

# The FMU Compliance Checker and FMU Cross-Checking

## Overview

Hubertus Tummescheit, Modelon



# Overview

- Compliance checker for FMUs
- FMU Cross-checking process

# Background

- Different tool implementors interpreted FMI 1.0 in different ways
  - Poor user experience when exporting/importing/combining FMUs from different tools
  - Industrial pressure to improve cross compliance of tools
- Modelica Association issued a RFQ in 2012 to develop a compliance checker
  - Provide an open source tool to support tool vendors developing FMU exporting tools
  - Modelon was assigned task of developing the FMU checker
- ***Achieve consistency and compliance of tools supporting FMI***
  - A freely available tool to promote tool interoperability

# Key features

- Check a given FMU's compliance with the FMI standard
  - FMI for Model Exchange 1.0
  - FMI for Co-simulation 1.0
  - FMI 2.0RC1
- Automatic unzipping into a temporary directory
- Checking of all DLL functions
- Checking of XML model description
  - for syntax errors
  - for correct order of elements and correct cardinality or relations
  - for correct cross-references
- Simulation
  - Explicit Euler for Model Exchange FMUs
  - Stepping for Co-simulation FMUs
  - Simulation results written to file in CSV format
- CMake build system
  - Builds on win32, win64, linux32, linux64 and Mac OS X
- Relies on FMI Library for FMU interaction
  - Open source (BSD) C package for FMU integration (<http://www.fmi-library.org>)

# The FMU Checker executable

```
>fmuCheck.win32.exe -e FMU_log.txt -f -l 4 -h 0.01 -s 10.0 -o FMU_out.csv SpringDamper.fmu
```

## Available Options:

- c <separator>      Separator character to be used in CSV output. Default is ','.
- e <filename>      Error log file name. Default is to use standard error.
- f                    Print all variables to the output file. Default is to only print outputs.
- h <stepSize>      Step size to use in forward Euler. Default is to use step size based on the number of output points.
- i <infile>        Name of the CSV file name with input data.
- l <log level>      Log level: 0 - no logging, 1 - fatal errors only, 2 - errors, 3 - warnings, 4 - info, 5 - verbose, 6 - debug.
- m                   Mangle variable names to avoid quoting (needed for some CSV importing applications).
- n <num\_steps>    Maximum number of output points. Zero means output in every step. Default is 500.
- o <filename>      Simulation result output CSV file name. Default is to use standard output.
- s <stopTime>      Simulation stop time, default is to use information from 'DefaultExperiment' as specified in the model description XML.
- t <tmp-dir>        Temporary dir to use for unpacking the FMU. Default is to use system-wide directory, e.g., C:\Temp.
- x                   Check XML and stop, default is to load the DLL and simulate after this.
- z <unzip-dir>     Do not create and remove temp directory but use the specified one for unpacking the FMU. The option takes precedence over -t.

# Error reports

Administrator: C:\Windows\System32\cmd.exe

Microsoft Windows [Version 6.1.7601]

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c:\FMUComplianceCheck\Example>fmuCheck.win32.exe -l 3 -x -o out.csv CoupledClutches.fmu

[WARNING][FMI2XML] Attribute noNamespaceSchemaLocation='fmiModelDescription.xsd' is ignored. Using standard

[WARNING][FMI2XML] FMI API function fmiGetPartialDerivatives is removed from the specification. Attribute pr

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[ERROR][FMI2XML] Attribute 'providesDirectionalDerivatives' has been renamed to 'providesDirectionalDerivat

[ERROR][FMI2XML] Unknown attribute 'canHandleEvents=true' in XML

[ERROR][FMI2XML] Unknown attribute 'canSignalEvents=true' in XML

[WARNING][FMI2XML] FMI API function fmiGetPartialDerivatives is removed from the specification. Attribute pr

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[ERROR][FMI2XML] [Line:1682] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1686] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1690] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1694] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1698] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1702] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1706] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] [Line:1710] Unknown element 'Derivative' in XML, skipping

[ERROR][FMI2XML] Model identifiers for ModelExchange and CoSimulation must be different

FMU check summary:

FMU reported:

0 warning(s) and error(s)

Checker reported:

9 Warning(s)

12 Error(s)

c:\FMUComplianceCheck\Example>

# Cross checking protocol

- First step: pass compliance checker
- Designed to work with little resources from Modelica Association
- Cross-checking provides additional tests
- Provides public documentation of verified cross-tool compatibility
- Public table of results: documented who actually puts in effort into standards compliance

