Holistic OEE-Management

Aachen, 11.07.2022

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OEE Management deals with all activities to increase equipment effectiveness

OEE Management

OEE Management

Method for increasing productivity in equipment-oriented companies
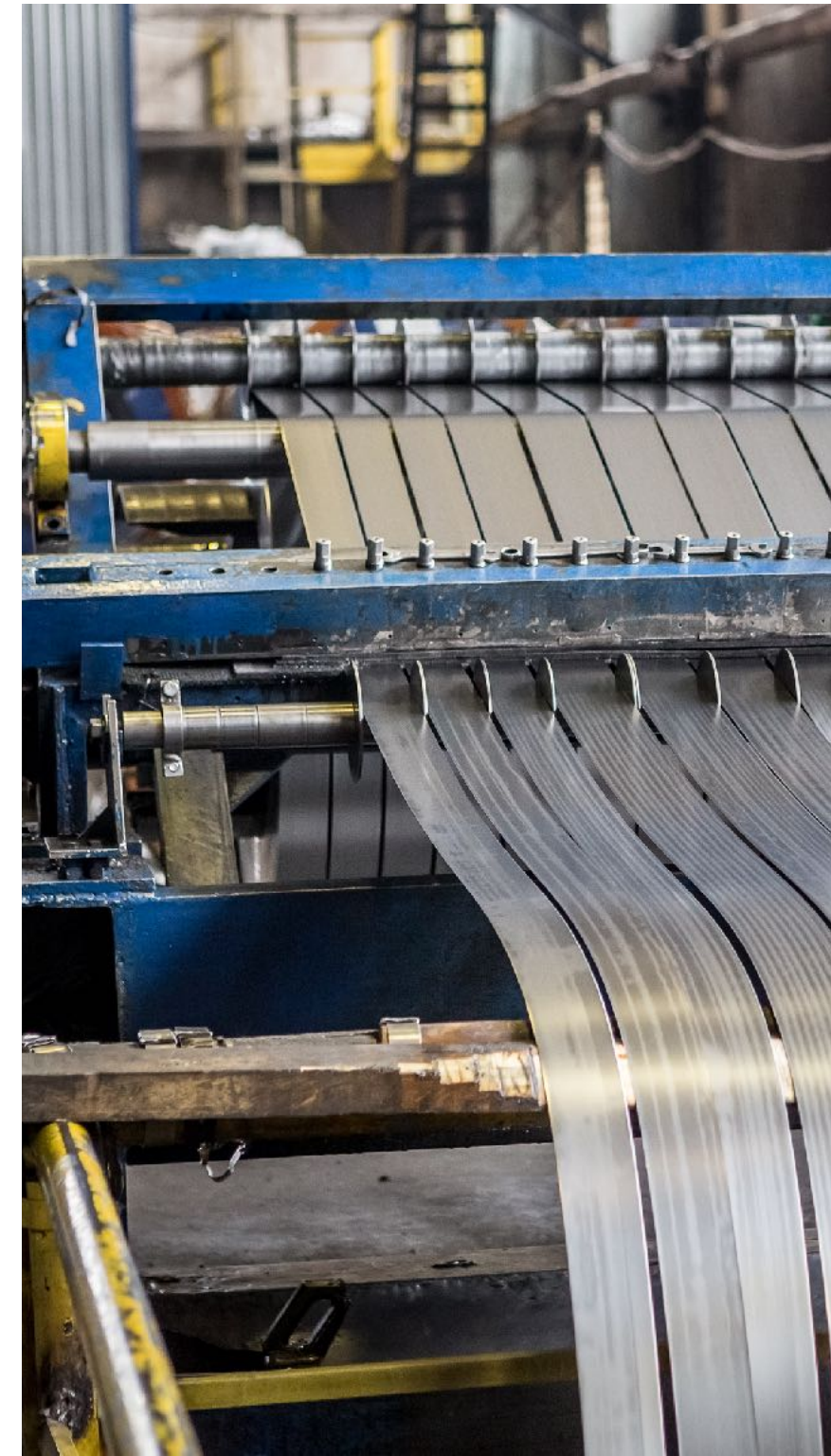
Metrics-based improvement process

Analysis of loss reasons as deviation from ideal equipment effectiveness

Integration of employees in the improvement process

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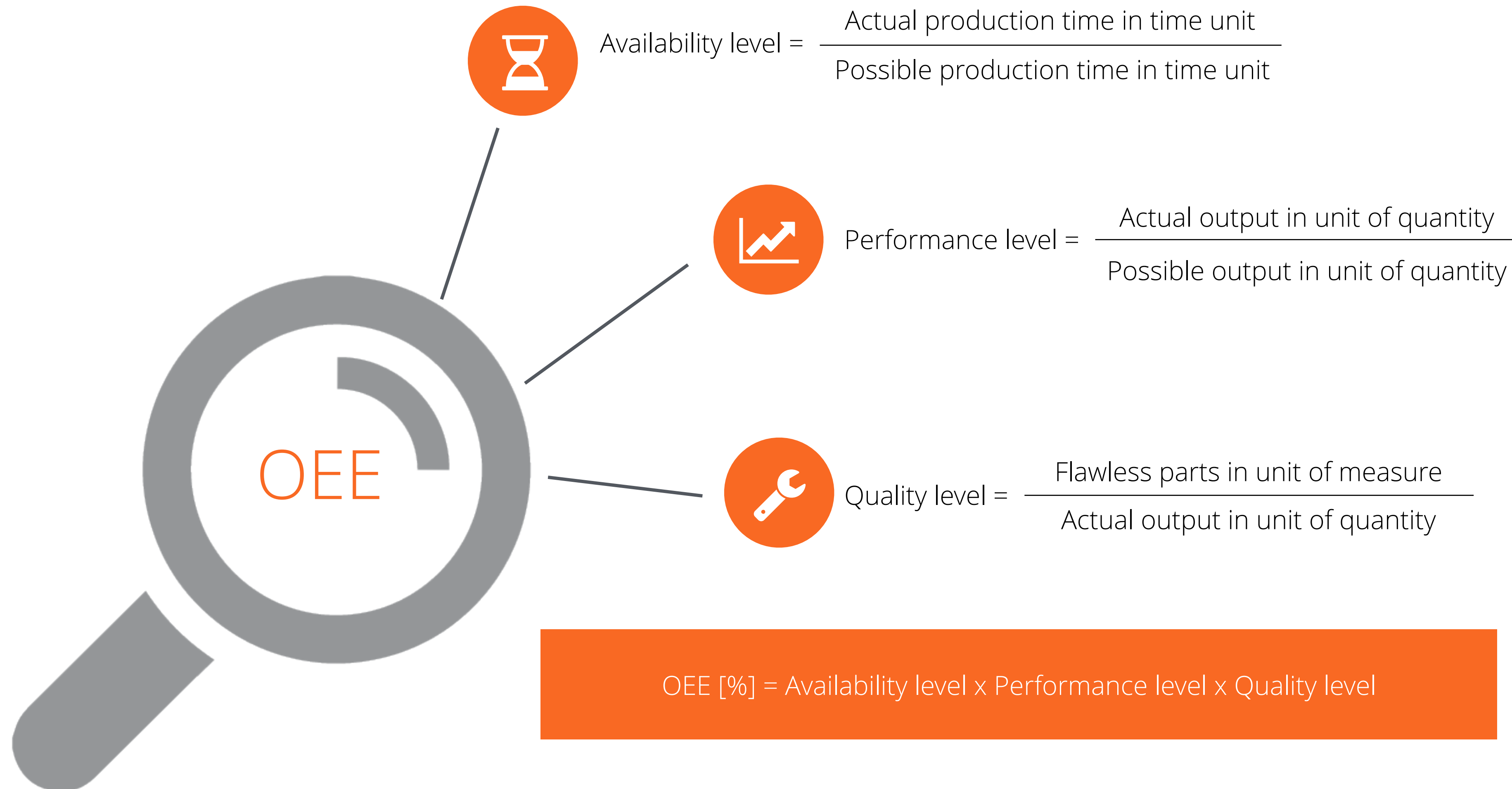# OEE is a powerful metric for the operational management of manufacturing companies

