Day 1 | User Conference 8th October

Delivery mode: Physical + Online / Hybrid

09:00 am – 09:15 am **Welcome & introduction**

Keynote Address

09:15 am – 10:00 am **Increasing engineering efficiency by cyberphysical prototyping**
Prof. Dr.-Ing. Guenther PROKOP | Chair of Automotive Engineering | TU Dresden

10:00 am – 10:30 am **Green, sustainable technologies for automotive transmission validation**
Mr. Hiral Kumar Patel | Deputy General Manager | Tata Motors Ltd.

10:30 am – 11:00 am **Tea / coffee / bio break**

Users' presentations

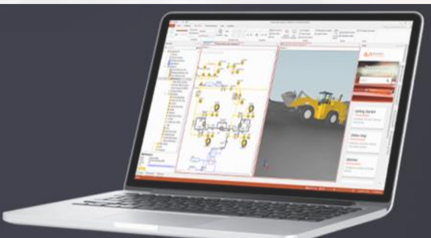
11:00 am – 11:30 am **Multidisciplinary concurrent design for reusable launch vehicle & space craft to realize future missions with multi-physics modeling & simulation**
Mr. Kaname Kawatsu | Associate Researcher R&D dept. | Japan Aerospace Exploration Agency (JAXA) & NewtonWorks Corp. Japan

11:30 am – 12:00 pm **Evaluation of low-frequency NVH phenomena in electric vehicles using a modular drivetrain library in SimulationX**
Mr. Martin Ebert | System Simulation Engineer | IAV GmbH

12:00 pm – 12:30 pm **Enhancing sustainability in machinery with digital twins and system simulation**
Mr. Sven Bätzing | Product Area New Business Virtual Engineering | Rexroth BRSL

12:30 pm – 01:00 pm **Simulation-based analysis of system hydraulics in building energy supply: A case study of a networked residential and industrial district**
Mr. Pascal Jirschik | Project engineer | EA Systems GmbH

Continued...



Day 1 | User Conference 8th October

Delivery mode: Physical + Online / Hybrid

01:00 pm – 02:00 pm **Networking lunch & break**

Users' presentations

02:00 pm – 02:30 pm **Gearshift simulation: shift feel perception using HIL method**
Mr. Yogesh Tongaonkar | Sr. Manager Transmission Development| Tata Motors Ltd.

02:30 pm – 03:00 pm **Multibody systems models of trucks for digital twin development**
Mr. Roktim Bruder | Simulation engineer | Daimler Truck AG

03:00 pm – 03:30 pm **Simulation models as the core of a digital twin for a copper ore mine**
Dr. Torsten Hellmuth | Sr. Key Expert – Product Management Mining | INNOMOTICS GmbH

03:30 pm – 04:00 pm **Utilizing SimulationX to assess and redesign jackleg hammer drill**
Ms. Srividya Kuppa| Researcher, Department Of Systems Design Engineering | University Of Waterloo, Canada

04:00 pm – 04:15 pm **Tea / coffee / bio break**

SimulationX news

04:15 pm – 05:00 pm **Key updates, news & announcements**

Wrap up & Dinner

05:00 pm – 05:30 pm **Closing remarks, summary & take-aways**

06:30 pm onwards **Team building & dinner**

Continued…

Day 2 | Tutorial Day 9th October

Delivery mode: Online

- **09:30 am – 10:00 am Introduction & gearing up**
- **10:00 am – 12:30 pm: Scripting in SimulationX with Python**

REQUIREMENT / Pre-requisites: Python 3.12 installed & virtual environment for SX set up

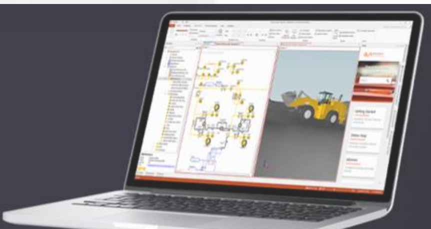
- Setting up the Python environment and introduction to Jupiter Notebooks, SimulationX tools and the Workflow Automation library
- Preprocessing and postprocessing data by means of Python
- Reducing a detailed physical model structure into a map-based type to improve computation time
- Utilize advance analysis methods by using Python to speed up your analysis
- Easier handling of big models by automation

