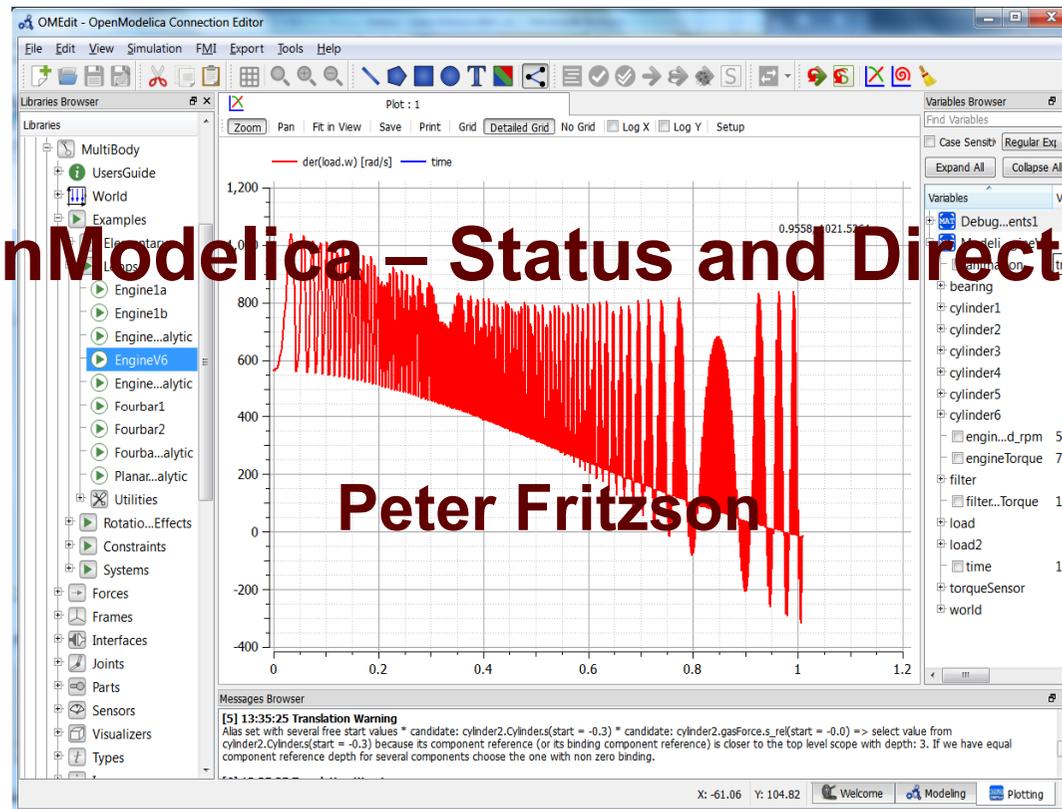


11th Annual OpenModelica Workshop

Feb 4, 2019

OpenModelica – Status and Directions



Goals for the OpenModelica Effort

- Comprehensive **modeling, simulation and systems engineering** environment for research, teaching, and industrial usage
- **Open-source** for both **industrial** and **academic** usage
- Invitation for **open-source cooperation** around OpenModelica, tools, and applications
- **Increased** emphasis on **industrial** usage

Main Releases 2018 and January 2019

- **OpenModelica 1.13.0 final release** (Dec 21, 2018)
 - **Experimental version of New Frontend** (enabled by flag)
 - **Improved OpenModelica DAEMode** for efficient solution of large models.
 - **Basic Matlab scripting** API to OpenModelica.
 - **Julia scripting** API to OpenModelica.
 - **OMSysIdent** - parameter estimation module for linear and non-linear parametric dynamic models.
 - **Interactive simulation** and control of simulations with OPC-UA.
 - **PDEModelica1** - experimental support for one-dimensional PDEs in Modelica.
 - Analytic directional derivatives for FMI export and efficient calculation of multiple **Jacobian** columns – giving much faster simulation for some models.
 - **Enhanced OMEdit** – including fast multi-file search (ctrl-H).
 - **Improved error messages** and **stability**.
 - **Encryption support** for packages (distributed in a special release binary, contact us if you are an OSMC member organization interested to use it)
- **OpenModelica 1.13.1, 1.13.2** bug fix **releases** (January, 2019)
 - Improved FMI simulation, FMI export, OMEdit functionality, Mac installation

New Frontend and OMEdit Replaceable Support

- The OpenModelica **new compiler frontend** – a **large** effort to rewrite about half of the compiler to gain high compilation **performance** and 100% Modelica semantics
- Effort was much bigger than initially estimated
- Status January 2019, OMC with newfrontend simulates more than 95% of MSL
- The New frontend is about **10 to 100 times faster** than the old one
- More details later today in talks by Francesco, Adrian, Per

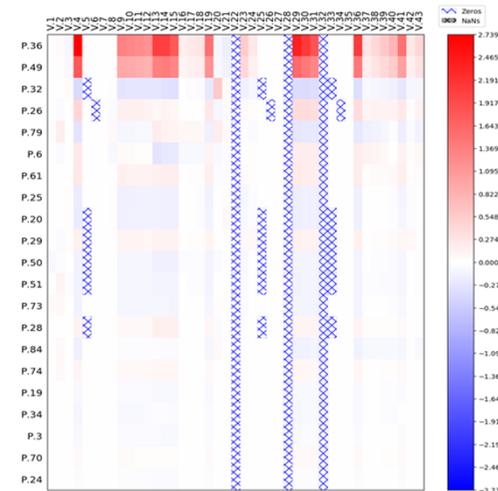
OMSimulator 2.0 (talk by Lennart and Robert later today)

