SIMPLAN

Simulation in Practice.

A GUIDELINE FOR THE USE OF SIMULATION.

SIMULATION SOLUTIONS FOR
PRODUCTION AND LOGISTICS PROCESSES

What is Simulation?

"Simulation is an essential part of the planning of production and logistics processes. It creates transparency, minimises risks and provides an objective basis for decision-making."

Dr. Sven Spieckermann
CEO SimPlan AG

Insights

This brochure will provide you with a brief insight into the world of discrete-event process simulation. It is intended to explain succinctly

- what simulation is,
- where and when it should be employed,
- what the objectives of simulation projects are,
- which benefits you can expect,
- what the requirements for a simulation study are,
- what the limits of simulation are and
- what your start into simulation could look like.

This brochure cannot replace an in-depth discussion about simulation. It is very difficult to convey on paper how transparent a plant becomes when it "comes to life" on the screen.

Definition and Fields of Application

Simulation is the representation of a system with its dynamic processes in an experimentable model to reach findings which are transferable to reality. [VDI Guideline 3633 (2010)]

Thus, in simple terms simulating means

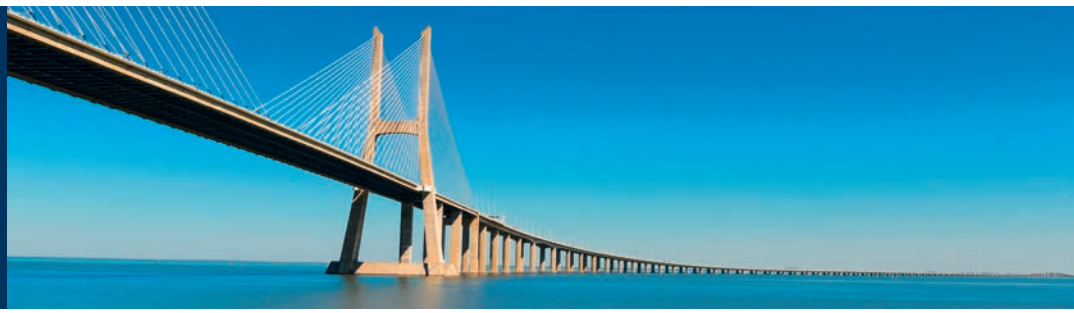
- generating a model in the computer,
- experimenting with the model and
- drawing valuable conclusions from these experiments for reality.

There are different types of simulation that are, for instance, used for weather forecasts or flight simulation.

In our case we talk about process or material flow simulation. This type of simulation is also called discrete-event simulation. Generally, it is about modelling the flow of units through a process with pre-specified times.

The range of applications of this simulation method has been expanded continuously for several years.

The bridge to reality.

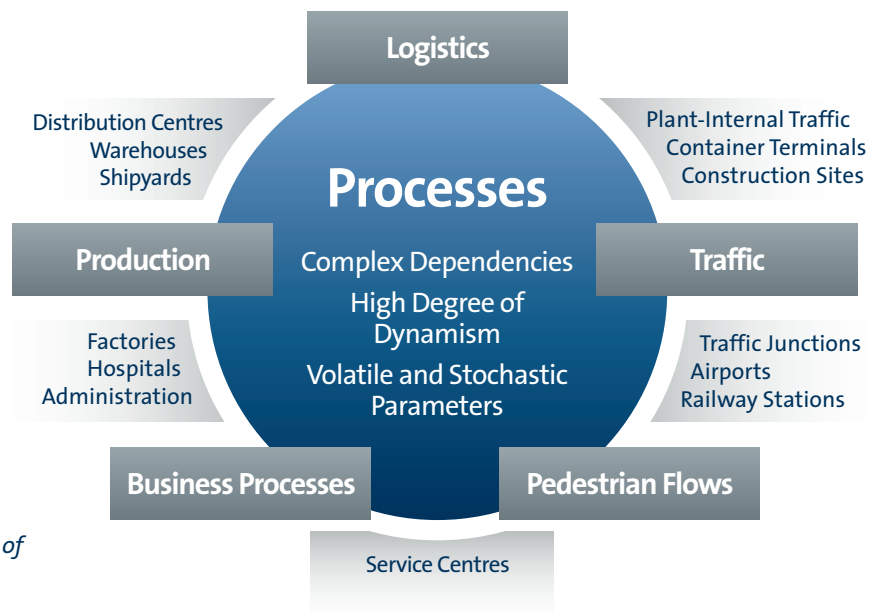


Nowadays, pedestrian flows, business processes and traffic flows can be simulated, which is why the term 'process simulation' describes this method best.

