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# Why is Virtual Commissioning and the use of a digital Twin essential today?

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machineering GmbH & Co. KG

## Lernziele

- Discover why it's necessary to use virtual commissioning these days.
- Discover when it's the right time to start virtual commissioning
- Learn what the digital twin should be able to do: What this includes, which interfaces and which areas.
- Discover a case study that examines how other companies have implemented virtual commissioning and the results that have been achieved.

## Description

Today, companies have to achieve perfect products in the shortest possible time and in high quality. This is possible through the use of virtual commissioning with a digital twin along the entire value chain. IPhysics is a physics-based 3D simulation software for the virtual commissioning of mechatronic systems. In this workshop, we will use numerous practical examples from different industries to show how other companies have already implemented this important topic and reveal the results that have been achieved.

## Speaker – Florian Wegmann



Mr. Wegmann, graduated in business administration and IT system administrator with several years of experience in sales, supports machineering since 2015 with his expertise in technical sales and selected customer projects. Within machineering, he manages key accounts and is responsible to extend the global dealer network. Before the 30-year-old Florian Wegmann worked as a sales manager at machineering, he worked at XR Systems for four years.

## The virtual commissioning

Virtual commissioning, industry 4.0, digital twin are today's buzzwords in factory planning. 3D planning is already standard in many areas today. But with Factory Design Utilities and Industrial Physics from machineering, new far-reaching simulation possibilities are emerging. The Digital Twin accompanies machines their lifetime long- daily business, changes or modifications on the machine, service works.... Its goal is to prevent errors, optimize machines and avoid failures. Use the simulation model as basis of the Digital Twin in the early stages of the development process to safeguard your concepts.

### Virtual commissioning

Virtual commissioning is the practice of using 3D-technology to create a simulation model of a manufacturing plant so that proposed changes and upgrades can be tested before they are implemented to the actual plant.

### Why to simulate?

#### More planning security

The bidirectional integration with the CAD process leads to a highly available real-time digital simulation model, called Digital Prototype. Mechanical, electrical and software engineers work together in an easy way – no matter where they are located. The team always works with the 'real' model. Besides a gain in quality, the improved planning control guarantees you to always be in time with your schedules.

#### Virtual commissioning

Higher quality and reduced costs: Thanks to virtual commissioning, machine designers and manufacturers can visualize and test the future machine before the real equipment is assembled. It is possible to examine different planning scenarios and gain security in the case of planning complex machines. The risk for bottlenecks is reduced thanks to early detection. If you plan to modify the dimension of buffers, conveyors, workpiece carriers and other transport mechanisms, you can throughput and instantly validate those changes. This way, you can elaborate concrete and binding statements on throughput and overall equipment effectiveness (OEE) already during the planning phase. The visualization of production processes not only optimizes the comprehension and acceptance of planning within the team but also helps to keep a customer updated on the latest status.

### **More transparency**

The integrated software discharges the developer from error prone processes, e. g. from copying and opening data models in data exchange formats; every developer continues to work in his native system but nevertheless has access to the latest model. Modifications on the machine are visible for everyone. As a mechatronic refactoring tool, the simulation software helps to detect obsolete functions, redundancies and to form new functional units. The possibility to check and double-check the structure and behaviour of the machine enables a better modularization as well as an optimized efficiency.

### **Significant cost and time savings**

A study executed at the iwb of the Technical University of Munich showed that the commissioning time can be reduced by 75% when performing virtual commissioning in advance. The total process time can be cut down by a rough 15%. Software quality is optimized by 40% and costs are saved thanks to running a simulation software like iPhysics. Those saving potentials are confirmed by the success of iPhysics's users.

## machineering GmbH & Co. KG

machineering GmbH & Co. KG is located in Munich (Germany) and develops innovative software solutions for real-time material flow and robot simulation. Our expert team advises companies on topics such as visualization and simulation to improve development, distribution and virtual commissioning.

3D simulation of complex material flows and mechatronic production represent the biggest efficiency reserves in mechanical and machine engineering. 3D simulation and virtual prototyping make it possible to accelerate and test the development and construction of machines. With iPhysics future installations can be visualized in an efficient way together with clients during the project acquisition phase.

The highest saving potential, however, represents virtual commissioning of machines and production streets: It is a proven fact that by running a simulation you can reduce installation, test and optimization costs up to 75%.

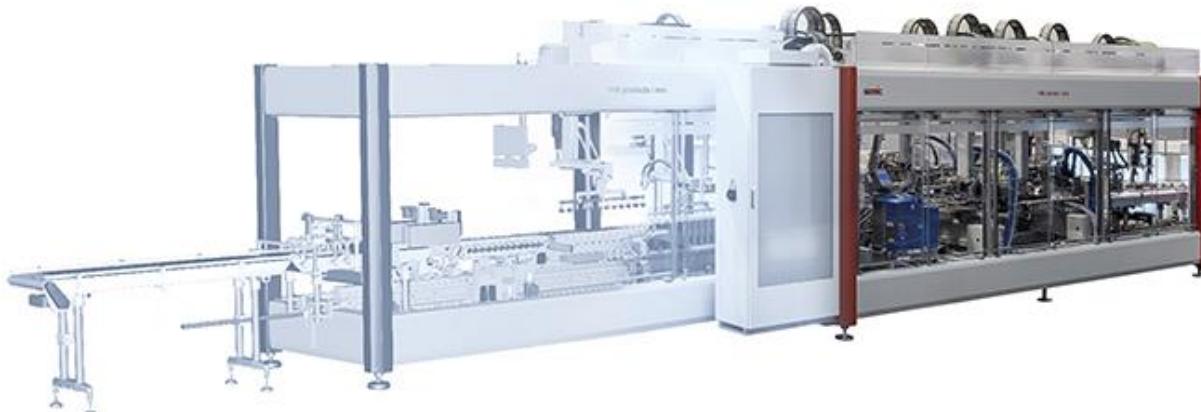
With the foundation of machineering in 2007 – a spin-off company of the iwb (Institute for Machine Tools and Economics in Munich), the team of Dr Wuensch started developing the physics-based simulation software "iPhysics" which, since then, is continuously refined and adjusted to our customer's requirements. In 2009 Dr Georg Wuensch and Beate Maria Freyer changed the company's name into machineering GmbH & Co. KG. Today the 3D simulations developed by machineering's engineers find successful application in leading companies around the world which deal with mechanical engineering, construction and production.

COMPANY LOGO OF MACHINEERING



## iPhysics

iPhysics is a physics-based 3D simulation software used to visualize the virtual commissioning of mechatronic systems in real-time. Given the innovative simulation technology, iPhysics allows a quick and easy modeling of complex machinery also with robots for intensive PLC testing. iPhysics offers a huge variety of functions for various fields of application like development, commissioning, production and sales.



DIGITAL TWIN AND REAL MACHINE (SOMIC VERPACKUNGSMASCHINEN GMBH)

### The advantages at a glance

Simulation model derived directly from your CAD data:

Design and simulation go hand in hand, directly and with no additional effort. Always simulate the newest development status of your machinery!

Connect PLCs:

iPhysics can be connected to a variety of PLCs. Test functionalities at a very early stage in the design process.

Industry robots just a mouse click away:

Visualize the virtual commissioning of robots with iPhysics. Decide to use internal kinematics or to connect to real robot controllers.

Synchronized engineering:

Thanks to iPhysics, engineers from different departments can already work together in the early stages. Check feasibilities and synchronize the workflow

Put on VR or AR glasses:

It is easy to render the running simulation in Virtual Reality (VR) or Augmented Reality (AR). Step into your running virtual machine.

Process consistency along the value chain

iPhysics smoothenes the whole process: from the first ideas to running systems and service cases at the end.