- **12:30 pm – 01:30 pm: Lunch break**
- **01:30 pm – 03:30 pm: Recommended tips & tricks to improve efficiency & experience**

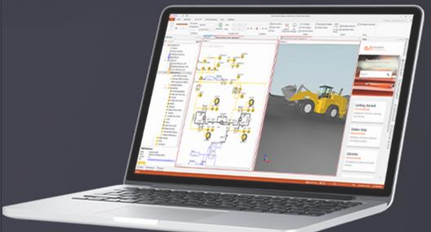
- Learn how to set up a convenient simulation environment for different use cases and how efficient workflows can improve your experience in SimulationX
  - Configuration of SimulationX
  - Configuration of result windows
  - Efficient workflows
- Inside .isx – short introduction to the structure of an SimulationX project file and how to attach additional data
- Advanced modelling methods for easier modelling
  - Using the inner and outer declarations for e.g. easier distribution of parameters
  - Use initial equations to define boundary conditions at simulation start easily

- **03:30 pm – 04:00 pm: Q&A with tea/coffee**
- **04:00 pm – 05:30 pm: Special use case – Inverse kinematics**

- Identify actuator movements and forces or torques to follow a predefined trajectory in a system with multiple degrees of freedom to derive the necessary operation range and size of drives in this kinematics



Transcripts of all the conference presentation abstracts



All Abstracts

Increasing engineering efficiency by cyberphysical prototyping

Prof. Dr.-Ing. Guenther PROKOP | Chair of Automotive Engineering | TU Dresden

Today's development cycles must be cost-effective, fast, flexible, and resilient. Thereby product complexity and requirements on safety, sustainability, and performance are ever increasing. The V-model is thus supplemented by agile methods, which impacts how test and simulation methods have to be combined efficiently. Cyberphysical methods are designed to support this change in system engineering methods:

1. Cyberphysical prototyping: the vehicle is divided into subsystems, each of which can be developed using respective testrigs and/or simulation models. Testrigs and simulation models can be coupled in real time to form cyberphysical full vehicle prototypes. Digital twins of testrigs and highly advanced control concepts are required.
2. Human centered attribute development: cyberphysical prototypes can be experienced subjectively at every development stage, if coupled with a highly immersive driving simulator. Moreover, driver experience and driver behavior can be understood and predicted by feeding measured driver behavior into driver models.
3. Smart test environments for automation and connectivity: the cyberphysical prototype has to be considered in context to its environment (road space, informational radio connections). The appropriate test environment is to combine physical vehicles with simulators for several traffic participants.

Prototypes for these instruments are being developed at TU Dresden. Their role in modern development is demonstrated in the presentation.

Green, sustainable technologies for automotive transmission validation

Mr. Hiral Kumar Patel | Deputy General Manager | Tata Motors Ltd.

With the increase in car emissions, several developing & developed countries are implementing strict regulations to minimize the environmental impact of the automotive industry. Sustainable product development and ensure minimal CO_2 emission are prime concern for automotive industry. Undoubtedly, moving towards a clean /greener, more ecological solution presents an ideal business move for automobile manufacturers, offering significant potential to drive a more sustainable future. Automotive OEMs target Net-Zero-CO_2 between 2030-2040. As a result, companies are actively focussing on development & launch Electric and Hybrid powertrain vehicle in the market. Recent statistics highlight the transformative impact of green energy on the automotive industry, with electric vehicle (EV) sales witnessing remarkable growth with multiple OEMs and startups entering in this field. Another pivotal aspect of this transformation is the front loading of development activities through digital validation process for robust product development catering to need for faster launch of new products. Road load data acquisition and accurate duty cycle generation for target market is need of hour as huge cost and resource gets engaged in this activity at early product development stage. Accuracy of this data determine success of the product in the market. Simulation tools available now-a-days can be used for this application. Range anxiety is another area where simulation tools can help to derive optimal drivetrain strategy.