Foreword

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The OEE is composed of the degree of availability, performance and quality

Calculation of the degree of availability, performance and quality

$$\text{Availability level} = \frac{\text{Actual production time in time unit}}{\text{Possible production time in time unit}}$$

$$\text{Performance level} = \frac{\text{Actual output in unit of quantity}}{\text{Possible output in unit of quantity}}$$

$$\text{Quality level} = \frac{\text{Flawless parts in unit of measure}}{\text{Actual output in unit of quantity}}$$

OEE

OEE [%] = Availability level x Performance level x Quality level

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OEE calculation and correlation of loss types

	Available time		
Availability	Possible production time		No production planned
	Actual production time	– Equipment standstill, loss, missing parts – Set-up, maintenance	
Performance	Possible output		
	Actual output	– Short shutdowns – Reduced speed	
Quality	Actual output		
	Flawless output	– Defects, rejects, rework – Start-up losses, yield	

Source: Following May C. und Koch A. 2008, S. 247

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OEE must be considered specifically for each equipment: Absolute level and fluctuations can be optimised

Analysis of OEE

Absolute level of OEE

Statements like "80% OEE is world class" are not meaningful!
- The level of equipment OEE depends on many factors:
  - Degree of automation
  - Batch size
  - Complexity of the equipment
  - Competence level of the operators

Rule of thumb:
- OEEs below 30% indicate weaknesses in equipment operation
- OEEs between 30% and 50% are common for equipment whose OEE has not been measured previously

Note: OEE is a key figure for self-comparison of a equipment over different time periods. A comparison between different equipment or benchmarking is not useful!
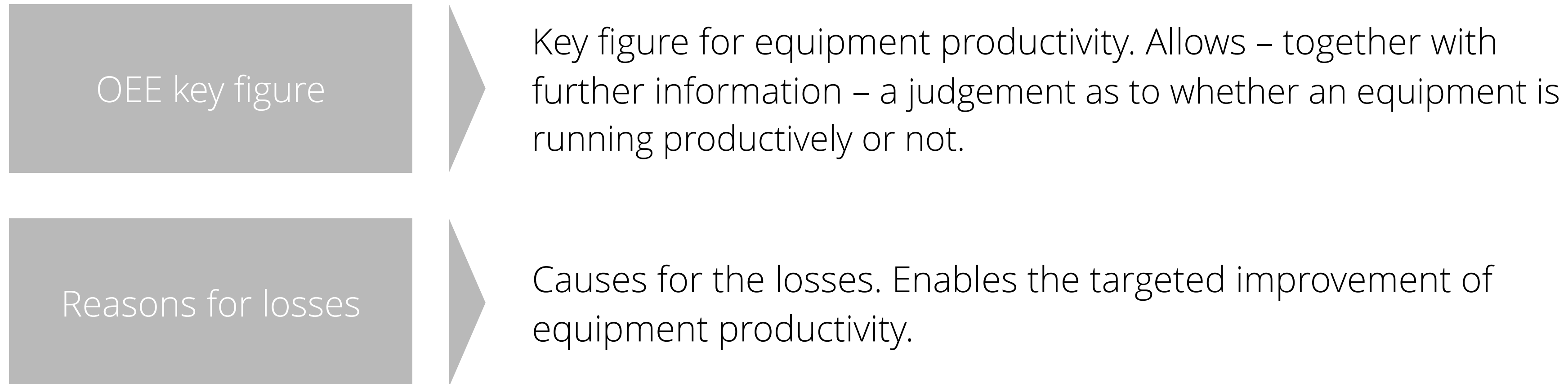
Fluctuations of OEE

In addition to the absolute level, **fluctuations** and **progressions of** the total OEE in shift, daily or weekly comparisons are relevant.
→ Fluctuations indicate process variations that can be eliminated

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In addition to the OEE key figure, the reasons for losses must also be recorded for a targeted improvement process

OEE key figure vs. reasons for disruption

OEE key figure

> Key figure for equipment productivity. Allows – together with further information – a judgement as to whether an equipment is running productively or not.

Reasons for losses

> Causes for the losses. Enables the targeted improvement of equipment productivity.

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OEE optimisation is usually done through CIP workshops together with the employees

Phases and objectives of an OEE improvement workshop

| Phase	**1** Qualification	**2** Analysis	**3** Optimisation	**4** Validation
Target	– The concept of OEE is well known* – The aim of the workshop is understood	– The baseline as the initial situation is measured – The levers for optimization are identified	– The prioritized measures have been implemented	– The success of the implemented measures is measured in a before-after comparison
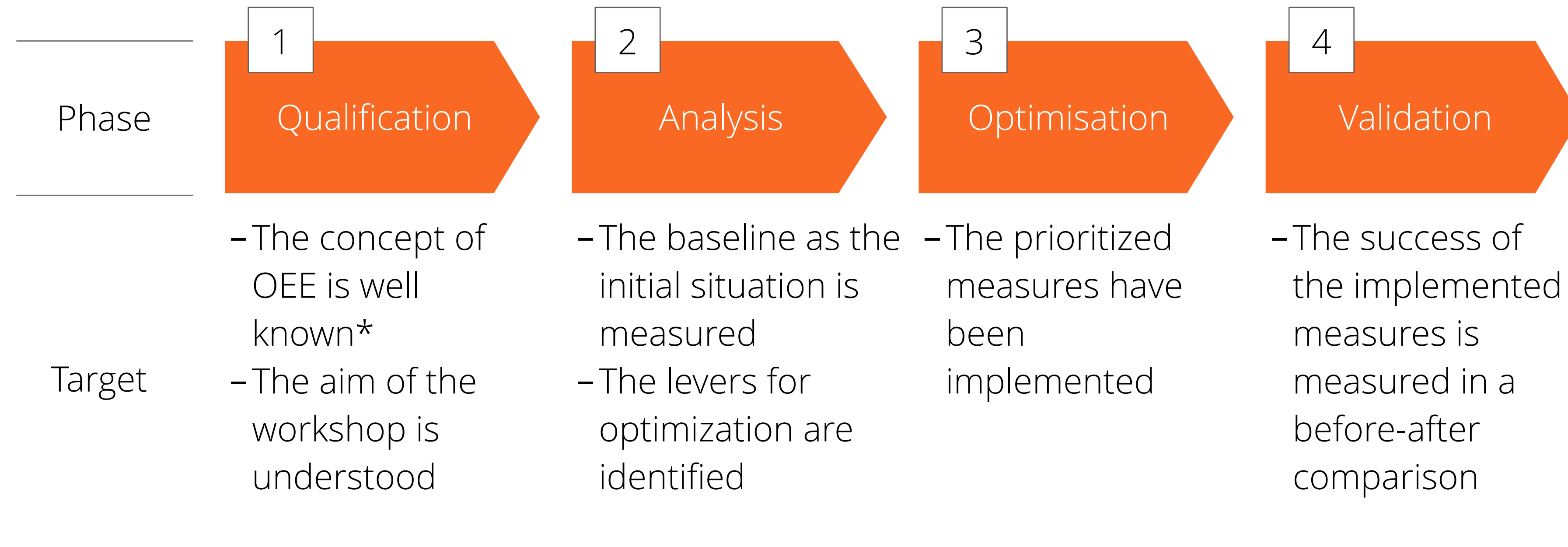
* For example, through this course

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OEE optimisation through workshops with experts from the production environment; diverse composition advantageous

