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Computer Simulation of Logistics Processes

Basic terms of computer simulation

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Basic terms of computer simulation

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Structure of the lecture

- **General information**
  - Organization of the course, lectures and exercises.
  - The aim of the course, previous and follow-up courses.
  - Completion of the course, required outcomes.
  - Literature.
- **Basic terms of computer simulation**
  - System, system approach, process, bottleneck.
  - Logistics, time funds of production facilities, facility takt, production capacity.
  - Pauses and shift calendar.
  - Facility availability, continuous workload time.
  - Kanban, JIT, JIS.
  - Data analysis.
  - Toyota production system, seven types of waste.

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Organization of the course

Topic	Time schedule
1. Basic terms of computer simulation	Lecture 1
2. Fundamentals of computer simulation	Lecture 2
3. Methodology of the simulation project	Lecture 3
4. Plant Simulation software	Lectures 4-8
5. Programming in SimTalk	Lectures 9-11
6. Invited lecture (representative of Logio)	Lecture 12

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The aim of the course, previous and follow-up courses.

- **The aim of the course** is to introduce computer simulation as a modern tool to support management decision-making.
- Further, the aim of the course is to introduce the students to work with one of the simulation software (PlantSimulation 16). The presented examples are focused mainly on the automotive industry and thus correspond to the real situation in ŠKODA AUTO a.s. with a certain degree of abstraction. Each example pursues one of the key objectives: maximizing utility, minimizing input costs, stabilizing production, verifying the functionality of the concept.
- **Previous and follow-up courses**. The course is related to the course "Operational Research I" and it is a methodological basis for computer simulation. It is followed by the course "Modelling of Production and Logistics Systems" in the follow-up Master's degree programme.

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Completion of the course

- **Evaluations**
  - Active participation at exercises and tutorials – max. 10 points
  - Semestral work (team, max. 3 members) – max. 20 points
  - Continuous e-test – max. 10 points
  - Final e-test – max. 35 points
  - Verbal exam – max. 25 points
- **Total evaluation**
  - (1) 90+
  - (2) 75 – 89
  - (3) 60 – 74
  - (4) <60

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Literature

- BANGSOW, S. Tecnomatix plant simulation: modeling and programming by means of examples. Springer Nature, 2020. 816 s. ISBN 978-3-030-41543-3.
- BANGSOW, S. Manufacturing simulation with Plant Simulation and SimTalk: usage and programming with examples and solutions. Berlin: Springer, 2010. 297 s. ISBN 978-3-662-51912-7.

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Problem

- A problem is a situation formulated by a subject that requires a solution for subjective or objective reasons with a defined objective. The problem-solving process is not a routine, so the solver must use informational, creative, evaluative, decision-making, and executive activities to solve it.
- A problem is the subject‘s formulation of the essential elements of the problem situation that requires a solution.
- A problem situation is a non-standard situation, different from a routine situation, in that its solution requires the use of activities other than routine, i.e., familiar activities.

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System, system approach

- System
  - System is a purpose-defined set of elements and links between them, which exhibit, as a whole, certain characteristics, virtually behavior.
  - System is an abstract object, purposefully created in the consciousness of people in relation to a primary object, in order to solve a specific problem on this object.
- System thinking (approach)
  - The first and the most important criterion of systems thinking is the movement from the parts to the whole.
  - System thinking is always about processes.
  - The typical approach of the system is that it rejects the optimization of parts and tries to optimize it as a whole.

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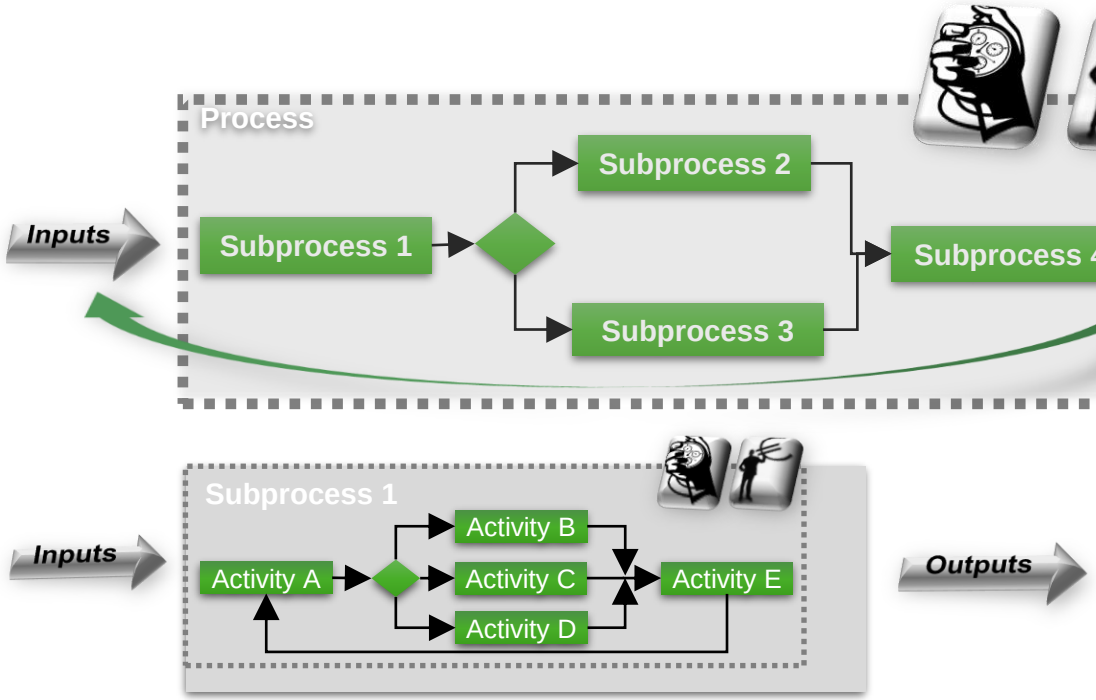
Process

- A process is a set of interrelated activities that create some new value in the form of output for subsequent processes as well as for the end customer.
- A process is a set of activities that transform inputs into outputs.



