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Computer Simulation of Logistics Processes

Fundamentals of computer simulation

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Fundamentals of computer simulation

Aim of the lecture

- Define terms, which are in relation with modelling issues.
- Show the possibilities of using discrete simulation in various areas of production and logistics (incl. software tools) that can be used for this purpose.

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Structure of the lecture

- **Explanation of computer simulation basic terms**
  - Data analysis, What-if analysis.
  - Real system vs. model, conceptual model, simulation model, layout.
  - Model, modelling, system boundary, level of the model detail.
  - Verification and validation.
  - Experiment, matrix of experiments.
  - Visualization, presentation, interpretation.
- **Application possibilities of simulation (ŠKODA AUTO a.s.)**
  - Moulding shop, welding shop, paint shop, assembly line.
  - Production plant.;
  - Logistics.
  - Non-production area.
  - Transport.

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Structure of the lecture

- **The most commonly used simulation tools**
  - PlantSimulation, SimPro, Witness, Simio, SimProcess, Arena, Simul8.
  - Choice of a suitable simulation platform.
  - Links to other software – digital plant.

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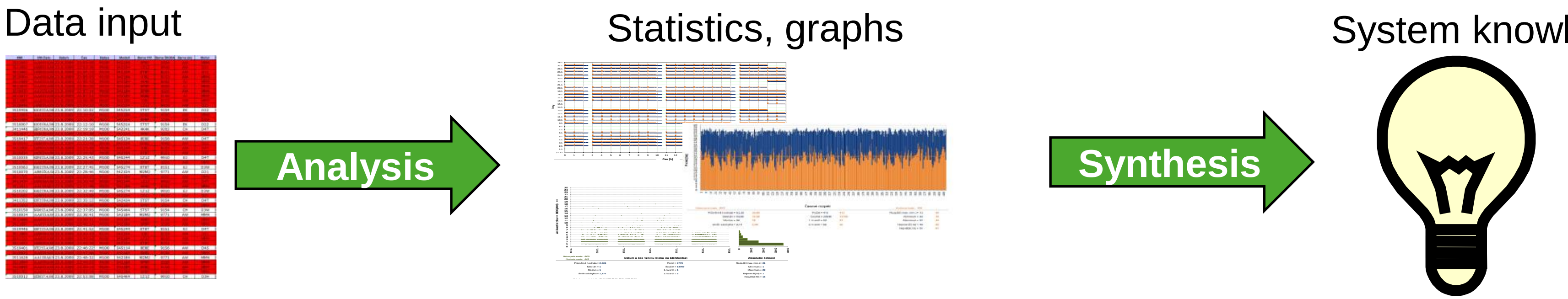
Data analysis, data synthesis

- Data analysis
  - It is a decomposition of more complex whole into simpler parts.
  - Properly performed data analysis is an important step in ensuring that the resulting simulation model displays the real system as best as possible.
  - Appropriate tools for data analysing are statistical characteristics, tables and graphical outputs in the form of graphs, diagrams and schemes.
  - It is possible to analyse input and output data from computer simulation point of view.
- Data synthesis
  - It is the opposite of analysis. In this way, we try to put more information into one whole. We can often move up a few pieces of information into the system knowledge.



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What-if analysis

- Basic tool for support of managerial decision-making with the use of computer simulation.
- It is trying to answer the question: "What will happen, if ...?"
- Classical examples from automotive production are:
  - What has to be production area cycle in order to achieve planned production?
  - How many offsetting positions do we have to have in each area?
  - What values can failure rate reach in order to achieve planned production?
  - What impact will the control logic of the device or area have on throughput of the system?
  - How many hangers (or skids) have to be in the conveyor system?
  - How many means of transport will be needed to supply the production lines?
  - How many pallets will be needed to continuously supply the production lines?

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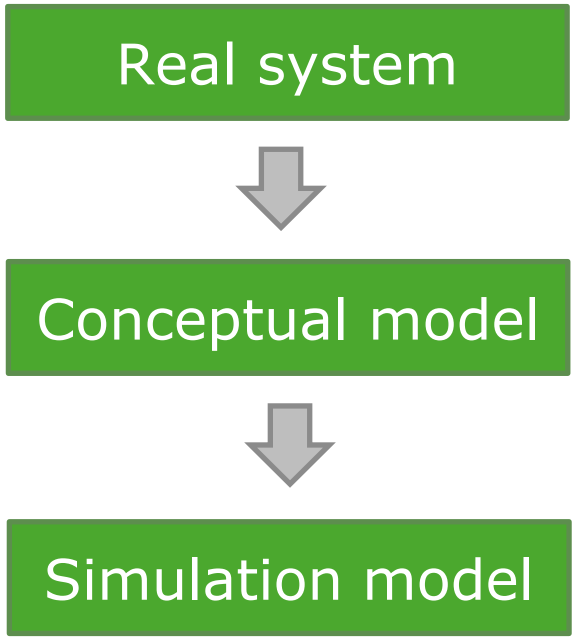
Conceptual and simulation model



- Conceptual model is a system description by verbal, schematical or mathematical means. Description should include all the essential features of the system's behaviour, but with the understandability and explanatory power.
- How can a conceptual model look like:
  - Verbal description.
  - Scheme.
  - Flowchart.
  - Mathematical description.
- We should not forget:
  - System boundary and interfaces to the system environment.
  - System elements and their interrelationships.
  - Behaviour of the system elements (with respect to the degree of abstraction).
  - Defining of the main system parameters.

- The simulation model is the conversion by thoughts defined in the conceptual model into the look of virtual computer model. The simulation model is concrete image of the conceptual model.