Participants of an improvement workshop

Production planner

Master

Equipment planner
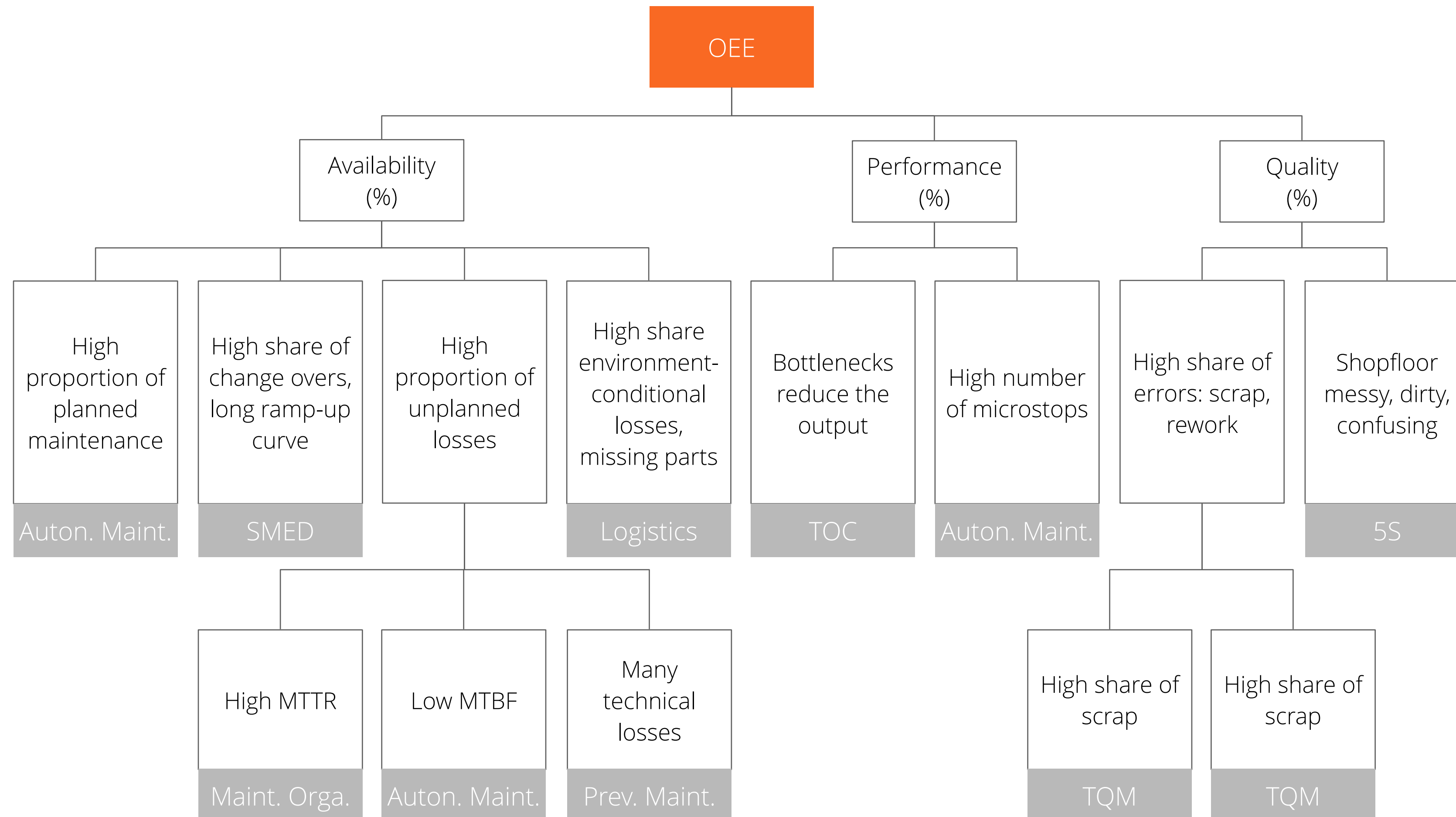
Facilitator

Production employee

Maintenance staff
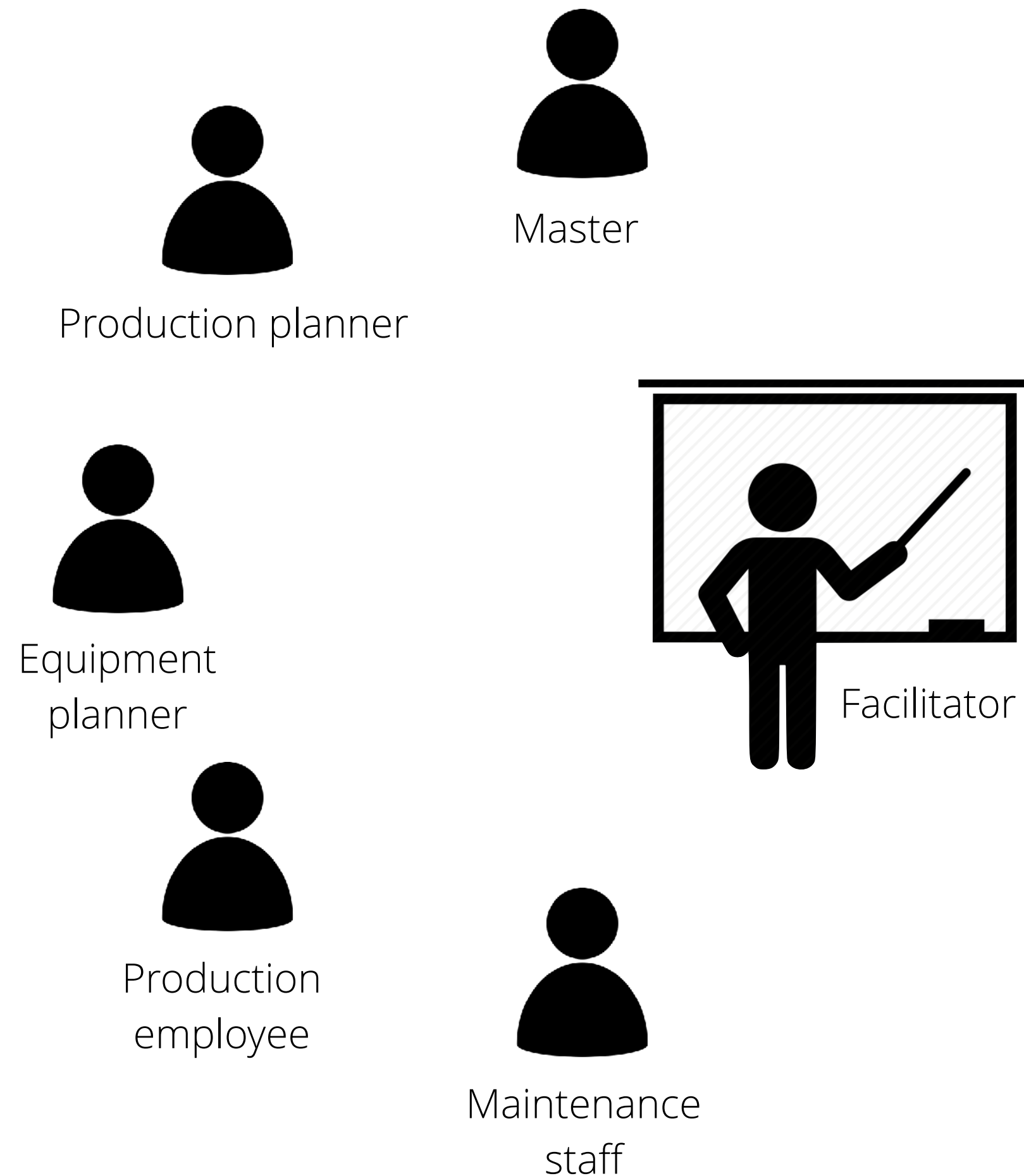
- Facilitator should have a technical background in Industrial Engineering or Lean Production
- Best results are achieved when participants are 100% dedicated to the task during the workshop
  → No distraction by day-to-day business
- Workshops can also take place over several weeks
- Presentation of results by the employees

