THE 2ND JAPANESE MODELICA CONFERENCE

May 17-18, 2018, Tokyo

The Second Japanese Modelica Conferences is sponsored by:

The Second Japanese Modelica Conference is organized by ANSYS and Modelica Association

Program of the 2nd Japanese Modelica Conference
Tokyo, Japan, May 17-18, 2018

Editors:
Mr. Sameer Kher and Dr. Yutaka Hirano

Organized by:
ANSYS Inc.
Southpointe
2600 ANSYS Drive
Canonsburg, PA 15317
USA

in co-operation with:
Modelica Association
c/o PELAB, Linköpings Univ.
SE-581 83 Linköping
Sweden

Conference location:
Bellesalle Jimbocho
Sumitomo Fudosan Chiyoda First Building South
3-2-1 Nishi-Kanda, Chiyoda-ku, Tokyo
Japan

Welcome Message

Following the first successful conference in 2016, the 2nd Japanese Modelica Conference takes place in Tokyo again. With this effort, we hope to create an arena in Japan and Asia for sharing knowledge and learning about the latest scientific and industrial progress related to Modelica and FMI (Functional Mockup Interface). We are now proud to present a conference with:

- 3 Keynote speeches
- 37 paper presentations
- An exhibition area featuring 9 exhibitors
- Great venue location in the heart of Tokyo

According to Modelica Association standards, all papers are peer-reviewed and will be freely available for download.

We want to acknowledge the support we received from the conference board and program committee. Special thanks to our colleagues at ANSYS Inc. and ANSYS Japan K.K. for taking care of all the practical matters. Support from the conference sponsors is gratefully acknowledged. Last but not least, thanks to all authors, keynote speakers, and presenters for their contributions to this conference.

We wish all participants an enjoyable and inspiring conference!

Tokyo May 17,

Sameer Kher & Yutaka Hirano

Sameer Kher Yutaka Hirano

Keynotes Speakers

Hilding Elmqvist

Mogram AB, Modelon AB

Modelica - History, State, Needs, Trends and Possibilities

Model based product design requires both intuitive and effective user interface and powerful computing power. The presentation will contain a brief history of Modelica evolution and current status including some applications. Some new needs that are currently not covered will be discussed. New technical possibilities will be introduced, such as web apps for intuitive and effective user interaction and easy access, domain specific language extensions for advanced modeling capabilities and cloud computing for large scale simulation deployment..

Koichi Ohtomi

Meiji University

Using Modelica Effectively in Industrial Research and Development

The main task of product development is to develop a good product at lower cost and to bring it to market in a shorter period. Conventional computer-aided design and computer-aided engineering systems are well established in this regard. However, although upstream design is particularly important in product development to add value and incorporate the required functions, it is difficult to apply conventional systems to the upstream design stage due to the lack of design information at that stage. As a solution to this issue, we are developing the product development environment by applying "Delight Design by System Simulation" methodology, which can be applied to the early design stage of product development including the conceptual and functional design phases. Here Delight Design is equivalent to attractive quality. I introduce the Delight Design technique and the application of "Crane cabin design" and "Hair dryer design". Delight Design is realized by applying "Modelica-based System Simulation" including not only product model but cognitive and human models.

 

Torsten Blochwitz — ESI ITI

Andreas Junghanns — QTronic

10 Years of FMI: Where Are We Now, Where Do We Go?

The exchange of simulation models is a key enabler for the distributed model based development and verification process. This was the main motivation to start the MODELISAR project 10 years ago. The main result of this research project funded by the European Union was the tool independent Functional Mock up Interface (FMI) for Model Exchange and Co-Simulation, which is now maintained within a Modelica Association Project. By now more than 100 tools support FMI. The presentation provides an update on the current status, planned new features and the roadmap towards a new release. A few examples demonstrate typical FMI use cases. As an outlook some related ongoing research projects like ACOSAR and EMPHYSIS are presented.

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Stefan Wischhusen, XRG Simulation Gmbh, Hamburg, Germany
Dr. Dirk Zimmer, DLR, Oberpfaffenhofen, Germany

General Schedule

Thursday, May 17:

Time	Room A	Room B	Exhibition Room
10:00-10:15	Opening		Exhibition
10:15-11:15	Keynote 1 (Dr. Hilding Elmqvist)		
11:15-12:15	Keynote 2 (Dr. Koichi Otomi)		
12:15-13:15			Lunch, Exhibition
13:15-14:30	Session 1a: Automotive Applications 1	Session 1b: Thermal System Applications 1	Exhibition
14:30-14:55			Break, Exhibition
14:55-16:10	Session 2a: Automotive Applications 2	Session 2b: Thermal System Applications 2	Exhibition
16:10-16:35			Break, Exhibition
16:35-17:50	Session 3a: Automotive Applications 3	Session 3b: Thermal System Applications 3	Exhibition
17:50-18:00			Break
18:00-20:00			Dinner

Friday, May 18:

Time	Room A	Room B	Exhibition Room
10:00-10:05	Opening		Exhibition
10:05-11:05	Keynote 3 (Mr. Torsten Blochwitz, Mr. Andreas Junghanns)		
11:10-12:00	Session 4a: HILS, Real Time Simulation	Session 4b: Electronic Systems Application	
12:00-13:35			Lunch, Exhibition
13:35-14:50	Session 5a: Model Based Development	Session 5b: Mechanical Systems Application 1	Exhibition
14:50-15:15			Break, Exhibition
15:15-16:30	Session 6a: FMI, Simulation Technologies 1	Session 6b: Mechanical Systems Application 2, Control	Exhibition
16:30-16:55			Break, Exhibition
16:55-17:45	Session 7a: FMI, Simulation Technologies 2	Session 7b: Vendor Session	Exhibition
17:45-17:50			Break, Exhibition
17:50-18:00	Closing		

Venue Map

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Sumitomo Fudosan Chiyoda First Building South
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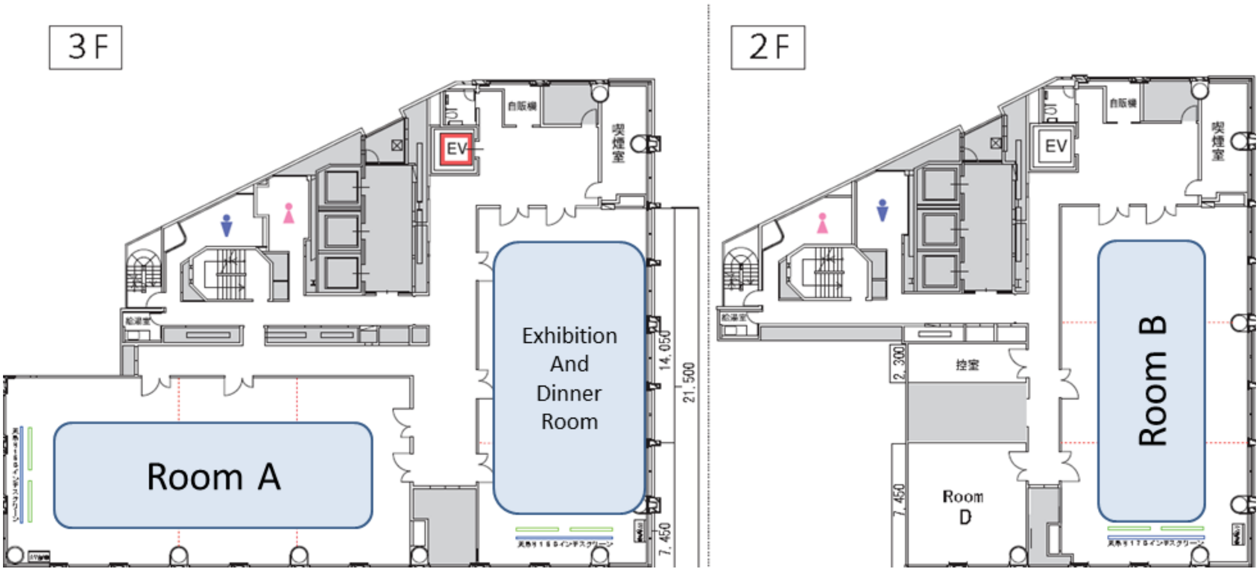

Scientific Program

Thursday, May 17:

10:15-11:15 Keynote 1

"Modelica - History, State, Needs, Trends and Possibilities"
Hilding Elmqvist (Mogram AB, Modelon AB)

11:15-12:15 Keynote 2

"Delight Design by System Simulation"
Koichi Ohtomi (Meiji University)

13:15-14:30 Session 1a: Automotive Applications 1

Chair: Yutaka Hirano

"Riding Comfort Simulation with air ride seat for heavy duty vehicle"
Hyung Yun Choi, Whe-Ro Lee (HongIk University),
Jong-Chan Park and Kee-Young Yang (Hyundai)

"Assessment of Ride Quality at Lane Change Maneuver Using Virtual Human Driver Model"
Manyong Han, Hyung Yun Choi (HongIk University),
Akinari Hirao (Nissan),
and Stefan Kirschbichler (VIRTUAL VEHICLE)

"Combustion Engine Mechanism Analyses Using SimulationX"
Tomohide Hirono and Takanori Watanabe (NewtonWorks)

13:15-14:30 Session 1b: Thermal System Applications 1

Chair: Christopher Laughman

"The CryoLib - Modelling Superconductors with Modelica"
Alexander Pollok and Dirk Zimmer (DLR)

"Robust Modeling of Directed Thermofluid Flows in Complex Networks "
Dirk Zimmer, Daniel Bender and Alexander Pollok (DLR)

"Liquid Cooling Applications in Twin Builder"
Anand Pitchaikani, Katrin Prölss, Mathias Strandberg, Hubertus Tummescheit (Modelon AB)
and Sameer Kher (ANSYS Inc.)

14:55-16:10 Session 2a: Automotive Applications 2

Chair: Hyung Yun Choi

"Development of a Flex-PLI System Model and Investigations of Injury"
Yong-Ha Han, In-Hyeok Lee (Hyundai)
and Whe-Ro Lee (ESI Korea)

"Vehicle Systems Modelling and Analysis (VeSyMA) Platform "
Hannah Hammond-Scott and Mike Dempsey (Claytex)

"Dual-Clutch Transmission Model Reduction Function"
Romain Gillot, Alessandro Picarelli and Mike Dempsey (Claytex)

14:55-16:10 Session 2b: Thermal System Applications 2

Chair: Alexander Pollok

"FluidDynamics Library for Coarse-Grid CFD-Simulation in Modelica"
Stefan Wischhusen, Timo Tumforde and Hans-Hermann Wurr (XRG Simulation)

"Modeling and Coordinated Control of an Air-Source Heat Pump and Hydronic Radiant Heating System "
Christopher Laughman, Scott Bortoff and Hongtao Qiao (MERL)

"Semiconductor Package Thermal Impedance Extraction for Modelica Thermal Network Simulation Combined with VHDL-AMS model"
R Eiji Nakamoto, Kentaro Maeda and Takayuki Sekisue (ANSYS Japan)

16:35-17:50 Session 3a: Automotive Applications 3

Chair: Leo Gall

"Modeling of Fuel Cell Hybrid Vehicle in Modelica: Architecture and Drive Cycle Simulation"
Sara Sigfridsson, Lixiang Li, Håkan Runvik, Jesse Gohl, Antonin Joly and Kristian Soltesz (Claytex)

"Modelling & Analysis of a Fuel Cell Hybrid Electric Vehicle using Real-World & Standard Driving Conditions "
Raees Basheer Kunthirikkal Parambu, Mike Dempsey and Alessandro Picarelli (Claytex)

"Hyundai framework for vehicle dynamics engineering based on Modelica and FMI"
Kwang Chan Ko (Hyundai),
Erik Durling (Modelon AB),
Jong Chan Park (Hyundai),
Wonyul Kang (Institute of Vehicle Engineering)
and Johan Andreasson (Modelon AB)

16:35-17:50 Session 3b: Thermal System Applications 3

Chair: Shigeru Oho

"Modelling of Oil Film Bearings"
Tatsuro Ishibashi (Meidensha)
and Tadao Kawai (Osaka City University)

"Gas Compressor System Simulation using Functional Mockup Interface for Human Machine Interface and Control"
Ryan Magargle and Hemanth Kolera-Gokula (ANSYS Inc.)