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System boundary, layout, model

- Layout is the elementary input for creating of simulation model. It is a technical drawing (usually a plan) of field of interest. The layout is normally used as a background of a simulation model during the simulation model. For creating of a layout, programme CAD can be used.
- System boundary determines range of modelled area. It says, where the model begins and ends. By that, system boundary also determines inputs and outputs of a model.
- Model is understood as a simplified picture of reality. Final look of the model is affected by an analyst who had created it and the level of abstraction, which was set.

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Modelling

- Modelling is an imitation of the real system and its simplified virtual image. Key characteristic of a model is that it behaves in essential characters as the real system itself.
- In order to achieve an imitation, we have to accept some kind of abstraction level. In case we would try to create a model with all influences that can affect it, it would be very time-consuming process and we wouldn't be able to make it, possibly (copies are not required, but a fast and operational model).
- Always, it is necessary to measure simulation studies based on the required outputs and invested sources (especially time and costs).

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Level of the abstraction

- Level of the model abstraction means how “deep in detail“ we will be modelling individual processes.
- Individual production field can be, for example, simulated as:
    - one element – conceptual modelling,
    - multiple interrelated elements – detailed modelling,
    - each of element in high detail – modelling with maximum level of abstraction (into the level of sensors on individual workplaces).

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Verification and validation

- Verification is checking, whether is the virtual computer model in accordance with conceptual model, so if we programmed everything in accordance with the conceptual model as we had set before.
- Validation is checking accordance of virtual model with the real system. The ideal measure for evaluation is the comparison of the model outputs with data from the real system.

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Experiment

- Experiment is understood as a one simulation run in the simulation environment. It is supposed to confirm or decline our assumptions regarding the real system‘s behaviour.
- With help of a simulation experiment, we are trying to verify the real system‘s behaviour.
- Each of experiments is conducted based on defined conditions.
- We mostly speak about specific setting of parameters values such as containers capacity, amount of means of transport, average device defects, number of workers on workplace, vehicle capacity etc.

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Matrix of experiments

- Matrix of experiments is an aggregation of all experimental simulations into one place (table). We use that for lucidity, automation and especially, not to forget on any of experiments (in a situation of tens and hundreds of experiments, this scenario is possible).
- Plan of experiments contains various combinations of values of monitored parameters. Each run gives results in a form of values of monitored parameters (criteria) such as average daily production, total inventory costs, production line effectiveness etc.

Variant/Parameter	Parameter A	Parameter B	Parameter C
Variant 1	1	1	1
Variant 2	2	1	1
Variant 3	3	1	1

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Visualization, presentation, interpretation

- Crucial parts of the simulation run. All these terms refer to the documentation part of the simulation project (see the lecture Methodology of the simulation project).
- Visualization is the representation of simulation results so that they are as understandable as possible to the audience. Appropriate tools are videos from simulation runs (2D and 3D animations).
- Presentation documents process of the simulation project itself. Appropriate tool is for example MS PowerPoint.
- Interpretation is the crucial phase of results presentation. It is the exact description of what the results of the simulation experiments mean for the real system (how the real system will behave under the conditions tested in the simulation experiments).

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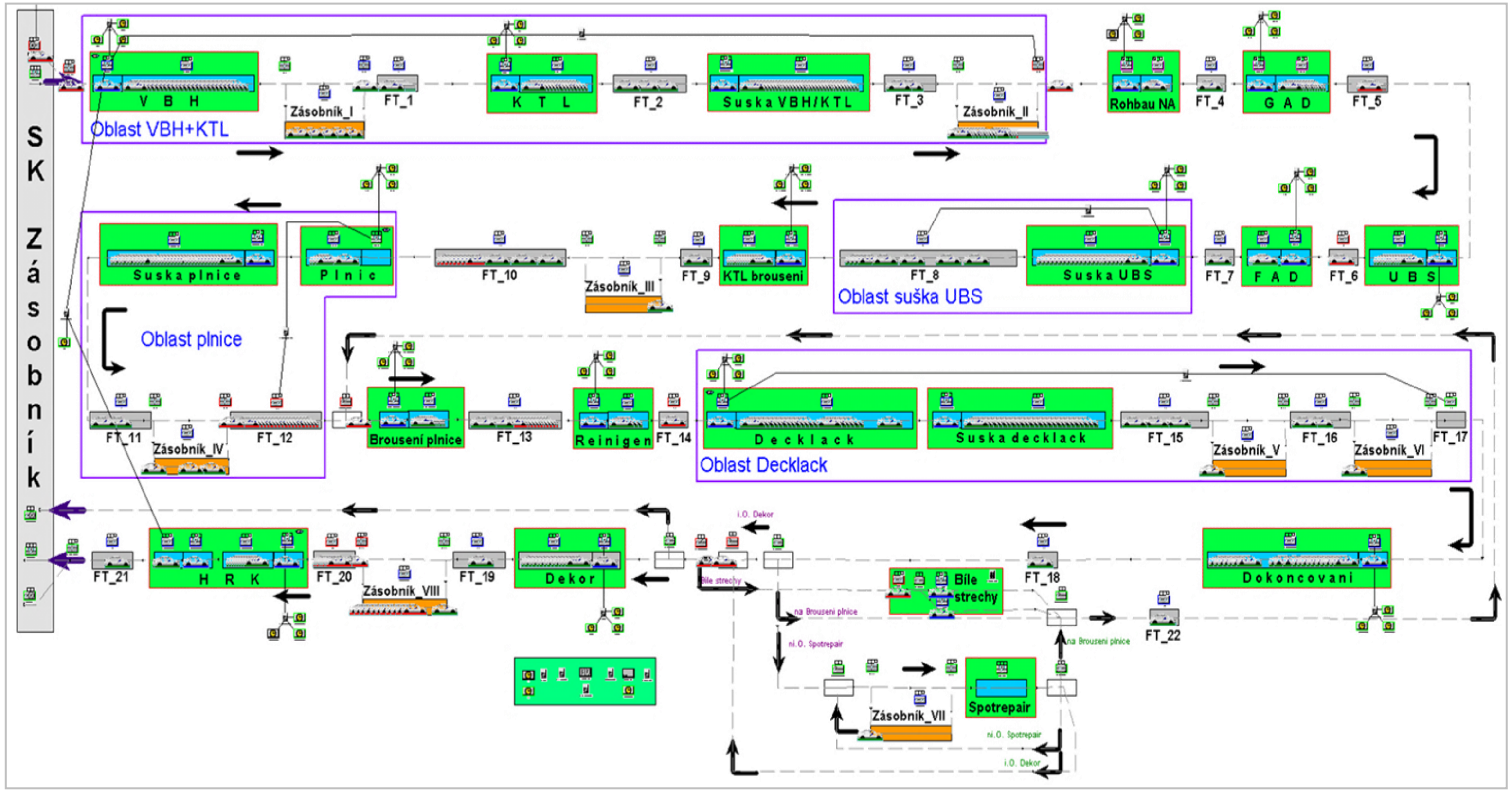
Example – paint shop