# Tools (from FMI [website](#))

	Export	Import	Slave	Master	
Adams		Planned	Available	Available	High end multibody dynamics simul
AMESim	Available	Available	Available	Planned	Modelica environment from LMS-Ir
ANSYS Simplorer		Planned	Planned		ANSYS Simplorer is a multi-domain
ASim - AUTOSAR Simulation	Available		Available		AUTOSAR product from Dassault
Atego Ace		Available		Available	Co-simulation environment with AL
@Source	Available				Simulink via @Source
Building Controls Virtual Test Bed				Available	BCVTB is a Software environment exchange with, building energy an
CarMaker				Available	CarMaker is an open test- and inte
CATIA	Available	Available	Available	Available	Environment for Product Design an on Modelica, by Dassault Système
ControlBuild	Available	Available	Available	Available	Environment for IEC 61131-3 contr
CosIMate		Available		Available	Co-simulation Environment from Ch
Cybernetica CENT		Available		Planned	Industrial product for nonlinear Mo
Cybernetica ModelFit		Available		Available	Software for model verification, st By Cybernetica.
DSHplus	Planned		Planned		Fluid power simulation software fr
Dymola	Available	Available	Available	Available	Modelica environment from Dassai using Simulink Coder.
EnergyPlus			Planned	Available	Whole building energy simulation p
FMI Add-in for Excel				Available	FMI Add-in for Microsoft Excel by I
FMI add-on for NI VeriStand		Available			NI VeriStand supports FMI through
FMI Blockset for Simulink				Available	Import of FMI Co-Simulation models
FMI Library		Available		Available	Open source (BSD) C library for in Modelon.
FMI Target for Simulink Coder			Available		Export of stand-alone FMUs for Co by ITI
FMI Toolbox for CarMaker		Available		Available	For IPG CarMaker via FMI Toolbox
FMI Toolbox for MATLAB	Available	Available	Planned	Available	FMI Toolbox for MATLAB from Mod
FMU SDK	Available	Available	Available	Available	FMU Software Development Kit fro
Hopsan	Available	Available			Hopsan is a free simulation tool de solver techniques with good supp
ICOS "Independent Co-Simulation"		Available	Available	Available	ICOS is a co-simulation tool develo

JavaFMI		Planned		Available	JavaFMI is a Java wrapper for the Windows 32 & 64 bit OS.
JFMI			Available	Available	A Java Wrapper for the Function
JModelica.org	Available	Available	Available	Available	Open source Modelica environme
LMS Virtual.Lab Motion		Available	Planned	Available	Virtual.Lab Motion is a high end m
MapleSim	Available	Planned	Planned	Planned	Modelica-based modeling and sim
MESSINA		Available	Planned	Planned	MESSINA is a test platform for mo
MWorks	Available	Planned	Planned	Planned	Modelica environment from Suzho
NI LabVIEW		Planned			Graphical programming environm National Instruments
OpenModelica	Available	Available	Planned	Available	Open source Modelica environme
OPTIMICA Studio	Available	Planned	Planned	Planned	Modelica environment from Model
Ptolemy II				Planned	Software environment for design
PyFMI		Available		Available	For Python via the open source p JModelica.org platform.
RecurDyn	Planned	Planned	Planned	Planned	High End Multi Flexible Body Dyna
Reference FMUs	Planned		Planned		Reference FMUs supplied by ent features
SCADE Display	Planned		Planned		SCADE Display facilitates embed code generation for safety-critica
SCADE Suite	Available		Available		SCADE Suite is a model-based de safety critical embedded applicati
Silver	Available	Available	Available	Available	Virtual integration platform for So
SIMPACK	Planned	Available	Planned	Available	High end multi-body simulation so
SimulationX	Available	Available	Available	Available	Multi-domain simulation tool for de by ITI.
SystemModeler	Planned	Planned	Planned	Planned	Modelica environment from Wolfr
TLK FMI Suite		Available		Available	TLK FMI Suite provides LabVIEW
TLK TISC Suite		Available		Available	Co-simulation environment from T
TWT Co-Simulation Framework			Available	Available	Communication layer tool to flexib front-end for set-up, monitoring a
TWT FMU Trust Centre			Available		Cryptographic protection and sign authentication and authorization f
xMOD		Available		Available	Heterogeneous model integration laboratory from IFPEN distribut



# Cross checking protocol

Start Downloads Tools Development Literature History Contact

CrossCheck Results for *FMI\_1.0*

Variant: 

ModelExchange

Platform: 

win32

Generated on 2014-03-03 16:49 UTC

Legend FMI Support:  
3 → 3 FMUs imported successfully 1 → 1 FMU rejected 2 → 2 FMUs failed test