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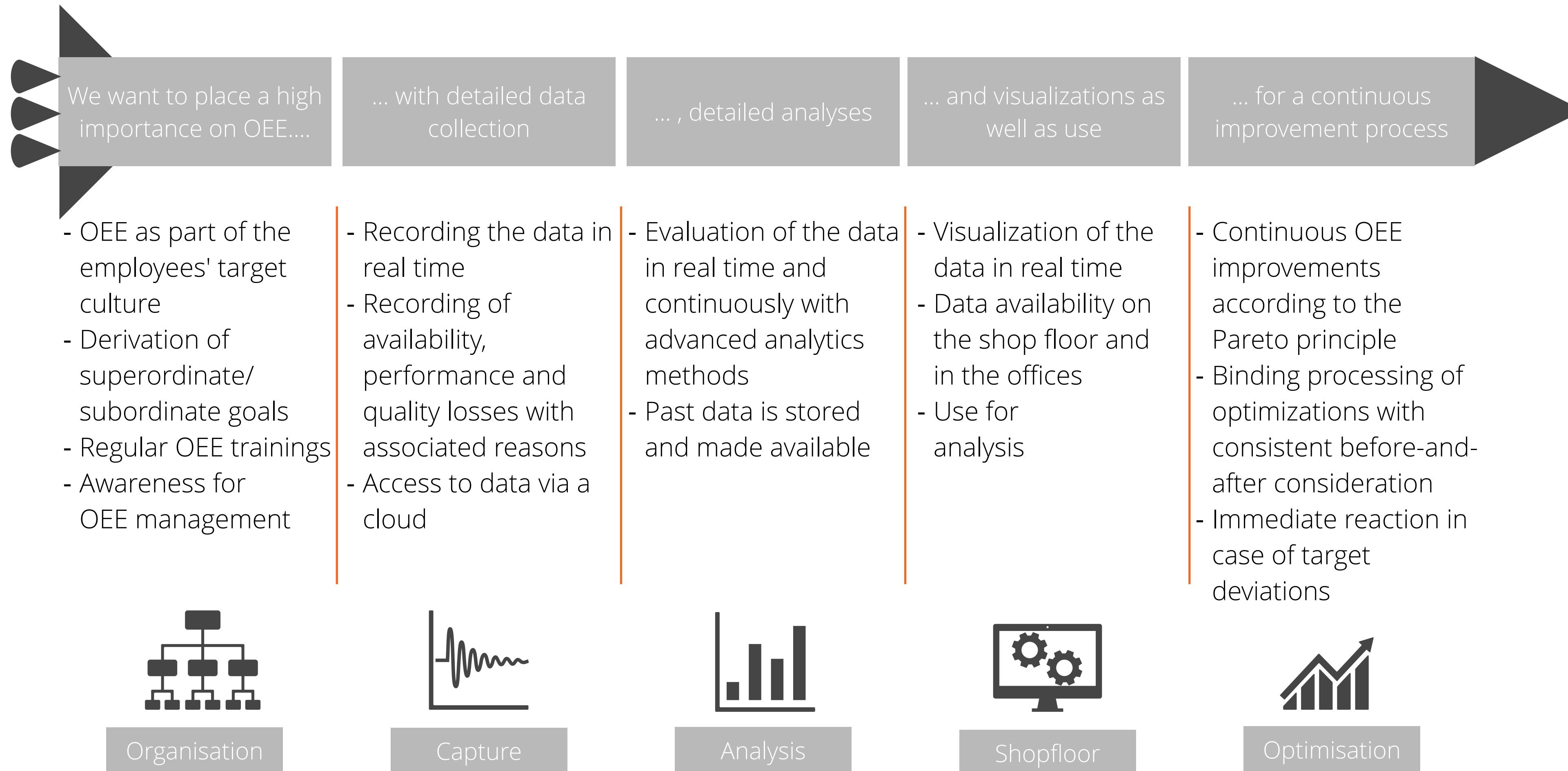# OEE loss tree with possible optimization approaches and methods

Derivation of OEE increase measures, loss tree


```
                                    OEE
          ┌──────────────────────────┼──────────────────────────┐
    Availability                Performance                   Quality
       (%)                         (%)                          (%)
  ┌──────┬──────┬──────┐      ┌──────────┐            ┌──────────────┐
```

| High proportion of planned maintenance | High share of change overs, long ramp-up curve | High proportion of unplanned losses | High share environment-conditional losses, missing parts | Bottlenecks reduce the output | High number of microstops | High share of errors: scrap, rework | Shopfloor messy, dirty, confusing |
| Auton. Maint. | SMED | | Logistics | TOC | Auton. Maint. | | 5S |

| High MTTR | Low MTBF | Many technical losses |
| Maint. Orga. | Auton. Maint. | Prev. Maint. |

| High share of scrap | High share of scrap |
| TQM | TQM |

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The vision of OEE management provides a north star which serves as orientation for companies

Vision of OEE Management

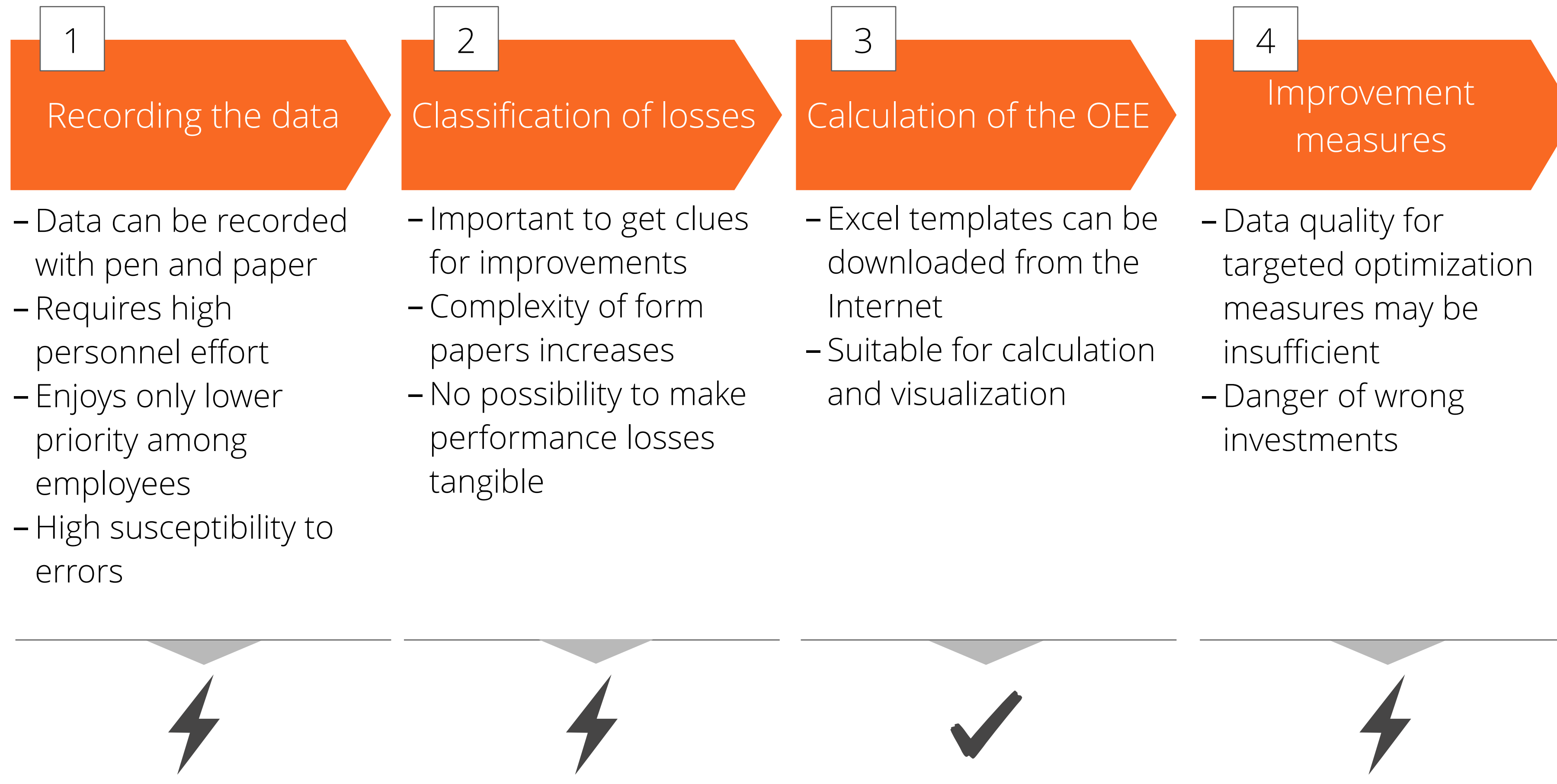| We want to place a high importance on OEE….	… with detailed data collection	… , detailed analyses	… and visualizations as well as use	… for a continuous improvement process
- OEE as part of the employees' target culture - Derivation of superordinate/ subordinate goals - Regular OEE trainings - Awareness for OEE management	- Recording the data in real time - Recording of availability, performance and quality losses with associated reasons - Access to data via a cloud	- Evaluation of the data in real time and continuously with advanced analytics methods - Past data is stored and made available	- Visualization of the data in real time - Data availability on the shop floor and in the offices - Use for analysis	- Continuous OEE improvements according to the Pareto principle - Binding processing of optimizations with consistent before-and-after consideration - Immediate reaction in case of target deviations
Organisation	Capture	Analysis	Shopfloor	Optimisation