Process simulation is used as a tool

- in sales and marketing,
- in design and engineering,
- the ramp-up and
- the operation of a logistic system.

Ideally simulation is used as a tool for optimising and forecasting key indicators in all lifecycle phases of a logistic system. The scope may range from a sub-area of the production process or a warehouse to a complete supply network.



The application areas of process simulation

Simulation in Sales and Marketing

3D animation with Demo3D
© TGW Logistics Group GmbH

Plant manufacturers, mechanical engineering companies or system integrators can use simulation in order to convey a realistic image of their system to customers. This is particularly interesting at the proposal stage in order to make the system's processes transparent, thereby boosting customers' confidence in the proposed concept.

At this stage, it is not always possible to create a detailed simulation model of the plant, as crucial data may still be missing or certain processes are not yet clarified.

Understanding through visualisation

The primary issue is not to deliver precise simulation results, such as throughputs, capacities or throughput times; instead, the animation is intended to develop a common understanding of the planned processes. To achieve this, it is helpful if the employed simulation system can create 3D animations of the highest possible quality quickly and easily.

However, in certain cases a detailed simulation of the plant is demanded by the future plant operator as early as the proposal stage. This is the case, for instance, if the customer himself has planned a specific concept prior to the call for proposals.

> As part of the call for proposals, simulation models of the proposed concepts are created and fed with identical data in order to compare them.

This concept, including all the required data, is a part of the call for proposals. The operator requests a simulation in order to use the resulting key indicators to make sure that the proposed plant meets his requirements. In many cases, an independent simulation service provider is engaged to ensure a neutral analysis of the proposed system.

Simulation in Design and Engineering

By means of simulation, new plants are evaluated with respect to performance, sufficient dimensions, throughput times, capacities, dependencies, staffing requirements and other planning parameters. Furthermore, various alternatives can be evaluated and compared.

Existing plants can be modelled in their current state. Planned modifications can be assessed and optimised using the simulation model.

Thus, it can turn out that for example the application of a different control strategy will improve the performance.

Saving time and costs!

Carrying out these examinations at a real plant would require considerable time and cause substantial costs. In contrast, changes to the system in the planning phase can be made easily with the aid of the simulation model, without interfering with the actual plant operation. Early application of simulation in the planning process often already helps with fundamental decisions at the start of the engineering process.

A simulation model, which grows with the level of detail and knowledge of the planning, accelerates the planning process and supports an iterative course of action in the decision-making process.

Simulation during Ramp-Up

For the control programmers the simulation model serves as a blueprint for the generation of the plant control. To make this possible, the IT structure is modelled as true-to-life as possible within the simulation model. For instance, the classic control levels within a storage system are:

- ERP (order management),
- WMS (warehouse management system),
- MFC (material flow controller),
- PLC (secondary controllers of the plant).

If the same structure is modelled within the simulation model, the configuration of the controls for the real system is simplified.

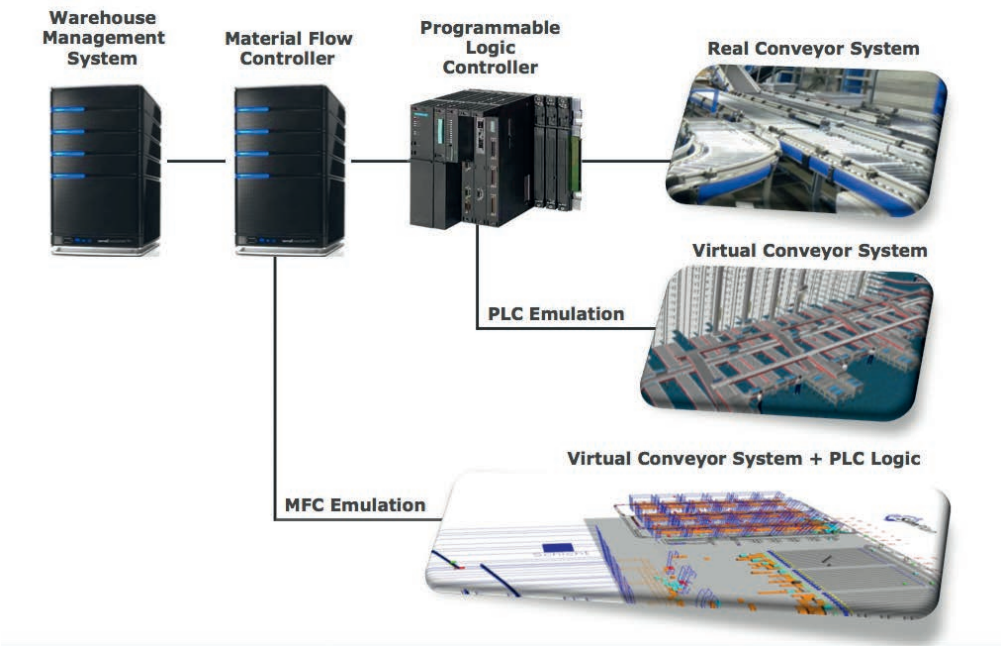
In addition, this structure is a requirement for using the model for the virtual commissioning of real controls; the model can be connected to the real system, provided that the model has the appropriate control structure.

