SIMULATION

Simulation is without any doubt one of the competence fields where we feel that we have the greatest expertise! We could therefore write page after page on the subject, but will here try to restrain ourselves! Instead we would like to refer you to one of our example models, which are commented a bit more further down.

For our other competence areas, simulation is often one of the most frequently used methods to tackle the issues presented to us by our customers – except when it comes to Program development, when the development itself might aim to create a simulation program (a simulator). It is one of the most applied methods within Operations research, an excellent tool to capture the unpredictability that is characteristic in Reliability analysis and is very well suited to describe the activities and processes involved in Maintenance optimisation.

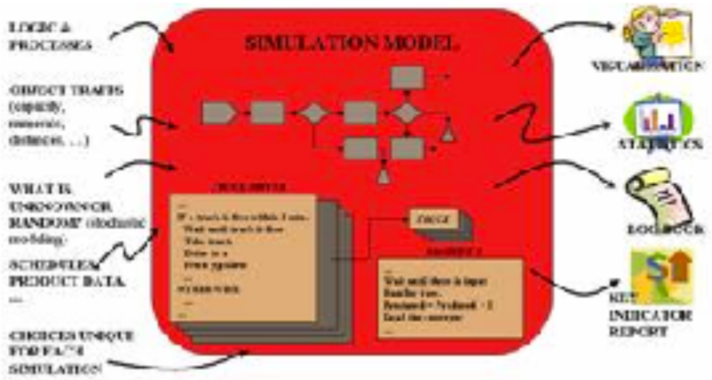
What is simulation?

When you simulate, you build a model of an activity, operation or enterprise, a process (or more common – several processes), or a "system" of some kind. This can both be something that already exists or something still imagined (that possibly will exist in the future). The model is then used to learn more about what is studied and often to evaluate various alternative options. It can be a situation where one tries to figure out whether an investment will pay off, compared to the choice of leaving everything as it is. One might want to analyse what productivity a planned production line will deliver – or the capacity of a whole factory. The focus could be on figuring out the best way to organise the maintenance activities, given known characteristics when it comes to operational reliability of the machinery. In a transportation system – for the public or the movement of goods – the aim could be to better grasp the capacity of the system and to see how changes in planning, schedules, control systems, and/or structure will affect the whole. The possibilities are unlimited!

Common for most applications is a wish and a need to get relevant decision support material – and for that end simulation is an excellent tool! A simulation model can be used as a "discussion partner to brainstorm with", so that all types of ideas – sound and wild ones – can be tested, rejected, and further developed. To even imagine conducting similar test in the "real world", is

usually not an option. A comparison with creating a prototype in a development project is fairly on the spot. Instead of evaluating a product, focus here is to analyse the described processes, changes, and options – even though the “behaviour” of products also can be simulated.
What is needed when simulating (and modelling) is input of various kinds:

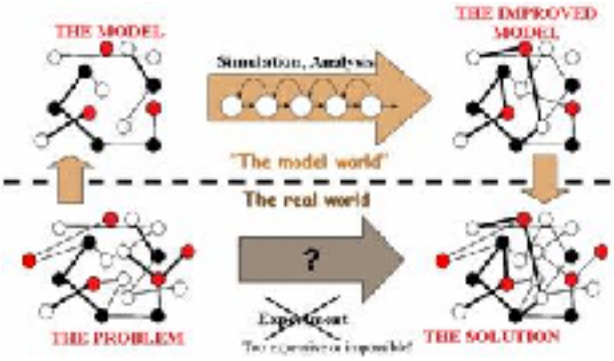
- An understanding and description of relevant processes and the logic behind it all
- Data and knowledge concerning the components of the system (machines, vehicles, humans ...), e.g. capacities, quantities, distances
- A sense of what is unknown or more or less unpredictable and whether this is best described stochastically (through mathematical probability distributions)
- Various files describing such data as product traits, time tables, work schedules, position data …