Process properties:

- input and output,
- boundedness,
- repeatability,
- has an owner,
- measurability.

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Types of processes

- **Main/Core/Primary process**
  - It creates the main added value to satisfy the needs of the external customer, i.e. the core business.
- **Support process**
  - It provides inputs for an internal customer in the company, its exclusion will affect the operation of the main process.
- **Secondary process**
  - It can be intended for an external customer or for an internal customer, but its output can be provided externally without affecting the operation of the main process.

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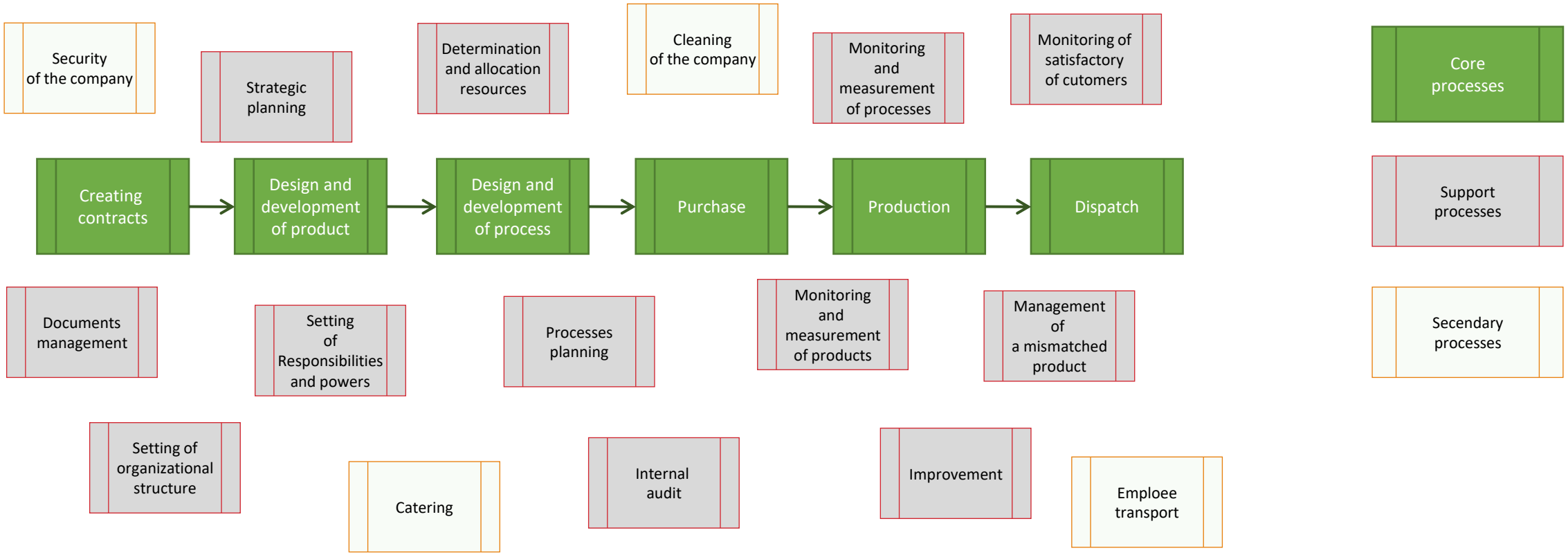
Process map



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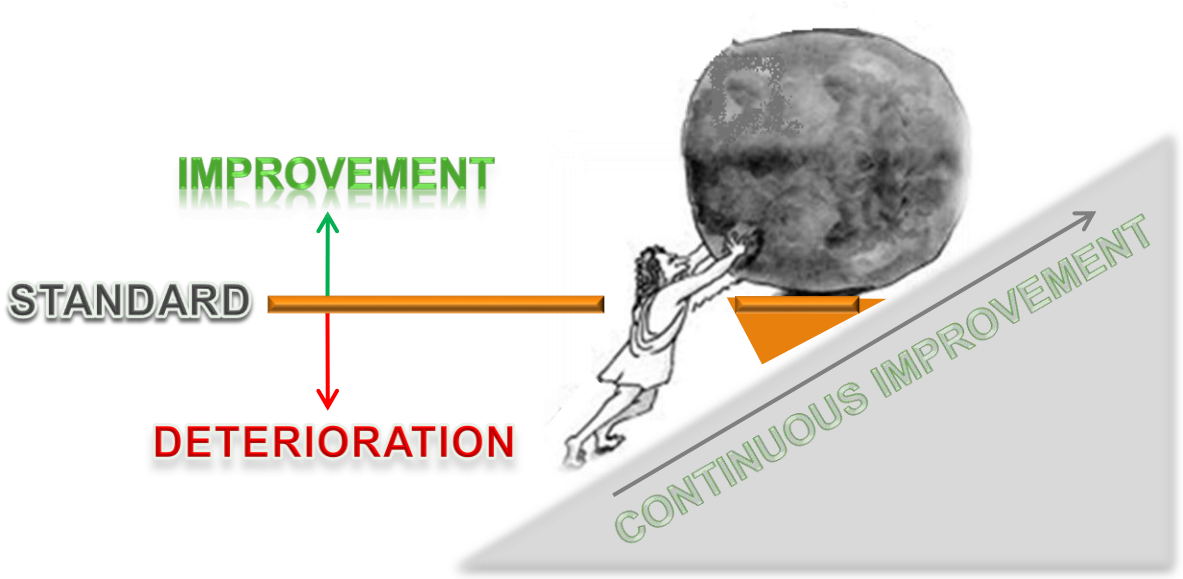
Monitoring of processes