FMI_1.0	Exporters →	CATIA	ControlBuild	Dymola	FMI Toolbox for MATLAB				JModelica.org	LMS Virtual.Lab Motion	MapleSim	OPTIMICA Studio	Silver	SimulationX	
ModelExchange win32															
↓ Importers		V6R2013x	2013-2a	2014	2013_FD01	2014_FD01	1.5	1.6	1.9.1	1.10	Rev11SL2	6.1	1.2a4	2.6.0.312_alpha12	3.5.707
ANSYS Simplorer	15.0.0			<div>300</div>				<div>300</div>	<div>300</div>		<div>100</div>	<div>200</div>	<div>300</div>	<div>300</div>	<div>400</div>
				2014-01-15				2014-01-15	2014-01-15		2014-01-15	2014-01-15	2014-01-15	2014-01-15	2014-01-15
ControlBuild	2013-2a	<div>210</div>	<div>300</div>		<div>300</div>										
		2014-01-16	2014-01-15		2014-01-15										
Dymola	2014			<div>300</div>			<div>300</div>	<div>300</div>	<div>300</div>			<div>200</div>		<div>300</div>	<div>400</div>
				2013-08-28			2013-08-28	2013-08-28	2013-08-28			2013-08-28		2013-08-28	2013-08-28
FMI Library	2.0a2			<div>300</div>			<div>300</div>		<div>300</div>		<div>100</div>		<div>300</div>	<div>300</div>	<div>400</div>
				2013-06-05			2013-06-05		2013-06-05		2013-06-05		2013-06-05	2013-06-05	2013-06-05
FMI Toolbox for MATLAB	1.5-MEX			<div>300</div>			<div>300</div>				<div>100</div>			<div>201</div>	<div>400</div>
				2013-05-19			2013-06-18				2013-05-19			2013-05-19	2013-05-19
	1.5-Simulink			<div>300</div>			<div>300</div>				<div>100</div>			<div>201</div>	<div>400</div>
				2013-05-19			2013-05-19				2013-05-19			2013-05-19	2013-05-19
JModelica.org	1.9.1			<div>201</div>			<div>300</div>		<div>300</div>		<div>001</div>		<div>300</div>	<div>300</div>	<div>400</div>
				2013-05-20			2013-05-20		2013-05-20		2013-05-20		2013-05-20	2013-05-20	2013-05-20
	1.10			<div>300</div>			<div>300</div>		<div>300</div>	<div>300</div>	<div>100</div>	<div>200</div>	<div>300</div>	<div>300</div>	<div>400</div>
				2013-07-11			2013-07-11		2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11
OPTIMICA Studio	1.2a4			<div>201</div>			<div>300</div>		<div>300</div>		<div>001</div>			<div>300</div>	<div>400</div>
				2013-05-20			2013-05-20		2013-05-20		2013-05-20			2013-05-20	2013-05-20
PyFMI	1.3.1			<div>300</div>			<div>300</div>		<div>300</div>	<div>300</div>	<div>100</div>	<div>200</div>	<div>300</div>	<div>300</div>	<div>400</div>
				2013-07-11			2013-07-11		2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11	2013-07-11
	1.2.1			<div>201</div>			<div>300</div>		<div>300</div>		<div>001</div>		<div>300</div>	<div>300</div>	<div>400</div>
				2013-05-15			2013-05-20		2013-05-20		2013-05-15		2013-05-20	2013-05-15	2013-05-15
Silver	2.6.0.312_alpha12			<div>300</div>			<div>201</div>		<div>201</div>		<div>100</div>		<div>300</div>	<div>300</div>	<div>200</div>
				2013-06-18			2013-06-09		2013-06-09		2013-06-09		2013-06-09	2013-06-18	2013-06-09
SimulationX	3.5.707			<div>200</div>			<div>300</div>	<div>300</div>	<div>300</div>	<div>300</div>		<div>200</div>	<div>300</div>	<div>300</div>	
				2013-09-20			2013-09-20	2013-09-20	2013-09-20	2013-09-20		2013-09-20	2013-09-20	2013-09-20	

# Future extensions

- Advanced FMI 2.0 features
  - Jacobian checking
  - Save-state functionality
  - Reset in Co-simulation slaves
  - Correctness of input derivatives
- Buffer overrun check
- Memory violation check
- Connection of FMUs

# Summary

- Freely available under open source (BSD) license
- Excellent tool for developers creating FMUs or creating FMU export functionality in their tool
- Easy to access command line tool to help finding problems in FMUs
- Basis for the FMI cross check protocol
- For more information see: <http://www.fmi-standard.org>

## Take away for FMI implementors:

- Use the Compliance Checker!
- Take advantage of the cross checking infrastructure and publish your results!