- **Greatly enhanced** OMSimulator tool
- **Simulation** environment based on **FMUs** that provide both **signal connections** and **TLM connections**
- Model exchange & Co-simulation FMUs
- **Scripting** interface (Python, Lua)
- Graphical user interface (OMEdit, Papyrus)
- Graphical **composition** of FMUs
- **Distributed** simulations utilizing TLM master
- **SSP** support for composite models
- (FMI tutorial tomorrow Tuesday)

OMSens – Simultaneous Param-based Sensitivity Analysis and Robust Optimization (release spring 2019)

- To define a sensitivity experiment:
 - The state variable to analyze
 - The set of parameters to perturb
 - The allowed perturbation intervals for each parameter
- Main goal: pinpoint a small number of parameters that produce the largest deviations when perturbed within narrow ranges around their default values
- To select parameters and their intervals is not a trivial task
 - Responsibility relies completely on the expertise of the user
 - Enabling all parameters can lead to very costly experiments
- Use a top-N subset of parameters from a ranked list
 - obtained using individual parameter-based analysis
- Using CURVIF robust derivative-free model building method for few function evaluations
- Heat-map visualization of parameter influence

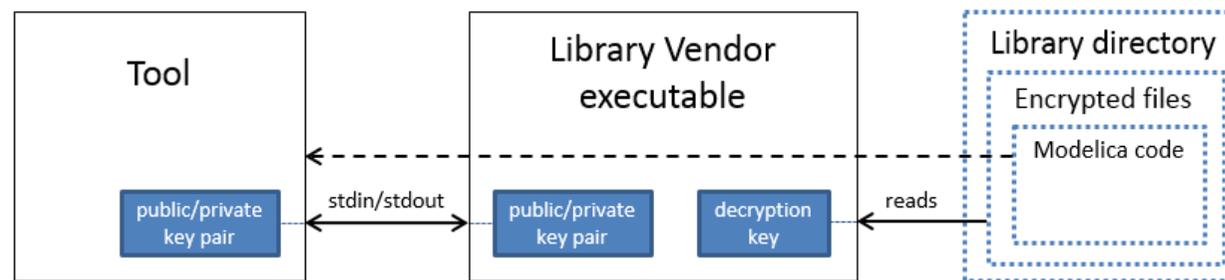
Paper at
EOOLT 2017
(prototype)



Encryption and Protection Annotations

(Released in 1.13.0) Further deployed during 2019

- Encryption done with public/private key pair and the encrypted library files (*.moc) are bundled in a zip file (.mol).
- OMC decrypts the Modelica code in memory by using the decryption key.
- Uses Modelon/MathCore Library Encryption module
- Full support for Protection Access annotation in OMEdit allowing user to restrict model usage.



OMSysIdent (Released in 1.13.0)

System Parameter Identification

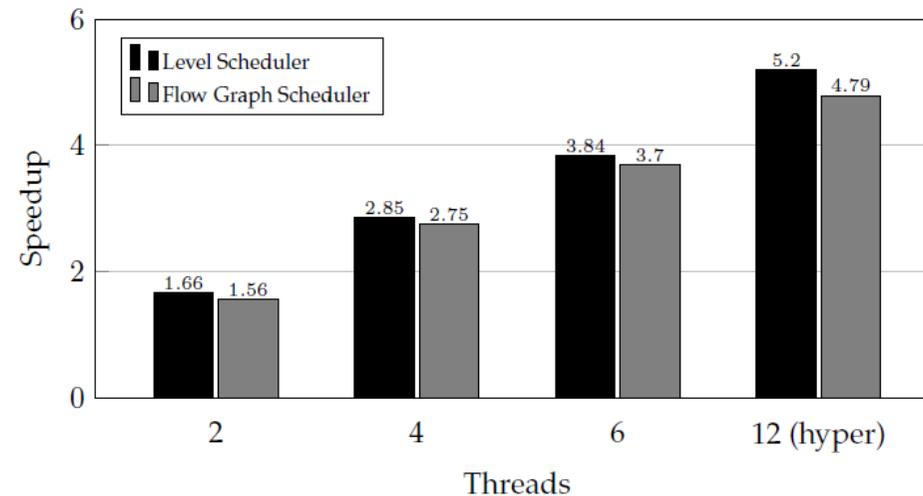
- A new module which provides **parameter estimation** for (composite) models compiled to FMUs
- It uses the **Ceres Solver** (developed at Google) for the solution of the **underlying optimization** problem
- An **API** that can be conveniently used from popular scripting languages such as Python
- The first version has been developed on Linux
- Available in the 1.13.0 release

ParModAuto Parallelization (Release spring 2019)