Field bus emulation with the Field Box 1

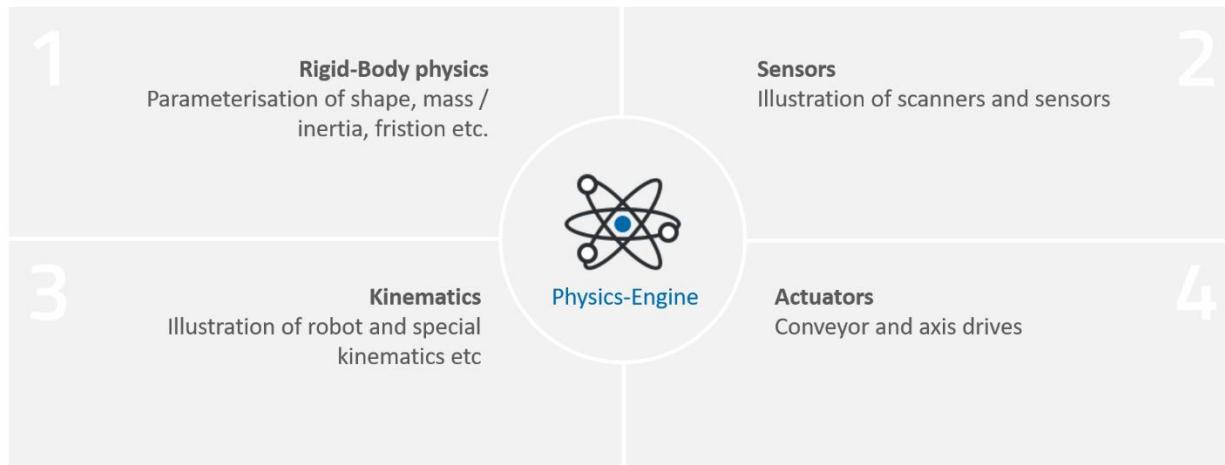
Machineerings Field Box 1 enables virtual commissioning with real PLCs via a native field bus.

Generate a Digital Twin

The simulation model (Digital Prototype) in iPhysics forms the basis for the Digital Twin. Its aim is to prevent failures on running machines and to pretest enhancements on exiting installations.

### Technology of the Physics simulation

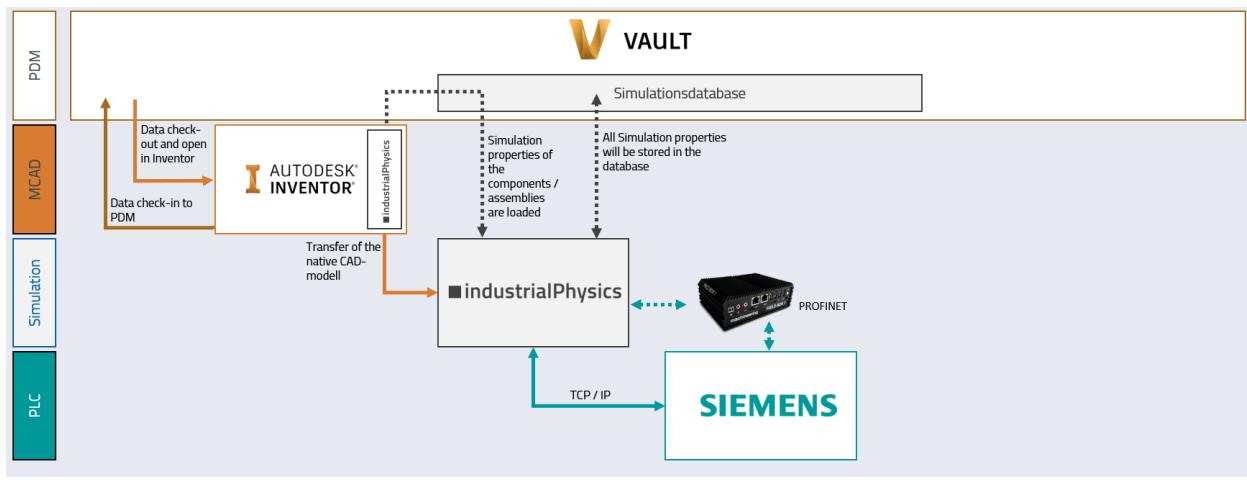
With the Physics-Engine inside iPhysics you could simulate the rigid-body physics, Sensors, Kinematic and Acuators



## The Virtual commissioning process with iPhysics

iPhysics could be integrated in all existing engineering processes. With the bidirectional interface to Inventor there is no STEP-export required. Other benefits of this interface are the use of the original CAD model and the delta synchronization of mechanical changes.

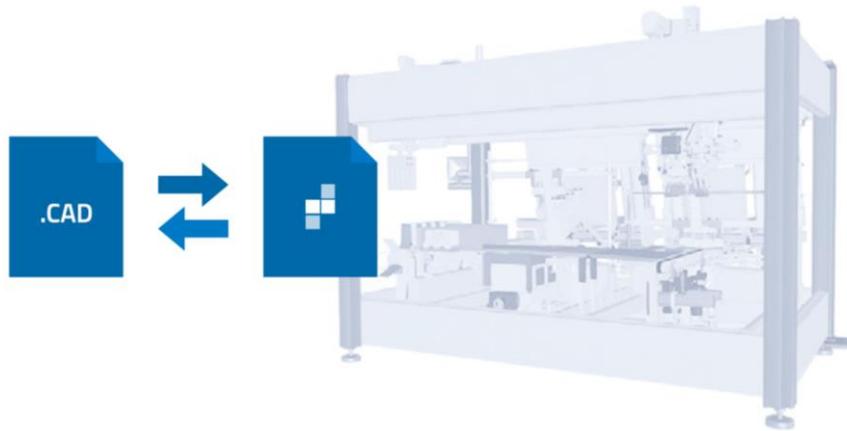
With this functionality the engineers could review their construction really quickly, could safe costs and could be integrated in the PDM-process



THE VIRTUAL COMMISSIONING PROCESS WITH IPHYSICS

## The Workflow in Autodesk Inventor

Design and simulation stay linked to each other with no additional effort thanks to a bidirectional interface. At any time, the design can be checked using iPhysics. Feedback can be quickly integrated back into the design.