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Manual data collection and evaluation via Excel is ok for one-off calculations – not for ongoing management

Process of manual data entry and Excel OEE capturing

1 Recording the data	2 Classification of losses	3 Calculation of the OEE	4 Improvement measures
– Data can be recorded with pen and paper – Requires high personnel effort – Enjoys only lower priority among employees – High susceptibility to errors	– Important to get clues for improvements – Complexity of form papers increases – No possibility to make performance losses tangible	– Excel templates can be downloaded from the Internet – Suitable for calculation and visualization	– Data quality for targeted optimization measures may be insufficient – Danger of wrong investments

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Artificial intelligence is able to automatically generate OEE optimisation approaches

OEE optimisation with artificial intelligence

Accumula-tions	Event/duration by period (day, hour, shift)	D: Fault A occurs more frequently between 08:00 and 09:00 P: We expect more short shutdowns today from 21:00 onwards
	Event/duration after event (weekend, maintenance, …)	D: Fault B occurs increased after weekend shutdown P: 600 hours after maintenance we expect a failure
	Event/duration by product	D: The fault C occurs at an increased level in product D P: The production program of the late shift will have - 4 % OEE
Inter-relationships	Consequential disorder	D: Fault E occurs after 5,500 hours/rev P: We expect a fault 7 minutes after restart with 82 % probability
	Probability at the time	D: Disorder F occurs at an increased rate after disorder G P: The current probability of subsequent disorder H is 14
Cyclicality	Probability	D: The fault H occurs with X % probability every Y to Z minutes P: A standstill in 5 minutes has a probability of 82%.
Trends	Trend reversal	D: Set-up times decreased until mid-May, stable since then P: With increasing set-up times we expect more short shutdowns
	Seasonality	D: In Q4, production lots are 8% smaller than in the rest of the year P: We expect more short shutdowns with higher humidity from October onwards
Events	Start/end set-up	D: The set-up process took 32 minutes, including start-up and shut-down.
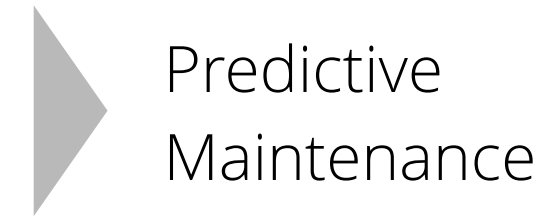
Predictive Maintenance

Cycle time optimization via artificial intelligence

1.

```
         _NAME"     "COMB_MESSAGE"   "RSNANNO"
"          LIT_MESSAGE" "MTEXT" "RSNUSER"        "TIME
        "ID"    "AL_CLASS"      "TIME_RECOGNITION"
          55591        38945   2020-01-13 06
          "320HA01_.0330"                 "320HA01_.0330
#"-MA01":Textliste: Text nicht projektiert, Langsame (
angewählt ;"               2020-01-10 11:21:55.0   5
                             "M - Meldung"
          55597        38945   2020-01-13 06
          "320HA01_.0330"                 "320HA01_.0330
#"-MA02":Textliste: Text nicht projektiert, Langsame (
angewählt ;"               2020-01-10 11:21:55.0   5
                             "M - Meldung"
          56194        38966   2020-01-13 06
0         "320HA01_.00"                   "320HA01_.00"
RLOOP_5:Transportauftrag storniert @OP: SAP_CCALL @TX
15:28:08.0     5       "W - Warnung"    3005778978
          1921         38929   2020-01-11 06
0         "320HA01_.03"                   "320HA01_.03"
NSTOERUNG:Entladestörung @OP: UNLOADING_FAULT"
Systembedingte Störung Entsorgung"       3005800926
Systembedingte Störung Entsorgung"
          2038         38947   2020-01-11 06
          "320HA01_.0332"                 "320HA01_.033:
#"+CW001":Fluss zu niedrig ;"             2020-01-11 03
Störung"       3005925618      7
          2038         38946   2020-01-11 06
          "320HA01_.0331"                 "320HA01_.033:
#"+CW001":Fluss zu niedrig ;"             2020-01-11 03
Störung"       3005925684      7
          2038         38948   2020-01-11 06
          "320HA01_.0333"                 "320HA01_.033:
#"+CW001":Fluss zu niedrig ;"             2020-01-11 03
Störung"       3005925746      7
          12           38929   2020-01-11 06
          "320HA01_.03"                   "320HA01_.03"
+ST480+SD001":Schutztuer Anforderung Zutritt ;"
Organisatorische Störung"       3005959828      8
Störung"
          138          38929   2020-01-11 06
          "320HA01_.03"                   "320HA01_.03"
+ST480+SD001":Schutztuer offen (Zwangsoeffnung) ;"
          "O - Organisatorische Störung"  3005959909
Organisatorische Störung"
          156          38929   2020-01-11 06
          "320HA01_.03"                   "320HA01_.03"
t alle FGs in der SG auf AUT START ;"          2020-(
```
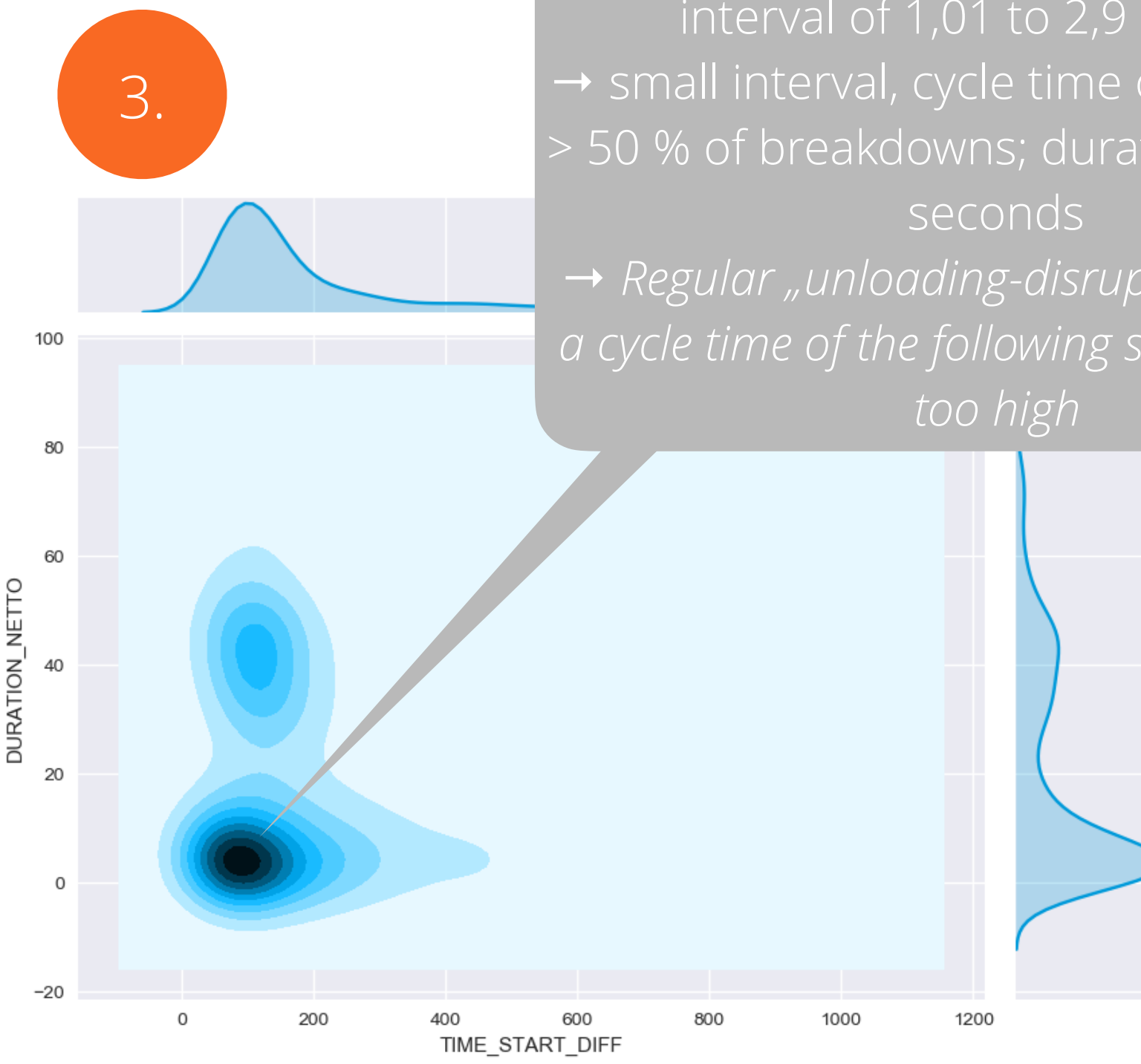
2.