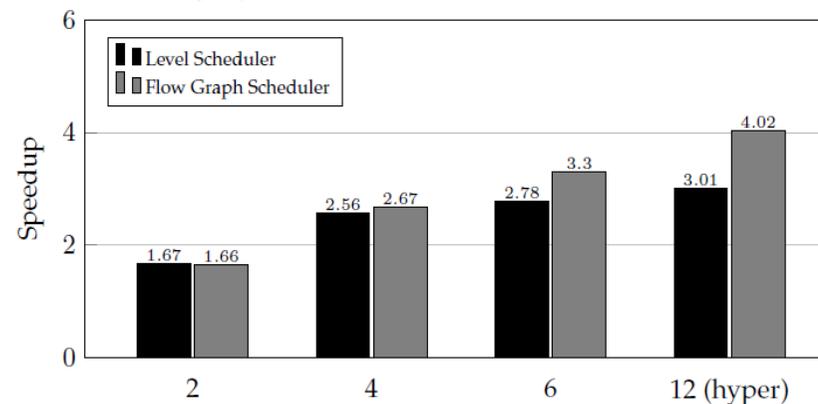
Automatic AutoTuned Parallelization of Equation-based Models

- Automatic **Parallelization**
- Automatic **clustering** of small tasks
- **Automatic load balancing** based on measurements, automatically adapts to changing load
- **Shared-memory** task parallelization
- Planned for release spring 2019

SteamPipe640 model, Speedup 5.2 on 6 cores:



BranchingDynamicPipes model, Speedup 4 on 6 cores:



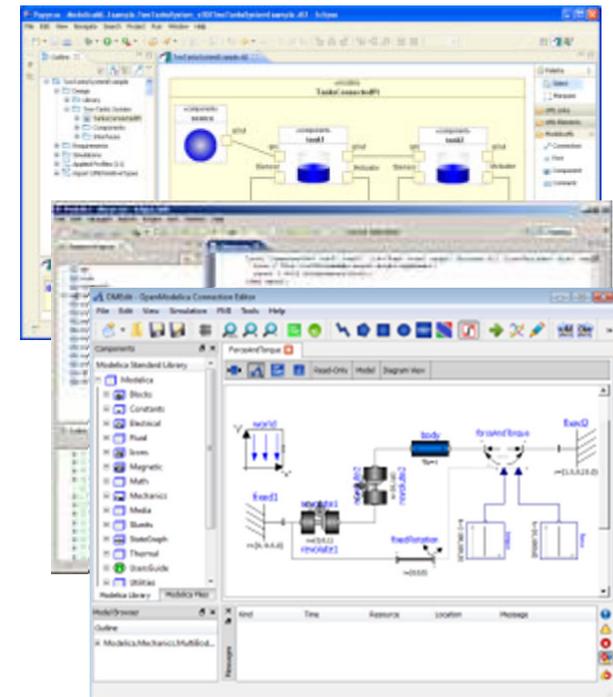
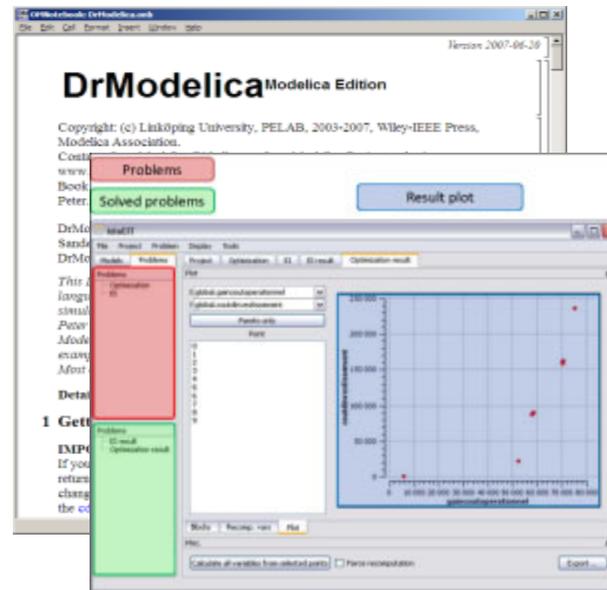
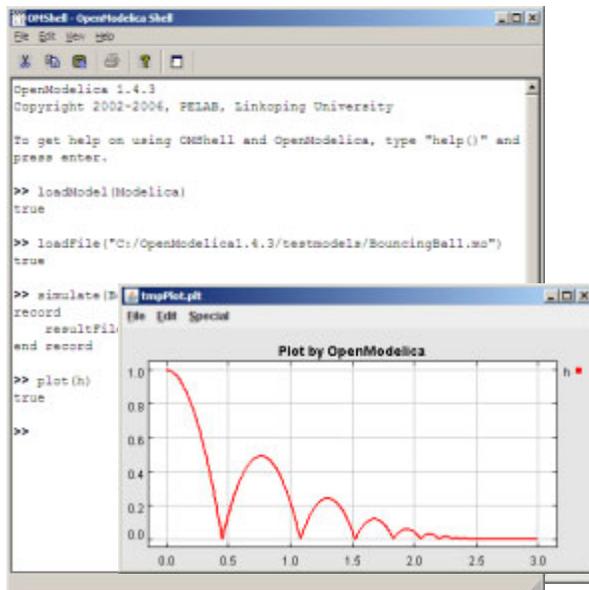
Plan of Operations for 2019