- Will the paint shop, as a whole, reach the planned production flow with set takt time?
- Will we achieve the given production flow with a certain level of body correction?
- How large have buffers to be between production places in order to achieve a given production?

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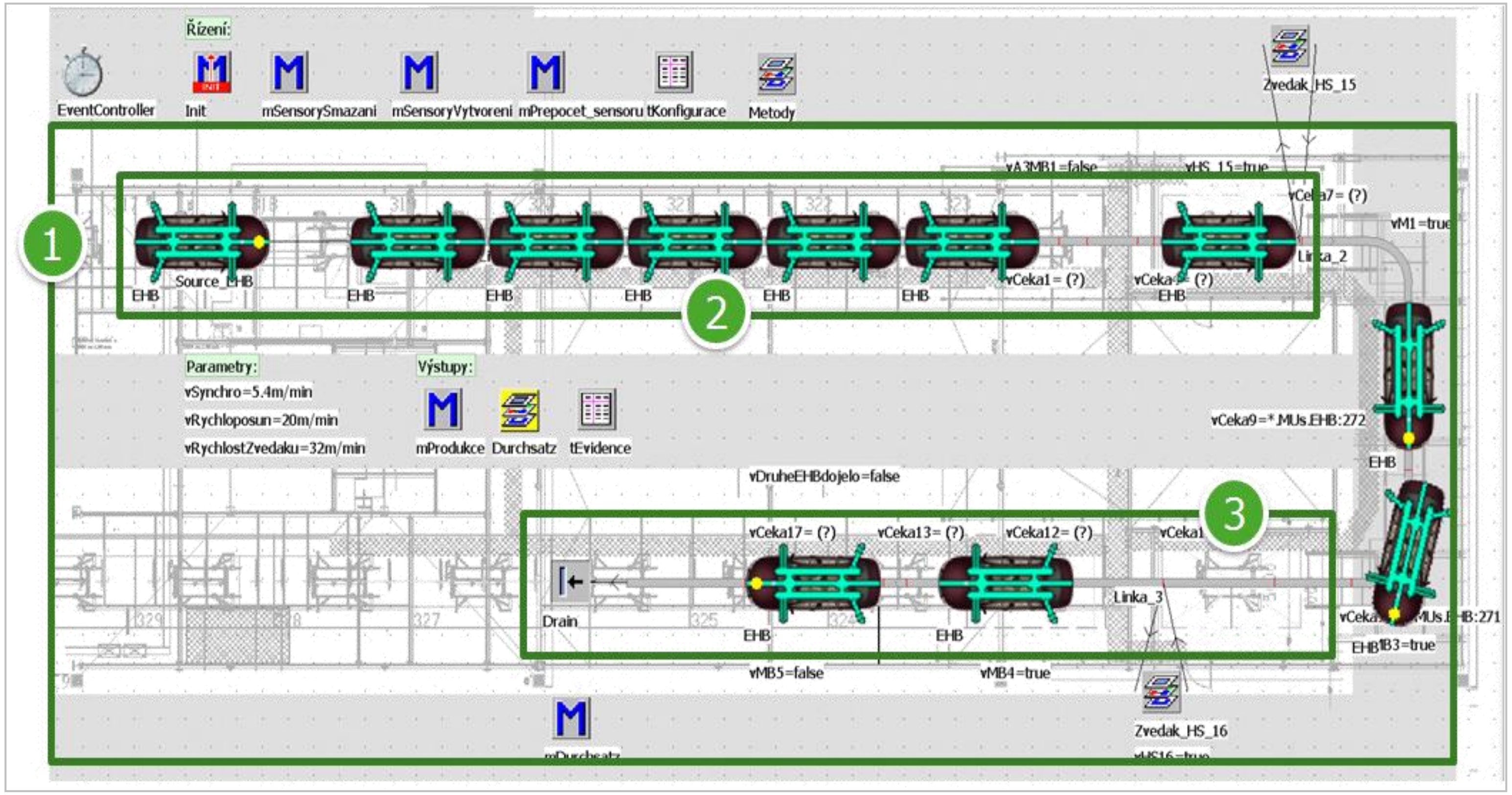
Example – detail of assembly line – EHB overhead conveyor



- Bottleneck analysis – what is the system bottleneck?
- Are we able to reach the target production?
- Can we afford to shorten the exit from lifts in favour of space for assembly takt time?