The connection of the model with the real control is also referred to as emulation. To do so, the control logic in the simulation model is replaced with the external control software.

Emulation shortens commissioning times

The exchange of information between the control levels is carried out at telegram level, just like in the real system. If the PLC level is tested, the emulation model only contains the hardware functionality. If the MFC or WMS is commissioned, the model also covers the PLC logic.

Using emulation, the control can already be commissioned before the real system exists. In addition, the control can be tested under a high system load. Critical situations can be created in the model at the push of a button. Another key benefit is the reproducibility of error events, since the simulation model always behaves the same way under unchanged conditions.



If you imagine carrying out the same tests in a real system or, for instance, during the commissioning of the plant on the construction site, it quickly becomes clear how much time and money emulation can save.

Emulation significantly shortens the commissioning time of a plant. Furthermore, it leads to a higher quality of the control as more scenarios can be tested within this short time. It is, for instance, possible to test load situations that would, in reality, occur only after several months or even years.

If controls of an existing system are changed, then emulation can be an important support, ensuring that the transition to a new control is as smooth as possible.

In addition, the emulation model can be used for training purposes during the ramp-up phase. With the aid of the model the operating personnel can be prepared for the new system and trained specifically with regard to important plant conditions.

Simulation during Operation

For simulation during operation, we generally have to distinguish between the following use cases:

1. **Application as a forecast tool ('simulation-based production planning')**

Testing the schedule of a plant beforehand anticipates information on the personnel and resources required, as well as on order lead times and plant utilisation. This is, for example, how different order sequences, batch sizes and machine utilisations can be verified prior to the daily operation.

The simulation delivers key indicators, which can be used to evaluate the quality of a schedule. This is how the best solution can be sought even before the daily operation commences.

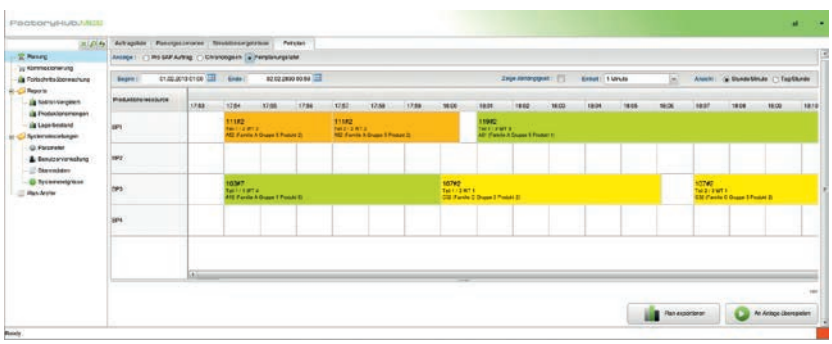
In many cases optimisation processes, e.g. heuristics, support this search for an efficient schedule. This is also referred to as 'simulation-based production planning'.

2. **User model**

A plant operator is also able to use the simulation model after the completion of a project, for instance in order to analyse future process adjustments, such as integrating new products into the existing production or, in case of a service provider, handling a new customer's logistics in an existing logistics centre.

An important benefit is the very short time needed for a a simulation study if an operator model is available, as the current process already exists within the model.