LINK BETWEEN CAD AND IPHYSICS

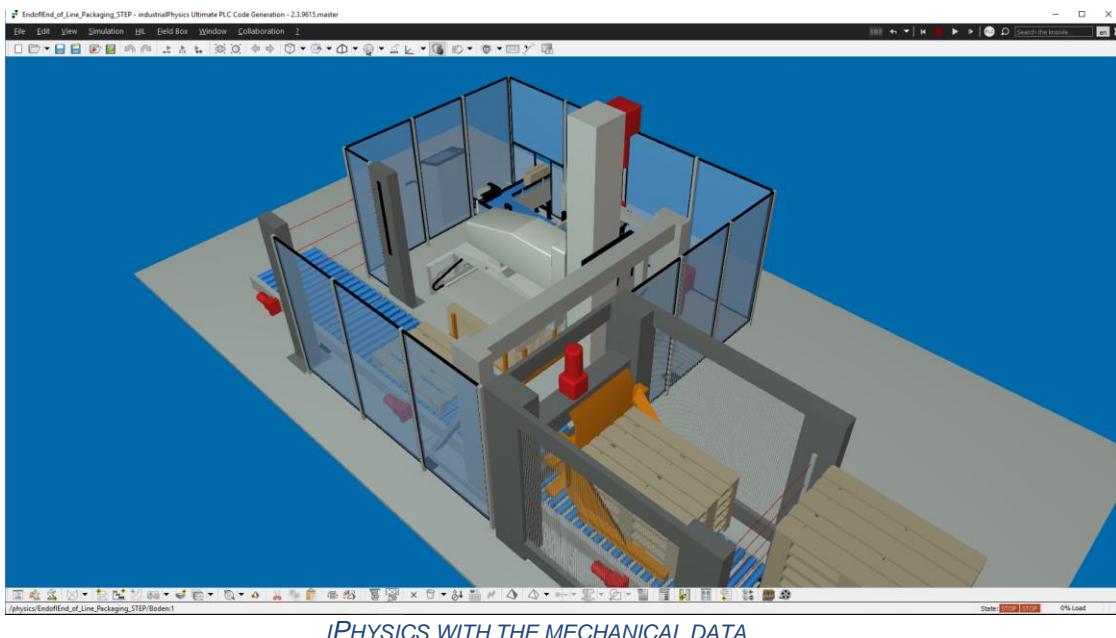


ADD-INS OF IPHYSICS IN INVENTOR 2019

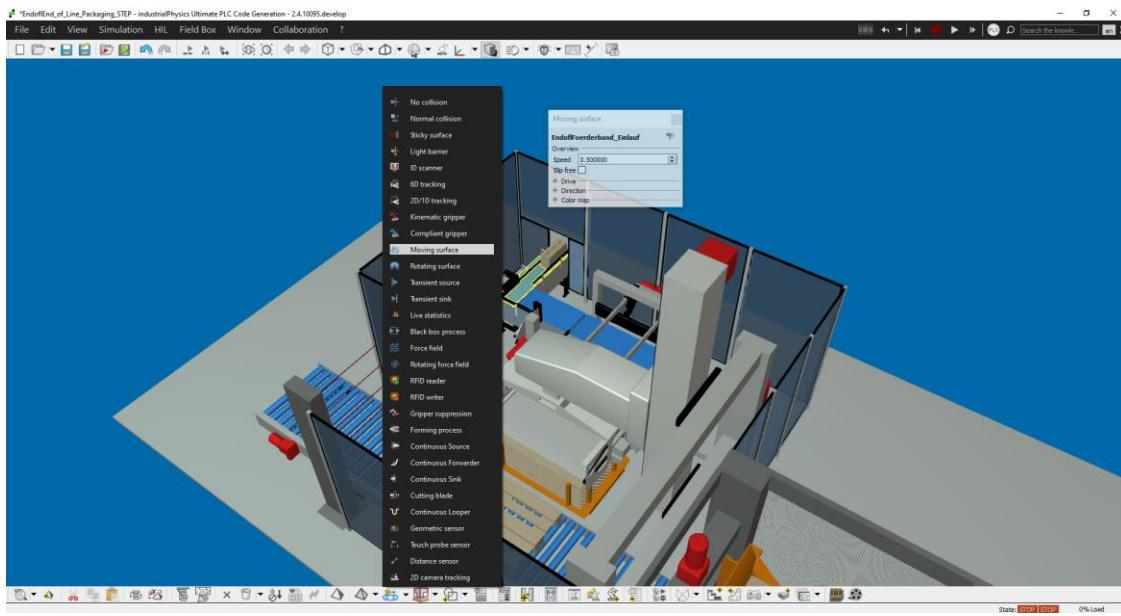
1. Push the button “Transfer All” button to transfer the mechanical data from Inventor to iPhysics.



2. Now iPhysics open and transfer the model from Inventor to iPhysics

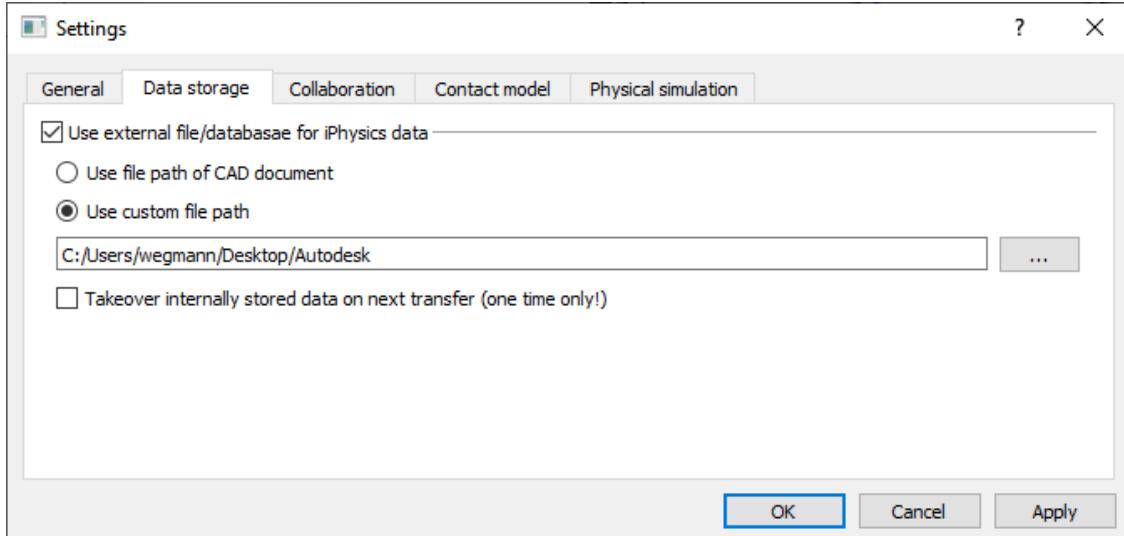


3. Now give the parts and assemblies some specification for simulation



THE SPECIFICATION IN INDUSTRIAL PHYSICS

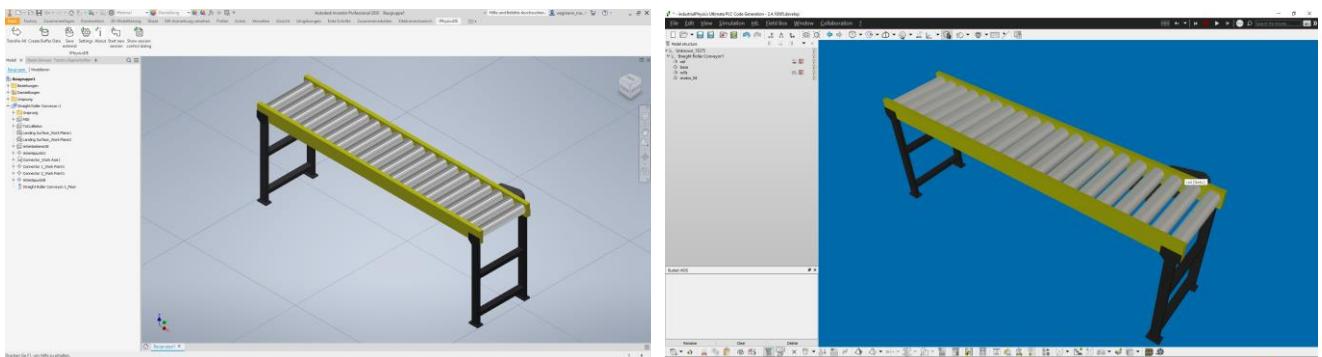
4. All Information are stored back to the part/assembly as an “iProperty” or to an additional folder. If you use this part/assembly in a new project or change the dimension of the part, all iPhysics information are restored from the database.



SETTINGS IN THE INVENTOR-PLUGIN

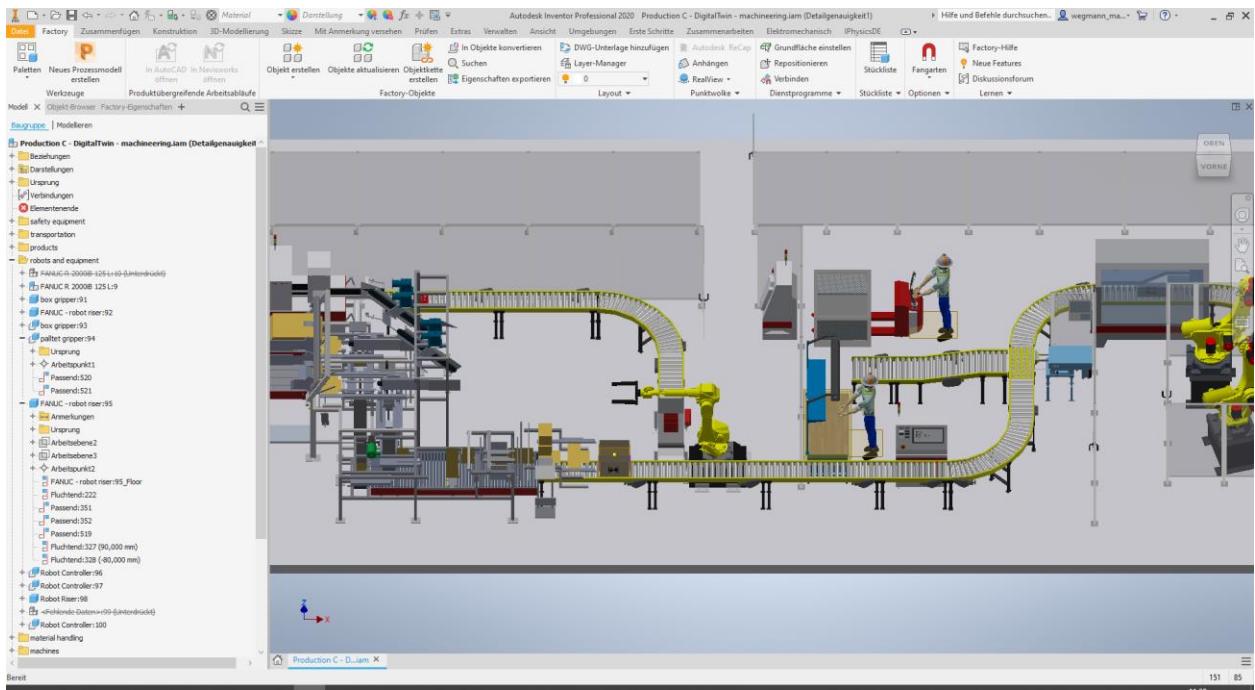
## The Workflow with Factory Design and the Factory Assets

The Workflow how you saw with the classic process in Autodesk Inventor is also working with the Factory.