- **Main goal: OpenModelica 2.0.0** release with significantly improved **coverage** for **libraries**, and significantly improved compiler and simulation **performance**, tool **robustness** and **quality**, including support for large-scale models
- Early spring 2019 Release of **OM 1.14.0** with **GUI** support for **replaceable** in libraries and an almost complete new frontend.
- Spring 2019. **Finalizing new frontend** modules with significantly improved flattening for enhanced coverage and performance
- Improved OMC **Backend** for stable simulation in OM 2.0.0. **Unified run-time** in fall 2019.
- Whole 2019. Development of more **Industrial Use Cases**.
- Late Spring 2019. Releasing **OMSens** – multiparameter sensitivity analysis and optimization.
- Spring 2019. Releasing **ParModAuto** – **Parallelization** capability from Mahder's PhD
- Further Enhanced Equation model **debugging** support
- Further enhanced **embedded** system code generation and development support
- **Further deployment** of **Encryption** support for use of commercial libraries with OM
- Enhanced **FMI**, complete FMI export, Full FMI 2.0, FMI Composition, OMSimulator 2.0
- **Matlab scripting** API to OpenModelica
- Enhanced MetaModelica 3.0 documentation & environment with improved ease-of-use; Further investigation of OMC **Julia** interfacing and **LLVM** code gen usage.
- Get a few **DFD/MSA contracts** signed and activated

The OpenModelica Open Source Environment

www.openmodelica.org

- **Advanced Interactive Modelica compiler (OMC)**
 - Supports most of the Modelica Language
 - **Modelica, Python, Julia, and Matlab scripting**
- **OMSimulator – FMI Simulation/Co-simulation**
- **Basic environment for creating models**
 - **OMShell** – an interactive command handler
 - **OMNotebook** – a literate programming notebook
 - **MDT** – an advanced textual environment in Eclipse
- **OMEdit** graphic Editor
- **OMDebugger** for equations
- **OMOptim** optimization tool
- **OM Dynamic optimizer** collocation
- **ModelicaML** UML Profile
- **MetaModelica** extension
- **ParModelica** extension



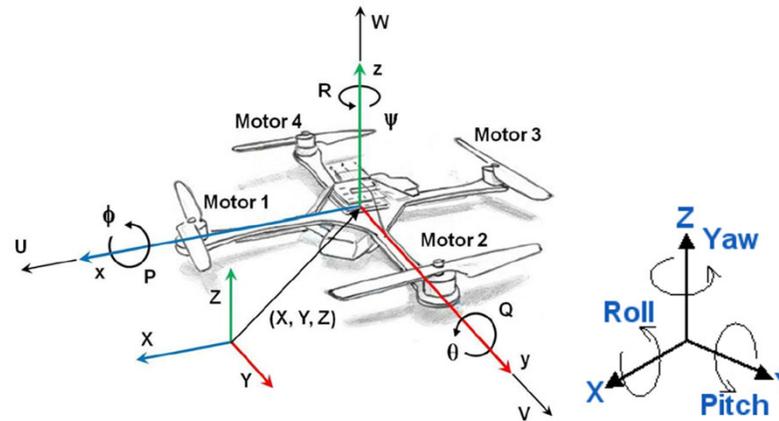
Current Main Industrial OpenModelica Usage (not including research usage)

- ABB OPTIMAX – Process control, generating code controlling almost 10% of German power production
- DHI, OEM usage of OM compiler frontend in DHI product
- Bosch-Rexroth, in-house product usage for Modelica model import and simulation
- EDF – ThermoSysPro Library and Applications
- Politecnico di Milano – molten-salt-powered once-through steam generator model
- ABB – fluid sub-model of a district heating plant is running in production
- New: Modelicon – Model-based Control of UAVs and Robots

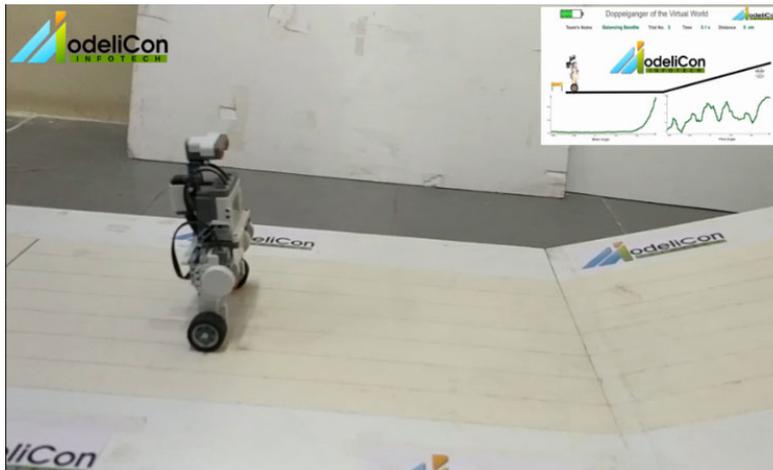
New Industrial OM Application by Modelicon in Bangalore

Model-based Control of UAVs and Walking Robots

- UAV control and simulation
- Walking 2-wheel robot
- sCO2 Loop transient analysis using ThermoSysPro