"A New Library For Modeling and Simulation of Pneumatic Systems"
Maximilian Kormann, Clement Coic and Guillaume Viry (Dassault Systèmes)

Friday, May 18:

10:05-11:05 Keynote 3

"10 Years of FMI: Where Are We Now, Where Do We Go?"
Torsten Blochwitz (ESI ITI), Andreas Junghanns (QTronic)

11:10-12:00 Session 4a: HILS, Real Time Simulation

Chair: Rui Gao

"The DLR EtherCAT Library - A template based code-generation scheme for accessing real-time hardware from Modelica"
Tobias Bellmann and Fabian Buse (DLR)

"Modelling and Development of a Pseudo-Hydraulic Power Steering Model for use in Real-Time Applications"
Theodor Ensbury, Mike Dempsey (Claytex)
and Peter Harman (CAE Tech)

11:10-11:35 Session 4b: Electronic Systems Application

Chair: Tommi Karhela

"Modelling silicon carbide based power electronics in electric vehicles as a study of the implementation of the semiconductor devices using Dymola"
Leonard Janczyk (Dassault Systèms),
Yoshihisa Nishigori (ROHM)
and Yasuo Kanehira (Dassault Systèms Japan)

13:35-14:50 Session 5a: Model Based Development

Chair: Dirk Zimmer

"AUTOMATED TEST OF CVT CONTROL SOFTWARE, USING FMI AND MODELICA MODELS"
Zeng, Weihua (Hunan Jianglu & Rongda Vehicle Transmission),
Liu Fei and Belmon, Lioneli (Global Crown Technology)

"The Fault library - A new Modelica library allows for the systematic simulation of non-nominal system behavior "
Julia Gundermann, Artem Kolesnikov, Morgan Cameron and Torsten Blochwitz (ESI ITI)

"Application for Optimization of Control Parameters for Multi-body and Hydraulics System by using FMU"
Nobumasa Ishida and Hideyuki Muramatsu (Dassault Systèms Japan)

13:35-14:50 Session 5b: Mechanical Systems Application 1

Chair: Ken-ichiro Nonaka

"Analysis of Lift-Generating Disk Type Blade Wind Power System Using Modelica"
Yeungmin Yoo, Soyoung Lee, Jaehyun Yoon and Jongsoo Lee (Yonsei Univeristy)

"Modelling of Asymmetric Rotor and Cracked Shaft "
Tatsuro Ishibashi (Meidensha),
Atsushi Yoshida and Tadao Kawai (Osaka City University)

"Composable Modelling for a Hybrid Gearbox"
Joshua Sutherland (The University of Tokyo)
and Rui Gao (Modelon K.K.)

15:15-16:30 Session 6a: FMI, Simulation Technologies 1

Chair: Torsten Blochwitz

"Toward the actual model exchange using FMI in practical use cases in Japanese automotive industry"
Yutaka Hirano (Toyota),
Junichi Ichihara (AZAPA),
Haruki Saito (Nissan),
Yosuke Ogata (Siemens K.K.),
Takayuki Sekisue (ANSYS Japan)
and Satoshi Koike (Denso)

"Managing Heterogeneous Simulations Using Architecture-Driven Design"
Bruno Loyer, Nico Vansina and Yosuke Ogata (Siemens)

"Simulation of high-index DAEs and ODEs with constraints in FMI "
Masoud Najafi (Altair)

15:15-16:30 Session 6b: Mechanical Systems Application 2, Control

Chair: Koichi Ohtomi

"Universal Controllers for Architecture Simulation"
Alexander Pollok (DLR) and Francesco Casella (Politecnico di Milano,)

"Mission-Dependent Sequential Simulation for Modeling and Trajectory Visualization of Reusable Launch Vehicles"
Lale Evrim Briese (DLR)

"Model predictive allocation control for leg-wheel mobile robot on loose soil considering wheel dynamics"
Takatsugu Oda, Hiroki Yoshikawa, Naoki Shibata, Kenichiro Nonaka and Kazuma Sekiguchi (Tokyo City University)

16:55-17:45 Session 7a: FMI, Simulation Technologies 2

Chair: Yutaka Hirano

"Generating FMUs for the Feature-Based Language Bloqqi"
Niklas Fors (Lund University),
Joel Petersson and Maria Henningsson (Modelon AB)

"A Web Architecture for Modeling and Simulation"
Hilding Elmqvist, Martin Malmheden and Johan Andreasson (Modelon AB)

16:55-17:45 Session 7b: Vendor Session

Chair: Joshua Sutherland

“Multibody simulation and control of kinematic systems with FMI/FMU”
Francois Chapuis, Jean Daniel Beley, Stephane Garreau, Olivier Roll, Tim Puls, Leon Voss and Sameer Kher (ANSYS Inc.)

“Deployment process for Modelica-based models “
Takashi Iwagaya (Cybernet Systems),
Chad Schmitke and Tetsu Yamaguchi (Maplesoft)

One Page Abstracts

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Session 4a: HILS, Real Time Simulation

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Session 5a: Model Based Development

Session 5b: Mechanical Systems Application 1

Session 6a: FMI, Simulation Technologies 1

Session 6b: Mechanical Systems Application 2, Control

Session 7a: FMI, Simulation Technologies 2

Session 7b: Vendor Session

Riding Comfort Simulation with Air Ride Seat for Heavy Duty Vehicle

Hyung Yun Choi[1] Whe-Ro Lee[1] Jong-Chan Park[2] Kee-Young Yang[2]

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[2]Hyundai Motor Company, Korea, {impactpart, yky}@hyundai.com

The design of driver's seat suspension of the commercial truck differs from the one of the passenger car. The vibration and the structural characteristics of the suspension are consequently quite different. Unlike passenger cars, the vibration frequency of commercial truck suspensions is considerably low at 1 to 3 Hz. (Mayton, 2006). The truck seat has an air ride seat. The structural design of air ride seat at heavy-duty vehicle includes serial and parallel combinations of the shock absorber, air spring, and PU foam pad to achieve a good vibration damping. The 1D lumped network solution is an effective design tool with the multi-physical subcomponents. And this also enables a direct coupling into the system modeling of the vehicle body for an optimal calibration of engineering parameters taking the relevant dynamic performance of neighboring parts into account. The mechanical characteristics of each component and their assembly were identified for the 1D modeling. The result of validation and verification of the proposing 1D model of the air ride seat is also introduced.

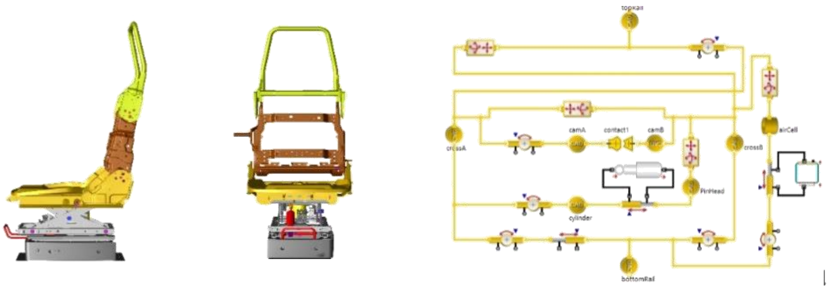

Figure 1. 3D CAD (top) and Diagram (bottom) views of air ride seat frame

The air ride seat in a heavy-duty vehicle has multi-physical subcomponents such as air spring, shock absorber, and viscoelastic PU foam pad. The 1D lumped network modeling can be effectively used at the front-loading phase to optimize its engineering design parameters taking the relevant dynamic performance of neighboring parts into account. The mechanical characteristics of each major component in-vitro was experimentally identified and the corresponding 1D model was accordingly validated. The assembly of multi-physical subcomponents into the air ride seat was also validated against the harmonic excitation with a good correlation of the transfer function. In order to verify the practical application of the 1D air ride seat model for a ride comfort assessment, the standard ISO 2631 process was carried out for evaluation of each driving over the highway and the rough road. The effects of damping levels of shock absorber on the comfort score were also investigated.

References

Mayton AG, DuCarme JP, Jobes CC, Matty TJ. ASME. Laboratory Investigation of Seat Suspension Performance During Vibration Testing., 2006. doi:10.1115/IMECE2006-14146 Whe-Ro Lee, Manyong Han,

Hyung Yun Choi, Jungtae Yang, Inhyeok Lee, Kee Young Yang, Jong-Chan Park. PAM User Conference Asia. Air Ride Seat for Heavy Duty Vehicle. 2017

Assessment of Ride Quality at Lane Change Maneuver using Virtual Human Driver Model

Manyong Han[1] Hyung Yun Choi[2] Akinari Hirao[3] Stefan Kirschbichler[4]
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The occupant kinematics occurring at a lane change maneuver affects the local ride quality. The precise analysis of the occupant kinematics requires a comprehensive understanding of the physiologic response to human body as well as the vehicle kinematics. A series of vehicle-based tests also confirmed that the alertness level of vehicle occupants is one of the important biomechanical elements. Therefore, it is necessary to have a virtual human body model (HBM), an occupant surrogate at CAE design process, with active muscle forces to represent the reflexive response of human beings. An active human body model that produces joint torques with PID closed-loop control as mimicking a bracing action to keep the sitting posture against the external jerk has been developed. In this study, this active human body model is validated against the subject test by simulating the similar occupant kinematics at a single lane change maneuvers. To further verify the use of active HBM as a design tool, an artificial lane change maneuver with a reduced lateral jerk is fabricated and good matching occupant kinematics are predicted.

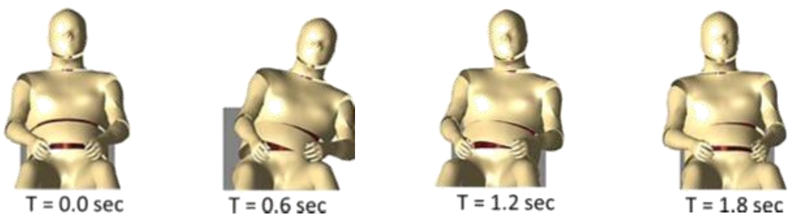

Figure 1. Frontal view of occupant kinematics at lane change simulation

The active human body model primarily developed for a ride comfort simulation to investigate the vibration response of human occupants is applied to predict relatively short-term ride quality via simulating a kinematics at an evasive lane change. The lateral movements of head and torso at three awareness conditions, unaware, anticipated, and informed were validated against the vehicle-based subject test.

In order to verify a practical application of the active human body model in the design process of the ride quality, an artificial single lane change maneuver with reduced lateral jerk was fabricated and its effect on the occupant kinematics was investigated. The model predicted a joint work, regarded as a muscle energy used to maintain the sitting posture against the lateral G-force with a comparable reduction at the created lane change maneuver and successfully demonstrated its feasibility of serving as an objective design tool for quantifying the ride quality.

References

H.Y. Choi, M. Han, A. Hirao and H. Matsuoka, *Virtual Occupant Model for Riding Comfort Simulation*, 12th International Modelica Conference, Czech Republic, 2017.

P. Huber, M. Christova, G. A. D'Addetta, E. Gallasch, S. Kirschbichler, C. Mayer, A. Prüggler, A. Rieser and W. Sinz, D.Wallner, *Muscle Activation Onset Latencies and Amplitudes during Lane Change in a Full Vehicle Test*, IRCOBI Conference 2013

[Industrial paper] Combustion Engine Mechanism Analyses Using SimulationX

Tomohide Hirono[1] Takanori Watanabe[2]

1,2 CAE Research & Development Center, NewtonWorks Corp., Japan,

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When we apply more efficient combustion profile using advanced mecha- nisms to ICEs, vehicles with ICEs can exceed BEVs from the view of total environmental performance. This paper illustrates SimulationX, a Modeli- ca simulation tool, can be a tool for the developments of advanced mechanical systems such as new valve trains and cranking systems. This paper al- so shows a case of FMI co-simulation of cam phaser between the tool and another hydraulic simulation tool which is used to model a conventional hydraulic system of an existing ICE.