- **Standardization**
  - Standards setting.
- **Utilization of process**
  - Ability to achieve required results.
- **Efectiveness of process**
  - Achieved results vs. used sources.



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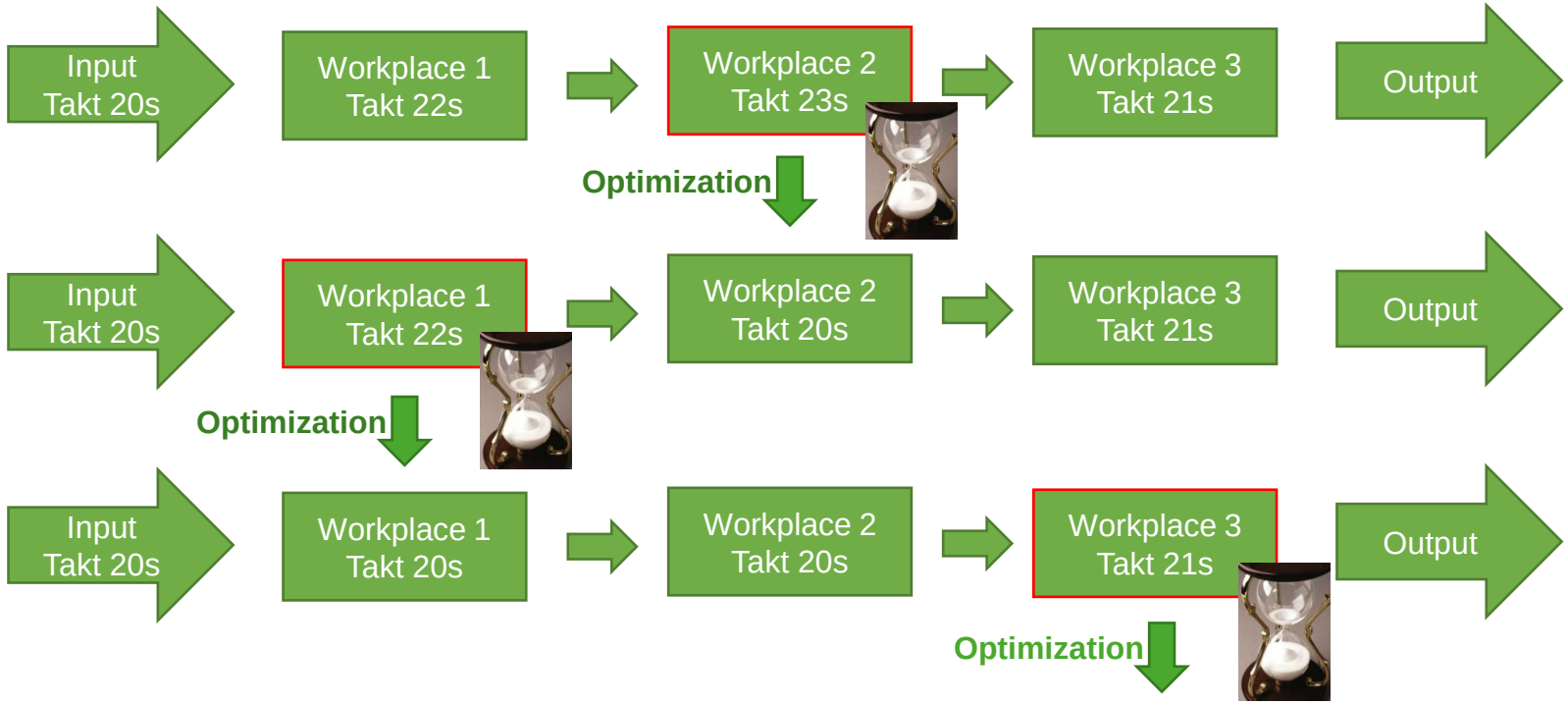
Bottleneck

- Operation, workplace, facility or zone that determine the performance of the system as a whole.
- In practice, we try to eliminate this bottleneck (speeding up the conveyor, reinforcing staff, building a parallel workplace, etc.). However, it is obvious that in such a case the bottleneck will then appear elsewhere in the system.