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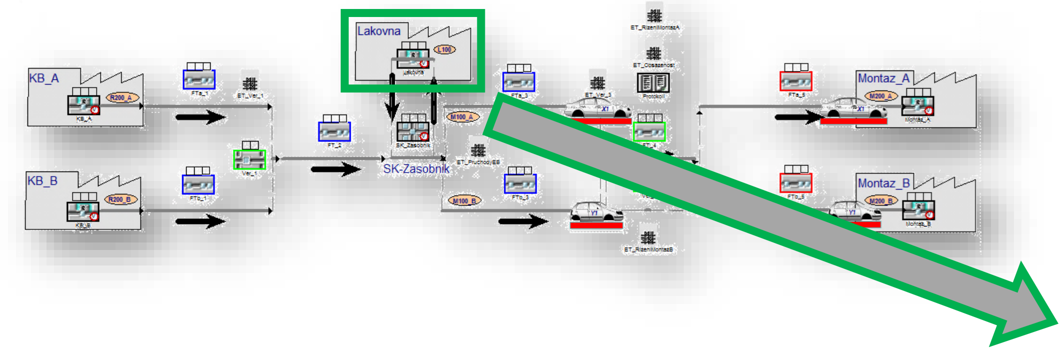
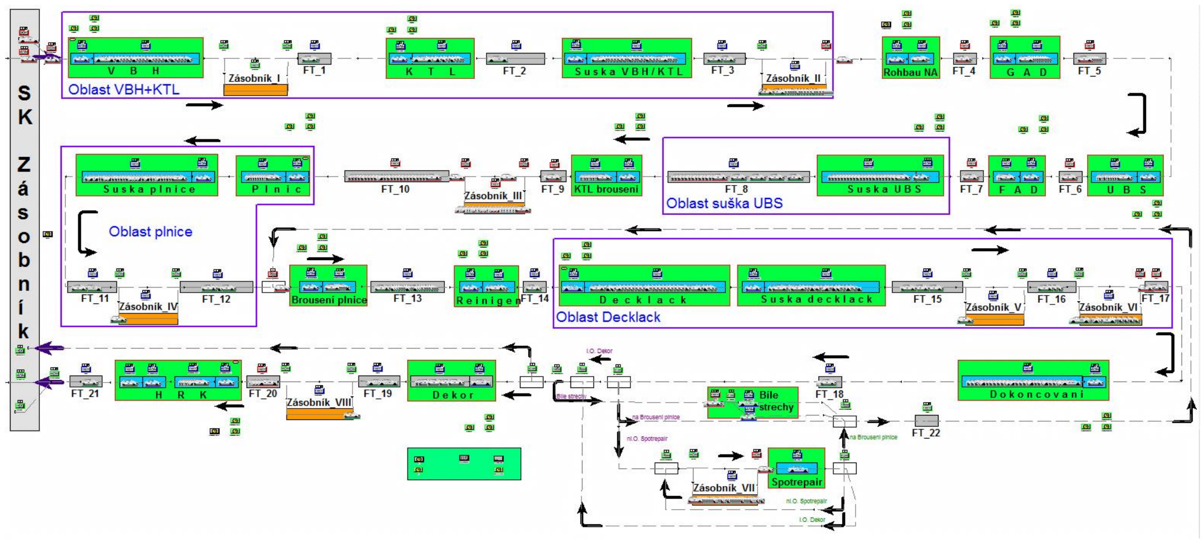
Example – production plant

”Conceptual model of plant“



“Paint shop model“



- What happens when the shift schedule changes in one of areas?
- What happens when the production quantity of one produced type is increased?
- How large buffers will be needed to compensate disproportions between production areas?
- What JIT/JIS time will suppliers have for parts supply?

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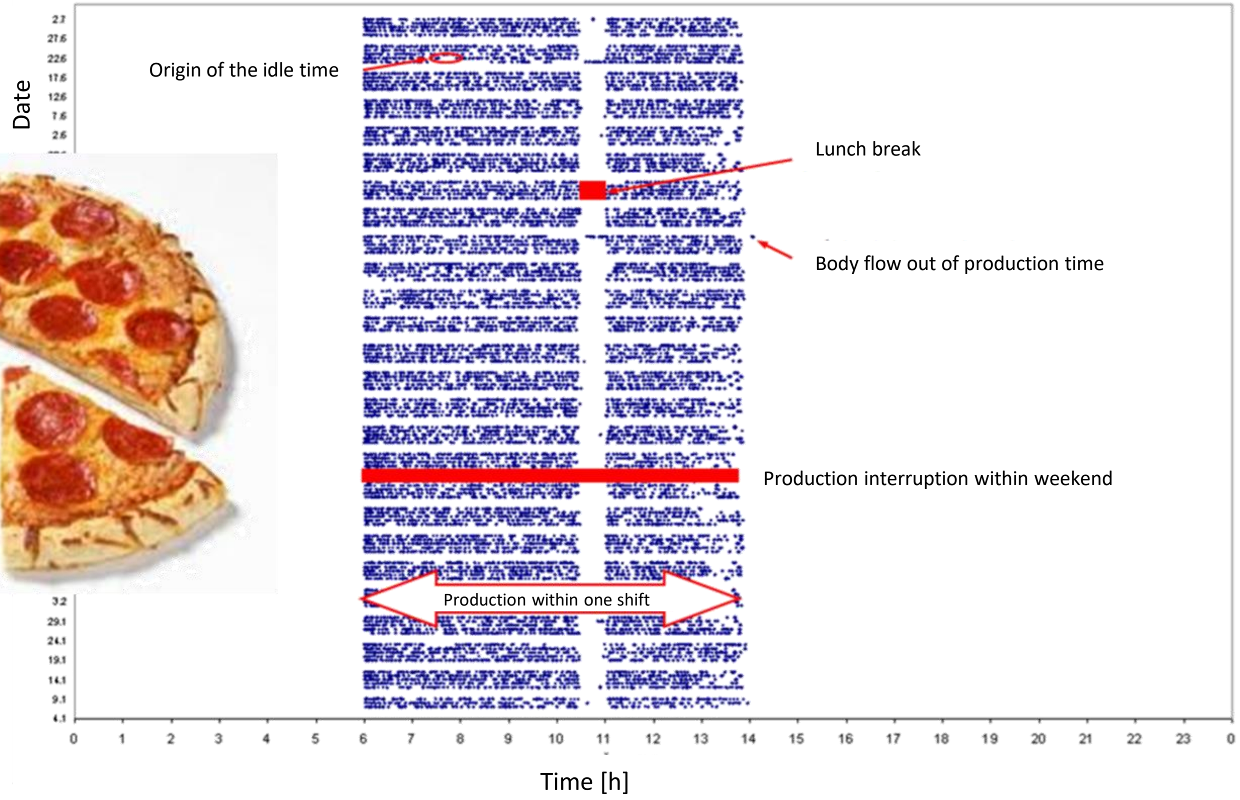
Examples of connection of production with non-production area