FACTORY ASSET IN INVENTOR (LEFT) AND IN IPHYSICS (RIGHT)

1. Transfer all Assets onetime to iPhysics.
2. Give all Assets the specific simulation properties
3. Save the iPhysics information
4. Save the Asset back to your library
5. Now all Assets has simulation properties
6. You could start simulation very quickly



*A DEMO DATASET IN AUTODESK INVENTOR*

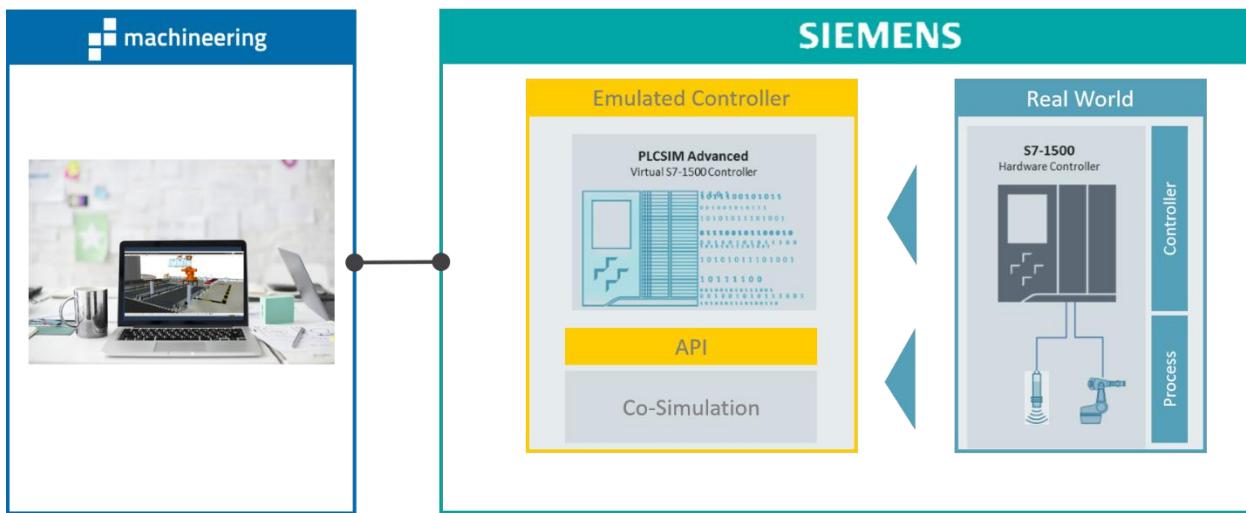
## HIL- / SIL-Engineering – Secure your PLC software at an early stage

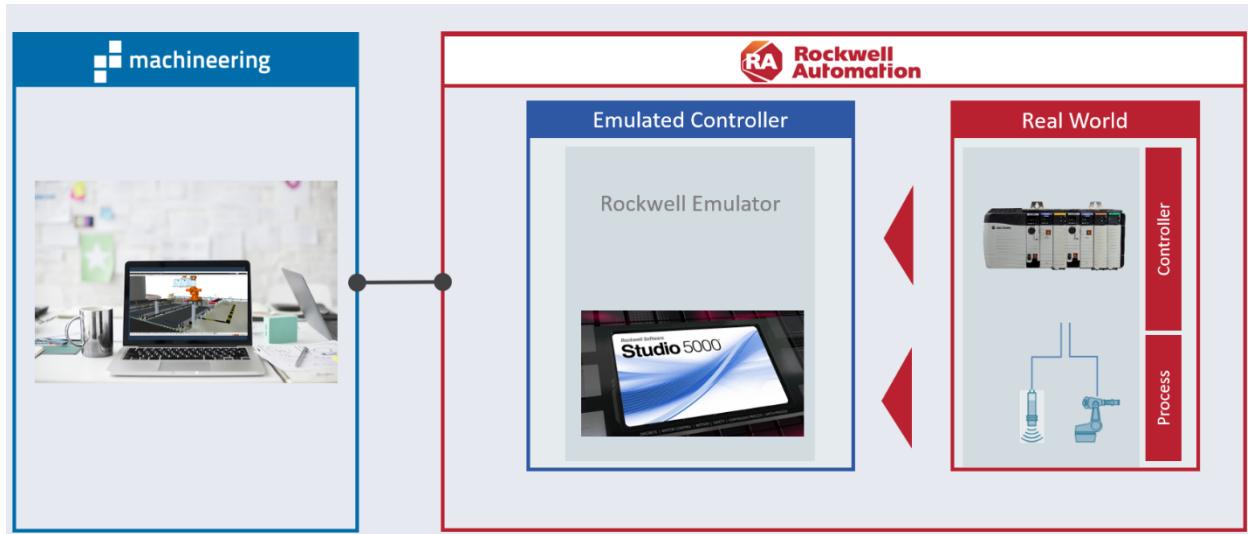
iPhysics offers an integrated Hardware-in-the-Loop (HIL) PLC connection to a variety of common PLC platforms. The simulation model can be run on any computer. No need to install additional hardware which saves costs and increases availability.

Furthermore, HIL engineering signifies a gain in quality: the 3D model and its peripheral devices are calculated in a 1 to 10 msec cycle. Besides the common PLCs, other PLC platforms can also be integrated. The only requirement is the need for a free Ethernet interface in the PLC.

Connect the following PLCs

- ABB
- B&R
- Beckhoff
- BoschRexroth
- Rockwell
- Schneider Electric
- Siemens





SOFTWARE-IN-THE-LOOP SIMULATION WITH ROCKWELL

## Virtual Commissioning including field bus emulation

For a real-time simulation through native field bus systems, machineering offers the Field Box 1.

The Field Box 1 enables multi device emulation for most common field bus systems.

In combination with the simulation software iPhysics, you only have to connect the Field Box 1 to both your computer and controller. Then start into multi device field bus emulation, thanks to a smooth web-interface.