ZYKLIZITÄT

```
>>>>> #SG03_@OP: UNLOADING_FAULT

OPTICS 75%
Total records: 4168.0 | interval of the
data(sec): 61.0 - 150574.0
*** Interval of the class(sec): 61.0 -
692.0 ***
 0.0     0.819534
-1.0     0.180466
Name: OPTICS_CLASS_HIGH, dtype: float64


OPTICS 50%
Total records: 4168.0 | interval of the
data(sec): 61.0 - 150574.0
*** Interval of the class(sec): 61.0 -
174.0 ***
 0.0     0.564675
-1.0     0.435325
Name: OPTICS_CLASS_MED, dtype: float64
```
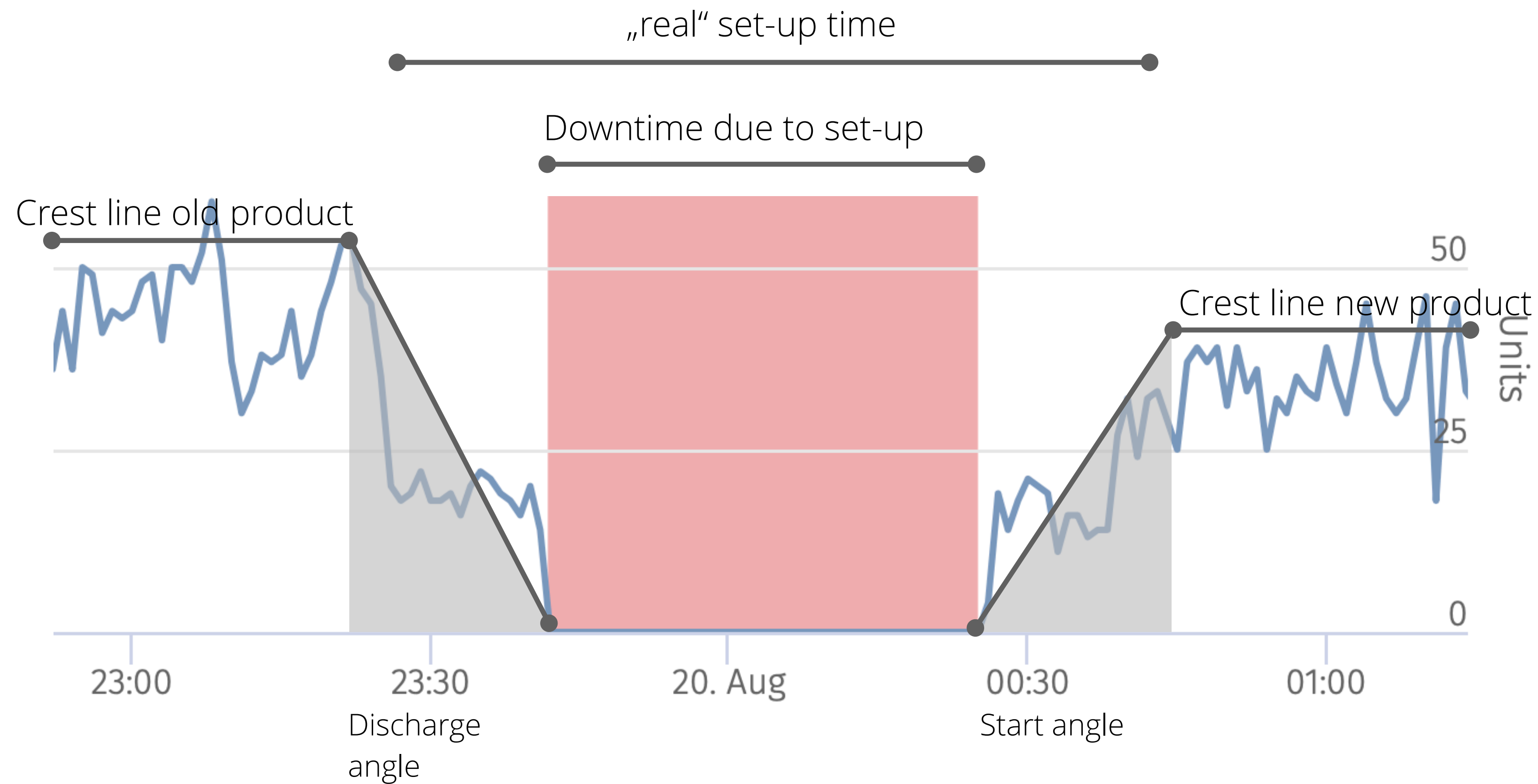
3.

56 % of breakdowns return in a time interval of 1,01 to 2,9 minutes
→ small interval, cycle time of 61 seconds, > 50 % of breakdowns; duration-focus at 4 seconds
→ *Regular „unloading-disruptions" point to a cycle time of the following station which is too high*

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Artificial intelligence can be used to analyse set-up behavior in order to identify potential for improvement

Setup optimisation by means of artificial intelligence,
extended setup understanding according to VDMA 8743

"real" set-up time

Downtime due to set-up

Crest line old product

Crest line new product

Units

50

25

0

23:00   23:30   20. Aug   00:30   01:00

Discharge angle

Start angle

VDMA 8743
Source: Bitkom https://www.bitkom.org/Bitkom/Publikationen/Mit-KI-koennen-produzierende-Unternehmen-die-Anlagenproduktivitaet-steigern