- Can canteen manage to serve staff in real time (lunch break)?
- How many servery places and cash desks do we need?
- How large canteen do we need? (area)?

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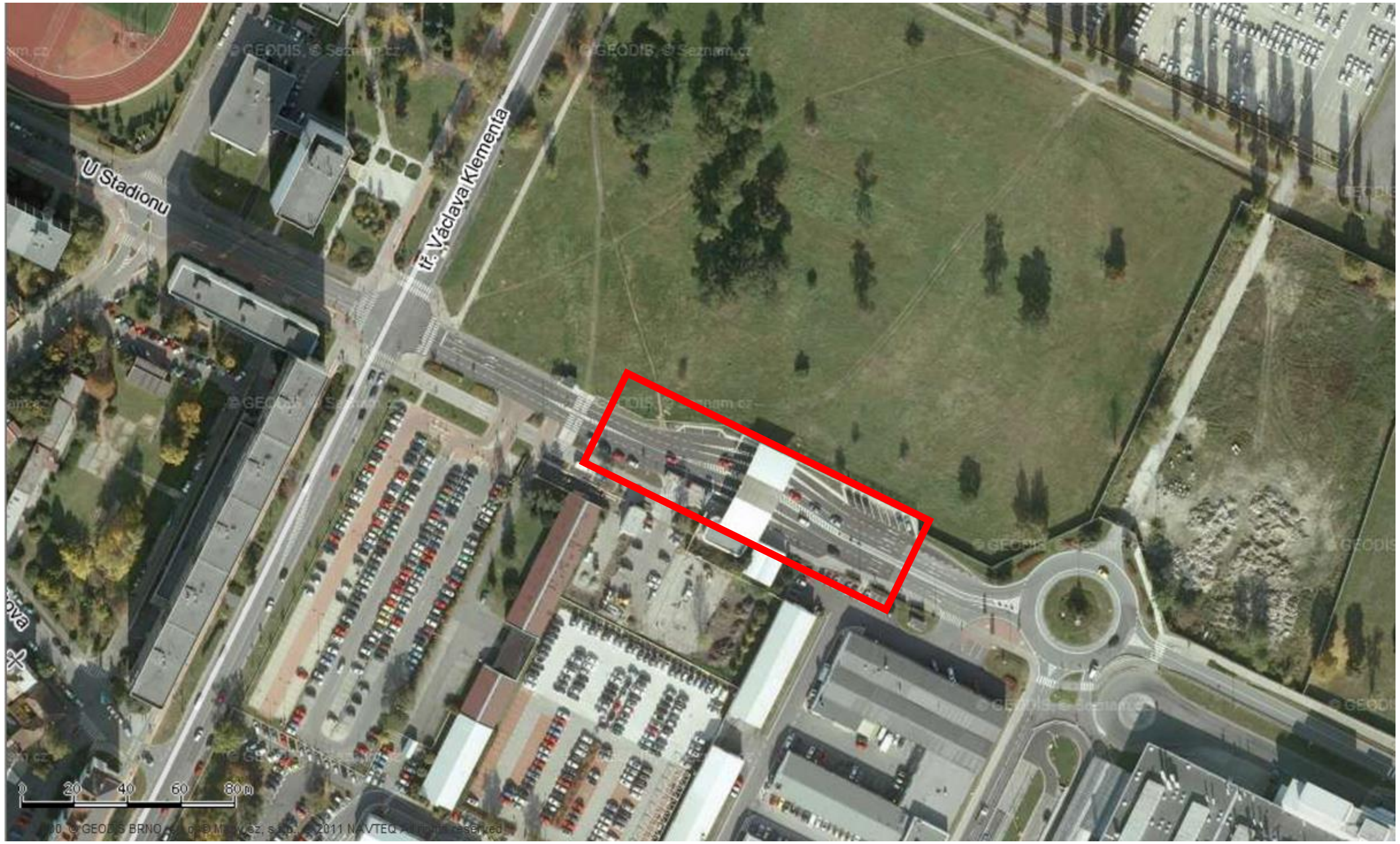
Non-production area - transport



Source: http://www.mapy.cz

- Bottleneck analysis – will be communication inside and outside of the company stay unblocked?
- Number of streams on incomings/outcomings of the company?
- Link to the company's information system (amount of turnstiles).