FactoryHub.MES as an example for a simulation-based manufacturing execution system (MES)



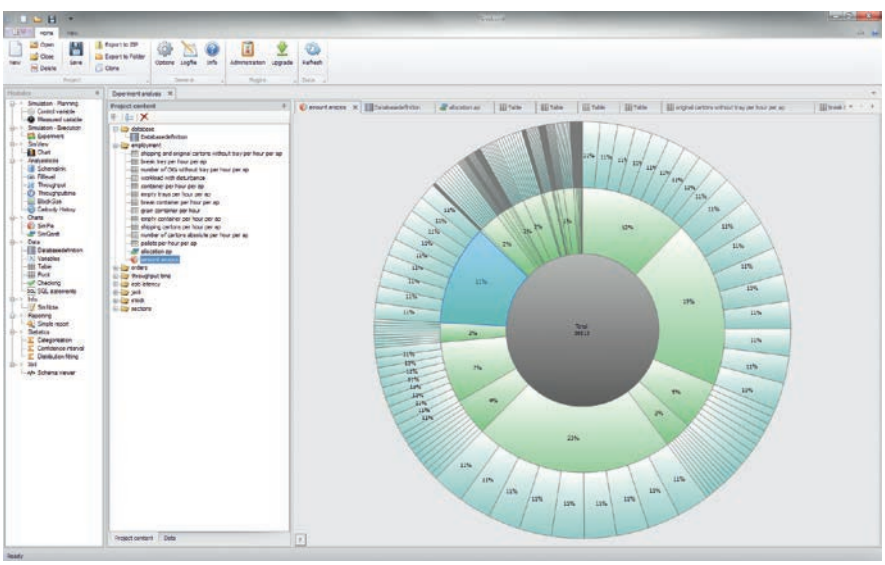
Prospects

The constantly increasing range of applications for process simulation offers a multitude of opportunities for your company.

Recent examples are the application of simulation for calculating the carbon footprint of a company across the entire supply chain, for optimising the energy consumption in production processes or for planning the assembly of off-shore wind farms.

The development of assistance systems for simulation aims at simplifying the collection and preparation of data, as well as the evaluation and documentation of experiments.

Software solutions to increase the efficiency within simulation projects and to expand the range of functions and their integration into existing IT environments are available and rolled out for example in the automotive industry.



The assistance system SimAssist

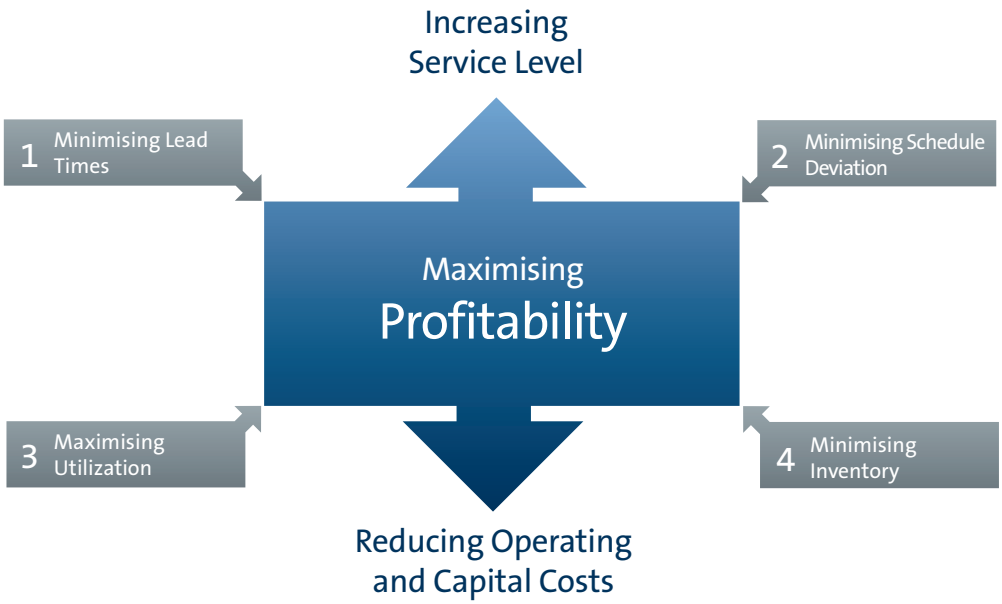
Setting Targets – Increasing Profitability

Every simulation study starts out with the definition of targets. The fundamental purpose of the construction of a new or the change of an existing plant is to increase the profitability of a company.