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Social Manufacturing improves motivation and thus self-management at the shopfloor – motivation substitutes disciple partly
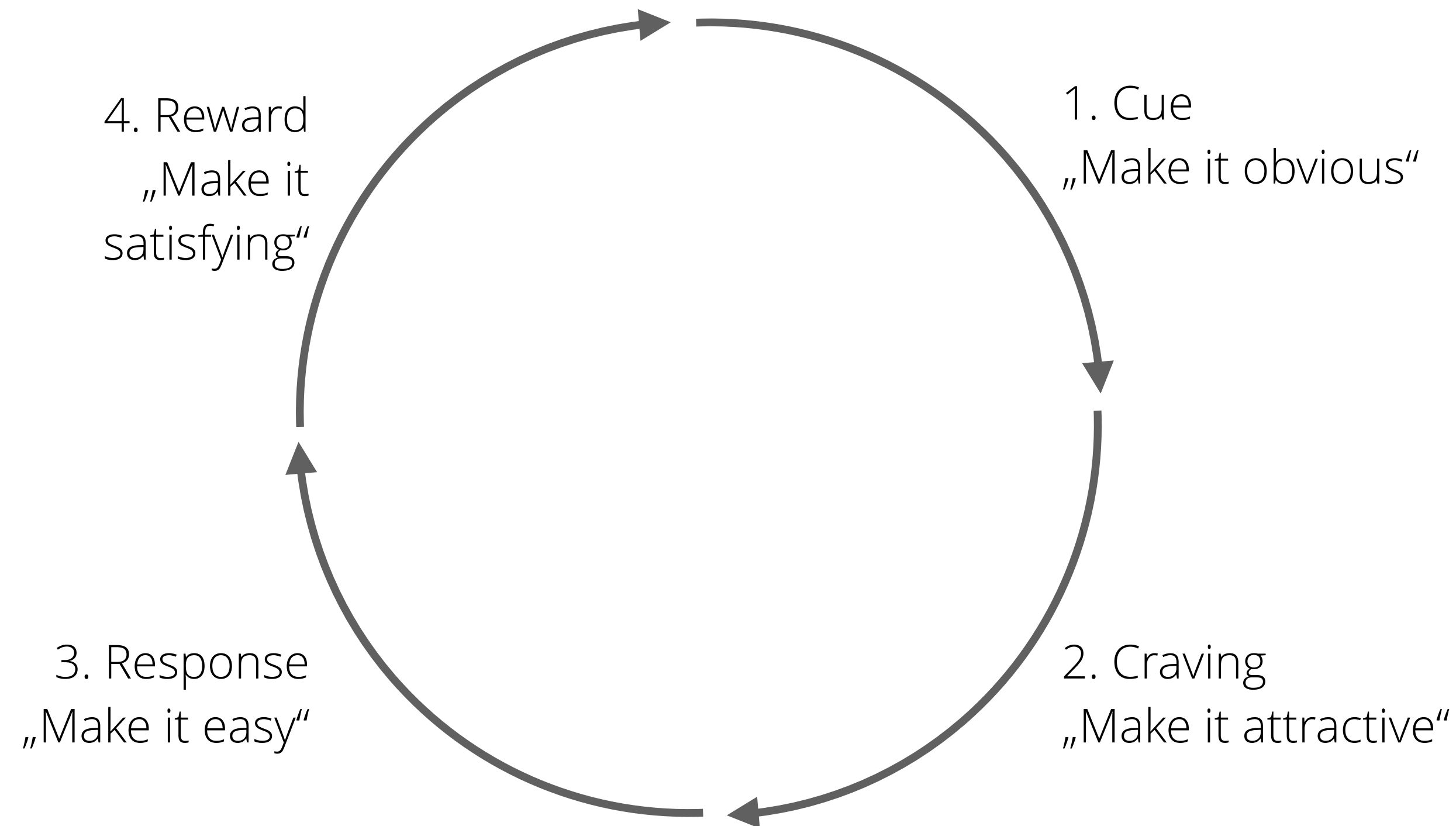
Objective of Social Manufacturing

Objective: Increase intrinsic motivation of operators by human-focused-design* to enable self-management and increase workplace satisfaction

Total level necessary to achieve results

Discipline

Motivation

Phases of operator work environments

Original Lean

Lean @ western world

Social manufacturing
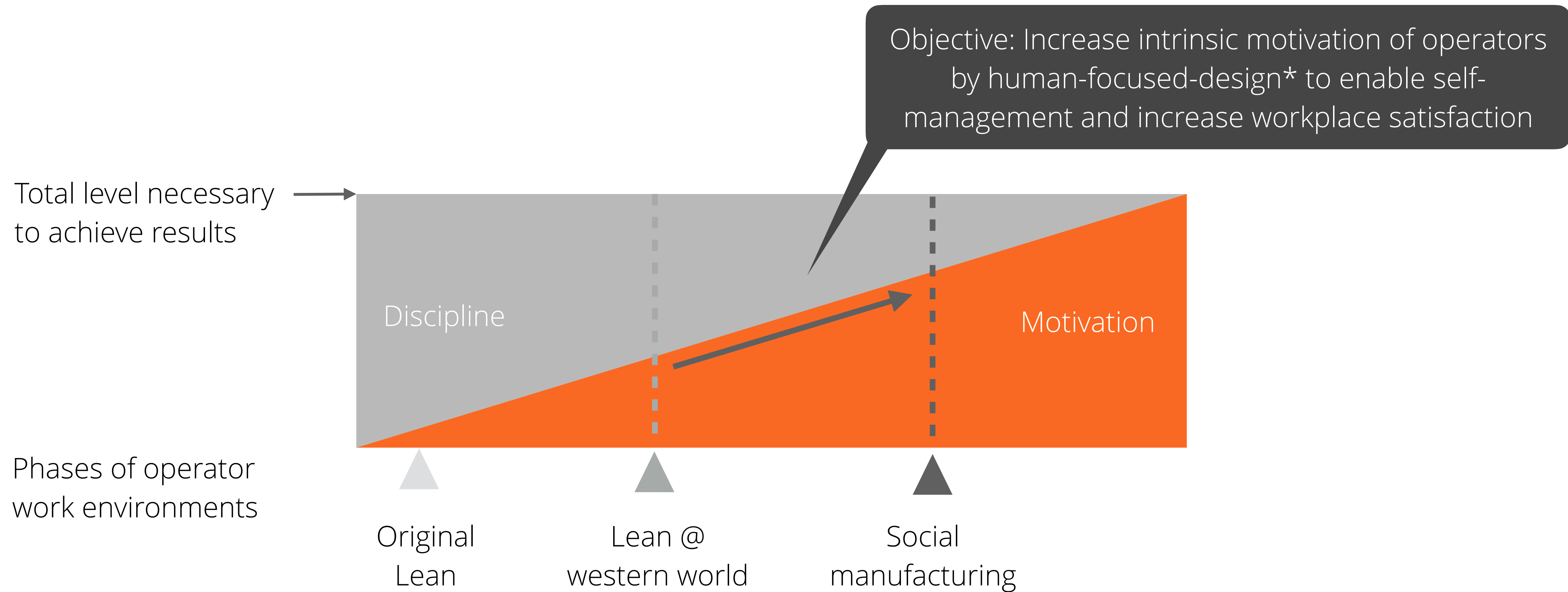
* Opposite: Function-focused-design

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To promote desired behavior on the shopfloor, the four steps of behavioral change have to be applied

Four Steps of Behavioral Change

– For enduring behavior, an *immediate* sense of achievement is necessary

4. Reward
„Make it satisfying"

1. Cue
„Make it obvious"

– Every activity starts with a trigger
– We are more likely to perceive conspicuous trigger

– Reduce the effort involved in good behavior
– When the effort is little, the behavior is easy