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Logistics

- Logistics is the science of coordinating the active and passive elements of an enterprise towards the lowest costs over time, improving the flexibility and adaptability of the enterprise to changing general economic conditions and the changing market.
- Logistics is the scientific discipline of planning, managing and controlling the movement of materials, people, energy and information in systems.
- The challenge is to make it available:
  - the right product,
  - in the right quantity,
  - in the right quality,
  - at the right time,
  - to the right place,
  - to the right customer,
  - at the right price (right cost).

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Logistics

- Logistics is the part of supply chain management that plans, implements and effectively and efficiently manages the forward and reverse flows and storage of goods, services and relevant information from the point of origin to the point of consumption to meet the customer needs.
- Typical managed activities include transportation, vehicle fleet management, warehousing, material handling, order fulfilment, logistics network design, inventory, supply and demand planning and management of logistics service providers.
- To varying degrees, logistics functions also include finding sources and purchases, production planning and scheduling, packaging and assembly, and customer service.
- It is involved in all levels of planning and execution - strategic, operational and tactical.
- Logistics management is an integrating function that coordinates and optimizes all logistics activities, as well as being involved in linking logistics activities with other functions, including marketing, manufacturing, sales, finance and information technology.

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Time funds of production facilities

- They are based on the need to define a planned number of time units within a certain period.
  - Calendar time fund F_K (number of hours according to the calendar).
  - Gross operating (nominal) time fund F_N (calendar time reduced by hours of weekend, state holidays etc.).
  - Net operating (usable) time fund F_E (nominal fund reduced by planned breaks).

$$F_E = d \cdot h \cdot s \cdot g \cdot \left(1 - \frac{z}{100}\right)$$

d – number of working days
h – number of hours in a shift
s – number of shifts per day
g – number of parallel workplaces
z – percentage of planned breaks

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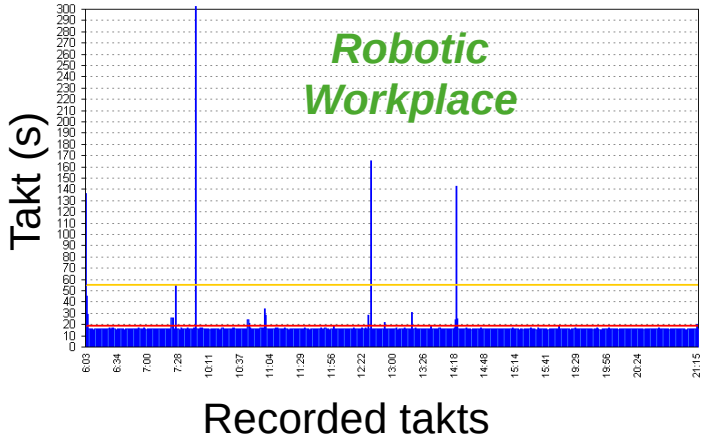
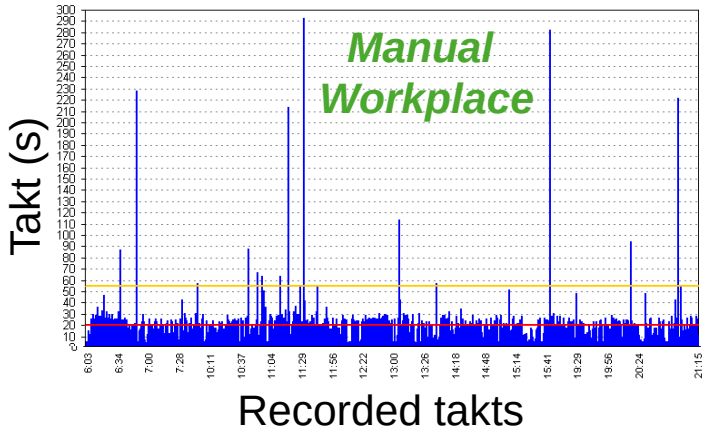
Facility takt

- The time between the completion of two consecutive products in production.
- The rate at which a customer takes products or services. Thus, it can be said that takt defines how fast the process has to go in order to meet the customer's requirements.
- We calculate it as the ratio of the available time (usable) to the number of units of products the customer requires.





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Production capacity

- It is the quantity that a production system is able to produce per unit time. A production system is thus represented by its capacity units. These can be machines, facilities, workers, workplaces, etc. In certain cases, a workshop, a plant, can be considered as a capacity unit.
- It can be characterized as the ability of an enterprise to produce a certain amount of products (or provide a certain amount of services). Production capacity is always related to a unit of time and under optimal conditions (fail-safe operation, sufficient amount of inputs, always available operators, etc.).
- Example of production capacity calculation:

$$VK = F_N \cdot N \cdot V$$

VK – production capacity,
F_N – nominal time fund,
N – number of time units of production facility,
V – the output of a production facility in material units per unit of time (i.e. capacity standard).