Figure 1 Hydraulic Cam Phaser (5 x 2 Room)

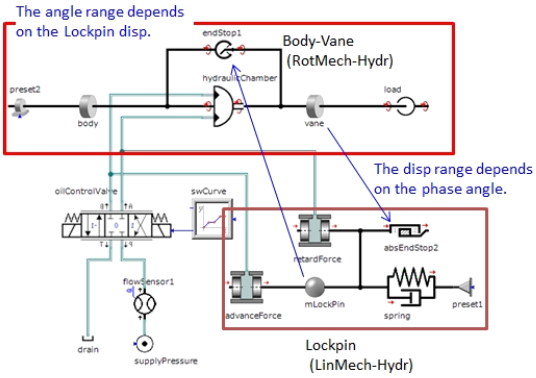

Figure 2 Diagram of Cam Phaser System

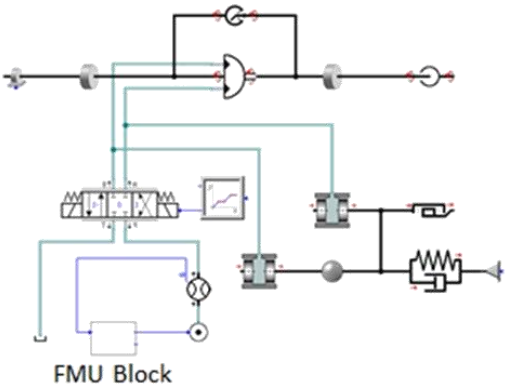

Figure 17 Diagram of Master Tool with a Slave FMU

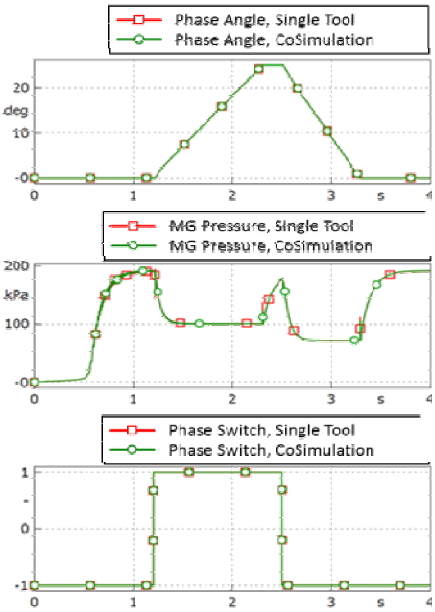

Figure 18 Results of FMI CoSimulation Model

The CryoLib –

Modelling Superconductors with Modelica

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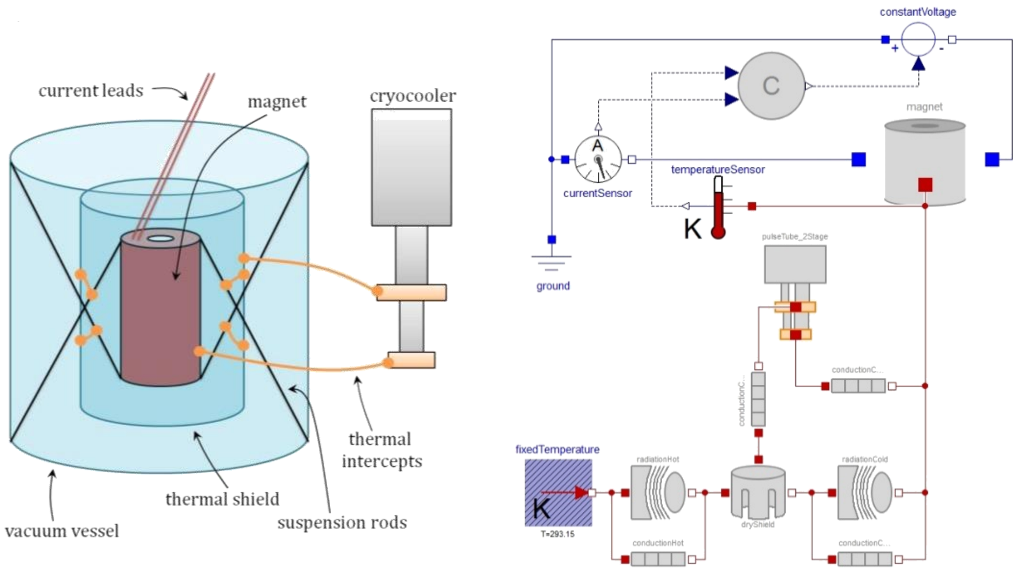
In 2018, the cost per kiloampere-meter for superconducting cables continues to go down, especially in the case of high temperature superconductors (HTS). This makes more and more applications viable. For example, cryogenic systems are envisioned for future electric aircraft projects.

Thermal design makes up a big part of the overall effort that goes into the development of superconducting systems. For some applications like nuclear magnetic resonance tomography (NMRT) systems this can be done in Excel. In other applications, the transient behavior of the overall system is more important. This is especially true if the super- conducting system is coupled to other systems and the overall system behavior cannot be neglected. In that case, Modelica is a naturally suited technology to describe the overall system behavior. However, no general-use library for the typical aspects of the design of superconducting systems is available to best knowledge of the author.



This work closes that gap by presenting CryoLib, an easy-to-use Modelica library that provides components and interfaces to simulate the transient behavior of superconducting systems. The library design is compatible with the electrical and fluid components from the Modelica Standard library. At the same time, several typical effects of cryogenic systems are modelled that have no equivalent in the Standard library. Easy usability and extendability of the components is emphasized.

In this paper, the different parts of the library are explained in more detail. To illustrate the capabilities of the library, three showcases are presented: a simple solenoid mag- net system, a current lead and a current limiter. The results show that many effects occurring in cryogenic and superconducting systems can successfully be simulated using this library.

Robust Modeling of Directed Thermofluid Flows in Complex Networks

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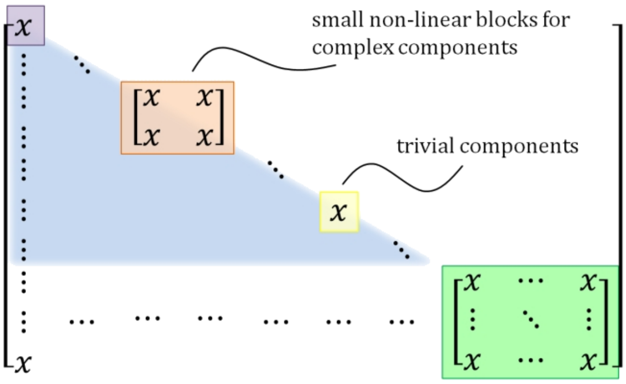
Modelica has established itself as a valuable tool for the modeling of thermal fluid sys- tems. To support these activities, several quasi-standards have been developed: a stream connector has been included in the Modelica language standard and a corresponding standard library supports the modeling of fluids. Furthermore, the Modelica.Media library provides models for a multitude of different fluid media, so that the same fluid models can be applied to different media. Yet despite these advances, there still remain reoccur- ring problems that make the application for the end user challenging.

This paper presents a new approach to model fluid systems that avoids the creation of large non-linear equation systems in the first place. This leads to a very robust fluid li- brary, and also high performing and scalable models.

In order to understand this approach, let us examine the root of the problem. What leads to the creation of large non-linear equation systems? Whereas smaller non-linear equation system may occur within a component (such as a heat exchanger), larger non-linear sys- tems are created by a network of such components. Especially critical are branches, by- passes and loops. Whenever fluid flows join, a (quasi-) static analysis will require an equivalence of pressure for each involved junction. In order to fulfill this equivalence, the corresponding mass-flows become are part of a non-linear equation system.

In order to increase robustness, we shall hence not rely on a generic solver but rather pro- vide differential equations that lead to the desired equivalence. Fortunately, the laws of physics offer a very favorable way to formulate this. This is described in the actual paper in more detail. Using this approach, large scale thermos fluid systems can be modelled and the resulting BLT-matrix will have the following form:



Given this BLT form, it is now clear how high robustness for the end user is achieved. No large nonlinear equation system will be created by building a complex network out of its components. If the components are very robust then the total system will be as well.

To demonstrate the feasibility of this approach, a complex electric architecture for an air- craft environmental control system is modelled and demonstrated in the paper.

[Industrial paper] Liquid Cooling Applications in Twin Builder

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This industrial paper introduces the Modelon's Liquid Cooling Library (LCL) that is available in ANSYS Twin Builder Heating and Cooling Library bundle. This library is a multi-tool compatible Modelica Library which can help customers to deploy simulation of cooling systems in a new way. Twin Builder supports the Modelica Standard Library and Modelica libraries offered by Modelon AB, including libraries for hydraulics, pneu- matics, liquid cooling, heat exchangers and thermal power. `In general, LCL can be used for modeling cooling circuits across many industries like aerospace, automotive and pro- cess industry. The combination with the extensive electronics and electrical machine li- braries in Twin Builder makes LCL a natural fit for cooling of power electronics and thermal management of electric vehicles. Twin Builder being a tool that covers the entire breadth and depth of physical modeling opens numerous possibilities on the type of stud- ies that can be made through the Liquid Cooling Library. Twin Builder can let the LCL models combine with detailed control element models involving advanced power elec- tronics devices and characterization tools (Semiconductors) along with state-machines and signal flow logic. Twin Builder's strong features like Co-simulation with 3D solvers and reduced order modeling can capture complex multi-physics interactions between the 3D and the 1D systems simulation world captured with Modelica Libraries. Twin Builder also supports Functional Mockup Interface through which models built can shared with many other Simulation tools.

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Development of a Flex-PLI System Model and Investigations of Injury

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Pedestrian accidents give direct damage to the human body. Pedestrians do not have any safe- ty devices and it results in a significant risk of injury to the pedestrians as compared to other accidents (Carroll, 2014). To protect pedestrians, EURO NCAP, JNCAP, and various pedes- trian safety laws are enforced. Korea also imposes KNCAP and related laws. Assessment of pedestrian injuries is performed throughout impact tests using the head, upper leg, and lower leg impactor. (Yong, 2006)

Pedestrian injury simulation is normally performed using the Finite element method at the early design stage to reduce a cost and research period. FE simulation requires detail design data, high-performance equipment and long computation time. FE simulation gives detail re- sults how each part is deformed, how much energy is absorbed and how much injury values are resulted in. But on the other hand, it requires well-designed simulation matrix and many simulations to find contributions to the injury values of various design parameters at the initial design stage.

The system model simulation allows more intuitive parametric studies than the existing de- tailed FE studies. The computation is much faster than the FE simulation, results are obtained results within in a few seconds and contributions of various parameters are directly get throughout simple parametric simulations.

In this study, the impactor and vehicle system model is developed for the lower leg injury risk assessment. The system model of lower leg impactor, Flex-PLI is developed by comparing to its FE model and system model parameters are calibrated against several static and dynamic certification tests of FLEX-PLI. The vehicle is modeled to equivalent mass-spring-damper systems and its parameters are obtained from existing FE simulation results. And finally de- veloped system model is verified against FE simulation results.

Keywords: Pedestrian injury protection, Flex-PLI, System Model.

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[Industrial paper] Vehicle Systems Modelling and Analysis (VeSyMA) Platform

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This industrial paper gives an overview of the Vehicle Systems Modelling and Analysis (VeSyMA) platform from Claytex. The VeSyMA platform is a suite of Modelica libraries created to provide a modular approach to vehicle modelling, where the user can tailor the complexity of the model to meet their specific needs.

The foundation of this platform is the VeSyMA library, providing the architecture of the vehicle model and the base classes for the vehicle subsystems. It builds upon the open- source Vehicle Interfaces Library (Modelica Association 2018). The idealized vehicle subsystem models in this library have been used to build vehicle models for performing longitudinal and drive cycle studies.

The VeSyMA extension libraries then provide more detailed modelling capabilities in specific subsystem and domain areas. Currently the VeSyMA platform includes libraries for engines, powertrains, suspensions and motorsport, plus rFpro drive-in-the-loop and terrain server integration. The VeSyMA extension libraries use the base classes from the VeSyMA library, so models are compatible and can be used together to build a vehicle model, as in Figure 1.

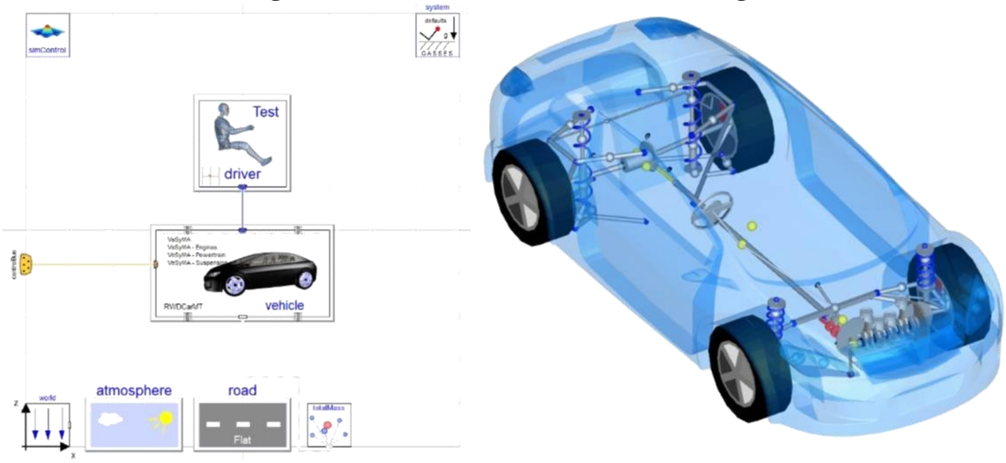

Figure 1. Vehicle model combining VeSyMA, VeSyMA – Engine, VeSyMA – Powertrain and VeSyMA – Suspensions to perform a double lane change test

The idealized subsystem models in the VeSyMA library can be combined with detailed subsystem models built from the VeSyMA extension libraries to build a complete vehicle model. This allows the detailed subsystem to be tested in a vehicle with minimal effort.

The VeSyMA platform libraries were designed with real-time simulation in mind from the beginning to support software, hardware and driver-in-the-loop testing. Models have been optimized to improve simulation performance, and model structure supports the use of the multi-threading features available in Dymola. VeSyMA – Driver-in-the-Loop and VeSyMA – Terrain Server further support the use of VeSyMA platform vehicle models in the driver-in-the-loop simulator environment using rFpro.

