5th Annual OpenModelica Workshop Feb 4, 2013

Workshop Opening

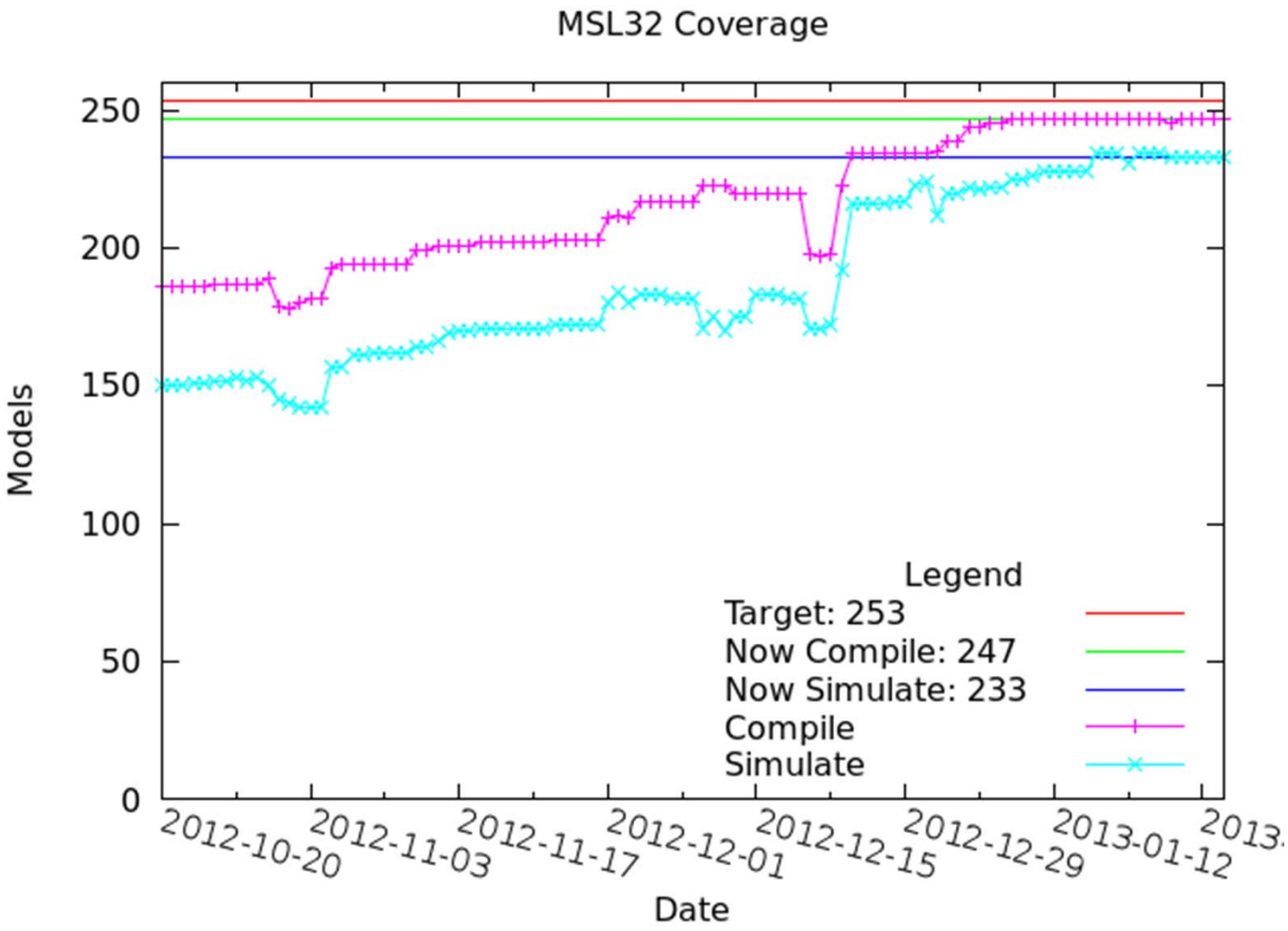
OpenModelica – Status and Directions

Peter Fritzson

To All Participants!

Very Welcome to this Fifth Annual OpenModelica Workshop!

Important Goal Achieved During 2012
MSL 3.2.1 Coverage > 90%, including most of Fluid



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

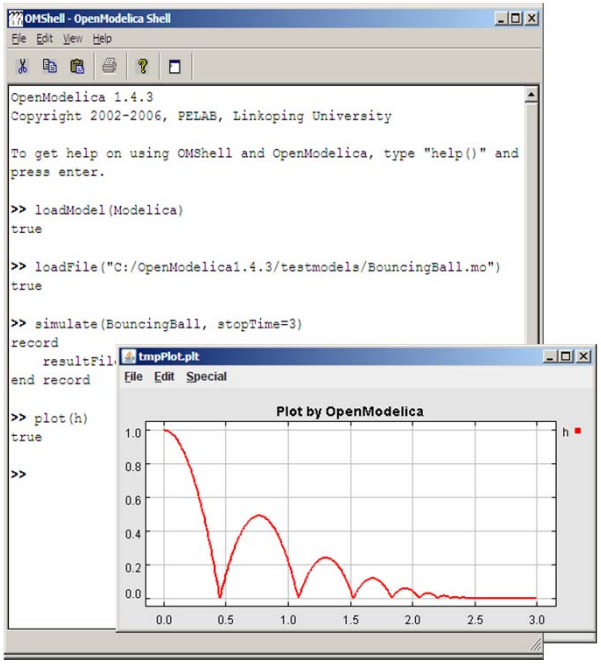
Updated OpenModelica Web Page

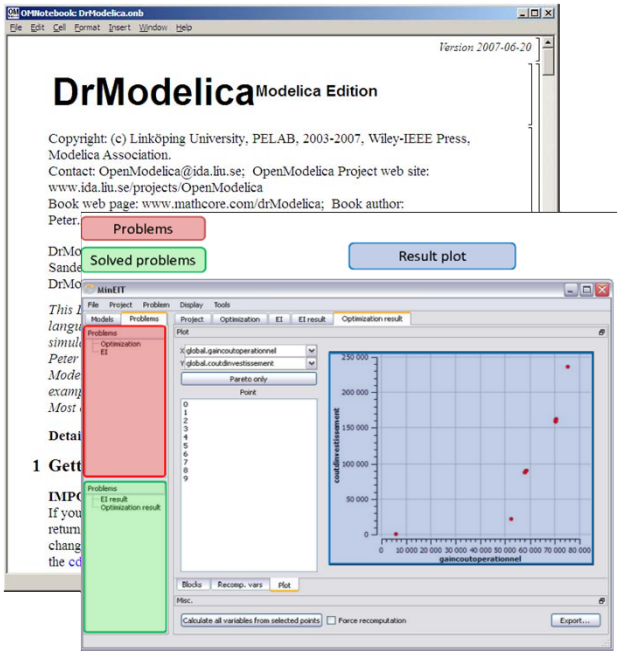
The OpenModelica Open Source Enviroment

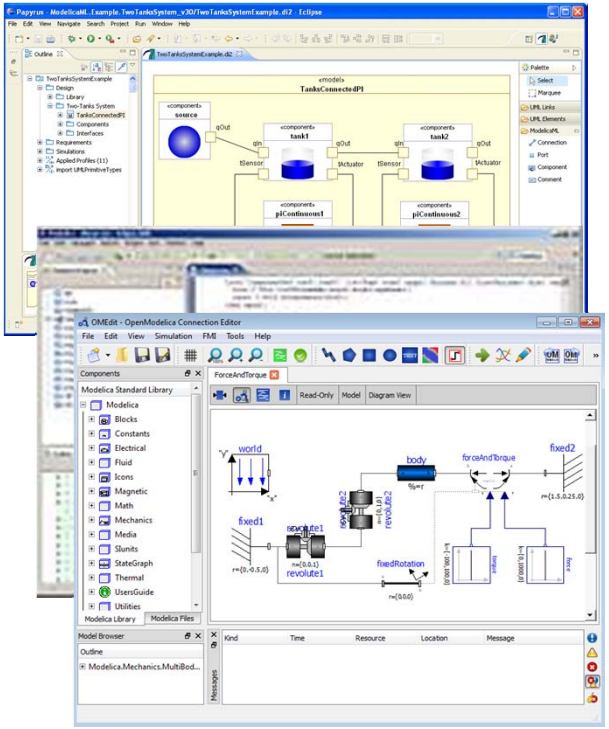
www.openmodelica.org

- 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
- **OMOptim** optimization tool
- **ModelicaML** UML Profile
- **MetaModelica** extension
- **ParModelica** extension







Main Events 2012 and January 2013

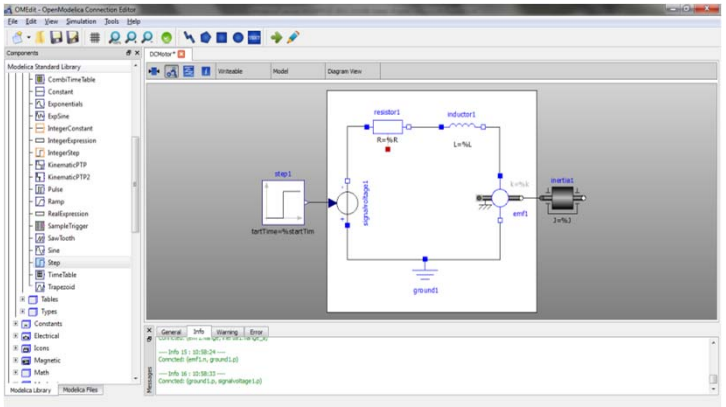
- OSMC expanded from 38 to 45 organizational members
- OpenModelica **1.8.1 release** (April 2012)
  - Operator Overloading support
  - Dramatically improved flattening speed for some models
  - Improved simulation run-time
  - ModelicaML with Modelica library import (MSL) and value-bindings
- OpenModelica **1.9.0 beta1 release** (August 2012)
  - MSL simulation improved, from 36 to 74 example models
  - Improved simulation of other libraries, e.g. ThermoSysPro, PlanarMechanics, etc.
  - Improved algorithms for tearing, matching, dynamic state selection, index reduction
  - Full version of OMPython, updated ModelicaML for requirements verification
- OpenModelica **1.9.0 beta3/4 release** (January 2013)
  - MSL simulation improved, from 74 to 233 example models (**92**% of MSL 3.2.1)
  - **Breakthrough**: Flattening of whole **Fluid** library, simulation of 58% of Fluid examples
  - Improved simulation of other libraries, e.g. ThermoSysPro, PlanarMechanics, etc.
  - Improved algorithms for tearing, matching, dynamic state selection, index reduction
  - Updated version of OMPython supporting new PySimulator release

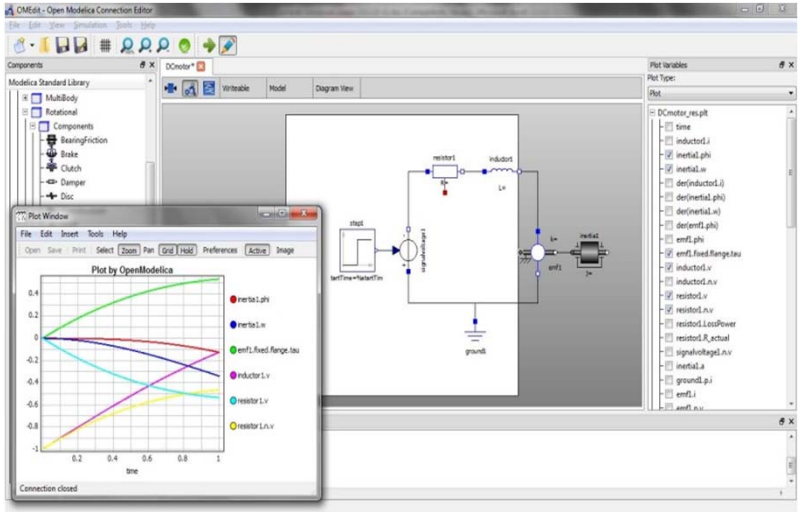
OpenModelica – Outlook for 2013

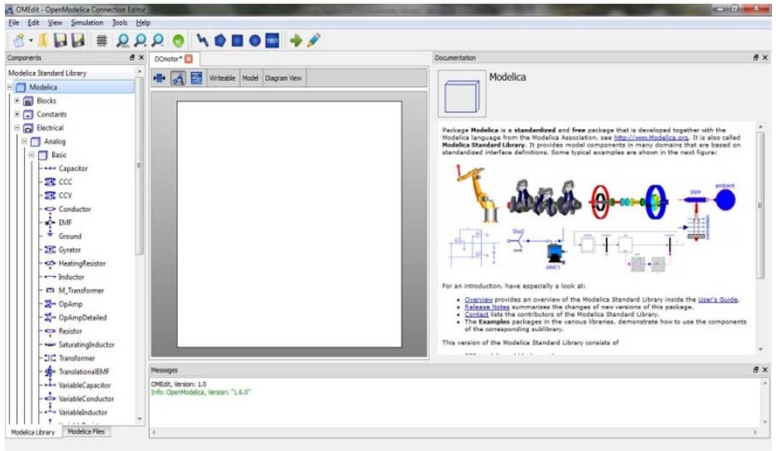
- Whole 2013. Continued high priority on better coverage for the Modelica standard libraries, increase from 92% to 100% coverage
- Late spring 2013. Support for larger models with new fast compiler frontend
- Spring 2013 All of Fluid library simulating
- Whole 2013. Improved simulation efficiency.
- May-June 2013. Integrated Modelica debugger.
- Sept 2013. Shifting to bootstrapped OpenModelica compiler for development.
- Fall 2013. Support for Modelica 3.3 clock-based synchronous and state machine features
- Whole 2013. Further improved Parallel Modelica simulation, OpenMP, and ParModelica for GPU simulation prototypes

Further Improved OpenModelica Connection Editor OMEdit

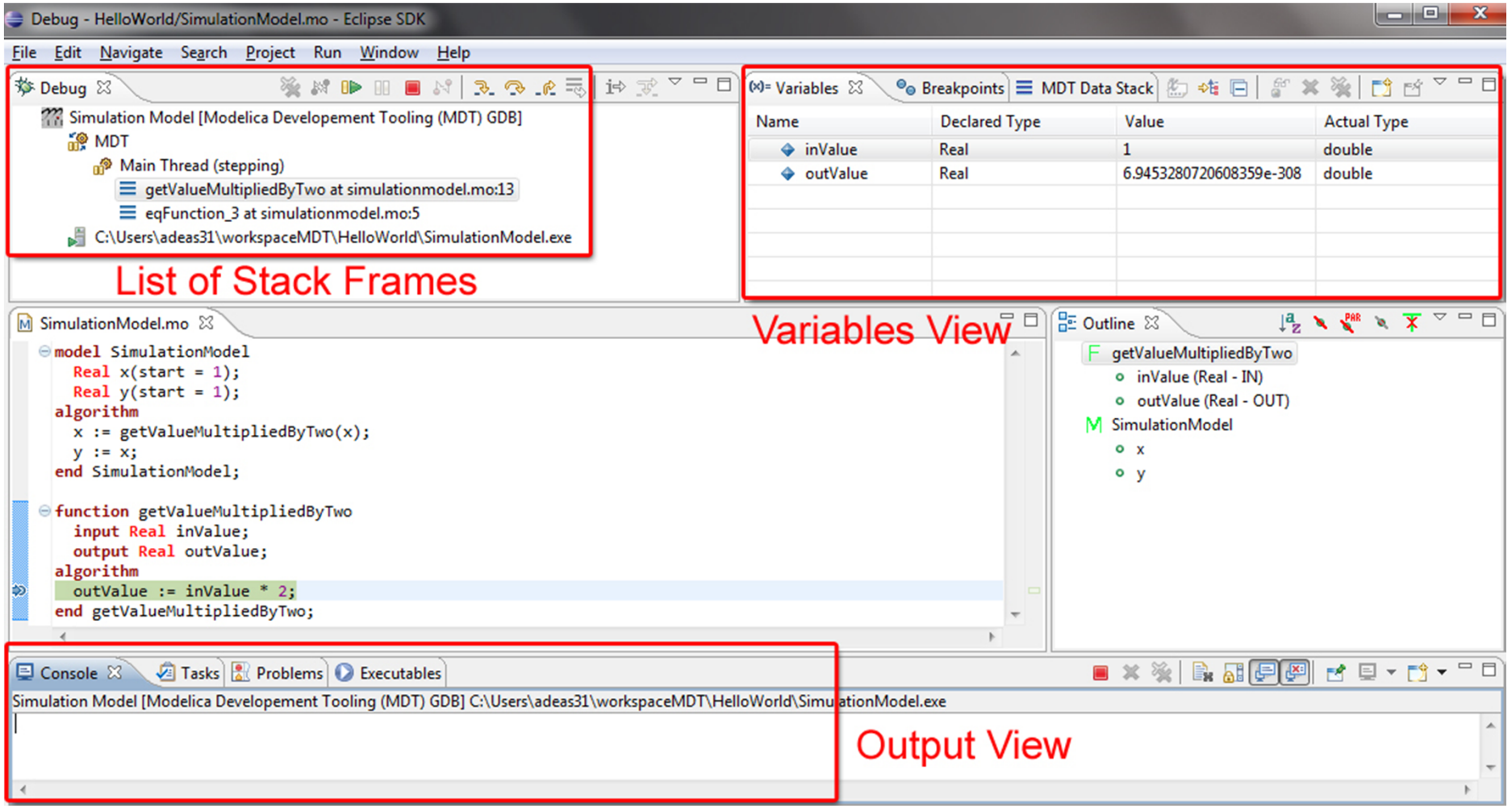
- Supports MSL 3.2.1
- Easy to use
- Stable
- Implemented in C++ Qt library
- **New version end of Feb 2013**





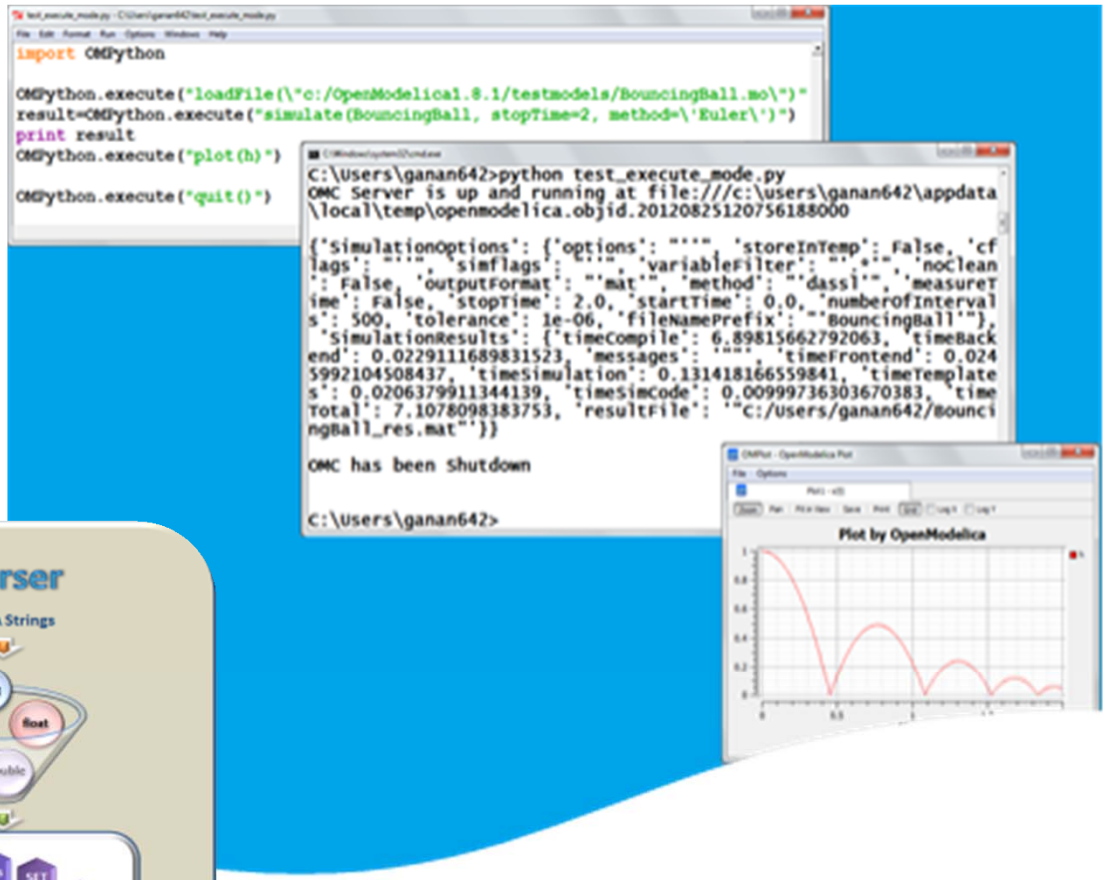


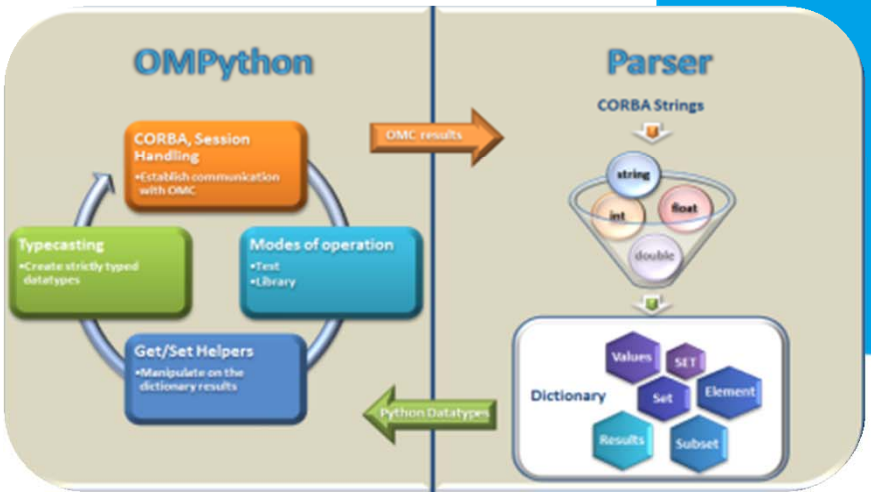
New Efficient OpenModelica MDT Run-time Debugger now also partly for Simulation Models



OMPython – Python Scripting with OpenModelica

- Interpretation of Modelica commands and expressions
- Interactive Session handling
- Library / Tool
- Optimized Parser results
- Helper functions
- Deployable, Extensible and Distributable



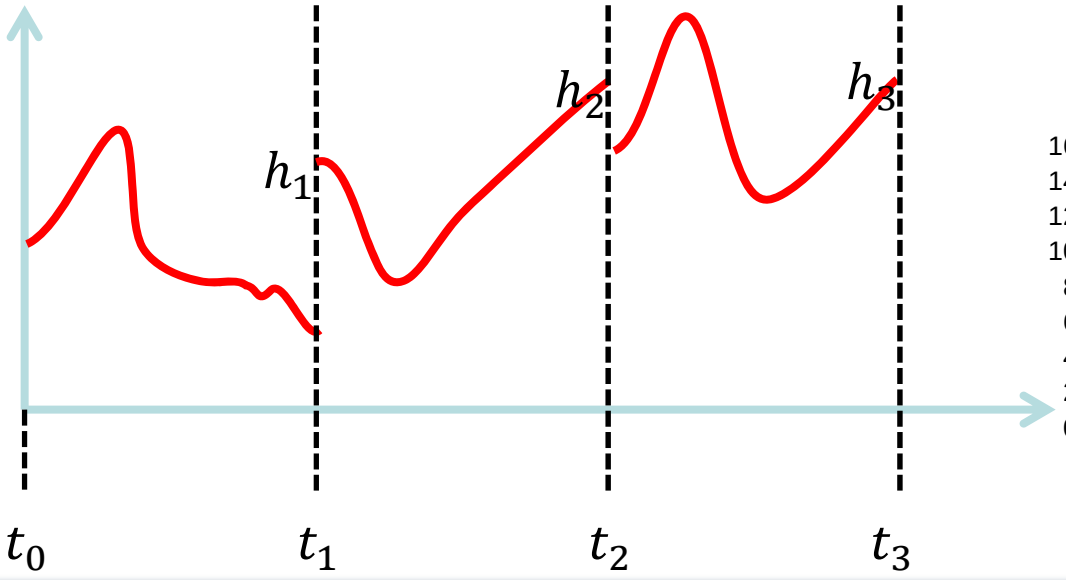


Prototype Parallel Multiple-Shooting and Collocation Dynamic Trajectory Optimization

- Minimize a goal function subject to model equation constraints, useful e.g. for NMPC
- Multiple Shooting/Collocation
  - Solve sub-problem in each sub-interval

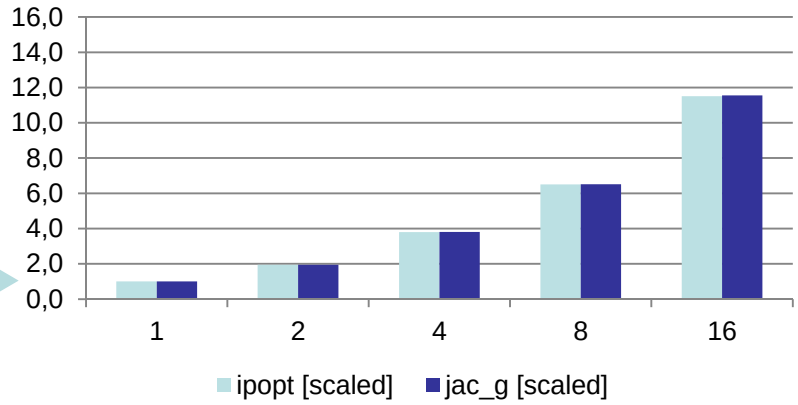
Paper in Modelica'2012 Conf.
Prototype, not yet in OpenModelica release.
Planned release 2013.

$$x_i(t_{i+1}) = h_i + \int_{t_i}^{t_{i+1}} f(x_i(t), u(t), t)\, dt \approx F(t_i, t_{i+1}, h_i, u_i), \qquad x_i(t_i) = h_i$$



Example speedup, 16 cores:

MULTIPLE_COLLOCATION



Prototypes of Parallel Execution with OpenModelica

- ParModelica – Parallel Algoritmic Modelica Code Execution on GPU
  - Speedup factor 300 of matrix multiplication on NVIDIA Fermi GPU
- OPENMP support in OpenModelica, parallelization of partitioned models
  - Speedup factor 4 of trivial model on 4-core machine

OpenModelica Compiler Bootstrapping

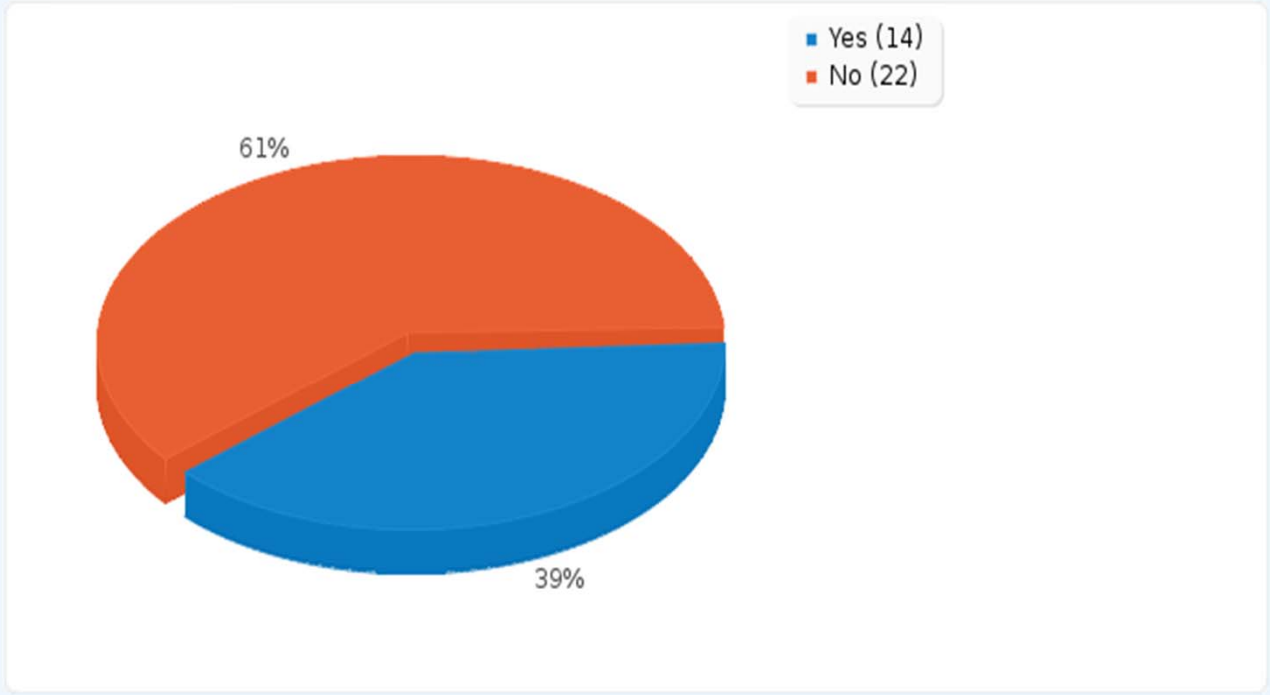
- Bootstrapping = OMC Compiler Compiles itself
- Advantages
  - **Faster** compilation for the developers
  - Complete Modelica language for **easier programming**
  - Better error messages and maintainability
  - Makes a faster Modelica **debugger** possible
  - Makes **performance** analysis possible
  - some **Modelica 4** like featureSupports s
- Status
  - Dec 2010, OMC first compiled itself
  - During 2011-now, used for development with the new debugger
  - Dec 2012. Automatic memory reclamation operational

Questionnaire to OSMC Org Members

- 23 Questions
- 36 out of 45 organizational members answered
- Slightly less than half OEM users of parts of OM compiler
- Slightly more than half end-users (usage for applications)
- 5 organizations only OEM users of compiler frontend (4 current, 1 near-future)
- 80% Research & Development usage of OpenModelica

Q: OEM usage (part of product of OpenModelica Compiler frontend

Field summary for OEMF		
OEM usage (part of product) of OpenModelica compiler frontend		
Answer	**Count**	**Percentage**
Yes (Y)	14	38.89%
No (N)	22	61.11%
No answer	0	0.00%

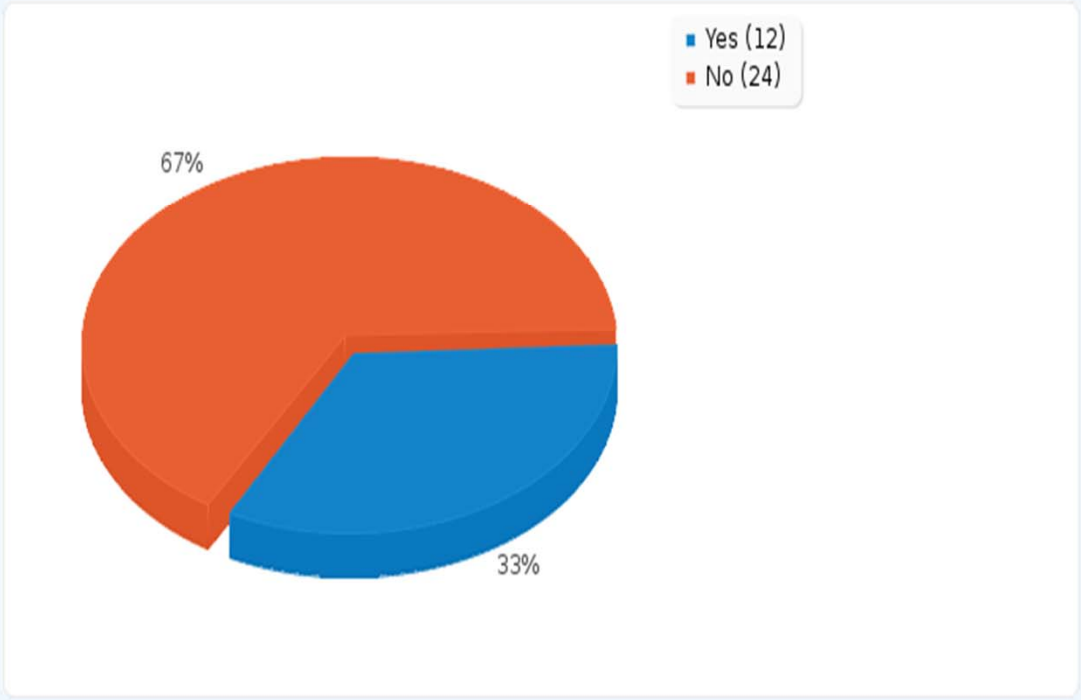


Q: OEM Usage (part of product) of OpenModelica compiler backend/simulator

Field summary for OEMB

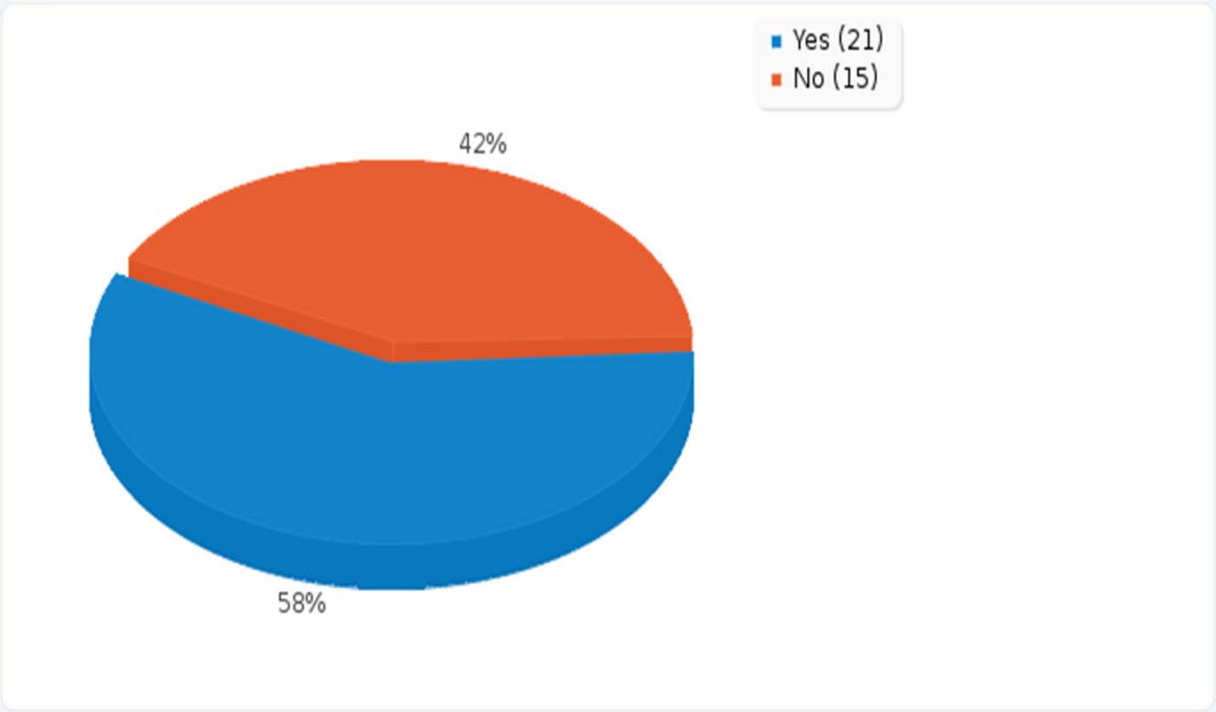
OEM usage (part of product) of OpenModelica compiler backend/simulator

Answer	Count	Percentage
Yes (Y)	12	33.33%
No (N)	24	66.67%
No answer	0	0.00%



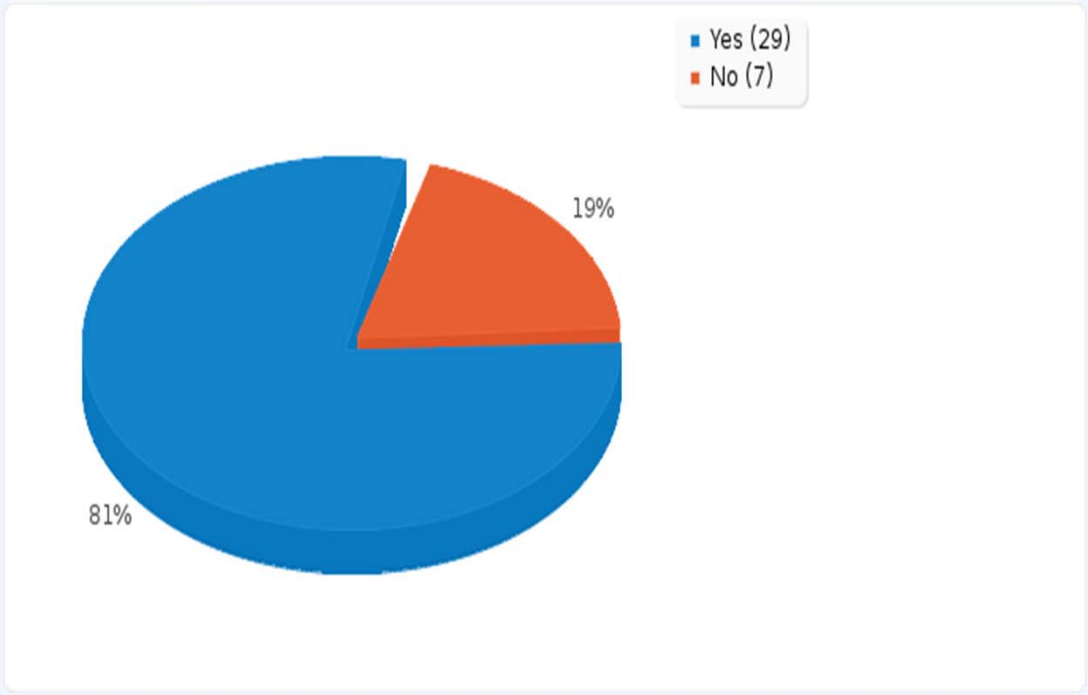
Q: End User Application Usage of OpenModelica

Field summary for EUSER		
End-user application usage of OpenModelica		
Answer	**Count**	**Percentage**
Yes (Y)	21	58.33%
No (N)	15	41.67%
No answer	0	0.00%



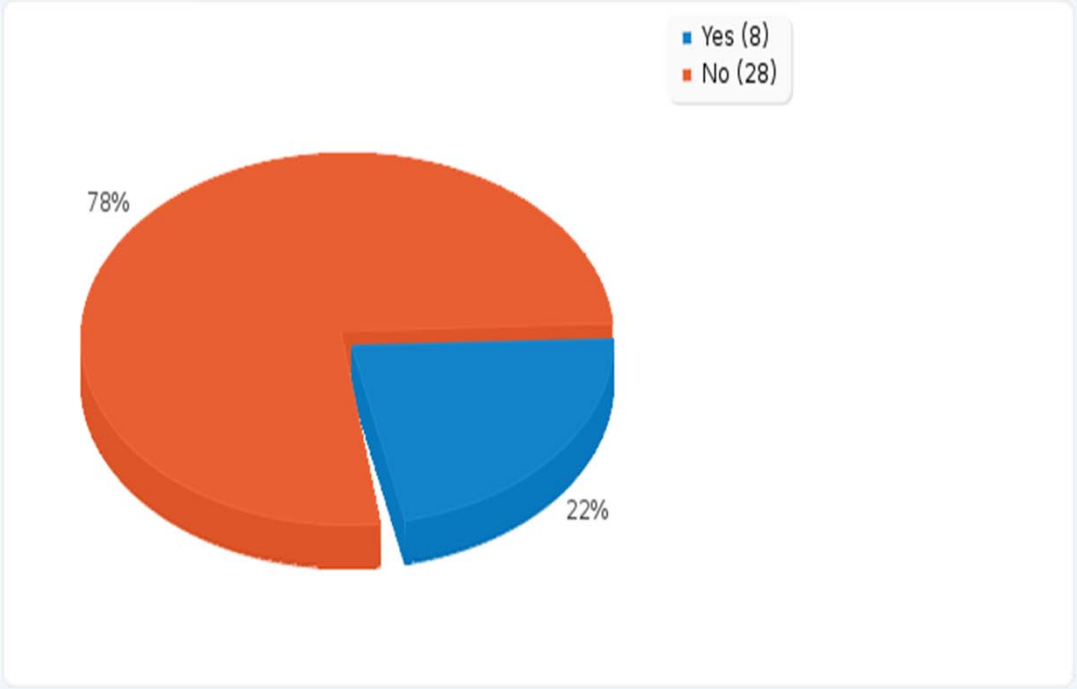
Q: Research and Development Usage of OpenModelica

Field summary for R_D		
Research and development usage of OpenModelica		
Answer	Count	Percentage
Yes (Y)	29	80.56%
No (N)	7	19.44%
No answer	0	0.00%



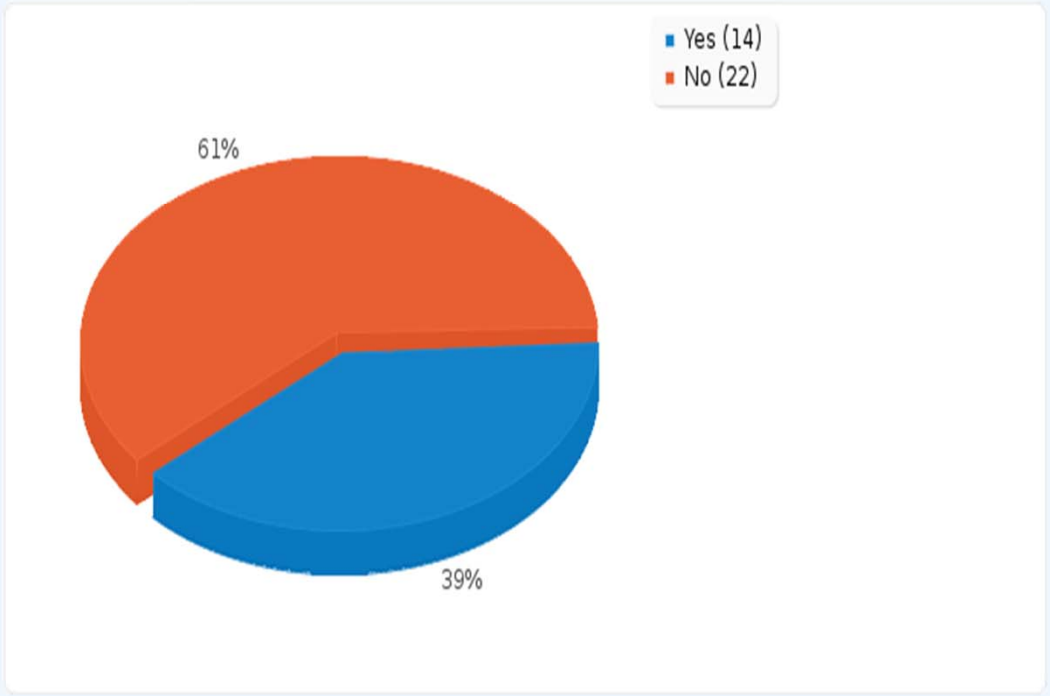
Q: Systems Engineering, requirement handling (e.g. ModelicaML) usage/development

Field summary for SysEng		
Systems Engineering, requirement handling (e.g. ModelicaML) usage/development		
Answer	Count	Percentage
Yes (Y)	8	22.22%
No (N)	28	77.78%
No answer	0	0.00%



Q: OpenModelica FMI Usage and/or Development

Field summary for FMI		
OpenModelica FMI usage and/or development		
Answer	Count	Percentage
Yes (Y)	14	38.89%
No (N)	22	61.11%
No answer	0	0.00%

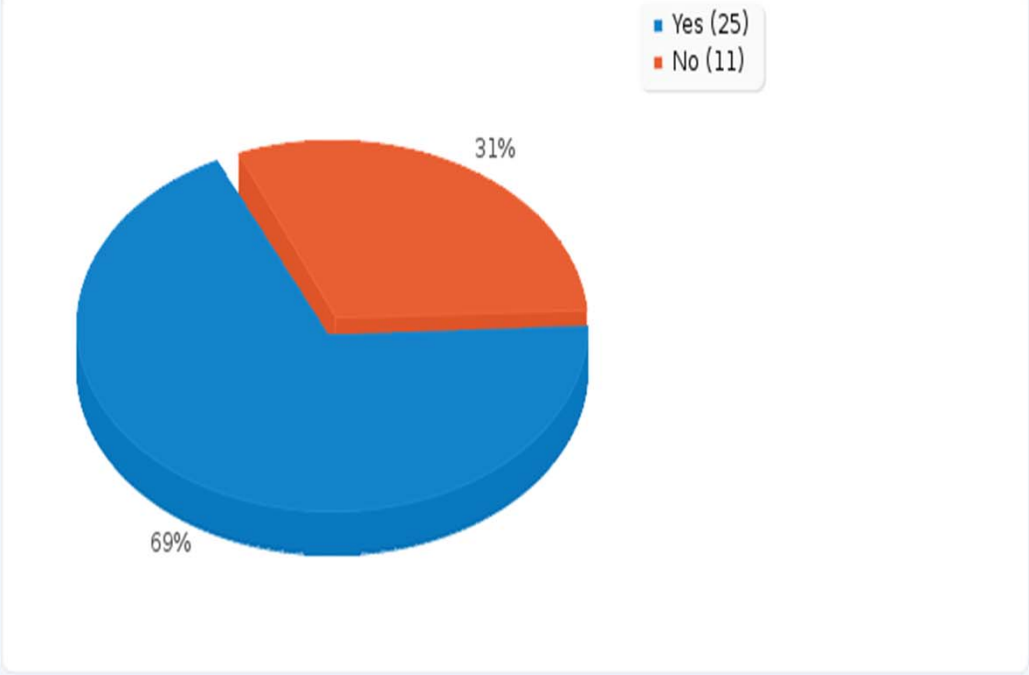


Q: Need for High Performance OpenModelica Tool (large models, fast simulation)

Field summary for HighPerf

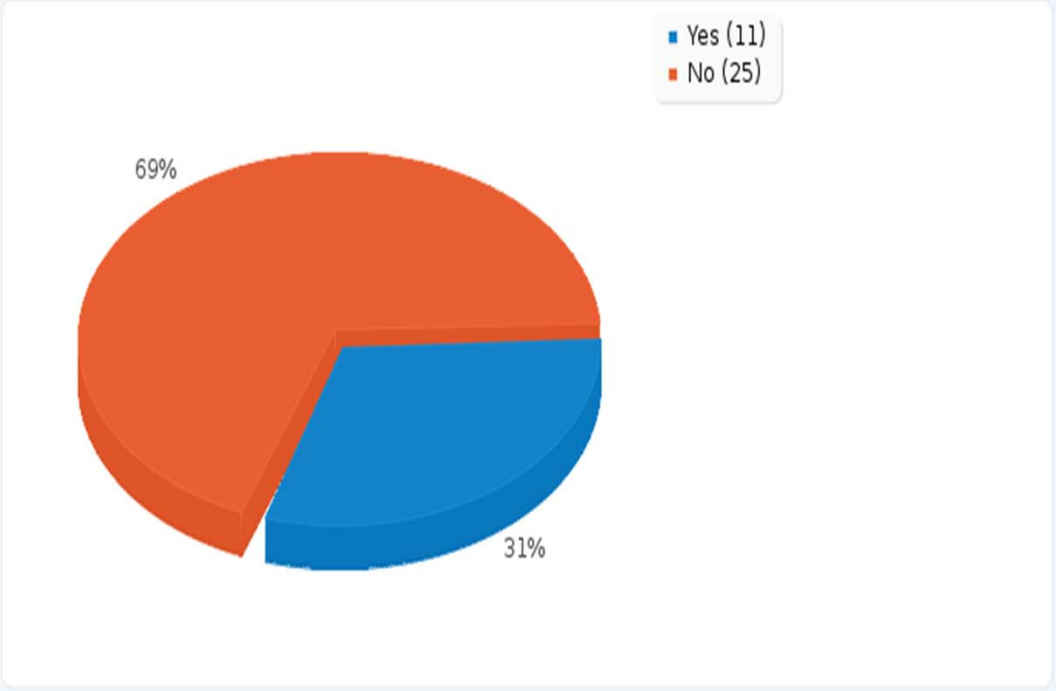
Need for high performance OpenModelica tool (large models, fast simulation)

Answer	Count	Percentage
Yes (Y)	25	69.44%
No (N)	11	30.56%
No answer	0	0.00%



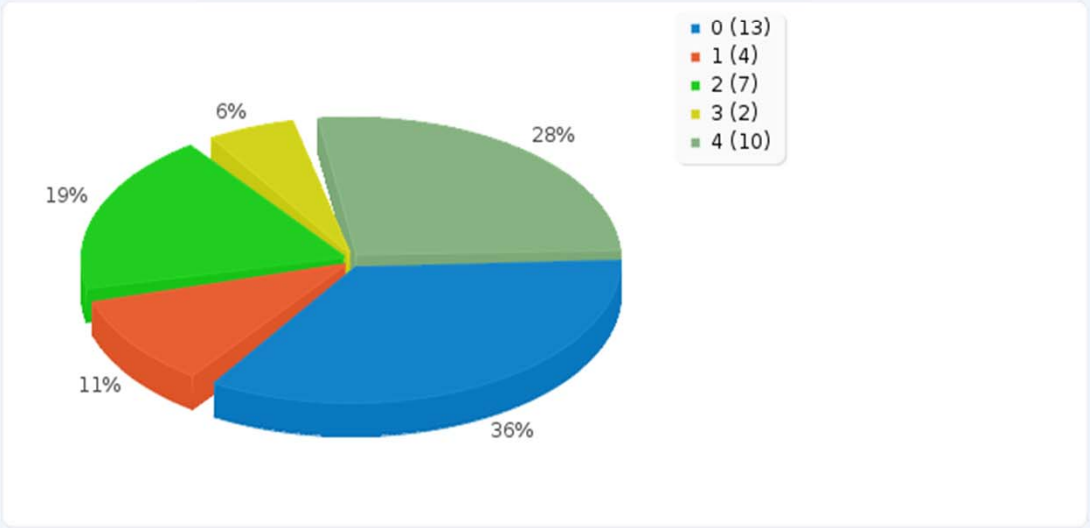
Q: Much Usage/Importance of MultiBody Library

Field summary for Mbody		
Much usage/importance of MultiBody (MSL) library		
Answer	Count	Percentage
Yes (Y)	11	30.56%
No (N)	25	69.44%
No answer	0	0.00%



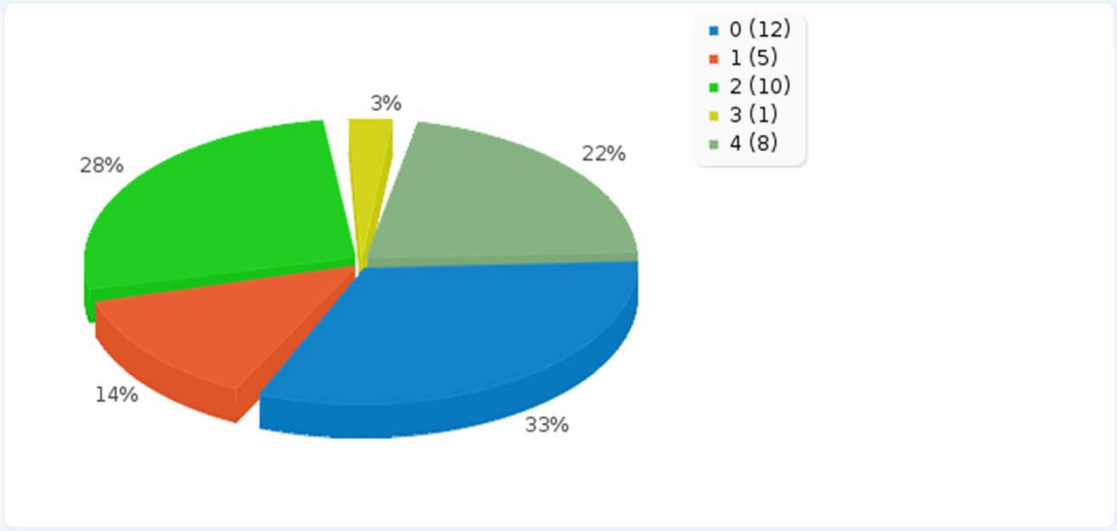
Q: Coverage Importance of MSL MultiBody (1-5)

Field summary for MbodyCov				
Importance of OpenModelica MultiBody (MSL) simulation coverage (1-5), (1= some models, 5=all models simulate)				
Answer		**Count**	**Percentage**	**Sum**
	1 (1)	13	33.33%	43.59%
	2 (2)	4	10.26%	
	3 (3)	7	17.95%	17.95%
	4 (4)	2	5.13%	
	5 (5)	10	25.64%	30.77%
	Sum (Answers)	**36**	**100.00%**	**100.00%**
	Number of cases	36	100.00%	
	No answer	0	0.00%	
	Arithmetic mean		2.78	
	Standard deviation		1.66	



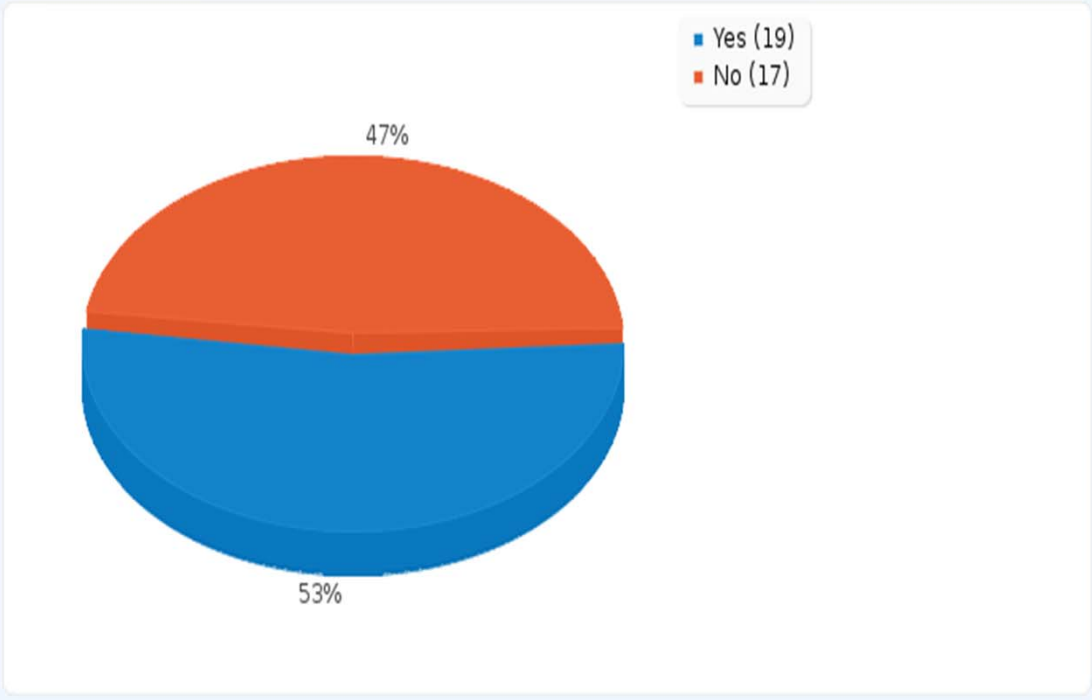
Q: Performance Importance MultiBody (1 to 5)

Field summary for MbodySim				
Importance OpenModelica MultiBody (MSL) Simulation performance - 1-5), (1= slow, 5=fast simulation):				
Answer		**Count**	**Percentage**	**Sum**
	1 (1)	12	30.77%	43.59%
	2 (2)	5	12.82%	
	3 (3)	10	25.64%	25.64%
	4 (4)	1	2.56%	
	5 (5)	8	20.51%	23.08%
	Sum (Answers)	**36**	**100.00%**	**100.00%**
	Number of cases	36	100.00%	
	No answer	0	0.00%	
	Arithmetic mean		2.67	
	Standard deviation		1.53	



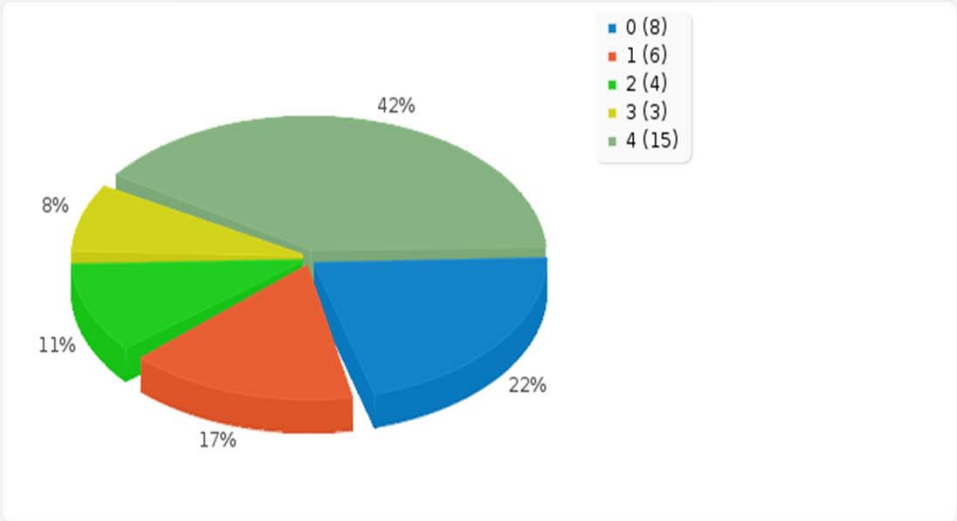
Q: Much Usage/Importance of Fluid/Media

Field summary for Fluid		
Much usage/importance of Fluid/Media (MSL) or similar libraries		
Answer	**Count**	**Percentage**
Yes (Y)	19	52.78%
No (N)	17	47.22%
No answer	0	0.00%



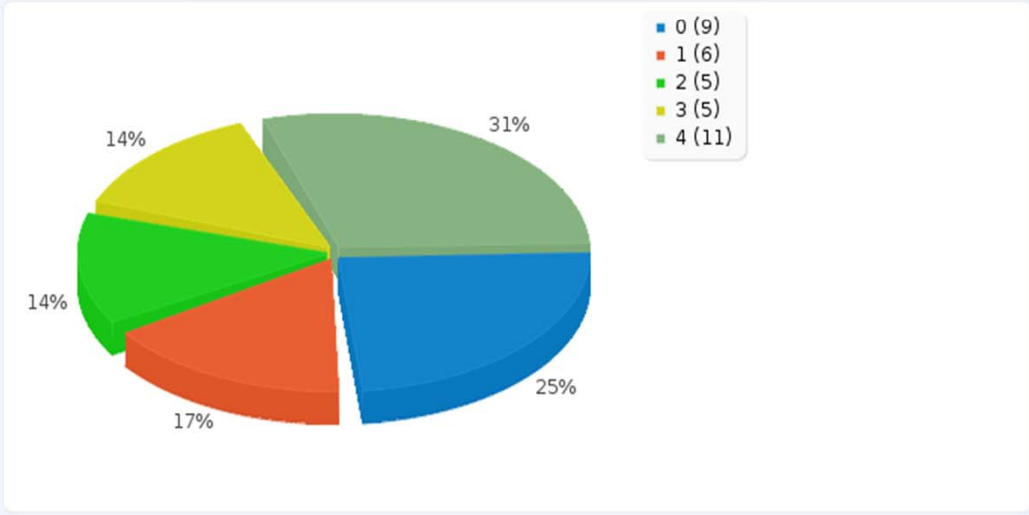
Q: Coverage Importance Fluid/Media (1 to 5)

Field summary for FluidCov				
Importance of OpenModelica Fluid/Media (MSL) or similar simulation coverage (1-5), (1= some models, 5=all models simulate)				
Answer		**Count**	**Percentage**	**Sum**
	1 (1)	8	20.51%	35.90%
	2 (2)	6	15.38%	
	3 (3)	4	10.26%	10.26%
	4 (4)	3	7.69%	
	5 (5)	15	38.46%	46.15%
	Sum (Answers)	**36**	**100.00%**	**100.00%**
	Number of cases	36	100.00%	
	No answer	0	0.00%	
	Arithmetic mean		3.31	
	Standard deviation		1.67	



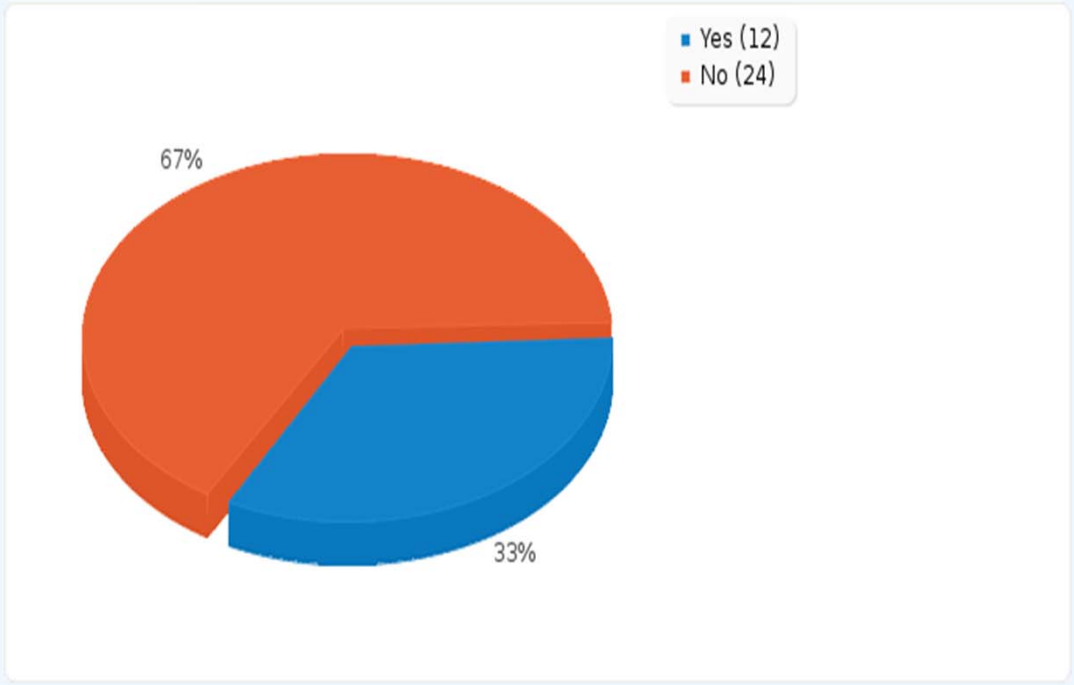
Q: Simulation Performance Fluid/Media (1 – 5)

Field summary for FluidSim			
Importance OpenModelica Fluid/Media (MSL) or similar Simulation performance - 1-5), (1= slow, 5=fast simulation)			
Answer	**Count**	**Percentage**	**Sum**
1 (1)	9	23.08%	38.46%
2 (2)	6	15.38%	
3 (3)	5	12.82%	12.82%
4 (4)	5	12.82%	
5 (5)	11	28.21%	41.03%
Sum (Answers)	**36**	**100.00%**	**100.00%**
Number of cases	36	100.00%	
No answer	0	0.00%	
Arithmetic mean		3.08	
Standard deviation		1.61	



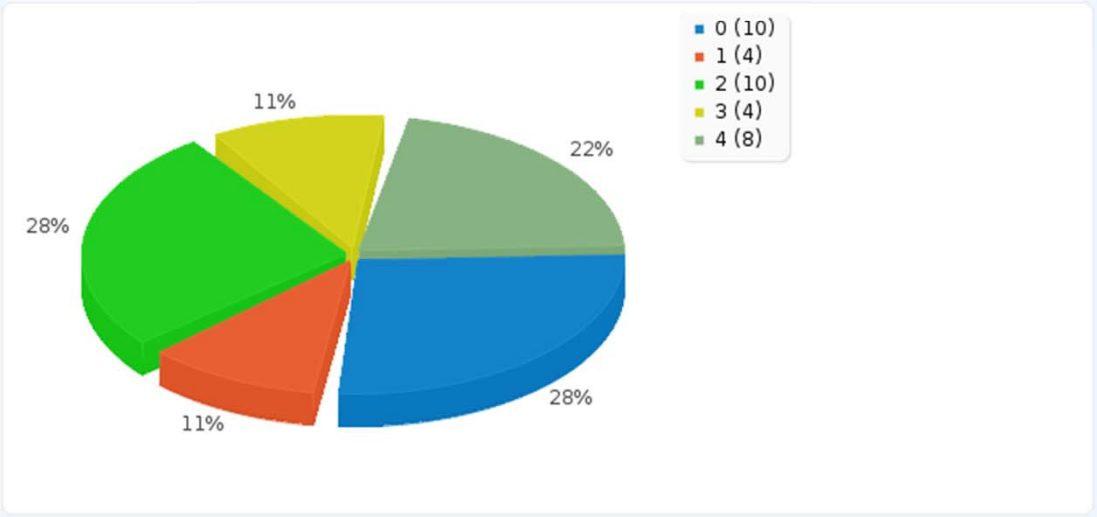
Q: Much Usage/Importance of Electrical lib

Field summary for Electr		
Much usage/importance of Electrical (MSL) libraries		
Answer	**Count**	**Percentage**
Yes (Y)	12	33.33%
No (N)	24	66.67%
No answer	0	0.00%



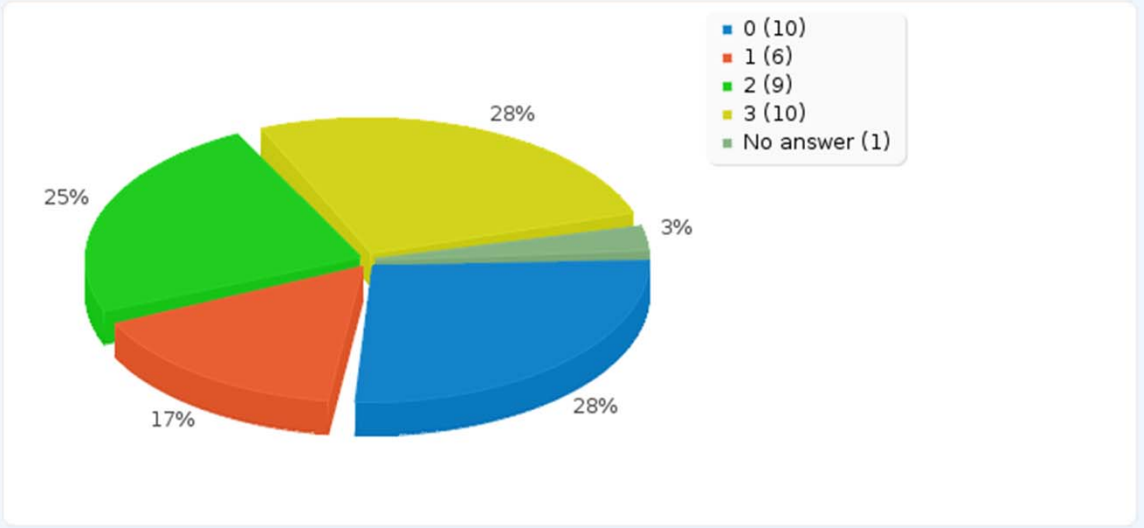
Q: Simulation Coverage of Electrical lib (1 to 5)

Field summary for ElectrCov			
Importance of OpenModelica Electrical (MSL) simulation coverage (1-5), (1= some models, 5=all models simulate)			
Answer	**Count**	**Percentage**	**Sum**
1 (1)	10	25.64%	35.90%
2 (2)	4	10.26%	
3 (3)	10	25.64%	25.64%
4 (4)	4	10.26%	
5 (5)	8	20.51%	30.77%
Sum (Answers)	**36**	**100.00%**	**100.00%**
Number of cases	36	100.00%	
No answer	0	0.00%	
Arithmetic mean		2.89	
Standard deviation		1.51	



Q: Simulation Performance of Electrical lib (1 to 5)

Field summary for ElectrSim				
Importance OpenModelica Electrical (MSL) Simulation performance - 1-5), (1= slow, 5=fast simulation)				
Answer		**Count**	**Percentage**	**Sum**
	1 (1)	10	26.32%	42.11%
	2 (2)	6	15.79%	
	3 (3)	9	23.68%	23.68%
	4 (4)	0	0.00%	
	5 (5)	10	26.32%	26.32%
	Sum (Answers)	**35**	**100.00%**	**100.00%**
	Number of cases	36	100.00%	
	No answer	1	2.78%	
	Arithmetic mean		2.83	
	Standard deviation		1.58	

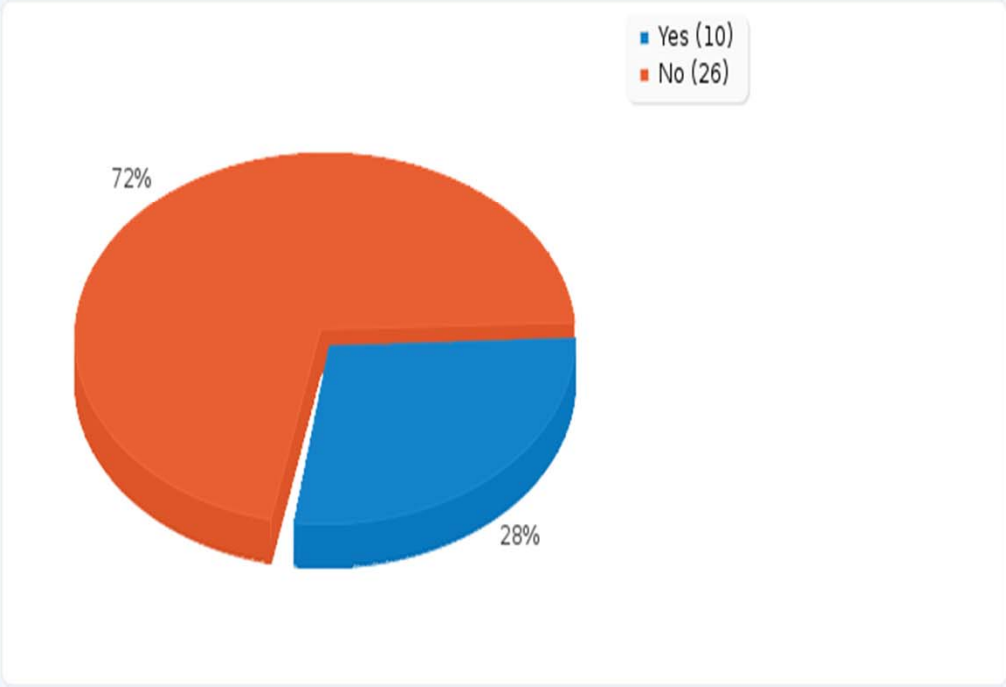


Q: Much Usage/Importance of OM Dev Environment

Field summary for OMDev

OMDev: Much usage/importance of OpenModelica development environment for OM compiler development

Answer	Count	Percentage
Yes (Y)	10	27.78%
No (N)	26	72.22%
No answer	0	0.00%

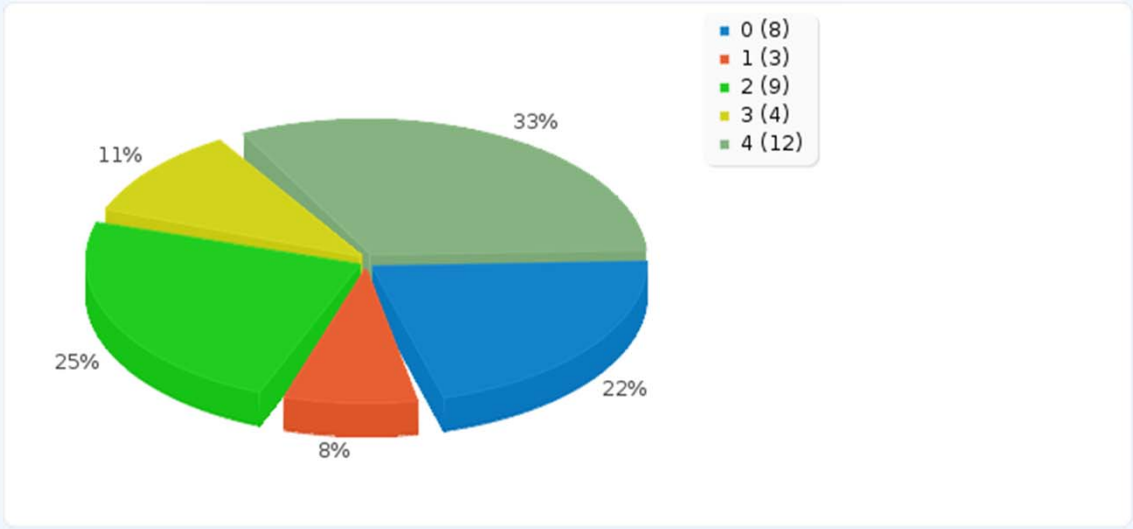


Q: Typical Appl Model Size (# of Equations)

Field summary for ModSize:	
Model size: What is the size (in equations) of your typical application models: (give a rough number)	
Calculation	**Result**
Count	32
Sum	534175.0000000000
Standard deviation	25639.59
Average	16692.97
Minimum	5.0000000000
1st quartile (Q1)	1000
2nd quartile (Median)	10000
3rd quartile (Q3)	17500
Maximum	100000.0000000000
	Null values are ignored in calculations
	Q1 and Q3 calculated using minitab method

Q: Priority Modelica 3.3 Clocked & State Machines

Field summary for Prio				
Priority of supporting new Modelica 3.3 synchronous and state machines features (1-5) (1=low, 5= high)				
Answer		**Count**	**Percentage**	**Sum**
	1 (1)	8	20.51%	28.21%
	2 (2)	3	7.69%	
	3 (3)	9	23.08%	23.08%
	4 (4)	4	10.26%	
	5 (5)	12	30.77%	41.03%
	Sum (Answers)	**36**	**100.00%**	**100.00%**
	Number of cases	36	100.00%	
	No answer	0	0.00%	
	Arithmetic mean		3.25	
	Standard deviation		1.56	



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

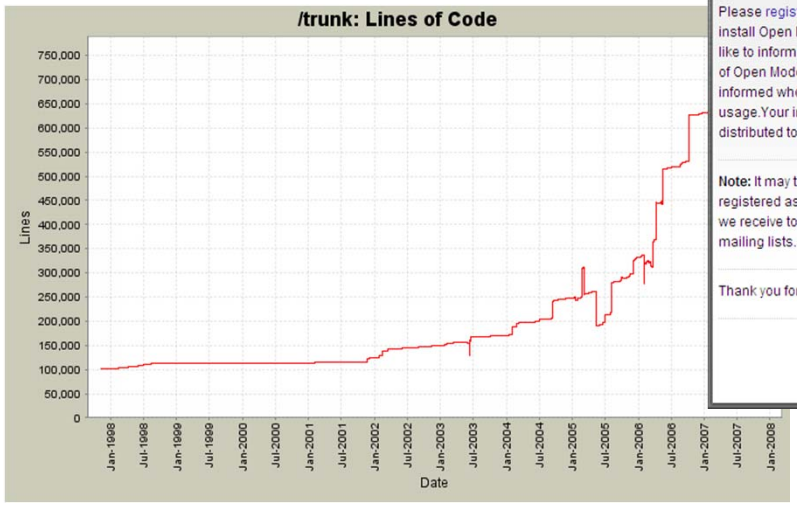
OSMC – Open Source Modelica Consortium
45 organizational members December 2012

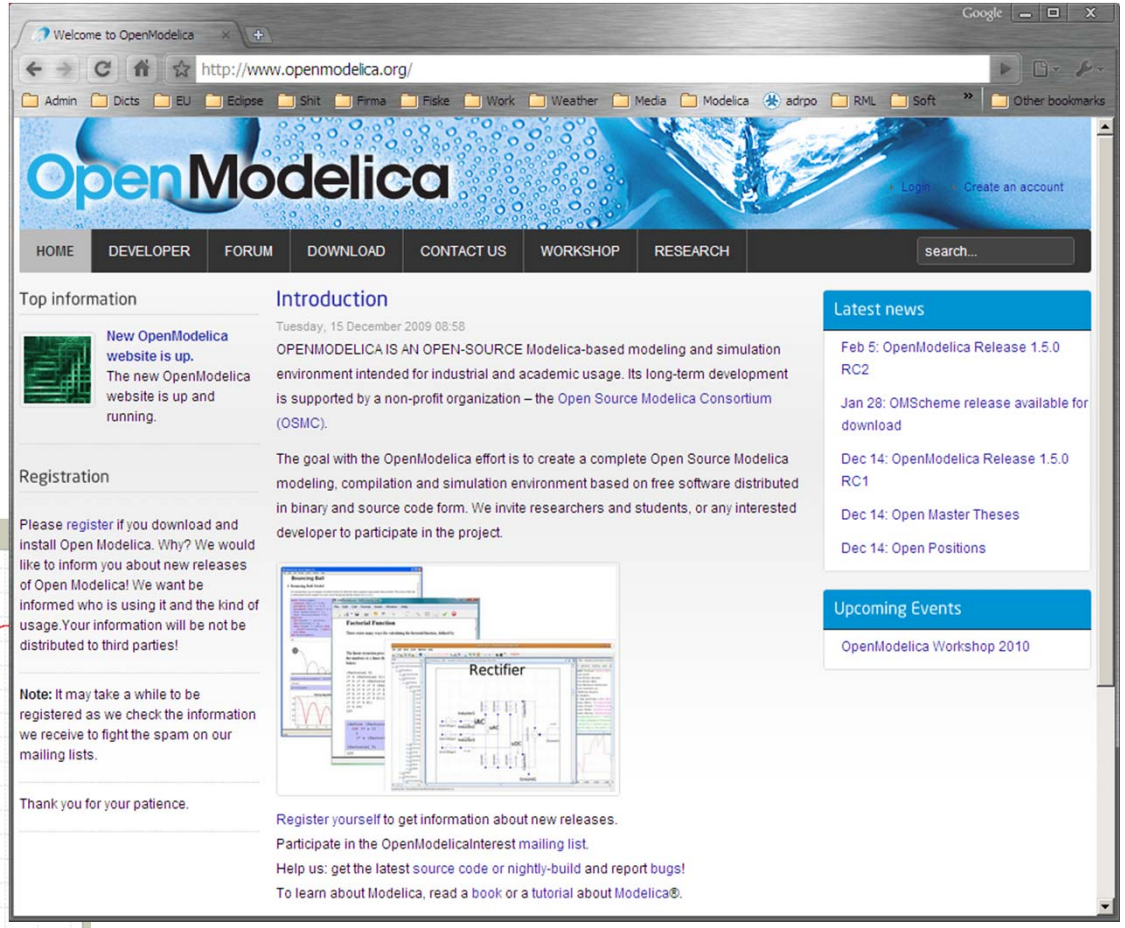
Founded Dec 4, 2007

Open-source community services

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

Code Statistics





OSMC 45 Organizational Members, Dec 2012

(initially 7 members, 2007)

Companies and Institutes (24 members)

- ABB Corporate Research, Sweden
- Bosch Rexroth AG, Germany
- Siemens PLM, California, USA
- Siemens Turbo Machinery AB, Sweden
- CDAC Centre for Advanced Compu, Kerala, India
- Creative Connections, Prague, Czech Republic
- DHI, Aarhus, Denmark
- Evonik, Dehli, India
- Equa Simulation AB, Sweden
- Fraunhofer FIRST, Berlin, Germany
- Frontway AB, Sweden
- Gamma Technology Inc, USA
- IFP, Paris, France
- ISID Dentsu, Tokyo, Japan
- ITI, Dresden, Germany
- MathCore Engineering/ Wolfram, Sweden
- Maplesoft, Canada
- TLK Thermo, Germany
- Sozhou Tongyuan Software and Control, China
- VI-grade, Italy
- VTI, Linköping, Sweden
- VTT, Finland
- XRG Simulation, Germany

Universities (21 members)

- TU Berlin, Inst. UEBB, Germany
- FH Bielefeld, Bielefeld, Germany
- TU Braunschweig, Germany
- University of Calabria, Italy
- TU Dortmund, Germany
- TU Dresden, Germany
- Georgia Institute of Technology, USA
- Ghent University, Belgium
- Griffith University, Australia
- TU Hamburg/Harburg Germany
- KTH, Stockholm, Sweden
- Université Laval, Canada
- 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
- Telemark Univ College, Norway
- University of Ålesund, Norwlay

Open Source Modelica Consortium Individual Members

(62 individual members, 4 February 2013)

- 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, 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, Alexey Lebedev, Oliver Lenord, Ariel Liebman, Rickard Lindberg, Håkan Lundvall, Abhi Raj Metkar, Eric Meyers, Tuomas Miettinen, Afshin Moghadam, 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 2012

- **Oliver Lenord**, OSMC Chairman; Manager, Siemens PLM, USA
- **Per Sahlin**, OSMC Vice Chairman; CEO, Equa Simulation AB
- **Peter Fritzson**, OSMC Director; Prof, Linköping University, Sweden
- **Juha Kortelainen**, Manager, VTT, Finland
- **Gerhard Schmitz**, Prof, Univ. Hamburg, Germany
- **Alf Isaksson**, Manager, ABB Corp. Research, Sweden
- **Francesco Casella**, Prof, Politecnico di Milano, Italy
- **Jan Brugård**, CEO, Wolfram MathCore AB, Sweden
- **Kilian Link**, Manager, Siemens, Germany (and Sweden)
- **Lars Mikelsons**, Manager, Bosch-Rexroth, Germany.

OSMC Board – 7 Meetings Jan 1 2013 – Dec 31 2013

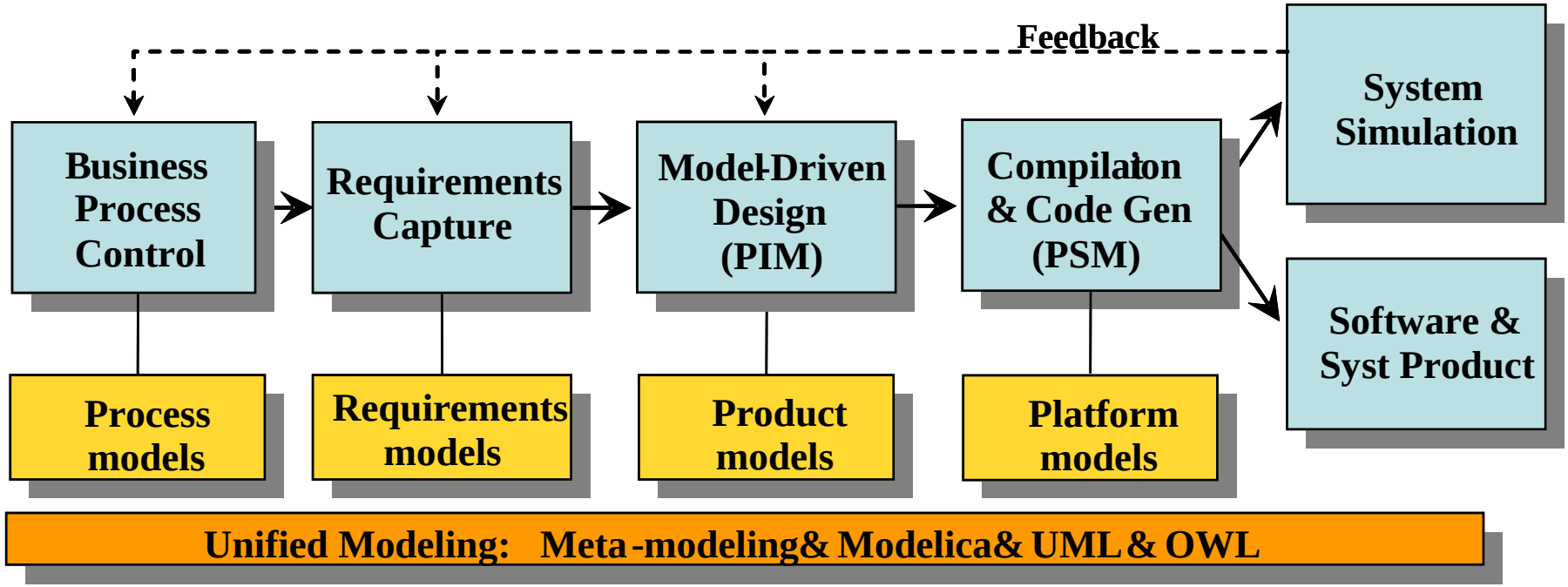
Meeting dates

- 120113
- 120314
- 120504
- 120614
- 120828
- 121018
- 121211

Board Work

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

Expanded Vision for OpenModelica Effort: Integrated Model-driven Development Based on OpenModelica, e.g. in OPENPROD project



Vision of unified modeling framework for model-driven product development from platform independent models (PIM) to platform specific models (PSM)

OPENPROD –OpenModelica related Project

- Duration: June 2009 – Dec 2012 (3.3 years)
- Budget: approx 11 Meuro, 94 Manyears
- 28 partners
- Very important for OpenModelica development
- Successful review Sept 2011 after 2 years
- Successful review Dec 2012 including most application demos
- (New project MODRIO approved, starting fall 2012)

Main workpackages

- Integrated hardware software modeling by Modelica - UML - SysML integration.
- Model compiler enhancements.
- Compilation of Modelica to parallel multi-core platforms.
- Tool interoperability.
- Application demonstrators.

Special Thanks

- The developers who worked very hard during 2012. Adrian Pop, Martin Sjölund, Per Östlund, Adeel Asghar, Jens Frenkel, Willi Braun, Lennart Ochel, Mahder Gebremedhin, Modelers Christian Schubert, Francesco Casella, Bruno Scaglioni, and several other people.
- The 45 OpenModelica consortium organizational members for support including Bosch-Rexroth, Wolfram-MathCore, Siemens Turbo Machinery, ABB, Siemens PLM, etc...
- Master students and PhD students who made important contributions.

Conclusions and Summary 2012

- OSMC expanded from 38 to 45 organizational members.
- April 2012. OpenModelica 1.8.1 release. Improved MSL support, Operator Overloading, OMPython prototype.
- Dec 2012/Jan 2013. Breaktrough Fluid support. 92% MSL 3.2.1 simulating. OpenModelica 1.9.0 beta3/4
- 2013. Good prospects for the future – towards a standard high quality open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.

Questions?

www.openmodelica.org