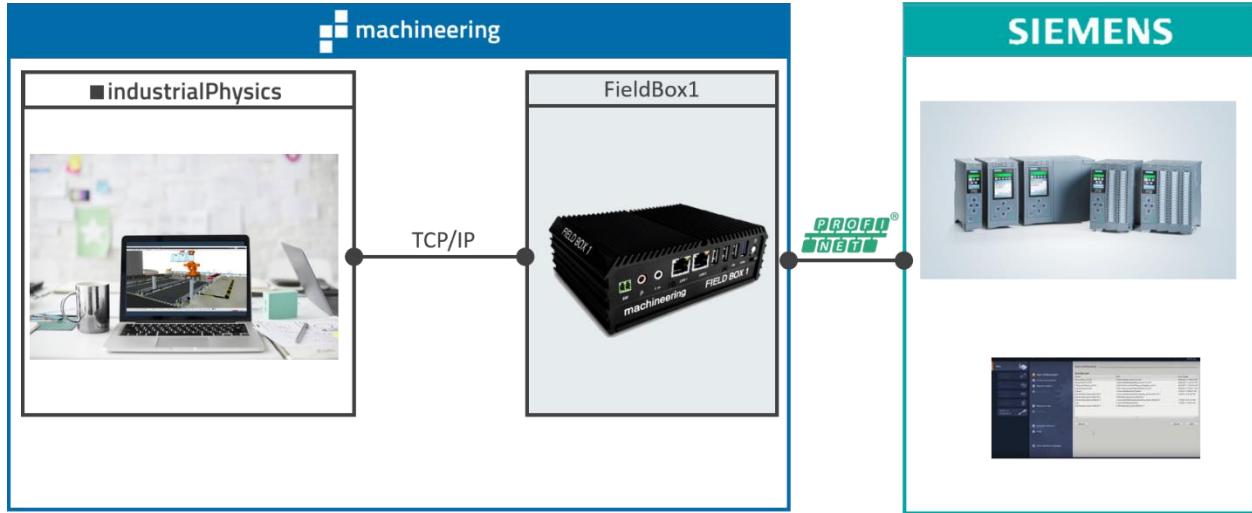
The big advantage in comparison to conventional virtual commissioning is that this field bus simulation doesn't run on any resources of the simulation computer. The whole field bus simulation is processed on the Field Box. Changes in the PLC program are obsolete

### Supported field bus systems

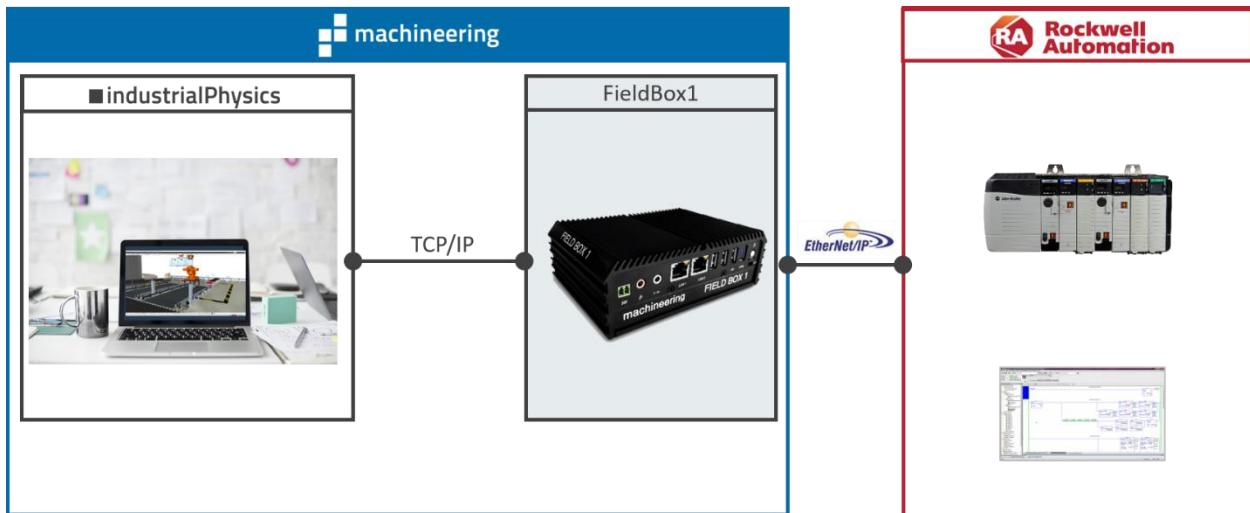
- Profinet
- Ethernet/IP
- EtherCAT



PICTURE FROM THE SPS IPC DRIVES IN NUREMBERG



HIL-SIMULATION WITH SIEMENS



HIL-SIMULATION WITH ROCKWELL

## Industry robots just a mouse click away

Thanks to iPhysics, the virtual commissioning of complete installations is possible no matter if you use the kinematic models or real robot controllers, iPhysics forms the simulation platform which enables mechanical, electrical automatization engineers to work hand in hand starting from the first minute. That way, in the early development stages, it is possible to evaluate design concepts, to test and to optimize PLC software and to plan robotics.

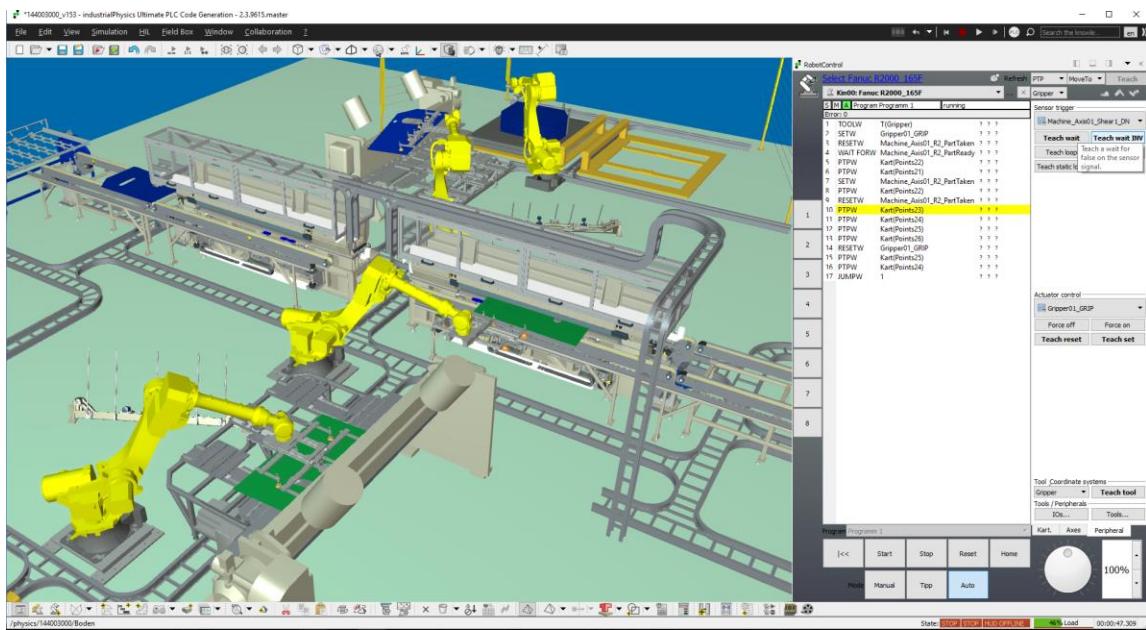


*ROBOTIC SYSTEMS IN THE REAL WORLD*

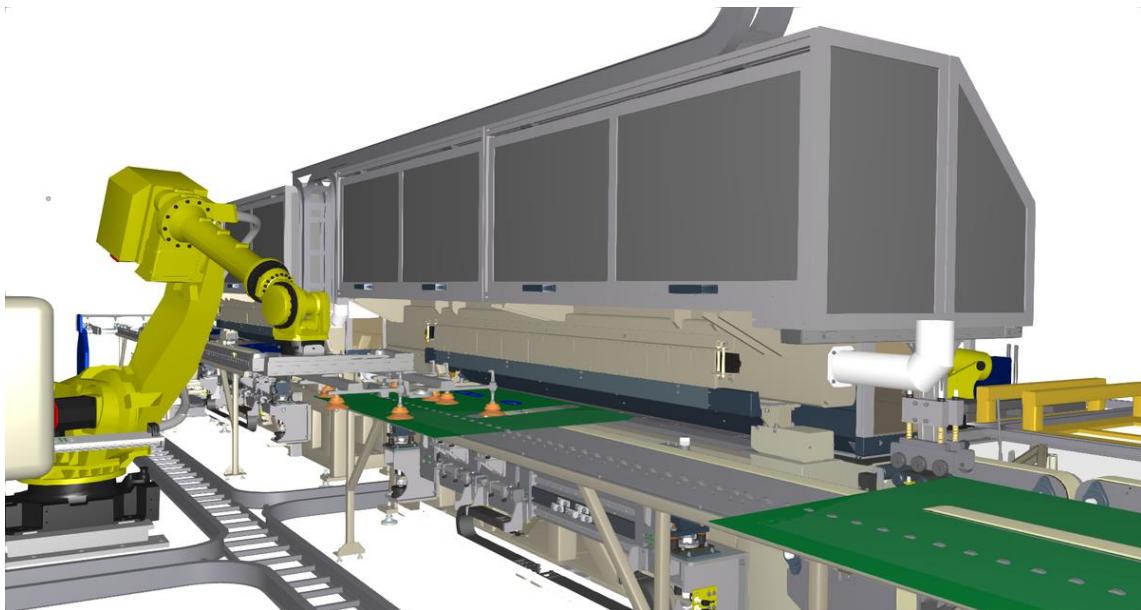
Running a virtual commissioning with iPhysics offers many benefits to companies: Choose out of a large variety of robot kinematics the one which is the best for your installation. Run calculations during the development process for collision detection and special tasks, such as the simulation of the tube packets mounted to robot kinematics.