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[Industrial paper] Dual-Clutch Transmission Model Reduction Function

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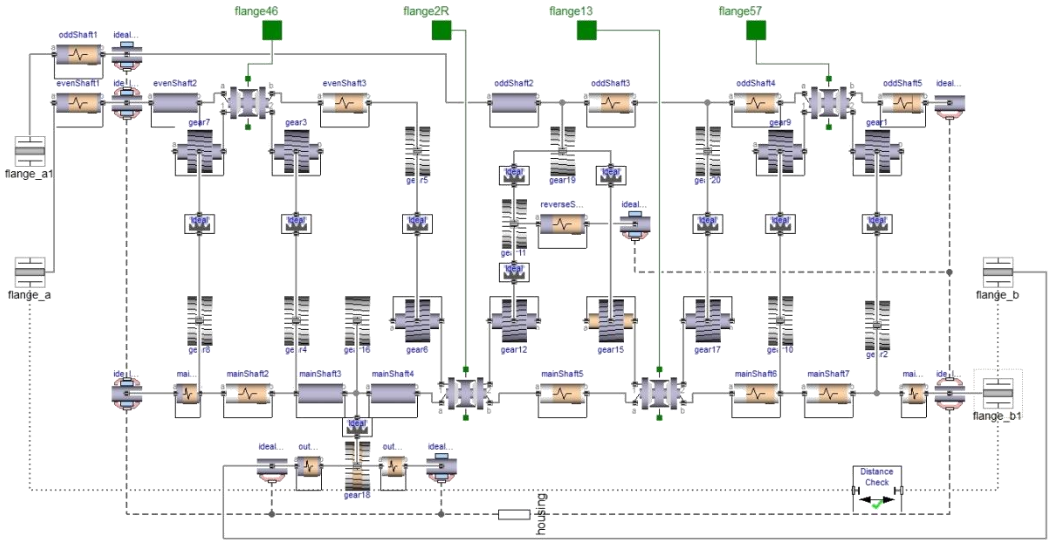
This paper introduces a gear set model reduction function. It is an automated process that works for any type of gear set. The focus is on a dual-clutch transmission in this paper. Reducing the transmission from a multibody model to a table-based loss and inertia 1D rotational mechanics model



leads to up to a 70% decrease in simulation time. This performance improvement allows engineers to run a detailed physics derived model over the NEDC urban section in real-time or faster.

Figure 1. Detailed dual-clutch transmission gear set.

It is an extended version of the function that was introduced in a previous paper (Gillot R., 2017). The functionalities and the process will be explained.

Whenever a full vehicle model is required to be run, simulation time becomes of prime importance. Some compromises can be made in terms of model detail in areas of the model that are not directly the subject of the study. However, the results the simplified subsystems produce still need to be close enough to the ones of the detailed subsystems in order to provide correct interactions amongst the components of interest. The gearbox is one of the most computationally expensive subsystems in a vehicle model. Bearing models with friction enabled, gear pairs with mesh and mesh loss models, shift mechanisms can slow down the model simulation.

This paper shows a method to reduce a gear set model in a quick and automated manner. Essentially, the gear set is run several times with different speed and torque inputs ranging from zero to a maximum defined by the user. This is repeated for every gear. The results of this series of experiments are then collected and mapped and the new reduced model is automatically generated and parameterized.

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[Industrial paper] FluidDynamics Library for Coarse-Grid CFD-Simulation in Modelica

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This paper describes the content and the use of the new FluidDynamics Library which can be applied to carry out CFD simulations using Modelica as an open modelling language. Typical applications until now have been in automotive, aircraft and buildings development. In this paper a fire dynamics and smoke removal simulation is presented. These simulations are very important in the process of approving a building permission. The FluidDynamics Library helps to identify promising ventilation and control setups and speeds up the simulation process significantly.

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Modeling and Coordinated Control of an Air-Source Heat Pump and Hydronic Radiant Heating System

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Recent interest in high-performance buildings with improved thermal comfort has pro- voked renewed investigations of radiant heating and cooling systems. Thermally-active building systems (TABS) are one popular variant of general radiant systems in which the heat transfer medium is embedded in the building material, such as water pipes that are em- bedded within a concrete slab. While the energy consumption and thermal comfort aspects of these systems make them attractive, their long thermal time constants make it dif cult to respond rapidly to sudden changes in heat load. Air-source heat pumps can be installed in parallel with the radiant system to reject these load disturbances with a much higher band- width, but conventional control architectures in which each system attempts to control the room air temperature can result in problematic interactions between the systems.

We address this challenge by developing a new control method that coordinates the operation of the subsystems by accounting for their interactions. Because the design of this coordinated controller is dependent upon the system dynamics, we rst develop a set of Modelica models for the occupied space, the radiant system, and the air-source heat pump, and then interconnect these subsystem models to describe the resulting dynamics of the overall system. This high-order nonlinear system model was then used to generate a set of reduced order models that were compatible with analytical methods for the design of a new control method for the overall system. The resulting controller achieves a faster thermal comfort response by improving the rise-time of the radiative temperature, and also reduces the energy consumption by decreasing the speed of the heat pump compressor. Finally, this new control architecture does not require signi cant modi cation of standard heat pump control architectures, making it potentially straightforward to tie in to contemporary vapor- compression systems.

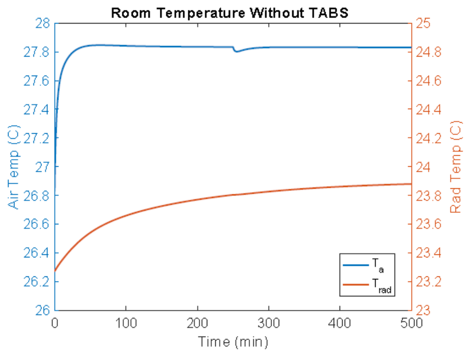

Figure 1. Slow radiative temperature response for decentralized control of TABS and heat pump.

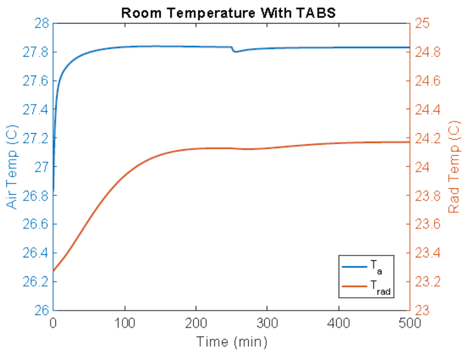

Figure 2. Faster radiative temperature response for coordinated control of TABS and heat pump.

[Industrial paper] Semiconductor Package Thermal Impedance Extraction for Modelica Thermal Network Simulation Combined with VHDL-AMS model

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Because of the emerging market demand for higher power with higher efficiency for the power semiconductor devices, thermal design of the semiconductor package and its cooling method has become one of the key elements for the power supply systems in power electric design. Thus, many thermal designers now require the junction-to-case thermal Impedance $Z_{\theta JC}$ since it is one of the most important thermal characteristics of semiconductor devices and thus, in November 2010, the more reliable and sufficiently reproducible measurement method without a case temperature measurement has been standardized by JEDEC as JESD 51-14

(https://www.jedec.org/standards-documents/docs/jesd51-14-0)

This paper shows the new feature in ANSYS simulation tool, ANSYS Electronics Desktop, which extracts $Z_{\theta JC}$ from JESD 51-14 compliant measurement data. The extracted $Z_{\theta JC}$, or its cumulative expression of thermal resistance $\Sigma^{n}{}_{i=1}(R_{thi})$ and capacitance $\Sigma^{n}{}_{i=1}(C_{thi})$ called "structure function", is transformed to the Modelica thermal ladder network model. This Modelica model was simulated by ANSYS TwinBuilder, Multi-domain system simulator, and the junction temperature is reproduced by this simulation, that agreed well with the original measured temperature data. Further, $Z_{\theta JC}$ is split into two components, Junction-to-Die part(IC pack-age DUT) and Heat-sink part (cold plate) in accordance with the guideline of Transient Dual Interface Measurement Procedure principle described in JESD 51-14. Then, $Z_{\theta JC}$ corresponding to IC package structure part is transformed to the VHDL-AMS model (as IC Package thermal compact model) while Heat-sink structure part is transformed to Modelica model(as testing fixture structure model) . Those models built by two well-known physical model description languages were connected with the acausal (i.e., conservative) condition in ANSYS TwinBuilder and the thermal response of the combined model is evaluated. The result of the simulation matches to the full Junction-to-Heat-sink Modelica thermal ladder network model, that ensures Modelica and VHDL-AMS models can be connected in a single physical multi-domain system simulation environment in ANSYS TwinBuilder under the energy conservative principle , that might expand the potential applicability and the coverage for Modelica simulation for the broader application area.

Please send an email to `eiji.nakamoto@ansys.com` if there are any questions or suggestions regarding this paper.

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[Industrial paper] Modeling of Fuel Cell Hybrid Vehicle in Modelica: Architecture and Drive Cycle Simulation

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This paper highlights recent development of fuel cell hybrid vehicle (FCHV) models using the Fuel Cell Library (FCL), the Vehicle Dynamics Library (VDL), and Electrification Library (EL) from Modelon. A flexible model architecture is implemented to support physical modeling of such large scale, multi-domain vehicle system. The top- level model, as shown in Figure 1, consists of a hydrogen fuel cell subsystem with detailed power characteristics and humidification, a hybrid powertrain including battery, converter and electric motor, a vehicle model with chassis and brakes, and a driver model. The control bus is used to pass control signals to various subsystems while expandable connectors of different domains. All the subsystems are replaceable, which supports future development of more detailed models. Drive cycle simulations are performed using these models for evaluation of overall system performance under different operating conditions.

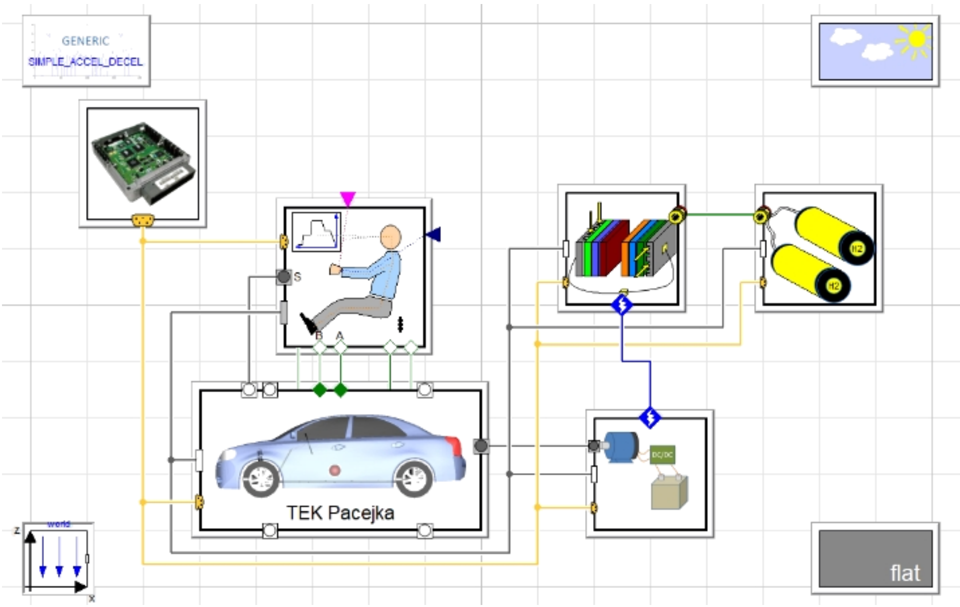

Figure 1. Top-level architecture of the Hydrogen fuel cell hybrid vehicle model.

Modelling & Analysis of a Fuel Cell Hybrid Electric Vehicle using Real-World & Standard Driving Conditions

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This paper presents an acausal model-based system-level simulation of a fuel cell plug-in hybrid electric vehicle (FCPHEV) (also known as the H2EV) in Dymola. The modelling part includes the development of a full vehicle and its subcomponents. The simulation (analysis) part involves investigation of the vehicle performance, fuel econo- my (Wh/km) and carbon footprint (C_f) using both standard & real-world (UK) and ho- mologation (Japan) driving conditions. The effect of the addition of auxiliary load on ve- hicle performance is also explored based on these two countries in conjunction with cor- responding drive cycles. Comparing to a commercial FCEV, the well-to-wheel (WTW) analysis results show that by adopting the proposed H2EV during Japan Olympics 2020, C_f can be reduced and fuel economy improved with an assumption that Japan produces hydrogen fuel from renewable energy resources only.