UAV
Movie demo



Walking 2-wheel Robot,

Movie demo

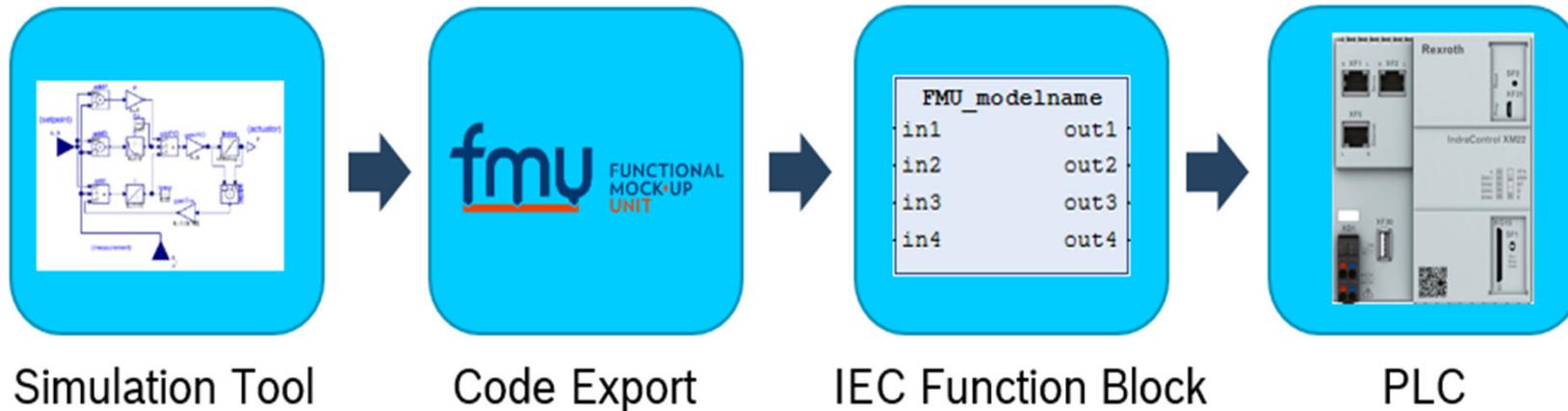


Bosch Rexroth Control Edge Designer and Testing Framework

The screenshot displays the Control Edge Designer 1.13 interface for a hydraulic valve system (EHC-0783-310). The main window is divided into several panes:

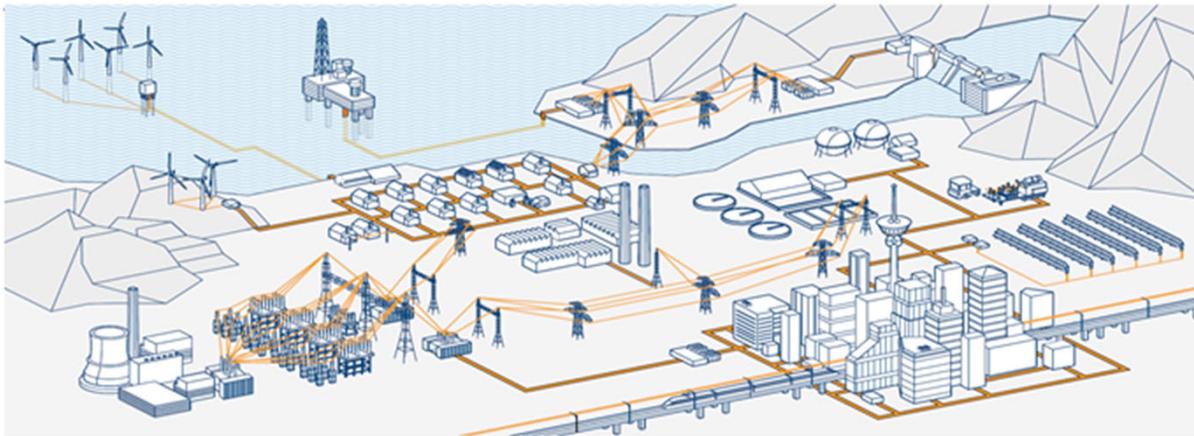
- Projektexplorer:** A tree view showing the hierarchical structure of the valve system, including the housing, spool, and various ports (A, B, P, T).
- Nutform (B.1):** A detailed view of a groove (Nutform) with parameters such as length, depth, offset, and angle. It includes a table for groove specifications.
- Flächentabelle:** A table listing surface areas for different parts of the valve, such as the spool and housing.
- Nutformansicht:** A 2D cross-sectional view of the groove with dimensions like 4.06, 8.1, 3.24, and 5.74.
- Kolbenwicklungsansicht:** A view showing the spool's profile and its interaction with the housing, including dimensions like 11.0 and 5.74.
- Nutkoordinatentabelle:** A table providing coordinates for the groove, including columns for number, angle, type, diameter, and width.
- Simulation Plot:** A graph showing pressure (p [Ventil]) versus piston displacement (Kolbenhub [mm]). The plot features several curves representing different valve ports and their pressure responses over time.