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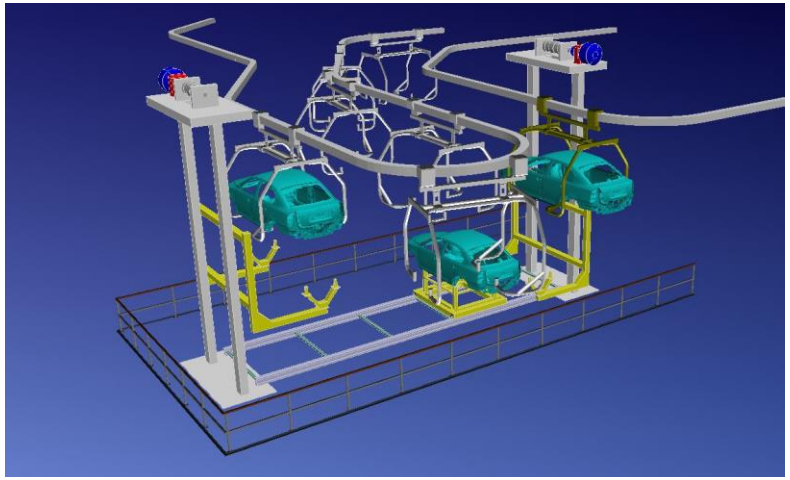
Simulation software – PlantSimulation 16 (Siemens)

- Universal software.
- Supported by automotive brands VW, BMW, Mercedes-Benz.
- Current VW standard.
- Large group of users.
- A number of extended libraries (VDA, VDB).
- Integrated programming language Simtalk.
- You can get more information within this course and on the website http://www.tecnomatix.com.



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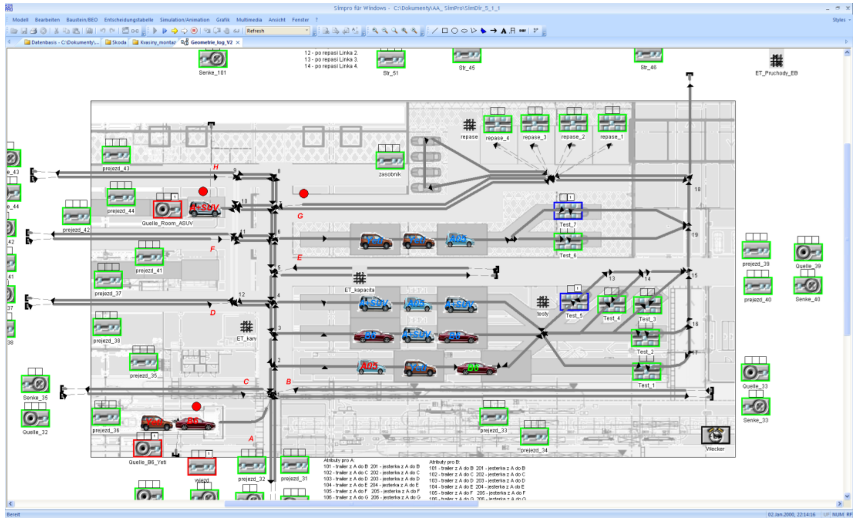
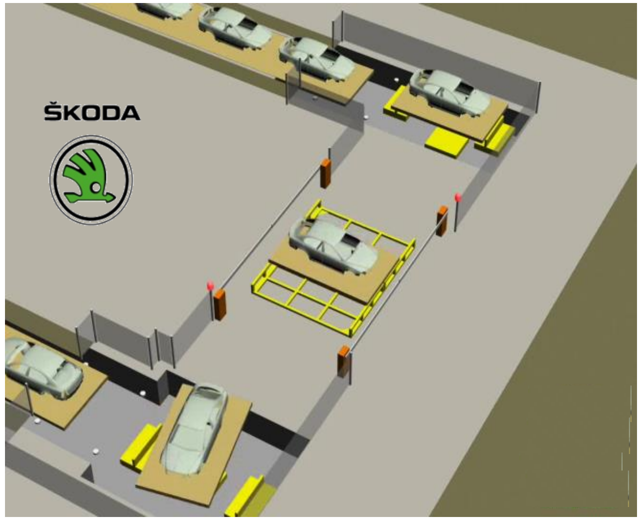
Simulation software – SimPro 5 (SDZ)

- Universal simulation tool with elements, which are usable in automotive industry.
- Used before as the standard at VW.
- Relatively low hardware requirements.
- More user difficult software interface.
- Integrated programming language MODULA2.





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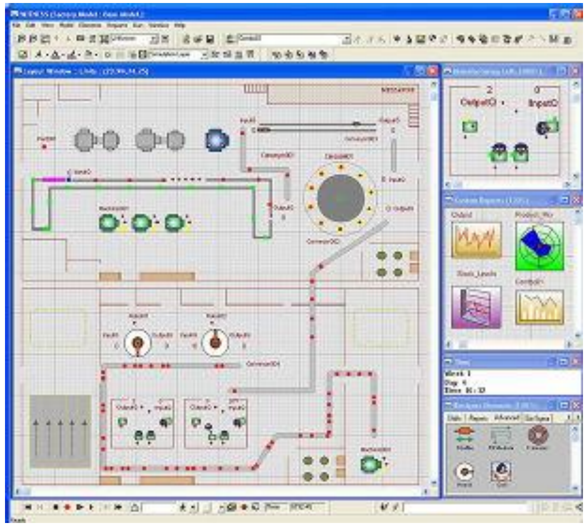
Simulation software – Witness (Lanner Group)

- Universal simulation tool.
- It is useful especially for simulation and production optimization, service and logistics systems.
- Interconnection with optimization tools, virtual reality and Microsoft Visio.
- Integrated programming language WCL (Witness Command Language).
- More information on http://www.lanner.com.