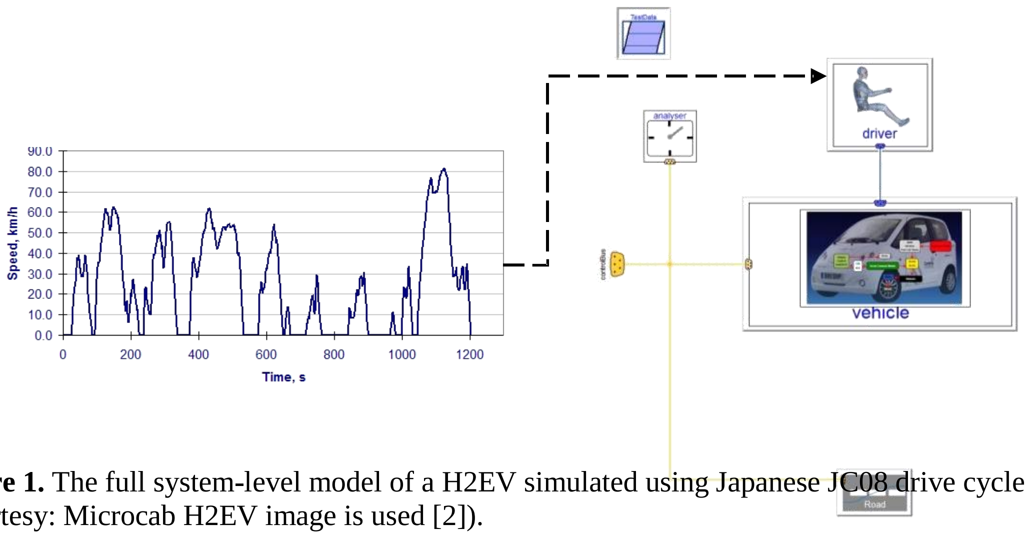

Figure 1. The full system-level model of a H2EV simulated using Japanese JC08 drive cycle (Courtesy: Microcab H2EV image is used [2]).

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Hyundai Framework for Vehicle Dynamics Engineering based on Modelica and FMI

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This paper describes a framework for systems engineering with primary application in the field of vehicle dynamics, addressing the need to be able to broadly deploy models to accelerate innovation and design. The framework is based on open standards Modelica, FMI and SSP.

Keywords: Vehicle Dynamics, Modelica, FMI, SSP

Modelling of Oil Film Bearings

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Oil film bearings are widely used for the large rotating machinery systems such as turbines and generators. Oil film bearings have the following advantages compared to rolling bearings. Oil film bearings provide the higher damping, which is required to pass through a critical speed and suppress vibration. Those also reduce noise, and have very long life under normal load condition because of the lack of contact between rotating parts.

At high rotating speed, self-excited vibration due to the motion of the oil film may occur in the rotating machinery system supported by oil film bearings. This instable vibration, generally called oil whirl or whip causes damage to the machine. To design the high rotating speed machinery, it is necessary to understand this instable vibration mechanism and prevent it. To diagnose the rotating machinery system supported by oil film bearings, it is important to grasp the behavior with faults such as unbalance and shaft bending etc.

In this paper, we use the linearized oil film force model (Hori and Kato, 2008) and estimate the fluid-induced instability for the design and the diagnosis of the rotating machinery system. The presented model is implemented in our original rotating machinery library by Modelica (Ishibashi *et al*, 2017). An example of a Jeffcott rotor system supported by plain circular journal bearings is simulated. To check the behavior of the model, Campbell diagrams and stability maps are computed by using the Modelica_LinearSystems2 library.

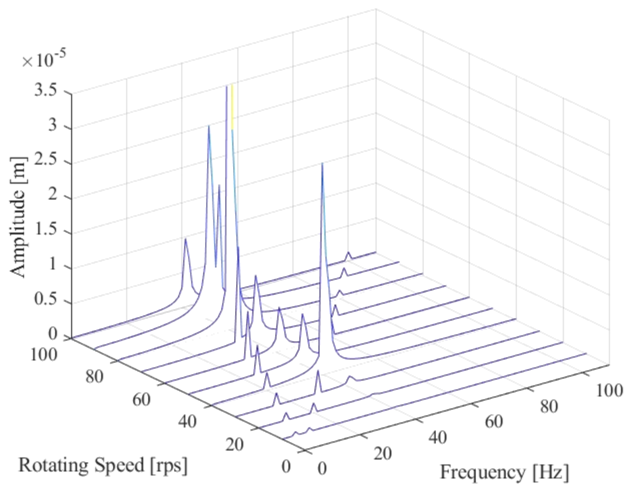

Figure 1. Waterfall plot of the light shaft rotating machinery system supported by oil film bearings.

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[Industrial paper] Gas Compressor System Simulation using Functional Mockup Interface for Human Machine Interface and Control

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This paper describes a gas compressor (GCS) system simulation for the purpose of verifying a controller's operation and interfacing simulation with measured data. The GCS is used to collect and compress low pressure gas streams for transmission into larger higher-pressure lines. This system is simulated with ANSYS TwinBuilder. It includes models of the compressor, motor, bypass valve, and piping along with pressure sources for the low and high-pressure lines, which are controlled with measured or test data. To cycle and pressurize the GCS, a controller is implemented using an FMU from ANSYS SCADE. To interact with the system and monitor current operating conditions, a human machine interface (HMI) is also implemented using ANSYS SCADE as an FMU.

[Industrial paper] A New Library for Modeling and Simulation of Pneumatic Systems

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The Pneumatic Systems library (PSL) by Dassault Systèmes is a new library aimed at modeling pneumatic power systems. Typically, such systems involve actuators in industrial plants, pneumatic brakes or suspension systems, etc. Also, this library suitable for aerospace applications such as cooling or engine bleed air systems. The library deals with common problems modelling fluid flow in Modelica like accuracy in throttles or multi-sided connectors. The library covers the following core features:

- Ideal gas model for temperatures up to 500K
- Import functionality for MSL fluid models
- Icons for valves and cylinders comply to ISO 1219 block diagrams and are animated according to their current position in the simulation
- Fully customizable cylinders covering one or double sided actuation, cushioning, return springs and proximity switching
- Optional computation of all fluid properties at pneumatic ports for clear understanding of the modeled system and comparison with experimental or measured data
- Neglection of kinetic energy in valves by default for increased computational performance, which can be deactivated by the user _ Modeling of heat transfer and losses

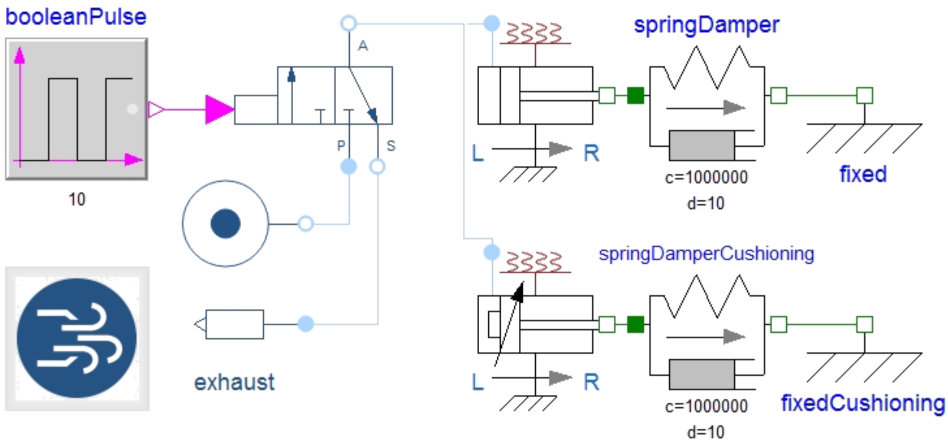

Figure 1. Example model comparing a cylinder with and without cushioning.

The Pneumatic Systems Library provides models for various applications of pneumatic power. The option to deactivate the neglecting of kinetic energy in orifices offer the possibility for more accurate simulations.

The DLR EtherCAT Library
A template based code-generation scheme for accessing real-time hardware from Modelica

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In this paper, a new concept to access real-time hardware from within Modelica via the EtherCAT bus is introduced and the implementation of a prototype library is demonstrated. The DLR EtherCAT library uses the open source EtherCAT library EtherLab to gather in- formation about the connected bus slaves. Thereupon, the slave information is used in a code generation process to build native Modelica blocks providing the interfaces to their hardware counterparts. These blocks subsequently can be used to build real-time models, running on a Linux based real-time system and therefore controlling the hardware directly from the model. The application of the library is shown in a robotic testbed where a motor drive is controlled via EtherCAT.

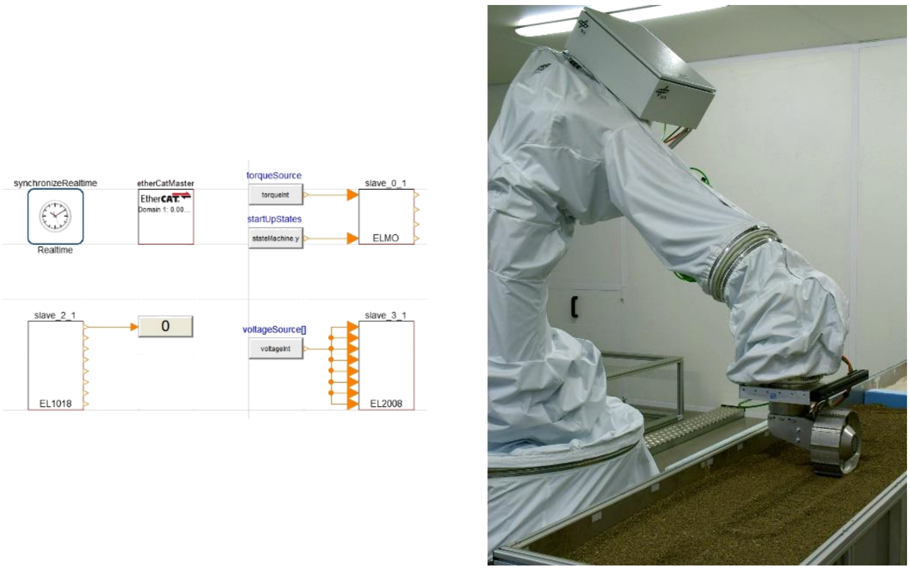

Figure 1. Left: Example model, using code-generated EtherCAT interface blocks to com- municate with real-time hardware from within Dymola. Right: DLR Terramechanics Robotics Locomotion Lab (TROLL) with rover wheel attached, controlled via the DLR EtherCAT Library.

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[Industrial paper] Modelling and Development of a Pseudo-Hydraulic Power Steering Model for use in Real-Time Applications

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Driver-in-the-loop (DiL) simulation is playing an increasing role in automotive OEM development processes. Vehicle models used in these activities therefore need to be as accurate, and realistic, as possible. When driving within a DiL environment, the driver senses what the vehicle model is doing through several senses; one of these is haptic (touch). This concerns the human/physical interface of which the steering forms a part (Ansible Motion, 2015). Essentially, the steering in a DiL simulator is a haptic feedback device. As a primary feedback on vehicle behavior, correct steering feel is therefore important to enable the driver to control the vehicle in as realistic method as possible. This has implications not only for limit driving, but also in 'normal' driving conditions as driver/vehicle control system interaction is important, such as for electronic stability program (ESP) development. For ESPs to be correctly developed, the driver must thus react as realistically as possible given the confines of a simulation environment (Ansible Motion, 2015).

This paper will present the modelling and development of a pseudo-hydraulic power steering model, designed for usage in DiL applications. The model presented is a pseudo- physical steering model based upon the Pfeffer et al. (2008) model, with a unique power assistance block which accounts for the dynamics of hydraulic assistance, such as the decay rate of force when the torque applied drops off suddenly, without the numerical complexity of a fully physical system model. The model relating the steering column dynamics to the assistance force is termed 'pseudo-hydraulic', as it aims to capture the key dynamics of a hydraulic power steering but without physical modelling of the internal elements of that system. Whilst many OEMs currently favor the use of electric power assistance systems, some, such as Nissan, still employ hydraulic assistance in their steering systems, as they perceive the hydraulic assistance to provide a superior steering feel (Nissan, 2018). Such systems typically feature an electrically driven hydraulic pump, therefore modelling of the hydraulic dynamics are required.

Specific focus during development has been towards the quantification and analysis of the torque feedback from the steering model to the simulator rig steering wheel, to produce as realistic a steering 'feel' as possible. Metrics derived from physical testing of vehicle steering systems have been deployed to analyze the torque feedback of the steering system. Subsequent assessment of the steering model and specific parameterization has been used to inform the model parameters utilized. Results quantifying the performance of the steering model during full vehicle testing using the Claytex VeSyMA platform are presented.

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Modelling silicon carbide based power electronics in electric vehicles as a study of the implementation of the semiconductor devices using Dymola

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In a joint effort, Dassault Systèmes and Rohm Semiconductor demonstrate how the introduction of silicon carbide (SiC) as a base material in power electronics improves the energy efficiency of a typical electric vehicle. As an application example simulation models of an electric drive and an electric vehicle are chosen.

After providing background information on power electronics and the advantages of SiC, the used inverter simulation models from the power electronics package of the Electrified Powertrains Library (EPTL) by Dassault Systèmes are introduced.

Subsequently, the thermal-electric modeling and calibration of an inverter module are explained.