Bosch Rexroth Controller Code Generation Based on FMI



Large OpenModelica Industrial Use Case: ABB Industry Use of OpenModelica FMI 2.0 and Debugger

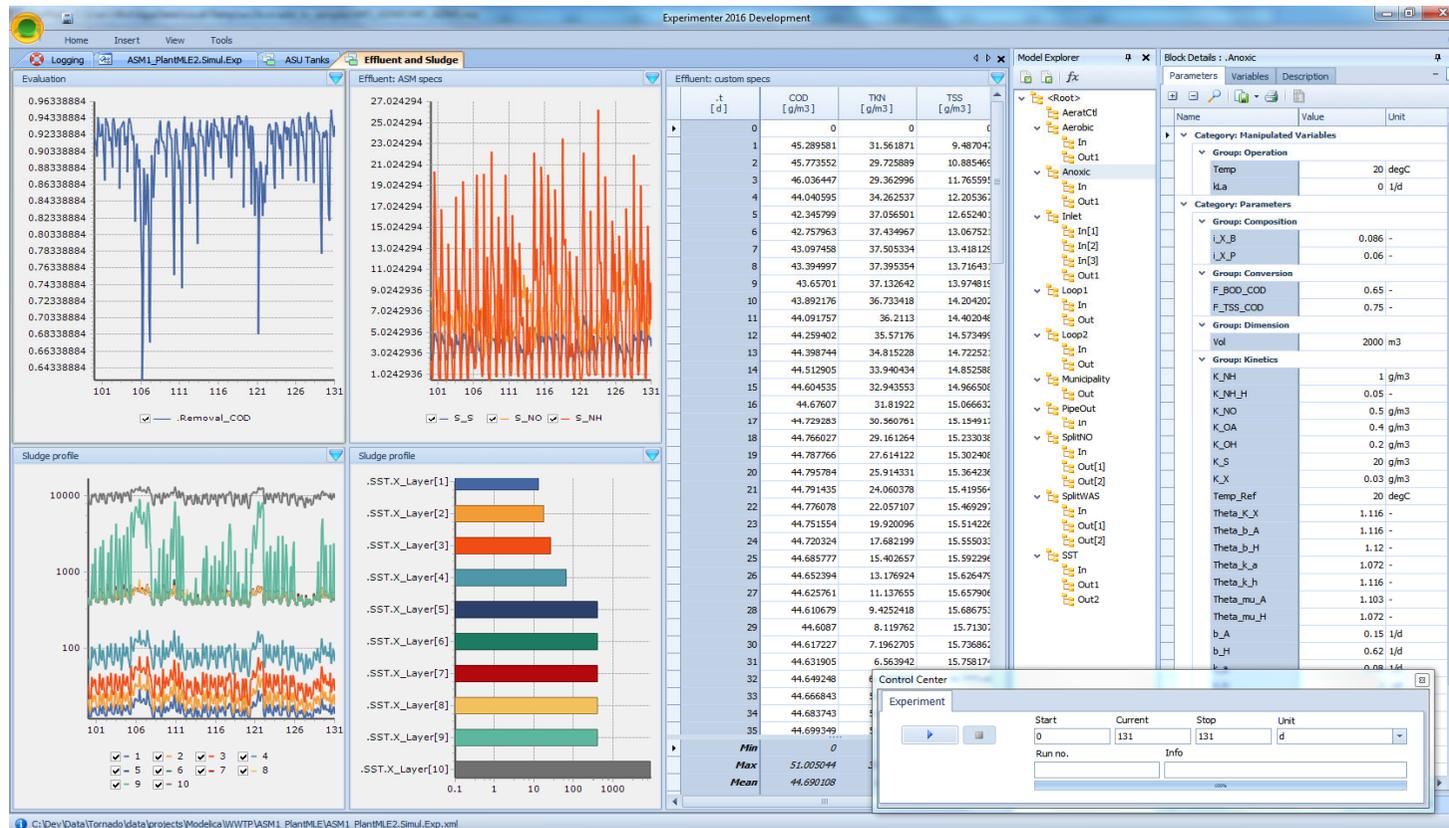
- ABB OPTIMAX® provides advanced model based control products for power generation and water utilities



- ABB: *“ABB uses several compatible Modelica tools, including OpenModelica, depending on specific application needs.”*
- ABB: *“OpenModelica provides outstanding debugging features that help to save a lot of time during model development.”*

MIKE by DHI, www.mikebydhi.com, WEST Water Quality Product

- The MIKE by DHI, www.mikebydhi.com, WEST Water Quality modeling and simulation environment includes a large part of the OpenModelica compiler using the OEM license.



The Open Source Modelica Consortium

Purpose of the Consortium

- The Open Source Modelica Consortium, created the 4th of December 2007 in Linköping, Sweden, in the following called OSMC, is a non-profit, non-governmental organization with the aim of developing and promoting the development and usage of the **OpenModelica open source implementation of the Modelica computer language** (also named Modelica modeling language) and **OpenModelica associated open-source tools and libraries**, collectively named the OpenModelica Environment, in the following referred to as OpenModelica.
- OpenModelica is **available for commercial and non-commercial usage under the conditions of the OSMC Public License**. It is the aim of OSMC, within the limitations of its available resources, to provide **support and maintenance of OpenModelica**, to support its publication on the web, and to **coordinate** contributions to OpenModelica.