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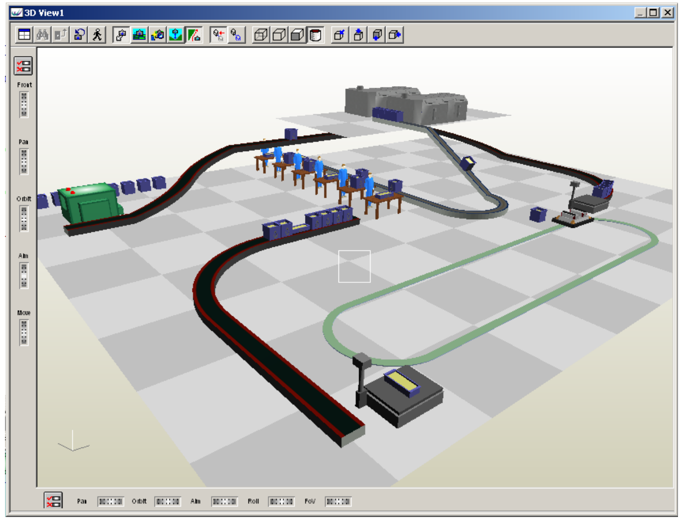

Source: http://www2.humusoft.cz/download/press/2009-22-4/witness/obrazky/W09_3D.png

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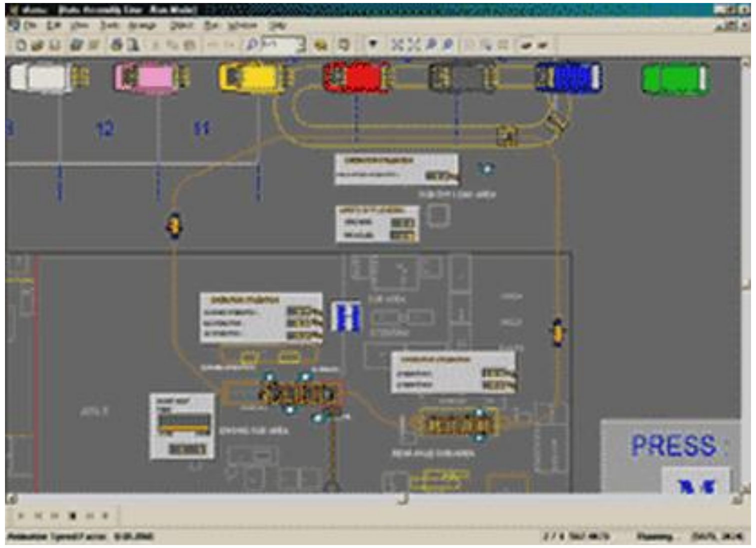
Simulation software – Arena (Rockwell Automation)

- General simulation language integrated into tools for managerial decision-making.
- It has graphical and animation extention.
- It uses hierarchical modelling principle.
- More information on http://www.arenasimulation.com.



Source:http://www.actsolutions.eu/img/varie/many_obj/Arena%20Simulation%20sample.gif

Source: http://i.udm4.com/screenshots_u4win/549/549833_1.JPG

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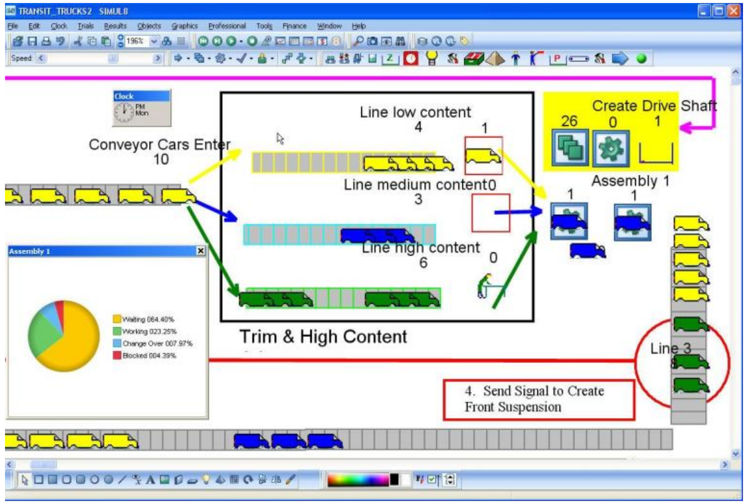
Simulation software – Simul8 (Simul8 Corporation)

- Universal tool for discrete events simulations.
- The tool tries to be user friendly and work maximum with it is not during programming, but during setting model parameters up.
- Simul8 is price friendly.
- More information on http://www.simul8.cz.



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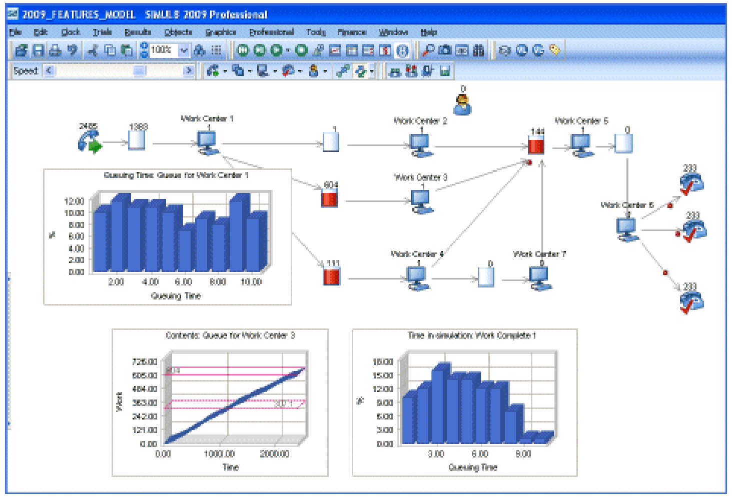

Source: http://www.simul8.cz/tipy/on-screen-charts/

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Simulation software – choice of the appropriate simulation tool

- It is not possible to define it exactly, which software is the best one. Rather, we can speak about the fact that under the given entry conditions, one of them will suit us the most. This is usually the last used simulation tool, because of our experience with the last project, where we have the most mastered modelling techniques in specific situations.
- Crucial for deciding about choosing of simulation platform is:
  - Business area of the company.
  - Software price (from free versions with limited functionality up to a million crowns for a sophisticated solutions).
  - Training opportunities and available educational materials (manuals).
  - Company support, which had developed the software (updates, new versions, solution of special occasions in model environment – „hotfix“).
  - User community (user meetings in order to exchange previous experiences).
  - Extended libraries (VDA, VDB).
  - Communication with other software (CAD systems, database systems).
  - Integration within higher units (digital plant concept).
  - Software adaptation in academical sphere (collaboration with universities).