### Advantages:

- Robot library with kinematics of well-known robot manufacturers like ABB, Comau, Fanuc, Kuka, Staeubli, Universal Robot, Yaskawa
- Connect real robot controllers
- Virtual commissioning of complete robot installations



*EXAMPLE OF A ROBOTIC SYSTEM IN iPHYSICS*



*EXAMPLE OF A ROBOTIC SYSTEM IN INDUSTRIALPHYSICS*

## Experience today what will be tomorrow – VR/AR

With no more effort, iPhysics models can be viewed on Virtual Reality glasses as well as with Augmented Reality glasses. This allows the user to experience planned equipment as well as augment real Plant with additional process data in the third dimension - with the dynamic simulation through motion also in the fourth dimension.

### The new quickness:

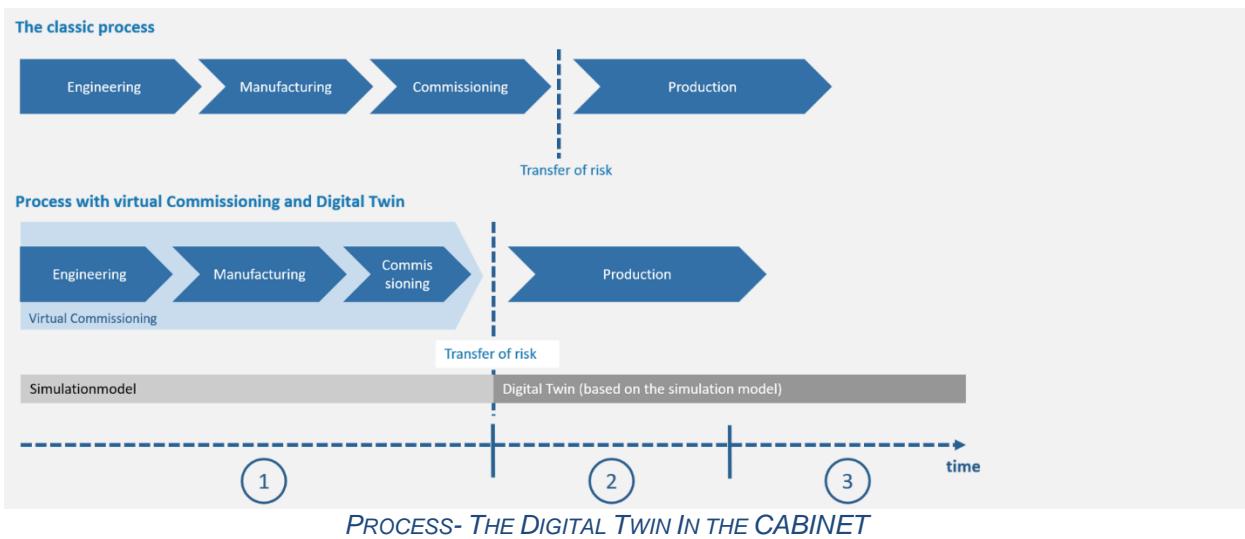
Transform your data within minutes into virtual reality environment, derive changes from the experience and update in unmet quickness for immediate review. Generate emotional moments with the planned production equipment for your colleagues and impress your customers!



PICTURE AUGMENTED REALITY

## The virtual counterpart in the cabinet

In the best case, the production equipment comes with the "machining Digital Twin" from the manufacturer and the Digital Twin already contains all relevant data of the machines. With an iPhysics model running directly in the cabinet, the machine can be easily enhanced with a wide variety of new functions. Parallel to the real implementation of the machines, the Digital Twin will deliver a virtual counterpart with deep insight into the actual state of machine parts that cannot be easily measured. An operator can immediately benefit from all the advantages which the application of a Digital Twin Box provides.



And furthermore, You can feed the local box behind the firewall with all important data of your production process without the risk of loosing strategic data in the internet cloud.

The Digital Twin is easy to integrate into your standard production. It delivers all the necessary data for smoothly running systems. It easily calculates complex geometric models. Virtual testing of new products can be executed running in parallel to the real production process. A Look-Ahead-Function helps to find possible collisions or bottlenecks in the machines and to react in the real system before they occur.



*THE DIGITAL TWIN*

## Case Study

How can real savings from virtual commissioning be quantified in monetary terms? A well-known company for special machines solved this task together with machineering. This case study is about a manufacturer of modular machines, based on a modular system with a large number of customer-specific adaptations. Sales are around EUR 140 million. The company currently employs 700 people, including 130 in research and development and 360 in production.

### Procedure

In the first step, an inventory was carried out and process indicators such as throughput times, complaint and error rates, KPIs for ongoing projects, personnel costs, etc. Based on this, the machineering experts developed a customer-specific concept with a set of rules for the use of simulations, which shows how virtual commissioning with iPhysics can be optimally anchored and lived in the company.

About a year after the concept was implemented and the software was implemented, the same key figures were determined again and the savings achieved were quantified. The complete order processing for a customer project was considered. The only exceptions were production and warehousing, which can hardly be influenced by virtual commissioning.

### Result: Realized potentials

If you compare the determined key figures with and without virtual commissioning, it becomes clear that the customer achieves savings of around EUR 2.5 million through the complete implementation of iPhysics during the development process.

Around two thirds of this is attributable to increasing employee productivity, mainly generated by the early validation of concepts and the avoidance of unnecessary activities such as B. Trouble Shooting.

26 percent are saved by improving quality, measured by the reduction in quality costs due to the decrease in customer complaints and error messages.

Another 8 percent can be attributed to time savings, measured by the increase in delivery reliability and the reduction in contractual penalties.

The corporate climate is also positively influenced. Because with the virtual commissioning and the associated lower expenditure of time for coordination and troubleshooting, more time is created for the actual activities. This creates employee satisfaction and acceptance.

The investment calculation shows that the relatively low expenditure for virtual commissioning and the additional employee capacities are offset by large increases in efficiency in many areas of the company. With a savings potential of around EUR 1.7 million when using a simulation such as iPhysics, the costs for the initial investment will pay for themselves after around 3 months.

### Sum of the realized potentials



#### SUM OF THE REALIZED POTENTIALS

### Productivity

The consistent application of iPhysics in all relevant company areas increases the productivity of employees, especially in the areas of research and development, commissioning and service. This results in savings of EUR 1.63 million per year. As a result, more projects can be implemented in the same period with the same staff.