Concrete targets of a simulation study could be:

- Increase of machine utilisation
- Reduction of staffing requirements
- Reduction of storage requirements
- Higher performance
- Shorter lead times
- Evaluation of layout alternatives
- Determination of the number of vehicles required within a transportation system
- Determination of required buffer sizes
- Optimisation of control strategies

Increase of profitability according to VDI 3633 (2010)

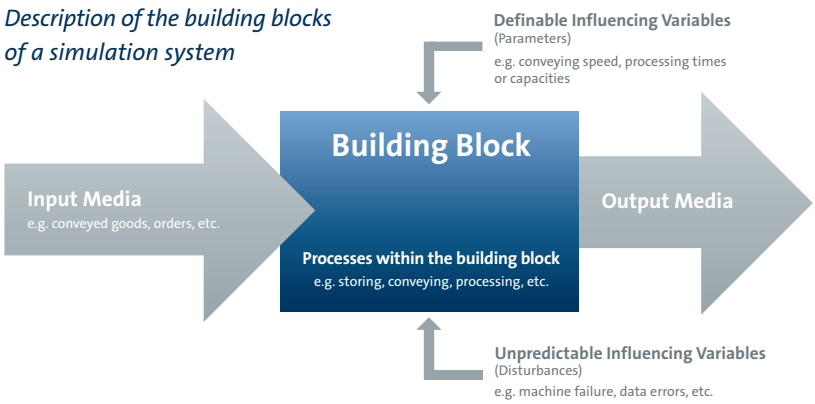


The bridge to reality.

Functionality

Several concepts form the basis of present-day simulation systems. A building block concept is very wide-spread. Thereby a simulation model is put together from individual building blocks. Each building block can be described as follows:

Description of the building blocks of a simulation system



The individual building blocks and the operations within the building blocks are linked in an overall process. Thus a network is set up. With the aid of the building blocks and network, various logistic systems can be modelled.

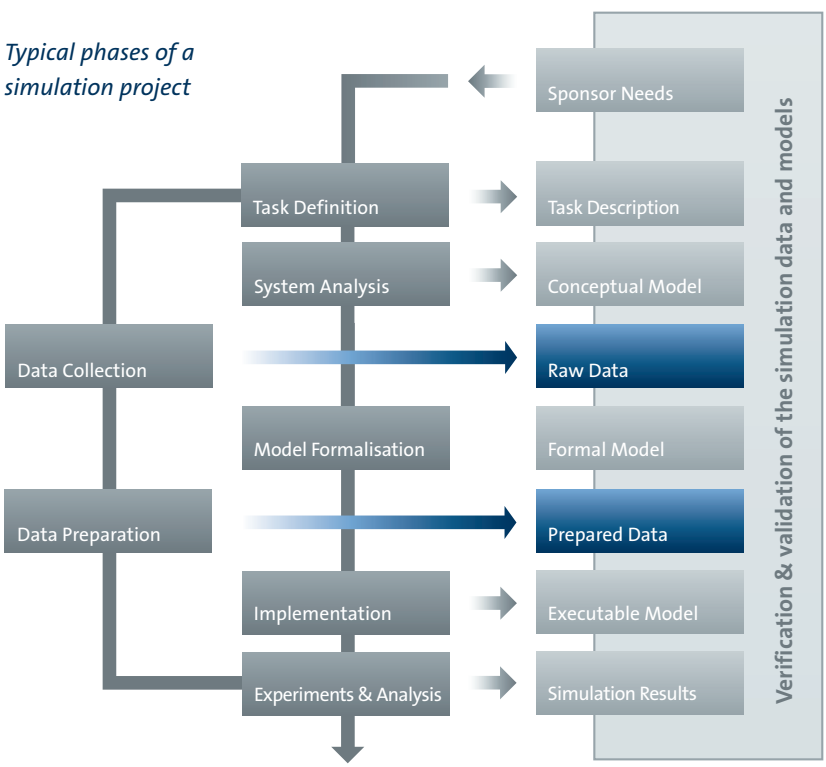
All processes within the network can be visualised in 2D and 3D animations.