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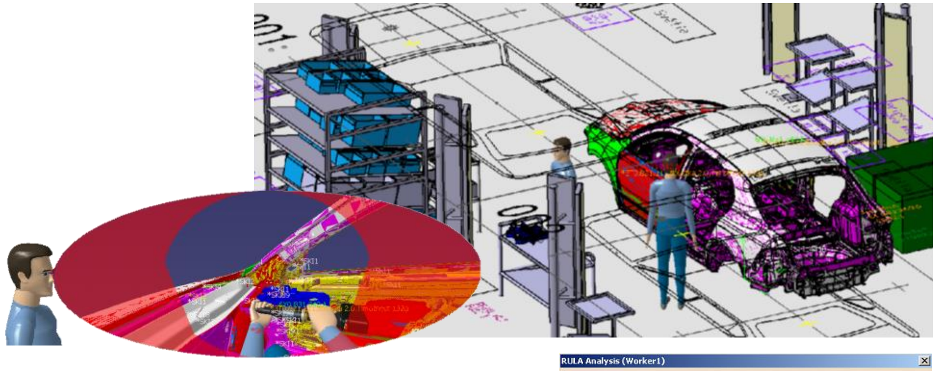
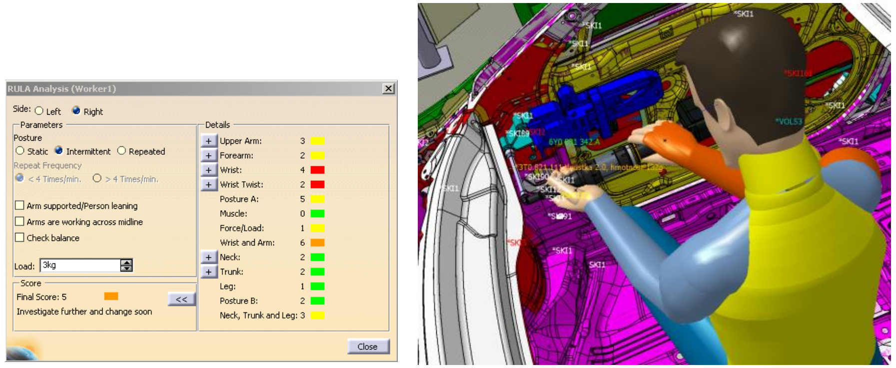
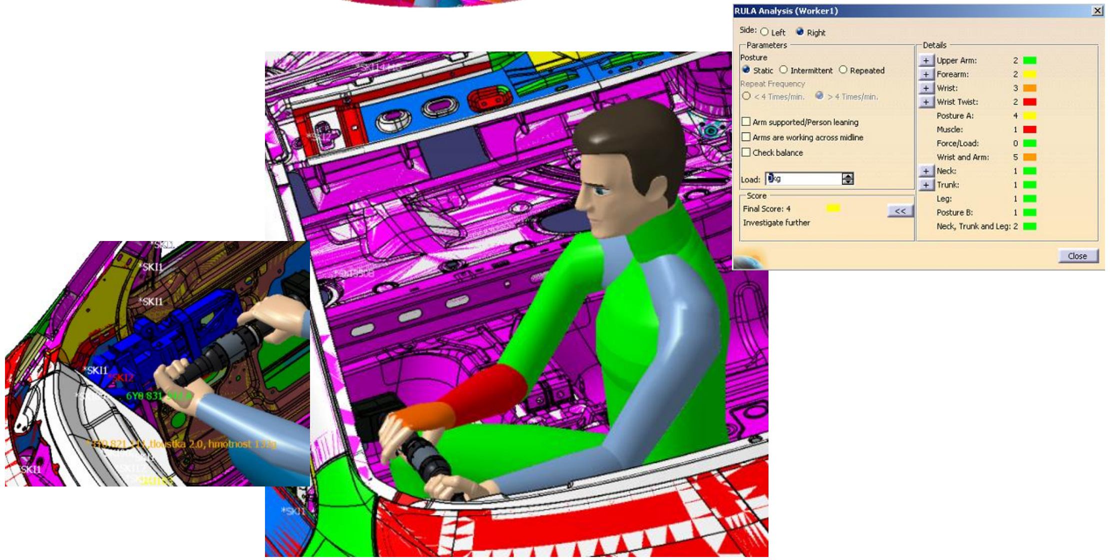
Digital plant – area of ergonomic simulations

- It is possible to support the development of assembly lines designing with help of ergonomic simulations.
- The main goal will be action optimization during assembly already in detailed planning phase while keeping of occupational safety and ergonomics.







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Digital plant – area of ergonomic simulations

- Benefits:
    - Optimization of workplaces arrangement and work procedures.
    - Understanding the spatial effects on human body.
    - Saving time during production designing.
    - Timely inclusion of human factor into production cycle.
    - Realisation of extensive ergonomic analysis.
    - Creation of 3D animation workflows and instruction manuals.

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Thank you for attention

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