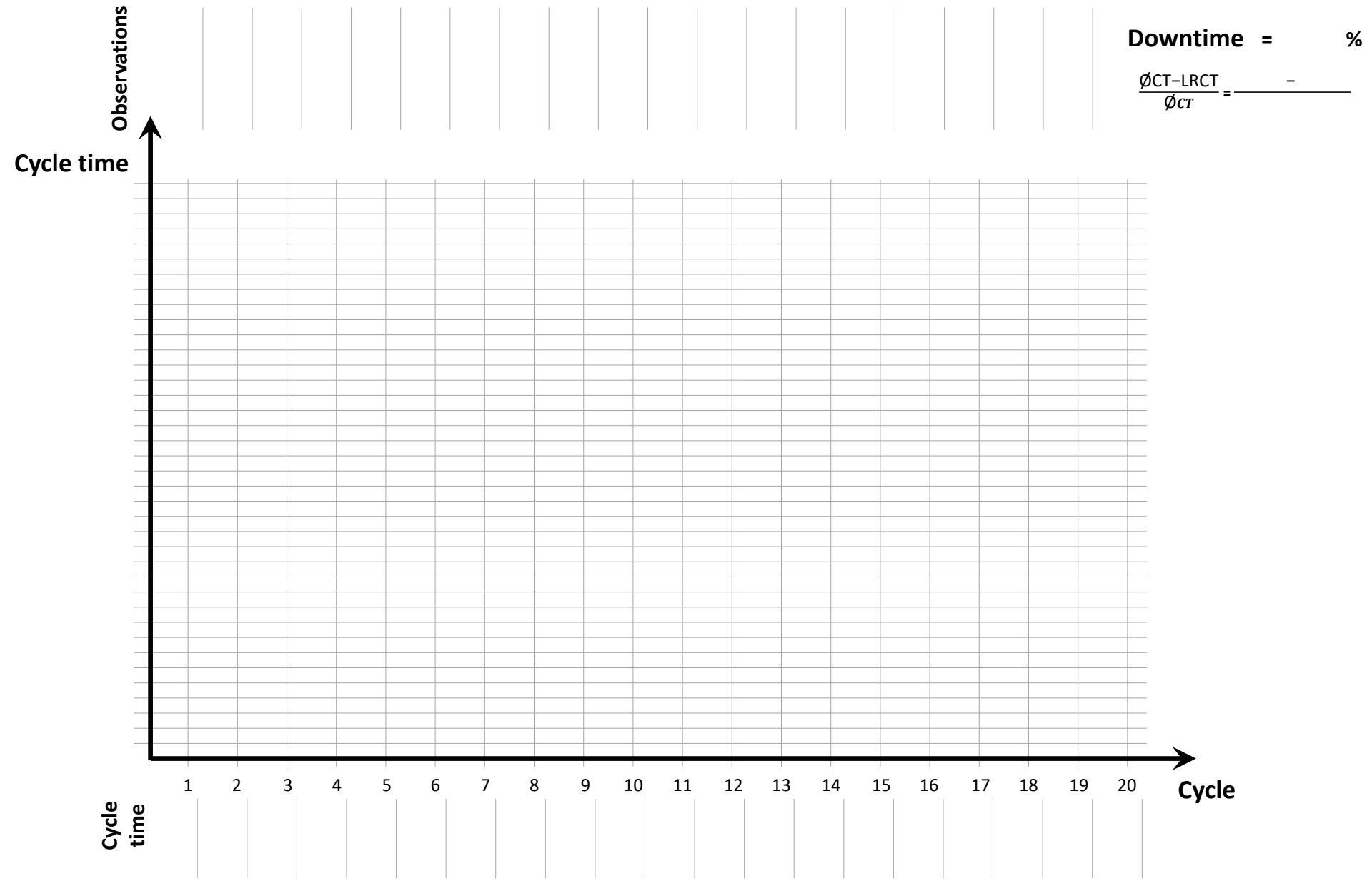

PA2-Process stability chart