Organisational requirements:

- Simulation ideally before construction and implementation
- Clear definition of targets
- Select team of planners and simulation experts
- Collect all required input data
- Assess time requirement and include it in the scope of the project
  - ➔ Simulation expenditure (from model generation to results)
  - ➔ Effort for the relevant specialist department (engineering support and data delivery for the simulation expert)
  - ➔ Effort for other relevant areas (supply of information that is important for the simulation, e.g. technical parameters of a machine)

Requirements for Using Simulation

Typical phases of a simulation project



Source: Rabe, M.; Spieckermann, S.; Wenzel, S.: A New Procedure Model for Verification and Validation in Production and Logistics Simulation. In: Mason, S. J.; Hill, R. R.; Mönch, L.; Rose, O.; Jefferson, T.; Fowler, J. W. (eds.): Proceedings of the 2008 Winter Simulation Conference, 2008, p. 1720

From experience, the total expenditure for a simulation project is divided approximately as follows:

- Simulation expert: 60%
- Specialist department: 35%
- Other, e.g. suppliers: 5%

Commercial requirements:

- Determination of costs
- Estimation of the benefit
- Budgeting

Technical requirements:

- Clarifying the hardware and software basis
- Determining data sources and data preparation

General conditions:

- Generate openness towards alternatives
- Challenge practical constraints and obstacles
- Ensure acceptance of the simulation results
- Draw consequences from the results if necessary
- Set up appropriate team

Limitations of Simulation

In order to achieve credible simulation results, the model must have the highest possible correlation with the real processes.

This level of realism essentially depends on two factors:

- Quality of the model (level of detail, model structure)
- Data quality

The decision for the right level of detail and a suitable model structure require experience with the implementation of simulation models. Simulation software can support the modelling in this respect, for instance by providing suitable building block libraries.

Of course, the quality of the input data determines the accuracy of the results. Therefore, the simulation data should be prepared with the greatest care.

Particular attention should be paid to the definition of disturbances (e.g. machine failure) and strongly volatile parameters (e.g. rework times).

Factoring in breakdowns and random variables

In simulation, so-called random generators are used to model random variables. In contrast to static planning processes, where the disturbances are often calculated via a fixed adjustment of the system performance and volatile process parameters via mean values, the simulation model delivers a result interval, as well as a more accurate picture of the impact of stochastic influences.

Cost-Benefit Ratio

Simulation of a car body manufacturing process with Plant Simulation 3D

Simulation supports the decision-making in the design of new and the optimisation of existing complex processes; it identifies interdependencies and facilitates an objective assessment of alternative solutions.

The financial benefit, however, is difficult to quantify in advance. Figures published by the VDI quantify the cost-benefit ratio as 1:6.

Simulation is profitable

In some cases, for instance in the planning of investment-intensive plants, such as a body shop in the automotive industry, the cost-benefit ratio is even more in favour of simulation. It is, however, possible that the simulation just confirms the design and engineering decisions and does not reveal any potential for improvement.

The decision about the use of simulation should be made based on the following criteria:

- Can the design and engineering risks be covered by means of alternative, less time-consuming methods?
- How high are the costs for simulation in relation to the investment? As a reference value, the cost for the simulation should not exceed 1% of the relevant investment.
- What are the expected optimisation potentials? If, for example, the task is to design an automated guided vehicle system, then making just one vehicle redundant may cover the cost for the simulation.
- How high are the risks of the engineered system? For instance, do you have to develop complex order controls for a picking system in order to ensure that the operation is profitable? If so, simulation can be used to develop a detailed concept and test it virtually. The savings are primarily a result of the shorter time needed to implement the real-world control, as well as the commissioning and the start-up of the plant.

Pedestrian flow simulation with AnyLogic
© The AnyLogic Company

Getting Started with Simulation

Before the decision for or against a simulation study is made, it should be clarified whether all conditions for a successful project have been fulfilled. If there is a lack of experience with the simulation tool, it is recommended to call in a consultant already during the initial decisions. He will be able to judge whether simulation is suitable for the specific problem.

During the initial phase you should also decide whether

1. **to set up an internal simulation service provider or**
2. **to commission an external service provider.**

This decision should be made based on the following conditions:

- Availability of skills: a minimum of two employees should be trained.
- Cost comparison for internal and external service provider (including support expenditure of the respective specialist department): Comparison of the costs for software procurement, training and getting acquainted with the tool with the costs for an external service provider.
- Estimated scope of the simulation tasks over the next 2-3 years: are there projects beyond the current one that are going to require simulation? Will these projects utilise the capacity of 1-2 employees?

Furthermore it must be noted that a lack of experience with handling simulation significantly:

- increases the probability of modelling errors and
- leads to longer project durations.

In order to avoid this, an experienced consultant should ideally support the first project, even if internal resources are being set up. This guarantees an effective transfer of know-how to the newcomer.