Evaluation of low-frequency NVH phenomena in electric vehicles using a modular drivetrain library in SimulationX

Mr. Martin Ebert | System Simulation Engineer | IAV GmbH

A very important aspect for the development of electric vehicles is the early analysis of vibration phenomena of the e-drive axles in their mounts, which lead to high dynamic loads on the drivetrain and high mount forces when the excitation is taken into account. The presentation will introduce an efficient simulation method using a modular model library in the software SimulationX - starting from the excitation source at the wheel-ground contact, to the vehicle model. Furthermore, the influence of the model detailing of the wheel-ground contact and the chassis on the accuracy of the simulation results is examined. These models can be used, for example, for an initial assessment of low-frequency vibration phenomena during different driving maneuvers, such as ABS braking on bad road surfaces or driving over uneven surfaces with one side (full-load approach and full braking). The presentation also shows mathematical optimization possibilities for the arrangement of the aggregate mount components based on these models. In addition, the partial model exchange with other simulation programs via the FMI interface is described.

Continued ...

Multidisciplinary concurrent design for reusable launch vehicle & space craft to realize future missions with multi-physics modeling & simulation

Mr. Kaname Kawatsu | Associate Researcher R&D dept. | Japan Aerospace Exploration Agency

In collaboration with NewtonWorks Corp. Japan

In order to realize future space missions that are unprecedented and difficult, such as landing of reusable rockets and automatic docking of spacecraft, it is important to determine feasibility and technical risks at an early stage. Furthermore, there are issues with the reproducibility of the actual operating environment and the costs involved in ground tests, making comprehensive evaluation difficult. Therefore, in addition to ground tests using conventional hardware, efficient model-based evaluation is required. Therefore, JAXA had introduced multidisciplinary concurrent approach for mission feasibility and safety evaluation by focusing on the interaction of complex physical domains and using models that integrate multiple elements (mechanisms, control, propulsion systems, etc.) to realize future space missions.

Reusable launch vehicles of the future are expected to drastically reduce space transportation costs. Realizing a radical reduction in cost for space transportation requires not only reusable design efforts for longer life but also technologies that will improve reusable launch vehicle readiness, reliability and safety. In evaluating system feasibility during concept studies, it is necessary to identify important characteristics and bottle-neck technologies that contribute significantly to capacity and mass regarding design specifications and operational conditions. Furthermore, from the perspective of robustness against weather conditions during operation, it is necessary to evaluate sensitivity and understand optimization trends through parametric study. During attitude control or landing phase, both vehicle reorientation and drag from atmospheric flight incite large amplitude propellant slosh that may affect vehicle stability. Landing mechanical load transfer to the vehicle body is key of structure design and stability is important. Each phenomenon needs to be evaluated certainly and has strong interaction through such as vehicle attitude, position, and velocity during landing phase. Therefore, achieving optimized design require a multi-physics system-level evaluation with affordable evaluation cost which enables parametric study considering vehicle specification, constraint, and variation of condition.

Rendezvous docking (RVD) is a key technique for space activities and missions, including in-orbit servicing and planetary exploration missions. This technology is gaining importance because it makes a wide range of space activities and missions possible. These activities include orbital supply and replacement services, and assembly of large space structures that cannot be launched as a whole. In fact, the RVD is one of the crucial technologies in the International Space Station (ISS) program to provide physical connection for the crew and resources. One of the planned missions of the HTV-X, successor to the HTV, is a demonstration of automatic docking system. After transporting cargoes and leaving the ISS, the HTV-X can be used as a platform for technical demonstration. The docking system needs to achieve a high level of reliability and safety. However, there are many scenarios for safety measures of the time-variant actuator states on both the vehicle and the docking mechanism. The HTV-X vehicle must integrate the attitude control system and the automatic docking system during design evaluation and safety assessment. For safe autonomous docking with the target spacecraft, it is essential to evaluate the interaction of the host vehicle and the automated docking mechanism regarding failures and other off-nominal events to ensure that the system is trustworthy. However, it is difficult to comprehensively evaluate and verify the system only by ground testing because of the difficulty of reproducing the operating conditions in space. Therefore, this study applied a model-based approach to the design evaluation and risk assessment of the automatic docking system, aiming to simulate normal and off-nominal scenarios under accidents or failures accurately.