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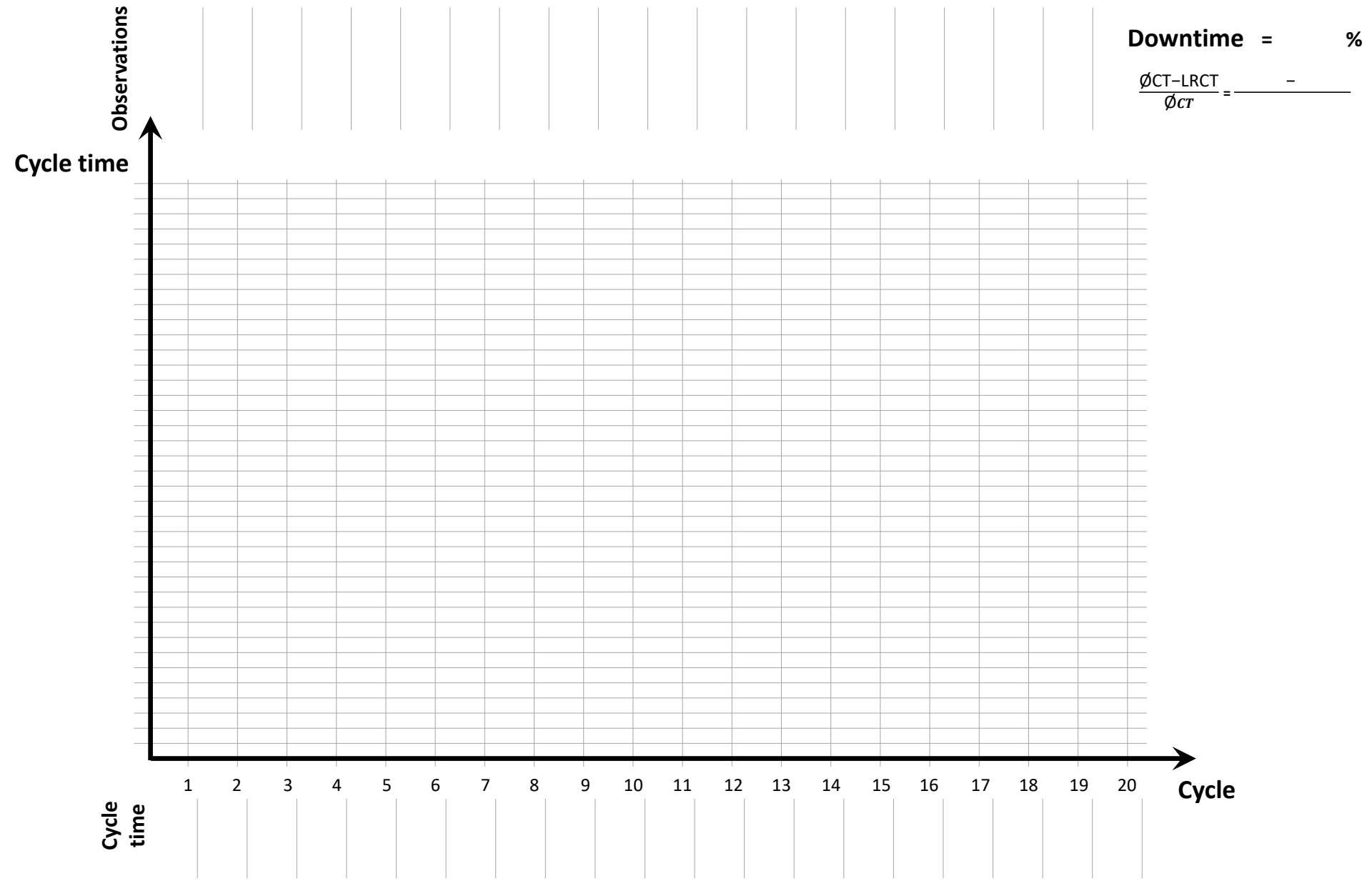