However, other alternatives, such as the ‘external workbench’ are also possible. This means that an internal employee is trained in the execution of simulation projects and in the operation of the models, while the models themselves are created by an external service provider.

Getting Started with Simulation

After the decision to carry out a simulation study has been made, the question of the right simulation system or the appropriate external service provider arises.

When purchasing a simulation system, several factors must be taken into account, for instance:

- Which qualifications does the future user of the software have?
- Is data from databases or CAD systems to be incorporated into the simulation model?
- Does the software offer specific solutions for the target application?

How to find the right software and service provider

Most simulation system vendors offer a trial installation or let customers rent their system for a limited period of time. These offers are particularly useful as it is only by handling the software that you get to know its' advantages and disadvantages and will be able to effectively determine the appropriate system for your individual requirements.

Alternatively, you may decide to use our tool laboratory. Within one or two days (depending on the scope of the task and the number of simulation systems to be tested) you can test established systems based on your individual project requirements.

This will provide you with a solid overview of the range of features and the user-friendliness of the different software systems. Today a constantly increasing number of consultancies offer simulation services.

Criteria for the selection of the right partner are:

- Has the service provider got experience in the specific area? (Ask for references.)
- Who will head the project on the part of the service provider? (Ask for profile.)
- Does the service provider use standard systems and industry-oriented building block libraries? (Avoid dependence on proprietary solutions.)
- What procedure model for the project does the service provider suggest? (E.g. according to VDI guideline 3633.)
- How will the know-how transfer to you be guaranteed?

A worthwhile investment for your company: this table shows the basic classification of simulation projects and the expected costs.

	Internal service provider	External service provider
Start-up costs	■ Simulation software as well as possibly additional software (database system, analysis software or similar) ■ Possibly hardware (powerful PC) ■ Training	■ No start-up costs
Project costs	■ Staffing costs ■ Software maintenance	■ Costs for the service provider ■ Possibly software, e.g. viewer for the simulation model or analysis software

Project Type	Total Expenditure in Person Days*	Costs for External Service Provider**
Small, e.g. simulation of a simple conveying system	10 to 30	5 to 15 T€
Medium, e.g. high-bay warehouse with loading zone or automated guided vehicle system	30 to 50	15 to 30 T€
Large, e.g. entire factories, distribution centres	50 to 150	30 to 100 T€
Simulation accompanying planning phases, long-term studies	From 100	From 50 T€

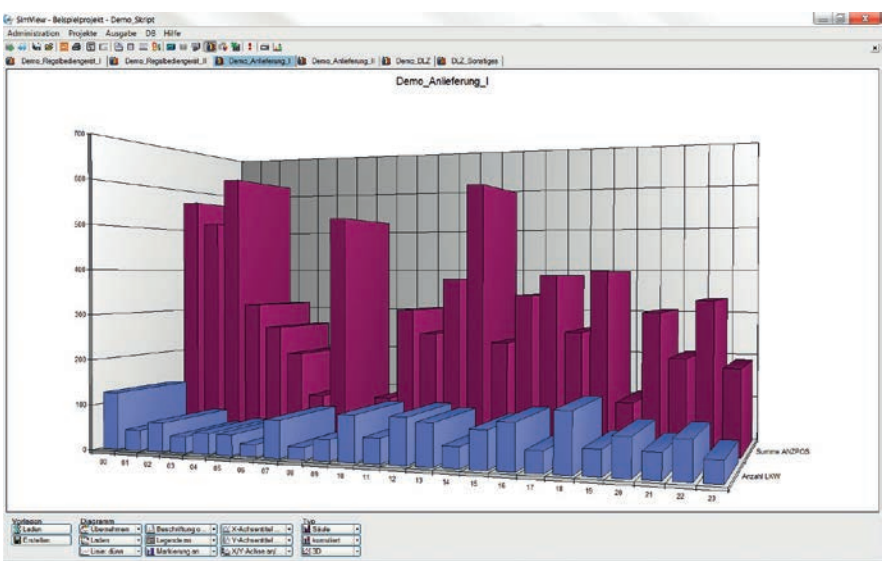
* Expenditure, including model generation, data acquisition and preparation, as well as the execution of experiments. The expenditure covers both internal and external services.

** These are rough price indications that may vary from project to project. Generally, the expenditure for a simulation study is determined by the complexity of the modelling. If, for instance, comprehensive controls have to be implemented, this noticeably increases the required budget.