### Derivation of savings

#### Research and Development

- Minimizing the Risk for humans and machines through early safeguarding of the machine concept and machine behaviour.
- Less coordination effort due to improved communication with the digital twin as a common basis.
- Reduced effort for troubleshooting through early, advanced knowledge.
- Development of the “optimal Program” – Running different variants on the digital twin
- Shorter meetings because quick and efficient change management can be realized with the help of the digital twin.
- Higher employee satisfaction through more time, peace and freedom for new concepts and further developments

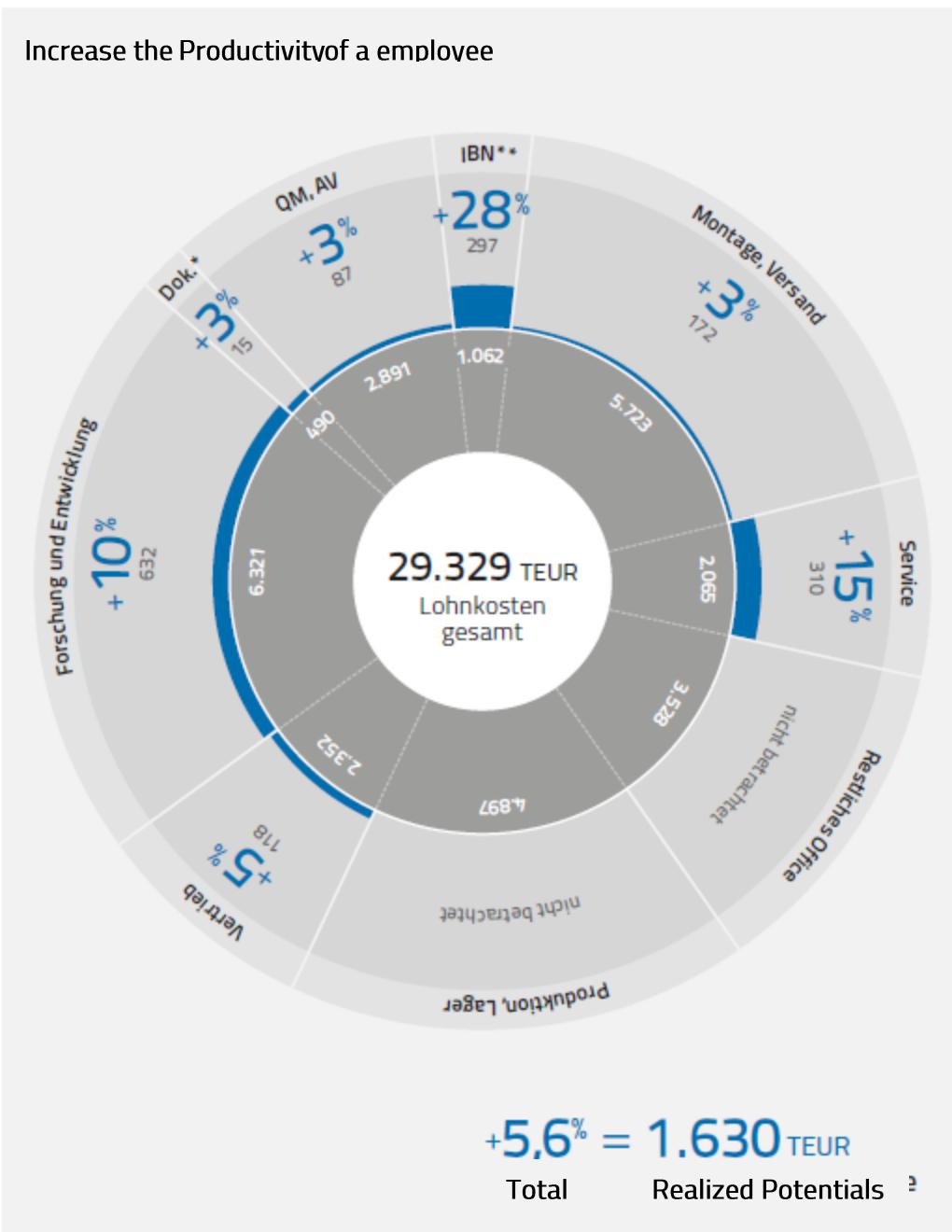
### **Commissioning**

- Fewer errors in the real machine thanks to the visibility of collision risk on the digital twin
- More efficient use of personnel because commissioning is moved forward; later only "fine-tuning" is necessary
- Higher motivation on the employees because longer stays abroad are reduced to a minimum.
- Fewer cost intensive errors "towards the end" because virtual protection takes place at an early stage
- Fewer consumables for test as real tests are hardly necessary anymore
- Less space for setups because test setups through virtual ones. Commissioning is largely eliminated

### **Service**

- Training of the customer takes place in parallel with the help of the digital twin on a virtual machine
- Fast conversion to new products because virtual protection with digital twin is possible in a parallel ongoing operation
- Lower complaint rate because errors are identified and remedied in advance
- More safety for the machine operator through the acquisition and evaluation of real machine data with the digital twin

## Increase the Productivity of an employee



SUM OF THE REALIZED POTENTIALS IN PRODUCTIVITY

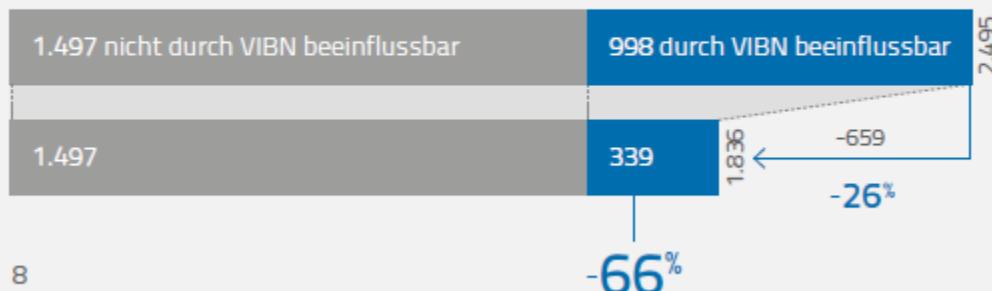
## Quality

With the help of virtual commissioning, errors, collisions and failures that would only have occurred during actual commissioning or during operation are recognized in advance and can be eliminated early on. In the customer example, this significantly reduces the number of internal error messages and customer complaints. As a result, the quality costs are reduced by around EUR 650 thousand. This corresponds to 66 percent of the quality costs that can be influenced by the simulation. The total quality costs also include factors that cannot be influenced by simulation. These cannot be reduced by virtual commissioning, or only with great effort.

### Derivation of savings

- Reduction of quality costs through early testing of all machine elements with the software to be installed
- Higher quality and more sophisticated machine through more trials, tests and “trying out”.
- Better quality perception by customers through the elimination of extensive test, rework, corrections, and modification after commissioning or during the ongoing process operation
- Improved coordination with customers development steps and approvals agreed on the basis of the digital twin.
- Visualize critical assemblies through to the use of VR/AR with the digital twin.
- Professional project management. Security for the customer through successful project implementation with the digital twin and open communication
- Remote maintenance in the event of machine downtime of the digital twin, rapid identification, and virtual reproduction of problems, testing of solutions on the model and transferring new machine programs to the real system.

### Reduction of the costs through less customer complaints



SUM OF THE REALIZED POTENTIALS IN QUALITY

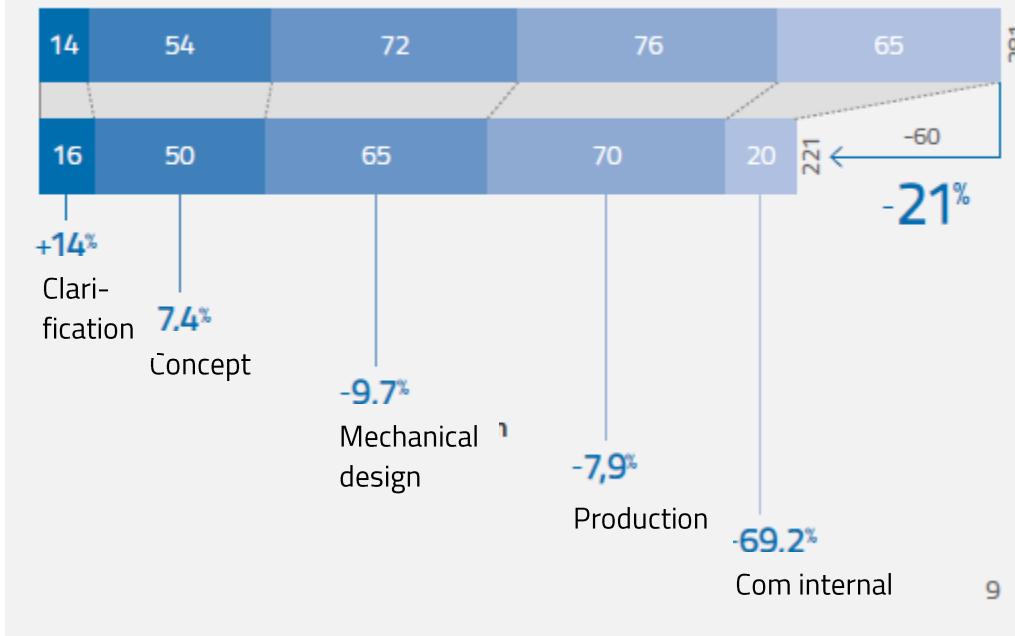
## Time

The use of the iPhysics simulation software leads to a significant shortening of the overall development time and to stabilization of the actual commissioning, which in turn improves delivery reliability over the long term. For the mechanical engineering company under consideration, the proportion of machines delivered on time almost doubles. At the same time, the costs for contractual penalties due to non-compliance with delivery dates are reduced by EUR 191 thousand. The processing time is shortened by 21 percent - a clear competitive advantage.