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Enhancing sustainability in machinery with digital twins and system simulation

Mr. Sven Bätzing | Product Area New Business Virtual Engineering | Rexroth BRSL

Co-Authors: Dr.-Ing. Nils Menager, Mr. Rüdiger Kampfmann

Sustainability has been gaining in importance in all areas of society for several years. Therefore, OEMs, machine operators, government and society expect extensive activities from machinery suppliers. Bosch Rexroth has taken this challenge and pursues a holistic approach from cradle to grave. This means that the whole life cycle of a product is considered, i.e., from raw material mining up to recycling.
In the industrial sector, the operating phase of a machine is of particular importance, as it has a massive impact on the CO2 emissions, whereas in the sector of consumer goods, it is often the manufacturing phase that is more significant. Hence, the power consumption of machines used in industrial production should be already considered and minimized during development. This applies especially to hydraulic machines such as presses and injection molding machines, which often have a high energy consumption.
However, a component-based approach alone is not meaningful. Instead, the interaction of the entire machinery must be considered, and the energy consumption is strongly dependent on the used cycle. Without the usage of digital twins and Virtual Engineering methods, the energy consumption can hardly be calculated before commissioning, especially since norm cycles are not always defined. Simulation usage makes it also easy to compare different machine concepts, including analyses regarding energy efficiency and power consumption, and thus to find an optimal setup.
Bosch Rexroth has recognized this demand and provides digital twins in form of the Modelica library Rexroth BRSL. The BRSL is a 1D system simulation library with a focus on hydraulic and electric drive technology. It provides everything from a single source that is needed to create a representation of the static, dynamic and kinematic properties of an entire machine or system in the form of a digital twin. Finally, this digital twin can be used both for well-known and established use cases like the validation of the dynamic system
behavior already in early phases of the development cycle, but also for future-relevant topics like the energy analyses mentioned above.
The library contains a huge variety of generic components, but also fully parameterized and validated models of Bosch Rexroth components. The generic models have to be parameterized manually, e.g. on the basis of data sheets, and can therefore be used in a versatile and flexible manner. This allows usage of these models to represent the behavior of products from many different manufacturers. The also available pre-parameterized models, however, require no further parameterization. All parameters including the required efficiency tables for energy analyses are already stored inside the component model, so that the models are ready-to-use as soon as they are placed on the modeling area. On the one hand, this avoids possible errors during parameterization, on the other hand, the time required for modeling can be significantly reduced. Every Rexroth component has a unique type key that specifies it. A Rexroth component model can be easily integrated into the Modelica model by selecting its type key from a dropdown menu inside the parameter dialog of the Rexroth base component model. This allows a well-organized representation of the huge amount of available type keys and makes it easy for the user to insert special Rexroth components into his system model.
In this contribution it is shown how Virtual Engineering based on BRSL can contribute to a future-proof engineering. First, an overview of the BRSL and its content is given and the possibilities of how BRSL models can be used together with components from other libraries within SimulationX are presented. Afterwards, the use of the library specifically for sustainability use cases is presented using an industry-relevant example.

Continued ...

Simulation-based analysis of system hydraulics in building energy supply: A case study of a networked residential and industrial district

Mr. Pascal Jirschik | Project engineer | EA Systems GmbH

For carbon-neutral and efficient design of energy systems, the complexity of the system hydraulics is increasing. Simulation-based analysis of system hydraulics is important for a better understanding of the planned energy system, especially when integrating renewable energy sources and other generation systems in parallel. For this reason, the simulation-based analysis and optimization of system hydraulics in the building energy supply will be investigated on the basis of a networked residential and industrial district.
The redevelopment of several commercial/office and cultural buildings will be supplied with heating and cooling. In addition to district heating, reversible heat pumps will be used to utilize waste heat from the cooling process for heating. A large ice storage system is planned for peak shaving. A cooling system with a downstream air heat pump for de-icing is planned to provide residual heat and cold from the environment. In addition to the dimensional analysis of the individual components, the comprehensive control of all components and their interactions represents a significant challenge.
Due to the dynamic characteristics of such a complex system, this presentation will analyze the possibilities and results of a model-based dynamic simulation with SimulationX and our in-house simulation library GreenCity.

Gearshift simulation: shift feel perception using HIL method

Mr. Yogesh Tongaonkar | Senior Manager Transmission Development| Tata Motors Ltd.

Gearshift feel is one of the basic customer touchpoint with which the customer makes an impression about the refinement and robustness of vehicle build quality. Current practice of evaluation of the gearshift quality involves measurement on vehicle and processing of this data to arrive at objective parameters quantifying the results. This process requires presence of physical components assembled in the vehicle making it a time consuming and costly process. In addition to this, to arrive at desired shift feel, might require multiple design iterations further delaying the final product. The process being discussed in the presentation involves HIL method using gearshift simulator. Gearshift simulator is basically a dynamic servo actuator capable of simulating a gear shift with real time inputs from the driver. Design parameters of the transmission are given as input to the controller and based on the driver inputs the controller provides real time feedback on the shift lever of the simulator which is perceived as gear shift event. Any design iteration can be readily accommodated in the model and its perceived shift quality can be evaluated quickly thereby reducing cost and time of the activity.