Open Source Modelica Consortium

Originally Created Dec 4, 2007

7 Founding Organizational Members

- Bosch-Rexroth AG, Germany
- Equa Simulation AB, Sweden
- TLK Thermo, Germany
- VTT, Finland
- Linköping University, Sweden
- Hamburg University of Technology/TuTech, Institute of Thermo-Fluid Dynamics, Germany
- Technical University of Braunschweig, the Institut of Thermodynamik, Germany

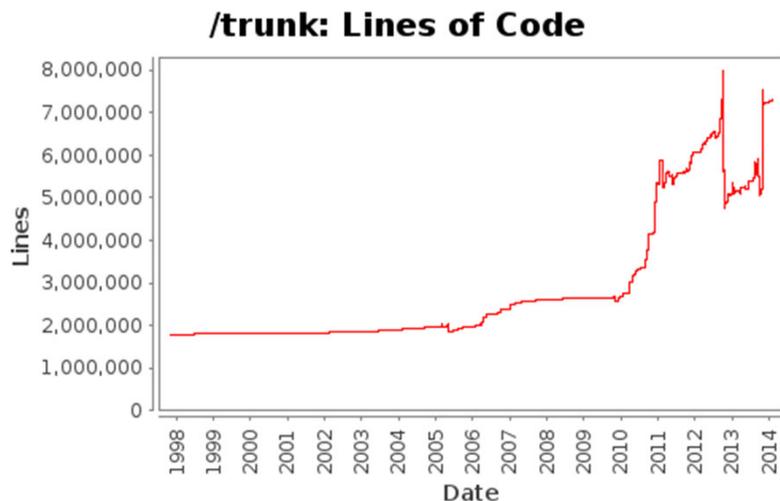
OSMC – Open Source Modelica Consortium

Founded Dec 4, 2007

Open-source community services

- **Website and Support Forum**
- **Version-controlled source base**
- **Bug database**
- **Development courses**
- **www.openmodelica.org**

Code Statistics



OpenModelica Login Create an account

HOME DOWNLOAD TOOLS & APPS USERS DEVELOPERS FORUM EVENTS RESEARCH search ...

Top information

Industrial Products
Commercial Applications using OpenModelica

OMEdit
Enhanced OpenModelica Connection Editor.

Library Coverage
Latest library coverage.

Modelica/OpenModelica Videos

Overview of Modelica..

Introduction

OPENMODELICA is an open-source Modelica-based modeling and simulation environment intended for industrial and academic usage. Its long-term development is supported by a non-profit organization – the **Open Source Modelica Consortium (OSMC)**.

The goal with the OpenModelica effort is to create a comprehensive Open Source Modelica modeling, compilation and simulation environment based on free software distributed in binary and source code form for research, teaching, and industrial usage. We invite researchers and students, or any interested developer to participate in the project and cooperate around OpenModelica, tools, and applications.

Latest news

- January 17, 2017: OpenModelica 1.11 Beta3 released
- December 20, 2016: OpenModelica 1.11 Beta2 released
- November 22, 2016: OpenModelica 1.9.7 released
- March 16, 2016: OpenModelica 1.9.6 released
- March 9, 2016: OpenModelica 1.9.4 released
- February 18, 2016: OpenModelica 1.9.4 beta2 released
- Program OpenModelica Annual Workshop 2016
- January 31, 2016: OpenModelica 1.9.4 beta1 released
- September 8, 2015: OpenModelica 1.9.3 released
- July 10, 2015: SIMS 2015 registration open

Register yourself to get information about new releases.
Participate in the OpenModelicaInterest [mailing list](#).
Help us: get the latest [source code](#) or [nightly-build](#) and report bugs.

To learn about Modelica, read a [book](#) or a [tutorial](#) about Modelica. Interactive step-by-step beginners Modelica [on-line spoken tutorials](#) Interactive [OMWebbook](#) with examples of Modelica textual modeling

OSMC 51 Organizational Members, Febr 2019

(initially 7 members, 2007)

Companies and Institutes

- ABB AB, Sweden
- Bosch Rexroth AG, Germany
- Brainheart Energy AB, Sweden
- CDAC Centre, Kerala, India
- Creative Connections, Prague
- DHI, Aarhus, Denmark
- Dynamica s.r.l., Cremona, Italy
- EDF, Paris, France
- Equa Simulation AB, Sweden
- Fraunhofer IWES, Bremerhaven
- INRIA, Rennes, France
- ISID Dentsu, Tokyo, Japan
- Maplesoft, Canada
- RTE France, Paris, France
- Saab AB, Linköping, Sweden
- SKF, Göteborg, Sweden
- TLK Thermo, Germany
- Siemens Turbo, Sweden
- Sozhou Tongyuan, China
- Talent Swarm, Spain
- VTI, Linköping, Sweden
- VTT, Finland
- Wolfram MathCore, Sweden