The inverter model is then used in a system model of an electric drive in order to analyze the effect of the new power electronics material on the system electric efficiency and cooling requirements.

AUTOMATED TEST OF CVT CONTROL SOFTWARE, USING FMI AND MODELICA MODELS

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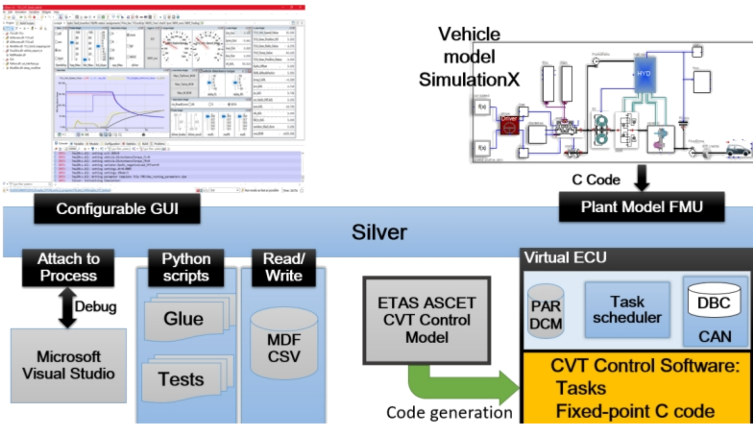

Hunan Jianglu & Rongda Vehicle Transmission Ltd., Co. has recently completed the development of a Continuously Variable Transmission (CVT). The transmission and the control soft- ware must be fitted to various vehicle platforms and must suit various driving conditions and driver requests. Because of the complexity of the system and due to the large number of driving conditions, systematic tests and validation methods are required. These methods should guarantee correctness and quality of the software and system behavior. For the test of the control software, Jianglu Rongda used an innovative test method based on automatic test scenario generation, Software in the Loop (SiL) simulation, and finally Hardware in the Loop (HiL) tests. The CVT control software is executed with a vehicle simulation model developed with SimulationX/Modelica, which is used both for the SiL and the HiL tests. The model accurately rep- resents the CVT transmission including mechanical and hydraulic systems based on mechanical and physical parameters. In this paper, we describe the corresponding test process and tool chain along with the model validation. We also discuss the advantages and costs of this approach.

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[Industrial paper] The Fault Library - A New Modelica Library Allowing for the Systematic Simulation of Non-Nominal System Behavior

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To date, most Modelica libraries consider physical systems in their nominal configuration. There have been limited attempts to extend model coverage towards behavior beyond that. These include the Fault triggering library (van der Linden, 2014), which allows for the insertion of faults into models of existing components; and the FAME library (de Kleer et al., 2013). The latter has served as a basis for the development presented in the paper. The Fault library developed at ESI ITI for modeling faults enables the user to model and simulate physical systems outside their nominal behavior in a systematic and semiautomatic way. We outline the motivation of how and why to model faults as well as a description of the library structure. In addition, the necessity and implementation of helper libraries (Features, PerformanceIndicators) and wizards (Fault Augmenter AddIn) is described.

The range of applicability of the Fault library we introduce is broad. Preliminary results - based on the given examples - are presented. We illustrate this using four examples we studied in the scope of our development: a braille printer, an automotive transmission drive line, a battery package with Li-Ion cells and a feed axis in machine tools. As an example, the pruned model of an electrical circuit shows various fault types of the library (Figure 1): connector, bridge and parametric faults. In this model, one of the resistors is replaced by its FaultAugmentedModels counterpart, modeling a parametric fault. To the connection between the inductor and the capacitor, a ConnectorFault has been added to model a short to ground. The connection between the two resistors has been cut by a ConnectorFault that models a loose contact. An additional switchable connection (BridgeFault) modeling a short circuit between two junctions in circuits of consuming components. In the presentation, we introduce the Fault library, exemplified in three fields of applications: reliability, virtual testing and diagnosis. Based on these, the broad range of applicability is outlined. In addition, we demonstrate several complementary tools and techniques for analyzing the results of simulations of faulted models.

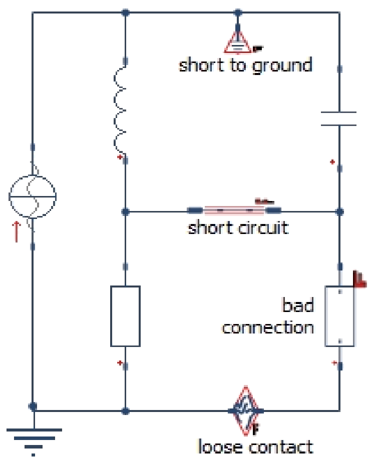

Figure 1. Screenshot of a model of an electrical circuit which has been augmented with faults

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[Industrial paper] Application for Optimization of Control Parameters for Multi-body and Hydraulics System by using FMU

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We developed a simulation environment using FMU (Function Mockup Unit) as performance prediction method in the early stage of development.

In this environment, hydraulic controller parts are modeled in Dymola which is one of 1D simulation tools based on Modelica language and controlled mechanics parts are modeled in Simpack which is multibody simulation tool. We created a total system model connected to hydraulic controller parts and mechanics parts by using FMI (Function Mockup Interface). Hydraulics and controller parts are converted to FMU by Dymola, and are incorporated in Simpack mechanical model.

Furthermore, we applied the system model optimization to control parameters by using Isight.

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Analysis of Lift-Generating Disk Type Blade Wind Power System Using Modelica

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This study investigated a lift-generating disk-type blade power generation mechanism that can effectively generate wind power. The research and application technology of wind power generation have attracted great attention in relation to the development of renewable energy. As wind power systems such as a propeller type are being enlarged to increase power output, various problems such as natural landscaping damage and shadow problems are occurring. Thus, we propose a lift-generating disk type blade power generation mechanism that can effectively generate wind power even with simple structure considering the problems of existing system.

As shown in Figure 1. (a), The basic principle of the system is that vertically supported tower structures from the ground move along the vertical axis with the disk type blade lifted by the wind. This type of system generates electric energy through a power transmission system that converts such motion into rotary motion along with a power conversion system, such as a generator. The proposed disk type blade has some distinct characteristics. First, the disk can move up and down to generate lift force that is converted into electrical energy. Second, owing to its symmetric shape, it is easily activated by the wind coming from all directions. Finally, the proposed model has a relatively weak contibution to shadow flickering because it does not feature multi-blade rotation and the space required for realizing its motion is comparatively small.

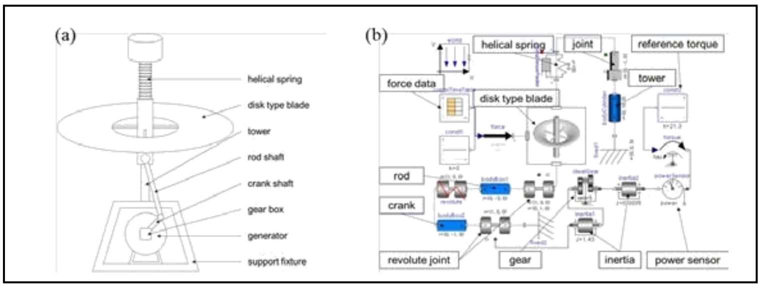

Figure 1. Lift-generating disk type blade wind power system. (a) Schematic diagram, (b) Modelica simulation

The disk type blades were first designed using computer-aided design, and then they were designed according to design parameters (Montgomery, 2017). As shown in Figure 1. (b), the modeling method of the wind power system is explained using the Modelica (Eberhart et al, 2015). After that, a wind tunnel test is conducted through a small scale model of the disk type blade created for simulation verification and the results were in good agreement. As a result, the modeling of the wind power system is verified and the results of the generator power output are presented through simulation.

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Modelling of Asymmetric Rotor and Cracked Shaft

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Rotating machinery systems have been the most important in almost all of heavy equipment such as turbine, generator, motor and so forth. A proper modelling and simulation of rotating machinery system with common faults should help engineers understand the performance with faults well, so that faults can be discovered or diagnosed in the early stage. We have created the rotating machinery library which has 5 DOF rotor dynamics model components by transfer matrix method using Modelica (Ishibashi *et al*, 2017). It is suitable for modelling and simulation of rotating machinery systems with faults. By using the Modelica_LinearSystems2 library, it is also possible to do eigenfrequency analysis in the linearized system.

This paper presents asymmetric rotor and shaft models in rotating machinery systems (Ishida and Yamamoto, 2012). Using these models, it is possible to analyze the electrical motors or generators which have different lateral stiffness or the moments of inertia in two orthogonal directions. The asymmetry causes unstable vibrations in some rotating speed ranges. A cracked shaft model is presented as the extension of the asymmetric shaft model. These models are implemented in our original rotating machinery library.

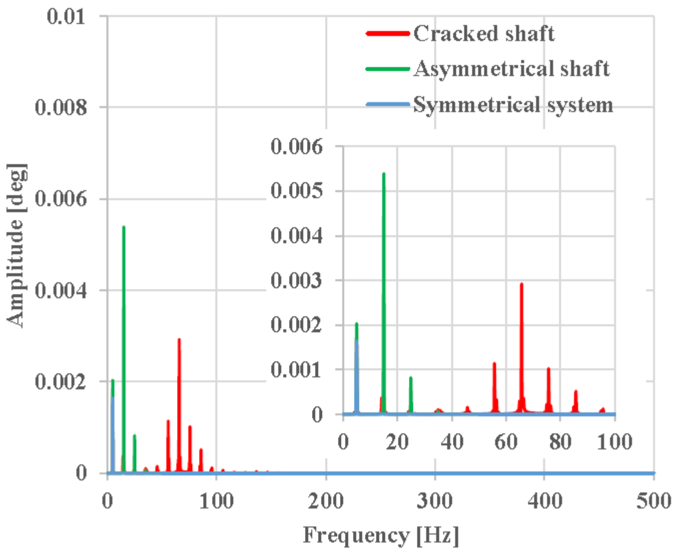

Figure 1. Comparison of simulation results analyzed by FFT.

Blue line: Symmetrical system. Green line: Asymmetrical shaft. Red line: Cracked shaft. The inset shows the enlarged view.

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Composable Modelling for a Hybrid Gearbox

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Gearbox modelling is an important topic to the simulation community due to its difficulty in representing mixed continuous and discrete behavior. Such kind of models also usually couple the loss of power that is dependent on the angular velocity and the load. However, one single gearbox model with a certain fidelity cannot satisfy the broader needs to of models during product development. In this paper, we will address hybrid modelling issues and take the gearbox model as an example to illustrate how to model gearboxes from a Systems Engineering perspective by describing explicitly the functionality of the gearbox (Figure 1 left) and its operational modes (Figure 1 right).

A supervisor (Figure 2 right) and supervised model structure is investigated (Figure 2 left) that could also be regarded as a use case to a general cyber-physical modelling approach. The resultant model achieves the same output as the LossyGear model in Modelica Standard Library.

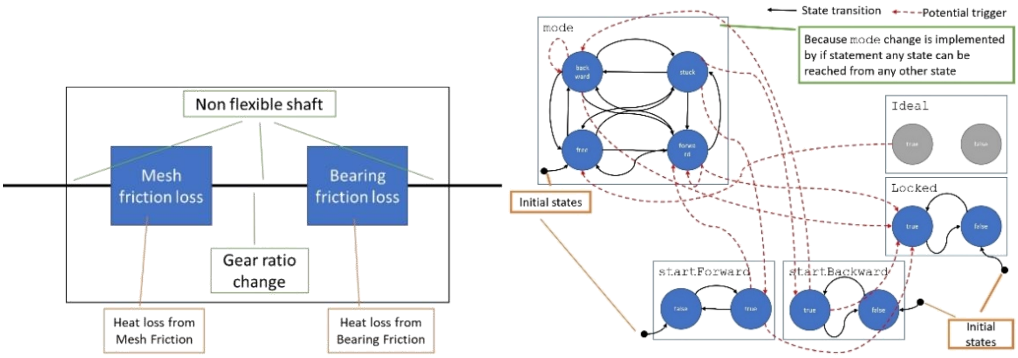

Figure 1. Left: Describing the key aspects of a gearbox. **Right:** State and state transition representation of gearbox for depicting operational modes.