Multibody systems models of trucks for digital twin development

Mr. Roktim Bruder | Simulation engineer | Daimler Truck AG
Co-Authors: Sven Dronka, Christoph Schramm (ESI Group)

In the past years, software-in-the-loop (SiL) simulation models have become more and more relevant for the development of ECUs (Electronic Control Unit) and the virtual validation of vehicles. Due to the increasing complexity of ECU functions and their interaction with different physical subsystems of the vehicle, SiL simulation is a powerful and resource-saving tool for the development of intelligent, sustainable, and safe vehicles.
Therefore, Daimler Truck develops a modular framework, which allows the rapid modeling of a Digital Interdisciplinary Vehicle (DIVe) with its mechatronic interactions between virtualized ECUs (vECU) and the physical models of the vehicle. The modularity of the framework allows experts of different fields of work to contribute to a pool of modules.
For many years already, SimulationX contributes different modules into the DIVe module pool for the generation of the Digital Twin. To increase the efficiency of the module generation process, the transformation of the SimulationX model into a DIVe conform module was fully automated. With this approach, various models of vehicle subsystems can be integrated quickly into the DIVe framework.
In the past, SimulationX provided various models of the conventional or electrified drivetrain or the pneumatic and hydraulic braking system. Recently, Daimler Truck utilized SimulationX to model the multibody dynamics of trucks to accurately simulate their vehicle dynamics. This multibody model was extended with models for the steering and tire subsystems to ensure that the Digital Twin represents the handling of the real truck as realistically as required.
Various applications of the Digital Twin models are already an integral part of the development process at Daimler Truck and save time and costs as well as provide options that cannot be covered by testing. The co-simulation of a multi body vehicle model with multiple control modules for the development of autonomous trucks and active safety systems is presented.

Continued ...

Simulation models as the core of a digital twin for a copper ore mine

Dr. Torsten Hellmuth | Senior Key Expert – Product Management Mining | INNOMOTICS GmbH

The transport line of a copper ore mine is about 13km long and consists of 12 belt conveyors. Each belt conveyor was modeled in SimulationX. The models run 24/7 in parallel with the real system and provide various data which, combined with the measured values of the belt conveyors, provide essential information and KPI´s on the technical condition of the system as well as on the process quality.
The models are continuously scaled automatically to minimize possible deviations between the real belt conveyor and the model due to wear or temperature influences.
The digital twin, in particular the belt conveyor models and the scaling function developed together with ESI, are the subject of this presentation.

Utilizing SimulationX to assess and redesign jackleg hammer drill

Ms. Srividya Kuppa | Researcher, Department Of Systems Design Engineering | University Of Waterloo, Canada

The project “Assessing and Redesigning Jackleg Hammer Drill for Mining Operation” aims to reduce the vibrations reaching the user’s hands and the weight of the Jackleg pneumatic drill through comprehensive vibration analysis and performance simulation. Using SimulationX software’s capabilities, we will simulate the Jackleg drill’s working mechanics and vibrational behavior under load, no-load, and different rock hardness operating conditions. Critical factors contributing to the vibration from the model, mapping vibration intensity and propagation across the device will be identified, and a design modification will be proposed.
SimulationX's dynamic analysis will enable us to create a comprehensive model of the Jackleg Drill. Physical characteristics and the operating parameters will be replicated as per the original design of the drill. By conducting vibration analysis within the simulated environment, we can pinpoint the sources of excessive vibration, predict their propagation route, and assess the overall performance. Proposed modifications may include redesigning specific parts of the device or selecting other materials. The effect of redesign and material replacements will be modeled against the mapped vibration across the device.
To validate the simulation results, experimental vibration measurements of the drill will be conducted by instrumenting the drill with accelerometers. The experimental data points will be compared against the simulation results to verify the model and design iteration.
The outcomes of this project will provide actionable insights into design insights, potentially leading to a redesigned Jackleg drill with lesser vibrations at the user’s end and reduced weight.