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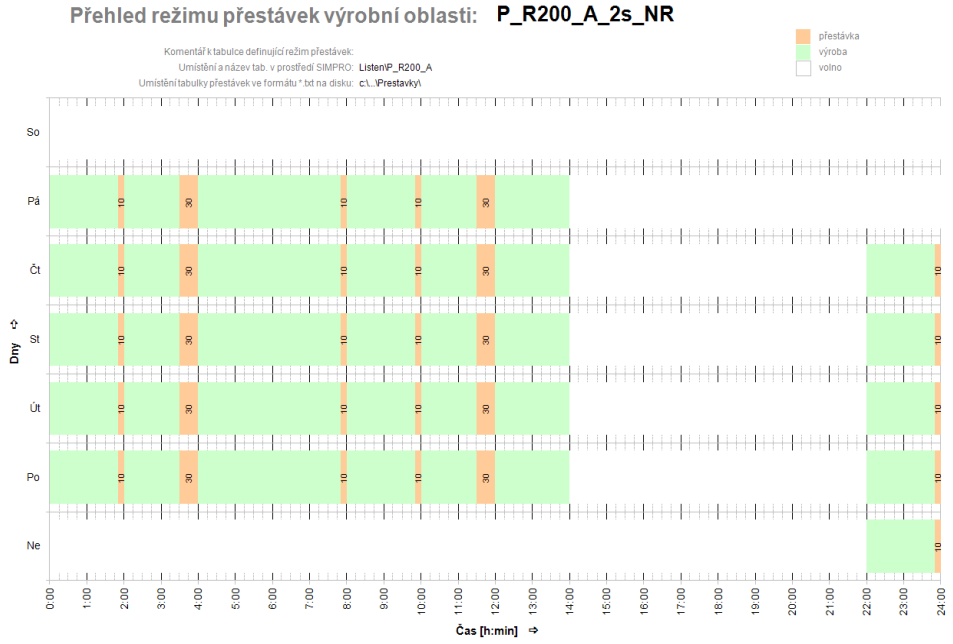
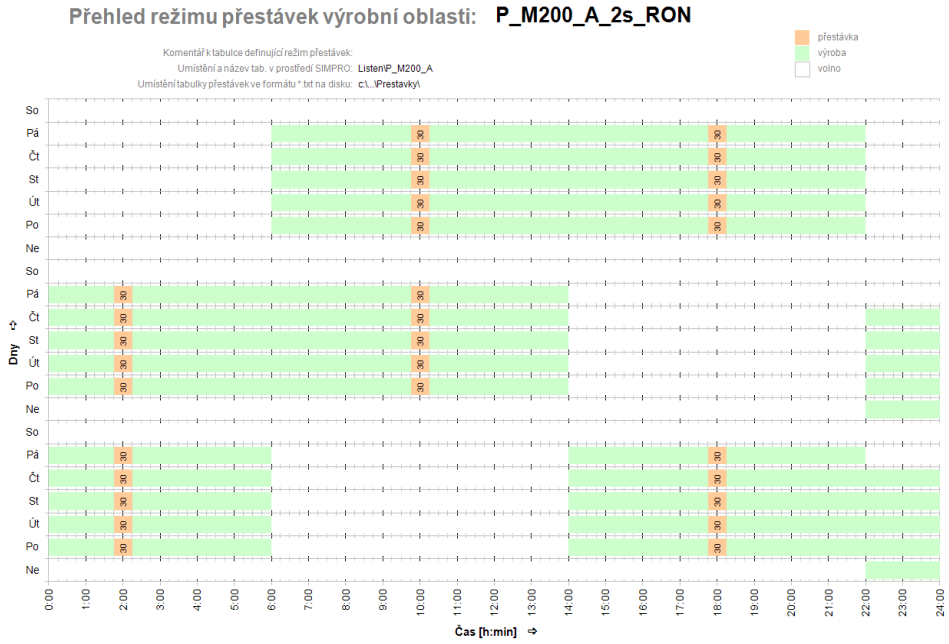
Pauses and shift calendar

- Pauses mode defines breaks during the working day. For the purpose of simulations, it therefore reduces the nominal time fund, i.e. the amount of time employees can work.
- Shift mode defines the possible rotations of each shift during a specified period. Thus, shifts can rotate in a two-shift system night-morning shift (left figure), morning-afternoon-night shift (right figure), three-week two-shift cycle, etc.





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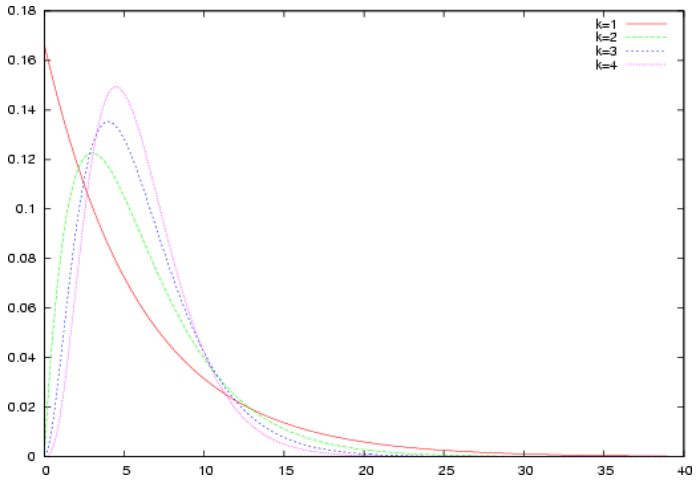
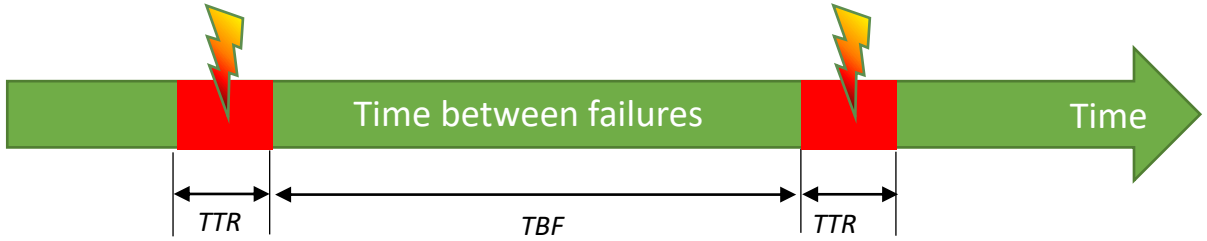
Availability