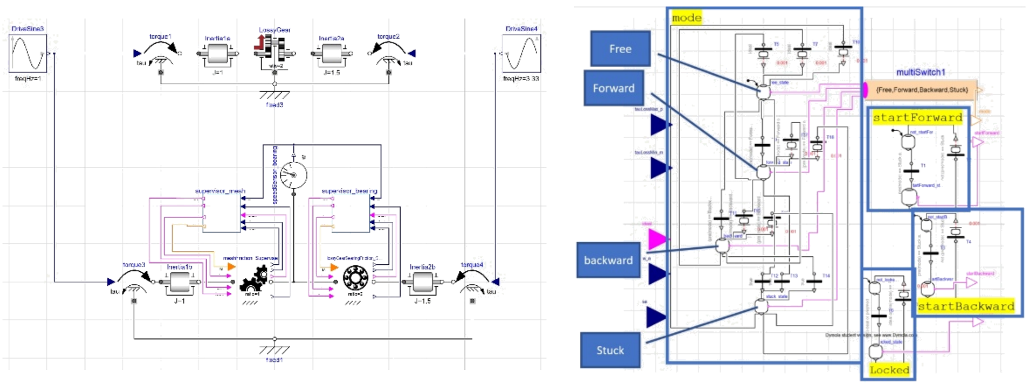

Figure 2. Left: Composed gearbox model of mesh loss, bearing loss and with separate supervision for each of those components. **Right:** Implementing the state transitions of Figure 1 right as explicitly as possible.

Toward the actual model exchange using FMI in practical use cases in Japanese automotive industry

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The working group in JSAE (Society of Automotive Engineers of Japan) proposed and published a guideline about a method using adapters to enable the connection of FMUs in acausal modeling tools in 2015. After that, more combination of exporting tools and importing tools of FMUs were tested for the benchmark model shown in Figure 1. The success of the method was confirmed in the case of using FMI for Model Exchange (ME). Additionally the connection of FMUs generated from various modeling tools was tested using FMI for Co-Simulation (CS) for a full-vehicle test model shown in Figure 2. Through the above-mentioned activities, we obtained much knowledge about utilizing FMI for practical model exchange in the industry. Finally the requests for future realization of FMI are described.

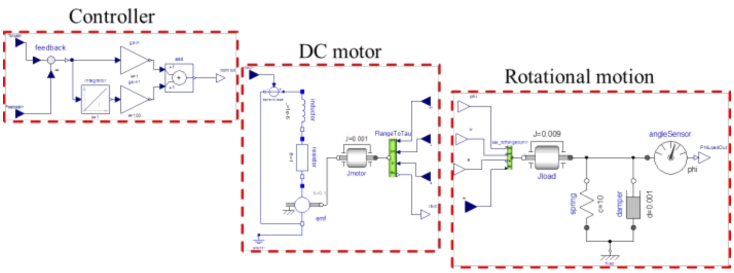

Figure 1. Modified benchmark model

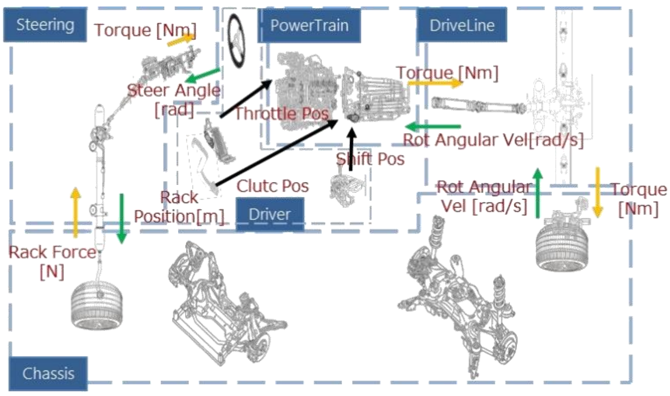

Figure 2. Full vehicle benchmark model

References

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[Industrial paper] Managing Heterogeneous Simulations Using Architecture-Driven Design

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System simulation is a proven method for anticipating the balancing of multiple performance attributes of a product. However, in the automotive industry today, a large diversity of vehicle architectures and technologies exists, resulting in a huge number of variants for all subsystems. It becomes increasingly difficult to manage and analyze all possible configurations. Additionally, subsystem models are implemented in different authoring tools. This paper presents an architecture-driven approach to manage heterogeneous simulations. A European automotive OEM has requested Siemens PLM Software to use its tools and process knowledge to demonstrate the value and need for architecture-driven simulation. Simcenter System Synthesis[1] was proposed as a neutral framework for managing heterogeneous simulations. This includes three major capabilities:

- Integration of different subsystem models in the form of Simcenter Amesim[2] "supercomponents" and Functional Mock-up Units (FMUs) exported from Dymola[3]
- . Plug-and-play configuration of subsystems regardless of their native software.
- Performant execution of heterogeneous simulation architectures with the numerical challenges of segregated strongly coupled systems

The focus of the project is on the process of model integration using Functional Mock- up Units (FMUs). An electrical vehicle case-study was selected to illustrate this process.

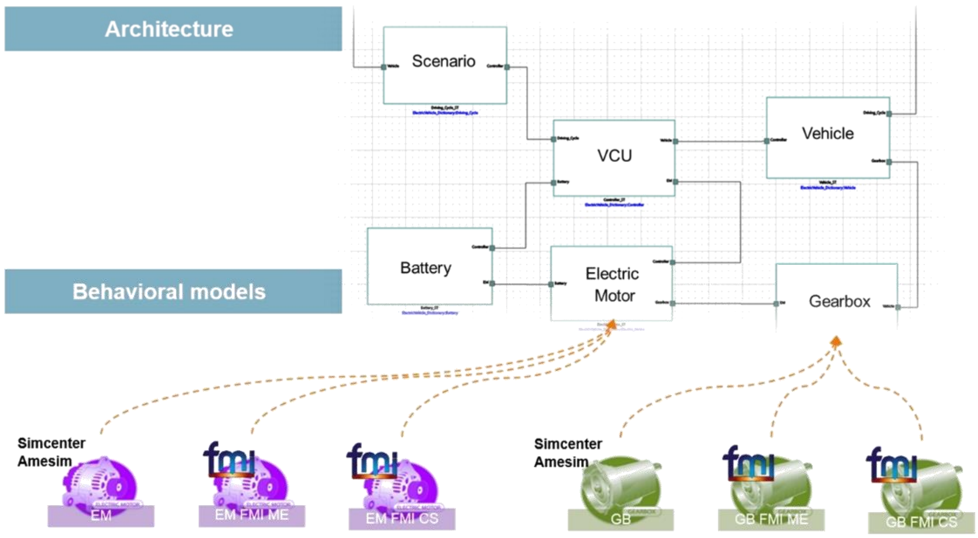

Figure 1. Simcenter System Synthesis as a framework for managing heterogeneous simulations

[1] Simcenter System Synthesis is a configuration management, system integration and system architecture management tool developed by Siemens PLM Software

[2] Simcenter Amesim is a commercial simulation software for the modeling and analysis of multi-domain systems, developed by Siemens PLM Software

[3] Dymola is a commercial modeling and simulation environment based on the open Modelica modeling language, developed by Dassault Systèmes.

Simulation of high-index DAEs and ODEs with constraints in FMI

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In the current FMI standard the dynamical behavior of a model can only be de ned as a system of Ordinary Differential Equations (ODE). The dynamics of many physical systems, such as the equations of motion of con- strained mechanical multibody systems, are expressed by high-index Differential Algebraic Equations (DAE) so they cannot be simulated directly using standard ODE or DAE solvers. These systems can be converted through index-reduction algorithms into ODE or index 1 DAE systems. However FMUs based solely on these latter systems suffer from drift in hidden constraints on the states. As a consequence, the simulation may results in physically meaningless solutions. In this paper, we proposed an extension of the FMI standard to handle DAE systems of index 1 or higher and ODE with constraints. In this extension, after applying an index reduction method to the high index DAE, the DAE is converted into ODE or index-1 DAE. The resulting equations is simulated using standard ODE integrators, but the solution is projected back onto the constraints after each time step. In other words, after completion of each integrator step of the ODE numerical solver, the required projection to bring back the solution on the constraints is computed, and if its norm is large enough, it is applied to the solution so that the constraints are satisfied. In this method, monitoring the magnitude of the projection and integrate it into the error control mechanism is required. This proposed FMI extension requires only few additions to the FMI specification, all of which can be omitted for FMUs that represent ODE systems or FMUs that do not support DAE handling. The extension has been implemented in solidThinking Activate^{TM} and two examples that show the ease of implementation and the effectiveness of the method will be discussed.

Keywords: Modelica, FMI, High index DAE, ODE with constraints, Coordinate Projection

Universal Controllers for Architecture Simulation

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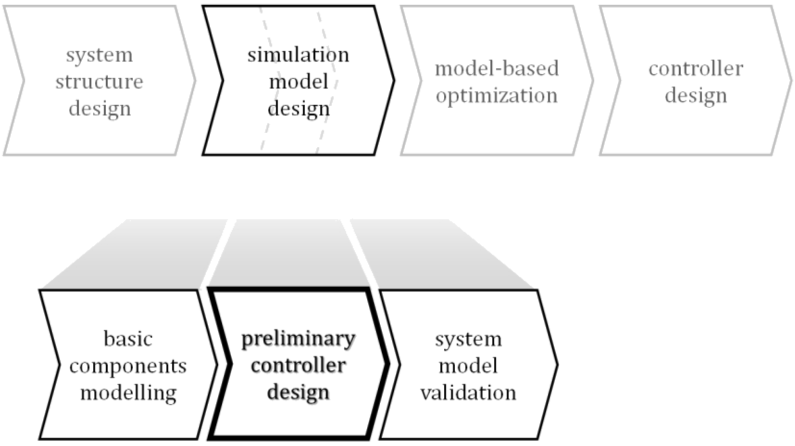
For optimization studies of dynamical systems, it is common practice to model and tune local controllers for miscellaneous subsystems. For instance, a model of a chemical plant may contain a valve motor model, and a model of a PID controller may be included to control the motor. The associated controller tuning effort is ultimately wasted. The actual controller will be retuned anyway after finalization of the system design, or will be structurally different.



For this reason, control algorithms are needed that just provide the functionality of the actual control algorithm that will be designed in a later phase of the system design.

These temporary algorithms need to have low tuning requirements, and it must be possible for non-control-specialist to generate them.

On the other hand, they only need to function inside a simulation environment.

Several mainstream control approaches are reviewed, and boundary layer sliding mode control is proposed as a suitable approach for this kind of task. This class of controllers can be used without any tuning effort, and is able to compete with tuned PID- controllers in terms of tracking performance.

An end-user friendly implementation of a universal controller in the equation-based and object-oriented modelling language Modelica is presented. Several examples are shown to demonstrate the performance of the proposed approach.

Mission-Dependent Sequential Simulation for Modeling and Trajectory Visualization of Reusable Launch Vehicles

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The multibody modeling and visualization of reusable launch vehicles is a challenging task due to their variable structure regarding component separation and engine cutoffs du- ring ascent and descent. However, the number of states within a MODELICA-based multi- body model has to remain constant during a simulation. Therefore, the variable structure of launch vehicle models is often considered by using time- and state-dependent conditional statements and separation components. Such an approach can lead to a higher number of equations in the model and to a higher model complexity, respectively.

In this paper, a mission-dependent sequential simulation approach for the modeling and trajectory visualization of launch vehicle systems is introduced. Here, the system is divided into characteristic phases, which are modeled with the DLR LauncherApplications Library capitalizing its modular, reusable and user-friendly structure to maintain compatibility bet- ween phases and to decrease the overall model complexity and the number of equations.

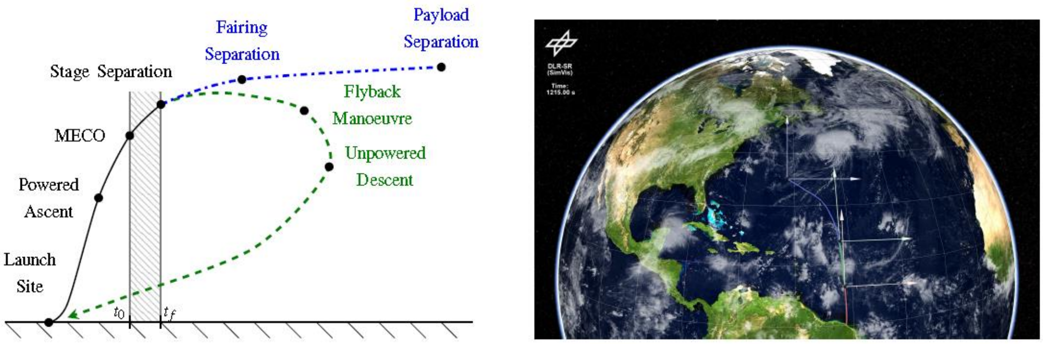

Figure 1: Overview of a Mission-Dependent Reusable Launch Vehicle Trajectory with Multiple Phases and corresponding Visualization with the DLR Visualization Library.