3. Response
„Make it easy"

2. Craving
„Make it attractive"

– The more attractive something is, the more likely it is executed
– Attractive is recognition, respect, praise
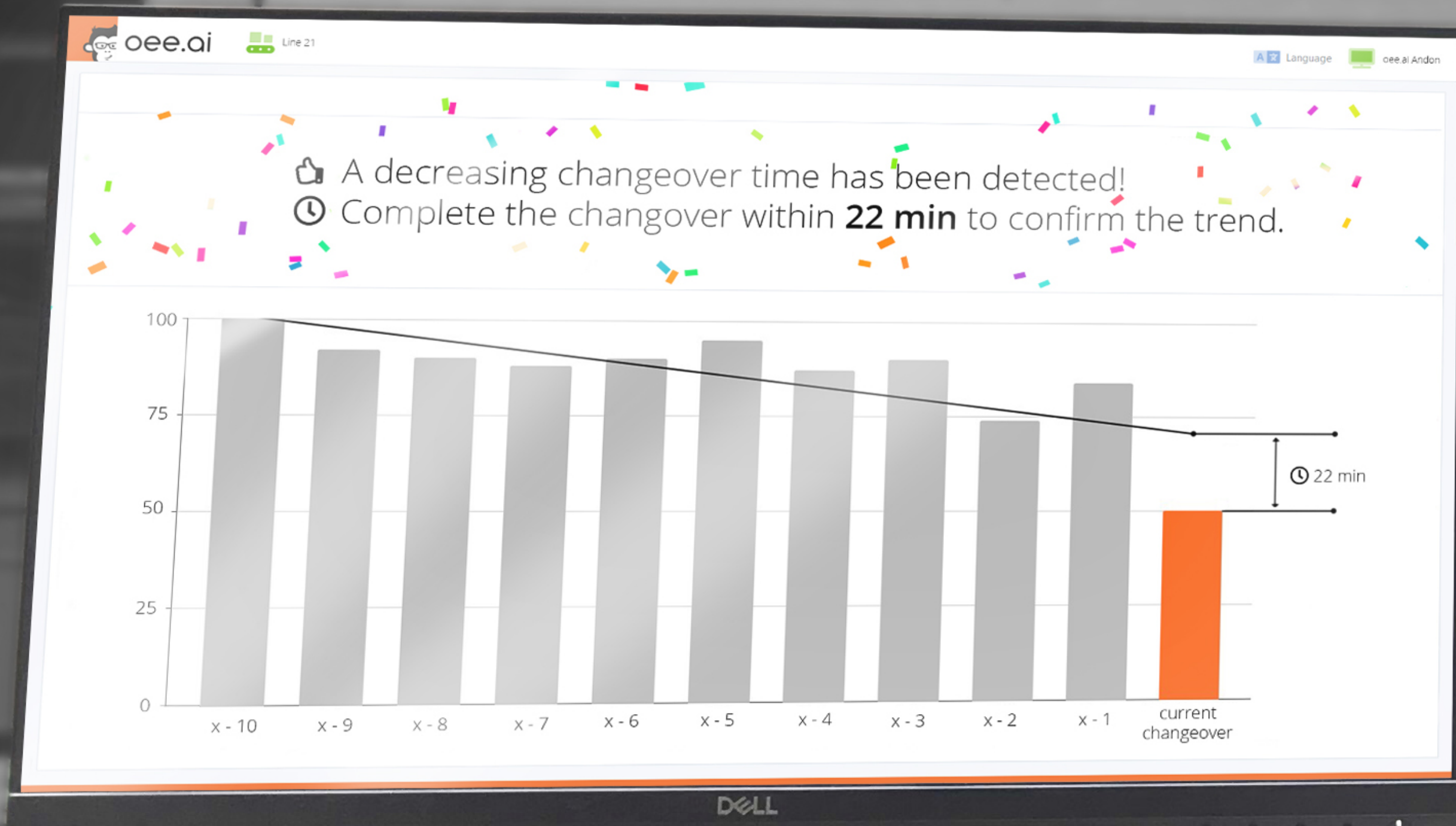
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MES are currently in the process of being replaced; more modern, flexible architectures modeled on apps are taking over the market

IT infrastructure

Manufacturing Execution System (MES)	Industrial Internet of Things- (IIoT-) Platform	MES Apps
– Also production control system – Control of production as a centralised system – Includes production data acquisition (PDA), machine data acquisition (MDA) and personnel data acquisition, if applicable, – Integration effort for each individual machine – Often old, expensive IT	– Collection of applications that in total map an MES functional scope (and more) – Modern, scalable software architecture – Integration effort for each individual machine	– Specific application that focuses on a specific/ the most beneficial use cases – Modern, scalable software architecture – Can include hardware and software components – Can be installed via Plug & Play
e.g. Forcam, proAlpha	e.g. Tulip, Cybus	e.g. oee.ai

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Increase plant productivity with oee.ai. fast and simple.

oee.ai is a system for Overall Equipment Effectiveness (OEE) analysis in manufacturing processes. With oee.ai, the OEE and the causes of its loss can be recorded and analyzed in detail without intervention in the plant control system, without IT effort and without investment.

The data based analyses and visualizations enable the plant operator to identify causes and use the information gained to increase plant productivity.

oee.ai is a start-up from the university city of Aachen. Since our foundation in 2016, we have grown to almost 15 employees by now. With satisfied customers, we have over 300 installations all over the world.

Our solutions are based on software-as-a-service. we are not an IT project, but rather a minimally invasive plug and play solution that is immediately usable

We love productivity! Fast and simple

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plug&play
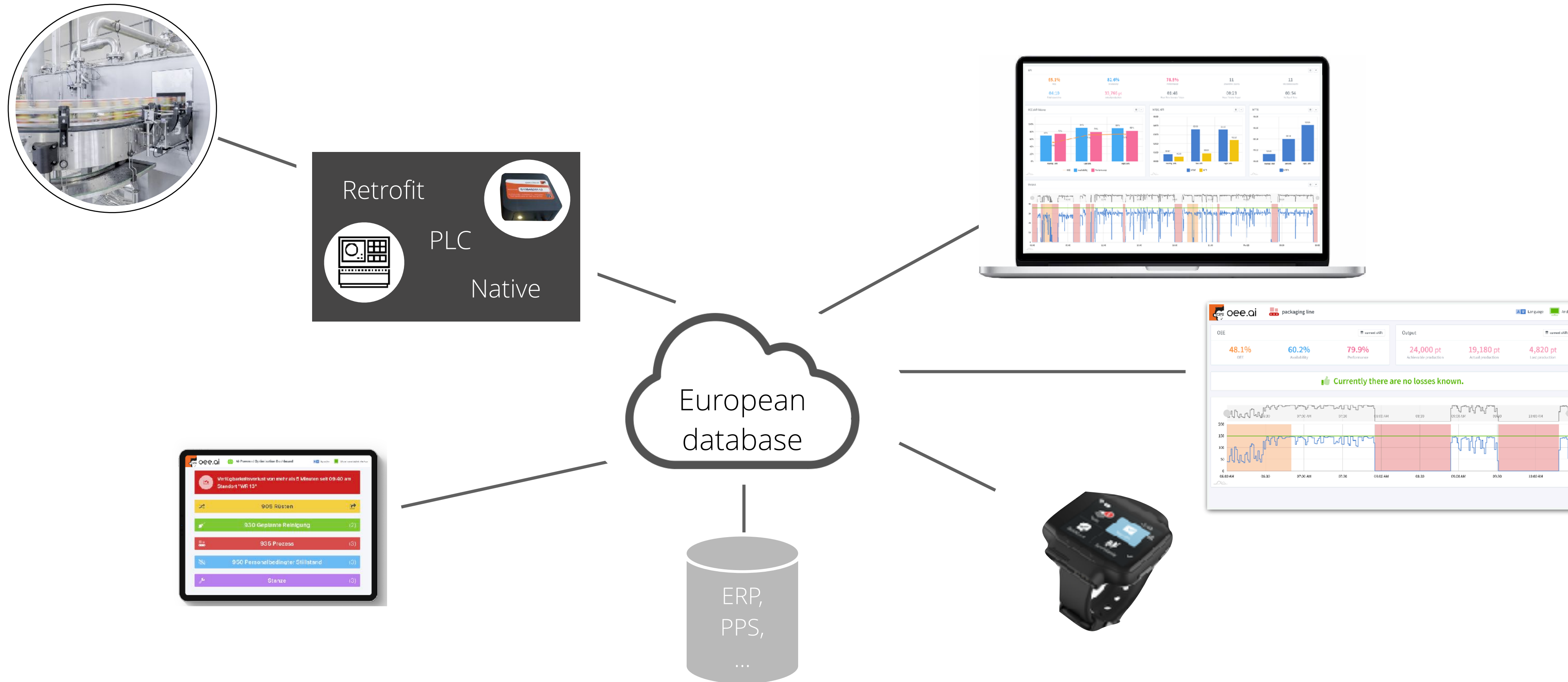manufacturing
intelligence

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oee.ai captures productivity data in a minimally invasive way and evaluates it in the cloud

Manufacturing Analytics Technology

Data collection

Data usage

Retrofit

PLC

Native

European database

ERP, PPS, ...

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Visualization of machinery performance in real time: Output, OEE, breakdowns..

Reports in real time

- Reports are created customer-specifically
- Widgets define data sources and display format
- Data is available in every browser in real time
- All losses, A, P, Q, can be analyzed in detail

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In case of questions – just ask!

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presented on:

PLATTFORM
INDUSTRIE4.0

Lernende Systeme
DIE PLATTFORM FÜR KÜNSTLICHE INTELLIGENZ

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