Getting Started with Simulation

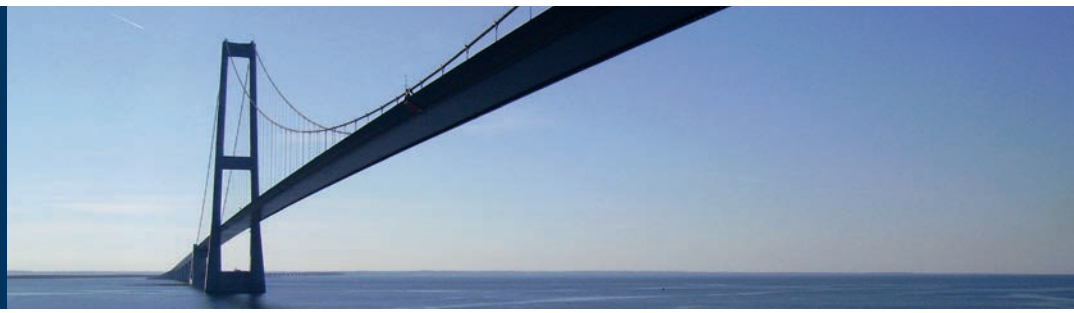
When executing a project, you should take care of the following points:

- Detailed description and coordination of the simulation concept, including all processes, controls, data and parameters at the start of the project
- Clear definition of the expected output key indicators and project targets
- Ensuring the quality of the model by means of a model validation after the modelling has been completed
- Documentation of all experiments by listing changes to parameters/ data/strategies, evaluation of the results, conclusions
- Making clear recommendations for actions based on the simulation results



Database-supported and interactive analysis of simulation results with the tool SimView

The bridge to reality.



Positioning within the Company

Finally, there is the question where within the company simulation is positioned correctly.

As simulation is a cross-divisional function and may concern several areas, such as the logistics and production planning or, for instance, the order management, it would be well-placed as a staff position at plant or management level.

It is also possible to position it within the department with the most comprehensive simulation requirements.

In many companies this is the department that deals with the layout and/or material flow design and engineering.

In particular, the simulation expert should be closely integrated in the relevant projects at an early stage. Fast access to the required data and a direct exchange of information with the members of the project team ensure the efficient execution of simulation studies.

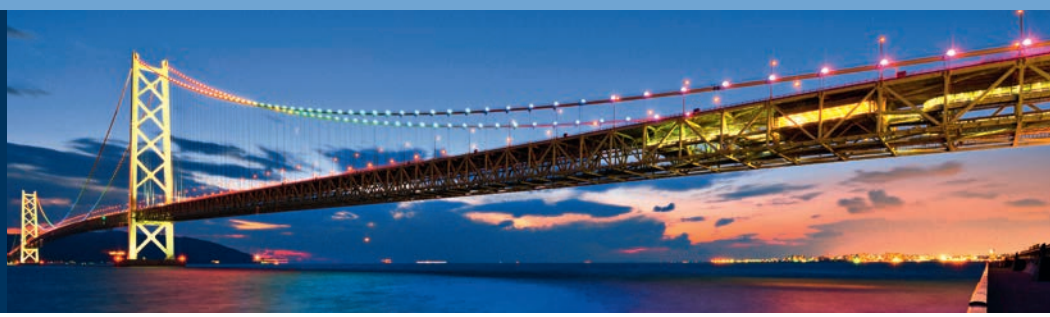
Further Reading

- A. Law: Simulation Modeling and Analysis, 4th Edition, McGraw Hill, 2006
- J. Banks, J. Carson, B.L. Nelson: Discrete-event simulation, 4th Edition, Prentice Hall, 2005
- M. Pidd: Computer Simulation in Management Science, 5th Edition, Wiley, 2004
- VDI 3633 Part 1, 2010-12: Simulation of Systems in Materials Handling, Logistics and Production – Fundamentals, Beuth Verlag, 2010

*There is additional comprehensive material on our homepage **www.SimPlan.de**. We look forward to your visit.*

SERVICE SOLUTIONS SOFTWARE SUPPORT

The bridge to reality.



No doubt you will have some additional questions; therefore, please do not hesitate to contact us. We will advise and inform you on an individual basis about the simulation solutions most suitable for your project and company.

From advice on selecting simulation software, through project support and training of employees, to the implementation of simulation solutions during operation – SimPlan offers all services under one roof.

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