- In the real world, there are inefficiencies in the use of working hours. This is due to time breaks (both technical and organizational). For this reason, we must account for availability in our considerations.
- To calculate the failure time, the mean time between failures (*MTBF*) and mean time to repair (*MTTR*) of an object are used.
- This can be represented by the percentage availability (*A*). The negative exponential distribution is taken as the basis of the calculation for the *MTBF* and the Erlang distribution for the *MTTR*.



Density fuction of Erlang distribution



$$A = \frac{MTBF}{MTBF + MTTR} \cdot 100\ (\%)$$

A – Availability
$MTBF$ – Mean Time Between Failures
$MTTR$ – Mean Time To Repair

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Continuous workload time

- Continuous workload time is a time interval that starts at the moment the customer gives the product requirement and ends by dispatch of products to customers.
- Continuous workload of individual components of a production order consists of smaller parts such as:
  - Waiting time before processing (workplace is busy).
  - Handling and transport time (between workplaces).
  - Setup time.
  - Waiting time after processing.
  - Processing time.

  First 4 times are called as wasting times.

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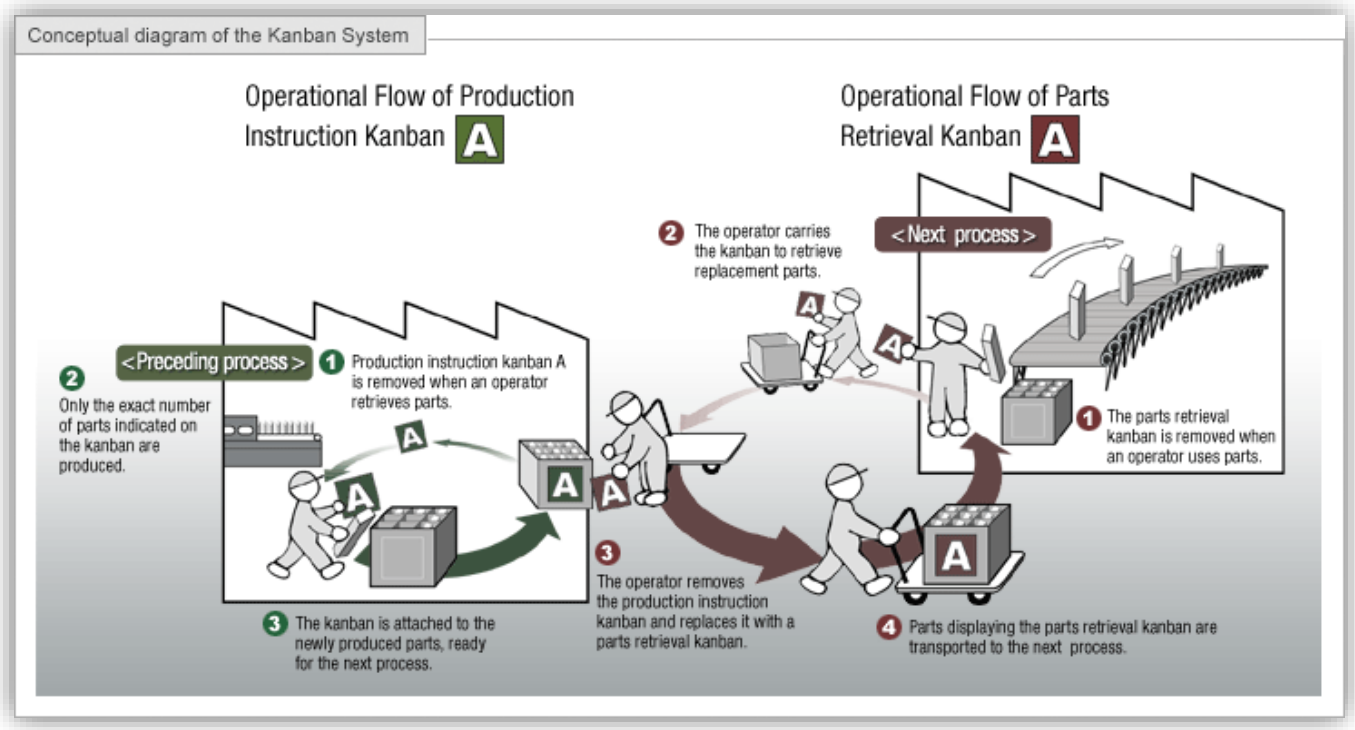
Production management – kanban

- In the system KANBAN (Japanese term), it is possible to divide on a workplace to sellers and buyers. Each seller is simultaneously buyer.