## Derivation of savings

- Parallel engineering through forward shift (the reduction of the lead team in PLC programming in the real commissioning by 70 percent. Significant reduction in overall development time).
- Less effort for troubleshooting by bringing forward findings, especially in the area of commissioning by up to 70 percent
- Less time during commissioning at the customer's site because the customer's employees are trained in advance on a virtual machine.
- Improved adherence to deadlines compliance with guaranteed delivery times does not result in additional costs due to contractual

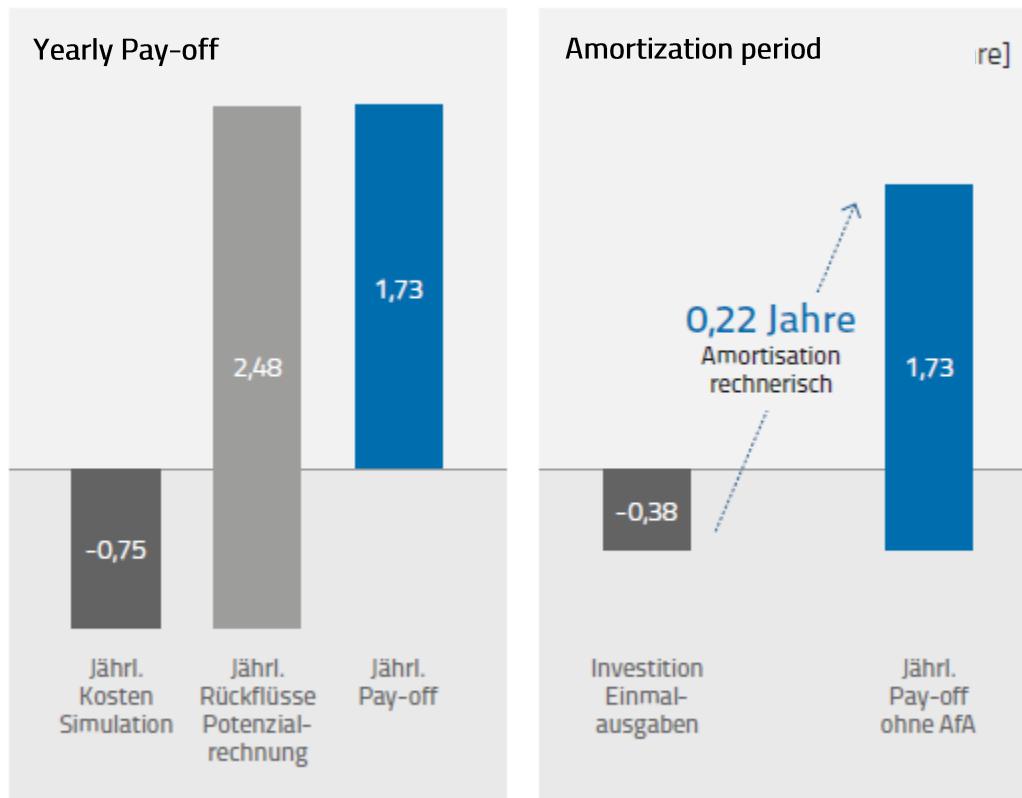
Processing time with and without virtual commissioning



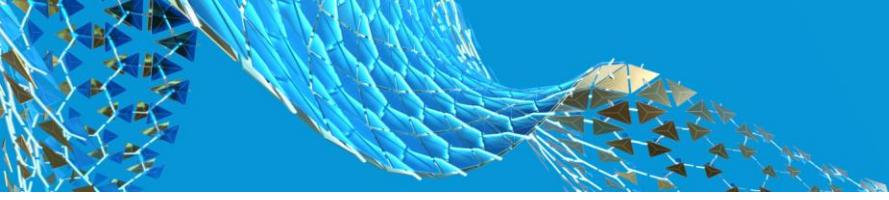
SUM OF THE REALIZED POTENTIALS IN TIME

## Investment calculation

The virtual commissioning with the iPhysics simulation software can help to reduce invisible waste in the processes and thus noticeably improve productivity, adherence to delivery dates and quality. However, this potential can only be achieved if the simulation is fully and deeply implemented in the organization and in the processes. In the following figures, the savings achieved are offset by the effort for a simulation department consisting of 8 employees and the corresponding hardware and software costs. The figure "annual pay-off" shows the advantages of the investment. The relatively low costs for the software for virtual commissioning and the employee capacities are offset by the high efficiency increases in the corporate divisions. In total, the customer saves around EUR 1.7 million annually if virtual commissioning is carried out. The costs for the initial investment have paid for themselves after around 3 months. The realized savings can be transferred to companies of various industries and sizes.



AMORTIZATION PERIOD



## Consulting of machineering

Yes, simulation with iPhysics saves time and money. And yes, simulation brings along an enormous gain in safety. However, the real potentials can only be reached if the infrastructure is regarded as a whole. Therefore, it's important to us to also act as consultants for our customers when it's about aligning both the entire development process and, later on, the production to simulation models.

The trend shows that – in addition to the design, electrical system and automation – simulation is also making inroads into engineering as a new process step. But how is it to be implemented?

### Broadly set up with iPhysics

iPhysics is the simulation basis in the entire engineering process. Starting with the design, iPhysics offers a bidirectional data exchange of the CAD data from popular CAD systems such as SolidWorks, Inventor, Creo, etc. Real controllers can also be connected to the virtual model in order to carry out virtual commissioning. Our customers can also access a large number of robot kinematics from various manufacturers, integrate drives and use numerous VR and AR glasses as standard with iPhysics.

The simulation as part of the big picture, which everyone involved can access at any time to get the state of development or the production process in real time.

As a software manufacturer and for you as a customer, it is important not to regard iPhysics as a stand-alone solution. The advantages that the use of our simulation software offers can only be used to the optimum if they are really a fixed component of the entire process.

### Away from the stand-alone solution

Our experience has shown that nowadays many companies do not use simulation widely enough and are thus missing out on potentials. In order to circumvent this, it is crucial that the principles of efficient working are established within the organisation and the corporate processes. And that is only possible with a deep, structured implementation.

For companies there are different ways of integrating the simulation. One of them that has stood the test of time is to establish a department or core team especially for this purpose.

### Start simulation management in a small way

Many companies have taken the route of creating simulation teams consisting of top experts from the fields of design and automation. Both work simultaneously on modelling projects (virtual prototype) and commission virtual plants on the screen step by step. At the end of this process they obtain a precise mechatronic image of a real machine (digital twin), on the basis of which the machine's behaviour can be tested and optimised in advance.

After the completion of a project the simulation models can continue to be used by adopting common parts, including simulation data, into libraries. This facilitates the simulation of follow-up systems enormously. In addition, they can be used by sales for customer acquisition, by after-sales and for production monitoring or training purposes. The simulation models or digital twins can also be visualised by VR / AR, web or apps.

"No machine leaves our company without simulation", states one of our customers, which has been putting the simulation process into practice for years. Its market leadership proves that it is right to do so. The initial investment in the form of manpower has quickly paid for itself; the software costs were already amortised in the first project.

### We support you with the implementation

Every company is aligned and organised differently. In order to facilitate the implementation for users of iPhysics, machineering cooperates with experienced consultants. On the basis of

defined levers, a concept is developed to enable the simulation to unfold its full potential in the company. Coupled with a simulation project running in parallel, the feasibility and practical application are guaranteed.

May we support you in using iPhysics profitably in your company? We'll be glad to send you the relevant documents.