PA2-Process stability chart

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☐ **Line exit cycle**
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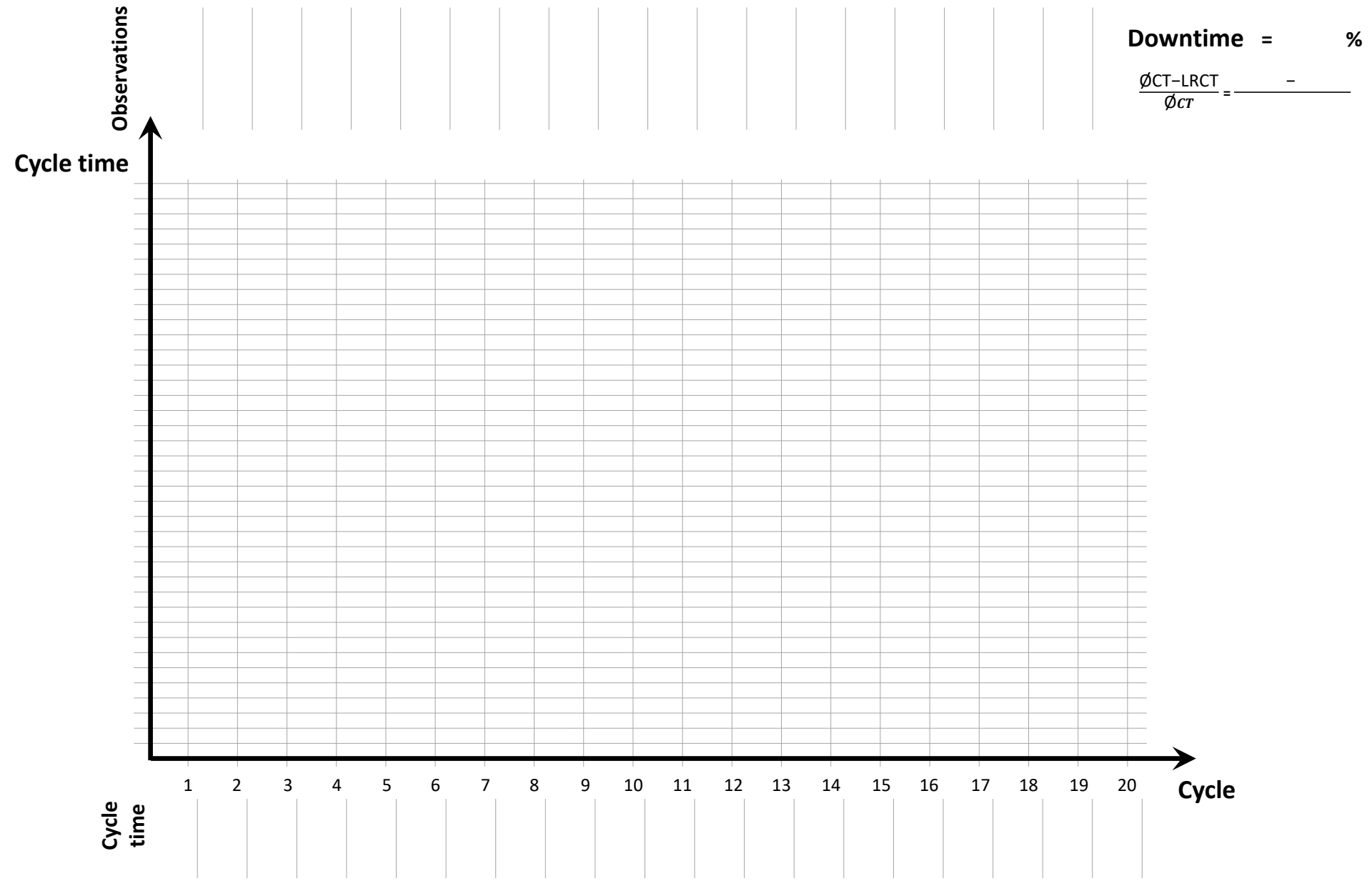
Process improver:



Process:

Process improver:

Customer Takt =

$$\frac{\text{Regular work time – breaks}}{\text{Demand}} = \frac{\quad}{\quad} -$$

Downtime = %

$$\frac{\text{CustTkt – ØLRCT}}{\text{CustTkt}} = \frac{\quad}{\quad} - \quad X\ 100$$

Planned DT = %

Right number of workers = $\frac{\textit{Sum of all LRCT of all AW}}{\textit{CustTkt x (1 – Target downtime)}}$ = ____ =

Process:

Process improver:

Customer Takt =

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PA4-Process-Steps-Analysis | **Process:** | ☐ Line ☐ Operator Nr. ____ | **Process improver:**

Nr.	Process step description	Comments	Current-State Running*	Current-State Step	Target-Condition Running*	Target-Condition Step
1			0:00	0:00	0:00	0:00
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
		Total time:				

PA4-Process-Steps-Analysis | **Process:** | ☐ Line ☐ Operator Nr. ____ | **Process improver:**

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14						
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16						
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18						
19						
		Total time:				

4- T-Formular **Prozess:** **Mentee:** **Coach:**

Current Condition (Date recorded: _____)

Current output:

because …

Current process:

Target Condition (Due Date: _____)

Target output:

and therefore we need…

Target process:

Use only numbers, explicitly write down all formulas, actual and target state must be mathematically conclusive, each measure with the actual and target value on the same row height, clearly legible writing with pencil

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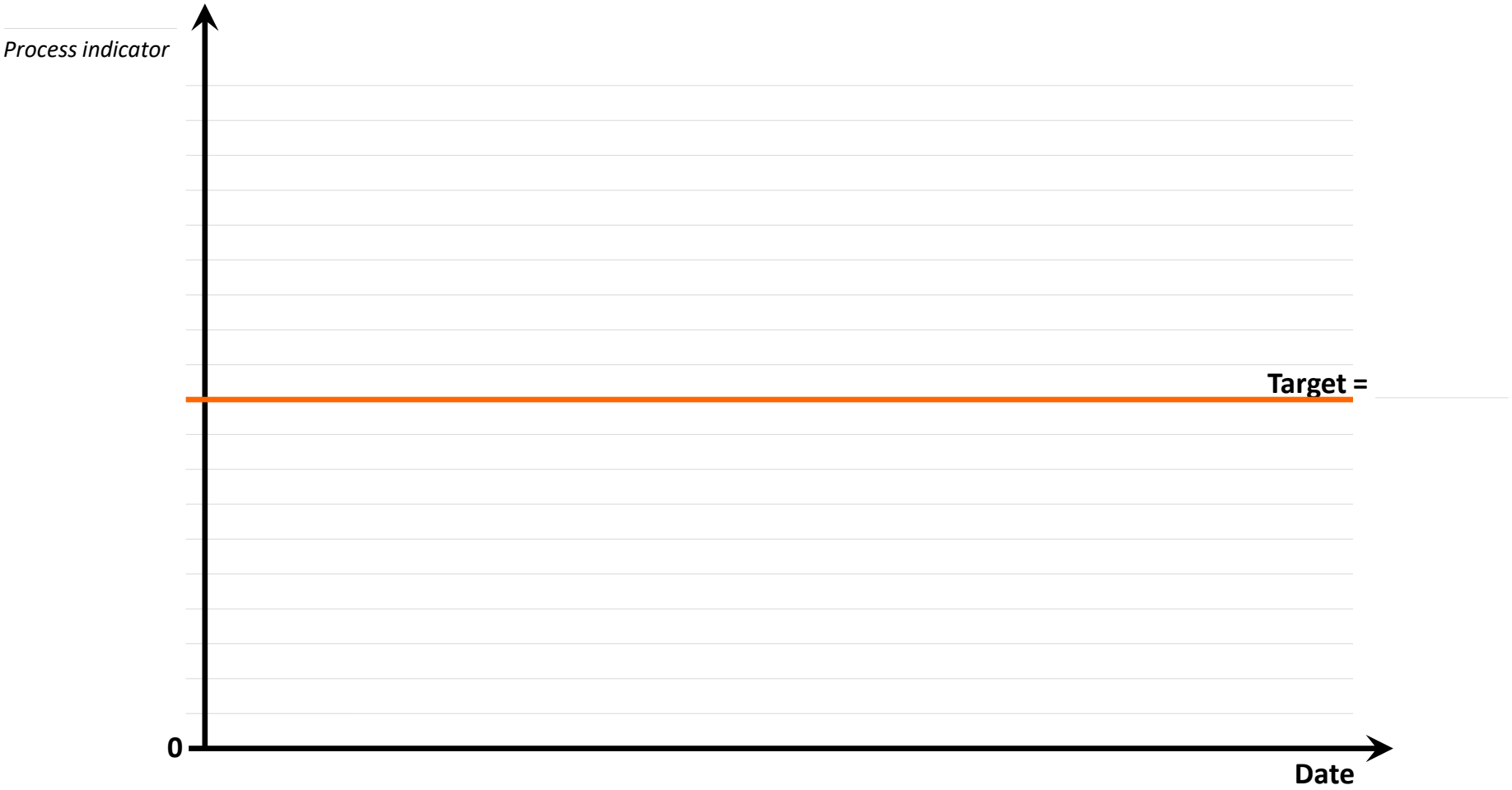
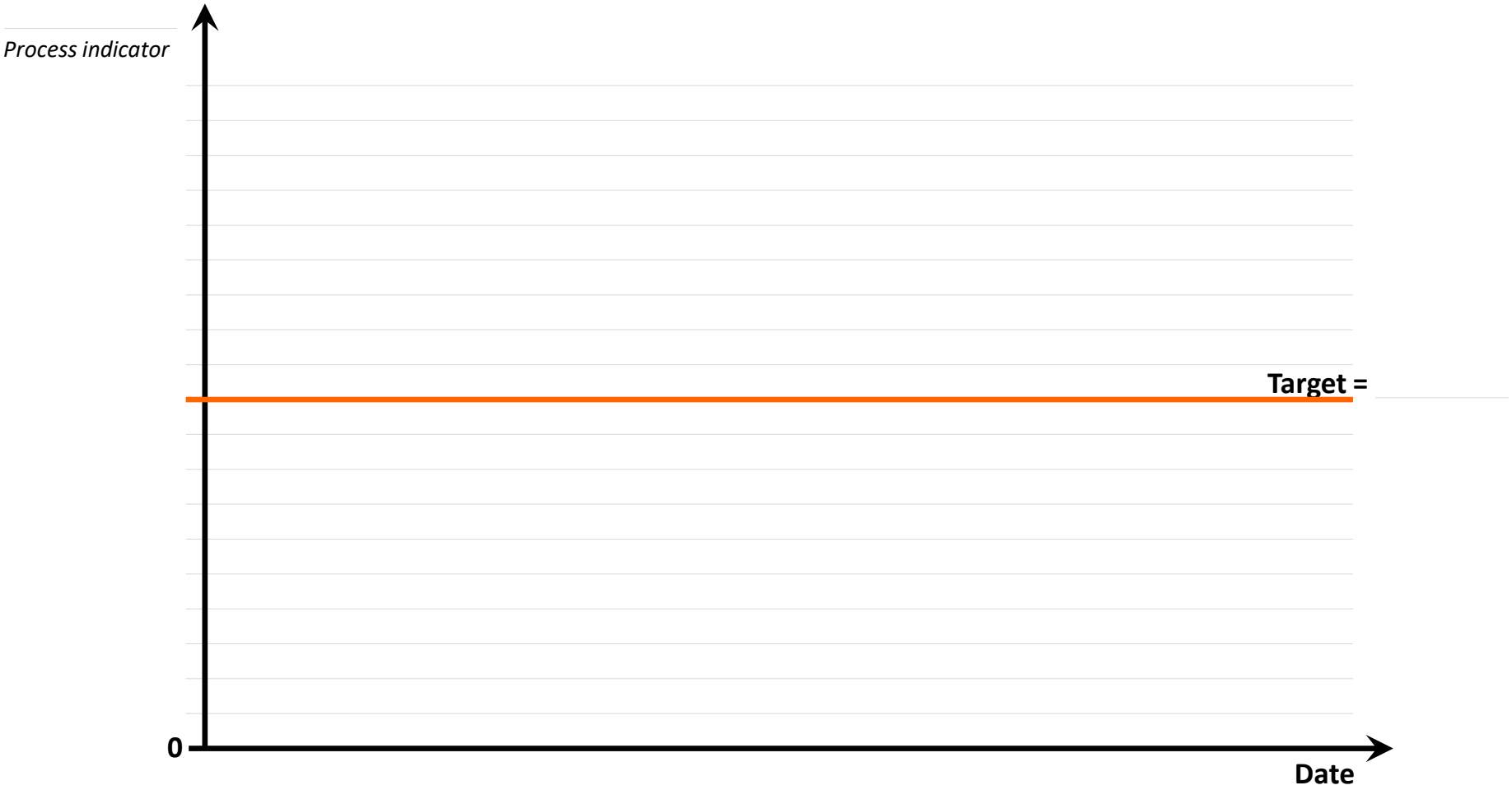
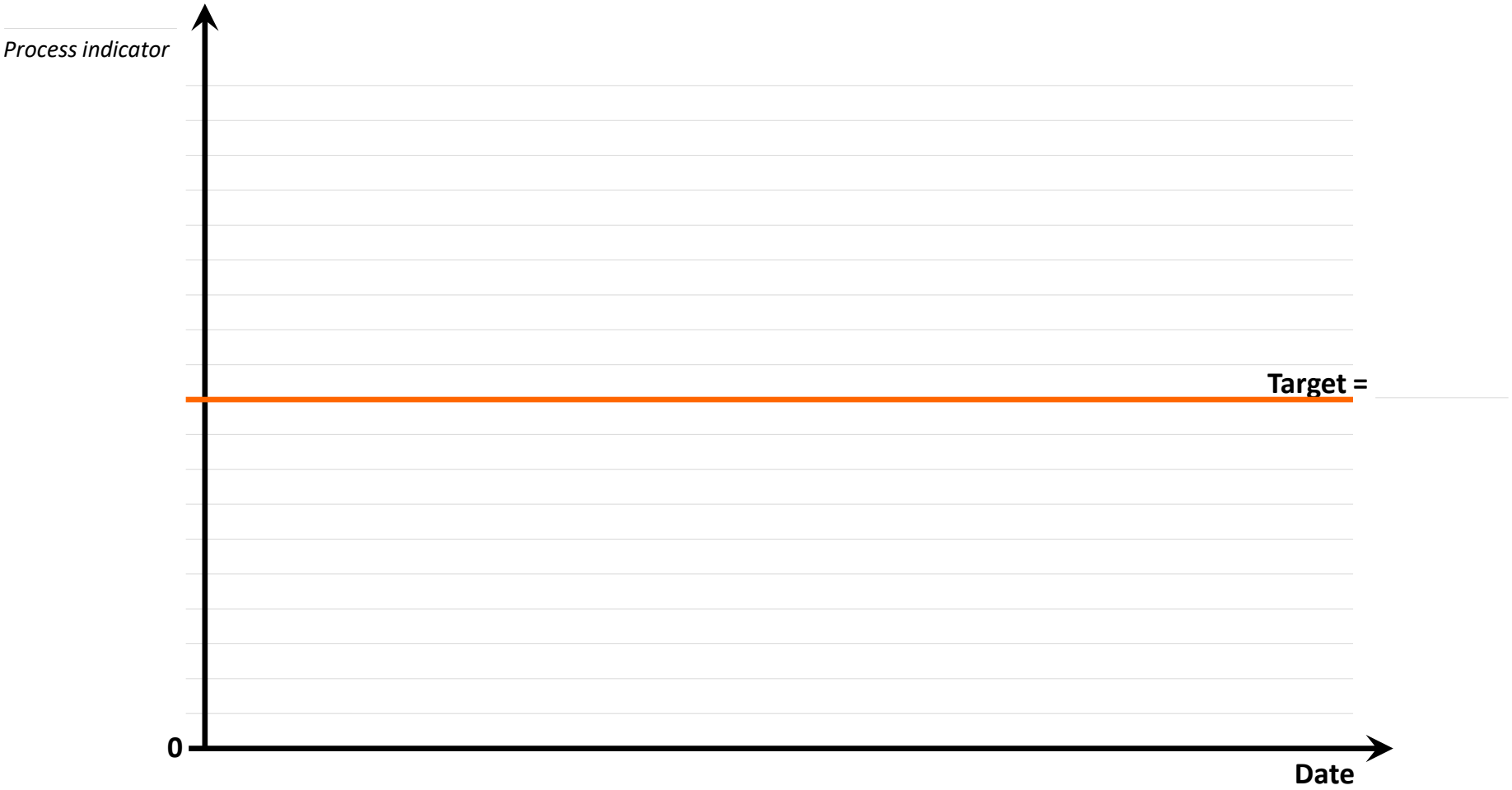
Process: **Mentee:** **Coach:**



Process: **Mentee:** **Coach:**



Process: **Mentee:** **Coach:**



6- Coaching-Sheet

Process: **Coach:** **Mentee:**

[1] Target-Condition (in numbers):

Output and Process Indicators

[2] Current condition Output and Process indicator		[2.3] Learned from last step? Was the last hypothesis refuted or confirmed?	[3.8] Only one obstacle at a time Has root cause been described and quantified?	[4.0] Next stept and what you expect A refutable hypothesis with an expected, numerical effect		[5.0] Date/Place Synchronized with step?

6- Coaching-Sheet

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[1] Target-Condition (in numbers):

Output and Process Indicators

[2] Current condition Output and Process indicator		[2.3] Learned from last step? Was the last hypothesis refuted or confirmed?	[3.8] Only one obstacle at a time Has root cause been described and quantified?	[4.0] Next stept and what you expect A refutable hypothesis with an expected, numerical effect		[5.0] Date/Place Synchronized with step?

Kata coaching board

Process:

Kata coaching board

Process:

Kata coaching board

Process:

Kata coaching board

Process: