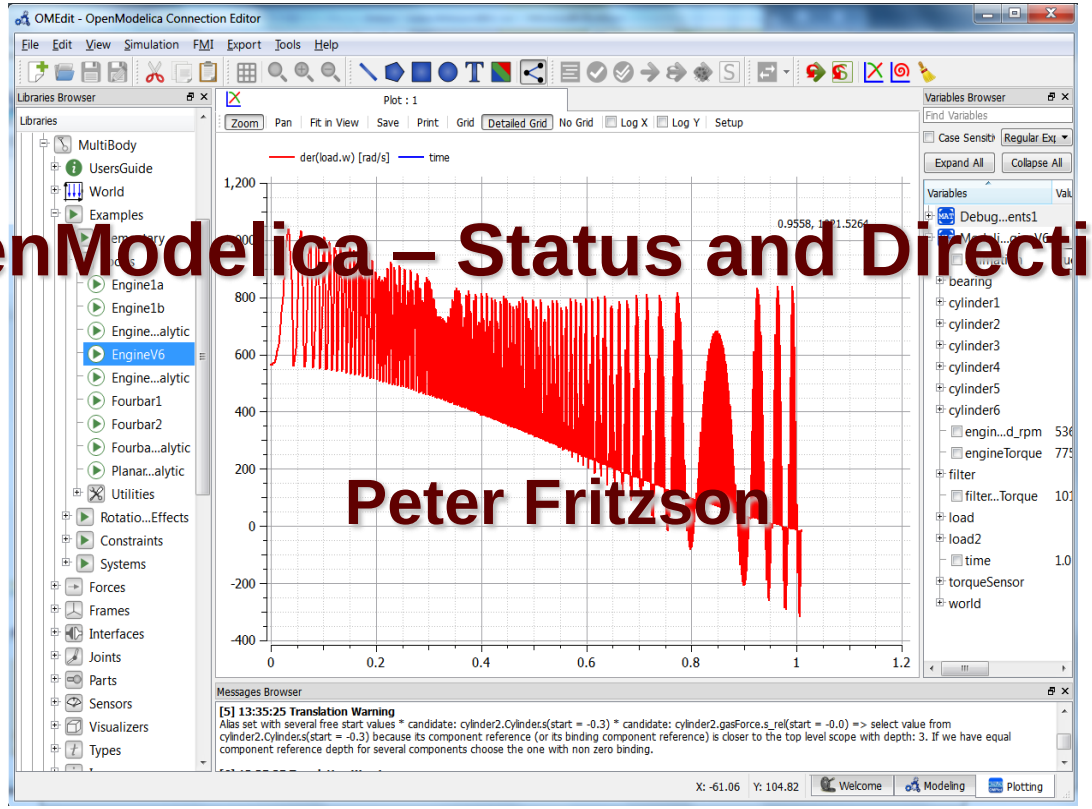
9th Annual OpenModelica Workshop Feb 6, 2017



OpenModelica – Status and Directions

Peter Fritzson

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 2016 and up to Feb 6, 2017

- OpenModelica **1.9.6 final release** (March 16, 2016)
  - 30% improved simulation speed. FMI 2.0 co-simulation. Improved coverage
  - Many OMEdit enhancements, including undo/redo, indentation-preserving
  - Initial support for clocked synchronous library; homotopy operator
- OpenModelica **1.9.7 final release** (Nov 22, 2016)
  - Further **improved GUI interactive** speed for library browsing, factor 2-3, of **OMEdit** graphical connection editor.
  - Further improved white-space and indentation preserving; Array fix for FMU generation.
- OpenModelica **1.11.0 final release** (February 6, 2017)
  - Dramatically improved compilation **speed** and **performance**, esp. large models
  - Stabilized **Windows 64-bit** support; Updated OMDev involving msys2
  - **3D animation** visualization of MSL MultiBody simulations & for real-time FMUs
  - Faster and **more robust** OMEdit **GUI**.
  - A **DAEMode** solver mode for using the sparse IDA solver
  - Clocked/Synchronous: Supports about **100%** of library Modelica_synchronous
  - **OMWebbook**, an on-line web version of OMNotebook

Higher Quality and more Robust Releases

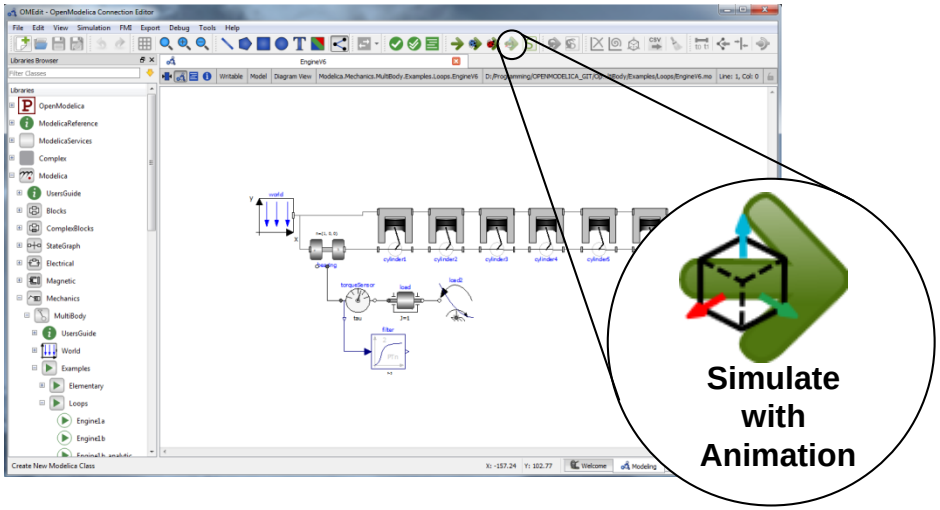
- More testing of releases, including nightly testing of more libraries
- Enabled by two additional test servers
- Releases from special stable release branch
- The OpenModelica 1.11.0 release is the first release produced in this way

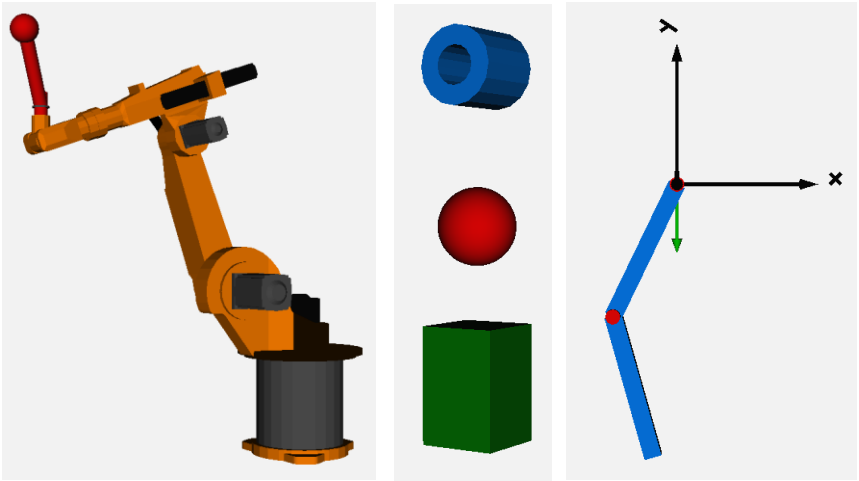
OM 1.11.0 Much faster for Large Models

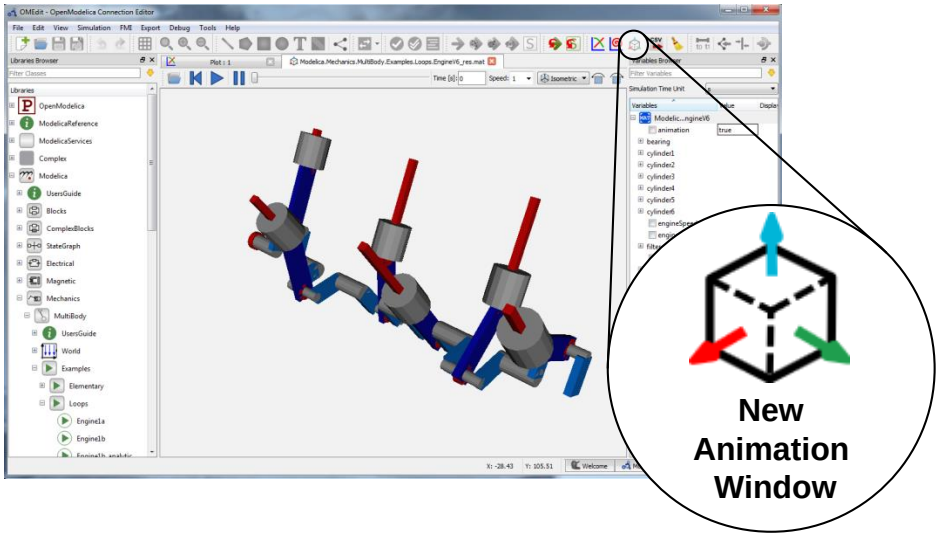
- European Electrical Grid model – 500 000 equations.
- In Nov 2015, 2 days to compile
- June 2016, 13 minutes to compile, 90 seconds to simulate
- OpenModelica 1.11.0 even faster

In OM 1.11.0 – New OMEdit 3D Visualization of Multi-Body Systems (talk later today)

- Built-in feature of OMEdit to animate MSL-Multi-Body shapes
- Visualization of simulation results
- Animation of geometric primitives and CAD-Files



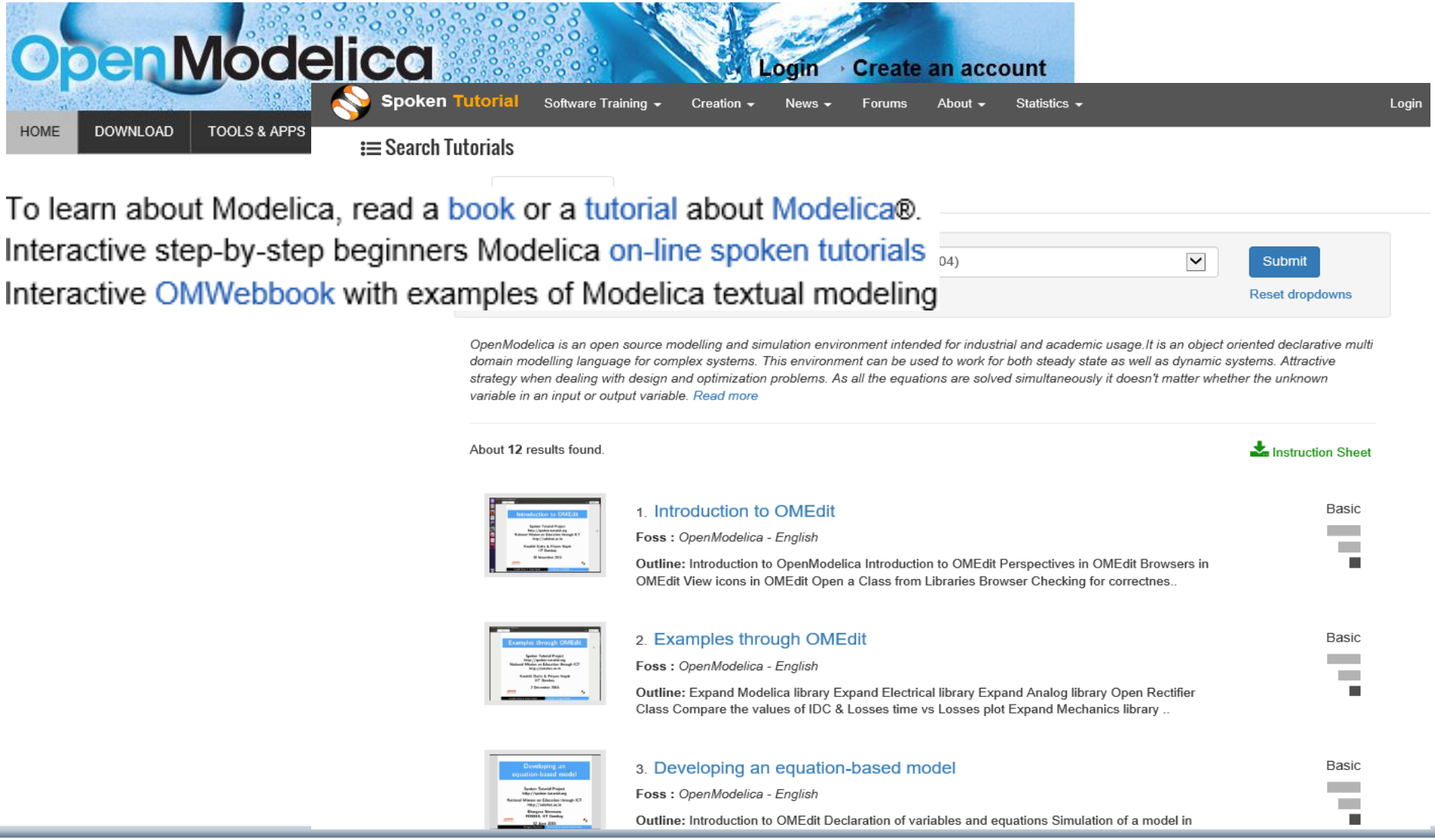




Embedded System Support in OpenModelica (talk later today)

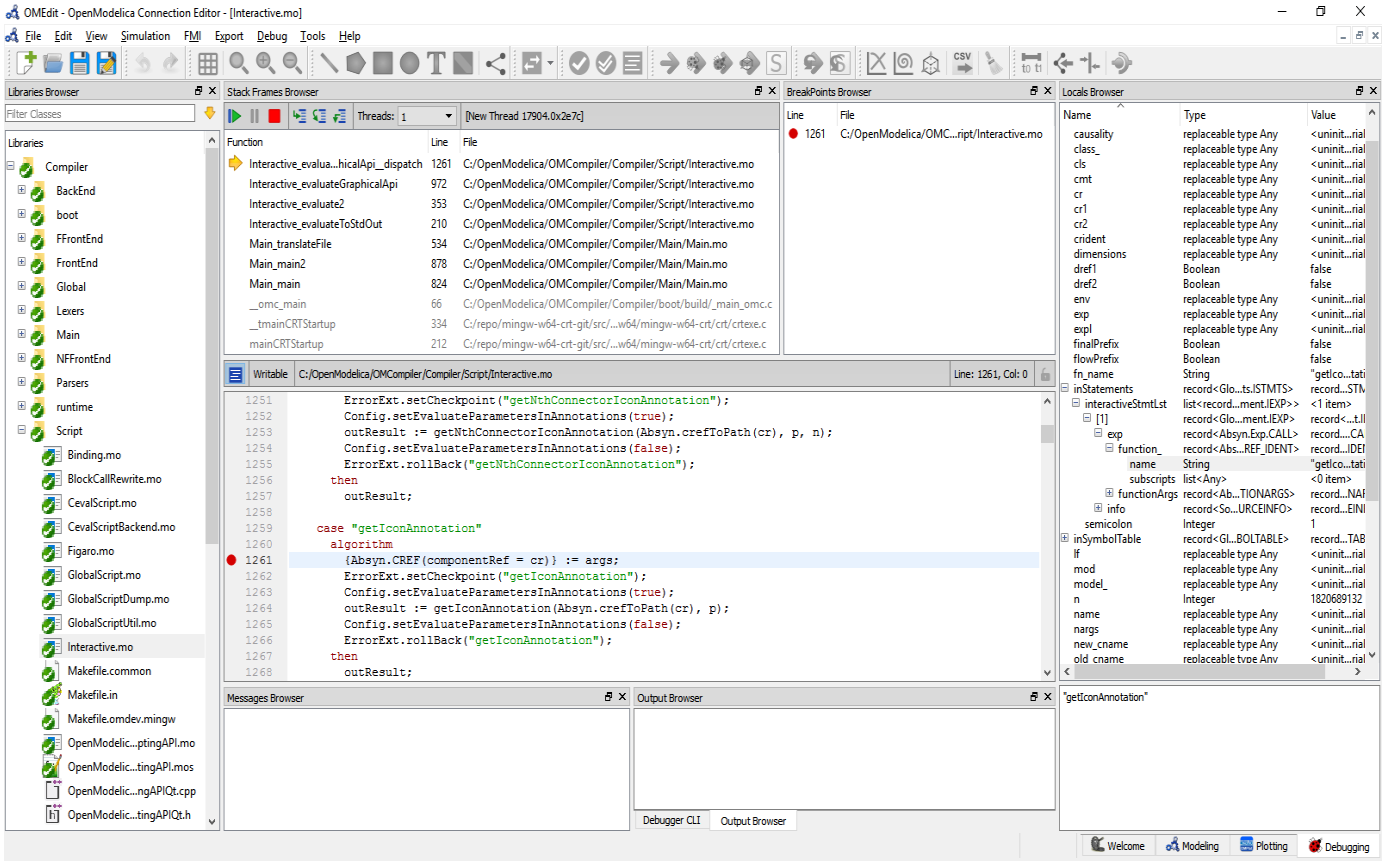
- Code generation of real-time Controllers from Modelica models for small foot-print platforms

Interactive OpenModelica Step-by-step Spoken-Tutorial using OMEdit. Link from www.openmodelica.org



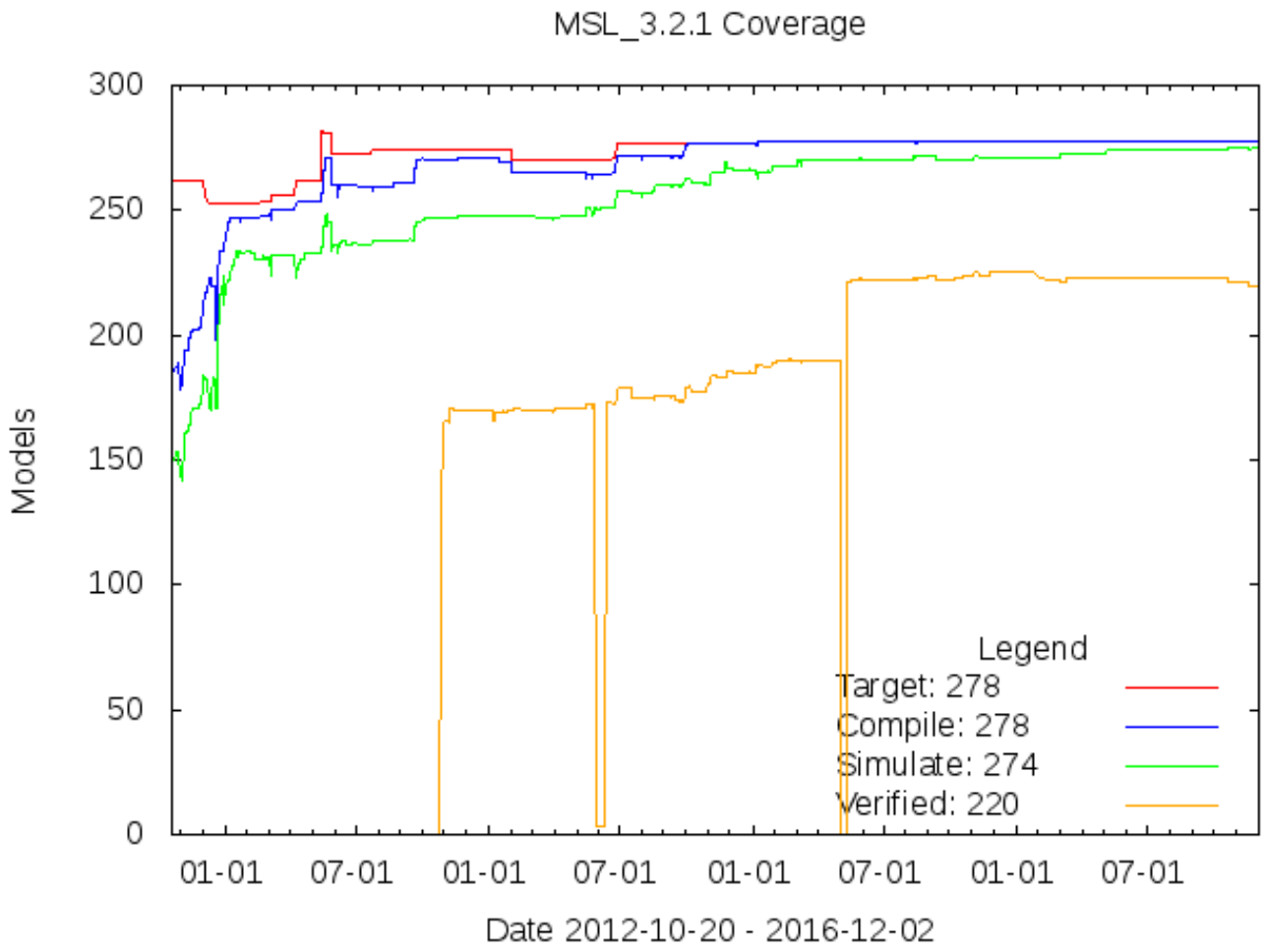
OpenModelica with Integrated Environment for MetaModelica 3.0

- A number of language improvements in MetaModelica 3.0
- Fast separate compilation, development, and debugging in OMEdit
- Integrated algorithm and graphical modeling



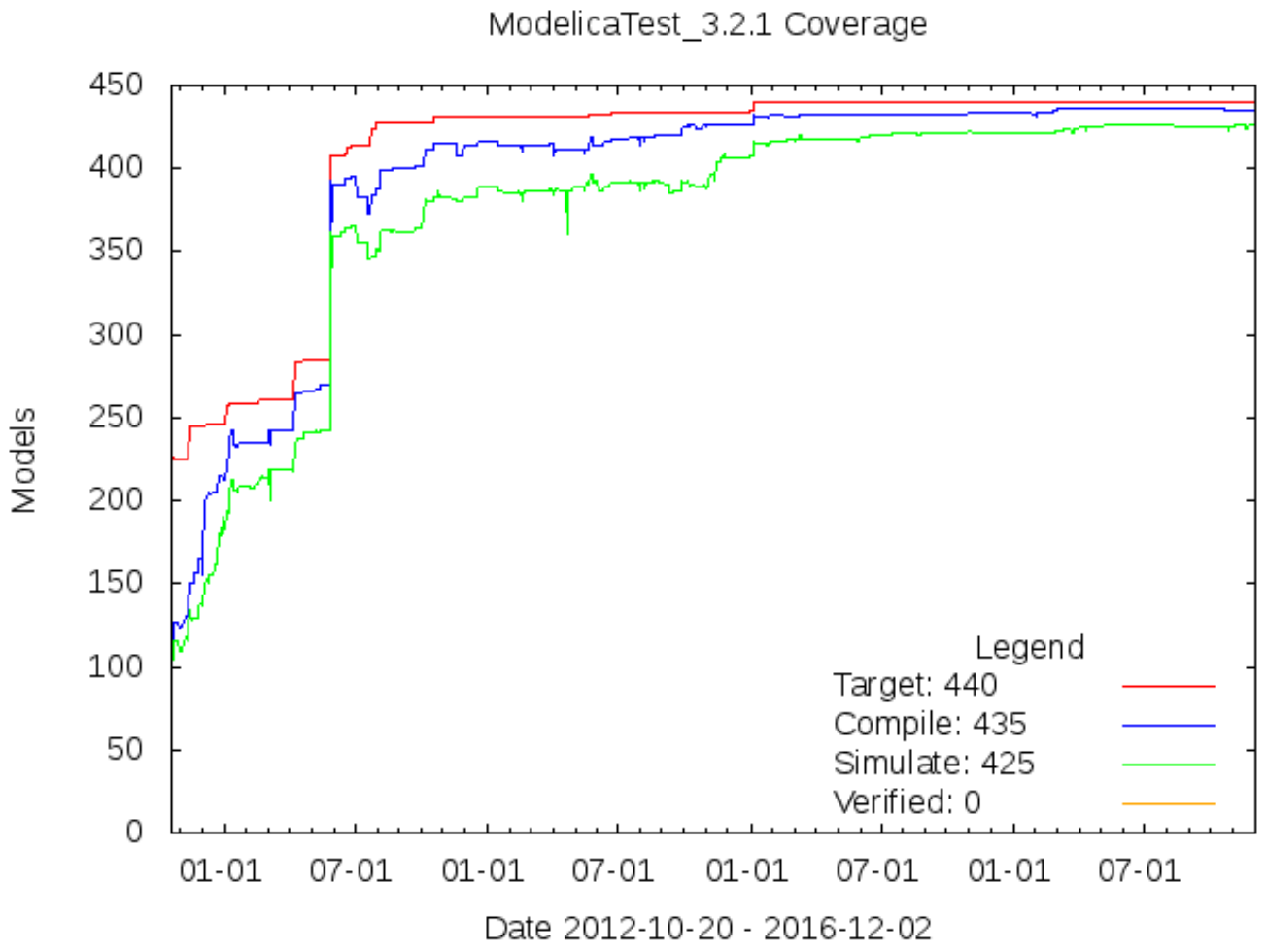
Improved MSL 3.2.1 Library Coverage

100% compilation, 98.6% simulation



Improved ModelicaTest 3.2.1 Library Coverage

99% compilation, 97% simulation



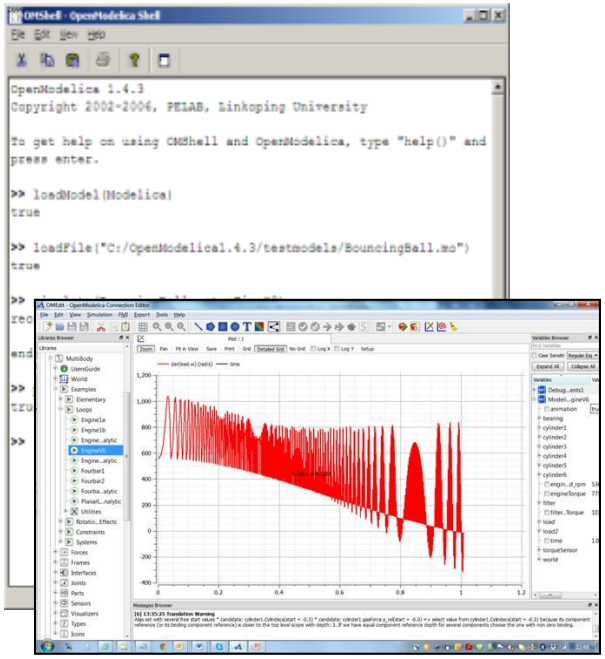
OpenModelica – Outlook for 2017

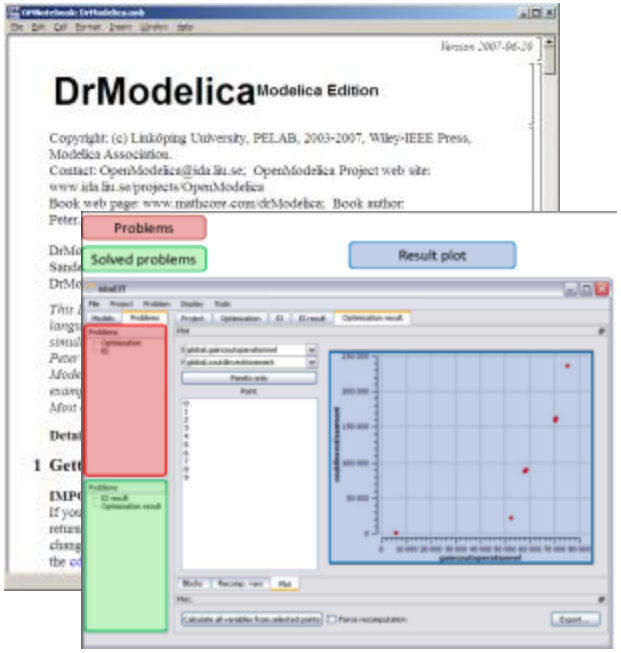
- **Main goal:** OpenModelica 2.0.0 release with significantly improved **coverage** for **libraries**, and significantly improved compiler and simulation **performance**, tool **robustness** and **quality**, including support for large-scale models
- Spring 2017. Release of OM 1.12.0 with **GUI** support for **replaceable** in libraries
- Whole 2017. Development of more **Industrial Use Cases**
- Spring 2017. Finalizing **new frontend** modules with significantly improved flattening for enhanced coverage and performance
- Fall 2017. Full **graphical** editing support for Modelica 3.3 **state machine** features
- Further Enhanced Equation model debugging support
- Further enhanced **embedded system** code generation and development support
- **Encryption** support by OpenModelica for use of commercial libraries with OM
- Enhanced **FMI** support, both co-simulation and model exchange, import/export
- Enhanced MetaModelica 3.0 documentation & environment with improved ease-of-use; consolidate; investigate Julia integration starting with API

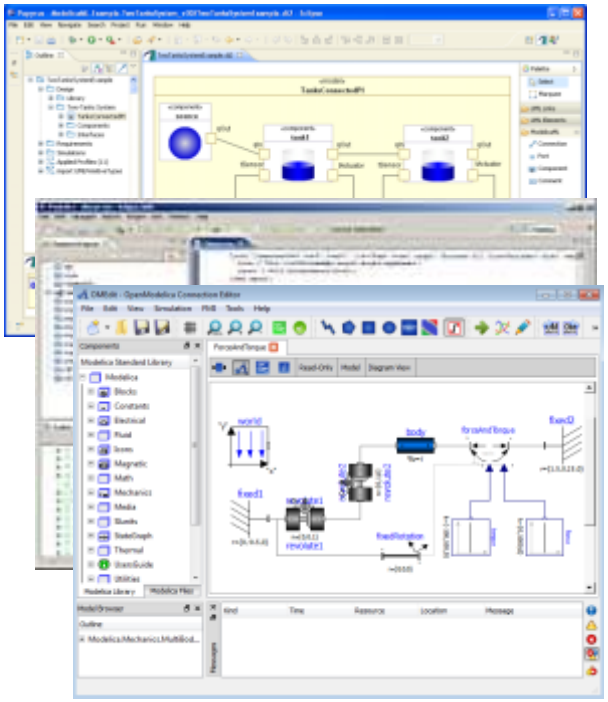
The OpenModelica Open Source Environment
www.openmodelica.org

- Advanced Interactive Modelica compiler (OMC)
  - Supports most of the Modelica Language
  - **Modelica** and **Python scripting**
- 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





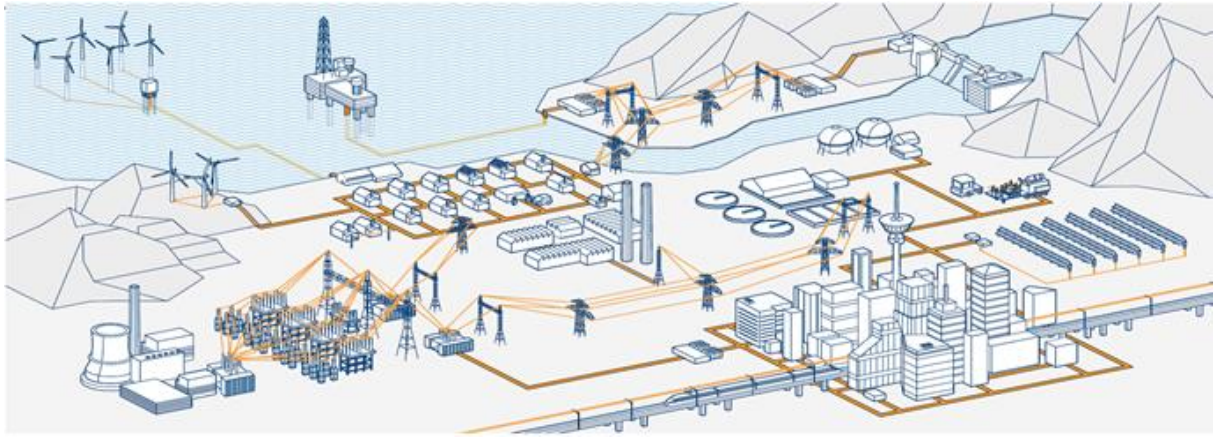


Current Main Industrial OpenModelica Usage (not including research usage)

- 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, inhouse 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

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.*"

ABB OM Application – Large-scale Virtual Power Plant
Manage vast numbers of renewable power units

ABB OPTIMAX PowerFit

- Real-time optimizing control of large-scale virtual power plant for system integration
- **Software including OpenModelica** now used in managing more than 2500 renewable plants, total up to 1.5 GW

High scalability supporting growth

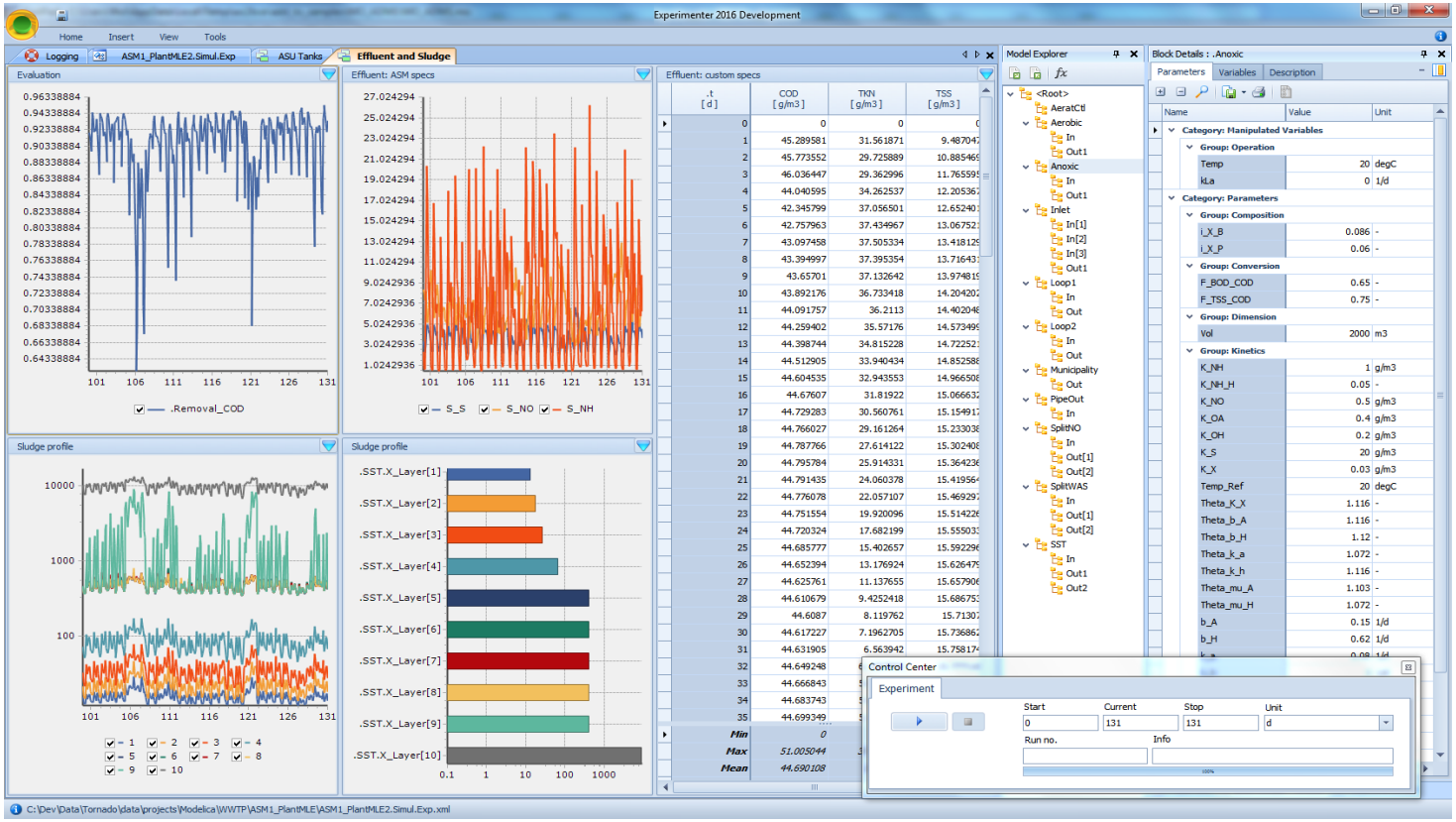
- 2012: initial delivery (for 50 plants)
- 2013: SW extension (500 plants)
- 2014: HW+SW extension (> 2000)
- 2015: HW+SW extension,
  incl. OpenModelica generating optimizing controller code in FMI 2.0 form

Manage 7.5% - 10% of German Power

- 2015, Aug: OpenModelica Exports FMUs for real-time optimizing control (seconds) of about **5.000 MW (7.5%) of power in Germany**

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

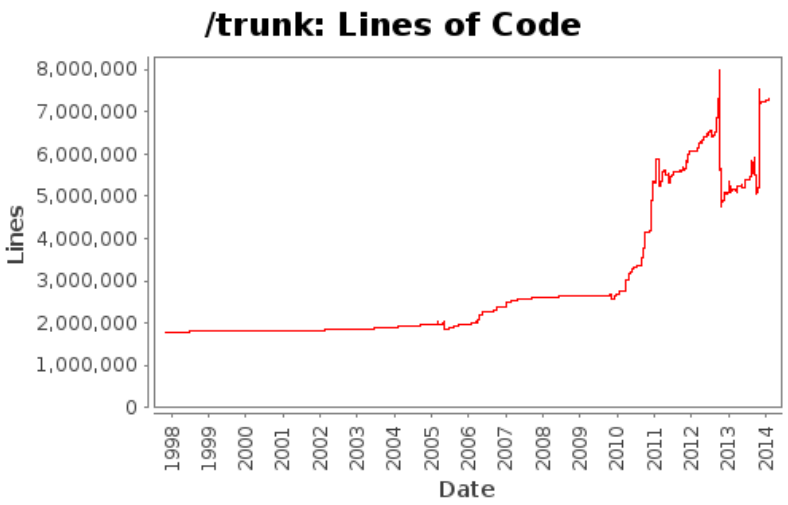
OSMC – Open Source Modelica Consortium

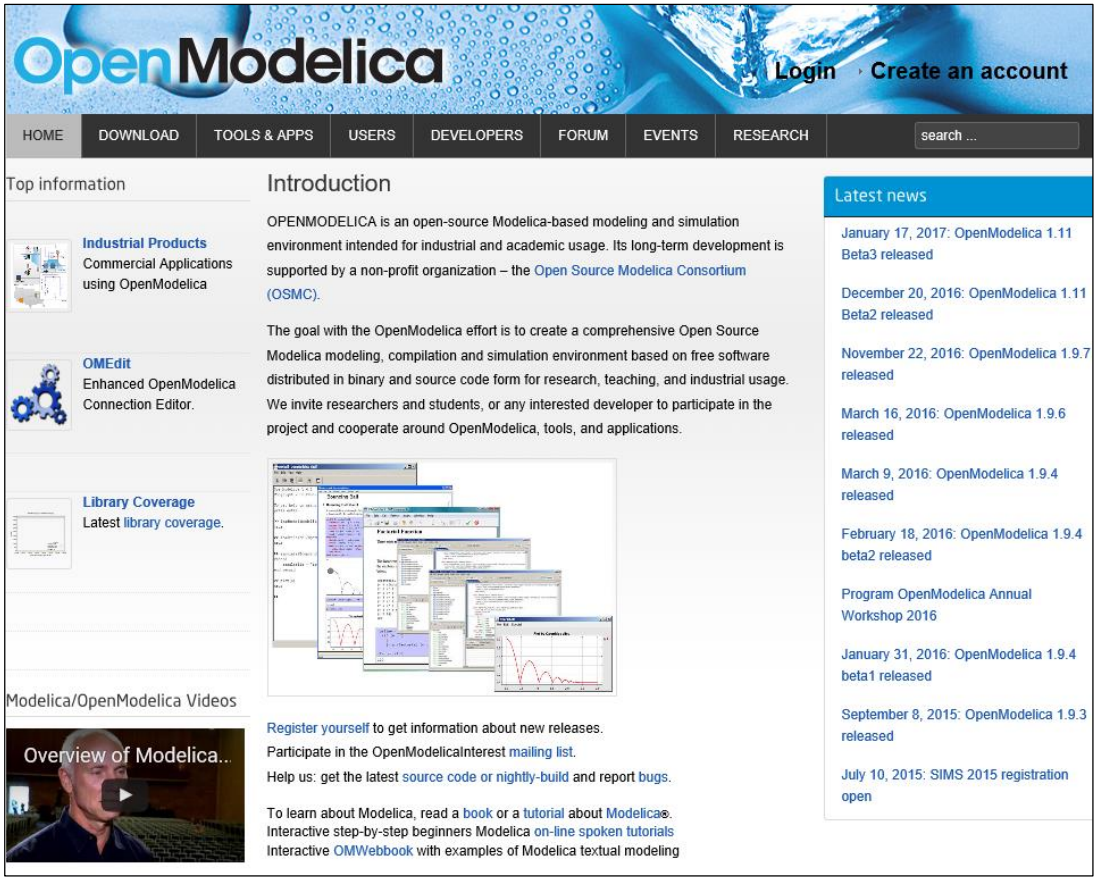
Founded Dec 4, 2007

Open-source community services

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

Code Statistics





OSMC 46 Organizational Members, Dec 2016
(initially 7 members, 2007)

Companies and Institutes (23 members)

- ABB AB, Sweden, Germany, India
- Bosch Rexroth AG, Germany
- Brainheart Energy AB, Sweden
- Siemens Turbo, 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
- IFPEN, Paris, France
- ISID Dentsu, Tokyo, Japan
- Maplesoft, Canada
- RTE France, Paris, France
- Saab AB, Linköping, Sweden
- Scilab Enterprises, France
- SKF, Göteborg, Sweden
- TLK Thermo, Germany
- Sozhou Tongyuan, China
- VTI, Linköping, Sweden
- VTT, Finland
- Wolfram MathCore, Sweden

Universities (23 members)

- FH Bielefeld, Bielefeld, Germany
- TU Braunschweig, Germany
- University of Calabria, Italy
- Univ California, Berkeley, USA
- Chalmers Univ Techn, Sweden
- TU Dresden, Germany
- Université Laval, Canada
- Georgia Institute of Technology, USA
- Ghent University, Belgium
- Halmstad University, Sweden
- Heidelberg University, Germany
- Linköping University, Sweden
- TU Hamburg/Harburg Germany
- IIT Bombay, Mumbai, India
- KTH, Stockholm, 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
- StellenBosch Univ, South Africa
- Telemark Univ College, Norway

Open Source Modelica Consortium Individual Members

(70 individual members, 6 February 2017)

- Peter Fritzson, 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, 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 2016

- **Rüdiger Franke**, OSMC Chairman; Manager, ABB AG, Germany
- **Jan Brugård**, OSMC Vice Chairman; CEO, Wolfram MathCore AB
- **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 (and Sweden)
- **Niklas Worschech**, Techn Specialist, Bosch-Rexroth, Germany.
- **Daniel Bouskela**, Manager, EDF, France
- **Bernhard Bachmann**, Prof, FH Bielefeld, Germany
- Oliver Lenord, adjoined to the Board, Manager, Bosch, Germany
- Adrian Pop, adjoined to the Board, Tech coordinator, OSMC

OSMC Board – 4 Meetings Jan 1 2016 – Dec 31 2016

Meeting dates

- 160317
- 160601
- 160908
- 161208

Board Work

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

Some Supporting Research Projects 2016

- ITEA2 MODRIO Project
- STREAM, small national Swedish project
- EU project PyModSimA – collaboration with DLR
- PARADOM, German national project including ABB, Bosch-Rexroth, Siemens AG,TU Dresden, FHBielefeld
- New ITEA3 project OPENCPS, started Dec 2015
  (Open Cyber-Physical System Model-Driven Certified Development)
  Sweden, France, Finland, Hungary
- New Swedish project RTISIM, started Dec 2015
- H2020 project PreFlexMS, 2015-2018

Special Thanks

- The developers who worked very hard during 2016 and modelers who tested and gave important feedback
- The OpenModelica consortium organizational members for support including ABB, Bosch-Rexroth, Wolfram-MathCore, Siemens Turbo Machinery, EDF, etc...
- Master students and PhD students who made important contributions.

Conclusions and Summary 2016/Jan 2017

- March 16, 2016. OpenModelica **1.9.6 release**. Faster simulation, undo/redo, better coverage.
- Nov 22, 2016. OpenModelica **1.9.7 release**. Faster GUI. Improved FMI.
- Feb 6, 2017, 2017. OpenModelica **1.11.0 release**
  Much faster performance for large models. Faster OMEdit. Stable 64 bit on Windows, 3D animation in Omedit, More robust OMEdit, etc.
- 2017. Good prospects for the future – towards a standard high quality compliant open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.

Questions?

www.openmodelica.org