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Model predictive allocation control for leg-wheel mobile robot on loose soil considering wheel dynamics

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For the planetary exploration rover, to cope with the layer of heterogeneous superficial deposits called regolith is important so as to achieve designed robot motion. However, the relationship between tire and loose soil is very complex. Then, to analyze and control such kind of the effect, *terramechanics* is introduced. In addition, the controlled robot in this paper has many wheel and joint; there is the redundancy to drive. In order to optimally allocate the traction force, we propose the model predictive allocation control. The controller adopts *mod- el predictive control (MPC)* that a computational cost problem might be occurred; to avoid this problem by formulating MPC as the linear optimization problem, we introduce the approximation model by using identification technique. Moreover, to evaluate not only wheel motion but also robot total motion, we adopt the leg-wheel mobile robot model previously modeled in (Yoshikawa et al., 2016); this model written by equation based language Modelica is suitable to model and simulate complex robot, because it is not required to care about causality of the wheel model based on terramechanics. Through the numerical simulation, we show the suppression of superfluous slip and enhancement of traction performance.

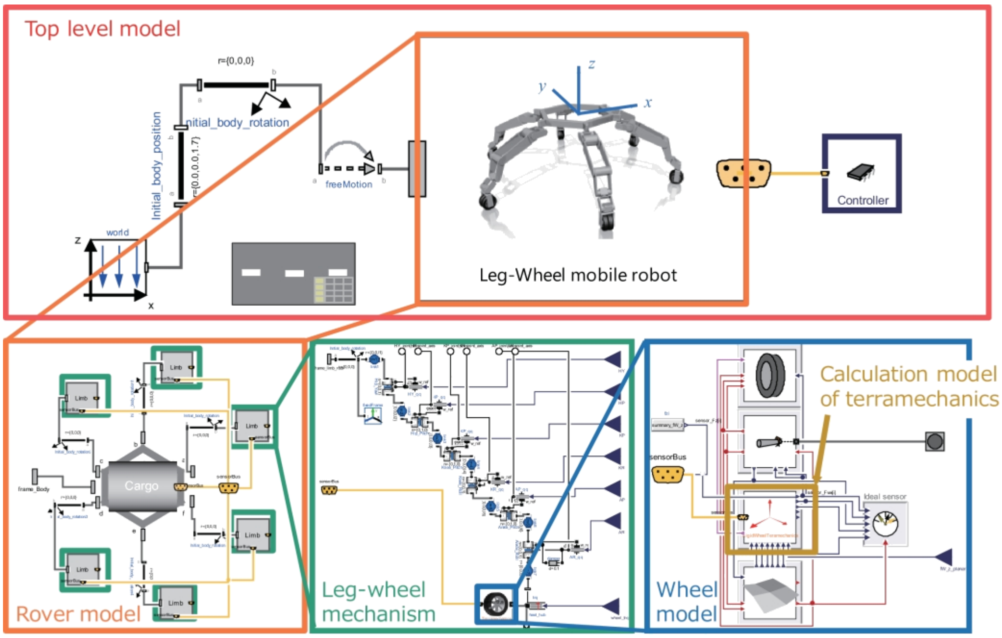

Figure 1. The leg-wheel mobile robot described by Modelica.

References

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Generating FMUs for the Feature-Based Language Bloqqi

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In this paper, we describe how we generate C code to create Functional Mock-up Units (FMUs) for the automation block language Bloqqi. This allows Bloqqi control programs to be tested with simulations of the physical processes they control. The physical process can be specified in any tool that supports the Functional Mockup-Interface (FMI) standard. For example, we have successfully run Bloqqi programs together with Modelica models exported as FMUs (see Figures 1-3). Bloqqi programs execute at discrete times, and we describe how this is handled in the implementation of the `DoStep` function, specified in the standard.

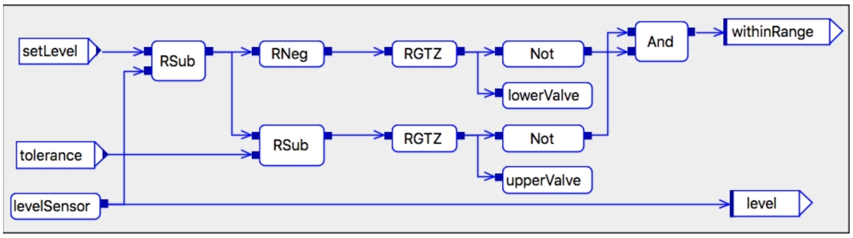

Figure 1. Simple tank regulator in Bloqqi that controls the liquid level of a tank using two valves: one input valve (upper Valve) and one output valve (`lower Valve`). The block `level Sensor` reads the current liquid level. The blocks `lower Valve` and `upper Valve` are actuators to the valves. The block `RGTZ` means greater than zero (for reals). The diagram is executed periodically.

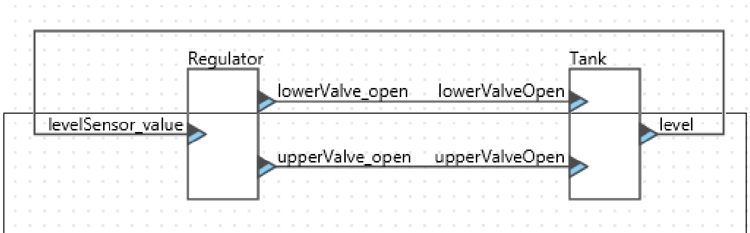

Figure 2. FMU composition in FMI Composer of the tank regulator (Figure 1) and tank model specified in Modelica.

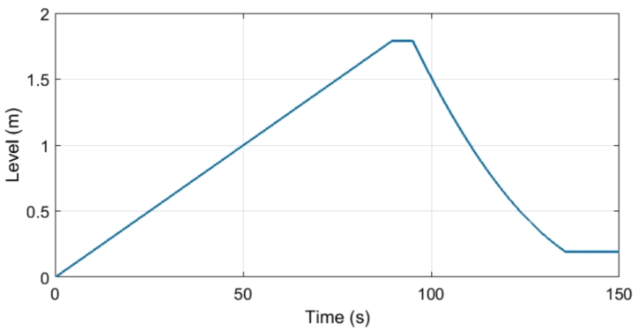

Figure 3. Simulation of the FMU composition in Figure 2. The set point of the liquid level is first set to 1.8 meter and then changed to 0.2 meter.

[Industrial paper] A Web Architecture for Modeling and Simulation

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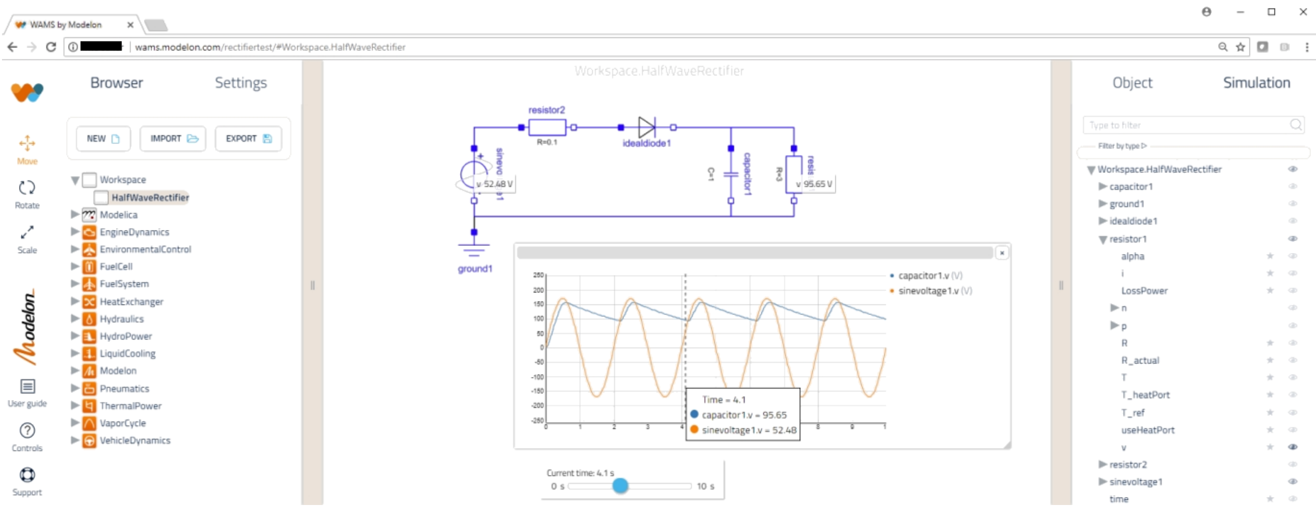
A Web Architecture for Modeling and Simulation (WAMS) is presented which enables system modeling in your browser using the Modelica language. Compilation and simulations are done on a server using the Optimica Compiler Toolkit (OCT) from Modelon.

Such an architecture is appropriate for making design space explorations such as sensitivity analysis, DOE, Monte Carlo analysis, optimizations, parameter estimation, etc. efficiently



[Industrial paper] Multibody simulation and control of kinematic systems with FMI/FMU

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Our connected world and environment make us interact every day with very complex devices. Driving our cars, monitoring health using smart phones, the extensive use of robots are all applications which involve large quantities of embedded functions and physics. To design and simulate efficiently such systems, individual physics simulators are not sufficient and coupled simulations are required. A new standard called FMI (Functional Mock-Up Inter- face) [1] has been created, allowing to federate these interactions between a wide variety of physical, digital and reduced models, either through a co-simulation approach or through model exchange strategy using a standardized and neutral interfacing mechanism. In this arti- cle, we illustrate through an example how it's possible to simulate mechanical assemblies, kinematics, dynamics and control systems in the same system model. Each mechanical sub- assembly is represented by a FMU (Functional Mock-Up Unit) exported from a multibody dynamics solver and includes a mix of rigid and flexible components. Flexible components are reduced order models of the full fidelity finite element model using the well-known CMS (Component Mode Synthesis) method. [2]

We apply the coupling through the FMI standard to a robot model, composed of rigid parts and one flexible sub-assembly. The highly non-linear behavior of the equations of motion of the multibody assembly is captured and consumed as a co-simulation FMU. The actuators detailed model – from the voltage source to the electric motors – are modeled in the system simulation platform ANSYS Twin Builder, while the control loops use SCADE which offers different control laws. The co-simulation of these 3 sub-systems can then be performed in an efficient manner, without the prerequisite of having on-off coupling developed between each of the individual simulators.

References

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[Industrial paper] Deployment process for Modelica-based models

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This paper introduces Maplesoft's solutions for deploying Modelica-based models for non-experts of simulation. In order to apply models to analysis, either non-experts need to learn how to use simulation tools, or simulation experts need to prepare easy-of-use GUIs, like Excel and Web technologies. Maplesoft's solutions allow more flexible and rapid analysis tools development.

Maplesoft product suite can offer three types of deployment (Figure.1) :

- Case 1 : With Standalone software, MapleSim Explorer. Users need to install software and store models and analysis tools developed by simulation experts on their own computer
- Case 2 : Web-based environment, MapleSim Server. Software, models and analysis tools are installed on web server. Users can access analysis tools via web-browser.
- Case 3 : Cloud-based environment, MapleCloud. Analysis tools containing models are uploaded to cloud service. Users can execute tools on cloud and download them to their own environment appropriately.

As the fundamental capability of Maplesoft product suite, it is easy to build user- defined analysis tools in Maple, which consist of calculation procedures and GUI, to set parameters to Modelica-based models and apply various type of post processing with the simulation results. The analysis tools developed in Maple can be executed in all types of deployment environment without any additional modifications.

These solutions can realize wider adoption of Modelica-based models to increase the usage of Modelica model.

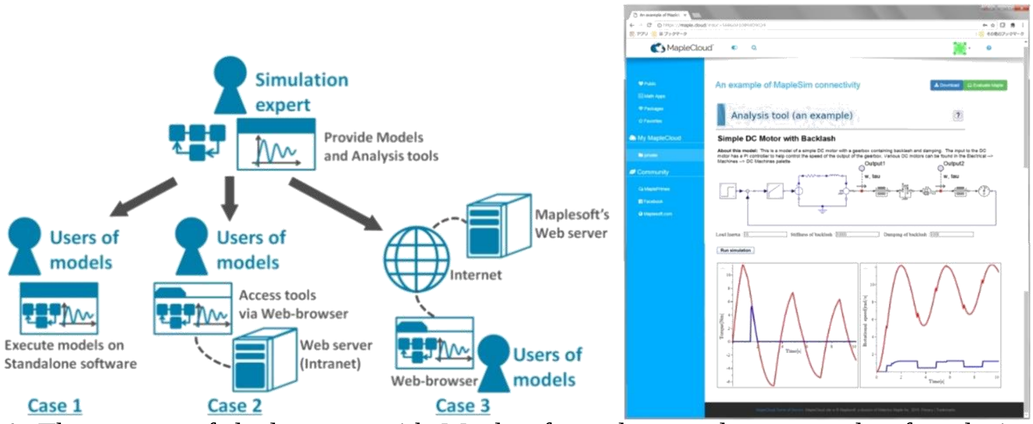

Figure 1. Three types of deployment with Maplesoft products and an example of analysis tool on MapleCloud.

References

MapleCloud 2018: https://maple.cloud

MapleSim Explorer 2018: https://www.maplesoft.com/products/maplesimexplorer/ MapleSim Server 2018: https://www.maplesoft.com/products/maplesimserver/