Source: http://www.toyota.com.cn/company/vision_philosophy/toyota_production_system/just-in-time.html, 2021

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Production management – JIT

- Produce only what is needed and as efficiently as possible - at the right time and in the right quantity.
- In the area of production, the philosophy is based on the following approaches:
  - planning and production to order (contract),
  - small batch production, delivering small quantities as late as possible,
  - very frequent deliveries (even several times during the day),
  - reducing the costs associated with holding stock,
  - quality assurance in production,
  - motivation of workers,
  - elimination of losses,
  - maintaining a long-term strategic line.

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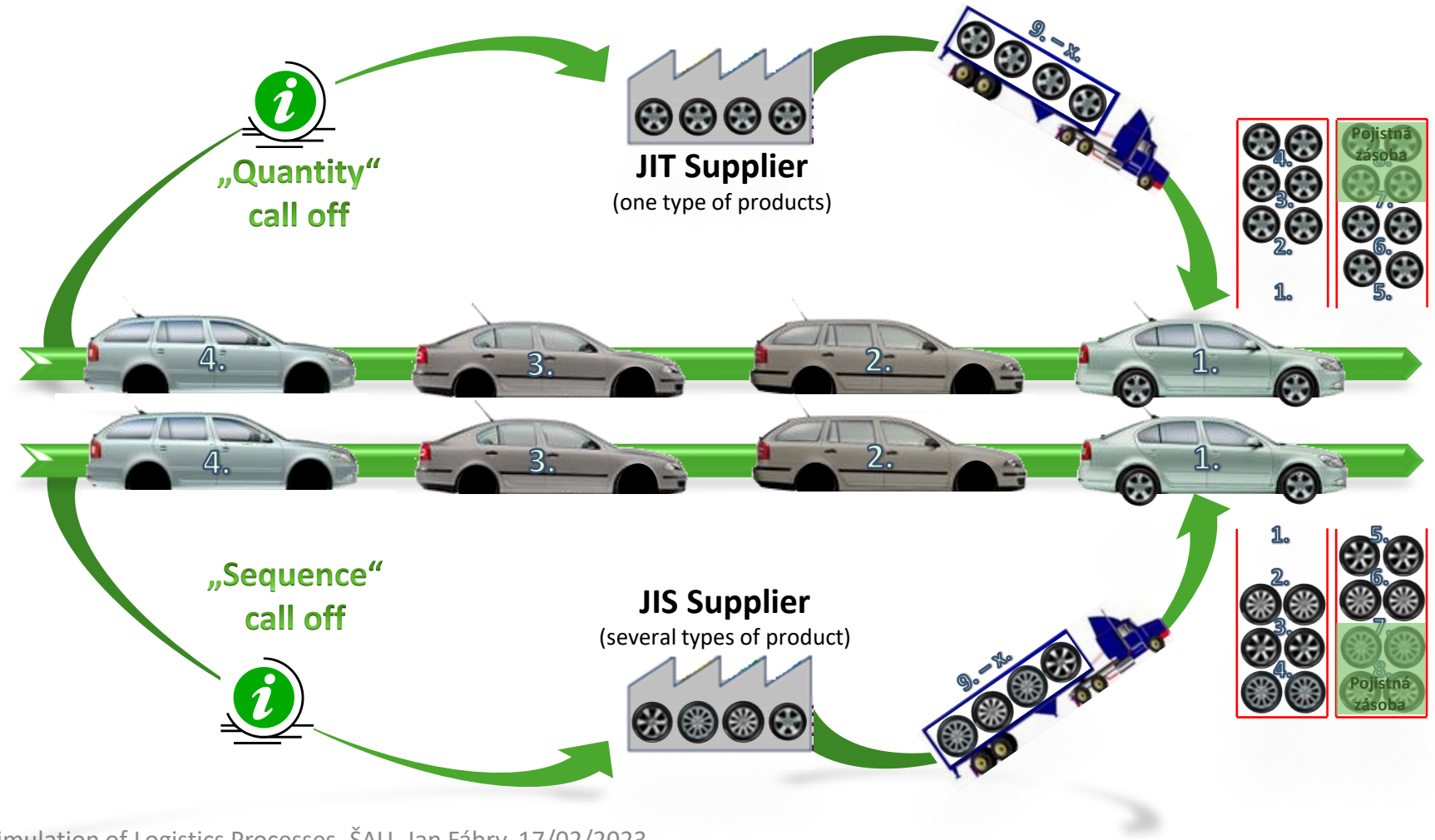
Just-in-Time vs. Just-in-Sequence