Universities

- Augsburg University, Germany
- FH Bielefeld, Bielefeld, Germany
- University of Bolivar, Colombia
- TU Braunschweig, Germany
- Chalmers Univ, Control, Sweden
- Chalmers Univ, Machine, Sweden
- TU Darmstadt, Germany
- TU Delft, Netherlands
- TU Dresden, Germany
- Université Laval, Canada
- Georgia Inst of Technology, USA
- Ghent University, Belgium
- Halmstad University, Sweden
- Heidelberg University, Germany
- TU Hamburg/Harburg Germany
- IIT Bombay, Mumbai, India
- KTH, Stockholm, Sweden
- Linköping University, Sweden
- Univ of Maryland, Syst Eng USA
- Univ of Maryland, CEEE, USA
- Politecnico di Milano, Italy
- Ecoles des Mines, CEP, France
- Mälardalen University, Sweden
- Univ Pisa, Italy
- RPI, Troy, USA
- Univ SouthEast Norway
- Tsinghua Univ, Beijing, China
- Vanderbilt Univ, Nashville, USA

Open Source Modelica Consortium

Individual Members

(74 individual members, 4 February 2019)

- Peter Fritzon, Adrian Pop, Martin Sjölund, Per Östlund, Peter Aronsson, Adeel Asghar, Mikael Axin, Bernhard Bachmann, Vasile Baluta, Adam Bergmark, Robert Braun, Willi Braun, David Broman, Stefan Brus, Francesco Casella, Filippo Donida, Atiyah Elsheikh, Jens Frenkel, Mahder Gebremedhin, Pavel Grozman, Daniel Hedberg, Michael Hanke, Zoheb Hossain, Alf Isaksson, Kim Jansson, Daniel Kanth, Tommi Karhela, Juha Kortelainen, Abhinn Kothari, Petter Krus, Rahul Jain, Alexey Lebedev, Oliver Lenord, Ariel Liebman, Rickard Lindberg, Håkan Lundvall, Abhi Raj Metkar, Eric Meyers, Tuomas Miettinen, Afshin Moghadam, Kenneth Nealy, Maroun Nemer, Hannu Niemistö, Peter Nordin, Kristoffer Norling, Lennart Ochel, Arunkumar Palanisamy, Karl Pettersson, Pavol Privitzer, Reino Ruusu, Per Sahlin, Wladimir Schamai, Gerhard Schmitz, Sunil Shah, Alachew Shitahun, Magnus Sjöstrand, Anton Sodja, Ingo Staack, Kristian Stavåker, Sonia Tariq, Mohsen Torabzadeh-Tari, Parham Vasaiely, Niklas Worschech, Robert Wotzlaw, Björn Zackrisson, Azam Zia

Open Source Modelica Consortium – OSMC

Board of Directors 2018

- **Rüdiger Franke**, OSMC Chairman; Manager, ABB AG, Germany
- **Oliver Lenord**, OSMC Vice Chairman; Manager, Bosch, Germany
- **Peter Fritzson**, OSMC Director; Prof, Linköping Univ, Sweden
- **Francesco Casella**, OSMC Vice Director; Prof, Politec. di Milano, Italy
- **Juha Kortelainen**, Manager, VTT, Finland
- **Gerhard Schmitz**, Prof, Univ. Hamburg, Germany
- **Kilian Link**, Manager, Siemens, Germany
- **Niklas Worschech**, Techn Specialist, Bosch-Rexroth, Germany.
- **Daniel Bouskela**, Manager, EDF, France
- **Bernhard Bachmann**, Prof, FH Bielefeld, Germany
- **Jan Brugård**, CEO, Wolfram MathCore AB, Sweden/USA
- **Adrian Pop**, adjoined to the Board, Tech coordinator, OSMC

OSMC Board – 3 Meetings Jan 1 2018 – Dec 31 2018

Meeting dates

- 180619
- 180926
- 181212

Board Work

- Planning and prioritizing the OSMC work
- OSMC Business models
- Admitting new members
- Planning the workshop
- Budget
- etc.

Some Supporting Research Projects 2018

- PARADOM, German national project including ABB, Bosch-Rexroth, Siemens AG, TU Dresden, FHBielefeld
- ITEA3 project OPENCPS, started Dec 2015, finished 2019 (Open Cyber-Physical System Model-Driven Certified Development) Sweden, France, Finland, Hungary
- Swedish project RTISIM, started Dec 2015, finished 2019
- ITEA3 project EMPHYSIS, Sweden joined Dec 2017
- H2020 project PreFlexMS, 2015-2018

Special Thanks

- The developers who worked very hard during 2018 and modelers who tested and gave important feedback
- The OpenModelica consortium organizational members for support including ABB, Bosch-Rexroth, Wolfram-MathCore, RTE, Siemens Turbo Machinery, EDF, etc...
- Master students and PhD students who made important contributions.

Conclusions and Summary 2018/Jan 2019

- Dec 21, 2018. OpenModelica **1.13.0 release**
OMSimulator 2.0 with Enhanced FMI simulation support, FMI composition, SSP, etc. OM with enhanced OMEdit, FMI export, OMSysIdent, OMJulia, basic OMMatlab, Encryption support, etc.
- January, 2019. OpenModelica **1.13.1** and **1.13.2** bug fix releases.
- 2019. Good prospects for the future – towards a standard **high performance, quality, compliant** open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.
Expected OpenModelica 2.0 release

Questions?

www.openmodelica.org