Part of this input is used to create a simulation model (and in the end an executable program that can be used to simulate with), part is applied when using the developed model. How to model usually the user does not have to bother with or even know. This is a task for the modeller (e.g. Trilogik!). What you do is, simply put, that you transform the knowledge of the studied system and the cognizance of what issues the user/customer wants to address. This is achieved through process descriptions, often supplemented by some “programming”. To this, animation is added, to describe chosen parts of what is going on for the user – and give her/him the possibility to interactively affect the prerequisites of the simulation.
What maybe is most important is in the end the results you get! One often ensures that these are of different types and can be split into a number of categories. The actual **visualisation** of the course of events can in itself be seen as a result, enabling the viewer or user to draw conclusions and have aha experiences. **Statistics** are generated of everything that might be of interest to analyse – degrees of utilisation, delays, waiting times, WIP (Work In Progress), and whatever might be relevant. One often tries to document important events, for example in a **log book**, to be able to analyse what has been going on after the simulation is finished. Finally it can be a good idea to summarise some major conclusions and performance indicators in a report, focusing on the most important objectives and aims with the simulation. Let us call this a **key performance indicator report**.

Why simulate?

The reasons for simulation to be an option have already partly been touched upon above. One way to summarise it is that you have a problem related to a business, enterprise, or operation (a system), where it can be established that the questions you want to have answered preferably not is handled through a "trial and error" approach – testing in the real world.



When you have reached this far, the conclusion is that you instead create a model of the system, which for obvious reasons will be a simplification. Sometimes this model is purely mathematical, since it was possible to describe what was needed this way. But other times it has been realised that the issue is too complex or hard to describe to be able to "calculate" an answer. The considered problem might have dynamic characteristics – the prerequisites change over time (or depending on the state the system is in) or some elements have an unpredictability (or haphazardness) as one of the major traits. In these situations simulation can be the best – and sometimes only – way to tackle the problem. When the model then is used in the analytical work, it is in reality always an iterative process, where you simulate, draw conclusions, ponders, test an alternative scenario and so on. Finally you will reach, hopefully, a state when you have found an option that is good enough. The inferences that can be made from this alternative are then applied on the real world!

There are many issues where this way to work can come in handy. Some categories are:

- To produce **decision support** material to evaluate **future investments and changes** It can be a new factory, an enlargement of an existing transportation/traffic system, a new production line, or something else
- To describe an **existing operation** – production, transportation/traffic system, logistical flow, maintenance organisation ... - and draw conclusions
  Here a need to change, improve, or correct is often identified – but one needs to figure out how to do this in the best way and what the consequences will be
- To test/evaluate various options relating to **planning, timetables, or control**
  Here the focus is more to optimise the usage of a given system. This often leads to the identification of possibilities to change the system (according to the previous bullet point), alternatively one also considers the effect of planning/control when the real focus was according to one of the other two categories.
- To in a more general manner **create an understanding** of a complex operation

Our tools

To our assistance, we primarily use a program that gives us a general development environment for any type of issue where simulation is to be used. The name of the program is **AnyLogic** and it is according to our studies the tool on the market that in the best way fulfils our need of a combination of flexibility and usability (with ease). It also has the clear advantage of being one of few (possibly the only one) development environments that combine several simulation techniques in the same program – and even enables these techniques to be used in parallel in the same model!

We do not plan to dive into the more technical issues related to different techniques of simulation. What follows is a list of some of the most well-known categories:

System dynamics (time continuous modelling)

This approach is usually applied when modelling physical or technical systems.

System dynamics (time continuous modelling)

Here the focus is more on the macro level – an "all-embracing" system – over a long period of time. We can be dealing with changes in population density, the effects of marketing campaigns on potential customers, macro economical models, biological courses of events in nature and much more.

Discrete event-governed modelling

The typical production simulation often uses this technique, as well as many issues related to traffic flows and transportation logistics.

Agent based modelling

When working with System dynamics or Discrete event-governed modelling, you often view the situation under consideration "from above". As a puppeteer pulling the strings, you describe your system or business – and after that included "components" like humans, products, and vehicles just have to adjust! In agent based modelling, you start in the other end, from the smallest piece of the puzzle (e.g. the human individual or car) – and describe what processes it follows and what logic that is relevant. Then a large number of these so called agents are "let loose" in the model, where often the environment they act in are described to some extent. The individual agent is typically not aware of the whole, but builds its decisions on what it knows. This way to tackle the modelling problem is characterised by a ”bottom-up” way of thinking, whereas the alternatives more follow a ”top-down” philosophy! Depending on the issue, one or the other method might be to prefer.

Trilogik