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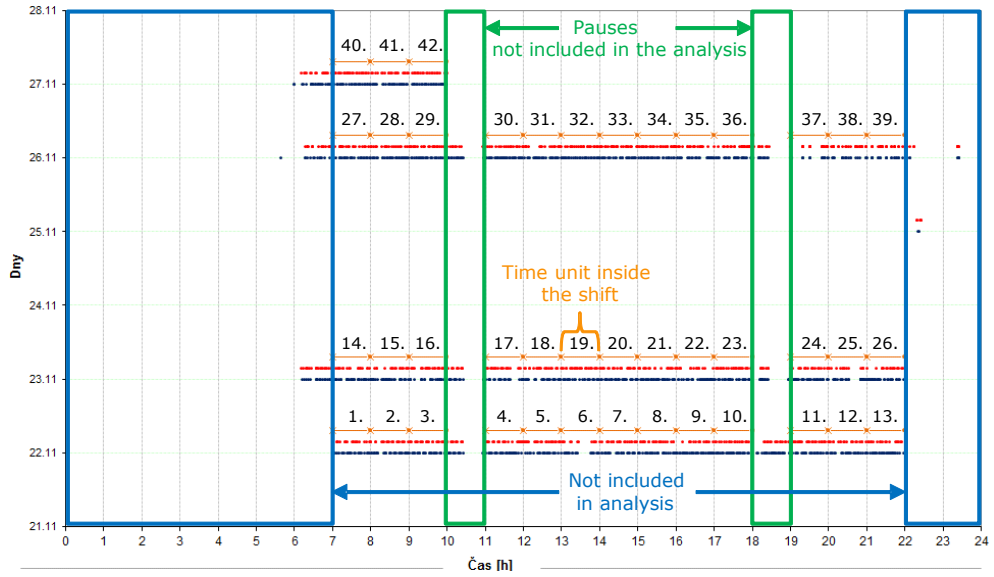
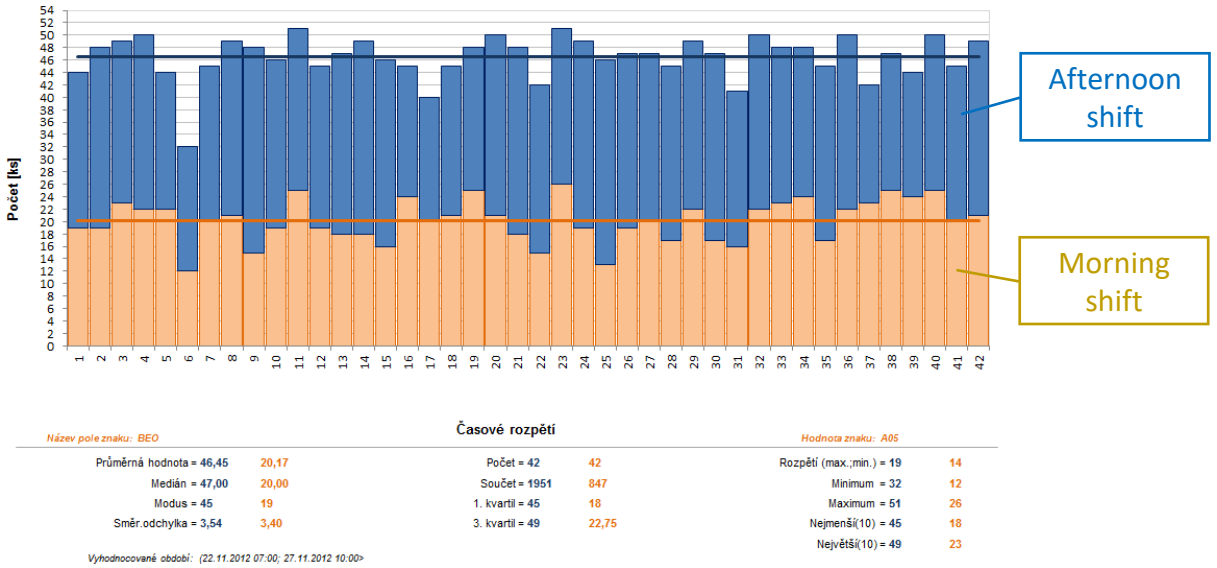
Data analysis

- The aim is to describe the properties of the studied object and thus also to gain new knowledge about the object itself. In the case of simulations, this is the analysis of the input data performed at the beginning of the simulation project, and then the analysis of the results of the simulation experiments (output data).

Passing the product through the check point



Achieved production at the check point



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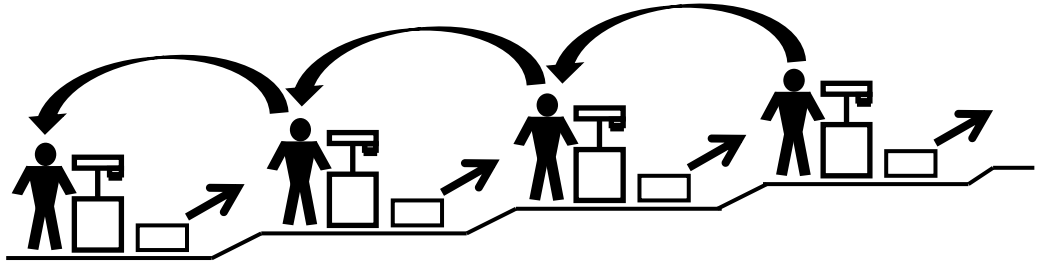
PUSH vs. PULL

- PUSH principle
  - It is based on forecasts of production needs.
  - A production-oriented system.
  - Production is based on availability of raw materials.
  - Often there is overproduction (high holding costs).
  - Bottlenecks arise.

- PULL principle
  - The impulse for production comes from the customer.
  - A market-oriented system.
  - The concept eliminates waste.



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Toyota production system – „Seven types od waste“

- It is based on lean production concepts presented by Toyota.
- Waste is the equivalent of the Japanese "MUDA".
- Seven key types of waste:
  - Defects.
  - Overproduction.
  - Unnecessary transportation.
  - Waiting.
  - Unnecessary inventories.
  - Unnecessary motion
  - Unnecessary processes.

Thank you for attention

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